

Understanding the risks of drinking water self-supplies
from the perspective of rural people

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Abstract

Due to the potential for serious and widespread outbreaks of waterborne disease, managing the risk of microbiological contamination of drinking water is of particular importance. In New Zealand, drinking water quality and safety are regulated under the Health (Drinking Water) Amendment Act 2007. However, there remains a subset of the population for whom there is no such regulation of drinking water quality and safety.

Rural households dependent on drinking water self-supplies, such as private wells, must take full responsibility for maintaining, monitoring and treating their own drinking water. Research suggests that these households often fail to engage in the actions recommended by public health authorities to protect drinking water quality and safety. To understand why this might be, this study set out to explore rural people's perspectives on drinking water self-supplies in one rural location in New Zealand: Hinds, Mid Canterbury.

Taking a social constructionist standpoint, I interviewed 15 residents responsible for and dependent on drinking water self-supplies in the rural Hinds area. Social constructionists argue that there is no single truth or reality. What is accepted as knowledge today is simply one of many ways of thinking which has been given the status of truth where others have not. Therefore, the social constructionist

encourages society to question accepted knowledge and to consider why it came to be seen as the 'truth' in the first place.

Through semi-structured in depth interviews, I focused on the Hinds residents' experiences with their drinking water self-supplies, their understanding of the risks thereof, and their perceptions of drinking water quality testing. A sample of drinking water from each participating household was tested for *Escherichia coli* (*E. coli*) by an accredited laboratory. Three of the thirteen samples collected were found to contain *E. coli*. The residents were provided with their test results as a means of initiating discussion on drinking water quality testing.

A thematic analysis of the data collected found that the rural Hinds residents I interviewed discussed water in a much wider context than simply their drinking water. They described how drinking water quality and quantity was influenced by other water resources in the area, drawing connections between groundwater, irrigation water and surface water bodies. To these water resources they applied a broad definition of water quality that extended beyond microbiological contamination to include health and the aesthetic attributes of water.

The data analysis confirmed that my participants held sole responsibility for their drinking water self-supplies. However, drinking water was just one of a number of competing priorities for the rural Hinds residents I interviewed and, as such, drinking water quality and safety may benefit from a collaborative effort between rural

residents and public health professionals. Rather than relying on scientific understandings of risk in promoting drinking water quality and safety, public health professionals may experience greater success in appealing to local values. These values include the protection of vulnerable populations, the preservation of resources for future generations, and the security of income and land values. Future research might expand on these understandings by seeking the views of non-farming rural residents in other areas of New Zealand, as well as those residents who have contracted a waterborne disease from their drinking water in the past, or are dependent on a different type of drinking water self-supply as their perspectives may differ from those of the participants in this study.

Preface

While still living at home with my parents in Hinds, Mid Canterbury, I went through a phase of boiling my drinking water and running it through one of those filter jugs from Briscoes. My Mum indulged the behaviour, all the while thinking I was slightly mad. My Mum likes to point out that, much like her cooking, our drinking water has never made anybody sick. Thus, just as she does not religiously wash her hands while preparing food, nor does she see a problem with drinking the water straight out of the tap.

This drinking water is pumped out of the ground and into an elevated concrete tank, after which it gravity feeds to the house. On the surface, it seems a simple system. However, unbeknownst to the casual onlooker, the pump periodically breaks down and it is not until the tank is empty that anyone realises the pump has stopped working. This necessitates the use of less than desirable sources of water.

The tank, as well, is a marvel to behold with its patina of cracks and green moss – its appearance raises suspicion of what might be lurking within. Having never seen inside the tank, this remains somewhat of a mystery to me. Nevertheless, if the last six years of study in public health have taught me nothing else, drinking water from a dubious source comes with the risk of vomiting and diarrhoea. No one is testing our water to make sure it meets the Drinking Water Standards for New Zealand nor have they written a comprehensive Water Safety Plan for the Sullivan household.

It was this apparent discrepancy between my academic and personal experience that first piqued my interest in drinking water self-supplies as a research topic. However, this thesis itself is the sum of a number of influences, to whom I owe my deepest gratitude: the experiences of my participants, the ideas of the writers I have drawn on, and the expertise of my supervisor, Dr Cheryl Brunton, my co-supervisor, Dr Gillian Abel, and my advisors from Community and Public Health, Denise Tully and Judy Williamson.

For me, this thesis also represents the long drive between Christchurch and Hinds, holidays spent transcribing interviews, early mornings occupied with reading textbooks, and weekends engaged in constructing meaningful sentences. I am indebted to my family and partner whose support and encouragement made this possible. While this research has taught me to question the truth of my own ideas, what stands out above all is the old adage: your mother is always right (or at least as right as everyone else).



Photo: The Sullivan Household water storage tank.

Table of Contents

Abstract	i
Preface.....	iv
Table of Contents	vi
List of Figures.....	viii
1 Background.....	1
1.1 Introduction	1
1.2 Mitigating Health Risk.....	3
1.3 Hinds, Mid Canterbury.....	6
2 Literature Review	10
2.1 Introduction	10
2.2 Risk Perception Theory	11
2.3 Drinking Water Quality	14
2.4 Drinking Water Safety.....	18
2.5 Health Risk Communication.....	23
2.6 Summary.....	26
3 Methodology and Methods.....	28
3.1 Introduction	28
3.2 Methodology.....	29
3.3 Methods.....	31

3.3.1	Sampling	31
3.3.2	Data collection	34
3.3.3	Data analysis	38
4	Water Resources and Competing Priorities	40
4.1	Introduction	40
4.2	Water Resources of the Hinds Area	40
4.3	Water and Drinking Water	44
4.4	Water Security	49
4.5	Health and Economy	53
4.6	Competing Priorities	57
5	Water Quality	63
5.1	Introduction	63
5.2	Aesthetic Attributes	64
5.3	Testing and Contamination	70
5.4	Health Risk Communication	77
5.5	Summary	85
6	Responsibility and Control	86
6.1	Introduction	86
6.2	Role of Individuals	87
6.3	Collaborative Effort	94

6.4	The Natural Sciences.....	101
6.5	Summary.....	105
7	Conclusions and Recommendations	107
7.1	Introduction	107
7.2	Experiences with Drinking Water	108
7.3	Risk Perception and Testing Behaviour	111
7.4	Summary.....	115
Appendix 1 Search Strategy.....		117
	Web of Science Core Collection	117
	Google Scholar.....	117
Appendix 2 Participant Information and Consent Sheets.....		118
Appendix 3 Interview Guide		122
References.....		124

List of Figures

Figure 1 Hinds Area Map (Google, 2016)	7
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1 Background

1.1 Introduction

Access to safe drinking water is a basic human right and a fundamental requirement for public health (Ministry of Health, 2008). Due to the potential for serious and widespread outbreaks of waterborne disease, managing the risk of microbiological contamination of drinking water is of particular importance. The microbiological contamination of drinking water has resulted in a number of disease outbreaks, including in New Zealand. Most recently, the Havelock North community experienced an outbreak of waterborne campylobacteriosis in August 2016, which caused more than 5000 people to fall ill (Department of Internal Affairs, 2016). This was preceded by an outbreak in Darfield in August 2012, which resulted in 29 confirmed cases of campylobacteriosis and 138 probable cases (Bartholomew, Brunton, Mitchell, Williamson, & Gilpin, 2014).

In New Zealand, drinking water quality and safety are regulated under the Health (Drinking Water) Amendment Act 2007. This Act requires drinking water suppliers to monitor drinking water; implement a Water Safety Plan; and take all practicable steps to comply with the Drinking Water Standards for New Zealand (Health (Drinking Water) Amendment Act 2007). The Drinking Water Standards for New Zealand (DWSNZ) 2005 (Amended 2008) describe the minimum quality standards for safe drinking water, based on maximum allowable levels of microbiological, chemical and physical contaminants. For microbiological contaminants, this represents the

concentration in water above which there is a significant risk of contracting a waterborne disease (Ministry of Health, 2008).

Despite this comprehensive set of standards governing drinking water quality in New Zealand, there remains a subset of the population for whom no such regulation of drinking water quality and safety exists. Rural households dependent on drinking water self-supplies, such as private bores (also referred to as 'wells'), must take full responsibility for maintaining, monitoring and treating their own drinking water. The Building Act 2004 simply deems as insanitary a building without a supply of potable water that is adequate for its intended use (Building Act 2004). This poses a potential risk to the health of rural populations in New Zealand.

Indeed, research suggests that rural New Zealanders may be at greater risk of contracting a waterborne disease than their urban counterparts. For example, ten years of surveillance data have shown rural cryptosporidiosis rates to be consistently higher than urban rates, with rates appearing to rise with increasing degree of rurality (Snel, Baker, & Venugopal, 2009). Approximately 39 percent of the cryptosporidiosis cases investigated by Snel et al. (2009) reported drinking or using untreated water, an important transmission route for the disease.

Similarly, Gilpin, Walshie, Smith, Marshall, and French (2013) have reported an increased risk of campylobacteriosis in sparsely populated rural areas of Canterbury

compared to urban areas, although the statistical significance of this apparent trend was not reported. Nevertheless, drinking water was identified as the most likely transmission route of *Campylobacter* infection for 1.4 percent of the study population. Research by Close et al. (2008) supports these findings, identifying *Campylobacter* species in six South Canterbury wells on at least two sampling occasions. Each self-supply also tested positive for *Escherichia coli* (*E. coli*) at least once during the study period (Close et al., 2008). *E. coli* is an indicator of bacterial contamination and is often present when pathogenic, or disease-causing, faecal bacteria are present. Thus, the presence of *E. coli* in drinking water indicates the likely presence of pathogenic bacteria of faecal origin and, consequently, a risk to public health (Ministry of Health, 2013).

1.2 Mitigating Health Risk

The New Zealand Ministry of Health has compiled several documents to aid rural households in the construction, operation, maintenance, and decommissioning of their drinking water self-supply. The Ministry suggests, for example, that bores be constructed away from potential sources of contamination (e.g. septic tanks, offal pits) and protected by a pump shed or fencing. The bore should be constructed in such a way that surface contaminants cannot enter the groundwater and the backflow of water into the bore is prevented (Ministry of Health, 2010a). In addition, the condition of supply components should be checked on a regular basis and preventive maintenance carried out (Ministry of Health, 2010b). A storage tank is recommended to guarantee an adequate and consistent supply of water. The storage tank ought to

be easily accessible so that maintenance can be carried out but secure enough to prevent contamination from pests and rainwater runoff (Ministry of Health, 2010c).

Furthermore, the Ministry suggests periodic monitoring of water quality to detect any changes that may affect the water's suitability for human consumption. Monitoring is useful because water quality is not necessarily static and intermittent changes in quality may occur (Ministry of Health, 2007b, 2007c, 2010a). Where water quality is poor, households may consider installing a treatment system however this must be fit-for-purpose. For example, UV light disinfection is not suitable for highly turbid water. In addition, to ensure the treatment system remains effective, equipment must be operated and regularly maintained in accordance with the manufacturer's instructions (Ministry of Health, 2007a, 2007d). Where treatment is required, regular monitoring of drinking water quality provides a measure of its effectiveness (Ministry of Health, 2007b, 2007c, 2010a).

When a drinking water self-supply, such as a bore, is no longer required, it must be appropriately decommissioned. This prevents the entry of surface contaminants which could eventually make their way into the aquifer below and pose a risk to other water supplies drawing from the same aquifer. Decommissioning should be carried out by appropriately qualified personnel (Ministry of Health, 2007a, 2010a).

While the Ministry of Health may promote these preventive actions to minimise the risk of drinking water contamination and associated illness, rural residents dependent

on drinking water self-supplies do not necessarily perceive nor prioritise this risk in the same way as the Ministry. Overseas research has shown that rural households dependent on drinking water self-supplies often fail to engage in the aforementioned preventive actions (Chappells et al., 2015; Hynds, Misstear, & Gill, 2013; Jones et al., 2006; Jones et al., 2004; Kreutzwiser et al., 2011; Roche, Jones-Bitton, Majowicz, Pintar, & Allison, 2013).

Kreutzwiser et al. (2011) found that over a quarter of the rural Canadians dependent on a drinking water self-supply in their study reported taking no action to protect their source water. Hynds et al. (2013) suggest this may be the result of a lack of awareness. Almost half of the participants in their study were unaware of any potential contaminants in the vicinity of their well, with 14, 31, and 24 percent failing to recognise the presence of fertiliser spreading, livestock grazing, and septic tanks, respectively (Hynds et al., 2013). While the majority of rural households indicated they had inspected their drinking water self-supply, fewer households did this regularly. Fifty-one percent of participants surveyed by Kreutzwiser et al. (2011) reported visually examining their supply, however, the average time since having done so was 2.6 years. Similarly, Hynds et al. (2013) found that more than three quarters of their participants were unaware of whether or not maintenance had been carried out on their supply.

Both studies found that less than half of the participants used a water treatment device that targeted microbiological contamination (Hynds et al., 2013; Kreutzwiser et

al., 2011). Further research by Roche et al. (2013) supports this finding. Although the use of point-of-use treatment methods, such as a filter jug, was reported by up to 79 percent of their participants, such treatment systems were unlikely to be effective against microbiological contamination (Roche et al., 2013). Jones et al. (2006) also reported that while the majority of their participants treated their drinking water, the most commonly used device was inappropriate for removing microbiological contaminants. Similar results have previously been reported by the same authors (Jones et al., 2004).

In contrast, a number of studies have shown that rural residents consistently report carrying out drinking water quality testing. For example, 89 percent of participants in the study by Roche et al. (2013) had tested their drinking water at least once. Similar proportions, ranging from 78.7 to 94 percent, have been reported by other North American researchers (Chappells et al., 2015; Jones et al., 2006; Kreutzwiser et al., 2011). However, no more than 35 percent of the participants in any one study were reported to have tested their drinking water quality at the frequency recommended by public health authorities.

1.3 Hinds, Mid Canterbury

This thesis focuses specifically on the rural area surrounding Hinds, Mid Canterbury, where I grew up and have continued to reside in my adult life. Hinds is a village located on the Canterbury Plains on the south bank of the Hinds River (see the map

below). It has a population of approximately 250 residents, however, the wider Hinds area has a population of around 4,000 living on farms (Ashburton District Council, 2016). While the Ashburton District Council supplies drinking water to households in the Hinds village, an estimated 80 percent of households in the rural area surrounding the village are dependent on drinking water self-supplies, largely from groundwater bores (Environment Canterbury, 2014a). Consequently, self-supplies sourced from bore water are the focus of this thesis. A more in depth description of water in the Hinds area can be found in Chapter Four, which highlights important connections between groundwater, irrigation water, and surface water bodies.

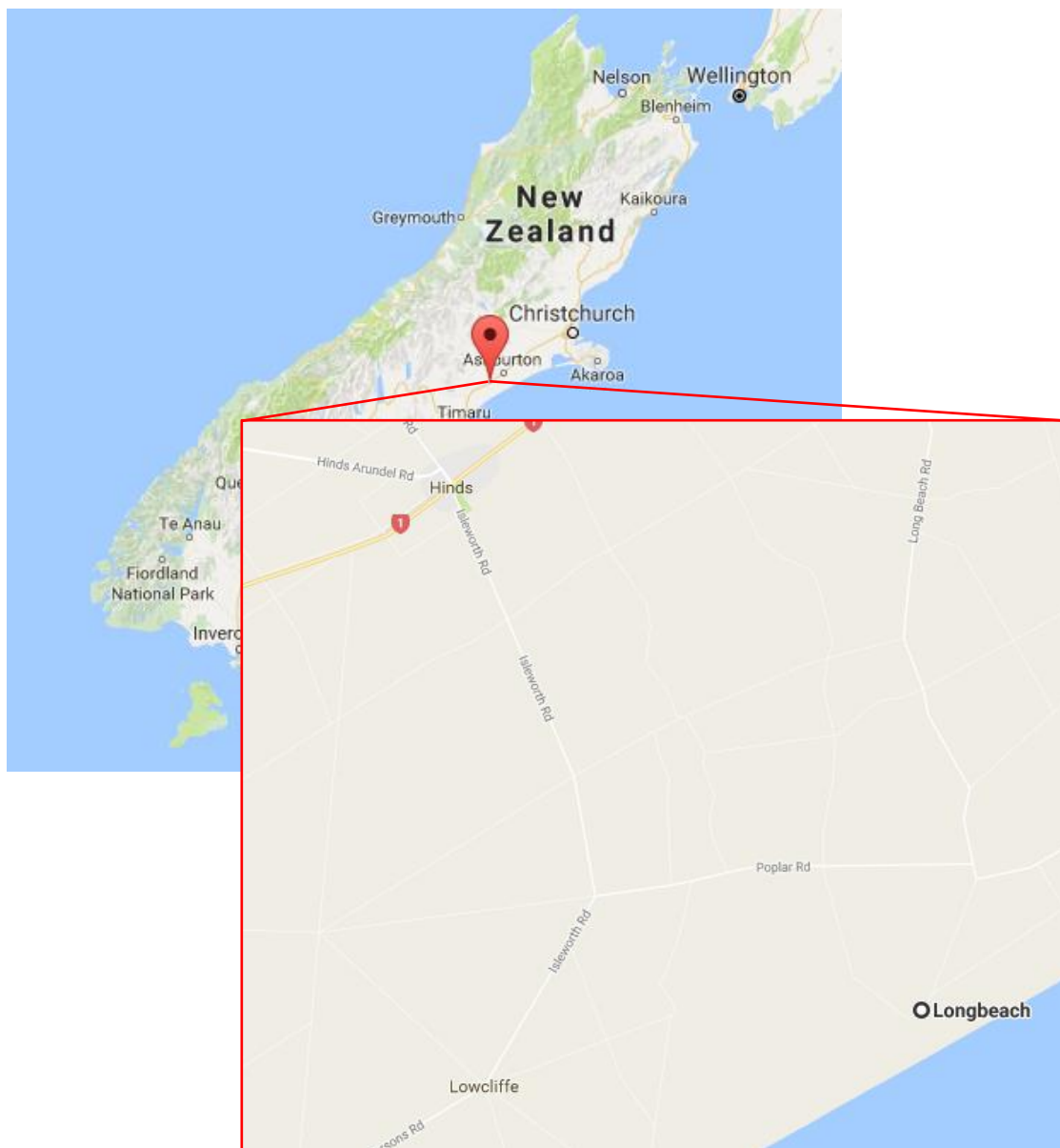


Figure 1 Hinds Area Map (Google, 2016)

The research summarised above suggests that those rural Hinds residents dependent on a drinking water self-supply may be at greater risk of waterborne disease than their urban counterparts. Moreover, while there are a number of actions that might be taken to mitigate this health risk, these research findings would also suggest that rural Hinds residents are unlikely to engage in these actions. It is important to note, however, that the DWSNZ and the Ministry of Health recommendations are only one way of understanding drinking water quality and safety.

