UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Christchurch Springs, What to do with them?

A community perspective for management and policy

A Research Project submitted in Partial fulfilment of the requirements of the Sustainable Urban Development Course (GEOG 402)

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Abstract

Christchurch city has an array of springs that have served many purposes over time. This varies from water supply, spiritual values and food sources. They have received different treatments from different policies at different stages of Christchurch development. Despite the many uses and changes in the way the water from and springs themselves are treated there is no formal management policy in place at this time. This project is aiming to seek a current community perspective as to what should be done with the springs, new and old, in terms of their management. The policy gap has been highlighted more following the Canterbury earthquakes of 2010 and 2011. Some springs that had been concrete capped (as is commonly practised) suddenly sprang up after the earthquakes or when structures were demolished in preparation for rebuilding. The research makes use of various forms of literature in exploring different ways of management of springs around the world. Some key informants in Christchurch were also consulted. The different management or development strategies for springs that were identified by the researchers were then put onto a public survey for respondents to choose their preferred "springs development" or management method. The survey included face to face interviews in the city centre as well as an online based survey. The opinions expressed by the public showed high variation with significant standard deviations from research means for most questions asked in the survey, but there were similarities too which helped to shape a conclusive trend. A combination of aesthetic value enhancement, respect for the course of nature as well as recreational uses of springs were favoured by over 74% of the respondents. The practise of capping with concrete is definitely not in the best interest of the public.

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Munsaka, P., Busobozi, E., Fagan, C. & Valdivia, E. © 2015

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List of Acronyms

CBD – Central Business District

CCC – Christchurch City Council

CCDU – Christchurch Central Development Unit

CCRP – Christchurch Central Recovery Plan

CERA – Canterbury earthquake recovery Authority

ECAN/ ECan – Environment Canterbury

GDE – Ground Water Dependent Ecosystems

NIWA – National Institute of Water and Atmospheric Research

RMA – Resource Management Act

UC – University of Canterbury

USEPA – United States Environmental Protection Agency

USGS – United States Geological Survey

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1 Introduction

Water is one of the most important life building blocks that enables the earth to support life. All living organisms need it for survival. It is essential to life, human health and the economy. Fresh water is a scarce resource and constitutes only about 3% of water on this planet, of which 69% of that is locked up in ice caps and glaciers (National Ocean Service, n.d). The availability of clean, safe drinking water is even more limited! Nearly 1 billion people in developing countries don't have access to standard potable water. Management and policy strategies are a key factor in success of water issues in all its various uses.

Nowadays, Water is part of public spaces within cities. Designers consider water an asset, making creative ideas with it e.g. scheming new plazas and parks using water as waterfalls, wetlands, fountains, streams, etc. People like to be in touch with water, feel it and stick their limbs in it, and sometimes even splash about in it. The Project for Public Spaces, a place making initiative, encourages the design and inclusion of water as an element in the public areas of the cities. The spaces that include water have a chance to increase the community engagement by raising awareness of water sector. Moreover, these places could increase the awareness and resilience of drinking water by providing information to increase community collaboration.

Water comes from different sources, Christchurch city is sited on a region with immense groundwater that occasionally emerges through the surface, this is also known as a spring. After the earthquake, many cold water springs have appeared within the city and many that were already there moved. Springs are formed when the water table intersects with the earth's surface, or groundwater rises to the surface through rock faults, fractures or depressions (Death et al. 2004). Springs form groundwater-dependent ecosystems (GDEs) (Hatton & Evans 1998). Springs provide moist refuges in arid landscapes and have been critical to the survival of indigenous peoples, Maori.

Spring water is currently capped or directed into streams and rivers across the city and is sometimes enhanced as a public space. Based on this knowledge, this research project will provide a baseline to develop a management policy regarding cold water springs centred in the community perspective.

1.1 Research Objective

The principal aim of this project is to provide a baseline for policy development regarding management for new and existing springs' in Christchurch city, with the community perspective in mind.

1.2 Definitions and scope of the report

A spring is a defined area where a natural discharge of groundwater returns to the surface (Van-Everdingen 1991; White 2005). A spring is the result of an aquifer being filled to the point that the water overflows onto the land surface (see Figure 1 below) (USGS, 2015).

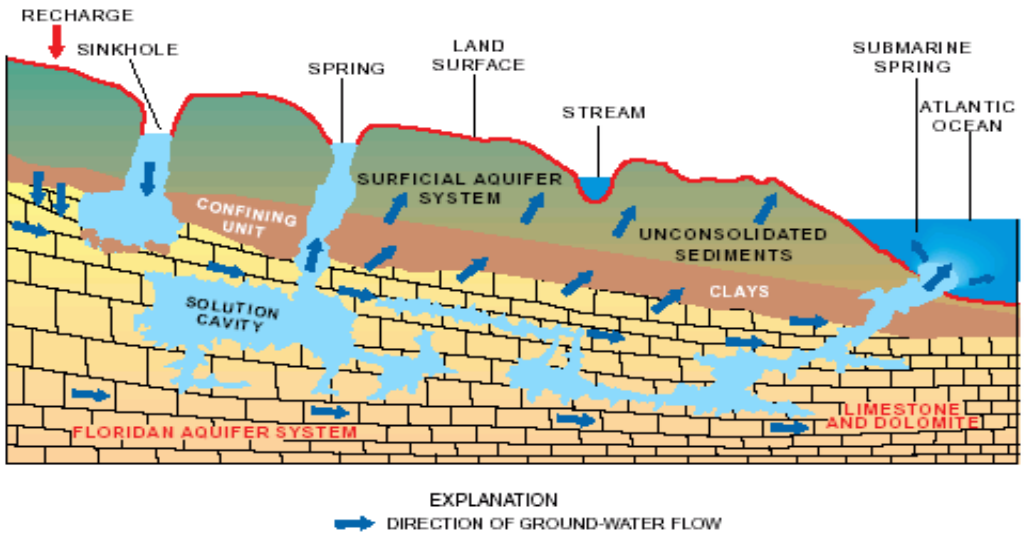

Figure 1: Conceptual depiction of formation of a spring (source: US Geological Survey, n.d.)

Springs vary in size and the amount of water that flows from them depends on many factors, including the size of the caverns within the rocks, the water pressure in the aquifer, the size of the spring basin, and the amount of rainfall. Human activities involving ground water withdrawal can also influence the volume of water that discharges from a spring. The quality of the water discharged by springs is affected by the source of recharge, the aquifer and the type of rocks with which the groundwater is in contact. It is also affected by the mixing of the spring freshwater and storm water at the discharged point.

This research project is focused in the spring located at the corner of Colombo Street and Cambridge Terrace in Christchurch city.

2 Literature review

2.1 Springs Management examples internationally

At international level, the management of springs is normally focused on larger springs that are in rural areas or not developed landscapes such as reservoirs, forests, etc. Most of the initiatives develop the springs through exploitation and treatment of the resource to achieve drinkable conditions.

The management is centred in pumping groundwater into storages and treats the water in order to be drinkable as is the policy in the City Of Downey in California (USA). The Urban Water Management Plan describes the procedure developed over the last few years for groundwater sources.

Most information is related to management of groundwater or surface water but it has not been found information regard springs management within urban areas.

2.1.1 Nigeria

The springs were put general purpose uses which include drinking, cooking, dish and clothes washing and bathing. The peak period of use of these springs are the morning and evening hours of the day. A few communities charge a token fee, which is used for maintenance and upkeep of the springs. This practice is found in communities where a committee assigned to maintain the springs. It is important to mention that the water quality is poor (Ewodo. 2009).

2.1.2 Cameroon, Yaoundé

The shortfall in the water supply is met by water drawn from springs, public drinking fountains and hand-dug wells (Ewodo, 2009). As the gap between supply and demand continues to widen with time, springs and hand-dug wells are increasingly becoming major sources of water supply for many inhabitants in the city.

2.1.3 USA, Pennsylvania State

Spring are considered a source of drinking water, and the State recognize its importance to ensure that the rate of flow in rivers during a year. Water quality is also important to consider before using a spring as a water supply. Springs are highly susceptible to contamination since they are fed by shallow groundwater, which usually flows through the ground for only a short

period of time and may interact with surface water. For this reason, most springs will need some treatment before the water is considered a safe source of drinking water.

The spring management policy in this State is mainly to be developed into a drinking water supply by collecting the discharged water using tile or pipe and running the water into some type of sanitary storage tank. In this matter, protecting the spring from surface contamination is essential during all phases of spring development. Springs can be developed in two different ways and the method you choose will depend on whether it is a concentrated spring or a seepage spring.

2.1.4 USA, Florida

Florida has one of the largest concentrations of freshwater springs, with more than 700 springs within its boundaries. Springs are considered as natural and economic assets for the residents in Florida (St. Johns River, 2015).

2.1.5 Northwest Florida Water Management District

The Northwest Florida Water Management District works in partnership with other state agencies, local governments, and stakeholder groups to protect and restore area springs. What is key to the protection of these important and complex natural systems is the understanding of various factors that can impact the health of springs, in terms of both water quality and the amount of water they discharge.

2.1.6 Springs of the Suwannee River Basin

The project is focused in the identification of springs in the North region of Florida, where the Native Indians located their villages near springs that were the main source of drinking water. Some of the springs in the area have been modified into artificial channels or streams, and others are touristic and recreational sites.

The water management strategy goals identified the location of springs in the area and determine the water quality and characteristic of them.

2.1.6.1 St Johns River District

The District springs policy is based on find the balance between environmental sustainability of the resource by protecting it from pollution and groundwater usage. The state developed as a

priority, projects that protect and restore the springs, by the Springs Protection Initiative. The initiative includes scientific research, restoration projects, water use regulation, and water supply planning and stakeholder outreach. Some of the projects developed to date:

- City of Ocala Water Reclamation Facility (WRF) 2 Nutrient Reduction Project
- Marion County Silver Springs Shores Reuse to Spruce Creek Golf and Country Club
- City of Apopka Keene Road Reclaimed Water Transmission Main
- West Volusia Water Suppliers Doyle Road Reclaimed Water Interconnect

2.1.7 Lacus Juturnae, Roma

During the Roman Empire this spring was used for religious ceremonies. The water at the Lacus Iuturnae was thought to have healing properties. The Spring of Juturnae is a formal pool built near a spring in the Roman Forum (Wikipedia, 2015).

Figure 2: Lacus Juturnae spring in Roma (Wikipedia, 2015)

2.1.8 Sachsenbrunnen, Germany

The Sachsenbrunnen is an enclosed spring at the Säperstelle near Bad Harzburg in the Harz Mountains of Germany. It is located on the Emperor Way (Kaiserweg) south of the spa town. From here drinking water was piped to castle of Harzburg over several hundred metres of wooden pipes in the Middle Ages and Early Modern Period.

