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“We can’t manage what we don’t measure”:

**Co-producing people and water with New Zealand’s Resource
Management (Measurement and Reporting of Water Takes)
Regulations 2010**

A thesis
submitted in partial fulfilment
of the requirements for the Degree of
Master of Natural Resource Management and Ecological Engineering

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by
Fiona Myles

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Abstract of a thesis submitted in partial fulfilment of the
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As in many other parts of the world, freshwater resources have become under increasing pressure in New Zealand. In Canterbury, where 60% of the total volume of freshwater for consumptive use in the country is allocated, the increasing demand for water amongst competing users has resulted in freshwater management becoming highly contentious. This study examines the role that the introduction of a new standard of quantification (the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010) has played in reconfiguring the relationships that have underpinned freshwater management in the region in the past. The conceptual analytical framework of co-production, and its common pathways of making identities, discourses, representations, and institutions are utilised to reveal how the new standard has altered these relations. It is concluded that the symmetry and filtering capacity of the Regulations has reconfigured the co-production of natural and social orders, and that the form that the new configurations have taken has been shaped by the power and control, the path dependence, and the network of supporting standards, of the new regulations. Although, the introduction of these regulations has been widely supported, it is considered unlikely that they will reduce the existing sources of contention in freshwater management in Canterbury significantly.

Keywords: co-production, standards, regulation, freshwater resource management, Rakaia-Selwyn, Canterbury.

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Chapter 1

Introduction

In November 2010, the Resource Management (Measurement and Reporting of Water Takes) Regulations (the Regulations) came into force in New Zealand within the existing framework of the Resource Management Act 1991 (RMA). For the first time, these regulations require all those who hold permits to abstract and consume freshwater over a specified threshold to measure and report their actual water consumption. These Regulations have been developed as a tool to assist with the long term planning and management of New Zealand's freshwater resources (MfE, 2013c).

The Regulations are being implemented in three stages, the first of which had a deadline of 10 November 2012, with the later stages having deadlines in November 2014 and November 2016. Although the Regulations have only been partially implemented, the first stage of implementation accounts for nearly 90% of all allocated water in Canterbury. It is intended that by investigating the implementation of the Regulations at this early stage, the findings of this research will be useful for the future implementation of the water metering programme. Furthermore, the experiences in Australia following the introduction of similar requirements for accurate water measurement (Collett, 2010) provide a useful insight into the consequences that may arise here as the implementation of the Regulations progresses.

The Regulations are a form of standard in that they provide a set of rules to which the actors involved must adhere. These rules facilitate and constrain behaviours and practices to particular, accepted ways. Standards of this form are ubiquitous in modern life, embedded within social norms and technologies, as well as the relationships between the two (Bowker & Star, 2000; Busch, 2010, 2011; Star & Lampland, 2009). Although standards most obviously apply to people and technologies (through laws, regulations, industry standards for example), in reality, nature is also subject to standards. For example, our understanding of nature typically arises out of the highly standardised scientific process, whereby the environment becomes known through the (often standardised) interpretation of a collection of measured and categorised data, usually obtained via standardised methods. Standards are therefore a mode through which both the social and natural are constructed.

This research investigates the challenges that have arisen out of the implementation of the Regulations, as an example of the introduction of a standard being introduced into a previously rule-free area. Sheila Jasanoff's critical co-production conceptual framework is used to examine the role that standards play in creating or altering the previously taken for granted relationships between

natural and social systems. This analysis will also identify potential implications and consequences (intended and unintended) for freshwater management heading into the future as a result of the introduction of the Regulations.

1.1 The Regulations

The Regulations (included in Appendix A) apply to all water permits (commonly referred to as resource consents) that allow for water to be drawn at a rate of greater than five litres/second with the exception of cases where water is drawn for non-consumptive purposes (i.e. cases where water is returned to the same water body at or near the point of abstraction, with no significant time delay) (reg 4). This therefore includes most uses for fresh water including irrigation, drinking water supply and industrial uses, whilst excluding major non-consumptive uses such as hydro-power generation.

For those water permits to which the Regulations apply, it is required that records be kept demonstrating a continuous measurement of the water taken over time, including periods when no water is taken and periods when water is taken in excess of the permit conditions. These records must be kept in a format deemed suitable for auditing by the regional council that has granted the water permit. In most cases the records must state the volume taken on a daily basis, but in some circumstances where this is inappropriate, regional council may grant approval for weekly recordings to be taken.

The device or system used to monitor the water taken must measure the volume of water taken to within $\pm 5\%$ for water abstracted using a pressured pipe system, though a lesser accuracy of $\pm 10\%$ is acceptable for non-pressure flow conditions (e.g. an open channel, race, or partially full pipe driven by gravity). The Regulations also require that the device or system must be verified in situ as meeting this level of accuracy by a suitably qualified person (reg 6(6)).

To assist with the implementation of the Regulations to existing water permits, a staged, transitional approach has been taken, based on the abstraction rate of the permits. The Regulations apply to all permits allowing abstraction in excess of 20 litres/second from November 2012. But the Regulations do not commence for permits allowing lower rates of abstraction until November 2014 (abstraction permits between 10 and 20 litres/second) and 2016 (permits of less than 10 litres/second). Therefore at this stage, only the largest of the existing permits and any water permits granted since the commencement of the Regulations in 2010 are currently required to meet the requirements of the Regulations, though it is expected that some water users with permits meeting the lower thresholds will also have implemented the Regulations as pre-emptive measures.

1.2 The Regulations as a case study

Standards, both formal and informal, largely govern how the world exists in that they “shape not only the physical world around us but our social lives and even our very selves” (Busch, 2011, p. 2). They are embodied within the technologies, conventions and infrastructure that allows for society to function in the way that it does (Busch, 2000, 2011; Star & Lampland, 2009).

As stated, the Regulations are a standard that must be met by permit holders. Nested within this standard is a vast range of other, interlocking and interrelated standards. Some exist as a result of prior processes, and some have developed alongside the new Regulations. While they are not specifically referred to within the Regulations, these standards are necessary for the effective implementation and operation of the Regulations. For example, standards are embodied within the technology used for the measurement of water (the dimensions and construction materials of a gauging control section of an open channel system, or the components used to construct a water meter for a pipe section), and there are standards for the installation of each piece of measurement technology to ensure it performs as intended by the manufacturer (Myles, Mahalingam, Beech, & Strang, 2011). To ensure that the flow data produced as a result of the Regulations is useful, each permit holder must also report their flow data in a standardised manner. Furthermore, it will be necessary to develop additional standards in the future to address the effects and consequences, perhaps unforeseen or unintended, of the implementation of the Regulations.

Standards are a social phenomenon applied to people and objects: “standards are always relative to the infrastructure within/upon/sometimes against which they are implemented” (Star & Lampland, 2009, p. 7). According to Jasanoff (2004b), society’s understanding of the environment is a socio-cultural product derived from the highly standardised practices, processes and methods of science and the deployment of technologies in developing this knowledge. The focus of this research is the role that standards play in the socio-cultural process of the co-production of nature and society. Jasanoff describes the parallel development and ordering of nature and society as “shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it” (Jasanoff, 2004a, p. 2).

The Regulations provide a case for developing an understanding of the role that standards (both the Regulations and those invoked and nested within them) play in the ordering of our natural and social systems. Co-production offers a suitable frame through which to view the case study by improving “explanatory power by thinking of natural and social orders as being produced together” (Jasanoff, 2004a, p. 2). The case study will focus on the agricultural sector (as opposed to other water users, such as industry) as this is where the impacts of the Regulations are likely to have the greatest impact, because it is an area previously subject to a much lesser level of regulation (or

standardisation) with regard to freshwater use. The research will be conducted in a sub-section of Canterbury, the Rakaia-Selwyn Groundwater Allocation Zone (RSGAZ), as an area representative of the wider region.

1.3 Purpose of this research

The aim of this research is to evaluate the potential implications of the introduction of the Regulations for freshwater resources in Canterbury in the future and to understand how they might influence the long term management of these resources in Canterbury. To achieve this aim, the research objectives are to:

- a) Examine how the Regulations have disrupted and reconfigured established social norms and understandings of the environment, and thus, their role in creating instability and re-ordering of social and natural systems;
- b) Identify the consequences (both intended and unintended) of the Regulations and the challenges in their implementation.

In order to meet the objectives of this research, the following research question has been used as a guide:

- What role have the Regulations played in reconfiguring previously taken for granted relationships that underpin freshwater management in Canterbury?

1.4 Structure of this thesis

Chapter 2 outlines a summary of the relevant literature, providing detailed background information into the management of freshwater resources in Canterbury and the context surrounding the introduction of the Regulations. The introduction of accurate water metering, similar to what the Regulations require, in northern Victoria, Australia is then discussed.

The theoretical framework used in this research is outlined in Chapter 3. This includes a brief summary of the literature regarding the role of quantification and numbers in modern society, an introduction to the conceptual framework of co-production, and the theory of standards. Chapter 4 returns the research aims and objectives, and outlines the methodology that has been used in this study. It provides justification for the case that has been used and discusses the ethical considerations that have been taken into account during the research.

The results of my study are described in Chapter 5. These results are then discussed in Chapter 6 and linked to the theoretical framework outlined in Chapter 3, as well as in relation to the context of

freshwater management in Canterbury. The final section, Chapter 7, will provide a summary of the study, draw conclusions and reflect upon the limitations of the research and future research direction.

Chapter 2

Literature Review

2.1 Introduction

As in many parts of the world, the sustainable management of freshwater resources in New Zealand is becoming an increasingly significant issue (Lennox, Proctor, & Russell, 2011). The continued success of New Zealand is heavily dependent on these resources as the primary sector makes up a major portion of the country's total export income, and this is expected to grow in the future (PCE, 2013) . However, due to the many competing users for these resources, freshwater has become a subject characterised by conflict, particularly in the region of Canterbury.

In this section, I provide a review of the current literature surrounding freshwater management in New Zealand and Canterbury to explore the circumstances under which the Regulations were introduced. Literature originating from Australia is also examined, to provide an international context to this research.

2.2 Background

2.2.1 Freshwater resources in Canterbury and their management

The Canterbury region, located on the east coast of New Zealand's South Island, has a wealth of freshwater resources despite having a relatively dry climate. Large snow-melt fed alpine rivers, rivers fed by rainfall in the foothills of the Southern Alps, and lowland spring-fed streams are all connected by a complex network of aquifers at a variety of depths (Creech, Jenkins, Hill, & Low, 2010; Duncan, 2013; Gunningham, 2011b; Jenkins, 2007; Weber, Memon, & Painter, 2011) . These same water resources have shaped the landscape, creating expansive plains on which agricultural production is centred.

However, over the past 20 years the demand for water has risen dramatically as agricultural production in the region has shifted from the traditional dryland farms (mainly sheep and beef production) of the past, to the much more profitable and water intensive land uses such as dairying, which rely on irrigation (Jenkins, 2007; PCE, 2013; Weber et al., 2011). The Canterbury region alone now accounts for 60% of all freshwater allocated for consumptive use and contains 70% of the irrigated land in New Zealand (Gunningham, 2011b; Jenkins, 2007; Weber et al., 2011). Furthermore, approximately 90% of all water allocated for consumptive use within Canterbury is used for irrigation, and the area of land in the region under irrigation is expected to continue to expand (Jenkins, 2007; PCE, 2013).

The management of freshwater resources in New Zealand relies on the legislative basis provided by the Resource Management Act 1991 (RMA), under which the primary responsibility for managing natural resources such as freshwater lies with regional councils (Gunningham, 2008; Lennox et al., 2011). Although initially welcomed as a novel way of managing land, water, soil and air in an integrated manner, in time the RMA has come to be criticised for having too narrow a focus on effects, and in many respects, failing to achieve its overarching aim of sustainable resource management (Gunningham, 2008; Lennox et al., 2011). The deficiencies of the RMA have become particularly apparent in the management of freshwater resources where key stakeholders have expressed concern about the “adversarial, costly, and time consuming planning processes” associated with the Act (Lomax, Memon, & Painter, 2010, p. 3).

Under the RMA, regional councils have two primary mechanisms for allocating and managing freshwater resources: regional plans and water permits, commonly referred to as resource consents. The Canterbury Regional Council, known as Environment Canterbury (ECan) only introduced a regional plan in 2004, and as a result, the allocation and management of resources in the region has relied heavily on the use of resource consents (Gunningham, 2008; Lennox et al., 2011). This has led to a system of allocation of freshwater resources based on the principle of first-come-first-served (Gunningham, 2008; Jenkins, 2007).

Given the rapid increase in demand for water resources in Canterbury over the past 20 years by multiple and competing uses, it is unsurprising that the allocation and management of freshwater resources in the region has become highly contested (Gunningham, 2008; Lennox et al., 2011; Lomax et al., 2010). With irrigation the reason behind the vast majority of applications for water resource consents, “agriculture is a major driver of water allocation and quality concerns in the region” (Lomax et al., 2010, p. 25).

2.2.2 The need for more information to address current issues

The failings of the tools available under the RMA to effectively manage Canterbury’s freshwater resources and the conflict that have arisen as a result have motivated a change in governance approach. The Canterbury Water Management Strategy (CWMS) is a non-statutory, collaborative planning process begun in 2008, following on from a series of related projects initiated in 1998. It is intended to address the long-standing issues within freshwater resource management in Canterbury (Duncan, 2013; Lennox et al., 2011; Lomax et al., 2010; Memon, Painter, & Weber, 2010). During the early consultation carried for the CWMS, a key concern raised was the lack of accurate information regarding the actual water use within Canterbury. For water resources to be managed effectively it was therefore considered necessary to “undertake new science and metering initiatives in order to produce more and better information about water resources and hydrogeology (groundwater) in

particular” (Weber et al., 2011, p. 52). The need for consistent collection of data has also been stated as necessary by the Land and Water Forum (Land and Water Forum, 2010).

One of the sources of contention surrounding freshwater in Canterbury has stemmed from the inability for stakeholders to agree on the science used to inform resource management decision making. Two predictive models have been developed to describe the hydrogeological characteristics of the region, each with supporters and detractors (Weber et al., 2011). ECan, along with many environmentalists has favoured the ‘bathtub’ model which projects the resources as a highly integrated whole, where withdrawal at any location will have an immediate effect on the water level everywhere. This model assumes that the series of aquifers under the Canterbury Plains have a high degree of connectivity. Many farmers, irrigators and developers meanwhile favour the ‘Aqualinc’ model which suggests that the presence of impermeable layers greatly reduces the connectivity of aquifers, thus impacts from withdrawal of water will not automatically be widely felt. As the research of Weber et al. (2011) shows, many of the stakeholders believe that improved monitoring (such as water metering) is the only way to move forward from this ‘science impasse’, as each side wants their chosen model to be the one that guides future water management policy decisions.

This void in the information available to inform models is a result of a lack of monitoring of resource consents once they had been granted. Gunningham (2011b) argues that the lack of effective water measurement has made it very difficult for ECan to estimate how much allocated water is being consumed “in aggregate” (p. 45), contributing to the lack of certainty around allocation of freshwater resources in Canterbury. It was not until 2004 that ECan began to require the metering of water takes as a standard condition on water permits (Gunningham, 2008). However, even with this requirement implemented, in 2008 when the CWMS was initiated the vast majority of the estimated 18,000 water takes in Canterbury remained unmonitored. This was due to the inability for ECan to apply new conditions to existing water permits, unless the permit holder applied for the existing conditions to be altered or the permit had lapsed and was subject to an application for renewal. Water permits in Canterbury have traditionally been granted for long time periods, often 35 years, in reflection of the significant financial investment required in developing irrigation infrastructure (Gunningham, 2011b). The slow turnover of consents is considered one of the key barriers to implementing water measurement on a region-wide scale through the resource consenting process.

2.2.3 The review of consents in the Rakaia-Selwyn Groundwater Allocation Zone

The increase in demand for water resources during the late 1990s and 2000s saw a large increase in the number of water resource consents and the total volume of allocated water across Canterbury (Jenkins, 2007). By the mid-2000s, many of the groundwater catchments in central Canterbury had been classified as ‘red’ zones where the volume of allocated water within the catchment exceeds the

volume considered by ECan to be the upper limit for maintaining the long term sustainability of the resource (Environment Canterbury Groundwater Resources, 2012). The increase in water abstraction coincided with a period of drier than average years between the late 1990s and 2007, resulting in the spring-fed lowland streams suffering from low or no flow for prolonged periods (Jenkins, 2007; Weber et al., 2011).

The Rakaia-Selwyn groundwater allocation zone (RSGAZ), as it is defined in the Proposed Natural Resources Regional Plan (PNRRP), is such a catchment and has been classified as a 'red' zone since 2004 (Environment Canterbury Groundwater Resources, 2012). In response to this designated over-allocation, as well as concern about degradation of the lowland streams in the area, ECan announced its Restorative Programme for Lowland Streams in 2006. The aim of this programme was to increase flows in lowland streams to improve their ability to support aquatic ecosystems, and to improve the reliability of supply for water users (Williams, 2006). To help meet these goals ECan further announced that it would review the conditions on 523 water permits to abstract water from the RSGAZ (Canterbury Regional Council, 2010).

The review process was directed towards achieving three primary outcomes for the water permits in the RSGAZ, including:

- The inclusion of an annual limit on total water abstracted;
- The provision of water metering to enable actual water use to be quantified; and
- Restrictions on abstractions directly linked to surface water flows during low flow conditions (Williams, 2006).

A fourth outcome, the ability to vary seasonal limits based on the abundance of the groundwater resource (referred to as 'adaptive management' by ECan), was also intended to be included in the review process (Williams, 2006). However future management approaches such as adaptive management were later considered to be outside of the scope of the review (Canterbury Regional Council, 2010).

The hearing process for the review took place during 2009, with hearing commissioners releasing their decision on 12 February 2010 (Canterbury Regional Council, 2010). The review successfully introduced changes to the water permits in the RSGAZ in line with the outcomes stated above, including the requirement for the installation of water meters on abstractions. A set of conditions outlining the specifics of how water metering was to be carried out was developed as part of the review based on different abstraction conditions, as summarised in Table 2.1 below.

Table 2.1 Summary of resource consent metering requirements following the consent review.

Abstraction Condition	Metering Requirements	Deadline
Annual vol. $\geq 357,000 \text{ m}^3$	Water metering & recording devices Water use reported monthly	30 September 2010
Annual vol. $< 357,000 \text{ m}^3$ + abstraction rate $\geq 5\text{l/s}$	Water metering with pulse output Water use reported annually	1 September 2011
Annual vol. $< 357,000 \text{ m}^3$ + abstraction rate $< 5\text{l/s}$	Water metering Water use reported annually	1 September 2011
Any permit with a minimum flow condition (i.e. those directly linked to surface water flows)	Water metering & recording devices Water use reported by telemetry	1 September 2011

The RSGAZ was therefore the first catchment in the Canterbury region where all major water takes (those over five litres/second) were to be actively monitored (Canterbury Regional Council, 2010). However, this progress came at a significant price. From the initiation of the programme in 2006, it was close to four years before the final hearing decision was released. Additionally, because ECan had initiated the review of existing consents, it had to bear the majority of the financial costs associated with the process. During this period the relationship between the farmers of the zone and ECan also suffered significantly. Although most of the conflict arose from the proposed restrictions on abstractions, with very few consent holders objecting to the introduction of metering (Canterbury Regional Council, 2010), the costs in terms of both time and money for all parties involved has meant that ECan has not pursued similar processes in any of the other catchments suffering from over-allocation. The introduction of the Regulations was therefore welcomed by ECan as providing a new mechanism under which metering could be implemented region-wide.

2.3 The development of the Regulations

A lack of information on water use was identified as an issue of significance not just in Canterbury, but for the whole of the country. The Ministry for the Environment (MfE) considers knowing when and where freshwater resources are used as critical for ensuring that these resources are managed and allocated amongst competing water users effectively and efficiently (MfE, 2013c). Yet in 2006, MfE estimated that only a third of all allocated water across New Zealand was actively measured (MfE, 2013c). This prompted the development of the Regulations, to ensure that a nationally consistent approach to water measurement was established.

The need for the Regulations was first raised by the last Labour Party led government in power between 1999 and 2008. During this period, the government developed the “Sustainable Water Programme of Action” in response to concerns about the way that freshwater resources were managed (MfE, 2009). By 2006 the government had identified three key instruments considered necessary for improving freshwater management including: a National Policy Statement for

Freshwater Management, a National Environmental Standard on Ecological Flows and Water Levels, and a National Environmental Standard for Measurement of Water Takes (MfE, 2009). However, the change of government that came with the 2008 general election disrupted the development of these proposals into policy.

With the change to a National Party led government in 2008, the “Sustainable Water Programme of Action” morphed into the “Fresh Start for Fresh Water”, with the three existing instruments (described above) providing the basis on which the new strategy was built (MfE, 2011). Within the new framework, the planned policy for the measurement and reporting of water takes was changed in form from a National Environmental Standard to a set of regulations under the RMA, which were instigated relatively quickly after the change of government. In addition to building on the prior work already completed under Labour, the Fresh Start for Fresh Water also saw the development of other initiatives including the Irrigation Acceleration Fund, the Fresh Start for Fresh Water clean-up fund, and the instigation of the Land and Water Forum (LaWF), a stakeholder group tasked with undertaking a collaborative and consensus-based approach to current issues in freshwater management in New Zealand (MfE, 2011).

The Regulations were therefore implemented at a time when freshwater management was subject to significant reforms, creating a wider context of flux. Since the introduction of the Regulations in 2010, the reforming process has continued with the release of the proposals for a National Environmental Standard on Ecological Flows and Water levels, amendments to the RMA, and amendments to the National Policy Statement for Freshwater Management to establish ‘bottom lines’ with the development of a National Objectives Framework. In this context, it is important to examine how the Regulations are being implemented to provide insight for future policy development and implementation.

2.4 Water measurement in New Zealand prior to the Regulations

Water measurement prior to the introduction of the Regulations was focused in specific regions, including the Bay of Plenty, Auckland, Manawatu and Wellington. These regions are characterised by freshwater resources of limited size that are easily stressed (P. Peters, Horizons Regional Council, pers. comm., 13 May 2013; S. Thawley, Greater Wellington Regional Council, pers. comm., 2 May 2013). The competition for the limited resources in these regions created a pressing need for water measurement. For example, in 2003-2004 Horizons Regional Council implemented a programme of supplying and installing telemetry equipment to water users in priority catchments (where competition was greatest), if the users installed their own water measurement device. The telemetry system feeds real-time data about the water use to an online platform (called WaterMatters) where it can be monitored by both council and the water users, enabling water abstraction to be staggered

both spatially and temporally within a catchment to prevent over-abstraction. Although this programme was initially voluntary, many water users in the priority catchments joined as they could see the benefit in having data on water use, particularly for ensuring compliance with permit conditions (P. Peters, Horizons Regional Council, pers. comm., 13 May 2013).

In these regions, water permits are also typically issued for volumes at the lower end of the range (often below the five litres/second threshold of the Regulations) and for relatively short time frames (e.g. five to ten years) as a result of the constraints on freshwater resources (P. Peters, Horizons Regional Council, pers. comm., 13 May 2013; S. Thawley, Greater Wellington Regional Council, pers. comm., 2 May 2013). Permits are also largely issued to discrete individuals, with no large water distribution or irrigation schemes (N. Kumar, Auckland Council, pers. comm., 3 May 2013). The characteristics of the water permits issued in these regions have enabled water measurement to be implemented through the addition of specific conditions within renewed water permits. For example in both Wellington and Auckland regions, water measurement was introduced as a standard water permit condition in the early 2000s as a result of both competition for freshwater resources and the discussion taking place at the national level around the Sustainable Water Programme of Action. Due to the relatively high rate of review and renewal of permits, water measurement had been largely implemented in these regions before the release of the Regulations in 2010 (N. Kumar, Auckland Council, pers. comm., 3 May 2013; S. Thawley, Greater Wellington Regional Council, pers. comm., 2 May 2013).

2.5 International experience in water metering

2.5.1 Experience in Australia

The introduction of the Regulations in New Zealand followed closely behind introduction of similar regulations in Australia. Paragraphs 87 – 89 of the Intergovernmental Agreement on a National Water Initiative (NWI) (Council of Australian Governments, 2004), a national strategy for freshwater management in Australia released in 2004, describes the need for accurate measurement and reporting of water consumption when:

- water entitlements are traded,
- water planning processes identify it as being necessary,
- conflict exists around water resources, or
- the community demands it (Council of Australian Governments, 2004 s 87).

Following on from this, the Department of Sustainability, Environment, Water, Population and Communities developed a National Framework for Non-urban Water Metering Policy in 2009. This document is similar to the Regulations in that it requires water meters to be verified in situ as accurate to within a permissible limit of error, stated as $\pm 5\%$. The responsibility for the implementation of this national policy rests with the state and territorial governments (Department of Sustainability Environment Water Population and Communities, 2009).

Although the Regulations in New Zealand and the National Framework for Non-urban Water Metering Policy in Australia have similarities, one of the key differences is the broader water management context in which they are placed. In Australia, the NWI places emphasis on the need for effective water markets and trading to help drive efficient water use (Council of Australian Governments, 2004), leading to the establishment of a National Water Market as part of water reforms implemented by the Council of Australian Governments (COAG) (Council of Australian Governments, 2012). Freshwater, as a result, is largely treated as a commodity and accurate measurement of water abstraction is therefore necessary for this market to operate in a fair and transparent manner. Currently in New Zealand the trade of water permits is still only on a small scale (Lange, Wood, & Winstanely, n.d.) though there has been much discussion around the potential benefits of introducing more comprehensive water trading, most recently in the reports released by the LaWF (Land and Water Forum, 2012). In addition to the LaWF (2012), others including Lange et al (n.d.), Counsell and Evans (2005), and Gunningham (2011a) consider water trading as a potential mechanism to drive increased water use efficiency and to ensure that water is used in highest value uses. The introduction of the Regulations would appear to remove one of the barriers that currently prevent such a trading system being developed in New Zealand on a large scale, by providing accurate information as to where and when allocated water is used, as well as identifying where it remains unused. However, under the Canterbury Land and Water Regional Plan (successor to the Canterbury Natural Resources Regional Plan) the transfer of water permits will become a restricted discretionary activity and up to 50% of the allocated volume must be surrendered for a transfer to take place (Canterbury Regional Council, 2012). While one barrier to trade may have been removed, the restrictions contained within the Regional Plan could discourage trade and transfer of water permits in Canterbury in the future.

In Australia another key driver for the water reforms of the NWI was the relative scarcity of freshwater resources (Collett, 2010), and the desire to improve water use efficiencies in catchments characterised by over allocation of the available resource (Council of Australian Governments, 2004, s 23). While New Zealand, by comparison has an abundance of freshwater resources, there are still catchments where over-allocation is a significant and increasing issue (Lennox et al., 2011), including the RSGAZ in Canterbury where this research is focused.

A further feature of the Australian NWI was the provision of funding for projects that would improve water use efficiencies, in order to free up water to be set aside for environmental water flows (Collett, 2010; Moore, 2012). This led to the establishment of a number of regional projects, characterised by the installation of technologies that allowed greater accuracy in water measurement and more automation and control over how and when water is used. One such project is the Total Channel Control™ (TCC) system implemented in northern Victoria, a telemetry based system for the management of water in gravity fed irrigation systems where manually operated control structures and Dethridge wheels (supply outlets) were replaced with automated FlumeGate™ technology (Collett, 2010; Cowan, Murdoch, Linehan, & Kaine, 2006). This occurred alongside improvements to the centralised system used by water users to request access to water for irrigation.

Although the irrigators in the scheme already had water measurement devices in place (the existing Dethridge wheels provided a crude estimate of water flow), the move to the highly automated and accurate TCC system still presented challenges for both the water users and the authorities, and unintended but significant consequences arose as a result (Collett, 2010). For example, on examining the human dimensions of the technology (TCC) use and management, Collett (2010) has identified that the negotiation between the water users and the water managers was the critical process for determining the outcome of the implementation of the TCC at the farm scale. He has also identified that a focus of the negotiation on the specifics of the TCC technology (i.e. improved efficiencies through automation) created issues at later stages of the implementation, when it became apparent that these efficiencies could not be proved as an original baseline of water use and water losses had not been negotiated. This led to the original objective of improving water use efficiencies in order to free up water to meet environmental flow limits, to become lost amid an unexpected level of uncertainty, particularly around water losses. The technology, although accurately measuring the water used for irrigation, could not account for what was not there: the large volume of water lost from the system, through often unknown routes (Collett, 2010). Conflict between the water users and the water managers arose as a result, especially when the water managers began to investigate “sneaky stuff” (Collett, 2010, p. 245) carried out by water users, despite these illegal activities being relatively uncommon and contributing very little to the overall water loss issue. This example suggests that an increase in the accuracy of data and the increased scrutiny of the irrigators’ behaviour that this enabled, led to an escalation in disputes in the negotiations between irrigators and the authority.