For example, modern Western society understands pathogenic microorganisms to be the cause of disease, while the dominant view of the 18th and early 19th centuries was that disease was spread through miasmas or bad air (Lupton, 1995). These different perspectives on drinking water quality and safety are reflected in the actions taken to mitigate health risk. In 18th century England, for instance, the regulatory authorities implemented sanitary measures to clean up the environment and remove bad air or miasmas. Furthermore, the use of perfume was seen to be a suitable defence against disease as it, too, addressed malodours (Lupton, 1995). In contrast, modern Western society relies on disinfection to deactivate microbiological contaminants and render drinking water safe for consumption (Ministry of Health, 2008).

Clearly, views about what constitutes safe, quality drinking water can change with time and place. This thesis aims to explore rural people's perspectives on drinking water self-supplies in Hinds, Mid Canterbury. This is the first step in understanding the health risks rural Hinds residents associate with their drinking water self-supplies and

the actions they take to manage these. As such, the thesis addresses the following research questions:

1. What are rural people's experiences with their drinking water self-supplies?
2. How do rural people understand the risks associated with their drinking water self-supplies?

A third research question is proposed in consideration of the importance of drinking water quality monitoring to the regulation of drinking water supplies in New Zealand.

That is:

3. What are rural people's perceptions of drinking water quality testing?

Prior to addressing these research questions, a review of the literature was carried out to ascertain current understandings on drinking water and risk. The findings of this literature review are presented in Chapter Two. The methodology and methods employed in sampling, data collection and data analysis are described in Chapter Three, while Chapters Four through Six discuss the study's results. The final chapter of this thesis draws conclusions about the research questions, and offers a number of recommendations for those working in the public health field of drinking water.

2 Literature Review

2.1 Introduction

As highlighted in Chapter One, municipal drinking water supplies in New Zealand are regulated under the Health (Drinking Water) Amendment Act 2007 (Health (Drinking Water) Amendment Act 2007). Not only does this Act allow for the adoption of drinking water standards, but requires drinking water suppliers to implement a Water Safety Plan (WSP). This chapter commences with a discussion of the risk assessment methodology advocated by the Ministry of Health for use in the development of a WSP. This is then contrasted with the ideas of some of the key writers on risk perception theory, namely Deborah Lupton, Ulrich Beck, Mary Douglas, and Sylvia Tesh.

The second part of this chapter presents research from developed countries on drinking water self-supplies. Web of Science and Google Scholar were searched for New Zealand and international literature between March 2014 and November 2016 using the terms and limitations set out in Appendix 1. A relative dearth of literature pertaining to lay perspectives on drinking water self-supplies, particularly in the rural New Zealand context, was found. The search was consequently expanded to include municipal supplies, as well as research from developing countries, in an effort to provide a more robust review of the literature on drinking water. Although the majority of the research pertaining to drinking water self-supplies originated from North America, it remains relevant to the New Zealand context as the studies

identified largely focus on non-regulated groundwater supplies (Chappells et al., 2015; Flanagan, Marvinney, & Zheng, 2015; Jones et al., 2006; Jones et al., 2004; Murti et al., 2016; Roche et al., 2013; Shaw, Walker, & Benson, 2005; Walker, Shaw, & Benson, 2006).

2.2 Risk Perception Theory

The purpose of the Health (Drinking Water) Amendment Act 2007 is to “protect the health and safety of people and communities by promoting adequate supplies of safe and wholesome drinking water from all drinking water supplies” (Health (Drinking Water) Amendment Act 2007, p. 7 s69A). As a result, drinking water suppliers are required, under the Act, to implement a WSP. A WSP must identify the public health risks associated with each part of the water supply and detail the preventative or corrective measures in place to mitigate or eliminate these risks (Health (Drinking Water) Amendment Act 2007).

The Ministry of Health has produced a number of guides for developing a WSP. Included among these is *A Framework on How to Prepare and Develop Water Safety Plans for Drinking-water Supplies*, which provides information on estimating risk. The level of risk associated with a particular event is calculated based on the likelihood of the event occurring and the resulting health consequences. Factors affecting the level of consequence include the number of people that may be affected, as well as the duration and severity of the event (Ministry of Health, 2014).

While municipal drinking water suppliers may be encouraged to evaluate risk in this manner, that is not to say that it is the only means of assessing risk. If society and each of its members were to calculate risk in such an objective fashion, there should be little difference in the risks perceived. However, Beck (2009) points out that what is deemed a risk in one country may not be seen as so in another. Lupton (1999), too, observes that risk is dependent on context and inclined to vary with time and place. She argues that the objective evaluation of risk based on severity and magnitude does not take into consideration how something came to be perceived as a risk in the first place (Lupton, 1999). Drawing on Douglas, Beck and Tesh, the remainder of this section discusses the construction of risk in the society of today.

Douglas (1966) proposes that society is constructed on the basis of maintaining order. People create and label categories of order, such as 'health' and 'disease', and these categories form their worldview. Where people's experience of the world they live in is consistent, their categories of order are reinforced and they learn to filter out those phenomena that contradict their worldview. This allows people to establish what is 'normal' in a given society. However, this system of order can be challenged. The challenge can be viewed positively: that is, the system of order is re-evaluated and the worldview changes; or negatively: that is, the challenge is labelled a threat to the order and therefore dangerous or a risk (Douglas, 1966; Douglas & Wildavsky, 1982). For example, Douglas (1966) proposes that the dietary restrictions encouraged in the Bible arose not to protect humankind from disease but because certain animals do not

fit neatly into a category of order. The pig, for instance, is cloven hooved but does not chew cud therefore it does not fit neatly into the category that is based on the cow (Douglas, 1966).

While Douglas refers to experience as reinforcing and challenging one's worldview, Beck (1992, 2009) observes that many of the risks facing society today, due to their catastrophic nature, cannot be directly experienced should society hope to survive thereafter. He proposes that such phenomena come to be perceived as a risk through a process called 'staging'. The staging of risk involves encouraging people to believe that they are vulnerable and that some threat can reasonably affect them. Beck highlights the importance of the mass media in creating this belief (Beck, 2009).

In addition, Tesh (1993) proposes that the catastrophic events referred to by Beck, which are invariably manmade, although not directly experienced, may be perceived as a threat based on society's beliefs about humankind's relationship with nature.

Where an environmentalist view is dominant, Tesh (1993) observes that any alteration of the physical environment's natural state is seen as harmful to nature and to humankind as part of nature. This is based on an underlying belief that nature, untouched, exists in its optimal state consequent to millennia of evolution (Tesh, 1993).

Ultimately, Lupton, Beck, Douglas and Tesh all argue that a risk does not exist outside the society in which it was constructed. Rather, risk perception is dependent on

people's experiences and beliefs of the world in which they live, as well as the experiences and beliefs of those around them. The next sections of this chapter explore the current literature on lay perceptions of drinking water health risks. The first chapter of this thesis argues that these perceptions may diverge from those of public health experts based on the failure of lay people to engage in the actions recommended by public health authorities to protect drinking water quality and safety. It is important to note here that both expert and lay perceptions of risk are socially constructed and provide equally valid versions of the 'truth'.

2.3 Drinking Water Quality

As discussed in Chapter One, perceptions of drinking water quality and safety can differ across place and time. Although the DWSNZ rely on the measurement of microbiological and chemical contaminants in determining drinking water quality and safety, this is not necessarily the only means of ensuring drinking water is safe for public consumption. For example, Fisher, Kabir, Lahiff, and MacLachlan (2011) propose that cultural norms informed by experience may also serve to protect the health of community members.

Fisher et al. (2011) assessed the impact of an intervention programme on the knowledge and practices of rural Bangladeshi villagers around clean water, personal hygiene and sanitation. Their study found that, while the two villages provided with health risk information had superior knowledge and practices for 16 of the 37 items

evaluated compared to a third village with no intervention, there was no difference between the three villages for 21 items. Many failed to reach significance because all villagers had equally good practices (Fisher et al., 2011).

Fisher et al. (2011) found through a subsequent focus group with six residents from the non-intervention village that half of the residents had not received any information about clean water, personal hygiene and sanitation. Of the remaining residents, one had received information from school teachers, one from the researchers carrying out this study, and one from local villagers. Fisher et al. (2011) thus proposed that the intervention simply allowed residents to explain, in formal terms, what culture and tradition had already instructed them to do.

Similarly, Strauch and Almedom (2011) found in their study of rural Tanzanians that cultural norms influenced the use of water in the community. For example, community members believed water quality to be the best during the early morning and this was when drinking water was collected. Conversely, the watering of livestock and washing of laundry occurred around midday when water quality was perceived to be poorer. Strauch and Almedom (2011) reported that this understanding, passed from generation to generation, was based on personal or familial experiences with water-related diseases.

Interestingly, scientific analysis of the water quality, carried out as part of the same study, showed that the concentration of total coliforms was lowest in the morning and

evening, and significantly higher at midday. *E. coli* levels exhibited a similar although less pronounced pattern (Strauch & Almedom, 2011). In this case, scientific knowledge and local knowledge are in agreement. This study, along with that by Fisher et al. (2011) suggests that practices informed by cultural norms and practices informed by scientific theory may be equally successful at mitigating health risk.

However, what lay people might consider acceptable to consume is not always viewed as such by the scientific community. For example, over a third of the participants in a South African study indicated they would drink water with a turbidity more than 18 times the recommended limit based solely on appearance (Nare, Odiyo, Ravululu, & Potgieter, 2013). It is therefore important to understand how the lay public perceive drinking water quality and any associated health risks.

Research has consistently shown that the aesthetic attributes of water, namely taste, colour and odour, influence perceptions of drinking water quality and safety. Studies conducted in both developed and developing countries agree that people value odourless, clear water that is free from turbidity and visible contamination. Odour and poor clarity, such as brown or yellow colouring, have been associated with quality and safety issues (Aini, Fakhrul-Razi, Mumtazah, & Chen, 2007; Da Silva, Heller, Valadares, & Cairncross, 2010; Wright, Yang, Rivett, & Gundry, 2012).

Researchers have also found that water with a chlorine or salty taste is largely disliked for being unnatural or chemical, its presence associated with the perception that the

drinking water is unsafe or of poor quality (Aini et al., 2007; Chen et al., 2012; Chenoweth, Barnett, Capelos, Fife-Schaw, & Kelay, 2010; Da Silva et al., 2010; Jones et al., 2007; Roche et al., 2013; Scherzer, Barker, Pollick, & Weintraub, 2010; Wright et al., 2012). However, the presence of chlorine in water has been reported to be a positive attribute as it indicates the water has been treated and is safe to drink (Rojas & Megerle, 2013). Consistent with this, Doria, Pidgeon, and Hunter (2009), in their comparison of perceptions of drinking water quality in the United Kingdom and in Portugal, found that their Portuguese participants viewed chlorine as necessary to ensure water safety. In contrast, their British participants perceived the addition of chlorine to be an artificial operation with potential for chemical contamination.

These studies focus on municipal drinking water supplies, the users of which may hold different perceptions about drinking water quality and safety than users of drinking water self-supplies. Research exploring drinking water self-supplies shows users express resoundingly positive perceptions of their drinking water quality. Employing a mixed methods approach, Chappells et al. (2015) found that almost three quarters of their participants described their self-supplied drinking water quality as good or very good. This reflected their ratings for taste, smell, colour and clarity. Chappells et al. (2015) further explored this association through semi-structured interviews, finding that the absence of chlorine positively influenced perceptions of taste and smell, and echoed their participants' dislike of chemicals. Data from focus groups conducted in Ontario, Canada supported this association, reporting that users of drinking water self-

supplies value the excellent taste and the freshness of their drinking water, as well as the absence of smell and chlorine (Jones et al., 2004).

The aesthetic attributes of drinking water are particularly important because they influence the actions lay people may take to protect their drinking water quality and safety. Drinking water that tastes, smells and looks acceptable discourages testing, treatment and use of alternative drinking water sources. For example, bottled water consumption has been significantly associated with poor aesthetic attributes in tap water (Dupont & Jahan, 2012). McLeod, Bharadwaj, and Waldner (2014) have also found that tap water consumption decreases significantly where its aesthetic attributes are perceived to be undesirable. While the aforementioned studies focus on municipal water, aesthetic attributes have been identified as key prompts to test drinking water for users of drinking water self-supplies (Chappells et al., 2015; Flanagan et al., 2015; Jones et al., 2004; Murti et al., 2016).

2.4 Drinking Water Safety

Unlike the DWSNZ, where safety is inherent in the definition of drinking water quality, the lay public clearly distinguish between quality and safety. For example, Jakus, Shaw, Nguyen, and Walker (2009) reported that perceived water quality (taste, smell, clarity) plays a much larger role than perceived risk in people's decision to purchase bottled water. Likewise, it has been shown that while people are less likely to consume tap water that they believe to be unsafe, the magnitude of this association is greater

where they also have aesthetic complaints (McLeod et al., 2014). Jones et al. (2006) reported that while 60 percent of their participants were certain that their water was safe to drink, 80 percent had at least some concern about the quality of their drinking water. This suggests that lay perceptions of drinking water quality and safety also extend beyond the influence of aesthetic attributes.

Past experience of a boil water notice or advisory has been found to significantly decrease the likelihood of drinking tap water daily, and increase the likelihood of drinking bottled water (Dupont & Jahan, 2012; McLeod et al., 2014). Similarly, those reliant on drinking water self-supplies have reported testing their water because of failed results in the past or because they had heard of local water problems (Jones et al., 2004). Jones et al. (2004) have also demonstrated that where previous testing has shown water quality to be good, testing behaviour is negatively affected as people become complacent.

Additional research from Guppy and Shantz (2011) indicates that experience of waterborne illness in the past can affect a household's decision to treat their drinking water. Almost all of the participants in their study who considered their drinking water to be of good quality reported treating it before consumption. However, 28 percent had also reported that their water had made them sick in the past, suggesting they may treat their water to avoid illness. Conversely, Chen et al. (2012) have found that past experience of waterborne illness does not always influence perceptions of drinking water safety. It may be that in areas where waterborne illness is prevalent,

diarrhoea is seen as a normal part of daily life rather than a health concern, as proposed by Morua, Halvorsen, and Mayer (2011). A similar phenomenon has been reported in rural areas of developed countries (Jones et al., 2004).

Research consistently finds that rural residents express confidence in the safety of their drinking water self-supplies despite a lack of monitoring and treatment to support such views. Rather, Jones et al. (2004) have found that knowing where one's drinking water comes from and having sole responsibility for it from source to tap encourages the belief that the supply is safe. This belief is reinforced over time as consumption of the water fails to cause illness (Imgrund, Kreutzwiser, & de Loe, 2011). While drinking water self-supply users know where their water is coming from and who is looking after it, they still express concern that actions outside their immediate control can negatively affect their drinking water quality (e.g. nearby construction and agricultural waste disposal) (Jones et al., 2004).

Several studies have investigated the specific risks that lay people perceive as a threat to their drinking water safety. A number of concerns have been identified, including radioactive and fracking contaminants; agricultural contaminants such as nitrates, pesticides and animal wastes; industrial pollutants; chemical carcinogens; pharmaceuticals; chemicals added deliberately such as chlorine and fluoride; and bacteria (Hu & Morton, 2011; Jones et al., 2006; Jones et al., 2007; Merkel, Bicking, & Sekhar, 2012). However, concern about a chemical or microbiological contaminant in a drinking water supply does not necessarily mean people are going to stop consuming

it or start treating it. An American may still consume potentially contaminated water even as they express concern about its arsenic content, and a Bangladeshi may fail to use a free water treatment device despite awareness of the causes of diarrhoea (Luoto et al., 2011; Walker et al., 2006).

These examples suggest that important barriers exist to the effective management of drinking water quality and safety. For example, research conducted in developing countries has found that people may drink from unsafe sources because other alternatives are not available year-round or are inconvenient to access (Islam, Sakakibara, Karim, & Sekine, 2011). Furthermore, they may not treat this water due to time and money constraints (Fisher et al., 2011; Kovalsky, Lacey, Kaphle, & Vaughn, 2008; Rojas & Megerle, 2013).

Drinking water self-supply users in developed countries have reported experiencing similar constraints. Studies have shown that the decision to treat and test drinking water is negatively influenced by cost in terms of the time, money and effort required (Chappells et al., 2015; Hexemer et al., 2008; Jones et al., 2006; Jones et al., 2004; Roche et al., 2013; Shaw et al., 2005). Testing is particularly hindered by the time and effort it takes to deliver a water sample to a testing facility in town. Moreover, laboratory opening hours tend to be when rural residents, too, have to work (Chappells et al., 2015; Imgrund et al., 2011). On occasions where the importance of testing outweighs the inconvenience of taking a sample to the laboratory, other constraints, such as difficulty in collecting the sample or not knowing who to contact

for testing, are encountered (Flanagan et al., 2015; Imgrund et al., 2011; Murti et al., 2016).

Drinking water self-supply users also incur costs through ensuring they have access to a consistent supply of water. The replacement of supply components requires ongoing monetary input and the owner faces significant expense should they have to install a new supply (Jones et al., 2004). Thus, drinking water self-supply users may not always have access to plentiful, good quality, safe drinking water. Beyond the obvious health effects from waterborne illness, this can affect their ability to maintain good personal hygiene. For instance, an inconsistent water supply can prevent people from showering, flushing the toilet, and doing the laundry (Chenoweth et al., 2010; Da Silva et al., 2010).

