

# URBAN BLUE SPACE

An **Architectural** exploration into **Sea-Level-Rise** Resilience  
and the future of **South Dunedin**.

by

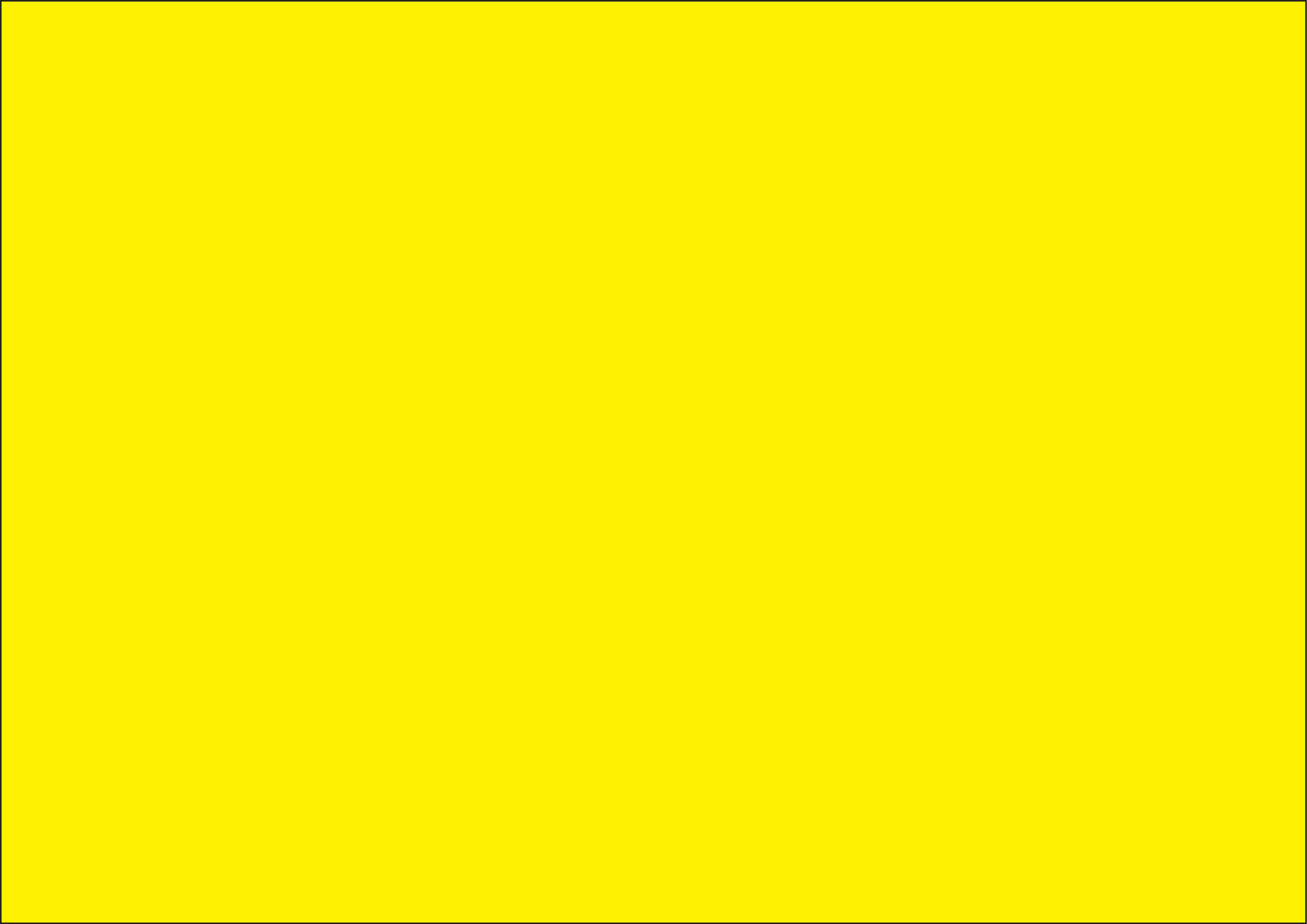
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the degree of Master of Architecture (Professional) 2017.





All unattributed illustrations are the author's own work.



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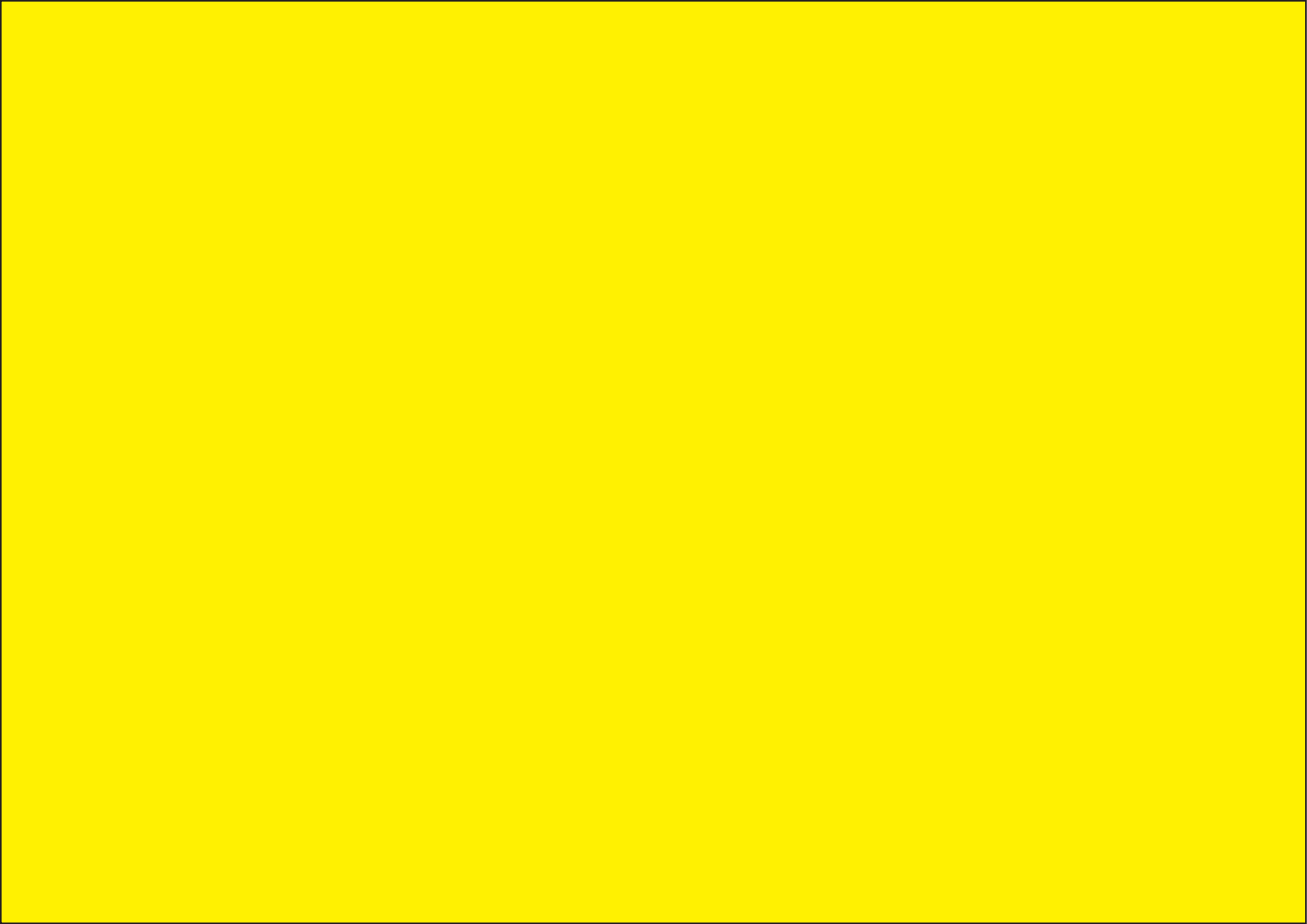
To my family,

my brothers **Kris and Alex**,

to my Grandparents, **Lloyd, Jean, Barbara and Paul**.

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the defining backdrop of my childhood.



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## List of Acronyms

**DCC** – Dunedin City Council

**EPS** – Expanded Polystyrene

**HR** – Holistic Resilience

**SLR** – Sea Level Rise

**ORC** – Otago Regional Council

**WSUD** – Water Sensitive Urban Design

**ZC** – Zero-Carbon

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“Hi Ali

I don't think we would have any issue with you using images as long as you note the photographer if we have mentioned them.

Regards

Glen and DSA team”

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# **01: ABSTRACT**

# URBAN BLUE SPACE

## An **Architectural** exploration into **Sea-Level-Rise** Resilience and the future of **South Dunedin**.

Due to anthropogenic climate change, sea level rise (SLR) will cause low-lying coastal areas such as South Dunedin, New Zealand, to be permanently flooded, jeopardizing future viability as a commercial and residential community. Using South Dunedin as a case study to test built environment issues, this thesis carried out design research into adaptation strategies for continued on-site occupation with SLR. Exploring the extreme scenario of a transition to a floating suburb, the research examines: retrofitting light-weight buildings with buoyant foundations, adapting larger heavy construction buildings to flood, and explores wider urban design strategies for the transition to a resilient floating suburb. Design interventions had to respond to changing conditions from present day Dry Land, to an Urban Wetland (0-500mm standing water), to the eventual Urban Blue Space (500mm+ water depth).

The project proposal has three design objectives:

- **ZC**, Zero-Carbon – While climate change is inevitable, mitigation to reduce the severity is possible through lowered emissions, improved building technologies and changes in human lifestyle.
- **SLR**, Sea Level Rise Adaption – Preparing for and adjusting successfully to the consequences of SLR, which will require radical lifestyle and architectural changes.
- **HR**, Holistic Resilience – For a community to be holistically resilient it must be able to consistently provide for all 5 human needs (Carmona et al 2010, 134) despite changing conditions. This meant addressing both existing and future challenges.

Adaption and continued on-site habitation is possible if significant lifestyle and architectural changes are embraced. SLR requires a site-specific design response. Successful adaptation requires a holistic multi-disciplinary long-term commitment to a resilient future.

## **02: INTRODUCTION**

Due to the effects of anthropogenic climate change, global sea levels are rising daily and could rise over 1000mm by the end of the century, the evidence for this is irrefutable (IPCC 2013). "It is estimated that 20% of the global human population lives in coastal cities and of these 100 million people live within 1000mm or less above mean sea level" (Dawe 2015, 1). Even if emissions were immediately cut to zero, the amount of carbon already in the atmosphere means that climate change on some scale is unavoidable, sea levels would still be expected to rise by up to 500mm by the end of the century and scientists agree that, due to geographical factors, New Zealand sea levels will rise 10% more than the global average (RSNZ 2016, 20). What this means is that, even in the best-case scenario, low-lying areas will still require a long-term resilience strategy for sea level rise (SLR). The New Zealand National government in 2016 indicated that managed retreat is the only feasible option for areas in New Zealand facing SLR (MFE 2016).

The question this design research addresses is: How can the built environment/architecture of a low-lying urban area be adapted for increased resilience facing SLR due to anthropogenic climate change?

It is certain that SLR and climate change will occur, what is not certain is when it will and to what severity. Therefore design interventions must be planned to respond to conditions rather than a timeline. The thesis establishes three sequential thresholds of SLR, to which the design interventions must adapt to in turn as SLR progresses. The thresholds are defined by changing environmental conditions which require different adaptive design responses.

1. **Dry Land.** This is the current environmental condition, land is still dry, and for the most part, life as usual continues. The end of this phase will be defined by the point at which it is no longer possible for surface water to be drained.
2. **Urban Wetland.** Shallow but permanent standing ground-water, within depths of 0-500mm above ground level. Vehicle use should still be possible to a limited extent; however ground conditions would become increasingly muddy. It would still be possible to walk around in these depths, although it would become increasingly difficult and not possible for small children or pets. Dry Land vegetation would begin to die and be replaced by wetland growth. Dry Land infrastructure would be severely compromised and

require replacement e.g. city sewerage and electricity lines. Foundations of Dry Land buildings could survive only for a short time in this condition. Pollution and environmental health would be a serious concern in this phase and require careful management and intervention by environmental scientists and local government.

3. **Urban Blue Space.** Water depth exceeding 500mm. This is when Dry Land vehicles would cease to be viable and complete conversion to water-bound transport necessary. Dry Land buildings would be un-inhabitable if not adapted and infrastructure would need to have been completely replaced.

The site for this investigation is South Dunedin in Dunedin, New Zealand, which has been described as a "litmus test for the nation facing climate change" (McNeilly 2016). A low-lying, socio-economically deprived, densely populated area with 10,000+ residents, 3000+ homes and businesses, South Dunedin is one of the area's to be first and most severely affected by SLR in New Zealand.

For the purposes of this thesis a decision was made to focus on Accommodation as a strategy (see Literature Review p.9), to enable residents to continue living on site. It is acknowledged that a more likely scenario would be a combination of strategies. The scope of the thesis has necessitated focus on only one of these. Design research was carried out at three scales: a residential house, a community site, including a supermarket, and an urban design strategy for the suburb. The thesis explored the following design objectives:

**SLR**, Sea Level Rise Resilience – Architectural strategies for resilience in a changing environment due to SLR. Design research was carried out in a theoretical capacity, structural advice was sought from university staff, however it is acknowledged that were these projects to become a reality they would require detailed consultation from structural and environmental engineers.

**ZC**, Zero-Carbon - Transition to a holistic post-carbon world is essential to achieve any degree of climate change mitigation. A Zero-Carbon philosophy has been a key design driver throughout the research, however detailed architectural investigation into Zero-Carbon building technologies, while very important, was deemed outside of the scope of the research.

**HR**, Holistic Resilience – For a community to be resilient it must be

able to consistently provide for all five human needs (see Design Chapter p.39) (Carmona et al 2010, 134) at all times despite changing conditions. Design research will test to what degree architectural interventions can support this.

Following this chapter is the Literature Review which establishes a broad understanding of the research topic by reviewing international precedents. The Case Study chapter then focuses on New Zealand precedents to gain an understanding of the national context. The Site Analysis chapter is a diverse study investigating existing and future challenges of ZC, HR and SLR. The Design Research chapter follows on from these demonstrating an iterative design methodology which tests precedents and ideas found during previous chapters against the research question, site and design objectives. Cross-pollination of precedents+research+objective+site, often led to further research enquiry, stimulating further design experiments. The final Conclusion chapter critically reflects on the thesis research as a whole.

## **03: LITERATURE REVIEW**

## Literature Review

This literature review surveys research related to resilience and the built environment addressing the research question: How can the architecture/built environment of an existing low-lying urban area be transformed for increased resilience against SLR due to anthropogenic climate change?

The review demonstrates that SLR is a global problem; however there is a lack of available published literature from many countries. The international leaders in publication, built work and research were found to be the Netherlands, the USA, UK and Australia and consequently this review focuses on sources produced from these countries. Sources were gathered in 2016 and were drawn from a wide range of sources, both academic and grey<sup>1</sup> literature.

### Introduction:

Humankind has known about climate change for decades now (Mann 1998, 5; Mooney 2013). The science is conclusive, climate change is the crisis of our time. So why are we so slow to act (Hamilton 2010, 20; Aitken et al 2011, 1)? The majority of scientists agree that we have already moved beyond key tipping points and irreversible climate change is under way (IPCC 2014; RSNZ 2016, 5; Hamilton 2010, 15; Murray 2008). Meetings of international leaders such as the 2015 Paris Climate talks, or of local governments and leading experts, have become frequent events. In April 2016 alone New Zealand hosted three such conferences (cop21; NZILA; NZPI). On the 18th of April a report was issued from the Royal Society of New Zealand titled: *Climate change implications for New Zealand*. The rapid public exposure of the report was encouraging and the findings of the report are clearly communicated, framing the threats of climate change in terms of specific risks to New Zealand. Information and commitments to climate change seem to be abundant, but will the proposed action be at the level scientists have advised is vital for a resilient future?

Aitken et al (2011, 2) discuss New Zealanders' preparedness to act against climate change, Hamilton (2010, 35) discusses why we distrust the science and the forces in place to discredit it. Their resound-

### The effects of climate change on ecosystems



### Implications for New Zealand

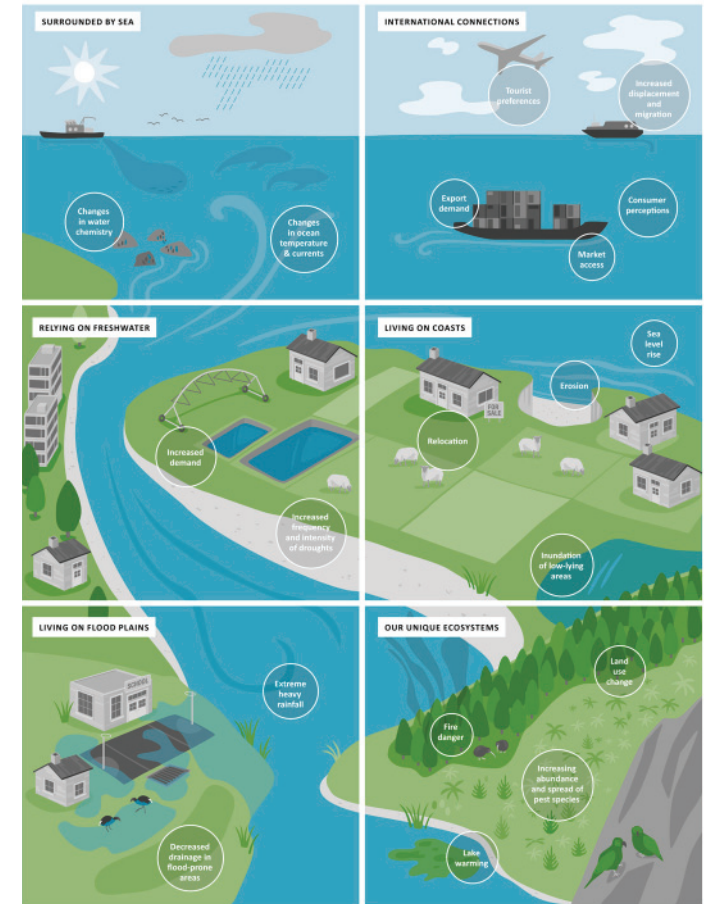


Figure 3.1 Effects of climate change on New Zealand, RSNZ (2016)

<sup>1</sup> Grey Literature covers non-traditional sources such as newspaper or magazine articles, television programmes and interviews and social media statements.



ing conclusion is a feeling of powerlessness and little hope. According to Murray, in his short film *Wake Up, Freak Out! Then Get a Grip!* (2008), literature and popular culture shows a society focused entirely on the economy and material gain at the expense of the natural world, social well-being and ultimately the future of humanity. Murray tells his audience “Generations before us didn’t know about *climate change* and generations after us will be powerless to do anything about it... We are the first generation to feel the effects of *climate change* and the very last able to do anything about it”. On the *Paul Henry Breakfast Show* (07/04/2016), Henry asked a renowned climate scientist Prof. Jonathan Bamber “Are you just a very educated man, standing on the beach and shouting at the tide to go away?” a crude but apt representation of popular opinion, a readiness to dismiss scientists as foolish, and the perception that anything we do will be futile. Bamber replied “I am a scientist but I’m also a human being, and I think without hope there’s not much left. As a human being I believe and I hope that we can turn things around.”

### A Carbon Zero World

Following the 2015 Paris climate talks, international leaders called again for a transition to a ZC world, something scientists have been calling for since at least 1989 (D’Amato 2016). Organisations like Architecture 2030 have been established to enable the transition of the building industry to ZC. Architecture 2030 reports that in America “the Building Sector consumes nearly half (47.6%) of all energy produced, and is responsible for 44.6% of CO<sub>2</sub> emissions” (Architecture 2030 2013).

Reviewing industry leaders such as Architecture 2030, NZ Greenstar Rating, *The Davis Langdon Sustainability Handbook*, *LEED rating system*, *wood for good* and *UK carbon initiatives* showed a bias focusing on emissions rather than embodied energy/carbon. Biswas (2014, 179) & Anderson (2016, 3), discuss the importance of whole of life calculation of embedded carbon/energy, from cradle to construction to grave, in order to get an accurate representation of the carbon/energy footprint. To assist in the calculation of these figures, ICE offers a free download table of common building materials and their calculated embodied energy/carbon in a cradle to gate assessment (McAlinden 2015). Carbon footprints of building materials in NZ are evaluated by BRANZ notably in papers by Jacques (2011, 31) and Dowdell (2013,

36). With endorsements from the Auckland City Council, Bernhardt published a *deeper shade of green* in 2008, written as a “catalyst” the book offers up the smorgasbord of “sustainable urban development building and architecture in New Zealand.”(1) Information on sustainable practice is widely available but it is yet to reach a critical mass into mainstream industry practice. Recent developments towards a ZC building industry include suggestions of a carbon tax, embedded carbon labelling on buildings products and whole of life carbon labelling and monitoring for buildings (Ng 2016, MFE 2015).

### Architectural Resilience Strategies for Sea-Level-Rise

Three categories of resilience strategies emerged from the literature, these were:

**Protection:** defence strategies designed to keep the water out and maintain the existing built environment.

**Accommodation:** adapting existing environment to cope with an influx of water.

**Relocation:** managed retreat from affected areas as current forms of inhabitation cease to be viable.

The final section of this review considers each of these in turn and their relevance for South Dunedin.

Figure 3.2 Sea wall in New Orleans, USA. An example of protection defence.



Figure 3.3 The Thames Barrier, London, England. Protection defence.

### Protection

Protection strategies typically take the form of hard-engineered defences, which keep the water out and cause the least disruption to business as usual. Global precedents for protection of low-lying coastal urban areas against SLR include sea walls, storm surge barriers, dykes, canals, water management by drainage and pumping systems, land reclamation and others. (Baca Architects 2010, 16; DEFRA 2004, 20). Cities that have chosen protection strategies typically have these factors in common:

- *Historical Characteristics:* High value assets supporting a large population which will result in extreme pressure on governing bodies to protect the lives and livelihoods of their residents. Big businesses can have a strong influence in this situation. If the economic risk is substantial they may even be willing to partially fund construction. A previous flooding event (or similar) resulting in major damage, economic loss, and a loss of life may also have kick-started a political “Never Again” response action on defence strategies. (Floating Cities 2010; Years of living dangerously 2015, 3)
- *Economic Wealth:* protection defences are expensive, requiring enormous up-front and ongoing maintenance costs.



To support this expense, cities need to have a large population with a large wealth resource (Bell 2001, 38; Building Futures & ICE 2010, 2; Feiden 2011, 5).

- **Geography:** Lack of varied topography can result in no feasible option of retreat. The Netherlands is a prime example as they have no higher ground to which they can retreat. Such a retreat would instead take them to Germany, France or Belgium. Building hard defences is the Netherlands only option. (RPA 2015; Protecting Coastal Communities 2009)

Protective defences are resource heavy and failure to meet supply at any point will result in strategic failure. Protective defences are built to withstand an estimated condition and theorists, such as Bowman (RPA 2015) believe that this leaves them open to a high chance of failure, meaning that they are unsustainable, short-term solutions only. Geography will also be a limiting factor for some cities, even if they met all other requirements, for example, the geography of cities such as Miami or large areas of Bangladesh are not defendable (Years of living dangerously 2015). The negative effect on the environment and extremely high carbon footprint incurred in building of hard defences is also a disadvantage of these hard infrastructure options.



Figure 3.4 Floating homes in IJburg District, Amsterdam



Figure 3.5 Floating homes in the USA, Canada and Malaysia



Figure 3.6 Buoyant Foundations, Mississippi, USA. (English 2016)

### Accommodation

Accommodation strategies harness natural systems, designed to achieve harmony between nature and the built environment. Like protection, accommodation strategies are in-situ. Unlike protection, accommodation adapts the existing environment rather than preserving it (Baca Architects 2010, 7). They can be categorised into amphibious buildings and green infrastructure.

Amphibious buildings are adapted for structural buoyancy to float as the water rises. Communities such as the Bajou in Malaysia have long traditions of living in floating coastal communities (Réhahn 2016). Modern examples of amphibious homes are becoming increasingly



popular developments in the Netherlands (Goldman 2011). English (2016, 1) champions the use of buoyant foundations, developed by fishing villages living on flood plains in America. Buoyant foundations allow the adaptation of existing houses, and with the correct supporting infrastructure, amphibious or buoyant buildings can be highly adaptive solutions.

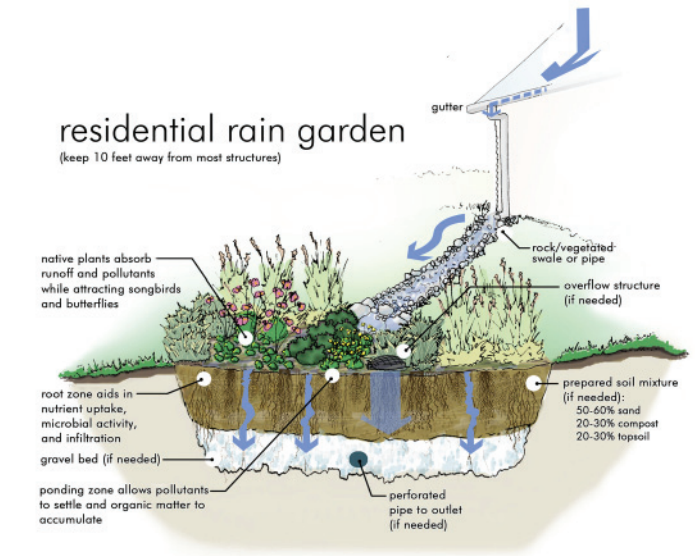


Green infrastructure has benefits that extend beyond SLR. As discussed by UNEP-DHI (2014, 8), EPA (2016) and CNT (2011, 17) green infrastructure increases biodiversity, provides wildlife pathways and opportunities for public recreation, creates a vibrant interaction between natural systems and daily human life and has a low carbon footprint. In recent history global culture has tended to divorce human aspiration from the natural world. Green infrastructure shows evidence of a growing environmental renaissance as a flow on effect of learning about the causes of anthropogenic climate change (Butlin 2016, 10). Accommodation strategies also include modifications that private land owners can make to their own properties, such as landscaping for water run-off and rain water harvesting.

On their own, accommodation strategies do not adequately safeguard residents from inundation and, like protective defence, some strategies can be short-term solutions only (Building Futures & ICE 2010, 12). For this reason accommodation strategies are commonly used in combination with other strategies (Urban Land Institute 2014, 15). Venice, Italy demonstrates a fierce commitment of people to place, despite high flood frequency and SLR. Venice's leaders are continually developing water management strategies and consequently the city is a good example of a combined protection + accommodation approach.



**Figure 3.7** Solar panels and green infrastructure in use on the roof of Kings Cross, London.



**Figure 3.8** Residential rain garden diagram

**Figure 3.9** Flooding in Venice, Italy in 1927, 1933, 2012



## Relocation

The New Zealand government has identified managed retreat or relocation as the only feasible option for coastal regions facing threats from SLR (Hayward 2008, 47). International planning committees, such as The LiFE Project, DEFRA & UNHCR, have also identified relocation as the only feasible strategy for long-term resilience against SLR (Abel 2011, 279; Ferris 2014, 8). The RPA Assembly 2015 has stated that many highly populated areas at risk from SLR will eventually reach a critical point where the land area is inundated and habitation is no longer viable. In order to avoid reaching this critical point unprepared, the RPA argues that work around relocation needs to begin as soon as possible (Hayward 2008, 47; Ferris 2014, 7). Education and communication will be crucial in getting the required level of understanding and support from all invested stakeholders. (RPA 2015; PCC 2014).

The Royal Society of New Zealand (26) described relocation as politically unpalatable, because it requires accepting a degree of loss, and demands a long-term management plan and commitment by all stakeholders. Given that the typical life of any local or national government is approximately five years, long-term commitment of this sort could be difficult to achieve. (Bell 2001, 65; Doberstein 2014, 1). The RPA alludes to options such as land buy-outs, preferential buy-ins, government subsidies and mortgage transference. Governing bodies and insurance companies will have an important role to play in how land at risk of SLR will be dealt with and how land-owners can move on from their land in a financially viable way (Doberstein 2014, 3).

Relocation projects remain largely un-built and communities looking to implement the strategy will face numerous challenges including (Harvey 2003; DEFRA 2004; Feiden 2011):

- What to do with the land left over?
- How to safely relocate residents and where possible salvage assets and infrastructure
- Funding and support from vital stakeholders
- Issues of culture and identity resulting from relocation
- Changing land-use

- Economic and market factors
- Landowner compensation for loss of land purchased without knowledge of the future threat.

## Conclusion

All resilience work must be undertaken with ZC principles in order to reduce emissions and mitigate the effects of climate change. It is likely that a combination of Protection, Accommodation and Relocation strategies will be employed throughout the world however of the three, Accommodation and Relocation appear to offer the most environmentally responsible, cost-effective, long term solutions. South Dunedin does not have the wealth resource and population size to support large scale protective strategies, therefore it is appropriate that design research would be best focused on exploring Accommodation and / or Relocation options.



Figure 3.10 Managed retreat/realignment project in Medmerry, England.

# **04: CASE STUDIES**



## 04 Case Studies

The literature review chapter examined international research and precedents responding to SLR. Accommodation and Relocation strategies including Amphibious Buildings and Green Infrastructure were identified as the preferred resilience strategies. Protection strategies were found to be prohibitively expensive short-term solutions. The case study chapter looks at projects within New Zealand to gain an understanding of the national context. The case study chapter acts to inform the development of the design work in the following chapters.

