

# Christchurch groundwater exposed

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## Abstract

Throughout history, groundwater has been an integral part of the subsistence, wealth and beauty of Ōtautahi/Christchurch – Aotearoa/New Zealand's second largest city, yet undisputedly its groundwater capital. The aim of this work is to expose that case and provide examples of how groundwater is manifested in Christchurch's cityscape, and cultural and architectural heritage. The result, presented here, is a historical and visual guide to Christchurch's groundwater-related sites, artefacts and attractions that can be visited by way of a self-guided tour.

## Keywords

artesian, Christchurch, fountains, groundwater, history, springs, water supply, wells

## Introduction

Throughout history, groundwater has been an integral part of the subsistence of Ōtautahi/Christchurch. The artesian aquifer system that underlies Christchurch provides the foundations to the city both literally and metaphorically. Physical aspects of that system are detailed in the works of Bowden *et al.* (1986) and Brown and Hanson (in press – this issue) to which readers are referred for hydrogeological background. The social geography of Christchurch groundwater is discussed in this paper and evidence presented for why the city deserves the moniker 'the groundwater capital of New Zealand'. The

purpose is to explore and provide a visual guide to groundwater-related features in a city whose socio-economic well-being has been built upon – and continues to be supported by – the exploitation of freshwater from the aquifers that lie directly beneath it.

Within this paper, I provide examples of how the influence of groundwater can be evidenced in landmarks, infrastructure, recreational amenities and geographic features of the city. I demonstrate how groundwater is manifested in Christchurch's architectural heritage and provide some historical context. This work has hatched from a personal interest in groundwater science and modern history, as well as a fondness of beer, which in Christchurch, is brewed using groundwater and triggered the initial discovery of the Christchurch artesian system.

Beginning with a description of the natural spring-fed river systems around which the city was developed, the work is structured as seven sections that loosely follow the timeline of groundwater exploitation within Christchurch. From hand-dug wells, artesian wells, beautification of the city, reticulated water supply and storage, through to modern utilities and miscellaneous items, the sections tell a concise history of groundwater use in Christchurch. For each section, case examples have been selected based on their historical, archaeological, cultural, technological or socio-economic significance. Or because they hold some notable aesthetic or amenity value with a demonstrated connection to the

Christchurch aquifer system. Site selection has mostly been limited to those that are publicly accessible, so that readers can choose to follow this work in the form of a self-guided tour. Maps of the study area show the locations of sites presented in this work (Figures 1 and 2). Site numbers in Figures 1 and 2 are cross-referenced throughout the text using square brackets: [#]. Historical and technical content was compiled from an analysis of the media discourse on wells in Christchurch, review of scientific and technical literature on groundwater, historic archives, and public information available from both the regional and city councils.

Compilation of this paper coincides with the time the Canterbury Museum [1] is undergoing redevelopment, which has forced decommission of the ‘Museum Wells’ – the oldest groundwater monitoring sites in the country. The ‘Museum Wells’ consist of a 30 m deep well that screened the Riccarton Gravel/Aquifer 1, together with a 55 m deep well that screened the Linwood Gravel/Aquifer 2 (Bowden, 1986). Groundwater level recordings started there in 1894 and groundwater hydrology study in New Zealand was founded on analyses of the well hydrographs (Hilgendorf, 1912, 1917, 1926; Hutton, 1896). The loss of the ‘Museum Wells’ marks the end of a chapter in collection of a big dataset of significance and provides a pertinent example of the fluidity of our structural heritage and historical landmarks.

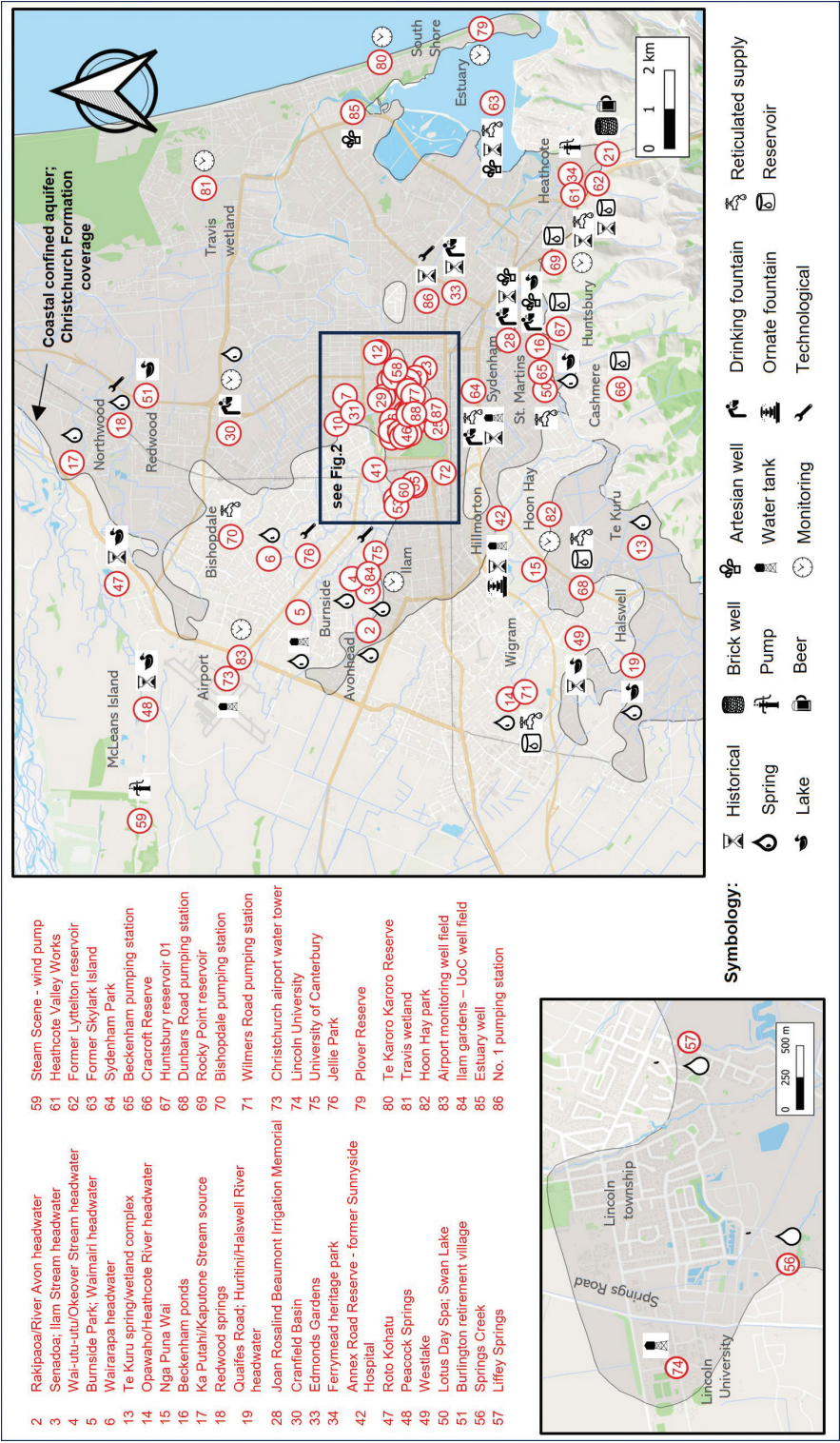
## Spring-fed rivers

There are four significant river systems within the Christchurch city limits – Ōtākaro/River Avon, Ōpāwaho/Heathcote River, Huritini/Halswell River, and Pūharakekenui/Styx River – all of which are spring-fed, sourced by groundwater discharge. The headwaters of the rivers and many of their tributaries coincide with the margin of the Christchurch Formation that is a capping layer of the

coastal confined aquifer (Figure 1) and acts as a barrier to vertical flow. Seasonal fluctuations in the water table drive variations in the exact position of where groundwater emergence occurs for many of the headwaters. The natural courses of the waterways follow paleo-features of the Waimakariri River fan (e.g., White, 2007). Weak points in the Christchurch Formation permit artesian flow at discrete locations, which can sometimes be evidenced as sand boils, either at spring heads or along the bed of the river itself. The groundwater that provides the natural baseflows of the waterways has a mixed Waimakariri River and land surface recharge provenance, the relative proportions of which vary depending on distance from the alpine river. The Ōpāwaho/Heathcote and Huritini/Halswell river catchments extend beyond the Christchurch aquifer boundaries and these two hydrological systems also receive run-off from the Port Hills. In modern times, stormwater run-off also contributes to the stream flows, as does water from Selwyn District Council’s Paparua water race, which is used for augmentation. All four river systems are of cultural importance to tangata whenua (indigenous people), traditionally being mahinga kai (food-gathering places) and historical transport networks through the vast swamp land that existed before the development of Christchurch in 1850. They also represent taonga (treasures) with springs feeding into the rivers historically used by tohunga (experts) for healing purposes, also for ceremonial purposes (Te Rūnanga o Ngāi Tahu, 2023). A detailed description of Māori cultural values and traditions is beyond the scope of this work.

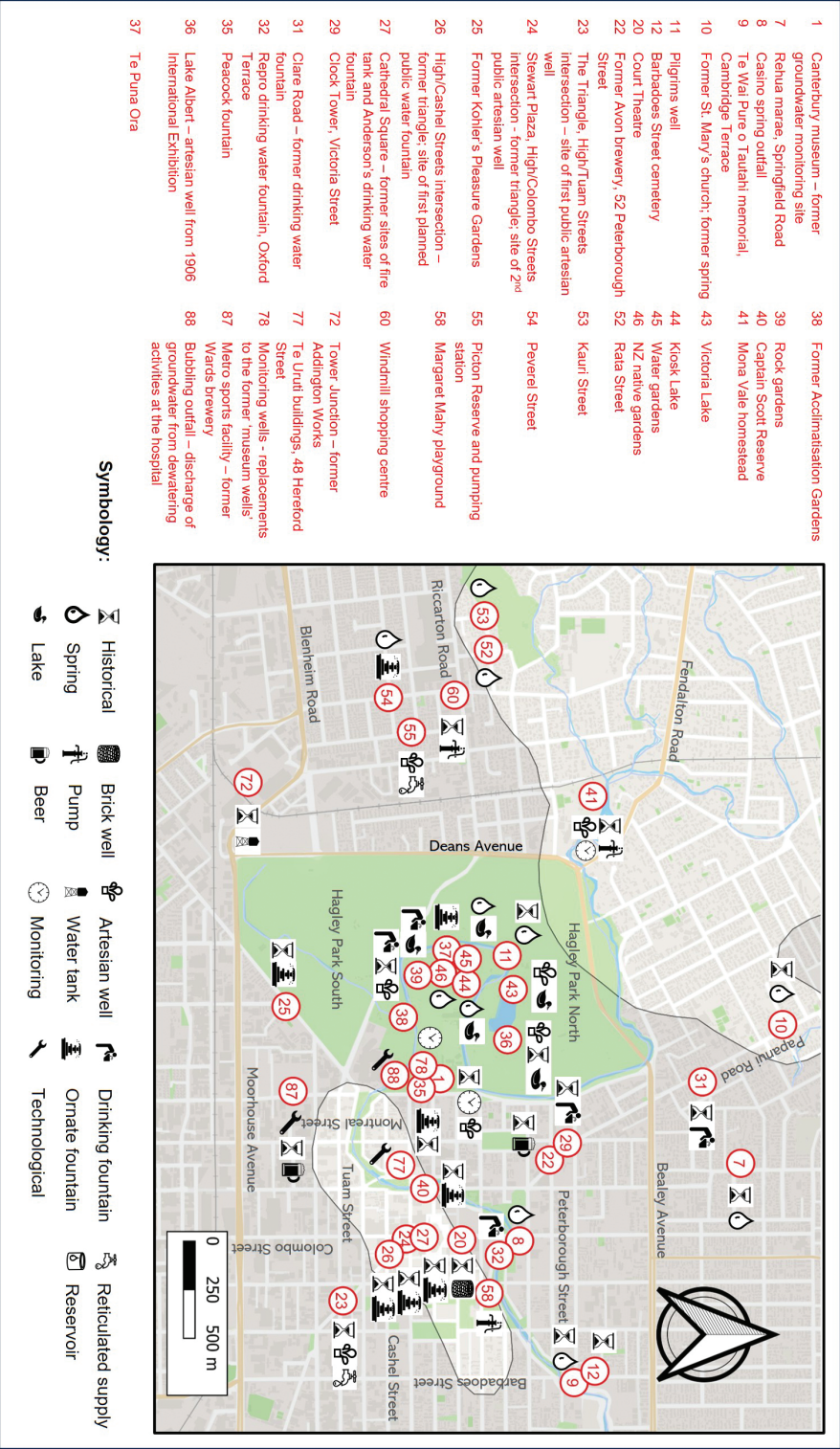
## The Ōtākaro/River Avon

In terms of modern history, the River Avon is arguably the most significant river within Christchurch, on account of it being the one around which the city was planned and an



**Figure 1** – Map and list of groundwater-related sites within Christchurch city, also Lincoln township (inset). Darker shading denotes the coastal confined aquifer, as defined by coverage of the Christchurch Formation. See Figure 2 for details of sites in the inner city region. Site numbers are cross-referenced in the main body text by numerals enclosed in square brackets: [#].





**Figure 2** – Map and list of groundwater-related sites within inner city Christchurch. Darker shading denotes the coastal confined aquifer, as defined by coverage of the Christchurch Formation. Site numbers are cross-referenced in the main body text by numerals enclosed in square brackets: [#].

