

# ALTERNATIVE INFRASTRUCTURES: URBAN STREAMS AND THEIR BIODIVERSITY IN TE ARO

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## ABSTRACT

In the face of expanding urbanisation, one of the opportunities for more resilient and sustainable cities is in the implementation of hybridised nature-based ecologies that function as engineering, community and landscape infrastructure. This is becoming more commonplace on greenfield sites. But very rarely does it happen in established city centres: partly because of land economics; and partly because of the difficulties associated with behaviour change in the community.

This research project, set in the centre of Wellington, explored the potential for community spaces developed from adaptations of water infrastructure. The project, called Waitoru, used Te Aro as a case study and produced speculative designs as a way of envisioning an innovative and hybridised future. The work shows the potential for underground streams to inspire and aspire to interventions into the fabric of Te Aro to improve water quality, biodiversity and flooding mitigation, provide community space integrated with water infrastructure, and strengthen the potential for self-sufficiency in stresses and shocks.

The project is significant because it demonstrates to territorial authorities how they can effectively connect urban ecologies through water infrastructures and create more amenity and identity in urban public realm. It provides a case study of the issues, methods, guidelines and opportunities for directing policy.

The project is also significant because it demonstrates the potential of the highly graphic language of design, and the potential of interdisciplinary collaborations in the design process. Too often environmental research is hindered by its seemingly incomprehensible complexity: the graphic quality shows how research can be more accessible to the community, and thus facilitate uptake to maximise impact. The inter-disciplinary approach to the project shows the potential for the devolution of autonomous disciplines and the increasing interconnections and interdependencies in engineering, landscape, social and ecological disciplines.

## KEYWORDS

**Resilience, nature-based ecology, design, water infrastructure, urban ecology, biodiversity**

## PRESENTER PROFILE

Stu Farrant is an Ecological Engineer and Manager of Morphum Environmental's Wellington branch. Stu has been involved in the implementation Water Sensitive Urban Design across Australia and now in New Zealand. As Wellington rep for The Sustainability Society Stu was instrumental in engaging in the work of VUW landscape architecture students.

# 1 INTRODUCTION

## 1.1 THE CHALLENGE

'There is growing recognition and awareness that nature can help provide viable solutions that use and deploy the properties of natural ecosystems and the services that they provide in a smart, 'engineered' way. These nature-based solutions provide sustainable, cost-effective, multi-purpose and flexible alternatives for various objectives. Working with nature, rather than against it, can further pave the way towards a more resource efficient, competitive and greener economy. It can also help to create new jobs and economic growth, through the manufacture and delivery of new products and services, which enhance the natural capital rather than deplete it.'<sup>1</sup>

As cities grow and expand into large greenfield and brownfield territories there is ample opportunities for a hybrid ecology of engineering infrastructure and community or landscape infrastructure. In New Zealand most territorial authorities encourage it, and provide guidelines that are becoming accepted in new development. Wellington Council's Water Sensitive Urban Design guidelines is one such example.<sup>2</sup> Not only does it recognise the potential for nature-based systems to strengthen resilience, and to promote mental and physical health and well being for urban communities and local economies, it also fits within the New Modernity model of a dense 'ecopolis' founded on local nature and local culture and bicycles<sup>3</sup>. But very rarely do we retrofit an existing city with a new ecology, either here or overseas. There appears to be three main problems.

Firstly we often see nature-based urban ecologies undervalued and diminished in the face of densification. The increasing attraction and pressures driving a global paradigm of higher urban densities are largely macro-economic - most countries rely on their big cities to maintain their GDP<sup>4</sup> - and partially to encourage sustainable low-carbon transport solutions. There are certainly debates against this global paradigm: GDP is no longer recognised as the only indicator of well-being<sup>5</sup>, and new ecologies are, as noted in the opening paragraph, one of the key adaptations that will make our 21C cities healthier, more abundant and more resilient. But the potential to retrofit urban ecology into existing cities is hard to justify in the face of these macro forces of globalisation. Especially because ecology does not easily lend itself to tangible measurement. So how do we make a latent ecology and inexorable density bedfellows?

Secondly there is poor capacity for environmental and ecological research to effect change in community. Too often it is hindered by its seemingly incomprehensible complexity. The New Zealand government has suggested that existing efforts to embed science into planning and decision making, while laudable, often fails to achieve significant uptake and use<sup>6</sup>. High-quality, well-intentioned ecological research fails to be implemented in what is often called the 'research-implementation gap'<sup>7</sup>. New processes are needed to generate new thinking that will expedite the uptake of this kind of scientific research. Urban ecology systems might only become more acceptable when there is a change in the thinking of the city as an urban system.

