ADDINGTON BROOK – A CATCHMENT APPROACH TO IMPROVING THE HEALTH OF AN URBAN WATERWAY

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ABSTRACT (500 WORDS MAXIMUM)

Worldwide urban streams face a multitude of environmental pressures that are now routinely summarized using the term 'urban stream syndrome' that was coined by Meyer et al (2005). The term describes the consistently observed ecological degradation of streams draining urban land.

This paper shares the journey of proactively enhancing one such urban stream in Christchurch, namely Addington Brook, a priority focus for Christchurch due to its degraded water quality. The story includes an honest account of the challenges, successes and opportunities of urban catchment improvement programmes. It highlights the principles of the approach and key steps taken in the early days, how this approach has evolved and what is planned for the future.

Addington Brook is a spring and stormwater-fed waterway that meanders through the south west of Christchurch and drains into the Ōtākaro / Avon River near the hospital and Botanic Gardens. Along its course it is mostly hidden underground, travelling through an extensive network of stormwater pipes (> 3.2 kilometers) before daylighting when it reaches the iconic Hagley Park. Features within the Addington catchment are typical of commercial and industrial land use. There are high percentages of impervious surfaces in the form of roads, roofing, carparks and pavements. Many roads are of high intensity use and a large proportion of the industrial roofing consists of zinc galvanised materials.

In 2014, the Christchurch West Melton Water Zone Committee[1] identified Addington Brook as one of several priority catchments to focus on remediating. This was mainly due to poor water quality shown by long-term stream monitoring and its negative impacts further downstream on the Ōtākaro / Avon River. Historically there had also been several significant environmental incidents resulting in fish kills through the Hagley Park section, for which the source was unfortunately not identified. Staff from Environment Canterbury were then tasked broadly with improving the health of this urban waterway, with modest resources and a knowledge that the problems evident were complex.

This paper outlines the deliberate focus taken since 2014 on reducing our catchment knowledge gaps, partnering with key stakeholders and building relationships, raising awareness of the waterway, engaging with individuals, schools and businesses to be part of the solution and importantly working with research organizations to support them in pioneering projects to help address the environmental challenges in the catchment.

[1] The Christchurch West Melton water zone committee is a joint committee of Christchurch City Council, Selwyn District Council, Environment Canterbury, local rūnanga representation and community members. Environment Canterbury's zone delivery staff deliver on work related to the water zone committee's recommendations.

KEYWORDS

Urban waterway, urban contaminants, challenges, learning, opportunities, holistic management, partnerships, water zone committee, land use, zinc, copper, modelling, education, research.

PRESENTER PROFILE

Growing up in rural Norfolk in the UK, Jenny Watters had a somewhat feral childhood roaming through fields, climbing trees and playing in streams. This created her lifelong love of nature and engaging people to solve environmental problems through connecting them with their local natural environments.

Michele Stevenson is a water quality scientist / ecologist who has worked at Environment Canterbury for nearly 12 years. Michele's work focusses on urban waterways and stormwater management, working closely with Environment Canterbury Pollution Prevention officers and a range of colleagues from territorial authorities to monitor, investigate and initiate change within urban catchments.

1 INTRODUCTION

The steady urbanization of the natural environment throughout the world since the onset of industrialization (termed the 'Anthropocene') has had a noticeable environmental impact on the streams and rivers that pre-existed the impervious surfaces now synonymous with urban living. Consequently, the term "urban stream syndrome" was coined by Meyer et al. (2005) and is now broadly used (e.g. Walsh et al. (2005), Booth et al. (2015)) to describe the plethora of issues urban streams face as a direct result of their modification to fit within urban landscapes. The mechanisms and causes of the urban stream syndrome are complex and interactive, but stormwater runoff is recognized as one of the key large-scale contributors, due to its impacts on both hydrology and water quality.

Christchurch, like many other cities in New Zealand and throughout the world, has many urban streams that are presenting symptoms of urban stream syndrome to varying degrees. Christchurch City Council's latest summary of 2017 waterways sampling data (Margetts and Marshall 2018), highlights that 17 of the 42 sites it monitors on a monthly basis were graded as poor, 17 as fair and 8 as good, with the differences between sites directly attributed to urban stream syndrome (CCC, 2018).

Originally swamp land, it was not long before the first British settlers embarked on sculpting Christchurch's abundantly watery environment to one more palatable to their sentiments and in 1875 the Christchurch Drainage Board was set up quickly utilizing tried and tested drainage engineering from their homelands.

"During its more than one-hundred-year existence the Board constructed many hundreds of kilometres of open drains, concrete- or timber-lined channels, and pipelines. It progressively deepened, widened and straightened the Avon, Heathcote and Styx rivers." Watts (2011)

Much of the makeup of Christchurch's waterways as we see them today is a legacy from this bygone era when water was seen as simply a drainage issue to get rid of, unlike today where increasingly our waterways are viewed as valued assets to be protected.

This is reflected in CCC's six waterway values that are presented in their Surface Water Strategy (CCC, 2009) – culture, heritage, ecology, recreation, drainage and landscape. Environment Canterbury has a statutory duty to protect our waterways and through the Canterbury Water Management Strategy (CWMS) is increasingly partnering with territorial authorities and key stakeholders to revive those streams that have degraded due to urbanization over the last 100 years.

The Christchurch West Melton Water Zone Committee was one of 10 water zones formed in 2011, across Canterbury, as part of the CWMS. This is a joint committee with Councilor representation from Environment Canterbury and the relevant territorial authorities, Christchurch City Council and Selwyn District Council. There are three rūnanga who have land in the zone that is recognized as part of their takiwā and as such each have an appointed papatipu rūnanga representative on the committee.