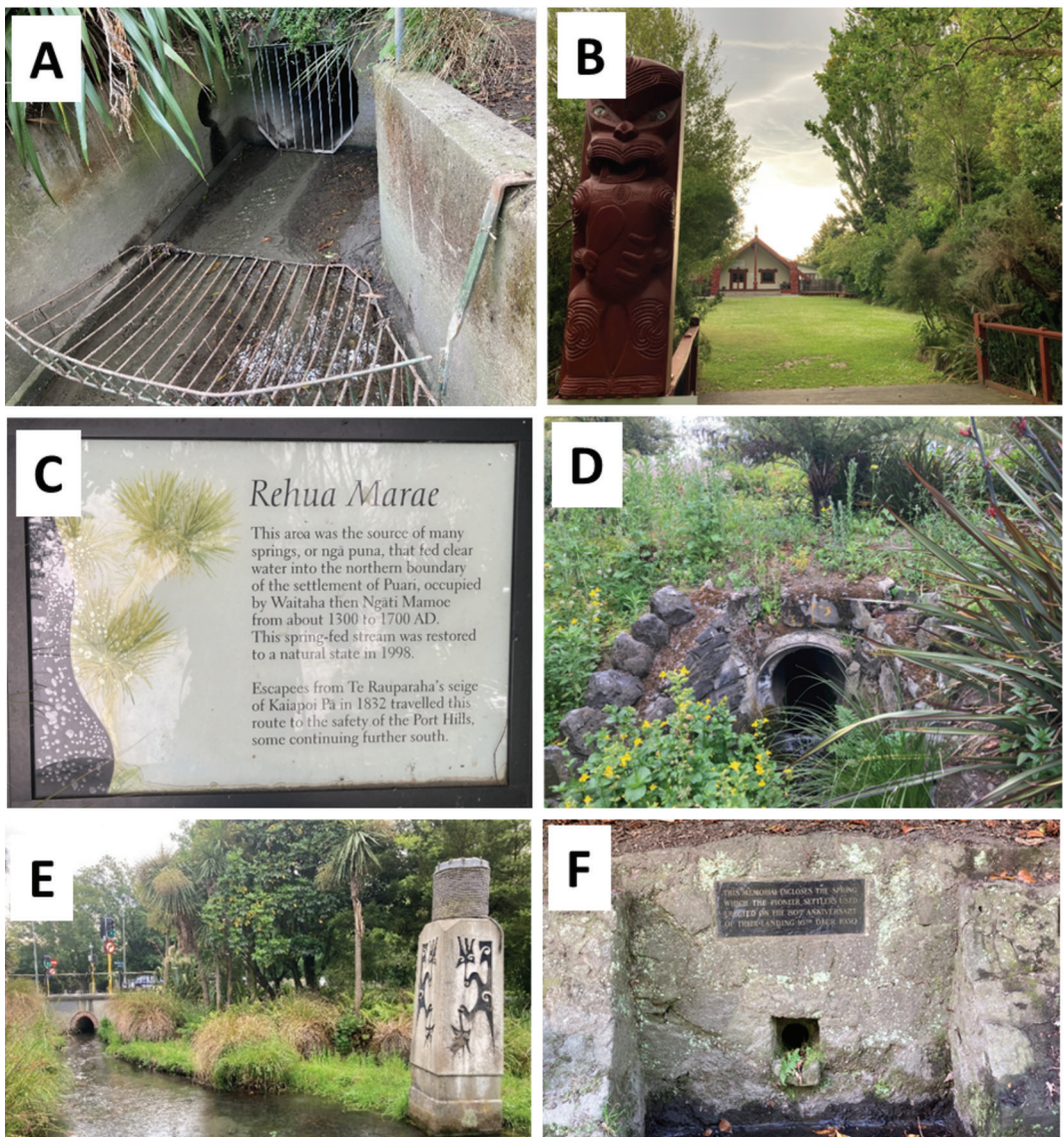


iconic place for recreation. The southern and main branch of the Avon River is known to Ngāi Tahu (main tribal group of the South Island) as Haereroa (the longest stream) and its headwaters as Ōrakipaoa (smoky sky) that today are represented by gravitational springs emerging between Balrudry Street and Avonhead Road [2] (Te Rūnanga o Ngāi Tahu, 2023). Kā Waimaero/Ilam Stream, that flows through the grounds of the University of Canterbury (UoC), is a tributary of Haereroa. Its original springheads at Senoda/Dovedale campus [3] are now obscure and are integrated into the storm drainage infrastructure there (Figure 3A). Groundwater emerging in the corner of the UoC's Ilam Fields [4] provides the source to Okeover Stream, Ngāi Tahu's name for which is Wai-utu-utu or 'water lifted up' (Taylor, 1950). Today, flows in Okeover Stream are augmented with groundwater discharge from wells operating on the UoC campus (see Figure 20B, below). The Waimairi or Waimaero tributary flows through the suburb of Burnside and its springhead is situated in a depression in Burnside Park, where the water tower is sited [5] (see Figure 19E, below). The Wairarapa is a northern tributary of the Ōtākaro /River Avon, also located in the Burnside suburb. The stream head was originally associated with a distinct patch of swampy ground close to where the Waimairi cemetery is located [6].

Between the years 1,000 – 1,500 CE there was a large Māori pā site on the banks of the Ōtākaro, called Puari. Originally settled by Waitaha (the iwi to whom Canterbury region shares its name), Puari roughly extended from Victoria Square, east across to Barbadoes Street, and north, past Bealey Avenue. It was later occupied by Ngāti Māmoe and eventually Ngāi Tahu. At Rehua Marae [7], on the aptly named Springfield Road, there is a plaque commemorating the site of freshwater springs that once fed waters into the northern

boundary of Puari (Figure 3B; 3C). Any evidence of a field of springs has long since disappeared – a casualty of urbanisation and the artificial drainage that European settlers installed to develop Christchurch city. However, there is one spring currently active in the city and within the domain of Puari, and that is located under the Casino. Indirect evidence of its existence is via the outfall to the Ōtākaro/River Avon [8], located immediately downstream of the Colombo Street bridge (Figure 3D). Discharge from the spring was connected to the stormwater drainage network to mitigate flooding issues and explains why this stormwater pipe flows outside of storm events.

Taylor (1950) documented that springs that 'used to bubble forth through large cones of sand' were associated with Ōtautahi Pā that Ngāi Tahu established on the banks of the River Avon, between the current locations of Madras and Barbadoes Streets. Sometime in the late 17th or early 18th century, spring waters in the vicinity were used in blessing the marriage between Ngāi Tahu chief Te Pōtiki Tautahi (from whom Ōtautahi takes its name) and Waitaha princess Te Auru. Both Ōtautahi Pā and Te Wai Pure o Tautahi (the ceremonial waters of Tautahi) are commemorated by the form of the spring-fed St. Mary's stream that emerges from a brick barrel culvert at Cambridge Green [9] and three pou (ceremonial posts) that were erected in 2005 but removed following earthquake damage suffered in 2011. The pou symbolised the three waves of Māori migration to Christchurch (Christchurch City Council 2005; Rewi, 2009) and today are marked only by the plinths on which they sat (Figure 3E). Historically, the source of St. Mary's stream was traceable to a spring at St. Mary's vicarage, 30 Church Lane, Merivale (now All Souls Anglican Church) [10], hence the name. Coincidentally, the wave of European migration orchestrated by the



**Figure 3** – Groundwater-related features exposed on the Ōtākaro/River Avon. **A:** Not particularly obvious or scenic, but the state by which groundwater discharge at Senoda/Dovedale campus now reveals itself as the headwaters of Ilam Stream. **B:** Rehua Marae on Springfield Road where a plaque **C:** marks the historic site of springs that once fed the northern boundary of the Puari settlement. **D:** Storm drain outlet near the Colombo Street bridge that includes discharge of a spring located under the Casino. **E:** Tribute to Te Wai Pure o Tautahi and Ōtautahi Pā, where Mary's Stream discharges to the River Avon at Cambridge Green. **F:** Pilgrims Well memorial on the banks of the River Avon in Hagley Park that marks a natural spring and the freshwater supply to the first Canterbury settlers who arrived in 1850.

Canterbury Association and which started in 1850, is commemorated by The Bricks monument located across the river from Cambridge Green reserve. That monument marks the furthest distance whaling boats could navigate up the river and the landing site established by the first European settlers. The name ‘The Bricks’ was assigned on account of the site being where the pioneering brothers Deans offloaded bricks for the construction of their homestead at Pūtaringamotu (Deans/Riccarton Bush), which, along with a copse at Papanui, were the only remaining stands of podocarp forest on the swamp in the 1840s when the prospective Canterbury settlement was being planned.

The Deans family legacy lives on in the River Avon which is the namesake of the river that flowed past the family farm in their native Scotland. It was a natural spring on the banks of the River Avon [11] that sustained the temporary camp of the Canterbury pioneers who arrived on ‘the first four ships’ in 1850. Many of the settlers camped in the Government Domain (now Hagley Park), pending development of their properties. The camp was established near a natural spring that provided a secure freshwater resource, and which today is marked by a memorial (Figure 3F).

Adjacent to Cambridge Green is the Barbadoes Street cemetery complex [12], which also has a groundwater story. The cemetery was the first European burial ground in Christchurch, opened in April 1851 (with the burial of someone by the surname Brown). Comprising swamp land of poorly draining peat and sandy clay, the cemetery and its surrounds were plagued with drainage problems, not helped by the shallow water table that flooded graves (City Council, 1883a). With expansion and urbanisation of the city, the issue of residents complaining of the fetid springs on Barbadoes Street was a topic the ‘Inspector of Nuisances’ became familiar with (Christchurch Borough

Council, 1868). When, in 1883, 41 people collectively complained about the stench and soakage emanating from the cemetery, the Sanitary Committee were called upon to investigate (City Council, 1883b). The medical officer ruled the city cemeteries unfit for interments (City Council, 1883a) and they were closed to all but close relatives on 1 April 1885 (“News of the Day”, 1884). In his investigative report, the medical officer also criticised the heaps of refuse and sump accumulations across the river, on Oxford Terrace, due to the health hazard they posed (Dew, n.d.). To this day, that locality (the Avon Loop) remains infamous for being a ‘shitty place’, now on account of the amount of Canada goose faeces (McDonald, 2020).

### **Ōpāwaho/Heathcote River**

Ōpāwaho gained its name from the outpost pā situated on the banks of the river, near to where SH75 now crosses the river (Te Rūnanga o Ngāi Tahu, 2023). The Canterbury Association named the river after their secretary Sir William Heathcote. The complex of springs and wetlands draining into the river close to the Port Hills were known to Ngāi Tahu as Te Kuru (the blow of the fist). This name now describes the 14 ha stormwater wetlands facility that is a buffer between Hoon Hay and Halswell, at the head of Cashmere Stream [13] (Christchurch City Council, 2024a). Ten permanent springs were recently surveyed in the land developments there (Ōpāwaho Heathcote River Network, 2024b) (Figure 4A).

The middle reaches of the Heathcote River near Spreydon were known as Waimōkihi, after a pā there named Ō Mokihi, meaning ‘the meeting place of flax staff rafts’ (Te Rūnanga o Ngāi Tahu, 2023). The upper tributaries about the Wigram basin were known to Ngāi Tahu as Te Heru o Kahukara – ‘the head comb of Kahukara’ (also the name given to Sugarloaf hill in the Port Hills) (Christchurch City Council, 2016a). From



Ōpāwaho, travellers would transit across land to access the Huritini/Halswell River system, which provided linkage to Te Waihora/Lake Ellesmere (e.g., Ōpāwaho Heathcote River Network, 2024a). The Heathcote River can be traced upstream as far as Wilmers Road, Wigram [14], albeit the numerous stormwater retention ponds now obscure any natural landforms or gravitational spring features there. The Ngā Puna Wai outdoor sports hub at Wigram [15] is so named because of the ‘many spring waters’ that traditionally occupied the area (Matapopore, 2016). Several springs can still be spotted along the river reach, downstream from Augustine Drive (Figure 4B).

Looking at the river today, it is difficult to imagine that the Heathcote River was 6 – 8 m deep when the Canterbury settlement was formed in 1850, and that regular shipping services and a tow path ran as far upstream as Richardson Terrace. Within 30 years of the development of Christchurch, the river was effectively choked with sediment washed from the deforested Port Hills. Although highly landscaped, a remnant of original swampland exists in the form of Beckenham ponds [16], which are fed by a spring in Beckenham Park (Figure 4C).

### **Pūharakekenui/Styx River**

Groundwater that feeds the Styx River has the strongest Waimakariri River provenance, by virtue of its proximity and hydraulic connectedness with the alpine river. Pūharakekenui translates to ‘large bundle of flax’ in English. Originally the European name given to the river was the ‘Sticks’, on account of sticks used to mark river crossing places. It was later changed to ‘Styx’ – the river of the underworld in Greek mythology (Hills, 2002). The river has two main tributaries: Smacks Creek and Kā Pūtahi/Kaputone Stream [17] (Figure 4D), and there are at least six sites in the catchment where substantial spring features with a

rich biodiversity can be found (Zollhoefer, 2007). Redwood springs [18] is the most accessible of the springs and the best site in Christchurch at which bubbling springs can be observed (Figure 4E). Stewart *et al.* (2018) determined the mean residence time (age) of the spring water to be 8 years.

### **Huritini/Halswell River**

Groundwater from a scattering of spring-fed sources around the suburban fringes of Halswell, Templeton and Prebbleton drive the baseflows in the Halswell River system. This system provides hydraulic linkage between the city and Te Waihora/Lake Ellesmere. The Māori name Huritini means ‘many turns’ and reflects the meandering characteristics of the mid and lower reaches of the river (Robilliard and Pauling, 2015). The river’s two main upper tributaries are Te Tauawa a Maka/Nottingham Stream and Ōpouira/Knights Stream. Springs at the head of Cases Drain [19] (which connects with Ōpouira/Knights Stream) are in the process of being transformed into a stormwater basin cum recreational area and are the most notable, publicly accessible groundwater point of interest in the catchment (Figure 4F). The nearby housing development has adopted the name Matai Springs on account of matai tree stumps exhumed from the stormwater basin. The stumps were radiocarbon dated as being 800 – 1,200 years old and were possibly killed after a Waimakariri River flood event (Gooding, 2020). The mean residence time of groundwater feeding the springs within this area is in the region of 14 years (Stewart *et al.*, 2018).





## Hand-dug wells

Springs initially provided a convenient source of clean freshwater but, as the Christchurch settlement developed, demands on water supply increased. European settlers were quick to tap into the shallow groundwater that lay beneath their feet as evidenced in this letter that was printed in the Canterbury Papers (Canterbury Association, 1850):

Till last week we have had *lovely* weather, indeed almost too fine, as the want of water began to be felt in some parts. We have always had plenty....., by digging a hole where it is a sandy beach you get most beautiful water.

Water supply in Christchurch city was originally obtained from digging wells, typically three to five metres deep. To mitigate sediment ingress and provide structural support, the wells were often internally cased with bricks or wooden beer barrels. Examples of these practices were unearthed in archaeological digs made following the 2011 Christchurch earthquake, including at the new convention centre (Te Pae), the new sports stadium (Te Kaha), the new Court Theatre premises, and at St. Asaph Street. Five wells associated with a soda drink manufacturing premises, active before the 1880s, were exposed at the St. Asaph Street site (Williams, 2017; Watson, 2023). Regrettably, with no legal requirement to preserve such artefacts, physical evidence of

them has now been destroyed. The exception is a distinct yellow-brick well exhumed from the new Court Theatre site on the corner of Colombo and Gloucester Streets [20], for which there is good intent to incorporate the remains into future development of the site (Figure 5A). The prime example of an early brick-lined well in Christchurch can be found at the Heathcote Valley Inn [21] where a 12 m deep, 1.5 m diameter well dug in 1880 now forms a centrepiece of the pub (Figure 5B).

## Early artesian wells

A comprehensive history on well-drilling developments and early exploitation of artesian groundwater in Christchurch has been provided by Weeber (2000 and 2001). The details provided here have been selected to give context for topics and case examples that follow, and to demonstrate the historic linkage between groundwater exploitation and beer brewing activities.

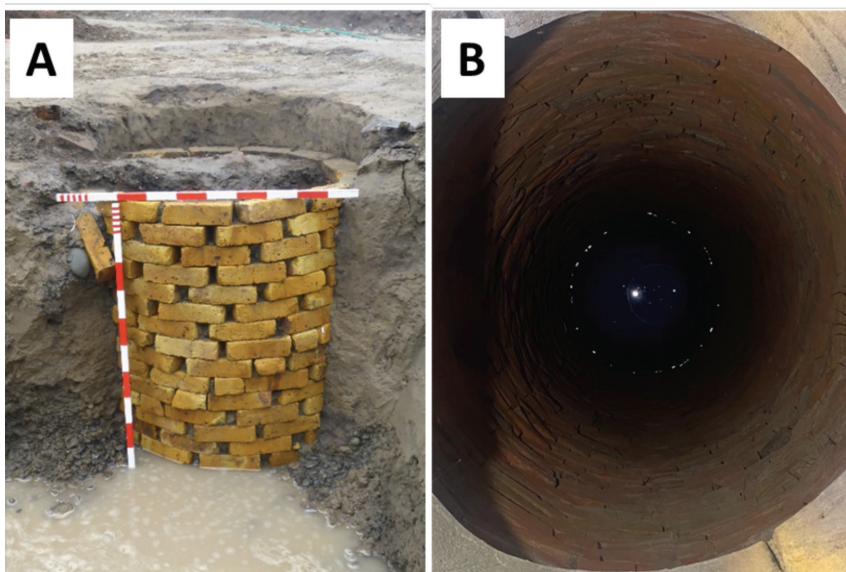
The first recorded account of artesian groundwater being tapped in Christchurch is accredited to Mr Taylor who was prospecting for a new fresh water supply for his Avon Brewery, at 52 Peterborough Street [22], in 1858 (“Local Intelligence”, 1858):

Mr. Taylor has been engaged in sinking a well, and at 12 feet he obtained water. This not proving of a satisfactory quality he continued to dig deeper, but as the

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*Opposite: Figure 4* – Points of emergent groundwater in the Ōpāwaho/Heathcote River, Pūharakekenui/Styx River and Huritini/Halswell River catchments. **A:** One of the deep springs at Te Kuru that are a natural source of the Cashmere Stream – a tributary of Heathcote River. **B:** One of several springs at Te Puna Wai Sports Complex that feed into the upper reaches of the Heathcote River – an area known to Ngāi Tahu as Te Heru o Kahukara Te Hera. **C:** Beckenham Ponds, which represent a remnant swamp area of the Heathcote River. **D:** Springhead of Kā Pūtahi/Kaputone Stream – a tributary of the Styx River. The spring flows are augmented with water that upwells from a 128 m deep artesian bore. **E:** Redwood Springs in the Styx River catchment where sand boils can be observed. **F:** Quaifes Road Springlands complex, which marks a headwater of the Halswell River.





