Wellington's Lost Streams

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ECOSYSTEM REGENERATION SUPPORTING URBAN AGRICULTURE USING ARCHITECTURE

BY
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A thesis submitted to the Victoria University of Wellington in fulfilment of the requirements for the degree of Master of Architecture (MArchProf)

Victoria University of Wellington

2020

ABSTRACT

Wellington's piped streams and harbour are both heavily polluted by land-based activities. Riparian zones around urban streams are almost non-existent, and native ecosystems are suffering or have been completely removed. These issues are to be engaged through architectural design focusing on ecosystem regeneration, cross-programmed with public infrastructure, and urban agriculture. Natural habitat in Aotearoa has dramatically diminished since European colonisation and continues to suffer significantly from the expansion of the built environment and farmland. The ideas that this design-based research explores is the incorporation of living-systems to aid in regeneration of native species and habitat, and prevent water pollution within urban contexts. The addition of permaculture practices will also be explored for its role in supporting civic life alongside public interaction through socially active design. Through these ideas, the goal is to create a network of architectural interventions that define a model of living which is regenerative to the environment. This would work towards people and nature coexisting in symbiotic relationships within urban centres.

ACKNOWLEDGEMENTS

Thank you to mum and dad for your continued support over the past five years of study. Whenever drafts of my writing needed a grammar check just before a hand-in, you were always there. Thanks again for all the delicious meals we have indulged in when you come over and visit me. To the little bro Joe and sis Charlie. Thanks for the quality chats and rare packages of baking posted from home.

To all the arci friends who chose to struggle with me for the past five years, been a blast, and I could not have chosen a better group for it. Cheers to the addictions you have inflicted. My new found love for coffee and the occasional beverage has helped me battle through the years of study.

Thank you to Covid19 for making the thesis one of the more interesting years of study. You made the vast majority of our cohort 6th-year students for a brief time and tested our motivation to work on thesis. The “break” from study during lockdown was much appreciated but did stitch us all up over Summer.

Cheers to the social arci running team, ‘The Overconfident Underachievers’ and our accomplishment of running around Lake Taupō in celebration of finishing thesis. Initially, we thought everyone would have been finished by now, but look at us battle on and celebrate our accomplishments before achieving them!

Finally, to my supervisor Maibritt. Thank you for your support over the past year through thesis. Circumstances have certainly been different from previous years, but you have helped guide me through with valuable feedback on my work.

Contents

1. Introduction

This chapter builds the framework and reasoning behind why this thesis tackles a regenerative design approach to living. The primary aims and objectives are identified as design which focuses on habitat regeneration, water purification and urban agriculture. Through a design-led research methodology, these primary issues are addressed for building the foundations of this thesis.

1.1 CRITICAL ISSUES

One of the primary contaminators of urban waterways is stormwater runoff (Department of Conservation, 2006, p. 6). Stormwater is defined as the water that is not absorbed by the land's surface, which flows into drainage systems. Within each of Wellington City's catchment regions, various contaminants are collected and congregate in local waterways. Urban stormwater catchment regions have been piped as standard practice in New Zealand. This is not a desirable method since ecological integrity, and water quality is degraded and often becomes toxic to aquatic life (Department of Conservation, 2006, p. 23). River and seabed habitats are then destroyed by layers of sediment, various chemicals, and heavy metals (Department of Conservation, 2006, p. 23).

Wellington's stormwater and streams are almost entirely piped underground, making waterways vulnerable to pollution caused by human activity. 150km of waterways are piped while a mere 12km are open semi-urban watercourses (Wellington Water; Wellington City Council, 2015, p. 3). This is mostly a result of poor stormwater management strategies within the Wellington City context for the effective ecological removal and mitigation of pollutants (Wellington Water; Wellington City Council, 2015, p. 2).

Streams play pivotal roles in aquatic wildlife. Eighteen of New Zealand's 35 indigenous freshwater fish species migrate up streams and waterways from bodies of saltwater (Department of Conservation, 2006, p. 35). Stream accessibility is a critical part of their life cycle; if passageways are heavily polluted or blocked, migration of native species becomes dangerous or impossible. Many pollutants are not visible to the naked eye; therefore, it is easy to assume that the stream is still relatively healthy. However, in reality, hot water discharges, vehicular pollutants, heavy metals, stormwater discharge and various chemicals often end up in waterways (Department of Conservation, 2006, pp. 6,18). As little as 10% of impervious land cover in catchment regions can reduce stream health due to contaminants on the surface washing into waterways (Perrie & Greater Wellington Regional Council, 2012, p. 87). Most urban centres are far more than 10% impervious and are closer to 80% (Blaschke, et al., 2019, pp. 26,29,34-35). From mapped data of the suburb Te Aro, impervious ground cover is 95% (Blaschke, et al., 2019, pp. 26,35).

As sediments, heavy metals, toxins and various other contaminants entering Wellington's waterways, they eventually end up in the harbour resulting in negative repercussions for both aquatic life and recreational activities. Wellington's Harbour is not safe for swimming in the day after rainfall due to the poor water quality conditions (LAWA, 2020). On average, the first 25mm of rain carries the most stormwater pollutants from impermeable surfaces to local waterways. The runoff from stormwater is a significant pollution problem in most cities worldwide that needs urgent attention (Wellington Water; Wellington City Council, 2015).

Rainwater is typically seen as a problem causing floods and is drained away from sites. This scenario often occurs due to the high percentage of impermeable surfaces that cannot absorb stormwater (Abrahams, Coupe, Sanudo-Fontaneda, & Schmutz, 2017, p. 149). Rainwater can be seen as an opportunity to be used in design for regenerative environments (Liptan & Santen, 2017, p. 21). An example is Waitangi Park in Wellington, New Zealand, where wetlands are integrated into the landscape design leading to greater local public acceptance of wetlands existing in urban settlements (Wood, et al., 2010). Wellington's stormwater pipes carry approximately 80 million cubic metres of runoff annually from drains and gutters into urban streams and the Harbour (Wellington City Council, 2015, p. 42). According to the Wellington City Council, stormwater is currently not treated before entering the harbour. The research in this thesis will go into depth with a regenerative design to remediate polluted waterways.

Streams in Wellington have always held great significance for Māori, well before they were put underground for the benefit of additional buildable land (Harmsworth & Awatere, 2013). Waitangi stream and lagoon provided an abundant food source and supplied materials such as Harakeke (flax) and Rakau (wood). The iwi of Te Aro Pā thrived off the lands where kumara and Aruhe (ferns) were grown (Wellington City Council, 2020). By 1874, Māori were mostly pushed out of the area due to colonisation. This resulted in the remainder of their land being stripped away for Wellington's development and expansion. Changes that happened to the land over these and preceding years decimated the native bird population through deforestation for construction and farming. The lagoon, formerly filled with native eel and surrounded by harakeke also disappeared due to earthquakes and Wellington's growing metropolis. Engagement with Mātauranga Māori (indigenous knowledge) could see the revitalisation of lost natural land features allowing an ecological, historical, and spiritual reconnection to the land (Harmsworth & Awatere, 2013, pp. 275,276).

1.11 FOOD SECURITY

The current and projected statistics for the consumption of fresh produce in New Zealand do not match net production rates, signalling that food shortages can be expected with certain crops (Horticulture New Zealand, 2017, p. 32). One example in 2020 was when courgettes reached a record high price of $29.60 per/kg compared to in-season prices of around $5.00 per/kg when imports from Queensland were suspended (Stats NZ, 2021). New Zealand does not currently have a food security policy with a future-proof lens. Food security is built on three pillars; food availability, food access and food use (Stevenson, 2013, p. 4). In the lower-income brackets of New Zealand, food security is an issue due to fruit and vegetables typically not being competitively priced to alternative high fat and sodium products (Stevenson, 2013, p. 6). Due to less healthy and nutritious food being more affordable, diets in the lower socio-economic brackets are less likely to meet nutritional needs. This can also be observed in obesity statistics, where New Zealanders in the lowest socio-economic group are 1.8 times more likely to be obese compared to those that are not (Ministry of Health, 2020).

Currently, only approximately 0.1% of food is produced locally in Wellington (Horticulture New Zealand, 2017, p. 11). By planning to help support the local population's fresh produce demand, food security can therefore be improved. Additionally, with 15% of people's diets in New Zealand consisting of fruit and vegetables, there is an opportunity to raise awareness of healthy food production. This will help support the local urban population to live healthy, affordable and sustainable lifestyles (MacPherson, 2017). Thus, to become more sustainable and further improve healthy living, consumption of greater than 15% of fruit and vegetables is necessary.

Wellington Central City has a rapidly growing population, including the suburb of Te Aro, which is currently around 7560 people. This is predicted to reach 14,500 by 2043 (Blaschke, et al., 2019, pp. 36-37). With a drastic projected change happening to central Wellington, ecological, residential, and food security needs to significantly grow in importance when considering the future.

1.2 RESEARCH QUESTION

How can Wellington’s piped streams provide and support habitat regeneration, public amenities, and urban agriculture through architecture?

1.3 AIMS & OBJECTIVES

This thesis aims to examine and explore regenerative practices that restore local ecosystems through architectural design. Grey and stormwater quality in Wellington are in a detrimental state (Wellington Water; Wellington City Council, 2015). By creating relationships between people and urban waterways, damage can be significantly reduced from the effects of climate change and other human interventions (Liptan & Santen, 2017). This is to mitigate the deterioration of ecosystems on both local and regional scales caused by current urban waterway practices.

The objective is to use local ecosystem services to help purify and filter the damage caused by impermeable surfaces and piped streams. These waterways should also engage with human life. This will be achieved by aiming to provide functional public spaces, contributing to food production, more and better-quality housing, education, and community-based infrastructure. These starting objectives build the framework for a city that can assist and function positively as a part of natural ecosystems.

One aim of using regenerative design is that people should be provided with access to education on environmental issues and then be motivated to act upon them (Reed, 2007, p. 674.). The inclusion of ecological processes should promote diversity and health in both natural and human communities. Living systems can "self-organise, self-design, and self-repair" (Todd J. , 2019, p. 17). Wai ora literally refers to water, both as a resource and as an essential part of the environment that provides sustenance for life. This reinforces the biophilia hypothesis that nature is essential to people as it improves our health and well-being (Kellert & Calabrese, 2015).

Integrating permaculture into architecture and urban infrastructure is a vital objective of this research. Significant amounts of space are required for growing crops, and cities rely heavily on external resources and land (Vale & Vale, 2009, pp. 35-43). This research explores whether permaculture practices can also be integrated into Wellington's urban centre on a larger scale. If combined with a focus on the city's waterways and hydrological systems, city flood and greywater can be further purified by crops. In return, this could also potentially act as an irrigation source. The aim with integrating permaculture practices is to utilise storm and rainwater in cities that currently cause pollution in local and regional ecosystems.

Bringing people and the community into architecture is a crucial role of socially interactive design. Cross-programming of buildings allow for the inclusion of different groups and provides purpose from a civic perspective. Such an architectural intervention could become a political statement to incite change in how urban infrastructure is designed to mitigate the effects of climate change and improve human health. Very few exemplars exist of regenerative architecture that also contributes to the human community. A significant change in the urban fabric for the benefit of ecosystem services and human life is vital for adapting people's lifestyles to become sustainable. By doing so, awareness and action can be taken on a much larger scale. Architecture can become a form of provocation, gaining local, national, and potentially international attention.

By incorporating these objectives into design, the thesis aims to use these qualities to create a sense of community and bring people together by incorporating public infrastructure into a regenerative landscape. Designing for both people and natural ecosystems through biophilia is beneficial to all life. It makes sense to design regenerative environments to restore and resurrect ecosystems against what urbanisation has removed from people's daily lives. Combined with the projected urban population growth in Wellington CBD, tackling the integration of ecosystem services is critical through regenerative design.

1.4 METHODOLOGY

This research's primary methodology is design-led research; concepts are tested against a set of devised sustainable and biophilic architecture principles. Where design fails or can be improved, research and further iterations are undertaken to develop work towards the thesis' aim.

Various mediums will be used for finding the desired design outcome. These include but are not limited to hand-drawn conceptual work, parametric and computational design, and physical modelling where tests may need to be executed. Each technique has its place in the design process for carrying out explorations towards a regenerative ecological outcome. These specific methods are explained in the preliminary and developed design.

Computational programs used included Rhino/Grasshopper for design explorations and analysis. This was to output various design outcomes based on the different parameters used to aid in ecological regeneration and human well-being.

Additionally, the software 'Land Utilisation and Capability Indicator' (LUCI) was used. Fabian Delpy from Utrecht University in the Netherlands ran analyses on Wellington City for how this program can be used to aid in urban design. Outputs and discussions were then used to inform design decisions based off the various LUCI ecological outputs on stream locations, flood mapping, sediment delivery, erosion risk, and water quality. The software was developed by researchers at Victoria University of Wellington for running simulations on hydrological data on farms.

Continued research focussed on a series of different topics. The research began with Landscape Architecture, specifically around the regeneration of polluted rivers and streams. Case studies by Kongjian Yu in China were of significant influence due to the need for remediation of many waterways in the country. Research into local projects included analysing Waitangi Park. This Wellington-based project tested what was and was not successful in relation to the remediation of ecosystem services and design efficiency.

Measurable research on urban farming, specifically permaculture, highlight the three primary benefits of growing organic seasonal crops: "Preserving biodiversity, tackling waste, and reducing the amount of energy used to produce and distribute food" (Viljoen, Bohn, & Howe, 2005, p. 21). Other research undertaken here investigates the social and economic impacts of introducing urban agriculture to a Wellington context.

Further research to undertook examined local ecosystem methods and strategies for how these can be integrated into Wellington's urban environment. This goes beyond viewing the urban environment as a living system, but also alongside social factors to provide an opportunity for dual programming. Engaging the community in the functions of the final design outcome is essential due to the pivotal role that architecture and public infrastructure plays in civic life. Programmatically, the design-led research explores opportunities for education facilities, community-based infrastructure, housing, market design, and food provisioning services.

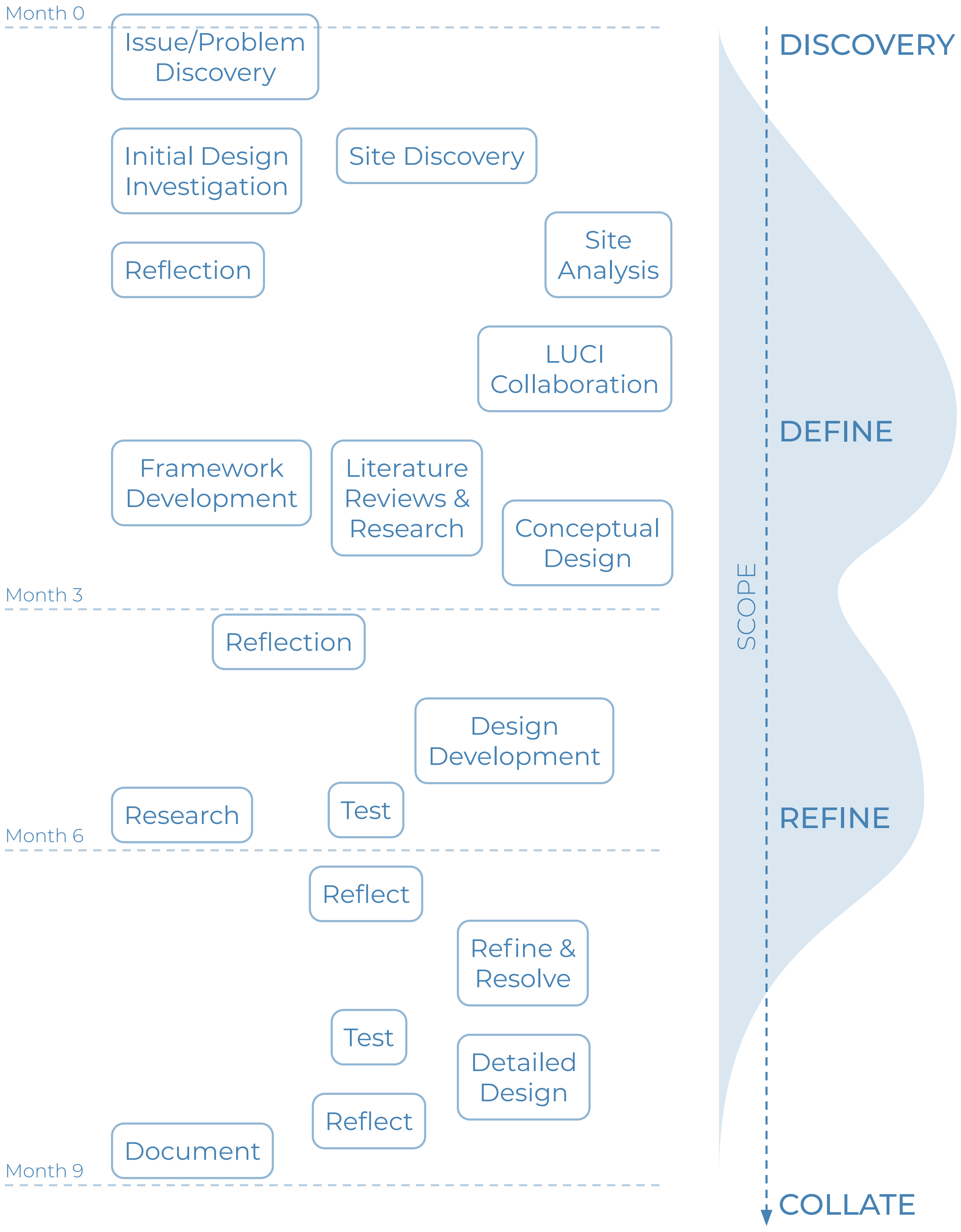


Figure 1.00: Methodology Diagram.

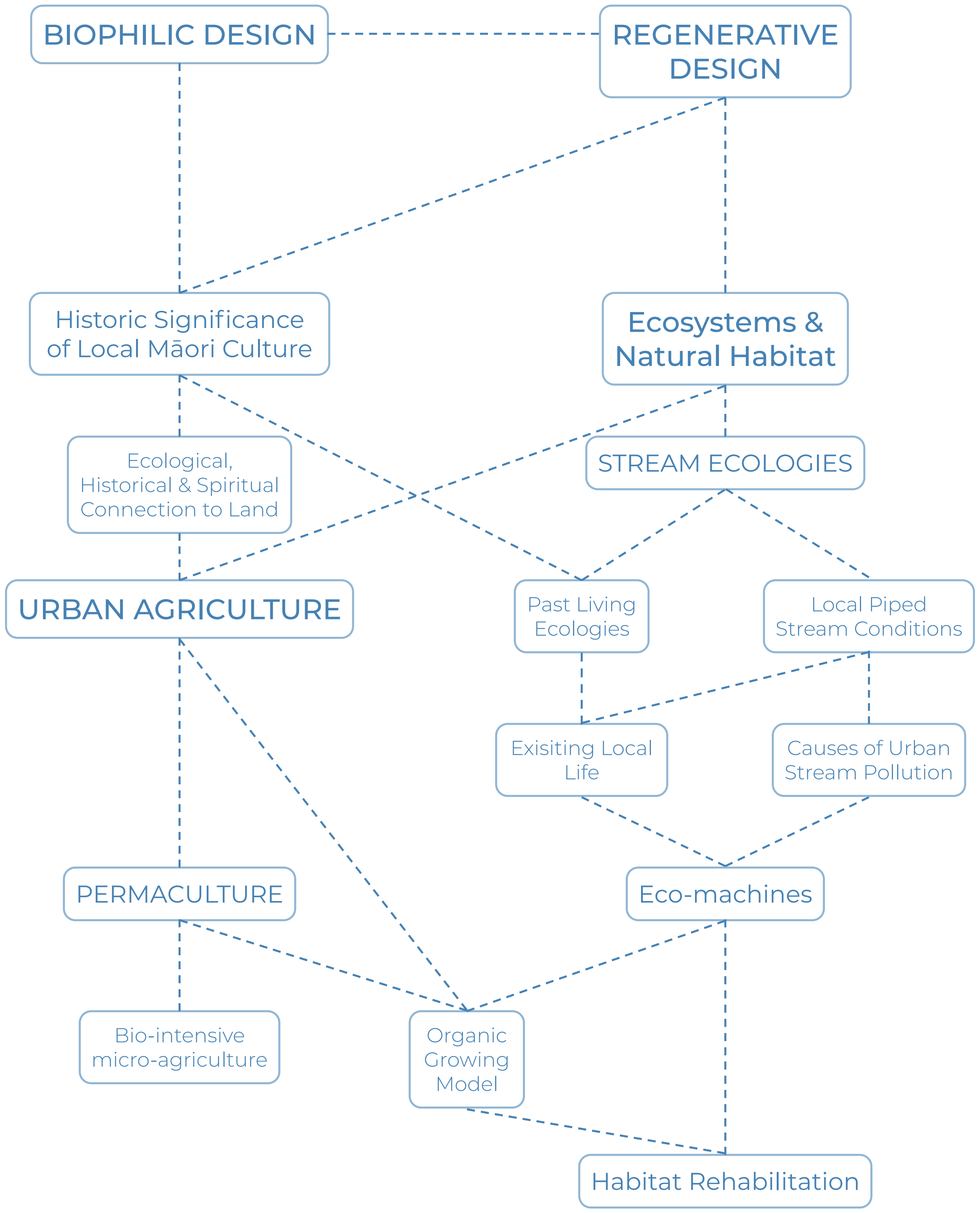
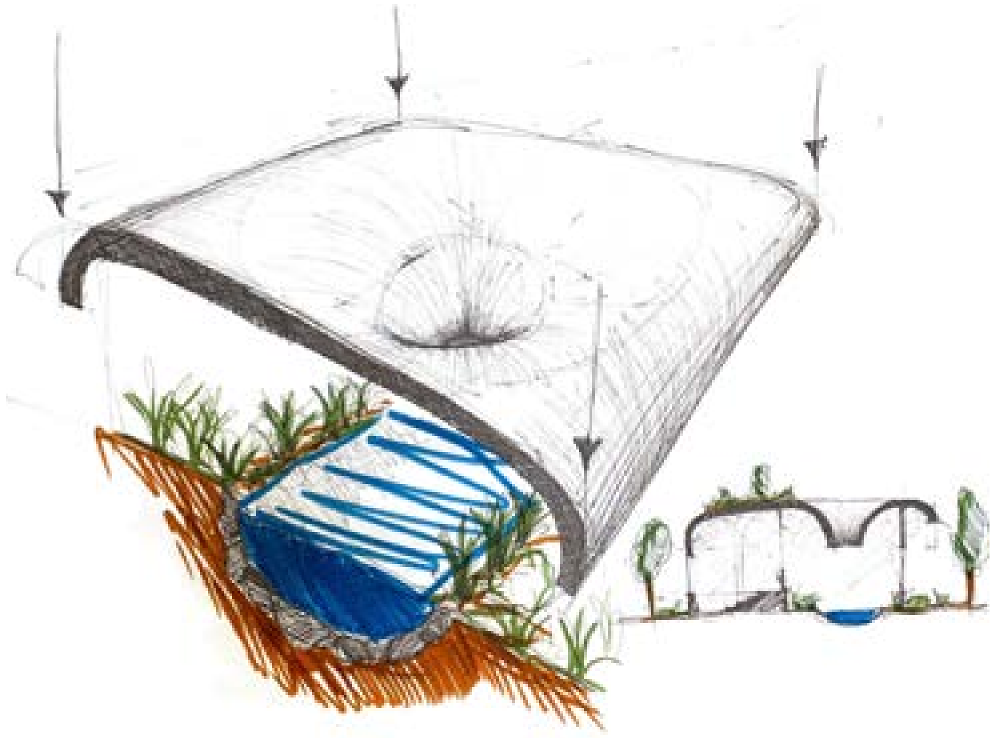


Figure 1.01 Research Diagram.

1.5 ONE MONTH QUICKSTART

A 'quick start' to the thesis took place in the first month as part of the Ecologies Design Lab (EDL) research stream's research approach. This provided an opportunity to conduct a trial and error method to explore many of the ideas initially thought-up and accelerate the initial design process. The first month's designing and research led towards an ecological concept based around Wellington's piped streams. Water is arguably the most important resource on earth and is often polluted by land-based activities from both rural and urban contexts. Concepts were visualised where architecture interacted with water to create a connection between landscape and built form. Often seen as separate, buildings and nature were combined into one. Concepts also began to develop around the idea of water purification in Wellington's urban context through eco/living-machines. The idea of urban farming was also born; organic growing could provide people with some food produce and further work towards water purification.

From the first month, an expanded research topic was developed by brainstorming a wide variety of ideas. This also brought attention to the realisation that the integration of people in architecture needed to be a key component. The significance of natural ecological systems became vital as part of the design to restore nature. There are many cases where habitat and natural living systems have been severely damaged and, in some cases, completely lost to urbanisation. Through the integration of eco-machines, habitats can be restored and brought back to life in the urban context (Todd J. , 2019). The realisation that a restoration of ecosystem services project becomes site-specific was valuable as research and understanding of local organic life became paramount drivers in the design process. Regenerative design principles alongside cross-programming people in the design were the other key points to take forward with the development of this thesis and will be discussed in the following chapters.



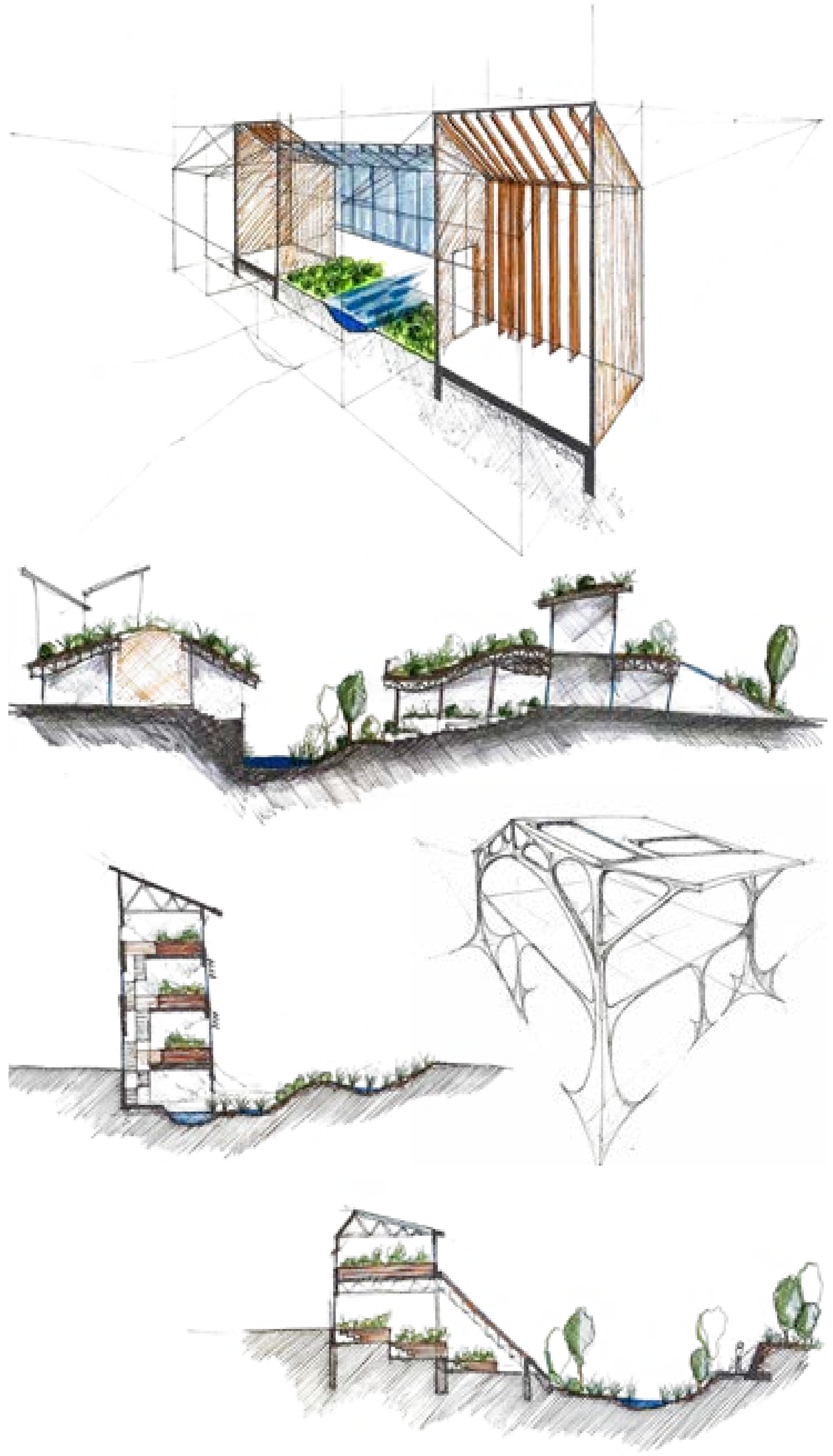


Figure 1.02: First design explorations.

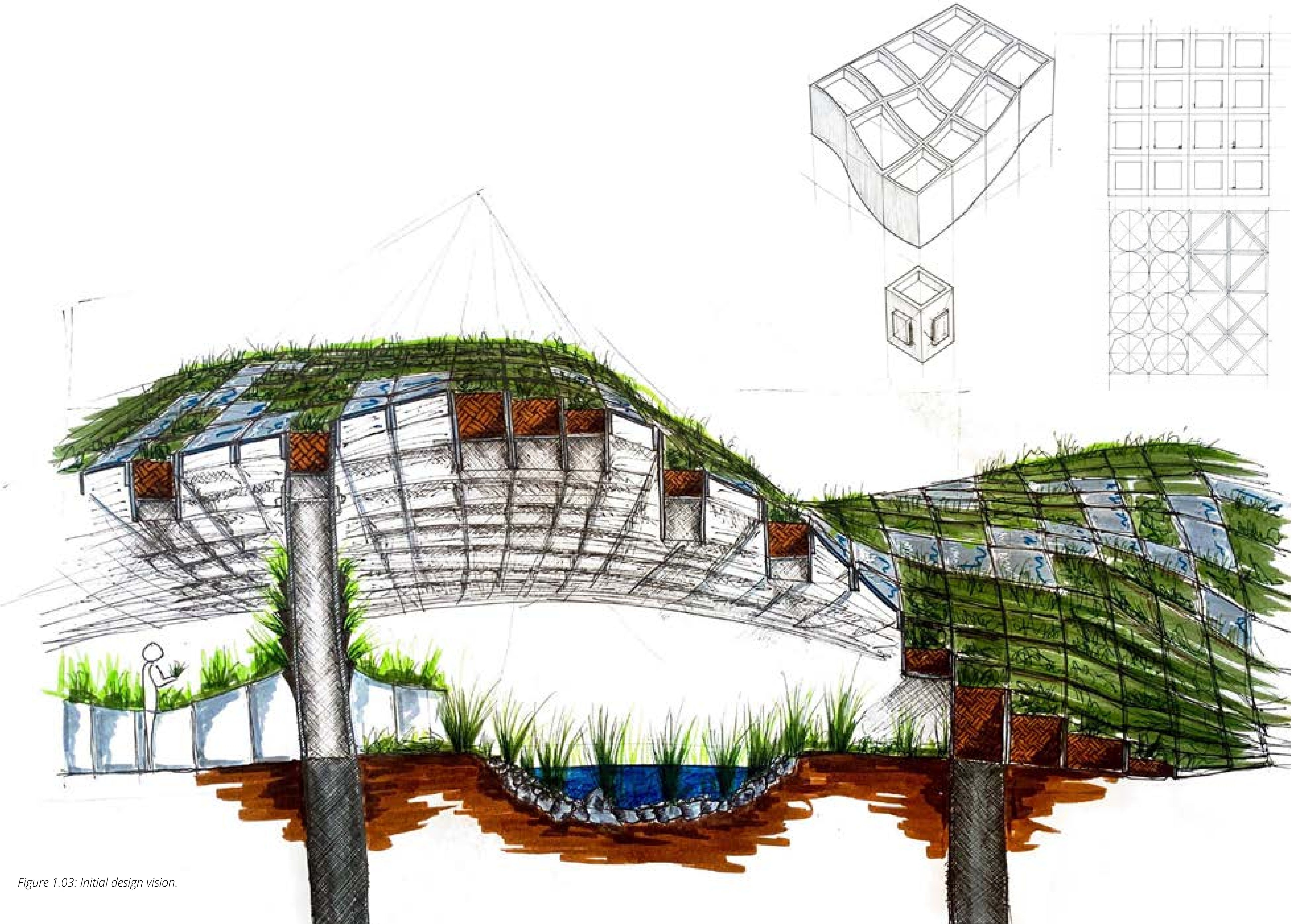


Figure 1.03: Initial design vision.

2. Literature Review

This section of the thesis explores how architecture can develop further to benefit both ecosystems and people. The advantages and drawbacks of regenerative design, biophilia and urban agriculture are explored for how they can be successfully integrated into a new improved standard of architectural practice. Through the three sections of this literature study, the limitations and application for the Wellington context are applied to find out how a radical development in architecture can occur. The findings from the literature review will then develop into a research through design methodology within Wellington City's context.

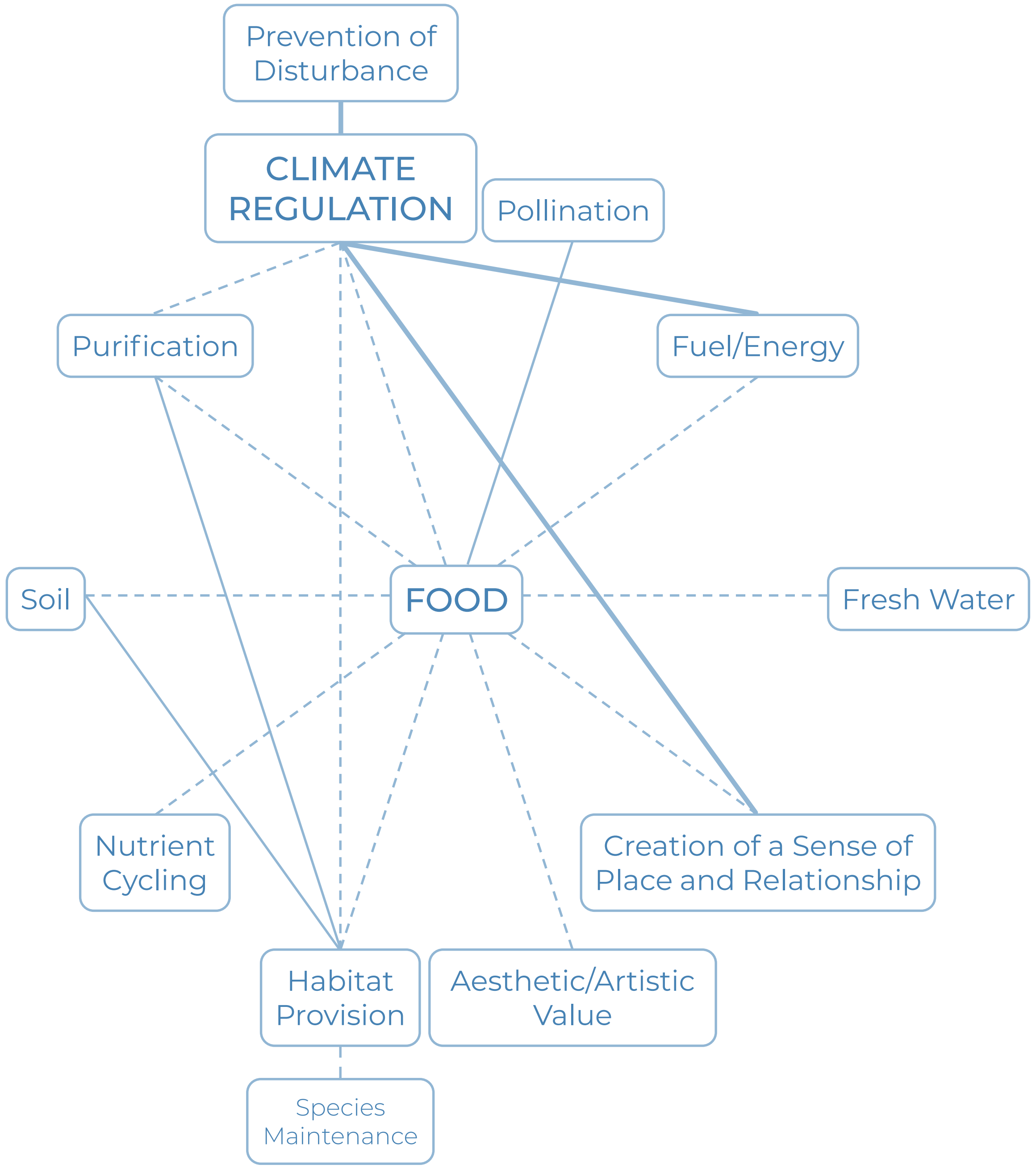


Figure 2.00: Diagram connecting different regenerative design aspects.

2.1 REGENERATIVE DESIGN AND & ECOSYSTEMS

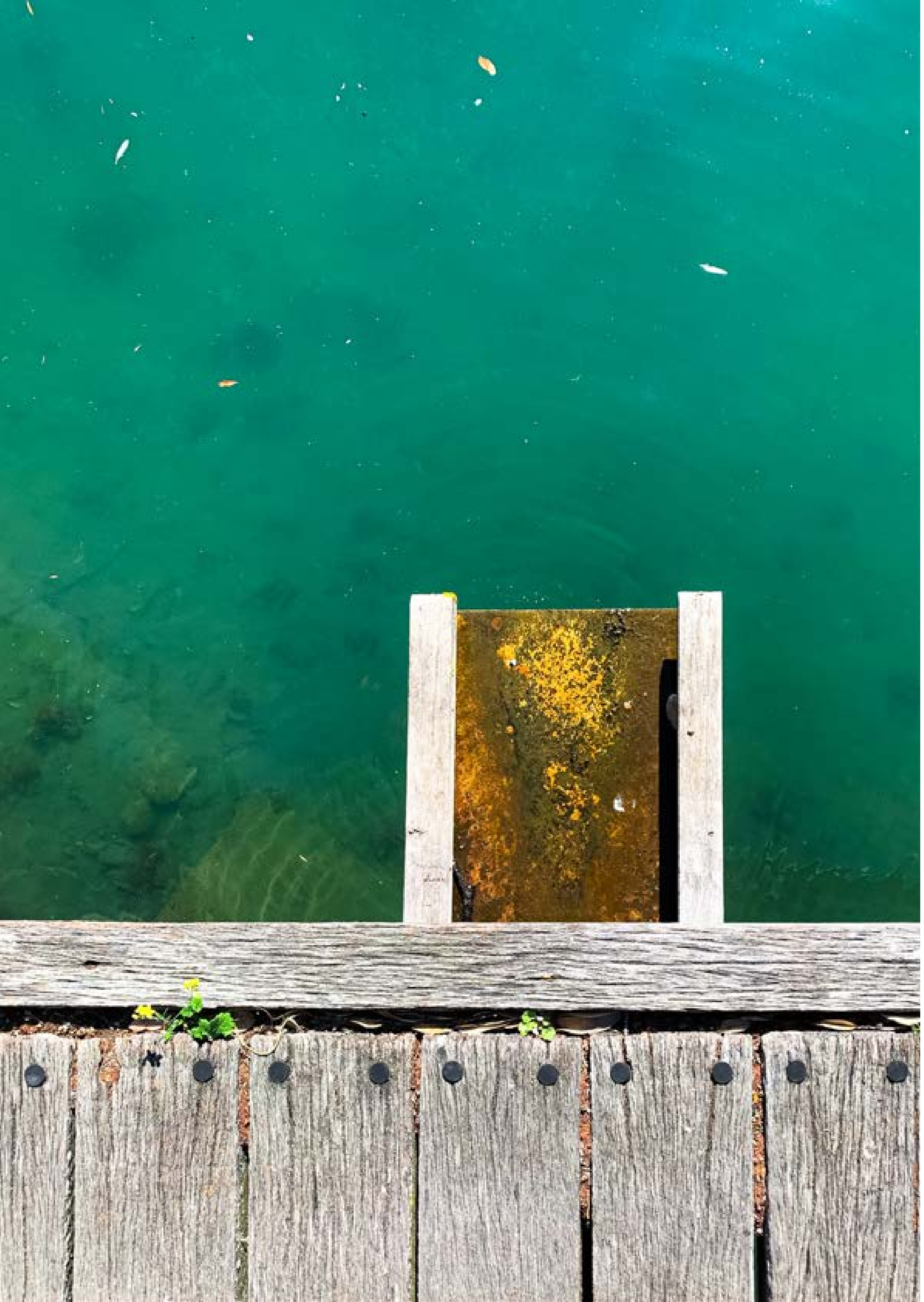
The aim of regenerative design addresses the degradation of all ecosystem services through designing the built environment to restore damage from human activity. From the research gathered, regenerative design provides a mutual benefit to both human and non-human life through a systems-based approach (Pedersen Zari, 2018, p. 5). This literature study explores the benefits and potential drawbacks of using ecosystem services in design-based research to develop towards an ecologically focussed built environment.

Sustainable design that is currently practiced in the built environment primarily focuses on efficiency and only mitigates the damage to an extent (Reed, 2007, pp. 674-675). However, there is still likely to be a negative impact on the environment (Reed, 2007). Regenerative design goes beyond this and creates positive cycles of resource use instead of what occurs in the vast majority of the cases from the urban environment. Positive environmental benefits should be the goal. "The built environment should contribute more than it consumes to ecosystems while simultaneously remediating past environmental damage" (Pedersen Zari, 2018, p. 5). The main piece of literature used 'Regenerative Urban Design and Ecosystem Biomimicry' by Pedersen Zari, 2018, has a primary focus on ecosystems in regenerative design. The topic of regenerative design encompasses both nature and people coexisting, but this book's scope primarily highlights the importance of ecosystems.

Architects design for sustainability and efficiency, but often lack crucial knowledge when understanding the earth's ecosystems and how they function (Reed, 2007, p. 675). People are a part of the natural world, yet the vast majority of people do not have an in-depth understanding of how ecosystems function and survive. Therefore, this is an area that can be developed by educating the population through architectural design. In both the past and present, people rely on earth's natural systems for survival and well-being (Estes, et al., 2011, p. 301; Beatley, 1994, pp. 133-134). Architecture in many aspects has strayed away from using traditional vernacular techniques with the use of fossil fuels, which are unsustainable. Understanding ecosystems is crucial to the health of all organic life. This is seen especially in urban settlements where historic and current trends do not significantly consider the effect the built environment has on local and global ecosystem health. Cities should consider and put into effect strategies that provide habitat for all life because we rely on other life to survive. Humans are also heavily dependent on ecosystems for their own survival, so human-ecosystem relationships become pivotal (Mathews, 2011). One of the simplest examples of this is with the role trees play. They absorb carbon dioxide from the atmosphere, produce the oxygen people breathe, conserve water and soil, support wildlife, and improve air quality (Seth, 2003). These roles mentioned are only a miniscule portion of benefits which trees play for supporting life.

One of the major issues that can be drawn from the research is that the living habits and consumerist lifestyle of westernised culture is unsustainable. Historical and current trends represent a model of trying to extract as many "resources" for human consumerism and industrialisation as possible, including the colonisation/eradication of indigenous cultures (Reid, Cormack, & Paine, 2019, p. 123). The result has been westernised societies trying to conquer and control nature. This ingrained method of thinking is deeply embedded in how people live and is where a significant change needs to occur. This is explained by Wahl (Wahl, 2006, p. 290).

> *"The root cause of the utter unsustainability of modern civilisation lies in the dualistic separation of nature and culture. It is in nature that all peoples and all species unite into a community of life. Yet culture is commonly conceived of as apart from nature, rather than a part of nature."*



There are very few ecosystems left in the world today that have not been affected by human intervention (Goudie, 2018). A conclusion to draw from this is that we need to work collaboratively with the living world to regenerate and sustain all life on the planet. There have been movements in recent years towards "human-nature systems" or "human-environment systems" (Pedersen Zari, 2018, p. 70). However, more rapid and widespread change must occur on a global scale for a truly positive impact to even occur. One area in particular where change can be incited, is within urban centres since most of humanity resides in cities (Goudie, 2018, pp. 20-21). Cities rely heavily on external resources and output a lot of waste (Goudie, 2018, p. 20). By adapting the urban fabric to become ecologically regenerative, there is likely to be a positive impact on the environment. This should incite change throughout the population by confronting the direct effects of our current unsustainable model of urban living on ecosystem health. By creating a reconnection to place and space, degraded or removed ecosystems can be used to provoke a shift in societal trends from standard and sustainable practices to regenerative design (Reed, 2007, p. 677). Therefore, people will have an attachment and feel responsible for the health of local ecosystem services through the use of architectural design. Wellington being the capital city of New Zealand, and an area of great prominence, is the ideal location for applying a shift in societal trends through built design.

There are common mistakes made when working with ecosystems that should be avoided. What is often seen with biomimetic design approaches is a romanticism and simplification of nature (Pedersen Zari, 2018, p. 36). This is due to designers using nature as a metaphor with symbolic a meaning. Biomimetic design is interchangeable with the term biomimicry, which is the mimicking of organisms or ecosystems through modern technology (Pedersen Zari, 2018, p. 17).

People's detachment from nature has created this knowledge gap of understanding how these complex ecosystem services work (Reed, 2007, p. 675). One aim of this research is to use design as a method to bridge the gap of understanding for how the natural environment beneficially contributes towards a coexisting world between people and nature. Conclusions made are that designers of the present and future need to include biologists, ecologists, and people with expertise on local ecosystem services in the design process. Dealing with nature is complex and takes a great understanding, as seen with the biologist John Todd and his creation of living machines (Todd J. , 2019).

Another significant motivation for integrating various ecosystems into urban environments are reducing the effects of climate change, and allowing human urban environments to become more resilient to its effects (Pedersen Zari, 2018, pp. 5,6). Climate change is causing permutations in weather patterns and extremities, alongside gradual temperature increases and sea-level rise (National Research Council, 2010). More vegetation and healthier ecosystems can help reduce the effects climate change has within urban environments. The 'urban heat island effect' is caused by large amounts of high mass material within cities absorbing the suns energy. This creates temperature spikes or consistent increases of two degrees within urban settlements dependant on local factors (Pedersen Zari, 2018, p. 56). Extreme weather events such as drought or heavy rainfall can also be mitigated by using increased urban vegetation for flood prevention and moisture retention (Liptan & Santen, 2017, p. 15). With the further inclusion of plant life through central Wellington City, the 'wind tunnel phenomena' can be greatly reduced by strategically located planting (Blaschke, et al., 2019, p. 69). Conclusions drawn from this is the fact that nature has a crucial role to play in helping maintain a stable environment for living. Many urban centres do not follow this model of thinking. By designing with nature, humanity can create biodiverse and productive cities that can benefit and sustain life on the planet.

A valuable insight that people should take from the understanding of ecosystem services is to define a healthy standard of living for both biodiversity and people. A change in how people view and think about the environment they occupy is required. Humans are not the only living organism that exists within urban centres, and creating a harmonic coexistence with surrounding organic life is crucial to the survival and health of all species (Estes, et al., 2011, p. 301).

Figure 2.01: Water quality in Wellington Harbour where some of Waitangi Streams unfiltered water enters the sea.

2.2 BIOPHILIC DESIGN

A compelling motivation for designing with ecosystems is research that proves that connection to the living world (plants, animals, water, natural light, etc) has a positive benefit psychologically on human health and wellbeing (Pedersen Zari, 2018, p. 18; Kellert & Calabrese, 2015). When nature is applied as an architectural medium, the term 'biophilic design' or 'biophilia' is used. It explores the theory of how interaction with nature, directly and indirectly, has a positive response on human health and well-being. 'The Practice of Biophilic Design' (Kellert & Calabrese, 2015) goes into detail examining the ways people affiliate and connect with nature to improve physical and mental health within an architectural context.

There are three different categories that define the attributes of biophilic design: (Kellert & Calabrese, 2015, p. 10)

- Direct Experience of Nature
- Indirect Experience of Nature
- Experience of Space and Place

The attribute of direct experience of nature can be intrinsically linked to the utilisation of ecosystem services for regenerating natural habitat and the integration of urban permaculture practices. By utilising these two aspects in the built environment, it could lead to a healthier human population. Many people in developed and high-income countries spend approximately 90% of their time indoors (Kellert & Calabrese, 2015, p. 5). This is a stark contrast to how people have evolved and historically lived (Kellert & Calabrese, 2015, p. 5). The research concludes that people have an intimate connection with nature through the direct contact of different environmental features within urban settings. With the contemporary model of urban living, it can be seen that detaching people from the natural world is potentially starving people from the ability to fully live a healthy, enjoyable life.

The indirect experience of nature is tied into the built environment where qualities such as natural colours, materials, and organic forms can create intimate connections between people and their environment (Kellert & Calabrese, 2015, pp. 9,10; Olmsted, 2014, p. 9). When exploring natural and organic forms, visually appealing architectural explorations can be generated to enrichen the built environments sensory experience. Biophilia plays a significant role where nature can be mimicked for replicating natural forms in architecture for the psychological wellbeing of people (Olmsted, 2014, pp. 38-39). This connection does not directly use flora and fauna in designing buildings. However, it creates an affiliation between the occupant and their spatial surroundings, which in turn creates healthy, productive living conditions. This is an area that will be explored through design within this thesis.

Figure 2.02: Plants applied to an interior space in Wellington providing a direct experience of nature.

Experience of space and place is the utilisation of humanity's naturally evolved instincts and comforts being transformed into architecturally designed spaces. One of the most significant attributes recognised in relation to the New Zealand context is the cultural and ecological attachment people have to their environment (Kellert & Calabrese, 2015, pp. 6,7; Harmsworth & Awatere, 2013). This is an essential factor to include within design, as ecosystems should be recognised from the perspective of how people and human systems fit into ecosystems. Culture is especially meaningful with the knowledge and wisdom held from Mātauranga Māori on the land. Ecosystems in urban environments are heavily impacted by people. This means that nature cannot be seen as separate from humanity but as part of the whole. Connections can be created between users and space when taking into consideration culturally inspired design and native flora and fauna. What is not explored in great depth with experience of space and place is the significance of how these aspects play a pivotal role in the lives of New Zealand's tangata whenua (indigenous people). Adoption of the norms and ideals presented by western culture has dramatically impacted the historic Māori model of living, learning, and their connection to the land as tangata whenua. Where natural resources were treated as tapu (sacred) or as vital to human life by Māori, these were not seen with the same significance within westernised culture. By recreating a deeply imbedded connection to the land by restoring removed or damaged ecosystems, there can be a return of knowledge and significance of mana whenua (Harmsworth & Awatere, 2013, p. 275).

The three categories that define biophilic design all play crucial roles when designing with nature for a positive human impact. Including these principals as part of the design framework will be pivotal for creating human nature relationships for the benefit of all life.

DIRECT EXPERIENCE OF NATURE	INDIRECT EXPERIENCE OF NATURE	EXPERIENCE OF SPACE & PLACE
o Light	o Images of Nature	o Prospect & Refuge
o Air	o Natural Materials	o Organised Complexity
o Water	o Natural Colours	o Integration of Parts to Wholes
o Plants	o Simulating Natural Light & Air	o Transitional Spaces
o Animals	o Naturalistic Shapes & Forms	o Mobility & Wayfinding
o Weather	o Evoking Nature	o Cultural & Ecological Attachment to Place
o Natural Landscapes & ecosystems	o Information Richness	
o Fire	o Age, Change, and the Patina of Time	
	o Natural Geometries	
	o Biomimicry	

Figure 2.03: Kellert & Callabrese's three categories for Biophilic Design (2015)

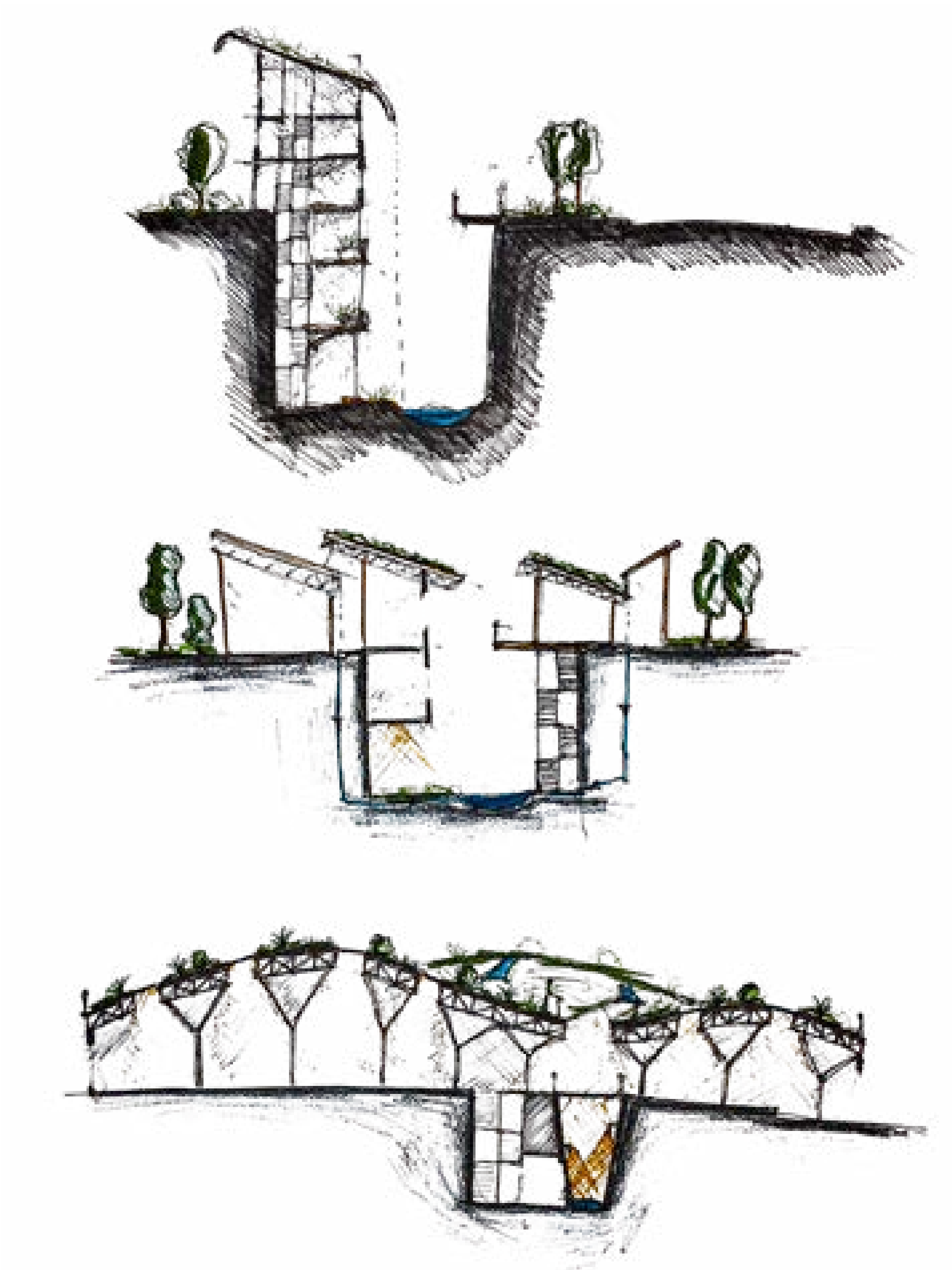


Figure 2.04: Early conceptual visualisations of urban agriculture with piped streams for the One-Month Quickstart.