Poor access to a sufficient quantity of water for daily living can indirectly affect physical and mental wellbeing. For people who cannot water their vegetable garden but are reliant on its produce, this creates issues of food (in)security. Similarly, the community aspect of sport disappears when there is no sports field to play on due to water restrictions that cause the field to die off. This can have a negative effect on mental health where sports clubs are an important forum for social interaction, without which many people may become isolated (Stebbing, Carey, Sinclair, & Sim, 2013).

While the study by Stebbing et al. (2013) was conducted in Australia, not all New Zealand communities have consistent access to plentiful drinking water supplies either. For example, Greymouth, a town on the west coast of New Zealand, experienced low rainfall during 2001 which resulted in low river flows and subsequent saline incursion at the intake of the town water supply. The town water supply during this time was not fit for consumption. Furthermore, residents dependent on rainwater collection systems in this region of New Zealand are often required to replenish supplies with tankered water as a result of recurring drought (West Coast Regional Council, 2002).

2.5 Health Risk Communication

Often, the lay public only receive information about their drinking water after experiencing a waterborne illness or upon receiving their water bill (Doria et al., 2009; Morua et al., 2011). Alternatively, they find that they have to contact government agencies or private supply companies for information (Chappells et al., 2015). In the few instances where information has been given proactively to the lay public, fewer report receiving information regularly (Chappells et al., 2015). As noted by Chenoweth et al. (2010), there is a lack of communication between professional and lay people as far as drinking water is concerned. They have highlighted the need for open, two-way communication between professionals and the lay public.

However, not all groups of society necessarily want outside assistance with their drinking water. Research from the USA suggests farmers tend to believe that individuals should be responsible for drinking water quality and safety (Hu & Morton, 2011). In contrast, non-farmers have been shown to be more likely to entrust water quality and safety to the government (Hu & Morton, 2011; Kite-Powell & Harding, 2006). Interestingly, a review of the literature has found that much of the research exploring drinking water self-supplies fails to distinguish between the different groups that make up rural communities (Chappells et al., 2015; Hynds et al., 2013; Imgrund et al., 2011; Jones et al., 2006; Jones et al., 2004; Kreutzwiser et al., 2011; McCann & Gold, 2012; Roche et al., 2013; Walker et al., 2006).

Stebbing et al. (2013) suggest that certain lay groups may be reluctant to accept the involvement of the government or health professionals in the management of their drinking water supplies due to a lack of trust in people and organisations who are not part of the local community. Those who are part of the local community may be perceived to be more trustworthy as their priorities are more likely to align with those of local residents compared to the government, for example (Jones et al., 2007; Stebbing et al., 2013). Additionally, there exists a concern that if there was an issue with the quality or safety of their supply then the government would force them to fix it (Chappells et al., 2015; Jones et al., 2007). As Stebbing et al. (2013) remark, these are people who value autonomy and self-sufficiency.

Strauch and Almedom (2011) have found that regulatory authorities who appeal to local values are more successful at protecting water quality and safety. For example, in rural Tanzania, traditional leaders known as mwanamijie impose a fine of one goat for those who breach water resource rules. The mwanamijie ensure that the village benefits, even when the rules are broken, by slaughtering the goat in a religious ceremony, with the meat offered to the gods and shared amongst village members. In contrast, the more conventional Village Environment Committee (VEC), which enforces regional government policies, imposes a monetary fine for breaches of water resource rules. These fines may be kept by VEC members. As a result, Strauch and Almedom (2011) found that many villagers perceived there to be greater gains from breaching the VEC rules and, consequently, water quality and safety were not as well protected.

Furthermore, Islam et al. (2011), in their evaluation of two risk communication programmes in Bangladeshi villages, found that including information about local drinking water quality had a positive effect on the dissemination of risk messages. While one programme provided information about source pollution, health risks, and supply maintenance, a second programme provided information about local water quality in addition to this. Both programmes achieved significant improvements in knowledge and associated behaviours, however, the groups that had received information about local water quality were more likely to discuss this with family and neighbours than those who had not (Islam et al., 2011).

Rural residents participating in a number of studies have consistently requested the test results of drinking water self-supplies in their area to better understand local drinking water issues (Jones et al., 2006; Jones et al., 2004; Murti et al., 2016; Roche et al., 2013). In addition to this, information in plain English about supply maintenance, testing, and water treatment options has been repeatedly requested by participants across studies (Jones et al., 2006; Jones et al., 2007; Jones et al., 2004; McCann & Gold, 2012; Roche et al., 2013). Jones et al. (2004) also found that their participants would like guidance on the interpretation of test results, as well as options for addressing any issues with their water quality. A range of media has been proposed for communicating this information, including flyers, websites, radio stations, TV, library displays, water bills, and newspapers (Jones et al., 2006; Jones et al., 2007; Jones et al., 2004; Roche et al., 2013). This would suggest that those dependent on drinking water self-supplies are at least open to expert assistance.

2.6 Summary

The research summarised in this chapter has shown that the aesthetic attributes of drinking water have a significant influence on lay perceptions of drinking water quality and safety. However, past experience with waterborne illness and drinking water testing, as well as the barriers of monetary cost and time have also been found to be important. These influence the actions people take to protect their drinking water and mitigate health risk. While the literature review suggests that the lay public may be open to assistance from public health professionals in managing their drinking water

quality and safety, health risk communication may prove more effective if it comes from within the community and includes information on local water quality.

These findings are consistent across developed and developing countries, municipal- and self- supplies. It should be noted, however, that no studies on drinking water and risk perception in the New Zealand context were identified. It is possible that the perspectives of rural people in New Zealand differ from people in other countries where research has been undertaken. It is well recognised that perceptions of risk vary across time and between cultures. This is supported by some of the differences observed in the research presented here, such as the instances where chlorine in drinking water was reported either as a positive or negative attribute, depending on the study. This literature review has helped to inform the development of this study, the details of which are discussed in the following chapter on methodology and methods.

3 Methodology and Methods

3.1 Introduction

In the previous chapter, I found a relative dearth of literature pertaining to lay perspectives on drinking water self-supplies, particularly in the rural New Zealand context. This study seeks to explore perspectives on drinking water self-supplies among a particular group of rural residents from Hinds, Mid Canterbury. The approach taken in this study is necessarily inductive or, rather, capable of generating theory as opposed to testing theory which does not yet exist (Bryman, 2008; Hansen, 2006). A qualitative approach is also well suited to addressing the research questions detailed in Chapter One, including rural people's experiences with their drinking water self-supplies, their understanding of the risks thereof, and their perceptions of drinking water quality testing, as it allows the exploration of phenomena from the perspectives of the individuals directly involved (Hansen, 2006).

As qualitative research, it is not the intention of this study to generalise the findings to a wider population (Bourgeault, Dingwall, & de Vries, 2010; Saks & Allsop, 2007).

However, Green and Thorogood (2009) propose that the concepts and ideas generated by qualitative research may be useful outside the study context. A public health unit, for example, may find that the conclusions of this thesis help improve health risk communication with rural communities dependent on drinking water self-supplies. This chapter provides a rich description of the study context, as well as the

methodology and methods employed, so that others might make judgment on the transferability of concepts.

3.2 Methodology

Quantitative research is based on the assumption that a single reality or truth exists outside of human society (Hansen, 2006). However, many qualitative researchers hold different beliefs concerning what phenomena actually exist (ontology) and how phenomena came to be known (epistemology) (Bourgeault et al., 2010). Crotty (1998), for example, proposes that the meaning ascribed to an object is constructed, not discovered. It is humankind who give objects labels and attribute associations to them.

However, Crotty (1998) also argues that the construction of meaning is not entirely subjective either. The world and the objects therein do exist outside human influence, the tangible qualities of which affect the construction of meaning. These qualities limit the associations that may be attributed to an object (Crotty, 1998). Culture also restricts the meaning attributed to an object. It allows human beings to function without having to analyse every aspect of their world, without having to independently label and attribute associations to every object they encounter. Culture provides a way of seeing but, in doing so, a way of not seeing, too (Crotty, 1998; Lupton, 1999).

Much like Crotty, Burr (1995) proposes that phenomena only have the appearance of objectivity. Drawing on Berger and Luckmann (1966), she explains that this apparent objectivity begins with the communication of an idea. As the idea proliferates, it becomes separated from the person who originally had the idea, seeming to exist outside human society. This is reinforced as people are born into the society where the idea pre-exists and it is no longer perceived as an idea but, rather, the nature of the world (Burr, 1995).

Social constructionists, like Burr and Crotty, argue that there is no single truth or reality (Hansen, 2006). What is accepted as knowledge today is simply one of many ways of thinking which has been given the status of truth where others have not (Burr, 1995). This is evident in the way knowledge changes with time and with social context (Burr, 1995; Hansen, 2006). For example, how society viewed women in the past is very different from how they are viewed today, as well as how they are viewed in Islamic culture. No one perception is necessarily correct, they simply represent different ways of understanding the world (Burr, 1995).

Consequently, the social constructionist encourages society to question accepted knowledge and to consider why it came to be seen as the 'truth' in the first place (Burr, 1995). This is not only because there are multiple versions of the truth but because knowledge is integral to action. For example, society's knowledge of alcoholism determines how it treats alcoholics. Where alcoholism is seen as an illness, alcoholics are more likely to be treated as a group in need of help compared to a

society that perceives alcoholics as responsible for their behaviour and therefore blameworthy (Burr, 1995).

Drawing on some of the key writers on risk perception theory introduced in Chapter Two, this thesis endeavours to discuss rural people's perspectives on drinking water self-supplies in Hinds, Mid Canterbury from a social constructionist standpoint. The ensuing discussion chapters go beyond describing rural Hinds residents' experiences with their drinking water self-supplies to explore the construction of these experiences. The subsequent sections in this chapter describe the methods employed in sampling, data collection and data analysis by which rural Hinds residents' experiences with their drinking water were first brought to light.

3.3 Methods

3.3.1 Sampling

Guest, Bunce, and Johnson (2006) have found that twelve to fifteen study participants produce sufficient data to reach saturation of themes in a relatively homogenous study population, using a structured data collection technique. That is, it is expected that no new themes will emerge from any data collected beyond the twelfth participant, making further recruitment redundant (Guest et al., 2006). Accordingly, I recruited 13 participants residing in the rural area surrounding Hinds, Mid Canterbury in May 2015. Data saturation was reached early on as participants had similar experiences with their drinking water self-supplies.

As suggested by Guest et al. (2006), the attainment of data saturation may have been aided by the employment of a purposive sampling technique. I selected participants on the basis of their being able to provide information useful for addressing the research questions (Bourgeault et al., 2010). Only those households dependent on a drinking water self-supply in the rural Hinds area were eligible to participate.

Furthermore, the household member selected had to be responsible for the operation and maintenance of the drinking water self-supply as they were considered likely to yield the richest data.

Having lived in the rural Hinds area for 15 years at the commencement of this thesis, my family and I were able to identify those residents best able to give a rich account of day-to-day living with a drinking water self-supply. They were our neighbours, the parents of childhood friends, families my sisters and I babysat for, or members of the same sports clubs. Nevertheless, Bourgeault et al. (2010) observe that connections to potential participants do not guarantee that they will share their experiences. The researcher still has to generate personal confidence, as well as a belief that the research will be helpful to the people and the community (Bourgeault et al., 2010). The generation of personal confidence in this research may have been aided by my being a member of the local community. Past research suggests that those who are part of the local community may be perceived as more trustworthy as their priorities are more likely to align with those of local residents compared to those of the government, for example (Jones et al., 2007; Stebbing et al., 2013).

All of the rural Hinds residents approached consented to participating in the study, including seven males and six females. An additional two males contributed significantly to the dataset while their spouses were being interviewed. Rather than risking the rapport I had built with these participants, I did not try to exclude them on the basis of their not having been directly recruited. All participants identified as European except one, who identified as both European and Māori. This is unsurprising given 87 percent of those residing in the Hinds area identify as European (Statistics New Zealand, 2013). The age of participants ranged from 40 years of age to more than 65 years of age, higher than the median age for Hinds area residents of 33.6 years (Statistics New Zealand, 2013). Most specified farming as their occupation, including dairy, dairy support, arable, and sheep and beef. In addition to farming, two of the female participants were employed as an office administrator and a fashion stylist. One of the male participants was an agricultural service operator.

Prior to collecting any data from the participants, written consent was obtained. The information and consent sheets were developed as part of the ethical approval process. These contained a general description of the research and its aims; how data would be collected and handled; how participants' confidentiality and anonymity would be maintained; and their right to withdraw from the study at any point. They also included details of the voucher offered to participants, as well as the contact information of myself and my supervisor should they have any questions (see

Appendix 2). Ethical approval was granted for this study by the University of Otago Ethics Committee.

3.3.2 Data collection

A drinking water sample was collected from the kitchen tap of each participant's household. Water from the kitchen tap was considered to best represent that consumed by the participant and other occupants. I was trained by a Drinking Water Assessor from Community and Public Health, Christchurch, to ensure sample collection and transportation were carried out correctly. This included the disinfection and flushing of the tap, aseptic collection of the sample into a sterile container, labelling of the sample, and the transportation of samples in a polystyrene chilly bin containing ice packs. A total of 13 drinking water samples were collected and transported to the testing laboratory over five non-consecutive days during May and June 2015.

Like the DWSNZ, this thesis prioritises the microbiological contamination of drinking water above chemical contamination. This is due to the potential for microbiological contaminants to cause rapid and widespread outbreaks of disease whereas chemical contaminants are usually slower acting (Ministry of Health, 2008, 2013). Therefore, each drinking water sample was analysed for *E. coli* by R J Hill Laboratories Ltd, Christchurch. This laboratory is approved by the Ministry of Health to carry out drinking water testing (Institute of Environmental Science and Research, 2016).

As it is not practically possible to monitor all pathogenic microorganisms in drinking water, the DWSNZ specify compliance criteria for *E. coli*, which is an indicator of bacterial contamination. *E. coli* has been selected as it is often present in large numbers when pathogenic faecal bacteria are present. Furthermore, its survival in drinking water subject to disinfection is as close as possible to that of pathogenic faecal bacteria and it is relatively quick and easy to detect (Ministry of Health, 2013).

Participants' perceptions of water quality testing were explored on their receipt of the test results during face-to-face semi-structured in depth interviews. In addition to water quality testing, other themes identified in the literature review were explored during the interviews. These were discussed before the test results were shared so that the discussion was not influenced by whether or not *E. coli* was found to be present in the participant's drinking water.

The interviews took place in the lounge or kitchen of the participants' homes during May and June 2015. Each interview took at least one hour to complete, with some exceeding two hours. Green and Thorogood (2009) suggest that participants may feel more empowered being interviewed in their own home or another familiar place. Similarly, my being of a younger age group than my participants served to position them as the experts. This position was strengthened in that the families of a number of my participants had been farming in the area for more than one generation, whereas my family moved from Christchurch city in 1999. At the time, I was also

working for a dairy company in which a number of the dairy farmers in the area held part-ownership.

Face-to-face interviewing is considered an efficient method of collecting rich data on individuals' experiences with their drinking water self-supplies (Saks & Allsop, 2007). In addition, it allows the researcher to explore how participants view their experiences and the meanings they attribute to them (Hansen, 2006). An interview guide was used to maintain the focus of the interviews on drinking water self-supplies (Bourgeault et al., 2010). The interview guide contained a broad introductory statement: "Tell me about your drinking water", followed by a list of themes and key words (see Appendix 3). The order of the themes explored did not necessarily follow that stipulated in the interview guide as the discussion was participant-led, however, all themes were covered by completion of the interview.

Probing questions were used to explore ideas introduced by a participant's response to the introductory statement (Bryman, 2008; Saks & Allsop, 2007). These questions were open-ended in nature, allowing each participant to set the direction of the interview without being restricted in their responses. Participants were free to speak about those phenomena important to them, ensuring that the data collected represented their perspectives on their drinking water self-supplies as much as possible (Bourgeault et al., 2010; Bryman, 2008; Green & Thorogood, 2009; Saks & Allsop, 2007). New lines of questioning not previously considered were identified and

followed up through this approach (Bourgeault et al., 2010; Bryman, 2008). Where this occurred, the interview guide was amended with additional keywords.

Because we came from a similar cultural background, I was accustomed to the language used by the participants and the context in which it was used (Bourgeault et al., 2010; Green & Thorogood, 2009). For example, I was familiar with terms such as spray irrigation and raceman where another researcher may not have been. However, clarifying questions were asked where a participant's meaning was not clear. This had the additional advantage of introducing new information in the re-telling of the response (Saks & Allsop, 2007). At the end of the interview, each participant was asked if there was anything else they wanted to include and basic sociodemographic details were collected (Bourgeault et al., 2010). These included self-reported gender, ethnicity, age, and occupation.

All interviews were recorded using a digital recorder. This allowed what was actually said by the participants to be analysed (Saks & Allsop, 2007). The recorder was checked before each interview to ensure it was functioning correctly and the batteries were changed every third interview. Most of the interviews were conducted in a quiet place so that background noise was minimal and the recordings were intelligible (Bryman, 2008). However, as the interviews were conducted in the participants' homes, noise from the television, fireplace and other people occasionally interrupted the recordings. This was noted after each interview where it occurred.

Without the need for constant note taking, the interviews progressed smoothly, simulating, as closely as possible, a natural conversation (Bourgeault et al., 2010). Nevertheless, some of the participants may have felt uncomfortable being recorded and this may have affected their responses (Bryman, 2008). For example, one of the participants expressed a reluctance to recount, while being recorded, how his drinking water self-supply had been contaminated.

Key observations were noted down after each interview and the first of these notes, along with their corresponding interview transcriptions, were reviewed with my supervisor and co-supervisor. This ensured my interviewing technique was appropriate to elicit information useful for addressing the research questions (Bourgeault et al., 2010). The transcription of all 13 interviews was completed by August 2015. All identifiers were removed from the transcripts to maintain participant anonymity and participants were given pseudonyms. Participant contact details were kept separate from the transcripts (Bryman, 2008).