### Case Study: Clyde/Twizel

The flooding of Cromwell in 1992 for the creation of the Clyde Dam hydro scheme, accompanied the creation of Twizel and Clyde. While not related to SLR, Clyde and Twizel provide one of the few examples of a relocation project. The project severely affected local wildlife, caused considerable damage to the natural environment and proved to be a political “maelstrom” (Cooper 2001). Landowners were faced with forced relocation and inadequate compensation, being paid out at below market value (Mighty Clutha 2016). One of the reasons for the political controversy was a lack of co-operation and open communication between the government and the New Zealand public (Te Ara 2016). Similar issues could be faced by relocation due to SLR but, in contrast to the hydroelectric scheme, government bodies could be situated as allies against SLR rather than the cause of the threat, which may be more conducive to co-operation. The Dunedin City Council (DCC) and residents of South Dunedin are currently grappling with the aftermath of flooding in June 2015. Similar problems were initially experienced due to a lack of transparency and poor communication between stakeholders, although significant progress has since been made on both sides.

Before the old town was flooded Cromwell residents were relocated up the bank, and some key heritage buildings were also moved, resulting in the curated heritage of Old Cromwell Town. Clyde and Twizel were built as Hydro Towns circa 1968 to service the construction of the Hydroelectric Scheme, rapid low-cost construction resulted in a homogeneous building style, similar to the New Zealand State House design (Te Ara 2016).

This case study identifies the following as important considerations for managed retreat:

- The relocation of key heritage buildings to preserve physical relics of town identity.
- Rapid low-cost construction can result in a homogenous typology which may lack character.
- Communication between invested stake-holders is crucial to a politically viable solution.
- Environmental impact must be factored into design at all stages.



Figure 4.1 Lowburn's Welcome Home Hotel, built in 1869 and the social focus of the community, was demolished and the area was flooded, '60ft under.'



Figure 4.2 Rachael and Fanny Short, Bannockburn. 'I wish they wouldn't change it.'

## Case Study: Wellington

The *Water Sensitive Urban Design Guide* issued by the Wellington City Council contains advice for planners, architects, engineers and landowners building in water sensitive areas (2015). Part four of the guide WSUD (pg47-66) details solutions for coping with increased water including: Rainwater Garden/Stormwater Planter/Street Trees, Green Roofs & Constructed Wetlands.

The advice in this design guide is tailored to individual property owners and is not a masterplanning solution, however similar principles could be adapted on a larger scale.

In 2004 the Wellington City Council also commissioned Gehl Architects to undertake an urban design assessment and report for future development of the CBD. In 2013 the *Sea Level Rise Options Report* detailed possible scenarios and strategies for adaption to SLR in central Wellington. Both these reports have useful and transferable advice for South Dunedin.

This case study identifies the following as important for sustainable management:

- SLR scenario planning and research into the future affects.
- Zero-Carbon guidelines for holistic climate change mitigation.
- Transferable on-site mitigation strategies designed to adapt to changing conditions that come with climate change including increased water, temperatures and SLR.

## Case Study: Nelson

Like South Dunedin, Nelson has vulnerable low-lying suburbs that will be at risk from SLR. Nelson has a recreational-tourism focus on foreshores, with some of the most beautiful beaches in New Zealand. These beaches may disappear in the near future as SLR occurs (MFE 2016). Nelson has a well-developed Walk and Cycle way, used by school children and the elderly for school commuting and recreational exercise (NCC 2016). Active travel (walking and cycling) in New Zealand is on a steady decline, Elder et al explains that council-led initiatives such as the Walk and Cycle way in Nelson can help to reverse this trend (Elder et al 2015, 188). Providing ZC transport options also lowers emissions in the area which contribute to mitigating the overall impact of climate change. Among adults of working age Nelson still

## AN INTEGRATED WSUD SYSTEM



Figure 4.3 Water Sensitive Urban Design systems from WCC (2015)

has a heavy car dependency, and separation between home and work is often beyond walking/cycling distance, as is the case in much of New Zealand. Fisheries and low-lying agriculture may also be jeopardized due to flooding and groundwater contamination. To tackle these concerns Nelson Regional Council has devised *Nelson 2060* a set of guidelines towards a ZC future for Nelson, holistic mitigation aims to reduce emissions and lessen effects of climate change including SLR (NCC 2013). Nelson is also a partner of Eco Design Advisor. Backed by BRANZ, this is a building industry-focused design tool giving advice on how to make your project more eco-friendly, from a building science background (EDA 2016).

This case study identifies the following as important for ZC communities:

- Well-developed cycle ways and provision of reliable public transport is important for sustainable transport and reduced emissions.
- Holistic climate change mitigation to reduce all effects of climate change including SLR.
- The use/promotion of Eco Design Advisor as a tool for building design.

## Case Study: Auckland

Auckland Council is also a partner of the Eco Design Advisor groups, in parallel with this it has issued Sustainable Home Guidelines. These guidelines cover green building techniques with advice from architects and designers tailored to suit local context and conditions. The guidelines show how councils can influence landowners to make environmentally responsible design and construction decisions which is a step in the right direction to achieving a ZC built environment (AC 2016).

In recent years Auckland has undertaken high-cost waterfront development. As SLR occurs this will mean increasing pressure for hard-engineered protection such as sea walls or storm surge barriers (AC 2017). Currently the Auckland Council distributes advice for individual land owners about modifications they can make to their own properties. While this is useful information, without a wider resilience strategy implemented at a regional level these individual modifications cannot hope to be standalone solutions.

The Auckland commute and dependency on cars is the worst in the country. To achieve a ZC status Auckland needs (among other things) a massive improvement in public transport networks. The commuting distance between work and home needs to decrease and residents must have improved access to housing close-by to their work-place.



This case study identifies the following as important for ZC cities:

- Reliable accessible public transport.
- City councils can provide sustainable home building guidelines and other information to aid residents in transitioning to Zero-Carbon lifestyles.
- Sustainable home building guidance distributed by local council.

### Case Study: Christchurch Rebuild

Holistic resilience (HR) is important for the continued survival of communities, especially when faced with disaster. The Canterbury earthquakes of September 2010 (magnitude 7.1) and February 2011 (magnitude 6.3), caused the death of 185 people, with many more injured, family and community upheaval and extensive damage to the built and natural environment (NZHistory 2016). Six years later the Christchurch Rebuild is still ongoing, and has been a politically divisive issue. This case study examines aspects of resilience which could inform the South Dunedin design proposal.

Following the earthquake “80% of inner city CBD buildings were damaged in such a way that they needed to be demolished” (Dalman 2014, 4), including community infrastructure, large commercial premises and iconic heritage buildings. The resulting rebuild is changing the architectural identity of Christchurch to form a 21<sup>st</sup>-century garden city (ArchitectureNow 2016). Prior to the earthquakes Gehl Architects completed an Urban Design Assessment for the Christchurch city council in 2009 which in combination with the Central City Recovery Plan have been the re-build roadmaps. Gehl’s report emphasised the human scale and experience of the city, as well as the importance of a holistic approach; addressing pre-existing, current and future challenges.

Initial disaster response architecture in Christchurch was rapidly constructed using temporary structures such as the Re-start mall. These structures are now outliving their expected lifetime as funding for permanent solutions is slow to come forward. Fast construction, low-cost pre-fab housing of variable quality filled the gap in the residential market, and it will be interesting to see how these weather over time. Quality of re-build construction was initially haphazard,

residents needed fast solutions and issues with insurance settlements and supply-demand shortages meant sometimes sub-standard construction solutions that compromised on quality (Chang-Richards 2012, 2-4).

*Greening the Rubble* and other volunteer-driven explorations in urban design are helping to re-build the Christchurch community. Gap fillers have tended to develop on sites where funding for commercial investment has stalled, providing a vibrant first step towards rejuvenation of the area. By creating an active dialogue about public spaces and place-making in Christchurch, urban design is being used as a powerful tool in the recovery process (Dalman 2014, 10). Making spaces that encourage social activities and help the community to re-engage with place, is forging a new identity which will hopefully develop into a fortified community (Christchurch City Council 2011).

This case study identifies the following as important for urban resilience:

- Human city scale, holistic re-build approach and assessment tools used by Gehl Architects.
- Temporary structures often outlive intended lifespan, designing initial structure to be adapted later on for permanence rather than entirely replaced would be more effective.
- Informal gap-fillers as a means of public engagement in civic spaces.

Figure 4.4 Greening the Rubble Nature Play Park, Christchurch



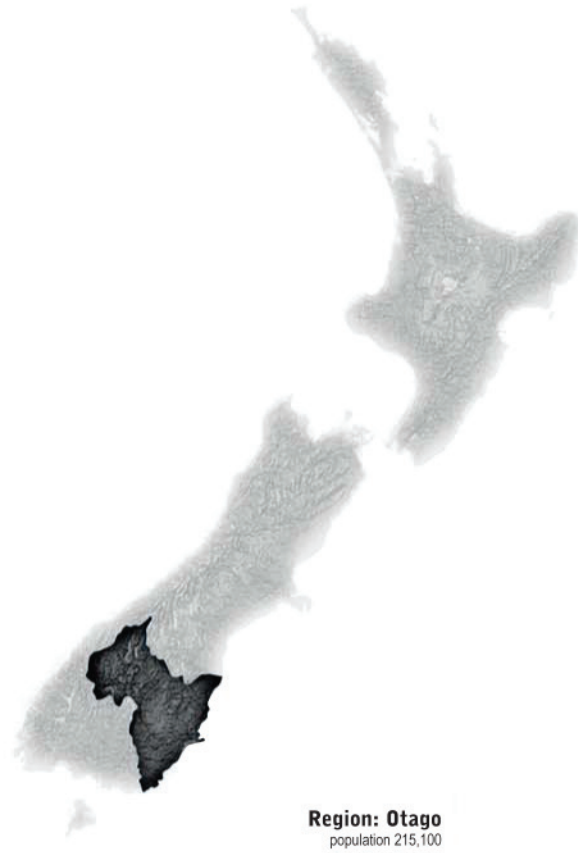


Figure 5.1 Location Map – NZ Census 2013

## 05: SITE ANALYSIS





Maryhill

Kensington

Vauxhall

Andersons  
Bay Inlet

shine

And

vers

ew

st

South Dunedin, Tainui, St Kilda, St Clair  
population 10,000

200m 1 km





## 05 Site Analysis

In order to achieve HR it is important to consider both existing revitalisation and future SLR adaption challenges. As indicated in the previous case study chapter, some of the methods used in this site analysis chapter are revitalisation tools used by Gehl Architects in their reports for Christchurch (2009) and Wellington (2004). Further urban design methods were drawn from *The Social Life of Small Urban Spaces* a film by William H. Whyte (1980) and *Public Places Urban Spaces* by Carmona et al (2010). Important sources were the *South Dunedin Revitalisation Plan* by the Dunedin City Council (DCC), *Natural Hazards of South Dunedin* by the Otago Regional Council (ORC), and other reports by the ORC, DCC and BECA. In order to gain an holistic



**Figure 5.2** South Dunedin from the track to Andersons Bay 1864  
understanding the site analysis is diverse including: physical geography, consequences of climate change, architectural typology, socio-economics and land use. Accompanying this site analysis chapter are two annotated bibliographies, Appendix 1 - South Dunedin in Policy and Appendix 2 - South Dunedin in Media.

Dunedin is a small city with an urban population of just over 120,000, the South Dunedin area has approximately 10,000 residents. The DCC's vision for Dunedin is to have a compact city with resilient townships (DCC 2015-2025). Estimated to be one of the most densely populated areas in New Zealand, South Dunedin is a socio-economically deprived area that has been described as geologically and environmentally frail (Early 2015, 195).



**Figure 5.3** Flooding in Tainui, South Dunedin, 1917  
Pre-European contact, the area now known as South Dunedin took the form of marshy wetlands covered in silver tussock, rushes and flax, which would have been an important biodiverse wetland used by local Māori and native wildlife. The *Natural Hazards of South Dunedin* report released by the ORC demonstrates the former wetlands in figures 4, 5, 6 and 7 (ORC 2016, 7-9). Before site drainage was completed, asphalt laid, and sewerage resolved, early residents used wooden plank pathways to manoeuvre their way through the mud (Wood 2005).

To facilitate the expansion of Dunedin, the area of South Dunedin and surrounds was reclaimed, during the mid to late 1800s, using any available fill material (ORC 2016, 9). Topographically flat, the land was reclaimed to just above the sea-level of the time which was an



**Figure 5.4** Flooding in South Dunedin, 2015  
estimated 170mm below current levels (ORC 2016, 9). The depth to bedrock in South Dunedin varies between 20m to 70m deep (ORC 2016, 69). Between bedrock and topsoil lies a mixture of quaternary deposits, sand, silt, and the thin layer (1000-2000mm) of reclamation material, see figure 5.5. Over 150 years since reclamation the water table of South Dunedin is extremely shallow (refer to *The Natural Hazards of South Dunedin*, Figure 19. ORC 2016, 20). The ORC reports that the groundwater levels have a normal position of 500mm below ground but notes that groundwater tables are dynamic, rising and falling with conditions (ORC 2016, 23).

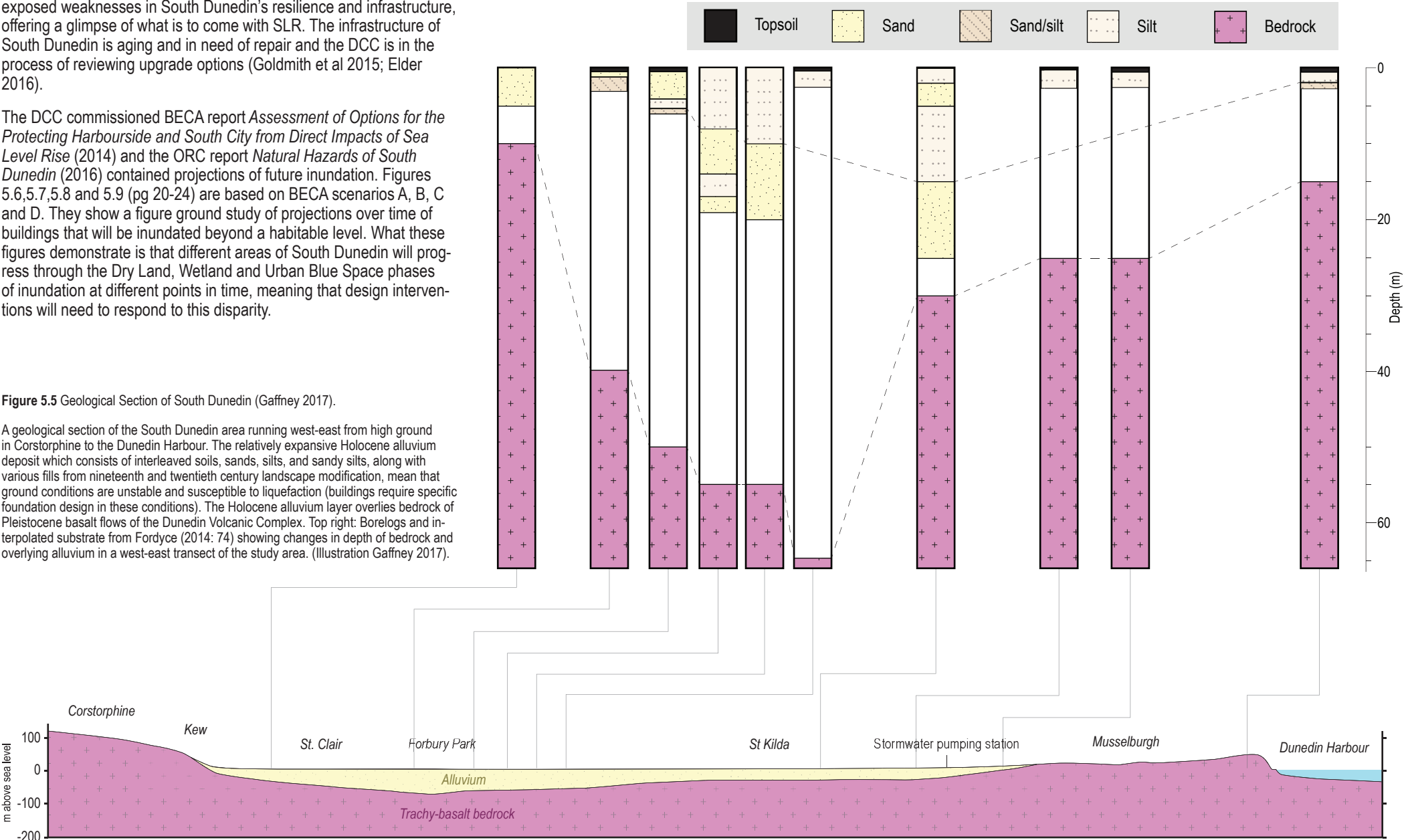
Without mitigation or adaptation the effects of SLR will increase over time gradually compromising the viability of South Dunedin as a residential and commercial community. The flooding in June 2015

exposed weaknesses in South Dunedin’s resilience and infrastructure, offering a glimpse of what is to come with SLR. The infrastructure of South Dunedin is aging and in need of repair and the DCC is in the process of reviewing upgrade options (Goldmith et al 2015; Elder 2016).

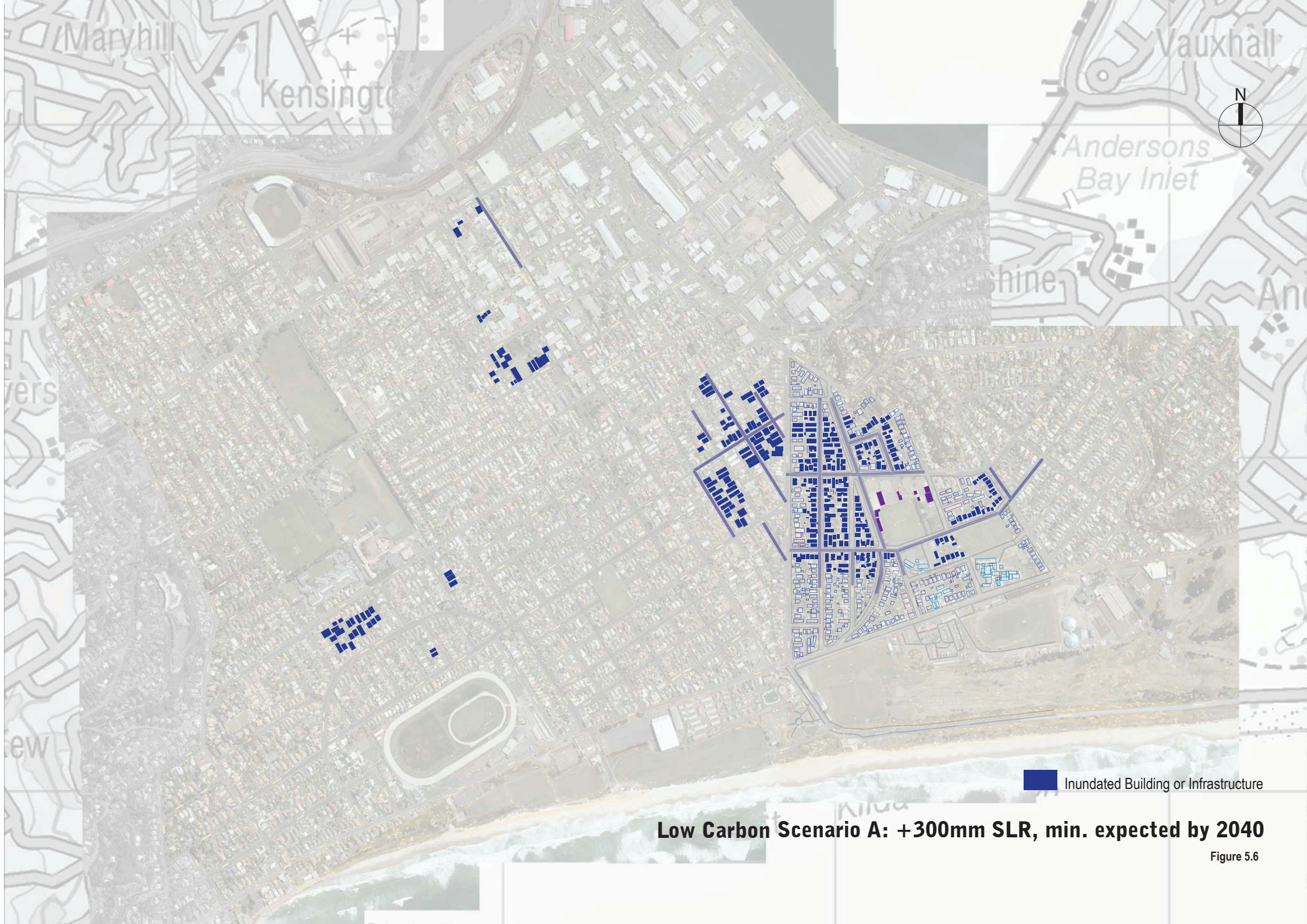
The DCC commissioned BECA report *Assessment of Options for the Protecting Harbourside and South City from Direct Impacts of Sea Level Rise* (2014) and the ORC report *Natural Hazards of South Dunedin* (2016) contained projections of future inundation. Figures 5.6,5.7,5.8 and 5.9 (pg 20-24) are based on BECA scenarios A, B, C and D. They show a figure ground study of projections over time of buildings that will be inundated beyond a habitable level. What these figures demonstrate is that different areas of South Dunedin will progress through the Dry Land, Wetland and Urban Blue Space phases of inundation at different points in time, meaning that design interventions will need to respond to this disparity.

**Figure 5.5** Geological Section of South Dunedin (Gaffney 2017).

A geological section of the South Dunedin area running west-east from high ground in Corstorphine to the Dunedin Harbour. The relatively expansive Holocene alluvium deposit which consists of interleaved soils, sands, silts, and sandy silts, along with various fills from nineteenth and twentieth century landscape modification, mean that ground conditions are unstable and susceptible to liquefaction (buildings require specific foundation design in these conditions). The Holocene alluvium layer overlies bedrock of Pleistocene basalt flows of the Dunedin Volcanic Complex. Top right: Borelogs and interpolated substrate from Fordyce (2014: 74) showing changes in depth of bedrock and overlying alluvium in a west-east transect of the study area. (Illustration Gaffney 2017).