Figure 3: Sachsenbrunnen, Germany (Wikipedia, 2015)

2.1.9 Baotu Spring, China

The Baotu Spring is a culturally significant artesian karst spring located in the city of Jinan, Shandong Province, China. The water of all these springs originates from an Ordovician karst aquifer under the city.


Figure 4: Baotu Spring, China (Wikipedia, 2015)

2.1.10 San Francisco

San Francisco's springs and streams were once common and visible, emerging from hills and ultimately draining to the Bay. Today most are routed through pipes and city sewers. In contrast,

the spring surfacing at this residence informed steps and strategies of a larger building renovation and garden design. The design applies precise structures, devices and details to the nuanced conditions of the site, creating an elegant composition of functional spaces, microclimates, and urban wildlife habitat.

This project develops a spring in a household environment into a functional living space for exercise, entertainment, kids play, experimenting and art projects to be combined in the garden with the spring and its design potential.

The spring emerges through a shallow clay layer in the soil eight feet off the back façade. Clay harvested from the soil was used to key a liner and basin into the ground. A copper rain chain from the deck above delivers rain water to the basin. A riser with a custom designed screen seemingly floats on the water surface of the basin. The riser conveys the spring flows to the upper runnel, a 1.5" copper channel that emerges from a steel headwall surrounded by mosses. Tunnels create the continuous presence of water and articulate the water surface. The lower tunnel extends to a wetland of irises at the lowest elevation of the site and drops the spring flow into a steel frame lined with black Mexican pebble. The frame and pebbles dissipate the flows and allow them to infiltrate back into the ground. Valves and overflows at each level create the ability to modulate and redirect the flows of the spring for maintenance.

This project challenges the widespread convention of suppressing urban water systems in favour of the wide arrays of common justifications- safety, mosquitoes, costs, progress, maintenance, etc. Like many cities San Francisco has paved and piped its hydrology away along with the benefits that it could offer an ever growing and densifying city. While it is a small site, and a relatively small amount of water, this project demonstrates the life enabling possibilities of inventive design in combination with urban waters.

Figure 5: San Francisco springs design (American society of landscape Architects, 2015)

2.2 Local Springs Management in New Zealand

In some areas of New Zealand, springs have always provided Maori with a reliable supply of fresh water and the value of this resource has been reflected in a wealth of legends and traditional practices (Thorne & Hikairo, 2005, pers. comm.). Recent work by NIWA with Tainui iwi around Kawhia Harbour on the west coast of the North Island has identified significant historical and cultural values assigned to springs by the local people.

Springs are an important source of human water supply in contemporary New Zealand (White 2001). The communities of Whangarei, Pukekohe and Rotorua, along with many smaller localities, use springs as water supplies (see Fig. 4A, B). Other important uses include bottling of water (e.g. Blue Spring, Putaruru, central North Island), and water supplies for fish farming (e.g. Waikoropupu Springs). Tourist operations also make use of cold water spring complexes, particularly around Rotorua (e.g. Paradise Valley springs, Rainbow Springs). Luxuriant growths of watercress are often associated with springs (e.g. Waikoropupu Springs), and this plant is utilised throughout the country as a food source (Michaelis 1976).

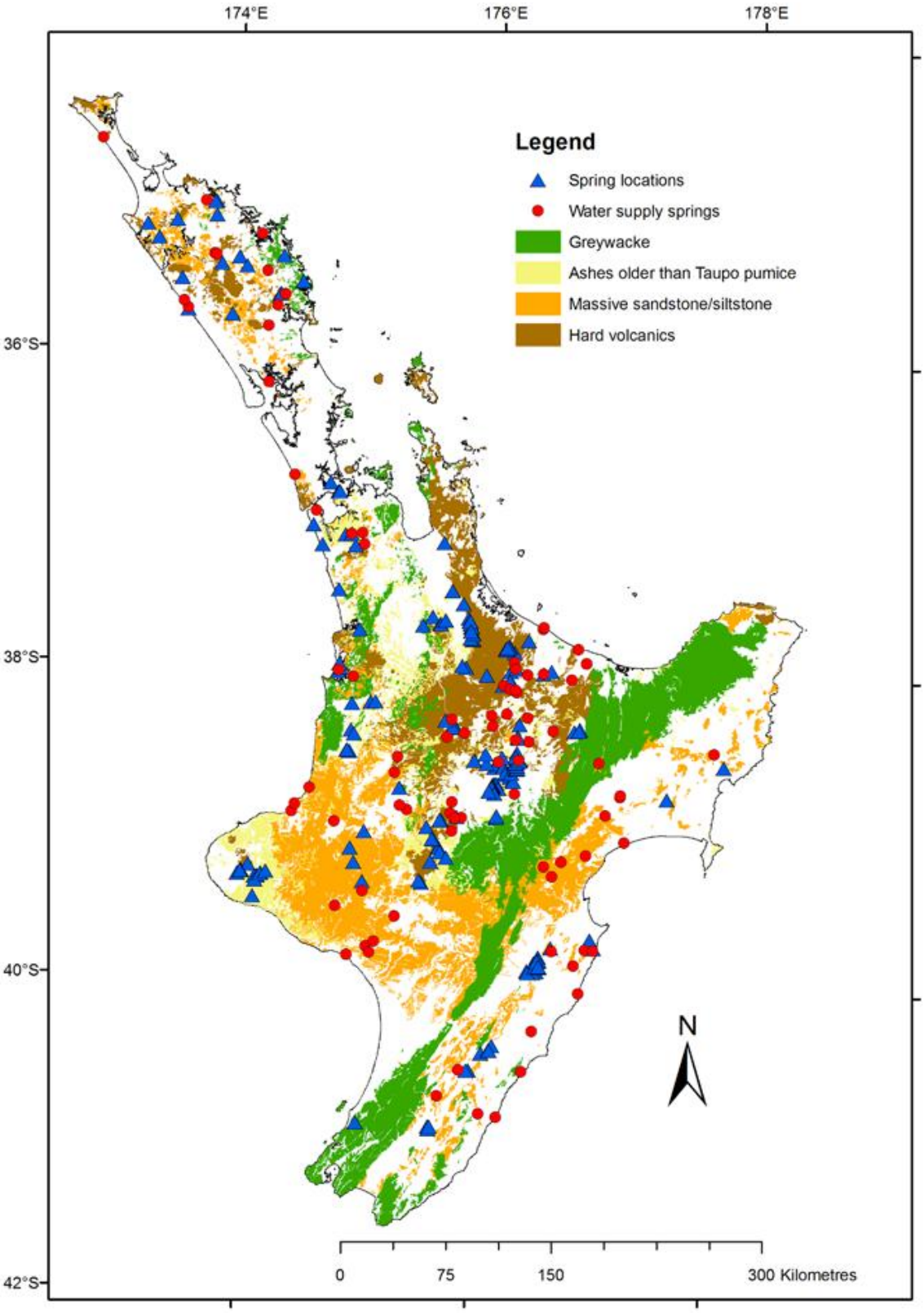

Figure 6: Identified Springs – North Island (NZ Department of Conservation, 2007)

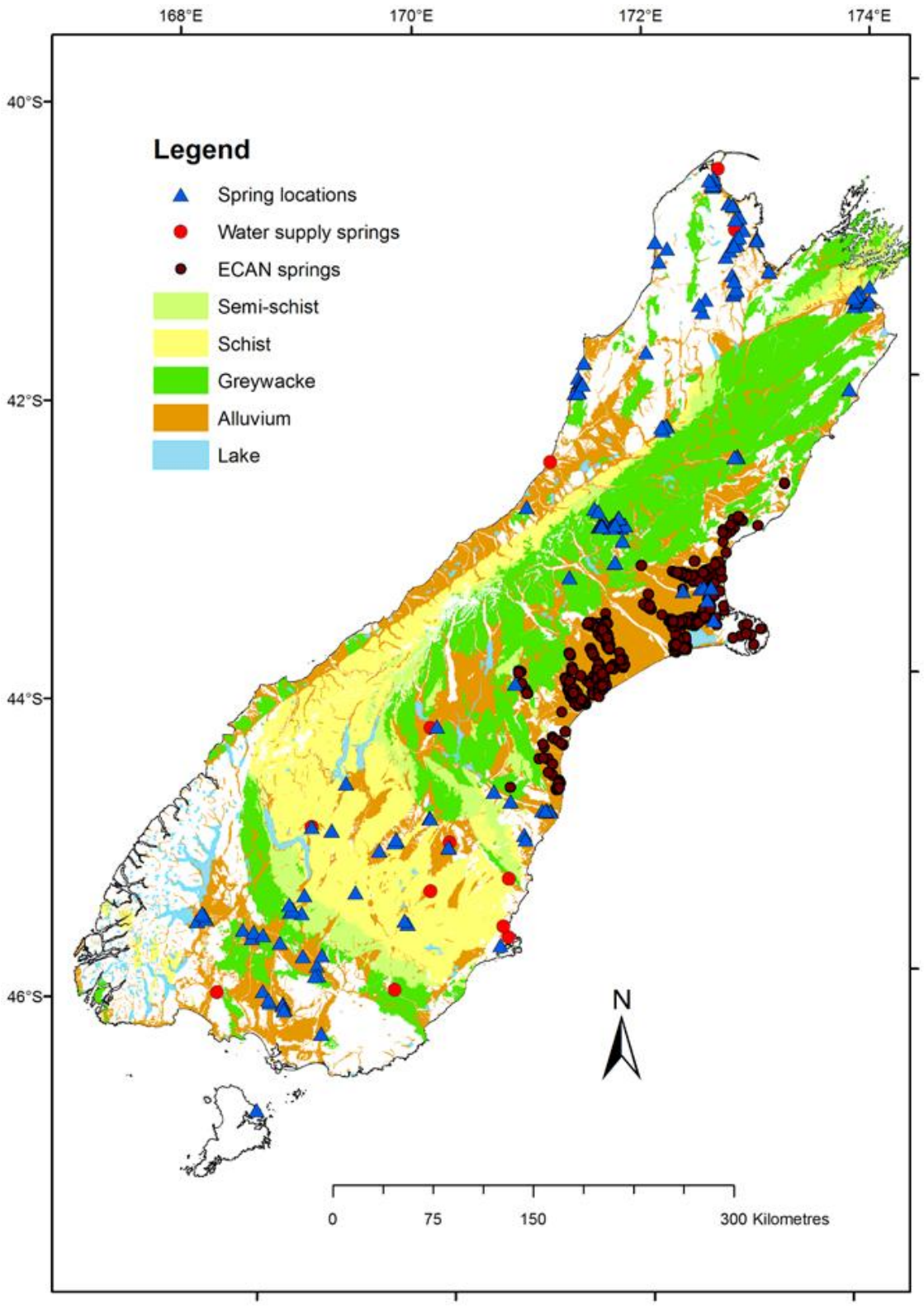

Figure 7: Identified Springs – South Island (NZ Department of Conservation, 2007)

New Zealand has a spatial database of springs within the country; it has been identified 426 springs through research studies. Moreover, Environment Canterbury (ECAN) maintains a spring database of over 1500 locations in their region.