**Figure 5** – Hand-dug, brick-lined well examples. **A:** Well constructed of distinctly coloured yellow bricks unearthed by archaeologists and salvaged by developers at the new Court Theatre site. It is possible the bricks will be incorporated in the new theatre complex (Photo: Alana Kelly, supplied and used with permission by Underground Overground Archaeology Ltd). **B:** 12 m deep well within the Heathcote Valley Inn.

water interfered unpleasantly with the work, he attached a common 1½ inch auger to a pole and worked with that, and having driven it through the soil about 8 ft. he was met by a fountain which rose several feet. We need hardly observe that this is in fact an Artesian well, and suggests to those whose situations on the plains may be remote from running streams an encouraging method by which the all-important requisite, water in abundance, may be obtained.

In the early 1860s, access to water for firefighting arose as a problem in Christchurch, coinciding with the time the Sanitary Commission was expressing concern over the unfit state of the shallow groundwater resource and advocating for more secure drinking water supplies to be found. In an essay on public health of that time, Rice (2021a) suggests the British settlers' penchant for drinking tea, beer and cider

was probably what saved many of them from pathogenic disease, given the unsanitary state of the drinking water in the city in the 1860s. Starting in 1862, the Christchurch Municipal Council debated on the topic of new alternative water supplies for the city for two years, during which they consulted with prominent engineers and geologists. It was the opinion of the esteemed Provincial Geologist Julius von Haast that diverting water from the Waimakariri River to the city via a canal network would be more cost-effective than exploiting any groundwater resource – an opinion that no doubt delayed the Council's final decision making. Whilst the Council debated the pros and cons of exploiting artesian water, private individuals forged on with their own explorations, which were promoted in the local press (e.g., Figure 6A, 6B). Along with tea and beer, soda water was also a popular refreshment amongst the Christchurch settlers. Indeed,

Robson (1995) calculated that, on average in 1916, there was an aerated water factory every 20 miles across Canterbury, and that Christchurch was home to more soft drink manufacturers than Auckland, Wellington and Dunedin combined. Like the brewing industry, the soda water manufacturing industry in Christchurch tapped into the artesian groundwater resource before it was exploited for public drinking water (Figure 6A) (see next page).

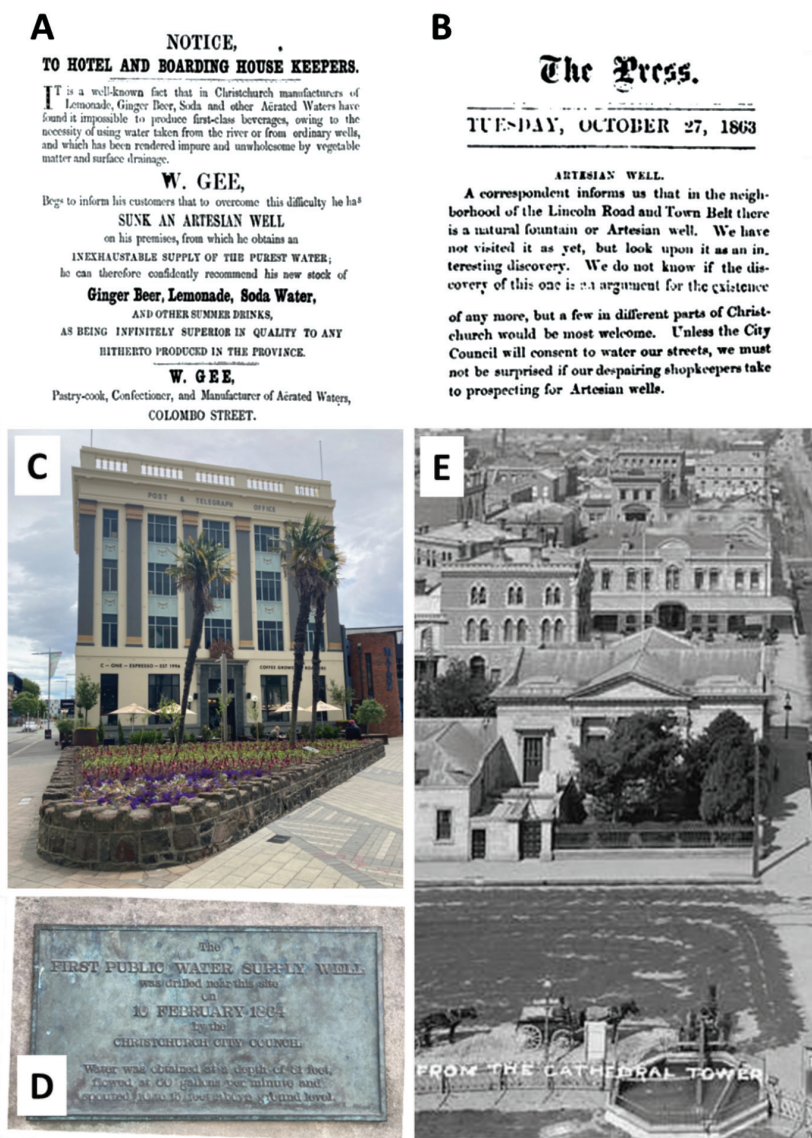
It was 14th February 1863 when the Council committed to an investigative drilling programme that aimed to sink three experimental wells located on the corners of High and Tuam Streets, High and Colombo Streets, and Peterborough Street and Papanui Road (“Town and Country News”, 1863). The Council proceeded to purchase a boring apparatus from the disbanded Kowai Coal company for this intent. They rented the apparatus out to the public whilst they deliberated over when to start their field experiments. The orphan asylum on Lincoln Road, Addington was one beneficiary of this lease arrangement from which a 107 foot (32.6 m) deep water supply well was produced (“Christchurch”, 1864).

It was 11th January 1864 when the Council finally used their boring apparatus to sink a 2.5 inch (63 mm) pipe through the ground of ‘The Triangle’ at the corner of High Street and Tuam Street [23] (Figure 6C). On 10th February, upon reaching 24.7 m depth, they struck artesian groundwater, marking success of the first artesian public water supply well in the city. The well yielded 60 gallons per minute – equivalent to 4.55 L/sec, which just so happens to be within the 5 L/sec permitted activity limit that applies to groundwater abstraction in the rules of today’s active Canterbury Land and Water Regional Plan (Environment Canterbury, 2023). A plaque marks the site of this historic achievement (Figure 6D). Soon after, on 15th February

1864, the Council instructed the drilling of the second experimental bore in front of the City Hotel on the junction of Colombo and High Streets [24], near Cathedral Square and in the vicinity of what was effectively the city’s first taxi stand (Figure 7A). Whilst the event was not as historically significant as the first, it was more eventful. To start, the drill auger broke drilling through buried tree stumps at 12 m depth, forcing the hole to be abandoned and a second attempt to be made (“Artesian Well”, 1864a). Stories then followed reporting that gold had been discovered during the drilling process, which for a brief period caused a stir (“Found at Last”, 1864; “Gold in Christchurch”, 1864). Finally, dissatisfied with the water yield of the completed bore, the Council instructed the City Surveyor to deepen it (in a bid to gain higher pressure), before he proceed to drill at the third site, on the corner of Peterborough Street and Whately Road (present day Victoria Street) (City Council, 1864) – at what today constitutes the frontage of the Christchurch Casino.

The Council had always intended for the three experimental bores to be fitted with pumps and wooden troughs (“Town and Country News”, 1863) and yet the records indicate it was possibly as late as March 1865 before such instruments were added to the wellheads (“Artesian Well Fittings”, 1865). In the interim, water issued freely from the artesian wells and caused a flooding nuisance. The wastage of water drew some criticism, as demonstrated by this witty article, ‘Aldermania’, published in *The Press* newspaper (1864):

There are two artesian wells discharging a very pretty supply of water from the bowels of the earth into the streets of our city. As you pass either of the iron pipes from whose tops the sparkling streams are bubbling, you will generally see two or three intelligent citizens standing looking



**Figure 6** – Evidence of early artesian well exploits that started in earnest in the 1860s.

**A & B:** Extracts from *The Press* newspaper 22 February 1862 and 27 October 1863 respectively, demonstrating exploitation of artesian groundwater by private enterprises at the time the Municipal Council were deliberating on exploring the resource for public supply. **C:** The Triangle on the corner of High Street and Tuam Street – site of the first public artesian well in Christchurch, sunk in 1864, and where a plaque **D:** commemorates the achievement. The site was turned into a garden in the 1930s. **E:** Detail of photo from 1880s showing horse-drawn water carts filling from the fire tank on the south-west corner of the cathedral grounds. Constructed in 1871, the tank was supplied by its own artesian well. It is likely the water tank was later used in the supply of water to the stream tram terminus in Cathedral Square. The Bank of New Zealand building is in the middle ground. (Image cropped from Burton Brothers photo 1880s, '4983 – Christchurch from the Cathedral Tower', Museum of New Zealand Te Papa Tongarewa. No known copyright restrictions).



at the beneficent fountain. It may be, some up-country man, who has not been down for a spree since the springs were tapped, is contemplating with satisfaction the facility with which he can now restore collapsed nature towards the small hours of the morning, by getting his head under the pump without having to pay a boy to work the handle. But we will venture to bet a new hat, that if we listen to the conversation for two minutes we shall hear the remark – ‘Why the deuce do they let all this water run away, why don’t they do something with it?’ And the citizen, who knows something more of the disappointments of civilised communities, is sure to reply, ‘Ask the City Council, it’s their look-out.’ Up-country-man will let a stream of smoke flow from the opposite side of his mouth to that in which the dirty dudeen is stuck, and will reply, as he moves away to get a glass of something he cares more about than water, ‘Scissors! What muffs they must be! What’ll ye take?’ The latter expression is a mere form, which occurs at the end of most conversations – a sort of colloquial ‘Amen’ in the Colonies..... ‘What will they do with it,’ has been on the lips of every man’s tongue since the bountiful earth yielded up its pellucid treasure. The publicans are in a state of nervous anxiety lest an infatuated public should actually yield to the temptation and take to drinking it.

The Council’s successful endeavours opened the flood gates to exploitation of artesian groundwater and a proliferation of artesian wells ensued (“Artesian Wells”, 1864). Notable artesian bores mentioned in the media that year included one at the Albion Brewery located on Moorhouse Avenue near the junction of Lincoln Road (“Artesian Well”, 1864b), the railway station at Addington (“Railway Tank”, 1864), Harg and Wilson tanners and fellmongers,

Woolston (“Canterbury Industry”, 1864) and at the city gas works (“Christchurch Gas, Coal and Coke Company”, 1864). In July 1864, *The Press* newspaper wryly reported on the numerous artesian well developments (“Another Artesian Well”, 1864):

The city has certainly been ‘bored’ with artesian wells to a great extent but it is our duty to publish facts as they occur.

Whilst the public wells were primarily developed to provide water for firefighting and potable use, the free-flowing artesian groundwater that issued from them also found use as a means to flush the open drains (“Armagh Street West”, 1880) and a convenient water source for those involved in the practice of watering roads to suppress dust (e.g., McBride, 1994) (Figure 6E). One of the quirkier exploitative artesian groundwater uses, documented in 1865, was as a kinetic energy source, to turn butter churns (“Artesian Wells”, 1865).

The rapid exploitation of the artesian groundwater resource across the city led to a noticeable reduction in artesian pressure (Hercus, 1942) and the problem of well interference effects (“News of the Day”, 1903), the story of which is well documented in Weeber (2001). It was at this stage in Christchurch’s groundwater history that the ‘Museum Wells’ played a fundamental role in informing scientific debate and understanding about the hydraulic function of the Christchurch artesian system. Hutton (1896) was the first to notice and report on the weekly periodicity of piezometric pressure under the city – a phenomenon that became known as the ‘Sunday Rise’ because groundwater levels rebounded on Sundays. Dr. Frederick Hilgendorf (of Lincoln College fame and who, as well as being a renowned crop scientist, proved himself as a pioneering groundwater hydrologist) subsequently provided scientific explanations for the occurrence. Ultimately, the drop in artesian

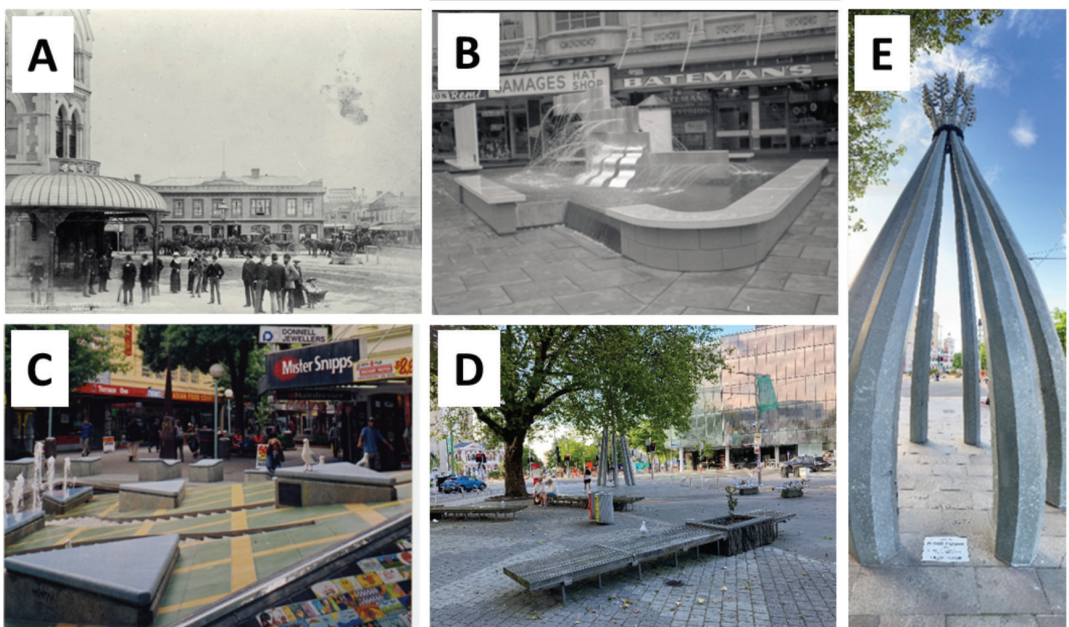
pressure due to groundwater exploitation led to a need for pumps and development of a pressurised water reticulation network, more of which is described below.

## Groundwater's role in beautification of the city

### Water fountains

From July 1864, the well-sinker John Jebson advertised his property on Lincoln Road (at which he had sunk an artesian well in October 1863) as Fountain Villa ("Town and Country", 1863; Jebson, 1864). The name and timing suggests this was possibly the venue of the first artesian fountain in Christchurch. From the time the first public well was sunk in February 1864, members of the public and city businesses made frequent requests to the Council for them to install fountains

on the wells to beautify them (Christchurch City Council, 1864). No action was taken by the Council until 1867, until which time the public artesian wells were purely utilitarian in form and function. Meanwhile, in 1865 and recognising an opportunity to capitalise on the potential beautifying benefits that a free-flowing artesian water supply might offer, Mr Kohler (who happened to be a neighbour to John Jebson) installed an artesian well at his pleasure gardens. These were located on the corner of Selwyn Street and Lincoln Road (on the south-west boundary of the present-day Hagley Community College [25]). The artesian water not only supplied a swimming pool but also operated an ornate artesian fountain feature and these were promoted to the public alongside his other garden attractions (Town and Country, 1865; "Social and Domestic", 1865).



**Figure 7** – High Street and Colombo Street intersection – site of the second public artesian well drilled in Christchurch and first equipped with an ornate public fountain. **A:** Photo from 1880s showing original well at the stone water trough (Burton Brothers, circa 1884). **B:** The replacement water fountain of 1971 (Ewing, 1971). **C:** The Stewart Fountain in 2007 (O' Beirne, 2005). **D:** The site present day. **E:** Flour Power sculpture - a replacement to any public water fountain feature.