The third issue is that the increasing complexity of environmental issues has led to a balkanisation of autonomous disciplines. In the past this complexity could only be harnessed by a coarse grained analysis and a reductive approach in planning: the problem was that this would never realistically address the human scale of engineering and amenity in an integrated way. With the explosion in availability of more land data, we now can look more readily at the fine-grained ecologies of sites and see more clearly how they fit into the broader scale. With this knowledge a synthetic, interdisciplinary outlook is possible, maybe essential. The outcome is that we could make broad-scale spatial decisions in the context of detailed cultural and ecological specificities.

These problems feed off each other in an iterative way. We need to think of ways to start to solve all three problems concurrently: solving one may not effect change if others aren't resolved as well.

## **1.2 RESEARCH QUESTIONS**

Three research questions arise:

How could an urban ecology be developed in a dense urban centre?

What role can urban design play in implementing scientific and engineering research?

How can we synthesise disciplinary specific research?

## **1.3 THE RESEARCH PROJECT**

Wellington's streams were once a vital part of the region's ecology. In Te Aro, where this research focused, there was once a network of streams and wetlands that provided an important food and water source for both Maori and European settlers. But the streams are now buried in underground culverts. The disappearance of these streams has impacted the health of fresh and saltwater ecosystems, and their invisibility has also made it easier for urban communities to ignore the contribution of streams to ecosystem decline in the city. It is unlikely that we could now re-establish streams above ground, because the city layout would preclude it: the human ecology has superceded the natural ecology. Yet the streams, and their network, offer a starting point to think how an urban ecology might co-exist within dense urban areas.

This research project looked at ways to design new infrastructures that perform the same as the pre-settlement ecosystems and ecologies, providing biodiversity and waterway health, and also providing space for urban activities, such as access and recreation. These hybrid ecologies could create new opportunities for urban communities to re-connect with the natural world, and thereby enhance human health and well being. They would also provide means to strengthen resilience in the urban environment

## **1.4 AN INTERDISCIPLINARY DESIGN METHODOLOGY**

The methodology developed for this research project, called Waitoru is design based and collaborative. This approach meant that the research was not linear: it relied on the iterative experimentations of design; and the disciplines working from different viewpoints to understand how change towards a more sustainable and resilient ecology can be effected.

Interdisciplinarity (and not multi-disciplinarity)<sup>8</sup> is an effective way of integrating complexities in scientific and environmental issues. The project integrated the skills of design researchers in masters programmes of landscape architecture with industry professionals in water, energy and transport management The Sustainability Society. The Sustainability Society (TSS) is a technical interest group of IPENZ, whose core focus is to foster sustainability thinking and practice within engineering and other related disciplines focused on the natural and built environment. TSS takes a complex systems approach to sustainability, recognising that human and natural systems are increasingly interconnected and interdependent. TSS is a member driven nationwide organisation.

Design as a method has the potential not just to solve problems within a codified framework, but also to identify opportunities, synergies and to enhance communication. Design research is a valuable investigative technique because it integrates diverse issues and recognises what-if opportunities within singular proposals. The design process is a good tool because it works iteratively across scales and across issues, it uses both top

down and bottom up approaches, and is integrative rather than discipline specific. It allows strategies to be seen in context of all the other issues, angling for win-win situations. Furthermore, design can facilitate change in the community, because the graphic outputs of design make it accessible to communities, enhancing the potential for uptake, behaviour change, and ultimately policy change.

Thus interdisciplinary design research suggests a way to address the three problems that threaten the potential of urban ecology in Wellington.

The five design proposals are discussed in this paper are all speculative approaches to making urban infrastructures that envision an innovative and hybridised nature-based future. The proposals do not fit together as a 'master plan': they are not fixed compositions. Their intent is to give an understanding of how to achieve beneficial relationships between the human and ecological environment. Each shows the potential for small and local physical surface interventions on the urban fabric that draw upon the network of underground streams to improve water quality, biodiversity and flooding mitigation, provide community space integrated with water infrastructure, and strengthen the potential for self-sufficiency in disaster. Each could be a catalyst to enhance the whole city centre, providing a network of connections through culture and ecology. As a collective the proposals embody an idea of flexibility and adaptability; and encourage further investigations that could continue to realign the specifics of this urban system.