2.2.1.1 Christchurch City Springs

The figure below shows the distribution of artesian springs in Christchurch city in 1992 taken during the hydrological study between Avon River Base Flow and groundwater in Christchurch.

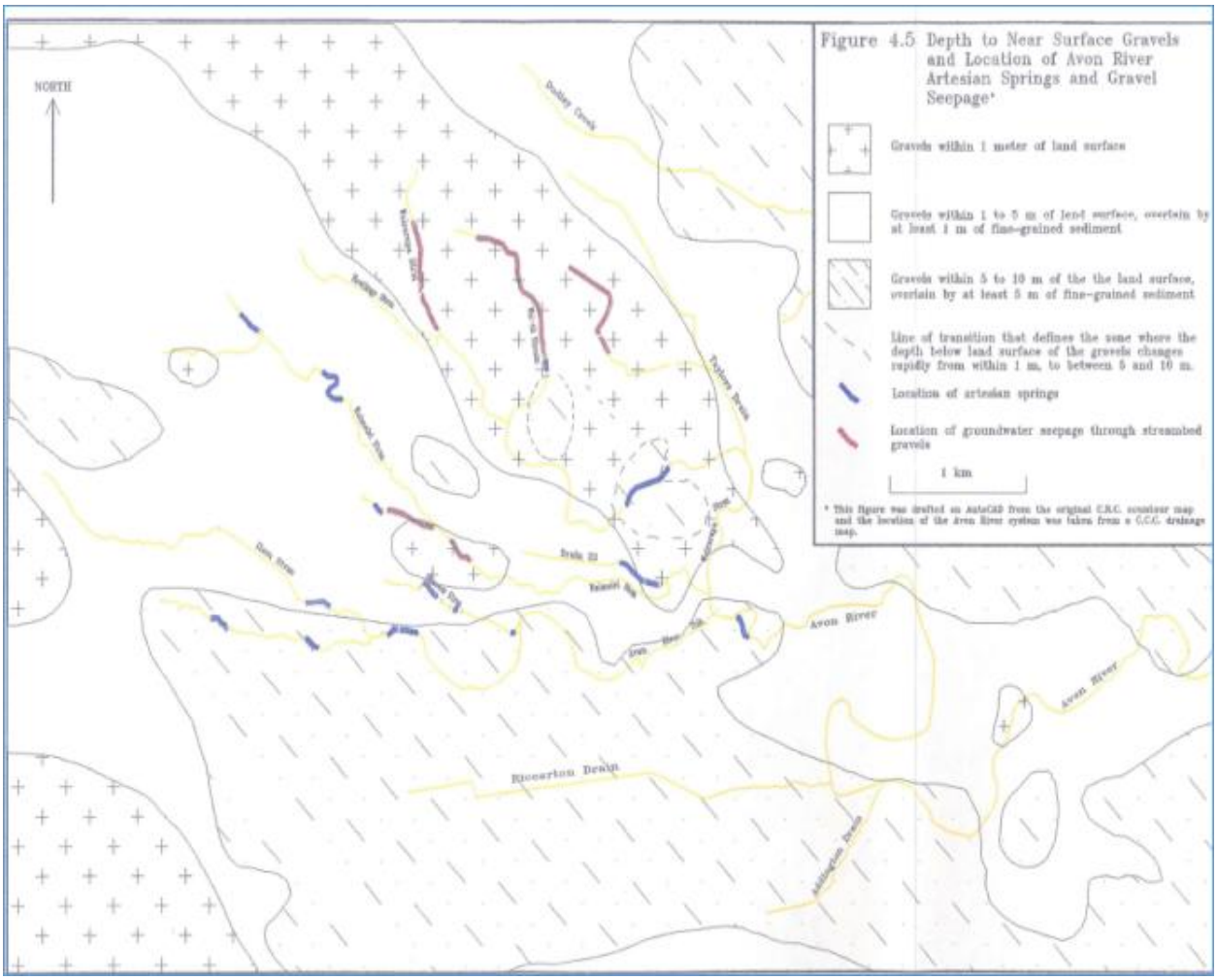

Figure 8: Map of springs in Christchurch (CCC, n.d.)

In historical times springs occurred in the Lower Riccarton on Deans Ave and within Hagley Park. But spring occurrence and flow had reduced by early 1990 due to the drainage of Christchurch, increases groundwater abstraction and construction of impermeable surfaces (Cameron, 1992). Furthermore anecdotal information and recorded historical observations both confirm that springs that used to flow, no longer flow. The flow during periods of high groundwater levels no longer exist because they have been buried. Those still existing contribute to river and stream flow where they were piped to the nearby stream channels.

Below Christchurch city underlies shallow water table. The city was founded on an extensive wetland with numerous natural springs (Harding, Neumegen & Smith, 2005). This is further manifested by the presence of Avon and Heathcote spring fed rivers running across Christchurch city. Direct groundwater discharge into these rivers is considered to be from both the water table aquifer and uppermost confined aquifer (Cameron, 1992)

Since the February 2011 earthquake many springs have come up to the surface. Buildings formerly constructed on water courses were seriously damaged by the earthquakes due to intense liquefaction. The groundwater regime involving intense ground water flow through artesian aquifers, wells and natural springs, was likely an additional factor that contributed to high liquefaction potential of Canterbury soils during the earthquake (Cubrinovski, Hughes & Rourke, 2014). Infrastructural urban development has been the biggest threat towards the management and restoration of springs in Christchurch city. The practices have always been capping and diversion of spring water into existing streams. This contributed to shifting of spring regimes from time to time. Barquine & Scarsbrook (2008), found that urban development produced a shift in the source of springs causing inefficient spring flows. However the recreation use of springs often involves capturing spring water, water diversions for aesthetic purposes and damming of spring pools (Barquine & Scarsbrook, 2008). These options have not been tried in Christchurch city.

Currently there is no policy for the management of natural springs in Christchurch city. According to Cameron (1992) Canterbury regional council placed restrictions on groundwater abstraction in areas where springs occurred as a way of maintaining Avon River base flow using ground water systems. This regulation never took consideration of other options of management for artesian springs. There are no policies for optional development of springs.

2.2.1.2 Spring management in Christchurch

The most recent case about spring management in Christchurch city is documented in the proposed Christchurch Redevelopment Plan for Belfast (940 Old Main North Road, 'the Site'). According to the plan this area has been zoned off for industrial development and includes a number of natural springs. One family-the Radford family owns approximately 20ha of the site. In their recent submission to the Christchurch City Council replacement district plan hearings panel through Aston Consultants Resource Management and Planning, various spring management issues were raised. In her submission, Aston (2015) notes that the Radford property includes a number of springs clustered in the centre.

According to the council proposed rules, any development should have 20m setback from the springs. Non-compliance with this rule renders the development a restricted discretionary activity. But Aston argues that the proposed storm water management area in the industrial plan be co-located with the springs to avoid substantial loss from developable area resulting from the 20m setback. The idea she says is also supported by the Christchurch City Council planner. She further notes that springs have not been historically evident in the property. Their management has always been draining them to box drains to provide an outflow for water. Springs occupy 1.6 – 2.4 ha of Radford's family land and when it is added to the required 20m setback, it becomes a substantial part of the property. Aston invokes consideration of alternative approaches of spring protection. Many springs in Christchurch are now located on the base of drainage channels or alternatively have specific drainage channels created to convey flow to the nearby main drainage channel (Aston, 2015).

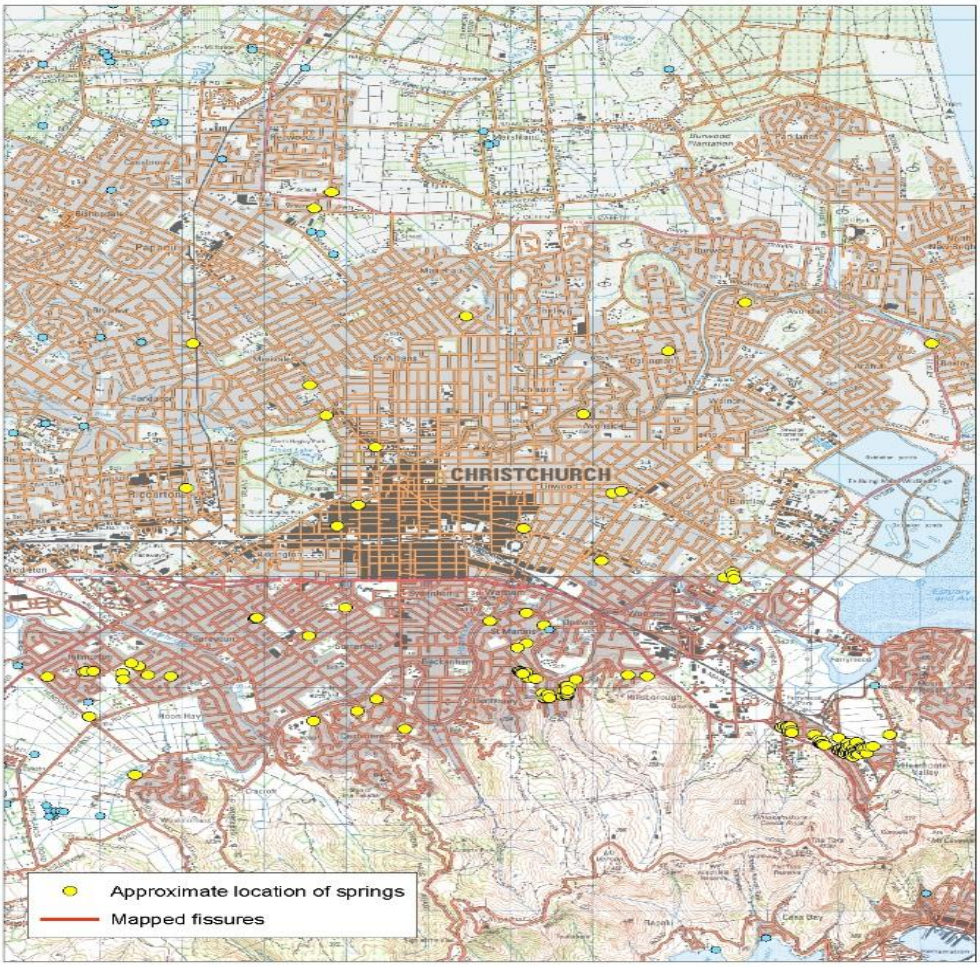

Figure 9: Springs as of June 2011 (CCC, n.d.)