Initially the committee was tasked with recommending a range of tactics and actions to the partners of the Canterbury Water Management Strategy through the development of a Zone Implementation Plan specific to their zone (Environment Canterbury, 2013).

In 2014 the Christchurch Water Zone Committee (ChCh WZC) received a presentation from CCC staff summarizing the previous year's water quality data in the Ōtākaro / Avon River catchment (Margetts, 2014). At this meeting it was highlighted that Addington Brook was one of two of the catchment's streams that had poor water quality which was likely to be negatively impacting on its receiving waterway the Ōtākaro / Avon River. The catchment was then highlighted as a ChCh WZC catchment and Environment Canterbury was tasked, as a partner of CWMS, to design and implement a programme to improve the health of this catchment.

Addington Brook catchment is situated in the south west of Christchurch, fed through spring and stormwater sources (Figure 1). Only a few sections at the top of the catchment are above ground with most of the brook flowing via an underground network of pipes. The brook reemerges to daylight travelling through Hagley park (see Figure 2), undertaking the last leg of its journey through the Botanical Gardens before joining the Ōtākaro / Avon river.

Figure 1. Addington Brook stormwater catchment boundary

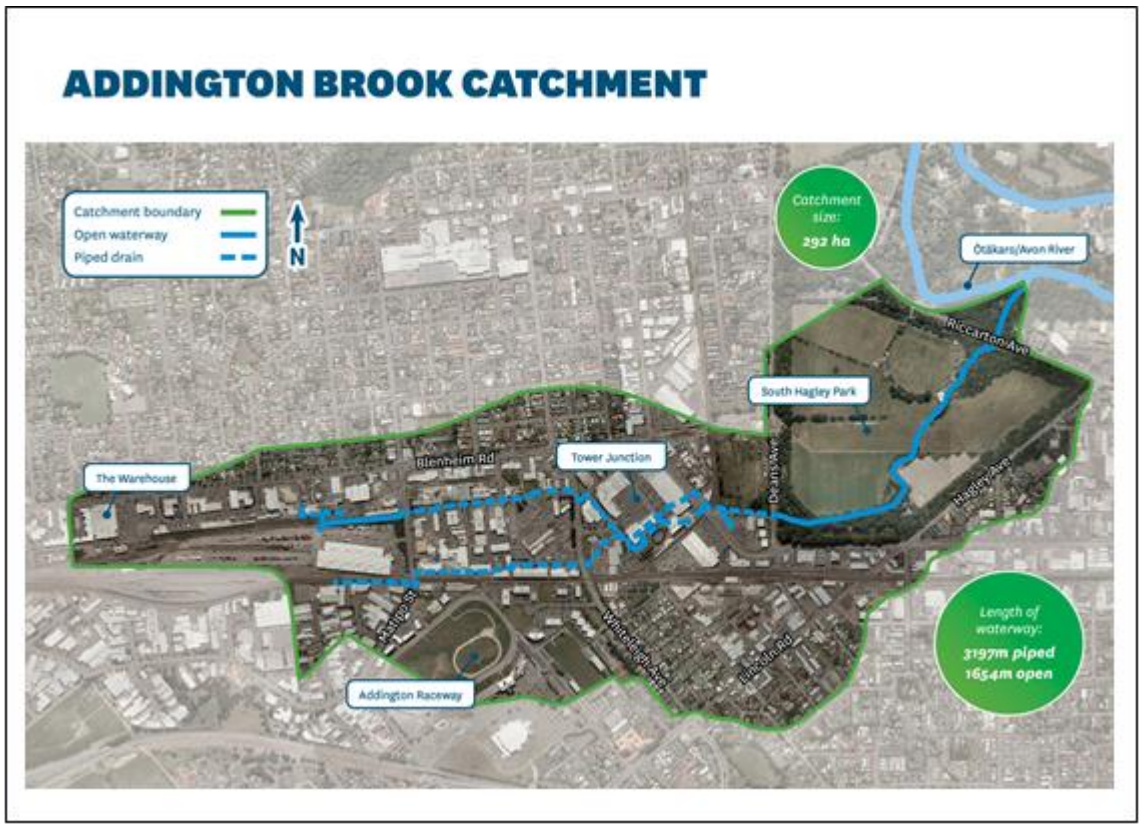


Figure 2. Photos of Addington Brook throughout the catchment
(a) timber-lined box drain upstream of Matipo Street stormwater ponds
(b) view down stormwater sump to the piped brook in mid-catchment
(c) stream as reemerges through Hagley Park
(d) section of stream through the Botanical Gardens

2 THE JOURNEY

2.1 KEY PRINCIPLES

Several key principles underpin the programme of work around Addington Brook over the last 5 years, which are detailed below.

- **Learning from previous urban catchment research and programmes**

Prior to the Addington Brook programme, work had been undertaken by Environment Canterbury in Christchurch's highly polluted Haytons Stream catchment, which drained a largely industrial subcatchment to the Ōpāwaho / Heathcote River. From 2009 to early 2014, a pollution prevention programme engaging with businesses in the area was run to assist them to reduce their environmental liabilities initiated through a free audit from a Pollution Prevention Officer.

Related research (Moores et al., 2009; O'Sullivan & Charters, 2014) and learnings from the Haytons Stream catchment programme were instrumental in assisting in the design of water quality monitoring in the Addington Brook catchment. The results questioned long held assumptions on the significance industrial sites were contributing to the overall poor catchment health. This flagged a large knowledge gap in our understanding around the proportions of contaminants entering our urban streams from different sources at a catchment-specific level. Questions arose around the proportion of pollutants originating from poor environmental management and those originating from building materials (e.g. zinc roofing) or road and car park surfaces (e.g. copper).