In May 1867, and in the form of a public competition, the Municipal Council invited designs for an ornamental fountain they planned to install on the corner of High Street and Cashel Street [26]. The winning design was selected in July ("City Fountain", 1867):

Two competitive designs for this work have been sent in to the City Council, one by Mr C. Cult, the other by Mr S. C. Parr. A premium of £5 was offered for the approved design. That of the former gentleman was accepted. The fountain is to consist of an octagon stone tank, constructed of stone from the

quarry of Messrs Ellis and Co. The tank is seven feet in depth, and placed upon a foundation of concrete, eighteen inches above ground. On the exterior will be placed two drinking fountains for public use, and two troughs of stone for watering horses. The tank is to be fed by five artesian wells. The centre-piece for the fountain consists of a stone pillar, surmounted by a basin in which the water obtained from the centre artesian well will play to a height of about six feet. It is intended to keep the four outer artesian wells plugged, except in the case of fire, when the full supply can be made available. The pillar stands upon a

**A**

**TO ARCHITECTS.**

**D**ESIGNS are Invited by the Christchurch City Council for an Ornamental Fountain, in connexion with the water supply. A premium of £5 will be given for the most suitable design, which will become the property of the City Council. Full particulars can be obtained at the office of the City Surveyor. Designs to be sent in not later than four p.m. on Monday, June 3, 1867.

GEORGE GORDON,  
Town Clerk.

City Council Office, May 28, 1867. 5-29

**B**



**C**



**D**



**Figure 8** – Cashel Street and High Street intersection – site of the second ornate public artesian fountain in Christchurch, albeit first to be planned from the outset. **A:** Advert in *The Press* seeking tenders for the design. **B:** The original fountain installed in 1867 (*Christchurch Star*, circa 1880). **C:** Modified design circa 1910s with basalt stone walled garden that Dr Chilton was critical of (Webb, 191-?). **D:** The site present day.



carved pedestal, also of stone. The tank will be 10 feet in diameter, the pillar seven feet in height, and the width of the basin will be three feet six inches. This basin will be either of stone or iron, whichever may be found less liable to discolouration. Around the fountain will be placed an ornamental iron railing inserted in a parapet of ashlar stone with curved plinths.

In September 1867, during the time when the wells for the planned Cashel Street fountain were being drilled, the Council coincidentally completed installation of what was the first public, ornate, artesian fountain in the city. An ornamental, cast iron fountain supplied by the proprietor of the City Hotel was added to the headworks of the public well on the corner of Colombo Street and High Street ("City Fountains", 1867). Both fountains have long since gone. The Cashel Street fountain was demolished in 1965 (Figure 8). The artesian fountain on the corner of Colombo Street and High Street disappeared even earlier but was rejuvenated in 1971 with a water fountain that did not rely on artesian pressure (Figure 7B). This later fountain, completed in February 1971, was funded by a donation that Councillor Robert H. Stewart had made in the 1960s. The stainless steel-clad fountain became known as the 'Stewart Fountain', although it also carried the moniker 'Piddle Fountain' as a play on the acronym PDL – the plastic mouldings company which Robert H. Stewart founded and made his fortune with (Christchurch Memories, 2019). In 1998 the fountain was replaced with one of a different design (Figure 7C). In 2007, the City Council heard the case from staff and business owners of the City Mall that the fountain was no longer desired (Christchurch City Council, 2007):

Like its predecessor, the current fountain has generally been viewed as less than successful. ...The fountain itself has

never properly functioned as originally envisioned owing to problems with the pumps and jet. ...rubbish is frequently deposited or blown into the fountain and represents an ongoing maintenance liability. ... The fountain occupies ... the sunniest, most sheltered spot in the City Mall. ... While the original intention of the fountain was to provide an interactive water feature for children, the combination of Christchurch's cool climate and aforementioned problems with trash mean that in practice the fountain is most commonly used by seagulls rather than children.

Demolition of the Stewart Fountain started on 13th August 2007, ironically coinciding with the day Sir Robert Stewart himself died. The act proved antagonistic and thirteen youths protesting to save the fountain were arrested. In 2017, the site was renamed the Stewart Plaza and a sculpture titled Flour Power installed in place of any fountain (Figure 7E). The 'Flour Power' sculpture has no hydrology relationship. Its artistic creator Regan Gentry described its form '....as if a friendly giant has walked through the garden city gathering lamp-posts like flowers and tying them into a bunch with a car tyre.' In terms of artistic meaning, he reasoned that, 'In Canterbury, fields of crops have given way to fields of houses. Rows of wheat have been replaced by rows of streetlights. Farm tractors have grown smaller and multiplied exponentially, growing sleeker and faster, modified to "pull chicks" instead of ploughs' (Scape Public Art, 2025). Who is to contest that a shiny, stainless steel, pivot irrigator-cum-water fountain would not have made an equally fitting piece of Christchurch street art? As Figure 7D illustrates, the site of the first public artesian fountain in Christchurch is shaded now because of the mature trees, it is still frequented by seagulls, and littering remains a problem. Research into whether

removal of the Stewart Fountain resulted in increased trade in the City Mall was beyond the scope of this work.

Another early fountain in the city which has been lost without trace but is mentioned here because of its historic connection to an existing artesian water feature, is the particularly ornate, cast-iron drinking water fountain that decorated Cathedral Square. The fountain was a bequest to the city in 1870 from Christchurch's first blacksmith and second Mayor, John Anderson ("News of the Day", 1870). Cast in Glasgow, Scotland, the fountain was topped with a gas lamp and was originally placed at the busy intersection of Colombo, Hereford and High streets, outside the Bank of New Zealand. In 1877 the fountain was relocated to the south-west corner of the Cathedral grounds [27], approximately 30 m west of the fire tank (shown in Figure 6E) and about where the present day Chalice sculpture is sited (Figure 9A) (next page) (City Council, 1878; Coxhead, 1882). The Anderson drinking fountain was relocated again in 1883 to its final (and last known) location, on the pavement outside the western doors of Christchurch Cathedral ("Local and General", 1883). It suffered massive damage there in 1890 when it was struck by a horse-drawn waggon ("A Fountain Destroyed", 1890) but nevertheless was restored and survived until the 1930s (Town and Country, 1890) (Figure 9B). John Anderson's public drinking water fountain may well be lost, but his groundwater legacy continues through the Joan Rosalind Beaumont irrigation water memorial (Figure 9C), located at what was originally the Anderson family homestead Murchiston, on Riverlaw Terrace, St. Martins [28]. The memorial fountain represents free-flowing water piped from an artesian well that was sunk circa 1893 to supply the homestead. The Beaumont family who now reside at Murchiston rigged up the free-flowing well to provide public unregulated

access to freshwater in the wake of the 2011 Christchurch earthquake. Since the City Council started chlorinating the public drinking water supply, water issuing from the Beaumont irrigation memorial has been a public source of untreated groundwater that is particularly popular with homebrewers and those who object to the taste of chlorine (Gates, 2022).

The Clock Tower, Victoria Street [29], houses a redundant artesian drinking water fountain (Figure 9E and 9F). The decommissioned artesian well originally installed to service this fountain revealed itself when it ruptured in the 2011 earthquake. Judging by the amount of guano at the site, one could be mistaken for thinking the main function of the inoperative fountain today is as a bird toilet. Like Anderson's drinking fountain, the Clock Tower has a transient history that is briefly recounted here. The clock was intended to adorn the building of the new Provincial Council Chambers. However, when it arrived from England in 1860, it proved too weighty for the timber-framed building. In 1897 the clock and tower (designed by prominent Christchurch architect Benjamin Mountfort) were erected on the corner of High Street and Manchester Street, to commemorate the Diamond Jubilee of Queen Victoria's accession. An artesian drinking water fountain was part of that original installation (City Council, 1897; "The Clock Tower", 1898). Proving an obstacle to road traffic, the tower and fountain were relocated to Victoria Street in 1930.

From the early 1900s through to about the 1960s, simple public drinking water fountains that were plumbed directly to their own free-flowing artesian water source were to be found across the city. The sole remaining example is on Cranford Street where a fountain tops a 19.8 m deep well [30]. The fountain was modified to accommodate the filling of water containers in 2023 (Figure 10A),





see next page. Removed in the 1990s, the public drinking water fountain on Clare Road, Papanui [31], represented one of the longest surviving examples (Figure 10B) (NZ Federation of University Women, 1989). The ornate design of the cast iron pedestal of that former fountain is replicated in some of the modern drinking fountains that now service the public's thirst and dispense groundwater (treated with chlorine) at the push of a button. Modern reproductions of the drinking water fountain can be found at Oxford Terrace [32] (Figure 10D), Woodham Park, Edmonds Gardens [33] and at Ferrymead Heritage Park [34]. On the topic of Edmonds Gardens – they were the preeminent factory gardens that regularly won awards in the Canterbury Beautification Society's Garden City competition. The luscious-looking ornate factory gardens that have been depicted on the cover of the iconic Edmonds Cookery Book since 1955 (Edmonds, 1955) were inevitably watered using groundwater. Irrigation water demand in the Garden City continues to contribute to Christchurch's high consumptive water use. At 359 L/person/day, water use in Christchurch – wholly supplied by groundwater from the artesian aquifer system – is almost twice the national median that lies somewhere between 159 and 231 L/person/day (The Greater Christchurch Partnership Committee, 2018; Pollard, 2022).

Whether the most iconic fountain in Christchurch – the Peacock Fountain [35]

– at any time shared a direct connection with groundwater remains obscure. In the planning of the fountain, it was at least determined that normal operation of the fountain from an artesian bore, and reliance on electrical pumps for the water jet display on special occasions, would be the most cost-effective mode of operation (“The Peacock Fountain”, 1910). The fountain (Figure 11A) was erected in 1911 by the Christchurch Beautification Association, using £500 gifted to them from the entrepreneurial colonist John Thomas Peacock. Peacock requested his donation be used for ‘beautifying the Reserves and Gardens’ in Christchurch and ‘in improving the River Avon’ (Wendy, 2012). A prefabricated metal fountain from the Coalbrookdale Iron Works in Shropshire, the Peacock Fountain received as much criticism as it did praise. Due to drainage problems, the fountain was relocated in 1915 to a pond dug on the archery lawn (“The Gardens”, 1915) where it stayed until the City Council mothballed it in 1949. In 1996 the fountain was restored and reinstalled close to its original position within the Botanic Gardens, without an associated artesian bore (Figure 11B).

Someone who was not a fan of the Peacock Fountain and who described it as an ‘obtrusive unveracity’ was Dr Charles Chilton (“Water Displays”, 1913). Dr Chilton was a high achiever within many fields but is renowned within the groundwater sciences for his pioneering work on stygofauna (see e.g.,

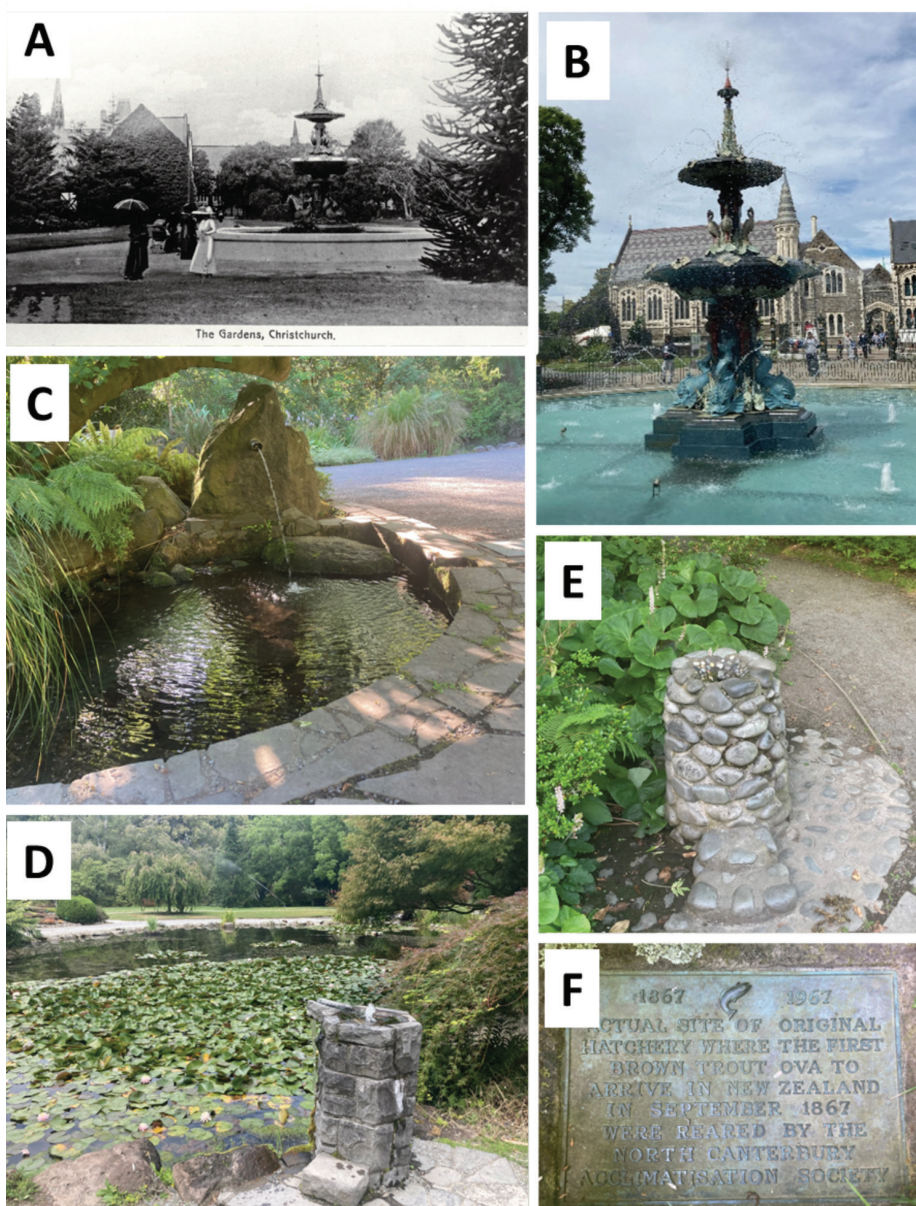
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*Opposite: Figure 9* – Artesian drinking water fountains of the city. **A:** The Chalice sculpture in Cathedral Square marks an early location of the cast iron water fountain John Anderson donated to the city in 1870, shown in **B** at its final location, outside the Cathedral steps (*Photo: Taylor, 1907*). **C:** The Joan Rosalind Beaumont irrigation water memorial in St. Martins, which flows from a well initially installed to supply the Anderson family homestead Murchiston. **D:** Similar artesian water supply at The Lotus Day Spa, located up-stream of the Joan Rosalind Memorial and where, for a small charge, the public can access unchlorinated groundwater. **E:** The Clock Tower, Victoria Street, which shelters an artesian drinking fountain that is now defunct **F. G:** Sydenham drinking fountain built to commemorate coronation of King Edward VII but also symbolic of the first pressurised reticulated water supply in the city.



**Figure 10** – Christchurch public drinking water fountains of past and present. **A:** Free-flowing artesian fountain on Cranford Street, revamped in 2023 to accommodate the filling of water containers. **B:** Similar fountain on Clare Road, installed at the turn of the 20th century and removed at the end of the same century, photographed in 1983 (Richardson, 1983). **C:** The same site today, bearing the scar of where the fountain once stood. **D:** Example of a modern drinking water fountain modelled on the same ornate design.





**Figure 11** – Artesian ornamental water fountains in the Botanic Gardens. **A:** Postcard showing the Peacock Fountain in its original form for which it was recommended reliance on artesian water pressure would be the most cost-effective mode of operation (Unknown (191-?) Peacock Fountain [Photograph]. Source: Christchurch City Libraries Archives, file ref: CCL PhotoCD 4, IMG0031. No known copyright). **B:** The Peacock Fountain, present day. **C:** Te Puna Ora/Spring of Life fountain. **D:** Free-flowing drinking fountain supplied by the Gardens' main irrigation bore and which sustains flows in the Rock Garden. **E:** Free-flowing artesian water fountain feature crafted from river boulders, built around the headworks of the last remaining deep bore, originally commissioned by the Canterbury Acclimatisation Society to run their trout hatchery, which is commemorated on a nearby plaque **F**.