3.3.3 Data analysis

The in depth interviewing process generates substantial amounts of data, which must be analysed in some way (Bryman, 2008). In addition, the chosen means of analysis was necessarily inductive as I had no pre-established hypotheses to guide the process (Hansen, 2006). Thus, I began the thematic analysis by reflecting on each interview and noting key observations. This continued with the transcription of the interviews and into the first reading of the transcripts. During subsequent readings of the

transcripts, I grouped common ideas together, labelling these with short codes that captured their meaning (for example, 'town water', 'thirst quenching', and 'part of living in the country'). The codes were, as much as possible, constructed using the language of the participants (Attride-Stirling, 2001; Braun & Clarke, 2006; Bryman, 2008). Where two or more codes described the same thing, they were combined (Bryman, 2008). This process of coding broke the data down into manageable sets so that they were more amenable to critical analysis (Bryman, 2008).

Similar codes were then further grouped into themes, such as 'contamination', 'income', and 'science', with each theme representing something important about the experiences participants had with their drinking water self-supplies (Attride-Stirling, 2001; Braun & Clarke, 2006). In grouping similar themes together, five global themes were identified. Constant re-reading and referral back to the transcripts throughout this process ensured the original meaning of the data was not lost during analysis (Bryman, 2008). Interpretation of the global themes and subthemes was achieved through comparing the different perceptions held by participants and making connections with the wider literature on drinking water and risk theory, supported by quotes from the interviews (Bourgeault et al., 2010; Bryman, 2008; Green & Thorogood, 2009; Hansen, 2006; Saks & Allsop, 2007). The following chapters of this thesis present the findings of this analysis, exploring the global themes of water quantity, cost, water quality, knowledge, and responsibility and control.

4 Water Resources and Competing Priorities

4.1 Introduction

This chapter, the first in a series of three, provides a largely descriptive account of the Hinds area's water resources, how these have shaped the area, and their continued significance for rural Hinds residents today. The chapter positions drinking water in relation to other water resources in the wider Hinds area, highlighting important connections between groundwater, irrigation water, and surface water bodies.

The final section of this chapter begins to integrate and expand on the risk theory introduced in Chapter Two, setting the tone for the remaining chapters of this thesis. The theme of cost is explored here, including the time, money and effort required to operate a drinking water self-supply. Discussion of my participants' experiences with their drinking water continues in Chapters Five and Six, with the focus turning first to water quality, then the theme of responsibility and control.

4.2 Water Resources of the Hinds Area

The Hinds Plains are situated in the Ashburton District of Mid Canterbury. They extend from the foothills to the sea, and are bound by the Rangitata River to the south and the Ashburton groundwater zone boundary to the north (Environment Canterbury, 2014a). The Hinds Plains were once dominated by vast areas of swamp land and dry tussock, however this has changed dramatically over the course of time, largely due to

the community's management of its water resources (Body & Cushnie, 2015; Mitchell, 1980).

In the latter half of the 1800s, a European settler by the name of John Grigg took up residence at Longbeach (see the map on page 7) and, with a vision of turning it into productive agricultural land, began the arduous task of draining over 18,000 hectares of swamp. This was achieved in three phases, the first being redirection of the Hinds River outlet to the sea. This was followed by the construction of open drains and then tiled pipes to allow further drainage of the area. The entire process took over three decades, finally reaching completion in 1903 (Mitchell, 1980).

Approximately 30 years after the completion of the Longbeach drains, the Hinds Plains landscape was further modified with commencement of the construction of the Rangitata Diversion Race (RDR). Today, the RDR runs throughout the Ashburton District, a network of canals (water races) from the Rangitata River to the Rakaia River (Body & Cushnie, 2015). The Mayfield Hinds Irrigation Scheme delivers water, via the RDR, to 32,000 hectares of land between the Hinds and Rangitata Rivers (Irrigation New Zealand, 2016). This has transformed what was traditionally a dryland farming area to such an extent that “even the most visionary of our early pioneers would today be in awe of the productivity, diversification and intensification of Mid Canterbury farming in the 21st century” (Body & Cushnie, 2015, p. 14).

Interestingly, the rural Hinds residents I interviewed dedicated a large amount of time to discussing the drains at Longbeach, as well as the RDR, which have remained important sources of irrigation and stock water today. For example, dairy farmer Michael discussed the current debate between the Ashburton District Council and Irrigation Schemes regarding the ownership and operation of the stock water creeks:

“There’s a stock water system that the Council’s trying to close. So there’s – I can’t remember how many cumecs [cubic metres per second] – I think six cumecs, which probably means nothing, but at the moment what the Council want to do is get rid of the creeks and they want the irrigation schemes to take over the creeks, and that probably makes total sense but what the irrigation schemes are going is “Well, that’s fine but the water that’s going there you’ll give us the water” and they’re going “No, no you won’t get the water, you’ll have to buy the water and then you can run the scheme” – they’ll give them enough water to run it but they won’t give them the full consent or they want them to buy the consent...”

Debate around the control of water resource management is a legacy of the past. For example, the Mayfield Hinds Irrigation Scheme was constructed under the direction of the Public Works Department during the 1930s and 1940s. However, in the ensuing years, the Department, in its attempts to recover costs, continued to raise the charges for the water to the point where irrigation became uneconomic for farmers. It was not

until the sale of state-owned assets in the early 1990s that the ownership of the Mayfield Hinds Irrigation Scheme transferred to the farming community it served (Body & Cushnie, 2015).

Under this new ownership, the Scheme has undergone significant development. The rural Hinds residents I interviewed made particular reference to the transition from flood or border dyke irrigation to spray irrigation. Where irrigation water was once allowed to flow freely across farmland or channelled between mounds of earth built up along the length of a paddock (border dykes), farmers in the area have increasingly made the transition to more efficient systems (Living Heritage, 2007; Te Ara, 2008). This includes the use of spray irrigation where water is pumped through a system of pipes and sprayed into the air through sprinklers to mimic natural rainfall (Food and Agriculture Organization, 2001). Spray irrigators require a continuous flow of water, which required farmers to construct on-farm storage ponds (Body & Cushnie, 2015). As dairy farmer Michael explained:

“Farmers went from border dykes to spray irrigation with no help from anyone else, no push from anyone else, we did it of our own accords... And I suppose we’re already storing water with Carew storage, there’s talk of Klondyke – ah Coleridge – you know, we’re using water out of Coleridge, they’re talking about building a pond at Klondyke for irrigation storage”.

Michael is careful to emphasise in the above quote that these initiatives took place without any outside help. On the one hand, this may be because there is no help available to rural residents. This is supported by further discussion on the part of Michael who described the difficulty in obtaining funding for irrigation projects:

“For some reason, our government – well, they’re putting in seed money and apparently it’s bloody hard to get hold of, like apparently it’s there for xyz, and that’s what it’s written as, but actually when you try and get it you can’t”.

On the other hand, past research suggests that farming residents may not be willing to accept government intervention. For example, studies have shown that farming participants tend to believe the individual should be responsible for water quality and safety, and are significantly more active in monitoring their local waters than their non-farming counterparts. In contrast, non-farming rural participants are more likely to entrust water quality and safety to the government (Hu & Morton, 2011; Kite-Powell & Harding, 2006). This notion of responsibility and control is discussed at length in Chapter Six.

4.3 Water and Drinking Water

What becomes clear throughout the interviews, as well as in the literature, is that the water resources of the wider Hinds area are seen to be connected. Although the

construction of the Longbeach drains and the RDR occurred in isolation from one another, both regional government and the farming community have, each in their own way, evidenced the effect irrigation has on groundwater levels and, subsequently, surface water flow in the drains at Longbeach.

Environment Canterbury, for example, has analysed data from one of their monitoring wells to investigate the effects of flood irrigation on groundwater levels. These data exhibit a declining trend from the year 2000, which corresponds with the increasing conversion of farmland to more efficient spray irrigation (Environment Canterbury, 2014b). Spray irrigation allows the adequate irrigation of almost an entire farm whereas border dyke irrigation can adequately irrigate just over 60 percent of a farm's area. Furthermore, today's on-farm water storage ponds provide farmers with greater control over when they irrigate whereas, previously, they had to use the water when it was available (Body & Cushnie, 2015). This more efficient use of irrigation water has resulted, however, in lower groundwater recharge as less water is wasted (Environment Canterbury, 2014b).

Many of the rural Hinds residents I interviewed spoke of their first-hand experience of the effect of flood irrigation on their well water levels, and the decrease in water levels they had witnessed during the conversion from flood to spray irrigation. As Kelly and Tim explained:

“We did know the irrigation well up the top, when we had borders, if we bordered the paddocks within say a vicinity of the well the water... level would rise. So, it was obviously the pressure of that border dyke water going down”. Kelly, Dairy Farmer.

“Approximately twelve to 13 years ago, our water table was generally two metres higher than what it will be now and it used to drop down in the winter and pick up again in October-November when the border dyke irrigation infiltrated the ground water source and boosted the water supply. But since now everything is ponded and sprayed on, generally the shallow wells are nowhere near as – have the capacity they did 15 years ago... We used to run shallow irrigation wells and we cannot anymore. That stopped about twelve years ago I suppose, as people were changing over to [spray irrigation] and our shallow irrigation wells just started becoming inconsistent. I can tell you exactly when it happened. So, 2001, they started for about a week; 2002, it was for about a three week process; and 2004, they just went dry. And then by the mid-2000s we had to, economically, do something completely different, thus the hundred metre deep well to compensate for the loss of the shallow wells”. Tim, Arable Farmer.

Another of my participants, dairy farmer Maree, recalled how her uncle, who farmed closer to the coast, would phone them to say *“It’s about time you started watering because our drains are dry”*. In support of this, dairy farmer Logan, who also resides nearer to the coast, described the surface water problems he had experienced on his farm since the conversion to spray irrigation:

“I believe that the water has always been there but the aquifers have dropped, the fact that it’s not getting recharged from north of the State Highway One. That’s certainly the way I see it. Because, as I say, when we came down here, especially this creek here, I remember the real estate agent said to us, I said “That’s good flow in there” and he said... and this is about April or something – he said “You wait ‘til November-December” he said “It’ll be twice as good as that”. And I thought he was “Oh, yeah, real estate agent, all talk”. [But] that was the case right because as the water was coming out the Rangitata River for the irrigation and it was recharging here and, of course, the whole way through. And now there’s all this business now “Oh, there’s not enough water” and, you know, “Aquifers are running dry” and all the rest of it. Is it that the water’s not there, to a degree, or is it caused by other farming practices further up north, further up towards Mayfield? And I believe that it is. And now, as I say, what can they do about it? They can try and recharge them by

tipping water back down there. But there's creeks out here that have gone dry and they've never been dry".

Environment Canterbury (2014b) has also been able to show a correlation between groundwater levels and the spring-fed flows in Blees and Flemington drains at Longbeach. They found that these drains go dry when the groundwater level drops more than 2.75 metres below the surface.

These examples illustrate the extent of the connection between irrigation use and groundwater levels in the area. This is of particular relevance to drinking water in the wider Hinds area as an estimated 80 percent of the resident population are dependent on drinking-water self-supplies that draw from groundwater (Environment Canterbury, 2014a). Indeed, all of my participants now obtained their drinking water from a bore, although many still recalled being dependent on race water and rainwater in the past:

"It used to be out the water race and it was for the first – 28 years we've been here. And it was the colour of the Rangitata River when it was dirty. We didn't drink it, no, we boiled it. We only drank off the roof, which was rainwater and that was part of the rules for letting us have a house here". James, Agricultural Service Operator.

This notion of what water is and is not suitable to drink is discussed further in Chapter Five. Chapter Four, thus far, has illustrated the interconnectedness of irrigation, surface- and ground- waters. Moreover, it shows that farmers and the regional council have arrived at similar conclusions, albeit by different means. While one has relied on scientific knowledge the other draws on knowledge derived from personal experience. The idea that there are multiple, equally valid ways of knowing is also explored in greater detail in Chapter Five.

4.4 Water Security

Where the supply of water is inadequate, health may be compromised in a number of ways. For instance, the ability to maintain good personal hygiene might be limited if prevented from showering, flushing the toilet, and doing the laundry (Chenoweth et al., 2010; Da Silva et al., 2010). Moreover, Stebbing et al. (2013) propose that the wider environmental impacts of water restrictions, such as the drying up of sports fields, can negatively affect the physical and mental wellbeing of community members.

My participants' access to water was commonly described as being restricted in the instance of power failure. As Georgina, a dairy and arable farmer, as well as a fashion stylist, explained *"If we get a snowfall and we lose power then the pump won't go, so then we don't have any water"*. This then affected their ability to wash, cook, clean and, in some instances, heat their home. Those participants with a wetback fire, for

example, were only able to heat their homes if there was water in their hot water cylinder. Heat from a wetback fire is used to heat water in a household's hot water cylinder and should only be used when water is available to avoid damage to the system (Pioneer Manufacturing Ltd, 2016). As dairy and arable farmer Maree explained:

“It’s like that snow storm and we had no power for the ten-twelve days – it was the water that was the biggest problem. I mean, we ended up getting a generator because we had to do stock water, you see, and a lot of them around here would’ve had to have done – well, because some of them would’ve had a few more races but the water races are gone now, you see, so you’re relying on that power. But it’s like the fire – you couldn’t have the fire going because that’s connected to your wetback and you can’t have the wetback fire going if you’ve got no water running... You can’t wash, you can’t cook, you can’t clean, you can’t do anything – food-wise you’re fine, you survive, we’ve usually got something in the cupboards so you’re fine but once that water’s gone, you’re gone”.

Moreover, a number of the rural Hinds residents I interviewed mentioned accessing potentially unsafe sources of water in the event that their usual drinking water supply was inaccessible. Irrigation water, be it in storage ponds or water races, was cited by the majority of my participants as an important backup to their domestic water

supplies. However, like Georgina, all reported boiling this water to render it safe for consumption:

“I guess, being an irrigation pond, the water comes from the RDR so you sort of don’t know what it’s done as it’s floated down, and then you’ve got weed in the pond and fish and ducks and, so, for flushing the toilet I just use it straight from the bucket and then we just boiled it for the drinking”.

Dairy support farmer and office administrator Kathryn also described how she added boiling water to the containers of drinking water that were stored in her garage, explaining that *“if things are kept airtight, after a while, when you release it, there’s a smell so I always stick boiling water in it and try and sterilise it a bit”*. The idea that stagnant water, such as that in an irrigation pond or a container, requires sterilising was common throughout my interviews with rural Hinds residents. One participant even reported flushing the kitchen pipes before filling her glass:

“The other thing I do... is I always run the tap a wee bit before I get a glass and I always rinse the glass out first, too, so, I don’t know why I do it but I just do it. Because I don’t know the last time the tap has been turned on and the water may’ve been just sitting there and it’s

all metal and then alkathene hose so I guess I just, you know, clear it a wee bit first and then take a drink". Debbie, Dairy Farmer.

In addition to boiling and flushing their water, my participants described a number of other actions they took to protect their drinking water. These included fencing off the well to exclude stock; carrying out maintenance work; ensuring tank lids were secure; installing water treatment systems; and getting their drinking water tested.

Interestingly, these actions are consistent with those recommended by the Ministry of Health and previously discussed in Chapter One (Ministry of Health, 2007a, 2007b, 2007c, 2007d, 2010a, 2010b, 2010c). However, while Patrick had installed a water treatment system to address *E. coli* contamination, Robert did not see this as a necessary measure for his own water supply:

"Of recent times we did put a UV filter on... that was mainly because we were extending the system and putting another house on... we chose a UV filter... because of an issue we were having with another property. We had an E. coli problem in another well". Patrick, Dairy & Arable Farmer.

"We don't have a wee special filtering system like some people do... they're a complete waste of money. I am yet to be convinced that there's anything wrong with our water. When it's sent away to the

Council to be tested for quality and the Council says it's fine, I don't see any reason to buy a filter". Robert, Arable Farmer.

In the examples above, both participants refer to non-routine drinking water testing in their decision to treat or not treat their water. The influence of perceived drinking water quality on the actions my participants took to protect their drinking water is explored at length in Chapter Five. This chapter instead turns again to the wider water resources of the Hinds area, with particular focus on farm productivity and profitability.

4.5 Health and Economy

During my first interview, dairy farmer Kelly, in describing the effect of water quantity on farm productivity and profitability, pointed out that *"cows like to drink when it's hot and if the cows don't drink, they don't give milk, and if they don't give milk we don't get paid"*. The agricultural sector and associated service industries are the main sources of employment in the Ashburton District (Environment Canterbury, 2014a). Almost 80 percent of employees in the Hinds area are employed in the agriculture, forestry or fishing sectors (Statistics New Zealand, 2013). Therefore, poor farm productivity and profitability can have repercussions that extend beyond the individual farming household to the community as a whole. For instance, a reduction in local spending may lead to job losses and business closures. Dairy and arable farmer

Patrick, in the following quote, mentions an annual loss of a hundred million dollars to the local economy:

“If there’s a restriction on agriculture without a way of solving an issue and the only way of solving it is to restrict or put a cap or a reduction on agricultural activity, the economic loss to the area is – I have heard figures chucked around for Mid Canterbury of a hundred million a year. The only other thing on that one, while through all this planning stage it starts to affect markets. Land values, to a degree. It’s very hard to have a long term business plan when you don’t know how you’re going to operate in five years’ time. So, therefore, it probably should, but I don’t think it has yet, should affect your degree of security as far as your bankability is concerned”.

As Patrick alludes to above, water, or a lack of it, also affects land values. This has been the case historically, for example, the drainage operations that took place in the 1800s were said to increase the land value five-fold (Mitchell, 1980). More recently, Boyle, Kuminoff, Zhang, Devanney, and Bell (2010) found that media coverage of high arsenic levels in groundwater in Maine, USA, resulted in a two year decrease in the sale price of residential property in the area. This suggests that land values are affected by water quality, as well, and is discussed further in Chapter Five.

Tesh (1988) proposes that the potential for economic loss, like that described above, can affect health policy. She provides a number of examples where public health measures have been influenced by economic interests. For example, quarantine measures to control the spread of disease began to lose support in the early 19th century partly because they disrupted trade between communities through the closing of ports. Conversely, the sanitary measures that arose from the belief that bad air transmitted disease, including, for example, improved drinking water supplies and waste water collection, were supported, in part, because they addressed illness in the working class and therefore promoted worker productivity and business profitability (Tesh, 1988).