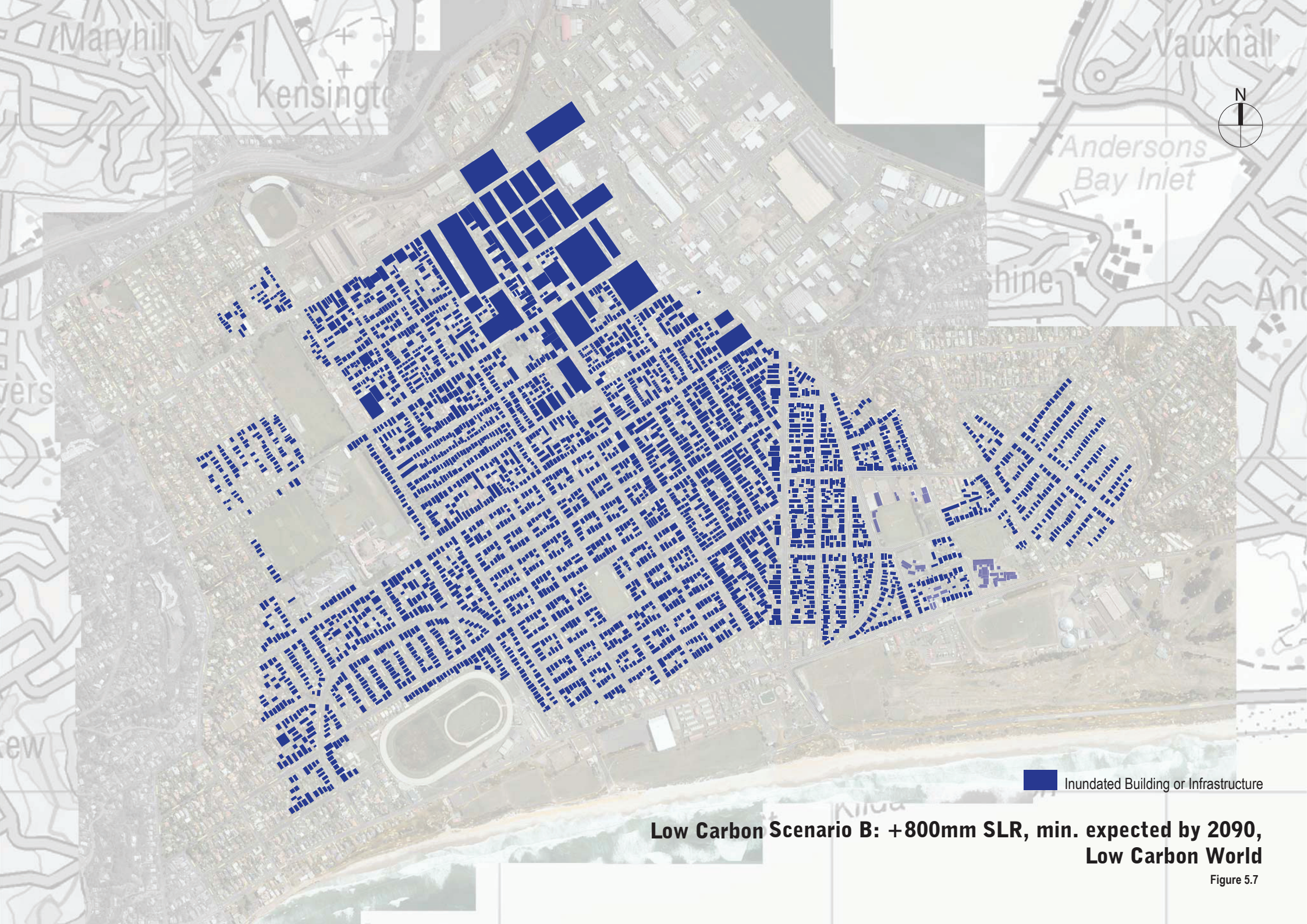


 Inundated Building or Infrastructure

**Low Carbon Scenario A: +300mm SLR, min. expected by 2040**

Figure 5.6

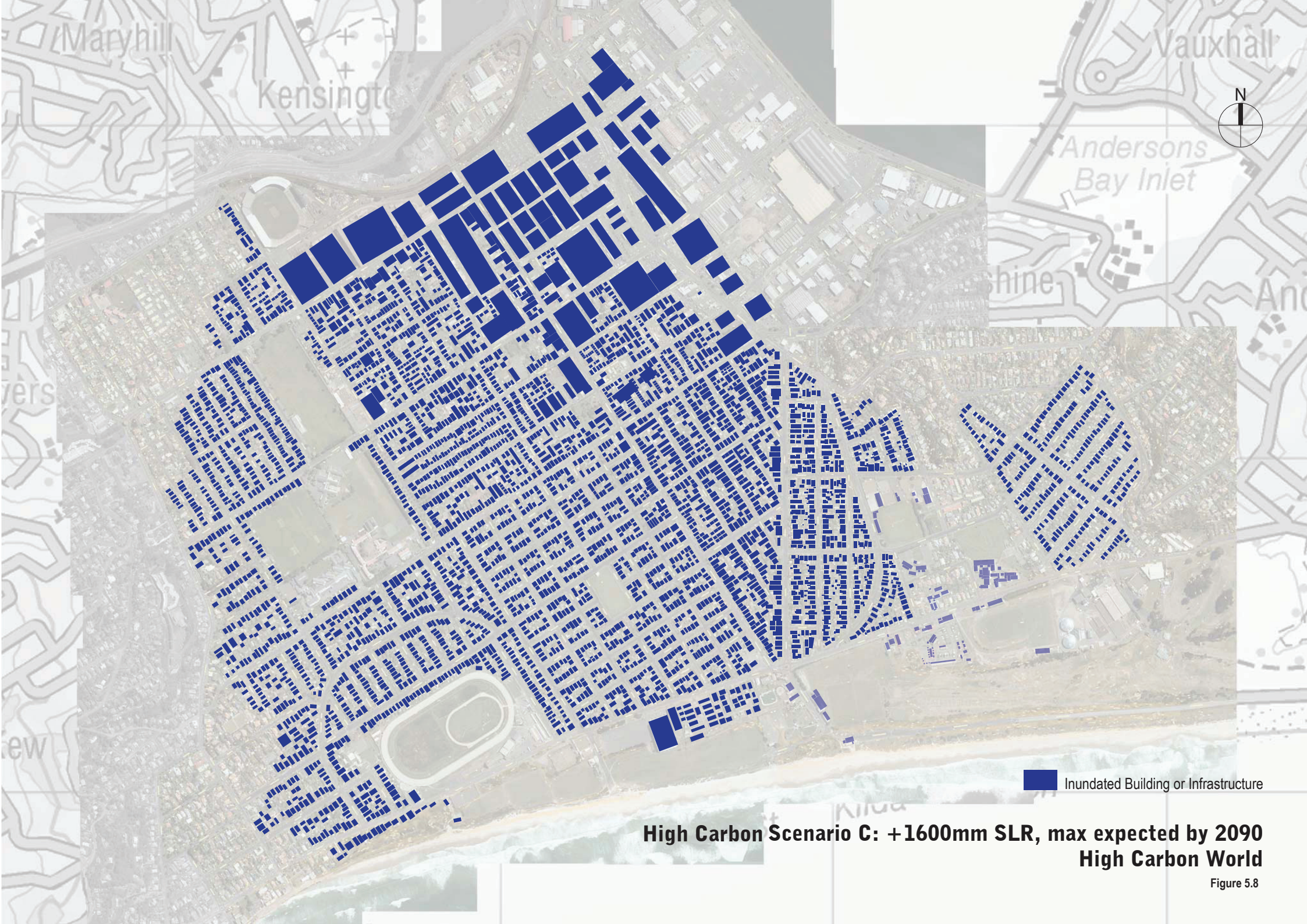




**Low Carbon Scenario B: +800mm SLR, min. expected by 2090, Low Carbon World**

Figure 5.7

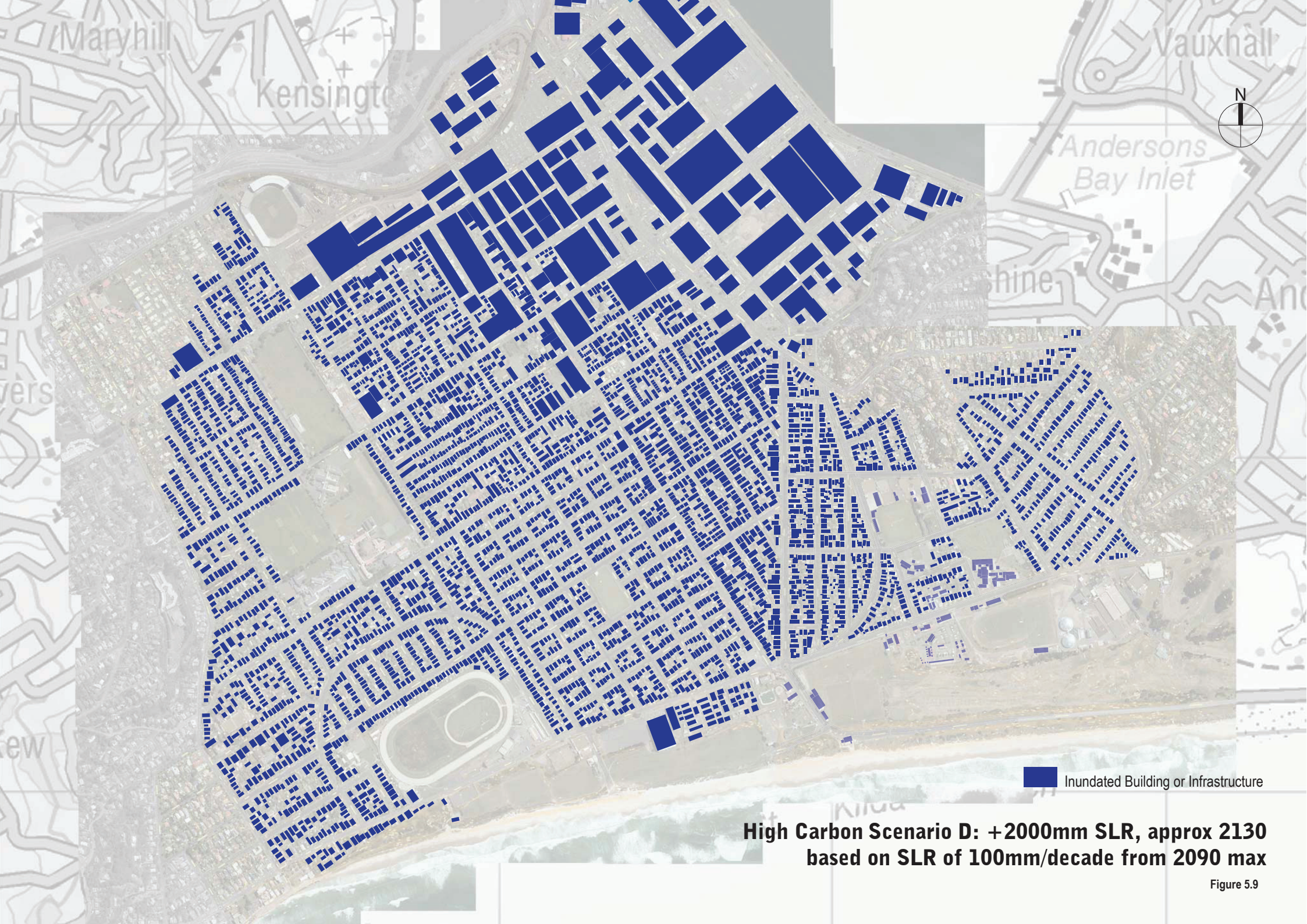




**High Carbon Scenario C: +1600mm SLR, max expected by 2090**  
**High Carbon World**

Figure 5.8





**High Carbon Scenario D: +2000mm SLR, approx 2130  
based on SLR of 100mm/decade from 2090 max**

Figure 5.9





**Figure 5.10** Images of view from John Wilson Ocean Dr, Dunedin, sourced from street view Google Earth 2016.

The Dunedin climate in the early twenty-first century has been temperate, summer temperatures average between 10-22°C, winter 0-10 °C, monthly precipitation averages between 40-70mm and wind speeds are generally low (Weather and Climate 2017). By the end of the twenty-first century, around 2090, it is estimated that in the Otago region average temperatures will be between 0.6 °C to 2.8°C warmer, rainfall in Dunedin is expected to increase by 4 to 10% and extreme wind events are also expected to increase (Ministry for the Environment 2017). These climatic changes will most likely require regional changes in building design and material use to cope with more extreme weather conditions.

**Figure 5.11** Images of King Edward St, Dunedin, sourced from street view Google Earth 2016.



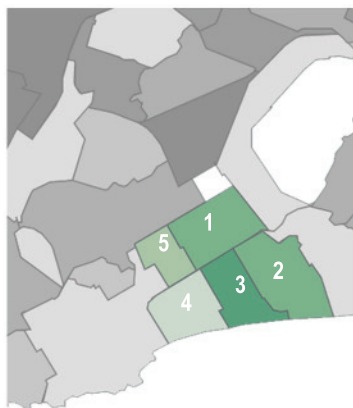




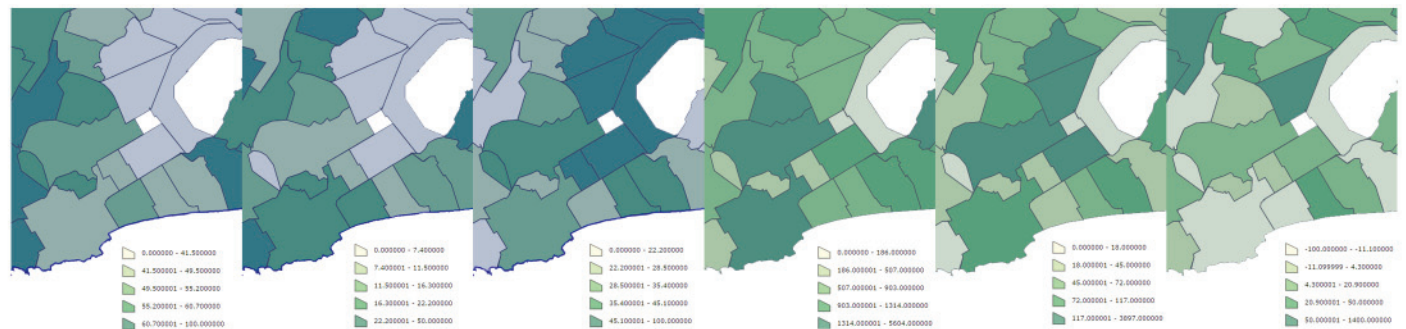
## South Dunedin 2013 Census Statistics

South Dunedin is a mainly suburban area, made up of the suburbs of South Dunedin, Forbury, St Kilda East, St Kilda Central and St Kilda West. One of the most densely populated areas in the country it is also socio-economically deprived. There is a higher than average proportion of single person households, young families and the elderly. Households are typically on lower incomes and there is a high percentage of rental properties.

**Figure 5.12** Images of socio-economic NZ 2013 census data. Source: Statistics New Zealand. Stats Maps. Web access 2016. <http://www.stats.govt.nz/statsmaps/home.aspx>



- 1 South Dunedin
- 2 St Kilda East
- 3 St Kilda Central
- 4 St Kilda West
- 5 Forbury



% dwellings owned or partially owned

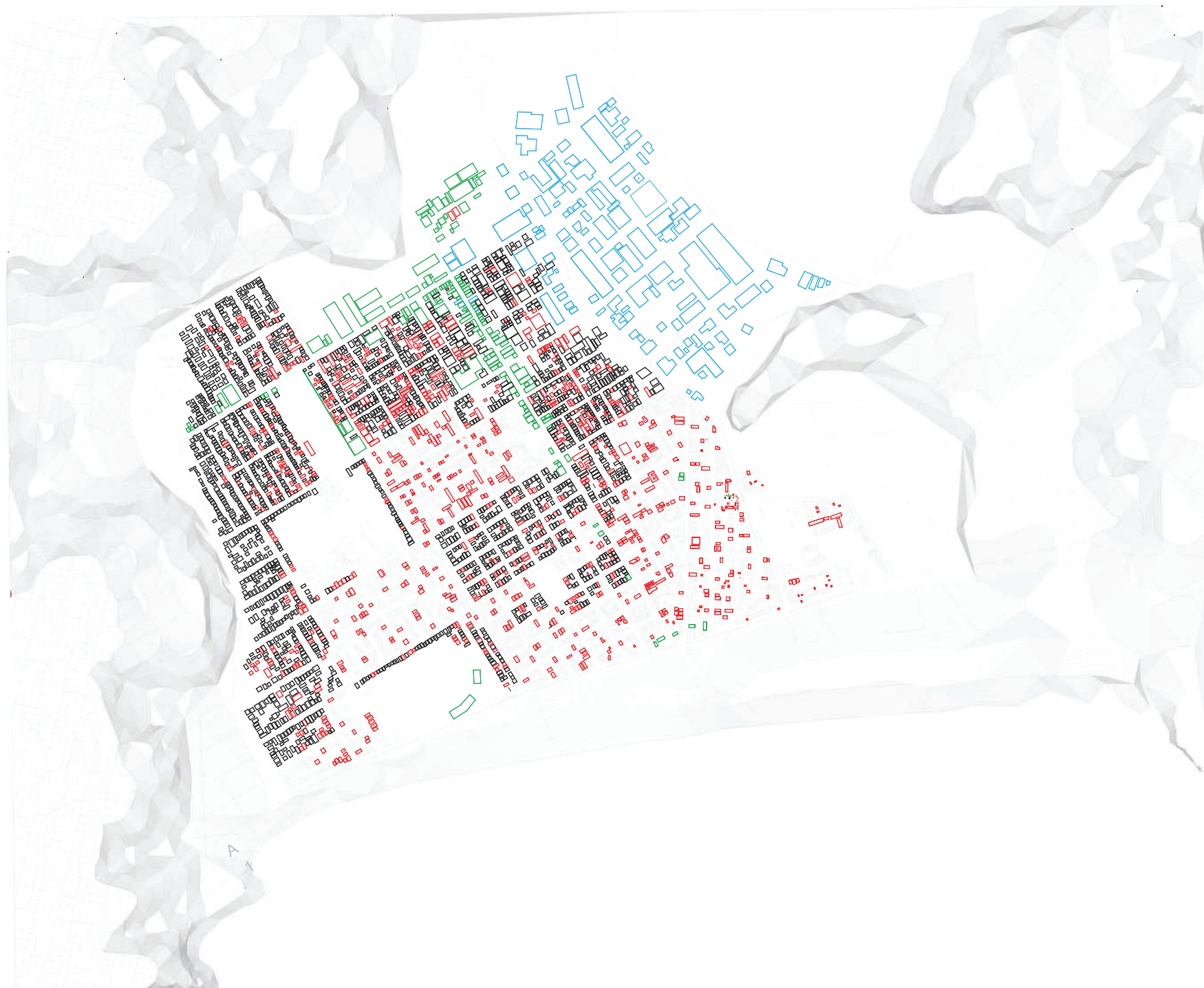
% dwellings held in family trust

% dwellings not owned & not held in family trust

no. of occupied dwellings

no. of unoccupied dwellings

% change since previous census for unoccupied dwellings



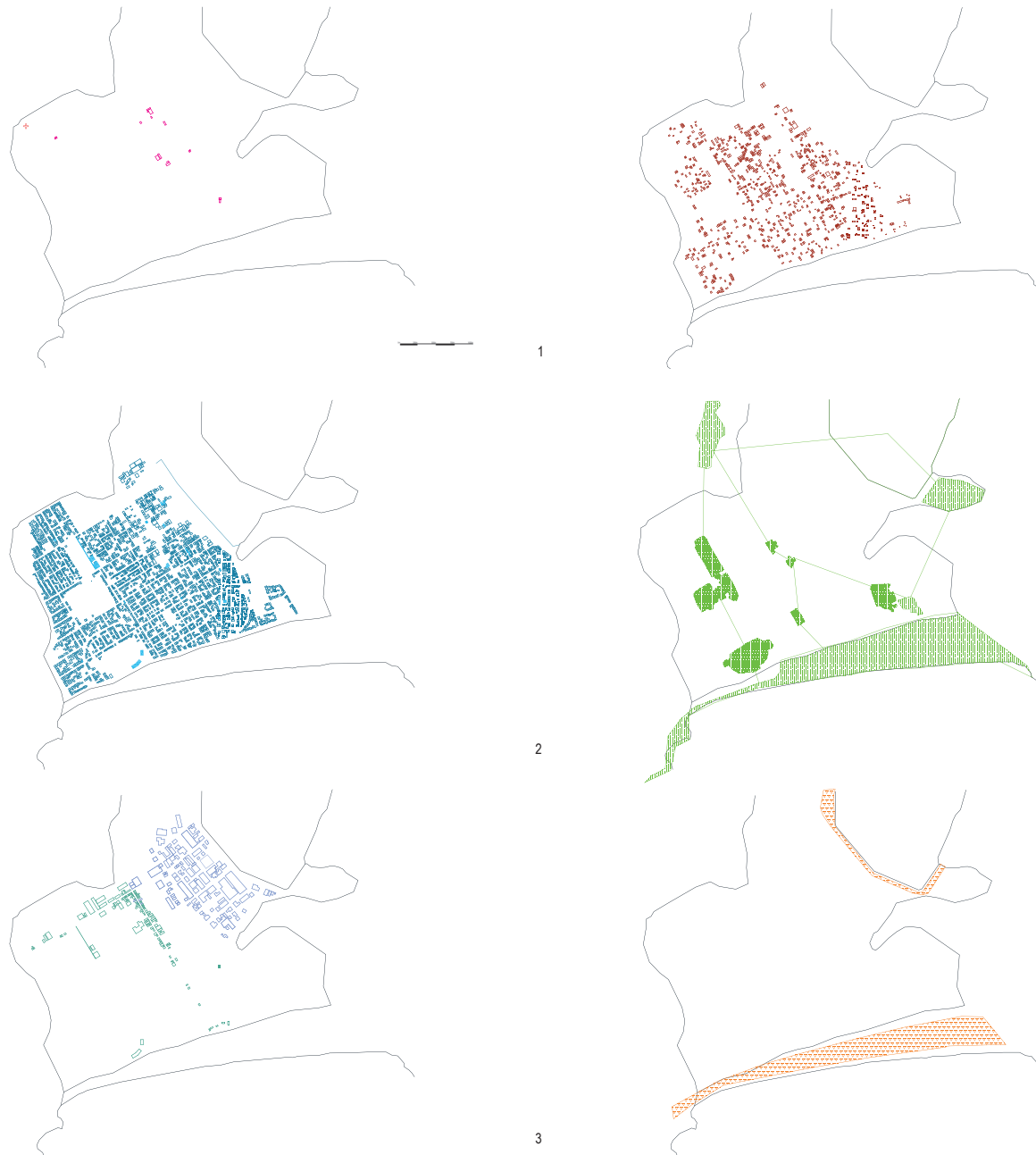


Figure 5.14 Separated layers of figure ground land and building use study.

## South Dunedin Urban Layers:

1: Public Buildings including community, health, religious and infrastructure facilities, located mainly within walking distance of the South Dunedin Retail Centre. Many of these facilities are in need of refurbishment and are currently underutilised.

2: Approximately 2/3 of buildings in South Dunedin could be adapted or relocated for continued occupancy facing SLR. Guestimate based on visual observation that approximately two thirds of homes are made of light-weight timber construction of acceptable condition.

3: Commercial and Industrial buildings are concentrated to the northern end of King Edward St (South Dunedin Retail Centre) and towards Portsmouth Drive (industrial zone), following a monofunctional planning structure.

4: Approximately 1/3 of buildings would need to be demolished or extensively renovated in the next 50 years due to age, construction condition and SLR. Guestimate based on the typical lifespan of buildings in New Zealand being 50 years (O'Sullivan 2013), and visual on-site observation that approximately one third of homes in South Dunedin are made of heavy construction or are in a condition not compatible with adaptation.

5: Existing Recreational Green Infrastructure including Sports Grounds. The northern green area shown is the end of the Dunedin town belt, located on Mornington rise at an elevation 20-50m above South Dunedin. There is potential for an extension of the town belt into South Dunedin and creation of a green corridor to the sea.

6: Riparian planting zones. These are a passive form of sea-wall protection against SLR using green infrastructure.

7: Following SLR existing green spaces will be the first areas transformed into Urban Blue Space. During early phases of SLR they could act as drainage ponds for the immediate surrounds (Beca Ltd. 2014, 11).



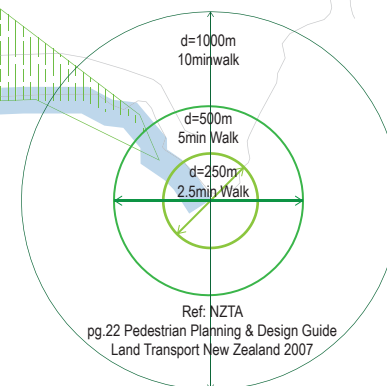
# **South Dunedin ORC Bus Routes** Updated ORC Bus Services and approximate times shown below. (ORC 2016, 11).

## **Bus Routes:**

- Waverly - Bell Knowes (30-60min intervals)
- Weekend Service (30-60min intervals)
- St Kilda - Halfway Bush (15min intervals)
- Shiel Hill - Opoho (20min intervals)
- St Clair - Normanby. (15min intervals)
- Ocean Grove - Ross Creek (30min intervals)

## **Destinations:**

- Recreational Green Space
- St Kilda/St Clair Beach
- Local Business
- Large Scale Retailers/Industrial
- Community/Religious/Infrastructure



**Figure 5.15 South Dunedin ORC Bus and Destinations Map**



Increasing use of public transport and active transport, such as walking and cycling, is a good way to cut down on greenhouse gas emissions moving towards ZC. The main form of transport in South Dunedin, and Dunedin as a whole is by private vehicle (DCC 2014). Public transport provided by the ORC bus service was reported by residents to be “appalling” and “terrible”, experiencing low ridership “making up only 1.14% of all trips in 2012-14” (Early et al 2015, 184-185). An upgrade to the service including a new central city ‘Dunedin Bus Hub’ began in July 2015, the final phase is expected in February 2017, updated ridership and quality results have not yet been released (ORC 2016, 3). The DCC has embarked on a cycle way project throughout Dunedin however its roll-out has experienced difficulties and the service is not yet fully functional, with the South Dunedin route yet to be installed (Loughrey 2016).

The South Dunedin Retail Centre located at the northern end of King Edward St, between the Hillside Rd and Macandrew Rd intersections, has been an historically important manufacturing and service area for Dunedin, and the centre and surrounds remain a destination retail area (DCC 2010, 3). Investment in South Dunedin has gradually declined in recent decades, and with existing fragilities South Dunedin is facing a challenging future, so far without a guiding plan or strategy. The flow on effect of this has been a “general impression of decline” particularly in the South Dunedin Retail Centre (DCC 2010, 4). Recent revitalisation initiatives by the DCC beginning in 2010 have made some improvements, chiefly through façade grants for business owners, this work is ongoing and includes a community hub proposal (DCC 2010; DCC 2011; Athfield Architects 2016).

Gehl states that “a public space of high quality will always be recognized by people opting to interrupt their walk or daily activities in order to rest, enjoy the city, the public spaces and be together with people... the key to establishing lively and safe public spaces is pedestrian traffic and pedestrian activities” (Gehl Architects 2009, 6). Movement through South Dunedin occurs chiefly via private vehicles. Pedestrian traffic, bicycles and public transport, are secondary. Prioritisation of motor-vehicles in South Dunedin has compromised the quality of public space. Walking down the footpaths of the South Dunedin Retail Centre during the day, pedestrian experience is dominated by traffic noise and pollution, desire lines are interrupted by car parking and traffic congestion, and there are no areas for recreation such as green spaces or a public playground. Dunedin nightlife is focused around the Octagon in central Dunedin therefore the South Dunedin Retail Centre is relatively quiet after dark, most restaurants close by nine o’clock and the two bars are generally quiet by midnight. For HR it is



Figure 5.16 South Dunedin Retail Centre, Pak n' Save and The Warehouse location in South Dunedin.

important to have high quality public spaces which residents feel connected to. Gehl discusses the types of users and activities in public space highlighting the importance of providing for recreational users of diverse demographics (Gehl Architects 2004, 6). The South Dunedin Retail Centre offers little opportunity for the type of recreational use described by Gehl. This is a clear opportunity for HR design intervention for South Dunedin.

Vehicle domination is the result of: a) historic planning policies that prioritised vehicles over people, and b) monofunctional zoning resulting in weak connections between destinations of different functions. High-value destinations in South Dunedin are typically not connected to each other by public transport and are beyond convenient walking distances of 5-10min. Therefore residents rely on private vehicles to perform essential tasks and travel between distant destinations.

The separation between small local retailers surrounding the South Dunedin Retail Centre and large-scale commercial retailers on the periphery of the South Dunedin Retail Centre towards Portsmouth Drive has developed over time and was exacerbated by the completion in 2001 of The Warehouse located next to Pak n Save (opened in 1997, building formerly New World South City built in 1978) on Hillside Rd (Scott, C. 2017; Todd, P. 2017). The separation has severely disadvantaged the economic viability of the businesses in the South Dunedin Retail Centre.

A dominant argument for the popularity of big box retailers are their great big carparks. This is a flawed positive, having the parks spread out means increased foot traffic for other retailers, and the health benefits of walking for customers. Designing for a motor vehicle dependant society is endorsing habits that lead to high carbon emissions that then exacerbate climate change. Development focus needs to move away from private cars and focus on reliable mass public transport. With inundation residents will soon not have a choice. Carpark space is dead, anti-social space in the urban environment. By reducing car-parking there is increased opportunity for public space, parks, pop-up instalments and civic vibrancy.



## Green Space Assessment

Green Space in the South Dunedin Retail Centre is minimal, consisting of sparsely planted trees and shrubs installed as part of the retail revitalisation scheme (2010). It is possible that due to the proximity of St Clair and St Kilda beaches, the green belt, and numerous sports grounds in the wider Dunedin area, green space was previously considered unnecessary in the Retail Centre.

The predominant groundcover typology is impervious concrete or tarseal. This exacerbates the effects of rainfall and flooding. Increasing the proportion of green spaces, such as raingardens, would improve the landscape's rainfall carrying capacity, reducing the risk of severe flooding.

10 min pedestrian shed

5 min pedestrian shed

-  Green Planting
-  South Dunedin Retail Centre
-  Main Roads
-  Building Footprint



Figure 5.17 South Dunedin green space assessment.

# What seating options are available in the South Dunedin Retail Centre?

There are 23 park benches in the retail centre, 20 are approx. 1800mm wide, seating two-three people, and three are single seats. The overall quality of seating is low. Seats are awkwardly positioned close to the road, often with unattractive surrounds.

Only three of the park benches are located



C1 V1 N1 C01 P2

C1 V1 N1 C01 P2

Gehl Criteria for evaluation of the Bench Quality  
Scale 1=Poor, 5=Good

C	Climate	1-5
V	View	1-5
N	Noise/pollution	1-5
CO	Comfort	1-5
P	Placement	1-5



C1 V1 N1 C02 P1

C1 V1 N1 C02 P1

Figure 5.18 South Dunedin seating in public space assessment.



C4 V3 N2 C02 P4

C2 V2 N2 C03 P2

C3 V3 N2 C03 P4

next to bus stops, despite there being seven bus stops in the area. The best seat is located next to Dinkum Doughnuts on the corner of Lorne St, as it provides a place for customers to sit and is located next to the only area of "public space" a public toilet and other retailers.

William Whyte's ratio for public space to seating is 1:30 (i.e. 1m<sup>2</sup> of seating per 30m<sup>2</sup> of open public space) as a minimum (1980). If you include the roads, pavements, Lorne St and all accessible outdoor space in the retail centre area there is approx. 13225m<sup>2</sup> of potential public space. Following Whyte's ratio, that should equate to 440m<sup>2</sup> of public seating. There is currently 28.5m<sup>2</sup> of seating. The amount of dedicated public space on Lorne St is 675m<sup>2</sup> which, following the same ratio, should have 22.5m<sup>2</sup> of seating, it currently has 12.15m<sup>2</sup>.

There is a clear opportunity for more seating and different typologies of seating as well as an opportunity for more defined areas of public space.





**Figure 5.19** Existing Building in South Dunedin

Many buildings in South Dunedin date from shortly after reclamation in the late 1800s-early 1900s. Some due to their building condition may not be able to be adapted or moved in the event of SLR. South Dunedin's housing stock has been found to be made up of old, cold and mouldy buildings which are negatively affecting resident health (Shannon et al 2003; DCC 2010). There is a high percentage of rental properties in the area and this has proved a barrier to maintenance, although tightened building regulations are slowly improving the situation (PSO 2013, 14). Due to their condition many buildings in South Dunedin are in need of renovation for improved resident health and quality of life. It is important to improve insulation, solar gain, natural ventilation, heating and cooling, and structural integrity across the board. Soft building materials such as GIB, plaster and carpet, cannot withstand flooding. Water-resistant materials are more resilient as they allow for healthy drainage and drying.

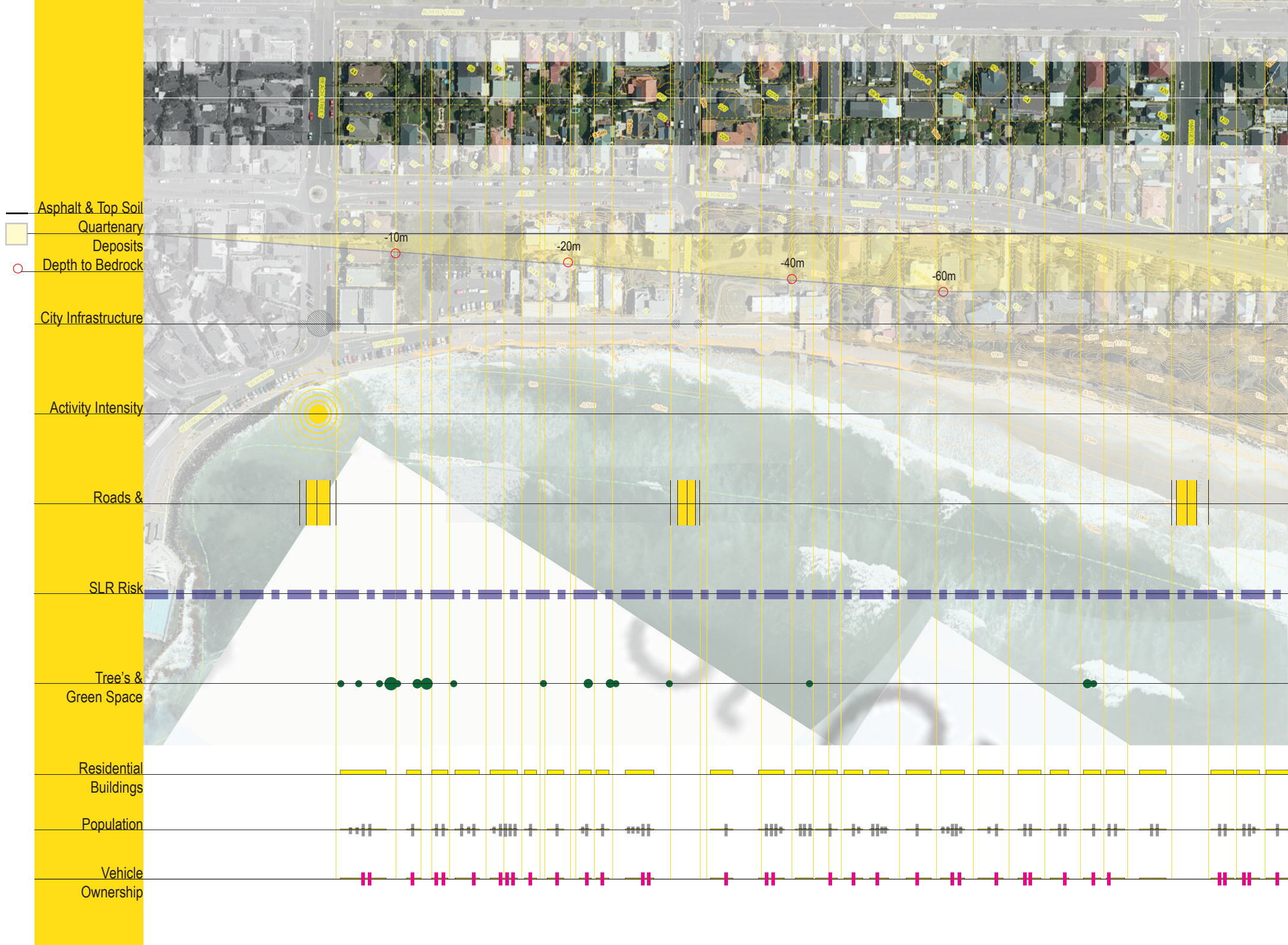


# Heritage Buildings in South Dunedin

**Figure 5.20** Heritage Buildings of South Dunedin sample selection of heritage listed buildings and other significant buildings in South Dunedin of architectural quality or importance in the community that will be threatened by SLR.

