2.3 URBAN AGRICULTURE AND PERMACULTURE

One way to help people understand how ecosystems function is through the integration of urban agriculture practices into daily life. From research into agricultural practices, permaculture comes out as a successful model of producing food because it is regenerative and does not further degrade the surrounding ecological environment (Rhodes C. J., 2015, pp. 404-405). Permaculture is consciously designed landscapes which mimic patterns and relationships found in nature for yielding an abundance of food and energy for provision and local needs (Rhodes C. , 2012, p. 365). The book 'Second Nature Urban Agriculture' by Katrin Bohn and André Viljoen, 2014, and journal articles by Christopher J. Rhodes, 2012 and 2015 are primary sources of literature for finding the benefits and complications of urban agriculture and permaculture practices. Urban agriculture focuses on a different perspective from how cities have historically functioned by producing physical resources and contributing to the health of cities occupants. This is expressed in the following statement made in the book 'Regenerative Urban Design and Ecosystem Biomimicry'.

> *"Although urban ecosystem services are intimately related social-ecological systems, many modern cities are primarily sites for cultural expression and the facilitation of trade, rather than the production of physical resources or the generation of services that provide tangible physical health" (Pedersen Zari, 2018, p. 111).*

Already, one-third of the Earth's cropland has become unproductive in the last 40 years due to soil degradation (Rhodes C. J., 2015, p. 409). This cycle can change by integrating practices that naturally fertilise and remediate soil. Permaculture avoids the monoculture that has developed with 'conventional farming' and takes a holistic approach where systems mimic relationships and patterns found in nature (Rhodes C. , 2012, p. 365). With this approach, systems can become self-maintained without compromising water and soil quality.

One of the challenges with integrating agricultural practices into cities is how to shift peoples' understanding of how urban environments could function. Many developers tend to value a space's economic value over other potential benefits such as health, wellbeing, productivity, connected communities, increased biodiversity, food security, historical or cultural significance, and ecosystem health (Bohn & Viljoen, 2014, p. 66).

For a regenerative model of urban permaculture to become successful, the by-products such as dead foliage and food scraps from the previous season must be reused to support new crops, so there is no waste produced (Rhodes C. J., 2015, p. 404). A constant positive feedback loop needs to be created where there is always a beneficial impact on ecologies, as opposed to a degrading one. "Two of the cornerstone permaculture design principles are that 'each element performs many functions' and 'each important function is supported by many elements'" (Rhodes C. J., 2015, p. 404; Mollison & Slay, 1994). This relates back to regenerative design and biomimicry, where ecosystem services work as a complex set of relationships to support each other (Pedersen Zari, 2020). "Permaculture seeks to reconnect humans with nature to bring forth abundance by regenerative means" (Rhodes C. J., 2015, p. 405). To change the model of food production, industrialised agricultural methods need to become restructured (Rhodes C. , 2012, p. 367). By bringing permaculture into the urban environment, food production starts to become a restructured model which benefits living ecologies, provides food security, and improves the health and well-being of the urban population. This has been similarly seen in recent years with New York, where urban agriculture has become increasingly popular to promote healthy food and sustainability (Ackerman, 2012, p. 6). The Brooklyn Grange farm is one of the largest in the city and promotes local food production, health benefits and education (Ackerman, et al., 2014).

The practice of permaculture should use three ethics defined by Rhodes: (Rhodes C. J., 2015, p. 405)

- Soil, water and air should be viewed as a sacrosanct to sustainability.
- Humans and their impact on the planet are part of the regenerative model.
- Sharing the surplus where you don't take more than you need is important, surplus is returned to ecosystems as there is no waste in nature.

These points are crucial to the survival for all of earth's life.

A primary challenge when implementing urban agricultural practices is the exposure food products can have to toxins from within the city. For the Wellington City context, these can include: (Carter, 2018, p. 10)

- Sediment
- Litter/rubbish
- Hydrocarbons and oil products from vehicles, road construction and unauthorised disposal in drains
- Nutrients (nitrogen and phosphorous)
- Pesticides, herbicides and fungicides from gardens
- Heavy metals including lead, zinc and copper (from vehicle wear, oils, buildings and paints)
- Animal faecal matter
- Hot water discharge

Estimated contaminant loads that end up in Wellington's Harbour have been located in three different catchment locations. Oriental Bay; Northern CBD which occupies Warring Taylor, Glenmore, Aitken and Aotea North; and Southern CBD which are within the region of my chosen site occupying Newtown, Tory, Te Aro, Taranaki and Harris (Wellington Water; Wellington City Council, 2015, p. 2).

	kg/year		
Location	Zinc	Copper	Polycyclic Aromatic Hydrocarbons
Oriental Bay	69	8	2
Southern CBD	1201	142	39
Northern CBD	716	81	23

It is noted that growing food crops within 50 meters of busy roads, such as Kent Terrace, is strongly not advised due to the pollutants released from vehicles (Bohn & Viljoen, 2014, p. 70). The impact of heavy vehicular use leads to contaminated soils, water and air. When pollutants meet soil, air or water that edible plants use to grow, they may contain harmful traces of the pollutants (Bohn & Viljoen, 2014, p. 69). It becomes evident here that urban food production may require bioremediation of soil and water (Bohn & Viljoen, 2014, pp. 72,73). Raised planter boxes and green roof designs may be suitable places where urban food production can take place in the most polluted areas. The integration of other planting with possibly a strategically designed remediation focussed wetland should be used to help filter out heavy metals, petroleum products and other toxins that leach into local soils (Todd J. , 2019). This is similar to landscape interventions completed by Kongjian Yu, such as Qunli Stormwater Park. Further benefits are that filtered water can then be used for irrigation purposes. Taking this into consideration, a pedestrian and public transport orientated system becomes a crucial move for the future development of Wellington City in conjunction with urban agriculture. Not only for urban agricultural practices, but also for the effects of air, soil and water pollution, safety, and making streets more pedestrian-friendly down Kent and Cambridge Terraces to cultivate social interaction. This would mean the removal of some vehicular traffic from Wellington CBD, which will provide a cleaner, greener, and more social city for the future. This would require significant urban re-planning, which is explored in chapter six and based on proposals from:

- Opus (Opus, 2018)
- Warren and Mahoney Architects (Warren and Mahoney Architects, 2018)
- MRCagney (MRCagney, 2018)
- New Zealand Transport Agency (NZTA), (NZTA, 2011)
- Wellington City Council (Wellington City Council, 2007)
- Let's Get Wellington Moving (Let's Get Wellington Moving, 2018)

Figure 2.05: Urban food systems star, (Bohn & Viljoen, 2014)

Food miles are the distance food is transported from the time of its making until it reaches the consumer. Food miles are commonly debated due to their contribution toward greenhouse gas (GHG) emissions. However, the GHG emissions from transporting food are insignificant compared to the GHG emissions released from industries such as meat and dairy farming (Bohn & Viljoen, 2014, pp. 62,63). For example, if people simply removed red meat and dairy products for one day a week from their diet, this could reduce GHG emissions by the equivalent amount of all food mile GHG emissions in a typical diet. Therefore, the real focus should be to target a change in food consumption habits (Bohn & Viljoen, 2014, pp. 62,63). Urban agriculture has also been seen to have a positive impact on food choice behaviour. By incorporating permaculture practices into urban environments, peoples eating habits can become far more sustainable beyond the benefits of urban food production alone (Ackerman, 2012).

Rooftops in the urban environment have often been wasted spaces that are left underutilised or unused. Every building has a roof, and each of these have the potential to become productive spaces. In New York City, this has started the popular practice of urban food production projects such as the “Not-for-profit Eagle Street Rooftop Farm”, located atop a warehouse in Brooklyn (Nasr, Komisar, & Gorgolewski, 2014, p. 26). With Wellington being a coastal city, rooftops become spaces that degrade water through contaminate runoff during rainfall events. These contaminants are commonly from the type of roof material and particles settling on hard, impervious surfaces. One common metal, zinc, is commonly used to prevent roof corrosion. However, this is not environmentally friendly, especially when layers of the oxidised material wash off into local waterways (Department of Conservation, 2006, p. 24). ColorSteel is a popular roof supplier in New Zealand, and their coastal roof system is coated with 45% zinc and 55% aluminium alloy (ColorSteel, 2021). By transitioning roof spaces into areas for urban agriculture, green roof design or public space, less contaminants end up in local bodies of water, and the heat island effect in cities would also be significantly reduced. This provides an opportunity to look into designing spaces that utilise roof spaces for permaculture practices within the context of Wellington City. This is another aspect that will be explored within the thesis for creating productive urban environments.

High levels of nitrogen can be harmful to aquatic species, and water runoff often has a concentration of this compound in the water. Plants, however, thrive off these nitrates, hence becoming effective filters to include in riparian stream environments for the filtration process of local water bodies. By applying this knowledge to designing with plants, a positive feedback loop occurs, which benefits the health of plant and aquatic life for creating a regenerative approach to urban ecosystems replicating what is seen in permaculture.

Conclusions drawn are that the urban environment should have more permeable surfaces with a wide variety of plant and animal species. This builds healthy ecosystems and provides an effective regenerative approach to food production that does not have a negative impact on the natural environment. Planting that has been designed just for the aesthetic impact or that is done in a monoculture is not a reflection of healthy ecosystems where everything is interconnected and relies on surrounding species for survival. By incorporating this concept into a new model of living, humanity can take a step forward towards undoing the significant damage caused since the industrialisation era.

3. Design Framework

This chapter goes into detail about the framework against which the design and process work as tested. Biophilia and regenerative design principles are studied, and the ideas are then used for creating guidelines to follow throughout the following chapters. Other guidelines when designing for native wetland environments and building successful permaculture practices are also explored throughout this chapter.

3.1 REGENERATIVE DESIGN FRAMEWORK

There are four most common ecosystem services recognised for designing healthy regenerative ecosystems (Millenium Ecosystem Assessment, 2005). These are provisioning, regulating, supporting and cultural services that all link together and rely on each other for creating healthy environments for human life (Pedersen Zari, 2018).

Provisioning Services:

Provisioning services offer some form of tangible resource to humanity aiding in survival at the most basic level through to the great variety of technology, products and people's desires. Provisioning services directly benefit humanity, so they are seen at a higher value due to their contribution as an integral part of most human economies. This, however, has often come at the expense of regulating and supporting ecosystem services, particularly in the extraction of raw materials such as fossil fuels. Significant impacts have occurred, creating detrimental problems such as climate regulation, habitat provision, erosion, and freshwater contamination, among many others.

Regulating Services:

Regulating services maintain and help regulate the essential functions of ecosystems that support health and growth. Many of the services here do not have direct links that lead to tangible products for people but are fundamental to all species' survival. The built environment can do some of the jobs of regulating services but cannot replace them, so careful consideration is needed with planning and design.

Supporting Services:

Supporting services are what allows for various organisms, species and ecosystems to endure. They also ensure the continuation of provisioning and regulation services as a crucial component of ecosystems ongoing health. When supporting services provide the base foundations for provisioning and regulating services, it also ensures the continuation of benefiting humanities wellbeing and existence. Therefore, supporting ecosystem services play a crucial role in ecosystems and are essential for life.

Cultural Services:

Cultural services are the interactions people have with nature on an intellectual, emotional, psychological, and spiritual level. Different plants, animals, water bodies, or landforms could be tapu (sacred) and held in utmost respect, resulting in more significant conservation, for example, burial, mythological or historical sites (Matunga, 1994, p. 220). In this regard, a strong relationship with a sense of place embodies the values of cultural services supporting natural ecosystems, especially within the context of Aotearoa. People's identity with nature drives a need to want and protect land and the life it supports, which should be paramount in life.

PROVISIONING SERVICES

- ◆ Food
  - o Human (land/fresh water/marine)
  - o Forage
- ◆ Raw Materials
  - o Fibre/flax
- ◆ Fuel/Energy
  - o Solar
  - o Biomass
- ◆ Fresh Water
  - o Irrigation
  - o For local ecosystems

REGULATING SERVICES

- ◆ Pollination and Seed Dispersal
- ◆ Biological Control
  - o Pest regulation
  - o Invasive species resistance
  - o Disease regulation
- ◆ Climate Regulation
  - o GHG regulation
  - o UV protection
  - o Moderation of temperature
  - o Moderation of noise
- ◆ Prevention of Disturbance
  - o Moderation of extremes
  - o Mitigation of flood/draught
- ◆ Purification
  - o Water/air/soil

SUPPORTING SERVICES

- ◆ Soil
  - o Formation
  - o Retention
  - o Renewal of fertility
  - o Quality control
- ◆ Nutrient Cycling
  - o Retention of nutrients
- ◆ Habitat Provision
  - o Suitable habitat for organisms
  - o Suitable reproduction habitat
- ◆ Species Maintenance
  - o Biodiversity
  - o Natural selection
  - o Self-organisation

CULTURAL SERVICES

- ◆ Education and Knowledge
- ◆ Aesthetic Value
- ◆ Recreation, Relaxation and Psychological Wellbeing
- ◆ Spiritual Inspiration
- ◆ Creation of a Sense of Place and Relationship
- ◆ Cultural Diversity and History

(Pedersen Zari, 2018, p. 112,113)

Figure 3.00: The four most common ecosystem services recognised.

3.2 BIOPHILIC DESIGN FRAMEWORK

Two different resources that explore biophilic design were compared against each other for similarities and differences. A combination of principles was then extracted. The table from Stephen R. Kellert and Elizabeth Calabrese's report "The Practice of Biophilic Design", 2015, is one of the primary drivers for design principles. They break principles up into three categories: direct experience of nature, the indirect experience of nature, and experience of space and place (Kellert & Calabrese, 2015). Frederick Olmsted's "14 Patterns of Biophilic Design" ,2014, breaks biophilic design into three categories: nature in the space, natural analogues, and nature of the space (Olmsted, 2014).

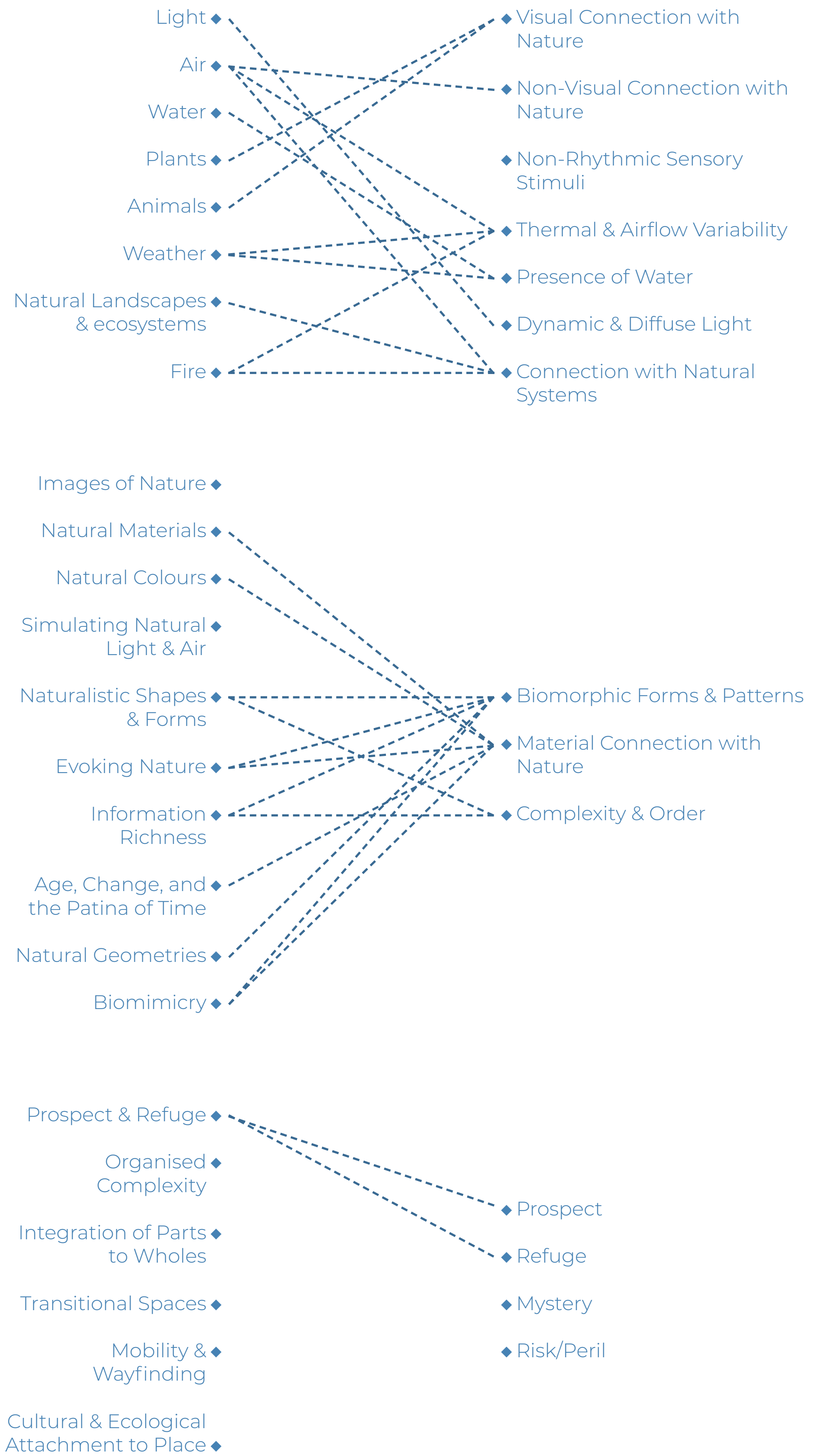
Principles for Biophilic Design: (Kellert & Calabrese, 2015, pp. 6,7).

- Biophilic design requires repeated and sustained engagement with nature
- Biophilic design focuses on human adaptations to the natural world that over evolutionary time have advanced people's health, fitness and wellbeing.
- Biophilic design encourages an emotional attachment to particular settings and places.
- Biophilic design promotes positive interactions between people and nature that encourage an expanded sense of relationship and responsibility for the human and natural communities.
- Biophilic design encourages mutual reinforcing, interconnected, and integrated architectural solutions

DIRECT EXPERIENCE OF NATURE	INDIRECT EXPERIENCE OF NATURE	EXPERIENCE OF SPACE & PLACE
o Light o Air o Water o Plants o Animals o Weather o Natural Landscapes & ecosystems o Fire	o Images of Nature o Natural Materials o Natural Colours o Simulating Natural Light & Air o Naturalistic Shapes & Forms o Evoking Nature o Information Richness o Age, Change, and the Patina of Time o Natural Geometries o Biomimicry	o Prospect & Refuge o Organised Complexity o Integration of Parts to Wholes o Transitional Spaces o Mobility & Wayfinding o Cultural & Ecological Attachment to Place

NATURE IN THE SPACE	NATURAL ANALOGUES	NATURE OF THE SPACE
o Visual Connection with Nature o Non-Visual Connection with Nature o Non-Rhythmic Sensory Stimuli o Thermal & Airflow Variability o Presence of Water o Dynamic & Diffuse Light o Connection with Natural Systems	o Biomorphic Forms & Patterns o Material Connection with Nature o Complexity & Order	o Prospect o Refuge o Mystery o Risk/Peril

Figure 3.01: Biophilic design frameworks, Top, Kellert & Calabrese (2015), Bottom, Olmsted, (2014)



DIRECT EXPERIENCE OF NATURE

- Visual Connection with Nature
  - Plants
  - Animals
  - Water
  - Natural Landscapes
  - Ecosystems
- Non-Visual Connection with Nature
  - Thermal
  - Smell
  - Sound
  - Touch
- Dynamic & Diffuse Light
- Connection with Natural Systems
- Presence of Water
- Non-Rhythmic Sensory Stimuli

INDIRECT EXPERIENCE OF NATURE

- Biomorphic Forms & Patterns
- Material Connection with Nature
- Complexity & Order

EXPERIENCE OF SPACE & PLACE

- Prospect & Refuge
- Organised Complexity
- Integration of Parts to Wholes
- Transitional Spaces
- Mobility & Wayfinding
- Cultural & Ecological Attachment to Place

These criteria, where Calabrese, Kellert, and Olmsted's ideas are combined, are the primary biophilic design principles to create an architectural result for the benefit of human health and well-being. Throughout the design process, architectural concepts will primarily be tested against these principles and consider the other guidelines for creating a successful outcome.

Left Image, Figure 3.02: Combination of Biophilic design frameworks.

Above Image, Figure 3.03: My developed design framework

3.3 PERMACULTURE DESIGN GUIDELINES

Permaculture design principles have similarities to that of regenerative design, where local ecologies are healed and self-sustaining. For all energy inputted into crop production and consumption, the same is returned to the soils and ecosystems so life can continually be sustained without the degradation of productive landscapes. Useful design guidelines to follow for successful permaculture practices should include: (Abrahams, Coupe, Sanudo-Fontaneda, & Schmutz, 2017, p. 148)

1. Each element in the design performs multiple functions and each function is supported by many elements.
2. Use biological resources within the design.
3. Maximise productive 'edge' within the system.
4. Capture and store energy – Create a yield.
5. Use and value renewable resources and ecosystem services.
6. Design from universal patterns to detail.

3.4 WETLAND & STORMWATER GUIDELINES

Five principles can be applied to practical landscape and stormwater management. These are: (Liptan & Santen, 2017, p. 22)

1. Put the water in the landscape.
2. Let the water move across the landscape.
3. Make sure the design looks good and works well.
4. Design to maintain.
5. Be aware of what will work on site.

All impervious surfaces provide an opportunity to be changed and adapted for stormwater management by creating new landscapes. By merely increasing a site's vegetative coverage, a greater water capacity can be managed for flooding and pollutant mitigation and restoring wildlife habitats in urban areas (Liptan & Santen, 2017, p. 25).

By allowing the water to move across the landscape instead of being piped underground, there is no risk of pipes getting clogged and causing overflows onto the impervious surfaces above. It can become far more expensive to replace old pipes with larger ones to manage stormwater. A successful example of daylighting such streams is Zurich, Switzerland (Liptan & Santen, 2017, p. 26). Just over twenty kilometres of stream networks have been daylit, relieving flood pressure and offering aesthetic quality to the city (France, 2008, pp. 91-104).

"A working design is also a beautiful design" (Liptan & Santen, 2017, p. 27). The importance of a landscape that works well and looks good comes from collaborating with different groups working together by combining their expertise.

Design so that irrigation is no longer necessary by effectively managing stormwater runoff and creating a self-sustaining ecosystem with plants suited to the climate and site conditions. Less operations and maintenance are then required for a natural ecosystem to thrive and survive.

When designing for stormwater management, be aware of the site conditions and what will work. This could mean collaborating or consulting with professionals on the local ecologies for the most effective system to put in place. A system that is not effective will have a lot more maintenance to keep the overall system alive and functional.

These frameworks are similar to a set of rules or guidelines the design process will take for formulating a successful outcome. A successful outcome will be an architectural form which aids in the health and well-being of city occupants through biophilic design principles, restores and provides habitat through regenerative design practices, and uses permaculture as a method for urban food production. These guidelines will be used to test concepts for their ability to perform and function in Wellingtons' urban environment.

4. Case Studies

This section of the thesis looks at exemplars of where regenerative design has been incorporated into urban environments to benefit both human and ecosystem services life. These range from built architectural interventions to landscape projects which have inspired or had a profound impact on the design-based research of my own work.

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Figure 4.00: Birdseye of Qunli Stormwater Park (Yu, 2011).

Project: Qunli Storm Water Park
Practice/Chief Designer: Kongjian Yu from Turenscape
Project Location: Qunli New District, Haerbin City, Heilongjiang Province, China
Project Completion: 2011

Qunli Storm Water Park performs many functions that support organic life and are beneficial to the local human population. These restorative functions are the collection, cleansing, and storing of stormwater, which recharges local aquifers. Aquifer recharge could be considered in Wellington since Waiwhetu aquifer below Lower Hutt, the Harbour and city support the freshwater supply used by the local occupants. A capacity of 115 million litres a day can be extracted from here; 70 million litres per day are currently used (Wellington Water, 2020). Water from flooding in the Qunli district now contributes to the local ecosystems and has been upgraded to a protected national wetland due to its ecological success (Yu & Saunders, 2012, pp. 152,153). The inclusion of various pavilion designs, a skywalk and other walkways allow for recreational use and an aesthetic experience within the city. This ties into the direct experience of nature from biophilic design. An ecosystem services approach has the benefit of self-managing itself instead of piped systems requiring regular maintenance. Many of the restorative projects undertaken by Kongjian Yuu are successful precedents when dealing with water. His landscape practice remediates land that has been damaged from human activity and provides us with productive spaces for both nature and people.

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Figure 4.01: Qunli Stormwater Park with surrounding urban monoculture (Yu, 2011).

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Figure 4.02: Photo of Qunli Stormwater Park with pavilion design (Yu, 2011).

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Figure 4.04: Photo of Waitangi Park (Devitt, 2016).

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Figure 4.05: Waitangi Park wetland (Young, 2016).

Left Image, Figure 4.03: Waitangi Park facing the harbour (Price, 2016).

Project: Waitangi Park
Practice/Chief Designer: Wraight Athfield Landscape + Architecture
Project Location: Waitangi Park, Wellington, New Zealand
Project Completion: 2006

Waitangi Park was designed for creating an area of public use along the Wellington City waterfront. It is also made to raise awareness of stormwater quality in a 'high profile location' entering the harbour through a wetland treatment process (Wood, et al., 2010, pp. 18-19). Very few people knew about the Waitangi Stream catchment and its history before the establishment of this project. The completed design of Waitangi Park successfully improves stormwater quality and creates active public spaces within the city. However, there are some ecological drawbacks in the design, which can be further improved. This thesis aims to address these to lead the city towards a more sustainable and hopefully regenerative future.

Firstly, Waitangi Park only filters approximately 10% of stormwater discharge or dry weather flow from the Waitangi catchment region (Wood, et al., 2010, p. 17). The other 90% is going untreated into the harbour containing traces of heavy metals and sediment that are harmful to local ecologies. One benefit to the 10% of filtered water is that it is then used to irrigate the rest of Waitangi Park. However, during dry spell periods, water levels get too low and water is taken straight from Wellington's mains water source to keep the plants alive. An alternative may be a transition towards also using greywater from local households to maintain water levels through recycling in the wetland to reduce city waste.

Kent and Cambridge Terraces are identified as having a significant flood risk, 10-year floods can occur with the potential of causing damage to infrastructure and property (Blaschke, et al., 2019, p. 67). By daylighting the stream and creating a permeable space designed to flood, large volumes of water can be kept under control, and central city flood mitigation can be achieved. Flooding is especially important with climate change; projections predict far more harmful weather events in the future. Plans have suggested designing a linear urban park along Kent and Cambridge Terraces to aid in flood mitigation. This will also be highly beneficial to the health of local ecosystems and urban population (Blaschke, et al., 2019, p. 68).

Another disadvantage with Waitangi Park is that water is pumped from the pipe network 8 metres underground to the surface for water treatment (Wellington Water, 2020). Pumping of water is an unsustainable practice. If the whole stream resides on the surface, there will not be a need to pump the water up from the underground pipe network. Alongside this issue, water can only be pumped 2 hours either side of low tide to prevent seawater impeding on the wetland's ecologies. Sea level rise will have detrimental effects in future years with water pumping into Waitangi Parks wetland and potential land retreat. Projections of sea-level rise are estimated to be a minimum of 0.3m, or upwards of over 1m by 2100 (Lindsey, 2021). Sea level rise is a factor to consider when working with Kent and Cambridge Terraces, although it is not something that will have profound effects on the design in the near foreseeable future.

From analysing Waitangi Park, an understanding of environmental factors was brought to light to consider in the design of filtering stormwater and the social benefits of extending a wetland through the central city. Flooding can be further mitigated, water purification can become more successful, and a higher quality of life can be achieved in Wellington City.

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Figure 4.06: Waitangi Park Site Plan (WALA, 2006).

Figure 4.07: Interior photo of Christchurch Riverside Markets, 2020)


Figure 4.08: Laneway at Christchurch Riverside Markets.


Figure 4.09: 1st level view at Christchurch Riverside Markets.

Project: Riverside Market
Practice/Chief Designer: Georgie Kirkcaldie from Kirkcaldie Interiors
Project Location: Christchurch Central City, Christchurch, New Zealand
Project Completion: 2019

The Riverside Market in Christchurch evolved from the response of the 2011 earthquakes to bring people back into the city centre. Previously, there were temporary container sheds with various popup shops. The container sheds were replaced by the permanent design of the riverside market space with various stores selling goods. There are 30 independent food outlets, and 40 fresh produce stores under 3500sqm of roof (Riverside Market, 2021). A vibrant culture and atmosphere are created in this space due to the many different local outlets selling their goods and services.

Upon visiting this space to analyse how a permanent market space could perform in Wellington, it became evident that they were targeting the middle- and upper-class population brackets with the types of stores. The types of products sold were mostly of a higher quality and not necessarily affordable for lower-income families. A vibrant and inviting atmosphere encompassed the space. However, healthy and fresh produce should be made available for all income brackets from my personal opinion.

Another point noted in the riverside market's design is that there aren't many open spaces other than the river's edge and a car park. Having common areas of expansion in and around the design can help create prospect and refuge areas in the design. Bringing in biophilic principles can make more comfortable and inviting areas where various activities and breathing room could occur throughout the design.

Overall, the riverside market successfully brings people to a place for social activity and celebration of local culture in a central city location that has been previously destroyed. The personal analysis will be considered when designing a regenerative built environment for both people and local ecosystems in my design.

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Figure 4.10: Riverside Markets Ground Floor plan (Riverside Market, 2020).

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Figure 4.11: Riverside Markets 1st floor plan (Riverside Market, 2020).

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Figure 4.12: Birdseye of Wellington Harbourside Markets (Kitchener, 2012).

Projects: Harbourside & Victoria Street Markets

Project Locations: Te Aro, Wellington City, New Zealand

The harbourside market, previously known as Waitangi Park market and Chaffers Market, is located on the Wellington waterfront beside Waitangi Park and runs every Sunday. Food trucks, popup fresh produce stores, buskers and other small local outlets come and sell their goods to the people that visit. I try to visit this market every weekend to enjoy the social environment and get cheaper healthy food each week. Harbourside Market is the oldest and largest outdoor market in Wellington. The market has a strategy which follows three goals. These are based on social, economic and environmental terms. They aim to involve the whole Wellington community sustainably, support local businesses while catering for all income brackets, and reduce waste by becoming a sustainable market (Harbourside Market Wellington, 2020). The guidelines which harbourside market work off is an exemplary model to base a design off for my thesis. There can be up to approximately 25,000 people that attend every Sunday to look around or buy products (Harbourside Market Wellington, 2020).

Victoria Street Market is located in Te Aro's suburb and functions very similarly to the harbourside market. Fresh fruit and vegetable products are sold alongside a few food trucks and other stores. However, a new development is planned to be put in place on this site for creating more apartment/laneway living in the central city (OneRoof, 2020). With developments to occur, Victoria Street Market is relocating on the 7th of March, 2021 out to Ballantrae Place. However, what was so useful with this market was its location for students and others alike in the central city without cars, by proposing a change in location to along Kent and Cambridge Terraces where an architecture dedicated towards a permanent market space. A central location can still be achieved by remediating a lost ecological feature in the central city.

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Figure 4.13: Wellingon Harbourside Markets, (Capper, 2017).

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Figure 4.14: Wellington Victoria Street Markets (Foursquare City Guide, 2015).

Harbourside Market:
4,000 sqm open carpark and walkway space approx. Can extend significantly depending on the number of stalls in attendance.

Victoria Street Market:
3,500 sqm approx of outdoor market space from carparking.

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Figure 4.15: Brooklyn Botanic Garden Visitor Center (Weiss/Manfredi, 2012).

Project:	Brooklyn Botanic Garden Visitors Center
Practice/Chief Designer:	Weiss/Manfredi
Project Location:	Brooklyn, New York City, USA
Project Completion:	2012

One firm's work explored is Weiss/Manfredi because of their interdisciplinary approach of using architecture and incorporating landscape design (Weiss, 2014, pp. 131-139). A project where this is recognised is with the Brooklyn Botanic Garden Center's design. It is neither a landscape nor a pavilion but merges the two through naturalistic forms and organisation of spaces (Schröpfer, 2015). The design acts as an "inhabitable topography" where the landscape is celebrated through becoming part of the architecture (Manfredi & Weiss, 2008, p. 102).

The design connects various garden typologies, and these are a traditional rose garden, a cherry esplanade, a Japanese garden, and a restored forest of ginkgo's (Manfredi & Weiss, 2008, p. 105). Different sustainable features are included in the design, the most notable being the collection and filtration of rainwater on the 930sqm of green roof and 3900sqm of the newly planted landscape. It is believed that 757,000 litres of water are filtered and retained each year. The complex native planting and specific soil selection filter and direct the runoff water towards the Japanese Hill and Pond Garden (Schröpfer, 2015, p. 109). Passive design strategies through natural light and heating from insulating qualities of the ground are carefully integrated into the design (Schröpfer, 2015, p. 109).

This design is successful because the architecture is integrated with the plants instead of plants being driven by the architecture. This is a crucial point for designing where local ecosystems are drivers of the designs form and function. Nature is celebrated through the Brooklyn Botanic garden Visitors Center design instead of being purely romanticised and used only for their aesthetic qualities.

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Figure 4.16: Brooklyn Botanic Garden Visitor Center in Winter (Weiss/Manfredi, 2012).

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Figure 4.17: Brooklyn Botanic Garden Visitor Center (Weiss/Manfredi, 2012).

ADDITIONAL PRECEDENTS

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Figure 4.18: The Omega Center for Sustainable Living (OCSL), (Omega, 2009).

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Figure 4.19: Rendering of the OCSL (Todd, 2009).

John Todd's eco-machines/living-machines (Todd J. , 2019; Todd N. J., 2005). Inspiration from eco-machines that use the knowledge of nature to combat problems created by people is an integral part of the thesis. John Todd is a biologist who does remediation projects of damaged or lost ecosystems by using nature as his design toolset.

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Figure 4.20: Bosco Verticale (Vertical Forest), (Boeri, 2014).

Stefano Boeri is an architect from Italy that works on reforesting cities and working towards bringing nature back into the city. His work is like an urban forest where trees and other plantings become an integral part of the building. One of the initial driving ideas of the thesis was based off the work he has produced such as the Bosco Verticale (Stefano Boeri Architetti, 2020).

5. Site Analysis

This section of the thesis discusses why and how Kent and Cambridge Terraces were selected as the design research site. The analysis explores the area's history from an ecological and cultural perspective. Ecological relationships, current and past ecosystem services and how people fit into the landscape are also studied for their importance from a biophilic design and regenerative design perspective. A particular focus of the analysis gathered is Wellingtons' hydrological information. This is because water has a pivotal role in the thesis.

5.1 WIDER WELLINGTON CONTEXT

The specific location being targeted for this thesis is the Basin Reserve and down Kent and Cambridge Terraces in central Wellington, where various car dealerships are currently located. On a macro scale, the whole Waitangi Stream catchment is considered part of the site from an ecological perspective. Water from within the entire catchment region flows directly under Kent and Cambridge Terraces before entering the harbour in a culverted stream (Waitangi Stream). Kent and Cambridge Terraces' are also known areas of considerable flood risk. Ten-year floods cause significant damage to existing built infrastructure (Blaschke, et al., 2019, p. 67).

Wellington has a series of urban streams that are piped below the surface of the city. These streams have been known to hold aquatic life and historically were an essential part of the land's local ecosystems. Over years of urban growth, the streams have been moved to underground pipes that are now no longer able to manage water capacity from catchment regions as more surfaces are made impervious (Blaschke, et al., 2019, pp. 67-68).

Figure 5.00: Context Map of Wellington City.

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Figure 5.01: Satellite Image of Wellington City.

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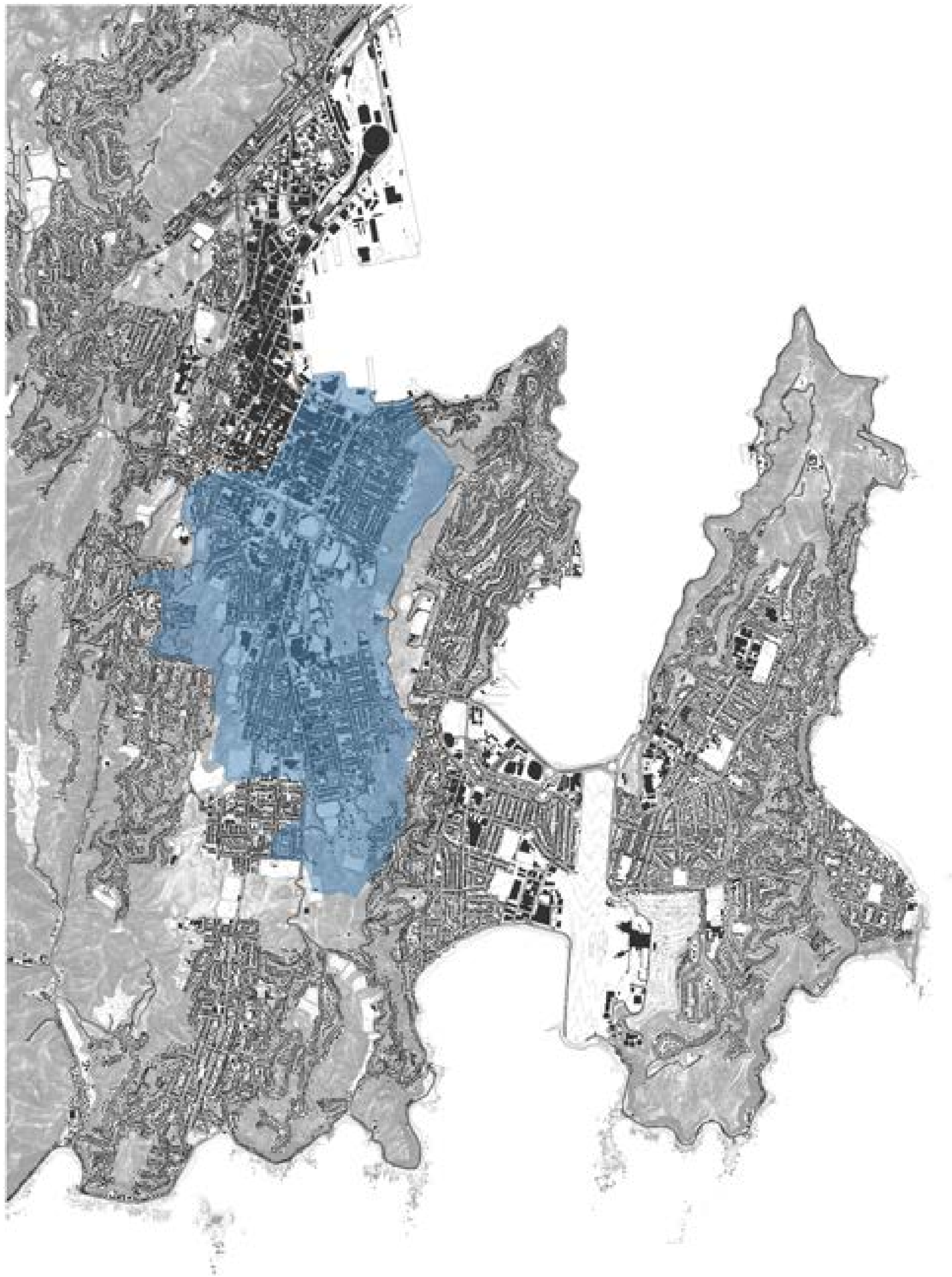
Figure 5.02: Merged historic imagery of Wellington City.



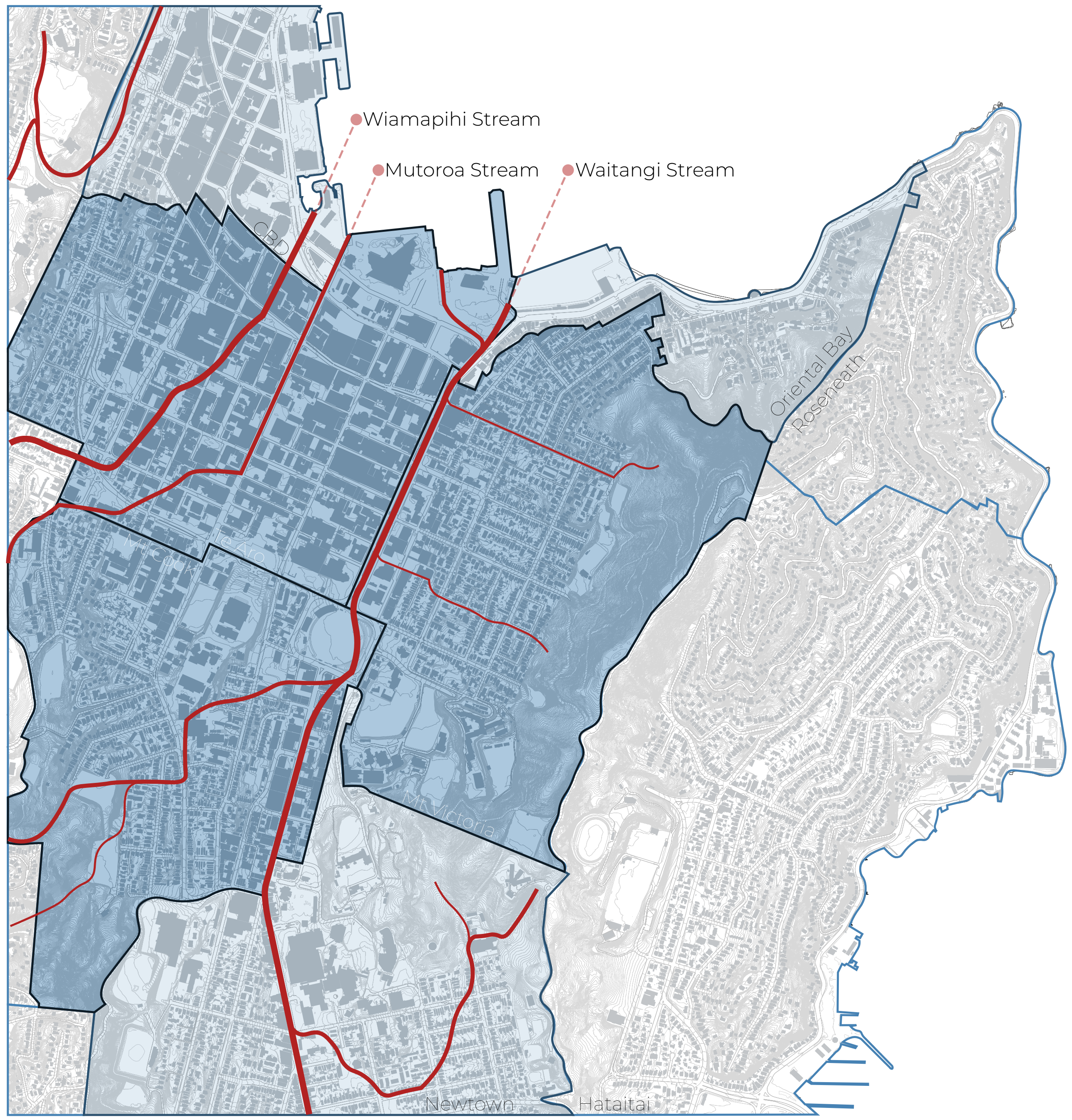


Figure 5.04: Piped streams in Wellington City in relation to surrounding suburbs.

Left Image, Figure 5.03: Waitangi Stream Catchment region encompassing the suburbs of Te Aro, Mt Vic, Mt Cook, and Newtown.

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Figure 5.05: Initial plan for the Basin Reserve (Mein Smith, 1855).

5.2 SITE HISTORY

Historically, Basin Reserve was a swamp named Hauwai, providing many natural resources to local iwi (Ministry for Climate & Heritage, 2015). One particular species that thrived in the swamps of Hauwai were short and longfin eels. After the 1848 and 1855 earthquakes in Marlborough and Wairarapa, the land was raised by about 1.5 metres, allowing colonists to drain the morass (Basin Reserve, 2020). Before the earthquakes rose Hauwai, there was a plan to transform Waitangi Stream into a canal to enable the Basin to become a safe harbour for ships (Basin Reserve, 2020). That is why both Kent and Cambridge Terraces are so wide. They were designed to run down either side of the canal.

The Hauwai swamp remained after the earthquakes but had become significantly diminished. A plan was put in place to transform the swamp into a cricket ground. Prisoners were used as free labour to drain the remaining swamp and fill it in with soil (Basin Reserve, 2020). The following years saw many sports and recreational events on these grounds. However, with these grounds' location and amount of use they get (not high), there is a potential opportunity to develop this piece of land into an ecological landmark within the city to aid in local ecosystems and biodiversity that more and broader crowds of people will use. This will also serve as a possible solution to flooding issues in the area and significant traffic flow problems. The Basin Reserve cricket grounds are thought to be a heritage site in Wellington and a famous and popular ground for the sport. Despite this, traffic management could potentially be significantly improved by removing the cricket grounds and using the space as the hub of a green and blue corridor in the central city.

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Figure 5.06: Painted illustration of the Baasin Reserve (Aubrey, 1889).

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Figure 5.07: Photograph of the Basin Reserve, Wellington (Bragge, 1875).

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Figure 5.08: Cambridge Terrace, Wellington (1920's).

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Figure 5.09: Southern part of Kent and Cambridge Terraces, Wellington (1931).

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Figure 5.10: Motoring premises on Kent Terrace, Wellington (1958).

Figure 5.11: Northern end of site to develop along Kent and Cambridge Terraces.

As the city developed, a light rail network was constructed, which ran down Courtney Place and onto Kent and Cambridge Terraces'. After the cricket grounds were built, the surrounding context proliferated with development. On the Mount Victoria side, many Victorian and Edwardian style houses were constructed. While in Te Aro, the city densified with the construction of factories and light industry. Te Aro had become known as a 'slum' area right through until the 1970's when a plan was put in place for the addition of high-density housing to change the demographic of people occupying the area (Menzies, 2002).

In the 1950s, further development along the terraces saw the terraces transform into an area filled predominantly with car dealerships *(figure 5.10).* The building programmes along both terraces are still dominated by car dealerships today or other vehicle-related buildings. These tend to be low density, mostly sprawling areas of concrete and other impervious surfaces with small buildings. The Terrace's existing development has created a barrier between Mount Vic and Te Aro's suburbs that is not pedestrian-friendly. This causes connectivity issues.

Figure 5.12: Central part of site overlooking the existing car dealerships.

Figure 5.13: Southern end of site looking back towards the Basin Reserve.

Figure 5.14: Northern end of site looking back towards the Basin Reserve during rainfall.


Figure 5.15: Current drainage systems in place along Kent and Cambridge Terrace's.

Figure 5.16: Basin Reserve during heavy rainfall contributing to sediment runoff into the harbour.

Figure 5.17: Condition of Wellington City harbour during heavy rainfall.

In the images above *(figures 5.16 & 5.17)*, heavy rainfall effects within the Wellington CBD are evident. The Basin Reserve shot shows significant sediment runoff entering into the local piped stream network. The image of the waterfront depicts murky brown water stretching hundreds of metres into the harbour. It does not take someone with profound knowledge of water quality issues to understand that there is a severe effect on local aquatic ecologies whenever heavy rainfall occurs in Wellington City. By daylighting and developing the Waitangi Stream's riparian edge, much of the water entering the harbour can be filtered while also creating habitat provision for local stream life.

The Central City Framework for Wellington highlights a fundamental plan toward future development with the proposal for 'stream streets' (Absolutely Positively Wellington, 2020, p. 18). These include urban wetlands for stormwater quality management, surface flooding, reflect the natural history, and build more attractive streetscapes (Absolutely Positively Wellington, 2020, pp. 18,57). Kent and Cambridge Terraces' were also selected as critical locations to develop these 'stream streets' for Wellington City's plan towards 2040.

5.3 SITE & LUCI ANALYSIS

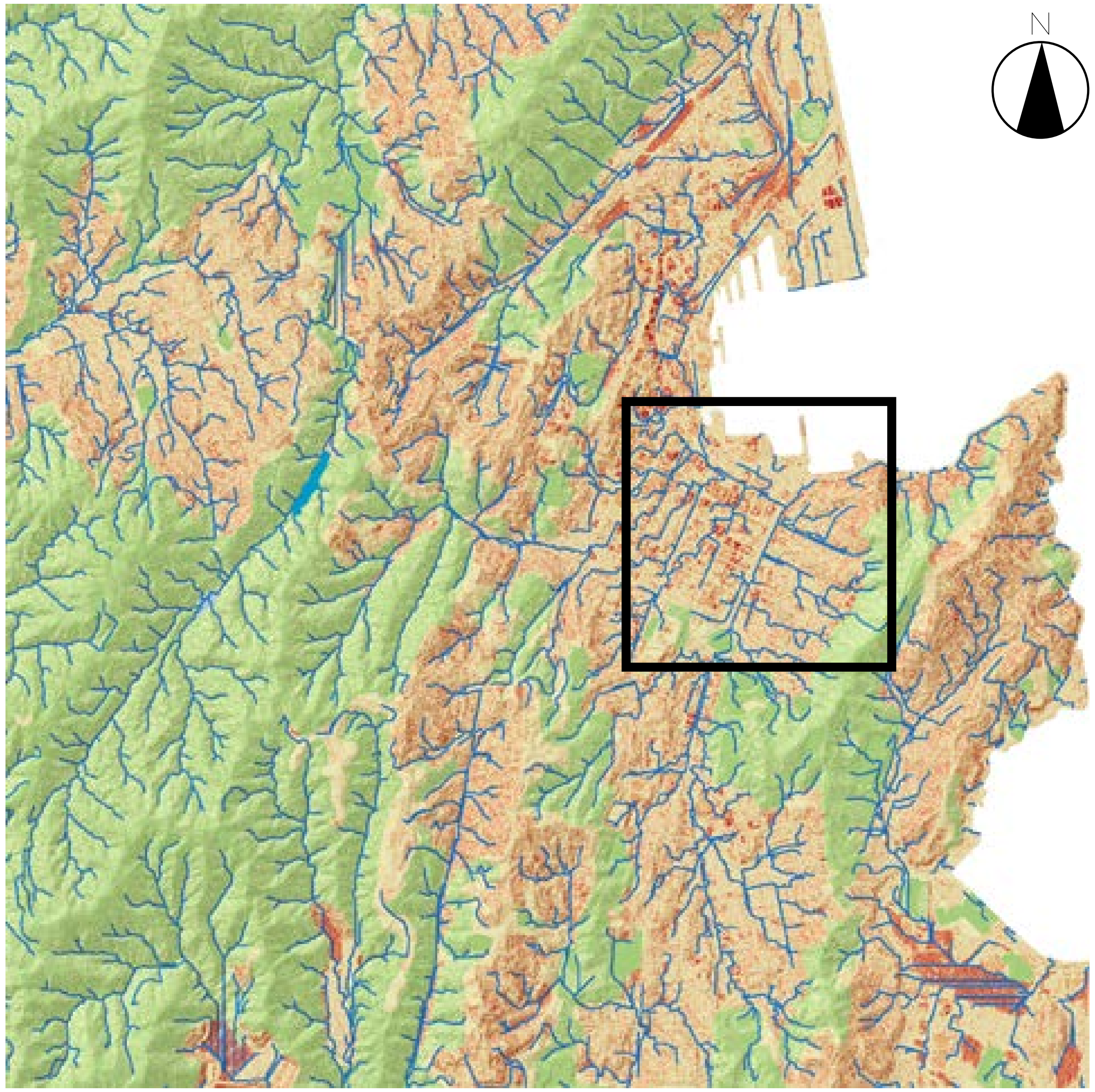


Figure 5.18: Wellington City LUCI analysis visualising stream simulation, erosion and sediment delivery (Delpy, 2020).