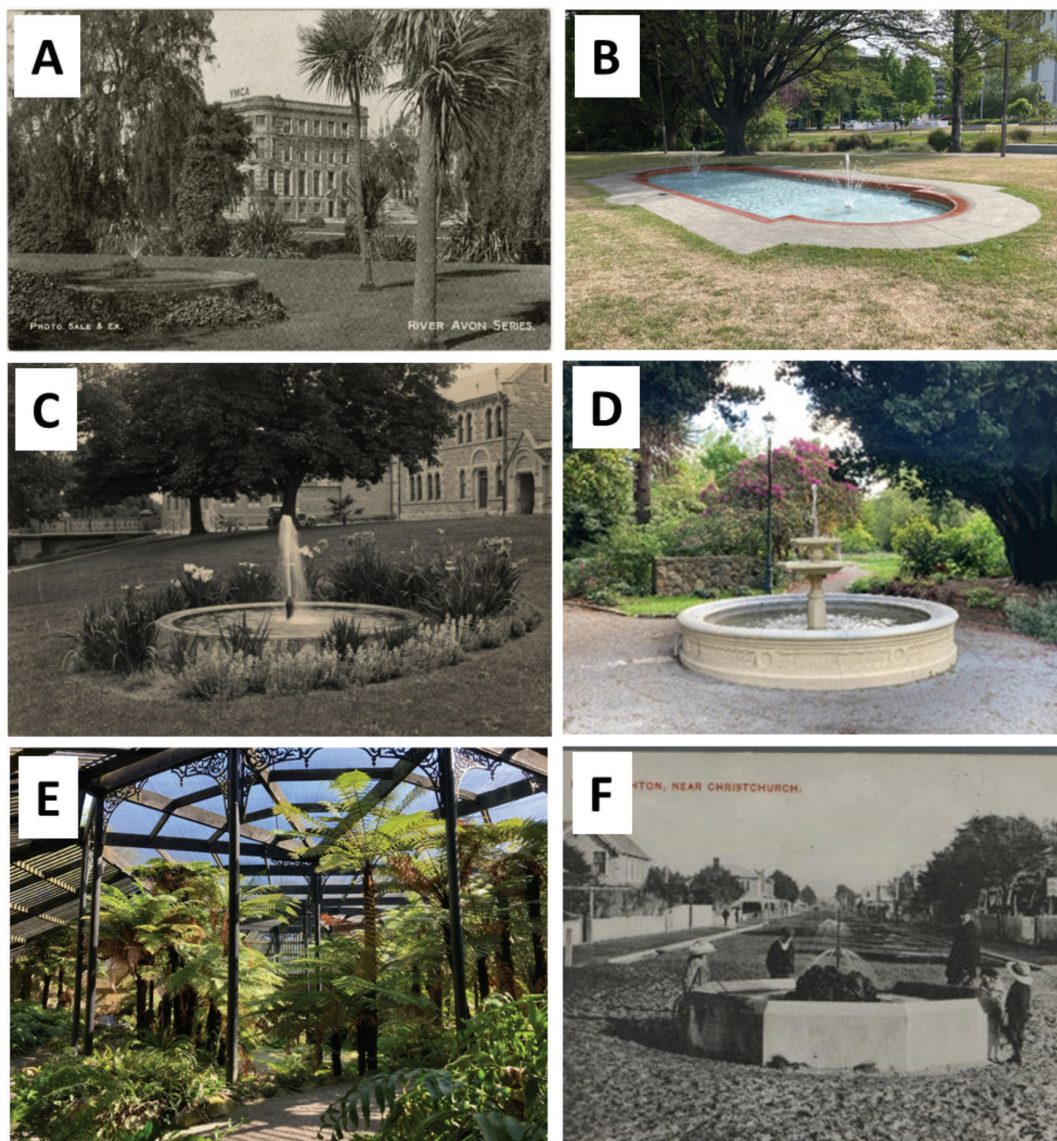
Chilton, 1894). In his later years, Dr Chilton promoted the improvement, maintenance and storage of Christchurch's artesian water supply, and actively campaigned to preserve and enhance the natural environment of the city (Pilgrim, 1996). Between 1913 and 1916 he contended publicly that Christchurch had the opportunity of acquiring a distinctive touch by way of low-cost, artesian fountain displays ("Water Displays", 1913; "Artesian Water", 1916). In promoting fountains, he said 'water cannot fall ungracefully' and questioned why nobody ever bothered to convert the numerous uncapped artesian bores in Hagley Park into ornate fountain features ("The Witchery of Water", 1913). The artesian well that feeds Lake Albert [36] remains a pertinent example (see Figure 13B).

Whilst probably not of the designs Dr Chilton imagined, the present day Botanic Gardens does contain several fountain features that are supplied by direct artesian water. One example is Te Puna Ora/The Spring of Life fountain at the Water Garden [37] (Figure 11C) that marks artesian groundwater issuing from a well that is believed to be 60m, or quite possibly 120m deep (Christchurch City Council, 2011; pers. comm. Sue Molloy, Christchurch Botanic Gardens). Another artesian fountain can be found at the southern end of the Botanic Gardens [38]. There, a free-flowing artesian well that was sunk in the 1880s has been repurposed into a drinking water fountain, decorated with river boulders (Figure 11E). The well is of historical significance for it represents the last of a set of deep wells (Taylor, 1958) that sustained the Acclimatisation Gardens and its fish hatcheries, from which trout were originally raised and released into New Zealand (e.g. Figure 11F). Finally, the water fountain crafted from basalt stone that constantly discharges into the Rock Garden pond [39] (Figure 11D) is sustained by groundwater that freely flows from the

Botanic Gardens' main irrigation bore that is 104.5m deep.

Dr Chilton was also scathing of the public fountain on the corner of Cashel Street and High Street (Figure 8C), finding the landscaping there unfavourable. But more to the point, he lamented the low groundwater pressure the site was suffering, using the case to highlight poor groundwater resource management and the city's frivolous water wastage habit. In describing the state of the fountain in 1913, he said, 'it is as miserable as I have seen in my life.... no one would imagine that millions of gallons of water were running along our gutters every day' ("Water Displays", 1913). The simple garden fountain at the Captain Scott reserve [40] was more to Dr Chilton's taste and one he supported in his capacity as a member of the Christchurch Beautification Association (Figure 12A). In the 1920s, a similar fountain could be found in the river reserve farther downstream, directly across from Victoria Park (Figure 12C). To mark their 75th anniversary in 1972, the Christchurch Beautification Association installed a modern replacement of the pond and fountain at the Captain Scott reserve that has recently been restored following damage sustained in the 2011 earthquake (Figure 12B).

In 1882 Christchurch hosted the New Zealand International Exhibition where a feature highlight was 'a very handsome fernery supplied by artesian water' (Mosley, 1882). Twenty-four years later, Christchurch again hosted the International Exhibition, yet on a grander scale. Artesian wells were sunk in North Hagley Park to supply drinking water ("The Exhibition", 1906), water for the fisheries display (Cowan, 1910) and, yet again, a fernery display ("Progress of the Exhibition", 1906). The fernery from the 1906 exhibition was purchased by Annie Quayle Townend who reinstated it at her Mona Vale homestead [41] where it remains



**Figure 12** – Other artesian ornamental water fountains. **A:** Postcard from 1900s showing the original pond and artesian fountain at Captain Scott Reserve (*Photo: Sale and Ex, 1900s*). **B:** The same site today with replacement fountain installed in 1972 (non-artesian). **C:** Evidence of a similar free-flowing artesian fountain on Cambridge Terrace, circa 1928 (*Photo: Beker, 1928*). **D:** Restored Sunnyside Hospital garden fountain, Annex Road. When originally constructed in the 1890s the fountain would have been supplied by artesian water. **E:** The fernery at Mona Vale that originated from the International Exhibition 1906. In both instances the fernery was watered with groundwater from artesian wells (see Figure 13B and Figure 21E). **F:** Period postcard showing artesian fountain at New Brighton circa 1900s (*Photo: Fergusson Taylor & Co. (n.d.)*).

a public attraction to this day (Figure 12E). The homestead at Mona Vale was built in 1899 complete with a 99.5 m deep well that tapped the Burwood Gravel aquifer and supplied water to both the house and gardens. Today the well is used by Environment Canterbury for monitoring the hydraulic state of the regional groundwater resource (see Figure 21E).

Sunnyside Hospital in Hillmorton was Christchurch's mental asylum that first opened in 1863 [42]. The hospital had its own artesian water supply and used steam pumps to lift the water into tanks concealed in the building's high towers and from which pressurised water was supplied across the hospital ("Christchurch Lunatic Asylum", 1913). Circa 1934, the reticulated water system was upgraded, which included addition of a 100,000 gallon capacity concrete water tower (see Figure 19D) ("Sunnyside Hospital", 1934). As well as its gothic buildings, the hospital was well known for its gardens. Closed in 1999, all the site buildings were demolished and the site was redeveloped for housing. The ornate fountain that adorned the gardens, and originally operated from the artesian water supply, is the only complete remnant of the hospital complex. Today, the restored fountain decorates the reserve on Annex Road (Figure 12D).

### Artificial ponds

There are a number of artificial ponds within the city that represent exposed groundwater. Most of these are in Hagley Park and the Botanic Gardens where they were constructed for beautification purposes. Victoria Lake in North Hagley Park [43] was transformed from an acre of swamp in 1897 to commemorate the jubilee of Queen Victoria. The lake was created using manual labour and two dray horses, which were used to pug the clay that sealed the base of the lake. Groundwater was used to fill the lake, supplied from six artesian

bores ("Victoria Lake", 1898), some of which still operate today and keep the lake refreshed (Figure 13A). The lake was not without its critics, as evidenced by this letter to *The Press* newspaper ("Victoria Lake", 1897):

Sir, I protest most strenuously against the inane proposal which has been put forward of making an alleged 'lake' in Hagley Park. Christchurch has already an ample supply of receptacles for the detention of water without any further water holes being made in the Park to create the foulness and damp unpleasantness which stagnant water must inevitably do. Beside, if such a 'lake' is made in the Park there will always be a great danger that some early bather of annexing proclivities may steal it with a large sponge.—Yours, &c., Old Fogey.

The entire construction project in 1897 cost about £250 ("The Record Reign", 1897) – equivalent to about \$60,000 in today's money (Reserve Bank of New Zealand, 2024). Nobody has ever stolen the water from the lake using a sponge or any other means, but in the earthquake of 2011 the lake bottom ruptured, causing it to lose water. Repair costs were substantially more than the original build cost. It's difficult to picture, but during the International Exhibition of 1906 part of Lake Victoria was fenced off to display penguins, 'Jumbo' the sea lion and seals (nick-named 'Bully', 'Lady Nelly' and 'The Sneak'), all sourced from MacQuarrie Island (Mitchell, 2024). At another end of the lake, New Zealand's first ever shoot-the-chute water ride operated, as part of the Wonderland attraction (Cowan, 1910).

Lake Albert [36] was added as a complement to Lake Victoria, in 1916. The water in Lake Albert is sourced from a 129 m deep free-flowing artesian well located on the lake islet (Figure 13B). The well was drilled in 1906 and represents one of the wells that were installed to supply water for the International Exhibition. The sound of its flowing water



can continually be heard, and the well can be seen during winter months when it is not obscured by wetland plants.

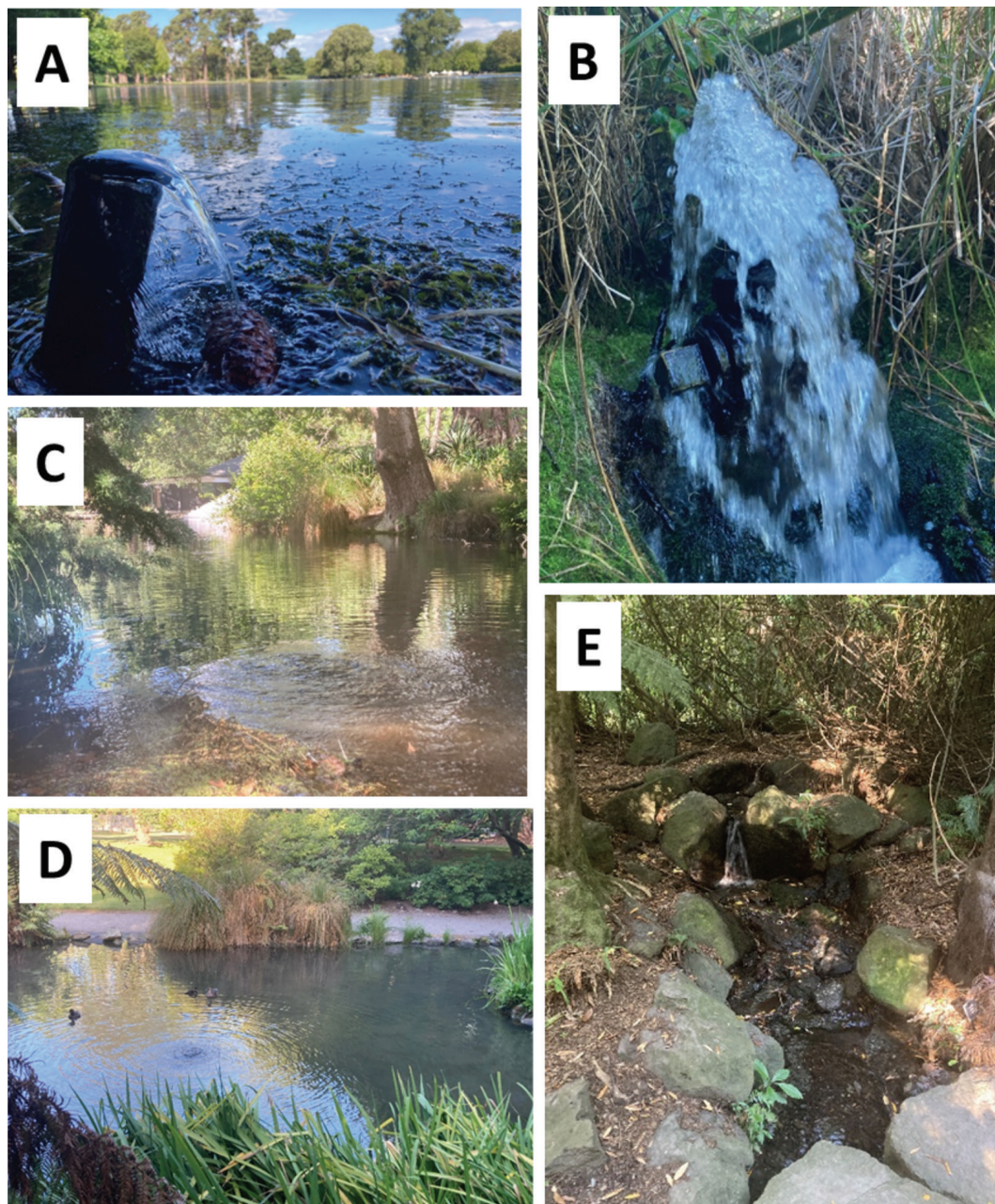
In 1910, the Kiosk Pond [44] was added to the Botanic Gardens. Parliamentary papers report that the meteorological society sponsored the construction, since they did not want the pond to be supplied from a conventional artesian well, the steel casing of which would have interfered with the magnetic observatory that was located nearby. The same papers describe the pond being supplied with overflow from Lake Victoria (AJHRNZ, 1911), although there is no physical evidence to indicate this was ever the case. What is apparent is that the pond is fed by a bubbling spring (Figure 13C). The pond was reformed in 1962 and today it is augmented with water from the Botanic Gardens main irrigation bore. Evidence of another bubbling artesian spring within the Botanic Gardens can be seen in the header pond of the Water Gardens [45] (Figure 13D), which were landscaped from old borrow pits circa the 1920s. Finally, a natural spring provides a baseflow component to the ponds around which the New Zealand garden [46] is curated (Figure 13E). However, as with the Kiosk Pond and Rock Garden Pond, the main pond of the New Zealand Garden is today augmented with some water sourced from the Botanic Gardens main irrigation bore.