In more recent times, the Ministry for the Environment has put forward a proposal to allow exceptions to the national bottom line for freshwater quality, which was designed to minimise unacceptable risk to public health, where significant infrastructure, such as hydroelectric dams, exists. Similarly, while they do propose to exclude stock from waterways, this is limited to flat land, low land and rolling slopes because of the low cost-effectiveness of fencing steep country (Ministry for the Environment, 2016).

Tesh (1988) suggests that society's fixation with productivity and profitability not only compromises measures to improve water quality but is the ultimate cause of water quality degradation in the first place. While increased fertiliser use and stocking rates may be the direct cause of environmental degradation, underlying this is a pressure on

farmers to produce more from less land in order to remain financially viable. This is illustrated in the below quote from dairy farmer Logan:

“Say 50 years ago, around this area here, there was probably only one or two dairy farms. Land was way, way cheaper of course and there was one sheep here and one sheep there, you know, the land wasn’t intensified as much as it is. And yet, now, through the cost of land and that, it’s been intensified, as much as the guys can get out of it, and they’re saying, you know, that financially, guys are being driven to, you know, put more fertiliser on to do more, to run more cows or whatever the case may be to make a buck out of it and yet, potentially, we’re bugging up the environment”.

Consequently, to effectively prevent and/or address water quality issues, a major societal shift is required (Tesh, 1988). Tesh (1988) maintains that this change can and must be addressed at a policy level, however this should be supplemented by preventative measures carried out by individuals to protect their health in the meantime. For drinking water, these may include routine testing and treatment of the drinking water self-supply.

However, previous research has highlighted that the decision to treat and test drinking water is negatively influenced by costs in terms of the time, money and effort required

(Chappells et al., 2015; Jones et al., 2006; Jones et al., 2004; Roche et al., 2013; Shaw et al., 2005). Testing, for instance, is particularly hindered by the time and effort it takes to deliver the sample to a testing facility. Moreover, laboratory opening hours tend to be when self-supply owners, too, have to work (Chappells et al., 2015; Imgrund et al., 2011; Jones et al., 2004).

4.6 Competing Priorities

Time, as a subtheme of cost, featured more strongly in my interviews with rural Hinds residents than did the monetary cost of operating and maintaining their drinking water self-supply. Georgina, a dairy and arable farmer perceived there to be little cost in running her drinking water self-supply, as illustrated in the following quote: *“Just... go back a bit, I mean, I don’t see any cost? Just the cost of running a pump to get it here. I don’t really know how much it costs to run a pump”*. Similarly, the monetary cost of maintenance was described by arable farmer Robert as *“just part of being on a farm. You just live with it. You just deal with it, replace your pipes”*.

In contrast, the time required to operate and maintain a drinking water self-supply generated more extensive discussion. While dairy and arable farmer Patrick described the negative impact the maintenance of his drinking water self-supply had on his time, stating *“Sometimes I have enough trouble finding time to put new door handles on doors let alone change filters and water systems”*, other participants referred to their drinking water self-supplies in terms of the time it saved them. For example:

“I’ve never thought much about the water actually, just the fact that it’s there and we, yeah. We’d be lost without it. Cooking, cleaning – imagine the extra work, [his partner] would love it. Taking your washing down to the river and rub it on a couple of rocks, no worries ay. The convenience of it really, because it’s, yeah, turn on the tap and it runs out. It’s always cold and it’s always not bad”. Matt, Sheep & Beef Farmer.

“If you had asked me when I was getting it out of the water race I would’ve said it took far too much time because it did. We used to have to pump the line to get it going each time, if you can imagine. We had the pipe buried but because we’d only bring the water down... well, it used to get clogged up quietly over a month so then you’d have to put a pump on it to pump the mud out and then it would activate itself and away it’d go again, as long as somebody on the race didn’t have a hiccup and you ended up with air in it, it just carried on running. Where now, well even here, for every six weeks we used to have to lay out cables because the well was there without any electrical connection. So, there was a wee bit of time involved there but now in the last – I can’t think when we had the electrician pass, say three months ago, it’s just a matter of turning a switch. It’s fabulous. So the time involved is probably very little now – it’s not

automatic but it's probably about one hour a month we're down to".

James, Agricultural Service Operator.

A possible explanation for the importance placed on time by the rural Hinds residents I interviewed, as well as participants of other studies can be found in the work of David Harvey. Harvey (1989, 1990) points out that while calendar and time measurement were originally promoted for reasons of imposing religious discipline, these ideas were expanded on by medieval merchants who sought a better measure of time for the orderly conduct of business. This served to change the rhythm of life in medieval towns, where labourers and merchants learned to respond to the clocks and bells that called them to work and market (Harvey, 1989, 1990).

The emphasis placed on time continued as society evolved, and modern society is characterised by continuous efforts to produce more in a shorter amount of time. Numerous technical and organisational solutions have been developed and implemented to shorten turnover times, including the acceleration of physical processes (e.g. genetic engineering), electronic banking, and the introduction of assembly lines to name a few. This has led to the intensification of living and working in general (Harvey, 1989, 1990). This extends to those living in a farming community, as dairy farmer Debbie aptly points out:

“But it’s like everything, Alex, these days, ah I don’t know, they just seem to be making mountains out of everything and creating so much more research, paperwork. Like here, I really should be spending three full days a week in the office, and it’d probably take longer. The information that we get through here, the booklets, the dairy magazines, the agricultural magazines, paper articles – all these sorts of things, questionnaires that we get, we’re forever getting surveyed, and we’re just at the stage where, you know, we just – it’s getting worse, it is getting worse, really. Let alone – and I often tell people, when I first came here in 1980, I took the accounts into the accountant in a bread bag and they rattled around in a bread bag but and, you know, I went to juggling a big cashbook and four folders across West Street into the accountant and now, of course, you have a memory stick. It just – the workload has become so increased over the last few years and the requirements of a farmer now, the responsibilities that’ve been put on farmers’ shoulders is big and, that’s not all, it’s all the meetings that you are expected to attend, discussion groups, and yet the intensity of the farming sometimes makes it impossible to keep up with all those... and you need to be involved in your own business, in the running out in the field and – as well as attend these meetings and have the information coming from that side to go to that”.

However, Debbie is not only referring to the intensification of living and working, but society's increasing desire to control risk. Foucault, Burchell, Gordon, and Miller (1991) and Beck (1992) suggest that the more society tries to control risk, the more risks that are created. This is because the controls that society puts in place to minimise risk are often a source of risk themselves. To illustrate this, Debbie expands on her comment that *"the requirements of a farmer now, the responsibilities that've been put on farmers' shoulders is big"* by saying:

"Like when you come in, I should be stopping you at the gate and saying to you "you are entering a dangerous ground here"... and "Where's your hard hat and protective gear?" All this sort of thing. So, and some farms do do it now, where any visitors have to stop and they have a half an hour interview... and you've got to make them aware of any dangers on the farm and all this sort of thing. It is just coming... crazy stuff, really".

The time it takes to do something, such as change a filter, is not necessarily the issue. An issue arises when there are other demands on people's time competing with changing the filter. This necessitates prioritising some risks over others. Therefore, in considering drinking water self-supplies, not only does one have to consider an area's wider water resources, but also everything else that might be competing for attention with drinking water.

This chapter has also highlighted the importance of water to income for my participants. While the health effects of this are not immediately clear, on further investigation, efforts to protect productivity and profitability have been demonstrated to have an effect on public health, including, for example, the loss of support for quarantine measures in the early 19th century due, in part, because of disrupted trade between communities through the closing of ports. Furthermore, society's focus on increasing productivity and profitability has been suggested as an underlying cause of environmental degradation. A deterioration in water quality, for example, has direct adverse health effects that may be addressed at an individual level but ultimately require a major policy shift. How people choose to address or ignore a potential risk is the subject of the next chapter.

5 Water Quality

5.1 Introduction

Throughout history, societies have developed strategies and beliefs in their attempt to contain and prevent danger, giving them some semblance of control over their environment (Lupton, 1999). In modern times, society has become increasingly focused on measurement and calculation in its effort to manage danger (Lupton, 1999). The management of drinking water is no exception and, in present day New Zealand, threats to drinking water quality are largely controlled through the monitoring of microbiological and chemical contaminants, as well as treatment processes, under the DWSNZ (Ministry of Health, 2008).

The rural Hinds residents I interviewed understood drinking water quality in multiple ways, sometimes referring to it in terms of health and other times referring to it in terms of aesthetic attributes or contamination. For example, dairy and arable farmer Patrick said *“First test for water quality for me is whether I can drink it and not get sick”*. In contrast, sheep and beef farmer Matt said *“When I look at my glass I can’t see any floaties or foreign bodies”*, while dairy and arable farmer Brandon described it as *“Full of E. coli”*.

These definitions serve to introduce three key themes identified during analysis of the data I collected from the in depth interviews with rural Hinds residents. These included health, aesthetic attributes, and contamination. These form the global theme

Water Quality, which may be more aptly described as fitness for purpose. This chapter proceeds to explore, with reference to the three themes, my participants' perceptions of what makes water fit to drink and why this might differ from a health professional's perceptions of drinking water quality.

5.2 Aesthetic Attributes

Research conducted in developed and developing countries, urban and rural populations consistently shows that people prefer to consume clear water without a noticeable taste or smell (Aini et al., 2007; Da Silva et al., 2010; Jones et al., 2006; Scherzer et al., 2010; Wright et al., 2012). The rural Hinds residents I interviewed had similar preferences with regards to their drinking water. Their expectations around taste, smell and clarity were consistent despite differences in age, gender and occupation. Again, the consensus was that water should not have any taste, smell, or colour:

"It shouldn't – well, to me, I don't think water smells. It shouldn't smell as far as I'm concerned. I'm not aware of this water smelling or – I don't know, how do you describe the taste of water? You know, it hasn't really got that taste. It's clear, you hold it up, you pour it out, you hold it up, you look through it, there's no imperfections or anything like that, so, yeah". Sam, Dairy Farmer.

*“...the water is just wonderful. Just knowing that it’s clean, it’s clear.
It tastes ok. Doesn’t really have – to me, water has no taste but if it
has a taste I’m not really happy yeah”. Kelly, Dairy Farmer.*

Friedman (2016) suggests that the meanings attributed to different sensations are socially constructed. What is considered fragrant and what is considered foul is learned, as is the appropriateness and inappropriateness of touch (Friedman, 2016). For instance, the smell of sewage and the smell of roses are simply odours in themselves. That one is foul and one is fragrant is something that society teaches its members from a young age. Indeed one might be taught the opposite: to enjoy the smell of sewage and recoil at the smell of roses. The desirability of water without colour, taste or smell is similarly socially constructed.

Furthermore, the idea of the five senses being sight, touch, taste, smell and hearing is not found in all cultures nor is it consistent across time. The Javanese, for example, speak of there being five senses but one of these is talking. Similarly, in Old English there was no distinction between taste and smell. Rather, the word ‘smec’ was used to denote both (Howes, 2011; Howes & Classen, 2013).

Humankind encounters innumerable sensory stimuli on a daily basis and, as such, there are innumerable ways humankind can experience the world. Society determines which sensory inputs are focused on and how they are evaluated (Friedman, 2016; Howes, 2011; Howes & Classen, 2013). Subsequently, members of the same society

become attuned to some sensory inputs and not others and this allows a shared view of reality. For example, in evaluating race, one is taught to focus primarily on skin colour as opposed to height or ear size (Friedman, 2016).

The importance afforded to each sense is not consistent across time and place. For example, it is only since the proliferation of the written word that sight has become the dominant sense in Western culture. This suggests that the number and order of the senses is not determined by nature but, rather, constructed by society (Howes & Classen, 2013). The dominance of sight in modern Western culture is evidenced in the way society appreciates art from afar, the sealing of contracts with a signature, and the importance of visual evidence in the court of law (Howes & Classen, 2013). The evaluation of water quality by experts is similarly predominantly sight-based, relying on written test reports. Conversely, traditional Māori perspectives on water quality rely on a wider use of the senses such as the sound of birds and of wind through vegetation (Tipa & Teirney, 2006).

The Ministry for the Environment funded the development of a Cultural Health Index (CHI) for Stream and Waterways to aid Māori in expressing traditional views on water quality and safety in a way that might be understood and utilised by resource managers today (Tipa & Teirney, 2006). The CHI comprises three components, including site status (current and likely future significance of the site for Māori), mahinga kai (ability of the site to support food gathering traditions), and cultural

stream health (condition of the waterbody and surrounding catchment area). These three components are brought together in an overall CHI score (Tipa & Teirney, 2006).

Interestingly, attributes associated with senses other than sight were not included in the final Cultural Health Index for Stream and Waterways as they were perceived to be 'difficult to replicate' (Tipa & Teirney, 2006). Likewise, while the DWSNZ specify limits for contaminants that affect the aesthetic attributes of drinking water, such as those minerals that affect taste (e.g. manganese and zinc), these are guidelines only and are not enforceable. These examples reflect the importance afforded to sight in mainstream New Zealand society.

The rural Hinds residents I interviewed, too, employed a wider use of the senses in evaluating their drinking water quality. During the in depth interviews, some of my participants mentioned an additional attribute rarely explored in the literature – the refreshing nature of drinking water. This largely related to temperature and, as sheep and beef farmer Matt described it, *"I think it feels more refreshing the colder it is"*. However, Kathryn, a dairy support farmer and office administrator, also spoke of water's ability to quench thirst: *"Well, I buy bottled water because I find [tap] water, I constantly want more of it so it doesn't quench my thirst, whereas I find bottled water does"*.

Douglas (1966) proposes that each society constructs a set of beliefs and behaviours and that these afford the society stability. The beliefs and behaviours accepted in a

given society depend on the unique context in which they were constructed.

Consistent experience within this context reinforces a society's constructions, while conflicting experience may be ignored or labelled as a threat (Douglas, 1966).

While much of the current literature refers to municipal drinking water supplies, which often rely on surface and/or stored water, rural Hinds residents are reliant on supplies that come from many metres below the ground and which are often pumped directly to their tap. This means that the water remains cold up to the point that it is consumed. This consistent experience of consuming cold water has reinforced rural Hinds residents' perceptions of what makes water fit for consumption; that is, drinking water should be cold.

Similarly, despite their drinking water being unchlorinated, chlorine was discussed, often unprompted, by my participants in every interview. All expressed a dislike of the taste and smell of chlorine in drinking water, favourably comparing their own 'unmolested' drinking water supply to town supplies in Hinds and Ashburton.

"It tastes like spring water, it tastes like decent water – you go some other places and the water's been chlorinated or whatever, you can tell. Our water is good here compared to what you drink – well, maybe it's because we're used to our water, who knows? It may be, yeah, because we're used to it. We like it". Robert, Arable Farmer.

The taste and smell of chlorinated water is inconsistent with that of the unchlorinated water typically consumed by rural Hinds residents. The presence of chlorine may be, therefore, perceived as undesirable or even a threat simply because it deviates from my participants' usual experience of their drinking water. In contrast, in some developing countries where waterborne illness is rife, the presence of chlorine has been found to be perceived as a positive attribute as it indicates the water has been treated and consistent experience has proven this water safe to drink (Doria et al., 2009; Rojas & Megerle, 2013).

Tesh (1993) provides an additional way of understanding my participants' dislike of chlorine in their drinking water. She proposes that society's beliefs about pollution stem from its beliefs about nature and humankind's relationship with nature. Over time, society has come to perceive nature in its natural state as optimum, perfected through millennia of evolution. Therefore, any alteration of this natural state is seen to be harmful to nature and harmful to humankind as part of nature. The addition of chlorine to drinking water alters the natural state of the water, which is consequently perceived as harmful to those consuming it. This may help in understanding the extent of Kathryn's reaction to adding chlorine to drinking water:

"Chlorine! God, you'd be able to taste that. You'd smell it a mile off, wouldn't you? God, no, don't want that in my water... chlorine, that's what you use to clean pools with, don't you? No thanks, I don't want

that. And that's got a definite smell to it. That might've been what I smelt in Waikato. Could've been, definitely got a tang to it. So, no, don't want that in my water".

The above quote from Kathryn illustrates the propositions put forward by both Douglas and Tesh. In describing chlorine as a chemical used to clean swimming pools, Kathryn is identifying chlorine as something that does not naturally belong in her drinking water, something that alters its natural state. Furthermore, she considers chlorine to impart a taste and smell to water that is not usually present in her own drinking water supply. Thus, the impact is two-fold: firstly, the natural state of the water is seen to be compromised and, secondly, the aesthetic attributes of the drinking water deviate from what she is used to. Consequently, she perceived chlorine in drinking water as undesirable or even a threat to her health.

5.3 Testing and Contamination

The rural Hinds residents I interviewed often described taste, smell and turbidity, or an absence of these characteristics, as influencing their behaviour with regards to their drinking water self-supply. Many stated they had not considered their drinking water quality at any length as, to them, it tasted, smelled and looked fine. Some participants, such as sheep and beef farmer Matt, recounted instances where they had avoided or treated their water because it did not look like they expected their drinking water to:

“They re-did the wells because Hinds used to actually run out of water and their water pressure was no good... I do remember when it first got... going again at Hinds and the water was actually [white] so a lot of it was aeration through the new – the fact that the water main had been emptied and then they flushed it, and the extra pressure caused [tiny bubbles]. So, you actually left it in the glass and they did settle out. It did that for a long time after the upgrade... But I remember them with their glasses lined up along the bench at squash and no one would drink the water ‘til the water all fizzed out and had gone clear again. And it’s like one of your first questions is “Why wouldn’t you drink the water?” – Because it didn’t look like you thought water should look so no one was drinking it. So, aeration is enough to make people think that there’s something wrong with their water... [Also, a local lady selling water filters] did a huge canvas in the area in the mid-90s. She used to come round with a pot of water and put it on the stove and she used to be able to make it go green in front of your eyes so you thought that you needed to do something about your water... Because once you think it looks awful you don’t like it. Once the water’s not that nice pure colour that you see in the – what you expected to see in the glass – and I believe we’re all sceptical of what it’s going to taste like, whether it’s good or bad for us”.