- **Changing the language used around urban waterways**

Historically, like many modified streams in Christchurch, the associated official name for Addington Brook (as it is now known) was 'Addington Drain'. The change in language in 2014 was deliberate as the word drain was thought to have certain connotations associated with it, particularly eliciting the imagery of getting rid of substances. Interestingly below are two common Oxford Dictionary definitions:

"Cause the water or other liquid in (something) to run out, leaving it dry"

"Deprive of strength and vitality"

Although the latter is generally used when talking about energy in a physical form such as "their body drained of energy" interestingly the concept holds true if used in the context of our urban drains. The word stream or brook in Addington's case perhaps conjures up a more traditional notion of a habitat full of life, babbling over riffles and meandering as it makes its way to join a nearby river. Over the course of the project this one concept has created a lot of discussion about the role language has in connecting people to care for their urban streams.

- **What is the science telling us?**

There has been a strong emphasis on ensuring that the programme and where we focus our resources is based on what the current science is telling us about each area of study. This has allowed us to direct limited resources to the areas where the largest potential improvements may be gained. We have done this by instigating a detailed catchment monitoring programme and engaging with research institutions to help with identifying and prioritizing the issues and evaluating appropriate solutions. We deliberately focused

research support on many of the contaminants which had previously been placed in the "too hard" basket e.g. zinc and copper.

- **Working within our means**

From the outset the budget for this programme has been modest with most funding to date sourced from Environment Canterbury's Urban Waterways budget. The programme has an associated project lead (0.4 FTE) with additional funding and support coming from other internal teams in staffing and budgets. The yearly average goods and services cost associated with this programme has been $22,000 (this includes monitoring costs).

- **Regular stocktakes**

As this is an ongoing programme of work it has been essential to undertake regular stocktakes of where we are at, what new information and research has come to light and to consider how this may have changed our thinking. We have maintained engagement with research institutions and coordinated workshops to keep interested parties connected with the research and the Addington work programme. This has been extremely helpful for communication at a governance level and kept key stakeholders informed and supportive of our programme approach. It has also been important to scaffold our learning as additional research adds ever new pieces of the jigsaw to the picture. Wherever possible information and research has been shared with others to spread knowledge. The Addington Brook Storyboard[2] was developed to house this catchment knowledge and serve the purpose of a one stop shop. This also prevents the common occurrence of institutional knowledge loss if staff leave the organization.

- **Valuing and incorporating cultural perspectives**

Working alongside the Zone Committee has allowed us to build relationships with the three appointed papatipu rūnanga representatives and gain essential guidance on cultural values pertaining to the catchment.

"As with all tributaries to the Ōtākaro/Avon River, the health of the waters, habitats and species that comprise the Addington Brook are of high importance to the mana whenua of Te Ngai Tūāhuriri Rūnanga."[2]

- **Being clear on what we can and can't do**

There was a recognition early on that Environment Canterbury would lead this programme, however there was also an acknowledgement that without the support of major land managers in the area, including CCC, our work would be constrained.

We knew that in areas such as catchment scoping, pollution prevention visits with high risk businesses, additional catchment water quality testing and raising awareness we were well placed to deliver.

There were however areas which we did not have direct responsibility for such as the stormwater network or management responsibility of the large section of Addington Brook which flows through Hagley park, both of which are managed and maintained by CCC. Therefore, our strategy was to build and maintain relationships with key staff, share catchment knowledge and use our influence to support them to effect change which positively impacted on the catchment health.

[2]The Addington Brook Storyboard under development at the time of writing is a public facing website which allows all the information and knowledge gained about the catchment to be housed in one space.

- **Relationships and awareness raising: inviting others on the journey with us**

Many of the above principles feed into an overarching principle that recognizes if we want to improve the overall catchment health we must concentrate at every step of the journey first and foremost on relationships. The challenges currently presented to improve urban waterways are larger than any one individual or organization and require a mobilization of connected individuals and organisations. In order to succeed in our task we need firstly to introduce people to the Brook, then inform them about the challenges it faces, after which inspire them to care about it and finally invite them to carry out whatever positive actions they have the power to undertake or influence. Whether this is students sharing what they have learned about protecting the brook, or local businesses improving their environmental practice to reduce the risk of incidents, it all helps.

2.2 KEY STAGES / ACTION – TIMELINE

Table 1 highlights the key activities to date within the financial years since July 2014.

Table 1: Summary of key activities within the Addington Brook work programme

Financial Year	Project / activity Description	Principle
2014 / 15	• Three new public signs (Figure 2c) to raise awareness of stream through Hagley Park and the Botanic Gardens	Awareness raising
	• Catchment specific communications material (leaflet and poster)	Awareness raising
	• Full catchment scoping and awareness raising of all drains in catchment leading to Addington Brook	Knowledge gaps / Awareness Raising.
	• Pollution prevention visits to 32 high risk businesses	Knowledge gaps and Awareness raising
	• Additional monthly instream catchment monitoring and data analysis	Awareness raising Knowledge gaps
2015/16	• Autosamplers installed and data analyzed (O'Sullivan and Cochrane, 2017)	Knowledge gaps
	• CCC Botanic Gardens stormwater visitor display (housed for a year)	Awareness raising
	• SCIRT staff drain stenciling volunteer morning	Awareness raising
	• MEDUSA commissioned in the catchment and initial findings reported (Charters, 2016)	Knowledge gaps
	• Targeted investigations at O'Shannessey Place as directed by additional catchment monitoring	Awareness raising
2016/17	• Development starts of public facing one stop shop (Storyboard) for Addington Brook	Awareness raising
	• Zinc and copper workshop hosted by Christchurch West Melton Zone Committee members - staff from CCC, ECan and Ministry for the Environment invited	Awareness raising
	• Faecal source tracking undertaken to speciate *E. Coli* in the catchment	Knowledge gaps
	• Joint Addington Brook project with ECan, Hagley College and Te Pā o Rākaihautū	