Other water features that represent restored gravel pits flooded with groundwater are located about the city. Examples include Lakes Tahi and Rua that form the Roto Kohatu recreational Reserve [47] and were formerly Ashby's gravel pit that was excavated from the 1960s. Today, the lakes serve as a boating, kayaking and swimming recreational resource (Figure 14A). The prominent earth mound adjacent to the lakes marks the old Waimairi County Council Landfill – one of the numerous uncontrolled landfills within the city that present long-term risks to shallow groundwater quality (Hayward and

Smith, 1999). Peacock Springs at McLeans Island, and Westlake, Halswell (Figure 14B) represent other historic gravel pits. These were worked at a time when excavation below the water table was permitted in Christchurch. Peacock Springs [48] is home to a conservation wildlife reserve and Westlake [49] forms a landscape centrepiece of the eponymous housing estate. Within the grounds of the Lotus Day Spa, Somerfield [50] is a duck pond that has long been supplied by passive groundwater flow and is colloquially known as Swan Lake (Figure 14C). Some lifestyle developments that incorporate pond landscape features now rely on abstracted groundwater to sustain water in the ponds, much like the water augmentation practised at the Botanic Gardens. One example are the ponds in Burlington retirement village, Redwood [51] (Figure 14D).

### Natural springs

The name Puna Street exemplifies the historic hydrological setting of the suburb of Riccarton. McBride (1994) describes how during Christchurch city's formative years, to overcome the problem of dragging logs by oxen across the notoriously boggy land, a drain connected to an artesian spring water source was dug along the route of what today is effectively Riccarton Road. Timber felled from Deans Bush was floated down it, for use in construction of the city's first buildings. Today, Rata, Kauri and Peverel Streets in Riccarton [52:54] provide the best examples of natural springs in Christchurch's built environment that have been left exposed and incorporated into the landscape architecture (Figure 15A-15E). Furthermore, at the local public drinking water pumping station [55], a 10 m deep free-flowing artesian well has deliberately been left uncapped, to serve as an artificial spring feature in the Picton Reserve (Figure 15G). The well also provides some passive dewatering function, to reduce risk of groundwater flooding in the vicinity.

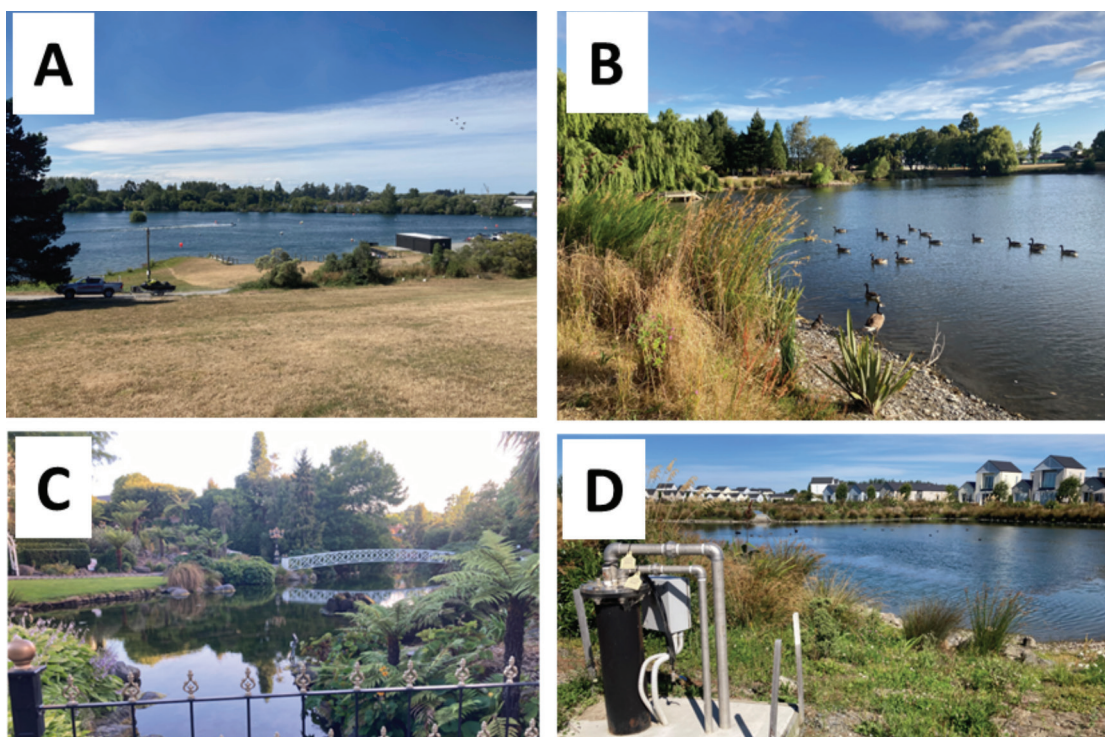


**Figure 13** – Artesian water features that support ponds in Hagley Park and the Botanic Gardens.

**A:** Exposed, free-flowing artesian well on the south-side of Victoria Lake. **B:** Free-flowing artesian well from the 1906 New Zealand International Exhibition supplying Lake Albert.

**C:** Evidence of a bubbling artesian spring at the Kiosk Pond. **D:** Similar natural spring feature at the Water Gardens. **E:** Spring supplying baseflow to the ponds of the New Zealand garden.





**Figure 14** – Examples of ponds supplied by groundwater that serve as amenity assets.

**A:** Flooded gravel pit that is Lake Tahi at the Roto Kohatu reserve – photo taken from the adjacent high ground, which marks a pit that was not flooded but used as a landfill site. **B:** Flooded gravel pit at Westlake, Halswell. **C:** Swan Lake at the Lotus Day Spa on Ernlea Terrace, Somerfield.

**D:** Artificial pond, part of landscaping at Burlington Retirement Village, Redwood – the pond is kept flushed with groundwater that is abstracted from a well that is recorded as an irrigation bore, seen in the foreground.

Other examples of artesian springs that have been transformed into recreational amenities are Redwood springs (Figure 16A) [18] and springs in Lincoln township [56, 57] (Figure 16C, 16D).

## Water reticulation and storage

### Pumps and private domestic supply

A fully reticulated, pressurised public water supply network across Christchurch was not completed until as late as the 1950s (“Water for New Brighton”, 1947), prior to which many properties relied on private well supplies. This meant pumps and private water towers were an integral part of Christchurch’s urban

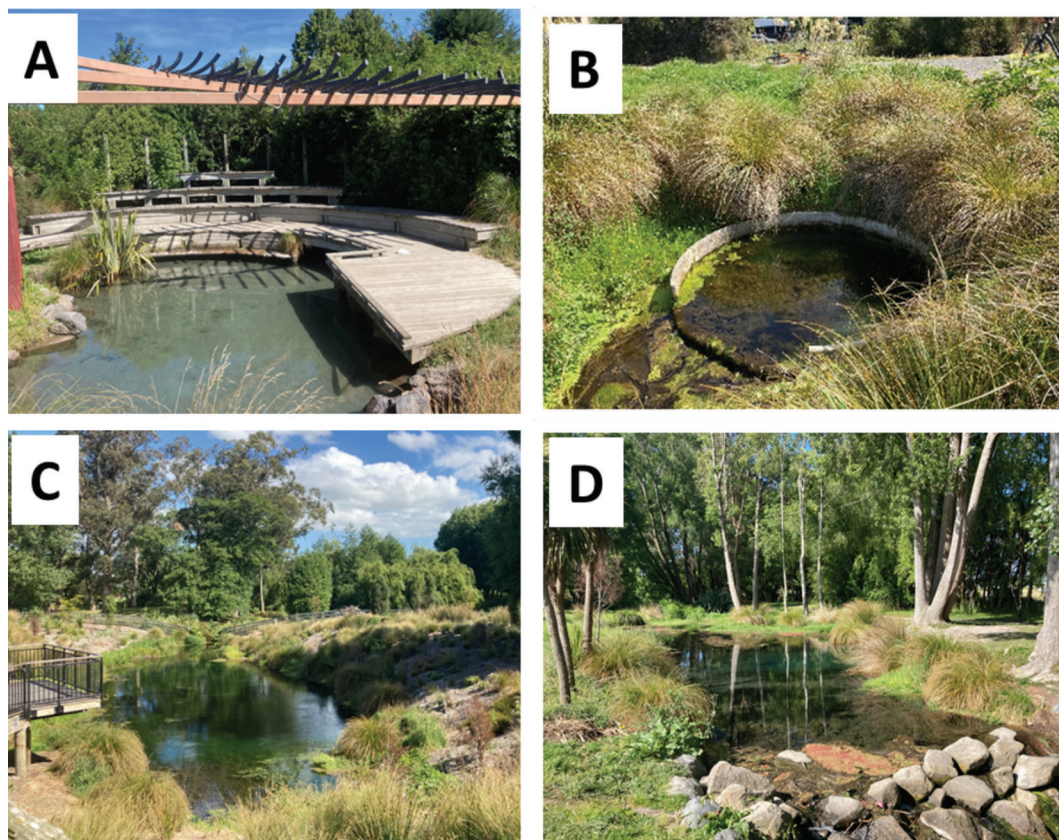
landscape, of which some indicators remain. In the 19th century, piston hand pumps would have been commonplace, whereas today the only examples to be seen in the city are as toys at playgrounds such as Margaret Mahy Family Playground and Redwood Springs Park [58, 18] (Figure 17A, 17B). Examples of original vintage pumps can be found in the exhibits at Ferrymead Heritage Park [34] (Figure 17C), or as garden ornaments in private gardens. Increasing demand for groundwater in conjunction with declining artesian pressure led to operation of pumped storage and low- pressure water supply driven by gravity. Wind-operated





**Figure 15** – Natural spring features in the built environment of Riccarton. **A, B, C:** Springs on Rata and Kauri Streets. **D, E:** Springs on Peverel Street. **F:** Plaque explaining the spring on Peverel Street from which some ornate paving work extends to a seating well. **G:** Artificial spring formed by an uncapped artesian well at Picton Reserve.



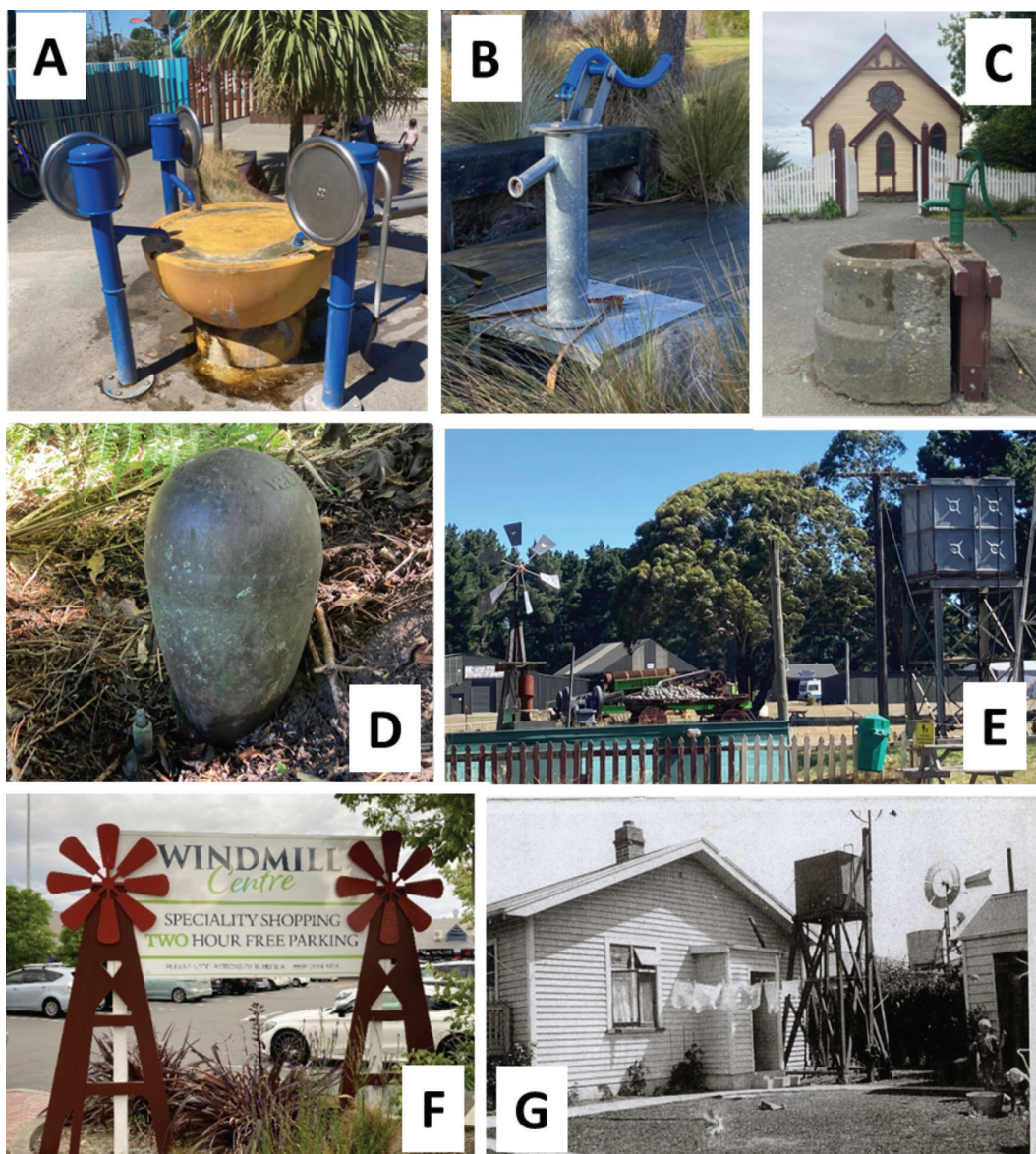


**Figure 16** – Bubbling artesian springs that have been transformed into amenity assets.

**A:** Redwood Springs (see also Figure 4E). **B:** The ugly sister of Redwood Springs located 170 m away. **C:** Springs Creek, Lincoln township, around which a viewing platform has been constructed. **D:** One of the several springs at Liffey Springs Reserve, Lincoln that marks the source of the Ararira/LII River and is a popular summer picnic spot.

pumps and ram pumps feeding water tanks were the principal means by which this was achieved, before the reticulated public supply scheme was established. Reminiscing about Christchurch life in the 1930s-1960s, Ogilvie (1981) described the rhythmic ‘clack-clack’ sound of ram pump valves operating on private, domestic, artesian wells as being the background to everyone’s lives. Examples of ram pumps (which ran off artesian pressure) can be found in the gardens of Mona Vale [41] (Figure 17D) where two original cast

iron pumps remain. These pumps lifted water from the private artesian well to a water storage tank concealed in the homestead roof space. The only remaining operational windpump in Christchurch is to be found at Steam World, McLeans Island [59] (Figure 17E). Ferrymead Heritage Park has an incomplete, non-working exhibit. The Windmill Shopping Centre in Riccarton [60] (Figure 17F) provides some tokenistic display of windpumps that were once commonplace in the city, as can be seen from Figure 17G.



**Figure 17** – Pumps and private domestic groundwater supply. **A, B:** Toy piston pumps at Margaret Mahy and Redwood Springs playgrounds – a throwback to vintage groundwater abstraction practices, as exhibited at Ferrymead Heritage Park **C, D:** One of two ram pumps (model No.5 manufactured by W & B Douglas Co., Connecticut, USA) located in the gardens at Mona Vale. **E:** Operational wind pump at Steam World, McLeans Island. **F:** The Windmill Shopping Centre, Riccarton – a nod to wind pumps that historically were commonplace, as can be seen in **G**, which is a photo of the rear garden of 32 Marlborough Street (now Lyndon Street), Riccarton in the 1930s (Photo: Christchurch City Libraries, file ref: CCL-OwenGenet-020. No known copyright.)