2.2.1.3 The Maori perspective of natural springs in Christchurch

The relationship between Ngai Tahu and spring water is fundamental to their culture. The Maori have two concerns about natural springs, the cultural beliefs or practices and environmental protection. The cultural values include the Mauri (life support) of spring water to the surrounding environment and the Urupa (burial sites) of the ancestors.

Historically the Maori had traditionally used springs as rivers, lakes, lagoons and sea as burial sites for the more reserved members the tribe (Bonis, Ohs, Scoon and Marie, 2006). These springs are in secret sites and where identified are usually only done so by the use of silent files for the fear of being disturbed. Furthermore springs were also preserved for cultural ceremonies such as healing and baptisms. Waiora (waters for healing) and Waitohi (waters used for baptism and initiation ceremonies) were spiritually significant uses of spring waters resources in Canterbury region (Bonis et at, 2006). The spring waters were believed to be pure and had restrictions in place to ensure continued purity. The most vivid example were the three springs in

the middle of Avon River which were used by Tohunga (healer or religious leader) for healing purposes (Tau, Goodall & Palmer 1990).

In the contemporary context, cultural spring management is valued for maintaining ecosystem health and sustaining of Maori cultural values. While assessing cultural heritage in the Belfast area plan, Bonis, (2006), note that there are number of natural springs in Belfast area and they are believed to be of spiritual significant to the Maori. Christchurch city council recognises the importance of natural springs in promoting the Maori culture. In the Belfast areas plan, the city council directs that any land use development likely to affect the quantity and quality of springs and ground water in the area be avoided or mitigated (Bonis et al., 2006). This is further highlighted by Aston (2015) where the city council discredits any activity that affects effects the ecological, cultural and amenity values associated with springs. She notes that council emphasis that any development in the Belfast area should be consistent with the Mahaanui Iwi Management Plan which largely promotes cultural values. However the Radford report says that Maori people are concerned about the mixing water with storm water. Aston (2015) argues that discussions with the local people, Ngai Tahu showed that protecting the spring head from storm water is sufficient to meet their concerns. This is contrary to the city council objectives and policies which talks of recognising the rights of Tangata Whenua (people of the land) to manage their ancestral land resources in a sustainable manner (Bonis et al,.2006).

2.3 Stakeholder Interviews on Policy and History

2.3.1 Spring Management Policy

In interview with Robert Watts, a now retired civil engineer with CCC, he talked about the transition in the approach to waterways and their management in the 1990s. The main aim of waterways was to enhance them as drains, to remove water from the city as quickly as possible. Springs and the streams from them were used as drains for storm water. Many were widened and deepened. Some were turned into wooden or concrete streams.

Figure 10: Board drain in Riccarton, Christchurch.

The boarding of streams into these channels was the normal policy. Planning was the issue here as no one had the mandate to actually look after the streams.

In the 1990s there was a change in the way that these streams were valued. Instead of being seen as just drains they were considered to have other values including cultural, landscape, recreation, heritage, ecological and still also drainage. One of the drivers in this change was the Resource Management Act 1991 which posed many challenges for the local government at the time. One of the first examples of the change of management towards springs and wetlands was that of the Travis Wetland. It was purchased by the CCC from private property owners. This allowed for it to be preserved and developed to increase public access whilst maintaining the many values of the wetland. See the following figures as examples of spring enhancements.

Figure 11: Styx Spring Redwood, Christchurch.

The teams of people from the CCC who managed the streams changed from been mostly just engineers to engineers and landscape architects, ecologists, botanists, and community engagement officers. This reflected the different values the team was now trying to achieve as required under the RMA 1991, the protection and restoration of waterways.

Robert also said, "Ideally the identification and protection of waterways, wetlands and natural flood plains should occur at the time land use is changed from rural to urban".

Once these areas are decided, between the authorities and the developer, then the development plan can then be designed around those protected areas.

Figure 12: Peverel Street spring- Riccarton, Christchurch

The protection of these springs and waterways also needs to be done in industrial areas, provide people to engage with the environment at work as well as out of work. In general springs should be dealt with in a sympathetic and caring way.

The Christchurch Earthquake Recovery Authority (CERA) is actively engage in partnerships to improve the quality of the water in both the Avon. These partners include the Christchurch City Council and Ngai Tahu. Ongoing measuring and observations of the quality of the water suggests that the Avon River through the central city is improving.

These improvements are being achieved by the use of several techniques. One is the formation of silt traps and channel modification throughout the river corridor. These are put in where the speed of the flow is slow allowing for the silt to fall into the catchment areas, these are periodically emptied. Another is to increase the amount of planting along the edges of the banks to reduce erosion, this also provides habitat for river fauna. A third technique is the inclusion of rain gardens along the edge of the river within the newly proposed Avon River promenade. These are designed to catch surface water runoff from paths and roads. The rain gardens function is to filter out pollutants to improve the water quality before entering the river. (Peter Matthews, 20/5/15)

The current management policy of springs is to treat them as a valuable asset as part of a valuable system. The Avon River as a lowland stream is a collect of springs and as such springs are considered important by CERA. Peter Matthews says “Key design principle for the Avon River is “Kia atawhai ki te tangata – Care for the People” which as an idea translates into the principle of a healthy river gives healthy people gives health city”. Further to this CERA is keen to increase the contact and connection that people have with the water in terms of accessibility and use.

With regards to the spring at the corner of Colombo Street and Kilmore Street there is possibly options for developing it into a more interactive area. It is the end of the Northern Green Belt and adjacent Victoria Square. Adjacent the spring on Oxford Terrace will be reconfigured into a shared space promenade with public areas looking across the river toward the adjacent river bank and spring. Cambridge Terrace north of the spring will have vehicles removed and provide access and provision pedestrians and cyclists only. Planting in these areas will include native trees to encourage bird life and additional habitat.

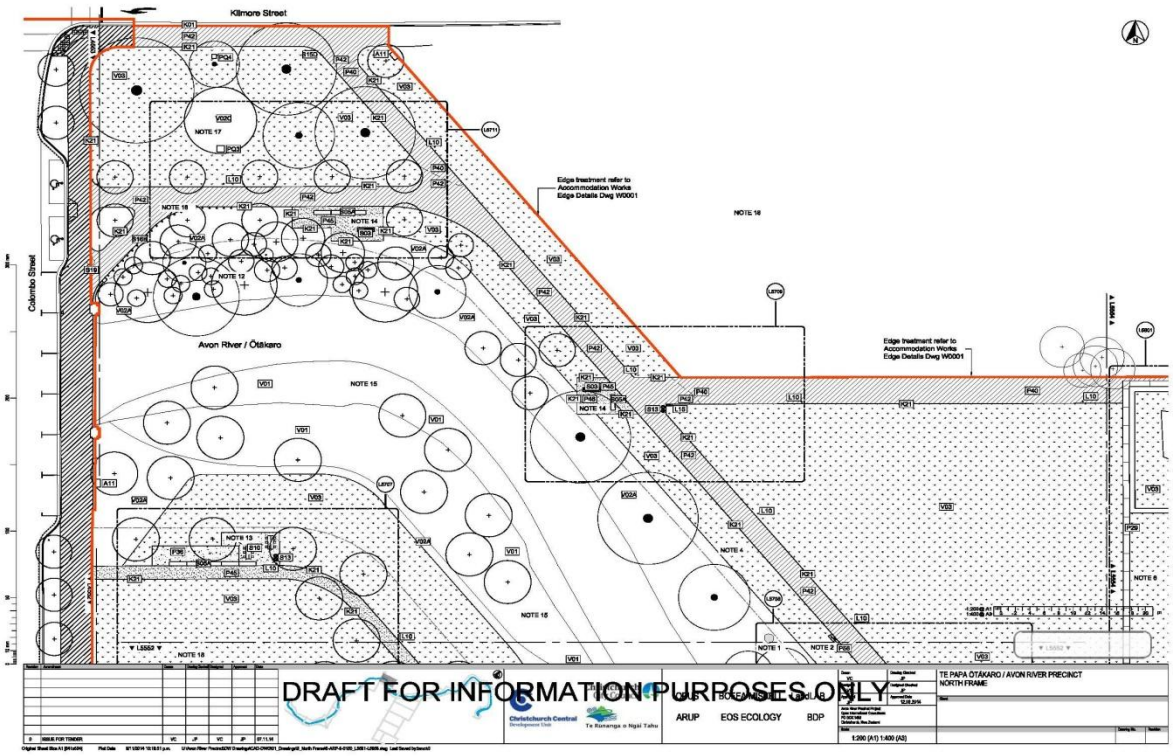

Figure 13: North Frame Development Plan (CERA, n.d)

One of the key design moves from CERA is to create "Moments along the river corridor". These are places created for people sit by the river, to reflect and rest and enjoy the river and its inherently fantastic qualities. The area immediately around this spring is to be one of these areas.

CERA are keen to look at options for this spring. Whilst at the moment they are planning to leave it as it is, there is good viewing of this spring across from the other side of the river. They are not averse to having it developed into a more interactive area and are open to hear from the community about ideas for it. Christchurch City Council has developed the Surface Water Strategy 2009-2039. This includes some goals as follows "The Councils Goals are to:

1. Improve the water quality of our surface water resources;
2. Reduce the adverse effects of flooding;
3. Improve the ecosystem health of surface water resources;
4. Protect and restore Ngāi Tahu values associated with surface water resources;

5. Support a range of recreation activities on and around waterways;
6. Protect heritage values associated with surface water;
7. Protect and enhance the landscape values of surface water;
8. Support community involvement in surface water management;
9. Manage stormwater in an efficient manner that supports Goals 1 – 8."

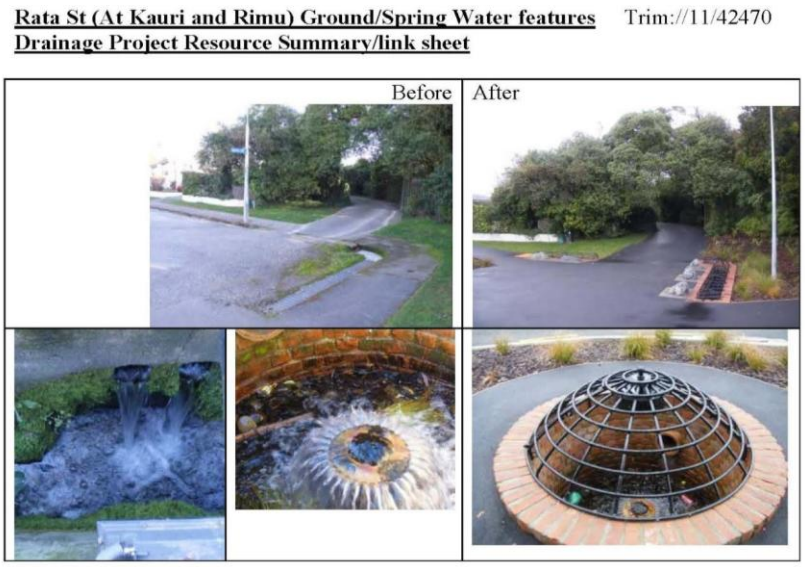

Figure 14: Example of Developed Spring (CCC, 2001)

This further broken down into objectives "Our objectives are to:

1.1 Implement stormwater treatment so that receiving waters in urban areas at least meet USEPA21 water quality standards for copper, zinc and lead.