## **1.5 URBAN ECOLOGY AND RESILIENCE**

One of the important frameworks for this design research is urban ecology. Urban ecology is the systems-based understanding of biotic and physical elements that occur in urban areas. It recognizes the interactions between natural systems and social and cultural systems, among others. Urban ecology focuses on the interdependence of key resources (such as food, water and energy) and their impact on city development. It places particular importance on the primacy of natural systems in contributing to livelihoods, well-being and resilience. The design research was thus also framed by the ideas of resilience.<sup>9</sup>

Resilience is inherently intertwined with urban ecology - indeed resilience thinking emerged from ecology<sup>10</sup>. Both are essential to creating cities that meet the life and livelihood needs of all of their citizens. Resilience is a complex and dynamic system-based concept used differently in a variety of contexts. In urbanism resilience thinking is an alternative to linear and positivist approaches in urban planning. It reinforces the primacy of the specific linkages between elements in the natural, physical, human, cultural, and social environments. Fundamentally it refers to the inevitability of change, and the ability of a system to return to a previous or improved set of dynamics following a stress or shock; and the potential for individuals, communities, and ecosystems to prevent, absorb, accommodate and recover from a range of shocks and stresses, from large to small, from earthquakes to the closing down of the corner store. Resilience gives us the capacity to adapt. A resilient system can continually survive, adapt and grow in the face of resource challenges and disturbances in an integrated and holistic manner for the well-being of the individual and collective.

Resilience thinking can also provide a useful base for designing substantial changes in the underlying social, political and economic systems of cities.<sup>11</sup> Rather than mandating more diversity or less diversity, more connectivity or more self-sufficiency, resilience thinking suggests that there is inherently tension between goals which need to be balanced on a case by case basis. The design research of this project sets out to explore these tensions through the case study of Te Aro, suggesting pathways for strengthening resilience through use of urban ecologies in urban settings.

Pragmatically, urban ecology and resilience requires investment in man-made and nature-based 'hard' infrastructures, as well as 'soft' systems such as knowledge and institutions. This project, with its five proposals focuses on the potential for nature-based infrastructures that can be retrofitted into Te Aro.

## **2 DESIGN RESEARCH**

### **2.1 THE PROPOSALS**

#### **2.1.1 THE BRIEF**

The brief asked design researchers to frame propositions for community spaces around urban ecology and resilience. The projects have technical rigour, but the community dimension also addressed social issues. Specifically the researchers needed to conceive a place which could be a 'hang-out': a place without much civic reverence but with lots of social significance. The idea of a 'hang-out' came from an international student design competition that was being concurrently run by the Australian Institute of Landscape Architects. The research teams entered their design in the competition, which was a way of ensuring that the design could be put into the public arena. Out of the 77 international entries the winners and the equal second placed entries were both masters student teams from this research project at Victoria University Wellington. The result suggests these proposals are high quality and innovative pieces of work that demand some attention for their research value.

#### **2.1.2 THE PROPOSALS**

Five proposals developed different ways of addressing the issues.

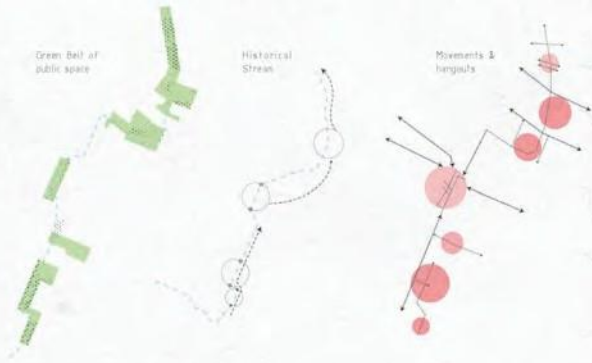
'Urban streaming' (figure 1) <sup>12</sup> retraced the path of one of the Wellington underground streams in Te Aro and proposed nodes of social spaces, or small parks, through the daylighting of parts of the stream in under-subscribed car parks. The small parks were all proposed as 'watery' green spaces: and each interpreted the operation of the original stream and its tactile qualities as it evolved from a narrow stream, to a convergence, to a broader meander, to an expansive wetland. These ideas provided the themes for designing each of the small parks. Overall the scheme shows the potential for a better use for all the surface car parks that currently fit around Te Aro, and show how a series of closely connected spaces has the potential to provide ecological stepping stones to increase biodiversity in the city. The proposal was equal second placed scheme in the competition.