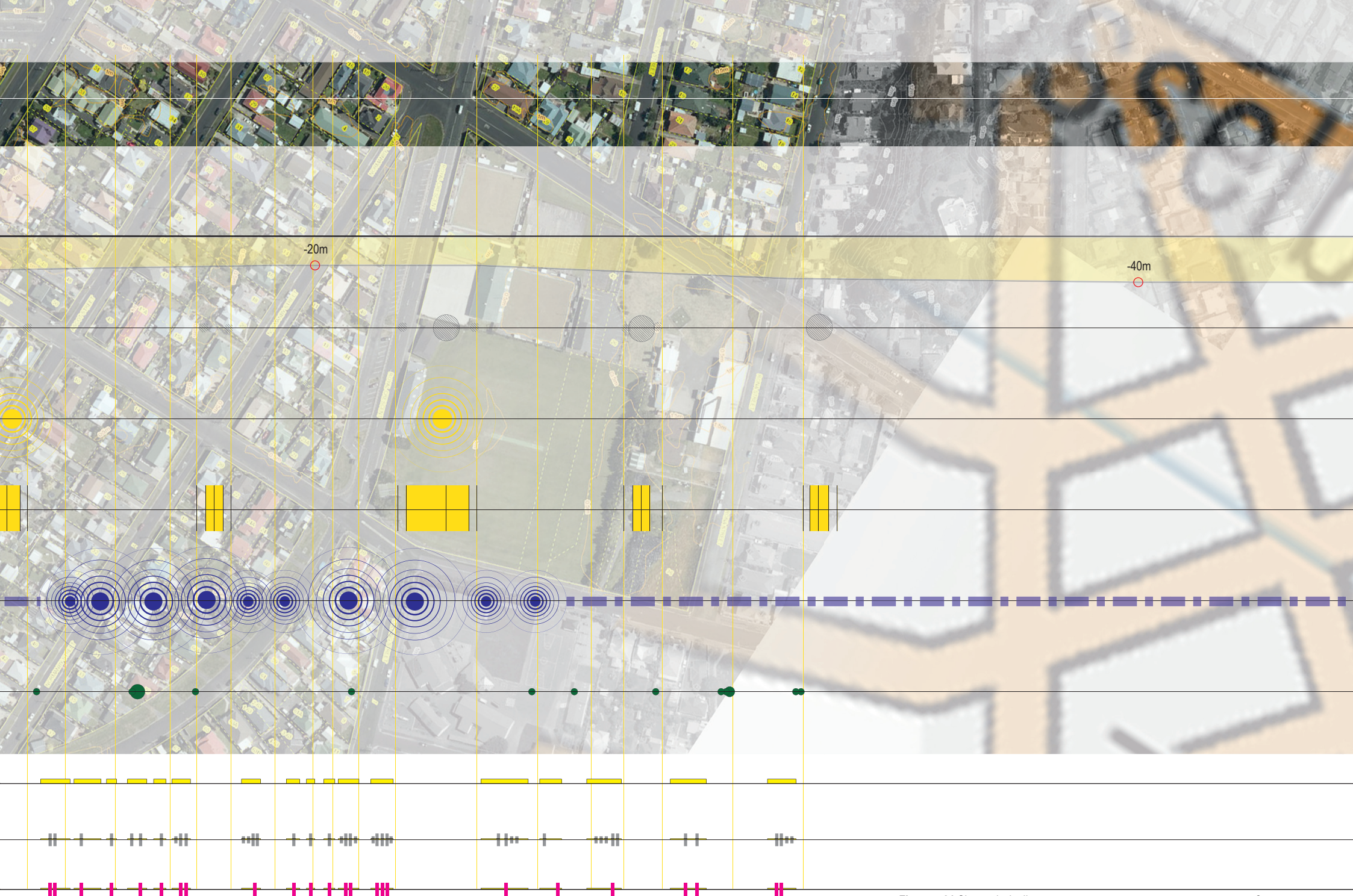


Figure 5.21 Site analysis diagram

# **06: DESIGN RESEARCH**

## 06 Design Research

Both Accommodation and Relocation have tangible possibilities for the future of South Dunedin. The immediate concerns of residents faced with SLR are often the loss of their homes and loss of their communities. Choosing to focus on Accommodation allowed the primary objectives of the design research to test strategies to keep and strengthen resident's' homes and community, building a resilient future for South Dunedin. Accommodation in some instances would involve substantial rebuilding of existing buildings and for some owners/buildings this would not be feasible, in which case relocation would be preferable. In the scenario of an accommodation strategy for South Dunedin it is acknowledged that it would result in a combination of adapting compatible existing buildings, new-build buoyant homes and where adaption is not feasible abandonment and relocation.

Design research was carried out on three scales, residential housing, a community site and a wider urban design strategy. The key design objectives are explained below:

**SLR**, Sea Level Rise Resilience – design research began focusing on architectural strategies to adapt existing buildings for SLR, then extended into the mechanisms necessary to support these strategies.

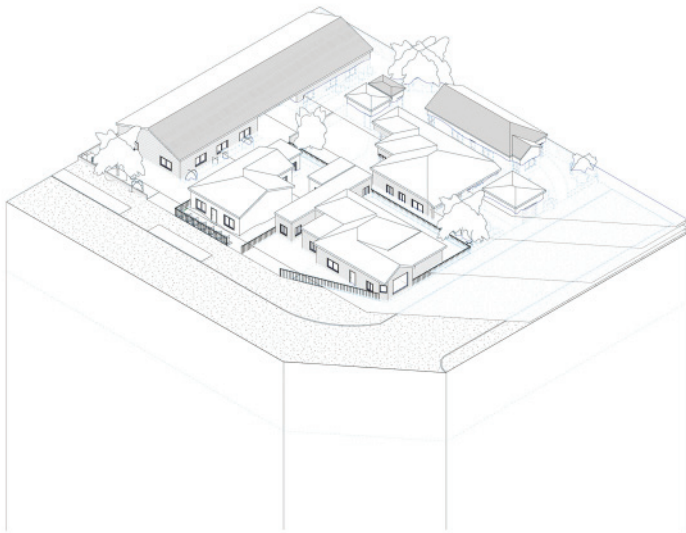
**ZC**, Zero-Carbon – Throughout the thesis, design decisions, such as material and strategy selection, were based on reducing the carbon footprint and environmental damage of the design.

**HR**, Holistic Resilience – For a community to be resilient it must be able to consistently provide for all five human needs (Carmona et al 2010, 134) at all times despite changing conditions. Design research tested the degree to which architectural interventions can support resilience in the context of SLR and the mechanism of accommodation.

1. Physiological Needs (food, warmth, survival)
2. Safety and Security Needs (harm avoidance)
3. Affiliation Needs (belonging, acceptance)
4. Esteem Needs (status, education, ownership)
5. Self-Actualisation Needs (artistic fulfilment, expression)

*Ref. (Carmona et al 2010, 134)*





**Figure 6.1** Residential design line drawing of Revit model showing the five buildings and layers of projected SLR.

## Residential Design

While South Dunedin is still enjoying the luxury of Dry Land it is important to make the most of this window to prepare for future inundation. Adaption work should begin as soon as possible. Five neighbouring properties in the Tainui suburb were selected as representative of the age, construction and condition of typical South Dunedin buildings. By modelling the buildings in Revit, three different methods of adapting the structure to deal with SLR were explored and assessed for suitability. These were:

- a) Static Elevation by raising the finished floor level
- b) Addition of a Second Storey
- c) Buoyant Foundations (for explanation see p.43)

**Figure 6.2** Residential design property location map, highlighted in yellow, Tainui, South Dunedin.



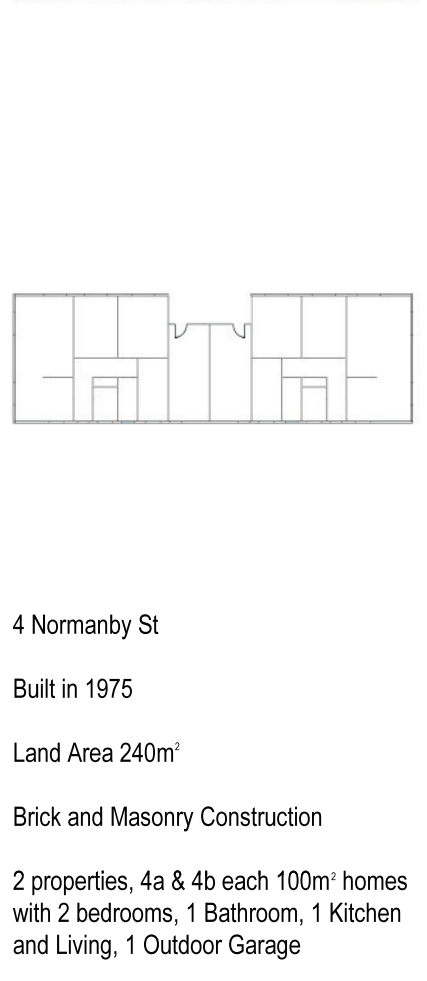
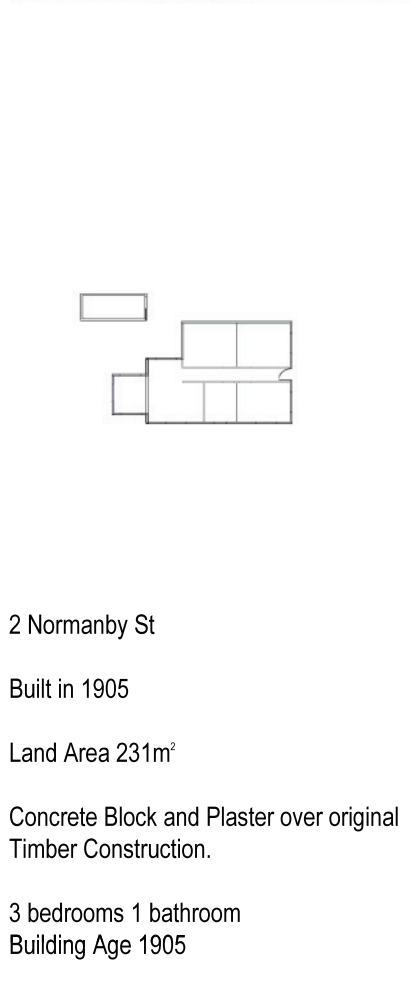
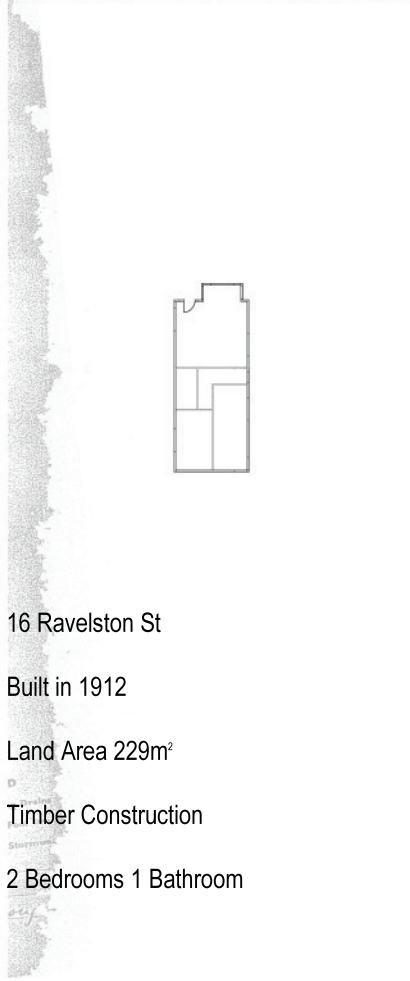
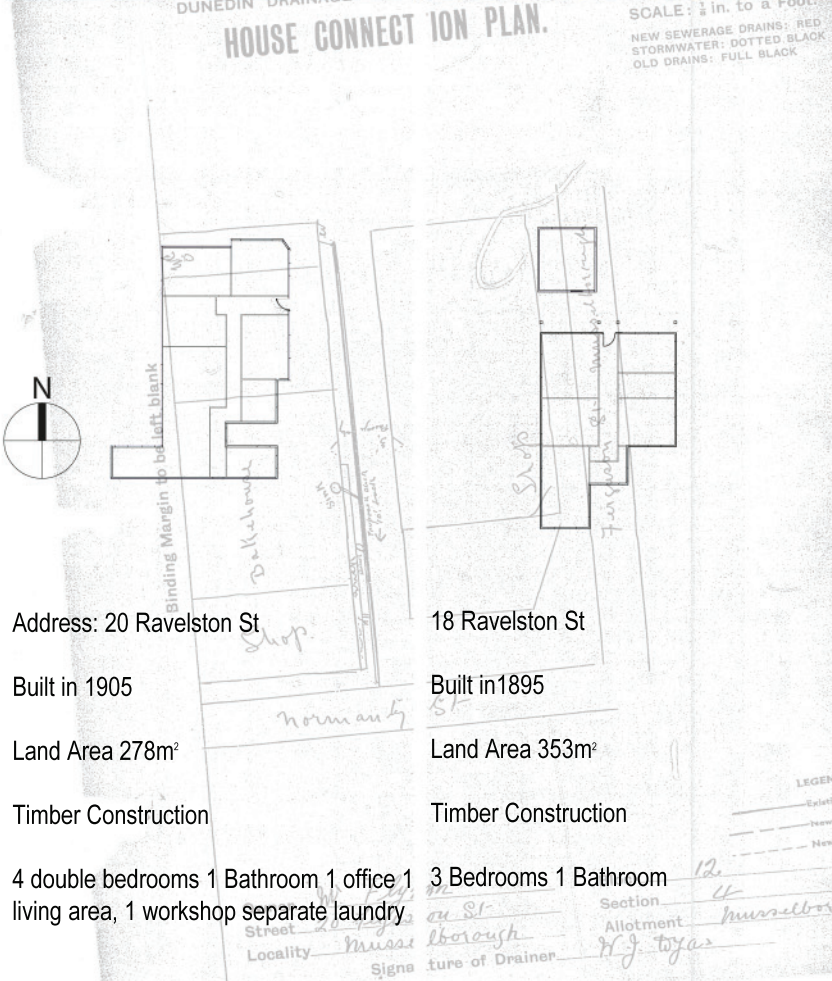


Figure 6.3 Residential design property images and information.



Figure 6.4 Preliminary design exploration images, testing strategies of adapting to SLR and the effect of inundation.

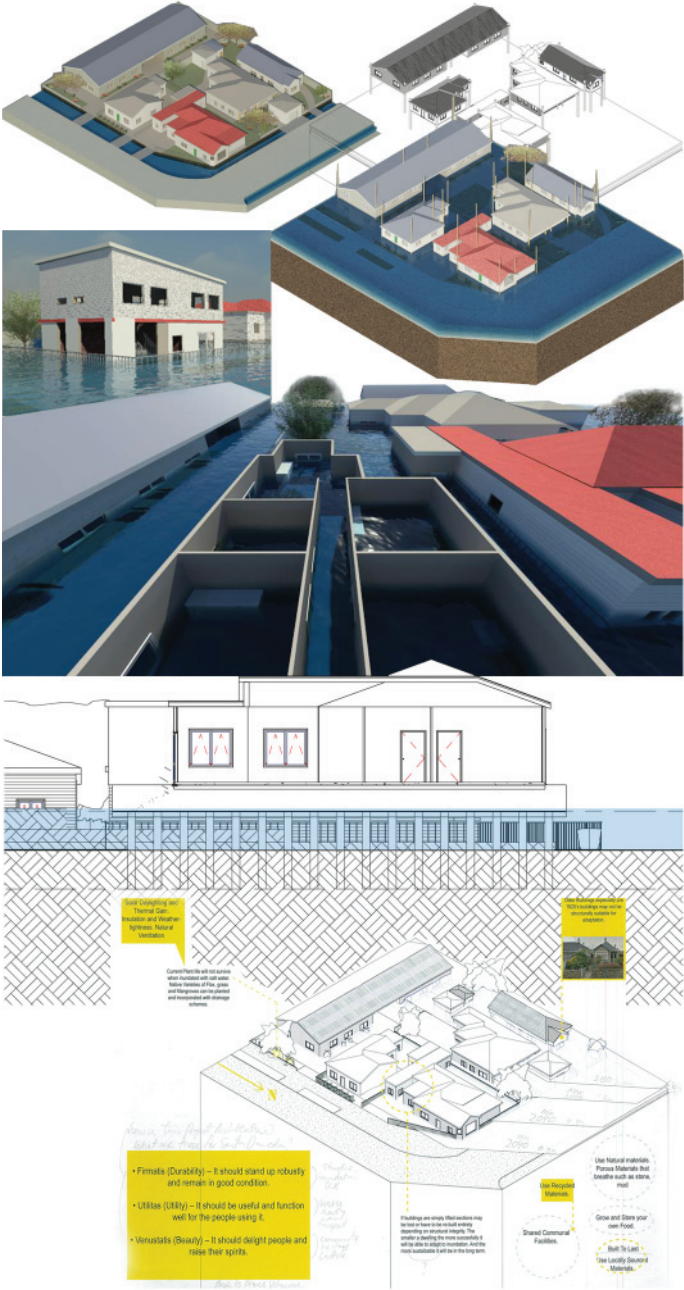
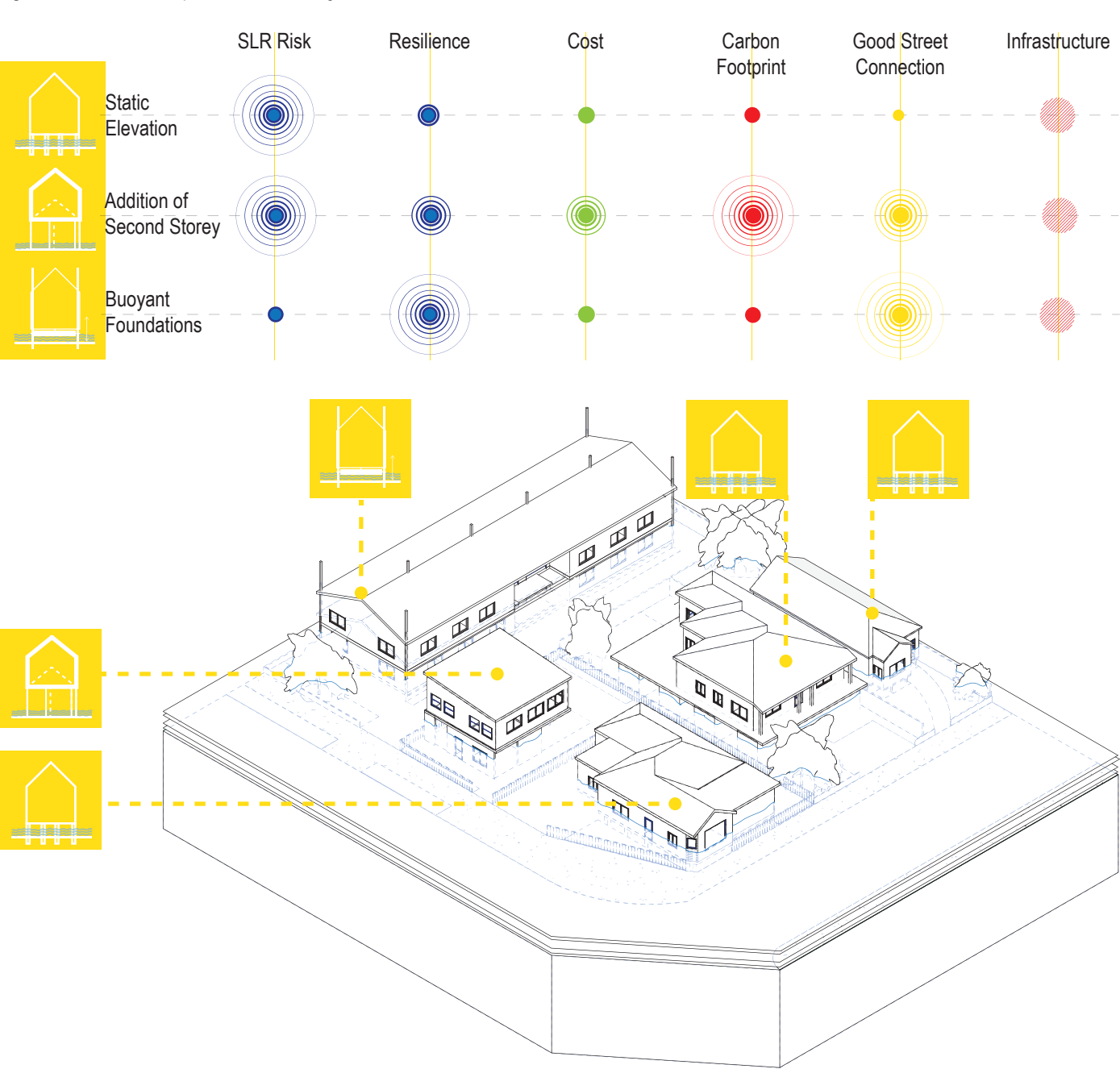


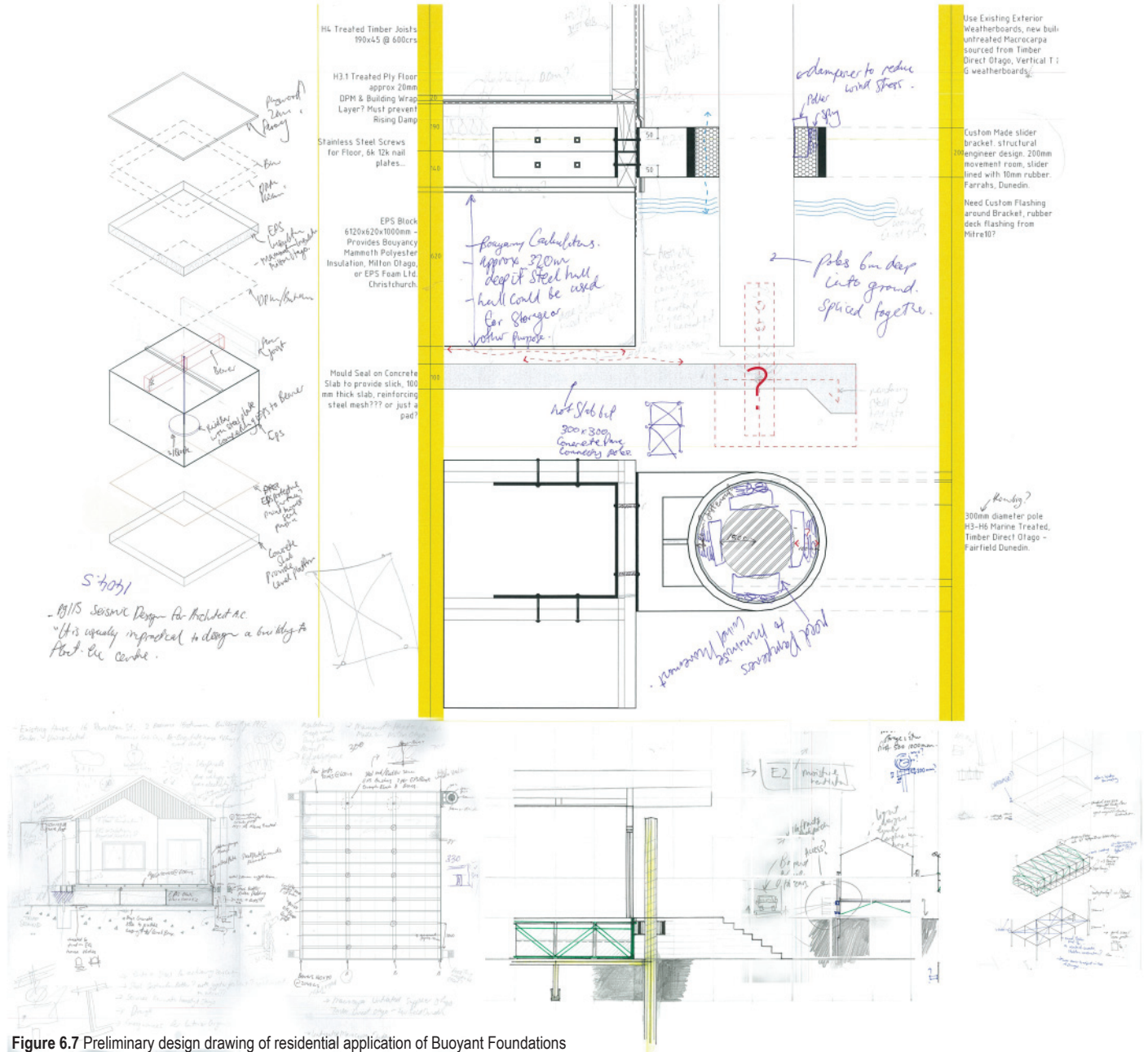
Figure 6.5 Residential SLR options Assessment Diagram



## Buoyant Foundations

Buoyant Foundations were found to be the most resilient strategy. Rising and falling with the water means that there is no built-in failure point. Should the water levels rise above original guide poles, poles can be extended or buildings untethered and easily removed to a Dry Land site or secured by different means.

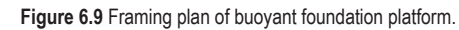
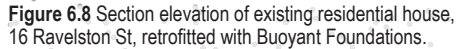
Buoyancy can be achieved in multiple ways. This thesis proposes using EPS as shown by English, because: it's cheap, entirely recyclable, the process of manufacturing EPS does not release green-house gases, it has a high strength to weight ratio, and can be locally sourced from Christchurch. Another option would be to use an EPS and concrete composite (refer figure 6.6). This is less environmentally friendly but structurally superior. Following advice from university staff that approximate buoyancy calculations were carried out to establish the required thickness of EPS blocks for a residential house on a 10x10m platform would be 300mm. For security and static elevation during Urban Wetland phase the thickness shown is 500mm.



**Figure 6.7** Preliminary design drawing of residential application of Buoyant Foundations



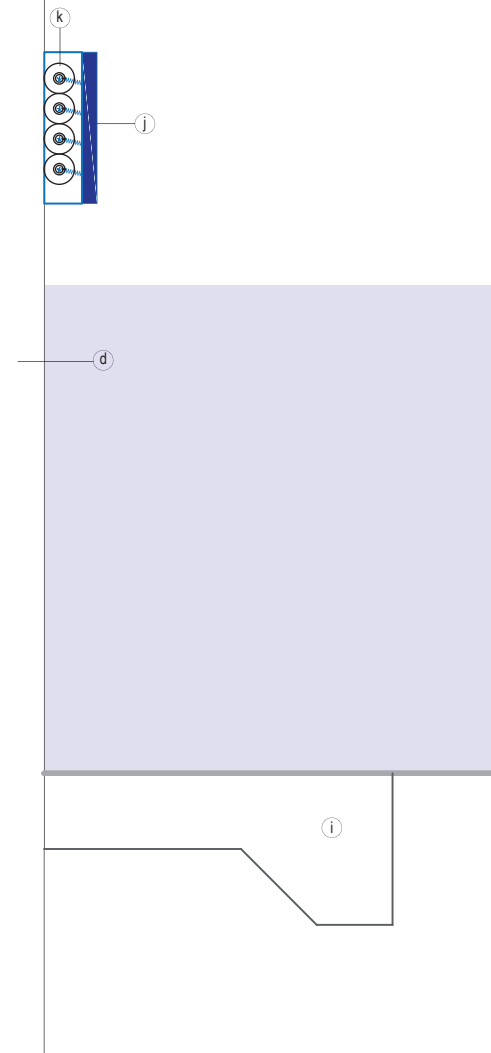
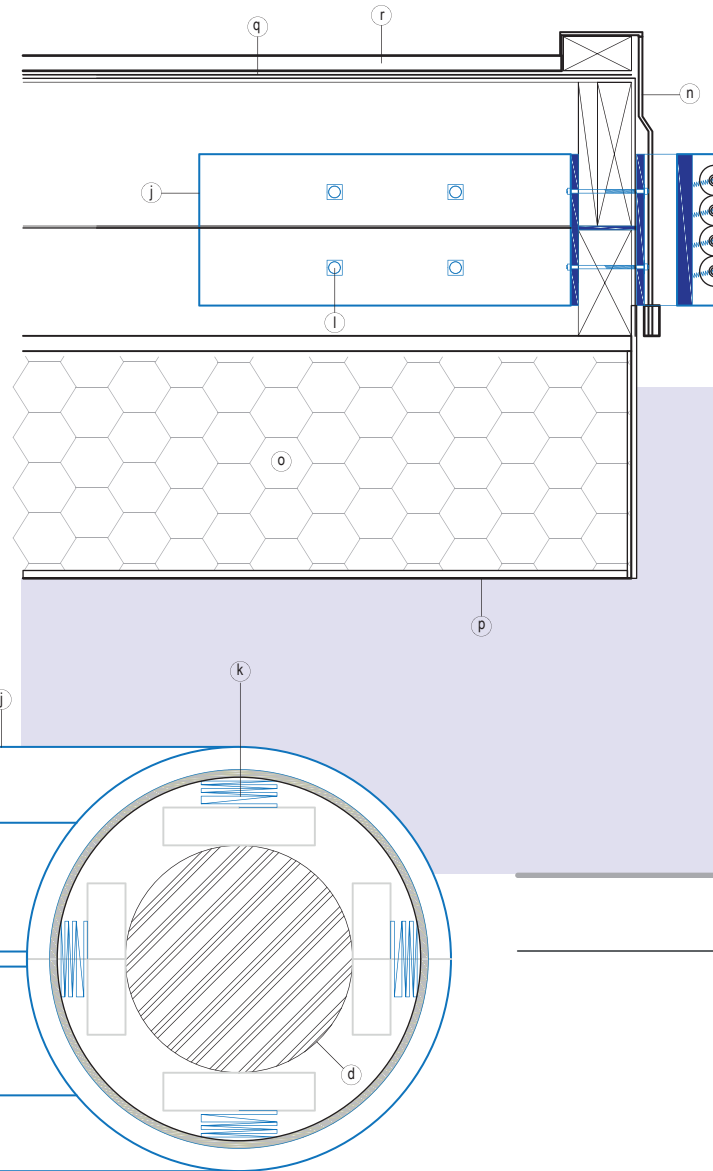
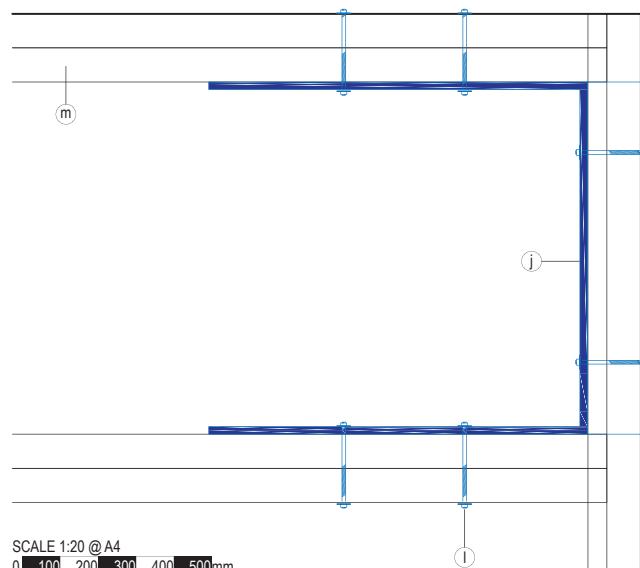
- d. Treated H6 timber or reinforced concrete wharf pile.
- e. Timber Bearers on top of buoyant EPS foundation H6
- f. Timber Joists H6
- g. Hanging connector fixing EPS foundation to timber framing.
- h. Strap around EPS connected to g.
- i. Concrete slab cross with reinforcing steel. Full slab not needed just cross to keep posts, d, in place.