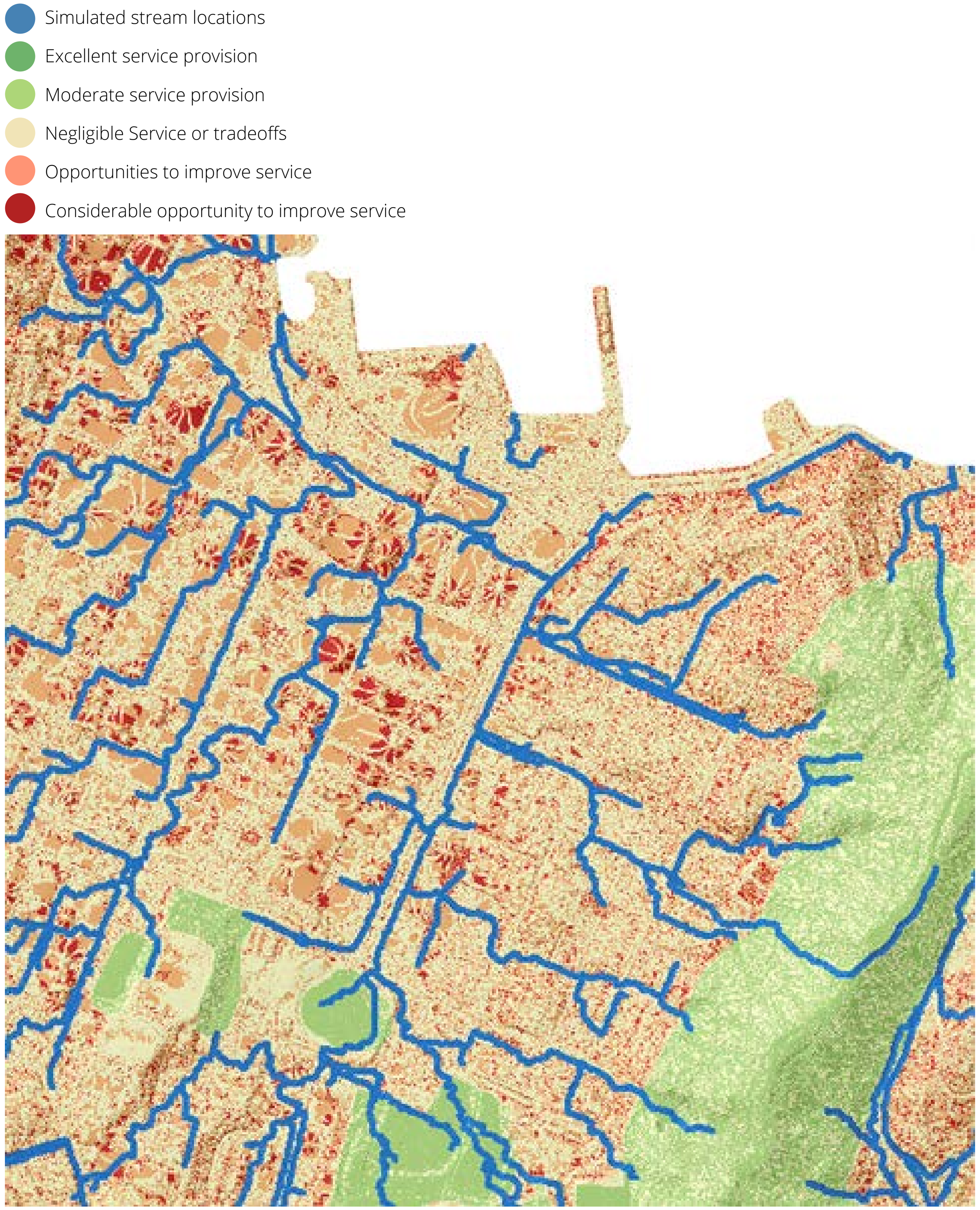
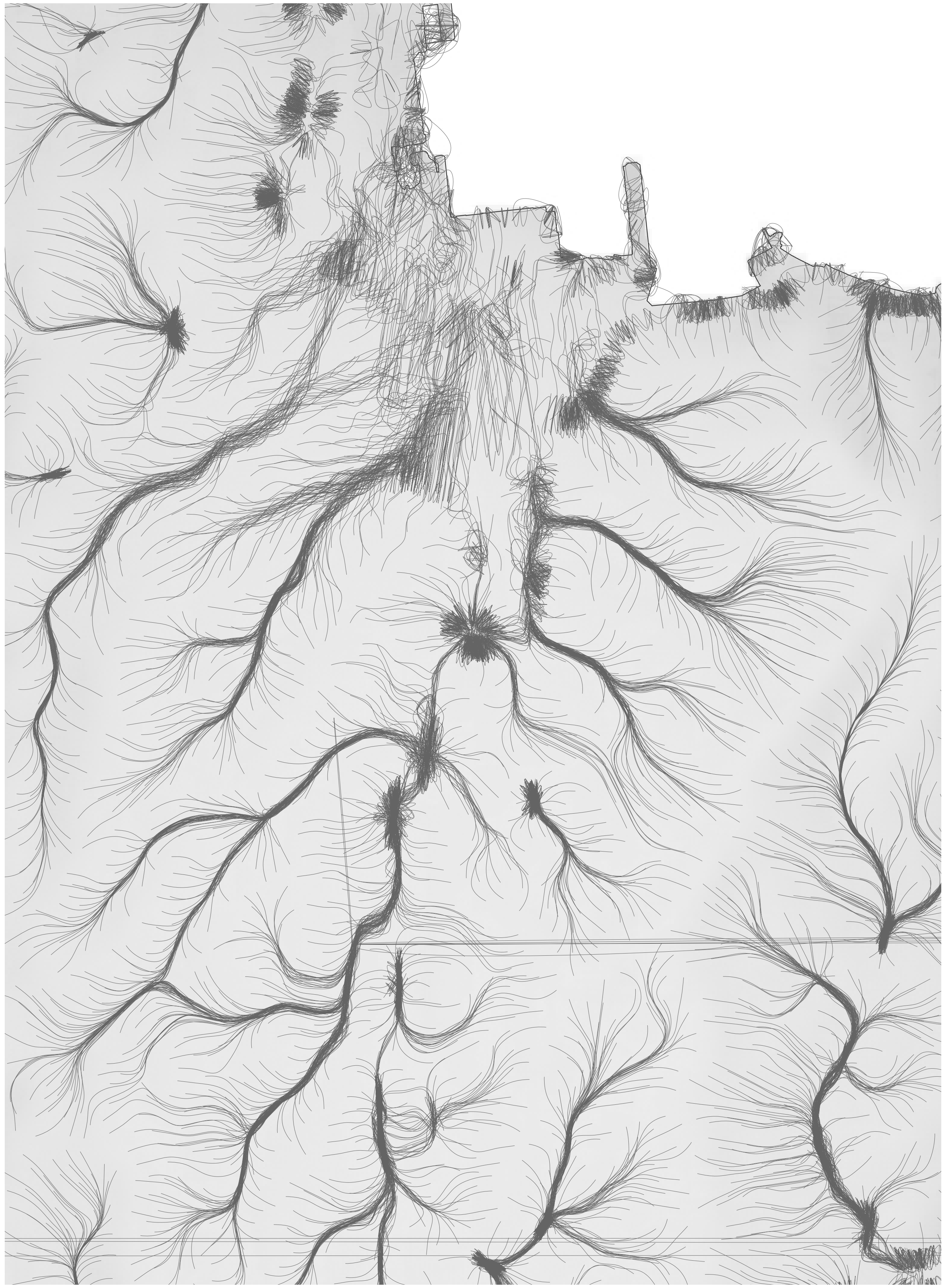


Figure 5.19: Kent & Cambridge Terraces LUCI analysis of stream simulation, erosion and sediment delivery for finding areas at risk at risk for intervention (Delpy, 2020).



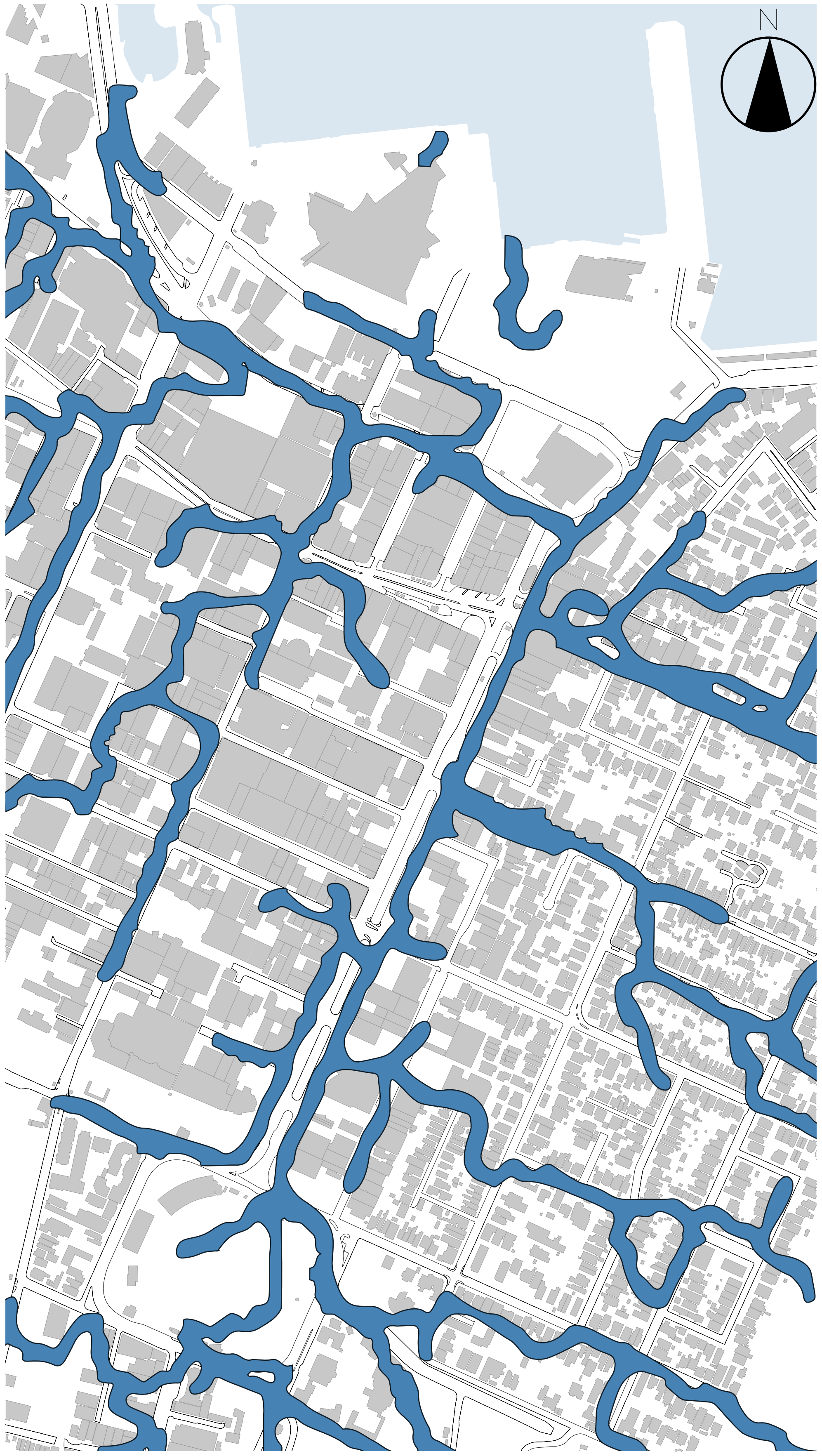


Figure 5.21: Visualisation of stream simulation from LUCI analysis.

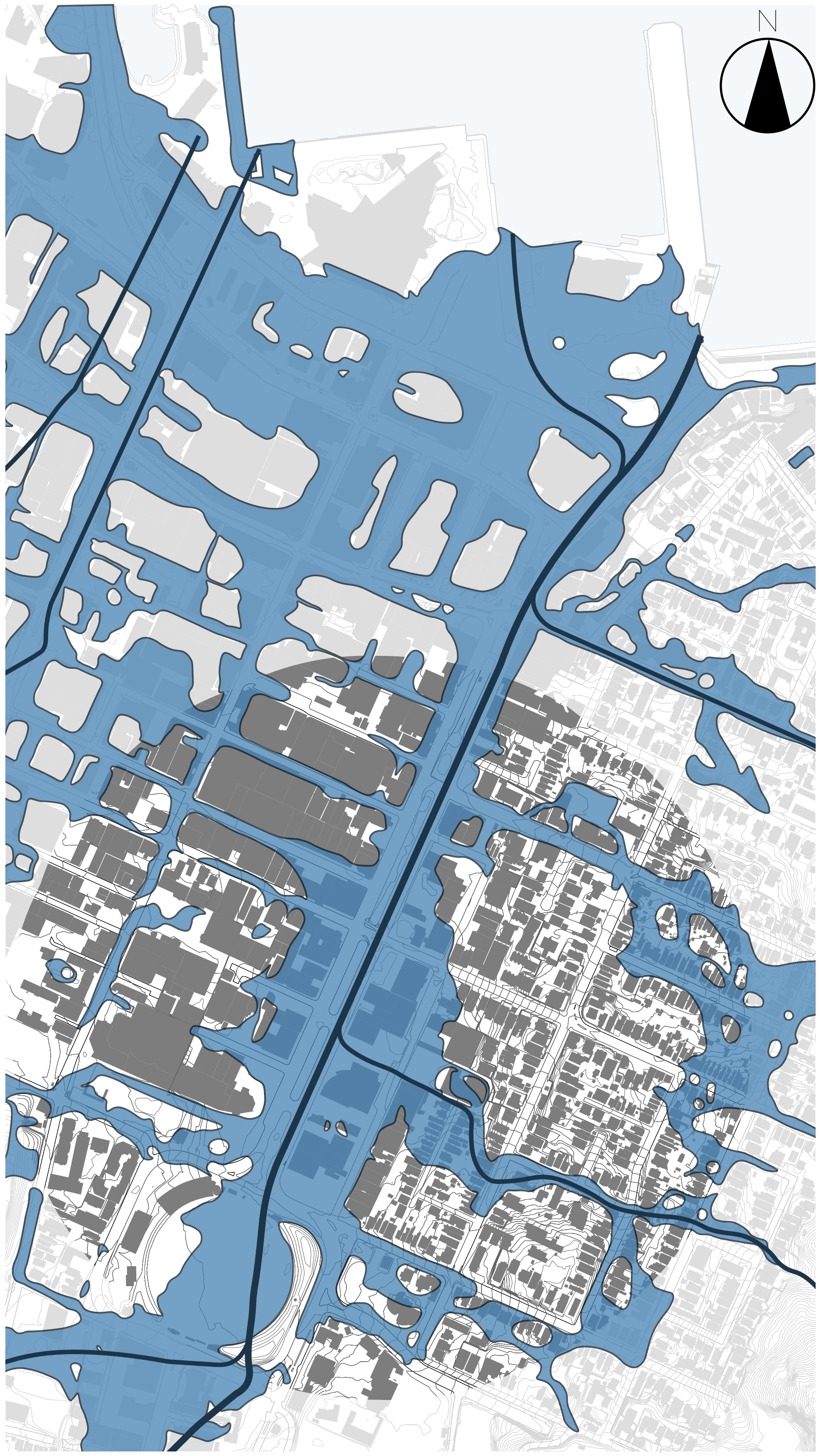


Figure 5.22: Flooding and piped stream paths mapped in focus area.

Figure 5.23: Mapped ground plane impervious surfaces around site area.

Figure 5.24: Mapped roof structures and other built infrastructure impervious surfaces around site area.

Figure 5.25: Mapped permeable/greenspace surfaces around the site area.

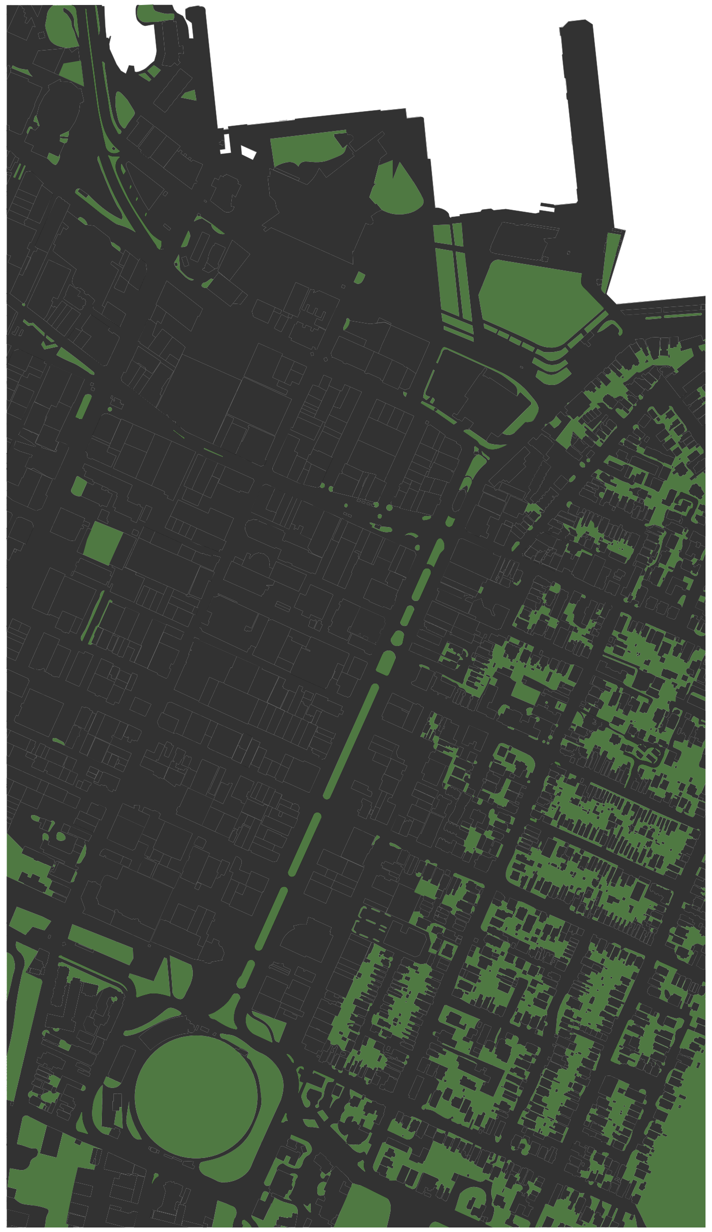
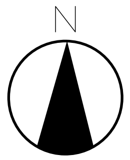


Figure 5.26: Merged figure-ground study comparing permeable & impervious surface ratios for water absorption.



	Willis St - Cambridge Tce	
Land Cover	Area (ha)	Percentage of landcover (%)
Discontinuous Trees	1.26	1.22
Continuous Trees	0.52	0.50
Hard Impervious Surfaces	98.27	95.41
Grassed Areas	1.88	1.83
Bushes, Horticulture areas	1.07	1.04
Total	103	100
Total excluding hard surfaces	4.73	4.59

(Blaschke, et al., 2019)

Figure 5.27: Storm Surge of 1m around the Wellington City coastline (Lane, 2012).

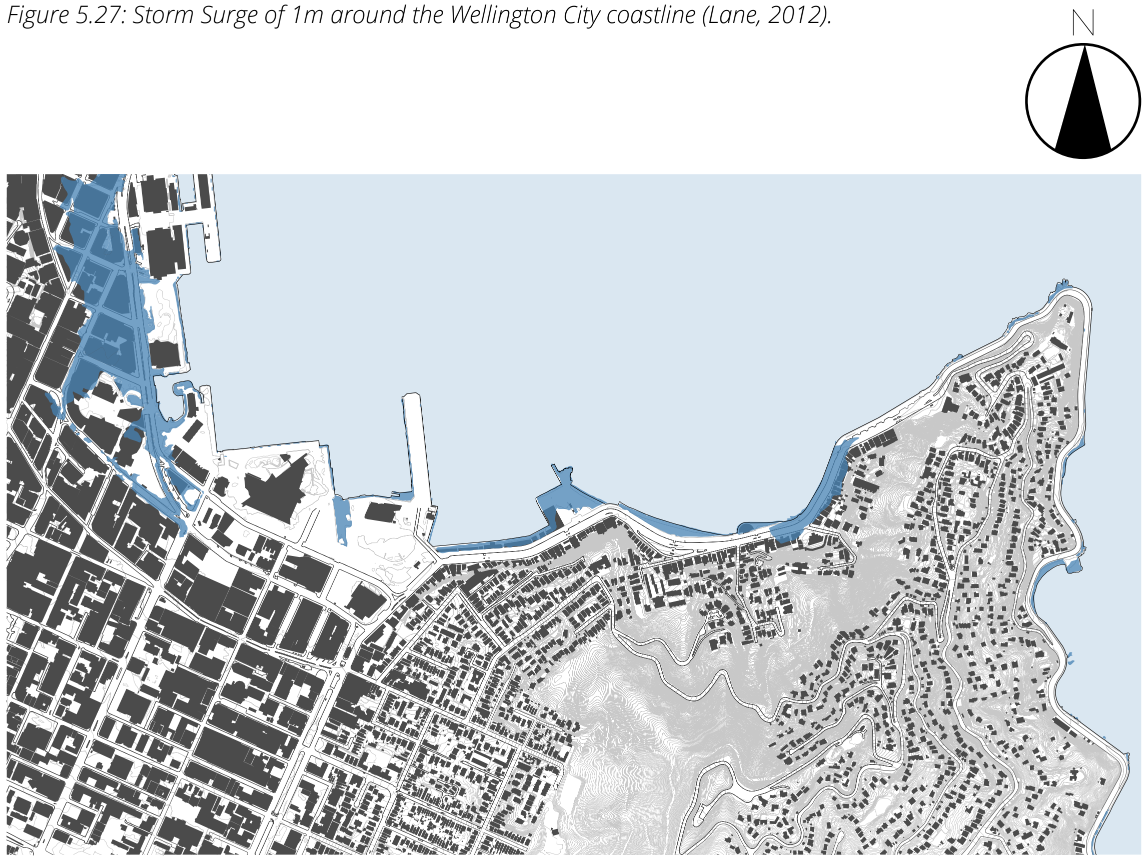
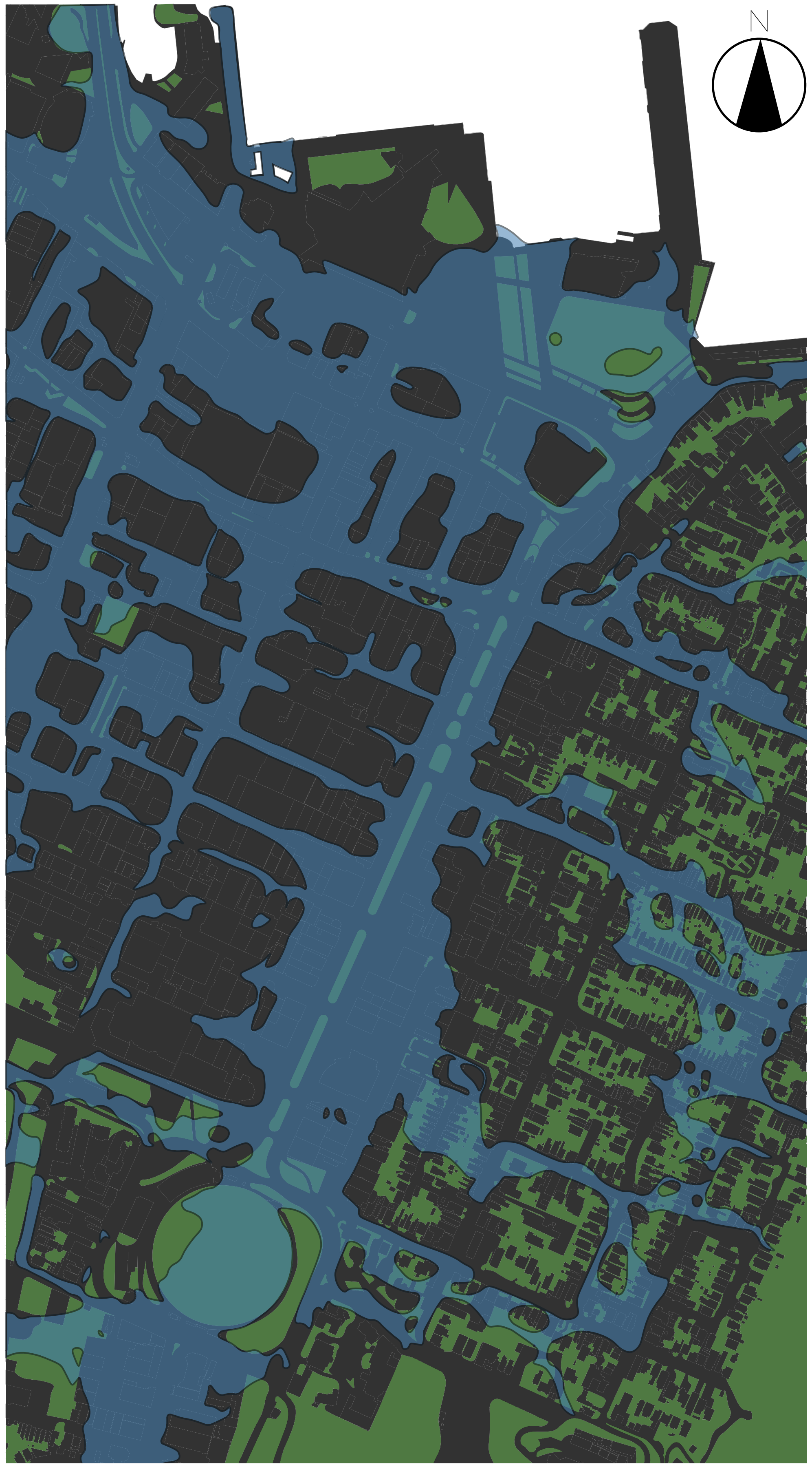
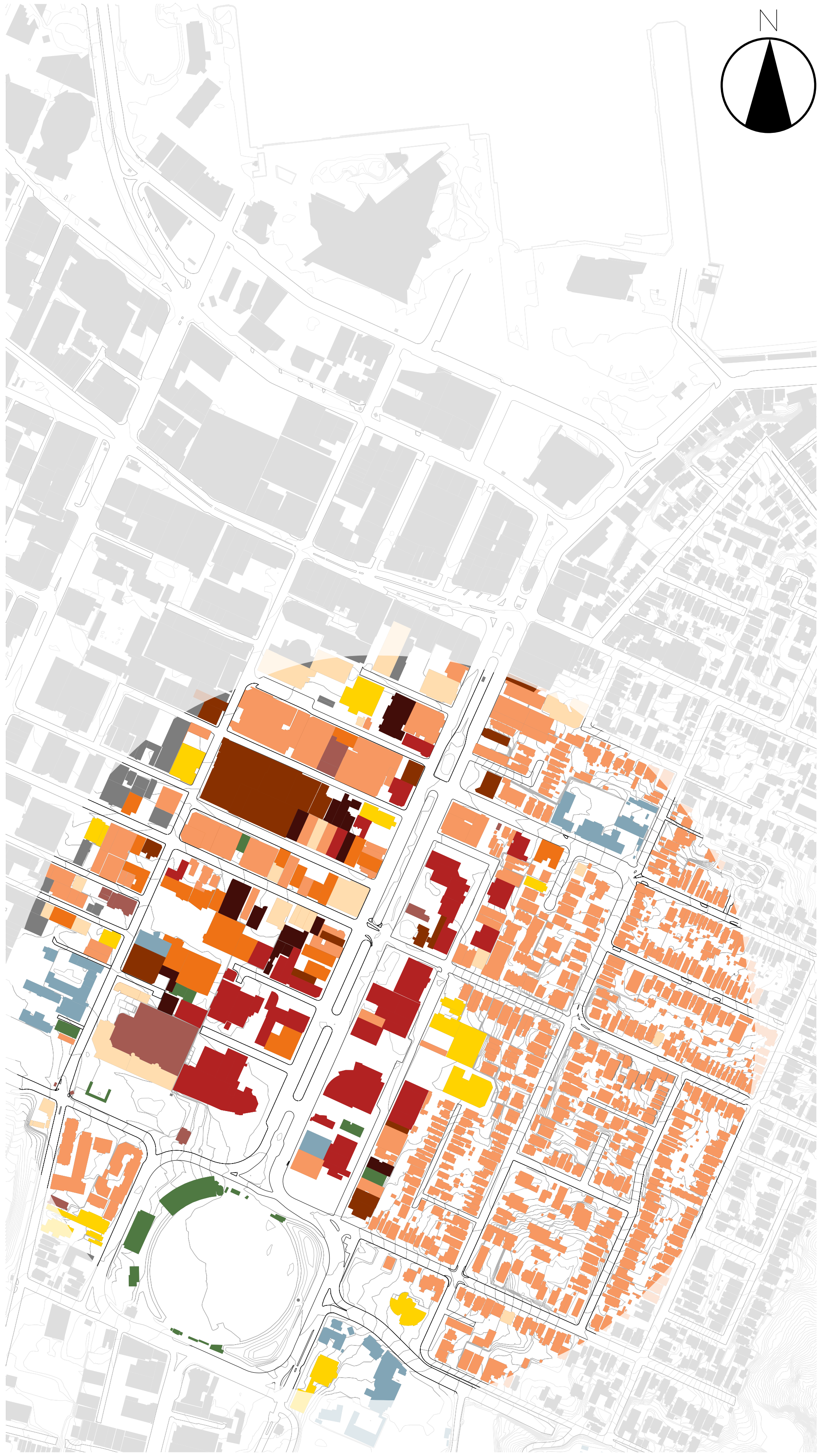
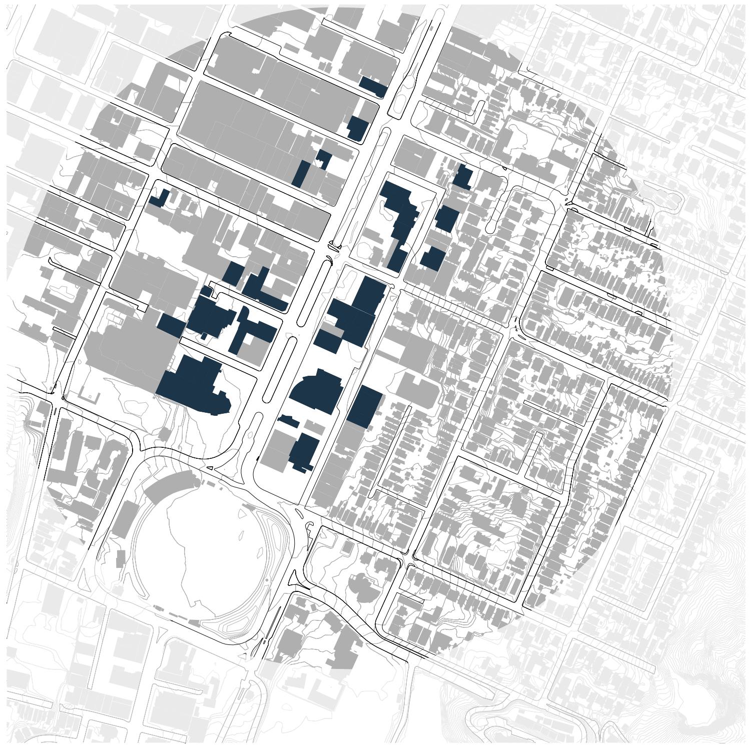


Figure 5.28: Sea Level rise of 1m around the Wellington City coastline.

Right image, Figure 5.29: Permeable figure ground study and flooding analysis to visualise the relationships between the two.



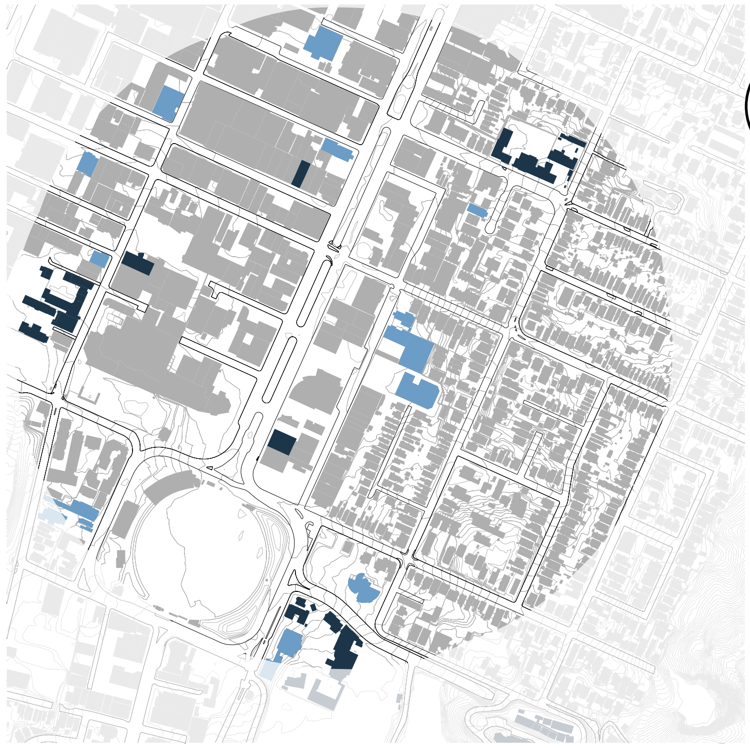


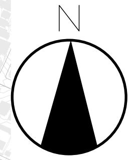


Car Dealerships, WOF/Mechanic, Modifications, Car Parts Store

Residential Housing, Apartments & Hotel/Motels

Figure 5.30: Programme analysis of all buildings in the surrounding context.



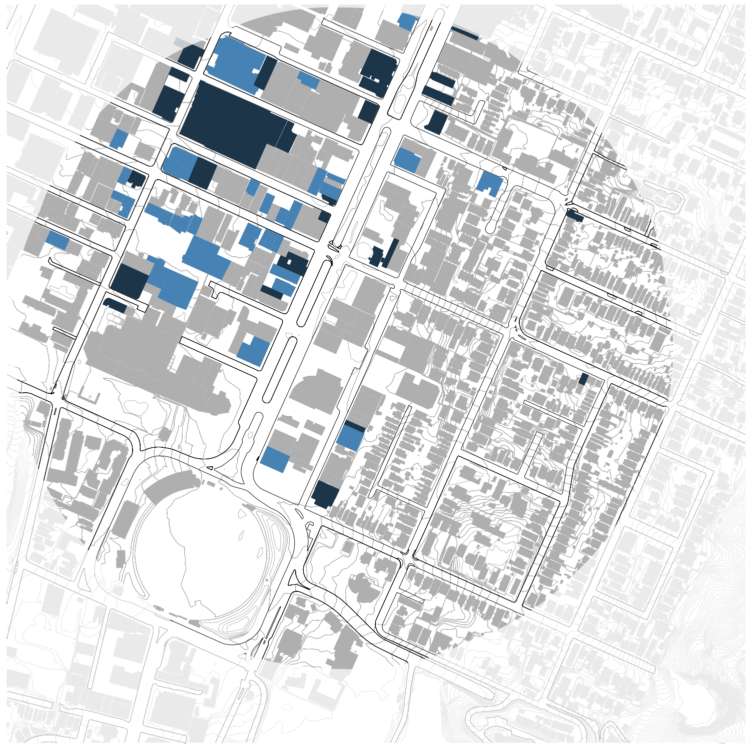


Education, Preschool, Primary & Secondary

Religious Centres, Churches, Stores, Youth Groups

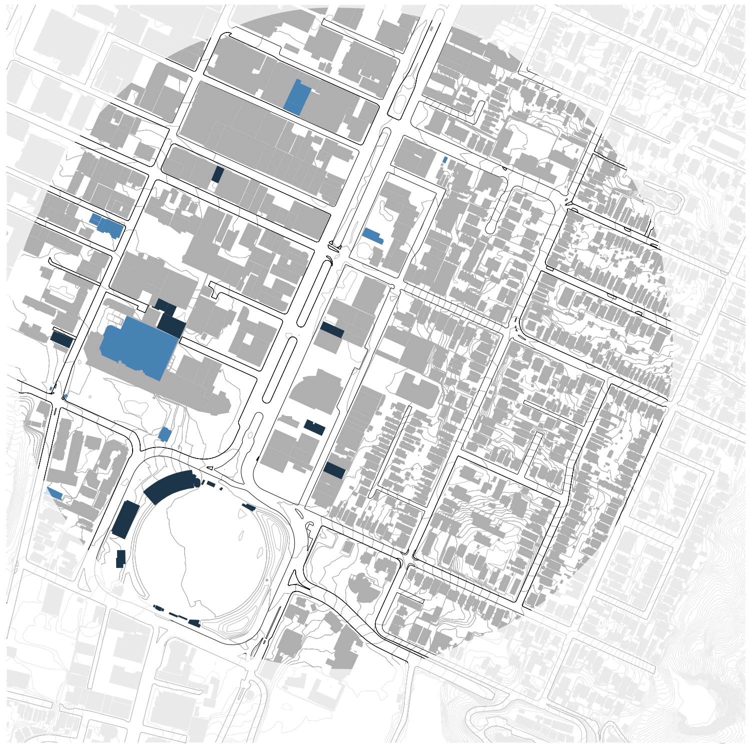
Commercial, Industrial Manufacturing of Goods & Services

Office Buildings, Home Offices



Supermarkets, Corner Stores, Liquor Stores, Cafes/Restaurants

Retail



Sport & Recreation

Other

Figure 5.31: Site map of buildings to remove for a future ecological benefit.

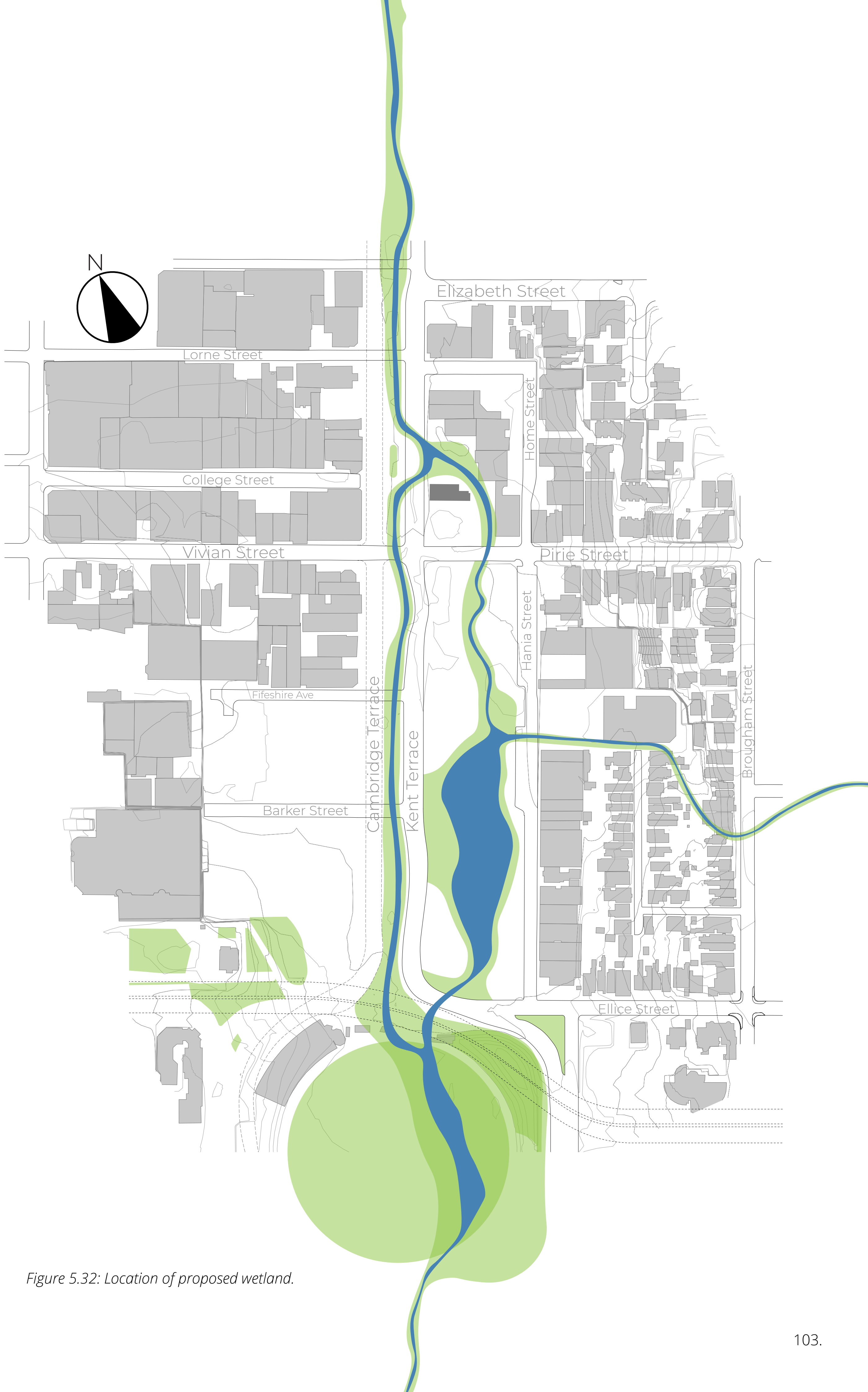


Figure 5.32: Location of proposed wetland.

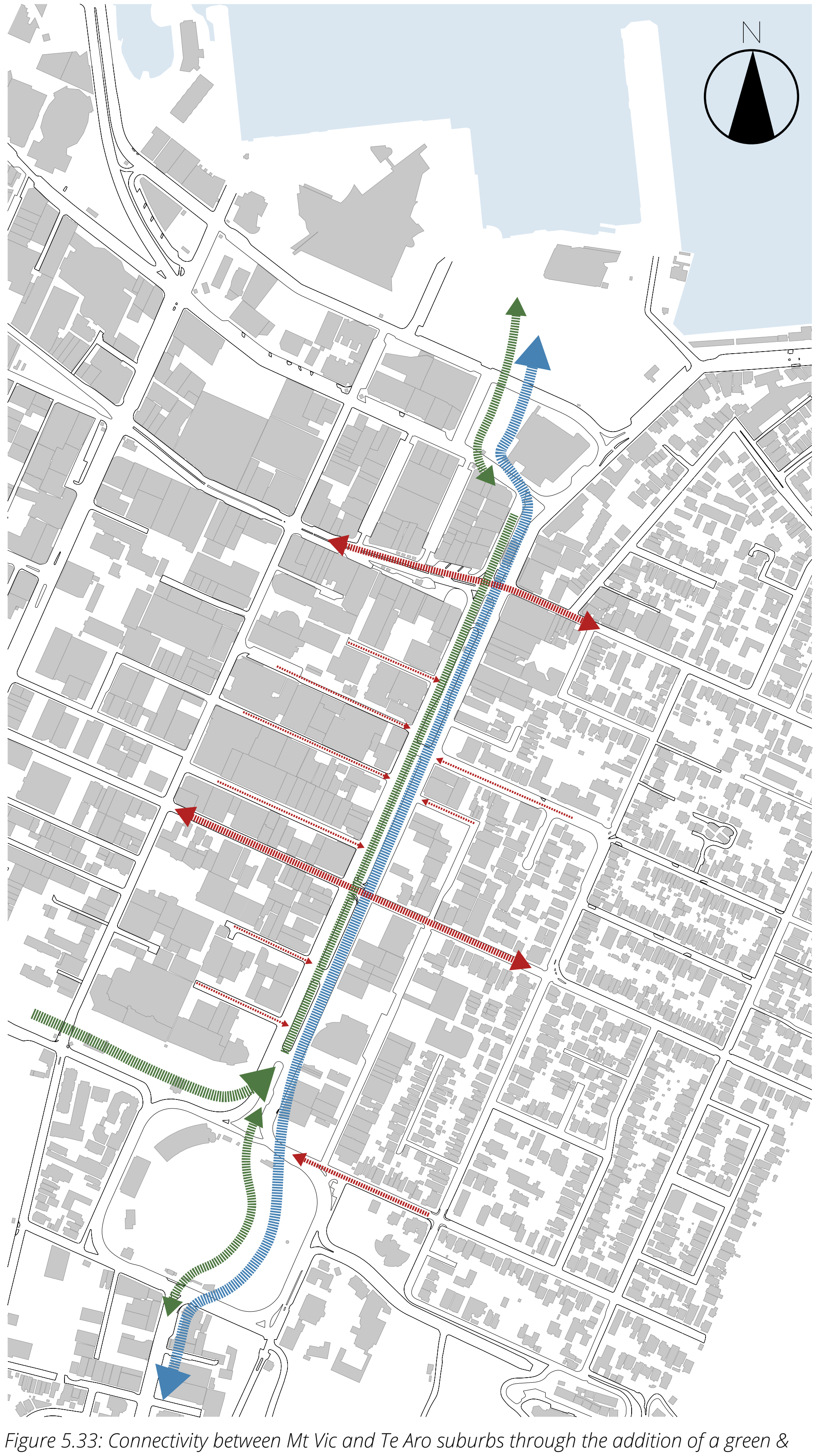
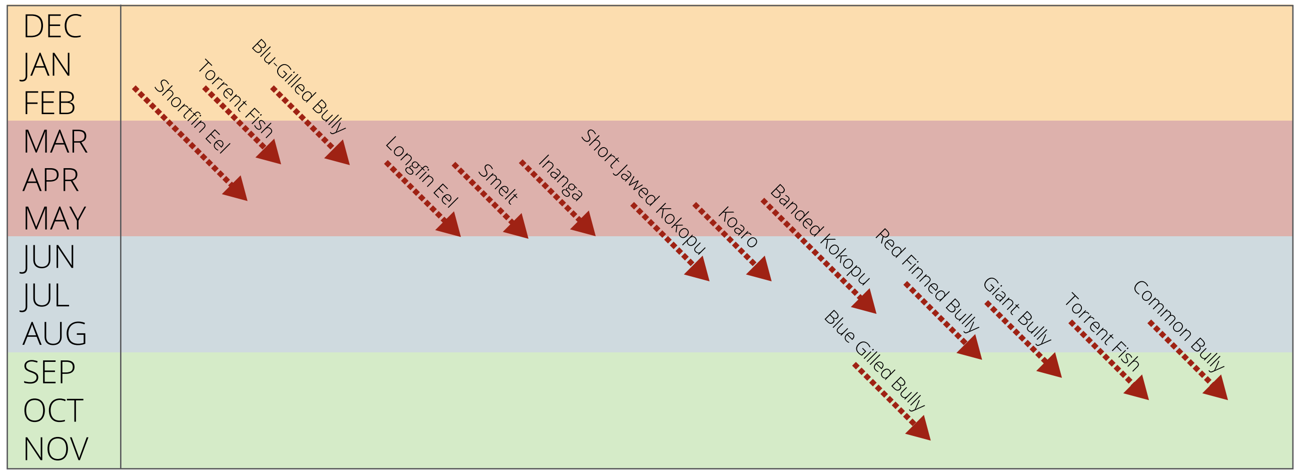


Figure 5.33: Connectivity between Mt Vic and Te Aro suburbs through the addition of a green & blue belt, and reducing vehicular traffic.

5.4 ECOLOGICAL DATA

MIGRATION CALENDER FOR INDIGENOUS FISH

Stream to Sea



Sea to Stream

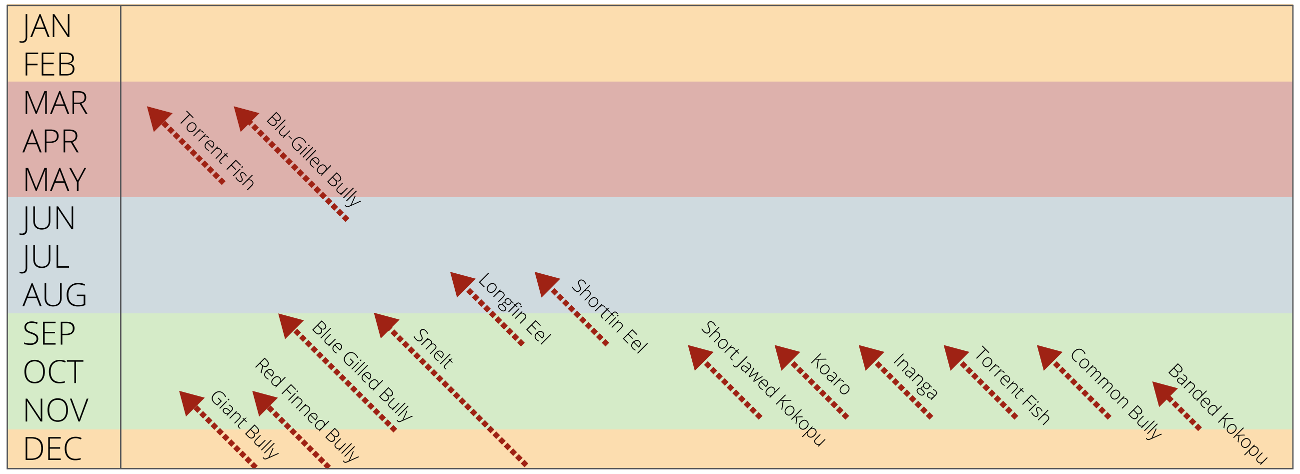


Figure 5.34: Indigenous fish which live in streams migration calender from the Wellington region (Departmnet of Conservation, 2006).

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Figure 5.35: Fish discovered from a study of Wellington's urban piped streams (James, 2020).

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figure 5.36: Fish and invertebrate species discovered in Wellington's urban streams (Harrison, 2019).

There is currently no fish passage (a way that fish can navigate the stream in both directions) from the beginning reaches of Waitangi Stream to the sea. It has been established that reintegrating indigenous fish species back into Waitangi Stream is a viable option. It is also currently impossible for eels (short and longfin) to migrate over from neighbouring urban streams, so fish passage from Waitangi Park with the introduction of a beginning population would be required (Wood, et al., 2010, p. 19). These two species are under pressure throughout New Zealand, so setting up habitat provision in a high-profile location would be productive (Wood, et al., 2010, p. 19). The addition of indigenous fish species, consideration of passage, and planting of a native riparian edge to the daylit stream would help recreate the original stream habitat. This is the basis of the design thesis.

From a Wellington City Council pilot study completed from some of Wellington's urban streams, native fish were discovered in five of the six locations (James, 2020, p. 12). To summarise, the open daylit sections of Miramar and Pae Kawakawa Streams were predominantly occupied by banded kokopu and kōaro (whitebait species when young), waikōura (freshwater crayfish), and inanga. Piped sections were almost exclusively dominated by short and longfin eels (James, 2020, pp. 12,13).

Habitat required for aquatic life of micro-invertebrates and fish species can be significantly improved from what the piped streams currently provide. Ways to improve habitat include increased water depths, more pool habitats, slow water velocities, measures that trap natural substrates and organic materials, and providing cover for fish (James, 2020, p. 29). These habitat modifications provide locations for fish to reproduce and take cover from predators. In addition to these factors, other signs of stream health from the Department of Conservation (2019) that I used to formulate design considerations include:

Signs of a healthy stream:

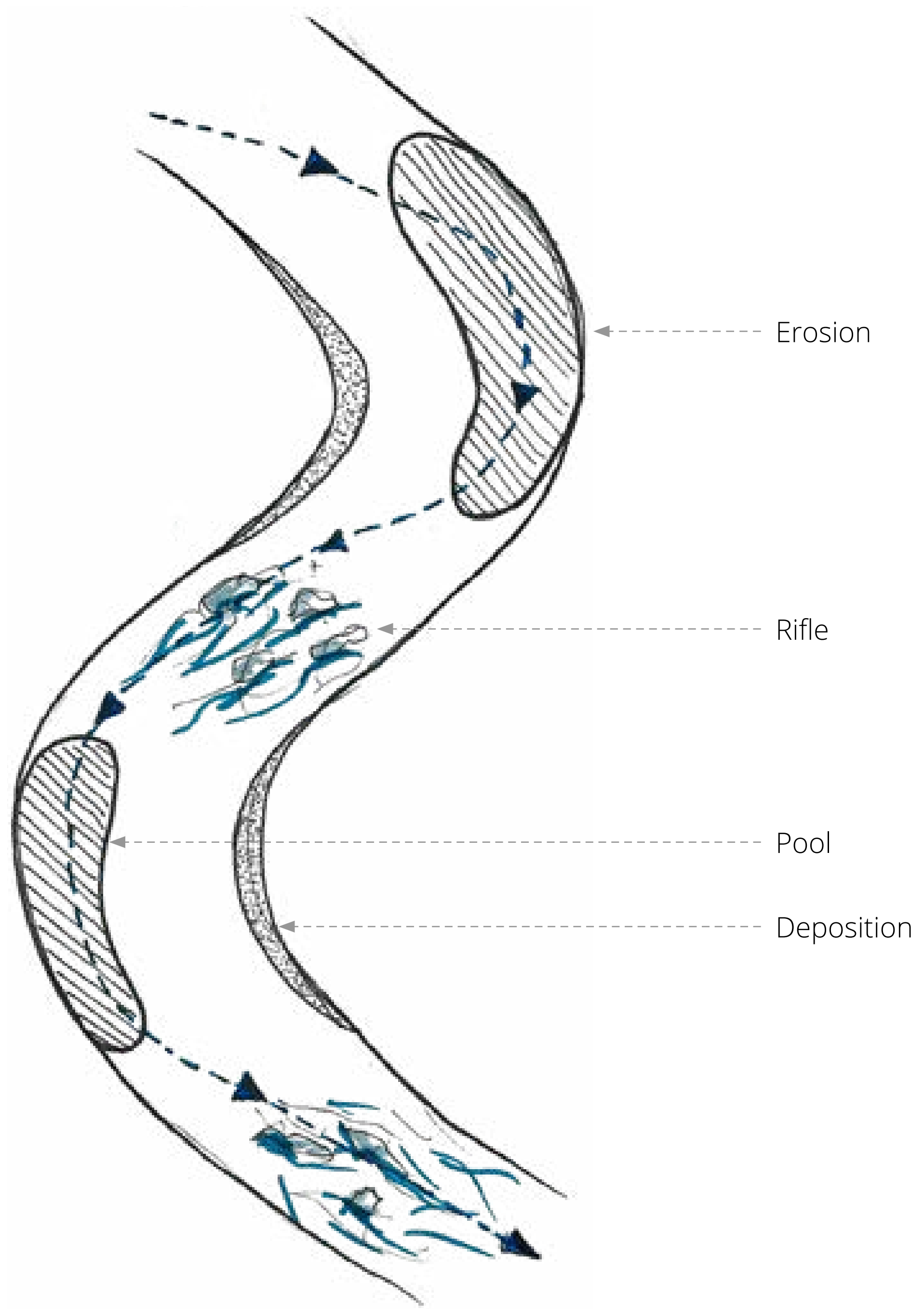
- Cool, flowing and odourless water.
- Deeper water and pools.
- Natural features such as rifles, runs and stony/rocky sections.
- Stream shaded by trees and shrubs.
- Natural habitat for birds and other life.
- Many different fish, water invertebrates and other aquatic animals.
- Algae and water plant growth similar between summer and winter.
- Logs, sticks and leaves along stream bed.
- Stones and plants in stream bed not covered in sediment.
- Rubbish-free environment.

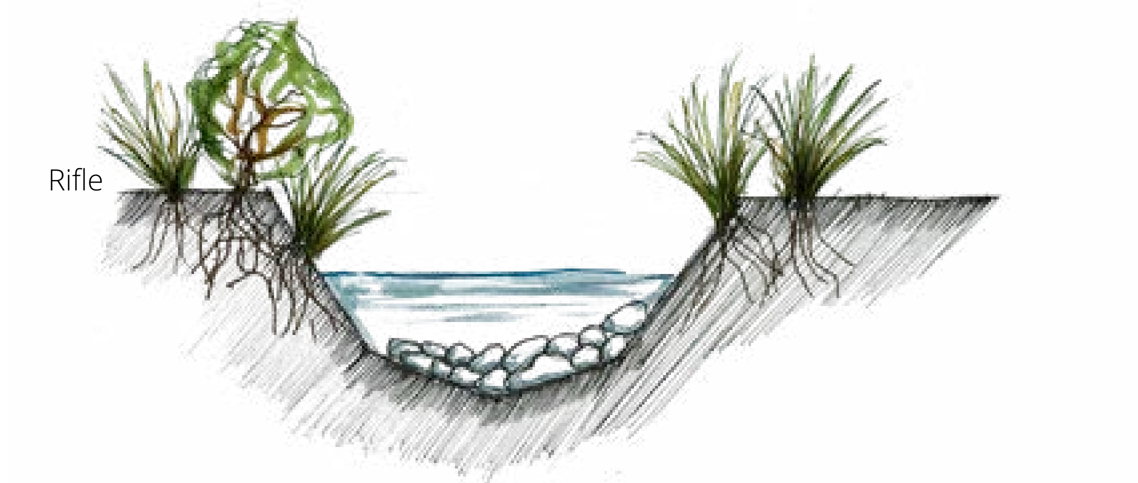
Signs of an unhealthy stream:

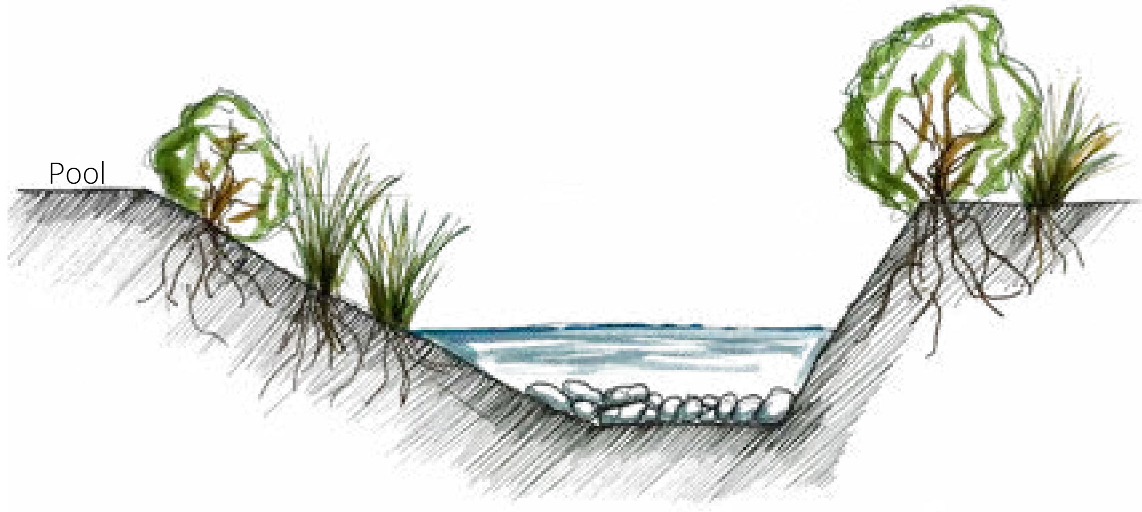
- Warm, stagnant water with bad odours.
- Few deep pools.
- Few natural features such as rifles, runs and stony/rocky sections.
- Weed plants blocking flow and competing with native plants.
- Minimal plant and animal life.
- Stream banks unplanted, providing no shade and causing erosion.
- Excessive algae and water plant growth in summer.
- Stream bed covered in sediment.
- Rubbish, dumped material or slash (logs from forestry) causing blockages.