'Te Waimapiri' (figure 2) <sup>13</sup> had a similar approach in that they followed one stream through Te Aro, but instead of transforming car parks they proposed to adapt three existing parks so that they included fresh water sources, wetlands and flood mitigation devices. The use of existing parks is an interesting approach to catalyse urban ecology: parks are the 'low-hanging fruit' in urban settings, where there is less contest over use.



# URBAN STREAMING

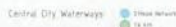
REINTEGRATION OF WETLAND STREAM ECOLOGIES INTO THE URBAN FABRIC FROM TE ARO TO THE WELLINGTON HARBOUR



Urban streaming is a landscape development within the suburb of Te Aro, Wellington. The design seeks to connect people to place through historic water sources. The aim is to enhance social interaction with water sources and provide a variety of activities to cater to the local community. The design consists of a string of landscapes that follow the path of a historic stream, utilising adjacent areas as new public space.

### Design Strategies:

1. Expose historic stream that exists in Te Aro.
2. Connect different demographics to a variety of activities – enhance social interaction.
3. Improve narrow and large spaces by applying different types of vegetation and plantings.
4. Enhance water elements to encourage social interaction.
5. Integrate a more social journey through the city.
6. Maintain a design language throughout Te Aro by using a palette of materiality, water interventions, and infrastructural systems.



Project Team Members

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Haven

Pinga (Haven) Park has been developed to re-integrate and enhance the water and ecology within the northern city area. Pinga focuses on providing a resting area away from the bustle of the city with opportunities for engaging with water.

The two distinct areas are:

-Urban wetland stream that has been daylighted from a stream pipe, it connects people from the path of the old historic stream along Taranaki Street to the new addition leading towards the waterfront.

-Recreational parkland and court offers users in the local area a destination for relaxing, play and wildlife engagement.

Pinga Park aims to create a haven for residents, visitors, and wildlife in Te Aro area. A space they can claim as their own for outdoor activities and leisure.

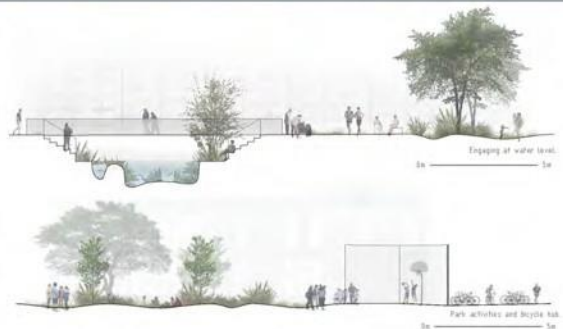
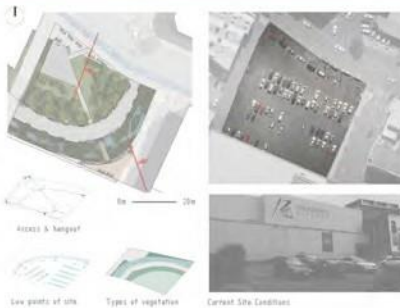


Figure 1: Urban Streaming



# TE WAIMAPIHI HŌPUA

CREATING AWARENESS OF SUB-SURFACE CITY WATER

Surfacing stream pathways as urban space animator. Wellington's significant rainfall and streambed natural landscape characterises the city. Flooding is a recurring problem for the city where current practices cloak natural stream pathways in sub-surface water systems. This we believe removes the beauty and animation of water flow. Water acts as a catalyst to animate public life, people subconsciously gravitate towards water as a place of social and natural convergence. The Wellington waterfront is currently the city's only celebrated water body and is a popular venue for public events. Wellington's three sub-surface streams have the possibility to act as arterial routes to intersect with the city grid and create awareness and enjoyment of the properties of inner-city water. Our design exposes the natural stream path of the Waimapihi to initiate the positive relationship between flood mitigation and hangout spaces. This integrates and augments sociality and infrastructure. These spaces inform the public on the conditions of the water that is used to run beneath their feet whilst improving water quality and flow of the wider catchment systems.