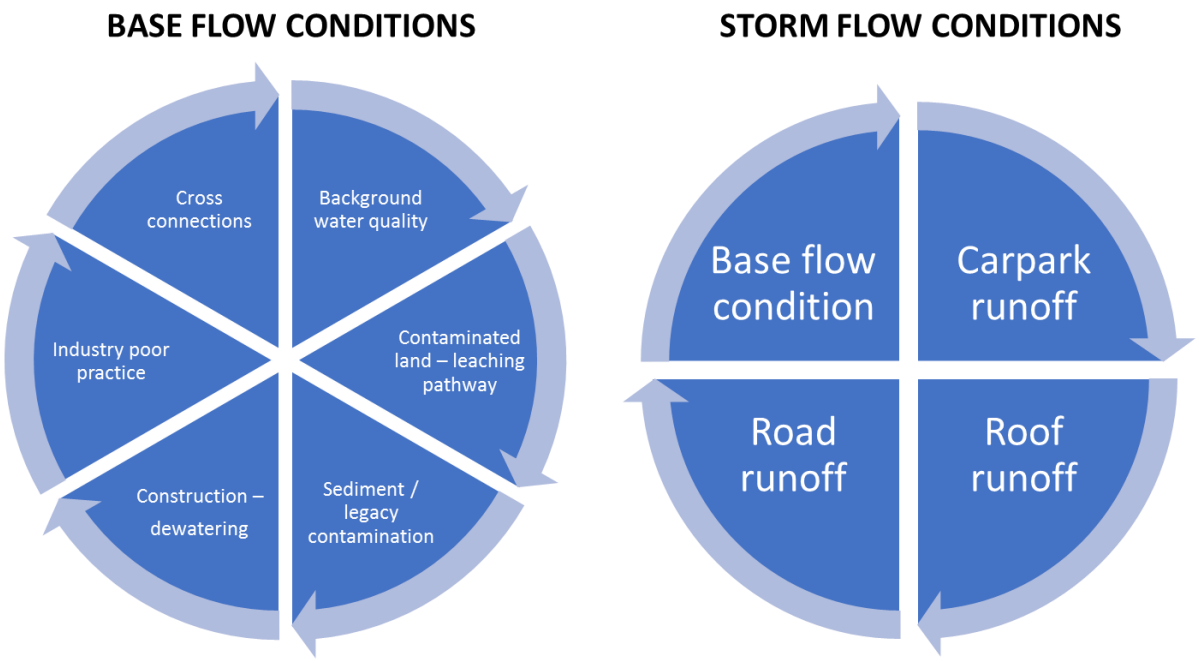
	• Continued pollution prevention visits where required	Awareness raising
2017/18	• Support CCC's long term plan funding submission for stormwater treatment of Addington Brook catchment • Addington Workshop 2018, building relationships and creating a shared vision • Continued pollution prevention visits where required	Building and maintaining relationships Building and maintaining relationships
2018/19	• Cultural Values Report undertaken and learnings fed in to programme / Storyboard / draft CMP • 1st draft of 'Living' Catchment Management Plan socialized with partners • MEDUSA online pilot platform completed by DHI and University of Canterbury • Hagley College Addington Brook project terms 3 and 1 • University of Canterbury commissioned to pilot x4 of their Storminator™ with businesses in the catchment. First two installed at Hagley College • Continued pollution prevention visits where required	Valuing and incorporating cultural perspectives Awareness raising / project management Knowledge gaps Awareness raising Innovative research Awareness raising

2.3 MONITORING AND RESEARCH

2.3.1 DEVELOPING A MONITORING AND RESEARCH PROGRAMME

In 2013-14 CCC's water quality data highlighted that Addington Brook had elevated levels of dissolved zinc, dissolved copper, dissolved lead, total ammonia, total suspended solids (TSS), biochemical oxygen demand and *Escherichia coli*, based on consistently recording results well above guideline values and/or recording a number of high one-off events compared to other sites (Margetts 2014). Sampling for CCC's monthly instream water quality monitoring programme typically occurs during dry weather and is limited to one site in the lower reaches of Addington Brook. Therefore, to further investigate the water quality issues we required more detailed catchment monitoring and research for Addington Brook, especially since it is a combined spring and stormwater-fed catchment. A key realization was that the water quality condition of the stream during baseflow and stormflow conditions was impacted by different factors. These are summarized in Figure 3.

Figure 3: Conceptual diagram of the complexity and different factors influencing water quality in base flow and storm flow conditions in an urban stream



In baseflow conditions there can be a diverse range of activities occurring within a mixed land use catchment that can result in contaminants entering a stream. These include cross-connections between the wastewater and stormwater networks, poor site management practices such as washing down of hardstand surfaces into a stormwater sump, and dewatering of construction sites resulting in sediment-laden discharges. Additionally, legacy contaminants may be mobilized from instream sediments or from leaching from contaminated land. All of these factors may be having an influence on top of the existing background water quality, which in the case of a spring-fed stream is driven by the quality of the groundwater in shallow aquifers. It is very difficult to determine the relative importance and contribution of these factors on the instream water quality that we measure.