- j. Buoyancy slider bracket
- k. Spring tensioned rollers allowing vertical movement, tensioned to dampen horizontal wind effect.
- l. Galvanised Bolts connecting buoyancy slider to foundations.
- m. Treated H6 timber framing as per NZS3604
- n. Flashing and perimeter drainage guttering.
- o. EPS, expanded polystyrene, providing buoyancy.
- p. Sealant applied to exterior of EPS to protect from elements.
- q. DPM
- r. Timber Decking

SCALE 1:20 @ A4  
0 100 200 300 400 500mm

**Figure 6.10** Plan view detail section of Buoyancy slider bracket and guide pole.



SCALE 1:20 @ A4  
0 100 200 300 400 500mm

**Figure 6.11** Detail section of Buoyancy slider bracket and guide pole.



A contributing factor of climate change is a global culture of excessive consumerism. For climate change mitigation it will be necessary to counter-act this through lifestyle changes towards ZC simplicity. Existing houses may also need to be renovated or downsized as part of adaption to buoyancy. Design experiments shown in figure 6.12 were about making things small.

For HR It is important to address existing housing problems in South Dunedin that are negatively affecting resident health and quality of life. Key challenges of Insulation, Solar Gain, Natural Ventilation, Building Construction and Material Selection were identified. These are explored in figures 6.13 and 6.14.

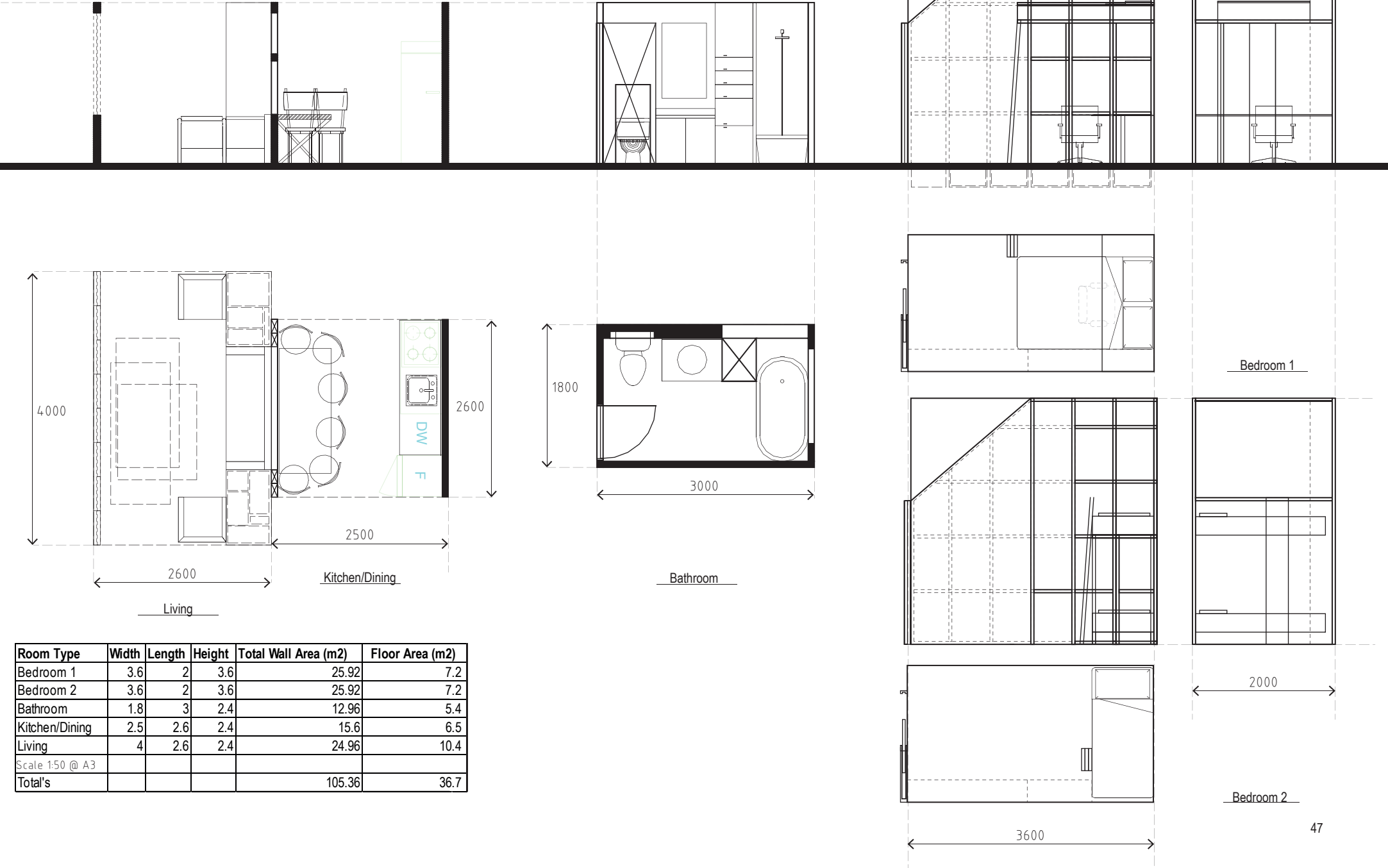
Living in warm dry homes is essential for health and well-being. Establishing a higher minimum building code insulation level that all homes, rental and owner-occupied must reach would greatly benefit the health of residents. Using EPS as the insulation material is low-cost, effective and would increase the buoyancy capacity of the structure.

Positioning buildings to maximise solar gain, typically for north orientation, is free and means houses are warmer, drier and sunnier. Re-orientation of existing houses for increased solar gain could easily be done when retrofitting houses with buoyant foundations as houses are already uplifted.

Adapting buildings for natural ventilation reduces reliance on artificial systems, lowers power bills and facilitates good airflow which combats damp. Given the direct contact with water, dampness is a critical issue in an Urban Wetland and Urban Blue Space environment. Material selection is also important in combatting damp.

Some houses in South Dunedin, whether by age, construction or condition would prove unsuitable for buoyant foundations, therefore the resultant adapted city would be a mixture of old adapted homes and new homes. Following design explorations into adapting existing homes the next step was to design a new home that learnt from those ideas.

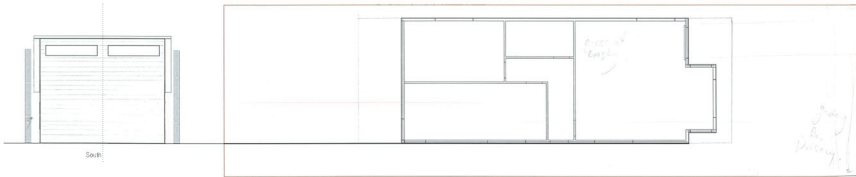
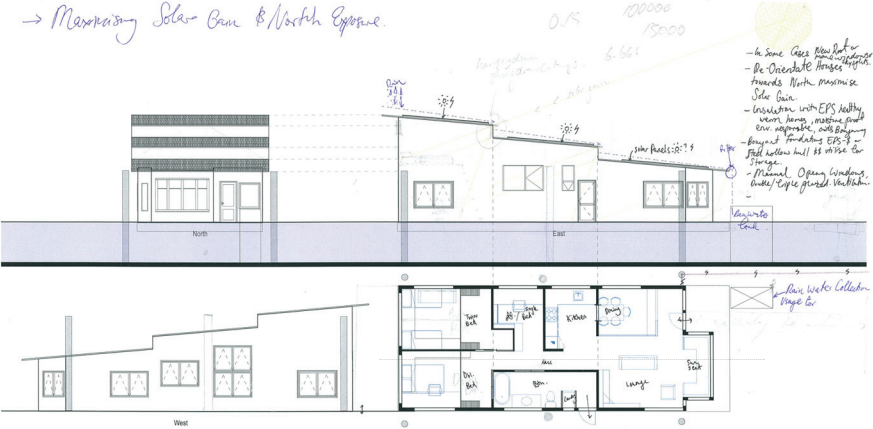
**Figure 6.12** Preliminary design experiments in compact room design, application in downsizing existing houses for buoyant foundation retrofit or for designing new houses for compact living and to replace houses needing to be demolished.

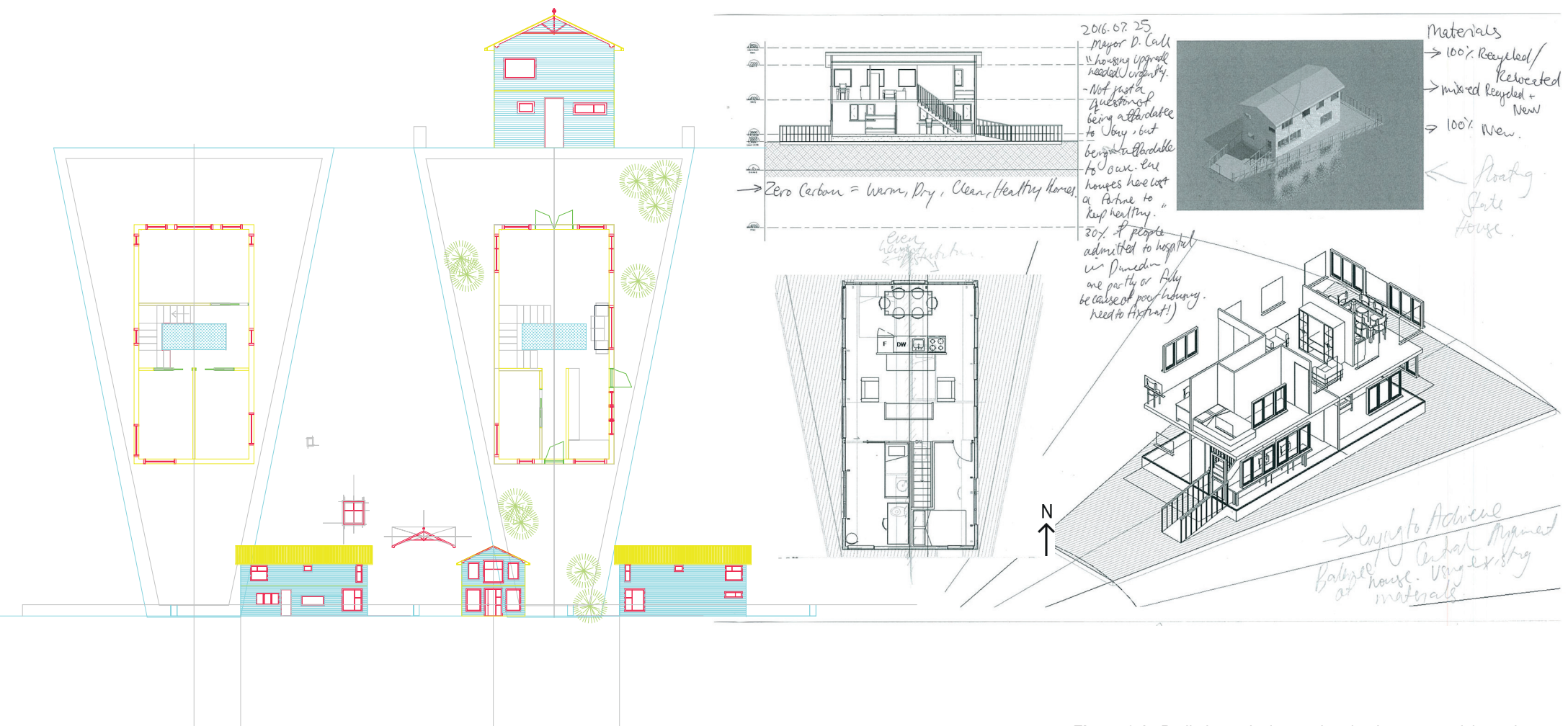




**Figure 6.13** 16 Ravelston St, preliminary design explorations for renovation to increase solar access and natural ventilation, re-organisation of interior floor plan and insertion of light well/garden.

**Figure 6.14** 16 Ravelston St, slight adjustment of interior walls, addition of new roof with north facing clerestory windows.





**Figure 6.15** Preliminary design exploration into reorganizing existing houses, thinking about re-use of materials and buoyant platform configuration. Early idea of designing groups of houses in a circular configuration, for stability and minimization of required guide poles, with each house on their own segment.



Buoyant Foundations as used in this design would give houses a standing elevation of 500mm above ground, meaning that the building would not float until water levels exceeded 500mm. During the urban wetland phase buildings would be elevated enough to protect them from shallow water and in the event of flooding, and would rise with the water. This elevation would necessitate accompanying access such as walkways, ramps, or steps.



**Figure 6.16** View of residential houses, mix of existing and new houses with buoyant foundations, during Urban Wetland Phase



Achieving stability would be an important consideration in Urban Blue Space. In the Netherlands floating houses are often equipped with a level and home owners adjust their furniture and supplement weight with the positioning of sand bags to achieve balance. Another option is to position houses in a chain, for example, of 10 houses. Each house would have to be of equal weight. Being part of a chain the houses would balance each other out. Individual houses would still make an effort to ensure equal weight distribution but there may be less of a need for sand bags. Wind forces would also need to be especially designed for as these are forecast to increase. This is addressed in the design similar to wharf construction, using tightly compressed spring rollers in the sliding bracket to act like shock absorbers and dampen/prevent movement by wind.

① Buoyant Public Walkway.

② 10mx10m buoyant residential building platform refer figure 6.9.

③ Rain Water Tanks

④ Front Door and Hallway

⑤ Kitchen/Dining Room

⑥ Living Room

⑦ Hallway

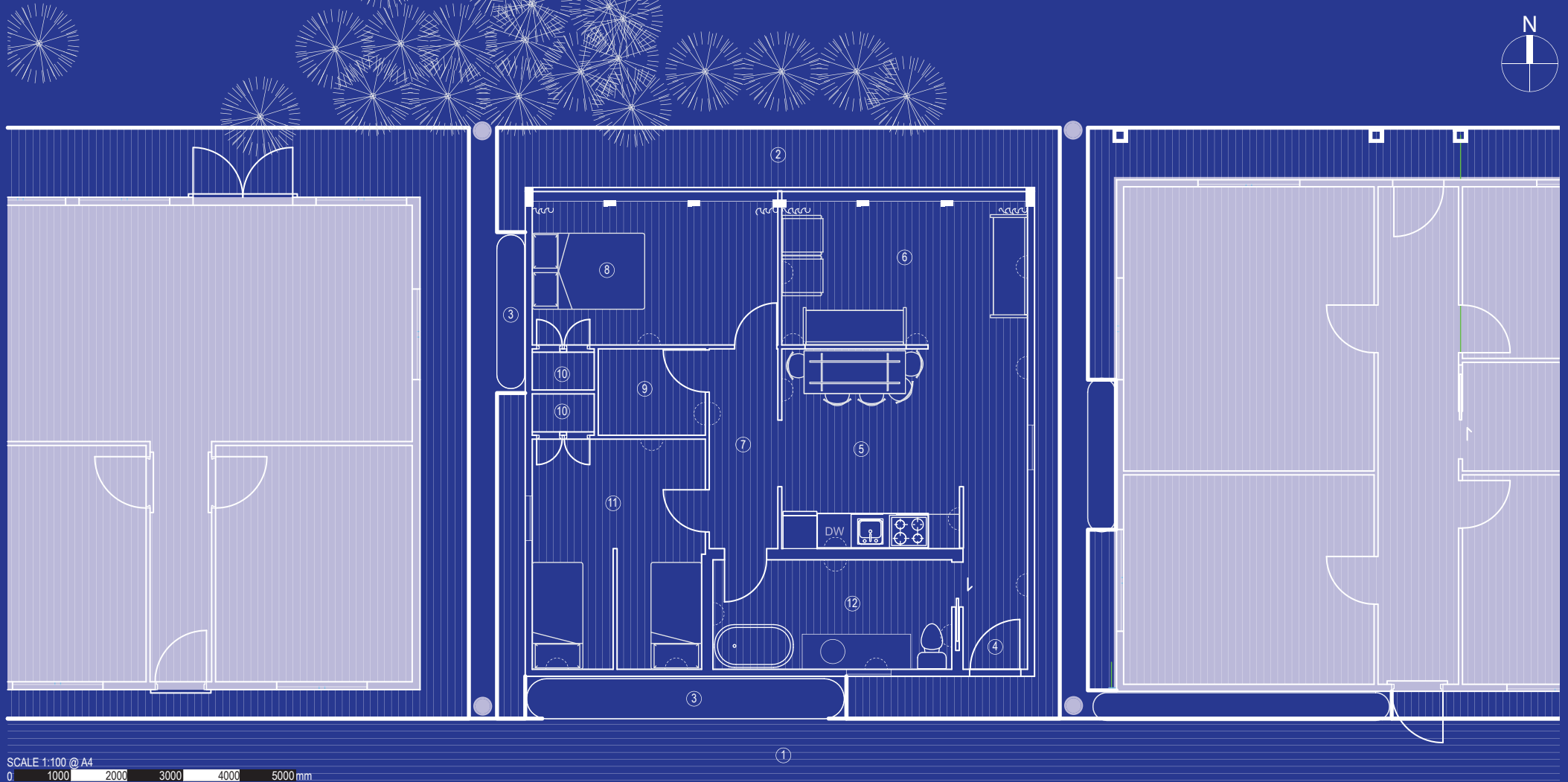
⑧ Main Bedroom

⑨ Storage

⑩ Bedroom Storage

⑪ Twin Bedroom

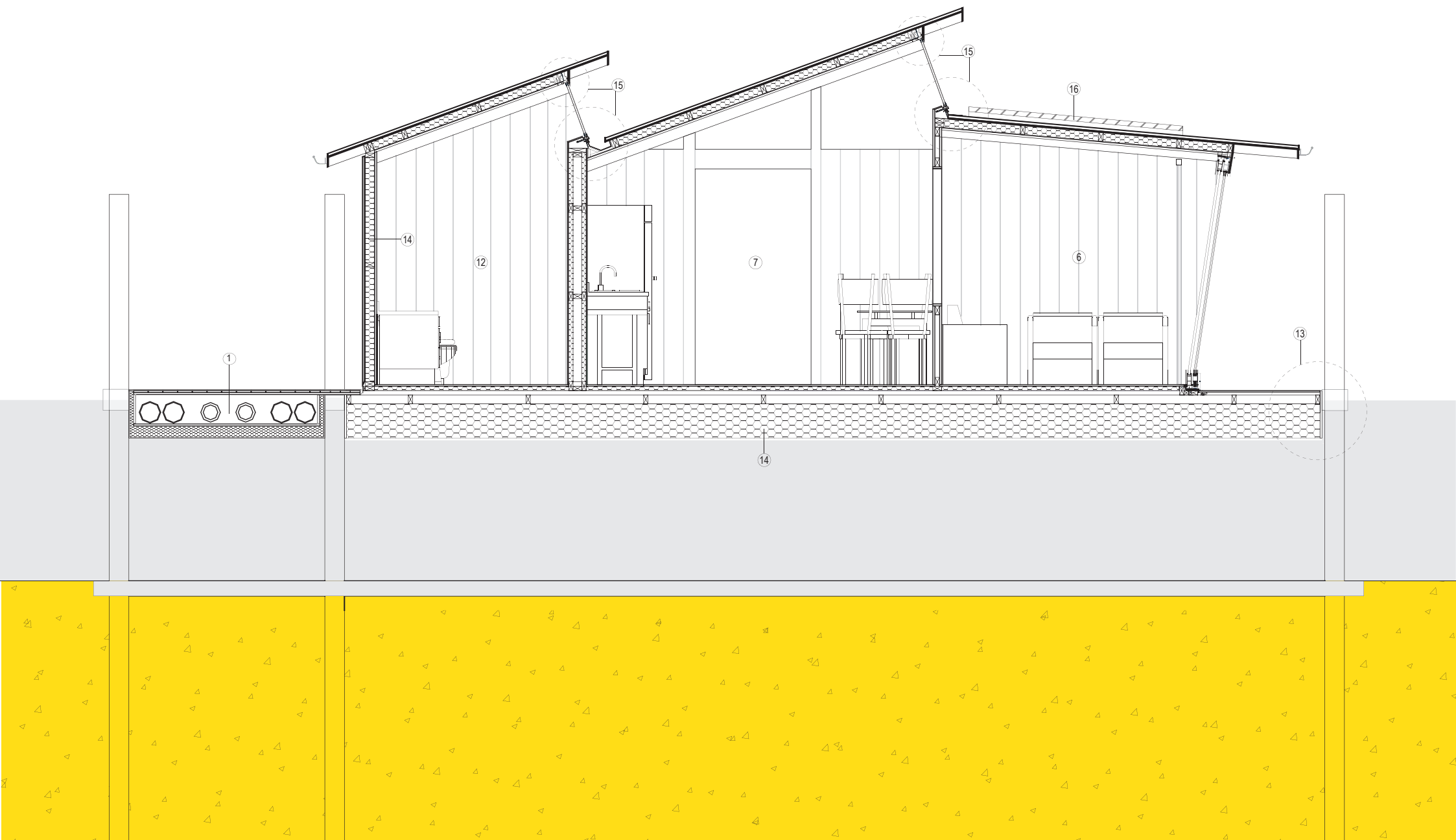
⑫ Bathroom



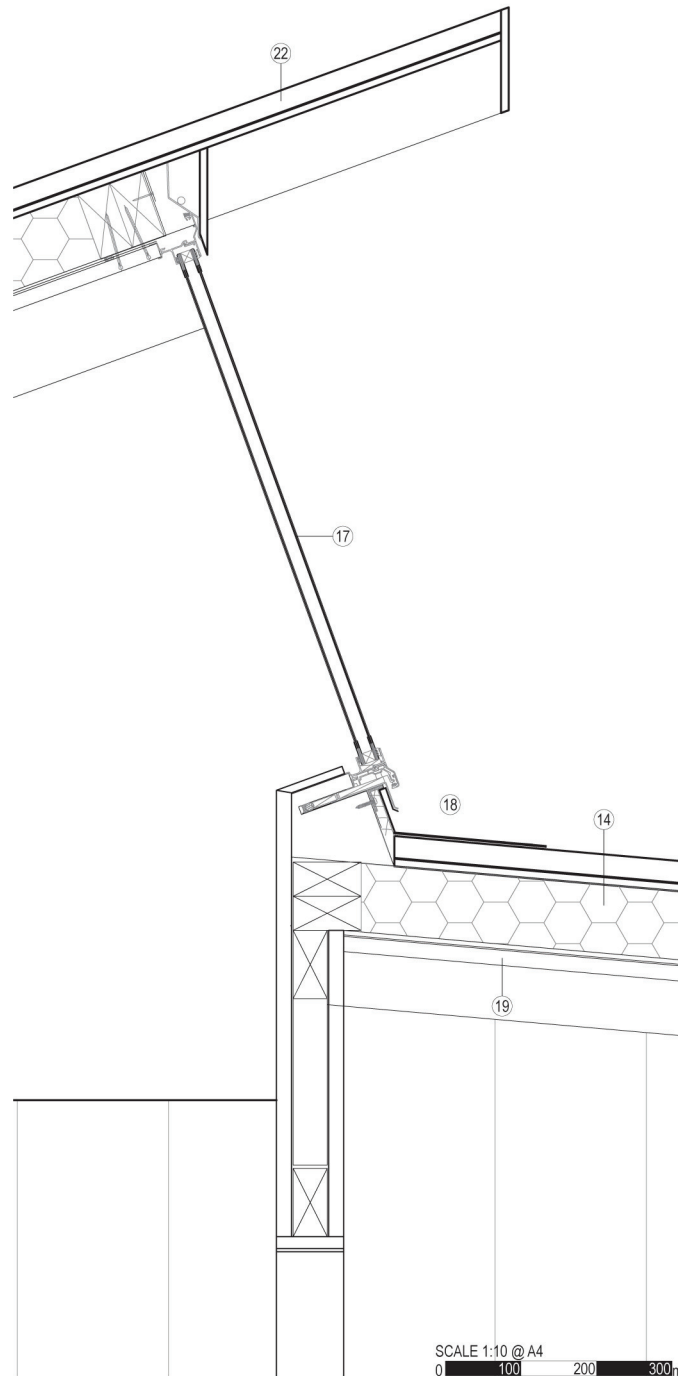
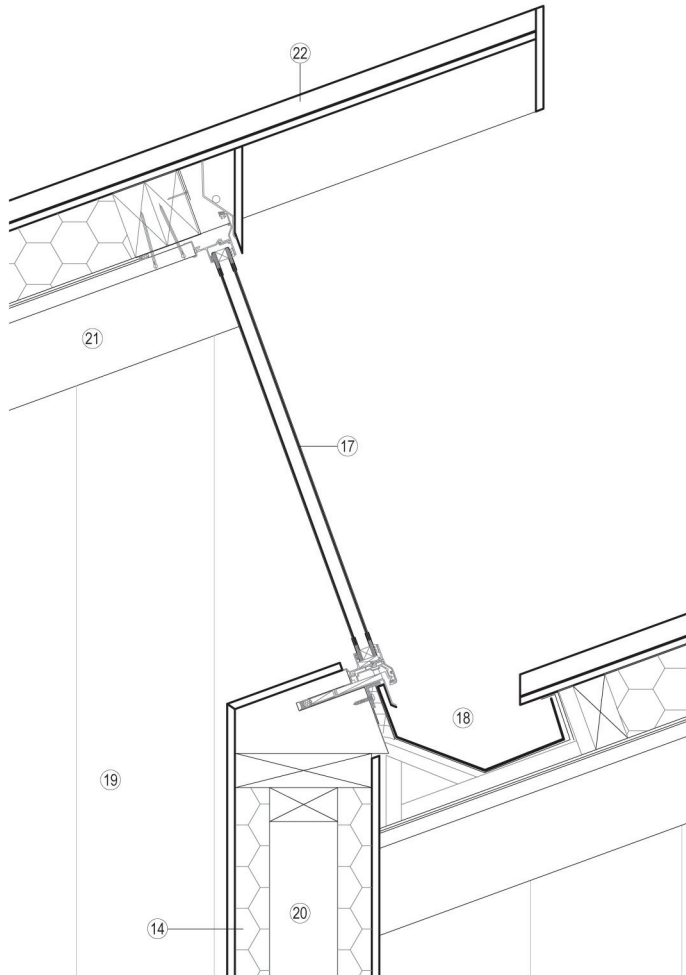
**Figure 6.17** Floor plan of new residential house design with buoyant foundations. This design draws on preliminary studies in figure 6.12 p.47.



**Figure 6.18** Section drawing of new residential house design with buoyant foundations (see p.55 for drawing legend).



SCALE 1:10 @ A4  
0 100 200 300mm



SCALE 1:10 @ A4  
0 100 200 300mm

**Figure 6.19** Detail Construction drawings of new residential house design with buoyant foundations

- 1 Buoyant Public Walkway
- 6 Kitchen/Dining Room
- 7 Living Room
- 12 Bathroom
- 13 Refer figures 6.8, 6.9, 6.10, 6.11
- 14 EPS, Buoyancy Blocks and interior insulation refer figure 6.19
- 15 Solar Panel
- 16 Clerestory window, window detail DWG sourced from NuLook (2016).
- 17 Internal Gutter
- 18 Wall and ceiling lining, H5 grade macracarpa interior panels
- 19 H5 timber framing as per NZS3604
- 20 H5 grade macracarpa exposed rafters
- 21 Recycled plastic corrugated roof
- 22





**Figure 6.20** Exterior view of North face of new residential house design with buoyant foundations during Urban Blue Space phase.