1.2 Meet PNRRP water quality standards for dissolved oxygen, temperature, pH, conductivity, suspended solids, turbidity, nitrate-nitrite, ammonia, phosphorus and E.coli.

1.3 Remove pollutants, including sediment, at source where possible.

1.4 Ensure there are no ecological impacts in receiving waterways from construction activities.

1.5 Protect springs and their surrounding habitats from the adverse effects of land-use activities.

Section 1.5 speaks directly of the springs. It is noteworthy that it specifically talks about protecting the surrounding habitats of the springs. This area of protection is further discussed later in the discussion on the Radford Property at Belfast. Rule 16.2.7.2.4(a) of the proposed Replacement District Plan requires that no development can happen with 20 metres of a spring. In the Redford report it is stated that a CCC planner has said that this can be modified to allow greater development of the area. It would seem the policy and the actual events are not exactly the same.

Figure 15: Example of integrated spring into a recreation area

In an email from Clive Appleton, CCC, he says that there are no specific management plans for springs but it is generally covered by the Surface Water Strategy 2009-2039. There are also storm water management plans and storm water discharge consents that require storm water to not be merged with spring water or put near springs.

Capping of springs, that is where the flow is blocked from making the surface, is a common practice according to Di Lucas, Landscape Architect. Spring waters are also frequently diverted

into storm water pipes. The capping and piping of spring waters has increased in prevalence since the earthquakes started, for two reasons. Firstly the earthquakes moved springs, so that those previously capped flowed from a new location. New ones also appeared where none was previously known. Spring flows have also been created by piling and for excavations for foundations for new buildings.

Figure 16 Capped spring allowed to flow to create riverlet

An example of this was at the north-west corner of Victoria and Peterborough Streets. Following site excavation there were two 250mm pipes flowing continuously at high capacity to drain the flow from the new spring that was on the site. Despite conversations between Di and the developer and architect regarding design options, the flow was considered a development 'nuisance' and was eventually diverted to the storm water system and thus mixed with contaminated waters to flow underground to the Avon. Di would have much rather seen a water feature created to flow down the street separated from contaminated storm water, to flow in the

open to the Avon River. This sort of approach is called day-lighting as opposed to piping or capping the spring flows.

Figure 16 Map showing storm water drains. The circled area is the location of the spring on the corner of Colombo Street and Cambridge Terrace. The network of piping suggests that storm water is carried in this same pipe, implying a mix between the spring and storm water.

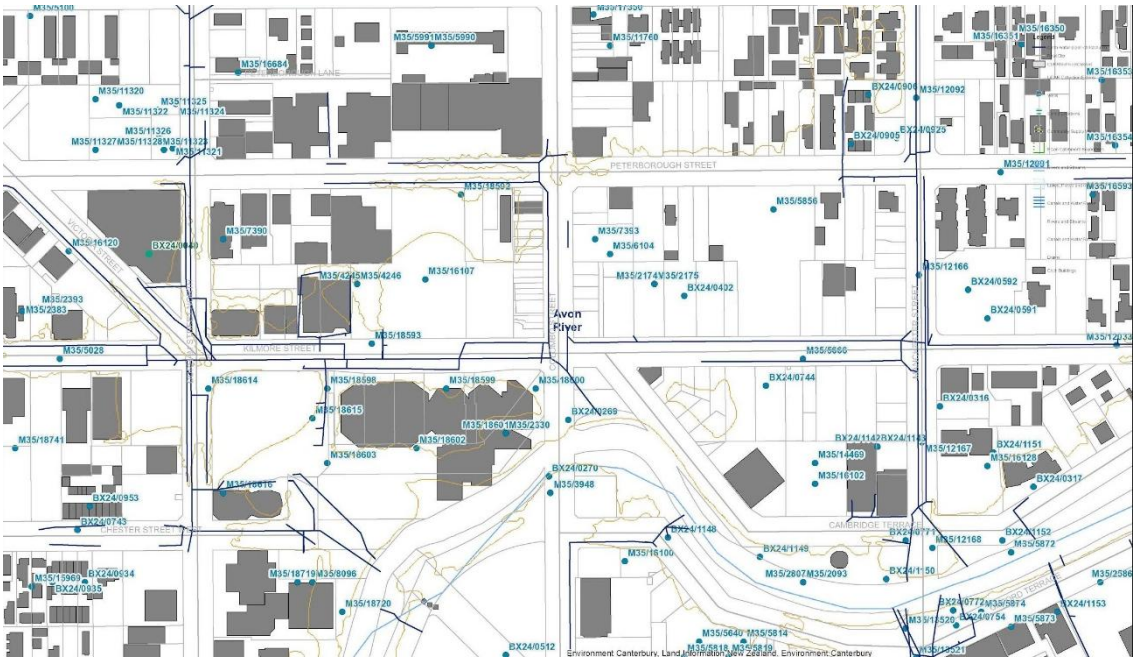

Figure 17: Map showing storm water drains (CCC, n.d).

This meant capping the springs with a pipe and running the pipe down the stream until in connected with the Avon River, then building the city right over where the springs/streams had been. Di is now very keen for these piped streams to be day lighted; this also came through from a few of respondents in the survey.

As discussed above this pattern of controlling springs and draining the wetlands continued to happen until the 1990s.

Clive Appleton from CCC says new springs popping up as a result of the earthquakes, are treated differently. If a spring comes up in a sports ground or road then it would be either capped/piped

or diverted to a stream. If one came up in a reserve area like Hagley Park it would be developed in an appropriate manner. If a spring comes up on private land then it would be up to the land owner as to what happens with the spring.

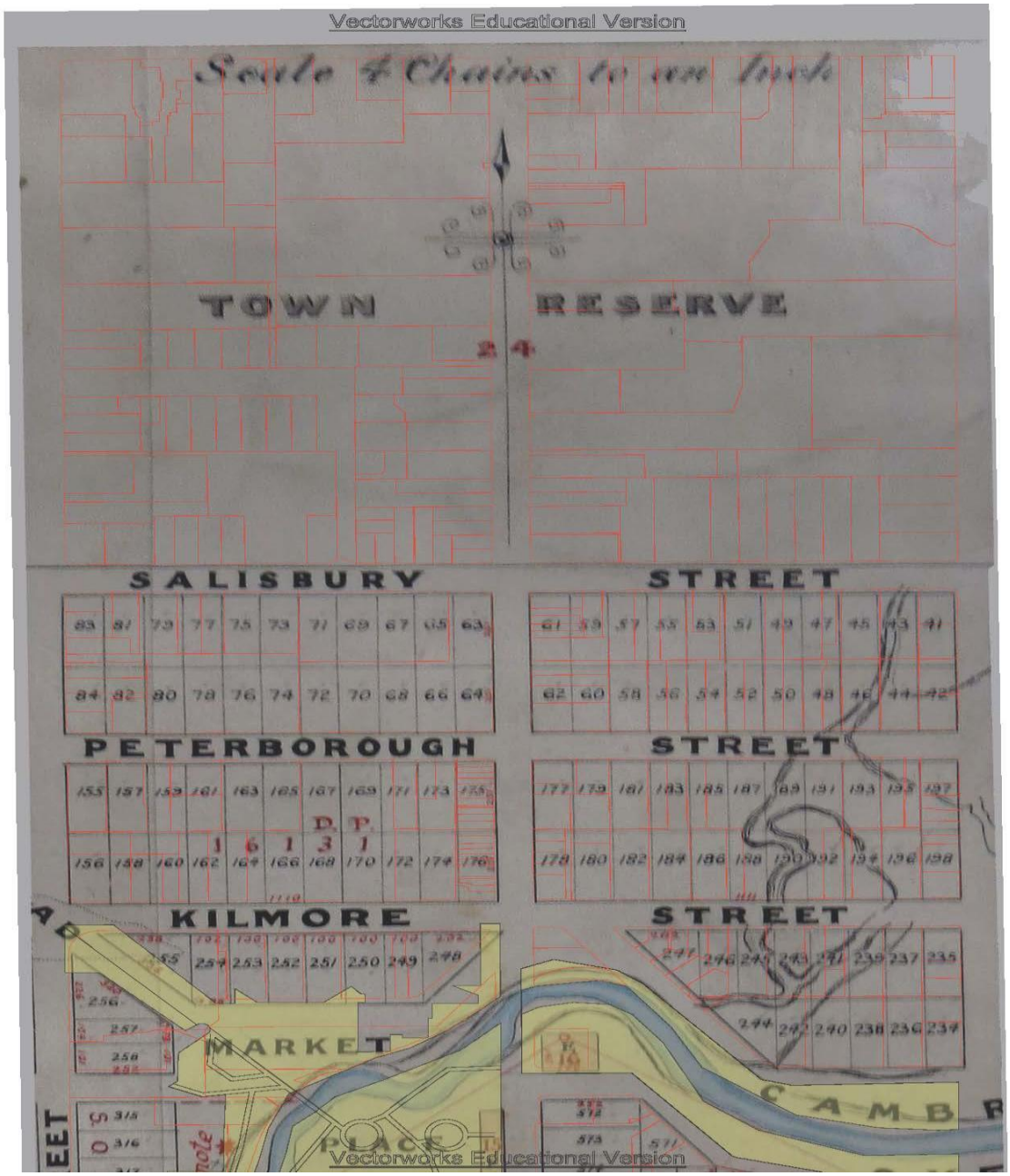

Figure 18: Black Map of Christchurch by Edward Jollie, showing stream locations in inner city in 1850 (Lucas & Associates, n.d)

3 Methodology

In trying to gain the opinion of what the community would like to have done with springs in Christchurch it was decided to focus on one spring as may be different springs in different locations with different histories might require different management. What might be done in a residential area might not be the same as that in Central Business District.

The focus of the research was the spring immediately downstream of the Colombo Street Bridge over the Avon River beside the Town Hall. This came as a suggestion from two community members, Di Lucas and Melanie Coker. This spring is believed to come out of the ground in the vicinity of the Casino. It was placed into a pipe to allow for town development. In this project we used two forms methodology.

The first is that of face to face interviews. The interviews were carried out in Central Business District in Christchurch in two main locations. The first of these was in Victoria square. The reason that this was used is that it has the Avon River running through it and it is close to the spring of concern.

Figure 19: The spring used in the research project

The second location that was used was the Restart Mall. This was used during the week as there was not enough people in Victoria Square during the week to make it worthwhile been there.