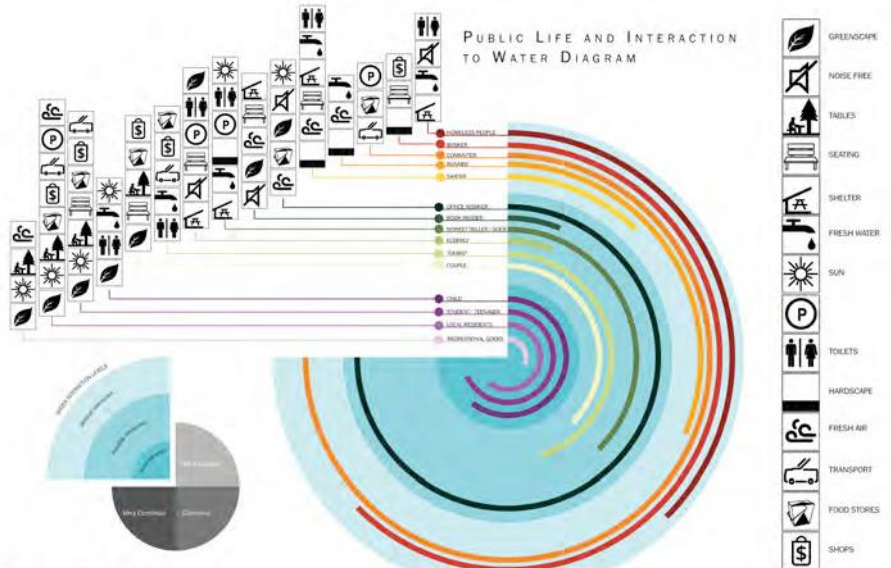
**MEC**  
 MARY JANE  
 ELLIOT BIRCHALL  
 CHRIS BRAYTON

## PUBLIC HABITATS

Wellington city has a diverse range of people. By doing a study of various commonly found Wellington demographics, we found that there are overlapping principles they require in the spaces they inhabit. To benefit and aid our design we studied how these demographics could/do relate to water through their interaction.

By diagramming each demographic and their needs, we were able to deduce attributes they each required in a public space and their linkages between other demographics.

## PUBLIC LIFE AND INTERACTION TO WATER DIAGRAM



## NETWORK DIAGRAM

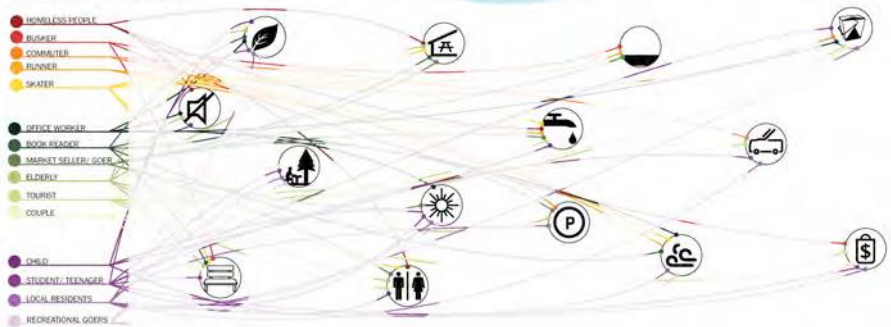
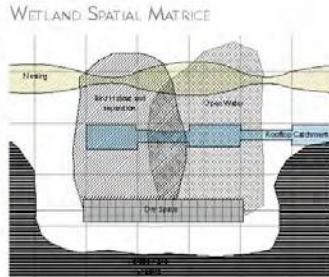


Figure 2: Te Waimapiri  
 Bryant Farrant Bowman 2016 Stormwater Conference



# REFUGIUM



THERE ARE BIRDS HERE,  
 NO MANY BIRDS HERE  
 IS WHAT I WAS TRYING TO SAY  
 WHEN THEY SAID THOSE BIRD-WISE  
 METAPHORS  
 FOR WHAT IS TRAPPED  
 BETWEEN BUILDINGS  
 AND BUILDINGS. NO?  
 THE BIRDS ARE HERE  
 TO ROOT AROUND FOR BREAD  
 THE GIRL'S HAND, TEAR  
 AND TOES LIKE COMFETTI.

JAMAAL MAY

## ABSTRACT

We as humans are experts at designing inhabitable spaces for ourselves, we are self-proclaimed urbanists. We have the ability to adopt our surroundings to fit our needs. Birds are urbanists also. But unlike us, birds don't get much say in what happens in their surroundings, instead they appropriate the spaces we create, taking tiny wall niches and turning them into homes, they take our litter to make nests and they freckle our urban environments with their adopted homes and routines.