**Figure 6.21** Interior view from the front door through to North facing living area.



**Figure 6.22** Interior view of the bathroom with North facing clerestory windows for natural lighting and ventilation.







**Figure 6.23** Interior view from hallway through to North facing kitchen/dining area.



**Figure 6.24** Interior view of Master Bedroom, outlook onto canal during Urban Blue Space phase.

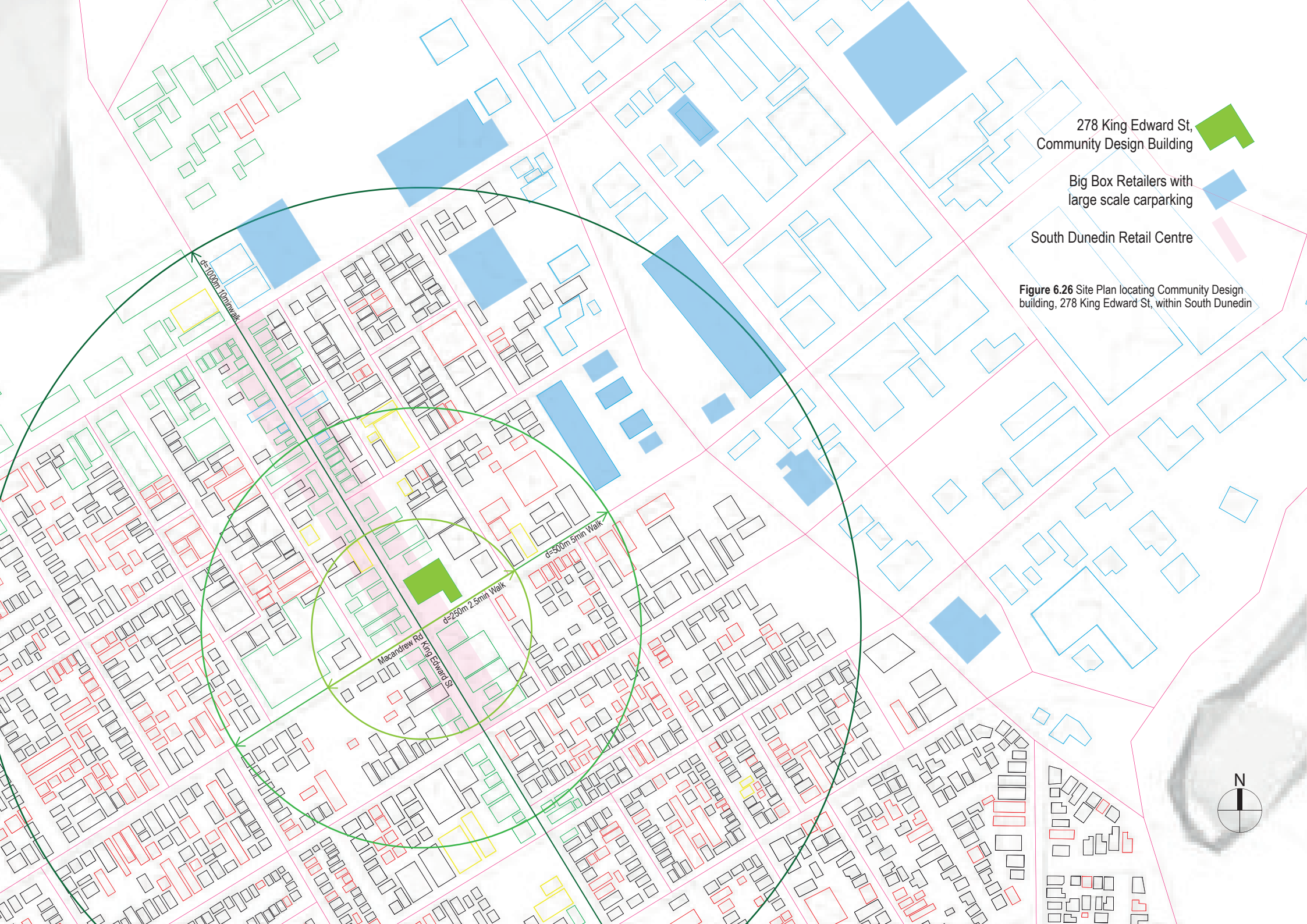


**Figure 6.25** Interior view of Twin Bedroom, clerestory windows for natural light, solar gain and ventilation, partition separating beds which could be taken out or reconfigured for storage.



## Community Design

Designing for SLR the residential explorations sought to uplift entire buildings and keep water out. Moving to the community scale, it was found that the majority of commercial buildings in the South Dunedin Retail Centre are unlikely to be compatible with buoyant foundations due to their typically heavy construction. Therefore the decision was made to explore ways to let flood waters in but have the building remain healthy and functioning. For HR the site analysis indicated a need to revitalise the South Dunedin Retail Centre. The corner of King Edward St and Macandrew Road is a prominent intersection in the South Dunedin Retail Centre, with proximate under-utilised retail and community infrastructure, and is the closest end to the geographical centre of South Dunedin. Supporting this intersection as the centre through the development of an anchor building would aid revitalisation and maximise walkability. Walkability is important for ZC and because SLR will necessitate residents primarily experiencing South Dunedin as pedestrians. During the Dry Land phase walkability has been compromised by big box development on the periphery of the South Dunedin Retail Centre, undermining the coherence of the South Dunedin Retail Centre as the centre of South Dunedin. In the Dry Land phase the design focuses on revitalisation for HR with a supermarket, cafe, retail programme and outdoor public space. These programmes continue into the Wetland phase as the design changes to focus on SLR adaption. Initial stages of Urban Blue Space retain the Dry Land programmes, but as the water rises the building transforms, the interior structure floats up and out. Emerging from the submerged building and changing function into a floating public garden.



278 King Edward St,  
Community Design Building

Big Box Retailers with  
large scale carparking

South Dunedin Retail Centre

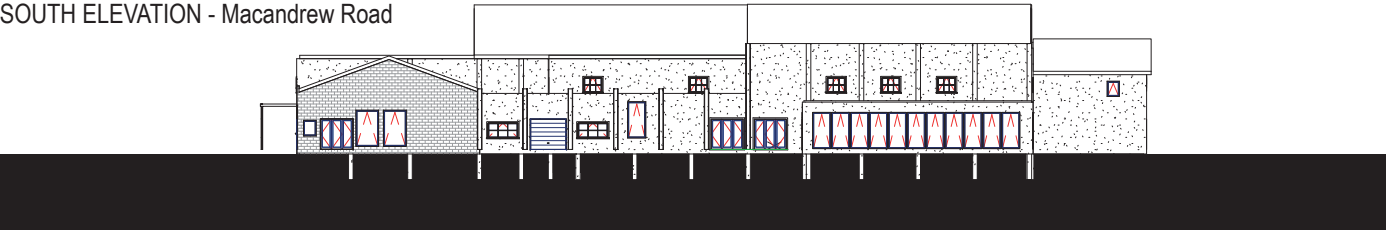
**Figure 6.26** Site Plan locating Community Design  
building, 278 King Edward St, within South Dunedin



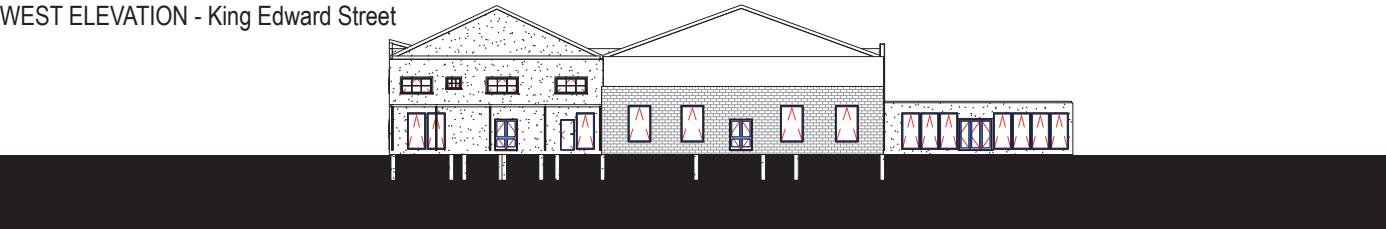
Figure 6.27 Elevations of existing building, modelled in Revit.



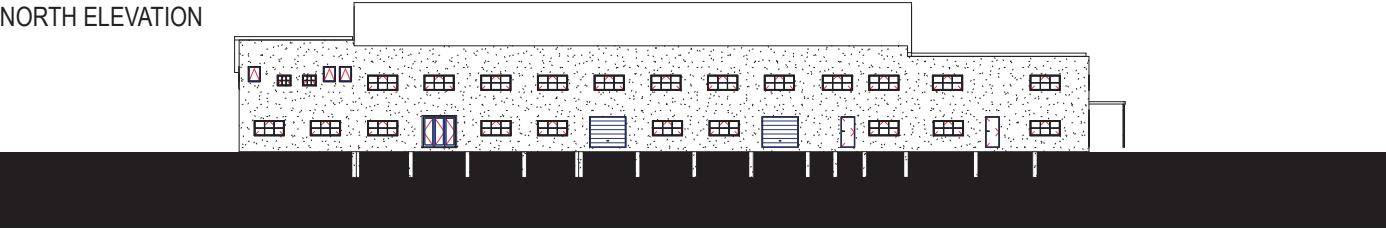
SOUTH ELEVATION - Macandrew Road



WEST ELEVATION - King Edward Street



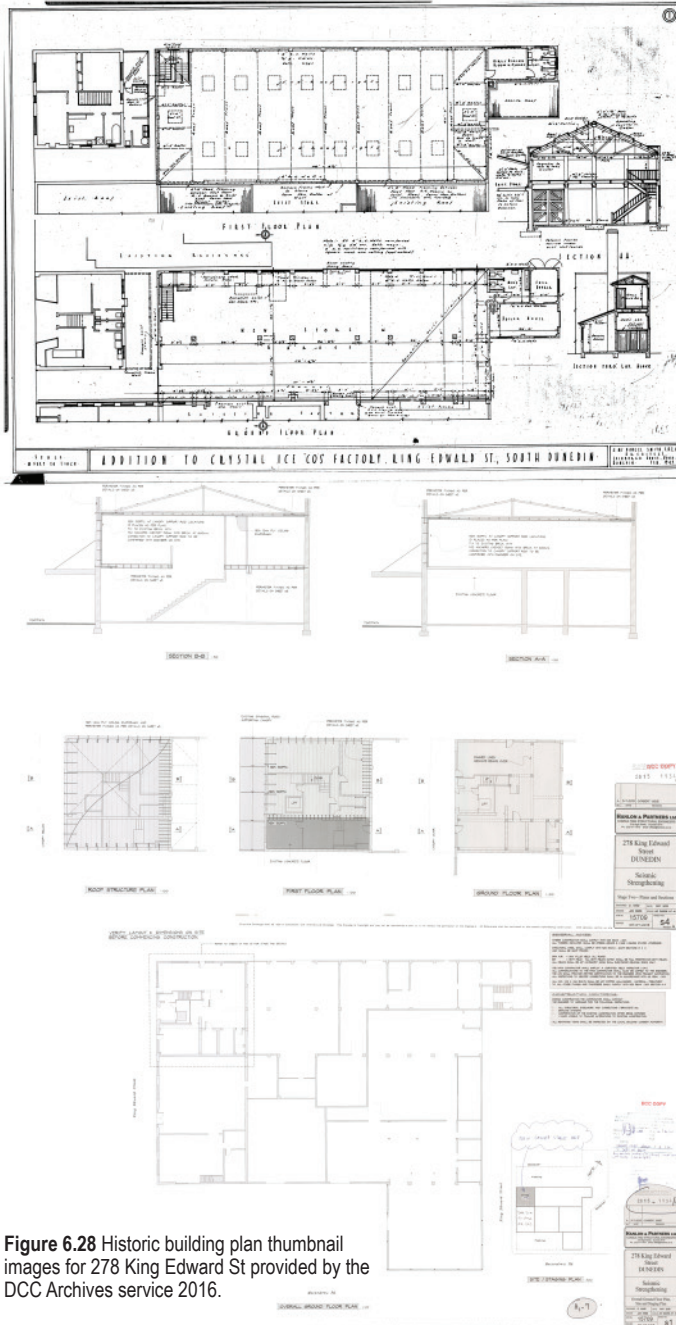
NORTH ELEVATION



EAST ELEVATION

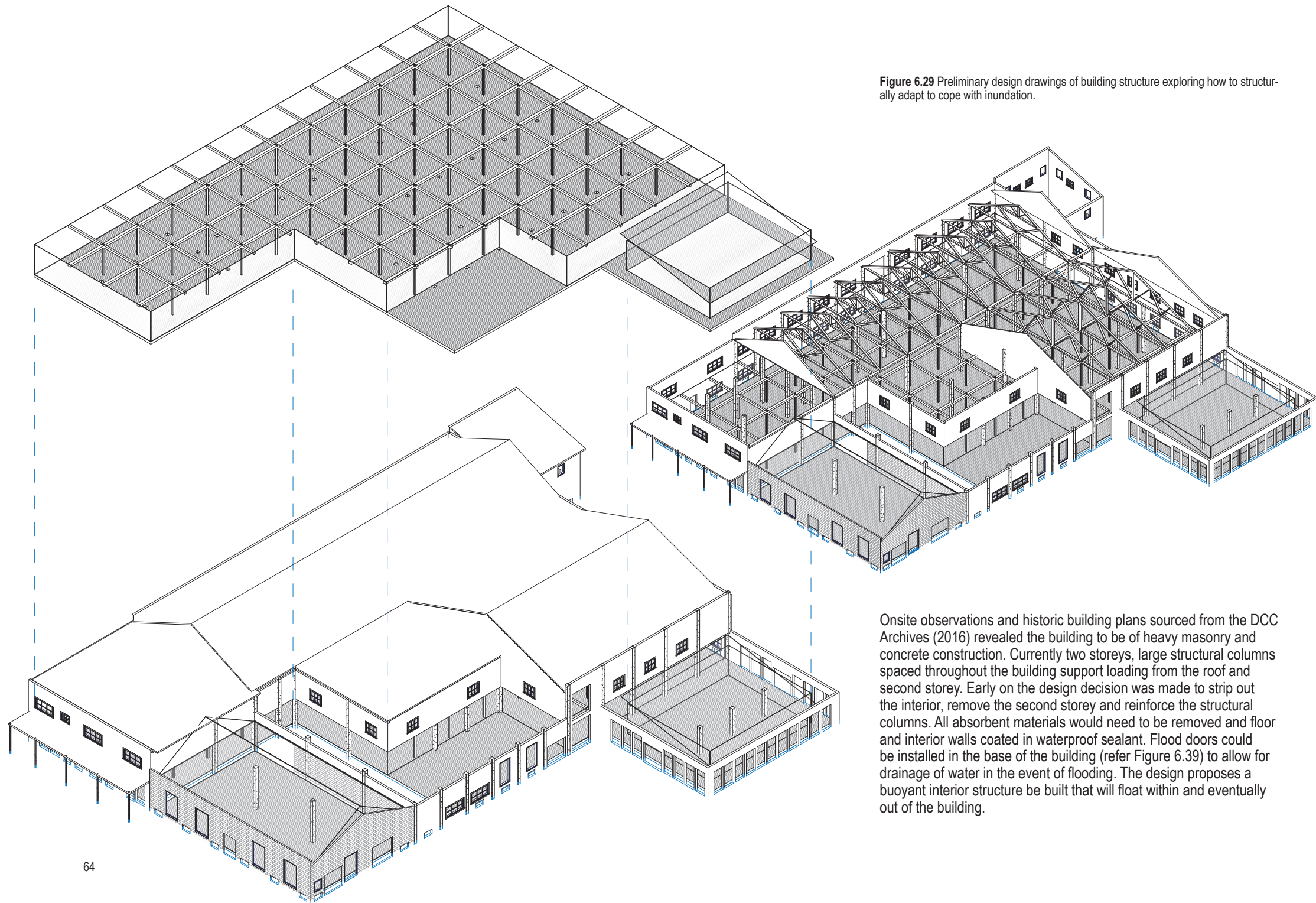


This section discusses the retrofitting of an anchor building at the geographic centre of South Dunedin on the corner of Macandrew Rd and King Edward St. The selected building is 278 King Edward St, the design follows a scenario proposal to close both the Pak n' Save and the Warehouse complex and install a supermarket into this building, either Pak n' Save or a locally owned version with similar low prices. Re-distributing retailers within the South Dunedin Retail Centre, which sell equivalent products to the Warehouse but preferably locally-owned, sustainably-operated businesses, would aid in HR by bringing back the business and amenity that was drained. The design of public space surrounding the building sought to encourage recreational activity and prioritise pedestrians, to support HR as discussed in previous chapters. Adaptation is explored over Dry Land, Wetland and Urban Blue Space phases of SLR.





**Figure 6.29** Preliminary design drawings of building structure exploring how to structurally adapt to cope with inundation.



Onsite observations and historic building plans sourced from the DCC Archives (2016) revealed the building to be of heavy masonry and concrete construction. Currently two storeys, large structural columns spaced throughout the building support loading from the roof and second storey. Early on the design decision was made to strip out the interior, remove the second storey and reinforce the structural columns. All absorbent materials would need to be removed and floor and interior walls coated in waterproof sealant. Flood doors could be installed in the base of the building (refer Figure 6.39) to allow for drainage of water in the event of flooding. The design proposes a buoyant interior structure be built that will float within and eventually out of the building.



Figure 6.30 Preliminary design drawings of community design phase

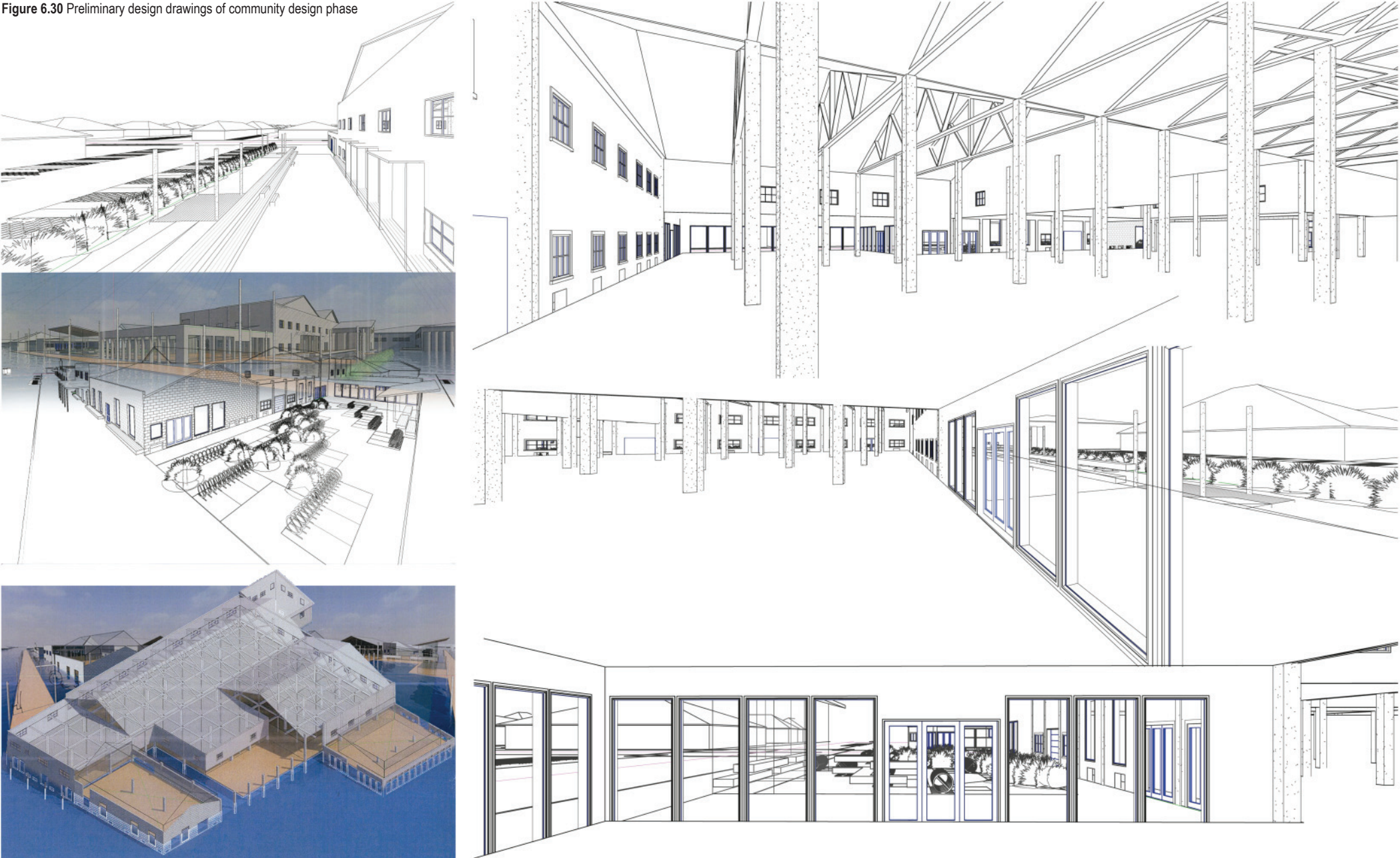
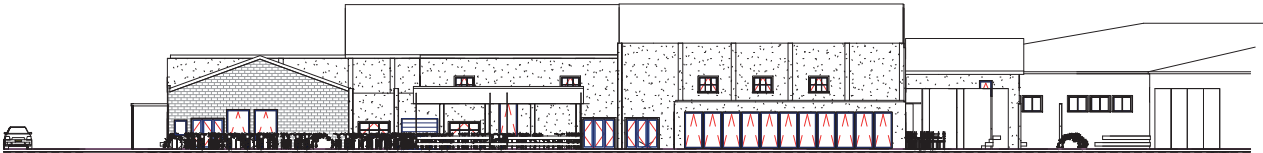




Figure 6.31 Elevations of community design during Dry Land phase.

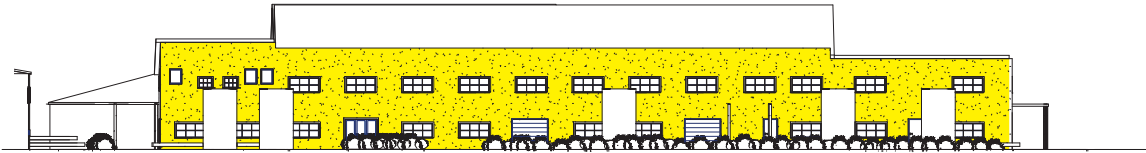
SOUTH ELEVATION - Macandrew Road



WEST ELEVATION - King Edward Street



NORTH ELEVATION

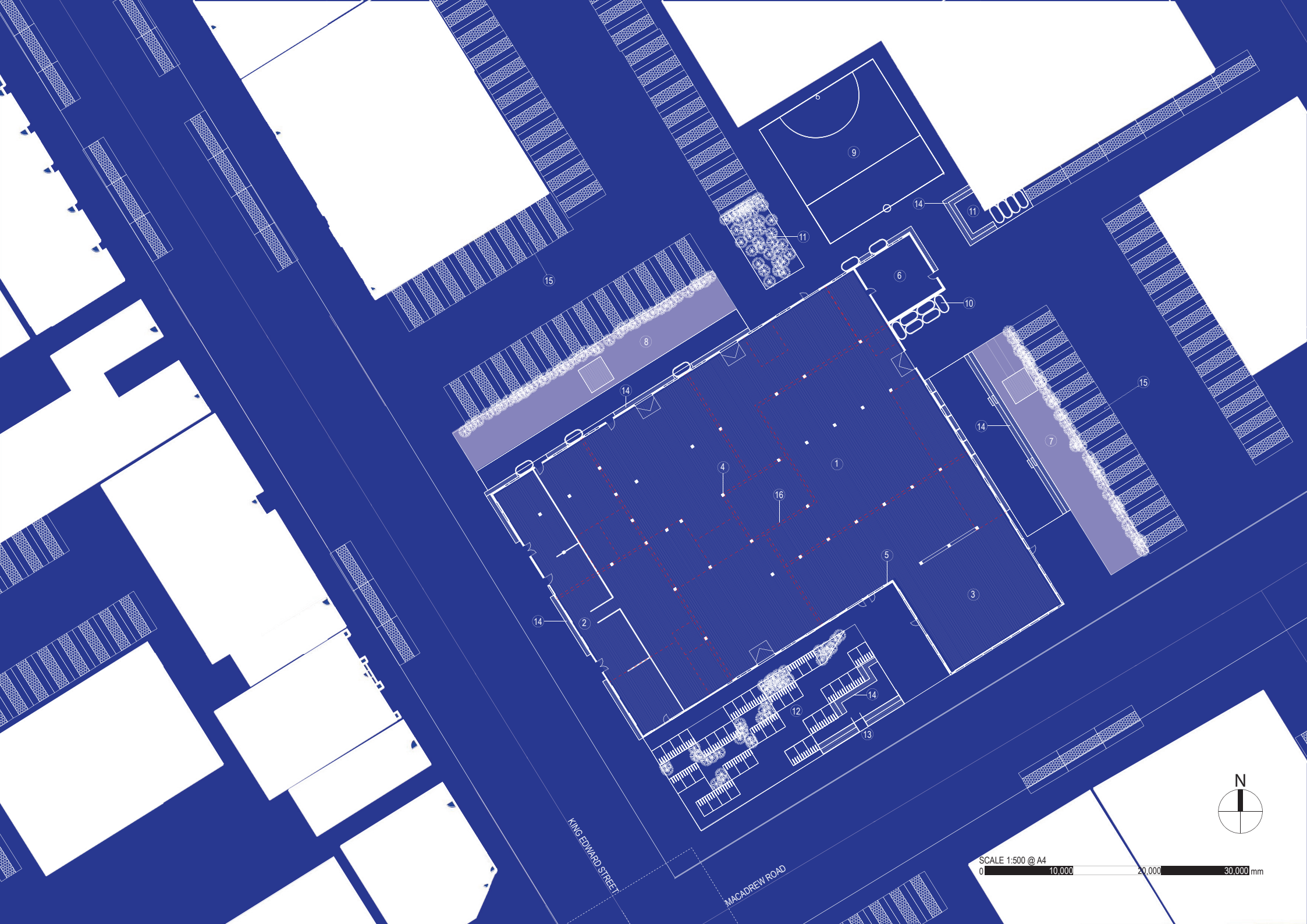


EAST ELEVATION



Figure 6.32 Site plan of community design during Dry Land phase. Prioritisation of pedestrians and cyclists. Creation of public space to facilitate recreation. Green infrastructure to increase water carrying capacity on site and provide beauty. Wetland pond designed to reveal the proximity of the groundwater to the surface, providing a live record of SLR progress.

- 1 Supermarket Interior
- 2 Retail Shops
- 3 Café
- 4 Structural Columns
- 5 Exterior Walls
- 6 Offices and Bathrooms
- 7 East Wetland Garden
- 8 North Wetland Garden
- 9 Basketball Court
- 10 Rain Water Tanks
- 11 Rain Garden
- 12 Bicycle Parking
- 13 Bus Stop
- 14 Seating
- 15 Permeable Paving car parking
- 16 Existing walls to be demolished.



SCALE 1:500 @ A4  
0 10,000 20,000 30,000 mm



**Figure 6.33** View of community design from King Edward St and Macandrew Rd intersection during Dry Land phase. Cyclist parking and Bus Stop shelter, increased seating and planting. Installation of veranda and pathway along perimeter of building providing shelter from elements and directing pedestrians around the building. For SLR adaption to be successful it is important for the community to be holistically resilient(HR). For this reason the thesis has a strong social focus. The Dry Land phase of the design focuses on revitalisation through urban design for HR.





**Figure 6.34** View from King Edward St looking towards community design. Mural proposed for North face next to public green space, basketball court visible in back corner of the site.





**Figure 6.35** View from Macandrew Rd towards café/supermarket entrance. Mural proposed for East face next to public green space, basketball court visible in back corner of the site.

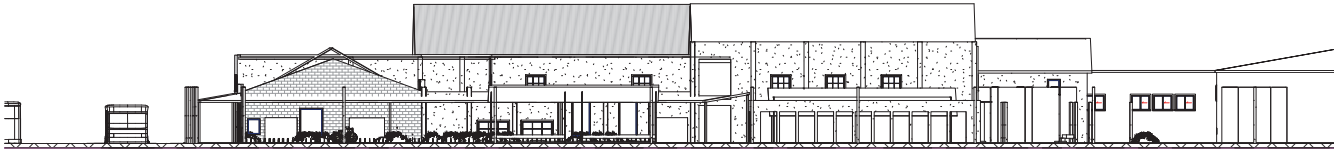




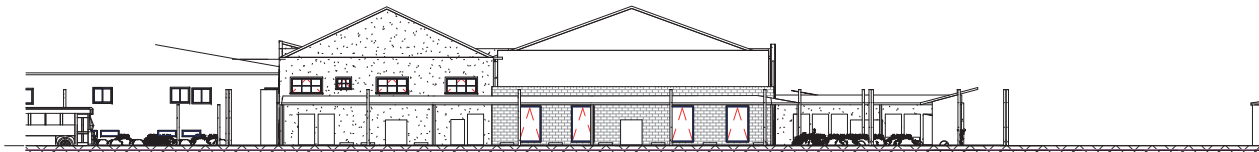
**Figure 6.36** Elevations of community design during Urban Wetland phase.