Unlike the Australian experience, where systems such as the TCC can be seen as a result of improvement or ‘toughening’ of existing water measurement standards, measurement of water use in New Zealand prior to the Regulations has been rare (MfE, 2013c), particularly in Canterbury

(Gunningham, 2011b). The implementation of the Regulations has therefore introduced monitoring into a largely unmonitored area. Furthermore, it is introducing not just monitoring, but accurate measurement as the Regulations state a minimum accuracy (reg 6(6)(a)) and a further requirement that in situ verification of this accuracy must be carried out (reg 7), enabling a high level of scrutiny to occur where there has previously been very little.

The implementation of the TCC technology was a move from an established, low-tech system where each irrigator had adapted to their unique circumstances a simple technology (manually operated Dethridge wheels) to deliver an allocated volume of water, to a high tech, automated system of improved accuracy (Collett, 2010). To provide the accuracy needed to achieve the goal of improved water use efficiencies, the new TCC technology was necessarily highly standardised, with limited capacity for adaptation by individual irrigators. This rigidity of the new standardised technology created a shift and re-ordering of both the social and natural systems. The limited capacity for irrigators to alter the technology meant that winners and losers were created through its introduction. Winners emerged as those whose irrigation and farming circumstances fell within the norm to which the technology applied and were therefore able to gain the full benefits offered by it. Whereas those whose irrigation system was not suited to the new technology became losers, either through the failure of the promised benefits to materialise, or in some cases, the failure of the new system to perform as well as the old system (Collett, 2010).

The TCC technology introduced in northern Victoria, is a highly standardised method of measuring the water distributed amongst competing farmers. Collett (2010) found that the inflexibility of the technology meant that the promised benefits failed to materialise for many of the farmers, with some made significantly worse off. The conflict that arose due to this, was further exacerbated by the failure to negotiate a mutually acceptable baseline to account for water losses and the increase in surveillance of farmers by the water managers. Despite the new technology being highly accurate and standardised, the goal of freeing up water for the environment through improved water use efficiencies essentially became lost in the conflict surrounding the remaining uncertainties, in particular the quantity of 'lost' water.

2.6 Summary

Much work has been done on studying water management worldwide as well as in New Zealand, reflecting the importance of freshwater resources to society (Lennox et al., 2011). This is particularly the case for Canterbury where the region's freshwater resources have become under increasing pressure due to a growth in the number of competing users. As demand for water in Canterbury has continued to increase with the expansion of intensive agriculture, the management of freshwater resources has become highly contested (Gunningham, 2008, 2011b; Jenkins, 2007; Memon et al.,

2010; PCE, 2013; Weber et al., 2011). In light of this conflict, it is perhaps unsurprising that the Regulations and the measurement of the water that they introduce, has been welcomed as a necessary process for driving change to improve how freshwater resources are managed.

The case study of the introduction of the TCC technology in Victoria, Australia has demonstrated how the desired improvements in water use efficiency through the introduction of the highly accurate and automated TCC technology could not be proved sufficiently because no base level for losses had been agreed upon. The seemingly accurate and indisputable number representing water that was used for irrigation by the TCC technology, was therefore subject to dispute because of its inability to quantify or account for the water that wasn't there, that lost through leakage and evaporation (Collett, 2010). The intended consequence of the introduction of the highly standardised TCC technology (improving water use efficiencies) became lost amid the unintended consequence of increased conflict between water users and water managers that occurred as a result. It is feasible to expect that similar issues may arise with the introduction of water measurement in Canterbury as required by the Regulations.

Memon et al. (2010, p. 36) states that "there is a need for improved social understanding of catchment governance focused on context, perceptions and interrelationships amongst and between water user groups, communities, regulators and other stakeholders, and the environments, from place-based, multi-scalar perspectives" in New Zealand. In examining the implementation of the Regulations in detail, this study intends to contribute to meeting this need by exploring the role that standards play in the re-configuration of these relationships.

Chapter 3

Theoretical Framework

In this section the theoretical framework which has been applied in conducting this case study is introduced.

As previously described, freshwater management in Canterbury, is characterised by conflict amongst competing users (Gunningham, 2008, 2011a; Jenkins, 2007). Improving the science through better monitoring, of which the Regulations are a part, is considered by many to be the best way to reduce the contention and improve the management of these freshwater resources. However, as Weber et al. (2011) argue, focussing exclusively on improving the science is unlikely to resolve the existing conflict as it will do nothing to address the low levels in trust between the actors. This chapter begins by expanding on this idea with an introduction to the literature on quantification and the use of numbers in public policy. This is followed by an overview of co-production which has been used as a conceptual framework in this study. The chapter is concluded with a description of the common characteristics of standards.

The theory of co-production embodies the idea that “the social and the natural are seen to intertwine in ways that make their separation – either in thought or practice – impossible” (Castree, 2001, p. 3). Therefore natural and social orders can be thought of as being produced simultaneously, acting either towards stability or change. Standardisation through the use of standards and regulations is a practice of governance used to order both society and our understanding of natural systems. They do this by helping to convert “the messy realities of people’s personal attributes and behaviours into the objective, traceable language of numbers” (Jasanoff, 2004b, p. 27). Thus, closer examination of the use of standards through the co-production lens should help to clarify how the process of standardisation reconfigures not only the social order, but also the order of nature.

3.1 Quantification and the use of numbers

Knowing how much water is being consumed is considered essential for effectively managing the fresh water resources of the Canterbury region (Gunningham, 2008; Weber et al., 2011). However, with over 18,000 water takes across the region, it is far from feasible for each one to be measured continuously by a person. As Latour (1992) describes in his analysis of a door groom (automatic door closing mechanism), even if you could find the necessary number of people to perform the measuring function, people are erratic in their behaviour and there would be no guarantee that all of the measurements would be taken or be of the same quality. When faced with this issue, it is necessary “either to discipline the people or to *substitute* for the unreliable humans a *delegated*

nonhuman character whose only function” is to perform the required task (Latour, 1992, p. 231). The Regulations aim to do just this by bypassing the need for people to measure water use and relying on the technology of flow meters and data loggers to perform the function instead. This also serves an additional purpose in keeping the measurements objective, as the technology is assumed to be free of the values that influence the behaviour of people (Latour, 1992).

The use of technology in this way is common place throughout society, although Wynne (1988) notes that “a formal public image of technology as mechanical, rule-following behaviour belies a far less clearly rule-bound and determined world of real technological practices” (p. 148). Although technology might be deemed to be value free, it is people that implement and ultimately use it to meet their needs. In adapting a relatively rigid technology to the variety of contexts in which it must operate, a balance must be struck between enabling it to meet the needs of a specific context and the ability to be used across a broad range of differing contexts (universality). The Regulations, for instance, must be broad enough to encompass the majority of different environments that exist across New Zealand. But in each location, there may exist specific conditions to which the technology must be adapted in order to fulfil its function in accordance with the requirements of the Regulations. Technology therefore only appears to rigidly follow rules, whereas in reality:

The operating rules of technologies are an ad hoc brew of informal modes accommodating imprecise general principles to particular circumstances of implementation. These practical rules are more complex, ambiguous and very different from the neat, rule-bound image of technology projected in public (Wynne, 1988, p. 149).

However, despite the best efforts to produce an objective measure of water abstraction through the use of non-human agents (meters and data loggers), the very act of quantification and assigning a number to something alters the way that we view it (Porter, 1996). Stone (1997) describes how the use of numbers to define and describe society is pervasive in contemporary culture and notes that “we do not measure things except when we want to change them or change our behaviour in response to them” (p. 167). Measurement is a common tool used to define a policy problem and numbers are typically invoked in order to give legitimacy to an opinion or policy. This legitimacy is valuable as whenever there is agitation for change, conflict is bound to arise between those who value the status quo and those who desire change, or over which direction or form any change should take. The legitimacy of numbers is therefore dependent on the existence of adequately uniform methods for quantification (Porter, 1996).

Yet although “numbers offer the promise of conflict resolution through arithmetic” (Stone, 1997, p. 174), they remain malleable and open to manipulation to suit different ends, even when they have been obtained via standardised quantification processes. All counting requires the use of judgement

and discretion as the act of quantifying relies on the creation of boundaries and criteria to determine what is to be included, and what is to be left out (Stone, 1997). As with technology, numbers therefore give a powerful impression of precision, accuracy and objectivity, but in reality, they can be simultaneously weak and open to dispute (Porter, 1996; Stone, 1997). For example, Stone (1997) describes how unemployment figures can be altered to suit political motives by manipulating the categories that are included in the count: excluding those who are not actively seeking work reduces the number of unemployed which could be used to indicate no significant problem exists, whereas including these people in the count may be useful for justifying that a problem does exist.

This ambiguity of numbers arises especially when measuring people and social phenomena, “because people, unlike rocks, respond to being measured” (Stone, 1997, p. 177). This reactivity exists amongst organisations as much as with individuals and is a result of human nature: people will always want their measurements to fit within the desirable norms and the perceived expectations of others (Stone, 1997). While reactivity is not a deliberate attempt to maliciously manipulate measurements, it is unavoidable and it is also in conflict with the principles of scientific practice and the ideals of objectivity under which most measurement is assumed to occur. In addition to reactivity, measurement also increases awareness of whatever it is that is being measured, and as the measurements are typically used to inform the direction of change, the measurers have a degree of power over those who are measured (Stone, 1997). This can motivate people to cheat or deceive the measurers in an attempt to get the outcome they desire. Minimising the risk of deception typically involves the use of standardised measurement methods, supported by a framework of scrutiny and authority:

Where there is incentive to deceive, the job of keeping the numbers honest will depend on ever more detailed regulations, and of spies and auditors who are in a position to examine things in relatively full detail. This means opening black boxes, thus compromising those key virtues of detachment and economy that made the numbers valuable in the first place (Porter, 1996, p. 50).

Measurement and the numbers it produces have become a dominant means of describing the world, particularly in the domain of public policy, where numbers offer legitimacy to decisions. However, although the technologies used in measurement and the numbers produced as a result are perceived to be value free and objective, in reality, they always reflect the values of those doing the measuring and those being measured. They are therefore always open to interpretation and manipulation: “numbers are always descriptions of the world, and as descriptions, they are no more real than the visions of poems or paintings” (Stone, 1997, p. 187).

As Stone (1997) reflects, it is assumed that numbers will provide proof that a connection exists between a human action and a problem, in this case the abstraction of water for irrigation in

Canterbury is having detrimental environmental effects, or not. Those studying the use of technologies and measurement in society consider that numbers are frequently not as objective and indisputable as they at first appear, but are open to interpretation and manipulation by those seeking to use them (Latour, 1992; Porter, 1996; Stone, 1997; Wynne, 1988). This is despite efforts such as the use of standardised quantification practices, intended to increase their legitimacy.

3.2 The co-production conceptual framework

Co-production is a theoretical framework that has been developed from the field of science and technology studies (S&TS) to help overcome some of the perceived shortcomings of other disciplines in describing and interpreting complex emerging and controversial phenomena. In *States of Knowledge: The Co-production of Science and Social Order*, Jasanoff (2004c) argues that “we gain explanatory power by thinking of natural and social orders as being produced together” (p. 2). In other words, science, society, culture and politics simultaneously embody and influence each other (Swedlow, 2011). Within the conceptual framework of co-production, science is “understood as neither a simple reflection of the truth about nature nor an epiphenomenon of social and political interests” (Jasanoff, 2004a, p. 3). Rather, scientific knowledge and technology are products of the interconnectedness of nature and society, with each enacting the reality of the other. The resulting orderings of nature and society act to orient each other towards either stability or change (Jasanoff, 2004b). As such, within the co-production framework the apparent separation of facts (nature) from values (culture) is something to be scrutinised rather than something to be accepted as a true representation of the world (Duncan, 2013).

Within the co-production framework, Jasanoff and many of the contributors to her book emphasise the importance of politics, specifically through understanding how “knowledge-making is incorporated into practices of state-making, or of governance more broadly” (Jasanoff, 2004a, p. 3) and vice versa. In other words, co-production can be useful for identifying not only how knowledge and its production influence the distribution of power within science, and socio-political orders, but also how the practices of governance influence the creation and use of knowledge. Co-production therefore sits well within the focus areas of S&TS, namely, the emergence of new phenomena, conflict resolution, the standardisation of knowledge and technology, and, the enculturation of science (Jasanoff, 2004a). Jasanoff states that within S&TS, co-production occurs along four distinct pathways: making identities, making institutions, making discourses, and making representations (Jasanoff, 2004a). She goes on to argue that these four pathways can help to link S&TS work with other disciplines in social analysis (Jasanoff, 2004a).

However, Jasanoff (2004a) does not consider co-production to be a comprehensive theoretical framework but rather an “idiom” that can provide greater interpretative power for understanding

complex phenomena. She argues that it can “be seen as a critique of the realist ideology that persistently separates the domains of nature, facts, objects, reason and policy from those of culture, values, subjectivity, emotion and politics” (Jasanoff, 2004a, p. 3). The lack of a defined co-production theory has been identified as a limitation to the explanatory and, in particular, the predictive power, of co-production in application (Swedlow, 2011). It also creates difficulty in describing the processes attributed to co-production as they are open to interpretation by the individual researcher (Kemp & Rotmans, 2009). However, despite these limitations, co-production is considered useful for providing a richness of description when investigating how science and socio-political orders are arranged and interwoven together (Jasanoff, 2004a). Its aim “is not to provide deterministic causal explanations of the ways in which science and technology influence society, or vice versa ... rather, it is to make available resources for thinking systematically about the processes of sense-making through which human beings come to grips with worlds in which science and technology have become permanent fixtures” (Jasanoff, 2004b, p. 38).

3.2.1 The application of co-production

To date, there is much diversity in the topics that co-production has been applied to, though Jasanoff argues that the topics can be loosely divided into two categories: the constitutive, and the interactional (Jasanoff, 2004a). The constitutive is that which considers the emergence of new socio-technical formations, and the interactional is that which deals with conflicts in existing formations. As a broad discipline that is frequently subject to the emergence of socio-technical formations and characterised by complex or messy problems that encourage conflict, the development of environmental policy is an area that has been scrutinised frequently through the co-production lens (Kemp & Rotmans, 2009; Miller, 2004; Storey, 2004; Swedlow, 2011; Thompson, 2004; W. Tuinstra, 2008; W. Tuinstra, Hordijk, & Kroeze, 2006; Waterton & Wynne, 2004).

3.2.2 Co-production of natural and social order

As previously stated, Jasanoff (2004a) considers that the co-production of natural and social orders occurs along four distinct pathways: the making of identities, institutions, discourses and representations. Through examining these pathways, it is possible to see how social and natural orders have been (or have failed to be) stabilised by what we know and how we know it. However, it is important to note that natural and social orders are not created anew through co-production, but are instead built upon and embed the negotiated outcomes from historical processes of conflict and stabilisation (Reardon, 2001). Thus, the orders of nature and society are always constructed on the basis of past identities, institutions, discourses and representations. In her case study of the Human Genome Diversity Project (HGDP), Reardon (2001) describes how the failure of the project to proceed beyond the planning phase was due to the organisers’ failure to adequately address past

debate around the nature of human differences from either a science (biological/genetic) or societal (race/population) basis. She argues that this prevented new configurations of natural and social order from being developed, as those involved had no past consensus from which to work from.

Making identities

Jasanoff (2004b) describes the process of redefining identities as a common tool used by people to restore a sense of order out of a world in disarray. Co-production can be used to describe how power or meaning comes to be ascribed to an identity. The identity of the expert is one that has been subject to much scrutiny in the past, with the identity often formed around knowledge and knowledge production practices of the experts in question (Carolan, 2006; Dear, 2004; Maiello, Viegas, Frey, & D. Ribeiro, 2013). Co-production thus helps us to understand how the development of knowledge and our understanding of nature, gives power and meaning to social and political identities, such as scientists and experts (Swedlow, 2011).

However, identities can be associated with groups as well as individuals, and these identities are equally open to being challenged and redefined. This can be seen in the case described by Thompson (2004), where a single identity for all African elephants was found to be insufficient for a species that inhabits a large geographical area where a diverse range of cultural attitudes towards the species existed. Enabling effective management of the species required redefinition of a single African identity to many regional identities. These new identities, as described by Thompson (2004), are neither exclusively cultural, nor natural, but both.

Making institutions

Institutions represent stable facilitators of knowledge and power, often looked upon to validate sources of new knowledge, serving “as sites for the testing and reaffirmation of political culture” (Jasanoff, 2004b, p. 40). They are therefore often examined through the co-production lens, either tracking how an existing institution has evolved over time (Storey, 2004; Swedlow, 2011; Thompson, 2004), or examining the emergence or formation of a new institution (Miller, 2004; Waterton & Wynne, 2004). As examples of interactional co-production, Thompson (2004) and Swedlow (2011) describe how the change in attitudes towards specific endangered species of animals, African elephants and North American spotted owls respectively, over time has helped to drive changes in the institutions charged with managing these animals.

In both of these cases, the reordering of nature – old-growth forest from biological desert to eco-system critical to the survival of an endangered species, and African elephants from universally endangered and protected to the management of regional populations in accordance with sustainable population levels – has occurred simultaneously with reordering of the existing social institutions in charge of the management of the animals. Swedlow (2011) and Thompson (2004) have

described interactional co-production through their examination of how the existing institutions, the U.S. Forest Service and CITES respectively, have evolved. By comparison, constitutive co-production is that which occurs during the formation and identity-building of new institutions. Miller (2004) and Waterton and Wynne (2004) have used co-production in this way to examine the Intergovernmental Panel on Climate Change (IPCC) and the European Environmental Agency (EEA) respectively, paying particular attention to how power is distributed between nation states, and these new political institutions that span multiple nation state boundaries. In these studies, the co-production framework has been used to demonstrate how new institutions must be accompanied by new knowledges in order to gain power and advantage over existing institutions.

Making discourses

New language or modification of existing language can help to stabilise new social and natural orders (Jasanoff, 2004b). This need for new discourses is described by Miller (2004) and Waterton and Wynne (2004) as being particularly necessary for establishing the identities and legitimacy of newly formed institutions. In the case of the IPCC, the reframing of 'climate' from an aggregation of local weather events over the long term to that of a global system at risk from human activity was crucial for the development of the IPCC as a global institution, spanning nation states (Miller, 2004). In her evaluation of the Human Genome Diversity Project, Reardon (2001) outlines how the failure of the project to move beyond the planning stage was in part due to the inability of those involved to disengage themselves from "prior debates, and the emotionally and politically charged scientific and social discourses of population, race, ethnicity and colonization" (p. 380).

Making representations

Representations, or the multiple ways of knowing has long been an area of focus for S&TS, but Jasanoff argues that the co-production framework can be useful to further explore the political implications of the use of representations (Jasanoff, 2004b). As Stone (1997) and Porter (1996) describe, numbers are frequently used to represent aspects of the world in modern policy debate where "statistics are able to describe social reality partly because they help to define it" (Porter, 1996, p. 49). However, quantified representations are not used solely to define society, but are also used extensively to define the environment and furthermore, this process of definition will always be conditional on the social system that is doing the quantification. Thus "representations of those things – in the form of words, concepts, and explanations – are not simply 'mirrors of nature'. Rather they are seen as cultural products freighted with numerous biases, assumptions, and prejudices" (Castree & MacMillan, 2001, p. 209)

Ezrahi (2004) claims that the traditional dominance of the representations put forward by the science community is losing ground to the alternative representations generated by the mass media. Where

science maintains distance from everyday human experience in order to remain objective, the representations created by the media contain emotion and opinion. He argues that this makes the media much more accessible to the general public. Therefore the natural and social orderings have been altered as the media has taken authority from scientists, and the representations of nature as constructed through the media become those ingrained within the cultural understanding.

Although co-production does not provide a comprehensive theoretical framework to work with, it does provide interpretative power for studying complex or emerging phenomena. Previous studies suggest that co-production occurs along four distinct pathways: making identities, making institutions, making discourses, and making representations. The introduction of the Regulations in Canterbury represents a significant change for the region with, for example, water abstraction being quantified, reducing the need to rely on assumptions. As described in the next section, standards are a ubiquitous part of modern life that are used to create order and structure in the world. They are also frequently tools of governance that can be exerted on both people, things and the environment. Using the conceptual framework of co-production to examine the introduction of the Regulations, therefore enables the research to focus on these four sites to explore the role that the standard has played in reconfiguring social and natural orders.

3.3 The role of standards

Standards and regulations govern the way in which we understand the world or as Busch (2011, p. 68) describes them: “standards are a means by which we construct objective reality”. Although often hidden, or so widely accepted that they are not immediately visible, standards pervade all aspects of objects, humans, and the interactions between them (Bowker & Star, 2000; Busch, 2000, 2011; Star & Lampland, 2009). In a messy and imperfect world, standards enable us to rely on aspects of the world behaving in expected and predictable ways (Busch, 2011). In this section, some common characteristics of standards are described. In examining the Regulations through the lens of co-production, it is anticipated that it is these characteristics that facilitate standards to act as modes through which natural and social orders are co-produced.

A note about terminology

In the context of New Zealand policy, the terms ‘standard’ and ‘regulation’ refer to specific documents in the legislative framework. A statutory regulation, such as the Regulations is a law made by the Governor-General or Minister of the Crown under the authority of an empowering legislation that deals with details or administrative matters that are subject to change (Parliamentary Counsel Office, n.d.). For example the Regulations themselves have been created pursuant to section 360(1)(d) of the RMA. But their status as a separate regulation enables the specific details contained within them to be amended in future if and when required, without the whole legislative base, in this

case the RMA, needing to be amended. Standards are similar to statutory regulations in that they contain detailed information that is subject to change, but they are drafted primarily by Ministers, officials and organisations and are considered to be deemed regulations (Parliamentary Counsel Office, 2012). Deemed regulations such as standards are a legislative tool that accompanies a specific legislation, rather than being a piece of legislation (Parliamentary Counsel Office, n.d.).

In this chapter the term ‘standard’ is used in a different and much more general sense to that detailed above. ‘Standard’ is used to describe the endless array of rules that govern and organise the world as we know it. I therefore consider the Regulations to be a form of standard, a group of rules that dictate how water users should behave, and that also provide a benchmark against which their behaviour can be monitored by those in authority.

3.3.2 Types of standard

Busch (2011) describes four types of standard; Olympics, filters, ranks and divisions. An Olympic standard is one where a single thing or person is identified as the best (or the winner) within a specific time or space. This type of standard includes competitions, and is characterised by the presence of many more losers than winners. Filter standards in contrast are used to distinguish those that meet the standard (or can pass through the metaphorical filter material) from those that do not (those trapped within the filter). Unlike Olympic standards which seek to identify only the best from the rest, filter standards are designed to eliminate the unacceptable. To do this, a filter standard makes use of a test or a series of tests which must be passed in order to prove that the item or person in question is of an acceptable standard. As implied in the name, ranks are standards that place people or things in an hierarchical order of many categories, in contrast to the bi-modal filter standard. Unlike an Olympic standard where only the top position is distinguished, all objects or persons are assigned a position by a ranking standard. This order may be linked to a reward/penalty system and as such can be highly contested. Division standards are those where many categories exist, but there is no common preference or hierarchical ordering for the categories. Table 3.1 below provides examples of these types of standard.

Table 3.1 Examples of the use of different types of standard for objects and people.

Standard type	Example for objects	Example for people
Olympic	Car of the year	Athlete holding the world title
Filter	Toys suitable for young children	Citizens of a nation state
Ranks	Grading of grains	Positions within the military
Division	Varieties of apples	Religious affiliations

The Regulations represent a standard of the filter type. A water measuring device or system either meets the standard (it passes through the filter), or it does not, and is retained within the filter. A filter standard is designed to eliminate the unacceptable in terms of a single or a series of tests. In the case of the Regulations some such tests include that the water measurement device or system must a) be verified as meeting the necessary in situ accuracy level (reg 6(a)), b) be suited to the qualities of the water it is measuring (reg 6(c)), and c) be sealed and tamperproof (reg 6(d)).

3.3.3 Characteristics of standards

Although standards exist and apply to a vast range of processes, objects, people and things, there are some characteristics that all standards have in common, including power and control, path dependence, and never existing in isolation.

Power and control

Standards arise out of a need to create order in a frequently messy and imperfect world. As described by Busch (2011, p. 73), standards allow us to package aspects of the world as “standing reserve”, or something that can be called upon when needed, safe in the knowledge that it will perform in a predictable way and conform with expectations (Busch, 2000, 2011; Star & Lampland, 2009). It is this feature that has seen the use of standards increase alongside the rise of globalisation in commodity markets, where it reduces transaction costs (Busch, 2000, 2010). But in ensuring quality and predictability, standards embody power and control; a standard is always defined by someone in an authoritative position and is either met, or not. As outlined by Busch (2000, p. 281) “the creation of standards disciplines, reorganizes, and transforms not only the thing that is standardized but all those persons and things that come in contact with it”. He refers to this process (which is also identified by Porter (1996)) as symmetry (Busch, 2000, 2011). It is this ability of standards to affect more than just the thing or person that is intended to be standardised that makes them pivotal to the process of co-production.

This symmetry between people and things can be seen in the Regulations as they are a standard of measurement intended to introduce a consistent method for quantifying abstracted water. However, they are also a mandatory set of rules, and failure to comply with the measurement requirements of the Regulations will lead to a consent holder being punished under the provisions of the RMA. Thus they simultaneously judge both the measurement of water and the behaviour of the water user as being acceptable or not. In doing this, they have therefore immediately constructed an identity and representation regarding what is acceptable and what is not. Hence, Busch (2000) argues that this symmetry means that “standards are ways of defining a moral economy, of defining what (who) is good and what is bad, of disciplining those people and things that do not conform to the accepted

definitions of good and bad” (p. 274). Thus, standards can be thought of as modes of co-production of natural and social orders.

There are different degrees of power associated with standards, generally determined by the sanctions they induce (Busch, 2011). Some, such as the Regulations, have the power of the law behind them. In such cases, mandatory sanctions are invoked where the standard either prohibits or requires a specific activity to take place. There are also many standards issued by private organisations, which do not have any legal basis of their own, but can sometimes be enforceable through contract or tort law (Busch, 2011). These private standards tend to be advisory, proscribing (poor work place behaviour for example) or prescribing (a corporate ethics code) specific activities. Sanctions associated with private standards are often associated with some form of recognition when the standards are met by the private organisation issuing them, for example through certification and accreditation schemes. Irrigation New Zealand’s Blue Tick accreditation scheme for the irrigation industry is an example of a private standard. Although not officially incorporated as a part of the Regulations, the majority of regional councils rely on the scheme for ensuring that the standard of industry professionals is of an acceptable standard (Irrigation New Zealand, 2011).

Star and Lampland (2009) argue that the impacts of standards are distributed unevenly across the sociocultural landscape with people often conforming to an established standard because there are no better choices available to them (Busch, 2000). This is demonstrated by the introduction of the TCC technology in northern Victoria, where the highly standardised and automated nature of the technology meant that farmers were very limited in their ability to adapt it to their specific farm conditions. As a result, those farms that were not fully within the norm to which the technology was intended to work became worse off by the introduction of the TCC. Some farmers found that the areas of their farms that could be irrigated was greatly reduced through the introduction of the technology, leading to a significant loss of income (Collett, 2010). In the process of accepting a standard, we amplify the standardised reality while reducing that which does not conform to it. Standards therefore can be used to both empower and disempower people and things by either facilitating or constraining actions (Busch, 2011). In adopting the critical perspective offered by the conceptual framework of co-production, these interactions can be examined more closely to identify the implications of the implementation of the Regulations.

Path dependence

Once a standard is established it can create path dependence, where the effort to reverse or alter the standard, and any policies or decisions linked to it, is large or expensive. As Busch (2011, p. 61) describes “standards create path dependence: they make it costly (in terms of money, skill, organization, and social networks) to shift to an alternative development path since future actions

are contingent on those in the past". This irreversibility is influenced by factors such as the infrastructure built to establish or support the standard (Busch, 2011; Star & Lampland, 2009). This can be demonstrated by the necessity for travellers to carry adaptor plugs to enable them to use their appliances in other countries. A universal power socket could be developed, but to replace every existing power socket would be a huge and expensive undertaking (Busch, 2011). Such path dependence can be further exacerbated due to the ability of standards to have far-reaching effects on seemingly unrelated objects, particularly in cases where other standards have subsequently been developed. For example, Lampland and Star (2009, p. 167) describe the origin of the U.S standard railway gauge of 4 feet 8.5 inches, a seemingly random number, tracing it back through history to the width needed to accommodate the breadth of two horses in an Imperial Roman war chariot. As the path dependence of this standard has become increasingly irreversible over time, consequences have emerged that could never have been foreseen by those fixing this gauge in place as 'the standard' in the 1880s. One such unintended consequence has been to constrain the size of the solid rocket boosters used to propel NASA's space shuttles, as they require transportation between the manufacturer and the launching site by railroad (Lampland & Star, 2009).