Interviews were conducted over five differing two hour periods of the day so as to get a wide selection of people. Two of these interview periods were done at the weekend in order to survey people who only came to the city at the weekend. A whiteboard was set up and on it were pictures of eleven different options for the management of the spring. Please see figure 20.

Figure 20: White board pictures used to exemplify springs development potential and options.

Pictures were used to try and clearly present/ explain/ describe the different options. This sort of method has been used by many others. Inspired knowledge says “Street interviews are top-line interviews often conducted in the street, at shopping parks, at events (such as the theatre, conferences, shows or exhibitions) or by knocking on residents front doors” (Inspired Knowledge, 2011).

It is also well known that the use of pictures is effective as “two thirds of all stimuli reach the brain thought the visual system”. Taking this into account we decided to use pictures to help communicate the different options to the interviewees. (Zaltman G, 1997)

Interviewees were asked questions verbally whilst having the interviewer point to the pictures on the whiteboard. These pictures were numbered so that when responding the interviewees only had to quote what number(s) they liked or disliked. The interviewer recorded the results on the questionnaire. Please see figures 21 and 22.

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UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

The GEOG402 "Sustainable Urban Development" class at the University of Canterbury would like to understand public perceptions regarding management of natural springs within Christchurch city. This is against a background whereby springs[1] have popped up in various locations after the earthquakes. Currently, the normal practice is "capping" the springs off. The attached survey explores the use and management of natural springs. It is part of our commitment to working with local communities. Results will be presented at an event open to the public at the end. Feedback will also be given to the community boards.

If you are willing to take part in the study, please complete the survey. Completing it also means that you are willing for your information to be used in a confidential manner.

This project has been reviewed and approved by the Department of Geography at the University of Canterbury and University of Canterbury Human Ethics Committee. Participants may address any complaints to The Chair, Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

The project data will be securely stored in a locked room and on a password protected computer system at the University. The university copy of your information will be destroyed after ten years.
If you have any questions about this survey and/or wish to receive a copy of the findings when they are available, then please contact caf23@uclive.ac.nz. If you have any other questions or comments about this please contact Prof Simon Kingham, Department of Geography, University of Canterbury simon.kingham@canterbury.ac.nz Phone. 03 364 2893.

You can access and complete this survey online on the following link:
http://christchurchsprings.weebly.com/

OR scan the next page after completion and email to pmu23@uclive.ac.nz

Figure 21: Survey form part 1

1. Do you live within the four avenues? (in the central city between Moorhouse, Bealey, Fitzgerald and Deans Avenues) (Tick **one** box only)

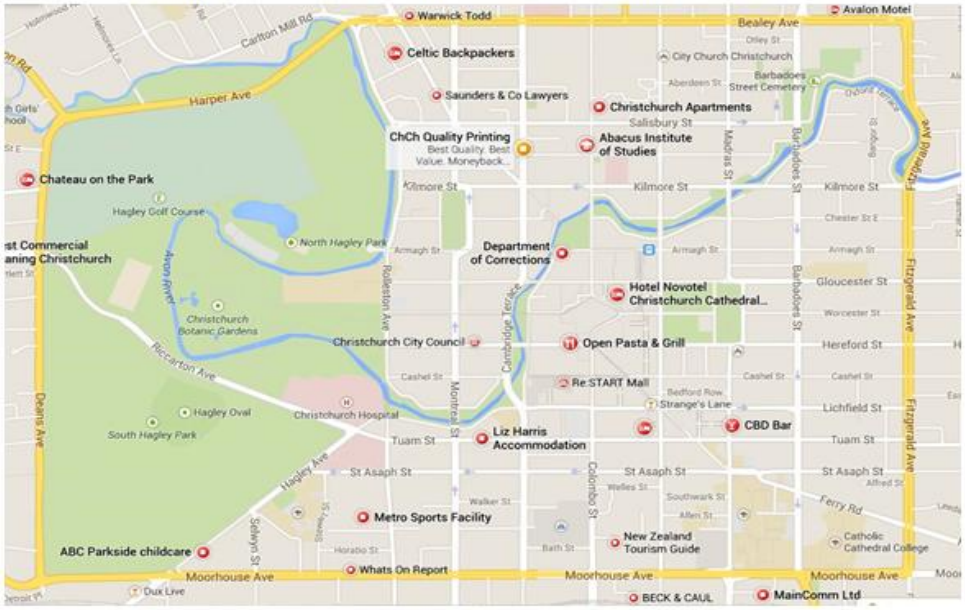
   ☐ Yes ☐ No

2. Are you aware there are springs within the four avenues?

   ☐ Yes

   ☐ No (if No, go to question 4)

3. Please indicate (X) on the map where you think there are springs within the four avenues?



4. What do you think should be done with springs? (Please tick **all** that apply)
   1. Capped (Current practice).
   2. Used for irrigation of public spaces / community gardens.
   3. Driving waterwheels for public energy generation (e.g. public places to charge cell phones).
   4. Develop into ponds or fountains.
   5. Develop into larger pools with potential for public bathing areas.
   6. Water storage e.g. fire management or use in construction.
   7. To create or enhance wetlands.
   8. Selling water or use for drinking.
   9. Channel into existing streams or other water bodies.
   10. Leave as it is, let it take its own natural course.
   11. Embrace cultural, religious and/or spiritual value.

5. Now circle the **most important** incentive in question 4 (circle **one** only)

6. Do you have any other ideas or comments?

   ☐ No ☐ Yes (Please state).....

Figure 22: Survey form part 2

- **Question 1**, "do you live within the four avenues…?" was asked to see if there was any difference of opinion between people who lived in or close to the CBD compared to those who lived outside/further away from the CBD.
- **Question 2,** "are you aware there are springs within the four avenues?" was asked to determine if the opinions of people were different if they knew about springs, would this affect their consideration for the management options?
- **Question 3**, if people knew there were springs in the four avenues were they able to identify where. This was designed to help find what people knew about the location of springs in the four avenues.
- **Question 4**, this is where the pictures on the whiteboard were used to help describe the different management options. People were encouraged to choose as many or as few of the options as they liked/disliked. The interviewer would run through these options to help clarify what they meant.
- **Question 5**, was to try and get people to say what their favourite was if limited to one option for one spring.
- **Question 6**, was designed to get further feedback on other possible options for the management of the spring, it took into account that there would be other options that were not listed in the pictures/questionnaire. It also allowed for people to make any comment that they liked.

3.1 Sample Population/Population engagement.

Having set up the whiteboard with the pictures on it we endeavoured to engage the public into discussion about the spring.

All people passing by asked if they "would be happy to take part in a research project on a spring as part of research being done by students from the University of Canterbury". Everyone, over the age of eighteen, was offered the opportunity to participate.

Sometimes other people would come and start talking to us when we were already talking to someone, this made getting face to face interviews fairly easy at times. At other times, like when it was cold, people were much less willing to stop and talk.

3.2 Online Survey

Due to the nature of the research, we aimed to target people living inside the Christchurch CBD and in particular Peterborough village, as such delivery of the research forms was done within Peterborough village along the four streets nearest to the Colombo street spring, i.e. Salisbury, Manchester…The respondents had 2 choices in making their response. They could either fill in the form physically, scan it and send to an email address provided or simply go online to a site stated on the form, where they would be redirected to an online version of the survey. According to a 2013 World Internet project on New Zealand, internet penetration is nearing saturation. This greatly justifies use of online surveys as a method of public engagement despite its lack of face to face persuasion. For a large number of people the internet is used daily. 4 out of 5 spend an hour or more online at home every day. Almost everyone under 40 is online, Most users check their email daily (89%) (World Internet Project, 2013).

3.3 Experimental Design for the online survey

The research utilised Qualtrics Research Suite's online survey tool. This was done through the licenced University of Canterbury site. It made it easier to capture data with a potential for multiple and independent entries. Qualtrics is a private research software company, based in Provo, Utah (US). Qualtrics software enables users to do many kinds of online data collection and analysis. Quantitative statistical analysis performed with Qualtrics is cited in a number of professional and academic journals and books (Albaum & Smith, 2006).

Using options given on the Survey Control panel, two versions of the same survey were created. One was used to enter data that we collected physically from interviewing people with the aid of a white board with pictures depicting possible ways of spring management or utilisation. The second survey was to be used by respondents directly, either after they receive a hard copy of the survey from their mail box or upon receipt of an email. Emails were sent to addressees in the database of Barry Booker, the chairperson of Peterborough Village Association.

For the second survey, respondents could only enter one survey and the software should automatically reject a second attempt on the same computer or device. However, they could start a survey and save it to continue later.

The survey was set to last for a month i.e. from 15-04-15 to 15-05-15. Qualtrics collates data entries, analyses quantitative summaries, means and mode values. In addition, the tool gives analysis of survey dropout rate from those respondents who started the survey but did not finish it. Making database queries to marry different survey attributes such as "residing inside the four avenues" and "knowledge of existence of springs" is also possible. It should be noted that, unlike for the face to face interviews, pictures depicting management methods were not employed in the online survey. Only descriptive text was used. The only exception was a heat map which allowed users to click areas on it where they believed springs existed.

4 Results and Discussion

4.1 General

A total of 120 people were interviewed face to face with 112 giving complete survey responses whilst the rest gave partial responses which were nonetheless recorded and credited towards the questions they applied to. Survey leaflets were dropped to about 200 households in Peterborough village, inviting residents to take up the online survey. In addition 380 emails were sent out through the Peterborough Village Association chairperson Barry Booker. 51 people started the online survey and 35 submitted their responses with 31 of them being complete while the rest were partial.

Table 1: Full table of Results (Comparing Interviews against the Online Survey)

Questions	Interviews		Online	
	Yes	No	Yes	No
Do you live within the City Centre?	18	94	23	10
Are you aware there are springs within the City Centre?	27	86	27	3
What do you think should be done with springs?	**Yes**	**Favourite**	**Yes**	**Favourite**
Capped (Current practice)	2	0	5	1
Used for irrigation of public spaces / community gardens	44	8	23	10
Driving waterwheels for public energy generation (e.g. public places to charge cell phones)	66	22	18	1
Develop into ponds or fountains	49	12	21	3
Develop into larger pools with potential for public bathing areas	37	9	12	0
Water storage e.g. fire management or use in construction	22	6	9	1
To create or enhance wetlands	54	20	21	6
Treating water e.g. selling water or drinkable water	9	5	7	1
Channel into existing streams or other water bodies	20	6	17	4
Leave as it is, let it take its own natural course	40	22	7	2
Embrace cultural, religious and/or spiritual value	16	1	11	2
Total	**112**		**33**	

A graphical impression of the responses for each question follows;

Table 2: Overall distribution of respondents' residential statuses in relation to the CBD

#	Do you live Within the CBD?		Response	%
1	YES		41	28.28%
2	NO		104	71.72%
	Total		145	100.00%

Table 3: Overall knowledge of existence of springs within the city centre

#	Are you aware of springs in the CBD?		%
1	YES		36.99%
2	NO		63.01%
	Total		100.00%

4.2 Preferred Development option for springs

As earlier stated, for the face to face interviews, the core question which asked respondents to choose a preferred development for city centre springs included exemplary visual depictions of the different choices of variables.