(Department of Conservation)

SIMPLE STREAM DESIGN PRINCIPLES







LOCAL STREAM HEALTH THREATS:

Hot water Discharge:

Hot water going straight into local streams creates sudden temperature changes to their habitat. These temperature changes can become a physical barrier for fish passage, especially in the case of migrating upstream. Water temperatures should sit below 15 degrees Celsius all year round for optimal stream health (Department of Conservation, 2019). By raising the water temperature, aquatic pests have an advantage over local indigenous species. These simple issues can be avoided by pre-cooling water. Such instances where this could take place is where cars are getting cleaned and fixed up along Kent and Cambridge Terrace. This also provides solid ground as to why intervention in this particular area should occur (Department of Conservation, 2006, p. 18).

Stormwater:

The significant land coverage of impervious surfaces throughout Te Aro and especially within the Waitangi Stream catchment means that very little water can be absorbed into the ground. This increases the rate at which water is discharged into local waterways, causing erosion and flooding in heavy rainfall events. The surface water collects many contaminants, which then accumulate in waterways. The sediments and pollutants collected by stormwater, especially in Wellington, end up in the harbour and can smother the seabed and damage the harbours ecosystems as a carry-on effect (Department of Conservation, 2006, p. 23). According to Izembart and Boudec, (2003), Liptan and Santen, (2017), there are several stormwater mitigation strategies. These helped me to redesign the new Waitangi Stream area along the Terraces. Strategies include:

Stormwater Mitigation Strategies:

- Reduce impervious surfaces (incorporate cobbles and grass swales into site design; minimise road widths; minimise parking).
- Retard the flow of stormwater using detention ponds, wetlands, etc.
- Maximise vegetated areas to maintain long-term infiltration.

TREATMENT STRATEGIES:

Sedimentation (detention ponds and wet ponds):

- Improves with the length of detention time.
- Requires large surface area and low turbulence.
- May not be as effective during heavy rain events.
- Fine particles may require flocculating agents.
- Ponds must have vehicular access for periodic sediment removal.

Decomposition (wetlands):

- Aerobic and anaerobic organisms can break down nutrients and organic compounds. Aerobic organisms may take up contaminants, die, and fall to the bottom of a wetland, where anaerobic organisms may further oxidise the compounds.
- Anaerobic microorganisms can denitrify contaminants, so wetlands are beneficial where stormwater is nitrate enriched.

Remediation Plans:

- Detention ponds are usually dry (accepting water intermittently and slowing water release into stormwater systems.
- Infiltration practices such as soak pits, trenches or porous block pavements for water to be dispersed into the ground.
- Rain Gardens
- Biofiltration and vegetative filters use plants to trap sediment and to retard flow. This allows for a recharge of groundwater.
- Roof meadows act primarily to retard flows during peak events, and if internal flows are slow, to provide a limited amount of absorption of contaminants.
- Artificially created wetlands. A versatile, low-cost option to high-tech solutions and natural ecosystems are made to mitigate such climatic issues, making them a viable solution.

6. Preliminary Design

Chapter six uses the previous chapters' research for developing design concepts through digital and analogue mediums. An iterative design process has applied for this chapter, where explorations into building program, form and detailing have been developed.

6.1 DESIGN STAGE 1

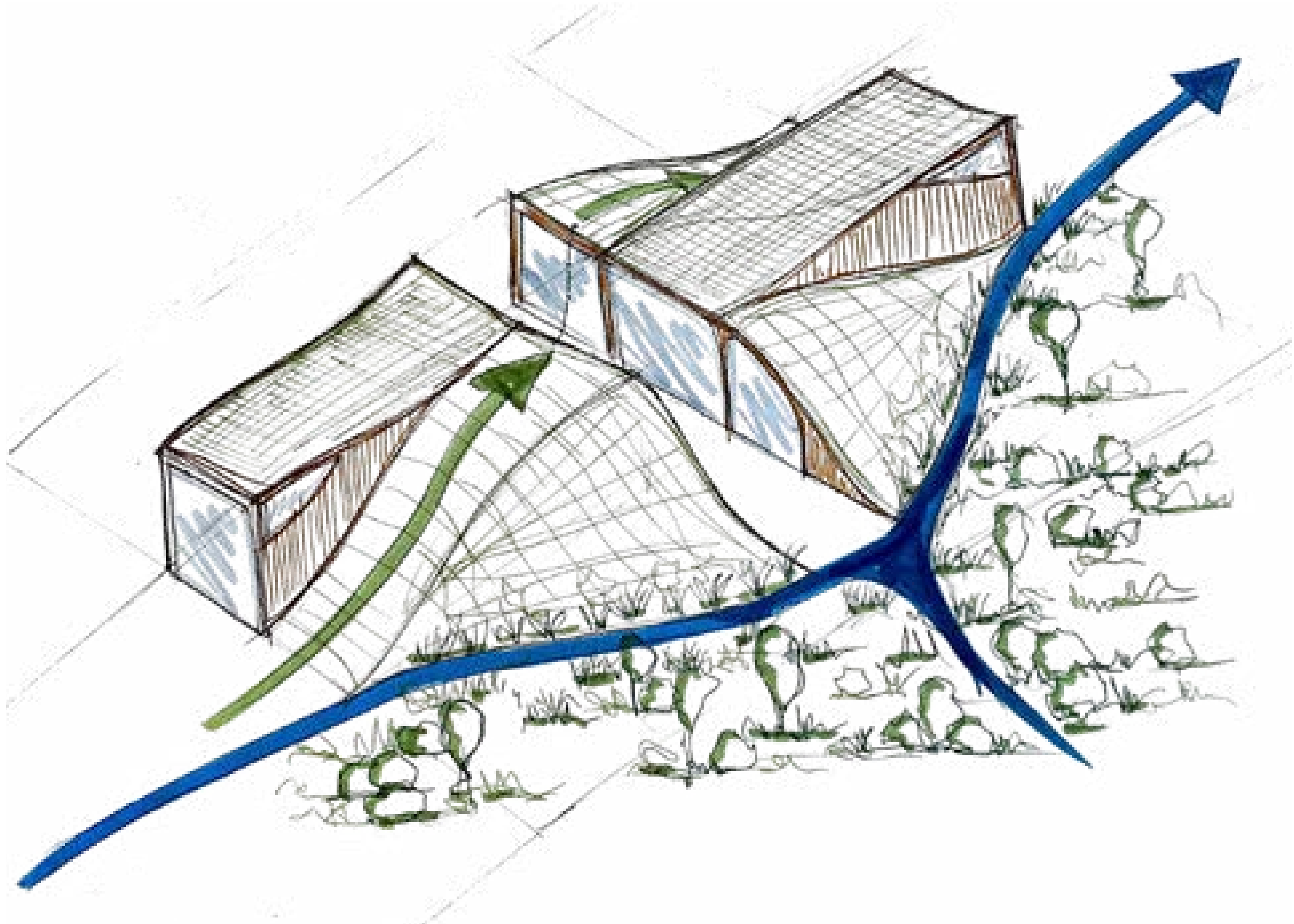
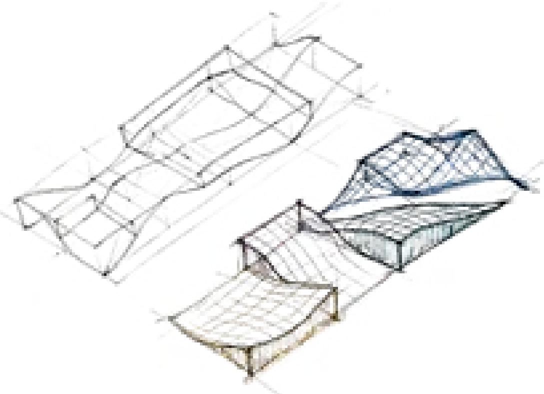
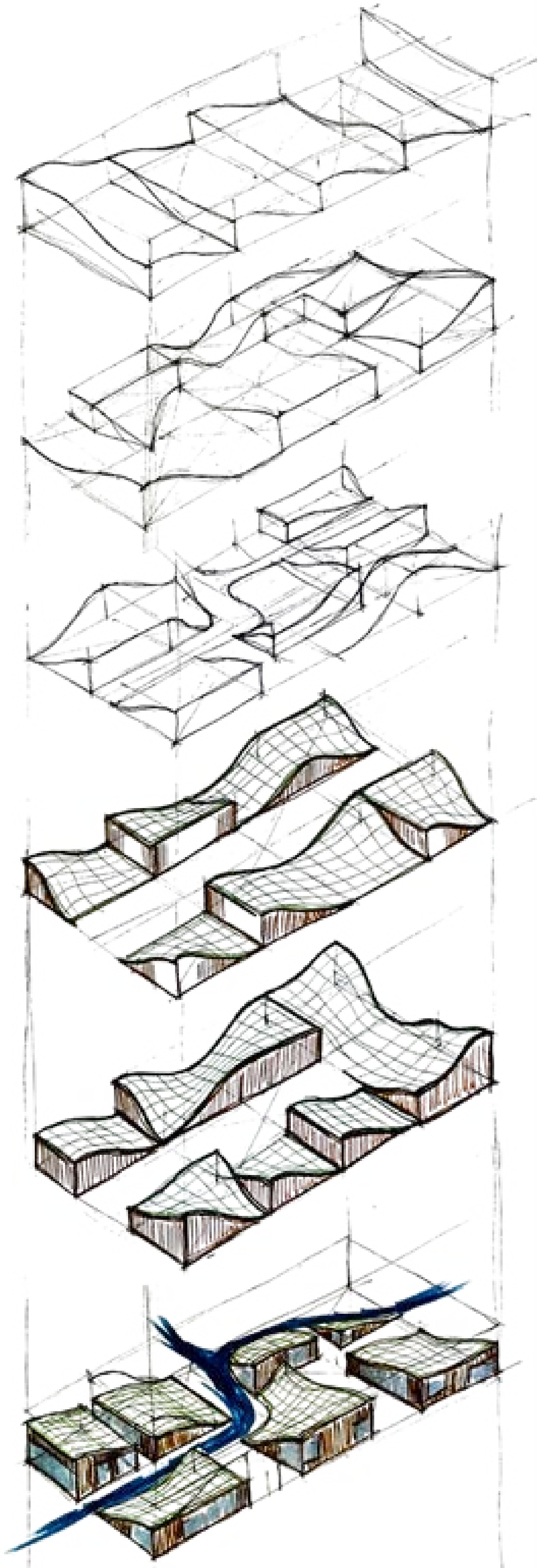


Figure 6.00: Early design form sketch..





The first design stage was entirely hand-drawn due to the impacts of COVID19, making access to digital and other mediums challenging as a student. However, this did create an opportunity for a series of fast design iterations to be formulated for the thesis's desired architectural form and language. Curved undulating roof forms that mimic natural landscapes for the indirect experience of nature were developed.

Difficulties in the early stages of the design process evolved from organising space since the project's scale appeared quite large. The site was initially segmented into three primary sections, the furthest south occupied by public infrastructure/housing, native planting and lagoon land to deal with the purification of water and providing habitat to native species. From the beginning, the site was designed to flood and manage heavy rainfall, so less damage was caused to the city in extreme weather events.

The middle section was dedicated to a research and education centre, where most of the built human orientated architecture is located on-site. An intersection of a small stream from Mt Vic joins the Waitangi catchment at this location as well. The research centre is dedicated to investigating ecological design and native plant species. Combining it with an education centre contributes to teaching people about the need to combat the causes of climate change and the need to adapt to its impacts, especially in our urban centres.

The most northern end of the site is devoted to urban agriculture in practice and the final component of filtering the stream and stormwater that runs through the Waitangi catchment. Greenhouses line the eastern side. The rest of the site is designed to be an intensive permaculture garden so that maximum crops can be yielded organically from the site to support local communities' health and well-being.

Figure 6.01: Massing studies when exploring different forms for integrating onto site.

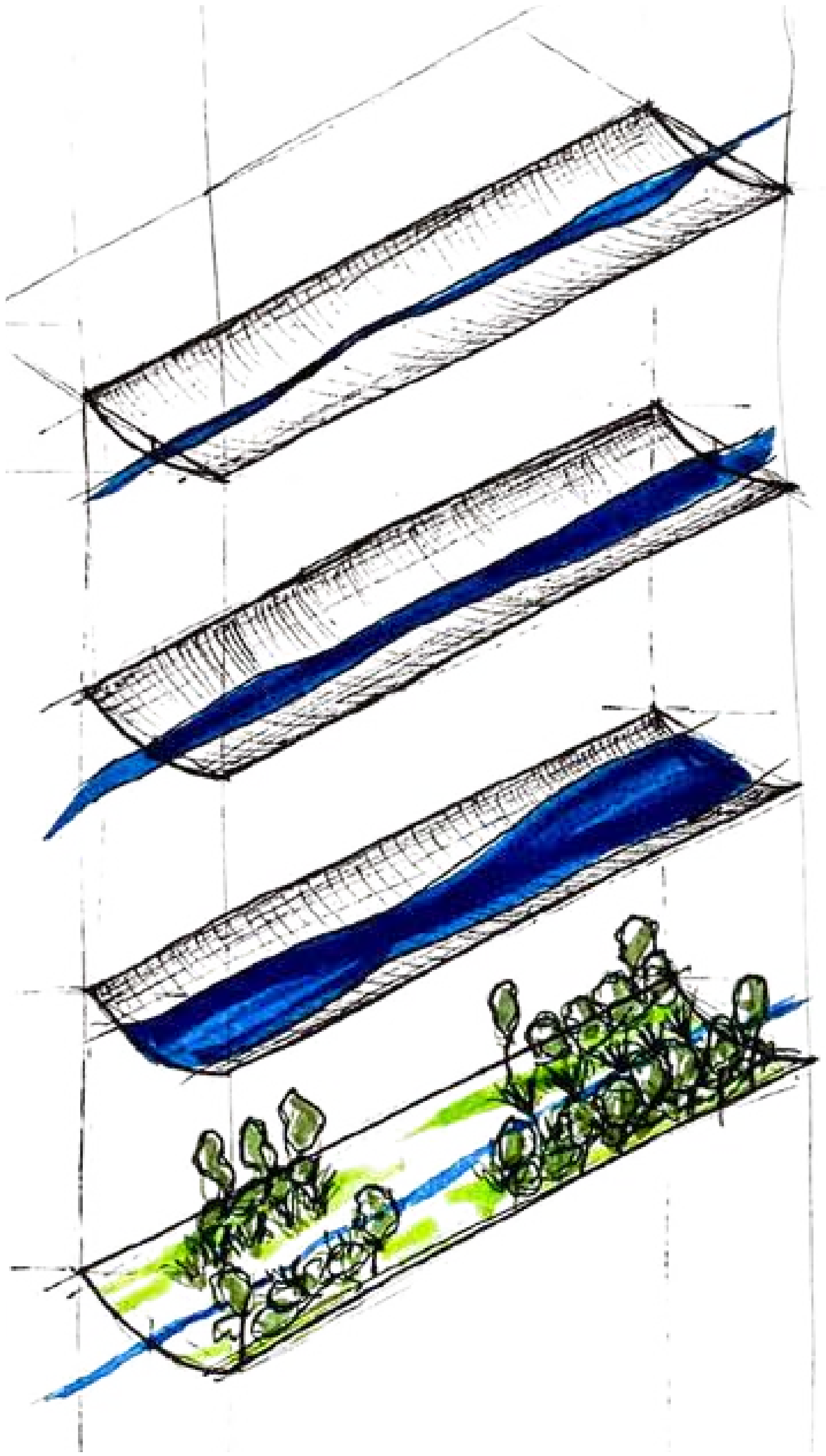
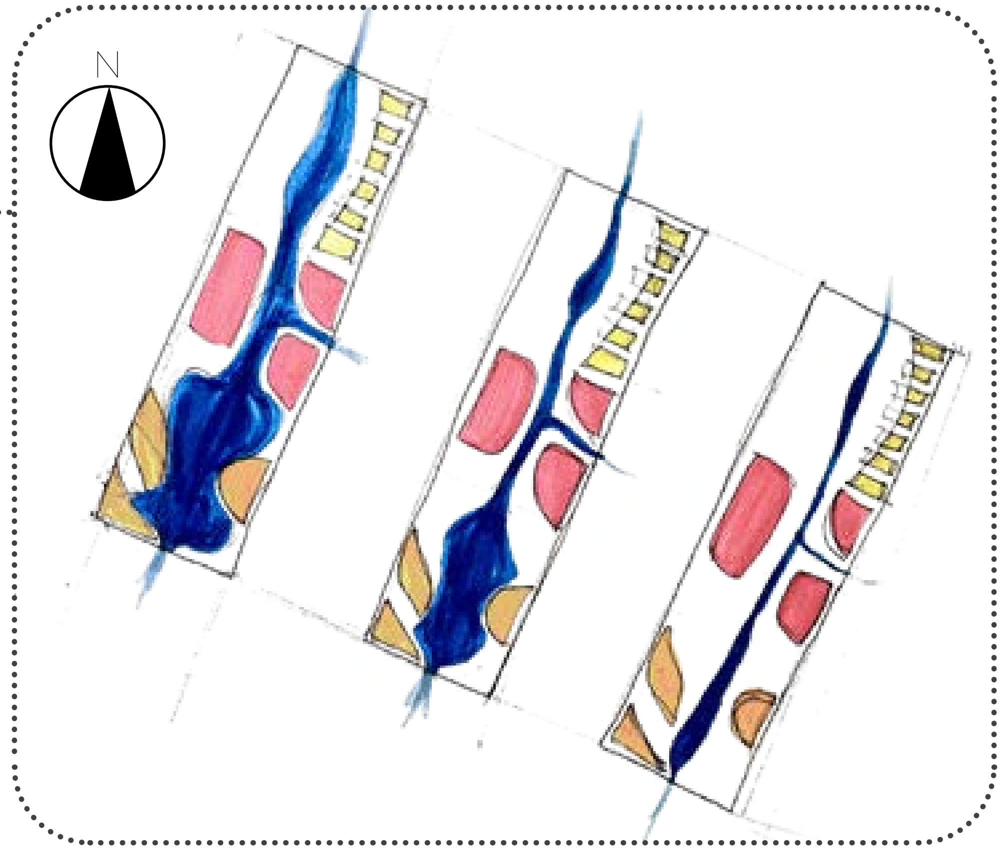


Figure 6.02: Flooding illustraion of the site.



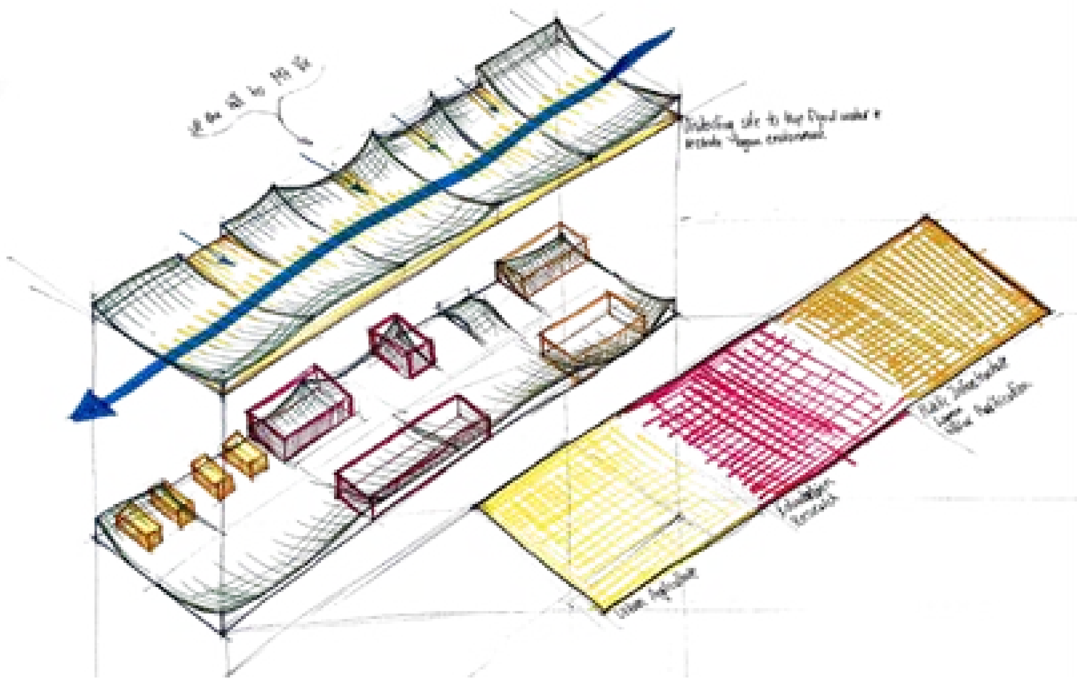


Figure 6.03: Site segmentation into different zones in first design stage.

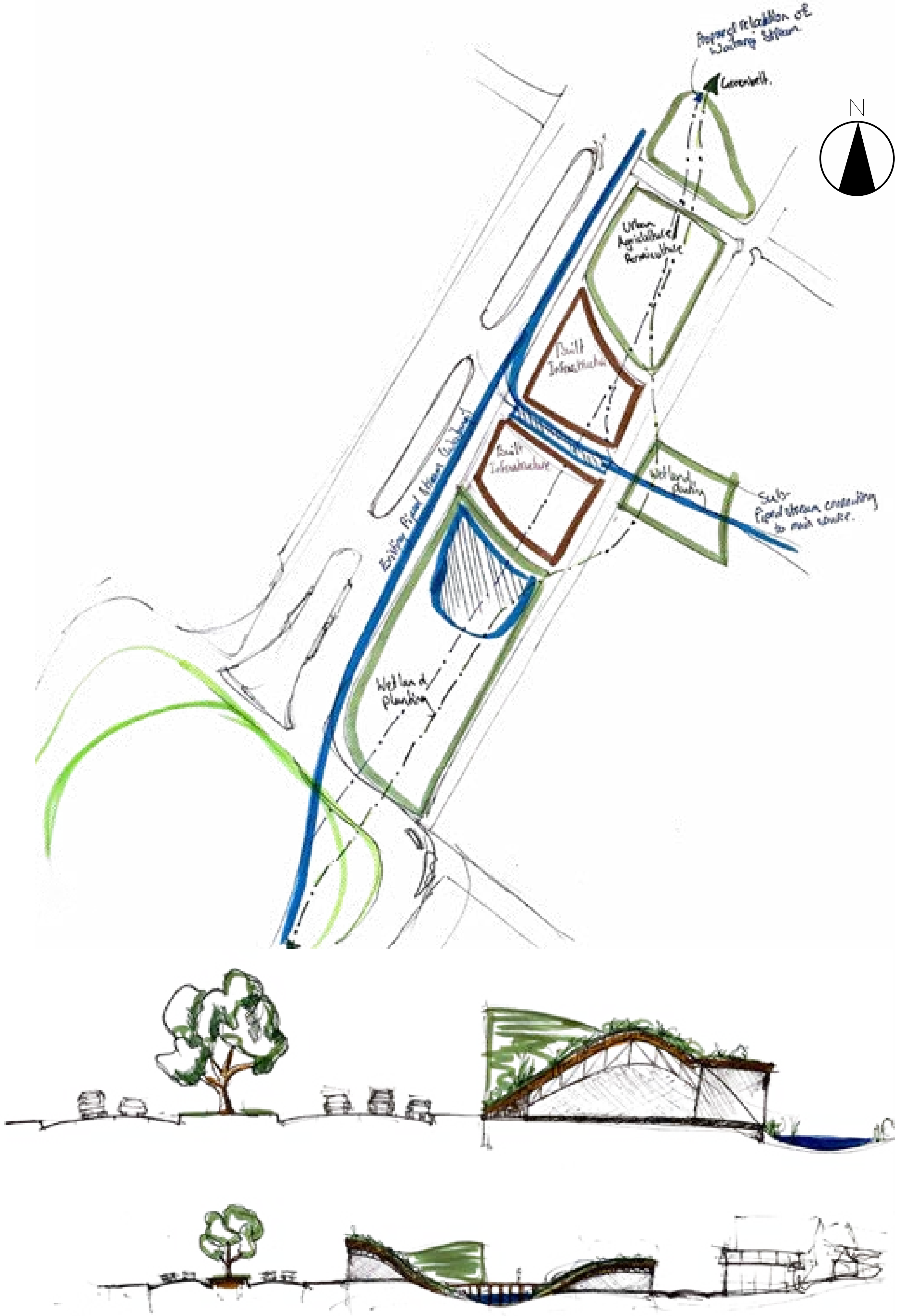


Figure 6.04: Site sections and plan for early attempts at organising different programmes within the surrounding context.

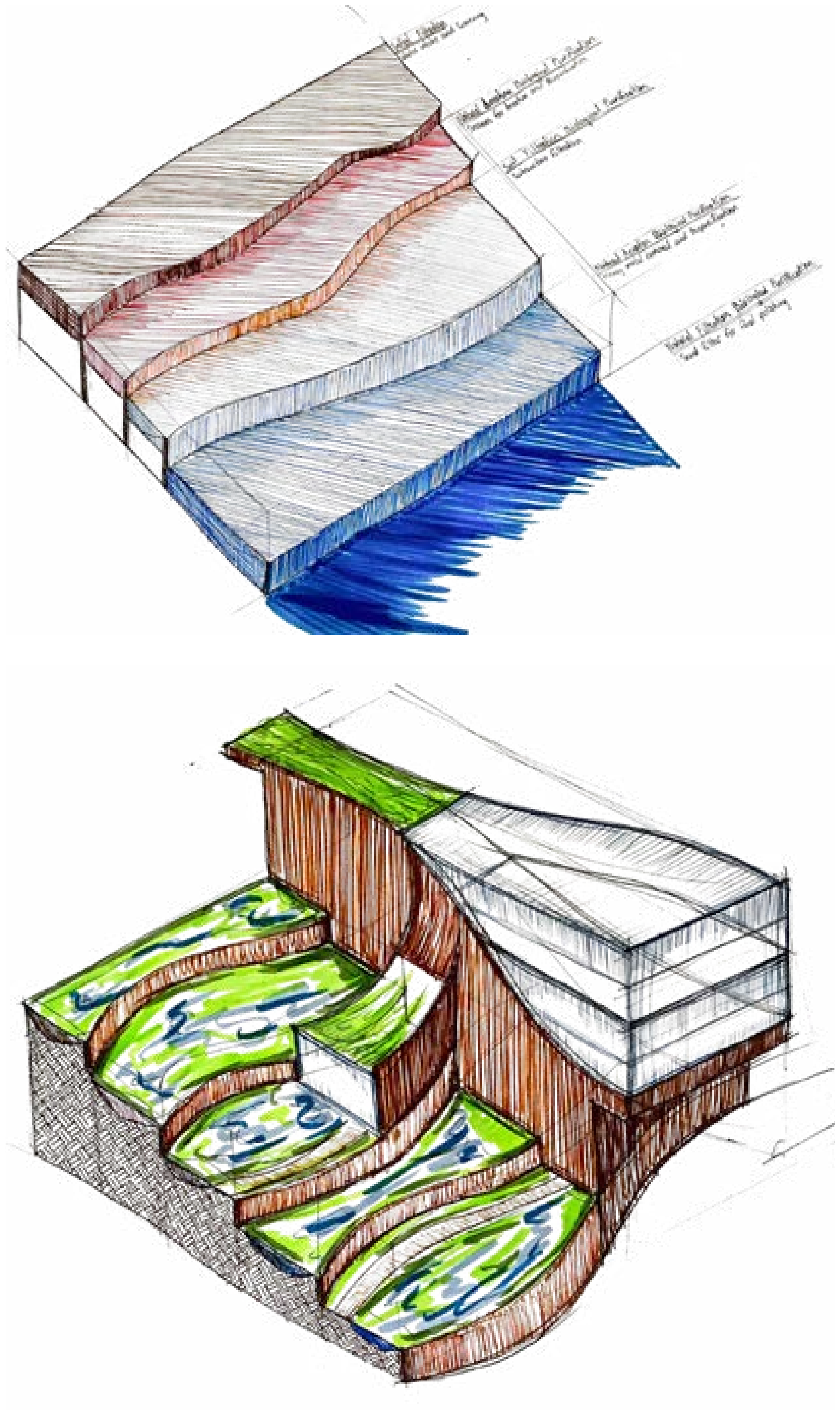


Figure 6.05: Terraced design for water management and reducing slope angle on green roofs.

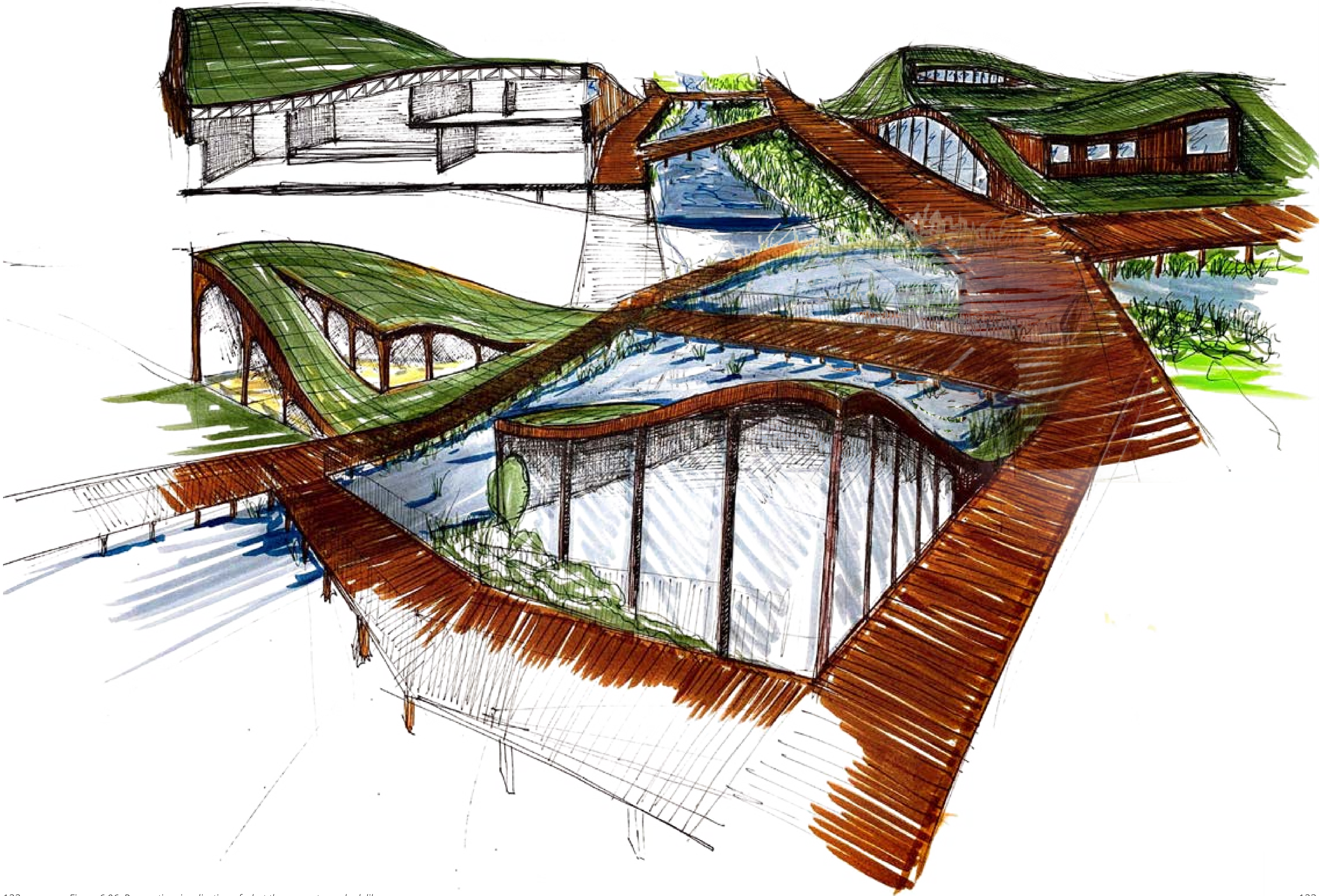


Figure 6.06: Perspective visualisation of what the concept may look like.

6.11 REFLECTION

Work was reviewed after three months. The 3-month review consisted of a 15-minute presentation, followed by a 15-minute critique. The work presented to reviewers was the biophilic design framework (see section 3.2), a detailed site analysis, and the concept from design stage 1, *(figure 6.06)*.

Feedback provided by the reviewers questioned how the architecture fits into the surrounding built context. The proposed form did not relate to existing surrounding architecture due to creating a provocative and explorative design concept. The reviewers said this was not a poor design decision but would need solid reasoning as to why I chose to work with an organic architectural form. Consideration of building scale and program would facilitate a transition from the suburb Te Aro, to the residential and heritage architecture of Mt Victoria. I was asked to consider what does the central city need for the capital's future growth to benefit both ecosystem services and human well-being?

One of the more significant aspects of the critique related to the choice of programme for the given area. The proposal of having an education and research facility did not come across as convincing. With a continuously growing need for homes in the central city, residential building demand is a pressing issue. Te Aro's suburb has a projected growth of 7000 people by 2043 (Blaschke, et al., 2019, p. 37). A 91.8% increase in population for the suburb compared to an average of 15% for Wellington City by the same date (Blaschke, et al., 2019, p. 37). If all the car dealerships were to be removed, there is plenty of developable land through Te Aro's eastern side. This is important because with the increase in population, a growing need for more green and blue spaces to ensure occupants' health and well-being is maintained and not damaged by the densification of the city (Blaschke, et al., 2019, pp. 41-42).

The addition of the proposed green/blue belt would also increase land values due to the access to high-quality urban green/blue spaces, thus improving the economic value of land in the central city (Browning, Kallianpurkar, Ryan, & Labruto, 2015). Combining urban agriculture into Wellingtons' central city living is an exemplary model for urban living that could be created in New Zealand (Ackerman, et al., 2014). A more sustainable focus on how people live can be incorporated into urban life and become beneficial to the surrounding ecosystem habitats, as illustrated by my design concepts. Kent and Cambridge Terraces have the potential to develop into a new hub of social activity rather than remain a car-orientated and ecologically damaging stretch of busy, noisy road.

Further feedback suggested making the overall scheme more radical by removing most vehicular traffic along Kent and Cambridge Terraces. This would give more space for designing a blue and green belt easily accessible by occupants in the central city and contributing to urban agriculture. Careful urban design work would be needed to plan where and how traffic could be redirected. Such a bold move would also facilitate towards a car-free central city for the future. Proposals such as the light rail scheme that have been suggested in recent years could become the means for transporting people more sustainably (Warren and Mahoney Architects, 2018; Opus, 2018). In addition to radically changing the city's streetscape, the reviewers proposed turning the basin reserve cricket grounds into a different kind of space with more of an ecological focus. Despite this being an iconic central sports facility, the basin reserve sits unused for much of the year. It creates various traffic and ecological problems, particularly related to flooding, as described in section 5.3. Rethinking how the city can be shaped without this cricket ground provides many opportunities for developing habitat and increased cultural and recreational activities.

The need to design at both the micro and macro scales was also an important point made by reviewers. For example, there is the need to understand the whole catchment region of Waitangi Stream and its impact on the city fabric. On the other hand, creating microhabitats for species and the detailing of resolved architectural design were also key aspects to explore as the design progressed.

The connection people have with the water was brought up and thought to be crucial. I was asked to consider what the streams connection and significance holds culturally, historically and ecologically? Following along from the role water has in the design, understanding what each space will feel like as a whole sensory experience holds great importance. How do these spaces make someone feel? I needed to relate my work to the biophilic design framework more carefully about how these spaces impact on people's interactive experiences.

These were the critical points discussed after the three-month review. Programmatically, a more convincing people-centred approach was required; grasping the design intervention scale, and being radical with the design moves would enable the thesis to question how the whole city functions for a regenerative future.

6.2 PARAMETRICS

In its simplest form, parametric design can be defined as a method of generation or exploration of ideas (Wortmann & Tunçer, 2017, p. 174). In architectural practice, there are six overlapping applications of parametric design. Three of these applications directly apply to the scope of this design-led research. These are the translation of ideas into parametric models, the control and setting-out of architectural forms, and the generation of design variants based on either efficiency or optimisation (Hudson, 2010). By using these different methods with the design tools available, many iterations can be explored and produced to get a desirable outcome. The way parametrics is applied in this thesis allows for greater control over the design's outcome than running simulations to develop an architectural built form that responds to its environment. Exploring Organic and natural forms found in nature was used to define the architectural language. Through drawing inspiration from the natural environment, the designed forms convey qualities discussed in Kellert's (2015) definition of biophilic design, specifically, the category of indirect experience of nature.

My method of developing architectural form uses the design tool Rhino with the plugin Grasshopper. Additional plugins into Grasshopper were used to provide a more flexible toolset for producing meaningful work. This expanded toolset enabled various design iterations to be created based on parameters from the surrounding context. Derived out of the wide variety of design solutions, the best outcomes were further developed. Many argue that parametric design can take away the authorship from architects (Zarei, 2012, pp. 87-88). However, when the user defines the different parameters and constraints, the authorship of the built outcome is driven by the designer's critical thinking and analysis (Zarei, 2012, p. 83).

Using the program grasshopper as a design tool, solutions that typically cannot be thought up and easily visualised by an individual can be realised and adapted. Parts of the design process can be sped up, and new innovative solutions for form, structure, and efficiency can lead to highly successful outcomes (Zarei, 2012, pp. 81-83).

How the software is applied in this research project has been used to replicate a natural hill form that responds to how a pre-colonised stream would behave, but with human interactive elements built into the design. There is also the optimisation of the structural form to cut back on building materials without losing out on the designers desired outcome of architectural language.

Plugins with Grasshopper used in this project include:

1. "Bison" is a landscaping tool that allows for manipulating the surrounding land formations to allow for a healthy stream and surrounding landscape design.
2. "Pufferfish" is a tool that enables the user to manipulate digital form with more ease to get preferred design outcomes.
3. "Millipede" for its ability allows for the structure to be optimised for reducing the amount of material going into the building so the design can become more sustainable from the initial build.
4. "Kangaroo" is a physics solver used in early explorations of form when exploring initial conceptual designs.
5. "Ladybug" is an environmental design tool that uses weather data and information from the surrounding context to develop complex site data analysis.

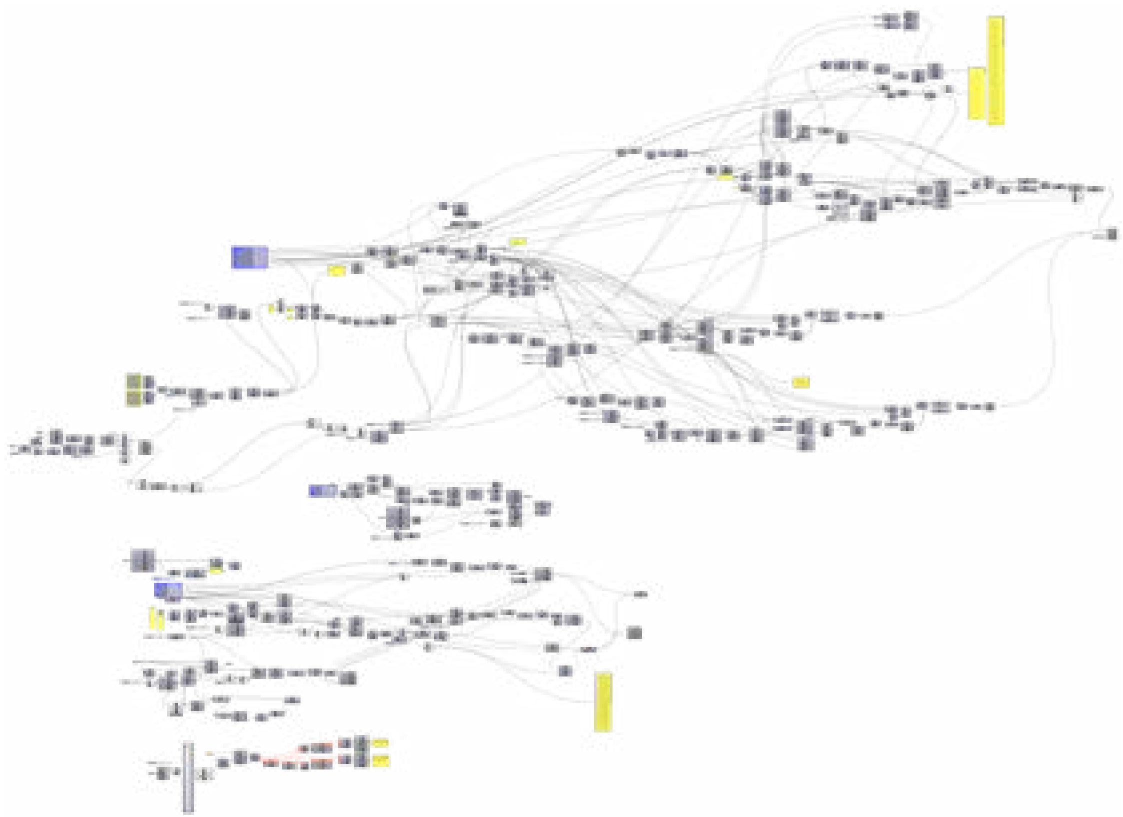


Figure 6.07: Grasshopper script used for creating the final designs facade.

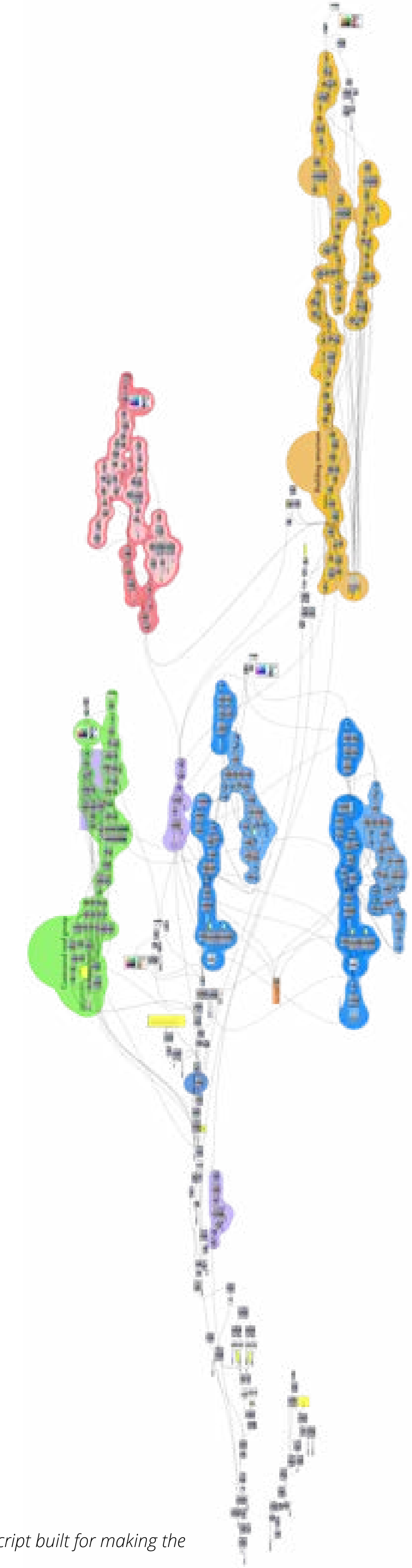


Figure 6.08: Grasshopper script built for making the first digital concepts.

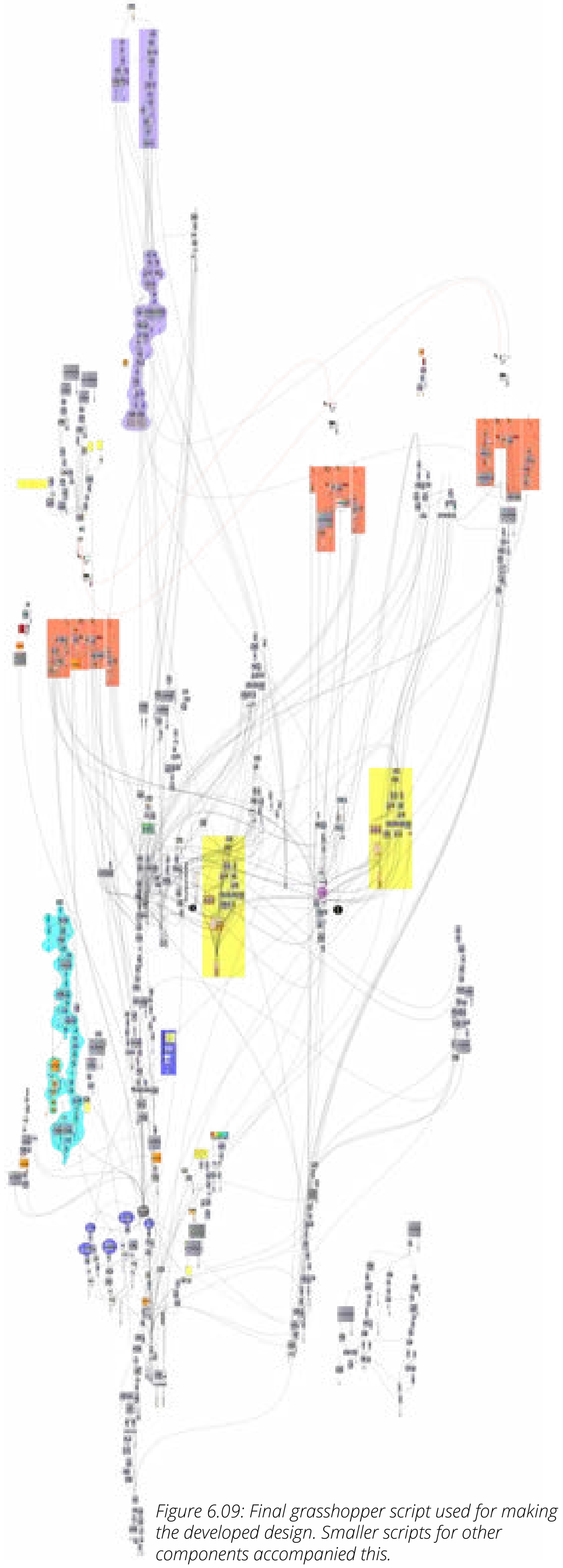


Figure 6.09: Final grasshopper script used for making the developed design. Smaller scripts for other components accompanied this.

6.3 DESIGN STAGE 2

The second design stage began by using the digital medium and focusing on building program after the feedback provided in the three-month review. A community centre was visualised first in the second design stage, where Grasshopper was used to generate 132 different configurations. The difference in each design evolved from the overall form, structure, and roof terracing. A form was derived by having many design iterations, which followed the design language that began in the sketched stage. The digital models took parameters from stream data, surrounding context, and landforms, then translated them into a physical structure. For maintaining a fast design process, the spatial organisation of programs was completed through hand-drawn mediums.

For the approaching 6-month review, a program inspired by urban agriculture was the development of a permanent farmer's market structure. Fresh produce and local goods could be sold to support local businesses and transform the area into a thriving social activity hub.

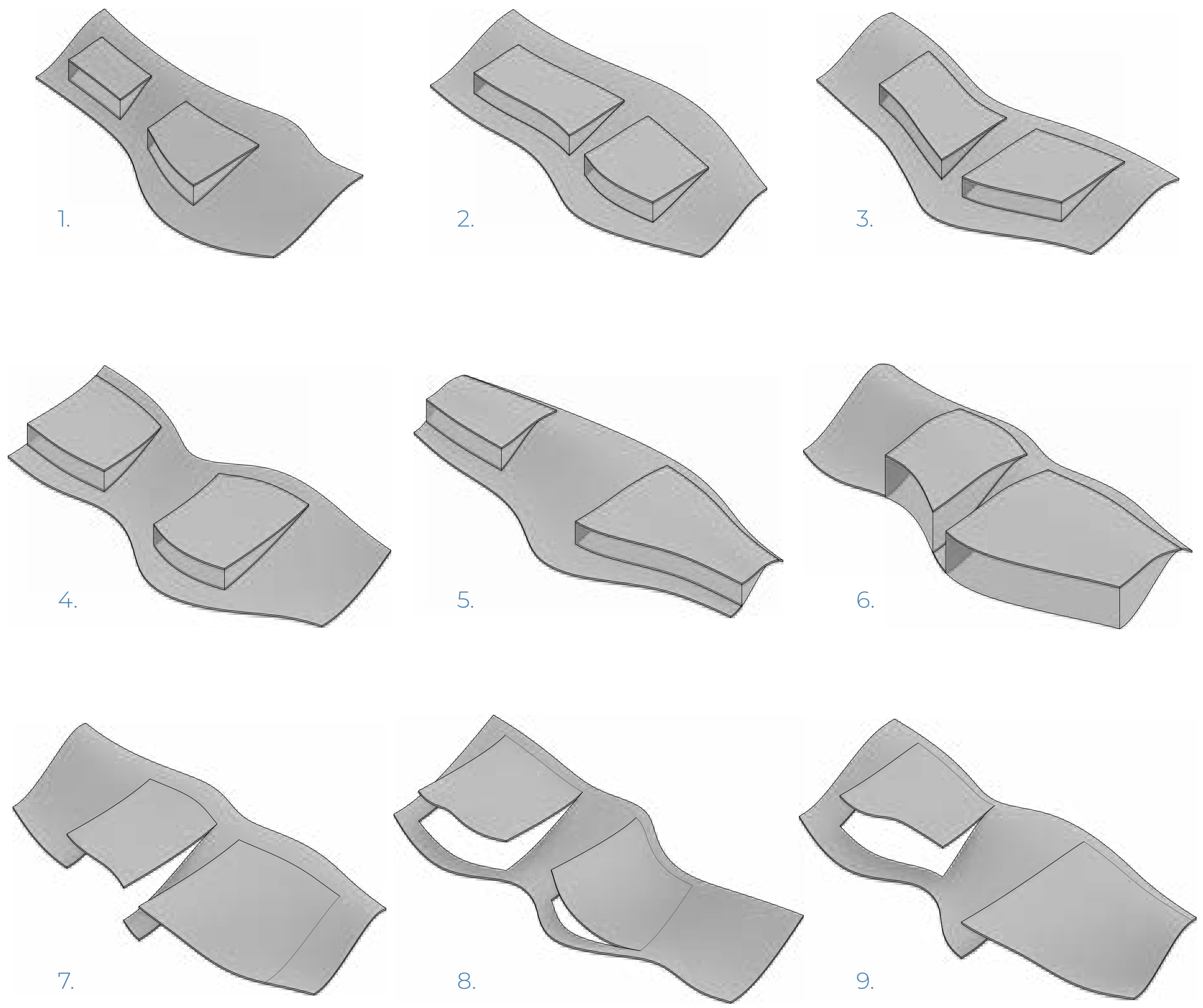


Figure 6.10: Massing models from the first grasshopper script exploring form for the Community Centre design.

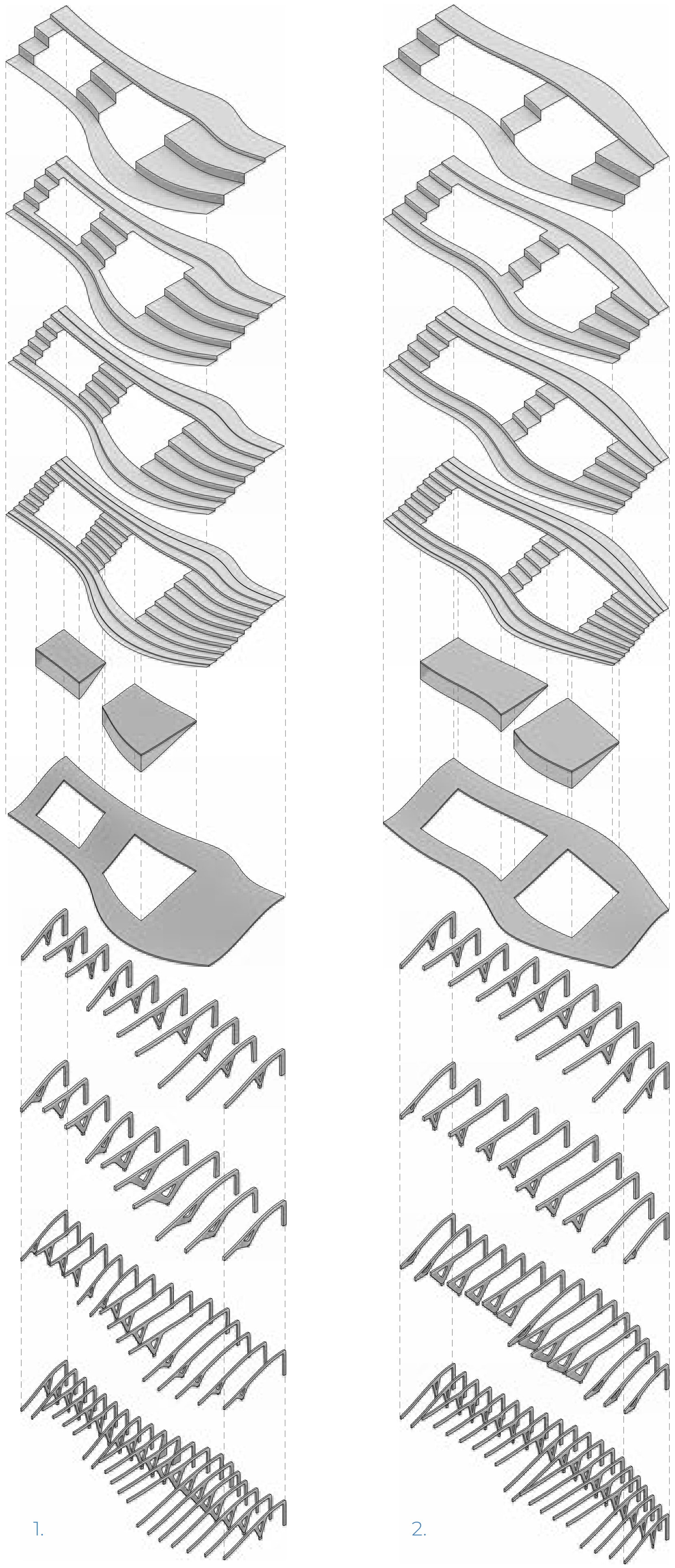


Figure 6.11: Design concepts 1 & 2 exploring terracing, form, and structural design.