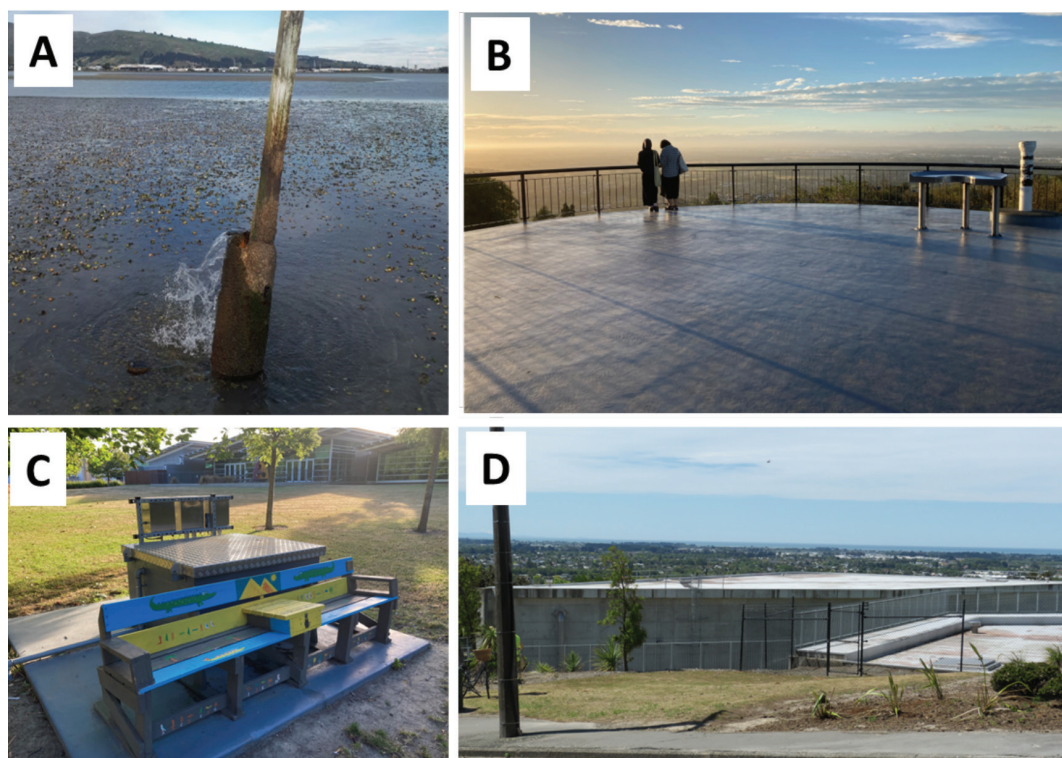
## Reticulated public water supply, water towers and reservoirs

The Christchurch artesian system was first exploited for a reticulated public water supply in 1877, although it was not to supply Christchurch city, but Lyttelton, on the other side of the Port Hills. Lyttelton Borough Council established a well field and pumping station complete with a '*pretty three-bedroomed cottage*' for the resident engineer, in Heathcote valley [61] ("Lyttelton Water Supply", 1877). The supply bore comprised a 1.5 m diameter hole excavated to 6 m depth from which 5" (127 mm) steel pipes were driven through a confining aquitard to tap artesian water in the Riccarton aquifer. Initially, a steam engine was used to pump the groundwater up to a 500,000 gallon, open storage reservoir that had been dug out of the basalt, 64 m up on the spur that leads to Castle Rock, above the Horotane Valley [62]. From the reservoir, water flowed under gravity through 5" diameter steel pipes that ran through the rail tunnel to Gladstone Quay and provided a pressurised water supply in Lyttelton. The reservoir reputedly became a much-favoured place for disposing of unwanted cats (Ogilvie, 1978), yet neither it nor the distinct red-brick pumping station on Scruttons Road remain. The latter was demolished as recently as 2017 following earthquake damage. Anecdotal evidence of the pumping station's existence remains in the form of a derelict car garage that complemented the cottage, and a brick shed that houses a disused well that was drilled for the Valley Station in 1954. Environment Canterbury now operate an automated groundwater level monitoring station next to the shed (Figure 21C). The original water pipes running alongside the railway line and through the rail tunnel are still in use today and are viewable from Heathcote Domain.

The second pressurised reticulated water system to tap the Christchurch aquifer was that of Sumner Borough Council, in 1893. In that scheme, water free-flowing from an

83 m deep well sunk on Fishermans Flat (i.e., the foreshore of Redcliffs) supplied a 48,000 gallon holding reservoir, from which water was transferred using a steam pump to a 61,000 gallon brick reservoir that was sited 24 m above sea level on the cliff near Shag Point. From there the water was supplied to Sumner by gravity, via a 100 mm diameter cast iron water main ("The Sumner Water Supply", 1893). In 1911 the borough council grew the water supply by adding an artesian well that was drilled in the estuary on what was formerly Kiore Mutu/Rat Island (also referred to as Skylark Island), just off McCormacks Bay [63]. Four more artesian wells were added to the island well field in 1921 (Penney, 1982). However, the completion of the causeway in 1907 promoted erosion of the island which was reduced to mudflats by 1922 (Findlay and Kirk, 1988). The headworks of one of the latter-drilled wells remains exposed within the middle of the estuary where it continues to freely discharge artesian groundwater (Figure 18A). The other wells are buried under the sandbar and one of them is believed to be the source of what Stewart *et al.* (2018) interpreted to be a freshwater spring producing groundwater in excess of 180 years old (Brown, 2019).

The next reticulated water supply to exploit the Christchurch artesian system was that of Sydenham Borough Council (SBC). In 1903 (just prior to amalgamating with the city), SBC sank a 174 m deep well just to the south of Sydenham Park (which back then served as the city's A&P grounds) [64]. At the time it was the deepest well in the city and the first to tap what is now referred to as 'Aquifer 5'. Well water was lifted into a water tower that stood 27.4 m high and dominated the skyline (Figure 19A). The tower provided pressurised reticulated water across the borough. Completion of the high-pressure scheme coincided with the coronation of Edward VII, which the Council marked by

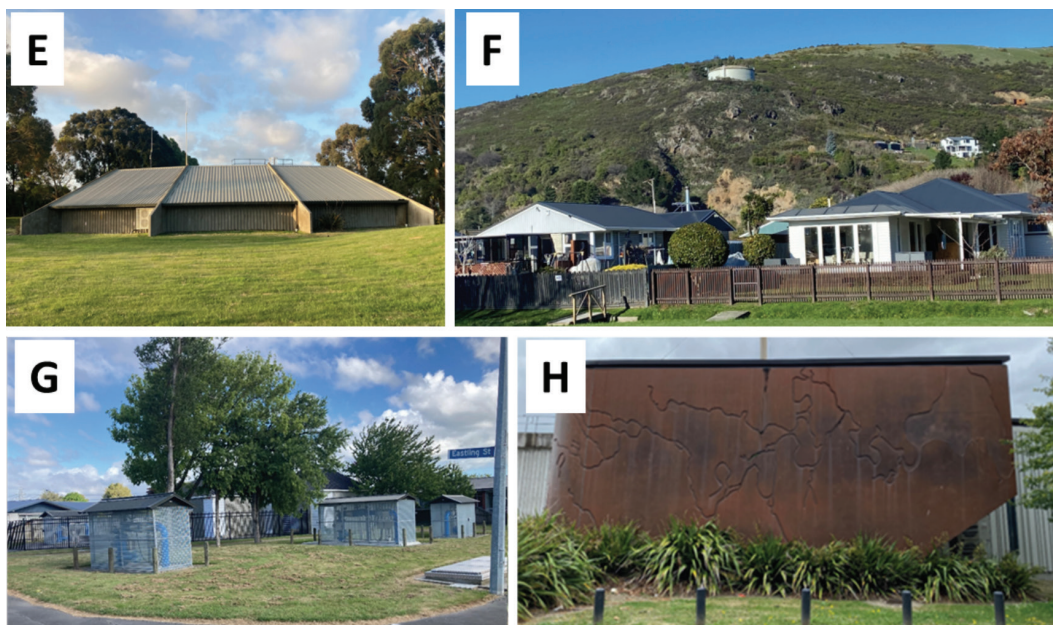


**Figure 18** – Examples of wells, reservoirs and pumping stations past and present, associated with the reticulated water supply network. **A:** A free-flowing artesian well located in the estuary and a remnant of Sumner Borough Council’s well field on what was formerly Kiore Mutu / Rat Island (Image supplied by Shaun Thomsen). **B:** Sign of The Takahe reservoir, Cashmere, where stored abstracted groundwater provides a vista to the public. **C:** A public bench erected at the headworks of one of the many wells that make up the city’s first and largest groundwater pumping station, Beckenham. **D:** Huntsbury reservoir 01 [67]. The original 1952 structure ranked number 1 in terms of size and could hold 35,000 m<sup>3</sup> of pumped groundwater. Remedial repairs after the 2011 earthquake split the reservoir into two separate chambers that have a combined storage volume of 13,400 m<sup>3</sup>.

erecting a drinking water fountain in the park. The fountain is still operational and now positioned on the corner of Brougham Street and Colombo Street (Figure 9G). Christchurch City Council continue to operate a pumping station at the site where the water tower once stood. The tower was demolished in the early 1940s.

It was 1907 when Christchurch City ratepayers approved investment into establishing a reticulated water supply for the city. The Council’s strategy included

a takeover of the Cashmere Water Supply Company in 1909, which already operated a private scheme servicing Cashmere Estate. Beckenham Pumping Station on Colombo Street [65] (Figure 18C) was duly established as the main point from which groundwater was abstracted and pumped up to reservoirs on the Port Hills, using electrical pumps. Reservoir examples can be accessed at Cracroft Reserve that is situated behind the Sign of the Takahe [66]. One reservoir provides the foundation for a public viewing



**Figure 18** – **E:** Slightly ominous looking support buildings for the well pumping station on Dunbars Road, Halswell [68]. **F:** Rocky Point Reservoir, Hillsborough [69] – with a storage volume of 2,250 m<sup>3</sup> the reservoir is small, yet is a prominent feature on Montgomery Spur. **G:** Very public display of wells with back-flow preventers at Bishopdale [70]. **H:** Frontage of pumping station on Wilmers Road, Halswell [71] decorated with the Heathcote River, whose spring source is located nearby.

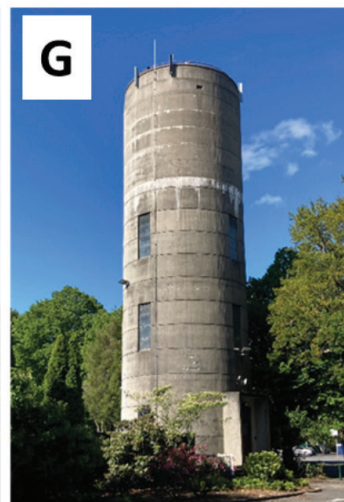
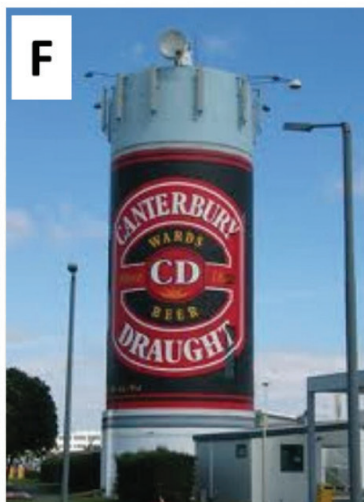
platform, offering panoramic views over the city and Canterbury Plains (Figure 18B).

The present-day Christchurch City water supply scheme operates from a network of 53 groundwater pumping stations with each station abstracting from as many as six wells. The network comprises over 3,000 km of pipework and many storage reservoirs (Christchurch City Council, 2024b) [67: 71] (e.g., Figures 18B-H). The deepest abstraction well draws water from 230 m depth and the highest reservoir to which groundwater is pumped (Mount Pleasant 5) is sited 341 m above sea level. Today, groundwater from the city aquifer is pumped as far as Governors Bay, and even under the sea to Diamond Harbour, sited on the south side of Lyttelton Harbour.

One of the most iconic water towers in the city is the one at the eponymously

named Tower Junction Retail Park [72] (Figure 19B). The concrete water tower was built in 1883 with capacity to store in excess of 104,500 L of water that was obtained from an artesian well and served as the core water supply for the Addington Railway Workshops (Figure 19C). During construction, quicksand – a sign of shallow water table conditions – was encountered at a depth of 1.8 m and was responsible for the 9" (229 mm) settlement and slight lean inflicted on the tower (Crosado, 2023). It seems that groundwater was not the last substance the tank held, for Crosado (2023) describes 20 tonnes of guano being removed from the tower when it underwent restoration works following the 2011 earthquake. The tower is historically significant for it represents one of the earliest reinforced concrete structures in the world and was designed with a low





centre of gravity to withstand earthquakes (of which it has survived two major events: in 1888 and 2011).

Another prominent concrete tower, albeit now lost, was that installed at Sunnyside Hospital when their water supply network was upgraded circa 1934 (Figure 19D). In suburbs distant from the Port Hills, water towers were required to provide storage of pumped groundwater and low-pressure supply to the public reticulated water supply network. Examples of such water towers are provided in Figure 19E to G.

## Modern amenities

### Ground source heat pumps

Ground source heat pumps (GSHPs) have become a popular thermal energy source for commercial redevelopments in the rebuild following the destructive 2011 earthquake (e.g. Seward et al., 2017). UoC was one of the earliest adopters of the technology [75]. A GSHP was installed there as early as 1997 and systems continue to be installed across the campus (Figure 20A). Discharge from one of the GSHPs is what maintains the waterfall feature outside the Central Library and augments flow in Wai-utu-utu/Okeover Stream (Figure 20B). Similarly, discharge from a GSHP at Jellie Park Recreation and Sports Centre [76] that uses water drawn

from 25 m depth is what supports the water cascade that augments flows in Hewlings Stream (a tributary of Wairarapa Stream) (Figure 20C) (Christchurch City Council, 2016b). Contained GSHP systems that inject groundwater drawn from depth to the surficial aquifer are more common in the CBD and have become a controversial topic, since there have been suggestions that the discharges from GSHPs there, including that at Te Urutī (48 Hereford Street) [77] (Figure 20D), are contributing to subsurface flooding problems within the city (Hutchings, 2018; Van Beynen, 2021).

### Groundwater monitoring

Whether they be to facilitate measurement of piezometric water levels and/or water quality, monitoring wells are other structural landmarks that expose the presence of groundwater beneath Christchurch city. Examples of such infrastructure are provided in Figures 21 and 22.

## Miscellaneous groundwater curiosities

### Place names

Figure 23 presents evidence of street and place names in Christchurch that signify the city's connection with groundwater (Christchurch City Council, 2016c). The Māori names

*Opposite: Figure 19* – Examples of prominent water towers storing Christchurch groundwater.

**A:** Water tower at Sydenham Park circa 1905 – marking the first pressurised water reticulation system serving a suburb in the city (Unknown (circa 1900) 'Sydenham Park with reading room, band rotunda and water tower' [Photograph]. Source: Christchurch City Libraries archive 527: Photographs of early New Zealand, p. 161 ref: CCL-KPCD05-0069. Out of copyright).

**B:** Former Addington Railway Workshops water tower at Tower Junction, present day.

**C:** Period photo of the Addington Railway Workshops showing the commanding position of the water tower (Unknown (1880s) 'Rail yard' [Photograph]. Source: French/Canterbury Historical collection Canterbury Museum ref: 198/2000; CHAC931). **D:** Former 100,000 gallon water tower at Sunnyside Hospital, built in 1934, demolished early 2000s (Photo: Larsen, 2002).

**E:** Water tower located at the spring heads of Waimairi in Burnside park and whose sole function now is as a mobile communications tower. **F:** Not an oversized can of beer, but the water tower at Christchurch airport [73], which is used as an advertising board (Photo: Farmer Homer, 200-?).