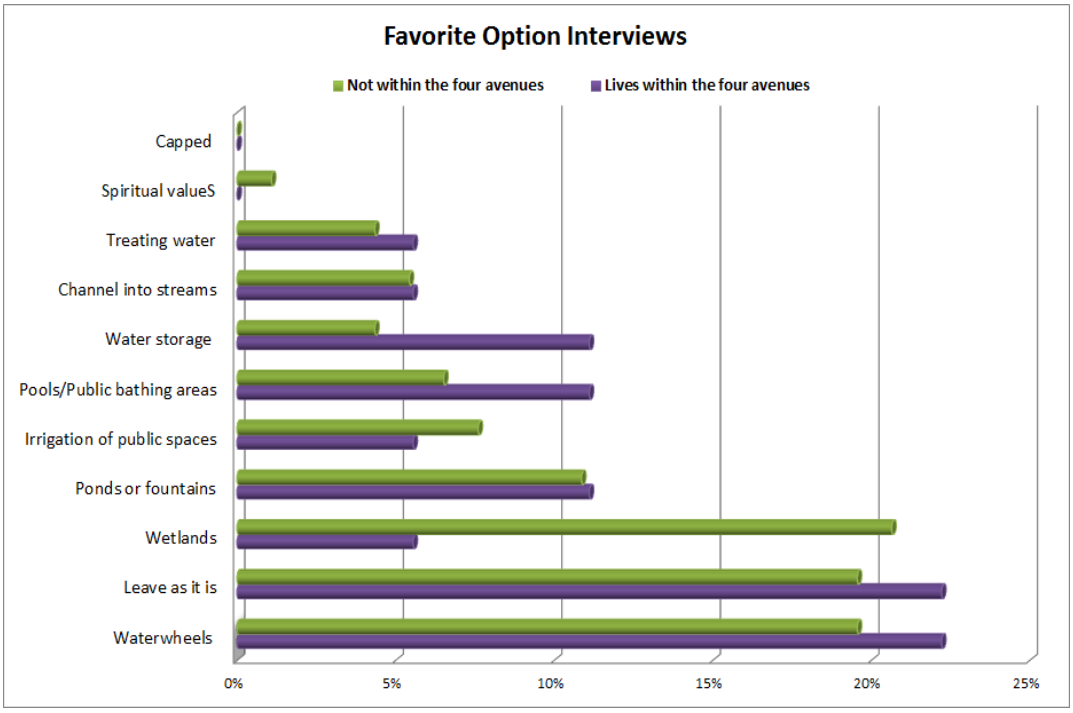


Figure 23: Preference of development options exhibited by respondents in the face to face interviews.

Responses are shown separately for non-city centre dwellers and city centre residents respectively.

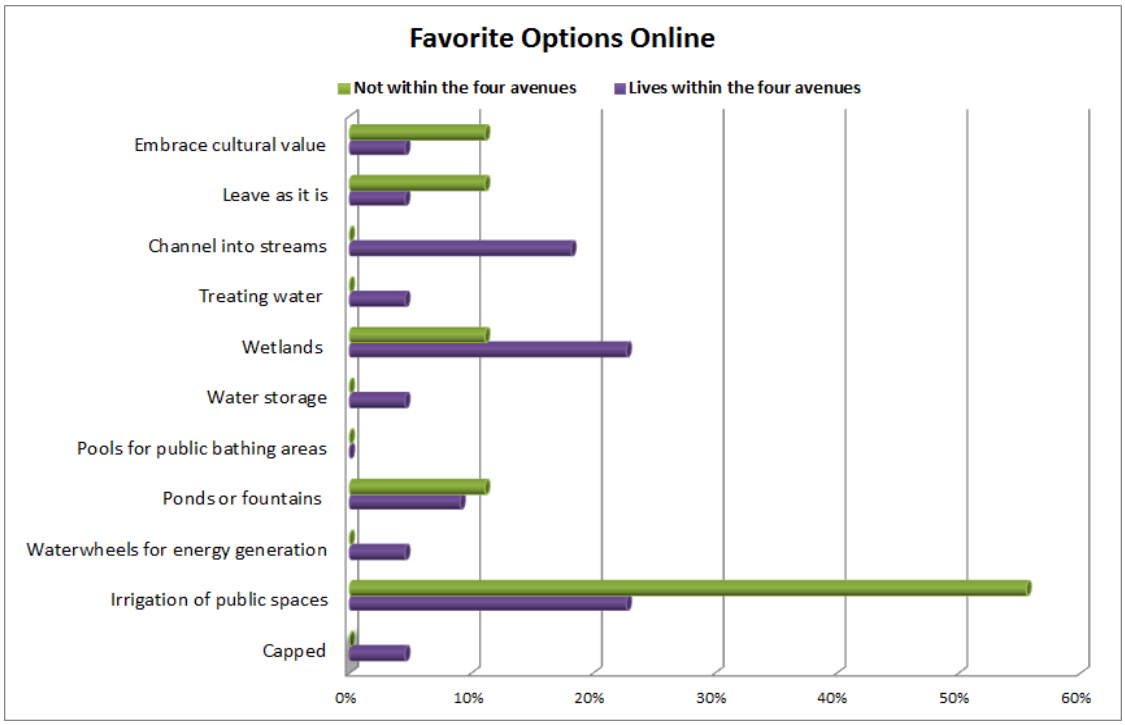


Figure 24: Preference of development options exhibited by respondents in the online survey

The preference of development options exhibited by respondents in the online survey (without visual aids or opportunity to ask for clarity from the researchers) is shown in Figure 22. Responses are shown separately for non-city centre dwellers and city centre residents respectively.

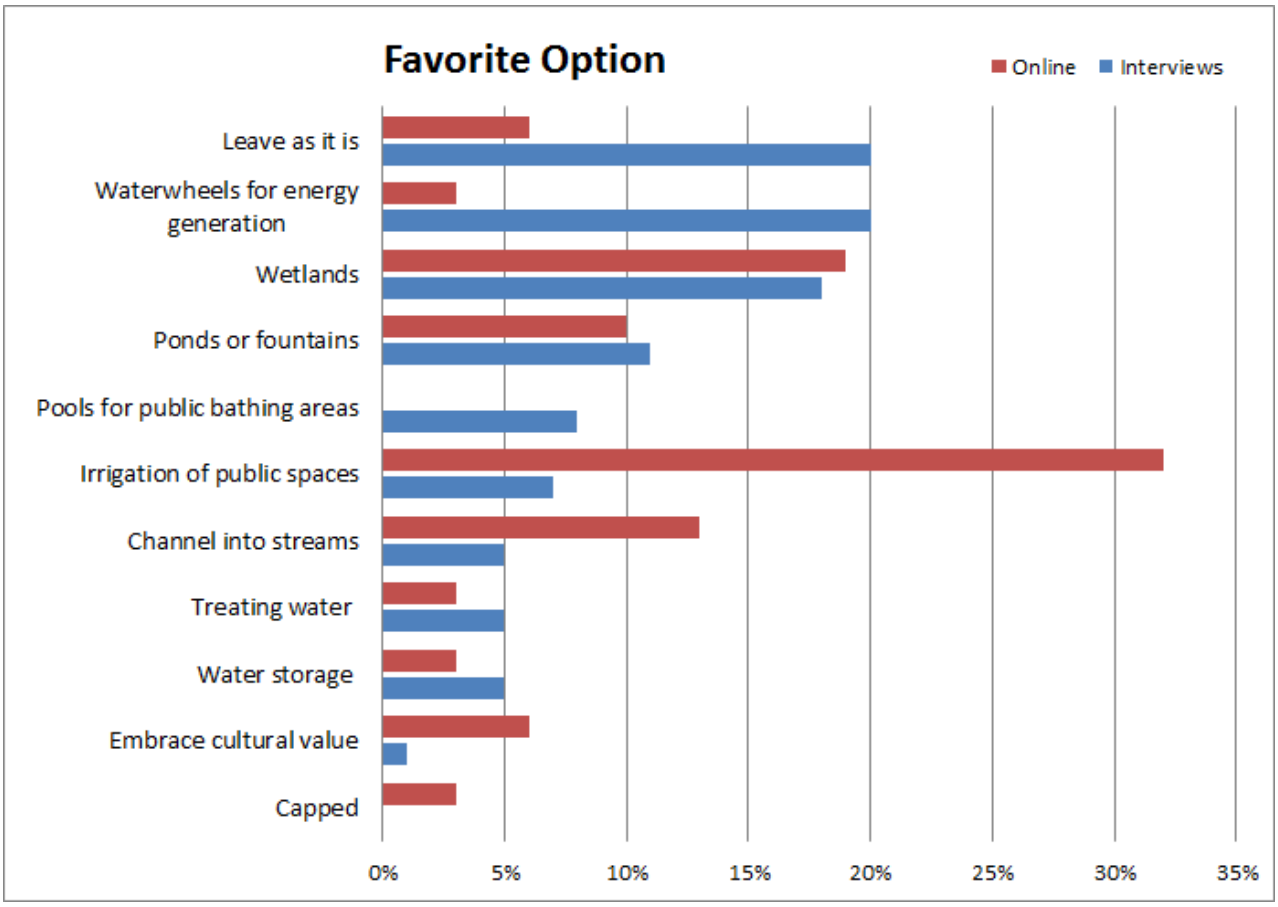


Figure 25: Comparison of responses from face to face interviews and the online survey.

4.3 Results Analysis and further discussion

4.3.1 Overall Preference

A combined total of 142 respondents participated fully in both verbal interviews and online surveys, (individual totals are given above). Combining the findings from online surveys and interviews gave an overall impression of the sampled population's preference to aid in coming up with a conclusive picture. Assuming a confidence level of 95% (α=0.05) since we do not know the exact population value where we obtained our sampled 142, analysis done using R-statistic and Qualtrics software gave the following:

The relatively high standard deviation can be possibly as a result of the difference between methods used in online interviews. Its significance is that preferences seem to vary highly. Unlike the interviews, online surveys had no pictures to aid in making their choices and there was no opportunity to seek clarity from the researchers.

Nonetheless, in overall, Wetlands creation/enhancement was the most preferred development for city springs, closely followed by Waterwheels. There is an insignificant difference between the two considering the high deviation. Also, there is a clear trend that favours aesthetic/recreational developments as opposed to service/utility ones such as Treating for selling or consumption and storage for fire fighting and construction. The practise of capping is the least popular.