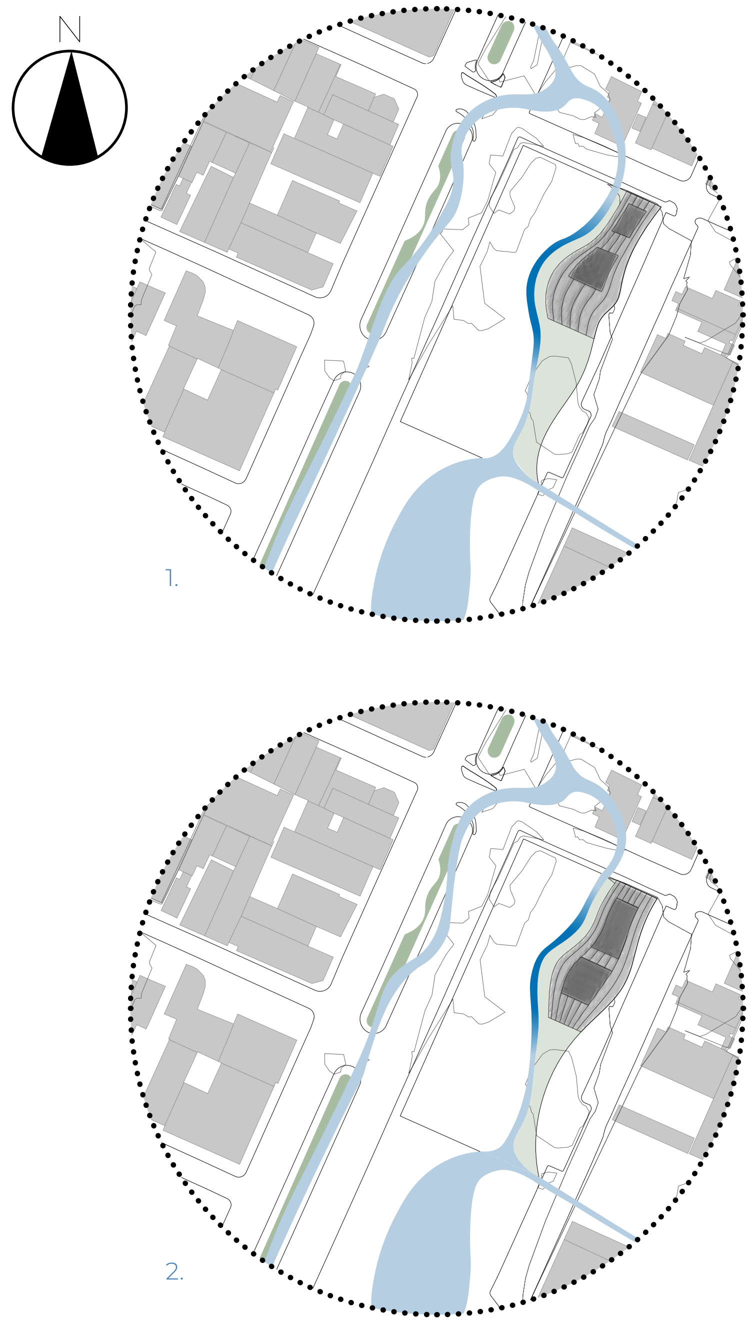


Figure 6.12: Design concepts 1 & 2 site plans for seeing their relationship to the surrounding built environment and daylit stream.

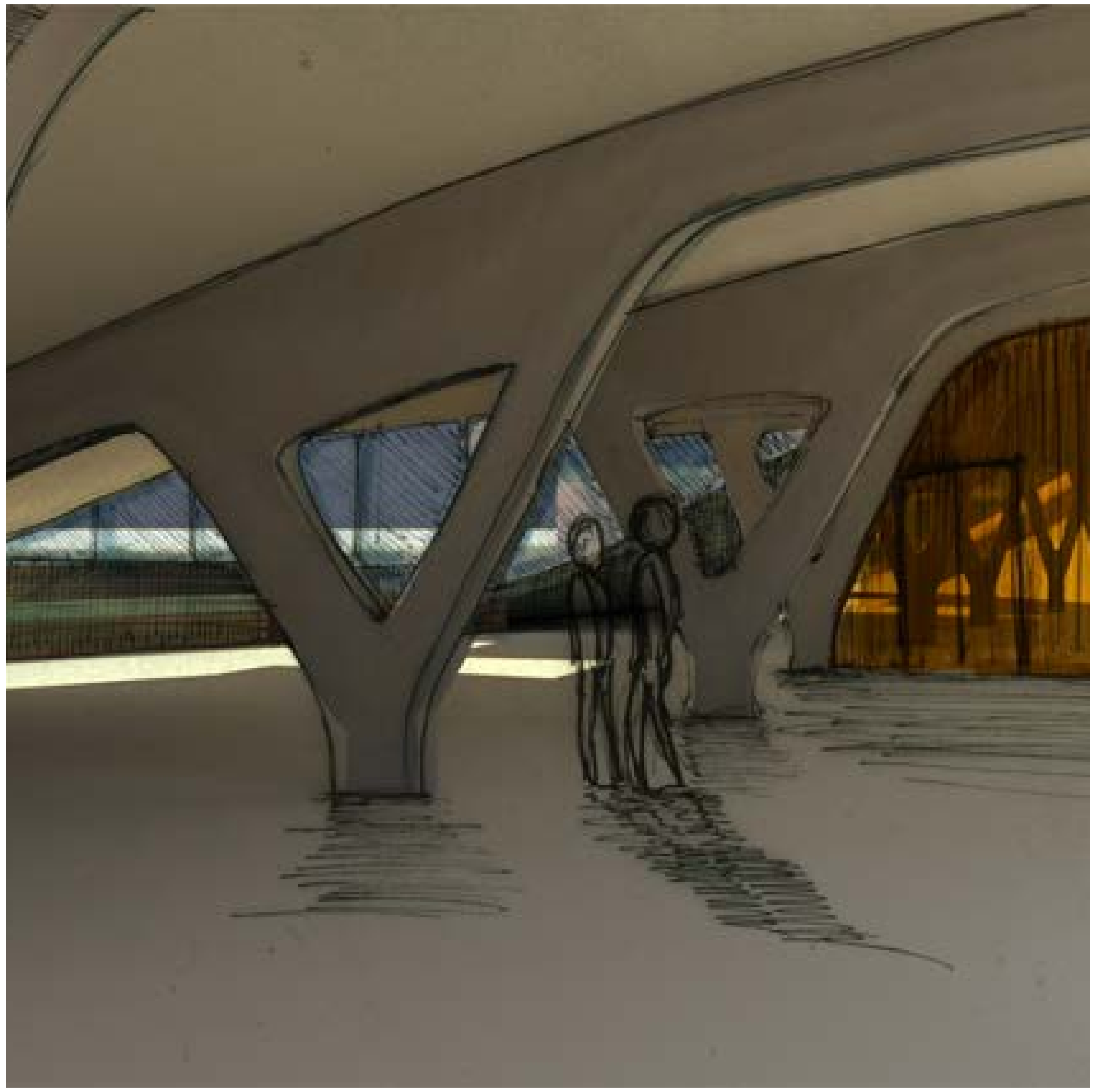


Figure 6.13: Interior render of design concept 1 showing exploration of material and form.

Figure 6.14: Exterior render of design concept 1 showing terracing and plant application.

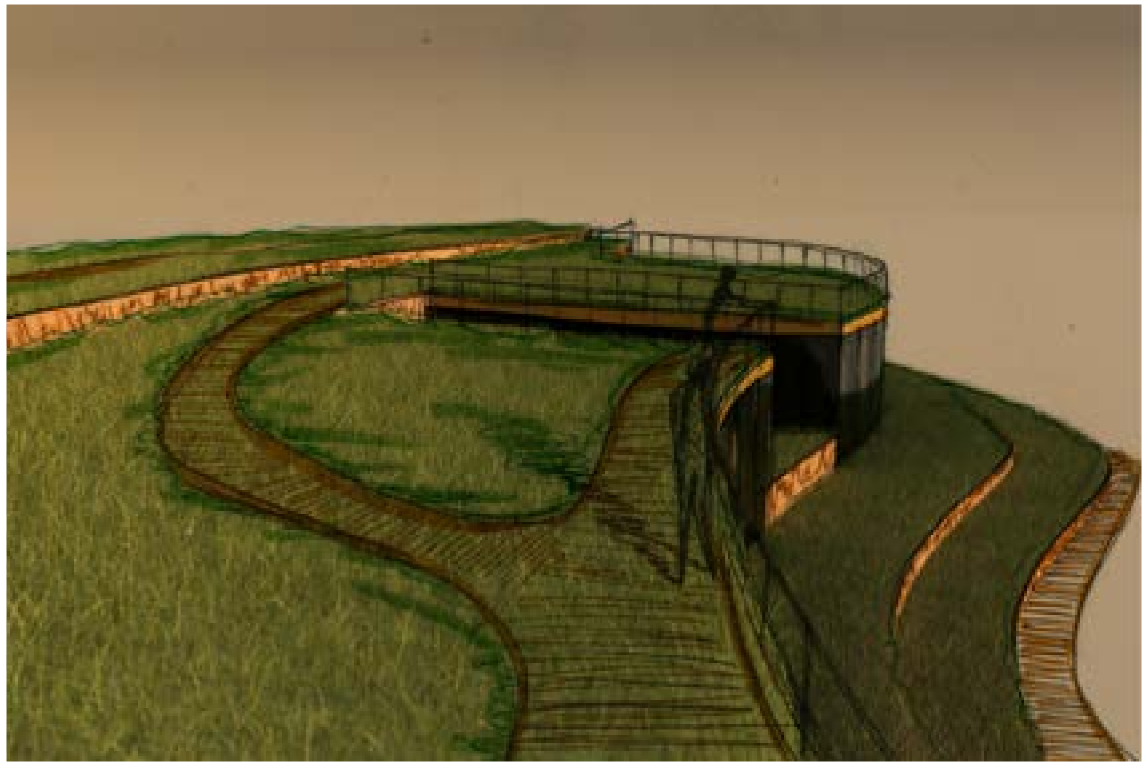


Figure 6.15: Exterior render of design concept 2 from the rooftop for visaulising the design from various perspectives.

Figure 6.16: Site planning, organising of spaces and different programmes.

Key:

- Performance space/ Theatre/Hall
- Lounge/Crush Space
- Music Studios
- Meeting Rooms
- Bathrooms
- Kitchen
- Storage
- Vehicular Traffic
- Light Rail

Figure 6.17: Site planning, organising of spaces and different programmes.

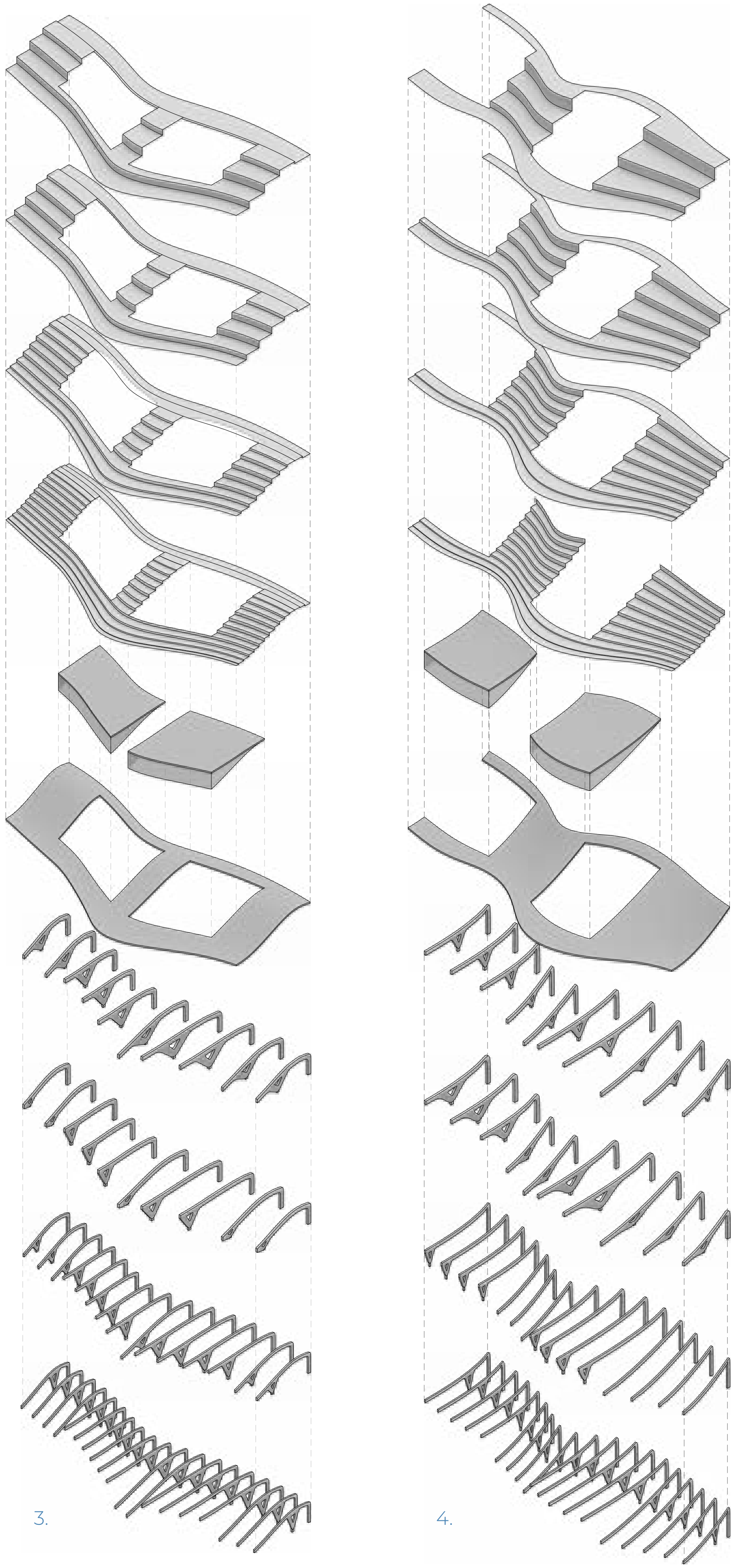


Figure 6.18: Design concepts 3 & 4 exploring terracing, form, and structural design.

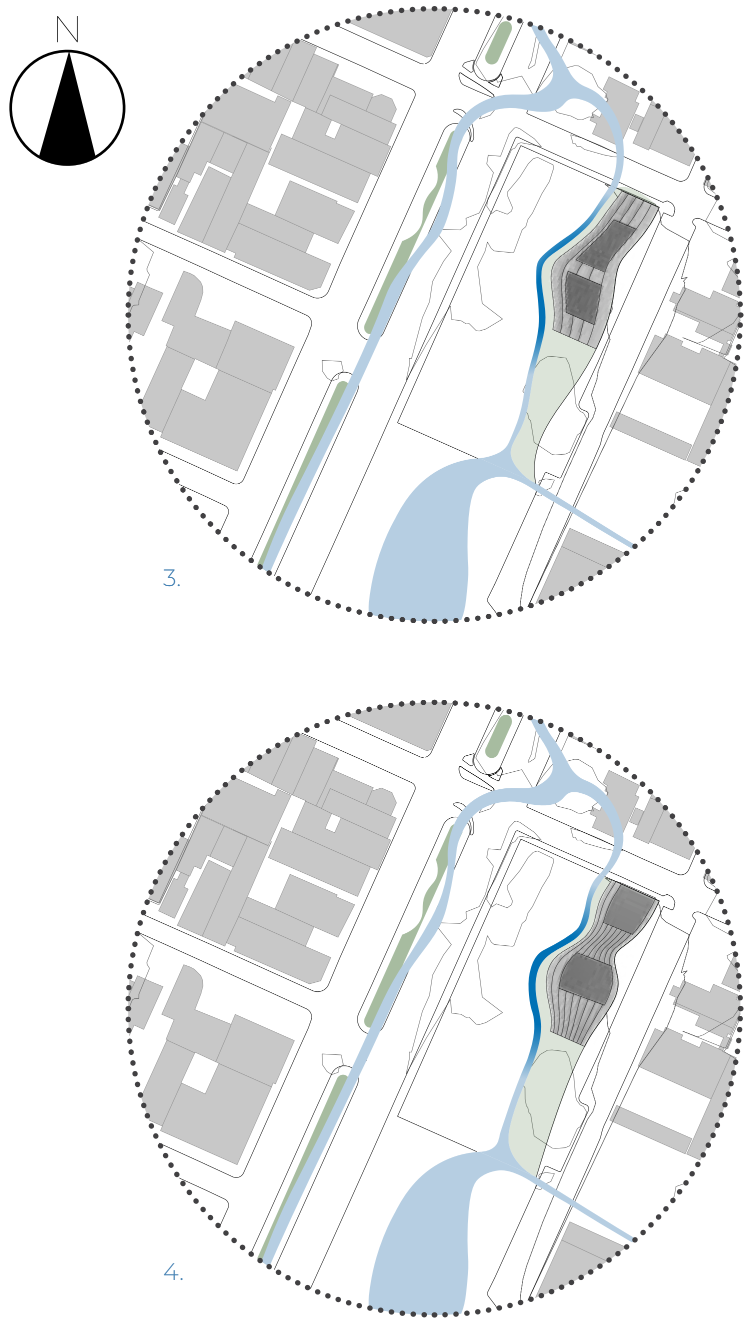


Figure 6.19: Design concepts 3 & 4 site plans for seeing their relationship to the surrounding built environment and daylit stream.

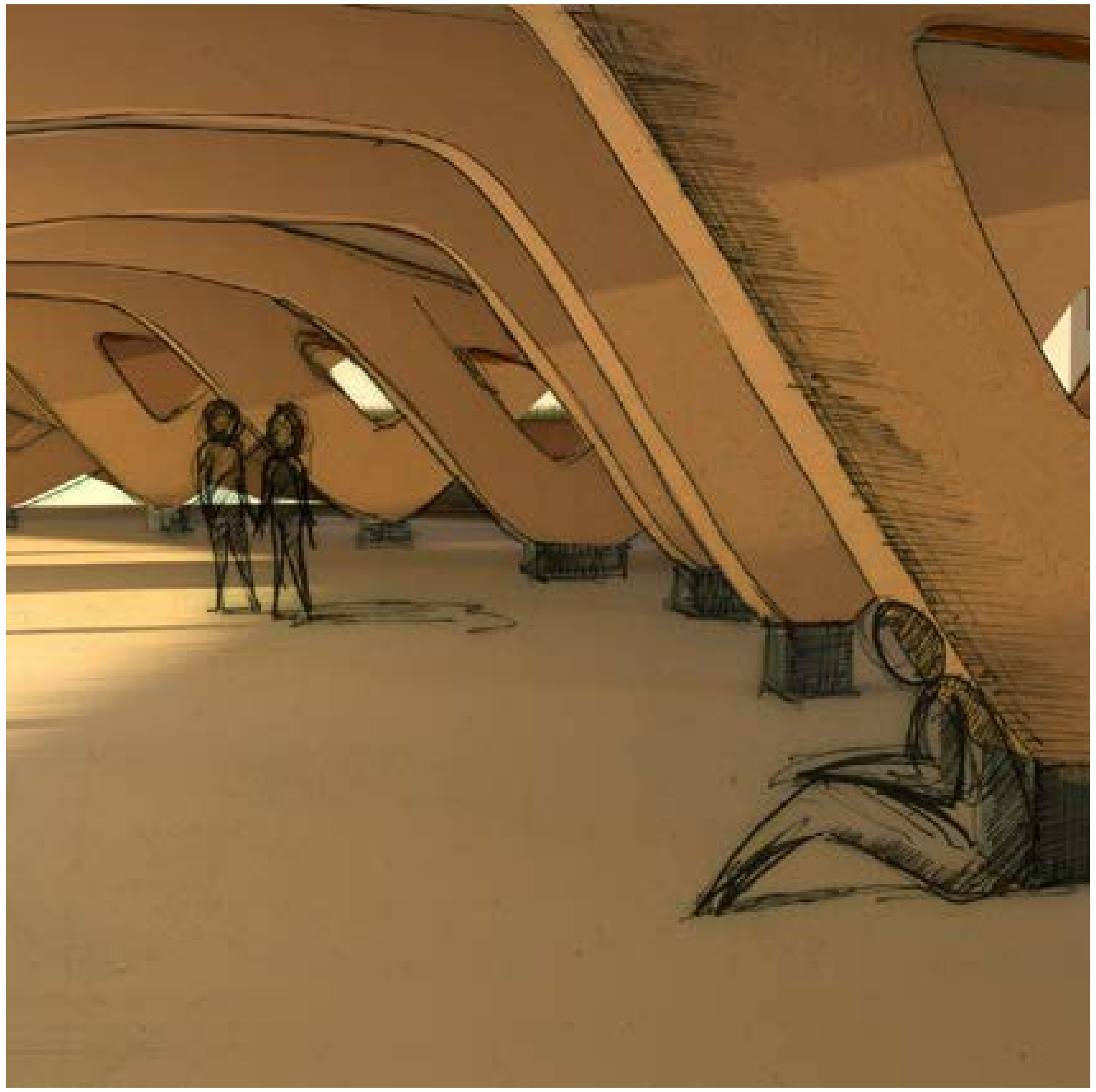


Figure 6.20: Interior render of design concept 3 looking at material application and sense of space.

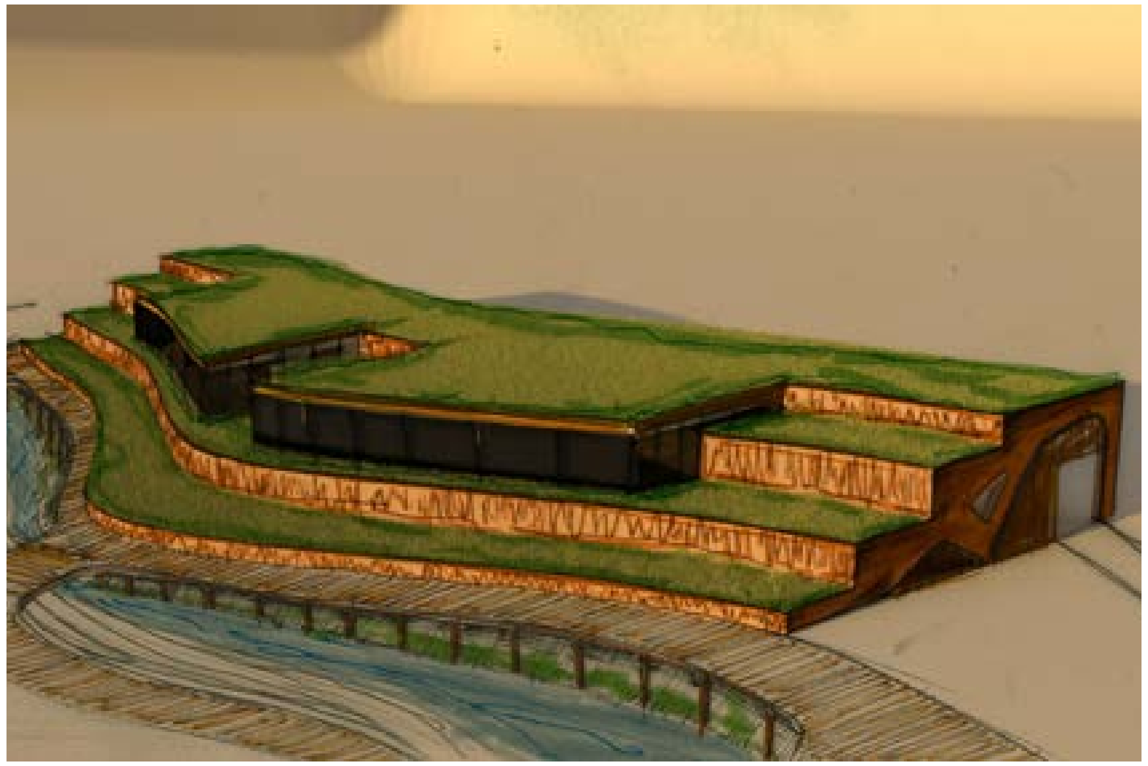


Figure 6.21: Birdseye view of design concept 3 with some landscaping.

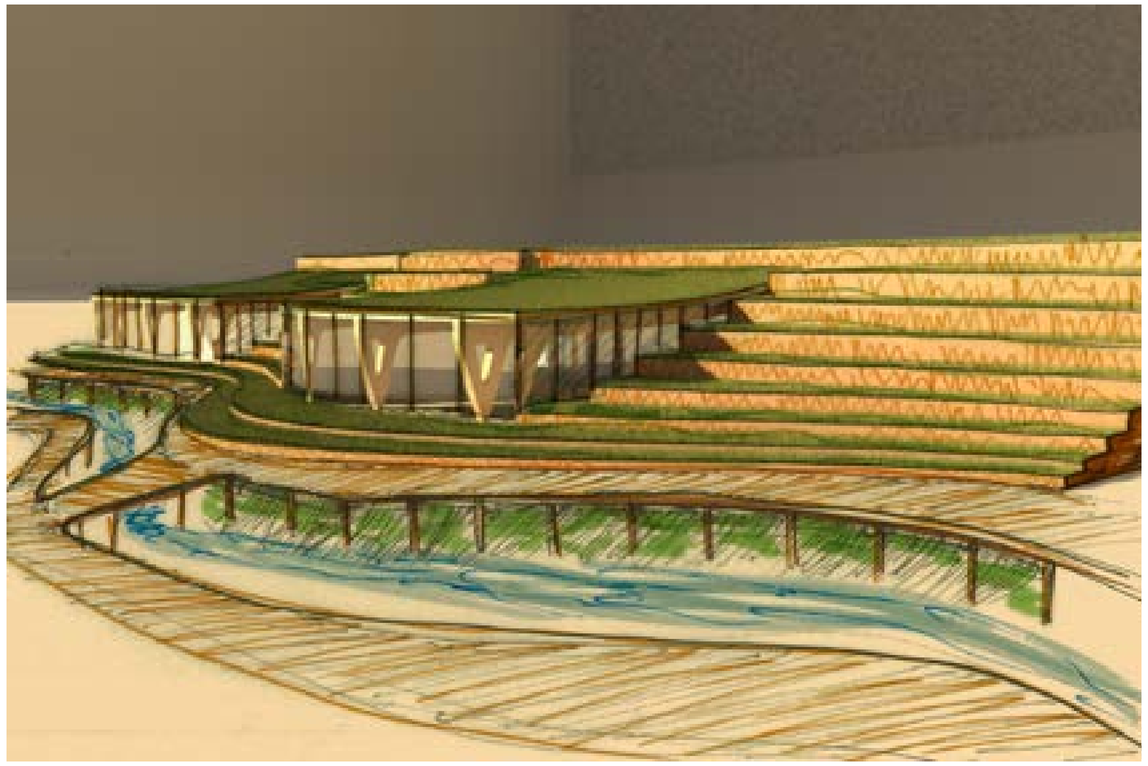


Figure 6.22: Exterior view of design concept 4 sitting within some landscaping context.

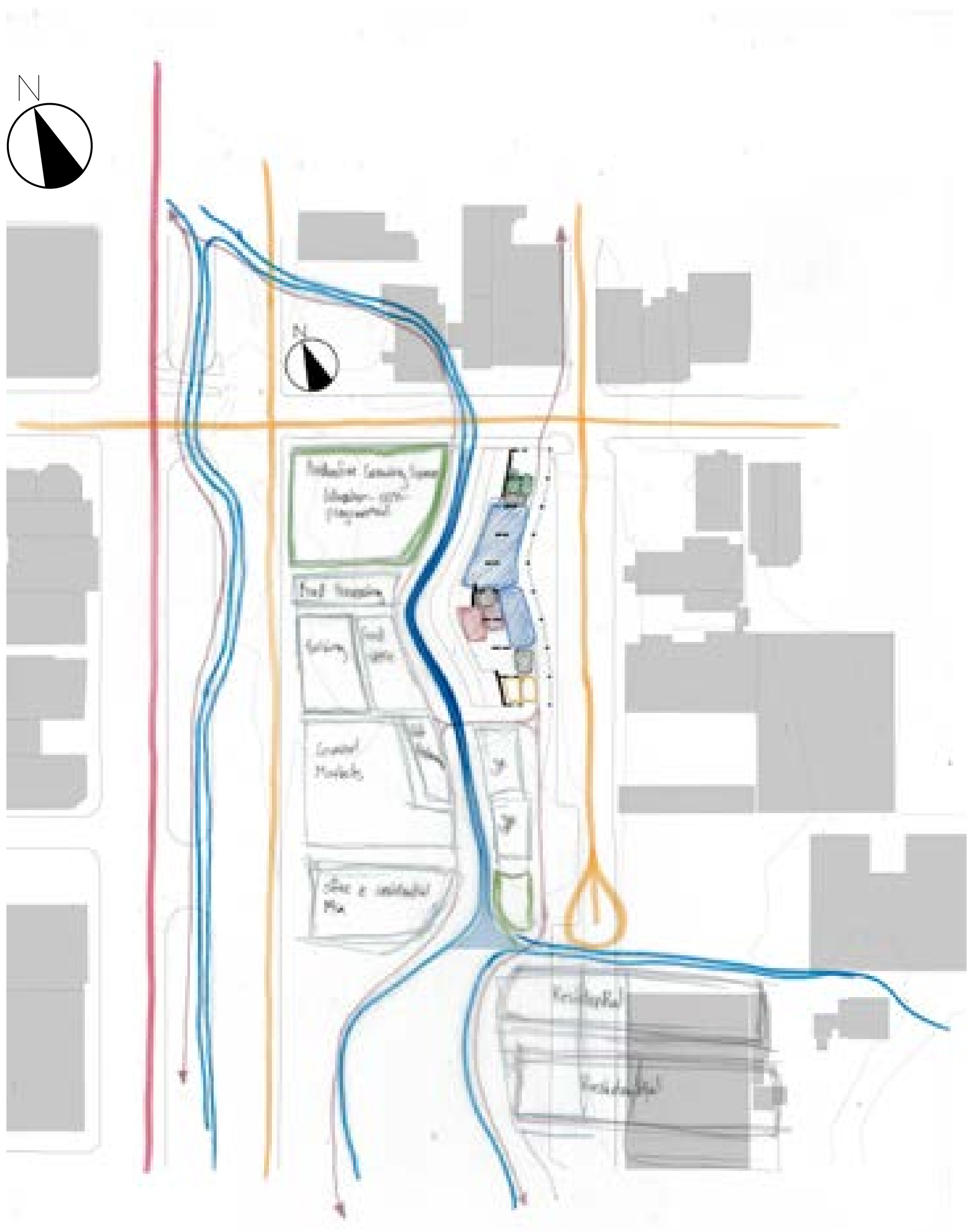


Figure 6.23: Site planning, organising of spaces and different programmes.

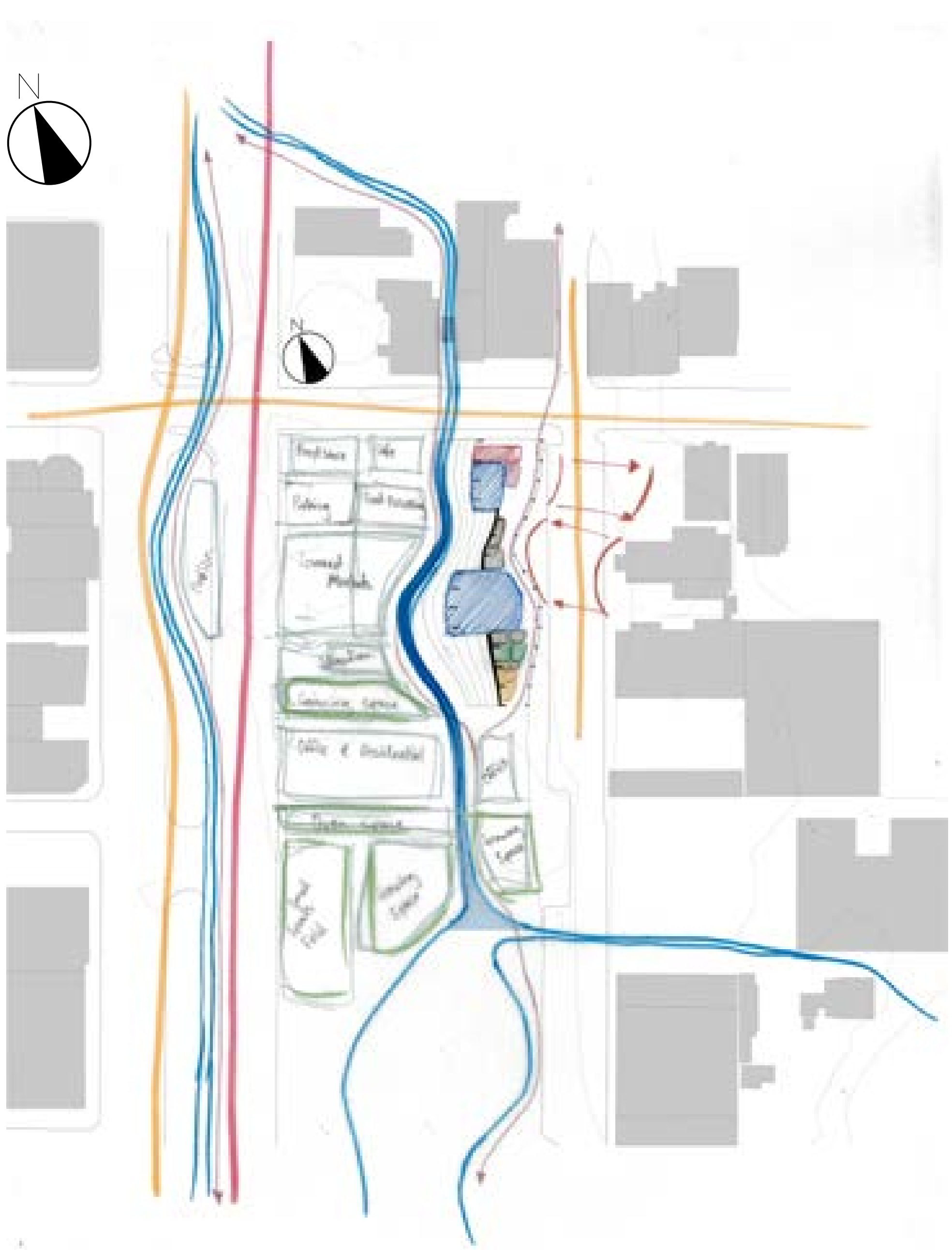


Figure 6.24: Site planning, organising of spaces and different programmes.

Key:

- Performance space/ Theatre/Hall
- Lounge/Crush Space
- Music Studios
- Meeting Rooms
- Bathrooms
- Kitchen
- Storage
- Vehicular Traffic
- Light Rail

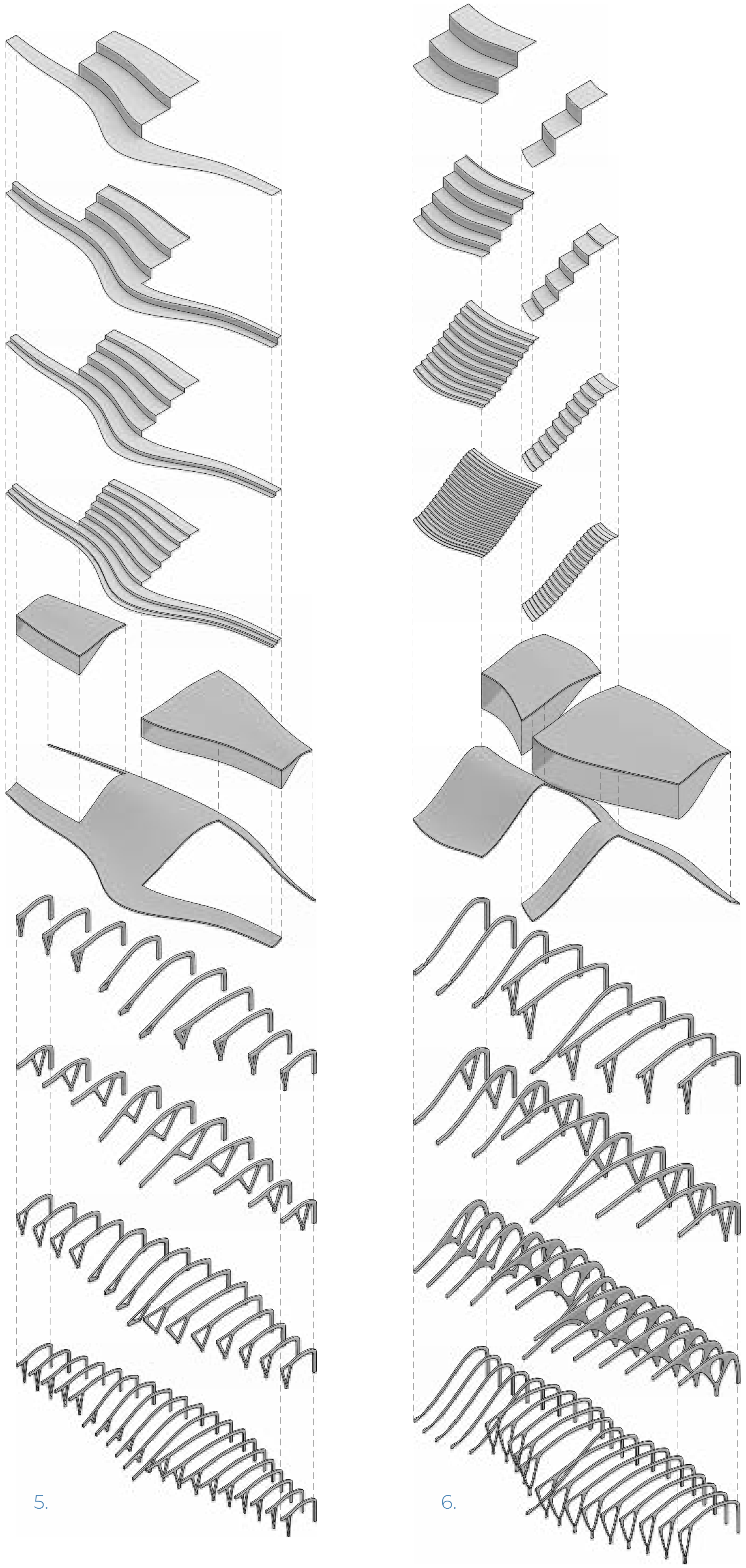


Figure 6.25: Design concepts 5 & 6 exploring terracing, form, and structural design.

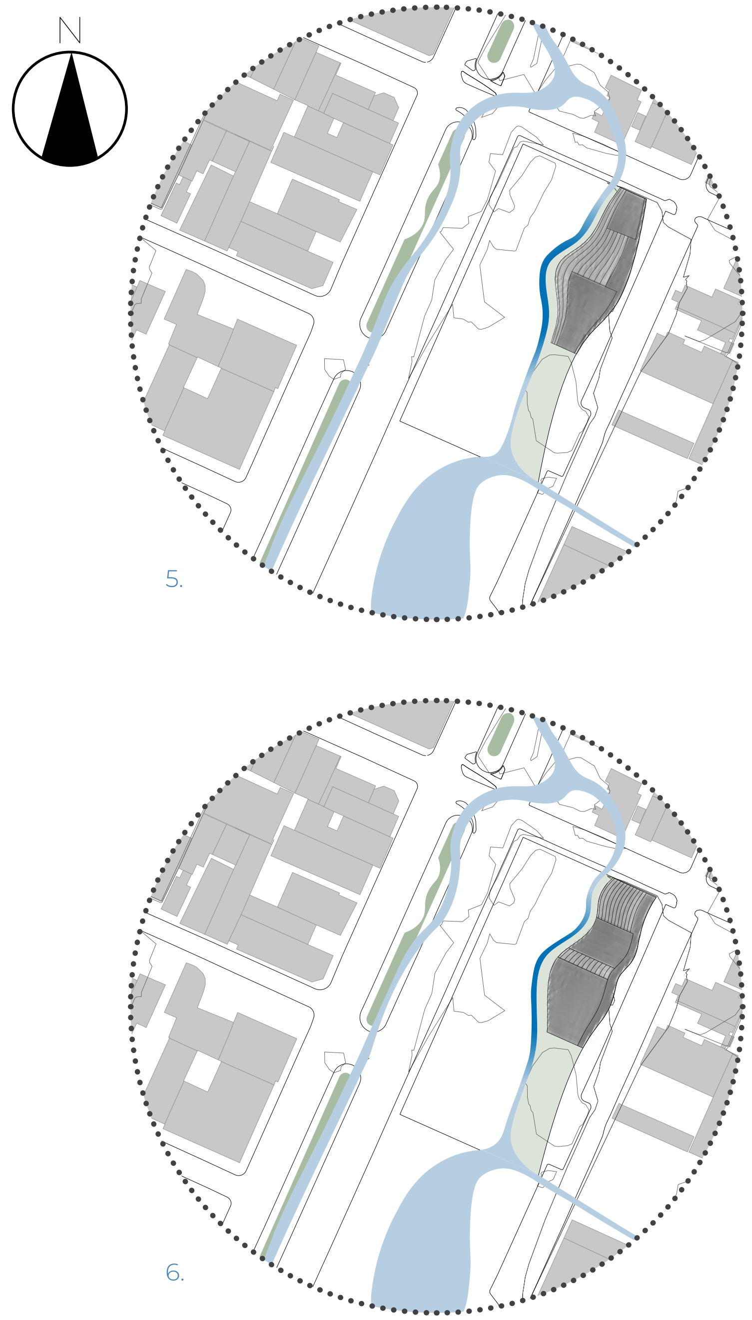


Figure 6.26: Design concepts 5 & 6 site plans for seeing their relationship to the surrounding built environment and daylit stream.

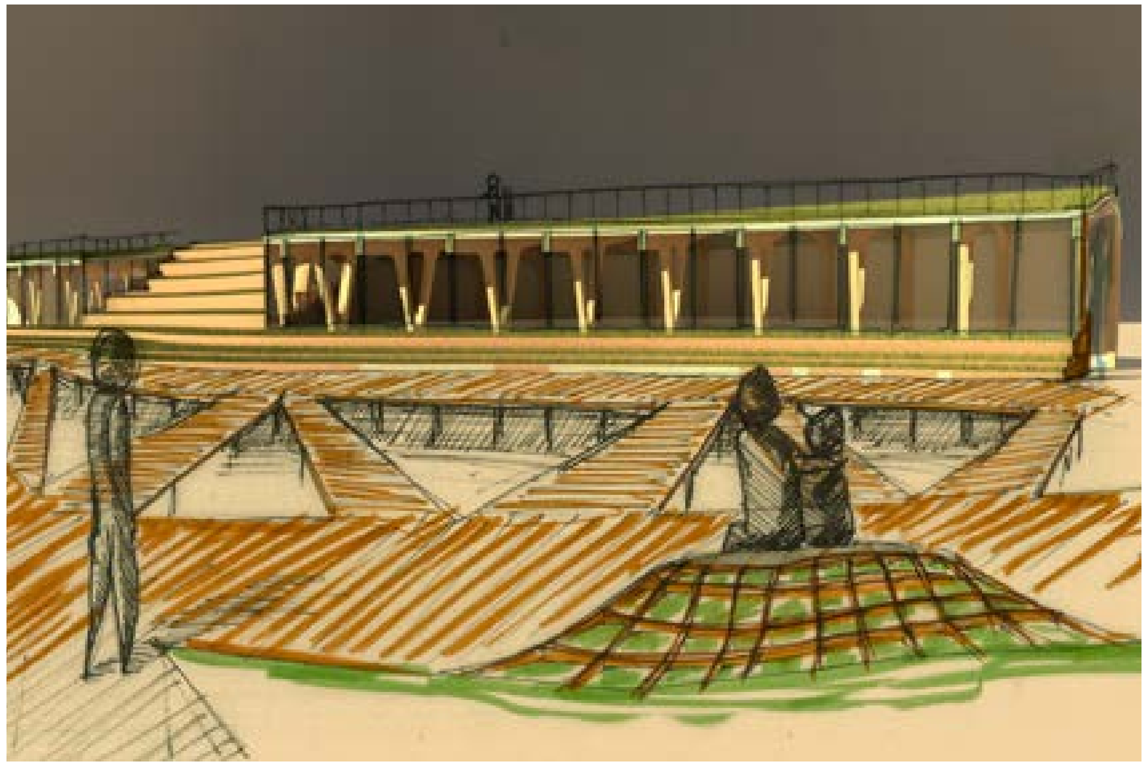


Figure 6.27: Exterior view of design concept 5 with landscaping of a network of pathways.

Figure 6.28: Exterior view of design concept 6 alongside the street edge with material application.

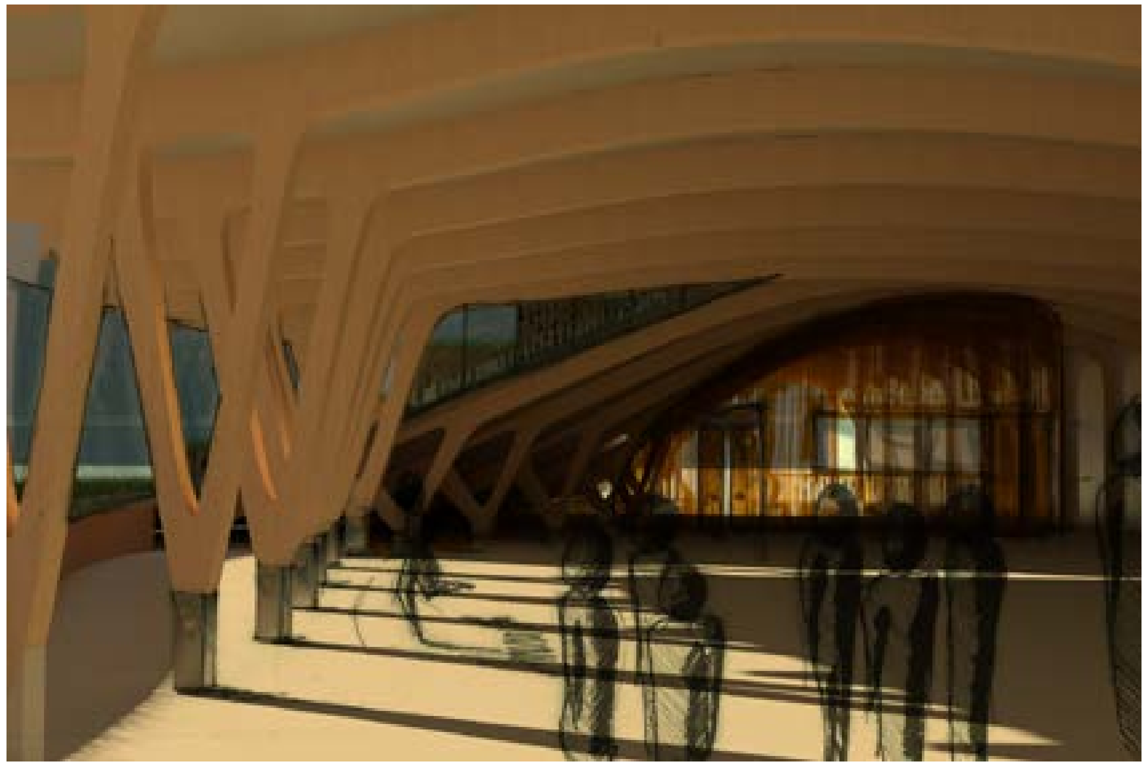


Figure 6.29: Design concepts 5 interior performance space and what the atmosphere may feel like.

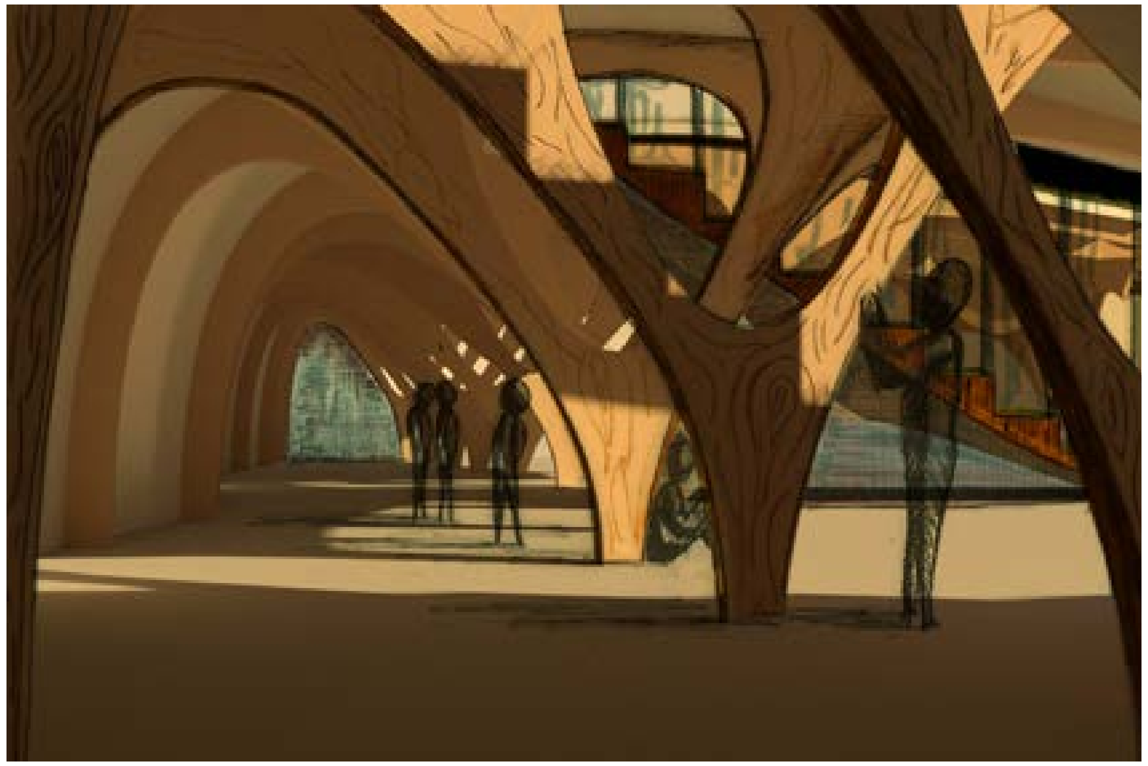


Figure 6.30: Design concepts 6 interior material application for an understanding of what the atmosphere may feel like.

Figure 6.31: Site planning, organising of spaces and different programmes.

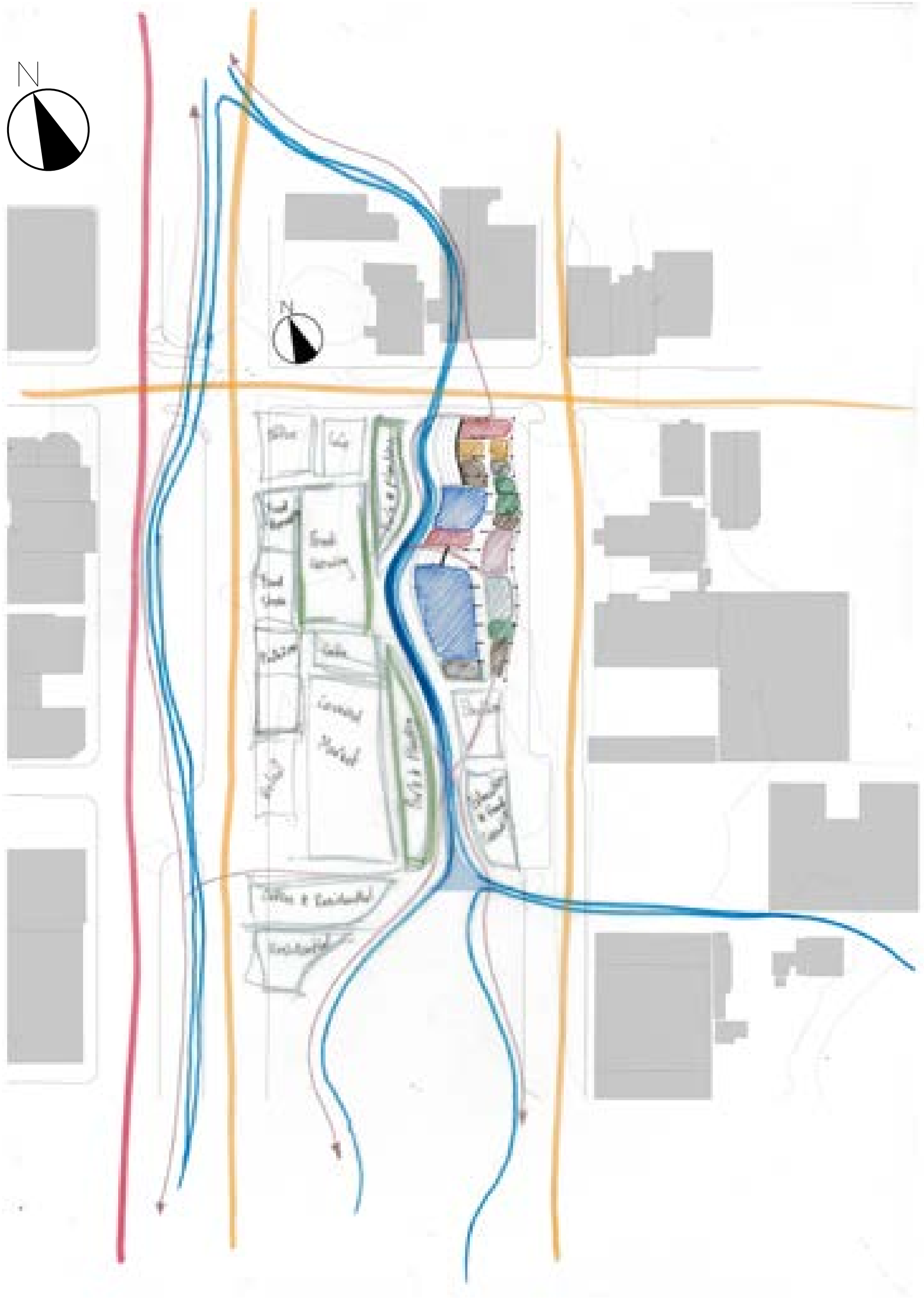


Figure 6.32: Site planning, organising of spaces and different programmes.