These examples are consistent with the findings of other studies, which have shown that the actions the lay public take to protect their own health are very much determined by the aesthetic qualities of their drinking water. For example, bottled water consumption has been significantly associated with poor aesthetic attributes in tap water (Dupont, Adamowicz, & Krupnick, 2010; Dupont & Jahan, 2012). While these studies focus on municipal water, aesthetic attributes have been identified as key prompts to test the water for users of drinking water self-supplies, too (Chappells et al., 2015; Jones et al., 2004).

Perhaps unsurprisingly, research investigating drinking water self-supplies has often found that people do not test their drinking water, at least not at the recommended frequency. When they do test their water, they often do not know what it has been tested for or the results of that testing (Jones et al., 2006; Jones et al., 2004; Roche et al., 2013). Interestingly, water testing was routine for those of my participants who identified as dairy farmers. The dairy companies they supplied required annual testing of their dairy shed water and, in some instances, this water came from the same source as their drinking water. However, the routine testing of drinking water specifically was not undertaken by any of my participants. Infrequent testing took place as part of a building consent, a local student's science fair project, and when they suspected there could be a problem with their drinking water. The general sentiment towards drinking water testing was summed up by dairy farmer Kelly when

she said *“Probably [wouldn’t test], not unless there was a problem. Nothing’s broke so why fix it”*.

The *E. coli* testing carried out as part of my study generated little discussion. The majority of my participants asked for an explanation of their results and some were interested to know the results of other households in their area as they saw these as a potential indicator of local issues. Three drinking water self-supplies tested positive for *E. coli*, however, the results were found to conflict with the affected households’ experiences of their drinking water. As dairy farmer Michael explained:

“You’d think people would be getting sick from that, wouldn’t you?”

Well, we were always told E.coli’s a bad thing so and people get sick from E. coli, so why aren’t we getting sick from E. coli? I don’t know.

I’m just surprised there’s not someone who’s unwell because of it”.

Allmark and Tod (2006) refer to this as the prevention paradox. They explain that, for example, public health professionals may advise the lay public to minimise their risk of cardiovascular disease (CVD) by reducing their saturated fat intake. While the overall burden of CVD may decrease at a population level, there will exist individuals who consume a diet rich in saturated fat who are not affected by CVD and individuals who adhere to seemingly healthy lifestyles that are. Consequently, the lay public may question the wisdom of a health professional’s advice just as some of my participants

questioned the importance of *E. coli* in their drinking water self-supply (Allmark & Tod, 2006).

Baker, Sneyd, and Wilson (2007) propose that where there is an absence of waterborne illness in rural households with poor quality water, this might reflect an acquired immunity due to repeated exposure. While their research on waterborne illness in New Zealand showed that rural residents were at significantly lower risk of campylobacteriosis than their urban counterparts, when they stratified their data by age group rural children were at significantly higher risk than urban dwelling children (Baker et al., 2007). Some of the rural Hinds residents I interviewed presented a similar argument regarding immunity to waterborne pathogens:

“You only get crook on bottled water. Because your body’s got to be exposed to certain elements. If your body’s not exposed to the elements you’ll get crook... So, that’s my simple answer to it all – if we drink what we’re drinking, and we never got crook off here. And if you lived on bottled water and you maybe tried this well water then you might get crook because your body has got to function. It’s a bit like eating organic and non-organic, isn’t it?” Brandon, Dairy Support & Arable Farmer.

Two of the rural Hinds residents I interviewed spoke of occasions where they had taken preventative action with regards to their drinking water, not to mitigate risk to their own health but the health of those they perceived to be vulnerable. Dairy and arable farmer Patrick described installing a filtration system after discovering one of the homes on his farm was supplied with contaminated drinking water. He explained that *“If there hadn’t been a wee baby in that house down there when we found that raised E. coli I don’t know whether I would’ve acted as quickly”*. Similarly, James, an agricultural service operator, explained how he bought bottled water for weddings that took place on his property because of the ‘delicate’ nature of the guests:

“We have bought water at times when we’ve been a bit desperate. We had a couple of weddings here and both boys have been delicate so they mainly bought water. I’m not saying there was anything wrong with ours but just as an extra precaution you could almost say... probably because the city boys were concerned about their guests”.

The presence of *E. coli*, expressed as Most Probable Number (MPN), also raised questions around the level at which it becomes a problem. Although I explained that the allowable level of *E. coli* in a municipal supply was <1 MPN, participants questioned how applicable this was to their drinking water self-supplies. For example:

“So, 3 MPNs per 100 mLs... to me, that’s nothing... Because potentially that could’ve said 3500, which means, to me, 3 MPNs per 100 mLs... could be the – going through the pump and then getting pushed through under these pipes – we would’ve been here for 13-14 years or whatever, and the house is ten years old [when it was relocated] – so 25 year old pipes, those three parts there could be coming through those pipes... So, if this was four figures, as in over a thousand, it would concern me a bit, but at 3 [MPN] I think I’ll go and get another glass of water... To me, three is... it might as well be zero. As in, if it was 3000 or 30,000 you’d be thinking “Oh, there’s something wrong here” and you’d be wanting to treat it or do something with it... That’s why they can get [a town supply] to zero, through chemically treating it whereas this is supposedly pure water, untreated – raw water you could even say”. Logan, Dairy Farmer.

Beck (2009) suggests that water containing *E. coli*, for example, is only perceived as contaminated by health professionals because they choose to evaluate water quality from a scientific standpoint. This chapter has already demonstrated that water quality may be evaluated in a number of ways, including but not limited to the presence of illness or undesirable aesthetic qualities. Furthermore, Douglas and Wildavsky (1982) propose that specifying an allowable level of pollution, such <1 MPN for *E. coli* in drinking water is not a reflection of what nature can withstand but what society is willing to accept. Logan, in the above quote, is clearly accepting of low levels of *E. coli*

in his drinking water. This may be due to an absence of illness in his household, as dairy farmer Michael suggests, or it may be that Logan believes low levels of *E. coli* naturally occur in water and, as such, *E. coli* is not harmful to health. The latter draws on the proposition put forward by Tesh (1993) that nature is optimal in its natural, untouched state and any alteration of this state by humankind is harmful to nature, as well as humankind as part of nature.

5.4 Health Risk Communication

Beck (2009) theorises that the construction of a risk as knowledge occurs, in part, through a process called staging. This involves encouraging people to believe that they are vulnerable and that some threat can reasonably affect them. He highlights the importance of the mass media in creating this belief (Beck, 2009). The mass media have been particularly important in the construction of bacteria and nitrates as health risks. Approximately a third of the rural Hinds residents I interviewed referred to news pieces they had read concerning nitrates or bacteria, such as *Campylobacter*, in the groundwater, as evidenced in the following quote from sheep and beef farmer Matt:

“The media was the nitrates and that was the levels were supposedly increasing. All the foreign bodies that we can’t see that aren’t supposed to be good for us”.

Lupton writes extensively on the use of digital technologies for health risk communication, with particular focus on the internet as a forum for two-way risk communication (Lupton, 1994, 2012, 2013, 2014a, 2014b, 2016). Interestingly, the

rural Hinds residents I interviewed did not refer to the internet as a source of risk communication. Instead, they mentioned television programmes, newspapers, community meetings and events, neighbours, family, drilling companies, plumbers, water diviners, doctors and dairy companies. For example, dairy and arable farmer Patrick spoke of installing a water treatment system after learning about it in a community meeting:

“As far as drinking water was concerned, the RO [Reverse Osmosis] issue came up at a community meeting down here in Hinds – community consultation meeting over the community’s aims for water quality – and one of the water quality scientists said that it might be the community’s choice to put a small thousand dollar RO plant in everybody’s house that was affected with high nitrates. And that got me thinking”.

The reason the internet was not mentioned as a means of communication may reflect the sociodemographic profile of my participants. According to Statistics New Zealand (2012), those aged 15 to 44 years old are among the largest groups of internet users. Just four of my participants reported being between 40 and 49 years of age, while the remaining participants were 50 years of age and above. In addition, Lupton (2013) proposes that trust becomes more important as modes of risk communication, such as digital technologies, become less personal. Research has shown that community members are more likely to trust those experts who reside within their communities

than those perceived as outsiders (Chappells et al., 2015; Jones et al., 2007; Jones et al., 2004; Stebbing et al., 2013). Therefore, it is perhaps not surprising that my participants turned towards their friends and neighbours before the internet for information about drinking water health risks.

That is not to say, however, that my participants did not use digital technologies at all. For example, some of my participants spoke of using digital technologies to automatically shut off an irrigator as it reached a fence or track; the use of software in nutrient budgeting; and GPS mapping for more efficient fuel use during harvesting. As arable farmer Robert described:

“I’m looking at a new – we’ve just sold this farm so and we’re moving to a new one in a couple of months and I’m looking at a new irrigator for it and it’s got a thing on it called VRI, which is Variable Rate, and it means that on the tracks the water will turn itself off automatically. You put it in your paddocks and it’s a circle, and you’ve got your square paddocks, and it will actually irrigate to here and then it will turn off and start over here. So it turns itself on and off automatically... But I said to the fellow, I said – he said “you’ll be able to do it from your computer in the kitchen or on your laptop or whatever” and I said “well, are you telling me that you will give me back up when I don’t know how to work that” and he said “well, probably talk to your kids””.

Thus, there is potential for the rural Hinds residents I interviewed to adopt digital technologies for use in drinking water health risk communication. Several participants, for example, expressed interest in knowing the test results from nearby drinking water self-supplies. There is opportunity for this information to be communicated using digital technologies such as the internet.

Although the internet was not mentioned as a direct source of drinking water health risk communication by my participants, there exists a possible indirect influence on other forms of health risk communication. Bennett, Calman, Curtis, and Fischbacher-Smith (2010) propose that the media, in their effort to compete with the internet, are under greater pressure to produce more frequent news updates with fewer resources. Therefore, they have less time to check news items before they are released (Bennett et al., 2010). A number of the rural Hinds residents I interviewed questioned the accuracy of some news items concerning the effect of dairy farming on water quality, for example. As dairy farmer Sam in particular explained:

“There was a campaign a while back by Fish and Game and they coined the phrase ‘Dirty Dairying’ and then they had this photograph of a Hereford cow standing in a river and saying how bad dairy farmers are. And we’re going “But that’s not a dairy cow, that’s a sheep and beef type animal”, nothing to do with dairying”.

Regardless of the accuracy of news items, the media plays a large part in determining what is and is not accepted as knowledge. “In other words, ‘if CNN defines a situation as a crisis, it will indeed be a crisis’” (Bennett et al., 2010, p. 81). Sam went on to describe a debate he had had with a family member which illustrates this point well:

“People who live in the big cities and that, a lot of them have never been onto a dairy farm, or on to a farm full stop, got no idea, and they’re just hearing what is put in the media and put in front of them and they go “Well, that must be the truth” and they just go from there... I’ll tell you how bad it is: I was at a wedding in [R] and my nephew’s girlfriend was there and she’s off a large sheep and beef farm in [D] and she was giving me a hard time about ‘Dirty Dairying’ and we should have all our waterways fenced off and all this sort of stuff, and I looked at her and said “But have you got your waterways fenced off?” and she said “Well, they’re not dairy cows”, I said “No, but they’re bovines” I said “And what are bovines?” And she was really adamant about how we should – I said to her “Well, we’ve got no waterways on our farm at all anyway, before we even start that” I said “But your cows will stand in a creek and they will shit and piss and drink out of that creek at the same time” and I said “That’s what bovines do” and I said “For that matter, deer are actually far worse than what cows ever are”, deer are shocking but, anyway. And it

took me probably about half an hour to get through to her that what her family farm was doing was worse than what we're doing because we keep all our cows out of the water ways. Every farm I've been on, we've always had the waterways fenced off and fenced off properly. So, yeah, she was sort of going "Fine". But that's just because she's been seeing what's in the papers, what's on the news, and all that sort of stuff about, you know, how bad it is, so she takes it at face value and goes from there".

The use of imagery that evokes negative emotional responses to encourage self-regulation is common in health risk communication. Lupton discusses this with reference to quit smoking campaigns, for example, which often employ images of blackened lungs and the like (Lupton, 2015). While a cow defecating in a stream may not be as disturbing as a blackened lung, the concept is the same: an image depicting a breach of what mainstream society considers 'normal'. It is this breach of 'normal' that evokes a negative emotional response, such as shame, fear, disgust or regret (Lupton, 2015).

This response ultimately results in the marginalisation of a group or groups of society perceived to be in breach of the accepted 'normal', inciting prejudice based on what is presented as appropriate and just social behaviour. Sam, for example, described two occasions where he had been discriminated against for being a dairy farmer:

“I went to a St John’s first aid course just to, you know – it was a two day course – and as soon as they found out I was a dairy farmer a lot of them wouldn’t talk to me. It was just really amazing...[and] I sat on a plane next to a woman coming back from Sydney there and she had a go at me about sucking all the water out of the ground and I’m going “Hang on a moment”... But I explained it to her and said, you know, “This is what is happening”, yeah, and she got “Oh, oh, ok, yeah, well, that makes sense” and, yeah, she wasn’t so anti after that”.

While not speaking directly to drinking water health risk communication, the ‘dirty dairying’ campaign example illustrates the power of the media in determining what is accepted as knowledge, as well as establishing the social worth of different sectors of society. There is potential to use imagery that evokes a negative emotional response in health risk communication for drinking water self-supplies. For example, this chapter has discussed that which is perceived to be ‘normal’ drinking water for my participants. Presenting rural Hinds residents with imagery depicting breaches of this ‘normal’ may incite change. However, Lupton (2015) debates the use of such imagery in public health campaigns given the possibility for prejudice and marginalisation, which, in turn, may adversely affect public health.

Furthermore, Lupton, while acknowledging the many uses of digital technologies to enhance health risk communication, also recognises that such technologies often

invade one's private space to the point where there is no escape from health risk communication. Confrontation with poor drinking water quality results, for example, may provoke a negative emotional response (Lupton, 2012). Moreover, Lupton (2014b) has questioned who should have access to health risk communication data, such as drinking water self-supply monitoring results. For example, several of the rural Hinds residents I interviewed expressed concern over the effect poor drinking water quality could have on local land values and the economy as a whole if it was publicised. As James, an agricultural service operator, explained:

“You know, we haven’t publicised much about our... cottage being in the middle of dairy farms and saying “well, it’s got huge nitrate levels”... that side of it is probably a delicate matter... even our other cottage could be in a similar light, you know, it’s got dairy farms right around it and... if you came out with a really bad figure, what do you do with it? You don’t shout it from the roof tops, I can imagine. You may discuss it with your locals but it’s still pretty big... if it was publicised at all, it could reduce the value of the local land or anything and I think probably people aren’t going to do a lot, just quietly get on and do your own thing without saying to your neighbour perhaps this is where it’s from”.

As discussed in Chapter Four, the quality and quantity of water available in the area is integral to the local economy. Publicising the contamination of the area's water

resources not only affects local land values but has the potential to affect the local economy as a whole. Chapter Four also demonstrated important connections between different types of water, including irrigation water, groundwater and surface water bodies. In particular, the type of irrigation used by inland farmers influences the amount of water available to those farming closer to the coast. Just as the effects of poor water quality and quantity are community-wide, so are the causes. This raises questions around responsibility and control, which are discussed in Chapter Six.

5.5 Summary

Unlike the DWSNZ, the rural Hinds residents I interviewed employed a broad definition of drinking water quality and safety that extended beyond the presence or absence of *E. coli*, to include their experience of waterborne illness, as well as the aesthetic attributes of their drinking water. Although my participants recognised the presence of *E. coli* in drinking water as a health risk due to media coverage and, in some instances, interaction with their dairy company, they did not necessarily see this as a risk to their own health. Furthermore, publicising the negative effects of poor water quality and safety can serve to stigmatise certain sectors of society, as experienced with the 'Dirty Dairying' campaign. Rather than focusing on the connection between *E. coli* and waterborne illness, health risk communication may be more successful if it emphasises, for example, the positive effects of good water quality and safety on land values and vulnerable populations.

6 Responsibility and Control

6.1 Introduction

Humankind has an inherent ability to organise itself and to divide labour, that is, to form a society (Foucault et al., 1991). A society is founded on the basis of common values and social institutions exist to ensure that these values are upheld. That which contravenes the common values of a society is labelled a threat by its institutions (Douglas & Wildavsky, 1982). Social institutions, such as religion or the natural sciences, provide society with a set of acts and observances that may be performed to ensure that threats are avoided and the welfare of society is preserved (Douglas, 1966). The adherence to these rules also serves to give members of society a sense of control over their world (Lupton, 1999).

The notion of responsibility and control emerged as a global theme during my interviews with rural Hinds residents and forms the basis of this chapter. While governmental responsibility for urban drinking water supplies has been institutionalised, responsibility for rural drinking water self-supplies, by default, falls on individuals. This chapter discusses this responsibility from the perspective of rural residents, drawing on the literature to explore key themes around the role of individuals, government regulation, and science.

6.2 Role of Individuals

Research shows that farming and non-farming rural residents may hold different views regarding who should be responsible for drinking water supply management. Non-farming rural residents tend to perceive the government as responsible for water quality, while farming rural residents most often see this as the role of individual citizens (Hu & Morton, 2011; Kite-Powell & Harding, 2006). I did not find evidence of similar differences in perception during my interviews with rural Hinds residents, however, all of my participants except one were farming residents.

The rural Hinds residents I interviewed were unanimous in their belief that they should be responsible for their own drinking water self-supplies, a view consistent with that found in other studies of private well owners (Jones et al., 2004; Stebbing et al., 2013). This responsibility was perceived to come with being the landowner and the ones dependent on and paying for the upkeep of a supply. As dairy farmer Logan explained:

“It’s on our property, it’s our well. If it was a town supply situation I would expect the Council to do it because they charge a water rate, or a water fee, or something along those lines... The water for the town supply is pumped up from the aquifers by the Council, potentially treated, and sent down your pipes so they can charge you for the water. But part of being in a rural environment, you’ve got to

bear the cost of that yourself. Hence I say, you know, your own well, your own pumps, your own pipework and all the rest of it”.