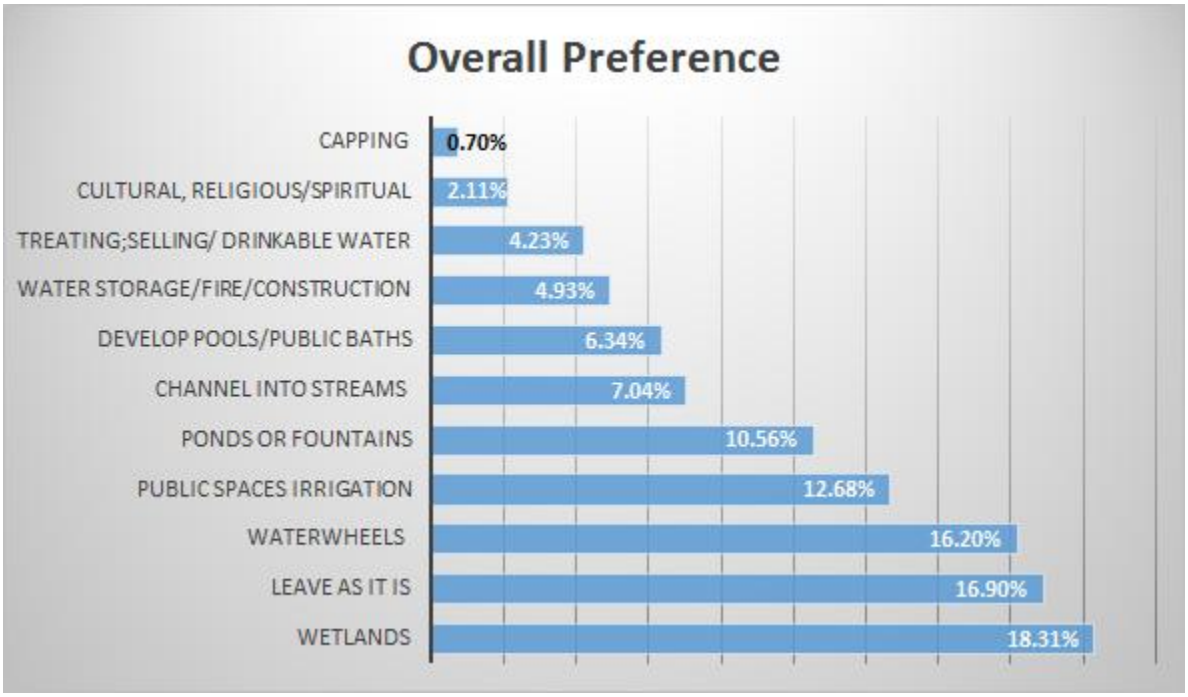


Figure 26: Overall preferences for all respondents

Table 4: Overall preference level of variation

Min Value	Max Value	Average Value	Variance	Standard Deviation	Total Responses	Total Respondents
1	11	5.96	8.42	2.90	142	142

4.3.2 Multiple Choice and Further Analysis

To get a wider perception of respondents' views, their selections were also analysed in terms of the different multiple choices they made regardless of their favourite option. Analysis of variance between the cumulative total of choices chosen pitied again the overall preferred values was done and the results of the analysis is shown in figure 27.

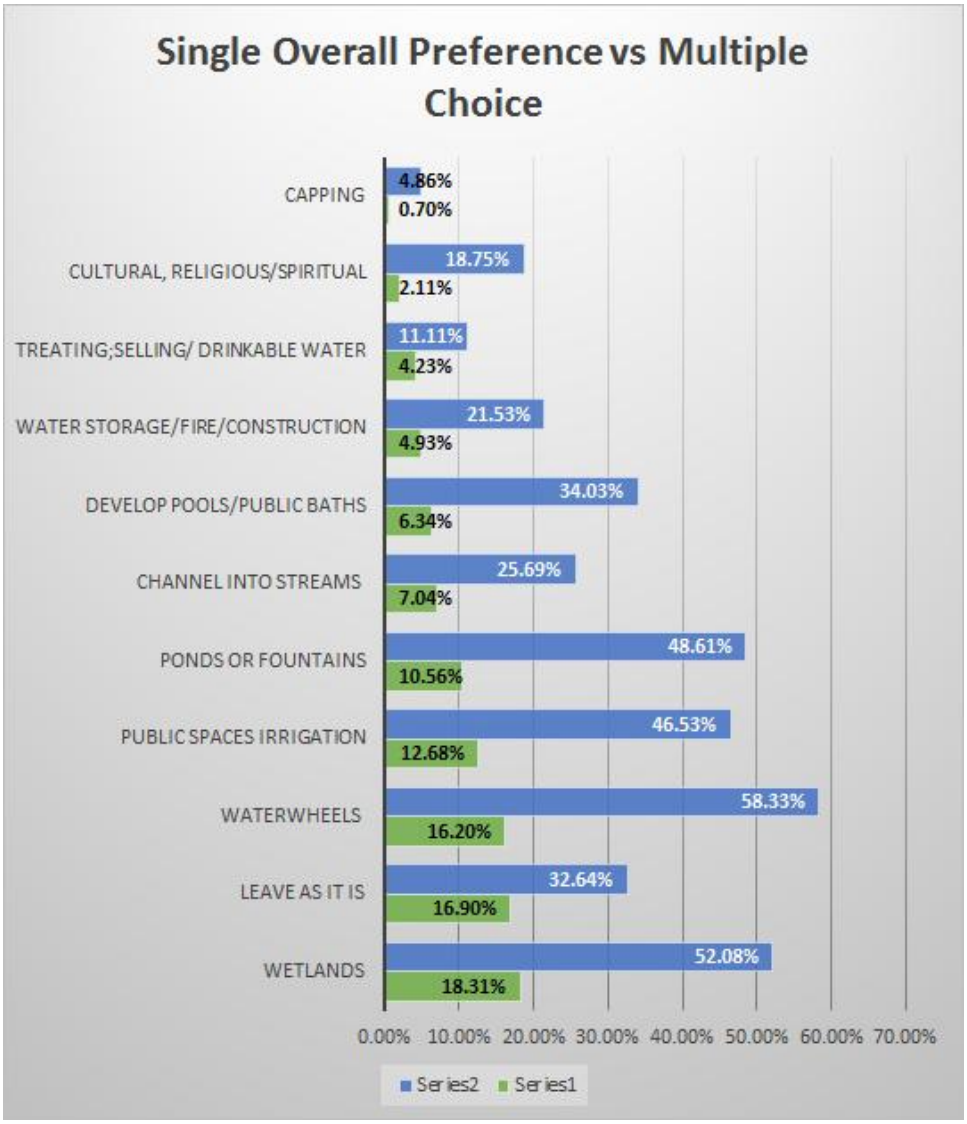


Figure 27: Single overall preference vs. multiple choice (Series 1 represents the overall value for the most preferred option chosen by each respondent. Series 2 represents % popularity of each option when respondents were given the liberty to tick as many options as they like)

Table 5: Significance of cumulative totals

Min Value	Max Value	Average Value	Variance	Standard Deviation	Total Responses	Total Respondents
1	11	5.60	8.15	2.86	510	144

5 Conclusion

Statistically there is no significant difference between the cumulative results when respondents could choose multiple options and when they were restricted to one favourite option. There is however a high variation in both interviews and online survey when analysing different preferences for springs development. This high variation could be attributed to the low consciousness to the existence of springs among the general populace despite having strong sentiments about what sort of management methods they would prefer to be incorporated into legal policies of the city.

Variation between the interviews and the online survey can also be due to lack of visual aids in the latter. However, it is conclusively clear that in all instances, the most popular options are developments that enhance aesthetic and natural value of the springs or promote recreational use. Wetlands enhancement, leaving nature to take its course, irrigating public spaces and building waterwheels, ponds or fountains were most popular in overall with over 74% of the respondents. The bigger picture is that the practise of capping is definitely not in the best interest of everyone whilst nurturing and enhancement of springs with the various options stated are preferred.

5.1 Limitations of the research

Time was a big constraint in the study. The face to face interviews were conducted in a space of a week, with 2 hour sessions each day. There was longer period given to the online interviews, as stated in the methodology, to try and encourage a higher response rate but that was not to be. A trend downloaded from our survey site shows that the responses we got were only from the first few days.

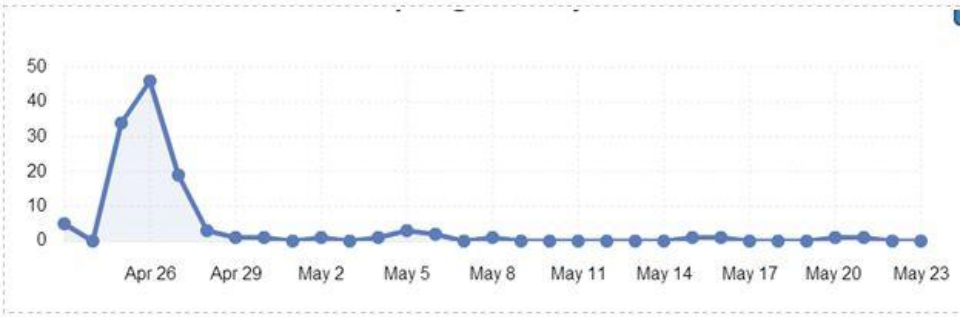


Figure 28: Survey webpage activity trend

Recording of many qualitative statements was difficult. This was due to being actively engaged in the conversation with the people. Having finished not all statements had been recorded, new people would arrive and some of the statements from the first people were not recorded owing to the distraction. In future it would be best to have one person doing the recording whilst the other does the interviews.

6 Recommendations

It is recommended that responsible authorities consider enacting a binding and definitive policy with clear guidelines on springs management in Christchurch. This is especially desirable now during the rebuilding exercise going on mainly in the central city. Both CCC and CERA have place making initiatives which can take springs on board in their plans. Their conservation and development can be a big part of creative place making in CCC. The management direction from the survey is in line with the international examples shown earlier. The responses from the surveys included international perspectives as tourists were also interviewed. Their responses were collated with all the other responses as they make up part of the community that is Christchurch

The community's perspective for the management of the spring at the centre of this project is for it to be developed into a place where, the water can be enjoyed in a way that highlights the

aesthetic values. Further to this it is in line with other springs that have been developed in Christchurch as shown in this report. CERA has indicated that it has some interest in developing this area and as such this report will be given back to them. Which they can use this report as a tool to develop a strategy for the management of the spring.

The report will also be given to Melanie Coker who will feed it into the Spreydon Heathcote Community Board for possible policy development into CCC. A written specific management strategy is required to ensure the continuation of the vitalization and restoration of the springs, which needs to protect those not only in public places but also on private properties.

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