Key:

- Performance space/ Theatre/Hall
- Lounge/Crush Space
- Music Studios
- Meeting Rooms
- Bathrooms
- Kitchen
- Storage
- Vehicular Traffic
- Light Rail

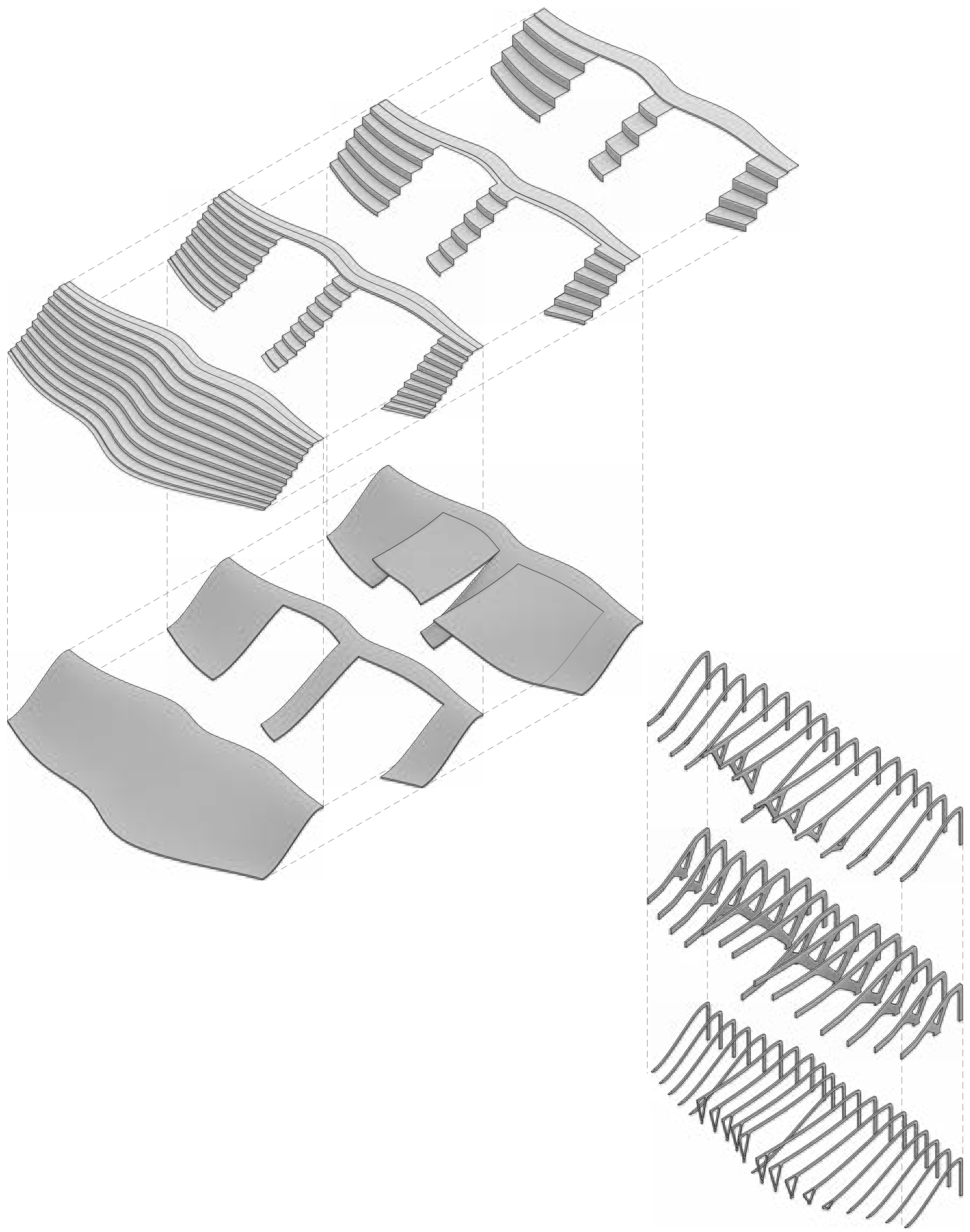


 Figure 6.33: Developed design concept 7 configurations.

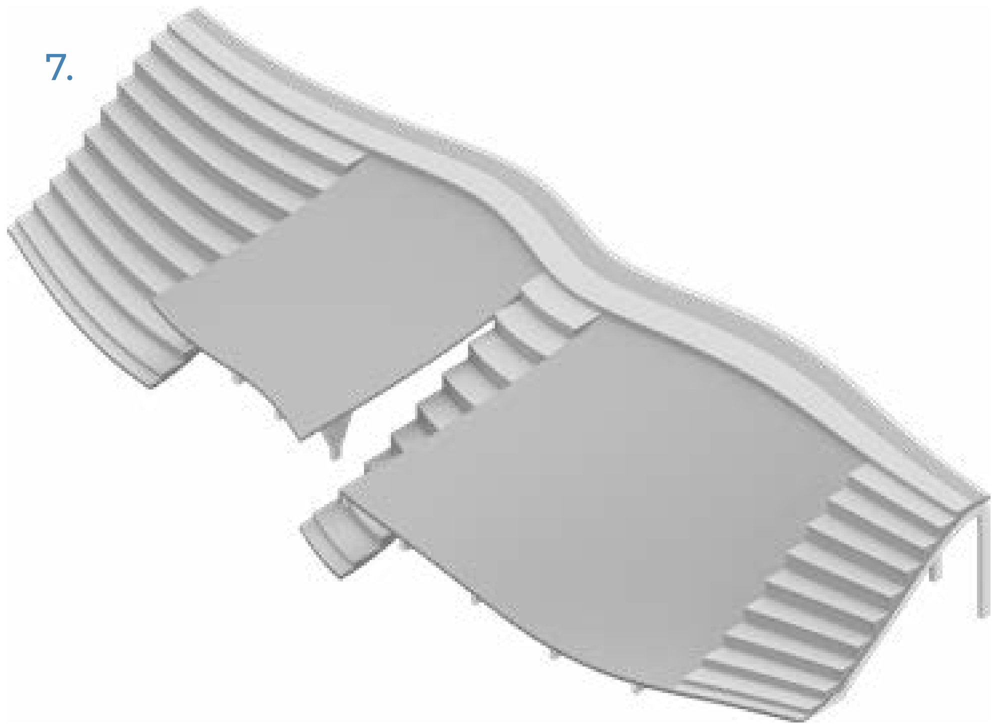
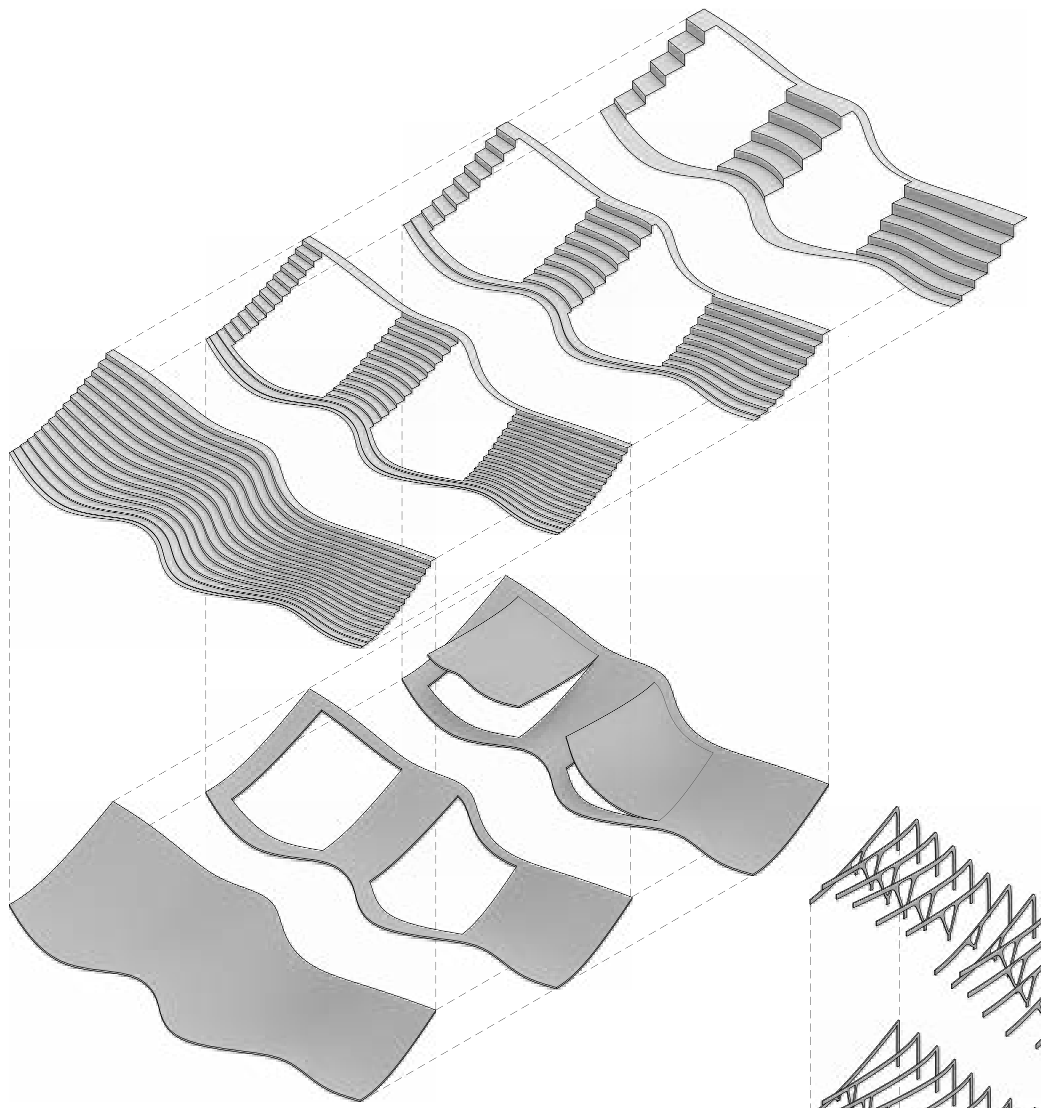


Figure 6.34: Rendered model of design concept 7.



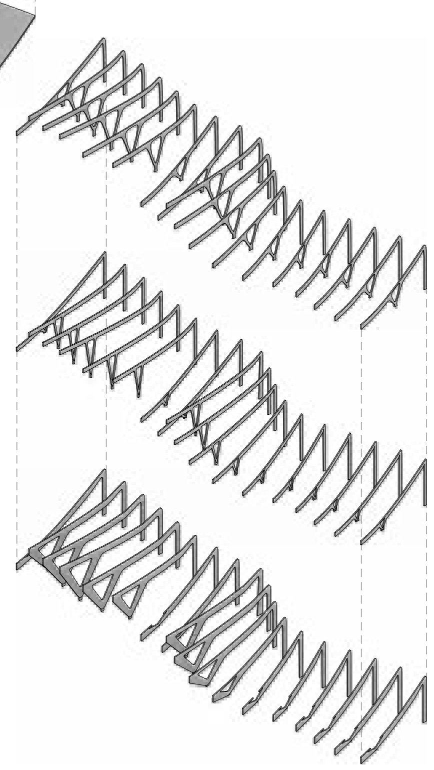


Figure 6.35: Developed design concept 8 configurations.

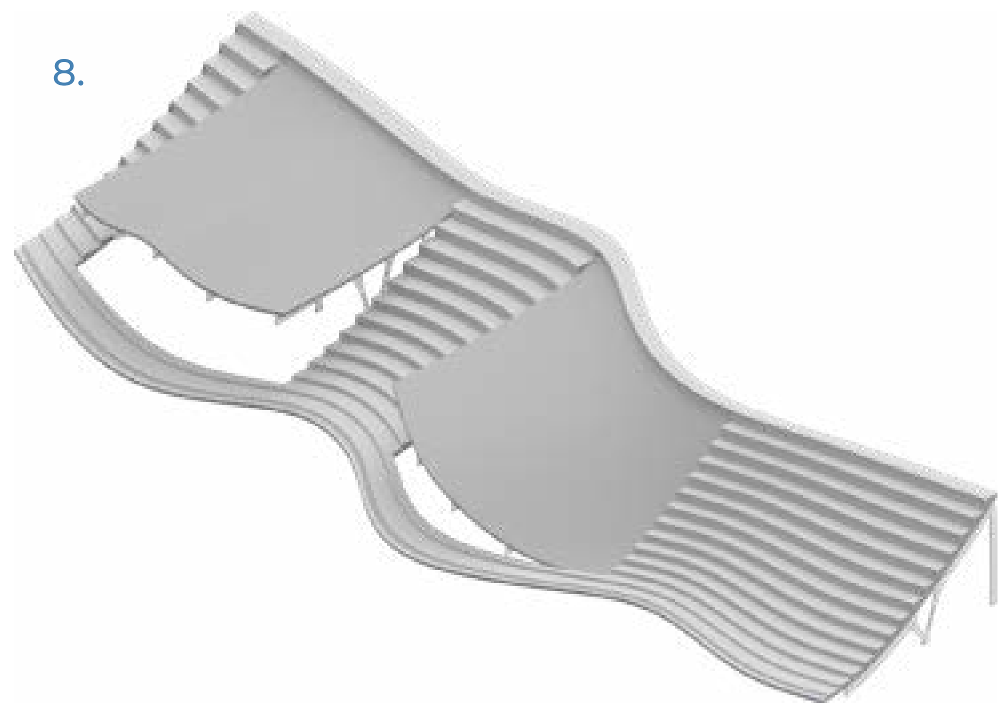


Figure 6.36: Rendered model of design concept 8.

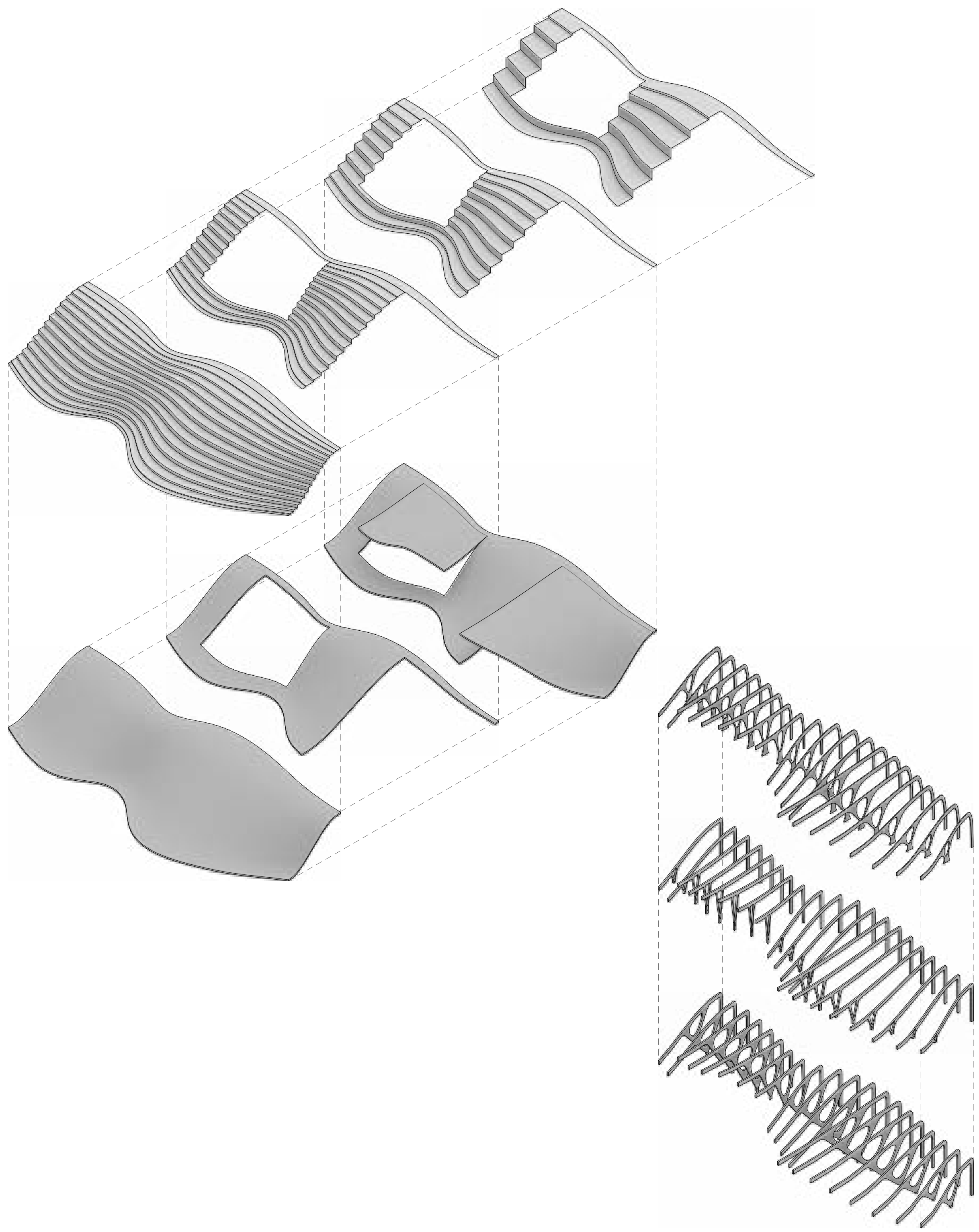


Figure 6.37: Developed design concept 9 configurations.

9.

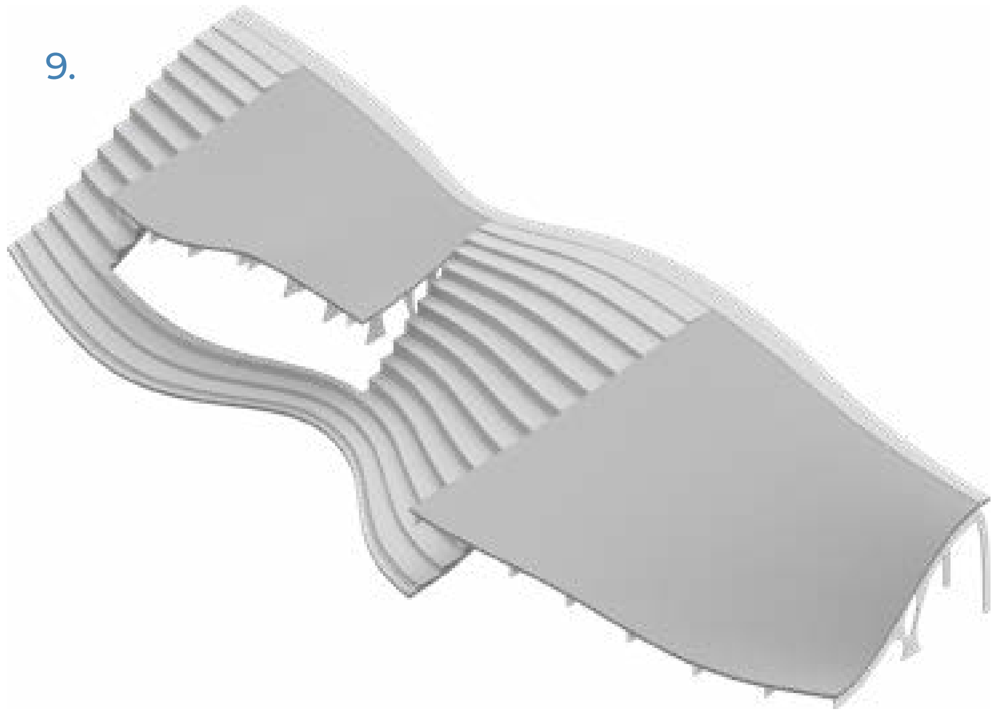


Figure 6.38: Rendered model of design concept 9.

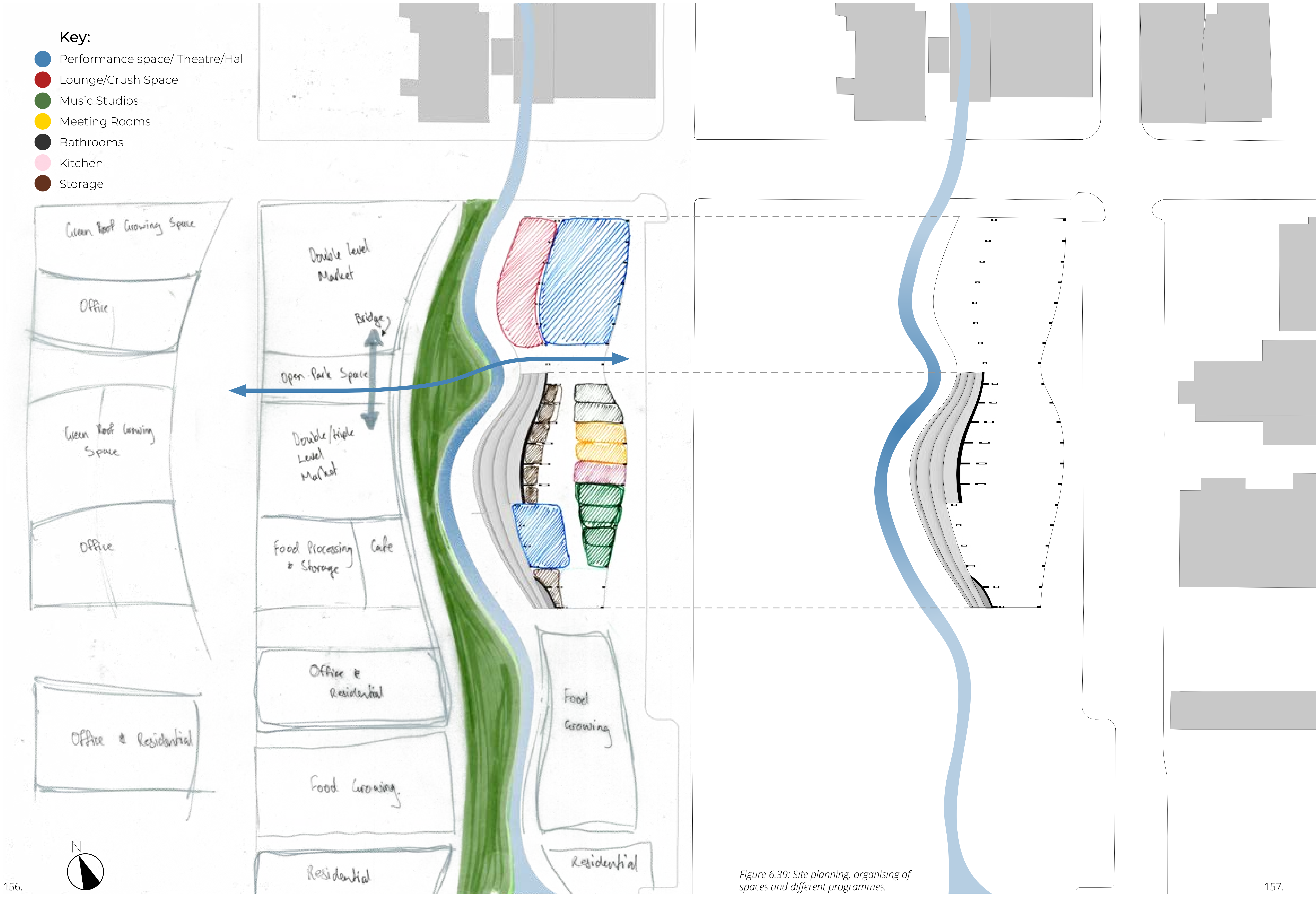


Figure 6.39: Site planning, organising of spaces and different programmes.

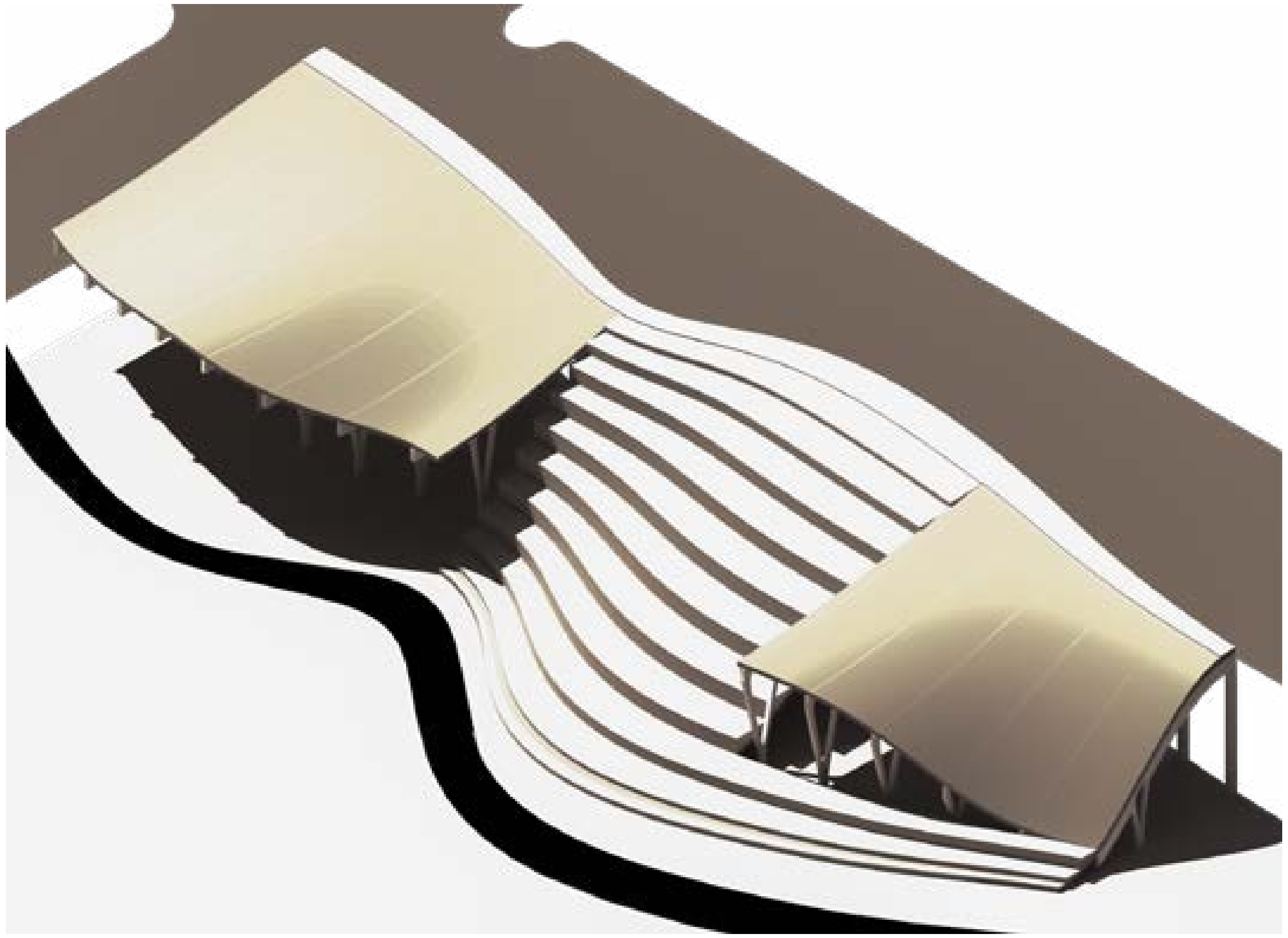


Figure 6.40: Developed model from the iterative design process using generating many different forms.

Right Image, Figure 6.41: Visualisation of community centre amongst planting made for the 6-month review.

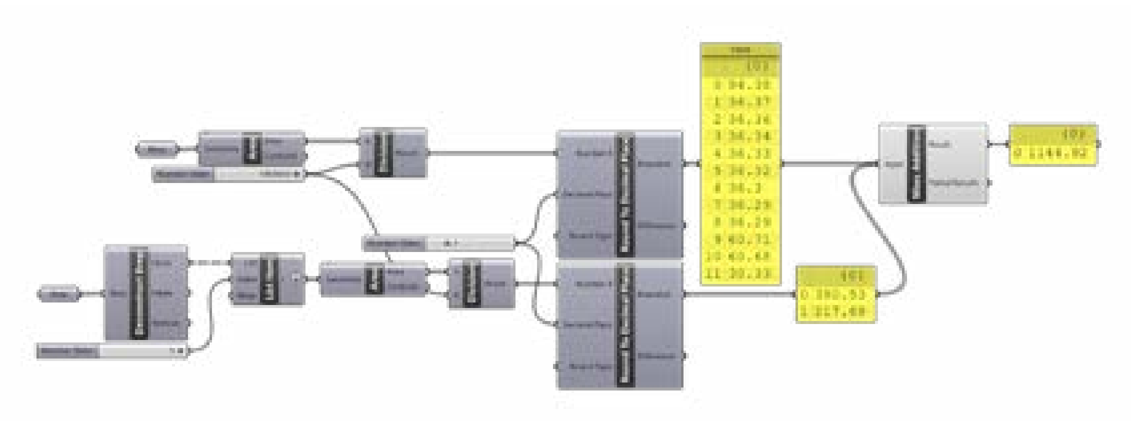
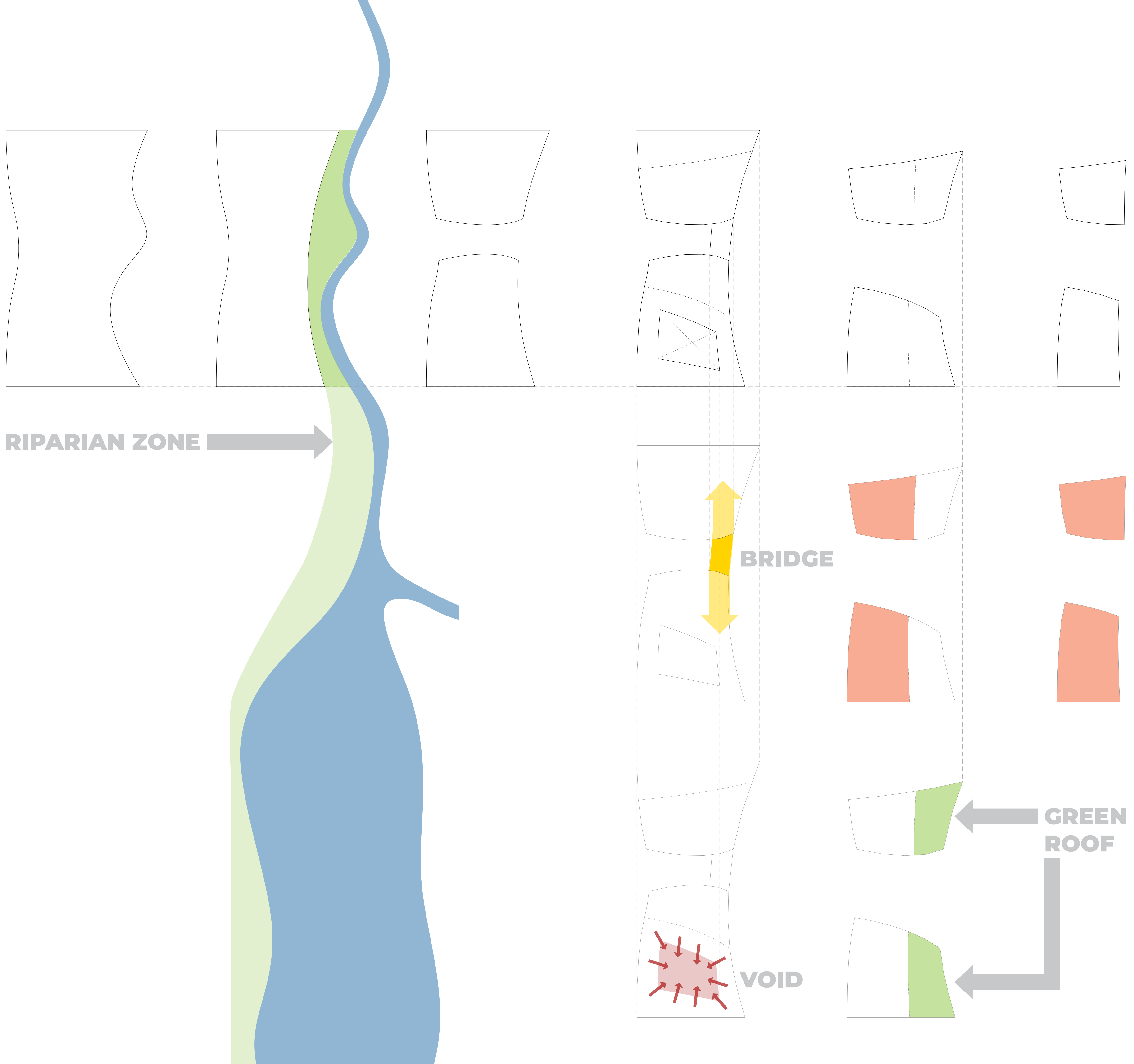


Figure 6.42: Grasshopper script for finding out the total amount of usuable green roof area for urban food production and planting.


RIPARIAN ZONE
BRIDGE
VOID
GREEN
ROOF

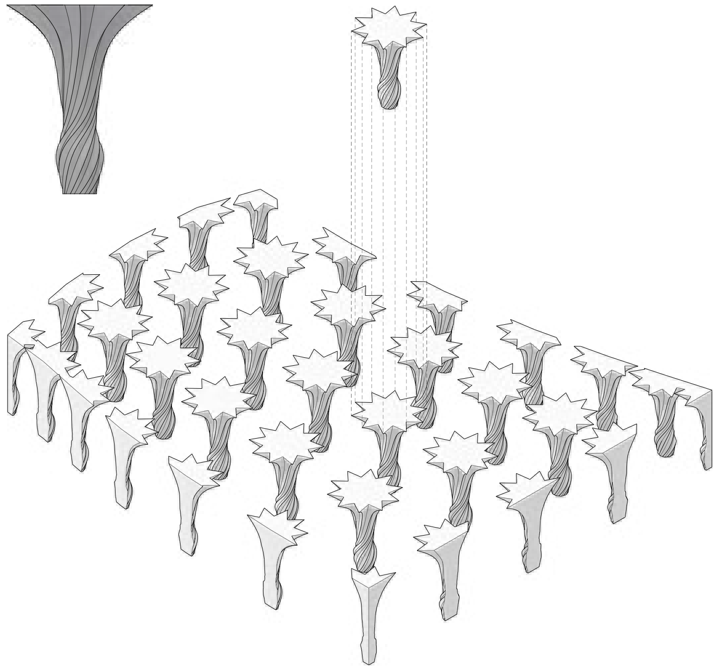


Figure 6.43: Parametrically designed formwork columns using twisting and various extrusion widths.

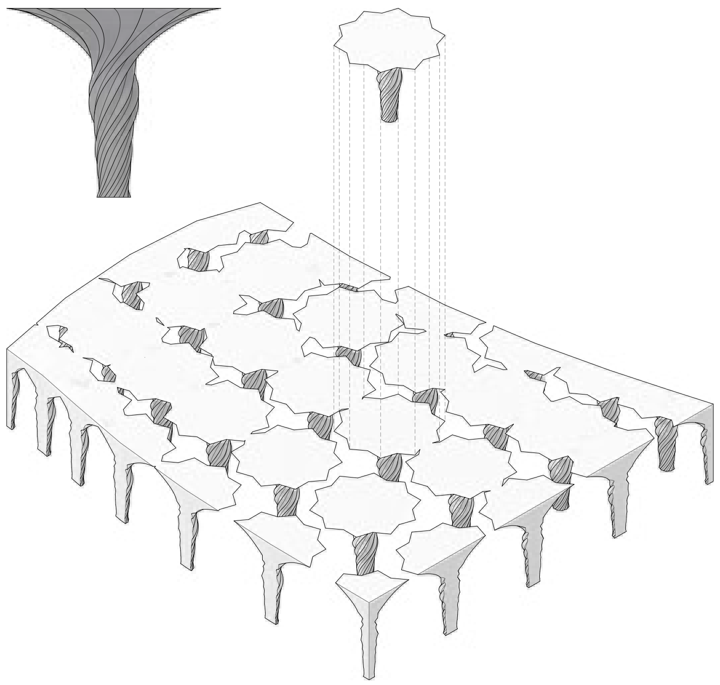


Figure 6.44: Parametrically designed formwork columns using twisting and various extrusion widths.

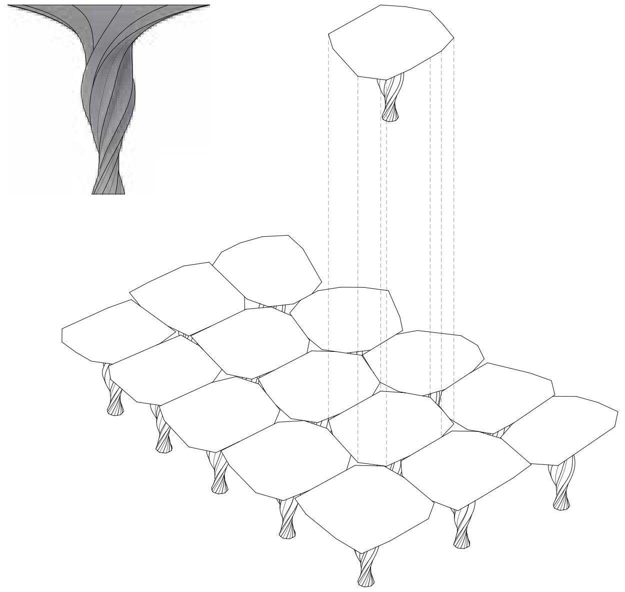


Figure 6.45: Parametrically designed formwork columns using twisting and various extrusion widths, shaped to match the roof structure.

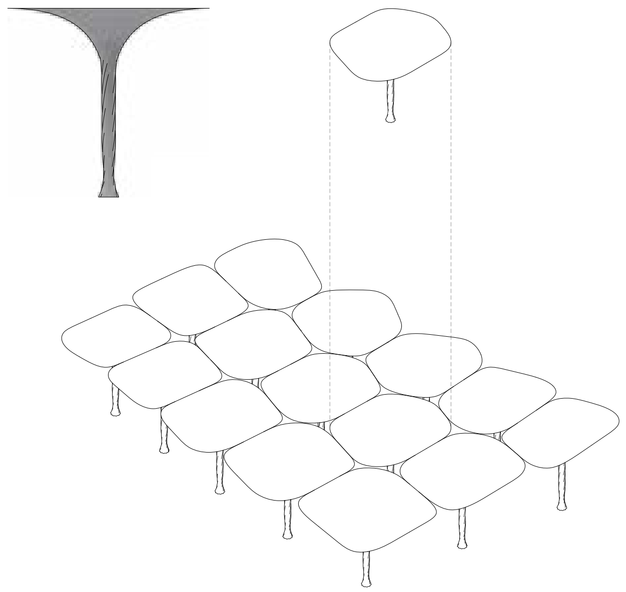


Figure 6.46: Parametrically designed formwork columns using twisting and various extrusion widths, shaped to match the roof structure.

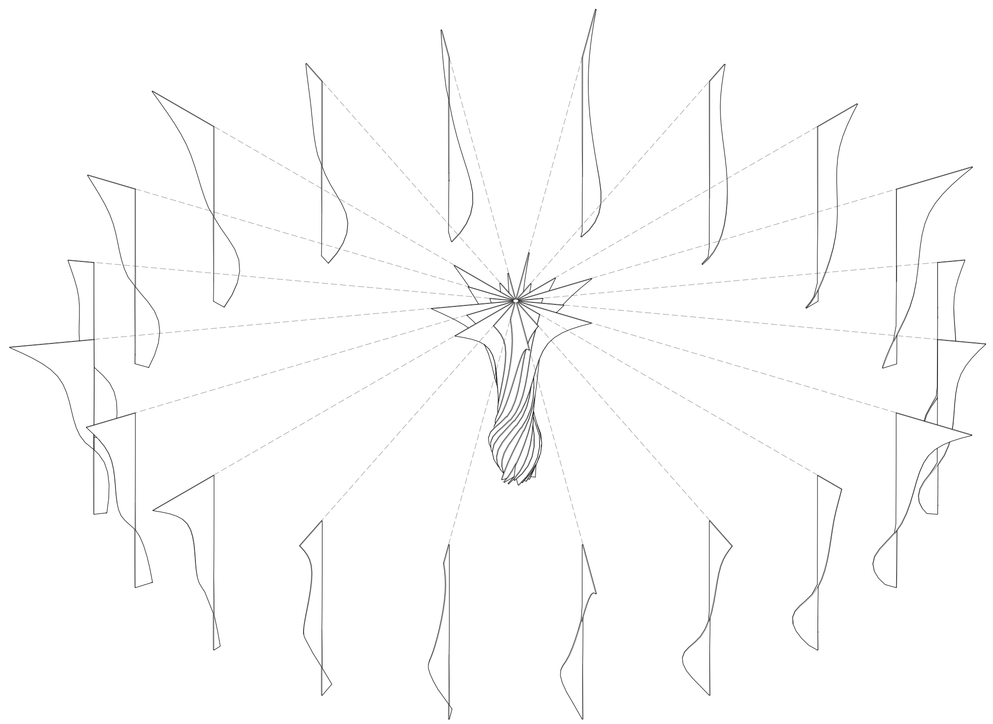


Figure 6.47: Parametrically designed tectonic columns using twisting and lofting of curves to create an aesthetically pleasing output.

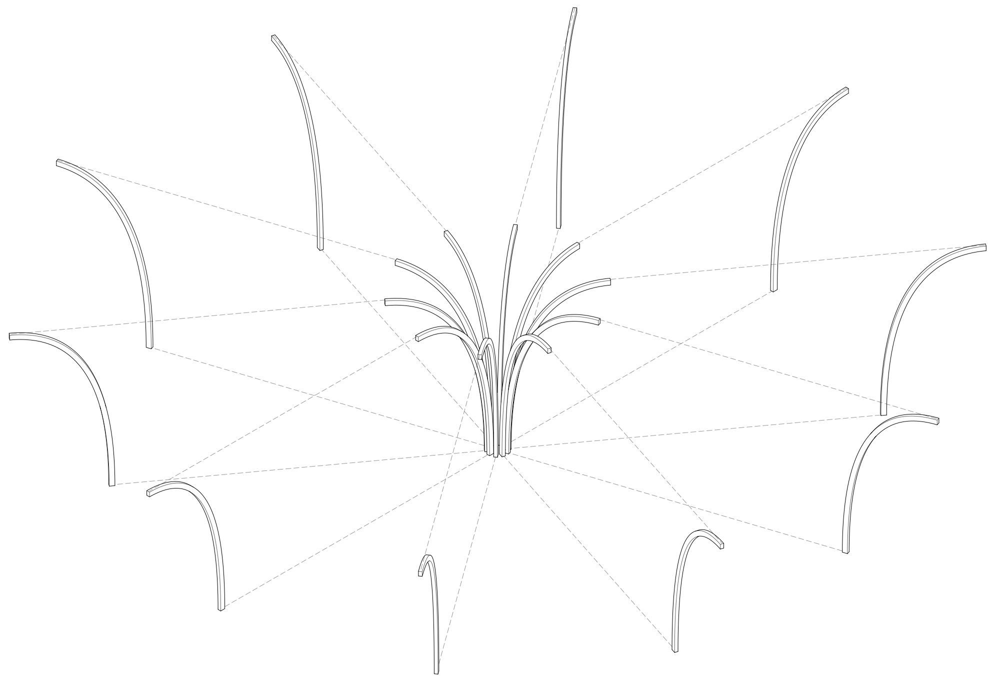


Figure 6.48: Parametrically designed column mimicking tree type structures for biomorphic forms seen in biophilic design.

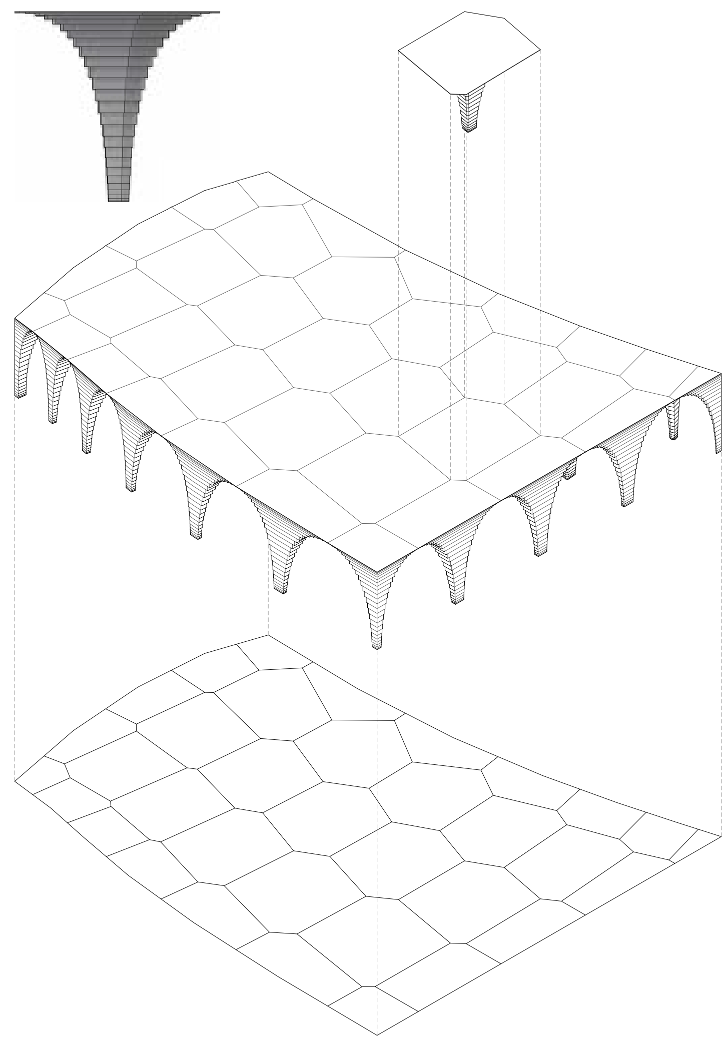


Figure 6.49: Parametrically designed stacked column using a voronoi to develop the structures form.

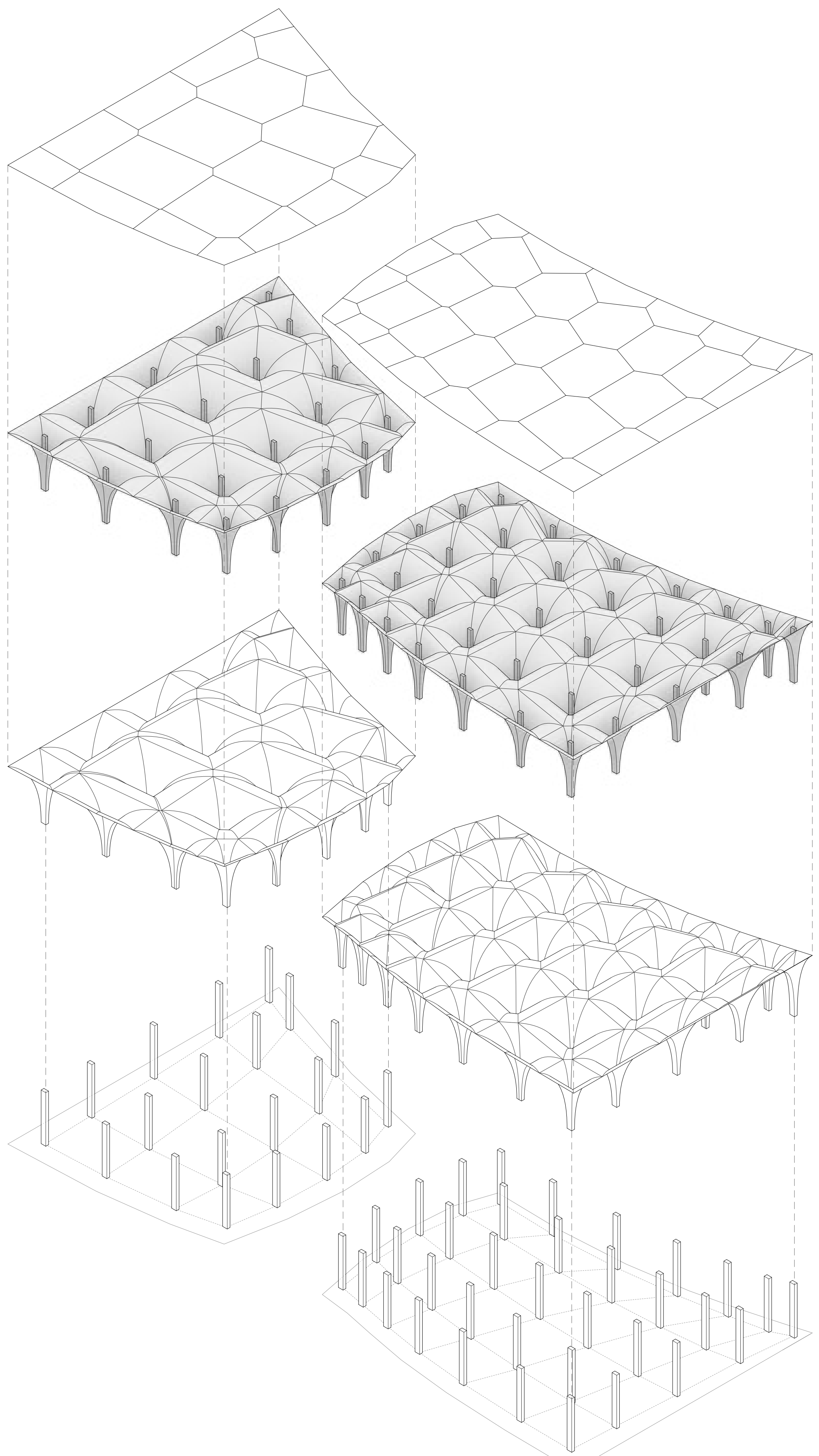


Figure 6.50: Parametrically designed translucent case structure using a voronoi to develop the form over a standard rectangular column.

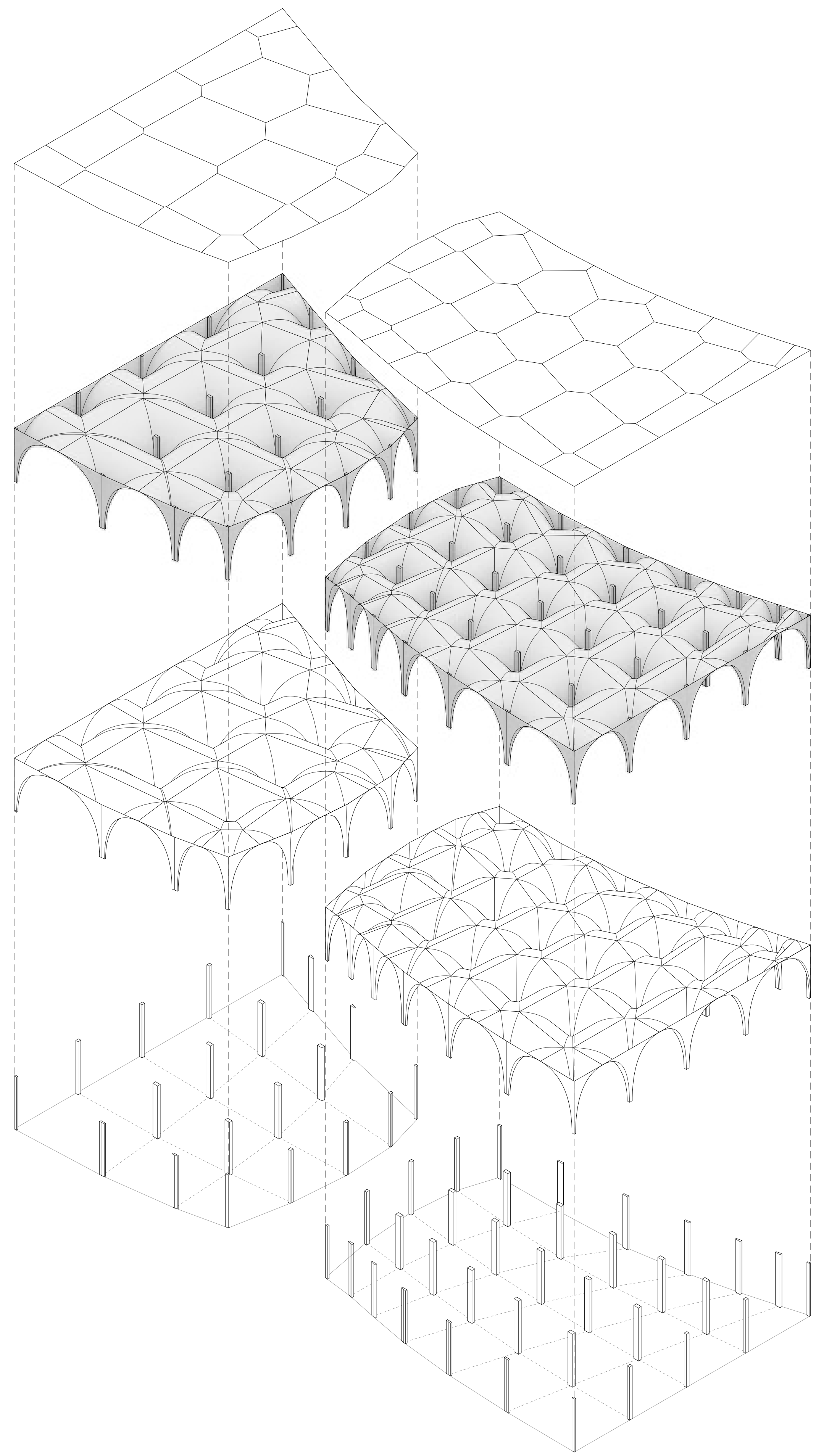
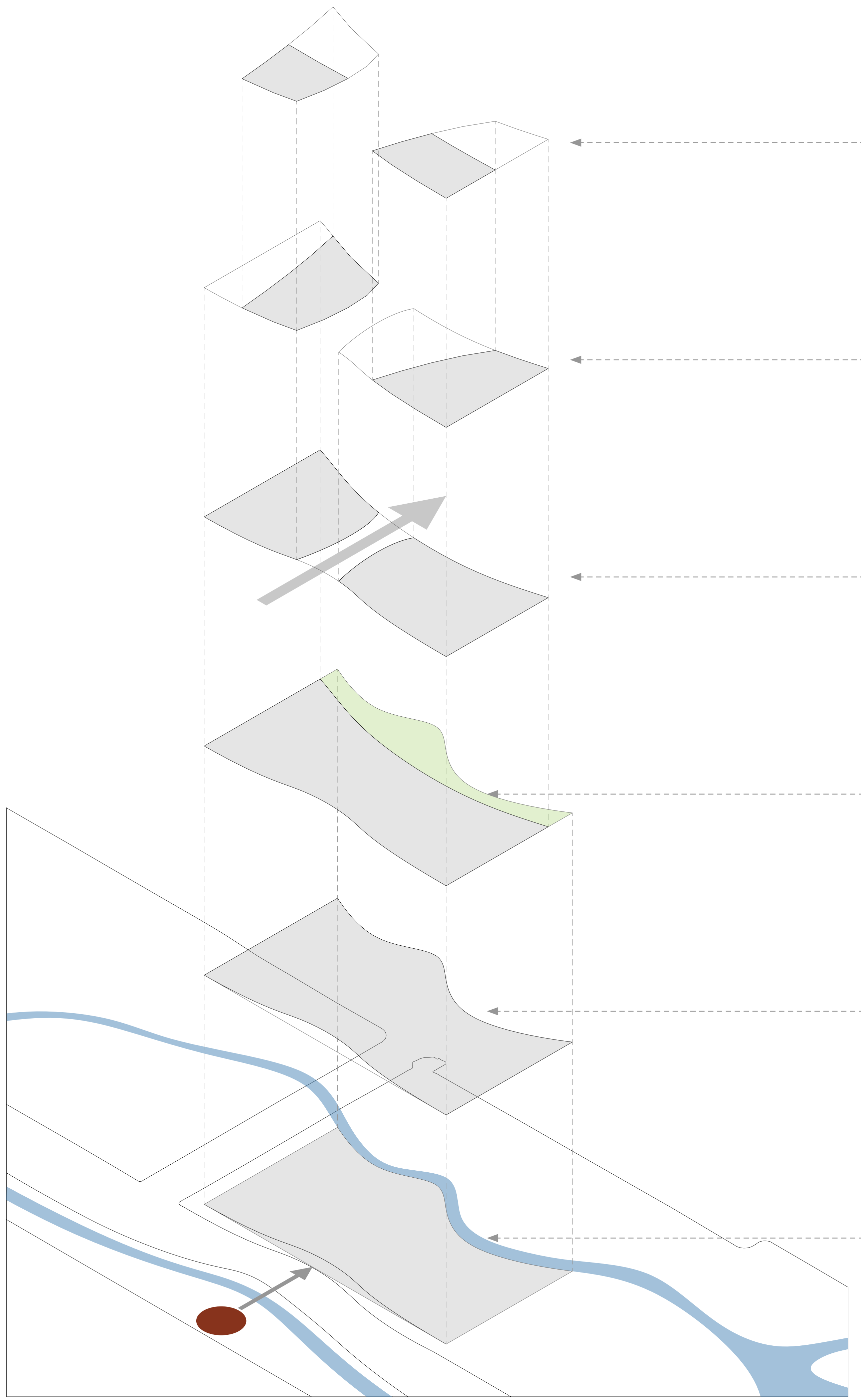


Figure 6.51: Parametrically designed translucent case structure using a voronoi to develop the form over a standard rectangular column.