This design exploration seeks to define how spaces can be designed based on local bird flight patterns, nesting's, and habitats, and how these spaces can be interpreted into hangouts for people. The framework

began with identifying the main underground stream that runs below the Te Aro area of Wellington and using this as the basis to measure the flight patterns and space inhabited by birds. Once a robust ecology and wetland was designed, forms started to take shape. To enhance the flight paths of birds from Wellington's green belt down to the coast we designed a series of spaces to be considered 'bird refuges' these are small green spaces that promote nesting, feeding and lingering. These refuges take on a steeply-asc shape, because to us the steeply encapsulates the cohabitation of birds and humans, with people below and birds nesting above.

JESS FIDLAY, DYLAN AND POLLY



## WESLEY CHURCH GATHERING SPACE



Figure 3: Refugium



'Refugium' (figure 3)<sup>14</sup> used the underground streams to map bird flight paths, and then proposed to create a matrix of bird sanctuaries across the city that correspond with these flight paths. The proposal not only suggested wetlands and recreation spaces in left over spaces it also proposed vertical structures and links to the left over spaces on the roofs, where bee hives could be cultivated as well. The proposal shows the potential for urban ecology to re-colonise vast areas of the city in a meaningful and achievable way.

'Gumboot City' (figure 4)<sup>15</sup> looked at water in a different way: topographically. After all, the original streams and wetland probably changed configuration a number of times as rainfall fluctuated and flooding occurred. This proposal suggested that the city's open spaces should be separated into high land and low land, and that the lowlands should be designed for stormwater overflows and wetlands and the high ground should be used for community activity such as community gardens and gathering spaces, which could be adapted for living areas in times of disaster. The proposal shows the potential for innovation that can be developed through design.

The 'Aftershock' (figure 5)<sup>16</sup> scheme proposed a network of hangouts in central Wellington that could be adapted into recovery spaces after an earthquake, thus linking the design of a hang out with community resilience. Their design was poignantly expressed through a collaged timeline, suggesting that hang outs are temporal just as much as they are spatial, and that the order of a scaled plan is less instrumental as a design tool, and maybe even antithetical to the idea of hanging out. It was the competition judges' unanimous winner.



Figure 4: Gumboot City

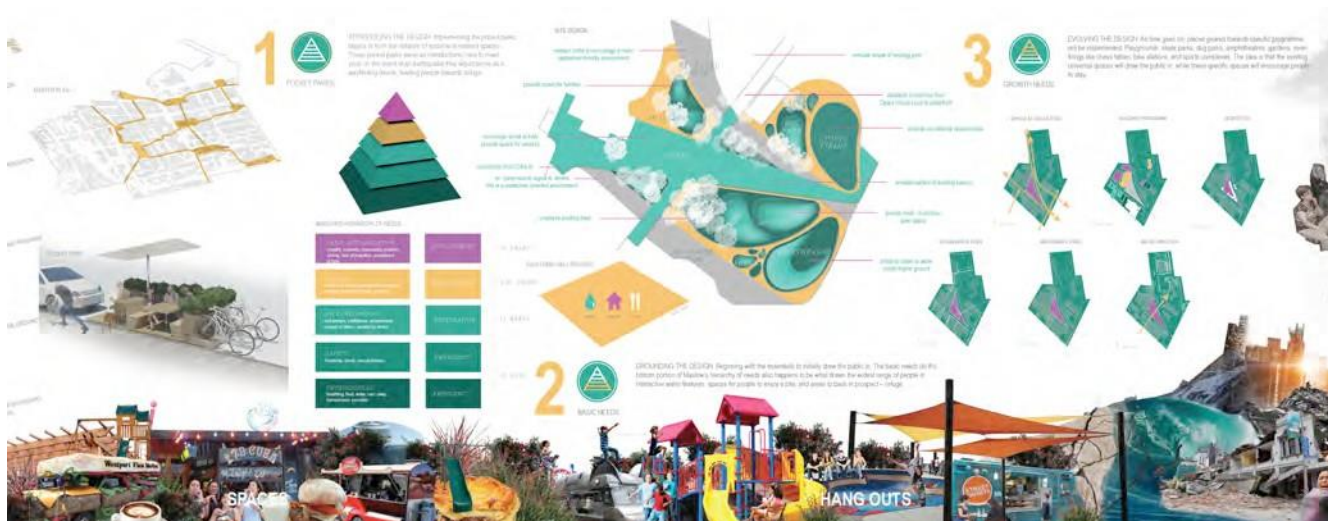


Figure 5: Aftershock

## 2.2 DISCUSSION

### 2.2.1 NETWORKS

Each of the five proposals put forward the idea that the city can accommodate a network of spaces that can perform a variety of social and infrastructural functions.