A similar path dependence can also be seen in the lack of active water measurement in Canterbury prior to the implementation of the Regulations. As described in section 2.2.2, in the absence of the Regulations, water measurement could only be required through specific conditions in water permits (Gunningham, 2011b). In Canterbury, the historic perception of abundant freshwater resources has led to the development of large water distribution schemes and large volume water abstractions to allow irrigated agriculture (Weber et al., 2011). The high costs of developing the infrastructure associated with this water use have then dictated that water permits be issued for long time frames of up to 35 years (Gunningham, 2011b). Despite the water resources becoming increasingly stressed, the slow turnover of permits has acted as a barrier, preventing ECan from addressing this resource stress by introducing a water measurement requirement during the permit renewal process. This path dependence has meant that the only alternative process open to ECan prior to the Regulations was to revoke and reissue each permit in stressed catchments, a time consuming and expensive process (J. Earl-Goulet, ECan, pers. comm., 11 April 2013).

Nested, layered and interlocking

Standards never exist in isolation, but are layered with other interlocking or interrelated standards, tests and categories (Busch, 2011; Star & Lampland, 2009). These include pre-existing standards that are commensurable with the new one, and cases where meeting the requirements of one standard is necessary to ensure another standard can be applied successfully. As with all technologies, a myriad of standards already exists to define the specifications for manufacture, installation and maintenance of water measurement devices (Bowker & Star, 2000; Busch, 2011). These standards can be drawn

upon to meet the filter tests as described above, for example the manufacturers of water measurement devices always provide a set of guidelines to accompany their products outlining the standard conditions under which the device can be expected to perform optimally (Myles et al., 2011). Such standards are used to help ensure the manufacturer's integrity is not compromised by the poor performance of their product due to poor product choice or installation technique. Pre-existing standards such as these industry guidelines are commensurable to the Regulations in that they can be used to help meet the filtering tests, ensuring the quality and accuracy of the data produced. Similarly, while the TCC technology used in Australia was primarily intended to measure and manage the distribution of water from a central scheme to individual farmers, it was also inextricably linked to both the water trading market and the need to improve water use efficiency in order to find the necessary environmental base flow (Collett, 2010). The standardised TCC technology was therefore both nested within the standards governing the water trading market, and linked to the policy dictating the need for environmental base flows.

Data format is another example of where an additional standard is required to support an original. In *Sorting things out: classification and its consequences*, Bowker and Star (2000) use the example of standard death certificates (and the International Classification of Diseases (ICD) document which provides standardised illnesses and is used to inform the filling out of death certificates) to describe how standardised methods around data capture, although necessary, will always create limitations as to how that data can be used in the future. The same example also outlines how different end users of data often have very different needs in what data is captured; to statisticians deaths by rare diseases are often ignored as unimportant outliers, whereas to a public health official, those rare cases may be of high importance for predicting the emergence of new diseases or potential cause of epidemics (Busch, 2011). Further, for the doctor charged with capturing the data, it may be considered as needless paperwork, distracting them from providing assistance to the patients still in need of care (Bowker & Star, 2000). Similarly with the TCC project in Victoria, the farmers want the data largely for confirming that they are receiving the water that they have paid for. Whereas for the water managers, the data is more valuable in aggregate to manage the system as a whole. This example demonstrates how a single standard can co-produce divergent identities and discourses through the use of the data to meet the individual needs of the different actors.

3.3.4 Standards and the Regulations

The need for standards often arises out of an environment of controversy and disagreement, through an iterative process characterised by alternating conflict and compromise (Busch, 2011). Freshwater management in New Zealand has long been an area defined by controversy as multiple users compete for a limited water resource (Lennox et al., 2011; Weber et al., 2011). This is reflected in the

on-going reforms around environmental and freshwater management, in the midst of which the Regulations have been developed and implemented (MfE, 2009, 2011, 2013a). The Regulations seek to reduce this conflict by providing a source of information and data to assist with future freshwater management decisions (MfE, 2013c). They also contribute to the existing water governance framework by introducing structure and order to the activity of water abstraction by providing rules of engagement for water users as well as the regulatory authority (Gunningham, 2011a). In effect, these rules are serving to shape the relationship between the water user and regional council as the authority in charge of water management (Gunningham, 2011a). This research examines this relationship and the role that the Regulations have played in reconfiguring it.

3.4 Summary

Standards are a tool of governance that is used to create order and structure in a messy and imperfect world and in doing this, they also co-produce nature and culture. Typically applying to people and things, they have the ability to both empower and disempower different elements as they construct reality. Some of the features of standards that enable this power include the extent that standards are always nested within and amongst others and the resulting path dependence. Furthermore, the Regulations are a standard of quantification and thus they embody assumptions about how the numbers they produce will construct objective and legitimate representations of reality.

A co-production analytical framework considers that although the social and natural systems are represented as separate from each other, they are both intrinsically intertwined with each helping to influence the construction of the other. Therefore, within the framework of co-production, any ordering that takes place within the social system of people and things as a result of the use of standards, will be accompanied by an ordering of nature as well. Jasanoff (2004c) argues that by considering the two (social and nature) as being produced together we gain explanatory power for examining controversial phenomena, such as freshwater management in Canterbury.

The experience of introducing the highly standardised TCC technology for measuring water in northern Victoria provides some suggestion as to how the introduction of water measurement in New Zealand through the Regulations will reconfigure natural and social orders. In the Australian case, not only were the water users re-ordered by the emergence of winners and losers, but the development of conflict and distrust between the water users and the authority over the issue of accounting for water losses further altered the existing social order (Collett, 2010). A previous relationship based on trust was altered to one where the authority began to utilise its institutional power over the water users, with an identity created for the water users as untrustworthy people trying to scam the system for their benefit. The conflict that led to this re-ordering of the social

system also had consequences for the ordering of nature, demonstrating how they can be considered to be co-produced. The preoccupation of the social actors in addressing the issue of 'lost' or unaccounted water caused a shift in the natural order to occur. The original goal of the TCC project to improve water use efficiencies to enable water to be set aside to meet environmental flow limits became lost amid the conflict. 'Lost' water therefore began to take precedence over 'environmental' water in the discourse of water management. This new order around the discourse of water arose after the expected benefits to the farmers and the environment of the TCC project failed to materialise (Collett, 2010; Cowan et al., 2006)

As stated, the co-production literature describes four pathways along which the production of natural and social orders are likely to occur: making identities, making institutions, making discourses, and making representations. Through examining these modes of co-production, this theoretical framework can assist in identifying apparent demarcations between nature and culture that created by the use of standards, whilst allowing further examination of the intermingling that the demarcations are obscuring. Thus, through investigating the implementation of the Regulations in the RSGAZ in terms of these four pathways, this study will answer the research question. The next chapter revisits the research question, and outlines the methodology used in conducting this research.

Chapter 4

Research Aim, Questions and Methodology

This chapter provides a description of how this research was conducted. It also details the rationale behind the selection of specific procedures and techniques that have been utilised over the course of the research.

4.1 Research aim and guiding questions

As stated in Chapter 1, the aim of this research is to evaluate the potential implications of the introduction of the Regulations for freshwater resources in Canterbury in the future and to understand how they might influence the long term management of these resources in Canterbury. To achieve this aim, the research objectives are to:

- a) Examine how the regulations have disrupted and reconfigured established social norms and understandings of the environment, and thus, their role in creating instability and re-ordering of social and natural systems;
- b) Identifying the consequences (both intended and unintended) of the Regulations and the challenges in their implementation.

In order to meet the objectives of this research, the following research question has been used as a guide:

- What role have the Regulations played in reconfiguring previously taken for granted relationships that underpin freshwater management in Canterbury?

4.2 Research Methodology

In order to evaluate how the introduction of the Regulations have affected key stakeholders and to draw conclusions about the role of standards in the reordering of social and natural systems, a research methodology that could provide rich descriptive data about the experiences and perceptions of those involved was required. Furthermore, despite the Regulations coming into force in 2010, the staged nature of the implementation has meant that at the time that the research was conducted, the Regulations were only partially implemented, though the first stage accounts for over 90% of the total volume of allocated water in Canterbury (Tricker, Young, Ettema, & Earl-Goulet, 2012). It was therefore necessary to use a research methodology that would also allow for the implementation of the Regulations to be studied at this intermediate stage.

Case study research is one of the means of inquiry used in the social sciences and is considered to be best suited to studying contemporary events embedded within real life contexts (Flyvbjerg, 2006; Thomas, 2011; Yin, 2009). Simons (2009b) describes the case study as a research method that allows “in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program, or system in a ‘real life’ context” (p. 21). Furthermore, Scholz et al. (2006) consider the case study research approach as particularly useful in the consideration of “complex problems concerning the interaction of human and environment systems” (p.228).

Yin (2009) describes how the case study method is best used for answering ‘how’ or ‘why’ questions of an explanatory nature. Although it could be argued that a survey is best suited for answering a question such as ‘what have been the challenges for the implementation of the Regulations?’, the use of a case study and qualitative data collection methods were considered necessary to investigate the theoretical basis of the research to provide insight into *how* the Regulations have created new, or altered existing ordering within both natural and social systems linked to the management of freshwater. A survey would constrain responses to what the researcher asks and therefore would be unable to reveal any complexity in responses, by preventing two-way dialogue for example. Based on the research aims and questions, and the constraints stated above, a case study research methodology was chosen as the most suitable methodology for conducting this research.

4.2.1 Defining and justifying the case

The case for this research is defined as the implementation of the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010 (the Regulations) in the agricultural sector located within the bounds of the Rakaia-Selwyn groundwater allocation zone (RSGAZ), Canterbury. The temporal boundary for the case was limited to the date at which the Regulations came into force (August 2010) through to the end of the data collection period (October 2013).

Within this case, the Regulations have been used as an example of the introduction of a standard into an area which was previously, largely free from formal regulatory rules in relation to monitoring of water abstraction. Although the Regulations apply to all water abstractions, the case focuses solely on the agricultural sector. Other large water users such as industrial users and domestic water supplies have been excluded from the case as the total volume of water used by these other users is small (14%) in comparison to that used within the agricultural sector (86%) in Canterbury (Environment Canterbury, 2007). Despite being the primary consumer of water in Canterbury, the agricultural sector has historically also been subject to very little measurement of water usage (Gunningham, 2011b). The socio-economic consequences of the introduction of the Regulations were therefore expected to be greatest for the agricultural sector.

Yin (2009) describes three main situations where a single case study, such as this, is appropriate. These are where the case represents a critical case, an extreme or unique case, or where it is a representative or typical case. Initially the Selwyn territorial authority district was selected as the geographical boundary for the case, in part because it is where the researcher is based, and was therefore more readily accessible than other parts of Canterbury. This district was also considered to be representative of the central Canterbury region, consisting of mountainous land to the west, with intensive agriculture concentrated on the plains to the east. However, as the research progressed, it became evident that a more suitable geographical boundary would be that of the Rakaia-Selwyn groundwater allocation zone (RSGAZ) as defined by ECan (see Figure 4.1), as all the farmer participants utilised groundwater resources abstracted from within this zone. As a result, this research only considers the abstraction of groundwater resources. While this is arguably leaving out the more complex abstraction type (in terms of quantification: it is more difficult to accurately measure water in an open channel than in a closed pipe), the majority of water use in the Selwyn area is from groundwater resources.

Covering an area of approximately 128,500 hectares between the Selwyn and Rakaia rivers, the RSGAZ is classified as a 'red zone', where an assessment by ECan has found the total volume of allocated water exceeds the allocation limit for the catchment (Canterbury Regional Council, 2010). As can be seen in Figure 4.1, the RSGAZ is one of 10 groundwater catchments in Canterbury classified as red zones. The RSGAZ is therefore a representative case of these over-allocated groundwater catchments in the Canterbury region.

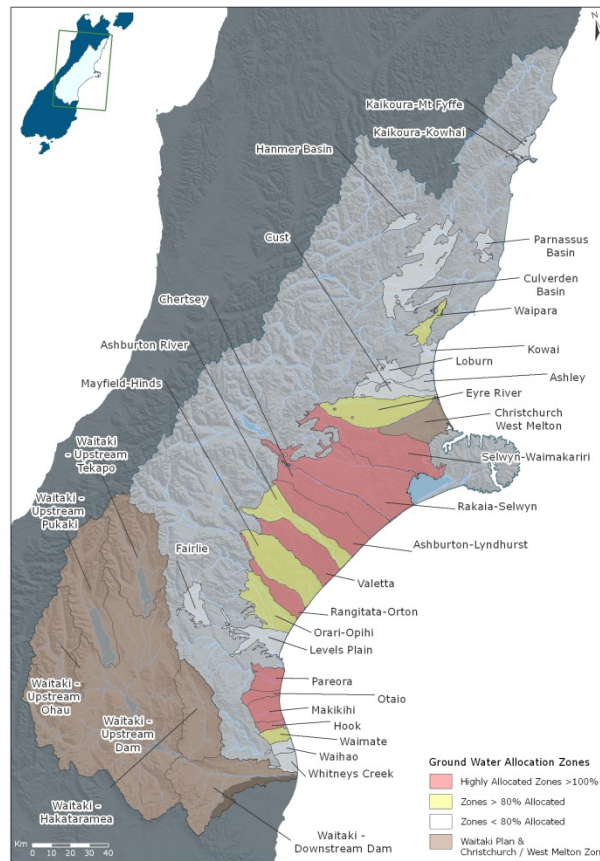


Figure 4.1 Groundwater allocation zones of Canterbury. Image taken from <http://ecan.govt.nz/services/online-services/pages/maps-canterbury-region.aspx> on 3/08/2014

However, there was a unique aspect of the RSGAZ that does differentiate it from other catchments in Canterbury: the review of the consent conditions of water permits to abstract groundwater from the zone. As described in section 2.2.3, this review process was initiated by ECan in 2006 as part of the Restorative Programme for Lowland Streams. A total of 523 water permits were reviewed as part of this process, with the requirement for installation of water meters one of the key outcomes (Canterbury Regional Council, 2010). The decision of the hearing commissioners was released on 12 February 2010, requiring permit holders with consent to abstract more than 357,000m³/annum to install water meters by 1 September 2010, and all other permit holders by 1 September 2011 (Canterbury Regional Council, 2010). The date at which the case begins, August 2010, therefore encompasses those water users who installed metering in advance of the Regulations due to the consent review process. However, the review itself has been excluded from the case, and is instead referred to for providing the ‘real life’ context that surrounded the introduction of the Regulations in the RSGAZ. This is in recognition that “irrespective of what a consent condition does, or does not explicitly require, water measurement and provision of data to the regional council will be required by law” (Tricker et al., 2012) under the Regulations. In other words, the Regulations are the main

motivator for installing metering. The consent review process that took place in the RSGAZ is therefore not considered to diminish the ability of the case to be representative of Canterbury.

Due to the temporal boundary of the case study, the research is only looking at the first of three stages of the implementation of the Regulations, applying to those water users that consume water at a rate in excess of 20 litres/second. In the Canterbury region, the majority of water permits (68%) are at or above this first stage threshold, representing over 90% of the total allocated volume of water in the region (Tricker et al., 2012). It is therefore assumed that the greatest effect of the introduction of the Regulations in Canterbury will be seen during this first stage of implementation.

4.3 Data Collection

Simons (2009c) states that interviews, observation, and document analysis are the data collection methods commonly used in case study research. The primary source of data from fieldwork used in this research was semi-structured interviews with three participant groups, namely:

1. water users within the RSGAZ,
2. personnel from within ECan, and
3. key individuals from industry service providers.

These interviews were supplemented with the analysis of documentation relevant to the case, particularly for establishing context. Observations made during the interviews were also used in this capacity.

4.3.1 Semi-structured interviews

Interviews for the purpose of case study research have been described as more akin to guided conversations than rigid or structured queries (Simons, 2009c; Yin, 2009). For this research, semi-structured interviews were used for the collection of data. During the interviews, a set of open-ended questions (included in appendix B) was used as a guide to ensure a consistent line of inquiry, but the direction of the questioning was also adapted based on each participant's responses. This ensured that a degree of flexibility and fluidity was maintained through the interview process, necessary for addressing any unexpected themes or findings as they arose. Three sets of questions were developed for the interviews, one for each of the main participant groups.

The interviews were conducted as face to face meetings at a location of the participants choosing, generally in the case of the water users, at their home, and the workplace of the council and industry participants. To ensure the interviewer was free to listen to the responses of the participants, with

the permission of the participants, the interviews were recorded using a digital voice recorder. No written notes were taken during the interview itself, but immediately following the interview personal reflections on key information or emerging themes were noted down. In instances where face to face meetings were impracticable due to participants living outside of the region, interviews were conducted over the phone. The interviews in these cases were unable to be recorded, so written notes were taken during the interview itself and while the conversation was still fresh in the interviewer's memory, a summary of the discussion was written. This was then forwarded to the participant to check for any misrepresentation of what was said.

4.3.2 Selection of participants

During the early stages of the research, informal conversations were held with key people involved in the implementation of the Regulations, including individuals from ECan and Irrigation New Zealand. The purpose of these discussions was to help refine the scope of the research, and to identify the key stakeholders from which to choose participants. It was through these discussions that the importance of the role that industry service providers (private companies that install and maintain water meters, telemetry services etc.) play with respect to the implementation of the Regulations was identified. The three stakeholder groups key to this research were therefore determined to be the water users, regional council, and industry service providers.

Two groups of water users in the Selwyn area were identified during the discussions at the early stage of the research. These groups, the Dunsandel Groundwater Users Association (DGUA) and the Ellesmere Irrigation Society Incorporated (EISI), represent the interests of their members as water permit holders with regard to water management related issues. The membership of the DGUA is located primarily west of State Highway 1 between the Waimakariri and Rakaia rivers, whereas the EISI membership is generally located to the east of State Highway 1. Both groups were involved in representing their members during the hearings for the RSGAZ consents review. Initially, contact was made to the leadership of both groups, requesting permission to approach the groups' members. Once permission had been given, the members were then contacted via email with a letter of invitation to participate, a research information sheet, and a copy of the consent form attached. In line with the Lincoln University Human Ethics Committee guidelines, those contacted were then requested to 'opt in' to the research by contacting the researcher directly if they were willing to participate. In total 10 water users contributed to the research.

Personnel from ECan were either identified by the researcher because of their position within the organisation, or were contacted at the recommendation of another participant. Industry service providers were initially identified from ECan's list of approved water metering installation and recording equipment providers. Specific individuals from within these organisations were then

recommended by other participants. As with the water users, contact with both those from ECan and industry was initially via email with a letter of invitation, a research information sheet, and a copy of the consent form attached.

In total, 14 participants were interviewed, of which 11 were conducted in person and recorded. The remaining three interviews were conducted via the phone. Table 4.1 below provides a summary of the participants and to which of the three participant groups they belong. Each participant has been assigned a pseudonym to protect their anonymity. These pseudonyms have been used for any in text references in this thesis.

The water users that were interviewed included those from the dominant farming types found in the RSGAZ, from locations across the full extent of the catchment. This is therefore considered a representative sample of farmers of the area. The participants from ECan included those in key positions directly involved in the implementation and on-going management of the Regulations. While other individuals from within ECan could have been approached, it was considered unlikely that pursuing further interviews would reveal any further details.

Table 4.1 Summary of the research participants.

	Description	Code used in text*
Respondent 1	Dairy farmer, DGUA member	1Df,D
Respondent 2	Dairy farmer, DGUA member	2Df,D
Respondent 3	Dairy farmer, DGUA member	3Df,D
Respondent 4	Dairy support and arable farmer, DGUA member	4Df+Af,D
Respondent 5	Dairy farmer, DGUA member	5Df,D
Respondent 6	Dairy farmer, DGUA member	6Df,D
Respondent 7	Arable farmer, EISI member	7Af,E
Respondent 8	Arable farmer, EISI member	8Af,E
Respondent 9	Arable farmer, EISI member	9Af,E
Respondent 10	Arable farmer, EISI member	10Af,E
Respondent 11	Environment Canterbury	11ECan
Respondent 12	Environment Canterbury	12ECan
Respondent 13	Environment Canterbury	13ECan
Respondent 14	Industry service provider	14ISP
* Where Df = Dairy farmer, Af = Arable farmer, D = Dunsandel, E = Ellesmere, ECan = Environment Canterbury, ISP = Industry service provider		

While many individuals from the industry were contacted, the response rate was unfortunately low. This may have been due to the timing of the research, with the interviews coinciding with the beginning of the irrigation season. Another factor that may have influenced the poor response rate is the serious windstorm that struck Canterbury on 10 September 2013, during the data collection. This storm caused widespread damage to irrigation infrastructure across the region, creating pressure on

the industry to make the necessary repairs before the peak of the irrigation season (Irrigation New Zealand, 2013).

4.3.3 Human ethics

As the data collection for this case study involved human participants, it was important that they were treated ethically, by adherence to the research principle of 'do no harm' throughout the research process (Simons, 2009d). Although the risk of harm to participants was considered to be low by the researcher, in recognition that freshwater management in Canterbury has been described as a contentious issue (Lennox et al., 2011), approval was sought from the Lincoln University Human Ethics Committee prior to the commencement of data collection.

Steps taken to ensure participants rights were respected throughout the research process included allowing participants to:

- Withdraw from the research at any point up until the 1 December 2013,
- Remain anonymous, by the use of pseudonyms in the place of names within the thesis and the interview record, and
- Review a record of the interview.

All private information held about the participants was treated as confidential with access to such information restricted to only the researcher and the supervision team. In light of these steps, the Lincoln University Human Ethics Committee approved the research on the 15 July 2013.

4.3.4 Document analysis

To support the data provided by the interview process, document analysis was also undertaken, including documents produced or published by ECan, by industry groups such as Irrigation New Zealand, and by academics. The types of documents that were analysed included journal articles, technical reports, evidence, submissions and the decisions of council hearings, and press releases. Such documentation was useful for both supporting the interview data, and for establishing the context of the case study. The use of additional data sources to supplement interview data helps to ensure the validity of the data by introducing triangulation (Simons, 2009a; Yin, 2009).

4.4 Analysis of data

Analysis of case study data is often considered challenging due to the lack of fixed formulae or prescribed methods (Yin, 2009). Instead, it requires the researcher to use their interpretive skills to best utilise the available data (Simons, 2009a).

Due to the time and funding constraints of the researcher, it was decided against transcribing the digital recordings of the interviews. Instead, the recordings were used alongside field notes that were taken at the time to produce a written summary of the interview. These summaries contained time reference points so that the researcher could easily go back to the recording to check specific details as necessary. This process formed the first step of the data analysis by enabling the researcher to become familiar with the content of the interviews. Each participant was provided with a copy of their interview summary to review for any misrepresentation or unintended content.

Once the recordings were in written form, they could be analysed alongside other written documents using thematic analysis. At this point, a group of codes were developed to represent themes, ideas and patterns that had emerged from first impressions generated during the interviews and from the writing of the interview summaries. An iterative process was then used to reassess the data to confirm these initially selected codes, and identify any additional or secondary themes. Similarly, the codes themselves were frequently reviewed to ensure they accurately represented the theme in question. As described by Simons (2009a), the iterations were stopped once no more new themes were found to emerge from the data and the categories were considered saturated. Yin (2009) describes how the use of theoretical propositions is a useful strategy for guiding case study analysis. In this case, frequent referral to the research questions, aims, objectives, and the conceptual framework has been used to keep the analysis on track and within scope.

4.5 Summary

A qualitative research approach based on a case study was chosen for this research to allow for a rich understanding of the participants experiences and perceptions about the subject matter. The case study has focused on the implementation of the Regulations in the Rakaia-Selwyn Groundwater Allocation Zone, an area which is considered to be representative of the greater Canterbury region.

Data were collected through semi-structured interviews with individuals from the key stakeholder groups: water users, ECan, and industry service providers. Document analysis was also used to supplement the interview data, and to help situate these data within their real life context. Guided by the research questions, aims and objectives, a thematic analysis has then been used to analyse the data. The following chapter details the results of this research, derived from the interviews and document analysis.

Chapter 5

Results

5.1 Introduction

In this chapter the results of the research are presented, which have been grouped loosely in chronological order. First the contextual background for the results is provided by describing key events that took place prior to the introduction of the Regulations. The experiences of the research participants during the implementation of the Regulations are then detailed. This is then followed by a description of how the participants have reacted to the availability of water use data, and what they believe this may mean for the future.

5.2 Background and context of results

The need for water metering to understand water usage in Canterbury had been identified by ECan prior to the development of the Regulations. Over the course of the 2000s, ECan implemented a number of measures related to water measurement, including establishing a dedicated Water Metering Team. This section describes the events that occurred in the lead up to the introduction of the Regulations in Canterbury. For many of the research participants, the boundaries between these events and the introduction of the Regulations were often ill-defined making it difficult to talk about one without reference to the others.

5.2.1 Early adopters of metering

From 2004, ECan required all new water consents issued over a threshold to install water meters and keep records of water use (respondents 3(Df,D), 4(Df+Af,D), 12(ECan), 6(Df,D)) (Gunningham, 2008). The introduction of this requirement coincided with a high demand for new water consents, driven by an increase in the rate of conversion of dry land farms to irrigated dairy, particularly on land located west of State Highway 1. Of the water users that participated in the research, four (respondents 4(Df+Af,D), 6(Df,D), 1(Df,D), 3(Df,D)) obtained new water consents in the early 2000s to enable irrigation of previously dry farm land and all four were required to install flow meters as part of their consent conditions.

However, at this time the requirements of the consents were minimal in comparison to those now outlined in the Regulations, demanding only that a flow meter be installed, and that monthly record of flow be taken to be made available to ECan, if requested (respondent 1(Df,D)). Additionally, the water measurement technology and support services available to water users through the irrigation industry in the early 2000s were also very limited. These two factors combined meant that the data

produced was of little value to either the farmer as a water management tool, or the regulatory authority as a compliance tool.

During their interviews, respondents 4(Df+Af,D), 6(Df,D), 1(Df,D) and 3(Df,D) describe how they first installed simple mechanical flow meters as this was the only affordable technology available at the time. All four participants found these to be inadequate and unreliable, requiring frequent maintenance and replacement. As the data was only being recorded manually on a monthly basis, it was often weeks before errors were identified (respondents 3(Df,D), 1(Df,D)). The quality of the data being produced at this time was therefore poor, with large gaps and frequent unexplained anomalies (respondent 12(ESCan)). Respondent 1(Df,D) described how there was also very little support around water metering during this period as the industry service providers were preoccupied with installing large scale irrigation infrastructure worth hundreds of thousands of dollars, leaving little incentive for them to focus on meters worth only a small fraction of that. There was also a lack of expertise within the industry around metering at this time, as demonstrated by the occasional installation of water meters back to front (respondent 6(Df,D)).

5.2.2 Metering trial

In response to the poor quality of data being produced by early water meter installations, in 2004 ECan began a programme to establish the best measurement technologies and data capture and management methods for monitoring water use (respondent 12(ESCan)). This trial lasted for approximately three years with the goal of finding the most efficient and effective way to implement water metering at a greater scale, in recognition that water measurement needed to be rolled out at a regional level in order to be a truly valuable water management tool. The trial was led by ECan's newly formed water metering team who actively engaged with industry service providers in the process, in addition to the water users. Respondent 14(ISP), who was involved in the trial, describes how it was both triggered by and helped to inform discussion at a national level around the need for water measurement and how this would best be achieved.

5.2.3 Rakaia-Selwyn consent review

Following the conclusion of the trial, ECan announced the Rakaia-Selwyn Consent Review process as part of its Restorative Programme for Lowland Streams in 2006. As described in section 2.2.3, the aim of the review was to have a consistent set of conditions on water abstraction consents in the RSGAZ, one of which was the installation of water meters and data loggers. Although the review was begun in 2006, it was not until 2010 that the hearing decision was released, and the process proved to be hugely expensive in terms of both time and money for ECan (respondent 11(ESCan)). In addition to these costs, the prolonged period of uncertainty for water users also meant that the process was

stressful for all parties involved as described by respondent 10(Af,E): “Environment Canterbury had never done anything like this before, and they haven’t done anything since, for a good reason”.

Many of the farmers involved in the review saw the proposed changes as a direct threat to their livelihood, creating tension between ECan and water users. The relationship between the two during the review has been described as “hostile” at times, and the effect on water users was significant: “we had a couple of people who were that worried about what was going to happen...that we were genuinely concerned about their state of mind” (respondent 8(Af,E)). Conflict also arose between the high users located west of State Highway 1, and the lower water users to the east. The source of this conflict originated from uncertainty around who was having the greatest depletion effect on the lowland streams; is it lowland users of shallow wells due to proximity to the streams, or inland users because of the much greater quantities being abstracted from their deep wells. The conditions proposed by ECan placed greater restrictions on the lowland farmers’ ability to abstract water, based on the assumption that proximity had the most significant influence on stream depletion. This made the affected farmers feel that they were being disproportionately targeted by the restrictions (respondents 8(Af,E), 10(Af,E), 7(Af,E)).