Office and city working spaces to be located on upper levels so lower levels are used for markets during the day.

Reducing the overall massing of the structure in above levels to mitigate sun shading on site.

To connect the site with the proposed light rail network, the building form has been split into two masses to create a clear entrance

Native planting for water purication and filtering to be located around the streams riparian zone.

The site shape is manipulated by the course Waitangi stream takes since the road impedes on the site boundary.

Light Rail stop and existing sculpture are located where the red dot is. The streams path reacts to the surrounding context.

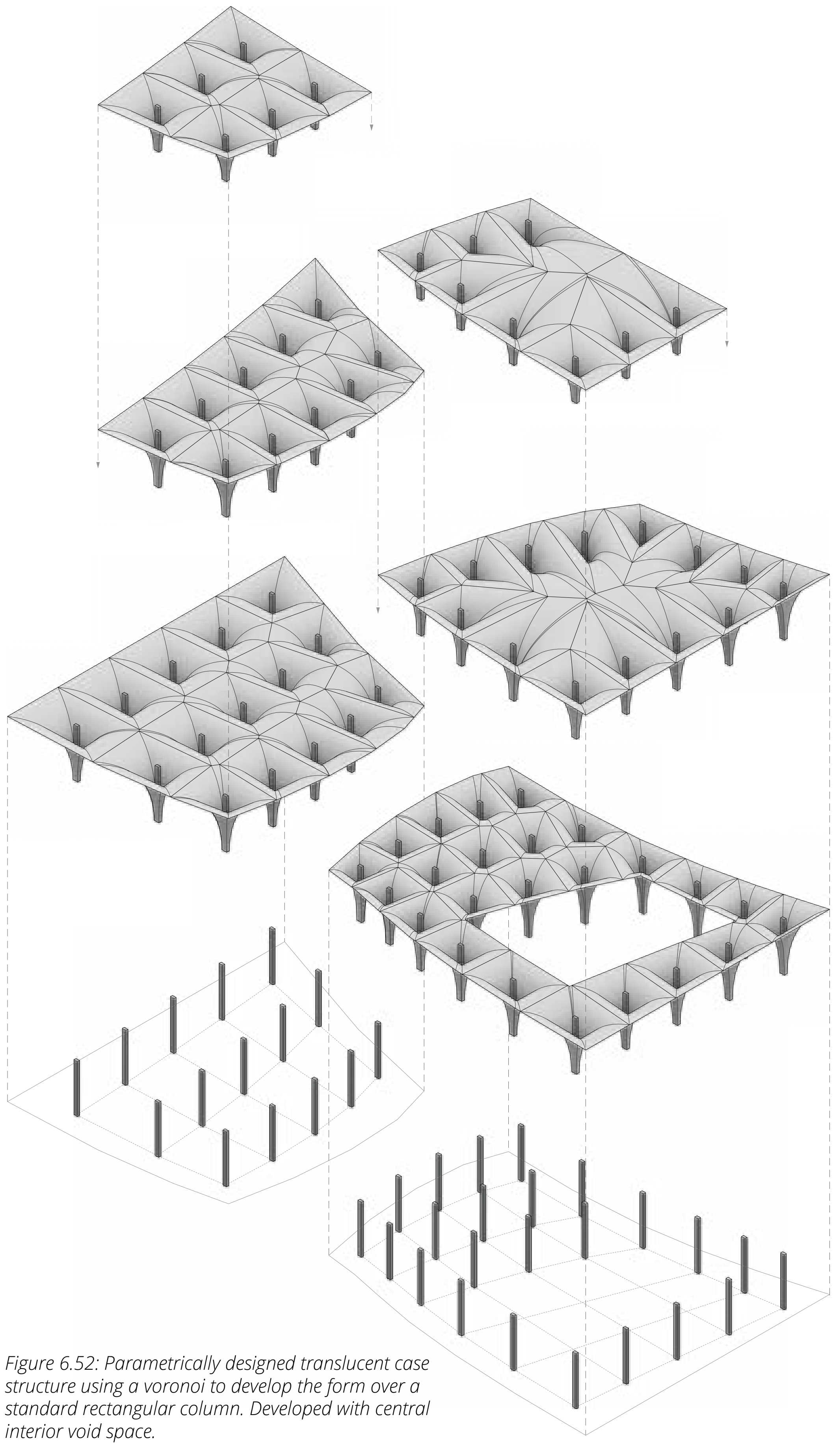


Figure 6.52: Parametrically designed translucent case structure using a voronoi to develop the form over a standard rectangular column. Developed with central interior void space.

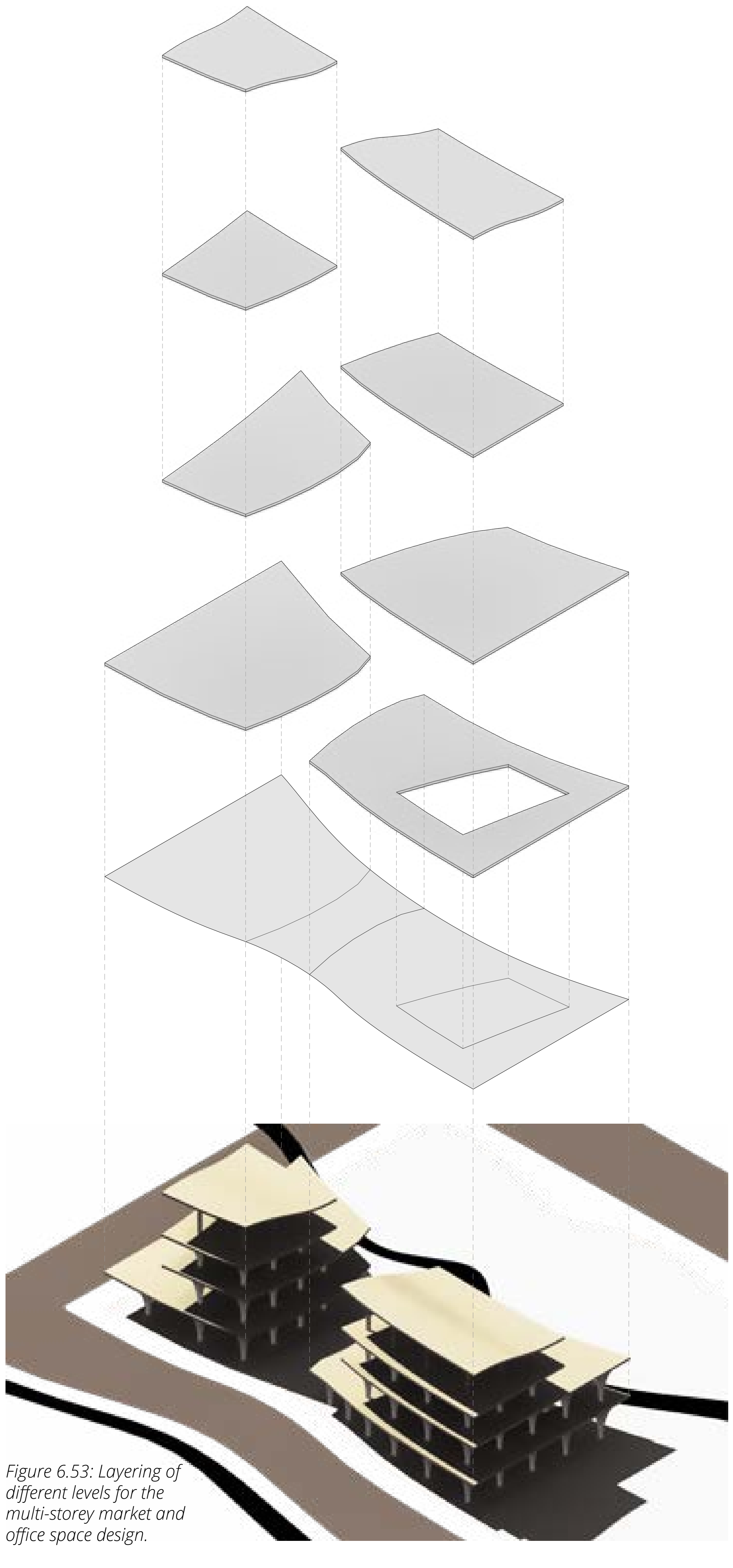


Figure 6.53: Layering of different levels for the multi-storey market and office space design.

Figure 6.54: Interior render of markets form void of social activity.

Right image, Figure 6.55: Visualisation of the mixed use structure on site with generic surrounding planting.

6.4 MAIN DESIGN MOVES

Several big design moves were proposed along Kent and Cambridge Terraces. These were daylighting part of the Waitangi Stream; removing all the car dealerships and car orientated architecture for future development; repurposing the Basin Reserve; integrating a light rail network into the scheme; and altering the existing street layout.

6.41 Building Removal

All car dealerships and car-related buildings along Kent and Cambridge Terrace should eventually be removed in order to redevelop the length of Kent and Cambridge Terraces. The site, which has been targeted for developing a wetland and daylighting the Waitangi Stream, does have a small population of residents that will be displaced. There are 51 permanent residents over the developed site area (Stats NZ, 2020). In the grand scheme of developing the green and blue belt down Kent and Cambridge Terrace, housing for many more people than are getting displaced will be made.

Figure 6.56: Car dealership, vegicular related infrastructure, and unnecessary buildings to remove for future devlopment along Kent and Cambridge Terraces.

6.42 BASIN RESERVE REDEVELOPMENT

Changing the Basin Reserve into a wetland, recreational, and sports area is a controversial move due to its rich cricket, event, and other sporting histories. However, the decision comes from the negative impacts it has on vehicular transport and ecological health, particularly related to water flow. As stated, the basin reserve grounds are not heavily used throughout the year and often lies unused. Giving it a function where regular use occurs, the basin reserve can become a productive social part of the city. A new world-class cricket ground could be redeveloped in an area of less ecological and cultural significance out towards Vogeltown on some of the large field spaces there. Central city green space that the public can regularly use is growing in importance as the urban population increases (Blaschke, et al., 2019).

Key:
- Green Space/Permeable Surfaces
- Waitangi Stream & Lagoon Proposal
- Light Rail Network
- Tunnelled Arterial Vehicular Route
- Heritage Architecture
- Exisiting Infrastructure
- Light Rail Stops

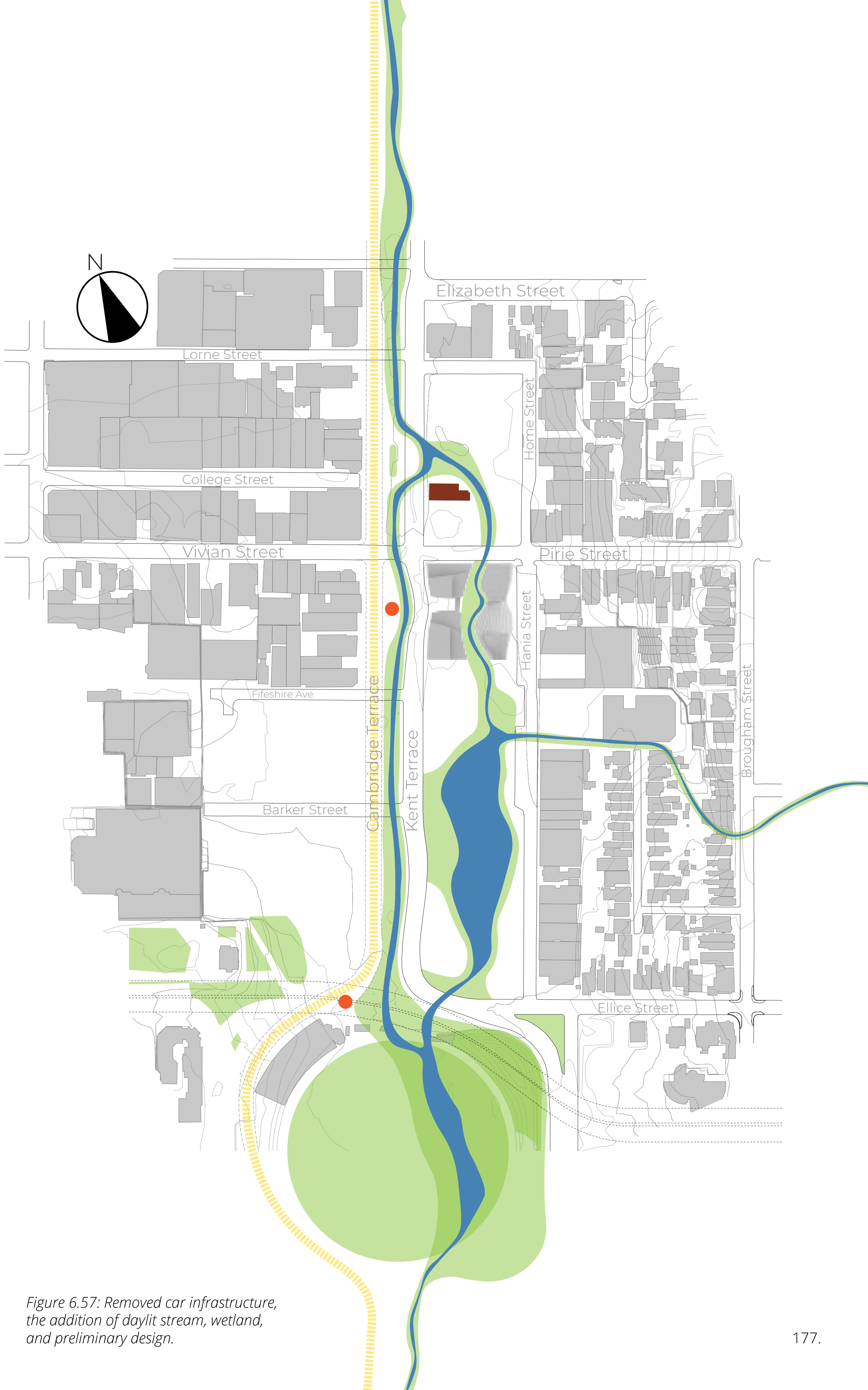


Figure 6.57: Removed car infrastructure, the addition of daylit stream, wetland, and preliminary design.

6.43 NEW ROAD LAYOUT

This content is unavailable.

Figure 6.58: Proposals set forth by the NZTA in 2011, there have been many other concepts over the past 50 years but little has been done beyond the development of War Memorial Park.

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Figure 6.59: One of the concepts from figure 6.57 that was further developed by extending the tunnell for the main arterial road (NZTA).

The removal of most of Kent and Cambridge Terraces vehicular traffic come s as a move to pedestrianize more of the central city. Vehicular pollution negatively impacts urban agricultural practices and makes streets less attractive and useable to pedestrians. Many proposals have been put forward over the years to solve traffic problems around the basin reserve (NZTA, 2011). Some are shown in *figures 6.58 and 6.59*. However, these plans do not appear to solve the question of how to reduce vehicular traffic in Te Aro. I have proposed a theoretical idea where the main arterial road is tunnelled underground will give the ground plane back to pedestrians and other infrastructure. Not dissimilar from subway systems set up in other international urban centres around the world, or even the Arras tunnel.

One complication that does arise is that Waitangi Stream would have to be piped or bridged over my proposed underground road system. However, there have been cases where streams have been bridged over infrastructure before. An example is in Nottingham, where one part of the canal system flows over the natural river on a bridge. Another issue with this idea is simply the cost of putting in a large tunnel. With the project being a thesis rather than a real-life proposal, I have chosen to develop creative best-case solutions and believe such explorations are vital for research and exploring new innovative ideas.

Key:

Proposed Arterial Road

Tunnelled Road

Old Arterial Road

Figure 6.60: Proposed plan for reshaping Central Wellington City's vehicular traffic system.

6.44 LIGHT RAIL NETWORK

A tram network historically existed in Wellington but was then removed. Proposals exist to bring back light rail to Wellington City (Warren and Mahoney Architects, 2018; Opus, 2018). If the redevelopment of Kent and Cambridge Terrace were to occur, the light rail network could be relocated along this stretch of the road instead of down Taranaki Street, as seen in the proposal from *(figure 6.60)*. A more resilient public transport system is of paramount importance for Wellington, especially with the growing number of people in the central city and the number of people now working in the CBD. The integration of light rail would be expensive. However, it will help the city move towards a more sustainable future by removing more cars from the streets and actively planning for increased populations in the area.

This content is unavailable.

Figure 6.61: Laying tram lines alongside the Basin Reserve (Nichols, 1900).

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Figure 6.62: Courtenay Place at the intersection of Kent and Cambridge Terraces (Smith, 1911-1912).

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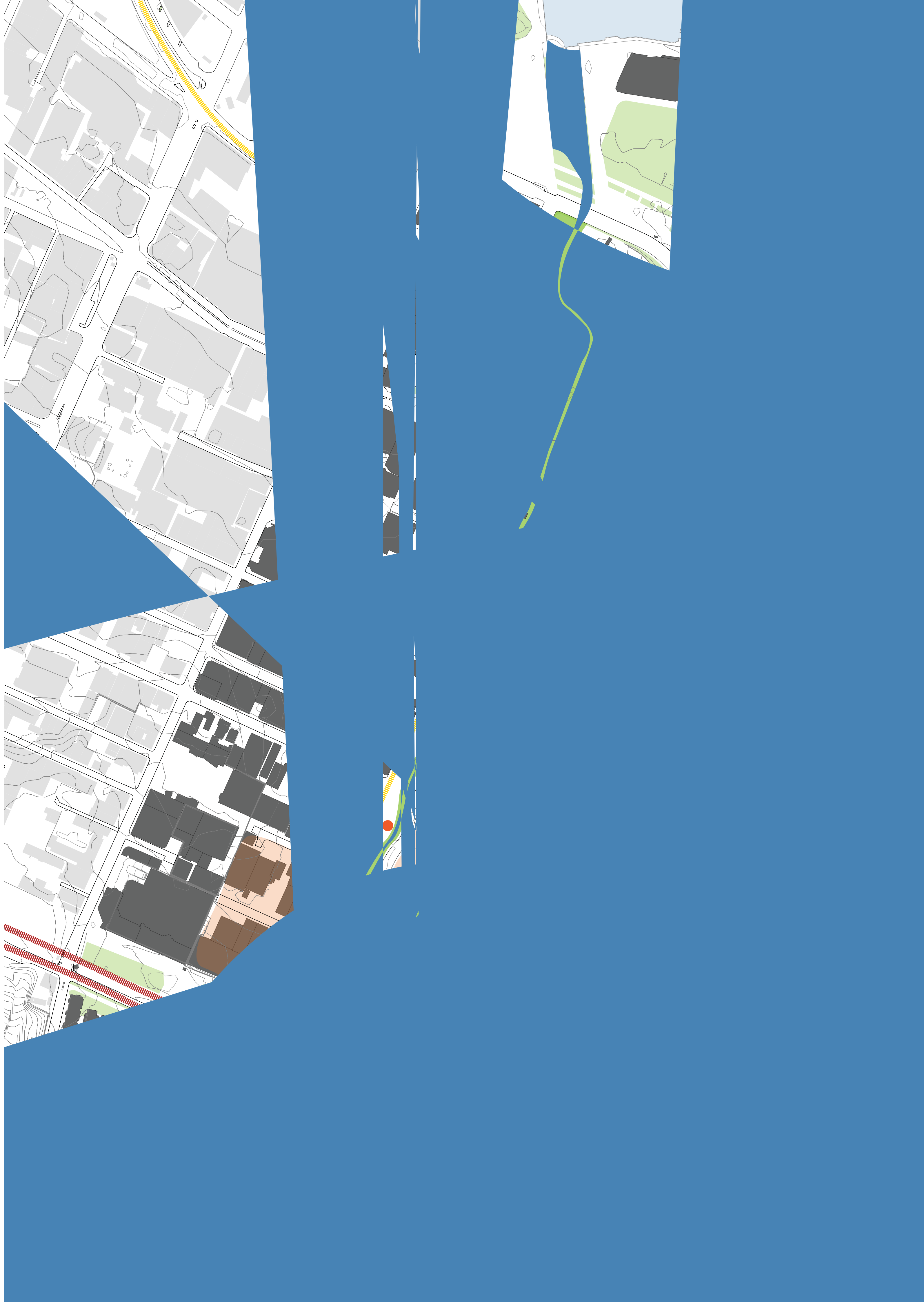
Figure 6.63: LRT route under consideration as part of the Let's Get Wellington Moving Project, (Opus, 2018)

Figure 6.64: My Proposal for where the LRT system should be located.



6.5 REFLECTION

At the six-month part of the thesis, the university held a formal review for offering valuable feedback on the work to date. Internal and external guests were invited and offered insight into the design outputs and research undertaken.

The multi-storey market design was placed on-site with the required floor area as determined by the research. However, the market did not follow the architectural language utilised throughout much of the initial process. The critique related to the design acting as a multi-storey structure that could be used for anything on site. Space's flexibility is essential; however, more market-orientated design thinking is required to make a successful outcome. Better expression of natural landscape features was needed for following the design language sought after.

Another important critique of the design outcome was that the design needed to be better integrated in relation to how it worked with the stream in section. The stream's water level was along the ground plane, making the site particularly prone to flooding. The stream design should sit deeper in the landscape and below the ground plane, especially considering the existing piped streams approximately nine metres underground (Stone, 2018). The stream design could then also positively affect flood mitigation and create a playful element by having a multilevel landscape for various social, cultural and ecological interactions.

Discussions also delved into how to be more playful with how the stream could be integrated into the architecture. The reason for doing this would be to bring the landscape and built environment together as one instead of as separate entities. This could occur from the stream flowing through/around the building or merely acting as an artistic water feature in the design.

The inclusion of plant species also needed to be more strategic. This can be achieved through specific landscape design of the surrounding environment. The built structure could then fit into the landscape, and the right native species can be grown on-site for water filtration and suitability of climate.

Suggested precedents to also explore were Cairo's markets, which went for kilometres through buildings. They would become an endless maze of stalls with a vibrant atmosphere. Another influence for organic forms suggested was architect Antoni Gaudi's work, such as his design of Park Güell. Gaudi took meaningful influence from nature and the biomorphic forms that flora and fauna generated and translated that into architecture (Kent & Prindle, 1993).

7. Developed Design

This chapter details the final design solution developed through the iterative process from chapter six. The research completed is a redesigned master plan of the city, right through to a detailed architectural intervention. A discussion of the finished design takes place through this chapter, detailing key ideas and moves throughout the thesis.

7.1 URBAN SCALE

The masterplan in *figure 7.00* displays each of the big design moves at the urban scale. These encompass a proposed transport system, a cultural and ecological walkway, the central city green and blue belt, future urban infrastructure plans, the wetland, and my market design proposal.

Transport

Cambridge Terrace has been transformed from a vehicular car-orientated route to light rail transit, coupled with a cycle lane and walkway to build a sustainable and future proof transport system. Kent Terrace and Vivian Street are now two-way vehicular traffic routes as part of a move to reduce the number of cars in Wellington's central City. Indicated by the red dashed line, the main arterial vehicular route of SH1 has been moved underground until it reaches Taranaki Street. These decisions have been made to reduce traffic and improve the connectivity between Mt Vic, Te Aro, and Mt Cook suburbs.

Cultural & Ecological Walkway

A walkway is included down Kent and Cambridge Terrace as part of an expression of cultural, ecological and artistic significance related to the site's history and contemporary culture. Installations that would be beneficial to include would be rainwater harvesting for urban agricultural practices, viewing platforms on and around the wetland for looking at the wildlife, work produced by local artists, and information on the area's history.

Green & Blue Belt

With the central city population only increasing, green and blue space per person decreases, meaning there is an ever-growing need for high-quality landscape and green architecture design (Blaschke, et al., 2019). This alone is enough reason to include a central city green and blue belt. The main arterial road of SH1 is proposed to travel underneath Waitangi Stream. Tunnelling roads under bodies of water is possible. Many cases exist in China from the previous three decades, which cater for almost any purpose under complex geological and environmental conditions (Hong, 2017, p. 879).

N

Key:
- Green Space/Permeable Surfaces
- Waitangi Stream & Wetland Proposal
- Light Rail Network
- Vehicular Arterial Route
- Heritage Infrastructure
- Office and Residential Development
- Exisiting Infrastructure
- Retail and Eatery Development
- Public Toilet
- Monuments

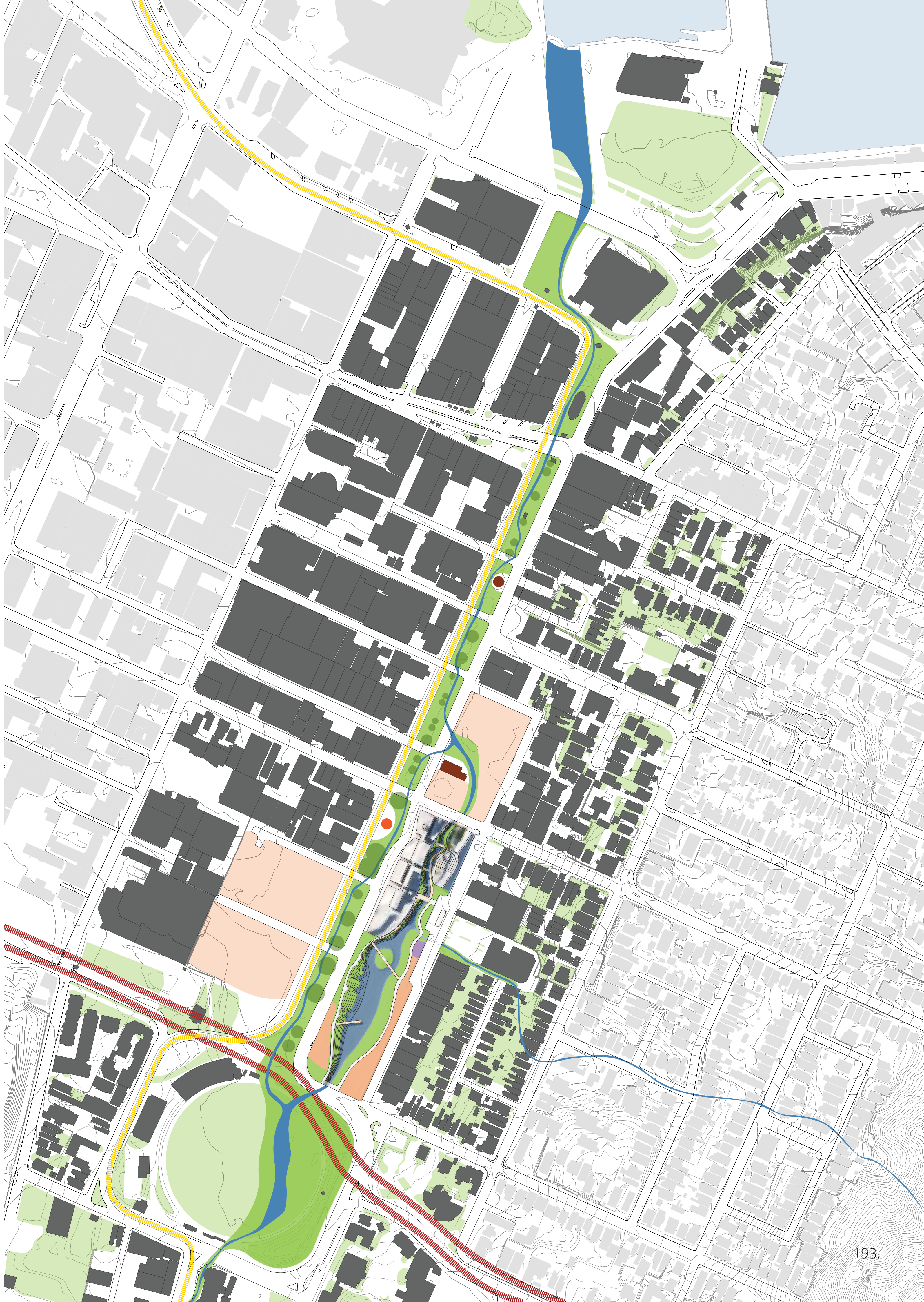


Figure 7.00: Master Plan indicating all the main design moves made.

The Wetland

For a wetland to successfully filter polluted water and alleviate flooding, approximately one-to-five per cent of the stream's watershed area is required (Mitsch & Gosselink, 2000; Smink, 2015; Stone, 2018). In urban environments and conventional farming, wetland requirements are in the higher percentile of land required for remediation and flood prevention. The designed wetland on-site, the Basin Reserve, and Waitangi Park combined only manages 0.5 per cent land coverage of the watershed. Although this may not be enough to treat and filter all water, it is a step towards this, and it is impractical to cover more urban landmass in wetlands is because of the need for built infrastructure in the central city. It may be possible to integrate other forms of water treatment in conjunction with the wetland.

Surrounding Future Development Plans

The areas highlighted in orange were all previously car dealerships or similar. These areas could be developed into mixed-use office and residential infrastructure to help manage the projected increase in urban population and central city jobs throughout Te Aro. By developing higher-density buildings around the market, green and blue belts reinforce the reasoning behind building the low-density market design. The land proposed for future development will also be of higher value and demand due to the immediate access to the green and blue belts (Browning, Kallianpurkar, Ryan, & Labruto, 2015).

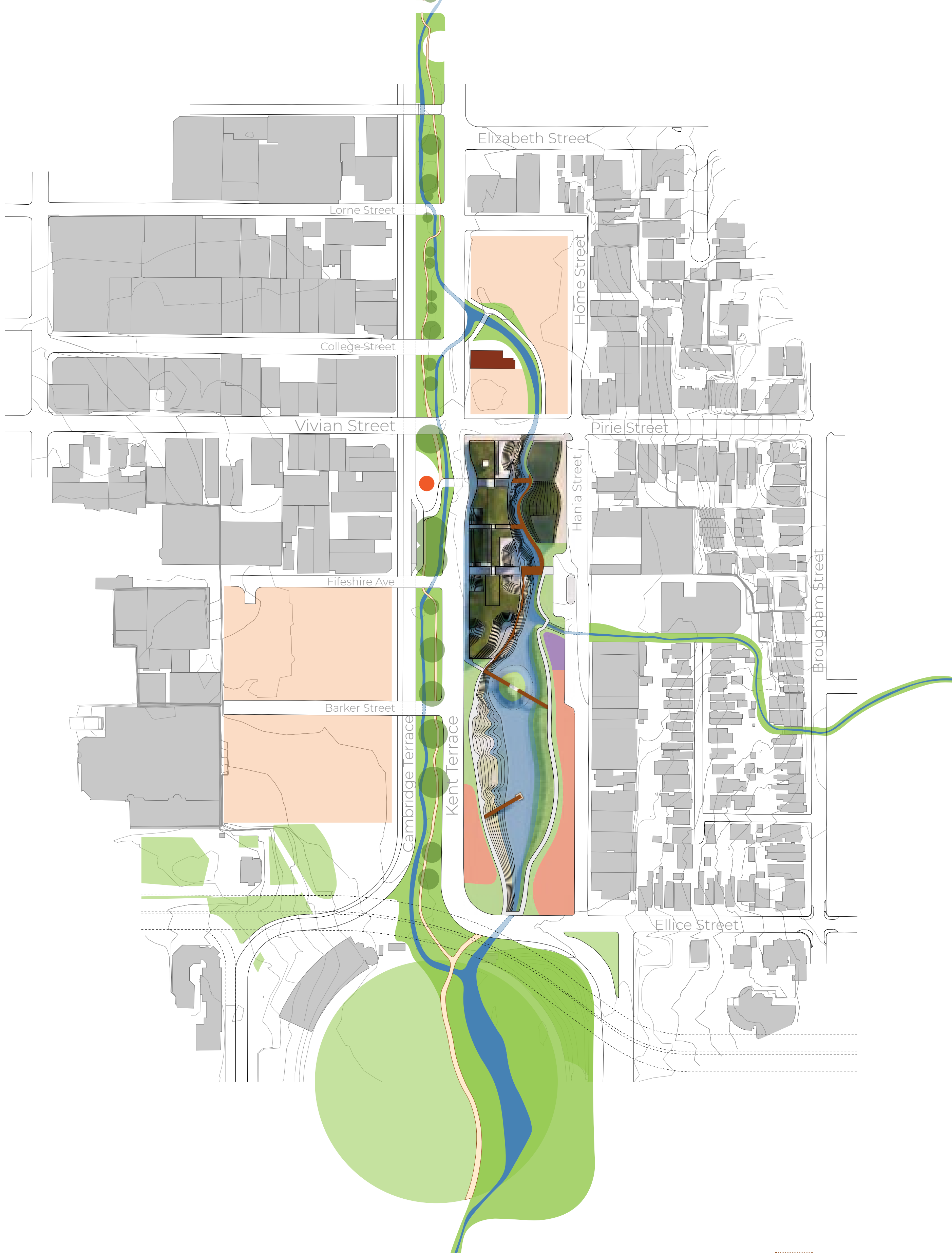
N

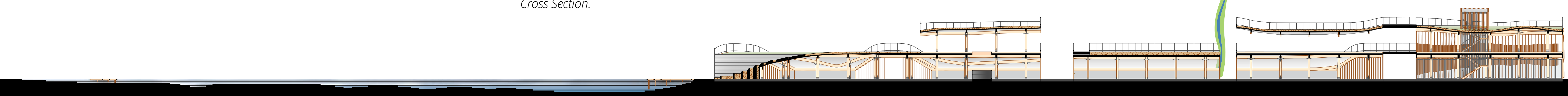
Key:

- Green Space/Permeable Surfaces
- Waitangi Stream & Wetland Proposal
- Tunnelled Arterial Vehicular Route
- Heritage Architecture
- Office and Residential Development
- Exisiting Infrastructure
- Retail and Eatery Development
- Public Toilets
- Monuments

Right Image, Figure 7.01: Site Plan of the completed market and landscaping design.

Bottom Image, Figure 7.02: Longitudinal Cross Section.





N

Key:

Revised Vivian Street Traffic

SH1 new Route

Pedestrian Traffic Flow

Figure 7.03: Vehicular traffic changes.

Figure 7.04: Pedestrian movement and connectivity diagram along Kent and Cambridge Terraces.

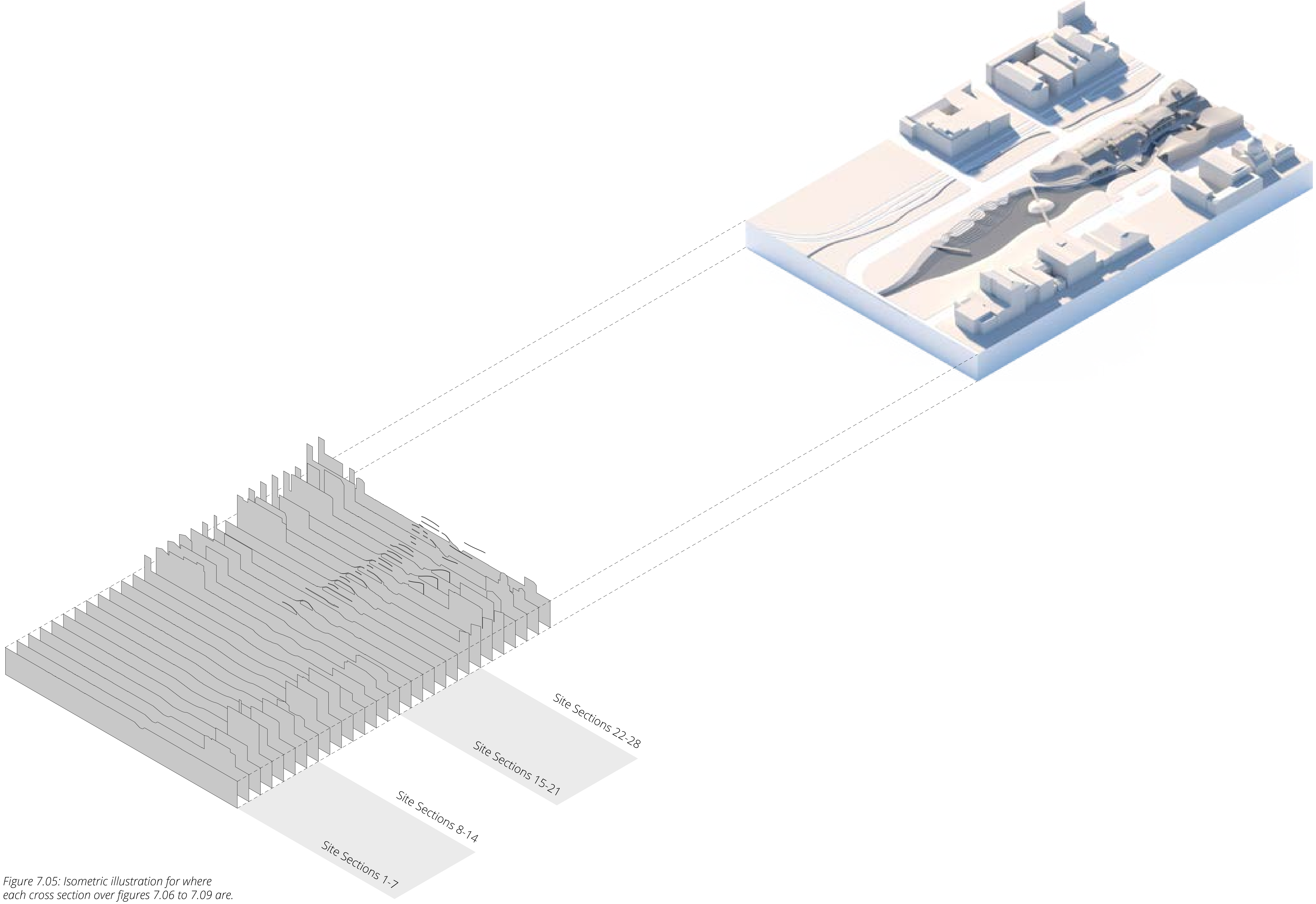


Figure 7.05: Isometric illustration for where each cross section over figures 7.06 to 7.09 are.

Figure 7.06: Site Sections 1-7.

Figure 7.07: Site Sections 8-14.

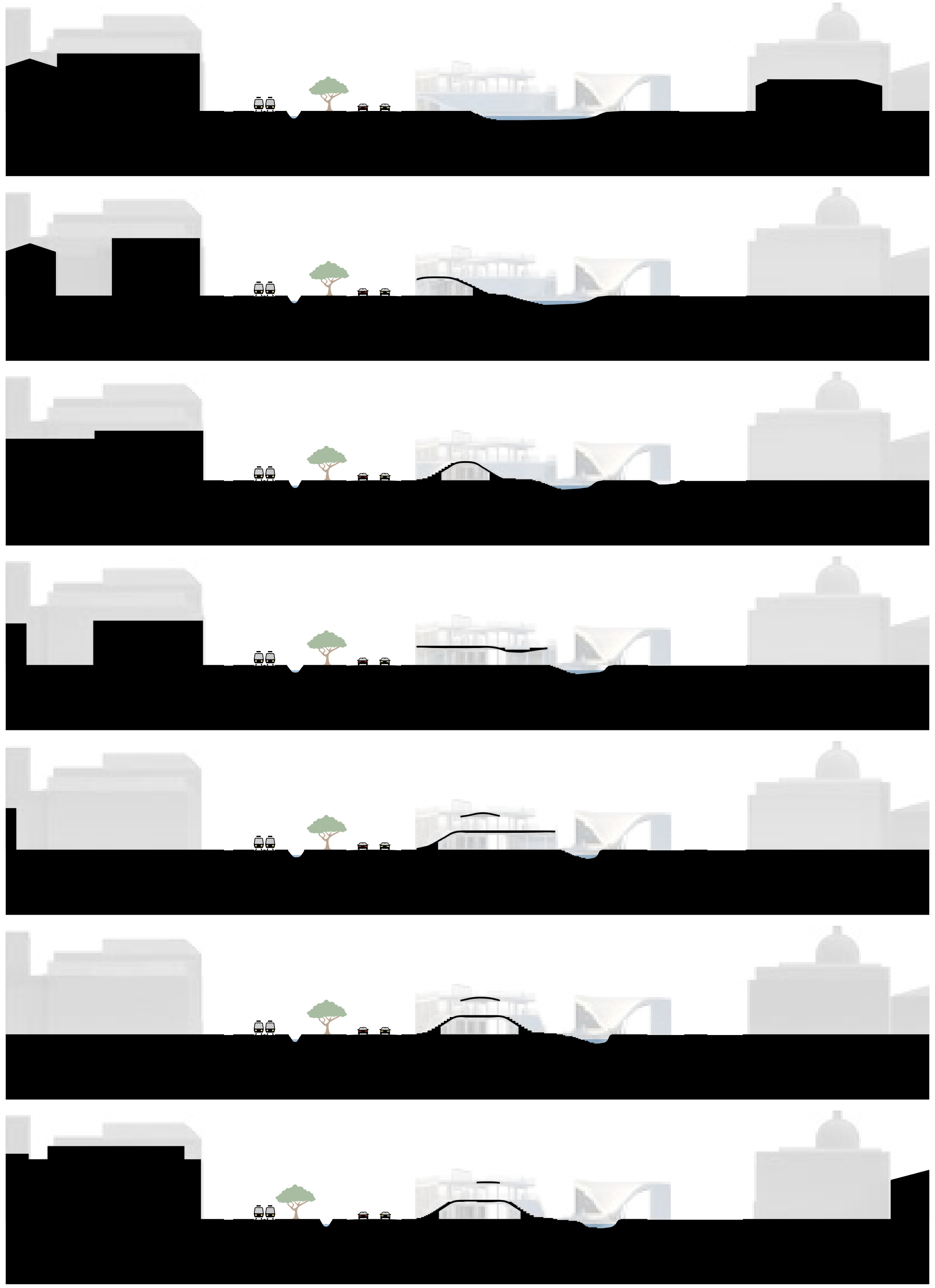


Figure 7.08: Site Sections 15-21.

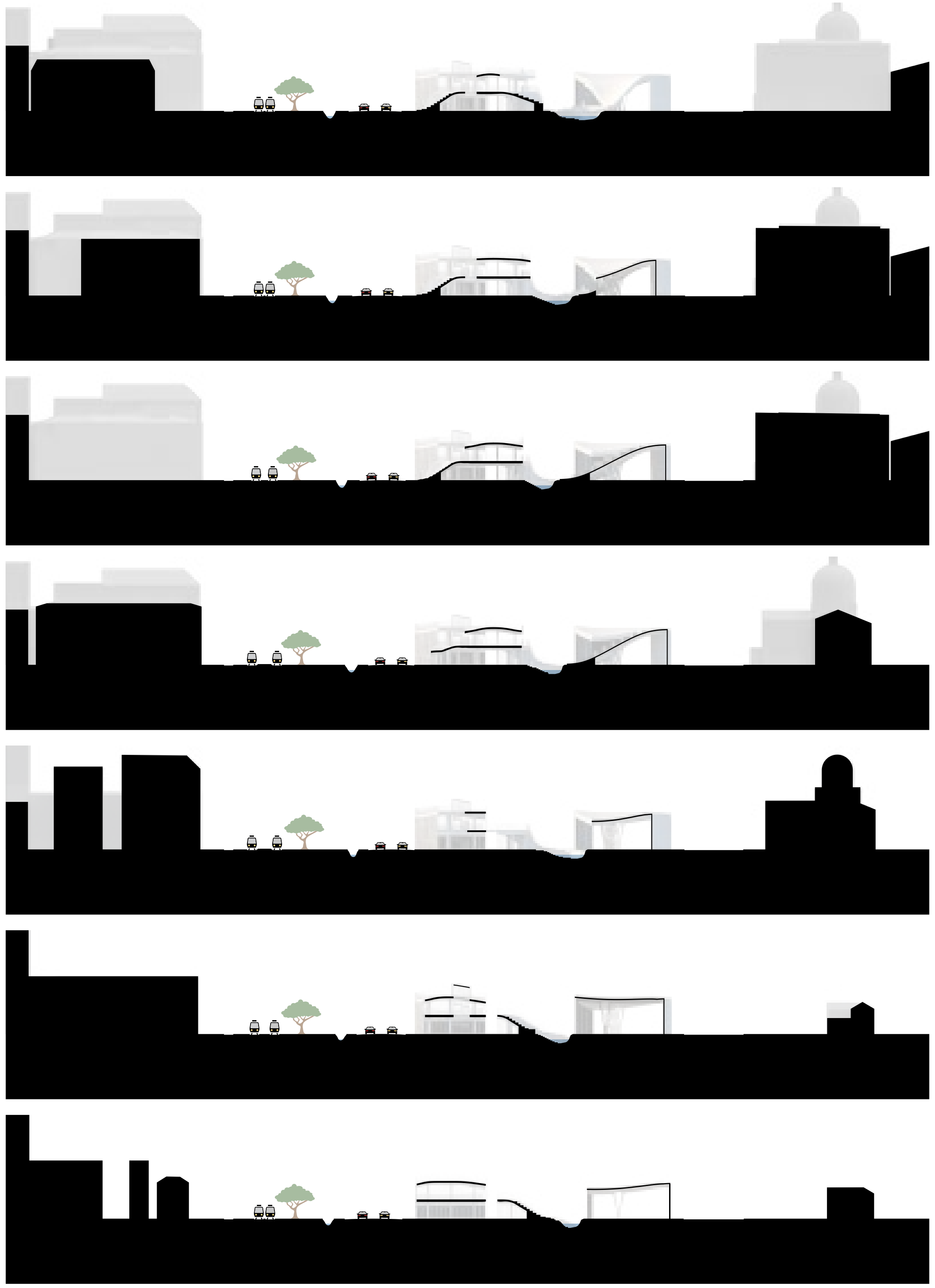


Figure 7.09: Site Sections 22-28.

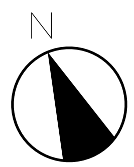
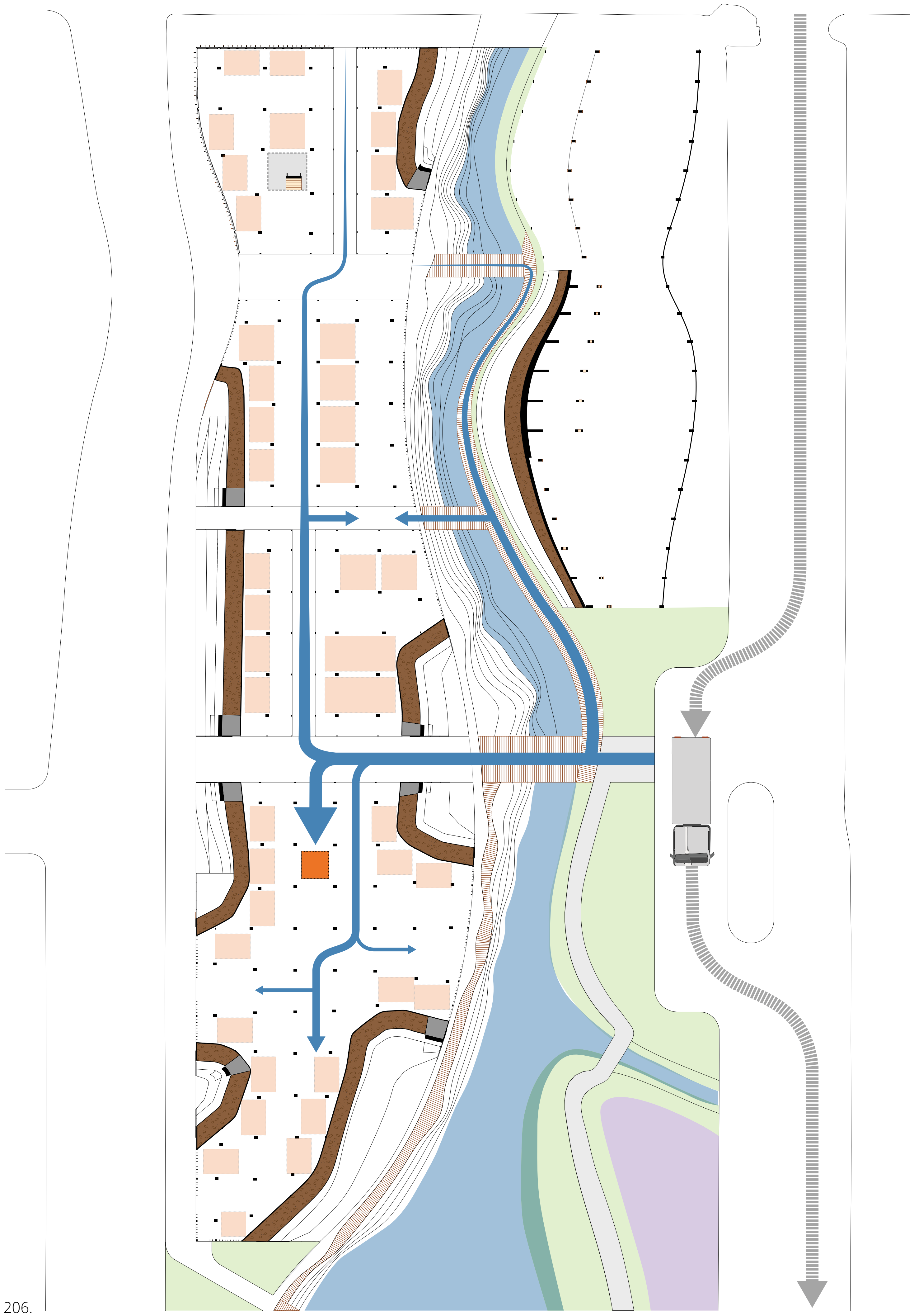
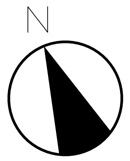


Figure 7.10: Ground Floor Plan.

Figure 7.11: Level 1 Floor Plan.





N

Key:

Generalised Stall Locations

Distribution of Food Supplies

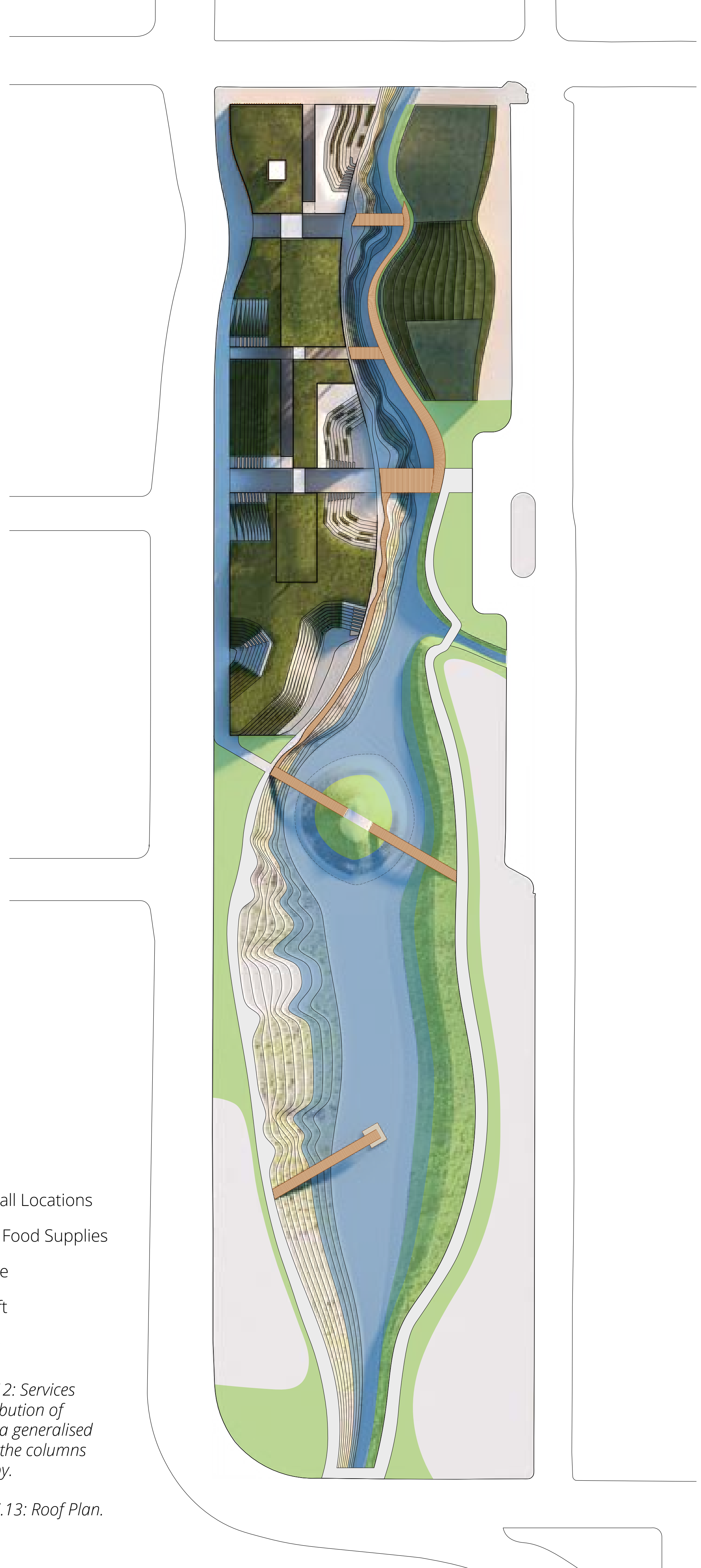
Vehicular Route

Commercial Lift

Staircase Zone

Left Image, Figure 7.12: Services Plan displaying distribution of market supplies and a generalised stall layout amongst the columns under the roof canopy.