Key questions and the approaches taken (or still to be taken) to address them include:

- What are the key contaminants of concern (CoCs) in baseflow and stormflow conditions? >> *dry and wet weather monitoring*
- What are the main sources and their relative contribution of these CoCs? Are there hotspots within the catchment where we can focus management actions? >> *monitoring and modelling*
- How effective are the existing stormwater treatment ponds in the upper catchment? >> *monitoring*
- What effect could different management approaches have on the loads of key stormwater CoCs derived from impervious surfaces in the catchment? >> *modelling*
- What approaches could we investigate to address CoCs derived from impervious surfaces, particularly dissolved metals in roof and road runoff? >> *support for*

novel local research and advocate for national policy change regarding materials used

- What part do legacy contaminants, stored in stream sediments and contaminated soils, play in influencing baseflow contaminant concentrations? >> *targeted monitoring and research on sediment/soil quality and the environmental conditions that influence contaminant remobilisation*

2.3.2 MONITORING TIMELINE AND KEY RESULTS

Since 2014, Environment Canterbury (ECan) has undertaken detailed catchment monitoring to:

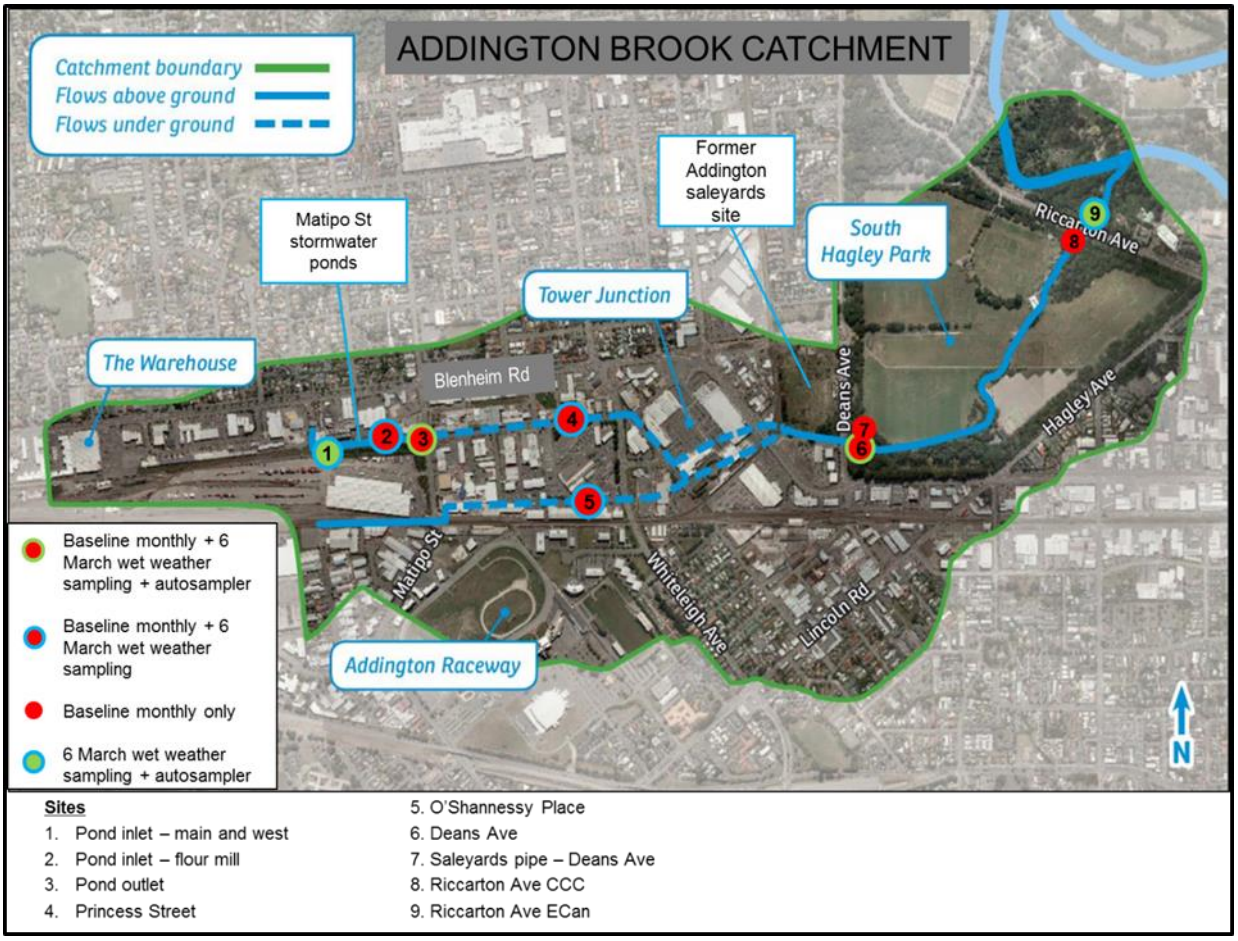
- Further identify contaminants of concern and potential contaminant sources or hotspots during baseflow conditions. This was achieved with monthly monitoring at additional sites in the catchment on the same day as CCC's monthly sampling.

- Identify key contaminants and their potential sources during storm flow conditions. This was achieved with the use of autosamplers at four suitable sites (notably where the waterway was not piped) during four rainfall events.

- Characterise the quality of water flowing into and out of Matipo Street stormwater ponds. This was achieved by including sites capturing the inflow and outflow from the stormwater ponds for both the baseflow and storm flow monitoring above.