SOUTH ELEVATION - Macandrew Road

SCALE 1:500 @A4  
0 10,000mm 20,000mm 30,000mm 40,000mm 50,000mm



WEST ELEVATION - King Edward Street



NORTH ELEVATION

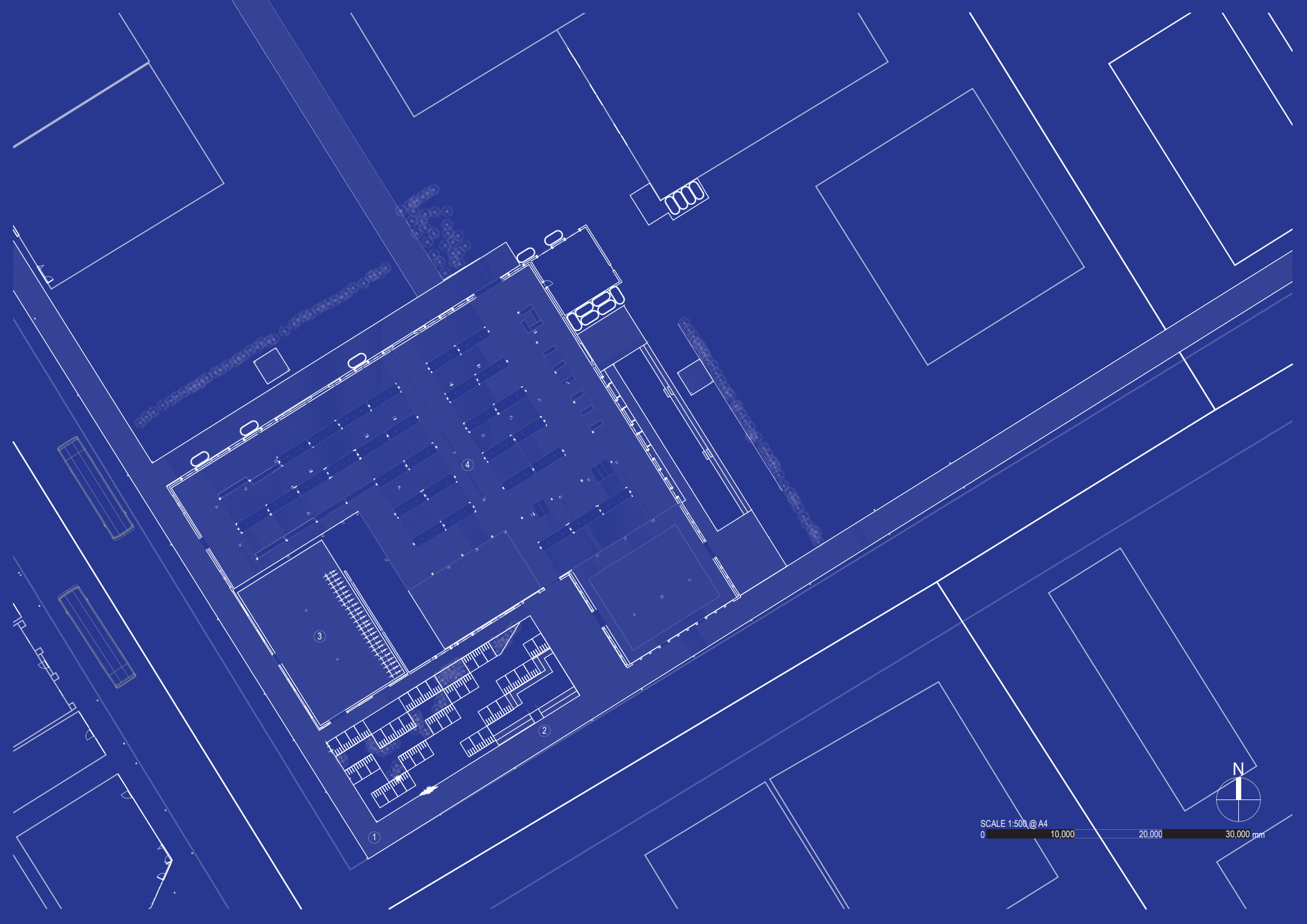


EAST ELEVATION



**Figure 6.37** Site plan of community design during Urban Wetland phase. Supermarket interior shown. Floating pathways now installed, during Urban Wetland phase pathways would not be buoyant but would be elevated 500mm above ground level, when water exceeded this level, pathways and building interior would begin to float.

- 1 Buoyant pedestrian pathways
- 2 4wd Bus Stop
- 3 Outdoor Area
- 4 Supermarket



SCALE 1:500 @ A4

0 10,000 20,000 30,000 mm





**Figure 6.38** community design section and construction details.

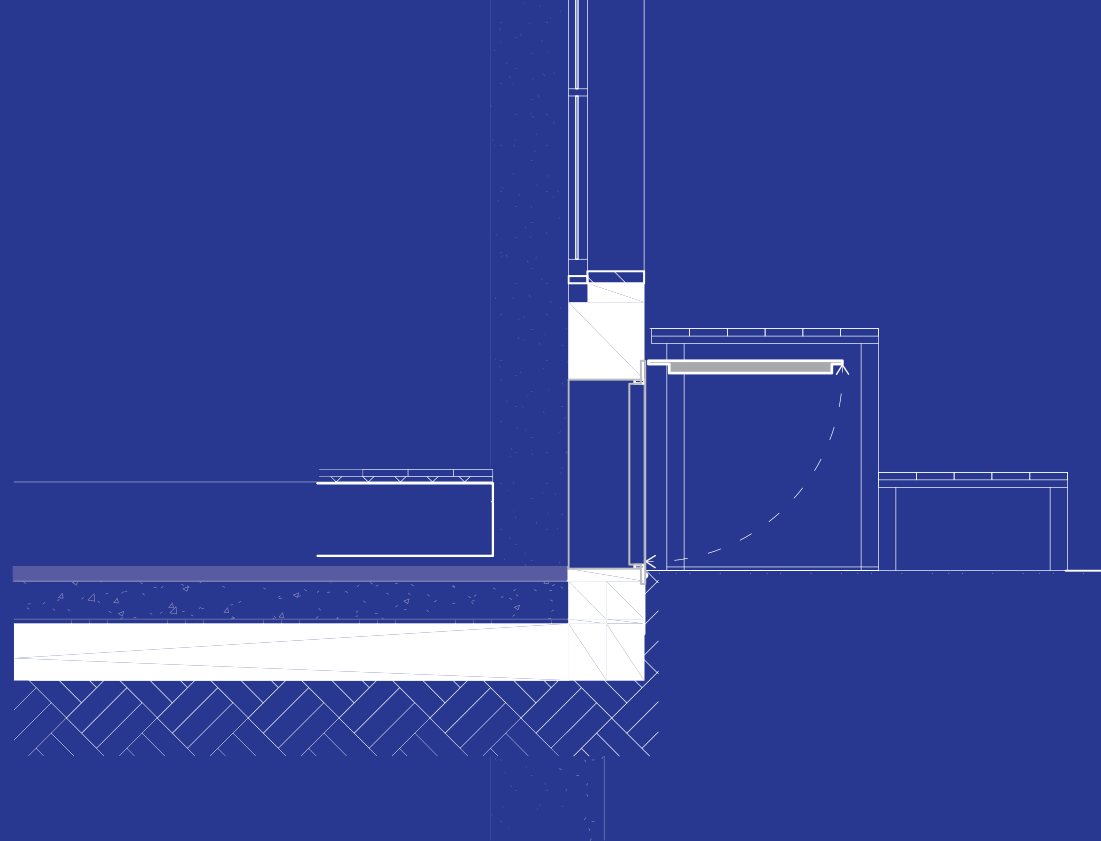
Top Left: Detail Section showing interior buoyancy structure supported by structural column.

Top Right: Drainage/Seating section detail, The design combines the need for drainage holes around the exterior of the building with the seating design that complies with William Whytes seating theory as discussed in the site analysis chapter. Doing this improves the relation of the building to the human scale. People can sit, lean on and occupy the building exterior, which would otherwise be dead space.

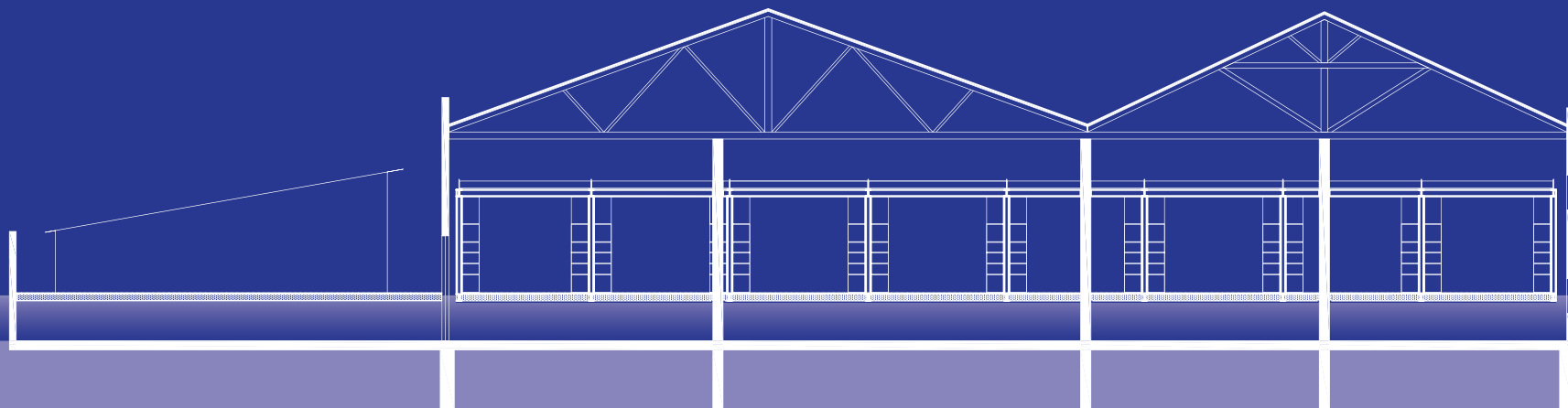
Below: Section through community design during Urban Wetland Phase.

- |   |  |
|---|--|
| 1 | EPS  |
| 2 | Sliding Bracket                            |
| 3 | Structural Column                          |
| 4 | Flooring                                   |
| 5 | Steel Structural Moment Frame              |
| 6 | Supermarket Shelves                        |
| 7 | Flood door used during Urban Wetland Phase |
| 8 | Seating                                    |

SCALE 1:20 @ A4  
0 100 200 300 400 500mm



SCALE 1:200 @ A4  
0 1000 2000 3000 4000 5000mm







**Figure 6.39** Interior view of community design supermarket.

**Figure 6.40** Community design view of North side during Urban Wetland Phase.



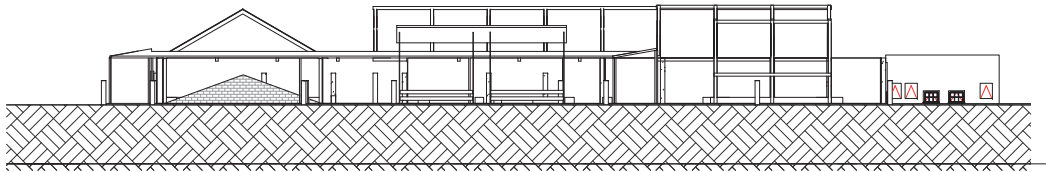




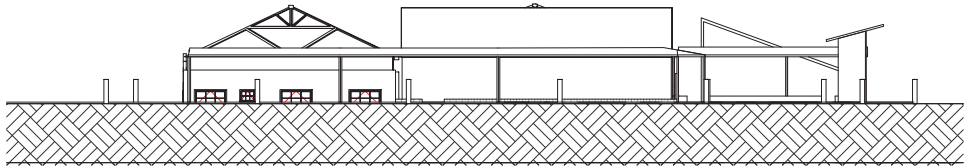
**Figure 6.41** Elevations of community design during Urban Blue Space phase.

SOUTH ELEVATION - Macandrew Road

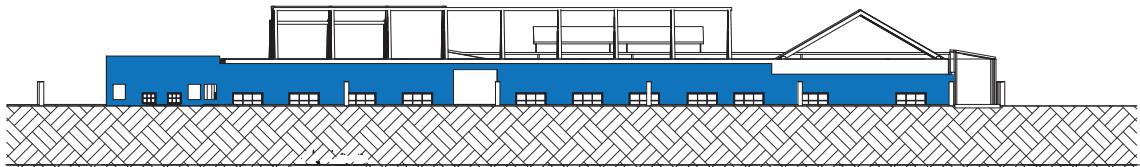
SCALE 1:500 @A4  
0 10,000mm 20,000mm 30,000mm 40,000mm 50,000mm



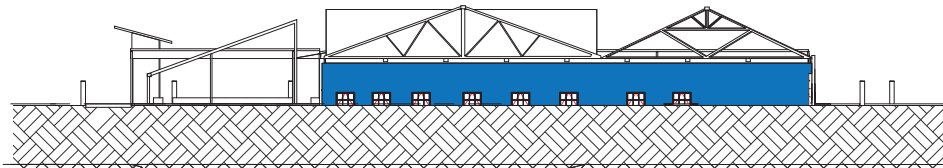
WEST ELEVATION - King Edward Street



NORTH ELEVATION

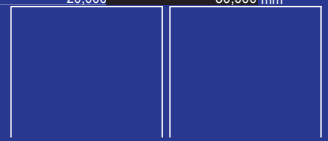


EAST ELEVATION



**Figure 6.42** Site plan of community design during Urban Blue Space phase. When sea levels rise to a height which causes the supermarket interior to float too high for the enclosed structure, the roof would need to be either re-built in a new form, or as shown in these images, removed. The structural trusses could be salvaged and attached to the floating interior structure which would then continue to rise up through and eventually out of the original building. The programme shown here is a floating community garden.

- 1 Buoyant pedestrian pathways
- 2 Ferry Stop
- 3 Floating Gardens
- 4 Buoyant Foundation Buildings
- 5 Public Transport Canal, formerly Macandrew Rd and King Edward St





**Figure 6.43** View of community design from King Edwards St and Macandrew Rd intersection during Urban Blue Space phase. Bus Stop, operating now as a Ferry Stop in original location.





**Figure 6.44** View of interior community design during Urban Blue Space phase.







**Figure 6.45** View from Macandrew Rd during Urban Blue Space phase.





**Figure 6.46** Images of plants that may be suitable for Dry Land and Wetland phase, refer to Appendix 4.



## Wider Urban Design

Building materials identified in design drawings were selected with a ZC philosophy. It is the design intention that all future development in South Dunedin follow a ZC philosophy, both as a mitigation and adaption strategy for SLR. Some of the materials used in design are discussed in Appendix 3.

SLR will require careful environmental management in order to mitigate pollution risk. The DCC provides information on common plants in the Otago region, a selection of plants from their document “Biodiversity Plant Species Listing” that may be suitable for planting as environmental management in South Dunedin during the Dry Land and Wetland Phases of SLR are listed in Appendix 4.







**Figure 6.47** Night time perspective of Urban Blue Space suburbs showing walkways and lighting.



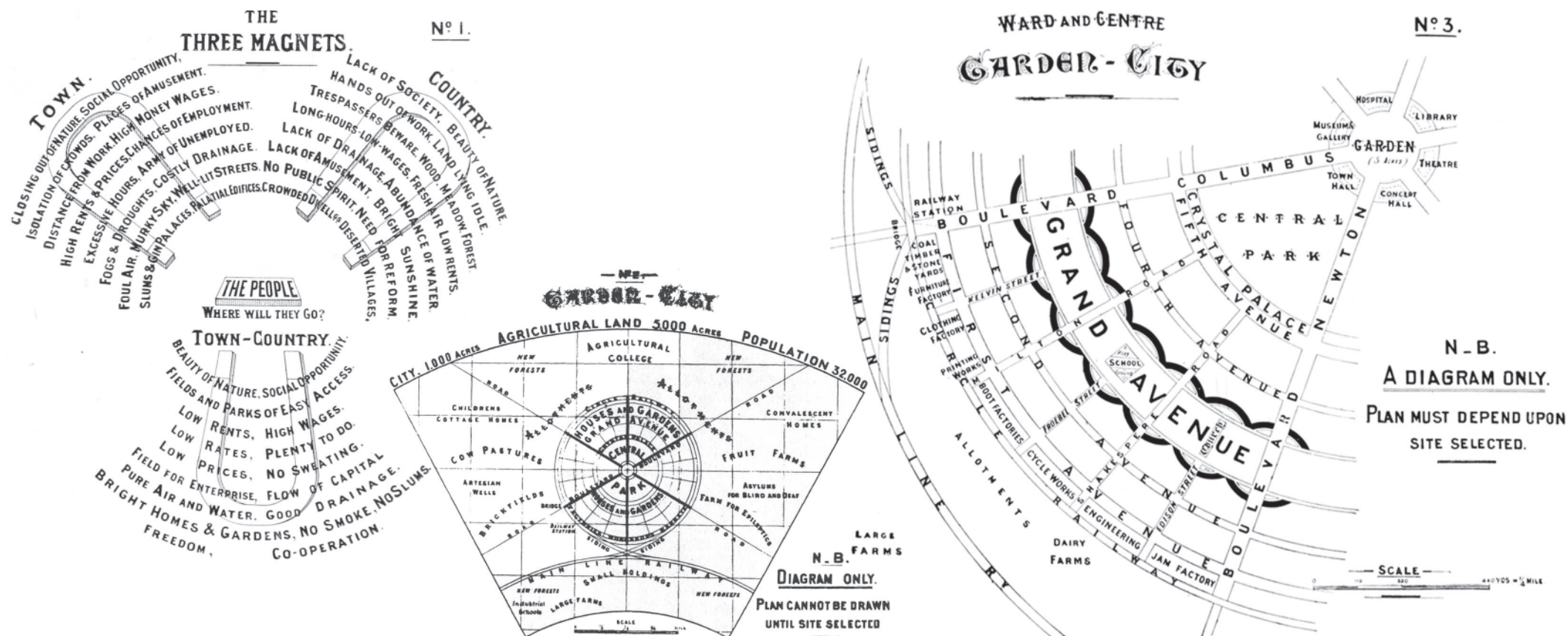


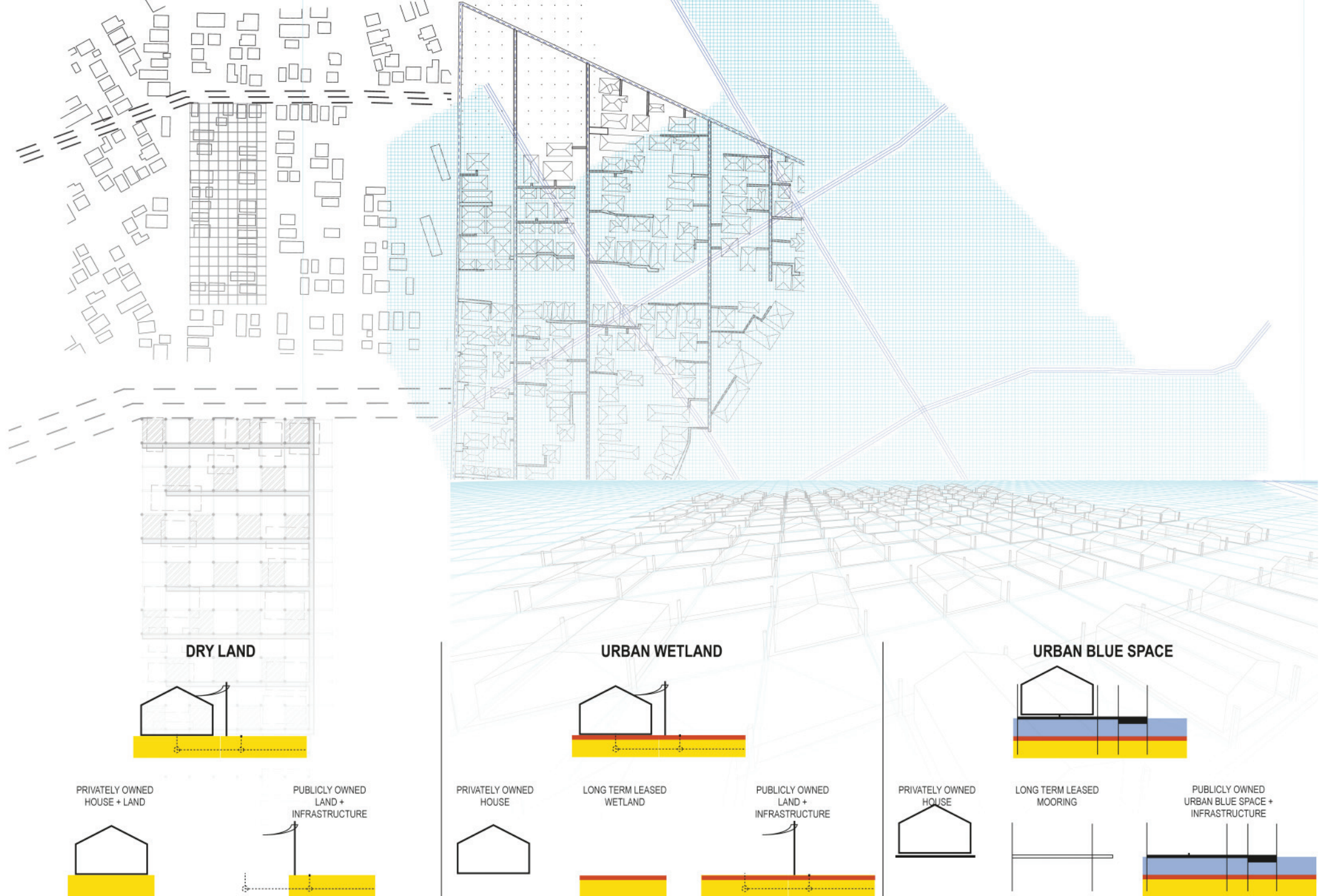
Figure 6.48 Howard's Garden City Diagrams. Howard, E. *Garden Cities of To-morrow*. London, England. Swan Sonnenschein & Co., Ltd. Paternoster Square. 1902

**Urban Blue Space following SLR** will require new models of property ownership to be negotiated as properties cease to have viable land. Development of these governance strategies will be a complex and contested transition, resolution of which is outside the scope of this thesis. For the purposes of this thesis a model based on E. Howard's Garden City is used to produce a scenario in order to advance urban design/built environment aspects of the thesis. An application of Howard's work produces the following scenario:

The South Dunedin Land Trust is established to own and manage the Area of South Dunedin. The board members are elected to represent each sector of the community. Existing South Dunedin property own-

ers would sell their land, but not their houses, in exchange for a cash settlement and a lease-free mooring entitlement. Lease-free mooring entitlements could be inherited, but not sold on the open market. They can only be sold to the South Dunedin Land Trust. New buyers would purchase a house only and long-term lease a mooring entitlement, which would be indefinitely renewed unless conditions of lease were breached. Conditions of lease would be a code of conduct to ensure environmental and community health and well-being. All residents would pay rates annually, for the upkeep of the infrastructure and environment. As described by Howard once initial purchase price of the land is paid off by the trust, all following profits would be re-invest-

ed into the community to fund public amenity projects such as civic buildings, outdoor recreational venues or infrastructure maintenance (Howard 1902).



**Figure 6.49** Diagram explaining the application of Howard's Garden City theory, showing how land ownership could change over time as SLR progresses.



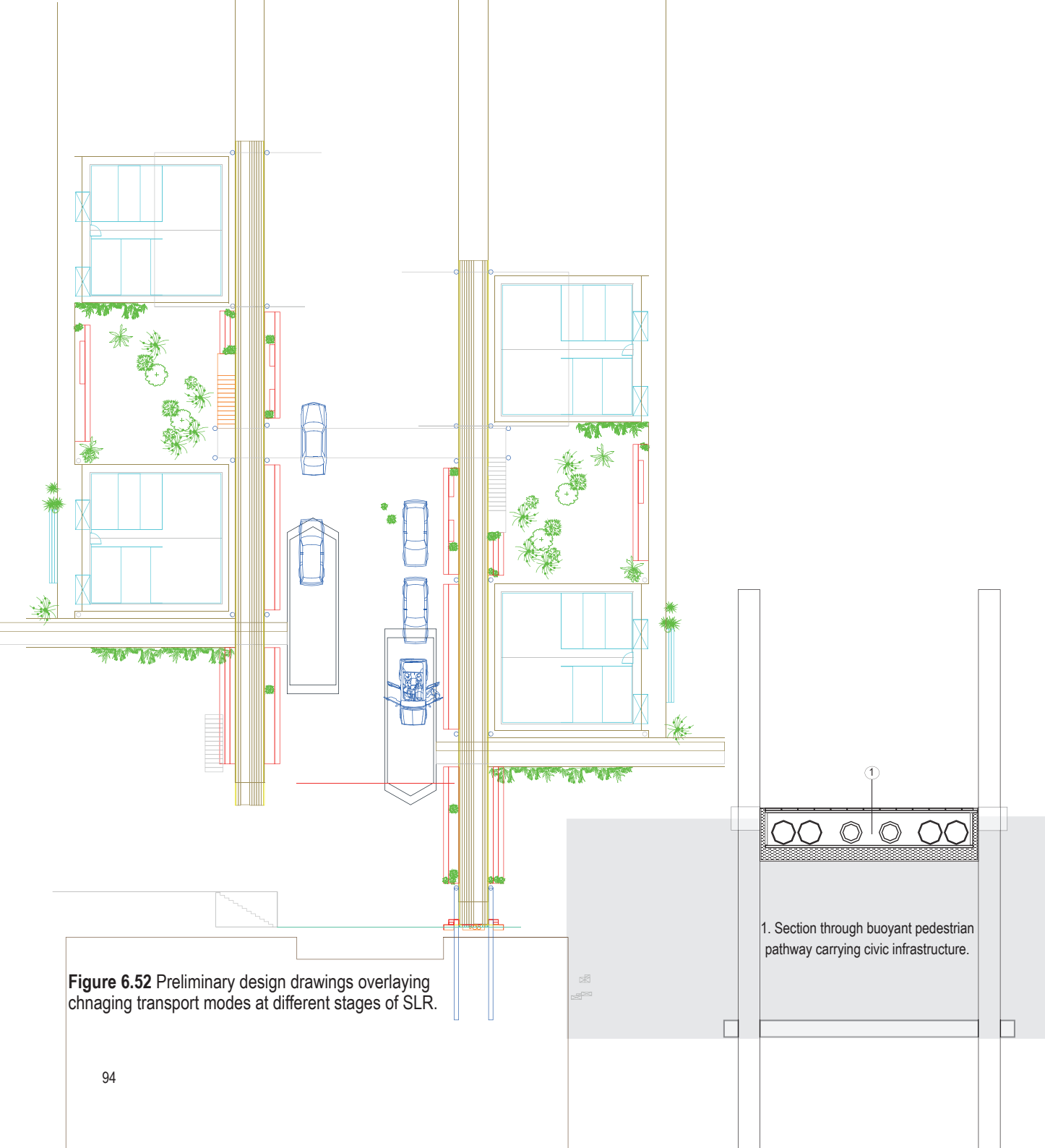






**Figure 6.51** Preliminary design experimentation testing capacity of 10x10m buoyant platforms capacity on an urban scale, against existing urban layout. The result was an increase in capacity and density.