The idea of a network is a common way of thinking about infrastructures. Both social and infrastructural systems use networks that are often characterised by nodes and flows. But perhaps the difference here is that the network created by these social infrastructure spaces is flattened - it is non linear and non hierarchical - and each space has a potential to operate as a module in the system, rather than one relying on what is upstream or downstream, akin to the idea of polycentric entities in urbanism<sup>17</sup>. Instead of being diverse in function, the nodes are diverse spatially. The *Refugium*, *Gumboot City* and *Aftershock* schemes are particularly poignant in this regard, creating a diversity of spaces, each with similar functions.

But this 'flattening' of social space does not remove the potential for interconnectivity. The spaces can still operate as part of a linear system: or can act as a redundancy -

something to provide a back up to the already installed underground water systems.



What each of the proposals are suggesting is that there is space in the city to operate these networks in a variety of ways – in car parks, in extant parks, in schools etc, – that the networks are important, and that within each network of spaces there is potential to create a flattened hierarchy to suit social needs of each locale, and still provide the potential for hierarchies of connectivity or interconnectivities that provide the potential for redundancies which are crucial to a resilient system.

### **2.2.2 WATER-BASED ECOLOGIES IN THE CITY**

There is a tendency to think of streams as needing to be daylighted in situ, but these schemes all show the potential for the spatial qualities derived from the topography and built form to affect the layout of the water infrastructure.

Each of the studies suggests that design does not have to be literal in interpreting the location of streams as they once were. What perhaps is more important is understanding the system in which the original streams and wetlands operated. The steeper slopes are suitable for faster running water, as per the design suggestions of upper Taranaki Street and Mt Cook School, and that wetlands – the successional landscape of flood zones – is more apt where there is potential to flood on the lowlands. The old streams provide the inspiration and some degree of authenticity to the design gestures, but the interpretation of the topography and built form and viewsheds (rather than the literal location of a once active stream) provides more clues to how water infrastructure in these spaces might operate rather than how they look.

*Gumboot City* converts this idea. Rather than being predisposed to stream locations, it simply defines high and low ground, and builds on the adaptability of water to move around low ground when it is flooding and for social groups to gather on high ground. The blurred line between where the water stops and starts represents the flaw in creating walls between high and low. This proposal capitalises on this blurring: ensuring that there is a capacity for both the water and people to adapt.

Underpinning these ideas is that water infrastructures can also add to the quality of life and the health of the city in the city. *Urban Streaming* suggests that the watery zones promise the potential for the population to get closer and touch the water. *Te Waimapiri* shows the potential for stormwater-based infrastructures to structure space and add to the quality of recreation in these parks.

### **2.2.3 BIODIVERSITY IN THE CITY**

The watery social spaces in the city clearly provide more than an alternative stormwater infrastructure. They also show the potential of biodiversity in the city. The *Refugium* scheme developed this idea with great clarity, and showed biodiversity as a powerful reason for appropriating vertical spaces and rooftops to accommodate a rich diversity of fauna. Key to this design was the elegant structures that could unobtrusively populate the network of spaces of the city.

What we get out of this proposal is not just the idea of biodiversity, but an idea of the extraordinary richness and abundance, not far removed from the abundance that the wetlands in te Aro once offered. It suggests a hidden garden in the city, like the fantastical garden in Frances Hodgson Burnett's *The Secret Garden*<sup>18</sup>: "I wouldn't want to make it look like a gardener's garden, all clipped an' spick an' span' he said. 'It's nicer like this with things runnin' wild an' swingin' an' catching hold of each other...It wouldn't seem like a secret garden if it was tidy."

Bringing water to the surface is an essential part of this scheme, but it interestingly goes beyond the idea of daylighting streams and suggests something about future cities, with their driverless cars, fewer carparks and multimodal transport, a city with an abundance

that enriches lives. No small part of this is the idea that the network doesn't just appropriate open space, it also uses the earthquake strengthened walls and roof tops, integrating built form and space with hybridized nature-based ecology.