The monitoring programme that commenced in late 2014 is summarised in Figure 4, showing site locations and the types of sampling that were done at each location.

Figure 4. Map of supplementary catchment monitoring by Environment Canterbury that commenced in 2014-15. Baseline monthly and occasional wet weather grab sampling continued at key sites in 2015-17 and reduced in frequency for 2017-19.



The first year of sampling additional sites within the catchment has thus far been the most revealing in terms of determining spatial patterns and hotspot identification for contaminants during base flow conditions. Key results were:

- Concentrations of many parameters, including dissolved zinc and ammoniacal-nitrogen, were highest at one site (location 5, O'Shannessey Place) and elevated concentrations of multiple contaminants often coincided indicating the possibility of a common source. The concentrations sampled suggested some illegal or accidental discharges were occurring which led to an intensive pollution prevention effort in the area by Environment Canterbury staff.

- Dissolved zinc concentrations exceeded guideline values on numerous occasions at all sites, indicating diffuse sources.

- The Matipo Street stormwater ponds create the baseline water quality for the downstream environment and this is generally better quality than the measured inflows, indicating that the ponds are a benefit to the catchment.

- Concentrations of key stormwater contaminants – TSS, zinc and copper – were significantly higher in the wet weather grab samples than the dry weather samples, which highlighted the importance of carrying out more detailed wet weather monitoring using autosamplers.

Four autosamplers collected samples during four storm events in the spring-summer of 2015-2016. The data were analysed and reported in O'Sullivan and Cochrane (2017) with the following key findings:

- Large amounts of TSS entered Addington Brook between the Deans Ave and Riccarton Ave sites, indicating either high suspended solids loads are discharged from the stormwater pipes entering in this area or direct input of sediment from eroding stream banks.

- Concentrations of dissolved zinc increased substantially between the Matipo Street stormwater ponds and Deans Ave, which can be attributed to the runoff from this industrial/commercial area of the catchment with large galvanized roof areas.

- Dissolved copper is removed in the Matipo Street ponds and increased downstream to varying degrees dependent on the rainfall event.

- Dissolved zinc and dissolved copper exceeded the guidelines for ecosystem protection in many of the samples taken during storm events, while dissolved lead never exceeded the guideline value in any sample.

- Flow data were collected at the furthest downstream site and load calculations were very similar to those that had been predicted by the contaminant load model MEDUSA.

2.3.3 RESEARCH SUMMARY

The Addington Brook catchment could be considered typical of a predominantly industrial/commercial urban area throughout New Zealand. We have therefore used this catchment project as a pilot for supporting research initiatives that investigate and address broader urban waterway and stormwater issues. These are briefly summarised below, with reference to documents and papers (including others at this conference) where appropriate.

1. The MEDUSA model – Researchers in the Hydrological and Ecological (HydroEco) Engineering group at the University of Canterbury (UC) developed the MEDUSA (Modelled Estimates of Discharges for Urban Stormwater Assessment) contaminant load model and it was applied to the Addington Brook catchment in 2015-16 (Charters 2016). This included monitoring of surface runoff quality from different roof, road and carpark types in the catchment to enable calibration of the model to Addington conditions. The model predicts the contaminant loads of TSS, zinc and copper from individual surfaces during individual storm events that can be aggregated to demonstrate average annual loads from varying subcatchment or catchment areas. It enables hotspot identification and selection of most appropriate treatment methods based on key source types and locations.

2. MEDUSA scenario modelling – An additional project was commissioned to use the Addington MEDUSA model to investigate the reduction in contaminant loads that could be achieved by applying a range of different treatment or surface replacement scenarios within the catchment (Charters and Cochrane 2017). This has been useful for demonstrating the limitations of existing treatment options for removing dissolved metals in particular and helped focus some attention towards advocacy for nationwide action on reducing key diffuse sources of contaminants from our environment, for example copper in brake pads.

3. MEDUSA Online – More recently Environment Canterbury has supported the development of an online portal for MEDUSA, which has been a collaboration between UC and DHI. The Addington pilot of this tool is being used to demonstrate its potential within stormwater management planning. A paper on MEDUSA Online is being presented at this conference by Dr Kalyan Chakravarthy.

4. The Storminator™ - Having recognized the lack of effective treatment options for removing dissolved metals from stormwater runoff, the UC's HydroEco Engineering researchers have developed a unique and retrofittable inline downpipe treatment solution for roof runoff. Environment Canterbury are supporting the field testing and further development of these devices, with four being installed on different roof types in the Addington catchment. The Storminator™ is being presented at this conference in the Innovations Showcase by Dr Aisling O'Sullivan.