Right Image, Figure 7.13: Roof Plan.



DETAILED DESIGN

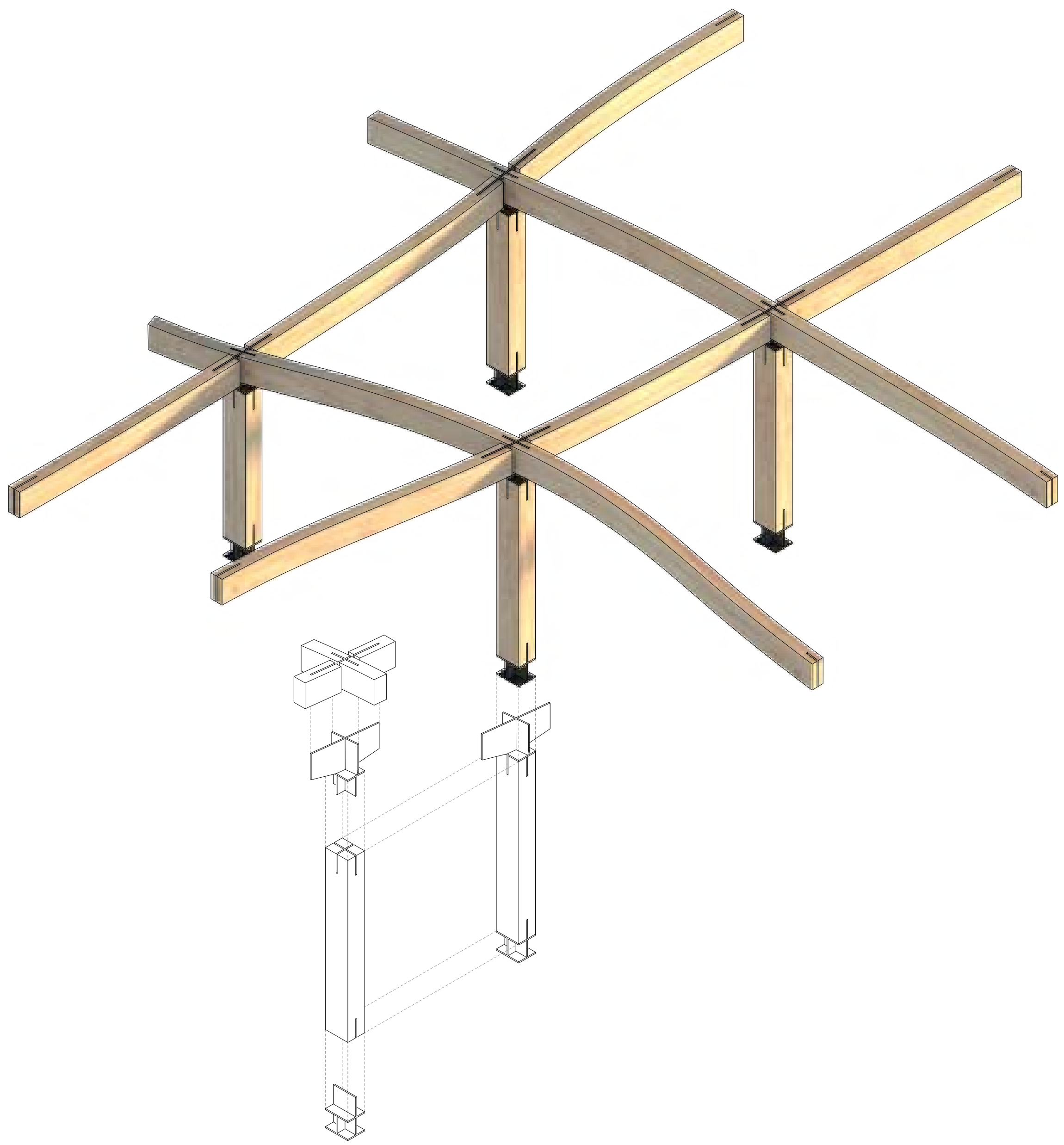


Figure 7.14: Structure detailing of final design.

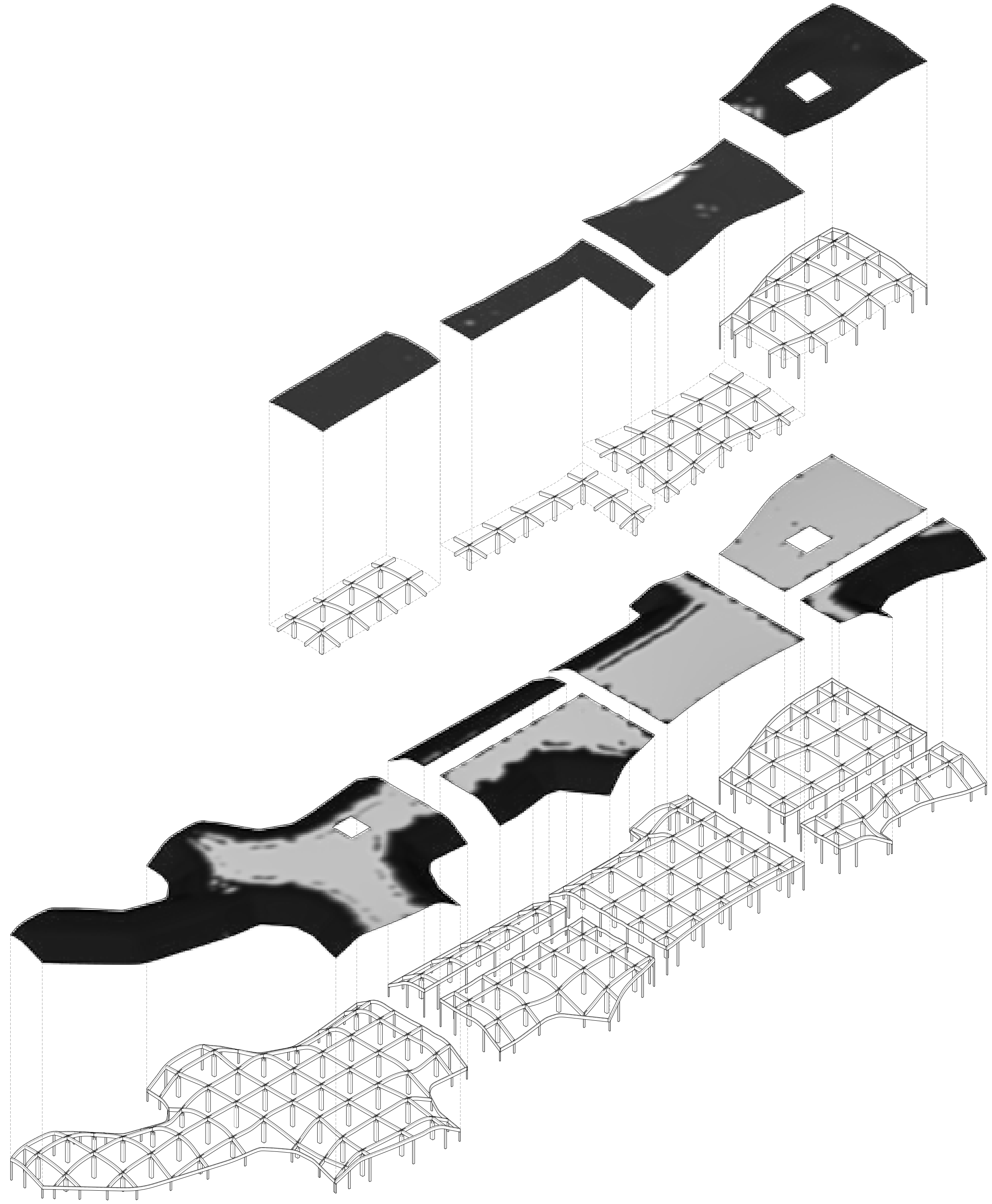


Figure 7.15: Grasshopper simulation for reducing concrete slab material where not needed.

Figure 7.16: Terraced roof design with greenspace availibility.

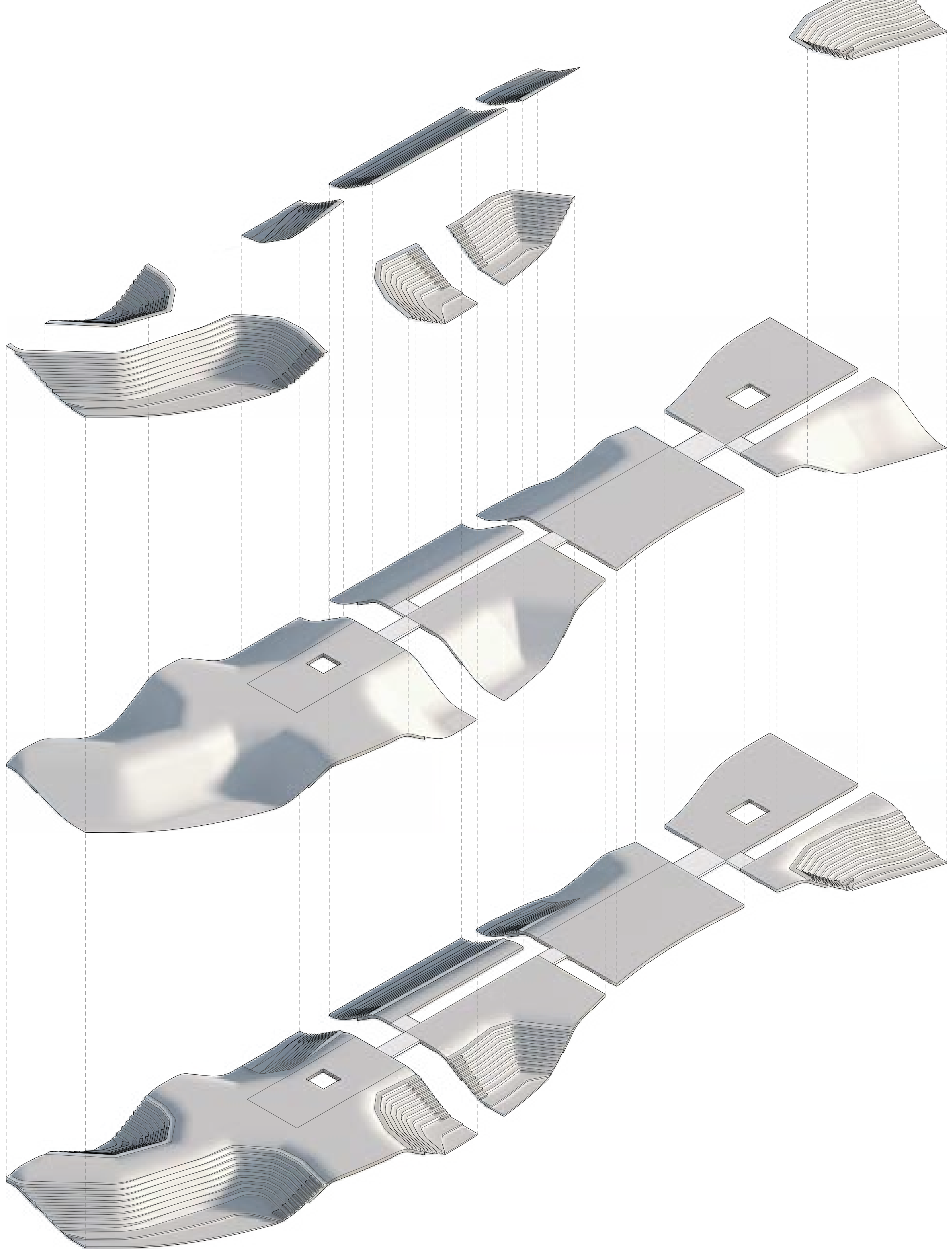


Figure 7.17: Terraced roof design illustration.

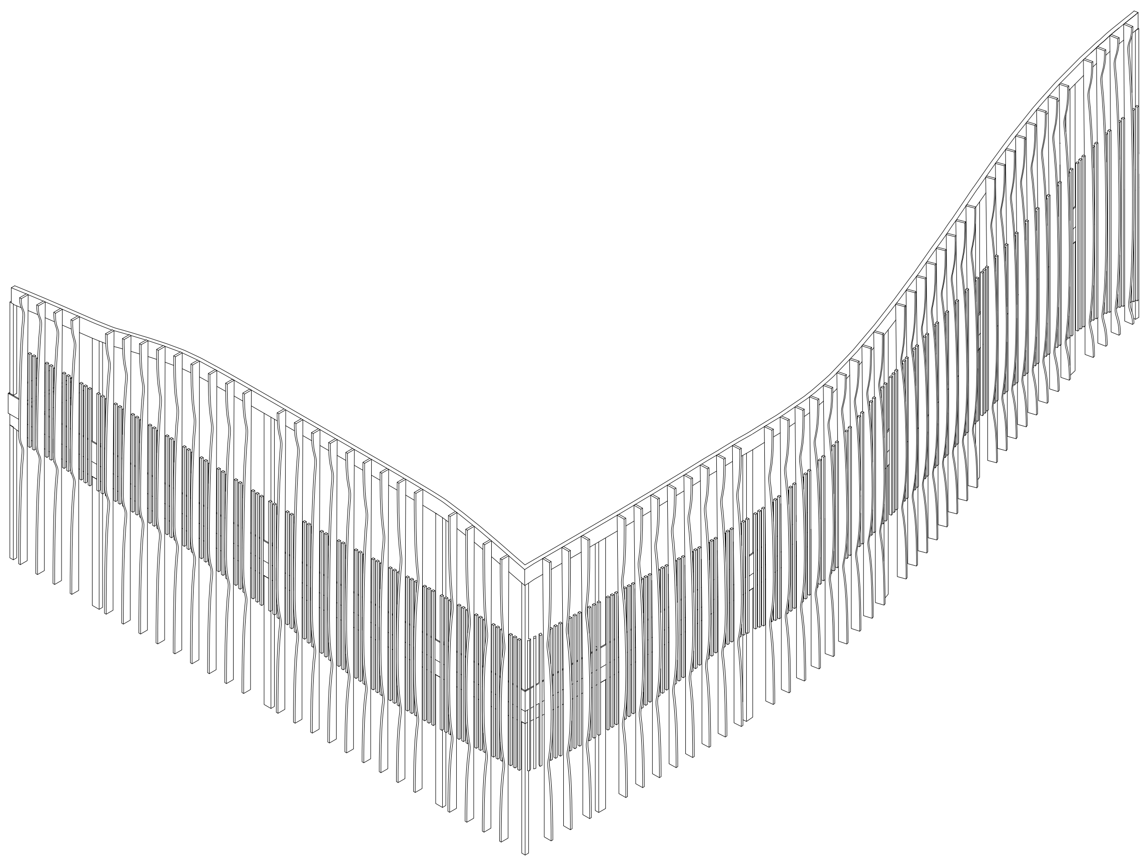


Figure 7.18: Facade design illustration.

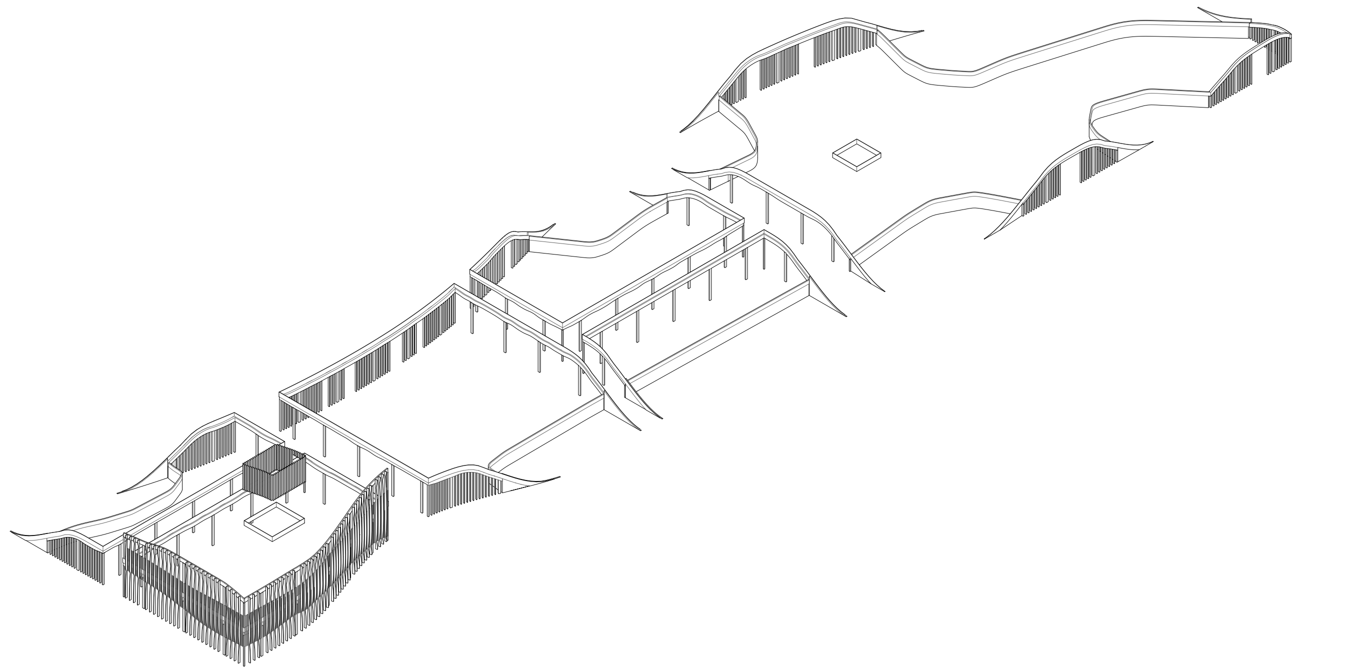


Figure 7.19: Facade design illustration.

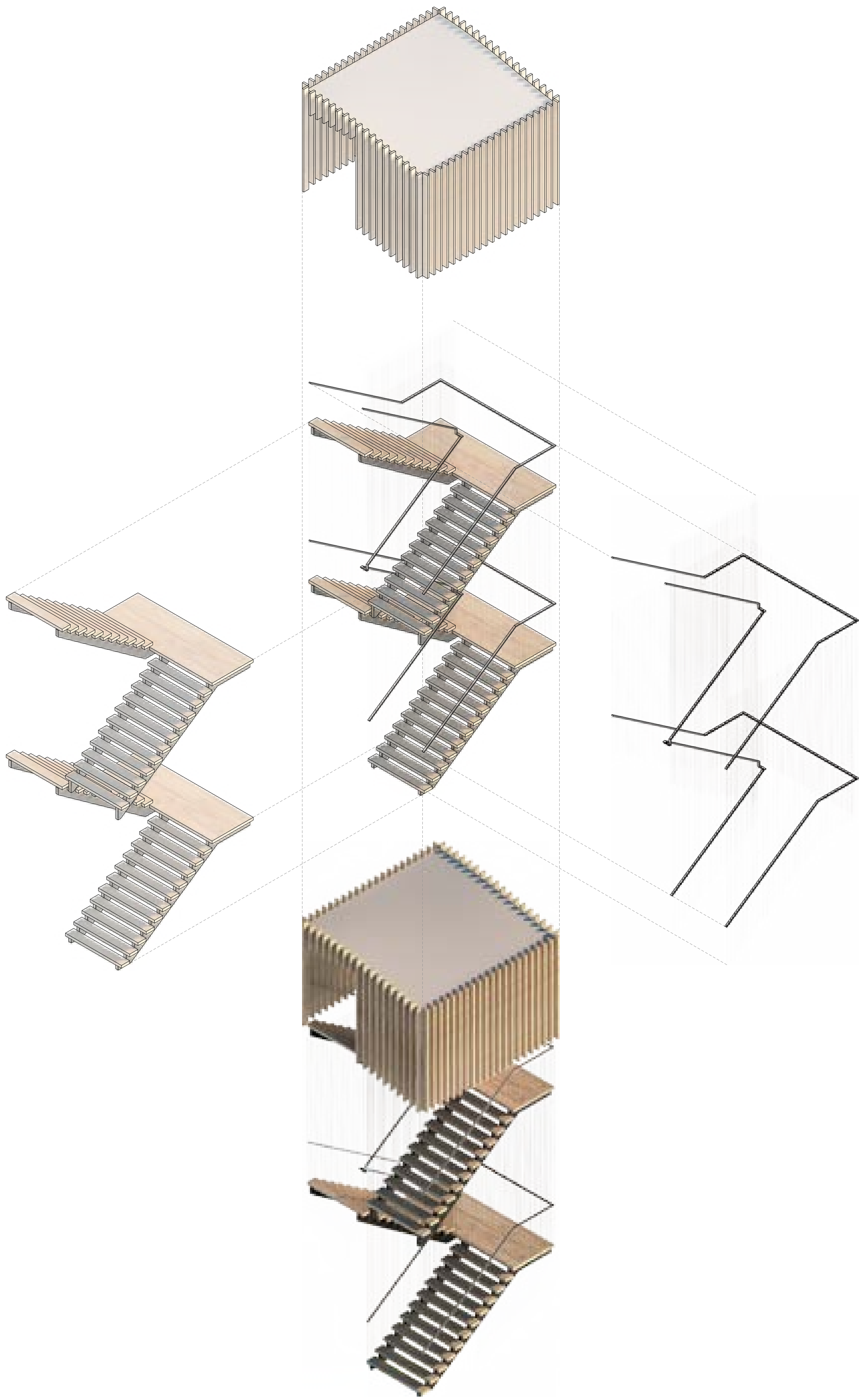


Figure 7.20: Exploded Isometric of Staircase.

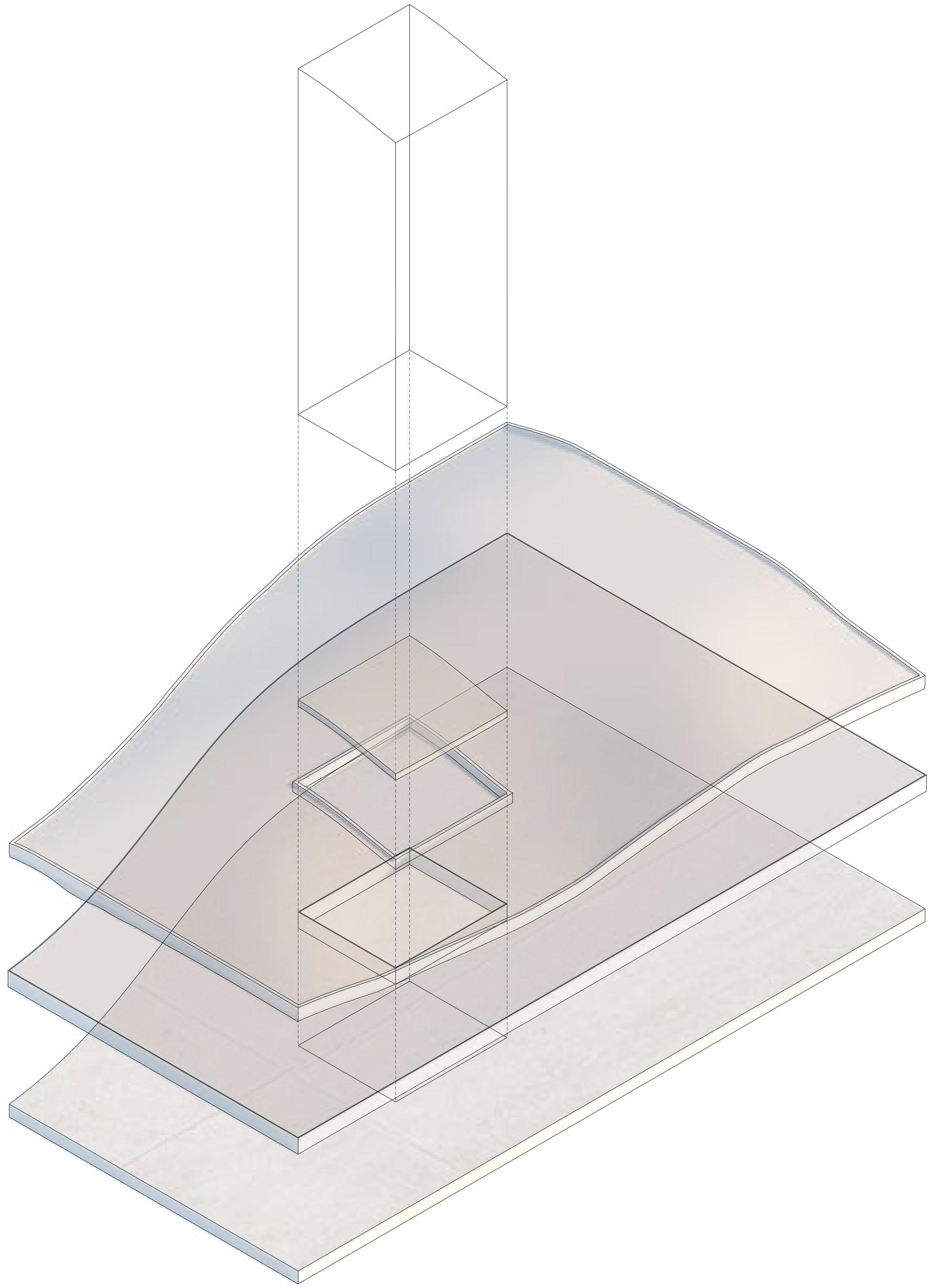
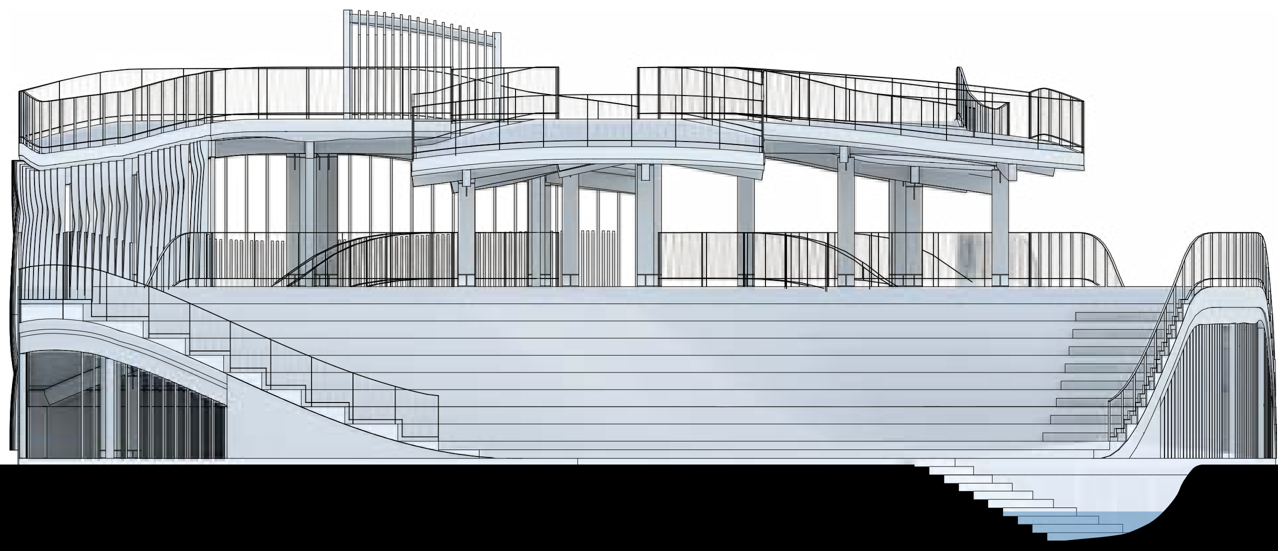
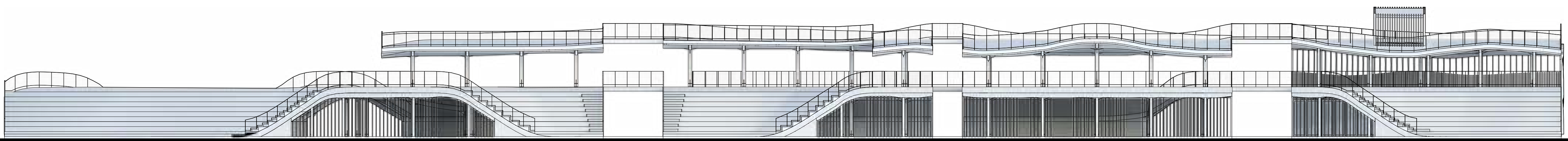


Figure 7.21: Vertical circulaation of staircase.

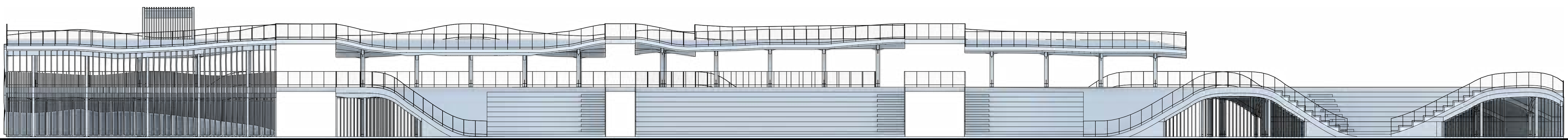
North Elevation



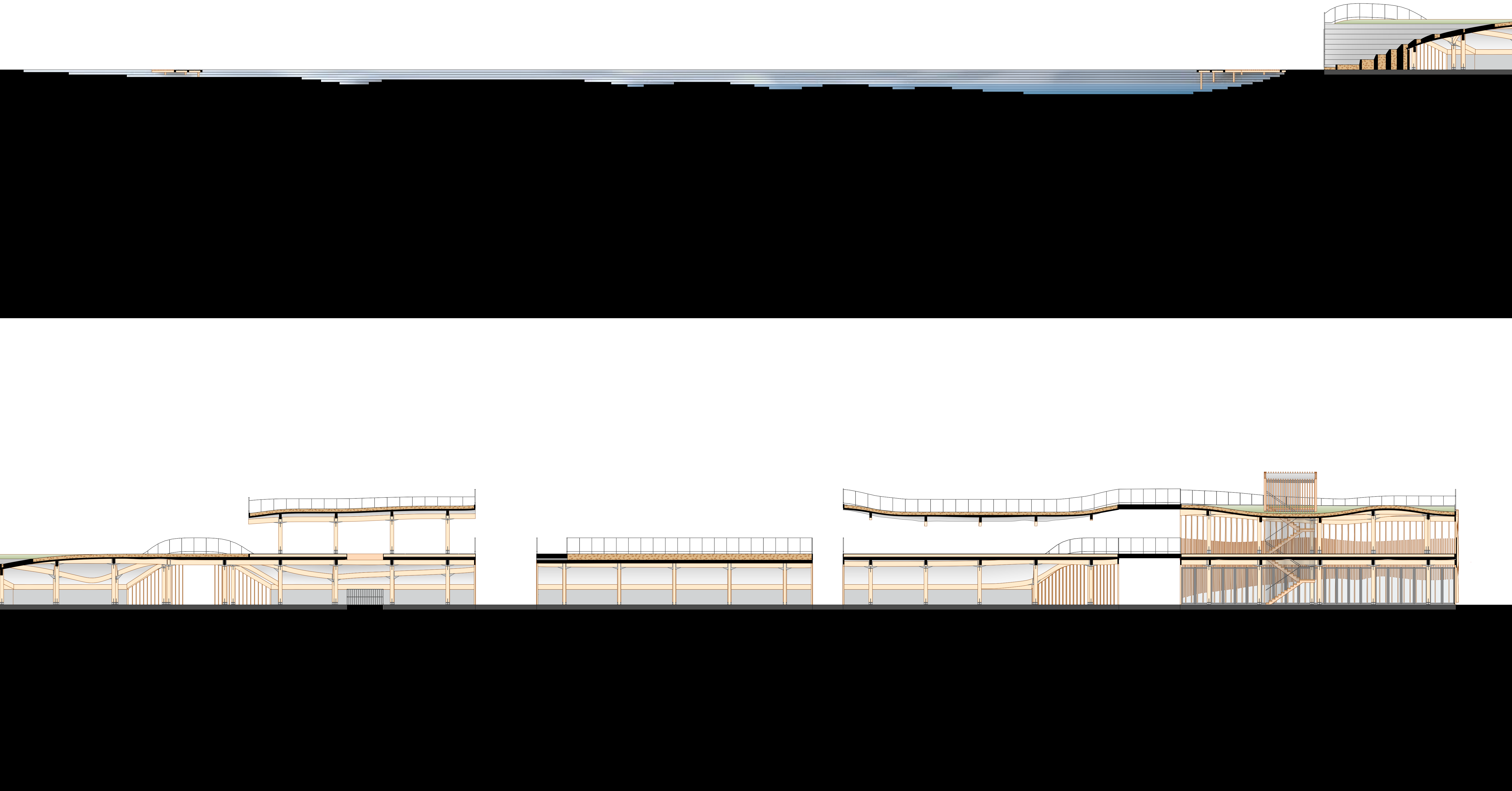
South Elevation



East Elevation



West Elevation



Longitudinal Cross-Section

Transverse Cross-Section

8. Conclusions

8.1 REFLECTION

This thesis sought to create a design outcome that would regenerate ecosystem services in the urban environment in order to benefit human well-being and ecological health. By including biophilic design principles, green and blue space have been created in a high-profile central city location. With a rapidly growing central city population, the design achieves one of the primary goals of providing more green and blue spaces for human well-being.

When analysing the completed design, each of the three biophilic design categories was integrated into the final result. Various direct experiences with nature were formed to allow interactions between people and local ecosystems. Natural forms and materials were used throughout the architecture to achieve an indirect experience of nature. Areas of prospect and refuge occurred between the uplifted artificial layers of the landscape, creating cover and open views. The design had a range of transitional spaces from open walkways, landscape design and open areas for release. An arranged grid type structure was used and provided efficient mobility and wayfinding, and works to organise the design's complexity. Cultural and ecological attachment to place was the most significant quality derived from the experience of space and place. This was achieved by reinstating the lost lagoon and its ecosystems so local ecologies can once again flourish. The cultural and artistic walkway also accomplished the experience of space and place with the green and blue belt along Waitangi Stream. The walkway celebrates regenerative design, along with Māori and Wellington/Te Whanganui a Tara. By including the biophilic design principles in the design, human health and well-being should benefit from the intrinsic connection developed with Wellington's biodiversity. In my opinion, utilising the biophilic design framework has helped create a design that could be successful for both human and ecological health. Through celebration of human-nature relationships, people want to understand, conserve, and regenerate local ecologies.

The market design reduces building density in the city centre, which developers may argue as counter-productive. However, it is vital to have green and blue spaces both, ecologically and to facilitate better human well-being outcomes. Plans for surrounding infrastructure with the market design include removing the other car dealerships and related outlets to make way for mixed-use higher density retail, office and residential infrastructure.

This proposal allows for the low-density design I have conceptualised. However, even with the amount of land set aside for wetland, full remediation was not possible. One quarter can be filtered when including Waitangi Park in the best-case scenario for the Waitangi watershed. Future developments could see further remediating wetland design between the proposed light rail transit and modified road along Kent Terrace for the filtration of pollutants additional future flood alleviation. Although the wetland designed here does not fully remediate the ecological problems discovered in this area of Wellington City, it is a move in the right direction for achieving a regenerative future for ecosystems in urban environments. By designing productive green and blue zones in urban centres, the land is returned in part to local ecologies and people, improving social interaction while supporting local ecosystems.

The final design of the market space creates a social hub that successfully connects the suburbs of Te Aro and Mount Victoria. This has been accomplished by significantly reducing vehicular traffic and developing pedestrian-friendly streetscapes within the inner city. Connectivity is critical for developing a pedestrian-friendly inner city (Let's Get Wellington Moving, 2019).

A fundamental point of learning from the thesis is that specialists such as ecologists, landscape designers, and biologists should be included in the design process for the regeneration of local ecosystems. The scope of knowledge required to understand and design with/for biodiversity and ecosystems is extensive. By including people from these professions, ecologically damaging mistakes can be better avoided.

Due to the thesis scope, completing permaculture design tests became difficult as a greater focus went towards remediation and socially active design. Instead, the holistic view of self-sustaining urban agriculture was sought to benefit a healthy urban living model. It is imperative to shift towards biodiverse permaculture over the monocultural practices that have evolved from the industrialisation of farming. Agricultural research has proved it is apparent that current farming practices render the soil less productive than self-sustaining ecosystems (Rhodes C. , 2012). Fifty-two per cent of land currently used for agriculture is moderate to severely affected by soil degradation, a change in behaviour with food production is in desperate need (Rhodes C. J., 2015, p. 409). What is also needed is more food growing in urban settings because this reduces the need for cities relying on external resources and creates a far more sustainable way of living. This thesis successfully addresses a sustainable living model by incorporating the tested practice of permaculture in Wellington City. Further research would focus on the practical application of permaculture's technicalities with species specification, soil nutrition, and plant requirements for the Wellington climate.

A difficulty found in this thesis was approaching the design from not only an architectural designers' perspective but also from the landscape architecture discipline. The design work became interdisciplinary with a focus on regenerating local ecologies through architecture. By learning about various landscape design principles, I recognised that how we treat the earth is hugely important. Damage can impact generations to come if the wrong design approach is taken, or little care is given to ecological outcomes. What went well with the design was restructuring the city on an urban master planning scale and integrating the design typology I created into the surrounding context. The aim was to create a provocative statement through regenerative design, and the outcome has achieved this by directly addressing pressing ecological issues in Wellington City.

8.2 CONCLUSION

Learnings from the research emphasise that we must urgently change the way people design to mitigate and adapt to the effects of climate change. If action is not taken, urban centres will not have the ability to cope with biodiversity loss, rising temperatures, sea-level rise, natural disasters, and numerous other location-specific issues.

A crucial finding from this research is that people must rapidly shift to being in a symbiotic relationship with ecosystems in order to regenerate them and, at the same time, adapt to climate change. It has become evident that architects and designers should incorporate provision for and integration with ecosystem services into their designs where possible. Therefore, it is essential to collaborate with ecologists, biologists, landscape architects, and associated professionals as the scope of work is extensive and often outside the traditional realm of architectural expertise. A multidisciplinary design process is required to achieve successful regenerative design for ecological health and human well-being.

A second key research finding is that the role of providing public interaction through socially active design. This is fundamental for provoking a change in people's lifestyles so they can begin to live in more sustainable and healthy ways. One method to achieve that has been explored through the integration of permaculture into urban design. This is to incite change in people's eating habits and reduce the ecological stresses induced by standard agricultural practices.

A third finding relates to how, through the careful treatment of water and providing access to all necessary elements that support life or health (waiora), Māori matauranga (knowledge or ways of knowing) become pivotal for the preservation of taonga (treasures). This is important if people move into a guardianship type relationship to land, water, and living ecologies. Wellington's piped streams can support human well-being, increased urban biodiversity, and urban agriculture. This is supported by using architecture that harnesses regenerative design, permaculture, and strategic design of public amenities that incorporate historical and cultural features alongside ecological ones. This reveals the last key finding. People's well-being must recognise collective histories and cultural understandings, which in the case of Aotearoa, cannot be divided from natural ecologies and the landscape's health. Architects must factor this into urban design, building, and infrastructure design.

The findings from this design-led research about regenerative design for ecosystem services and human well-being highlight that it is crucial that architects and built environment professionals understand and then act upon local ecological information effectively. When integrated into the process of architectural design, we could live with urban ecosystems in a more symbiotic rather than damaging way, particularly as social, ecological, and climatic conditions continue to change at ever-increasing rates.

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10. Appendices

10.1 PRESENTATION IMAGES

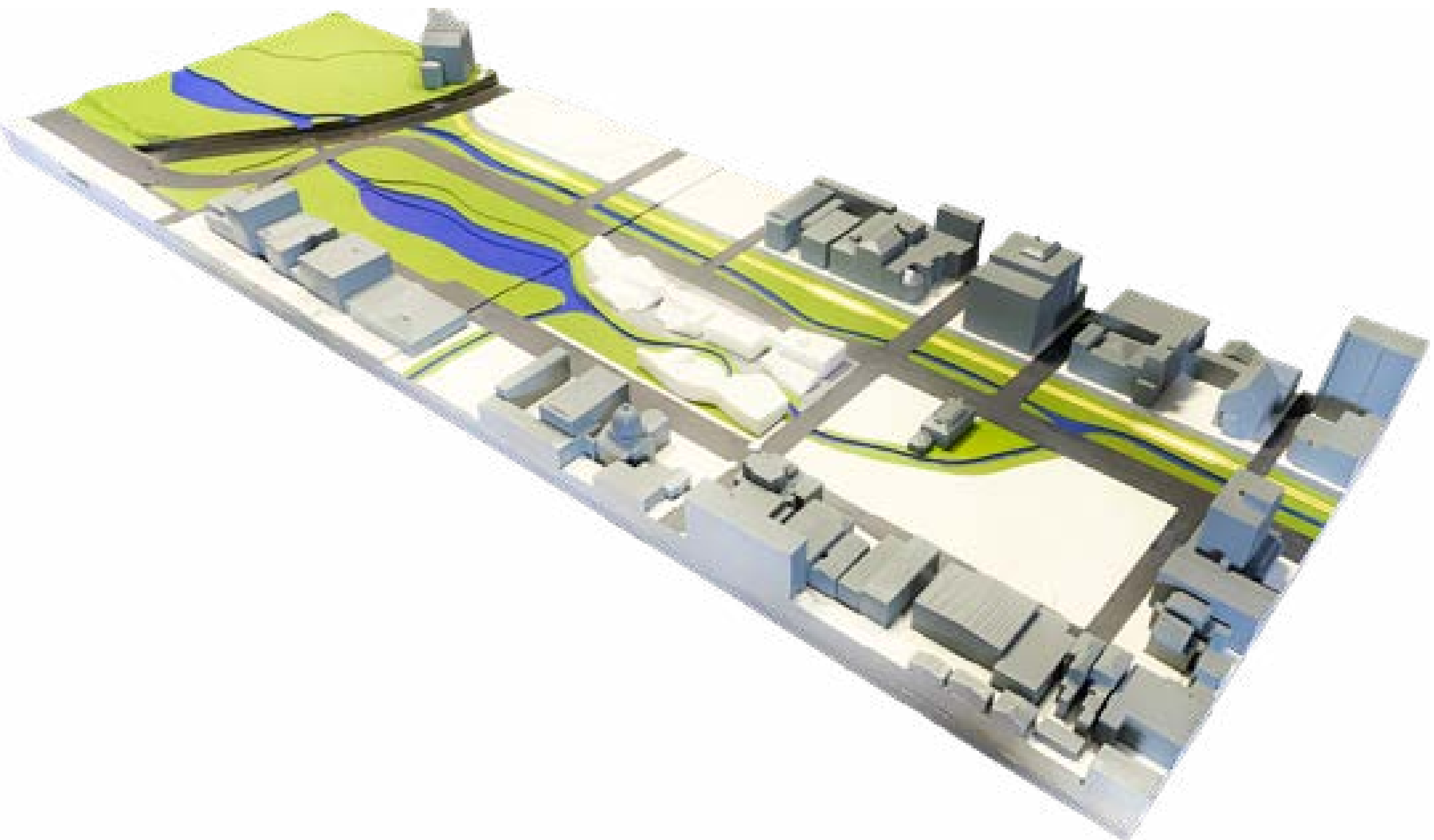
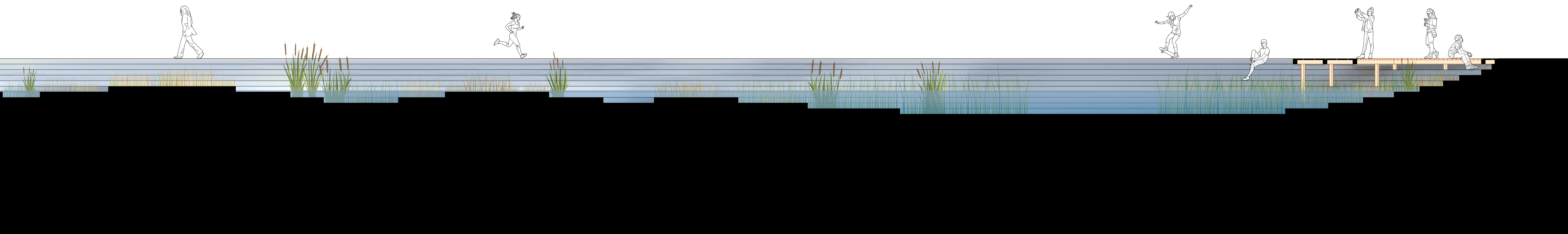


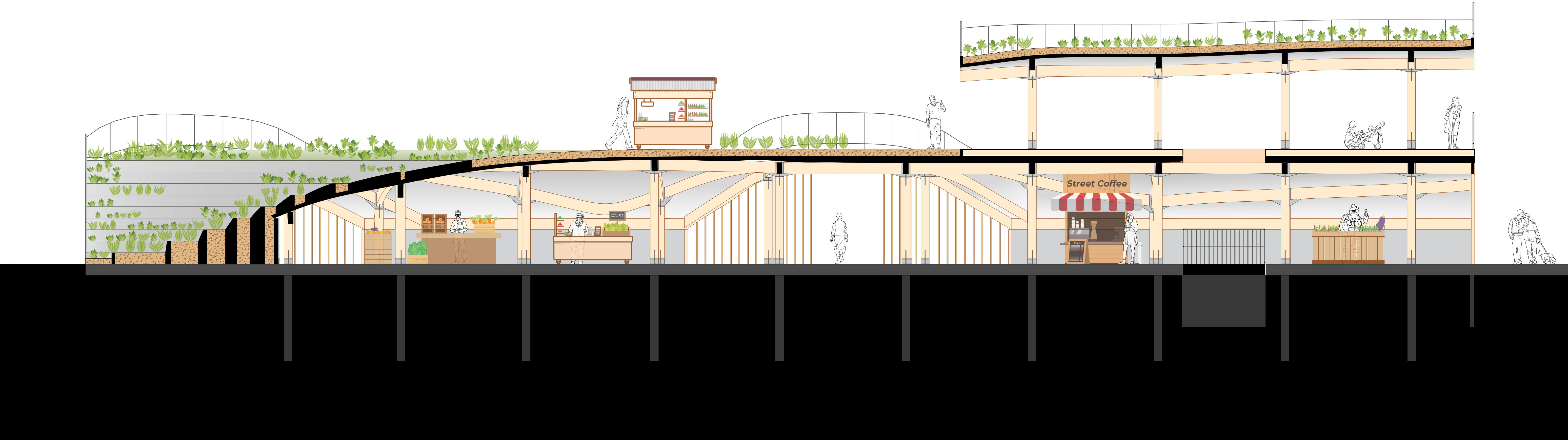
Figure 10.00: 3D View of 1:500 physical model from presentation.

Figure 10.01: Plan View of 1:500 physical model from presentation.

Top Image, Figure 10.02: Longitudinal section of design pt1.

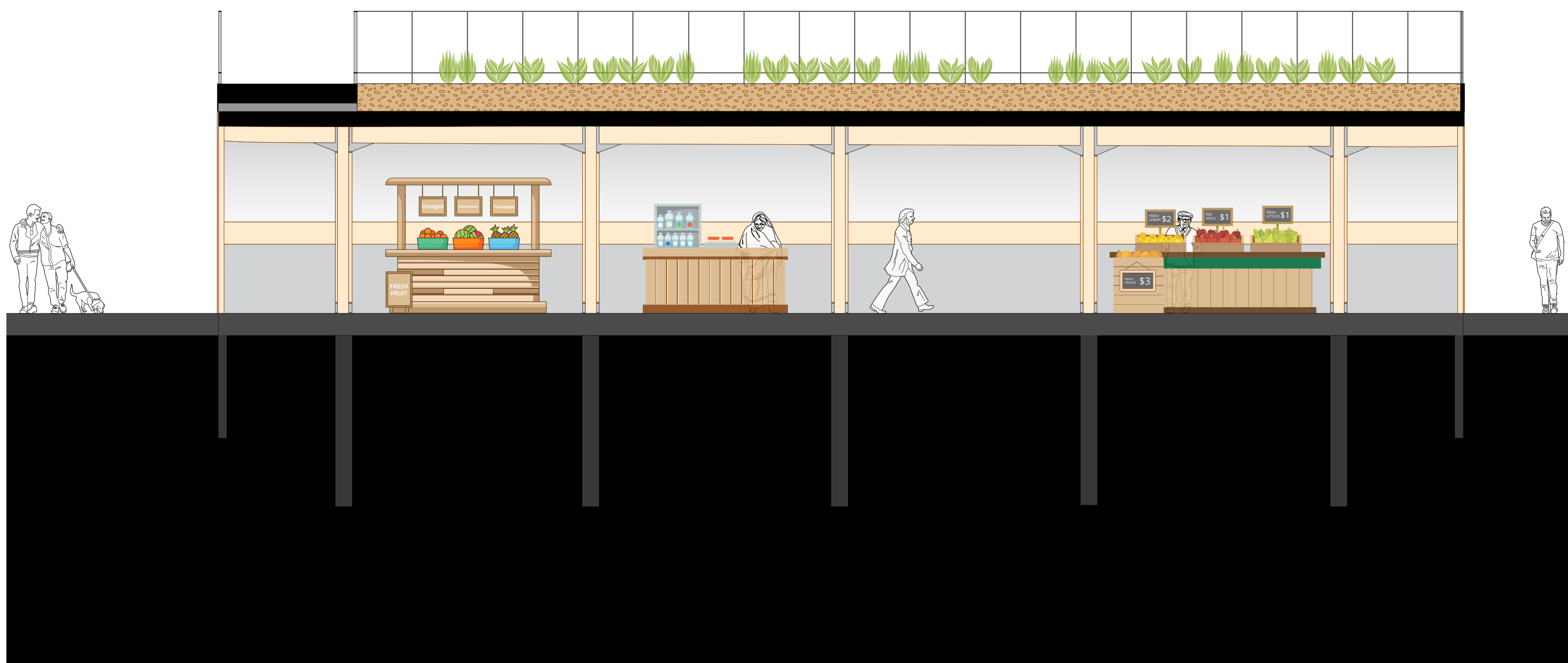
Bottom Image, Figure 10.03: Longitudinal section of design pt2.

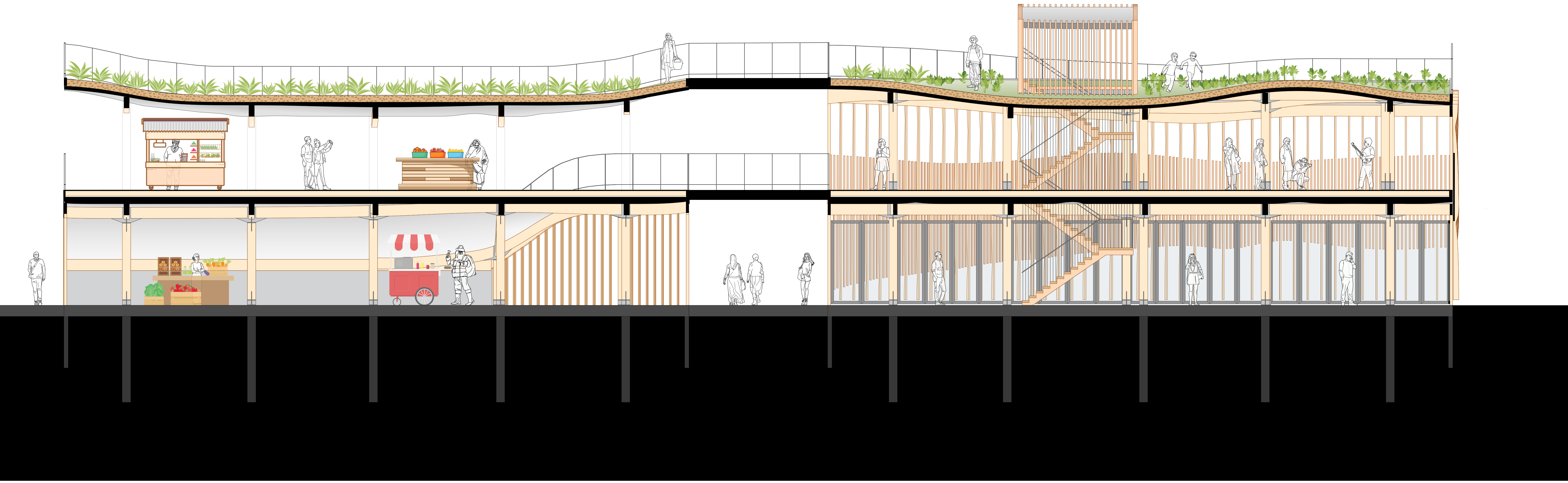




Top Image, Figure 10.04: Longitudinal section of design pt3.

Bottom Right Image, Figure 10.05: Longitudinal section of design pt4.





Top Image, Figure 10.06: Longitudinal section of design pt3.

Bottom Image, Figure 10.07: Complete longitudinal section of design.

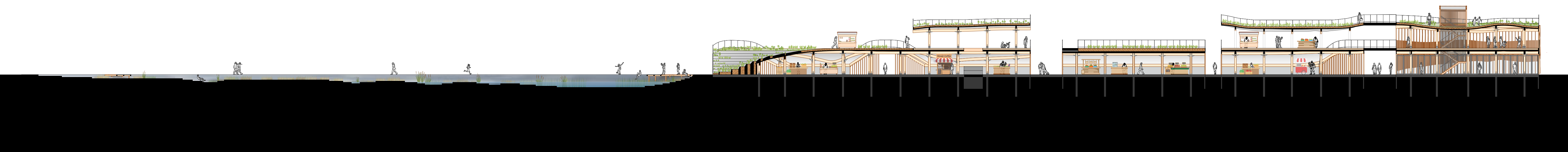


Figure 10.08: Transverse Section of design.

Figure 10.09: Above persperctive render of design.

Figure 10.10: Stream at ground level render.

Figure 10.11: Interior visualisation render.

Figure 10.12: Walkway render view.

Figure 10.13: Activated corner view of design.

A Thesis by

Tom Westend