#### **2.2.4 RESILIENCE THROUGH SOCIAL SPACE**

If *Refugium* showed the potential for the city of the imagination, *Aftershock* shows the potential for spaces to be practical – to suit the present needs and the future needs in times of disaster. *Aftershock* exemplifies a different way of thinking about city space – as a time and space continuum, where a layout can adapt to different programmes. It suggests that these parks each need to be self sustaining, and to service a local community independent of others, and to do this, they must encourage the development of community in the vicinity of each park. And to do this, they need attention now, so as to encourage institutional investment and community action in land that is currently underutilised, with a long term picture at stake.

#### **2.2.5 DESIGN AS A TOOL TO CLOSE THE RESEARCH IMPLEMENTATION GAP**

The director of the New York Museum for Modern Art, Cyril Smith said in 2006, that 'Humans need to adapt to new conditions; and to do so we need to change minds; and to change minds, art, images and design will lead the way, more so than politics and science.'<sup>19</sup>. In many ways this potential is importantly demonstrated in this project. Supported by the technical expertise developed through the creative friction between industry experts and designers, this project, and its rich graphic outputs show the possibilities of Te Aro in an appealing and captivating way.

But it would be misleading to think of this only as a series of pretty drawings that represent some well-coordinate engineering thinking. The design has been a careful balancing of different types of infrastructure: traditional network of piped infrastructure, some less linear nature based infrastructure; and some non-hierarchical infrastructure of social space. Interdisciplinary design has been able to bridge these infrastructures and make some powerful gestures about the possibilities of this place. The graphic quality is merely a well chosen language, an expression of well considered spatial thinking, that allows these powerful ideas to be expressed in a way that also has the potential for major impact.

We suggest that this is the way we, as industry experts, perhaps might think of all infrastructure in the future: as a balance of tensions between efficient pipework or roading, some interconnected nature-based systems and the integration of public social space within all.

### **3 CONCLUSIONS**

#### **3.1 PROJECT CONCLUSIONS**

The project is significant in a couple of ways.

Firstly because it demonstrates to territorial authorities how they can effectively connect urban ecologies, reduce the impact of urban stormwater on the receiving environment, and create more amenity and identity in urban public realm. It provides a case study of the possible methods, guidelines and opportunities for directing policy and maximising impact. It demonstrates that it is very feasible that any development can and should include another way of thinking about its infrastructure, and that resilience can be strengthened now. Policy needs to be directed to achieving these goals, and showing the process of interdisciplinary design as key to these solutions. [There are extensive financial](#)

and environmental benefits if this encourages communities to make better use of their natural resources such as streams, firstly to make communities more resilient, and secondly to create a healthier way of living in the face of the demand for increased densities in urban areas. The research has high relevance to local and national government planners and policy makers, infrastructure engineers, architects and landscape architects, scientists, curators and designers of exhibitions.

Secondly the project recognises the need for inter-disciplinary solutions for urban infrastructural issues and shows the potential for the devolution of autonomous disciplines in a world of increasingly complex environmental issues. The complex systems approach for urban infrastructural issues of sustainability and resilience recognises that engineering, social and natural systems are increasingly interconnected and interdependent. The commitment of The Sustainability Society in investing in this research, and working with landscape architects, is significant for both disciplines.

### **3.2 FUTURE RESEARCH**

Future work is needed to develop and explore ideas for the underground urban streams as a driver of health and well being in cities. More work is especially needed into the history, understanding issues concerning stream daylighting, improving biodiversity, coordinating transport, culture and recreation. Tasks should include:

- Research of waterways in terms of their eco-hydrology, spatial layout, pre-settlement unmodified state and post-settlement modifications. This should include review of early maps of the region, GIS analysis, liaison with ecologists and research into pre-earthquake landforms.
- Research into the cultural significance of these waterways and biodiversity to settlement (Maori+ European) and how the waterways influence development patterns, cultural customs and resource use.
- Research method that is inclusive of all areas of expertise.
- Research methods that include design research in addressing these problems.
- Development of a publication of visual material and associated annotation to articulate the story of these important waterways, to reinstate ecological function and their biodiversity within the systems and to enhance the connectivity between the sea and catchment.

In this way the three important issues of this project - how urban ecology fits spatially, how design helps, and how interdisciplinarity works - can be concurrently addressed in future work and understood in greater detail to bring about positive change.

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- <sup>6</sup> MBIE (2014) National Science Challenge.
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