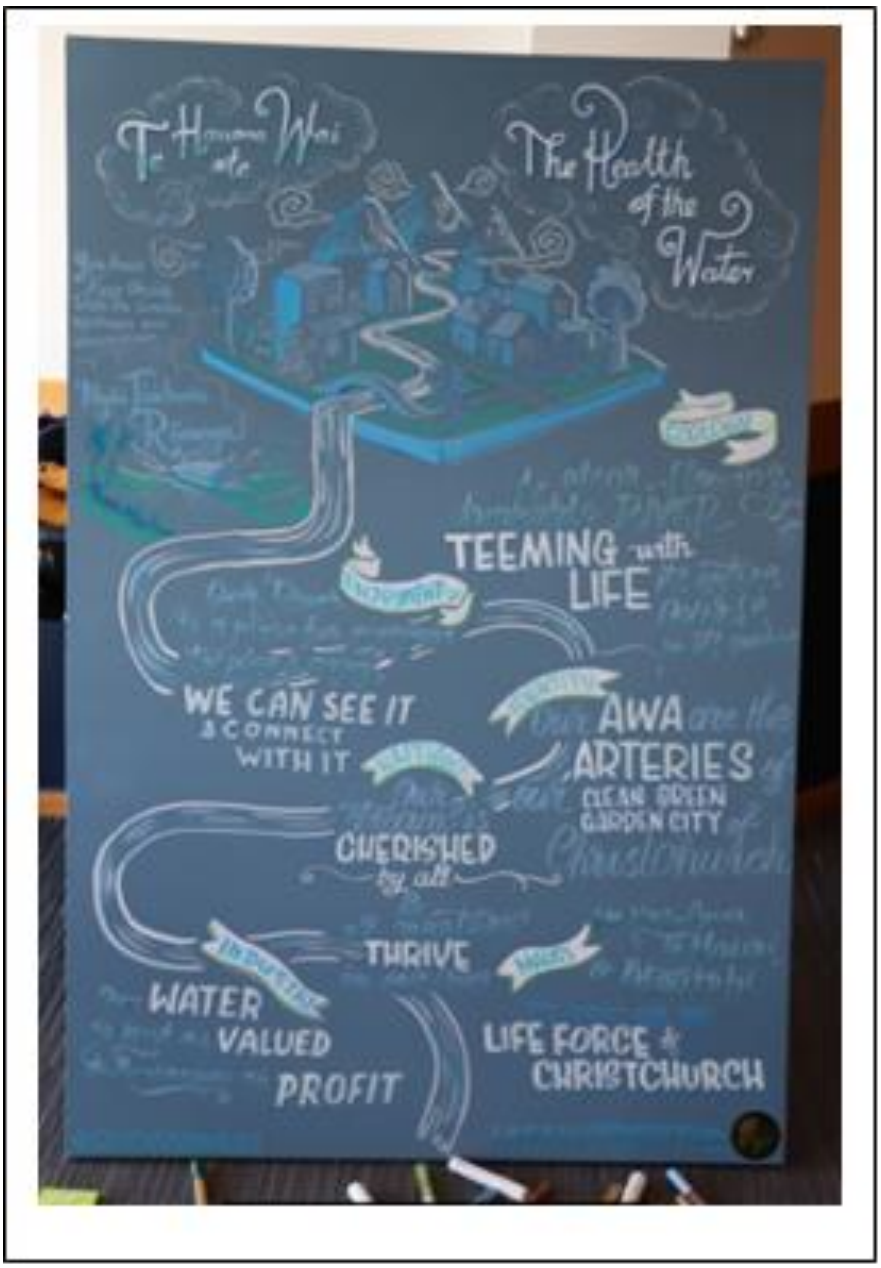
2.4 WHAT'S NEXT?`

Over the last year a draft 'living' catchment management plan has been developed in collaboration with key partners. The aim of this document is to provide a clear shared vision (see Figure 5) and road map for our work over the next three years. It recognizes that it has taken over 100 years for Addington Brook to deteriorate to its current state and it may take many years of hard work before there is any obvious improvements in stream health. At the time of writing, this plan is due to be agreed and signed up to by the ChCh-WM Zone Committee by May 2019, along with the launch of the supporting Storyboard.

There is an emphasis in the plan on continuing to commit to work which follows the key principles as described earlier in this document. It was developed to take into account work that partner organizations were already committed to which contribute to the improvement of catchment health. There was an emphasis that key work would be progressed as the plan was drafted and that it would be a 'living' and adaptive document in order that knowledge and incremental improvements in the catchment would continue whilst all the threads were being pulled together to assist with a holistic long-term approach.

It also commits partners to additional pieces of work which build on the progress in the last 5 years and move us towards the vision of a "waterway that thrives with life and in turn positively contributes to the Ōtākaro / Avon River" (Environment Canterbury, 2019). It is explicit about potential projects and pieces of work which could greatly contribute to this area however are currently unfunded, in the faith that funds may become available. An annual review presented to the ChCh WZC would allow a degree of flexibility in any additions or changes to the work programme given new learnings or advancement in science or solutions, with an opportunity in the 3rd year to put forward recommendations for further work.

Figure 5. Shared vision created at Addington Brook April 2018 workshop



Looking forward, the ongoing monthly monitoring of the downstream site by CCC will allow us to assess trends over time that may indicate whether management actions within the catchment have resulted in improvements in water quality. We are continuing the monitoring of three sites further up the catchment at a reduced frequency to allow us to keep a watch on the water quality variance within different subcatchments. We recognize that with stream water quality being inherently highly variable, particularly within a catchment with such intense and varied land use, and due to the scale and pervasiveness of the sources of many of the contaminants (e.g. zinc in roof runoff and copper in road runoff) it is likely to be a long time before significant improvements are detectable.

A great opportunity for the Brook will be the roll out of stormwater treatment in the catchment which CCC secured though its 2018-28 long-term plan. Over $10 million has been set aside over the next 10 years to improve the stormwater quality for Addington and Riccarton catchments combined. Currently this project is at very early stages with no decision on what it may look like, however the commitment of these funds will result in

significant improvements in catchment water quality. The MEDUSA Online platform provides a supporting tool for CCC when deciding on stormwater treatment options.

Several other key pieces of work have been identified as:

- Sediment profiling along the lower reaches of the Brook through Hagley Park, the Botanic Gardens and at the confluence of the Ōtākaro / Avon. This will determine the level of legacy contaminant issues which may need to be remediated to enable life to once again thrive in these areas.

- Launch of the Storyboard alongside the 'living' Catchment Management Plan which will provide a space for all partners to pool knowledge and resources.