Although the consent review process was characterised by contention, the source of the conflict was focussed on the introduction of restrictions on abstraction during periods of low stream flow, and the assumptions and methods that had been used to justify the restrictions. None of the participants challenged the introduction of water metering during the review process, and many in fact welcomed the move as they felt that the lack of detailed and accurate information on water use had created a significant barrier to effective management of the groundwater resource: “information is power. You can’t make decisions without it” (respondent 3(Df,D)). Similarly, respondent 1(Df,D) specifically welcomed the introduction of water metering so that in the future when resource consents conditions are in dispute, “we’re not arguing the facts, but just arguing the effects”.

The hearing decision for the consent review was released in February 2010, requiring meters to be installed on the largest water users ($\geq 357,000 \text{ m}^3/\text{year}$) by 30 September 2010, and by 1 September 2011 for all other consent holders involved in the review. Despite the conflict the review triggered, many believe that by the end of the process, the relationship between water users and ECan had improved markedly (respondents 8(Af,E), 4(Df+Af,D), 3(Df,D), 10(Af,E), 1(Df,D)). The process also allowed for the need for water meters to be discussed and become accepted by water users within the RSGAZ prior to the introduction of the Regulations: “when the regulation came in, nothing was a surprise to us. We were already down the track, we already had it implemented and we had time to have lots of conversations and get together as a largish group about it” (respondent 8(Af,E)). As a result of both the trial and the review, ECan was also well prepared for the implementation of water

metering at a large scale, including allocating funds for this purpose in its programme of works (respondent 11(ESCan)).

In 2009 ESCan initiated a Request for Proposal (RFP) process to identify industry service providers who could deliver the necessary range of services (supply and installation of equipment, data capture, storage and processing etc.) to a suitably high quality in the RSGAZ. In 2010 following the release of the Regulations this process was extended to include the whole of the Canterbury region, but has subsequently been replaced by Irrigation New Zealand's national Blue Tick accreditation scheme. Respondent 14(ISP) provides services across much of the South Island, and describes how the combined effect of the processes that took place in the lead up to the implementation of the Regulations can be seen in comparing the progress that has been made in terms of water metering in Canterbury compared to other regions such as Otago. This is despite Canterbury having the greatest number of consents in need of meters of any region in New Zealand.

5.3 The implementation of the Regulations

5.3.1 Implementation in Canterbury shaped by the scale of the task

The implementation of the Regulations in Canterbury was shaped by the scale of the task and the large number of consents to which they apply. Respondent 11(ESCan) describes how across the Canterbury region there are approximately 5,800 consents that fall under the requirements of the first stage of the Regulations (those greater than 20 litres/second) and over 8,000 in total over all three stages. In comparison, other regions such as Wellington and Manawatu have less than 200 consents in this first category. In order to meet the requirements of the Regulations by the stipulated deadline for this large number of consents, ESCan has relied on the irrigation industry to provide much of the technical expertise and support to consent holders due to the limitations of their own resourcing (respondents 11(ESCan), 12(ESCan)). ESCan itself has instead focused on a role of advocacy and education, working to inform water users of their regulatory obligations regarding water metering (respondent 11(ESCan)).

In addressing the huge number of consents in Canterbury, ESCan has also been aided by some ambiguity in the wording of the Regulations. Although they require that each water meter be verified in situ as being suitably accurate, "verification is not defined in the Regs [sic]. Thank god" (respondent 12(ESCan)). While some regions have interpreted this requirement as necessitating that each meter is checked for accuracy with an alternative measuring device, ESCan, in recognition that visiting every meter in the region is not feasible with the resourcing available, has instead relied on ensuring good installation practices are maintained by the industry (respondents 13(ESCan), 12(ESCan)). The RFP process, first carried out during the Rakaia-Selwyn consents review, later

extended to the whole region and then superseded by INZ's Blue Tick scheme, identified industry service providers who were approved by ECan as able to provide suitably high quality services to this end. The RFP and the subsequent national accreditation scheme were necessary during the implementation as there were very few companies with proven track record in the area of water metering to guide water users (respondents 11(ECan), 8(Af,E)).

However, the Regulations place the responsibility for meeting the requirements squarely on the water user. As a result ECan has no direct authority over the industry, and must rely primarily on market forces (through water users providing their custom to companies of good repute) to ensure that these necessary high standards are maintained and that data quality remains high (respondent 13(ECan), 12(ECan), 11(ECan)). To date this relationship between water users, industry and ECan has worked well, with some water users appreciative of the introduction of an independent third party who can act as a mediator between water users and ECan should disagreements arise (respondent 14(ISP), 4(Df+Af,D), 2(Df,D)). However, respondent 14(ISP) also describes how at the time of the RFP process, around 50 companies were approved to operate in Canterbury, with many appearing to be trying "to make a quick buck" by selling and installing water meters during the initial period of high demand. He notes that the number of companies that are now accredited by the INZ scheme in Canterbury has roughly halved from those operating in 2010.

5.3.2 Providing consistency

The Regulations provide a set of minimum requirements that ensures a level of consistency in the data across Canterbury and New Zealand as a whole (respondents 14(ISP), 13(ECan), 12(ECan), 11(ECan), 5(Df,D), 3(Df,D), 10(Af,E), 1(Df,D)). This baseline of data is considered to be important for ensuring that the metering data is able to be used in aggregate for understanding freshwater resource use in its entirety. After the experience of the Rakaia-Selwyn consent review process, those involved believe that an additional benefit of the Regulations for the Canterbury region is that they spare other water users from having to go through a similar expensive and stressful process (respondents 11(ECan), 10(Af,E), 12(ECan), 1(Df,D)).

Although the Regulations provide a consistent set of minimum requirements for water users across the region, the research participants all have additional requirements written into their resource consent conditions as an outcome of the consent review process. Such use of more stringent conditions by regional councils is allowable under Reg. 12 of the Regulations. While the exact requirements vary from consent to consent in the Rakaia-Selwyn groundwater allocation zone, they typically involve the need for electronic storage of data, for example using a data logger and in some cases, telemetry.

However, the participants do not see these additional requirements in a negative light. Despite the use of technology such as data loggers increasing the cost of the metering significantly, especially for those who have multiple abstraction points where it can get up to the tens of thousands of dollars, many water users prefer having an automated system that is managed by a service provider (respondents 14(ISP), 4(Df+Af,D), 1(Df,D), 3(Df,D), 8(Af,E), 9(Af,E)). Participants describe how they are happy to pay the increased costs of such a system for the confidence that it provides in terms of meeting their obligations under the Regulations, with the additional benefit of requiring a minimal amount of effort on the part of the consent holder (respondents 4(Df+Af,D), 1(Df,D), 3(Df,D), 8(Af,E)): “people don’t want to worry about something like the metering. So if it is something that is automated – it can just be without them having to worry about it – it’s perfect” (respondent 9(Af,E)).

In fact, during the consent review process, the water users were able to negotiate for telemetry networks to be established in the Rakaia-Selwyn groundwater allocation zone, taking advantage of the economies of scale that could be achieved by working collectively (respondents 7(Af,E), 3(Df,D), 8(Af,E), 10(Af,E), 9(Af,E), 6(Df,D), 13(ESan)). As a result of this, all of the participants in this research are connected to telemetry networks, including those whose consents do not explicitly require them to be (respondent 7(Af,E)). Respondent 14(ISP) also notes that as more and more water users have connected to telemetered systems, the alternative of manually downloading data is becoming more expensive as the cost of a technician to visit and download from each data logger is spread across fewer farmers.

5.3.3 Challenges for water users during the implementation

For most water users, the implementation of the Regulations has been a relatively straight forward process in terms of the physical installation of the equipment. The participants located inland around Dunsandel (respondents 5(Df,D), 4(Df+Af,D), 1(Df,D), 3(Df,D), 6(Df,D), 2(Df,D)) are all operating farms that have been converted to irrigation relatively recently during the late 1990s or 2000s. The modern infrastructure on these farms was therefore either constructed to include water meter installation from the start, or was able to be readily adapted. Although respondent 9(Af,E) and respondent 8(Af,E) had older wells and irrigation systems, they were both undertaking planned upgrades to their systems around the time of the consent review process. This enabled them to incorporate the introduction of water meters into the planned work schedule. The older irrigation systems of respondent 7(Af,E) and respondent 10(Af,E) both required minor alterations to accommodate the requirements of the Regulations, but neither felt that these modifications presented any significant challenges.

Collectively, the water users consider that the biggest challenge that faced them during the implementation of the Regulations was the delays in getting work done due to the high demand

created by the large number of consent holders in Canterbury (respondents 3(Df,D), 10(Af,E), 8(Af,E), 9(Af,E)). For example, despite having operational water meters installed for approximately three years, both respondent 8(Af,E) and respondent 9(Af,E) are yet to receive the final paperwork certifying the installations from the company that carried out the installations. Overall, water users feel that the implementation of the Regulations has been well managed, and they have noticed and appreciated the pragmatism used by ECan in dealing with issues as they have arisen (respondents 6(Df,D), 1(Df,D), 7(Af,E)).

5.3.4 Challenges facing ECan and industry during the implementation

From the perspective of ECan and industry, after addressing the large number of consents in the short time available, the greatest challenge during the implementation has been getting water users to understand their obligations under the Regulations and to see value that water metering data could provide (respondents 11(ECan), 14(ISP), 13(ECan), 12(ECan)).

During the initial stages of the implementation, the water metering team at ECan provided a role of advocacy and education, working closely with consent holders to help them understand the requirements and find solutions to issues as they arose. As a result of this, over 80% of consent holders covered by the first stage (>20 litres/second) of the Regulations have installed meters by mid-2013 (respondents 13(ECan), 11(ECan)). Now that the November 2012 deadline for this stage has passed, the role of ECan has become “less of the carrot and more of the stick” (respondent 11(ECan)) as they have transitioned to an enforcement role, actively targeting the remaining water users who have failed to install meters. No punitive measures had been taken against water users for non-compliance with the Regulations at the time of the interviews, but it was expected that this would start within the weeks following (respondent 13(ECan)).

However, although most water users have installed meters as required, there is still a lack of awareness amongst water users around their on-going obligations, with many consent holders finding themselves with minor non-compliances (respondents 11(ECan), 13(ECan), 14(ISP)). Many of these non-compliances relate to missing or poor quality data, particularly over the winter months when farmers are not irrigating, and therefore not monitoring the flow measurement system. Notifications (via text and email) sent by service providers flagging problems with the metering equipment in the off season either go unnoticed or are ignored by consent holders under the erroneous assumption that the metering is only necessary when water is being abstracted (respondent 14(ISP)). Although farmers might not have any use for the metering data when they are not abstracting, knowing when water is not being used is just as important for the monitoring of water use by regulatory authorities which is why the Regulations require flow records be kept for a year, not just the irrigation season. In part this lack of awareness is thought to be a consequence of

the popularity of automated metering systems, and the misguided belief by consent holders that they are meeting their obligations or “ticking the box” by installing the meter and paying a service provider to manage the data (respondents 14(ISP), 11(ESCan)). However, as respondent 14(ISP) states “there has to be some responsibility on the farmers here. They are paying us for a service and putting the information on the web where they can see it every day. You could argue that if they aren’t keeping on top of things, there is no excuse really”.

This lack of understanding around the on-going obligations of the consent holders in terms of the Regulations is compounded by a lack of awareness as to how the metering equipment and the telemetry systems operate. Respondent 14(ISP) describes how at the end of the irrigation season farmers will often switch off the mains power in order to carry out maintenance on the irrigation system, not realising that although the data logger has a back-up battery, it cannot last for the entire off-season without a power source. Similarly, portable solar powered units are often stored away in a dark shed for the winter, also leading to unintended loss of data capture. However, Respondent 14(ISP) also notes that these actions are not malicious attempts to influence the data, “it’s the lack of awareness rather than trying to pull the wool over anyone’s eyes”.

Since the introduction of the Regulations approximately 10% of the consent holders that submitted metering data were found to be non-compliant with the requirements of the Regulations (respondent 12(ESCan)). It is expected that this number will fall significantly over the next few years as the awareness of consent holders with regard to their obligations improves.

5.4 Data use in farm management

All of the research participants believe that water use data produced as a result of the water metering will improve the understanding the region’s freshwater resources. The phrase “we cannot manage what we do not measure” or some variation of it was used by virtually all of the research participants, demonstrating the belief that accurate information and data is fundamental for managing these resources effectively. Prior to the introduction of the Regulations, only around 20% of water consents in Canterbury were subject to active water measurement (respondent 11(ESCan)). In the absence of actual data on water use, the decision making of ECan in relation to water resource management was based largely on assumptions, as was much of the on-farm decision making in relation to managing water use within consented limits. The introduction of water metering was therefore welcomed as a move towards knowing “what is actually happening rather than what is perceived to be happening” (respondent 4(Df+Af,D)).

Despite the apparent high value that is placed on accurate water use data and its necessity for informing decision making, the use of the metering data varies amongst the research participants.

5.4.1 Data as proof

The ECan website promotes the use of water metering data as a farm management tool to improve water and thereby, farm efficiency, providing three case studies of farmers who have benefited from the introduction of water metering on their farms (Environment Canterbury, 2013). However, while some farmers have embraced it as a useful tool as in ECan's case studies, others see it as just another compliance requirement to get ticked off (respondents 11(ECan), 14(ISP)). Despite the promotion of water metering as a farm management tool by ECan and industry, the majority of the farmer participants see water metering first and foremost as a way to *prove* to ECan that they are operating within their specific consent conditions (respondents 5(Df,D), 2(Df,D), 10(Af,E), 7(Af,E), 4(Df+Af,D), 8(Af,E), 9(Af,E)).

During the consent review process, many of the Ellesmere farmers facing restrictions felt that the assumed water use figures used by ECan in determining the effects of abstraction on lowland streams were much higher than reality (respondents 8(Af,E), 7(Af,E), 9(Af,E), 10(Af,E)). The data is therefore also considered useful by the arable farmers in Ellesmere to provide proof that they are low water users: "we were quite happy to put water metering in because we wanted to prove that we don't use very much water at all ... but the other side of the state highway they are using gazillions" (respondent 8(Af,E)). They believe that this data is essential for determining whether the greatest effect on lowland streams comes from low users close to the streams, or high users located further away.

5.4.2 Data to manage compliance in arable farming

The metering data is also used by the participants to avoid compliance issues from arising, but the degree to which this occurs depends on the farm type and the sophistication of the irrigation system being used.

The arable farmers spoken to (respondents 9(Af,E), 8(Af,E), 7(Af,E), 6(Df,D)) describe how they irrigate only if and when their crops demand it, to supplement rainfall as necessary, over a short two to three month period. The amount of water used in irrigation therefore varies from year to year, dependent on the types of crops being grown and the rainfall received. These four participants' farms were also all located on the lower plains, in the vicinity of Lake Ellesmere where the soils are considered 'heavy' with a shallow depth to groundwater. This means that the land is prone to water logging, discouraging high water use in irrigation: "we spend two thirds of the year getting rid of water, and one third applying it" (respondent 7(Af,E)).

As a result of these factors, all four participants' water use is typically quite low, particularly in comparison to other farm types common in Canterbury, such as dairying. Respondent 8(Af,E)

describes how during the past two years since having access to the metering data, adequate rainfall has occurred at crucial times in the season, resulting in water use of less than 25% of their consented allocation. Similarly, respondent 7(Af,E) estimates that he has only ever used a maximum of 70% of his consented allocation over the course of a year. Therefore knowing that they are operating well within their consent limits means that to date, there has been little incentive to actively monitor the data (respondents 8(Af,E), 9(Af,E), 6(Df,D)). Respondent 14(ISP) is aware of a number of farmers in this situation, including many who have never logged on to the web based system (one of the services offered to those connected to the telemetry networks) to view their own telemetered water use data.

The irrigation systems used by these farmers also tends to be relatively simple technology as the high water table and the many spring fed streams and drainage ditches that exist in the Ellesmere area as a result, creates farms with irregularly shaped paddocks. This places physical constraints on the types of irrigation systems that can be used, restricting the use of large infrastructure such as centre pivots and lateral travelling irrigators. The low water use that characterises arable farming further limits the use of such systems, as the pay-back period on the capital investment is often too long to be economically feasible (respondents 9(Af,E), 7(Af,E), 10(Af,E)). There is therefore a prevalence of simple rotary boom and gun irrigators amongst the arable farmers in Ellesmere (respondents 9(Af,E), 10(Af,E), 7(Af,E)). The operation of such irrigation systems requires a significant amount of manual input. This necessarily hands-on approach to irrigation and the lack of sophistication of the irrigation technology being used contributes to the lack of interest in the telemetered data for informing farm management decisions. In his study of the implementation of agri-environmental policy on Finnish farms, Kaljonen (2006) refers to the farming concept of “living one’s field” (p. 211) to describe the strong links between the farmer and his land. The hands-on approach of the arable farmers thus makes the metering data somewhat redundant as they are able to make decisions based on their present and past experiences.

Lack of sophistication in the overall technology is considered a significant barrier to the ability to use the data (respondents 9(Af,E), 7(Af,E), 14(ISP)). At the very least, telemetry that allows access to the data in near real time is stated as crucial to enabling the metering data to become useful: “if you only have a logger, you haven’t got a management tool” (respondent 14(ISP)). This reflects the comments of the participants who had meters installed prior to the Regulations, where manually recording of flow data was felt to be a waste of time (respondent 1(Df,D), 3(Df,D), 12(ESan), 6(Df,D)). The use of telemetry allows remote monitoring of water abstraction, particularly useful on larger farms with multiple irrigation systems. The farm of respondent 9(Af,E), for example, is split into two blocks located approximately three kilometres apart. He will sometimes log into the web interface to check that the pump is still operating on the other block to save having to drive down the road to physically

check it. However, he notes that the time delay in the telemetry system of up to 15 minutes currently limits the use of this data for more complex tasks (respondent 9(Af,E)). He hopes that in the future, upgrades to the telemetry network and increased sophistication of his irrigation system will enable it to be operated remotely, saving him time in travelling between the two blocks.

5.4.3 Data to manage compliance in dairy farming

In contrast, the other farmer participants spoken to were all located inland on the upper plains, between Dunsandel and Te Pirita. All six are involved in the dairy industry, either through the operation of dairy farms (respondents 5(Df,D), 2(Df,D), 6(Df,D), 1(Df,D), 3(Df,D)) or in providing dairy support (production of feedstuffs for dairy cows) (respondent 4(Df+Af,D)). As with the arable farmers, most of these participants see the primary value of the water metering as a compliance tool (respondents 5(Df,D), 2(Df,D), 4(Df+Af,D), 3(Df,D)), but due to the characteristics of their land and farming practices, they are more likely to be using the data as a farm management tool as well.

Traditionally, the upper plains west of State Highway 1 has been used for dry land (unirrigated) sheep and beef production or cropping, but over the last 20 years the land use has changed significantly, with many farms converting to irrigated dairy production (respondent 6(Df,D)). The dairy industry has become profitable enough to justify large capital expenditure in farms, and as such, the participants are all operating large scale irrigation infrastructure such as centre pivots and lateral travelling irrigators. Unlike the arable farmers where water is applied as a supplement to increase security, for dairying, regular irrigation throughout the drier months is a necessity in a dry climate such as Canterbury's (respondent 11(ESan)). Dairy farms therefore use a much greater volume of water in irrigation than arable farmers. Due to the reliance on irrigation, water security is crucial for the success of a dairy operation, so deep wells (>100m depth) are commonly used, despite the large cost associated with drawing water from such depths (respondents 3(Df,D), 1(Df,D), 14(ISP), 4(Df+Af,D)).

As high water users, the dairy farmers typically operate their irrigation systems much closer to the upper limit of their consented allocation than the arable farmers. This provides a significant incentive for the participants to monitor their metering data over the course of the irrigation season.

Furthermore the land of the upper plains is described as having light sandy soils which are much more permeable than the heavy soils of the lower plains. Water can therefore be wasted much more easily through over watering, as it can freely drain out of the bottom of the soil profile. Given the high costs associated with abstracting water from deep wells, losing water in this manner is a waste of money and therefore it is common amongst the participants to have soil moisture monitoring in place in addition to the flow monitoring. With both monitoring instruments connected to the same telemetry system and available to view through the same web interface, irrigation becomes an act of

balancing between the two limits; not exceeding consent conditions and not wasting water (respondents 3(Df,D), 2(Df,D), 6(Df,D), 1(Df,D)). However, in most cases the decision making around irrigation is influenced more by the soil moisture monitoring than the flow monitoring, and it tends to be the farmers with a history of non-compliance issues that pay particular attention to the flow monitoring (respondents 14(ISP), 4(Df+Af,D), 3(Df,D), 6(Df,D), 2(Df,D), 1(Df,D)). As a service provider, respondent 14(ISP) describes how it is more common for clients to be in contact when there is an issue with the soil moisture monitoring than the flow monitoring as they rely on this data more, and therefore place a higher value on it.

Conversion to dairy from dry land farming requires substantial capital investment to establish the necessary irrigation infrastructure. Given the large amounts of money involved, it has been common for industry consultants to be involved throughout the process, in both the design of infrastructure and the application for resource consents (respondents 12(ECan), 14(ISP)). Therefore, although dairy farmers typically operate their irrigation systems much closer to their allocation limits than the arable farmers, their irrigation infrastructure is often designed so that it is physically constrained to operate within the consented limits (use of pumps that only pump water at rate below consented flow rate limit for example). Respondent 12(ECan) reflects that there are some farmers who in this situation who are completely unaware of what their consent conditions even are, due to their reliance on consultants and the technology of their irrigation system. Such faith in the irrigation technology to operate within the design parameters and permitted limits is another reason that the flow metering data is considered primarily as a compliance tool (respondents 5(Df,D), 1(Df,D)). However, reliance on the physical constraints of the irrigation system to ensure abstraction is within allocation limits is not without risk, as there are external factors that can alter or influence the system constraints. Both respondent 1(Df,D) and respondent 6(Df,D) are aware of cases where a natural fluctuation in groundwater level (a rise of approximately 10 metres corresponding with the end of a period of lower than average rainfall (Weber et al., 2011)) resulted in over-abstraction occurring. The increase in water level reduced the work load of the pumps, allowing a greater abstraction rate. While the water meter identified that the over-abstraction was occurring, there was little that could be done about it because of the narrow operation range of the irrigation system: “you can only throttle a pump back so much before you damage the electrics and the pump” (respondent 1(Df,D)).

5.4.4 Data use in the longer term

Although the majority of farmers have not been using the data directly in their day to day decision making so far, there is general consensus that in time, once a significant data set has been built up, the metering data will be useful for identifying trends. Depending on the type of irrigation system

being used, the data can be useful for detecting issues or faults in the irrigation system (respondents 3(Df,D), 6(Df,D), 7(Af,E), 4(Df+Af,D)). “We know what our wells should do so if there are any sudden fluctuations higher or lower, we know that something is not right” (respondent 4(Df+Af,D)). For example a sudden increase in flow could indicate that a major leak has occurred somewhere in the pipe network, and a general reduction in flow over time could be used to gauge when pumps need to be lifted for maintenance. This is particularly useful for those with deep wells, where lifting the pump is an expensive exercise (respondent 6(Df,D)).

Similarly, many of the participants believe that looking at trends in water use over a period of years will help to drive improvements in water use efficiency (respondents 13(ECan), 11(ECan), 1(Df,D), 3(Df,D), 6(Df,D), 2(Df,D), 4(Df+Af,D)). The now operative Canterbury Land and Water Regional Plan places a greater emphasis on water use efficiency, and farmers will soon be required to demonstrate that they are using water wisely (respondents 12(ECan), 11(ECan)). The metering data is expected to be crucial for performing this task, and it is hoped that the irrigation industry and groups such as Irrigation New Zealand will use the data to develop benchmarks against which farmers can measure their water use efficiency (respondent 6(Df,D), 1(Df,D), 12(ECan)): “What are some quick metrics that a farmer can do to see if they’re being a good irrigator or not” (respondent 1(Df,D)). However, concern was also expressed about the potential for benchmarks to become a hindrance, if they do not adequately allow for the complex range of factors that influence irrigation decision making (respondent 7(Af,E)).

The water metering data is not necessarily in a form immediately useful in assisting with on-farm decision making; therefore farmers see its value primarily as a compliance tool to prove that they are operating within their permitted limits and to ensure they do so. The use of the data as a farm management tool is dependent on the individual and the characteristics of their farm; a high user, dependent on irrigation with a financial incentive to minimise water use is more likely to monitor the metering data than a low user who is only irrigating as a supplement. Similarly the data is more useful in operating a sophisticated, high tech irrigation system on a large farm where remote monitoring can reduce human resource input, than with a relatively low tech system that requires a lot of direct manual input. The attitude of the participants towards the water metering data can be summarised by respondent 4(Df+Af,D): “I’ve got a water meter in now, how can I best use it to my advantage”.

5.5 Water metering as a science tool

While the use of the water metering data for informing decision making at the farm scale varies between the participants, they all want to see the data being used to inform and improve the management of the resource as a whole through use in predictive modelling. There is a general

consensus across all the participants that understanding water use is essential for effectively managing the region's resources. "You can't do anything without information ... I don't think that [ECan] can build the models that they need to build [without metering data]" (respondent 14(ISP)). ECan's reliance on assumptions in the past is considered by many to be a major deficiency in water management in Canterbury to date (respondents 8(Af,E), 7(Af,E), 9(Af,E), 14(ISP), 3(Df,D), 4(Df+Af,D), 1(Df,D), 6(Df,D)). "If you are going to manage a resource, you have to know what is happening with that resource ... ECan is there to manage the resource and they [have been] guessing" (respondent 9(Af,E)).

This is particularly the case for the farmers who have invested significant amounts of money in the installation of flow monitoring equipment. For those with multiple abstraction points the cost of implementing the metering is typically upwards of \$30,000 (respondents 4(Df+Af,D), 1(Df,D), 3(Df,D)), with many paying extra to enable connection to telemetry, despite not being required to (respondent 7(Af,E)). There is therefore a feeling amongst the farmers that they have made a major contribution towards getting the data and that it is now up to ECan to use the data in such a way that it will return value on their investment: "we've done our bit. It would be nice to see some results out the other end" (respondent 7(Af,E)).

Although the staff at ECan agree that the Regulations present an opportunity for improving the science of predictive modelling in relation to the resource and they intend to use it to this end (respondents 11(ECan), 12(ECan), 13(ECan)), there is still some concern amongst the farmers that the data will go unused or will not be used to its full potential (respondents 7(Af,E), 9(Af,E), 1(Df,D), 8(Af,E)). Respondent 1(Df,D) is worried that the data will "disappear into a deep dark hole, never to be seen again" because in the three years of submitting metering data, no form of acknowledgment of receipt has been received from ECan. Similarly, despite receiving a summary report this year based on the metering data and resource consents held for the respondent's own property, respondent 8(Af,E) was disappointed that an aggregate report covering the collective consents of the Ellesmere Irrigation Society was unable to be produced by ECan (respondents 8(Af,E), 7(Af,E), 9(Af,E)). However respondent 7(Af,E) reflects that "regulatory authorities are always very quick to make people pick things [such as the Regulations] up, but they are very slow to deliver any value on that ... But I appreciate the sheer volume of information that they are dealing with, and the intricacies of every consent being different". Although farmers understand that ECan is faced with a large task in processing all the data, consent holders are anxious to see that something beneficial is produced from it.

5.5.1 From compliance to science

The Regulations provide very little detail around the form in which the data should be recorded or submitted, requiring only that the data be submitted in a format that is considered suitable for auditing by the relevant regulatory authority. During the metering trial and the consent review process, ECan worked alongside industry service providers to develop a basic reporting structure that provided a simple daily breakdown of water use (respondent 14(ISP)). The recording of metering data in this way is perfectly adequate for the purposes of monitoring of compliance against consent conditions. If a non-compliance is detected then the raw data can be accessed and investigated in greater detail to determine whether any further action needs to be taken by the authority. Whereas if no issues are flagged, then there is no need for valuable resources to be spent looking through the raw data in any detail.

However, if the metering data is to be used to inform predictive modelling science as is generally desired by all parties, then the data needs to be of a much higher quality (respondent 12(ECan)). Each data set needs to be manually audited, with any anomalies such as power surges (common in wet conditions due to interference from electric fences) that cause spikes or gaps in the data to be logged in a standardised manner. This process is essential for use as an input into models to ensure that the data is uniform temporally and spatially. Auditing the data in this manner represents a massive increase in workload associated with the data capture and management. ECan is currently in the process of developing a data management protocol for this purpose, though due to the large number of data sets in the region, ECan does not have the resources within the existing water metering team to do this auditing (respondents 12(ECan), 11(ECan)).