**G:** Water tower at Lincoln University [74].



# Installing sustainable systems



Reducing our carbon emissions to become carbon net neutral by 2030 is a major focus of our current capital works. We're upgrading the thermal performance of our buildings, converting our coal boiler to a biomass boiler and establishing 'Ground Source Heat Pump' (GSHP) systems.

GSHP systems are already in place in Haere-roa and Tupuānuku and are working well to heat these facilities in a sustainable way. The work underway on this site will establish deep bores for new GSHP systems.

[www.canterbury.ac.nz/about/capitalworks/projects/](https://www.canterbury.ac.nz/about/capitalworks/projects/)

One of UC's values, tiakitanga – caring for our taonga, resources and people – helps guide our decisions and actions, so that we contribute to a more sustainable world. The current work reflects this value and is a stage on our way to being carbon net neutral.



#CarbonNetNeutral2030 #UCSustainability

You might hear some disruption, thank you for your understanding. Please take care around work sites and respect the basic safety instructions.

Carbon net neutral for the University of Canterbury means that we will reduce our carbon emissions as much as possible and then offset remaining emissions by sequestering carbon in our existing forest estate.



B



C



D



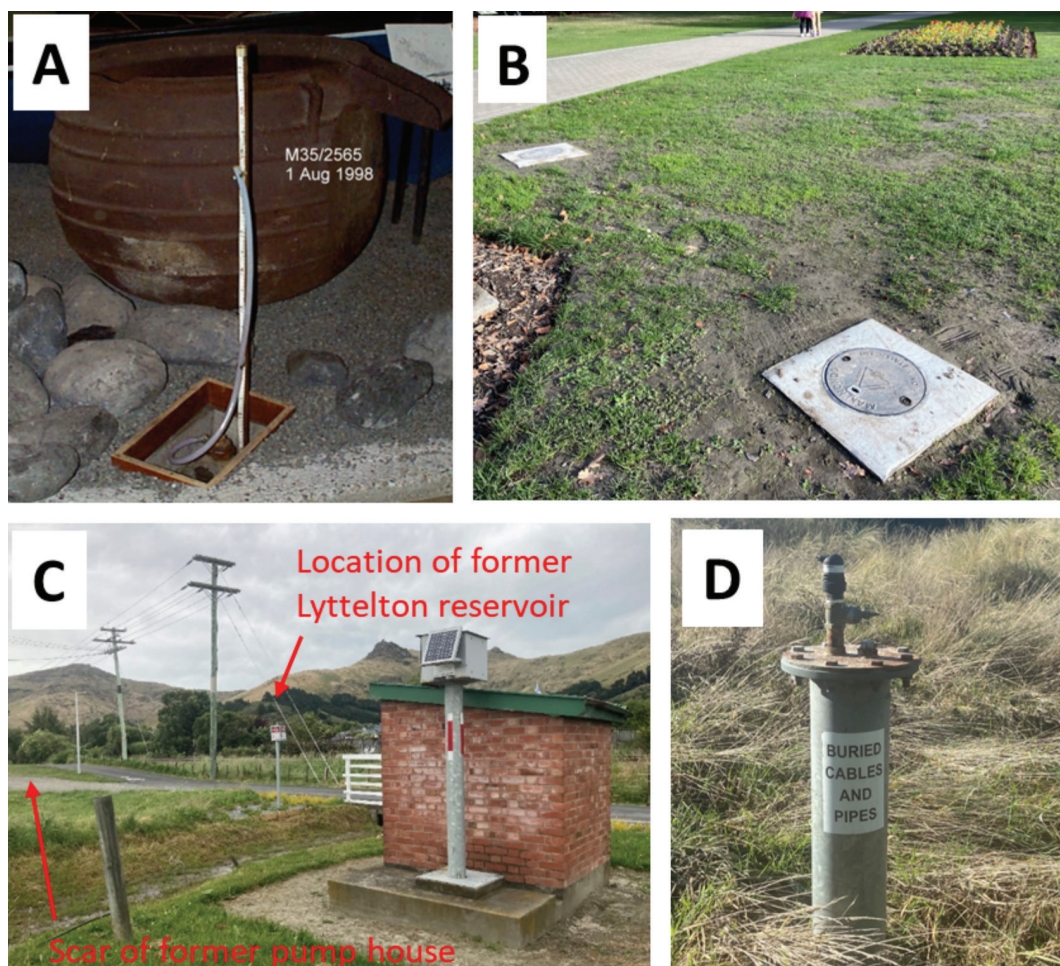
E

**Figure 20** – Ground source heat pumps. **A:** Public notice at the University of Canterbury (UoC) explaining the GSHP developments there. **B:** Waterfall feature at UoC, the water source of which is discharge from a GSHP. **C:** Water cascade at Jellie Park that represents discharge from the GSHP that serves the sports centre. **D:** Wells associated with the GSHP at Te Urutū, Hereford Street. **E:** Public information notice for the Te Urutū GSHP.

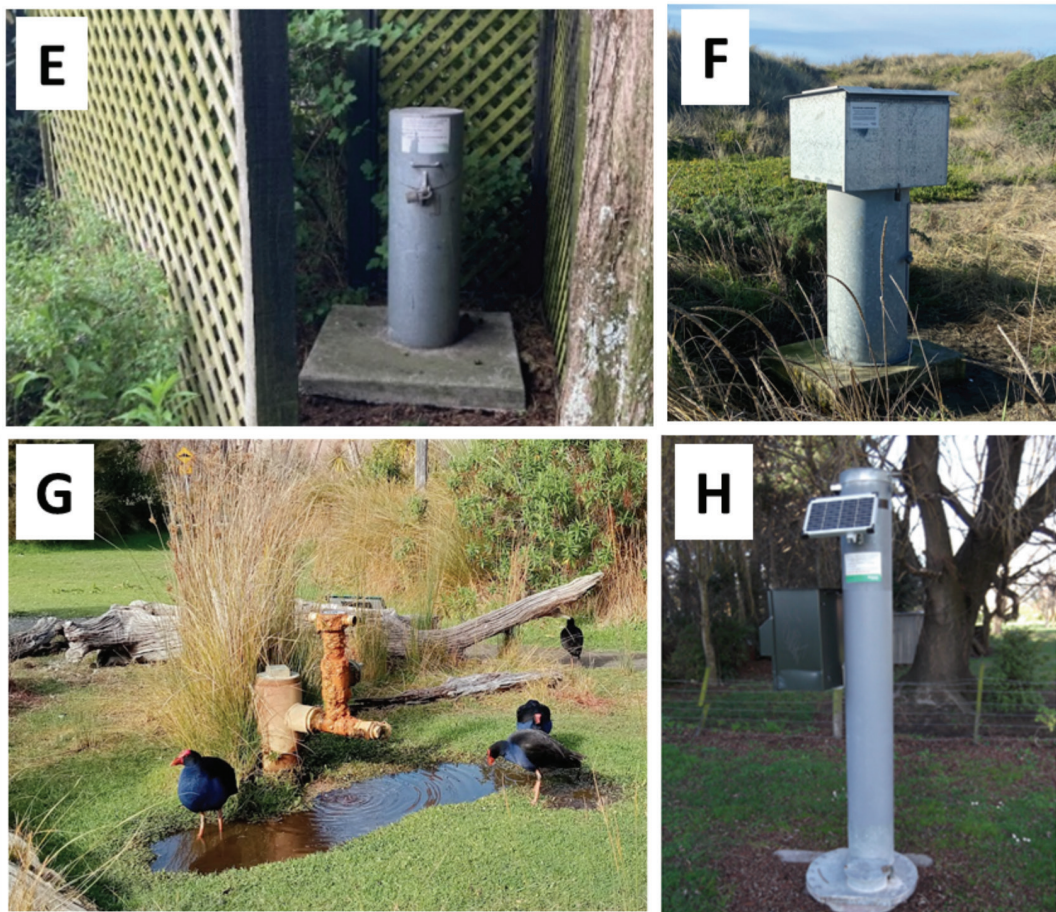


gifted to Christchurch Art Gallery – Te Puna Wai o Waiwhetū, and Hagley Community College – Te Puna Wai o Waipapa, respectively translate to ‘the freshwater spring of Waiwhetū’ and ‘the freshwater spring

of Waipapa’ and were so chosen because of the cultural significance of springs to those localities. In English, waiwhetū means ‘water in which stars are reflected’ and was the name of the spring upon which the art gallery



**Figure 21** – Examples of groundwater monitoring sites and infrastructure operated by Environment Canterbury **A:** Measurement of piezometric head at the Canterbury ‘Museum Wells’ that were recently decommissioned and where water level measurement started in 1894 (Image supplied by Environment Canterbury). **B:** Replacement monitoring wells to the ‘Museum Wells’, recently installed at the Botanic Gardens [78]. **C:** Autonomous groundwater level monitoring station operated by Environment Canterbury at the site of the Heathcote Valley pumping station – site of the first reticulated public water supply scheme in the province and which provided pressurised water to Lyttelton. Location of the former pump house and reservoir are marked. **D:** One of three multi-level monitoring wells at Plover Reserve on South Shore spit [79].



**Figure 21** – Examples of groundwater monitoring sites and infrastructure operated by Environment Canterbury **E:** The historic water supply bore to Mona Vale homestead now part of Environment Canterbury’s groundwater level monitoring network. **F:** Prominent groundwater level observation station at Te Karoro Karoro Reserve, South Shore [80]. **G:** Redundant production well at Travis wetland visitor centre [81] now used for groundwater quality monitoring. **H:** Multi-level well monitoring station, Hoon Hay Park [82].

*Opposite: Figure 22* – Examples of other groundwater monitoring infrastructure and old well curiosities. **A:** Exposed headworks for groundwater level monitoring at the airport [83]. **B:** One of a cluster of monitoring wells at Ilam Fields that UoC use collectively for educational purposes [84]. **C:** Exposed headworks for groundwater level monitoring on Quaifes Road, Halswell, finished in vibrant yellow. [78] **D:** Similar headworks and one of the plethora of monitoring wells at Cranford Basin. This one completed in what is more customary red livery and with a well shut-off valve. **E:** Old artesian driven pipe well at Travis Wetland visitor centre for which there is no well record of. The obtrusive riser pipe is to accommodate the artesian head and mitigate overflow. **F:** Example of flush protective covers for monitoring wells, such as seen at petrol stations. The distinctive equilateral triangle is the petroleum industry standard symbol for a monitoring well (American Petroleum Institute, 1987). **G:** At the root of this spring feature located at the top of the estuary [85] and which is exposed at low tide, is an abandoned free-flowing artesian well.







**Figure 23** – Street and place names in Christchurch that expose the city’s close connection with groundwater. **A:** Puna Street, Riccarton, named in 1940 after a spring that was discovered in the area. **B:** Springfield Road, St. Albans. **C:** Te Puna Ora Place, Avonhead. **D:** Springs Road - the main route between Christchurch and Lincoln, named after Springs Station run, the old homestead of which was located near Lincoln University. **E:** Despite the misspelling Welles Street in the central city is apparently named on account of the numerous wells that were in that vicinity. **F:** Spring Grove Street, Spreydon, developed in 1914 by subdivision of an estate of the same name. **G:** Spring Grove is a new housing development around the Styx River, Belfast. **H & I:** Springwater Avenue and Springbrook Lane, Northwood. **J - L:** Appropriately named residential estate near to Redwood Springs (see Figure 4E). **M:** Springbank Street, Bryndwyr that abuts Wairarapa Stream. **N:** Nga Puna Wai Sports Complex at the headwaters of the Heathcote River. **O:** Property named Ngapuna, Halswell, in the vicinity of Te Kuru. **P:** Matai Springs, Halswell is a new sub-division near the springs that feed Caseys Drain, a tributary of Halswell River (see Figure 4F).

now rests (IFACCA, 2002). Waipapa means ‘surface water’ and is the name of another main spring, often cited as being located in the vicinity of Canterbury Museum and Hagley Park (Parata-Goodall, 2019; Hagley College, 2021).

### The role of groundwater in wastewater management

Commencing with the first artesian wells that were left to overflow onto the streets, groundwater in some capacity has long been used to flush the drains of Christchurch. The low fall across the city forever limited





**Figure 24** – Evidence of the relationship between sewage and groundwater topics in Christchurch.

**A:** Tuam Street No. 1 Pumping Station, completed 1882 and an integral part of the first sewage works in New Zealand. Construction of the 6.1 m deep sewage collection tank in what was effectively quicksand was a notable feat of civil engineering. An artesian well at the site supplied water to operate the steam-operated pumps. **B:** Distinct yellow cover for an air gap separator valve marking the site of a flushing tank at the head of a sewer line. Historically, each flushing tank was supplied with water from its own free-flowing artesian well.

the capacity of any gravity-fed drainage. Under the Health Act reforms of 1876, the Christchurch Drainage Board was established and was tasked with improving drainage across the city. In 1882, following plans drawn by eminent engineer William Clark, the Board completed a reticulated sewerage system (“The Drainage System”, 1882) – the first in New Zealand, and more than 20 years prior to development of a reticulated water supply. At the heart of the system was a pumping station on Tuam Street [86], the buildings of which still stand (Figure 24A). The grades on some of the smaller 6" (152mm) sewer lines were flatter than what Clark recommended and so were fitted with flushing tanks, each equipped with its own artesian well. The flushing tanks were kept topped up by the continuous feed of free-flowing artesian water and were periodically opened to flush solids down the sewer pipes (Wilson, 1989). Later, flushing tanks were supplied with water from the city’s high pressure water supply, for which back-flow preventer devices were required to prevent the sewers contaminating the drinking water

supply (SCIRT, 2014). Evidence of these flushing systems can be spotted across the city at the head of sewer lines, displayed in the form of distinct yellow covers that protect the air gap separator valve devices (Figure 24B). It is estimated that infiltration of groundwater to the city sewer lines contributes to almost 30% of the city’s annual wastewater flow (Christchurch City Council, 2022).

### Dewatering excavations

Dewatering activities associated with construction projects are a common sight within Christchurch and offer a reminder of the shallow water table below the city (Figure 25). A high-profile development in the city that has most recently fallen foul to the geotechnical challenges of the high water table, is the Parakiore Recreation and Sport Centre [87] (Metro Sports facility) (Gates, 2023a). Malfunctions with groundwater dewatering operations at the construction site promoted local subsidence of the ground that has required expensive delays and remedial works (Gates, 2023b). The high water table at the site has also precluded implementation





of a GSHP, in lieu of which a heat energy recovery system that operates off sewage is to be installed (Christchurch City Council, 2020). Coincidentally, the site of the Parakiore Recreation and Sport Centre was originally the site of beer-making. It was first developed as a brewery by John May sometime between 1857 and 1859 and last operated by Lion Breweries who brewed Canterbury Draught there until the destructive earthquake of 2011 (Rice, 2021b). No doubt easy access to groundwater played a role in John May's original site selection and sustained the site's long history as a brewery.

## Summary and conclusion

Exploitation of groundwater from under Christchurch has long supported the socio-economic well-being of the city. Whilst not commonly promoted or advertised, groundwater is integral to many cultural, heritage and amenity values of Christchurch. This paper has provided a comprehensive set of examples which jointly demonstrate the important role that groundwater has played and continues to play in the subsistence, prosperity and aesthetics of Christchurch. It is fair to say that Christchurch might be considered the groundwater capital of Aotearoa/New Zealand. So, *'what'll ye take?'*

## Acknowledgements

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*Opposite: Figure 25* – Exposing groundwater dewatering activities in Christchurch. **A:** Well-pointing apparatus that was a common sight after the 2011 earthquake where trenching works were carried out to replace horizontal infrastructure (SCIRT, 2021). **B:** Dewatering from a single well at a construction site on Manchester Street. **C:** Separator tank as part of dewatering apparatus at a construction site on Tuam Street. **D:** Discharge of groundwater from dewatering operations at the hospital, which manifests itself as an intermittent bubbling spring in the Ōtākaro/River Avon [88]. **E:** Evidence of a dewatering well at the construction site that is the new Metro Sports facility and former site of New Zealand Breweries/Lion Nathan.

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