- Further support for Storminators™ and other novel research which looks at pioneering solutions to the environmental issues in the catchment. UC's HydroEco Engineering group have plans to investigate the capability of Storminator™ devices to treat elevated nutrients found in some roof runoff (e.g. as a result of atmospheric deposition from fertilizer factories) and to model the lifecycle footprint of different stormwater treatment systems, using the Addington catchment as a case study.

- Continued engagement with businesses in the catchment on best environmental practice. These relationships need to be maintained and pollution prevention remain on their agenda as staff turnover occurs or businesses move.

3 CONCLUSIONS

CHALLENGES

The challenges in improving the health of Addington Brook presented over the last 5 years are diverse reflecting issues facing urban streams throughout New Zealand and no doubt the world. It is a catchment with a multitude of individual land managers with differing constraints, priorities and attitudes towards environmental issues. Sixty-six per cent of the stream is piped underground, this alone presents massive challenges in identifying and investigating individual pollution events and connecting the communities within the catchment to the fact that the drains lead to an unseen stream.

Although our knowledge base has grown dramatically since 2014, there are still many areas where there are significant gaps as listed below:

- Emerging contaminants – there are many parameters which may be having a detrimental effect on the brook that we do not currently test for e.g. microplastics, hormones

- Proportions of contaminants and where they are coming from – although our knowledge in this area around zinc, copper and sediment loads from stormwater run-off have improved, for other contaminants particularly in baseflow conditions (where there are many potential and differing sources) we still have little knowledge on how much is coming from ground water and how much from surface water or instream

- Re-mobilisation of contaminants from sediment – prior to sediment profiling in the lower reaches of Addington Brook we are not sure what kind of legacy issues are present and if re-mobilisation of contaminants is contributing to poor water quality.

- Piped network – understanding flow in relation to the extensive underground network of pipes in the catchment.

SUCCESSES

From the outset of the programme we were aware that a change in water quality in the catchment was a long way off. It was also understood that even if there was an improvement in water quality it would be extremely hard to link this with much of the awareness raising and improved business practice that was initially planned. As expected continued water quality sampling has not yet shown any tangible improvements for the Brook, however there have been many broader successes as detailed below:

- Catchment knowledge has significantly increased and we are clear on what actions need to be undertaken next.

- As one of their priority catchment programmes the knowledge gained has allowed ChCh WZC to fully engage with the issues facing urban streams and utilize learnings to educate and influence for positive change in their own networks.

- Many businesses in the catchment have improved their environmental practice.

- The cutting-edge research undertaken by the University of Canterbury staff and researchers has provided a more complete understanding of key contaminants and loads under stormwater conditions. It has also offered the hope of future low-cost source control solutions for zinc removal, which may have far reaching implications for urban streams.

- The MEDUSA modelling through the University of Canterbury and DHI offers a supporting tool for future stormwater treatment options in the catchment.

- Historically there were regular fish kills in the Hagley Park section of the Brook. Since the start of the programme there has only been one report of one tuna / eel kill over five years.

- The targeted investigations at O'Shanessy place identified several cross connections, which were remediated. Staff also worked with several businesses to improve their environmental liabilities around stormwater. The cumulative impact of this was that the flow in dry conditions at the nearby monitoring point was visibly reduced.

- Relationships – the amount of relationships forged over the past 5 years and the support from these organisations and individuals has been a real strength of the project. The extensive acknowledgements section is reflective and testament to all those who have positively influenced this programme through their engagement with it.

- CCC LTP funding – it is likely due to the poor water quality of Addington Brook that this funding may have been secured with or without this programme. What is clear is that it is a huge success for the catchment and the catchment knowledge built up over the last 5 years will be informative to those managing it.

OPPORTUNITIES

It may sound cliché, however for every challenge listed there is always one or many opportunities available, whether they are seen as opportunities is often the determinant of forward momentum. The work on and in Addington Brook through research establishments and their research students demonstrates just a small amount of the potential there is to carry out projects that add to our knowledge of urban waterways and the issues they face. Trials for innovative projects such as the Storminators™ are forging ahead in finding solutions to problems that seemed insurmountable four years ago, and are proof that with a modest amount of funding we can tackle the 'too hard basket'.

As the land manager for approximately a third of the catchment, CCC has a great opportunity to positively influence improvements to water quality in the lower reaches of the Brook. Their commitment to this has been demonstrated with the LTP funding recently secured for stormwater treatment in this and the neighbouring catchment of Riccarton Stream. Other major landowners in the catchment such as Ngāi Tahu at Tower Junction and Kiwirail have demonstrated how positive relationships with land owners and occupiers provide the potential for businesses to host research projects and champion cutting-edge research.

To date funding has come from traditional council avenues via rate payers. Nowadays there are many tried and tested non-traditional funding models available which could be explored in finding future avenues to increase finance for further remediation, restoration and projects incentivising businesses to retrofit stormwater improvements. This may be an opportunity that partners might look to explore as a way of speeding up progress in the catchment.

Undeniably like so many urban streams the health of Addington Brook has been neglected for many years and much of it, like the saying, is 'out of sight, out of mind'. Compared to its counterparts Addington Brook has a major advantage of travelling through two iconic city parks. With the committed stormwater treatment funding through CCC and a bit of imagination on how this stream offers huge potential as an exemplar for holistic restoration of an urban stream in Christchurch, there is an exciting opportunity to bring it back from the brink. The catchment approach to enhancing Addington Brook could be a catalyst for change in how we engage our urban residents in connecting with and caring for our urban streams.

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