At present, industry data hosting services only provide the raw data, complete with any erroneous spikes and gaps to ECan, in addition to a brief report summarising the daily volumes, highlighting any non-compliances that have occurred over the course of the year. Respondent 14(ISP) describes how when the company first started to offer data hosting services, the staff would go through the data, attaching comments to any anomalies in the data to explain the cause if known, as some of the clients requested that this be done. The relatively small number of consents being monitored at this time meant that this was feasible. However, with the increase in metering as a result of the Regulations the respondent states that “it’s become too big a monster in many respects ... we’ve got 2,000 meters out there. We are going to need another 10 guys just to process that information”.

In addition to the lack of immediate resourcing available, respondent 14(ISP) is also aware that if ECan starts to require data hosts to audit the metering data, the costs associated with this extra work will need to be pushed back on to their clients, the water users. Knowing that clients of the company have already contributed substantially to the implementation of the water metering, respondent

14(ISP) is reluctant to further burden them financially: “this information that we are collecting is for compliance, and the consent holder pays for it to the compliance level. [ECan] want to bring in a certain quality of data to use for science, and I don’t believe that the consent holder should be paying for that ... Why should they? [It] would be more appropriate for it to be funded out of the general rates as everyone is going to benefit”.

Respondent 14(ISP) also describes a case in the past where at the request of the client, raw metering data was ‘smoothed’ with erroneous spikes and gaps removed and replaced by comments before the data was submitted to ECan. This led to an accusation that the data had been deliberately tampered with, and ECan threatened to prosecute both the consent holder and the data host. Although the prosecution did not proceed, the experience has made the respondent wary of manipulating metering data in the future, due to potential issues of liability.

Although the Regulations do not explicitly state a purpose, to the majority of the consent holder participants, they are seen primarily as a compliance tool, providing proof that consent conditions are being adhered to, and for assisting in managing water use within these limits. Despite this, all participants agree that the metering data should also be utilised in informing science and modelling, to aid with understanding freshwater resources and improve their management. But in extending the purpose of the Regulations from one of compliance to one of science, the data needs to be of a much greater quality. With consent holders already feeling that they have contributed their share of the costs of metering during the implementation of the Regulations, how this additional work around data management is to be funded remains unclear, and is expected to be a source of contention in the near future.

5.5.2 Accuracy of water metering

Water flowing in a closed pipe system has the benefit of being a very measurable parameter. With the metering technology available today, achieving an accurate figure for the volume of water that is abstracted is a straightforward process. This has led to some participants questioning why water metering hadn’t been introduced at a regional scale much earlier, instead of ECan relying on assumptions as for past decision making (respondents 7(Af,E), 8(Af,E), 3(Df,D)). But although the water abstracted from the ground is easily quantifiable with a high level of certainty, there are still a great number of other factors that cannot be quantified so readily within water management.

Given that groundwater is invisible from the surface and has ill-defined boundaries, accurately quantifying the resource as a whole and the effects of abstraction is difficult and is characterised by a high level of uncertainty (Gunningham, 2008; Weber et al., 2011). This is further compounded by the fact that the resource is a natural system that is in a constant state of flux due to a range of both

natural and anthropomorphic factors. For instance, the 10 metre increase in groundwater level described by respondents 1(Df,D) and 6(Df,D) is attributed to a natural fluctuation (at the end of a dry spell), whereas a sudden drop in groundwater pressure experienced around Lake Ellesmere every spring is attributed to the increase of abstraction from deep wells on the upper plains at the start of the irrigation season (respondent 9(Af,E), 7(Af,E)). Despite the new availability of water use data created by the introduction of the Regulations, it is likely that when the accurate and largely indisputable metering data is introduced as an input into the science of predictive modelling, the high uncertainties associated with other parameters will reduce the overall effectiveness of the information. For instance, the debate over which of the two dominant models (Aqualincvs. bathtub) better represents the hydrogeological situation in Canterbury is likely to remain (Weber et al., 2011).

The Rakaia-Selwyn groundwater allocation zone has been classified as a 'red' zone by ECan since 2004, where the volume that has been currently allocated is considered to be greater than that which the resource can sustainably provide (Environment Canterbury Groundwater Resources, 2012). Many of the participants accept that over time, once a decent data set is built up, the metering data may be useful in informing allocation practices in the future as they feel actual data has got to be an improvement on assumption (respondents 13(ESCan), 8(Af,E), 10(Af,E), 9(Af,E), 4(Df+Af,D), 1(Df,D), 3(Df,D), 7(Af,E)). However, not everyone agrees that the catchment is over-allocated. Respondents 4(Df+Af,D), 1(Df,D), 9(Af,E) and 6(Df,D) believe that the issue of over-allocated has been overstated by ECan, stressing that water allocation and water use are two separate things. They emphasise that water use is routinely lower than the total volume that is allocated across the region

Similarly, during the consent review process, it was assumed that the greatest contribution to the reduced flows in the lowland streams were from those abstracting water from shallow wells in close proximity to the streams. In making this judgment in the absence of actual data, ECan had assumed a figure for water used by the lowland farmers considerably higher than the past two years' worth of metering data has shown to be used (respondents 8(Af,E), 9(Af,E), 7(Af,E)). However respondent 9(Af,E) notes that although the actual water use was much lower than assumed, the streams were still suffering from reduced flows during these seasons. This would indicate that either the effect of the shallow abstractions has been greatly underestimated, or that other factors, such as the abstraction taking place on the upper plains play a significant role in influencing flows in the lowland streams: "who is causing low flows? Is it us because of proximity, or is it the accumulative effect of everyone? ... We are the ones that are supposed to be affecting the streams, but if we aren't pumping it, the streams should be flowing" (respondent 9(Af,E)). Due to the complex nature of groundwater resources, quantifying such effects will always remain characterised by uncertainty.

Although access to accurate water metering data is a major improvement from relying on assumed figures for water abstraction in understanding and managing the resource, there are many sources of uncertainty surrounding the resource. When the data are introduced into the wider resource management arena, the certainty and indisputable nature of the accurate water metering data is likely to be lost amongst the other factors. Given the high value that water has for farmers, contention around freshwater and its allocation is therefore likely to remain.

5.5.3 Water abstraction as a proxy for water use

The water users that participated in the research all have resource consents attached to their properties for the abstraction of water for the purpose of irrigation. The measurement of water abstracted in these cases, is therefore directly equivalent to the quantity of water used for irrigation. However this is not always the case.

In Canterbury there are many irrigation schemes where water is abstracted under resource consent and then distributed to multiple individual farms for use in irrigation. In such cases, because the Regulations exist within the framework of the RMA, only the initial abstraction is required to be monitored with flow metering as this is the activity that requires resource consent. As the use of the water for irrigation is a permitted activity (it is not subject to resource consent), the individual farms have no obligation to install meters to provide a record of their water use (respondents 11(ESCan), 14(ISP)). The water metering data is therefore only telling half the story. While the water metering provides an accurate account of how much water is being abstracted from the freshwater resources across the region, it does not necessarily provide an accurate indication as to where or when that water is then used. In those areas where irrigation schemes exist, or when the data is intended to be used in aggregate across the region, the use of the data in science and modelling may therefore be limited if it is seeking to understand patterns in water use.

While ECan is unable to require farmers in this situation to install meters, it has been actively encouraging the operators of irrigation schemes to introduce metering within the schemes distribution networks. Respondent 11(ESCan) expects that water metering will be installed on most schemes voluntarily in time, either through operators wanting to ensure that water use is in accordance with their rules, or by the farmers wanting to ensure that they are getting the volume of water that they have paid for. The effect of this limitation may therefore reduce in time.

5.6 Outcomes of metering – fear of the future

5.6.1 Increased scrutiny of water users

For the majority of consent holders, the introduction of water metering under the Regulations represents monitoring of an activity that was previously unmonitored. With the wide scale use of automated data capture and telemetry systems, not only is the data now available, in many cases it is available in near real time. This opens up the consent holders' behaviour to a much greater level of scrutiny than has occurred in the past.

The farmer participants generally accept this increased scrutiny as a necessary consequence of the Regulations, and actually view it as a positive (respondents 9(Af,E), 7(Af,E), 3(Df,D), 5(Df,D), 2(Df,D), 4(Df+Af,D), 1(Df,D)). Reflecting on the idea of the metering data as proof (section 5.4.1), the consent holders welcome the potential scrutiny as a way of demonstrating to ECan that they are operating within their respective consent conditions. They also see it as a useful way to improve the public's perception of the agricultural sector by showing that as farmers, "we are doing our bit for monitoring the resource and how we use it" (respondent 9(Af,E)). Even respondent 2(Df,D), who feels like water use "is totally under the spotlight" after the metering revealed that there was over-abstraction from two of his wells, recognises the importance of maintaining a good relationship with both ECan and the wider public.

Although the consent holders feel that there is now greater scrutiny of their water use, they also understand that ECan is dealing with a huge volume of data and that they are therefore physically unable to investigate every consent holder's data in great detail. As respondent 12(ECan) describes, although the introduction of metering increases scrutiny of water use, "it is not like big brother is watching over them". It is expected that for the purposes of monitoring compliance against consent conditions, those consent holders with a known history of non-compliance will be checked, along with an audit of a random sample from the remaining the consent holders (respondents 11(ECan), 13(ECan)).

5.6.2 Increased enforcement

Although the consent holders accept that increased scrutiny is necessary for effective resource management, there is still concern that the availability of the metering data will lead to an increase in enforcement activity for compliance issues. This is largely due to a long held belief that "compliance officers don't do grey" (respondents 6(Df,D), 14(ISP), 11(ECan)).

The first year of data collection was expected to reveal a number of farmers who were unwittingly over-abstracting, simply because they have never had access to such information in the past. ECan

intended to adopt a pragmatic approach during this period, issuing warnings to the farmers rather than pursuing punitive measures (respondents 13(ESCan), 11(ESCan), 14(ISP)). Respondent 2(Df,D) was found to be in this situation with two of the four wells on his property exceeding an instantaneous flow limit. Once aware of the issue, the respondent approached ECan with the proposed solution of putting four the wells under a single consent so that the lower abstracting wells could balance out the higher ones. Despite receiving verbal confirmation from ECan that this solution was acceptable, respondent 2(Df,D) was surprised to receive a warning letter about the matter. This approach was considered to be greatly unfair given his attempt to be proactive approach in finding a solution. It is stories such as this amongst the farming community that make consent holders nervous about how compliance issues will be dealt with in the future (respondents 1(Df,D), 6(Df,D)).

As previously mentioned, ECan is currently transitioning between the role of education and support, to one of enforcement with regard to the Regulations (respondent 11(ESCan)). This change of approach has been noticed by the consent holders with many receiving warnings for minor transgressions that would have gone undetected in the past (respondents 14(ISP), 1(Df,D), 8(Af,E), 9(Af,E), 6(Df,D)). Respondent 8(Af,E) notes that while those familiar with the processes of the RMA do not get too concerned when receiving such notifications from ECan, for others, particularly older farmers it can be a stressful experience.

The increase in enforcement activity is also considered in part to be due to the large volume of consents that must be monitored. The compliance team at ECan relies on automatically generated exception reporting to identify individuals that need to be followed up with (respondent 13(ESCan)). While this process is efficient for dealing with the volume of consents, it limits the capacity for personal judgement to be applied: “the fast solutions are a tool that tells people if they are being naughty or not, without the human intervention in the middle” (respondent 14(ISP)).

While this black and white approach could be considered to be fairer as “everyone gets nailed equally as there are no grey areas” (respondent 14(ISP)), it could also potentially antagonise consent holders in cases where a non-compliance is unavoidable or due to a factor beyond their immediate control. Respondents 9(Af,E) and 10(Af,E) found themselves in this situation when the telemetry network they are connected to failed to transmit their data over a period of weeks. Technicians from their service provider were called but were unable to identify any fault with the equipment. Eventually, it was discovered that a new cell phone tower had been erected near the network base station as part of the Government’s rural broadband programme, and this was interfering with the telemetry signal. Although the relationship between water users and ECan is considered greatly improved since the consent review process, the past conflict has certainly not been forgotten

(respondents 8(Af,E), 7(Af,E), 1(Df,D)). Actions viewed as unfair could therefore aggravate past grievances.

Similarly, respondent 1(Df,D) fears that a black and white approach to compliance will fail to adequately accommodate the reality of operating large irrigation infrastructure where the operational constraints mean that there is very little flexibility available to accommodate unexpected events. In the event of a natural rise in groundwater, as has happened recently in parts of the Rakaia-Selwyn groundwater allocation zone, the respondent notes that to throttle back pumps to remain within the instantaneous flow rate limits may not only damage the equipment, but may also reduce the water use efficiency of the system, as it is no longer operating within the optimal design conditions. In situations such as this, where an unforeseeable natural event has created the non-compliance, it is considered crucial to adopt a pragmatic approach (respondent 1(Df,D)). It may be more efficient to operate the system over the instantaneous rate limit, but to do so for a reduced period of time so that overall volume limits are not exceeded.

Among some consent holders, there is an additional concern that the metering will be used to justify the introduction of volumetric charging or a water tax (respondents 10(Af,E), 8(Af,E), 11(ECan)). “Why else would you put a water meter on if you aren’t going to charge?” (respondent 10(Af,E)). Charging for water has been identified as a potential mechanism for improving water use efficiency that could be introduced in New Zealand (Counsell & Evans, 2005; Gunningham, 2011a; Land and Water Forum, 2012), despite this, most of the research participants expect that the introduction of such a measure would be hugely contentious and is therefore unlikely in the immediate future. However, the introduction of the Regulations has come at a time when farmers are facing a range of new regulatory measures, such as the introduction of nutrient limits. The costs (both in terms of time and money) associated with compliance can be significant, and as respondent 7(Af,E) reflects “it seems that the regulatory stuff is set up for the corporates to thrive and the family farms to be pushed out”.

5.6.3 Highlighting unused water

While the consent holders around Ellesmere with typically low water use welcome the metering as an opportunity to prove that their water use is low, there is apprehension around how the data will be used in the future: “water metering is probably 55% great for us. But it has also probably 45% created worry of what will happen in the next 15 years” (respondent 8(Af,E)). The source of this anxiety is that in highlighting that actual water use is low, and making the discrepancy between water use and water allocation more visible, the metering data may be used to justify reducing allocation limits (respondents 8(Af,E), 9(Af,E), 7(Af,E), 10(Af,E)).

There are two main sources of this concern. The first is that for arable farmers, water use can vary significantly dependent on the climatic conditions during the growing season, and the crops being grown (respondents 7(Af,E), 10(Af,E), 9(Af,E)). Although the past two years since meters have been installed have seen low water use, in less favourable conditions, water demand can rise dramatically: “if we get a really dry year, we can triple what we are currently using” (respondent 9(Af,E)). There is therefore concern that if only a few years’ worth of data is used to set new allocation limits, it may greatly reduce their capacity of these farms to operate in future dry years.

The second source of concern is that reducing allocation limits to reflect the current water use will restrict the future development of the property to land uses with a similar or lesser water demand: “it restricts your future land use basically. If our allocated water, which is not massive, is reduced right back, then that puts the kibosh on conversion [to dairy]. Which isn’t necessarily what we want to do, but the next generation may want to” (respondent 8(Af,E)). With the catchment already classified as over-allocated, consent holders know that increasing their allocation limits in the future will be virtually impossible. They therefore place a high value on continuing to hold the right to use water in surplus of their current needs, as this can affect the value of their whole property (respondent 7(Af,E)).

Many of the farmers feel that they are being responsible guardians of this allocated and unused water and that it would therefore be unjustified for ECan to take it from them (respondents 9(Af,E), 7(Af,E), 8(Af,E)): “if we aren’t using it, the environment is receiving it. So it is almost like our environmental contribution to get the streams to flow” (respondent 9(Af,E)). This might be the case at present, however if they all convert to higher water demand land uses in the future, as they wish to protect their right to do, then this benefit will be lost and the streams will be worse off. The reasoning behind not reducing allocation limits is therefore contrary to their claims of environmental protection.

However, there is a danger that the threat of allocation reduction may encourage a use it or lose it mentality amongst consent holders if ECan does decide to pursue it. The reduction of allocation limits to help reduce the pressure on the resource from over-allocation may therefore create the perverse effect of increasing water use (respondent 11(ECan)). The high value that access to water represents for a consent holder and their property means that it is a resource that is worth protecting. For arable farmers whose water use is low in an average year, when faced with the concerns cited above, some already feel under pressure to use more water in order to protect their right to it: “you are almost encouraged to go out and use as much water as possible to protect [it]” (respondent 10(Af,E)).

5.6.4 Central Plains

Although the issue of unused water is of primary concern for arable farmers at present, the likely introduction of the Central Plains Irrigation Scheme (CPIS) means that some of the dairy farmers from the upper plains will face the same issue of highlighting unused water in the future. The first stage of CPIS will supply surface water from the alpine-fed Rakaia River under gravity to 20,000ha across the plains of central Canterbury between the Rakaia and Horarata rivers (Central Plains Water Ltd, 2014; Lomax et al., 2010). The scheme is especially attractive for those farmers who currently rely on abstracting groundwater from deep wells where the electricity costs of pumping can be in the order of hundreds of thousands of dollars over a season: “it won’t get any cheaper to pump water” (respondent 3(Df,D)).

For some, the opportunity to use surface water originating from the inland alpine environment is that attractive in terms of cost reduction that they plan to completely abandon their existing abstraction infrastructure and consents (respondents 6(Df,D), 3(Df,D)). A key driver for this is the large fees that the local lines company (Orion) charges consent holders to stay connected to the electricity network, as irrigation consumes such a large portion of electricity demand (respondents 12(ESCan), 6(Df,D)). Though others plan to continue to hold on to their groundwater consents as “insurance” for the event that the scheme is unable to meet demand (respondents 2(Df,D), 5(Df,D)).

Many see the introduction of CPIS as the only way that the over-allocation in the Rakaia-Selwyn Groundwater Allocation Zone can be solved, as once it is constructed and operational, it will see many large water users no longer using groundwater from the upper plains (respondents 6(Df,D), 3(Df,D), 8(Af,E), 7(Af,E), 2(Df,D), 5(Df,D), 12(ESCan)). In fact some believe that the effect may be so significant that those on the lowland plains will complain about the excess water (respondent 3(Df,D)). However, by continuing to hold groundwater consents as insurance, farmers who are using the scheme as their primary irrigation source could jeopardise this, as the water would remain able to be abstracted. In this case, it is expected that ECan will use the lack of use of the water, supported by the metering data, to justify the non-renewal of these consents when they expire (respondent 12(ESCan)).

5.7 Summary

Prior to the introduction of the Regulations, steps had already been taken by ECan to introduce water metering to existing unmonitored consents. Given the poor quality of the data being produced by those consents with a monitoring requirement, ECan initiated a trial to find the best way of implementing water metering on a greater scale. This was followed by the review of 523 consents in

the RSGAZ to include among other things, water metering, a process that proved to be hugely expensive in terms of time and money.

The Regulations were welcomed by ECan as a way of avoiding the need to repeat the consent review process by introducing a mandatory minimum level of monitoring for all consents over the five litres/second threshold. While some farmers did have to make minor upgrades to their infrastructure to accommodate the new metering requirements, most felt that the greatest challenge during the implementation was due to the struggle of the industry to cope with the scale of the task in terms of numbers of consents. In addition to coping with the huge number of consents, the main challenge for ECan and the industry was the lack of understanding of the farming community as to their obligations.

The farmers see the Regulations primarily as a compliance tool and the metering data as a way to prove to ECan that they are complying with their consent conditions. Whereas arable farmers have little use for the data in the operation of their farms, dairy farmers are more likely to monitor the data to ensure they do not over-abstract. Both arable and dairy farmers believe that the data will be useful in the long term once a significant data set has been established, for identifying trends in water use. Furthermore, they would also both like to see the data being used by ECan to improve the science that resource management decisions are based on. While ECan does intend to do this, it will require the quality of the data to be much greater and questions have been raised as to who should pay for this.

Despite the farmers welcoming the metering data as proof and wishing to see it used to improve science, they also worry about how the data will be used in the future. The increased scrutiny already appears to have increased the enforcement activities, and there is concern that the metering will be used as justification to reduce the allocations of low water users, such as the arable farmers. Thus, while the Regulations have been widely accepted as a necessary and useful tool, they have also created anxiety for the future. The following chapter explores these findings in terms of the theoretical framework.

Chapter 6

Discussion

6.1 Introduction

The purpose of this study has been to examine the role that standards play in reconfiguring orderings in social and natural systems. In this section, the results of the fieldwork in Chapter 5 are linked to the conceptual framework set out in Chapter 3. The results will first be examined through the lens of co-production, with examples of the reconfiguration of natural and social orders examined in terms of the four sites of co-production identified by Jasanoff: making identities, making discourses, making representations, and making institutions. The role that the Regulations has played in this co-production will then be discussed. This chapter will be concluded by placing these findings in the context of freshwater resources in Canterbury.

6.2 Co-production in the implementation of the Regulations

The Regulations are a filter standard that embodies and expresses power, path dependence and reinforces a network of existing and perhaps future standards. While the intention of standards is to create structure and predictability, Busch (2011) states that “standards always produce *partial and impermanent* orderings and never complete ones” (p. 6). In other words, the order that is created through the introduction of a standard, is constantly open to negotiation and change, as standards always incorporate a metaphor or a simile: they are a measured comparison and never an absolute (Busch, 2011).

As a standard, the Regulations are an instrument of governance that can be used as justification for imposing sanctions upon water users for breaching their resource consent limits. But they are also an instrument of quantification that seeks to contribute to the production of knowledge around freshwater resources. Jasanoff (2004a) argues that the idiom of co-production is useful for “highlighting the often invisible role of knowledges, expertise, technical practices and material objects in shaping, sustaining, subverting or transforming relations of authority” (p. 4). This section seeks to examine the Regulations through the lens of co-production, to explore the role that standards play in constructing and reconstructing order in natural and social systems.

In Chapter 3, the conceptual framework of co-production is described as a critique of the tradition of considering facts, nature, policy, and objects as separate from the domains of culture, subjectivity, values and politics. Rather, Jasanoff (2004a) argues that we gain explanatory power for the examination of complex and controversial phenomena by considering nature and culture as being

produced simultaneously, intertwined in such a way that makes their separation impossible. She identifies four pathways along which co-production typically occurs: making identities, making representations, making discourses, and making institutions. Evidence collected during the research demonstrates that standards co-produce social and natural order along these pathways. Examples of this from the results are described in the following sections.

6.2.1 Making identities through standards

Standards are intended to help reduce unpredictability by creating order and structure. An object or person subject to a standard can be expected to have the same characteristics as all the others subject to the same standard. However, standards can be used for more than just the creation of uniformity. They can also be used to differentiate. In making a claim of standardisation, standards also create a distinction between the standardised thing, and all other things (Busch, 2000, 2011; Stone, 1997).

Standardised differentiation is commonly used by people in the construction of identities. For example, Fairtrade coffee is a standardised product: it must meet all the same food safety and consumer standards that non-fair trade coffee must meet. But in choosing to purchase a Fairtrade coffee over the available alternatives, a consumer is sending a signal to the wider world that they are a person that supports issues of social justice, or (perhaps more cynically) that they can afford the luxury of paying for a more expensive product. The consumer is therefore choosing, either consciously or not, to distinguish her or his self as belonging to a defined social group. Jasanoff (2004a) argues that the making of identities is one of the four common sites of co-production. In studying the introduction of the Regulations in the RSGAZ, the research demonstrates how standardised differentiation co-produces social and natural order through the construction of identities.

While standards may be specifically designed to promote either sameness or difference, there will always be a degree of ambiguity to them. Whether a standard is seen as universal (promoting uniformity) or particular (promoting differentiation) is largely dependent on the situation and the network in which it is placed. The Regulations for instance can be interpreted as a universal standard promoting standardisation as they seek to introduce a uniform method for measuring abstracted water. When the Regulations are placed in the context of the regulatory authority trying to improve understanding of water resources so as to manage them better, it appears that the Regulations have been designed with standardisation in mind.

However, Busch (2011) argues that there is a “symmetry between standards for people and standards for things” (p. 4) and that the two can never be fully separated (Busch, 2000). Therefore,

while the Regulations introduce a standardised method of measuring abstracted water, they are simultaneously introducing a measure of the people who are abstracting the water. In the context of compliance, the Regulations cease to be only about the monitoring of water, and can instead be interpreted as a standard to monitor water user behaviour. In this context they clearly become a standard of differentiation, distinguishing between those whose water use, and thus who themselves, comply with their resource consent conditions, and those that do not.

During the interviews, many of the interviewed farmers stated that the identity for the whole farming community in the eyes of ECan and the general public in the past, appeared to have been formed on the basis of a small number of instances of unacceptable behaviour and high profile conflicts played out in the environment court. They felt that the dominant discourses in the past reflected an assumption of poor management and non-compliance, even though without monitoring, ECan was limited in its ability to prove bad behaviour. This combined with the history of contention that has characterised freshwater management in Canterbury, and the reliance of ECan on assumption in its past decision making, has led to the water metering data being commonly viewed by the water users as proof. The water users have welcomed the opportunity to be able to distinguish themselves from what they perceive to be a very small minority of farmers who deliberately flout the rules, breaching their consents and using water inefficiently. Through the process of implementing the Regulations, installing a water meter and gathering data on the quantity of water at significant personal expense, an identity has been constructed for the farmers as responsible and worthy recipients of the portion of the freshwater resource that they have been allocated. This reflects Jasanoff's argument (2004b) that "when the world is in disarray, redefining identities is a way of putting things back in familiar places" (p. 39).

With the construction of this new identity, the farmers are able to deflect any criticism regarding the effects of the water abstraction on the environment back towards ECan. The water users can now prove that they are operating within their permitted limits, and in some cases that the rates of abstraction have been overestimated by ECan in the past, in the absence of such data. Using the metering data as proof that they as individuals are behaving appropriately, the farmers have framed the issues associated with the freshwater resources in the RSGAZ (over-allocation and reduced flows in lowland streams) as a product of governance and management of the resources at the regional or catchment scale, rather than the accumulative effect of many poorly managed individual abstractions at the farm scale.

As stated by Reardon (2001), "natural and social order cannot be created *de novo*. Rather, these orders are the products of long historical processes that embed past contestations and settlements" (p. 359). The exact identity constructed for the farmers using the metering data varies between

individuals and is built on the basis of their past experiences. For the dairy farmers abstracting water from deep wells on the upper plains, their experience of abstracting water has always indicated that there is plenty of it as they have never suffered any problems with pumping (respondents 1(Df,D), 6(Df,D), 3(Df,D), 4(Df+Af,D)). Without any physical evidence that the resources are under stress, they are reluctant to accept ECan's classification of the catchment as an over-allocated red zone.

In contrast, the arable farmers on the lower plains have seen the reduced flows in the lowland streams, and some also report that there is a noticeable drop in groundwater pressure on the lower plains when the irrigation season starts. They therefore agree with the red zoning of the catchment. However, while they acknowledge that their irrigation must be a contributing factor, they feel that the responsibility for the reduced flows in the lowland streams has been disproportionately placed on them due to their proximity to the streams themselves. Their irrigation rates have not increased significantly since before the streams began suffering from low flows, and they have therefore concluded that the issue is a result of the increased abstraction from the upper plains. Despite these differences in experience, both the arable and dairy farmers have had similar identities constructed as responsible water users, using the new proof provided by the Regulations. In doing this, the Regulations have enabled the existing order to be reconfigured to reflect this identity: validating the water users' experiences of the water resource through the metering data.

The relationship between ECan and the water users is conventionally hierarchical, with ECan as the regulatory authority holding power over the water users. The Regulations have reinforced the power of ECan by allowing a greater level of scrutiny of water users and their water abstraction. Thus the filtering capacity of the Regulations has constructed identities for water users as being acceptable and behaving within consented limits (and therefore compliant), or not. The ability provided by the Regulations to differentiate between the compliant and non-compliant water users means that ECan can more easily enforce sanctions against those who are non-compliant than they have been able to in the past. During the research, water users did indeed express that a noticeable increase in enforcement activity by ECan had occurred since the introduction of the Regulations. However, the Regulations have also enabled the empowerment of water users, by providing them with the proof they need to demonstrate that they are operating within the limits that have been deemed acceptable by ECan. In using the Regulations to construct the identity of farmers as responsible and rule-following, they have distinguished themselves from what they perceive to be a minority of farmers who do not adhere to the rules, and focused the attention of the debate on the actions of ECan.