A household’s access to drinking water was described by participants as dependent on a number of factors. These included well depth, irrigation practices, and access to electricity. Access to electricity was of particular importance as drawing groundwater to the surface and distributing it to a house requires at least one electrical pump. Rural areas are susceptible to extended periods of power outages, especially due to adverse weather conditions. Participants spoke of losing power for up to twelve days during the 2006 snow event and the 2013 windstorm. As dairy farmer Sam explained:

“You come down this road here, these power poles stop at our gateway and does these two properties here, so we were one of the last ones to be fixed because there’s only two people on it. So, that’s just where you’ve got to be aware in the country... Our friends just out of Temuka, even though they’re on the main Geraldine power line, they had four power poles to get to their house and they lost three of those power poles and the power board just said “Well, we can use those power poles elsewhere, you know, instead of going in and putting all those poles there we can put them somewhere else and get 30 or 40 people up and going with that number of poles rather than one person at the end of this line of poles””.

Unsurprisingly, a number of participants expressed a desire to be self-sufficient with regards to water, both for drinking and on the farm, and had put in place a system of backups to ensure continuity of their water supply. These backups included access to multiple wells, generators, and stored water, as well as melting snow in some instances. As arable farmer Tim explained:

“Just a generator system. So we just supply ourselves power. We’re pretty self-contained really. Since the snow of 2006 – a week without power makes you [think]. We need to have access to looking after ourselves”.

However, one might argue that this desire to be self-sufficient stems not only from the experience of days without power but also from the underlying neoliberal ideologies present in today’s society. Neoliberalism questions the capacity of the government to govern everything for the best, and requires active participation in the labour market rather than public provision (Petersen, 1996). An individual’s social destiny is thus no longer determined by class or gender, for example, but by their competitiveness and ability to care for themselves, that is, their ability to self-govern (Beck, 1992; Foucault et al., 1991; Petersen, 1996). To flourish in such a society, one must engage in risk avoiding behaviour, subsequently lowering one’s burden on others and society as a whole (Lupton, 1999).

In becoming self-sufficient, the rural Hinds residents I interviewed were demonstrating their ability to care for themselves and, consequently, their social worth. This extended well beyond simply ensuring continuity of water supply to include looking after their own health and that of others. For example, Kathryn, a dairy support farmer and office administrator, explained how, in taking responsibility for her drinking water self-supply, she was taking care of her own health:

“Well, why would I make anyone else responsible for [her drinking water self-supply]? It’s my health, I mean, too many people try and palm things off, don’t they? You are responsible for yourself. Why would you expect anyone else to... unless they were indirectly responsible. Let’s say the Council put something into the soil and it affected all the water, well, yeah, then they’re responsible but otherwise, no, we are”.

The latter part of the above quote highlights that failure to engage in risk avoiding behaviour also puts other members of society at risk. Self-governance requires one to look after not only oneself but others, as well, in an effort to reduce one’s burden on society (Lupton, 1999). James, an agricultural service operator, described how, in taking responsibility for his drinking water self-supply, he was taking care of the health of others:

“Well, I guess the reason is that if you’re offering people a drink you like to say “Look, this is safe to drink” and if you’re being offered a drink you would expect it to be safe to drink in New Zealand – you know, you’re not expecting it to be contaminated. It’s not the sort of thing I’ve really thought much about but I’d like to think we were doing our bit, keeping it up to standard, yes. Checking the water, doing your best as regards how you treated it from when you got it to your house, you know, don’t have any chance of contamination. Keep your tanks clean, your pumps and everything up to scratch and... not allowing any contamination between the ground and when you are drinking it”.

Beck proposes that the consequences of the risks society faces today span national borders and generations. He refers to these risks as ‘global risks’ because their effects are no longer confined to their time or place of origin (Beck, 1992, 2009). Thus, an individual’s actions not only effect that individual. Some of the rural Hinds residents I interviewed not only spoke of the effect of their actions on others, as James describes in the above quote, but, in line with Beck, discussed the impact of their actions on the resources available to future generations. For example, dairy farmer Michael explained:

“I suppose from my point of view I’m a sixth generation farmer in this area and I’ve probably got two sons, as you know, and one I think

will probably go farming and I'm not sure about the other one but, and the last thing I want to do is ruin the environment for his family or, and if his children want to be farmers then, of course, the last thing I want to do is ruin the environment for the next round of generations. So, it just seems crazy that we would be – put ourselves in a position where we would ruin where we live”.

As discussed in Chapter Four, the rural Hinds residents I interviewed took a number of actions to look after their drinking water. These included erecting a pump shed, sealing the well head, fencing off the immediate area from stock, ensuring lids remain on storage tanks, and installing a treatment system. However, Lupton (1999) suggests that not everyone has the capacity to self-govern due to limited resources such as time and money. For example, in developing countries, people may drink from unsafe water sources because other alternatives are not available year-round or are inconvenient to access (Islam et al., 2011). Furthermore, they may not treat this water due to time and monetary constraints (Fisher et al., 2011; Kovalsky et al., 2008; Rojas & Megerle, 2013). Although my participants largely referred to the monetary costs associated with their drinking water self-supplies as ‘part of being in a rural environment’, time in particular was noted as a barrier.

Whether or not resource constraints can be overcome, Tesh (1988) questions the fairness of a society that blames the individual for falling victim to poor health. For instance, should one of my participants experience an episode of illness attributable

to their drinking water, they would be perceived as culpable for failing to protect themselves and their self-supply. However, the drinking water, in its raw state, may be unsafe to drink for a number of reasons, not all of which the individual household has control over. For example, the rural Hinds residents I interviewed spoke of the flow of water underground and the effect of those activities taking place upstream from their water supply. As dairy farmer Debbie explained:

“So, it’s beyond our control really, we’ve got no control, you know, what our water is like, it’s really sort of the people above us where the stream flows through as to what they put on and it seeps through into that stream and flows through and we use it sort of thing, just like what we use here probably affects somebody further downstream”.

Similarly, dairy farmer Michael considered the effect of historic use of agrichemicals and the change in farming practices on water quality in the rural Hinds area:

“I suppose the area we live in has gone through a big change, from border dykes to spray, so it’s going to take a while to wash out... Sometimes you look at it and go “Well, the nutrients are there, I wonder how much of that has been from past nutrients – not from

now – and from lack of dilution”, so the nutrients may have already been there but we’ve lost the dilution”.

As discussed in Chapter Four, the contamination of water, both historic and present, is a manifestation of a much greater issue. At its heart, the issue is not the intensification of farming practices per se, but a society that is driven by profit and productivity. Tesh (1988) argues that the individual should not need to protect themselves from their drinking water, rather they should live in an environment where their drinking water is safe. Putting the onus on the individual to keep themselves safe allows the unsafe environment to continue to exist because society is not addressing the underlying cause of environmental contamination (Tesh, 1988).

6.3 Collaborative Effort

Both water quality and quantity have been a concern of the New Zealand government for some time. The government’s objectives and policies around freshwater management in particular are detailed in the National Policy Statement (NPS) for Freshwater Management 2014 (Ministry for the Environment, 2014). This NPS provides direction, in the form of objectives and policies, with regards to local government management of freshwater resources under the Resource Management Act 1991. The Canterbury Regional Policy Statement (CRPS) for Freshwater echoes these objectives and policies, including consideration of drinking water quality and quantity (Environment Canterbury, 2013).

Both the NPS and CRPS are addressed in the Canterbury Water Management Strategy (CWMS), the aim of which is “to enable present and future generations to gain the greatest social, economic, recreational and cultural benefits from our water resources within an environmentally sustainable framework” (Environment Canterbury, 2014a, p. 5). The CWMS promotes a collaborative approach to freshwater management and includes the establishment of ten Zone Committees comprising government, industry and user stakeholders. According to the CWMS, these committees are involved in identifying the issues facing freshwater quality and quantity in their respective zones, as well as putting forward proposals on how these might best be managed (Environment Canterbury, 2014a).

Some of the rural Hinds residents I interviewed, who had been involved in the Zone Committee, questioned the influence of the local community on decisions made around freshwater management. They felt the decision making power largely belonged to central and local government, embodied in policies and regulations that could not be overruled. As dairy and arable farmer Patrick explained:

“It’s the weighting that you probably put on things and that’s supposedly meant to be established by the community but I just don’t know whether the community are driving it because it’s been driven from all these overarching policies from above that do control the overall standards so it makes it a little bit... inflexible for a

community to actually decide what they want... It's driven from the top, from overarching legislation so it makes it a little bit inflexible to have a variable or something outside those parameters, which the community might want".

Patrick's view is supported by a recent consultation document on freshwater management. This document acknowledges that the government aspires to support communities to identify freshwater issues and propose solutions, however, this is to take place within a national framework, bringing into question the freedom afforded to the community to make decisions (Ministry for the Environment, 2016). Dairy farmer Michael also expressed concern over the effectiveness of the present forums for consultation and participation in the management of water-related risks. Central to this discussion was the element of trust. As Michael explained:

"I suppose when you get down to your ECans [Environment Canterbury] and your other agencies, they can be – it's probably not what they're trying to do, it's probably how you get treated a bit and that's more that you're guilty by – as dairy farmers, you feel like you're treated as guilty even though you may not be, you might be but you may not be so, yeah, that's probably one issue... So, I suppose there's probably a lot of mistrust between farmers and ECan and it's probably because of the way they seem to perceive us as the enemy, and obviously it's not a very nice way to have the

relationship... Rather than looking at us as the people who can make the solutions, we seem to be treated as people who create the problems”.

Trust is integral to the functioning of modern day society, which relies on the technical expertise of a few to create rules and guidelines for the population as a whole. Hence, the lay public invests substantial trust in technical experts whom they likely have never met and do not personally know (Bennett et al., 2010; Lupton, 1999). While the lay public may be capable of learning the technical concepts informing such rules and guidelines, one cannot be an expert in every technical field known to modern society. Instead, the lay public delegate this responsibility to established expert systems (Bennett et al., 2010).

Bennett et al. (2010) suggest that trust, such as that between Environment Canterbury and the farming community, can be fostered through consistency, impartiality, and transparency. Where conflicting messages are received, whether based on actions or words, trust may be compromised (Bennett et al., 2010). Dairy farmer Logan, for instance, expressed distrust of Environment Canterbury’s groundwater allocation zones based on what he perceived as conflicting communication:

“You know, we’ve got another block on [another] road that we bought there and they say that it’s classified as a red zone, that it’s

over-[allocated]. How do they really know that? They test wells and that and it's only their – scientific, it may be – viewpoint on that... Your classic example was... the block behind us, this guy he tried to get a consent to irrigate it and they said “No, no, no, it's over-allocated” and then he had another block further down on the other side of the main road and he was able to – the other block had surplus water – to then take some off that and then put it up to there. So, he could re-allocate some water from this farm 15-20 k's up the road to this farm. How do you push water uphill? You can't. And yet, as far as ECan were concerned, you know, the area was over-allocated and he could take water from here, say 20 litres a second off what he had here and move it up to there. And he now irrigates that block up there and yet the guy said he couldn't, there was no way they would let him have water... So, this idea about how much water's under there, to me, is not a hundred percent accurate... ECan say – like we're in a grey zone here, it's not over-allocated – but they don't really know”.

Simply put, a person farming in an area where groundwater is deemed to be over-allocated cannot obtain a consent to draw water from a bore for irrigation. However, if the person holds a consent in another area where groundwater is available, part of that consent can be transferred to other properties under the same ownership, allowing the person to effectively draw water in an over-allocated area. Initially

denying consent but then allowing the abstraction of groundwater anyway has led Logan to distrust Environment Canterbury's zoning of groundwater in the first place.

Trust is likewise influenced by whether or not someone is perceived to have an ulterior motive (Bennett et al., 2010). A number of the rural Hinds residents I interviewed spoke of a lady who had sold drinking water filters in the Ashburton District. She would test their water and suggest filter systems based on the results. Many of my participants who recounted such an experience did not purchase the water filters because they questioned her impartiality. By contrast, test results from an independent laboratory were perceived as more trustworthy because the laboratory was not perceived to have other vested interests. As Robert and Michael explained:

"It was too obvious for a sale, it was so "Look at it, your water's no good, you're going to have to buy – ", you know, it was like "Oh, no, we'll get our water tested independently thanks". The wee alarm goes off that, yeah, because she wasn't suggesting that we did that... [Hill Laboratories are] not going to make any money by saying it's – they're just going to give you what it is, they're not going to tell you because their cousin's got a water factory. It's not like there's a Hill's water bottle market because it's not what Hill's do – they are a laboratory that tests all sorts". Robert, Arable Farmer.

“Well it’s no skin off their nose if you pass, don’t pass, so, yeah, independence is huge. Yeah, they need to be independent because if it – like if we’re doing our own testing then we could be biased, if ECan was doing the testing they could be biased, and then if people start questioning where that information comes from, why, and who’s got another vested interest involved, so independence – it has to be independent really”. Michael, Dairy Farmer.

Along with full disclosure of conflicts of interest, trust is also established through the transparency of decisions. This involves not only the communication of a decision but how the decision was come to in the first place (Bennett et al., 2010). Sheep and beef farmer Matt, for example, expressed his frustration with Environment Canterbury, partly because of their failure to explain their decisions:

“I believe that they could have some more facts, they tend to rely on us to – we put something to them and they always turn it over and then we go away and do the research, they never actually come up with true data and true facts to say that “No, you physically can’t”, that “This is a – “. They never – they’re very clever as far as the fact that they roll it over and we do all the work. So, if we went back to the Blue Baby Syndrome, if it was nitrates in the water that caused

the blue baby, what level was it? What level was that water that caused that? But there's no – we don't tend to get any of the actual data... We try to put all the facts and figures that we can find so that they can look at it, add it up, and see if it actually works. But we get fed from ECan quite often, they say "No" but they don't tell us why".

In the above quote, Matt refers to 'true data' and 'true facts', however, the core argument of this thesis is that there are multiple versions of the truth, one no less valid than the other. The next section of this chapter aims to establish what version or versions of the truth are upheld by the rural Hinds residents I interviewed.

6.4 The Natural Sciences

The rural Hinds residents I interviewed held scientific knowledge in high regard, dairy and arable farmer Patrick describing it as *"proven rationale... not being driven by emotion and if, cans and maybes"*. A number of participants expressed faith in the ability of science to identify and monitor risks to water quality, as well as address these risks. As arable farmer Robert explained:

"I don't, myself, think continued intensification is the right thing either. It's got to go hand in hand with balances... like people using state-of-the-art water systems for recycling and all that. You can intensify if the science takes you – you can't just keep adding stock

numbers... you've got to support it by keeping your environment clean".

In addition to technology like state-of-the-art water systems, some of my participants identified a need for more science around water quality and quantity, particularly regarding the leaching of nutrients and the availability of groundwater. For example:

"So, farmers need to get smarter, we definitely need to be able to grow more, and we have to also work out how to grow more with less. And scientists are working, technology is marching on, it will happen. Just by going to spray irrigation is a step forward, we can grow a lot more, but that's not the bee's knees either because we can't water alone". Matt, Sheep & Beef Farmer.

Upon reflection, this regard for science is not surprising as the Western scientific paradigm has dominated what can and cannot be known for more than 200 years. Over this time, society has come to rely on science to identify and manage the risks that threaten its existence (Beck, 1992; Douglas, 1966; Lupton, 1999). Furthermore, Tesh (1988) maintains that society continues to be dependent on scientific knowledge as a means of refuting discriminatory beliefs that, by definition, are considered 'knowledge' all the same. Otherwise, society would be at the mercy of whoever has the most power to ensure their views are adopted.

The government, too, continues to rely on scientific evidence to support its water policy decisions. The most recent evidence of this can be found in the Next Steps for Fresh Water consultation document released by the Ministry for the Environment. This document specifies that “Good decision-making about freshwater management requires community-based judgements supported by *scientifically* robust technical information and an assessment of economic impacts. This is the reason attributes and national bottom lines have been included in the NPS-FM. They provide *non-contestable nationally agreed science* when setting freshwater objectives” [emphasis added] (Ministry for the Environment, 2016, p. 17). Similarly, any funding proposals must be backed by equally robust scientific data (Ministry for the Environment, 2016).

Interestingly, my participants’ regard for the natural sciences was not reflected in discussion where scientific evidence conflicted with their own personal experience. In particular, those participants with drinking water supplies that tested positive for *E. coli* countered these results based on an absence of waterborne illness in their households, as discussed in Chapter Five. Moreover, the following quotes from Logan and Brandon emphasise the importance of personal experience over scientific evidence in deciding what is ‘true’:

*“You know, how do you know how much water’s under the ground?
How do you know that the aquifers run like that – and I mean by that
that the Pacific Ocean will hold it back... so you can, supposedly, get*

a bank of water?... How do you know that? Because ECan put restrictions on us. And they say that they have evidence to prove that the water's not there... How do they know just by testing it that that is the case? It's a bit like telling you that it's cold, until you walk outside and experience it yourself... it might be 30 degrees outside. And that's what happens with ECan, you've just got to take what they say". Logan, Dairy Farmer.

"Nobody's ever been down there to see and look up and say "Ted, there's water over here and it's coming from the Rangitata" – or is it coming from the Rakaia? Don't know. You know. The Hinds disappears underground – where does it go? Who's feeding the Hinds? Is the Rangitata or the Rakaia feeding the Hinds? And the Ashburton? Nobody knows, nobody has no idea – well, they have a few theories, they've just created it". Brandon, Dairy & Arable Farmer.

Lupton and Beck, among others, propose that society's faith in science is diminishing as a consequence of science itself. They call attention to science's inability to control or eliminate risk and, moreover, its capacity for creating risk (Beck, 1992; Douglas & Wildavsky, 1982; Lupton, 1999). Beck (2009) remarks at science's propensity to contradict itself, promoting a medication, for example, as beneficial in the present only to remove this endorsement two years later. Finally, disagreement among

scientists, as well as an emphasis on the critique of scientific research has further contributed to the lay public's scepticism of science (Beck, 1992; Petersen, 1996).