The data produced as a result of the Regulations was always intended to be used to improve understanding of freshwater resources. However, the use of the data as proof by water users and the

reconfiguring of their identity that has resulted is an unforeseen and unintended consequence of the Regulations. Busch (2011) argues that standardised differentiation means that “there are innumerable branches, partial orderings, and social groupings” (p. 198). However, in constructing identities and differentiating between the acceptable and the not, the Regulations are not only ordering social groups, but are also co-producing order in the natural world. Based on their past experiences, the Regulations have enabled the farmers to frame the freshwater resources as a collection of well managed parts (allocations), reflecting their elevation in the social order as responsible water users. The Regulations have co-produced natural and social order as the new farmer identity frames the problems associated with freshwater management in the RSGAZ as a product of poor management at the catchment or regional scale, rather than the individual farm scale. Therefore, while the Regulations have enabled ECan to increase the scrutiny of the water users’ behaviour, the quantification of abstracted water may also increase the scrutiny of past and future planning decisions made by ECan with regard to freshwater management.

Stone (1997) argues that quantification is commonly used to define policy problems and the numbers that result are commonly utilised to justify a need for, and dictate the direction of change. With the contention that has characterised freshwater management in Canterbury, the measurement of water abstraction embodied within the Regulations is seen by many of the research participants as essential to improving the management of this resource. With the Regulations enabling the construction of identities for the farmers as responsible water users and thereby framing the resource problems as a product of poor management of the resource at a regional scale, the empowerment of farmers might enable them to determine the future direction of policy changes towards protecting their access to the water. An unintended consequence of the Regulations that has the potential to arise in the future is the new identity of the farmers leading to a reduction in the credibility of ECan as past decisions in the management of the RSGAZ are scrutinised.

6.2.2 Making representations and discourses through standards

Busch (2011) argues that standards always incorporate a metaphor or simile in that they are intended to provide a measured comparison. As with numbers, standards can assist in providing a description of the world, but they are never absolute and are open to interpretation (Porter, 1996; Stone, 1997). Standards and standards of quantification in particular, therefore offer one way through which representations of the world are constructed. Furthermore, it is also common for a specific language to evolve to support representations. As predicted by Jasanoff (2004a) and others (Reardon, 2001; Swedlow, 2011), the representations and discourse that the Regulations support, are sites of co-production of social and natural order. They (the representations and discourse) reflect the assumptions about the world that have been embedded within the Regulations.

The introduction of the Regulations is an attempt to better understand freshwater resources, through the quantification of the water that is abstracted from these resources. Although on its own the metering data will not enable a full understanding of the resource, it is intended that it will contribute to a range of other direct measures (such as the static groundwater level, flows in spring-fed streams, bore hole logs, etc.), as inputs into predictive models. The subterranean nature of groundwater means that quantifying the resource and the effects on the environment from abstraction directly is impossible. These models therefore offer a representation of the resource as measurable and therefore controllable, in the absence of being able to physically measure it directly. While the data from the Regulations is not yet being used in this manner, this results show that it is intended to be, and that there is wide support for this to occur. Thus, the co-production of this 'quantified resource' representation through the implementation of the Regulations will act to stabilise what we know about the resource, and how we know it.

During the research the majority of the participants spoke of the inability "to manage what we do not measure". Although the Regulations are a measurement tool that applies to both people and abstracted water, this phrase was only ever used in reference to the water, despite water users stating that they see the Regulations primarily as a compliance tool (a measure of people) rather than as a tool for management and planning. This discourse of quantification as necessary in order for management to be effective demonstrates how entrenched the 'modelled' representations of groundwater resources is in Canterbury. However, although the model representation is entrenched, according to Weber et al. (2011) there has been a long running conflict over the merits of two conflicting models: the Aqualinc model versus ECan's so called bathtub model. The emphasis on the need for more measurement reflects this conflict, the dissatisfaction that exists with the modelling that has been done to date, and the hope that more information might resolve this conflict. During the research, many of the participants expressed disbelief that any model could be adequate without any accurate data on how much water is actually abstracted. This reflects the findings of the previous work completed in the Selwyn catchment by Weber et al. (2011) where it was found that "getting the science right" (p. 51) was thought to be the best way to resolve the conflict and move forward. As respondent 1(Df,D) said during an interview, it is hoped that the Regulations will firm up the science of the models sufficiently so that "we're not arguing the facts, but just arguing the effects".

In this sense, the Regulations are contributing to the reinforcement of the existing ordering and the perpetuation of a quantitative, 'rule-by-numbers' discourse by specifying a standardised set of rules for the quantification of abstracted water, and thereby emphasising the perceived necessity for measurement as the best means for defining reality (Busch, 2011; Porter, 1996; Stone, 1997). These rules embody assumptions about the reality that they are intended to help define. For example, the Regulations assume that the quantification of water abstraction is useful in improving the

understanding of patterns of water use and the impacts of this use on the environment. However, as described in the results, this assumption works well for groundwater abstractions (such as those used by the research participants) where the volume of water abstracted is directly equivalent to the water then used in irrigation. In these cases, the pumps driving the abstraction also drive the irrigation systems. Whereas for users of surface water or those connected to irrigation schemes which commonly utilise water storage to increase reliability, the measure of water abstracted does not necessarily indicate where or when the water is then used. The assumption about the value of the data embodied within the Regulations therefore fails to adequately account for the variety and complexity of situations that exists in the real world. Variation in the value and usefulness of the data is therefore a consequence of using a single set of standard rules to cover a broad range of contexts. For the Regulations to be implemented nationally, they were necessarily created to be broad and universal. However, this universality has constrained the range of contexts to which they easily apply. Thus the representation created through the metering of surface water takes will differ from that constructed for the groundwater takes. As surface water abstractions have not been covered in this research, direct conclusions cannot be drawn about how these differing representations affect the co-production of natural and social orders. However, it is expected that these differences between surface and groundwater abstractions may have consequences for the construction of the representation of the resource at a regional scale through future modelling endeavours.

The reliance on numbers in the representation of the freshwater resource dictates that they and the effects of their use on the wider environment can only be truly understood and managed in accordance with the representation constructed by the technical experts and their models. Even when the expert representation is in conflict with the understanding of the water users (as with the arable farmers whose experience indicates that their impacts have been overstated in past representations), they still see the models as essential to managing freshwater resources effectively. Rather than the water users outright rejecting the role of experts, the Regulations and the metering data are instead seen as a way of adjusting the existing representation to better reflect the water users' reality. The Regulations offer an accurate measure of how much water is actually abstracted, which will replace the assumed values that have been used in the past. However, in doing this, the Regulations act to reinforce and stabilise the world as it is represented through expert knowledge.

The use of the metering data derived from the Regulations in this way demonstrates that the "physical characteristics of nature are contingent upon social practices: they are not fixed" (Castree, 2001, p. 13). Just as the representation of nature can evolve over time to reflect changes in social practices of quantification (the introduction of water metering for example), interpretations of the products of quantification also change to reflect the power relationships amongst the social actors. For instance, as described in the results, the metering data is a double edged sword for low water

users: it proves that they use less water than has been assumed, but also makes this allocated but unused water more visible. When speaking of the ability to prove their low water use, the discourse of the farmers spoke of being good guardians of the resource, with their unused allocations protected from use by anyone else and thus benefitting the environment. However, this discourse changes significantly under the threat that the metering data will be used as justification to reduce allocation limits. The unused water is no longer an environmental contribution, but is described in terms more typically associated with monetary value, such as insurance and future potential development.

These changes in discourse reflect the changes in the power between ECan and water users that the Regulations introduce. As Castree and MacMillan (2001) argue, “the ability to define nature’s ‘truths’ or to alter it physically can, it is argued, help secure relations of cultural and economic dominance in society” (p. 209). In enabling the water users to prove that they are low water users, the Regulations empowers water users against ECan, as they are also able to prove that the assumptions made by the latter have been wrong in the past. Rather than being the cause of reduced stream flows as described in the past, the arable farmers can prove that they actually use much less water than has been assumed. On this basis, the Regulations have led to a reconfiguration of the existing representation: from cause of the problem to part of the solution.

To date ECan has not made any indication that it intends to make reductions to allocated limits however, the quantification of the Regulations and the resulting increase in visibility of unused water has created a situation where farmers feel vulnerable. During the research, the farmers in this situation were the lowland arable farmers, the same group that the research found to be in agreement with ECan as to the over-allocation of the resource, and who also faced the greatest restrictions on their activities during the Rakaia-Selwyn consent review. These past experiences have been compounded by the highlighting of unused water via the Regulations, resulting in farmers making assumptions about the ends to which the data will be used by ECan in the future. Reducing allocation limits in the manner that water users are predicting would be an example of ECan exercising its power as the regulatory authority over the water users by imposing sanctions. In response to this potential power shift, the farmers’ discourse changes to emphasise the personal hardship that would result from this action should it be taken. Some farmers even take this to the extreme, threatening to increase water abstraction rates in order to protect their access to it. The perverse outcome of increased water use therefore has the potential become an unintended consequence of the Regulations. This is likely to have implications for ECan as they attempt to address the over-allocation in the RSGAZ, and other red-zoned catchments across the region in the future.

This shows that a tension exists between the representations, discourses, and identities that have been constructed with the introduction of the Regulations. Bowker and Star (2000) describe similar tension between representations, identities and discourses in their study of the Nursing Interventions Classification (NIC) system. In this study they identify that the NIC as it sought to define the role of nursing through categorisation of the activities that they perform. As with the farmers in the research, the new standard (the NIC) increased the visibility of nurses' roles in medical care, a function that was welcomed as a way to improve recognition of their work. But they also recognised that the politics of the new classification system involved "walking a tightrope between increased visibility and increased surveillance" (Bowker & Star, 2000, p. 29). As a result, the nurses were observed to adopt behaviours that both increased the degree of standardisation within the new classification system, whilst also attempting to offset the scheme to prevent the categories from dictating their role to the point where they lose all discretion (Bowker & Star, 2000; Kaljonen, 2006). Kaljonen (2006) states that while there is tension between welcoming an increase in visibility whilst trying to minimise the effects of surveillance, the two are not in opposition but exist as a duality. This tension is a product of co-production as the way that the nature is constructed through identities, discourses and representations reflects the construction also taking place within the social system. Thus, the tension arises between the allocated and unused water as being revealed to be protected from other users for the benefit of the environment versus a resource being hoarded for later economic gains, and the water users as protectors of the environment versus potential exploiters. These divergent identities for water users and their allocated water therefore reflect changes in the distribution of power across the socio-cultural landscape, with the construction of the latter identity (hoarder for economic gain) only arising with the perceived threat that ECan will exert its institutional power over water users through sanctions.

The representations and discourses that are used to define the freshwater resources in the RSGAZ are sites of co-production. With groundwater resources unable to be measured directly, the dominant representation of the nature of the resource and the effects of abstraction on it is that defined by technical experts through the use of predictive models. This representation of nature is well entrenched within the order of freshwater management in Canterbury and during the research it became apparent that all parties (water users, ECan and industry) see the Regulations as a way to strengthen these existing quantitative representations, by assisting to remove sources of uncertainty and contention. As Stone (1997) argues, numbers are frequently used to construct representations that suit the desired direction of change in policy and as Porter (1996) argues, quantitative rules have a "remarkable if perverse ability to remake [the] world" (p. 50). Thus the discourses used in discussing changes to the existing representation reflect the relationships of power that exist between the social actors, and how they then portray the environment. While the intended

consequence of the Regulations is to improve freshwater management by understanding the resource better, unintended consequences (such as an increase in water use) may also arise due to assumptions held about the Regulations, what their data will reveal, the tension between the constructions, and the actions that these might enable in the future.

6.2.3 Making institutions through standards

The Regulations have been introduced into a setting already containing organisational institutions. All three of the stakeholder groups that participated in the research belong to an institution: ECan as a regulatory authority, the water user groups to which the water users belonged, and the company and the membership to Irrigation New Zealand's Blue Tick accreditation scheme for the industry professionals. The introduction of the Regulations has undoubtedly altered these institutions. For example, the establishment of the water metering team and the new powers granted to the consents compliance officers are changes that have occurred within ECan. The empowerment of water users individually with their data as proof is likely to be reciprocated by a similar empowerment of the water user groups as they represent the water users collectively. Industry operators also report that the mandatory monitoring of consents has provided them with a new source of work. However, providing a detailed analysis of these institutional changes is considered impracticable as the interviews conducted during the research did not explore these changes in great depth, focusing primarily on the experiences and opinions of the participants as individuals.

Although the organisational institutions are considered outside of the scope of this study, the Regulations also represent an institution of practice by defining a set of rules that must be followed. In doing this they facilitate and constrain the behaviours of the actors involved. The results of the research indicate that the degree to which this facilitating and constraining action occurs for the water users is dependent on the type of farming and the sophistication of their irrigation system. The arable farmers' irrigation as a supplementary activity, are typically well within their consented limits. With little fear that they will breach their consent conditions under normal circumstances, the consequences of the introduction of the Regulations on their farming practices has been minimal. The Regulations neither facilitate nor constrain the arable farmers' existing behaviours in the short term (however as described, there is concern about how the data will be used in the long term), beyond the mandatory requirement of installing the metering equipment. Furthermore, the lack of sophistication of their irrigation systems requires much hands-on input in the irrigation process, by moving irrigators manually for instance. The in-depth experience of the farming process that this contributes to makes the quantification of abstraction redundant to an extent, as the farmer is directly aware of how much water is being applied to the land. In contrast, the results indicated that dairy farmers tend to use more sophisticated infrastructure (large automated centre pivot or

travelling irrigators) and operate their irrigation systems much closer to their consented limits. With this type of system, the monitoring offered by the Regulations facilitates the water users to manage their water use within their limits more effectively, actively avoiding non-compliances. Thus, the dairy farmers are more likely to be using the Regulations as a farm management tool, as promoted by ECan, ensuring that they do not over-abstract.

This example demonstrates that the order of nature and society is always conditional on and constructed on the basis of past experiences. Thus, the institution of the Regulations is interpreted differently by different users based on their individual contexts. While ECan promoted the water metering as a farm management tool, this intended consequence of the Regulations has only really arisen within the dairy sector where the rule-bound nature of the new standard better reflects the relatively high-tech and therefore necessarily highly standardised irrigation infrastructure used. In this sense, both the farmer's behaviour and his abstraction of the water are already operating within predetermined constraints. In fact, as became apparent during the research, in many cases the irrigation technology has been designed to operate within clearly defined boundaries and with little flexibility to cope with changes such as a rise in groundwater level (as described in section 5.4.3). The Regulations have therefore not contributed to any additional constraints of the system, but have instead reinforced the facility to use technology to manage water use from a distance. In contrast, the more hands-on farming approach of the arable farmers due to their less standardised irrigation technology means that they have direct experience of the impact of their irrigation activities on the land. Furthermore, with heavy soils that are prone to water logging the arable farmers can easily tell through this experience whether they are using water effectively or not.

The Regulations have an assumption embodied within them that water abstraction and use can only be understood regarding what is acceptable and efficient use through quantifying it. However, despite the oft repeated "we cannot manage what we do not measure", the actions of the arable farmers indicate that they are able to manage their water use effectively without measuring their water abstraction, by using their own experiences of the interaction between their activities and the outcome for their land. However, while the Regulations have not reconfigured natural and social order for the arable farmers at their individual farm scale, they acknowledge that ECan (and to an extent the dairy farmers reliant on technology) do not have the same capacity for "living one's field" (Kaljonen, 2006). Thus, the assumption of the Regulations (that measurement is necessary) is considered to be true when considering water resources at the catchment or regional scale. As described previously, the introduction of the Regulations has enabled water users to frame the issues of the RSGAZ as a product of poor governance of the resource in aggregate. The construction of the institution of the Regulations in the contexts of individual farms has therefore reconfigured nature as an aggregate of parts, where it is necessary to measure the parts to understand the whole.

Meanwhile, it has also reconfigured the social by revealing through the identity of responsible water users that ECan is unable to understand the resource through means other than measurement, as farmers can.

6.3 The role of the Regulations in co-production

In the previous section, the results have been explored to reveal examples of where natural and social order has been reconfigured by the introduction of the Regulations. Intended and unintended consequences that have arisen as a result have also been described. The next sections will explore how it is that the Regulations have co-produced natural and social order, with particular reference to the common characteristics of standards including power and control, path dependence, and that they never exist in isolation.

6.3.1 The Regulations as a filter type standard

As previously described in Section 3.3.2, the Regulations are a standard of the filter type in that they provide a series of tests that must be passed in order to determine if the thing (object or person) being tested is of an acceptable standard, and passes through the metaphorical filter material. Standards of this type are common amongst environmental standards (Busch, 2011). However, the results indicate that the Regulations are a filter standard in two ways, both stemming from their purpose as a measure of compliance under the RMA: compliance with the Regulations themselves, and compliance in terms of resource consent conditions.

Compliance with the Regulations

The first of these two ways, is that explicitly stated within the Regulations in relation to the requirements (or tests) that must be met by the permit holder, beginning with a test to determine whether the Regulations apply to a permit holder or not (reg 4 and 5). This is then followed by further tests describing the requirements that a permit (resource consent) holder must meet in order to fulfil his legal obligations under the Regulations (reg 6-8). These tests explicitly described within the Regulations apply not only to the permit holder, but also to the technology the permit holder employs. Reg 6(6) outlines specific requirements that a measuring device must meet in order for it to pass the filter and comply. Failure of the permit holder (and the technology they engage) to comply with these requirements means that they have not met the acceptable standard necessary to pass the filter, and are liable to punitive measures under the RMA.

Compliance in this regard has been widely achieved with the majority of water users accepting that they must meet the tests as set out within the Regulations. As described by respondent 12(ECan), the Regulations offer a set of minimum requirements necessary for effective water metering. As such the threshold for passing this filter standard is relatively low and readily achievable. Provided a

consent holder is willing and has the financial means to purchase suitable technology, there is little to prevent them from complying with the Regulations. This is reflected in the wide uptake of metering within the prescribed deadlines, with only a small minority (<20% of takes >20 litres/second in the RSGAZ, (respondents 11(ETCan), 13(ETCan))) who remain non-compliant with the direct requirements of the Regulations. Those who have failed to comply with these requirements are those who have refused to engage in the process at all, rather than a failure to comply with just some aspect of it. The Regulations have therefore been successful in achieving water metering across the Canterbury region within a relatively short time frame.

The Regulations and a broader sense of compliance

The second and more implicit sense that the filter of the Regulations acts is through the relationship between the Regulations and resource consent conditions. Although no overt purpose or aim is stated within the Regulations, given that they sit within the legal framework of the RMA and apply to those who hold resource consents, the majority of the farmers spoken to view the Regulations foremost in terms of compliance with resource consent conditions. This is despite the efforts of ETCan to promote metering as a farm management tool (Environment Canterbury, 2013). The Regulations, and more specifically, the records of water taken that they require be kept, are instead viewed as an opportunity by consent holders to *prove* that they comply not only with the Regulations themselves, but also with the conditions of their individual resource consents. Despite the Regulations making no direct reference to how the water take records relate to resource consent conditions, the farmers view the Regulations primarily in terms of a second filter: do I comply with my resource consent conditions or not?

Filtration as a mode of co-production

As a filter standard, the Regulations are designed to identify those that are acceptable (pass through the metaphorical filter material) from those that are not. However as Porter (1996) and Busch (2000) argue, it is impossible to separate standards and acts of quantification for things from those for people and vice versa, a process that Busch (2011) refers to as symmetry. It is this inability to separate standards for people from those for things that makes standards a mode of co-production. In cases where a standard applies to an object, the need for the object to be subject to and tested against a standard is the result of the social needs of people, and furthermore, any testing must be carried out by people. Likewise, any standard for people will require some form of object to assist in the testing process: “to the extent that we create standards for things, we implicitly create standards for humans. Similarly, we cannot create standards for humans without creating standards for things” (Busch, 2011, p. 26). It is therefore unavoidable that in quantifying an aspect of the environment (water abstracted) using standardised means, those abstracting the water will also be subject to measurement against a standard.

The results indicate that the Regulations operate as a filter in two ways. The first explicit sense of a filter is intended to enforce a standardised process for the consistent monitoring of water abstraction. However, in light of the history of contention that has characterised freshwater management in Canterbury, it is perhaps unsurprising that the Regulations are also viewed as a means of proving their acceptability in terms of the second interpretation of the filter: a measure of acceptability (compliance) with regard to resource consent conditions. The Regulations are therefore providing a simultaneous measure of abstracted water and of water user behaviour, a feature Porter (1996) states is common in standardised quantification practices where “adequate measurement means disciplining people as well as instruments and processes, particularly when ... there is advantage to be gained in deception” (p. 38). Furthermore, Stone (1997) argues that evidence in the form of numbers is considered valuable as it is assumed that “numbers will “prove” a connection between some controllable human action and the problem” (p. 173) and thereby drive change. This faith in numbers is demonstrated by the widely held belief that more monitoring is essential for addressing the conflict and improving freshwater management in Canterbury (Land and Water Forum, 2010; Weber et al., 2011).

Thus, as the Regulations provide a measure of both abstracted water and water user behaviour and are intended to contribute towards better managing freshwater resources, they will co-produce natural and social order by defining what is acceptable and what is not. The availability of metering data means that past assumptions about resource use and those using the resource, made in the absence of this data will inevitably be scrutinised. As demonstrated in the previous sections, this has resulted in the construction of new or altered identities, institutions, representations and discourses. The following sections describe how common characteristics of standards have enabled the Regulations to co-produce natural and social order in this way.

6.3.2 The Regulations as a mode of power and control

As previously explained, standards are intended to create order in a messy world (Busch, 2011). Standards are therefore expressions of power through which we amplify by facilitating some actions, whilst constraining others. They are therefore always implemented from an authoritative position. Furthermore, standards are commonly used to ensure that quality is maintained, so that the subject of the standard can be treated as standing reserve, ready to be drawn upon as needed, safe in the knowledge that it will perform in a predictable way. However, as Busch (2011) argues, “quality is about control and control of things often morphs into control of people” (p. 234), a product of the aforementioned symmetry of standards. This control is typically exerted through sanctions that aim to either promote (facilitate) or discourage (constrain) particular activities. Sanctions range from soft, voluntary nudges towards a particular behaviour (for example earning recognition from a respected

accreditation scheme) through to strong incentives, such as the threat of punitive measures enforceable by law (as with the Regulations). However, even when sanctions within them are of the softer kind, standards often act to impose order, as the thing (or person) that is being standardised may have little choice in the matter (Busch, 2000). For instance, the industry professionals in Canterbury are not required by the Regulations to be a part of Irrigation New Zealand's Blue Tick accreditation scheme. However, because ECan promotes the use of accredited professionals in Canterbury as a means of quality assurance, it is unlikely that water users will engage with unaccredited professionals.

The power and control that can be expressed through a standard is therefore one of the ways that natural and social order become reconfigured with the introduction of a new standard. This research indicates that the introduction of the Regulations has altered the positions of power held by ECan, water users, and technology all to more or lesser degrees. As described in the following sections, the empowerment and disempowerment of these actors has contributed to co-production and the resulting reconfiguration of the relationships that underpin freshwater management in Canterbury.

Power and ECan

As the regulatory authority in charge of managing freshwater resources and issuing resource consents to use them, ECan already holds a position of power over consent holders. Under the legal framework of the RMA, ECan has the right to impose sanctions on water users, from denying a water user a new consent, imposing conditions of use within permits, through to issuing punishment to those caught in breach of their consent conditions. The fact that the Regulations have been introduced within the existing framework of the RMA means that all consent holders over the five litres/second threshold must legally meet the requirements or face potentially serious consequences. Consent holders therefore have no choice but to meet the requirements of the Regulations if they wish to continue to abstract water. It is common for filter standards such as the Regulations to be mandatory with the weight of the law behind them (Busch, 2011). Although ECan was already in this position of power in relation to the water users prior to the introduction of the Regulations, the fact that the Regulations are compulsory means that water users are largely *powerless* to act in any way but in accordance with them. To not do so means invoking ECan's sanctioning power and facing seriously detrimental consequences such as prosecution. The introduction of the Regulations therefore did not create this relationship of power, but the results show that it has been strengthened.

For instance, in addition to the mandatory nature of the Regulations, they have also enabled ECan to scrutinise the activities of water users much more easily than they were able to in the past. Without this monitoring data in the past, ECan had no option but to trust water users to behave in accordance

with their consent conditions. Despite ECan's position of power, they were frequently unable to act on it in the past due to the lack of information. The introduction of the Regulations has changed this with mandatory daily monitoring of high accuracy for all water abstracted. Farmers spoken to over the course of the research are aware of the significance of this increase in monitoring, stating that they feel that their water use and they themselves are now subject to a much greater level of scrutiny than has existed in the past. ECan no longer has to rely on trust and can now readily check the monitoring data to see if consent conditions are being met. Whether or not the filter is passed has therefore become much easier for ECan to determine. Both ECan and water users acknowledge that due to the scale of water use (and the huge number of consents that exist) in Canterbury, it is very unlikely that this high level of scrutiny will actually extend to every individual consent holder due to limited resources within ECan. However, even if "it is not like big brother is watching over them" (respondent 12(ECan)), the potential for scrutiny has still acted to strengthen ECan's position of power, as shown by the awareness of the farmers to it.

As noted by Busch (2011) and Stone (1997), standards and the need to measure frequently arise in situations of conflict and/or where change is desired. The outcomes of standards and measurement therefore frequently inform the direction that this change will take. As Stone (1997) states, "measurers ... have power over the fate of the measured, since measuring is done to help decide on policy actions" (p. 182). The scrutiny that farmers now feel as a result of the Regulations is a product of this power. Furthermore, the concern felt by farmers around how the monitoring data is to be used in the future (as justification for reducing allocation limits for example) indicates that they are vulnerable to the effects of this power.

As shown in the results, the increase in scrutiny has also raised concerns that there will be a corresponding increase in the enforcement (sanctioning) activities by ECan. Since the introduction of the Regulations, participants in the research have noticed an increase in the number of warnings being issued for minor compliance issues. In the past, these would likely have gone undetected, but with the introduction of monitoring they have become more visible. A filter standard such as the Regulations is intended to sort the acceptable from the unacceptable, a characteristic that lends itself well to the enforcement of compliance, whereby resource consent conditions are either met (acceptable) or not (unacceptable). The Regulations have therefore constructed compliant and non-compliant identities for the water users. ECan's compliance officials already have a reputation for interpreting the world in a very 'black and white' manner ("compliance officers don't do grey" (respondents 6(Df,D), 14(ISP), 11(ECan))) and farmers worry that the Regulations and these new identities will lead to a reduction in the use of personal judgement in dealing with issues of compliance. While such an approach could be considered fairer by treating all consent holders equally through the sanctions they face, as Wynne (1988) describes, such a simplified view of the

world “denies access to and appreciation of the complex, open-ended and incompletely rule-determined technical-social constitution of technologies” (p. 160). While a water meter may indicate that a non-compliance has occurred, it does not necessarily explain why. To a technology such as a water meter, an over-abstraction due to a farmer deliberately ignoring his limits looks the same as an over-abstraction due to an unavoidable accident such as a burst pipe. Applying equal sanctions to both cases risks being unfair for the victim of the accident.

Reducing the assessment of compliance against consent conditions to one where there is only two categories; acceptable and not, without any capacity for human judgement to be applied will disempower water users. It will fail to adequately accommodate the complexity that exists in operating an irrigation system on a farm. This deficiency is noted by Busch (2011) when he states that “quantification often assumes that the things quantified are in fact the (only) relevant factors” (p. 145). The deployment of standards is therefore not without risk. While the Regulations empower ECan further, they may also lead to a loss of authority and credibility over time if the organisation fails to acknowledge the limits of the compliant and non-compliant identities constructed for water users.

Power and water users

While the introduction of the Regulations has undoubtedly increased the power of ECan in relation to water users as described above, it also provides the opportunity for the water users themselves to become empowered. Despite the cost of implementing water metering in accordance with the tests outlined in the Regulations, water users were largely in support of measuring water abstraction. They saw it as an opportunity to prove to both ECan and the wider public that they are behaving within their limits, and thus the Regulations have constructed an identity for the water users as good and responsible water users.

The measurement with water meters produces tidy and indisputable numbers to demonstrate how much water has been abstracted, and “to offer one of these numbers is by itself a gesture of authority” (Stone, 1997, p. 177). The water users that participated in the research maintain that they are well aware that they must operate within the rules and that they feel that they have all been tarnished in the eyes of the public and ECan by a small minority of farmers who deliberately disregard the rules and use water inefficiently. Just as ECan was limited in its ability to identify and act on non-compliances in the past due to the lack of monitoring data, water users also had few means to demonstrate that they were abstracting and using water in a responsible manner when faced with such criticisms in the past. This lack of influence, especially given the highly contested nature of freshwater management has led to the wide acceptance of water metering amongst the

farming community and explains the popularity of the idea of the water metering data as proof of compliance with the rules.

The balance of power between ECan and water users is also affected by the presence of the industry service providers, who play a crucial role in both the implementation and the on-going management of the Regulations. Due to the limited resources within ECan, the organisation has had to rely on industry to provide much of the technical expertise and support for water users in meeting the requirements of the Regulations. However, unlike with the water users, ECan has no direct authority over the industry players and instead must rely on standards being maintained by the industry itself through Irrigation New Zealand's Blue Tick programme, a third party certification scheme (Busch, 2011).

In contrast, the water users do have direct influence on the industry as paying clients and users of their services. The relationship between the three parties has worked well to date in relation to water metering, with industry even acting as a mediator between the other two parties in some cases (respondents 14(ISP), 11(ECan)). However, if a major point of contention does arise between ECan and water users in the future, it is likely that the industry will support the position of their paying clients, becoming a useful ally to strengthen the position of water users. This can be seen in the reluctance of respondent 14(ISP) to take on the task of auditing the metering data on behalf of ECan, unless ECan itself pays for it. As this task is unrelated to the requirements of the Regulations in terms of monitoring compliance, respondent 14(ISP) believes that it is unfair to push the cost of such work back onto the water users. Within Canterbury there is already an extensive history of water users employing the industry to support its position, particularly during regional council and environment court hearings (Gunningham, 2008). Indeed, many of the consent holders involved in the Rakaia-Selwyn consent review were represented at the hearing by industry professionals (Canterbury Regional Council, 2010).

Although at first glance it would appear that the Regulations act to embolden the pre-existing power of ECan at the expense of the water users, this is not strictly the case. The access to the monitoring data is also empowering for the water users as they can now prove that they are operating in the acceptable category of the filter standard. This is particularly important for the low water users, as they now have the opportunity to prove not only that their behaviour is acceptable, but also that the past assumptions about their behaviour and its effects are wrong. Through the professional relationship that exists between water users and the industry, water users also have an important ally that will increase their power should a major disagreement arise with ECan.

Power and technology

As previously mentioned, it is impossible to separate standards for people from standards for things (Busch, 2000, 2011; Porter, 1996). In assessing the relationships of power that exist within the framework of the Regulations, it is important to include the technology itself, and not just the human actors.

In installing a water meter to measure the amount of water that is abstracted, the technology is automatically granted an element of power as it is replacing the need for a human to do the task. Furthermore, it is assumed that the technology will not only be able to replace a human, but will be able to perform the task better, as it removes the risk of erratic behaviour that accompanies humans (Busch, 2000; Latour, 1992). Indeed, the Regulations attempt to minimise the influence of people on the technology as much as possible, through requiring that the metering equipment is both sealed and tamperproof (reg 6(6)(d)). In using technology in this way, The Regulations and the regulatory authority assume that the numbers produced will be objective and free of any pre-determined agenda, and will therefore be honest (Wynne, 1988). The Regulations embody what Porter (1995) calls “mechanical objectivity”, where the presumed reduction of subjectivity is an attempt to create legitimacy and validity within the process of quantifying abstracted water.

In delegating the responsibility for quantifying water abstraction to technology, people hope to produce objective numbers that can then be used to support a policy position (Stone, 1997). The technology is therefore not only granted power as the provider of the numbers, but it will also strengthen the power of those who use it, as was seen with the introduction of the TCC technology in Victoria. The highly accurate Flumegate™ technology was also fully automated leaving the farmers with limited capacity to interact with and adapt the technology to meet their needs (Collett, 2010). However, when debate arose with regard to the water that was unable to be accounted for through the TCC system (losses due to leakage etc.), the water managers reacted by increasing the scrutiny of water user behaviour. By exercising power over the water users, the water managers attempted to protect the objectivity of the measured water and the authority of the TCC system. Given the history of conflict around freshwater management to date, it is considered likely that similar consequences may develop in the future in Canterbury, should the legitimacy of the data be questioned.

Whereas the farmers in Victoria had no choice but to adopt the TCC technology, the farmers of Canterbury have had more flexibility in the technology that they can use under the Regulations. Yet, the impacts of standards are distributed unevenly across the sociocultural landscape and it is common for winners and losers to emerge as a result of the introduction of a new standard (Busch, 2000, 2011; Star & Lampland, 2009). For instance, the Regulations have required water users to invest in upgrading their existing infrastructure to enable the installation of the necessary measuring

technologies. For many farmers, particularly those with multiple abstraction points or with older irrigation infrastructure, this cost is significant, frequently in the tens of thousands of dollars. It is therefore perhaps unsurprising that they have sought to minimise the impact of the introduction of the Regulations on themselves and their farms by embracing technology. For instance, many farmers have connected to telemetry networks regardless of there being no regulatory requirement to do so. For those farmers that have no reason to monitor their water abstraction closely (such as the arable farmers that operate well within their limits), being connected to a telemetry network means that they can be sure that they are meeting the requirements of the Regulations, with minimal input from themselves in terms of time and effort. Paying a little more in capital to employ better technology therefore reduces the impact of the standard, as the farmer can ignore it for the majority of the time. The farmers are happy to delegate their responsibility for meeting the requirements of the Regulations to a complex network of non-human machines. They trust that they can ignore the Regulations while focussing on other tasks, safe in the knowledge that they will be notified by email or text message via the telemetry system should any issues arise.

However, the downside of water users delegating too much responsibility to the technology is that it is prone to failure, particularly when the water users do not fully understand how the technology works and the requirements of the Regulations, and thereby unintentionally compromise it. During the research a number of cases of this were described including farmers switching the mains power off at the end of the irrigation season, not realising that this will stop the meter from performing its function, and that the Regulations require continual readings even when no water is taken. As Latour (1992) describes, for technology to successfully measure water in accordance with the Regulations, it presupposes that the user of the technology will behave in a particular way, by not turning the power off for example. Failing to acknowledge these embedded assumptions has therefore led to unintended consequences during the implementation of the Regulations, as the unpredictable behaviour of people has failed to match the predictable behaviour of the technology.

The power of standards in co-production

As described in the preceding sections, the introduction of the Regulations has resulted in an empowerment of ECan, water users and technology. Jasanoff (2004b) argues that “what we know about the world is intimately linked to our sense of what we can do about it, as well as the felt legitimacy of specific actors, instruments and courses of action” (p. 14). It is the distribution of power that determines this sense of what one can do in the world to alter it. Thus, as standards such as the Regulations facilitate and constrain the possible actions that can be taken, it is the distribution of power that gives constructed identities, representations, discourses and institutions authority. Such authority and legitimacy are essential in situations where tension exists between multiple and sometimes divergent constructions of the world. For instance, it is the threat of ECan expressing its

sanctioning power over water users by reducing their allocations that reconfigures the identity of water users from one of environmental protectors to that of protecting access to the resource. Similarly, the power that is granted to technologies such as water meters, data loggers, and telemetry through the Regulations gives the metering data produced as a result its perceived legitimacy, by attempting to remove the potentially erratic behaviour of people from the process. Although this process is flawed as people can never be completely removed as they are always required to deploy technology, as can be seen with the farmers unintentionally affecting their water measurement by turning off the power in the off season.

However, power can be a double edged sword and the same thing that may strengthen one position can also be manipulated to weaken it. It is this ability to simultaneously strengthen and weaken a position that enables standards to reconfigure natural and social orders. Furthermore, the deployment of standards is not without risk. Any shift in the distribution of power across the socio-cultural landscape as a result of a new standard may act to cast doubt upon the authority and credibility of actors as well as their past actions. For instance, the empowerment of water users and their new identity as good and responsible water users created by the Regulations has enabled the water users to reframe the issues of the RSGAZ as a product of a poorly managed whole resource, as opposed to an aggregate of many poorly managed allocations. In doing this, they are opening the policy decisions made by ECan in the past to increased scrutiny.

6.3.3 Path dependence and the nested, layered and interlocking nature of standards

The ability for standards to become well entrenched and difficult to reverse is called path dependence (Busch, 2011). During the research it was found that the Regulations contribute to existing path dependence as well as developing new ones. Furthermore, standards never exist in isolation but are always supported by a complex network of other standards (Busch, 2011; Star & Lampland, 2009). The existence of these networks contributes to and reinforces the path dependence of the standard, as the more complex and entrenched the network, the more difficult it is to reverse or abandon.

In this section, the Regulations are discussed in terms of the path dependence and the network of standards that support them. These features of standards are then described in terms of how they assist in the reconfiguration of natural and social order.

Path dependence and the Regulations

The reason that water metering was not widely implemented across the region of Canterbury prior to the Regulations was due to the path dependence of previous standards in freshwater

management. As described in section 2.2.1, in the absence of a regional plan, ECan relied heavily on the resource consenting process to manage freshwater resources, and it was not until 2004 that water metering became a standard condition for all consents issued (Gunningham, 2011b). Furthermore, due to the high capital costs associated with irrigation infrastructure, these consents tended to be issued for long durations, often 35 years. To retrospectively apply new conditions (such as the requirement to monitor water abstraction with a meter) to existing consents it was necessary for ECan to either wait until the consent expired and an application made for its renewal, or alternatively ECan could withdraw consents in order to review and reissue them. Both of these options demonstrate the path dependence embedded within the consenting process, as they have both been proved costly methods to alter the status quo. The long duration of Canterbury's consents has meant that to wait for them to expire is costly in terms of time as the turnover is so slow, and as demonstrated by the Rakaia-Selwyn consent review (section 2.2.3), the review of consents proved to be costly in terms of money, time and the strain placed on the relationship between water users and ECan.

The Regulations were therefore crucial and offered a way for ECan to circumvent this existing path dependence. As they are a national policy produced within the existing framework of the RMA, they require water metering to be installed by all consent holders (over the five litres/second threshold), regardless of the specific conditions of their individual consents. They therefore complement the existing freshwater management framework making any reversal of original standards (such as resource consents) unnecessary. However, in building on the existing processes, the Regulations are further increasing the prevailing path dependence. As the implementation of the Regulations is attached to resource consents, they further entrench the use and reliance on resource consents in freshwater management within Canterbury.

In addition to contributing to existing path dependence, the Regulations will also develop their own path dependence in Canterbury due to the large number of water consents in the region and the scale of the task of implementation. With nearly 6,000 consents subject to the requirements of the Regulations in the first stage alone, making any radical changes to the standard, or replacing it with something new is likely to be very difficult. Water users, industry service providers, and ECan have all invested both time and money in developing infrastructure (both physical and organisational) to support the implementation and the on-going management of the Regulations. While changes that are commensurable with this existing infrastructure may readily occur (the replacement of a meter unit with an upgraded model for example), more drastic changes that do not allow for the existing infrastructure would likely be met with a great deal of resistance.

Furthermore, it is likely that the data that is produced as a result of the water metering will contribute to this path dependence over time. The majority of the research's participants remarked that the metering data will be most valuable once a large data set has been built up, containing many seasons worth of metering data. At the farm scale it is thought that this will be useful for identifying trends in water demand such as the variation in water demand with different crops and help drive improvements in water use efficiency. It is also predicted that it will be useful for identifying issues with irrigation infrastructure, such as declining performance of a pump indicating that maintenance is required, or a sudden deviation from the normal abstraction rate revealing a leak in the system. When used in aggregate at the catchment or region scale, the data over time will highlight trends in water demand, showing where and when water is being abstracted, and hopefully assisting to better understand how this water abstraction affects the resources as a whole.

Once a data set comprising many years of data is built up, and more specifically, once this data set is embedded within the knowledge and processes that govern freshwater management, it will be very difficult to introduce new ways of measuring or new formats for the data, without compromising the ability to continue using the data already obtained. For instance, if a new rule requires soil moisture levels to also be monitored and reported alongside the flow metering, will the new data for flow metering be directly equivalent and comparable to the older data captured in isolation? Or will it render the historical data set redundant? The path dependence of data is discussed in detail by Bowker and Star (2000) who use the example of the International Classification of Diseases (ICD) to demonstrate the difficulties in creating standardised reporting processes for complex situations such as human illnesses and cause of death. They describe how as medical knowledge has improved throughout the history of the ICD, some of the original categories of classification are now no longer appropriate as they are too vague. However, to remove these categories or to replace them with a collection of more defined ones, while it will improve the ICD for the physician trying to attribute a cause to a death, it will also create difficulties for statisticians and epidemiologists who are interested in the progression of trends over a time. As many of the participants see value in the metering data for distinguishing trends over time, major changes in data collection or form will likely create similar issues for the Regulations in the future.

Nested, layered and interlocking network of standards that support the Regulations

A standard for people or objects never exists in isolation and is instead always supported by a complex network of other standards, nested, layered and interlocked together (Busch, 2011; Star & Lampland, 2009). This feature of standards contributes to their path dependence. At the very least, every standard is supported by a standard of categorisation, to determine exactly which group of people or objects the standard applies to. Standards are also commonly supported by a standard of measurement, to determine whether the object or person in question does indeed meet the

standard. Further standards may be invoked less directly, such as one that applies to a specific piece of equipment used in measurement, or a standardised method of certifying or validating that the object or person has met the standard.

Other standards involved in the implementation of the Regulations

The interlocking nature of the Regulations and resource consents can be seen in Canterbury where some water users have installed meters due to consent conditions (such as those involved in the Rakaia-Selwyn consent review), and others due to the Regulations. These two processes exist in parallel, despite those water users who have water metering as a requirement of their consent conditions tending to have more stringent requirements than those required under the Regulations (as described in section 2.2.3). In the consented cases, ECan has introduced additional requirements to reflect the intention to use the metering as an input into predictive modelling and to inform decision making. Due to the inability for ECan to use the resource consenting process to implement water metering across the whole region (a result of the path dependence of the consenting process), the Regulations have provided an opportunity to introduce set of minimum requirements region wide. The more stringent requirements needed to use the data in predictive modelling can then be added through attrition as existing consents expire and are renewed. In the interim, the data from the Regulations will enable the groundwork for using the data most effectively to be established.

Regardless of whether water metering is required by the Regulations or through a resource consent condition, the quantification of abstracted water by the use of a water meter will invoke a range of nested standards that apply to the technologies used. The manufacturers of water meters specify the environmental conditions and installation configurations under which their technology can be expected to perform to a specific accuracy. Furthermore, the metering technology will have been designed to work alongside the standards for other technologies, such as pipes (standard diameters, materials etc.) and electricity distribution (standard phase, voltage etc.). It is these well embedded nested standards that have made the implementation of the Regulations relatively straightforward and free of significant challenges for water users, particularly those with modern irrigation infrastructure that is already commensurable with the standards that the metering technology relies on. In some cases, the entrenchment of these standards is so well established that farmers were able to simply purchase and install the required water meter themselves largely forgoing the need for the technical support of the industry service providers.

ECan was also able to use the existing network of standards to their advantage during the implementation of water metering across the region. The Regulations require that all water meter installations be verified as being suitably accurate, however, they do not specifically define verification or what this should involve. Due to the huge number of installations that ECan was

having to deal with across Canterbury, actively visiting each meter in turn to physically test its accuracy (with a second measuring device for example) is simply not possible. ECan has therefore welcomed the ambiguity around verification within the Regulations, and instead of using a measurement to verify meter accuracy they exploit the entrenched network of standards that already exist for the metering technology. If the meter itself is suitable for the environment and the installation of the meter is in accordance with the manufacturers' specifications, it is assumed that it will be performing adequately and meeting the accuracy requirements. Furthermore, rather than checking every installation visually themselves, ECan relies on the certification of the industry professionals through Irrigation New Zealand's Blue Tick accreditation scheme to ensure that the meters are installed to a high quality and in accordance with the right network of standards. Thus, the existence of a stable network of other standards has reduced the number and magnitude of the challenges associated with the implementation of the Regulations significantly.

The relationship between the standards of a network often becomes most apparent when a technology fails to perform as expected (Busch, 2011). For example, during the research a situation where the telemetry network stopped transmitting the data was described by some of the participants. Initially there was no obvious reason why this failure had occurred as all the necessary components appeared to be working as they should, though after a period of weeks it was eventually discovered that the erection of a new cell phone tower in the vicinity of the telemetry base station was interfering with the outgoing signal. Both the cell phone tower and the telemetry system utilise the same transmission type and therefore their standards networks overlap. However, the operators of the cell phone tower and the base station both failed to recognise the overlap, leading to the problem with transmitting the water metering data. Although both systems are using the same transmitting system and therefore some of the same standards, they had been set up assuming that they were operating in isolation. Once the existence of the cell phone tower had been identified, it was relatively straightforward for the base station signal to be adjusted to accommodate the other.

Future expansion of the standards network

The lack of accurate data around how much water is being abstracted in Canterbury has been identified as a significant barrier to effectively managing freshwater resources (Gunningham, 2008; MfE, 2013c; Weber et al., 2011). The introduction of the Regulations has therefore been welcomed by many as a way of addressing this deficiency in information. Both farmers and ECan wish to see the metering data used for more than just compliance monitoring. They believe that it can contribute to improving the science of the freshwater resources as an input for predictive modelling activities.

However, the use of the metering data to inform science in this way requires the data to be of a much higher quality than if it is to be used to monitor compliance. This has been the driver for ECan

in implementing more stringent metering requirements where it is in a position to do so through resource consent conditions. The Regulations themselves contain very little detail about the form that metering data should be reported as, and so prior to their implementation, ECan worked alongside the industry to develop a simple standard data capture and reporting format to ensure that there was consistency across the region. This standard for reporting water metering is suitable for assessing the compliance of a water abstraction or even for assessing regional or catchment scale trends in water abstraction. However, it is insufficient in depth of detail to be used as an input into predictive modelling scenarios. Thus in order for the Regulations to move from a filter standard for measuring compliance, to a tool for the informing of science (as is desired by both water users and ECan), it is necessary to add another layer of complexity to the existing standards network, in the form of a new data management standard.

While ECan has already begun work on this new standard, questions have arisen over who should pay for the increased work associated with it. For the data to be used in predictive modelling it must be audited so that any anomalies in the data can be attributed to a cause or removed. Given the huge number of consents in Canterbury that are metered, this auditing is a resource intensive process, however, neither ECan nor the industry currently has the capacity to perform the function. As found during the research, the industry is reluctant to take on the task without ECan paying them for the work, as they do not wish to push the cost of doing so back onto their clients, the water users. The water users meanwhile, feel that they have already made significant financial contributions during the implementation of the Regulations. Although they wish to see the data being used to improve freshwater management, they see this next step as the responsibility of ECan.

This emerging conflict is typical of the negotiation that accompanies the development of all standards. As standards are poorly distributed across the socio-cultural landscape, they create winners and losers when introduced (Busch, 2000, 2011; Star & Lampland, 2009). It is therefore unsurprising that where possible, the actors involved will seek to manipulate the final form of the standard so that it is to their benefit, or at worst, does not create any negative impacts. As the Regulations were implemented at a national scale as a mandatory requirement, the water users were limited in their ability to participate in negotiations during their development and implementation. They instead accepted the financial costs of the implementation of meters, in part because they could see that there was a need for the metering data. Furthermore, the majority of farmers benefitted from the metering directly through the ability to prove that they are operating within the permitted limits, or in some cases improving their farm management (by ensuring they did not exceed their limits for instance).

However, improving the science that informs freshwater management decisions will not have any direct benefit to the farmers. Rather, any improvements to freshwater management in Canterbury will benefit the whole region indirectly, not just farmers. Furthermore, if the science is used to justify reducing the allocation limits of low water users as is their current concern, it will be to their detriment. Due to the lack of direct benefit, potential for negative impacts and the financial investment already made, farmers will likely negotiate to reduce the impact of any future standards as they have done with the use of technology to date. During the research it was indicated that the industry would support them in this as they feel their loyalty ultimately lies with the water users as their paying clients, rather than with ECan. The evidence from the TCC project in Australia would support this finding. In this case the farmers also had no choice but to install the new technology. When the technology was implemented, the water managers did not negotiate an acceptable standard method for quantifying water losses from the system. Thus, when it failed to deliver all the promised benefits (with some farmers worse off than before the TCC project), the farmers began to cast doubt on the whole programme by highlighting the inability for the new technology to adequately account for water losses. Without that nested standard to account for losses, the farmers had a target at which to vent their frustrations.

The role of path dependence and standards networks in co-production

Common characteristics of standards include that they always exist within a network of other supporting standards. The complexity of this network contributes to a standard's path dependence, or the difficulty in altering or reversing a standard once it is established. These features of standards contribute to the co-production of natural and social order because as Reardon (2001) argues orderings are never constructed anew, but are instead built upon past configurations. Therefore, constructed identities, representations, institutions and discourses formed as a result of a new standard embody past conflicts and settlements.

As already described, the Regulations exist within a network of standards ranging from the technical specifications that accompany the metering technologies, through to the resource consents that determine how much water is allocated to each user. The presence of these other standards has helped to shape the form of that the new constructions have taken. For example, quantification as a means of knowing and understanding the world was already well entrenched within the management of water resources of Canterbury before the Regulations were introduced, as can be seen by the high value placed by both water users and ECan on representations produced by predictive models. The discourse of "we cannot manage what we do not measure" that was frequently used during the research in reference to freshwater resources reflects the dominance of the modelled representation for water in Canterbury. These discourses and representations have not been constructed solely on the basis of the introduction of the Regulations, but rather, they are

contributing to an existing and well established network of standards that support a 'rule-by-numbers' approach to governance of freshwater resources.

Furthermore, ECan is developing a data management protocol to further support the Regulations, to assist in making them (and the data they produce) better suited to being used in predictive models. This will further increase the path dependence of the Regulations and provide increased authority to the discourse and representations as described above. Similarly, the introduction of the Regulations under the legislative framework of the RMA and the fact that they apply to resource consent holders, increases the path dependence of both of these tools of governance. In doing this it also strengthens the institutional role of ECan in the management of freshwater resources in Canterbury as its power over water users is granted through these regulatory standards.

Water management in Canterbury in the past has been characterised by conflict, part of which has stemmed from the use of assumptions in the absence of measured data. As previously described, the Regulations have constructed an identity for water users as good and responsible users of a sought after resource. This new identity has not been constructed *de novo* but has been constructed from the basis of these past conflicts instead, leading the farmers to welcome the opportunity to prove that they operate within their consented limits. Thus the contestations that have occurred at other points in the network of standards in the past (debate about the new resource consent conditions imposed during the Rakaia-Selwyn consent review for instance) have contributed to the reconfiguration of natural and social orders that have occurred through the introduction of the Regulations.

The path dependence of the Regulations that has been created by the large number of consents in Canterbury to which they apply, as well as the infrastructure that has been developed to enable their implementation, mean that the orderings that has been co-produced as a result of the Regulations will be similarly difficult to reverse in the future. As these orderings have been constructed on the basis of past experiences, to completely reverse these constructions would require the past contestations and settlements to be acknowledged, scrutinised and perhaps renegotiated. This can be seen with the new farmer identity described above. With this identity, the farmers have reframed the issues of water management in the RSGAZ from the aggregate of many poorly managed allocations at the farm scale, to one stemming from the management of the resource as a whole at the regional or catchment scale. The ability for this representation of the resource to shape the direction of future policy changes in freshwater management will therefore be limited by the capacity for the actors to recognise and respond to the meanings, identities and practices that others have already assigned to the natural world in the past (Reardon, 2001). ECan for instance is unlikely

to readily accept this representation of the resource and its management as it will cast doubt on their past decisions and actions.

Thus, as co-production always constructs identities, representations, institutions and discourses on the basis of past constructions, the existence of a network of supporting standards and path dependence within a standard will always contribute to how natural and social orders are reconfigured when a new standard, such as the Regulations, is introduced.

6.3.4 Nested, layered and interlocking constructions

It is not only the standard that can be thought of as nested, layered and interlocking. The identities, representations, institutions and discourses that have been constructed by the introduction of the Regulations also exist not in isolation, but alongside each other. As with standards, this network helps to stabilise the constructions. Although multiple and divergent constructions may arise (as with the arable farmers' identities), it is their relationship towards the other constructed identities, representations, discourses and institutions that will determine whether they become stabilised.

Within this case study, the effect of this nesting can be seen. The institution of practice that is the Regulations themselves has co-produced the construction of discourses, representations and identities of natural and social orders through constraining and facilitating different actions. This institution contains embedded assumptions around how the metering data will be of use, which has contributed to the development of the "cannot manage what we do not measure" discourse, the dominance of the modelled representation of the resource, and the water user identity as either compliant or non-compliant. These constructions all reflect the hierarchical position of power that ECan is in, as the organisational institution charged with implementing the Regulations and managing the resources. However, within this relatively stable network there also exists an unintended, and therefore less stable representations and identities that are in tension with those described. The empowerment of the water users through use of the metering data as proof, has given rise to the identity of water users as responsible users of their allocations and the representation of the resource as poorly managed. Although, as these new identities and representations have the capacity to reduce ECan's entrenched credibility and authority as an institution, it will be difficult for them to become stabilised within the network without the constructions that they are nested within being scrutinised and renegotiated.

6.4 Standards and co-production in the context of freshwater management in Canterbury

Freshwater management in Canterbury has a history of conflict as multiple users compete for the increasingly scarce resources (Gunningham, 2008, 2011b; Jenkins, 2007; Lennox et al., 2011). One of

the key issues that have been identified in the region is the lack of accurate information around how much of the total allocated water is actually being abstracted. Without this knowledge, many stakeholders believe it is difficult to really understand the effects of the abstraction on the resources themselves and the wider environment. The lack of monitoring of resource consents had therefore been identified as a barrier to effectively managing the resources prior to the introduction of the Regulations (Gunningham, 2011b; Weber et al., 2011).

However, despite the need for better monitoring being identified, the path dependence of the existing management processes (through resource consenting) created a significant barrier to ECan pursuing it at a regional scale. As a standard introduced nationally within the framework of the RMA, the Regulations have enabled ECan to implement the much needed region-wide water metering. To achieve this they have exploited the path dependence of the existing system, by making the new monitoring requirements mandatory for (virtually) all consent holders. While this approach has enabled ECan to avoid expensive alternatives for introducing metering, it has also reinforced the already strong path dependence of the use of resource consents in the management of freshwater resource management in Canterbury and New Zealand as a whole.

The RMA and the resource consenting process are considered to be part of the reason that freshwater management has become such a contentious topic. The expense of the process, the reliance on first-come-first-served allocation, and the inability to fully account for accumulative effects of multiple takes are all considered to be major drawbacks to the system (Gunningham, 2011a; Lennox et al., 2011). Although the data that will be produced as a result of the introduction of water metering is intended to improve freshwater management, the Regulations will also contribute to the entrenchment of the consenting process in the allocation of freshwater. This could potentially limit the ability to introduce new systems or tools for the management of freshwater resources in Canterbury in the future.

As a result of the introduction of the Regulations, accurate and extensive data detailing the actual volume of water abstracted will be available for essentially the first time. All of the participants in this research expressed the need for this data to be used for more than just the monitoring of compliance, stating that “we cannot manage what we do not measure”. They see the real value in the data is not so much at the farm scale, but in aggregate at the catchment and regional scale. In the absence of this data in the past, ECan has had to rely on assumptions about how much water is abstracted. Given the uncertainty associated with these assumptions, many farmers believe that they have greatly overstated the abstraction rates and thus the estimation of the resulting effects is one of the major sources of the conflict between water users and ECan. Accurate measured data will always have greater legitimacy than assumed figures for the same parameter.

However, the metering data from the Regulations, whilst it is accurate, there are many other sources of uncertainty in the understanding of groundwater resources such as the total volume of the resource and the degree to which different aquifers are connected. The Regulations are therefore unlikely to offer a magic silver bullet to remove all sources of contention. For instance, while the data may be useful for updating and improving both of the dominant models used to represent groundwater resources in Canterbury (Aqualinc vs bathtub), the points of distinction between the two will remain. The metering data alone is unlikely to remove all uncertainty associated with the estimation of the connectivity of various aquifers beneath the Canterbury plains.

Furthermore, as argued by Porter (1996) and Stone (1997), all numbers are open to manipulation and interpretation, regardless of how accurate the process for obtaining them. As can be seen in the farmers' construction of identity as responsible water users, and the representation of the groundwater through models, the numbers appear to be already being enrolled to push the direction of future policy decisions to favour (or at least to minimise the harm to) the water users. As a result of the new farmer identity, the dominant issues in the RSGAZ (over-allocation, effects of abstraction on lowland streams) have been reframed as a product of failures in the management of the resource as a whole, rather than an aggregate of failings at the farm scale. However, this research has also demonstrated that the threat of ECan exercising its sanctioning power is enough to construct a second identity for the farmers, changing from environmental guardians to protecting their access rights to exploit the resource. These divergent identities show how the distribution of power that a standard creates, alters the configurations of natural and social orders.

Thus, with the broader context of freshwater resource management in a state of flux both at the regional and national level, how the identities, representations, institutions and discourses that have been co-produced with the introduction of the Regulations in Canterbury will shape policy decisions remains in the future remains uncertain. However, it is considered likely that as a more substantial data set is built up, the constructed identities, representations, discourses and institutions that have been identified through this research at this early stage of the Regulations life will evolve greater authority and legitimacy in time.