Nevertheless, this is in direct contrast to the discussion of my participants, who demonstrated a high regard for science. Chapter Five discussed Douglas' notion that risk arises from a breach of what one perceives to be 'normal'. However, a breach of one's perceived 'normal' does not always result in risk perception. Instead, an individual might adjust their worldview or, alternatively, distort or ignore the breach (Douglas, 1966). Therefore, although three of my participants had *E. coli* in their drinking water supply, for example, they were able to distort this knowledge by suggesting that *E. coli* is not a suitable predictor of health risk for the untreated water consumed by rural residents that have built up an immunity. Similarly, Brandon might deny that water security is a risk in Mid Canterbury by claiming that the evidence thereof has been fabricated.

6.5 Summary

Although Chapter One of this thesis described drinking water self-supplies as unregulated, this chapter has demonstrated that a form of self-regulation takes place as a result of the pressure placed on individuals to take care of themselves and others. Even so, this study suggests that the health risks posed by drinking water self-supplies are greater than the individual can address alone due to the interconnectedness of water resources, which was discussed in Chapter Four. Instead, both the government

and the rural Hinds residents I interviewed recognise the need for a collaborative effort across different groups of society. Integral to the success of this effort is a mutual trust based on consistency, transparency and independence on the part of all stakeholders.

7 Conclusions and Recommendations

7.1 Introduction

This study set out to explore rural people's perspectives on drinking water self-supplies in Hinds, Mid Canterbury. This chapter, drawing on the three preceding discussion chapters, presents a number of conclusions pertaining to rural people's experiences with their drinking water self-supplies, their understanding of the risks thereof, and their perceptions of drinking water quality testing. Several recommendations are made based on these conclusions. These recommendations are made with the public health professional in mind, particularly those who have occasion to be involved with rural drinking water self-supplies.

As discussed in Chapter Three, a qualitative research approach was the most appropriate for addressing my study aim. Having taken this approach, the findings of this thesis are not intended to be generalised to a wider population (Saks & Allsop, 2007). However, while the following conclusions and recommendations are only relevant to my participants and the context in which they were interviewed, there is potential for some of the concepts explored in this thesis to be useful outside the study sample (Bryman, 2008; Green & Thorogood, 2009; Saks & Allsop, 2007).

7.2 Experiences with Drinking Water

The rural Hinds residents I interviewed clearly discussed water in a much wider context than simply their drinking water. A large part of each interview was dedicated to talking about water used for irrigation, livestock and dairy sheds. Rather than dismissing this as irrelevant, this thesis has emphasised the direct and indirect effects of the Hinds area's water resources on drinking water quality and quantity. Not only did my participants use, among other sources, irrigation and dairy shed water for domestic purposes when their drinking water self-supply was unavailable, they spoke at length about the influence of irrigation practices on groundwater and the consequent effect on surface water flows.

Given the interconnectedness of the water resources of the Hinds area, there is an advantage to looking beyond drinking water self-supplies. Public health professionals might design risk communication that addresses water resources as a whole to avoid improvements in drinking water quality and quantity being offset by deterioration in other water resources. Similarly, there is benefit in protecting other water resources that may be accessed for drinking water from time to time.

In the opening chapter of this thesis I proposed that drinking water self-supplies in the rural area surrounding Hinds may present a health risk to the public because they are not formally regulated. However, this thesis has subsequently argued that regulation can be achieved outside the use of legislation. Lupton (1999) proposes that modern society, in its critique of the government's ability to govern everything for the best,

has seen the rise of the self-regulating individual who willingly engages in risk-avoiding behaviours to lower their burden on others and society as a whole. This concept of self-governance was reflected in my participants' sense of responsibility for the management of their drinking water self-supplies.

It is important to note that, in taking responsibility for their drinking water supplies and other water resources, the rural Hinds residents I interviewed were not only protecting their health but also their income and local land values. My participants identified important connections between the quality and quantity of water available and farm productivity and profitability. Poor water quality and quantity were perceived as having a negative effect on farm productivity and profitability, the consequences of which were seen to extend beyond the individual household to the community as a whole.

As Tesh (1988) points out, this drive for productivity and profitability may be viewed as the underlying cause of environmental degradation and, therefore, major societal change is required to prevent and/or mitigate poor water quality and quantity. In contrast, based on my interviews with rural Hinds residents, this thesis suggests that improved productivity and profitability may be incentives to address water quality and quantity issues. Tesh and Williams (1996) propose that public health messages are more likely to be socially accepted if they are aligned with existing societal values and, rather than promoting the health benefits of improving drinking water quality and

safety, public health professionals might appeal to rural Hinds residents' desire to secure their income and protect local land values.

Water quality and quantity are subject to a multitude of influences that, in turn, have effect beyond the individual household. Chapter Six highlights that a collaborative approach is therefore required to address water quality and quantity issues. The government also promotes a collaborative approach to managing water quality and quantity, such as that detailed in the Canterbury Water Management Strategy, which draws on the National and Regional Policy Statements for Freshwater Management.

Bennett et al. (2010) support this notion by pointing out that individuals, while capable of learning technical concepts, cannot be an expert in every field known to humankind. Furthermore, the competing activities of daily living experienced by my participants meant that water quality and quantity were not necessarily their priority all of the time. A collaborative approach may require government involvement but does not necessarily require enforcement through government regulation. Indeed, increased government regulation may serve to undermine self-governance by reducing the sense of individual responsibility.

Although my participants felt a strong sense of responsibility for their drinking water self-supplies, previous research has suggested that non-farming rural residents may not feel the same way (Hu & Morton, 2011; Kite-Powell & Harding, 2006). Only one non-farming rural Hinds resident was included in my study sample. This is unsurprising

given the sociodemographic profile of the rural area surrounding Hinds (Ashburton District Council, 2016). It is thus suggested that future research, which might take place in other rural areas of New Zealand, includes more non-farming rural residents to explore this idea of responsibility further.

Future research might also consider households who are self-supplied water from sources other than bore water. While drinking water self-supplies are predominantly sourced from bore water in the rural area surrounding Hinds, Mid Canterbury, other parts of New Zealand, such as the West Coast, continue to rely on rainwater, for example. The perspectives of residents dependent on different types of drinking water self-supplies may differ from those of the participants in this study.

7.3 Risk Perception and Testing Behaviour

The rural Hinds residents I interviewed defined water quality in much broader terms than those found in the DWSNZ, which largely focus on microbiological and chemical contaminants in drinking water. In addition to contaminants, my participants also considered their health, as well as the aesthetic attributes of the water. On the surface, the different water quality measures drawn on by my participants are not directly comparable to those used by health professionals. For example, my participants' drinking water may have tasted acceptable yet still contained pathogenic microorganisms. Similarly, water containing pathogenic organisms may not have made

my participants ill, however, their visitors or vulnerable individuals such as infants may not have experienced the same outcome.

In saying this, Chapter Five presented arguments from Douglas and Tesh supporting the notion that risk is simply a deviation from what is perceived to be 'normal' or 'natural' (Douglas, 1966; Tesh, 1993). From this perspective, the measures used by my participants and those used by public health professionals are the same: they define the normal or natural state of drinking water quality, whether that be the absence of taste or of *E. coli*. Rather than concluding that public health professionals should include aesthetic attributes in their assessment of water quality, it would be more pertinent that they encourage the routine testing of drinking water self-supplies. The absence of *E. coli* in rural Hinds residents' drinking water self-supplies needs to be constructed as 'normal' or 'natural' before the rural Hinds residents I interviewed will recognise the presence of *E. coli* as a health risk by itself.

None of the rural Hinds residents I interviewed had conducted routine *E. coli* testing of their drinking water self-supplies, although annual testing of dairy shed water did take place for those of my participants that identified as dairy farmers. Therefore, they had limited experience to which they could refer in evaluating the test results presented to them. Instead, those with supplies that tested positive for *E. coli* were sceptical of the results, arguing that they had not experienced any illness attributable to their drinking water self-supply. Indeed, some participants believed their drinking water improved their health in terms of acquired immunity. Future research would benefit from

including individuals who had contracted a waterborne disease from their drinking water, as they may provide a different perspective.

Three of my participants were dependent on self-supplies that had tested positive for *E. coli* in the month preceding the interviews. From a public health perspective, the presence of *E. coli* in drinking water does pose a threat to health. My participants' sense of responsibility for their drinking water supplies encompassed not only caring for themselves but caring for others as well. They demonstrated care where vulnerable groups, such as infants, were concerned and expressed a desire to preserve the area's water resources for future generations. Thus, public health professionals may encourage drinking water testing by also appealing to these values in addition to those discussed above.

That is not to recommend that public health professionals ignore the aesthetic attributes of drinking water altogether. Where required, any proposed treatment options should take into consideration their effect on the taste, odour and colour of drinking water. Treatment systems that impart a taste or odour such as chlorination, for example, are likely to be seen as undesirable by my participants as they alter the perceived normal or natural state of the water. Filtration followed by ultra violet (UV) sterilisation may be a more acceptable solution, however, these treatment systems require significant ongoing maintenance, including the replacement of filter cartridges and lamps, for instance. These activities also take time.

Cost in terms of time was of particular concern to my participants. Chapter Four, drawing on Harvey, explained that the intensity of living and working in modern society means that individuals are increasingly time-poor (Harvey, 1989, 1990). Furthermore, Foucault et al. (1991) and Beck (1992) point out that the more society tries to control risk, the more risks are created and, consequently, the greater the pressure put on an individual's time in an attempt to manage those risks.

Public health professionals, in encouraging rural Hinds residents to test and treat, as necessary, their drinking water self-supplies, must be mindful of the time-cost incurred. This cost could be mitigated by establishing relationships with external providers of drinking water testing and treatment services from which individual rural households can purchase these services. Alternatively, where these services do not exist, it may be in the interest of a public health unit to establish and provide such services themselves on a cost recovery basis.

The rural Hinds residents I interviewed discussed community members as sources of information and support with regards to their drinking water, however, those resources existing outside the community such as government agencies and the internet were rarely accessed. This is in line with research by Stebbing et al. (2013), which suggests that, where their drinking water is concerned, rural residents distrust people and organisations who are not part of the local community. Therefore, uptake of testing and treatment services may be greater where the provider is based in the community they serve. It is recommended that public health professionals first look

within the community for providers of these services. Based on my interviews with rural Hinds residents and supported by theoretical insights provided by Bennett et al. (2010), trust may be further developed through consistency, transparency and independence on the part of public health professionals, but also other stakeholders, including rural residents dependent on drinking water self-supplies.

7.4 Summary

Rural residents' perceptions of drinking water quality and safety are complex and embedded in their social and environmental context. My participants demonstrated an intimate knowledge of the wider water resources of the rural area surrounding Hinds, Mid Canterbury. To these water resources they applied a broad definition of water quality that extended beyond contamination to include health and aesthetic attributes. This definition was reflected in my participants' management of their drinking water self-supplies, a responsibility that was largely borne alone.

It is important to recognise that drinking water quality and safety was just one of a number of competing priorities for my participants and, as such, may benefit from a collaborative effort between rural residents and public health professionals. In promoting drinking water quality and safety, public health professionals may experience greater success in appealing to local values, including the protection of vulnerable populations, the preservation of resources for future generations, and the security of income and land values. Future research might expand on these ideas by

including non-farming rural residents in other areas of New Zealand, as well as those residents who have contracted a waterborne disease from their drinking water, or are dependent on a different type of drinking water self-supply as their perspectives may differ from those of the participants in this study.

Appendix 1 Search Strategy

Web of Science Core Collection

Key Words

Rural	Water	Risk*	Perception*
Farm*		Quality	Perceive*
Zealand		Disease*	Attitude*
		Illness	Understand*
			Communicat*
			Priorit*

Date Range: 2004 – 2016

Limited to: Science Citation Index Expanded, Social Sciences Citation Index, and Arts & Humanities Citation Index.

Google Scholar

Key Words

Rural	“Drinking water”	“Risk perception”	Perception
Private	“Well stewardship”	“Risk communication”	Perceive
Zealand	“Private well”	Quality	Attitude*
	Supply	Microb*	Understand*
		Risk	Communicat*
		Infect*	Priorit*

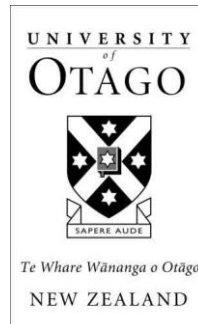
Date range: 2004 – 2016

Limited to: Articles

Appendix 2 Participant Information and Consent Sheets

[Reference Number: **D14/103**]

[April 2014]



Both sides of the story: understanding the risks of drinking water self-supplies from the perspective of rural people.

INFORMATION SHEET FOR PARTICIPANTS

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you and we thank you for considering our request.

What is the Aim of the Project?

This project is being undertaken as part of the requirements for Alexandra Sullivan's Master of Public Health degree. The aim of this project is to explore rural people's perspectives on drinking water self-supplies in Hinds, Mid Canterbury. This includes rural people's experiences with their drinking water supplies, their understanding of the risks associated with their drinking water supplies, and their perceptions of drinking water quality testing. The study's findings may contribute to better understanding among public health staff dealing with drinking water issues of how rural people perceive the risks associated with their drinking water.

What Types of Participants are being sought?

You, as a resident of the rural area surrounding Hinds, Mid Canterbury, have been invited to participate in this research project. Twelve to fifteen participants who are responsible for and dependent on a drinking water self-supply (e.g. private well, rain water collection) are being sought. This includes males and females, dairy and non-dairy farm residents. You must be over 18 years of age to participate. You will be offered a 30 dollar voucher for participating in the study. In addition, your water supply will be tested for bacteria as part of the study.

What will Participants be asked to do?

Should you agree to take part in this project, you will be asked to participate in two face-to-face interviews with Alexandra Sullivan. A time commitment of approximately one hour per interview will be required. A drinking water sample will be taken from your home and sent to an accredited laboratory where it will be tested for the presence of the bacterium *Escherichia coli*. Should *E. coli* be detected in your drinking water supply, you will be provided with information to help you to manage the situation.

Please be aware that you may decide not to take part in the project without any disadvantage to yourself.

What Data or Information will be collected and what use will be made of it?

All information will be collected primarily to fulfil the requirements of Alexandra Sullivan's Master of Public Health degree. While each interview will be audiotaped and transcribed by Alexandra Sullivan, her supervisors from the University of Otago, Christchurch and advisors from Community and Public Health, Christchurch may also have access to the data. In addition, data from the drinking water quality test results will be available to the aforementioned parties as well as the testing laboratory.

The data collected, including transcriptions and drinking water quality test results, will be securely stored in such a way that only those mentioned above will be able to gain access to it. Data obtained as a result of the research will be retained for **at least five years** in secure storage. Any personal information held on the participants, including audiotapes, may be destroyed at the completion of the research even though the data derived from the research will, in most cases, be kept for much longer or possibly indefinitely.

Key themes and supporting quotes identified from the collected data will be presented in the completed thesis. This may be published and will be available in the University of Otago Library, Dunedin, New Zealand but every attempt will be made to preserve your anonymity. A copy of the completed thesis will be made available to you at your request.

This project involves an open-questioning technique. The general line of questioning focuses on your experiences with your drinking water supply, your understanding of the risks associated with your drinking water supply, and your perceptions of drinking water quality testing. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the Department of Population Health is aware of the general areas to be explored in the interview, the Committee has not been able to review the precise questions to be used.

In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question(s).

Can Participants change their mind and withdraw from the project?

You may withdraw from participation in the project at any time and without any disadvantage to yourself.

What if Participants have any Questions?

If you have any questions about our project, either now or in the future, please feel free to contact either:-

Alexandra Sullivan

and

Cheryl Brunton

Department of Population Health

Department of Population Health

Ph. 027 3450710

Ph. 03 3641777

sulal857@student.otago.ac.nz

cheryl.brunton@cdhb.health.nz

This study has been approved by the Department stated above. However, if you have any concerns about the ethical conduct of the research you may contact the University of Otago Human Ethics Committee through the Human Ethics Committee Administrator (ph 03 479-8256). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

Both sides of the story: understanding the risks of drinking water self-supplies from the perspective of rural people.

CONSENT FORM FOR PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:-

1. My participation in the project is entirely voluntary;
2. I am free to withdraw from the project at any time without any disadvantage;
3. Personal identifying information, including audiotapes, will be destroyed at the conclusion of the project but any raw data on which the results of the project depend, including transcripts and drinking water quality test results, will be retained in secure storage for at least five years;
4. This project involves an open-questioning technique. The general line of questioning focuses on my experiences with my drinking water supply, my understanding of the risks associated with my drinking water supply, and my perceptions of drinking water quality testing. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops and that in the event that the line of questioning develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s) and/or may withdraw from the project without any disadvantage of any kind;
5. Should *E. coli* be detected in my drinking water supply, I will be provided with information to manage the situation;
6. I understand that I will be given a \$30 voucher for participating in the study. In addition, my drinking water supply will be tested for bacteria as part of the study;
7. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve my anonymity.

I agree to take part in this project.

.....
(Signature of participant)

.....
(Date)

.....
(Printed Name)

Appendix 3 Interview Guide

Opening question

Tell me about your drinking water...

Key topics

Knowledge (belief)

Source, Treatment, Maintenance, Testing, Pollution sources, 'Bugs', Taste, Smell, Clarity, Illness, Immunity, Amount of water, Water use, Physical barriers

- 'Clean' vs. 'Polluted' drinking water
- Drinking water quality vs. safety
- Water (in)security

Community & individual access

Health services, Laboratory, Information, Time/Money/Effort, Equal access, Convenience, Visitors, Independence/Self-contained

- Quality/safety/quantity drinking water
- Support networks

Responsibility & control

Regulations, Treatment, Maintenance, Testing, Trust, Outsiders, Information, Technology, Pollution, Human rights, Accountability, Requirement, Moral obligation, Standards, Dairy company, Owner

- Role of the (lay) individual + Neighbours
- Role of the State
- Role of industry
- Role of science/'experts'

Is there anything else you would like to add?

Drinking water quality test results

(Other people's results)

What do your drinking water test results mean to you?

Is there anything else you would like to add?

Demographics

Gender Male/Female

Ethnicity European/Maori/Pacific Peoples/Asian/Other (*specify*) _____

Age <20 yrs/20-29 yrs/30-39 years/40-49 yrs/50-59 yrs/60-64yrs /65+ yrs

Occupation (*specify*) _____

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