The empowerment of the farmers that has come through the ability to use the metering data as proof is considered to be one consequence of the Regulations with the greatest potential for future implications. In a resource management system that already places a great deal of emphasis and value on quantification, the Regulations have provided the farmers with their own data that they can use to more actively participate in the number-centric debate around how best to improve freshwater management. Thus, they may be able to negotiate the future direction of policy change so that it is to their benefit, or so that they are at least not any worse off. For example, although the

farmers wish to see the data used to improve resource management decision making by informing the science of predictive models, the research indicates that they will likely oppose any attempt to push the costs of doing so back onto them as the water users have already invested considerable amounts of money during the implementation of the water metering programme.

The findings of this research are especially relevant given the reforms to the regulatory framework that are currently taking place at the national level. In November 2013, the Ministry for the Environment (MfE) released a discussion document for public consultation on proposed amendments to the National Policy Statement for Freshwater Management (NPSFM) 2011 (MfE, 2013b). The NPSFM is the overarching document intended to guide regional councils when setting objectives within their regional plans. The discussion document released by MfE outlines the changes to the NPSFM, intended to make it more effective and easier for regional councils to implement at the regional level. Some of the key amendments include:

- Requiring councils to implement water accounting systems to monitor water quality and quantity;
- A National Objectives Framework including standard values and attributes is to be developed to assist councils in negotiating the outcomes for freshwater wanted by their communities;
- National bottom lines for the two compulsory values (ecosystem health and human health); and
- Providing standardised measuring requirements for long term monitoring of water quantity and quality parameters.

These proposals indicate that the 'measure-to-manage' approach to freshwater resources is set to continue in the future, with the Regulations also set to become increasingly important as a key component of any water accounting system. The co-production of natural and social orders, as has been seen with the introduction of the Regulations in the RSGAZ, can therefore be expected to continue as these standardised management tools are implemented by regional councils across the country.

Chapter 7 Conclusions

In this final chapter, the main findings from this research are summarised in terms of the identities, representations, institutions and discourses that describe both the freshwater resource and those social actors who use and manage it, that have been identified as being co-constructed as a result of the intervention of the Regulations. The role that the Regulations have played in this co-production of what is known, and how it is known is also summarised. The chapter will be concluded by a brief discussion as to the limitations of the research and possibilities for future research.

7.1 Conclusions drawn from this research

This research has sought to evaluate the role that the Regulations have played in reconfiguring previously taken for granted relationships between stakeholders and the environment within the context of freshwater management in Canterbury. In examining the Regulations through the conceptual lens of co-production, it has been found that there have been multiple re-orderings of both natural and social systems along the four pathways that the literature identifies as being common sites for co-production: making identities, making representations, making discourses and making representations (Jasanoff, 2004c; Reardon, 2001; Swedlow, 2011). As with standards, these exist within a nested network that acts to stabilise the dominant constructions.

7.1.1 Making identities

The Regulations are a filter type standard that is intended to sort the acceptable from that which is not. Thus in being implemented into Canterbury where monitoring of water consents has been historically low and therefore difficult for ECan to enforce compliance, the Regulations have immediately constructed identities for the abstracted water as either being compliant or not. Furthermore, the literature dictates that due to symmetry, it is impossible to separate standards for things from standards for people (Busch, 2000, 2011; Porter, 1996). It is this symmetry of standards that facilitates the co-production of natural and social orders, as seen with the Regulations, as it is not only the abstraction of water that is given an identity of compliant or not in the eyes of ECan, but also the water user. While it is the Regulation's inherent symmetry and filtration capacity that co-produces natural and social orders, it is the exertion of power and control that they enable, their path dependence, and their network of supporting standards that has determined the form that these reconfigurations have taken.

As a tool of governance, standards are always deployed from a position of authority and they also enable sanctions to be imposed upon the standardised, ranging from a gentle nudge or incentive, through to penalties backed by the legal system. It is this power and control that is embodied within

standards that enables them to both facilitate and constrain the actions of those subject to the standard. This power is never evenly distributed across the socio-cultural landscape though. As seen with the Regulations, the distribution of power contributes to the shaping of orderings within identities, representations, discourses, and institutions. The Regulations undoubtedly increased the power that ECan already held over water users by allowing greater scrutiny of their behaviour, with the farmers noticing a corresponding increase in enforcement activities by the regulatory authority. However, despite this the water users have also been empowered against ECan with the metering data enabling them to demonstrate to ECan that they are indeed operating within their consented limits. A new identity has therefore been created for the farmers as good and responsible users of their allocated portions of the resource. For the arable farmers this identity extends further to one of environmental protector as their unused water remains within the environment, but is protected from use by others. Yet, the threat that ECan will use the Regulations as justification of exerting their sanctioning power through the reduction allocations of low water users has created a second identity for them. They not only have an identity as protectors of the environment, but also as hoarders, protecting their ability to exploit the resource in the future. In the extreme form, this identity may have a perverse and unintended consequence of motivating more water use as the farmers seek to offset the imbalance of power and protect their allocation. These divergent identities have evolved in response to changes in the distribution of power between ECan and farmers.

7.1.2 Making representations

Importantly, power does not come without risk for those deploying the standards. The deployment of standards can have unintended consequences. This new responsible water user identity has enabled the issues of the RSGAZ to be framed (by those with the new identity) as a product of poor management of the resource at the catchment and regional scale, rather than as a collection of poorly managed individual allocations. In the face of the now empowered water users, ECan could potentially lose credibility if this new representation of the resource gains legitimacy through increased scrutiny of ECan's past decision making.

The subterranean nature of groundwater makes these resources difficult to directly quantify. However, the portion of this resource that is abstracted for use is in contrast very measurable. The intention of the Regulations is to take this quantifiable portion to represent freshwater (as a whole) as a measurable, and thus controllable resource. It is intended to do this through using the metering data not only to manage and monitor water users' behaviour, but also to contribute to the science of predictive modelling. The Regulations are therefore contributing to both what we know, and how we know it, reinforcing the dominance of the knowledge of technical experts and models in describing the world through the co-production of representations. This dominance is shown by the assumption

embedded within the Regulations that the data will be of most use within ECan's institution for both compliance and science purposes. Thus, the use of the data by water users as proof and the construction of a responsible identity for them is an unexpected consequence of the introduction of the Regulations.

7.1.3 Making discourses

The Regulations as a standard of quantification also contain embedded assumptions within them as to the value of the metering data: we would not be investing time and money into the quantification of water abstraction if there was not some preconceived value placed on the data. These assumptions become apparent through the power that is granted to the water measurement technology. In using technology rather than people to measure, it is presumed that the numbers produced will be value free, objective and therefore have greater legitimacy. The Regulations have not created the value placed on numbers. Rather they have contributed to reinforcing the existing path dependence of the freshwater management systems in Canterbury, as seen by the 'rule-by-numbers' discourse of "we cannot manage what we do not measure", and the reliance on predictive models to represent freshwater resources, in the absence of being able to measure them directly. These discourses are already well entrenched within Canterbury and thus the Regulations have reinforced the existing orderings of nature as something that can only be truly understood through the numerical language of technical experts in society. Thus, the Regulations embed, deploy and justify the 'measure-to-manage' discourse.

As demonstrated in the results, the interviewed stakeholders see the metering data as a way to reduce some of the uncertainty and conflict that has characterised freshwater management in the past. Particularly, the conflict that has arisen in relation to the two competing modelled representations ('bathtub' versus Aqualinc) and the degree of connectivity that exists in the groundwater system in the region. However, as Stone (1997) and Porter (1996) argue, despite the metering data being accurate with a perceived authority, numbers are always open to interpretation. The intended consequence of the Regulations is to improve the science of predictive models to assist the stakeholders move beyond what Weber et al. (2011) refers to as a 'science impasse' in the RSGAZ. However, due to the complexity of the science, the multiple sources of uncertainty, and the history of contention between the stakeholders the results of this research support his conclusion that improved science alone is unlikely to lead to better freshwater management outcomes (Weber et al., 2011). Thus, the discourse of "we cannot measure what we do not measure" is indicative of past conflicts and settlements that have occurred in Canterbury, which have stabilised the current problems in freshwater management as originating from a lack of information. Both those who think

the RSGAZ is over-allocated and those who do not think that the data will in time reveal the other opposing party to be wrong.

7.1.4 Making institutions

One of the contributing factors to a standard's path dependence is the complexity of the network of other standards that support it, as no standard exists in isolation. The existing network of standards is one of the reasons that few major challenges arose during the implementation of the Regulations in Canterbury beyond addressing the vast number of consents in a short time frame. Reardon (2001) argues that the co-production of nature and society never occurs *de novo*, but rather is always on the basis of past experiences, contestations and settlements. This can be seen in the differences in construction of the institution of practice of the Regulations between the arable and dairy farmers in their day to day farm operation. For the dairy farmers operating large-scale, sophisticated irrigation infrastructure that is necessarily highly standardised and largely hands-off, the structured rules of the Regulations fit well within how their farms are operated, complimenting existing processes of farming at a distance (monitoring systems online for instance). Furthermore, these irrigation systems are operated much closer to their limits as irrigation is a necessary rather than a supplementary activity. The Regulations have acted to facilitate better management, by enabling the farmers to more accurately manage their water use within their limits. In contrast, the arable farmers tended to use less sophisticated technologies that required more manual input. As such, they are out 'living one's field', receiving first-hand experience of their water use on their land. Thus, institutionally the metering data neither facilitates nor constrains the arable farmers' behaviour or relationship to the resource. The complexity of the system of standards into which the Regulations has been introduced at the individual farm scale has therefore altered how this institution of practice has been constructed.

Furthermore, the Regulations have not only contributed to existing path dependence by reinforcing existing standards such as resource consents in freshwater management as well as requiring large investment by water users, ECan and industry. It has been found that they are also likely to continue to further entrench this path dependence in the future. ECan is developing a new standard for the management of the metering data, to better facilitate its use in the science of predictive modelling. By increasing the network of standards that support the Regulations in this way, ECan is not only strengthening the path dependence of the Regulations, but is also strengthening its own institutional role in the management of freshwater resources in Canterbury. The construction of this new data management standard also further reinforces the 'measure-to-manage' discourse and the dominance of the expert modelled representation of the resource.

This study has demonstrated that the introduction of the Regulations in the RSGAZ has reconfigured the orderings of natural and social systems along the pathways of making identities, making representations, making discourses and making institutions. It is the inherent symmetry of the Regulations that have enabled this co-production as they filter what is acceptable and what is not for both the abstracted water and those that abstract it. It is the power and control, the path dependence and the existence of a network of other supporting standards that have shaped the form of these reconfigurations that have taken place in response to the introduction of the Regulations. This new standard has reinforced some existing orderings such as the dominance of quantification and modelled representations and the measure-to-manage discourse for understanding freshwater resources. However, it has also created a perhaps unexpected redistribution of power, particularly amongst the social actors. The relationship between water users and ECan has been highly contentious in the past, and thus it is expected that the empowerment of water users will enable them to determine the direction of future policy in a manner that is either to the benefit of, or at least minimises the negative impacts on water users. If the water metering data continues to support the representation of the resource as a poorly managed whole, as opposed to a collection of poorly managed parts, the path dependence of the whole system might require past points of conflict and settlement to be renegotiated before changes to the freshwater management system in Canterbury can be made.

While the introduction of the highly standardised TCC technology in northern Victoria saw the emergence of clear winners and losers amongst those involved, this has not happened to the same extent in the RSGAZ with the introduction of the Regulations. But, although the relationships between the social actors and the environment have undoubtedly been altered by the introduction of this new standard, the extent to which these changes impact on the management of freshwater in Canterbury is likely to become more apparent in the future as a full metering data set is built up, and the data starts to be really be examined in terms of justifying policy decision making.

MfE has recently proposed changes to the National Policy Statement for Freshwater 2011 which seek to increase the standardised monitoring and measurement of not only water quantity, but also water quality across New Zealand. While the importance of accurate data cannot be underestimated in better understanding a complex issue such as freshwater management, the results of this research demonstrate that the introduction of a standard for quantifying an aspect of the resource will never only measure just that aspect. It will also simultaneously measure the social actors involved, leading to a reconfiguration of both social and natural orders. Thus, for future quantification tools to be effective, it is important that they acknowledge this symmetry of standards. Failure to do so may lead to unintended consequences.

7.2 Research limitations and future research direction

7.2.1 Limitations of the theoretical framework

Co-production does not provide a comprehensive theoretical framework, but rather it offers a lens through which the world can be viewed, to provide a descriptive richness for the interpretation of complex phenomena (Jasanoff, 2004a). As a conceptual framework, Jasanoff (2004a) argues that it is not intended to provide deterministic causal explanations and thus, it is limited in its ability to predict future outcomes (Swedlow, 2011). Thus although co-production has enabled this research to examine the role that standards play in reconfiguring natural and social order in the context of the management of freshwater resources in Canterbury, the framework has only allowed limited capacity for predicting how these orderings might be further altered in the future, and the effects of these future configurations on the broader freshwater management policy context. Possible implications for the future made during the discussion of the results in the broader context are therefore largely conjecture.

7.2.2 Limitations of the research methodology

The main limitations to the study outside of the constraints of the theoretical framework were in relation to the methodology and the time constraints of the research period.

Due to the requirements of the human ethics approval, enrolment of participants was on the basis of opting-in to the research process. The participants that took the time to respond to the request for participation are therefore likely to be those who are already actively engaged with processes to do with the management of freshwater in the region. Particularly for the farmers, the fact that those approached as part of the research belonged to water user groups would indicate that they are proactive in this sense. Although during the interviews some participants referred to the “grumpy old men” farmers in the RSGAZ who oppose all attempts to regulate their behaviour, none of the farmer participants that were interviewed could be considered to be of this type. The interviews conducted therefore might not have covered the whole range of opinions held amongst the farming community.

Another limitation related to the participants is the lack of industry service providers that took part. As described in section 4.3.2, it is thought that a major windstorm that struck Canterbury during the data collection phase resulting in widespread damage to irrigation infrastructure is likely the cause of the poor response from the industry. Unfortunately because the research had to be completed within a year, it was not feasible to wait until the end of the irrigation season to re-approach those from the industry at a less busy time. Interviewing more industry service providers may have provided a greater level of detail into the relationship between the industry and both ECan and water users and how this has changed as a result of the Regulations.

7.2.3 Possible future research

The limitations of this research as described above could be addressed through further research involving a greater number of participants, particularly including farmers from more diverse backgrounds and a greater number of industry professionals.

This study has focused on the introduction of the first of three stages of the Regulations. The deadline for the second stage of implementation for those whose abstractions are of between 10 and 20 litres/second is in November 2014, and the third stage (for those five to ten litres/second) has a deadline of November 2016. Investigating these later stages through the same co-production lens could therefore add a greater level of complexity to the analysis done in this study with regard to the Regulations. Although the stage that has been studied here includes the vast majority of the allocated water in Canterbury, the latter stages may present unique issues. For instance, the cost of implementing the Regulations for farmers of smaller takes is likely to be much greater proportionally to the benefit they get from the abstracted water due to the economies of scale.

Furthermore, this study has only focused a representative catchment for the Canterbury region. The Regulations have been implemented nationally and therefore further studies could be undertaken in other regions of New Zealand to enable comparison to help determine why the orderings that have been co-produced in Canterbury have arisen.

Appendix A

The Resource Management (Measurement and Reporting of Water Takes) Regulations 2010

2010/267



Resource Management (Measurement and Reporting of Water Takes) Regulations 2010

Anand Satyanand, Governor-General

Order in Council

At Wellington this 23rd day of August 2010

Present:

His Excellency the Governor-General in Council

Pursuant to section 360(1)(d) of the Resource Management Act 1991, His Excellency the Governor-General, acting on the advice and with the consent of the Executive Council, makes the following regulations.

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Regulations

1 Title

These regulations are the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010.

2 Commencement

These regulations come into force on 10 November 2010.

3 Interpretation

(1) In these regulations, unless the context requires another meaning,—

Act means the Resource Management Act 1991

full pipe means a closed pipe or conduit that is full of water when it is conveying water

permit holder, for a water permit, means the person who holds the permit

water permit means a water permit under the Resource Management Act 1991 to which these regulations apply

water year, for a water permit, means a period during the term of the permit—

- (a) starting on 1 July or, for the permit's first water year, starting on the first day on which these regulations apply to the permit; and
- (b) ending on the next 30 June or, for the permit's last water year, ending on the last day on which these regulations apply to the permit.

- (2) Unless the context requires another meaning, a term or expression that is defined in the Act and used, but not defined, in these regulations has the meaning given by the Act.

4 Regulations apply to certain water permits

- (1) These regulations apply only to a water permit that allows fresh water to be taken at a rate of 5 litres/second or more.
- (2) However, these regulations do not apply to a water permit if the taking of water under the permit is non-consumptive in that—
- (a) the same amount of water is returned to the same water body at or near the location from which it was taken; and
 - (b) there is no significant delay between the taking and returning of the water.

5 Determining rate in litres/second for purposes of regulations

- (1) The rate at which fresh water may be taken under a water permit, for the purposes of regulations 4(1) and 13(2), must be determined under this regulation.
- (2) If the permit specifies only 1 rate at which water may be taken in litres/second, then that is the applicable rate, even if the permit specifies any other rate.
- (3) If the permit specifies 2 or more rates at which water may be taken in litres/second, then the applicable rate is the greatest of those rates, even if the permit specifies any other rate.
- (4) Otherwise, the applicable rate is the greatest rate at which water may be taken under the permit, after applying the following rules:
- (a) each rate specified in the permit must be converted into the average rate at which water may be taken in litres/second during the period to which the rate applies;
 - (b) any conversion of a period of time must ignore daylight saving time and leap years;
 - (c) if the permit specifies the amount of water that may be taken, but not the period of time during which the water

may be taken, the permit is to be treated as if it allowed that amount of water to be taken each year:

- (d) if the permit does not specify any rate at which water may be taken or any amount of water that may be taken, or specifies only a rate that is not a fixed number (for example, a rate that depends on the flow rate of a water body), then the permit is to be treated as if it specified a rate of 20 litres/second:
- (e) a reference in the permit to a “head” or “sluice-head” is to be treated as a reference to water taken at a rate of 28.3 litres/second.

6 Permit holder must keep records of water taken

- (1) A permit holder must keep records that provide a continuous measurement of the water taken under a water permit, including water taken in excess of what the permit allows.

Form of records

- (2) The records must comprise measurements (in cubic metres) of the volume of water taken—
 - (a) each day; or
 - (b) each week, but only if the permit holder has approval under regulation 9.
- (3) The records must be able to be combined to produce further records that cover each water year of the permit.
- (4) If no water is taken, the records must specify the volume of water taken as zero cubic metres.
- (5) The records must be kept in a format that, in the opinion of the regional council that granted the permit, is suitable for auditing.

Manner in which records kept

- (6) The records must be kept using a device or system that—
 - (a) measures the volume of water taken—
 - (i) to within $\pm 5\%$ of the actual volume taken, for water taken by a full pipe; or
 - (ii) to within $\pm 10\%$ of the actual volume taken, for water taken by another method (including by an open channel or a partially full pipe); and

- (b) is able to provide data in a form suitable for electronic storage; and
- (c) is suited to the qualities of the water it is measuring (such as temperature, algae content, and sediment content); and
- (d) is sealed and is as tamper-proof as practicable; and
- (e) is installed—
 - (i) at the location from which the water is taken; or
 - (ii) at the location specified by any approval granted under regulation 10 that is held by the permit holder; and
- (f) has been verified as accurate in accordance with regulation 7.

7 Verification of device or system

- (1) This regulation specifies how a device or system that keeps records for a water permit must have been verified as accurate (**verified**) for the purposes of regulation 6(6)(f).
- (2) For records provided under regulation 8 for the permit's first water year, the device or system must have been verified before the end of that water year.
- (3) For records provided under regulation 8 for any later water year, the device or system must have been verified at any time in the 5-year period ending when that water year ends.
- (4) Verification must have been performed by a person who, in the opinion of the regional council that granted the water permit, is suitably qualified.

8 Permit holder must provide records and evidence to regional council

- (1) A permit holder must provide records that cover each water year of the permit to the regional council that granted the permit.
- (2) The records for a water year must be provided no later than 1 month after the end of the water year.
- (3) The records must comply with regulation 6.

- (4) The regional council may request evidence from the permit holder that the device or system that kept the records has been verified as accurate in accordance with regulation 7.
- (5) The permit holder must provide the regional council with the evidence as soon as practicable after receiving the request.
- (6) The records or evidence must be provided—
 - (a) in writing; or
 - (b) electronically, if requested by the regional council.

9 Approval to measure water taken each week (instead of each day)

- (1) The regional council that granted a water permit may, at its discretion, grant approval to the permit holder to keep records of measurements of the volume of water taken under the permit each week (instead of each day).
- (2) The council must grant approval by providing a written notice to the permit holder that specifies the period of approval.

10 Approval to use device or system installed near (instead of at) location from which water taken

- (1) The regional council that granted a water permit may, at its discretion, grant approval to the permit holder to keep records using a device or system that is installed as near as practicable to the location from which water is taken under the permit (instead of at that location).
- (2) The council must grant approval by providing a written notice to the permit holder that specifies—
 - (a) the location at which the device or system may be installed, which must be a location that, in the council's opinion, is as near as practicable to the location from which the water is taken; and
 - (b) the period of approval.

11 Approval may be revoked

- (1) The regional council that granted an approval under regulation 9 or 10 may revoke the approval at any time if, in the council's opinion, the approval was granted on the basis of incorrect information provided by the permit holder.

- (2) The council must revoke approval by providing a written notice to the permit holder that specifies when the approval is revoked.

12 Relationship with regional rule or condition of water permit

- (1) These regulations prevail over a regional rule or a condition of a water permit.
- (2) However, a regional rule or a condition that is more stringent than these regulations prevails over the regulations.
- (3) Despite the rest of this regulation, the requirement under regulation 8(1) to provide records that cover each water year of a permit by the deadline under regulation 8(2) is additional to any requirement of a regional rule or a condition to provide records that cover a different period or periods.

13 Transitional provision for existing water permits

- (1) These regulations do not apply immediately to a water permit held at the commencement of the regulations.
- (2) Instead,—
 - (a) the regulations apply to the permit only on and from 10 November 2012 if the permit allows water to be taken at a rate of 20 litres/second or more:
 - (b) the regulations apply to the permit only on and from 10 November 2014 if the permit allows water to be taken at a rate of 10 litres/second or more, but less than 20 litres/second:
 - (c) the regulations apply to the permit only on and from 10 November 2016 if the permit allows water to be taken at a rate of 5 litres/second or more, but less than 10 litres/second.

Rebecca Kitteridge,
Clerk of the Executive Council.

Explanatory note

This note is not part of the regulations, but is intended to indicate their general effect.

These regulations are the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010.

The regulations impose minimum requirements on the holders of certain water permits to keep and provide records of fresh water taken under the permits.

The regulations apply to a water permit that allows fresh water to be taken at a rate of 5 litres/second or more, unless the taking of the water is non-consumptive (as described in *regulation 4(2)*).

The permit holder must keep records that provide a continuous measurement of the water taken under the water permit. The permit holder must provide the records to the regional council that granted the permit.

The regulations specify—

- the form and manner in which the records must be kept; and
- when and how the records must be provided to the council.

The regulations prevail over a regional rule or a condition of a water permit, unless the rule or condition is more stringent.

The regulations do not apply immediately to existing water permits. Instead, the regulations start to apply to a water permit 2, 4, or 6 years after the commencement of the regulations, depending on the rate at which water may be taken under the permit.

The regulations come into force on 10 November 2010.

Issued under the authority of the Acts and Regulations Publication Act 1989.

Date of notification in *Gazette*: 26 August 2010.

These regulations are administered by the Ministry for the Environment.

Accessed on 24/02/2014, from

<http://www.legislation.govt.nz/regulation/public/2010/0267/latest/DLM3174201.html?src=qs>

Appendix B

Interview questions

Questions used for semi-structured interviews with water users

Background – Describing your farming operation

1. Can you please describe your farming operation? E.g. farm size, production type, length of time the farm has been in this production type.

Water use

2. How many water permits do you have? When were your permits issued?
3. How many water takes does this correspond to? What type of take are they (e.g. ground or surface water)?
4. What activities do you use the water for?

The Regulations and water measurement

5. How many of your water takes/permits fall under the requirements of the Regulations? Did you have any form of water measurement in place before the Regulations came into force?
6. Can you describe how the water measurement on your water permits takes place (e.g. type of meter/measuring device used)? Who holds and manages the records of water use?
7. Was establishing water measurement on your system a straight forward process? What were the challenges and how did you deal with them? Have you had any on-going issues with the water measurement system?
8. Have there been any direct benefits to your operation from the introduction of the Regulations? Is the measurement data useful for your operation? Are you planning to alter how you operate to make use of this information?
9. Do you feel that there has been adequate support for water users during the implementation of the Regulations? Where has this support come from?

Implications of water measurement on freshwater management

10. Has knowing your actual water usage changed your perspective on the resource? Do you use more or less water than you thought? Are you likely to use more or less water as a result of knowing your actual usage?

11. Do you feel that your water use is now under scrutiny? Are you interested to know how your water use compares to others?
12. What do you think the effect of the Regulations will be on the allocation of water in the Selwyn district? Do you think the data will be useful in addressing the over-allocation of the district's resources?
13. What do you think will happen to allocated water that is found to be not being used?
14. Do you currently take part in any water trading? Does having access to accurate data on water use encourage you to look into or to begin trade in water? Or do you think there are still other barriers preventing wide scale water trading to occur?
15. What do you think the benefits of the Regulations are in the context of fresh water management in NZ?

Questions used for semi-structured interviews with Environment Canterbury

Background – Describing your role

1. Can you please describe your role at council?
2. How do the Regulations relate to your role? Were you directly involved in the implementation of the Regulations?
3. In your role, do you work directly with other stakeholders involved with the Regulations? Which ones?

The Regulations

4. Do you believe that there was a need for a national policy around water measurement such as the Regulations, prior to their implementation?
5. In your opinion what are the key benefits of the Regulations for freshwater management?
6. What are the primary disadvantages of the Regulations?
7. What have been the main challenges during the implementation of the Regulations?
8. Do you believe that the Regulations allow a greater level of scrutiny to occur of water users' behaviour? Will they also increase the scrutiny of how council allocates freshwater resources?

9. Will the information/data generated through the Regulations about water use be most useful at the farm/catchment/regional/national scale? What activity around water management do you think the data will be most useful to (e.g. compliance of consent conditions, informing scientists/modellers)?

Implications for freshwater management

10. What do you think the effect of the Regulations will be on the allocation of water in the Selwyn district? Do you think the data will be useful in addressing the over-allocation of the district's resources? What effect has the Rakaia-Selwyn consent review process had on the implementation of the Regulations?
11. Will the information around where and when water is used allow water trading to increase amongst water users? Or do you think there are still other barriers preventing wide scale water trading to occur?
12. Do you think that knowing accurately how much water is being used will cause water users to use their allocated water more efficiently? Will it make them more likely to use more of their allocation over the course of a season?
13. What do you think should/will happen with allocated water that is currently not being used?

Questions used for semi-structured interviews with industry service providers

Background – Describing your role

1. What services do you provide for water metering? Is this a large component of your business?
2. Did you offer these services prior to the introduction of the Regulations? What role did the Rakaia-Selwyn consents review process play in terms of you offering water metering services?
3. In your role do you work directly with other stakeholders involved with the Regulations? Have you found yourself having to act as a mediator between water users and ECan? How do you address issues of non-compliance?

The Regulations

4. Do you believe that there was a need for a national policy around water measurement such as the Regulations, prior to their implementation?

5. In your opinion what are the key benefits of the Regulations for freshwater management?
6. What are the primary disadvantages of the Regulations?
7. What have been the main challenges during the implementation of the Regulations?
8. Do you believe that the Regulations allow a greater level of scrutiny to occur of water users' behaviour? Will they also increase the scrutiny of how council allocates freshwater resources?
9. Will the information/data generated through the Regulations about water use be most useful at the farm/catchment/regional/national scale? What activity around water management do you think the data will be most useful to (e.g. compliance of consent conditions, informing scientists/modellers)?

Implications for freshwater management

10. What do you think the effect of the Regulations will be on the allocation of water in the Selwyn district? Do you think the data will be useful in addressing the over-allocation of the district's resources?
11. Will the information around where and when water is used allow water trading to increase amongst water users? Or do you think there are still other barriers preventing wide scale water trading to occur?
12. Do you think that knowing accurately how much water is being used will cause water users to use their allocated water more efficiently? Will it make them more likely to use more of their allocation over the course of a season?
13. What do you think should/will happen with allocated water that is currently not being used?

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