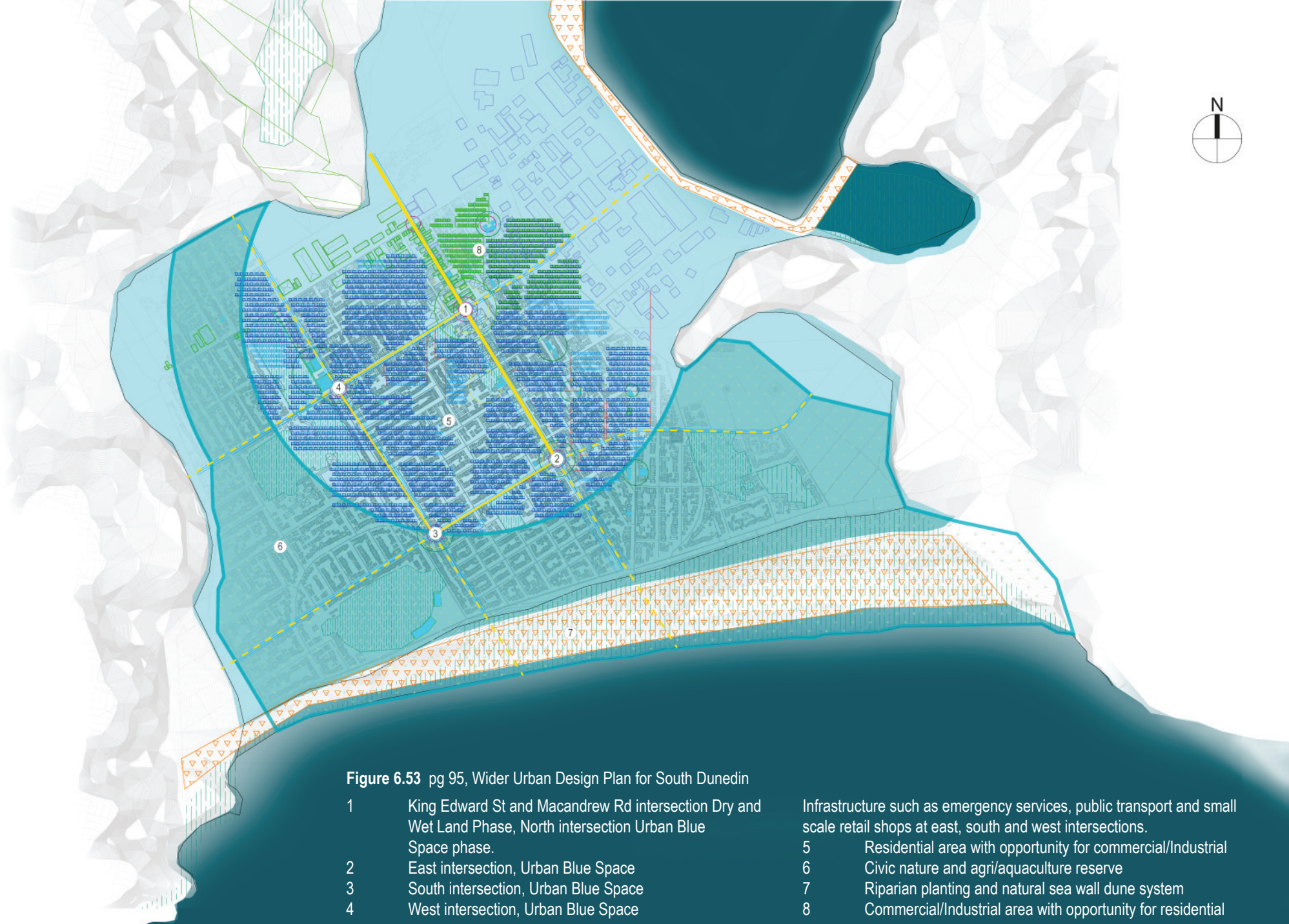




**Figure 6.52** Preliminary design drawings overlaying changing transport modes at different stages of SLR.

Work towards improving the public transport system and developing a cycle way in South Dunedin has already begun. Further improvements to public and active transport networks in South Dunedin to decrease the reliance on private motor-vehicles would help mitigate and adapt to SLR. As SLR progresses in South Dunedin, Dry Land vehicles will become obsolete, mass public transport (powered by renewable energy) will be essential to the viability of continued inhabitation. Ensuring a high quality public transport system now, that residents could depend on would ease the forced transition away from private vehicles and cut down on city emissions sooner.

Residents replacing private-cars with private-boats was considered but decided against as mass public transport is more efficient and sustainable. Architectural problems caused by motor-vehicles could be similar with boats, removing private vehicles allows more room for public amenity. In this scenario restriction of motor-boat ownership to emergency services, law enforcement, civic agencies and some businesses would be necessary. A network of buoyant pedestrian pathways, statically elevated during the Urban Wetland phase and floating in Urban Blue Space, would facilitate pedestrian transport around the suburb, and could also carry civic infrastructure. Detailed investigation is beyond the scope of the thesis, but it is assumed that at the edge of South Dunedin, between Urban Blue Space and Dry Land there would be a change of transport mode. Pedestrian infrastructure would merge seamlessly, other mode options could include a ride-share vehicle fleet or public transport.



**Figure 6.53** pg 95, Wider Urban Design Plan for South Dunedin

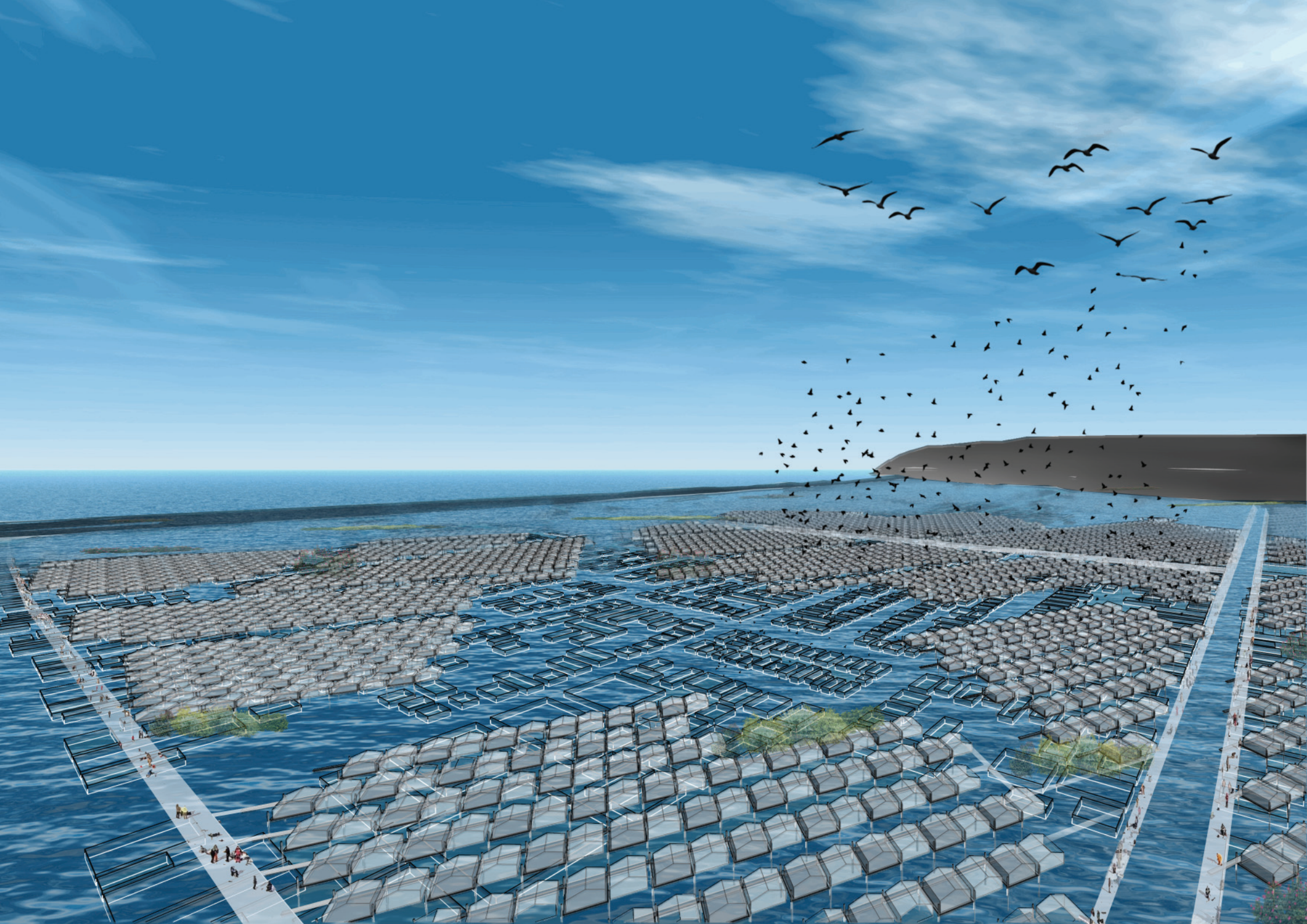
- 1 King Edward St and Macandrew Rd intersection Dry and Wet Land Phase, North intersection Urban Blue Space phase.
- 2 East intersection, Urban Blue Space
- 3 South intersection, Urban Blue Space
- 4 West intersection, Urban Blue Space

Infrastructure such as emergency services, public transport and small scale retail shops at east, south and west intersections.

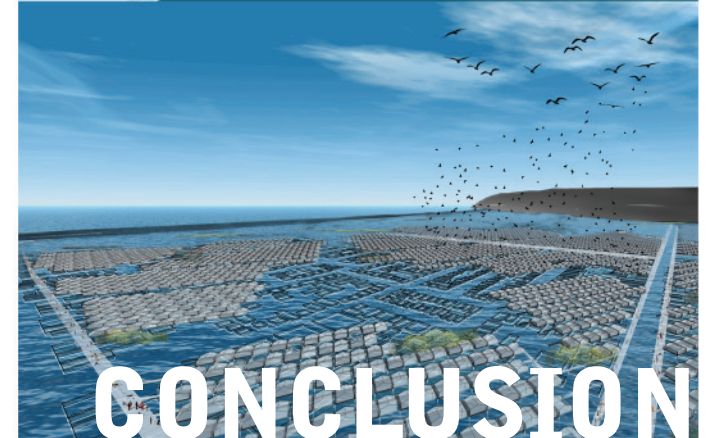
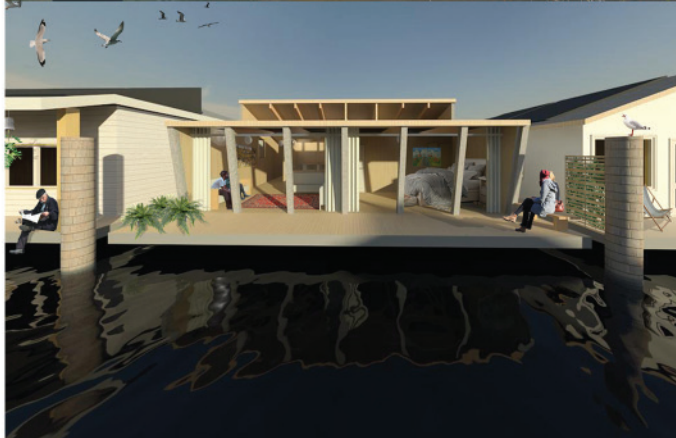
- 5 Residential area with opportunity for commercial/Industrial
- 6 Civic nature and agri/aquaculture reserve
- 7 Riparian planting and natural sea wall dune system
- 8 Commercial/Industrial area with opportunity for residential



**Figure 6.54** Birdseye view looking south from King Edward St and Macandrew Rd intersection over South Dunedin in the Urban Blue Space phase.







07:

CONCLUSION

Figure 7.1 Dry Land, Wet Land and Urban Space across Residential, Community and Urban scales.



The question this thesis sought to address was: How can the built environment/architecture of a low-lying urban area be adapted for increased resilience facing sea level rise (SLR) due to anthropogenic climate change?

The research found that adaption and continued on-site habitation is possible if significant lifestyle changes are embraced. SLR requires design interventions to respond to the specific challenges of the site, context and community. Successful adaptation facing SLR will require a long-term commitment to HR and a ZC future.

Adaption of the built environment to SLR was explored through an urban transformation towards a floating city. This proposition makes possible the reorganization of an existing city for extreme revitalisation. Uplifting existing buildings for buoyancy or relocation could help to retain the physical heritage of an otherwise displaced community. The community design building strategy of building up and out of a slowly failing building has the potential to become common place as SLR progresses throughout the world. Urban design ideas for the resilience of a community learnt through the design process are potentially transferable to other urban situations. Increasing density, freeing up land for mixed use and civic management for community self-sufficiency would be useful tools facing future resource scarcity as climate change advances.

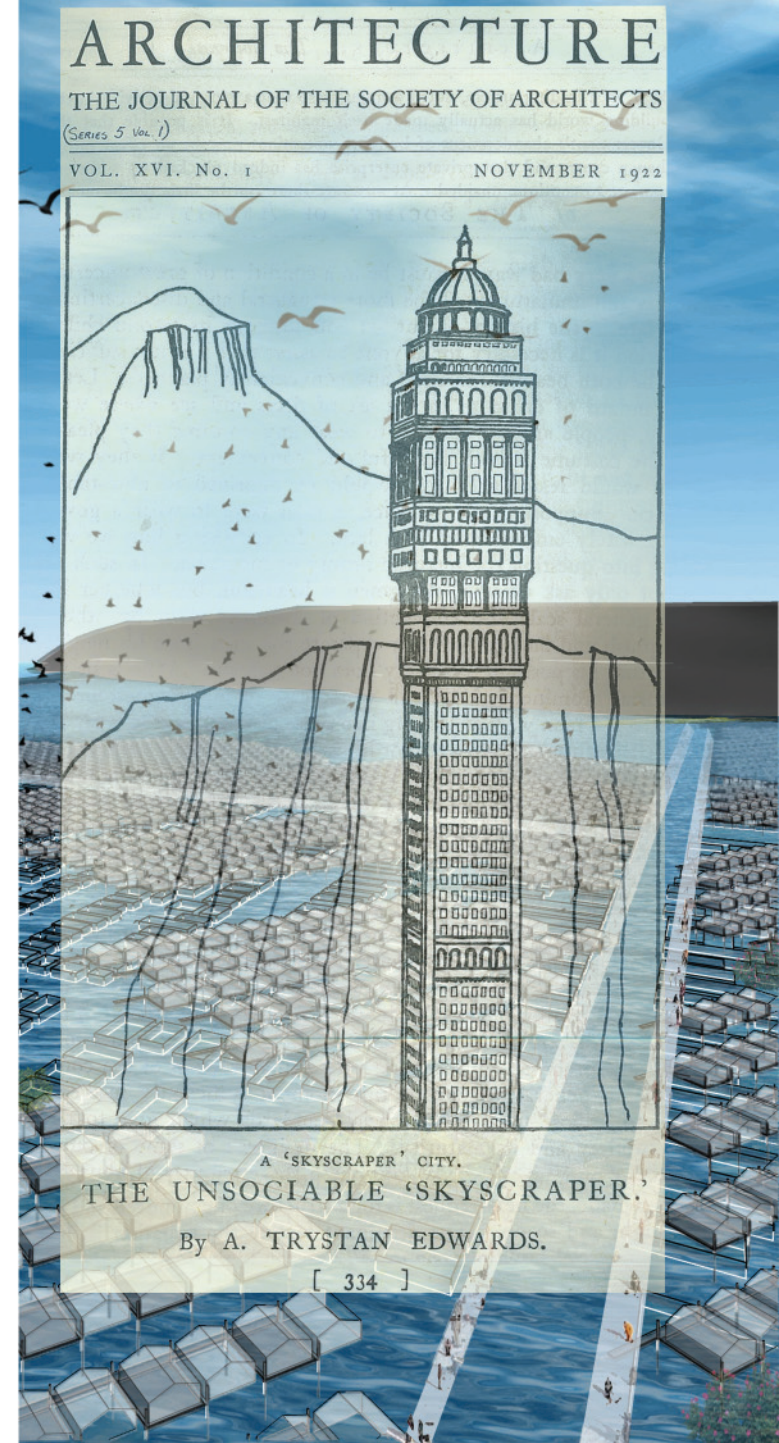
A ZC transition within the building industry at all levels is more important than ever given recent events in international politics. Design research found prioritisation of public and active transport to be beneficial for the civic environment and for lowering greenhouse gas emissions.

Holistic Resilience cannot be achieved by Architecture alone; Architecture is best suited to address physiological, safety, security and self-actualisation needs and can be an ally for affiliation and esteem needs. Research concluded that civic identity and the strength of residents commitment to place could be the main driver for realising the extreme scenario of staying on site, historically this has been demonstrated in Venice. Multi-disciplinary input including on-site structural analysis and specific structural engineering design would be required should the designs explored be intended to be realised.

Community-led participatory design was not a part of this project but it is acknowledged as important for HR, instead an extreme and speculative approach was taken. Resident interviews were not carried out as research did not reach a stage early enough where presentation and communication with residents would have been feasible.

The scope of the thesis allowed for a specific investigation into one avenue of the research question. The effects of SLR and anthropogenic climate change are complex and there is an urgent need for ongoing research and action within all disciplines. Residents in South Dunedin, and in similarly at risk locations around the world, are already beginning to grapple with the effects of SLR, their future is precarious to predict. Perhaps looking to the past could provide lessons for the future? 100 years ago skyscraper cities (figure 7.2) were thought to be preposterous and inhumane, now, they cover the globe. It might be that over the next 100 years floating cities, now considered extreme, become common place?

Figure 7.2 A 'skyscraper' city of the past or a 'floating' city of the future?











## Appendix 1 - South Dunedin in Policy and Research Reports

*South Dunedin in Policy: annotated bibliography reviewing government and scientific reports concerning South Dunedin facing SLR.*

2016

**Athfield Architects. South Dunedin Community Hub Proposal. Dunedin City Council. August 20th 2016.** <http://www.dunedin.govt.nz/your-council/council-projects/south-dunedin/south-dunedin-community-hub>

Information on Community Hub development for South Dunedin, preferred site assessed as former BNZ building King Edward St and Gasworks.

**DCC, Dunedin City Council, Bidrose, S. South Dunedin and Stormwater. June 20th.** <https://dunedininstadium.files.wordpress.com/2016/07/sue-bidrose-south-dunedin-and-stormwater-june-20-2016-presentation-to-public-meeting.pdf>

*Public Meeting presentation about south Dunedin storm water/ground water capacity and system. Brief, explained that it is complex, not much else learnt.*

**DCC, Mayor Dave Cull, WELLBEING OF SOUTH DUNEDIN RESIDENTS AND BUSINESSES TOP PRIORITY.** <https://www.odt.co.nz/opinion/council-taking-flooding-seriously>

Mayor Cull releases statement reporting that South Dunedin is a top priority

**DCC, Dunedin City Council. *Landuse and urban form*. Section 1 – Major Issues and Strategies. Long Term Plan 2015/16-2024-25 Dunedin, New Zealand.**

<http://www.dunedin.govt.nz/your-council/long-term-plan-2015-2016/section-1-major-issues-and-strategies/city-profile/landuse-and-urban-form>

“The overall objective for urban form and future development for Dunedin is to have a ‘Compact City with Resilient Townships’.

**DCC, Dunedin City Council. Context and Major Issues for Dunedin's Infrastructure, DCC Website:** <http://www.dunedin.govt.nz/your-council/long-term-plan-2015-2016/section-1-major-issues-and-strategies/infrastructure-strategy/context-and-major-issues> ; <http://www.dunedin.govt.nz/your-council/long-term-plan-2015-2016/section-1-major-issues-and-strategies/infrastructure-strategy/infrastructure-strategy-at-a-glance>

*Outlines weaknesses of existing infrastructure system and challenges faced in improving those weaknesses, brief plan of the next 30 years. Key considerations: aging faulty infrastructure, aging population, low population and economic growth*

**DCC, Dunedin City Council. *Te Ao Turoa - The Natural World. Dunedin's Draft Environment Strategy for Consultation*. Dunedin, New Zealand. 2016**

<http://www.dunedin.govt.nz/your-council/strategic-framework/te-ao-turoa-the-natural-world-dunedin-s-environment-strategy>

Pg.8-9. Legal framework for environment development, climate change has been taken under consideration.

**ORC, Otago Regional Council. *Dunedin Bus Timetable*. GoBus, Dunedin, New Zealand**

<http://www.orc.govt.nz/Documents/Content/Information%20Services/buses/2016/2016%20Bus%20Timetable.pdf>

Bus Timetable and Route Map including ‘Changes to services proposed for 2016/2017’.

**ORC, Otago Regional Council. *South Dunedin- A changing environment*. Web access 14/10/2016.**

<http://www.orc.govt.nz/Information-and-Services/Natural-Hazards/South-Dunedin/>

3 videos and additional information explaining the environmental science of South Dunedin, the causes and effects of flooding.

**ORC, Otago Regional Council. *The Natural Hazards of South Dunedin*. July 2016** <http://www.orc.govt.nz/PageFiles/1404/July%202016/The%20Natural%20Hazards%20of%20South%20Dunedin%20>

<report%20-%20July%202016.pdf>

Comprehensive information about the area, inundation mapping seems to contradict previous BECA report.

**NZPI (2016) Over the Rainbow Conference 2016.13-14th April 2016 Dunedin Town Hall.** [https://www.planning.org.nz/Attachment?Action=Download&Attachment\\_id=3683](https://www.planning.org.nz/Attachment?Action=Download&Attachment_id=3683)

Presentations: Climate change and natural hazards, T. Weeks, C. Tripp; Planning for sea level rise - the role planners can take to help communities manage risk from sea level rise. M. Hobson, K. Panayatu; Climate change and coastal hazards: A risk-based approach that connects science, engineering and planning. M. Russ, T. Shand; Drawing lines in the sand or going with the flow: Can we ‘plan’ for sea-level-rise? S. Vallance, A. Reddish.

2015

**Goldsmith, M., Payan, J., Valentine, C., MacLean, S., Xiaofeng, L., Vaitupu, N. and Mackey, B. (2015) *Coastal Otago Flood Event 3 June 2015*. Ed. Goldsmith, M. ORC, Otago Regional Council. October 2015.** <http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/2015/Coastal%20Otago%20Flood%20Event%203%20June%202015.pdf>

A review and assessment of the June flooding that affected the South Dunedin area. Analysis takes into account infrastructure, ground topography, SLR and other important factors.

**Harper, B. (2015) *Emissions Management and Reduction Plan, CEMARS and the carbonZero programme*. Dunedin City Council, Corporate Policy Team** [www.dunedin.govt.nz](http://www.dunedin.govt.nz)

“This report is the annual greenhouse gas (GHG) Emissions Management and Reduction Plan prepared for Dunedin City Council and forms the management step of the organisation’s application for Programme certification.” pg2. “New Zealand has targets to reduce national greenhouse gas emissions to 5% below 1990 levels by 2020 and 50% below 1990 levels by 2050. Achieving these targets will require action not only at the national level, but local efforts as well.” pg8 Consideration of Built Environment is minimal, advises to minimise waste during construction only.

**PCE, Parliamentary Commissioner for the Environment. Regional Land Elevation Maps: Otago. Preparing NZ for rising seas: Certainty and Uncertainty. 2015**

Mapping clearly identifies South Dunedin as having land elevation <50cm above current sea-level and to be severely at risk from sea-level-rise, or in this case groundwater rise.

**PCE, Parliamentary Commissioner for the Environment. Preparing NZ for rising seas: Certainty and Uncertainty. 2015**

Discusses implications of climate change and SLR, places most responsibility on local council, identifies managed retreat as the only feasible option in NZ and calls for pro-active planning approach. Not very strongly worded and unlikely to have made much of an impact.

2014

**Beca Ltd, (2014). Assessment of Options for Protecting Harbourside and South City from Direct Impacts of Sea Level Rise. Dunedin City Council, Dunedin, New Zealand.**

<http://www.dunedin.govt.nz/your-council/latest-news/july-2014/sea-level-rise-assessment-for-south-city-and-harbourside>

Analysis of South Dunedin area and possible effects of sea level rise causing a rise in groundwater levels. Four scenarios are modelling, ranging from 0.4m SLR to 2m SLR in year 2090-2130. Defence strategies are considered, improvements to infrastructure for drainage purposes are evaluated, author warns of the extreme and on-going cost that would be incurred. Reveals extent of flooding risk due to SLR through projection maps fig 1 -15.

**DCC, Dunedin City Council (2014), CLIMATE CHANGE ADAPTATION – HARBOURSIDE AND SOUTH CITY (FORMERLY ‘SOUTH DUNEDIN’) UPDATE. Corporate Policy Team Leader, 24 July 2014**

<http://www.dunedin.govt.nz/whats-on/2gp/natural-hazards-phase/climate-change/climate-change-adaptation-harbourside-and-south-city>

This report provides the Planning and Regulatory Committee with an update on the long-term climate change adaptation work programme, which is currently focused on climate change adaptation for the Har-

bour side and South City (formerly ‘South Dunedin’) area (see Map 1). Two key pieces of work have now been carried out:

- an assessment of protection options for the Harbour side and South City area; and,
- an initial valuation of the Harbour side and South City replacement cost.

This report sets out the main points from this work and attaches the full protection options for information. The report also outlines the next steps in this work programme, namely: developing the metrics to enable cost-benefit analysis and beginning community engagement around the key issues and work to date.

**DCC, Greenhouse Gas Emissions Inventory Report. Corporate Policy Team. Dunedin, NZ. 2014**

<http://www.dunedin.govt.nz/your-council/councils-greenhouse-gas-emissions>

*Record of emissions from council monitored and owned facilities. No record of Built Environment. Focus on transport and waste recycling.*

**DCC, Life in Dunedin: Residents Opinion Survey 2013 and 2014 Dunedin, NZ. 2014**

<https://www.dunedin.govt.nz/your-council/long-term-plan-2015-2016/section-1-major-issues-and-strategies/city-profile/life-in-dunedin>

Resident survey of life in Dunedin including modes of transport and quality of life.

2013

**PSO, Presbyterian Support Otago. Out in the Cold: A survey of low income private rental housing in Dunedin in 2013. Povey, D., Liebergreen, N., McKague, F. eds. Dunedin, New Zealand.**

<http://psotago.org.nz/assets/Documents/Out-in-the-Cold-2014.pdf>

Residents survey of poor housing conditions available to and experienced by low-income residents in Dunedin.

2012

**ORC, Otago Regional Council(2012). Community vulnerability to**

**elevates sea level and coastal tsunami events in Otago. Goldsmith, M.**

<http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/Community%20Vulnerability%20Report/Community%20Vulnerability%20to%20Storm%20Surge%20and%20Tsunami%20-%20Introduction.pdf>

Report that prompted changes in minimum building levels for building consents in Dunedin, see <http://www.dunedin.govt.nz/council-online/webmaps/minimum-floor-levels>

**Rekker, R. The South Dunedin Coastal Aquifer & Effect of Sea Level Fluctuations. Otago Regional Council. Dunedin, New Zealand. October 2012**

<http://www.orc.govt.nz/Documents/Publications/Research%20And%20Technical/Groundwater/South%20Dunedin%20Coastal%20Aquifer%20Study%20FINAL.pdf>

Scientific analysis of the effects of groundwater/sea-level-rise on South Dunedin, monitoring begun in 2009. “South Dunedin urban area, which is mainly residential, is generally low lying reclaimed land, having once been coastal dunes and marshes. The underlying area has a groundwater system (or coastal aquifer) with a water table very close to the surface. The water table is closely tied to the surrounding sea level at both the ocean and harbour margins.”pg.3

2011

**DCC, Dunedin City Council (2011), Climate Change Predictions Policy 2011. Corporate Police- Sustainability Advisor 6 Sep 2011.**

[http://www.dunedin.govt.nz/\\_data/assets/pdf\\_file/0008/225908/Climate-Change-Predictions-Policy-2011.pdf](http://www.dunedin.govt.nz/_data/assets/pdf_file/0008/225908/Climate-Change-Predictions-Policy-2011.pdf)

\*Table 1 page 2

**DCC, Dunedin City Council. South Dunedin Retail Centre Revitalisation Plan. Planning and Environment Committee, Urban Design Special Projects Manager. Dunedin, New Zealand. [http://www.dunedin.govt.nz/\\_data/assets/pdf\\_file/0008/330848/South-Dunedin-Retail-Centre-Revitalisation-Plan-Report-to-Council.pdf](http://www.dunedin.govt.nz/_data/assets/pdf_file/0008/330848/South-Dunedin-Retail-Centre-Revitalisation-Plan-Report-to-Council.pdf)**



2010

**DCC, Dunedin City Council (2010), 3 Waters Strategic Direction Statement 2010-2060.** <http://www.dunedin.govt.nz/your-council/council-documents/policies/3-waters-strategic-direction-statement>

"The 3 Waters Strategic Direction Statement is intended to provide a generalised set of priorities and approaches for use in all areas of water, wastewater and storm water management undertaken by the Dunedin City Council."

**DCC, Dunedin City Council. Corporate Policy Team. Climate Change Adaptation Project Plan. 29 Nov 2010.**

<http://www.dunedin.govt.nz/your-council/council-documents/policies/climate-change-adaptation-plan>

Pg.2 the Climate Change Adaptation Project Plan for Council is attached (Attachment 2) for consideration by the Finance, Strategy and Development Committee. The key elements of the Plan are:

- Mainstreaming Adaptation – Early actions
- Setting up a Joint Climate Change monitoring and adaptation group
- Alignment to Council's Risk Management Framework
- South Dunedin Study
- Climate Change opportunities
- Vulnerability and Impact studies for remaining hotspots and for critical infrastructure.

**DCC, Dunedin City Council (2010) Dunedin Code of Subdivision and Development 2010** <http://www.dunedin.govt.nz/your-council/council-documents/policies/code-of-subdivision-and-development>

NZS 4404:2004.

**DCC, Dunedin City Council (2010), Dunedin City Social Housing Strategy 2010-2020.** <https://www.dunedin.govt.nz/your-council/council-documents/policies/social-housing-strategy>

*South Dunedin has a low socio-economic profile and many residents are a part of the social housing scheme, receive housing subsidies or living benefits from the NZ government. The DCC has a modest social*

*housing portfolio at present. The effects of SLR may cause displacement and increase demand for social housing.*

**DCC, Dunedin City Council (2010). South Dunedin Retail Centre Strategy; Issues and Opportunities Consultation Document. Planning and Environment Committee, Urban Design Special Projects Manager. Dunedin, New Zealand.**

[http://www.dunedin.govt.nz/\\_data/assets/pdf\\_file/0009/129816/South-Dunedin-Retail-Centre-Issues-and-Options-Consultation-Document.pdf](http://www.dunedin.govt.nz/_data/assets/pdf_file/0009/129816/South-Dunedin-Retail-Centre-Issues-and-Options-Consultation-Document.pdf)

Urban site analysis of current issues and challenges in South Dunedin Retail Centre, prepared as a consultation document.

**Fitzharris, B. Prof. (2010), Climate Change Impacts on Dunedin Dunedin City Council, 25 Mar 2010.** [www.dunedin.govt.nz](http://www.dunedin.govt.nz)

Places predictions of climate change from international sources in Dunedin context and adjusts science to suit local conditions.pg5 Identifies "low-lying densely populated urban areas, especially South Dunedin" at high risk from the effects of climate change namely SLR.

2007

**Boffa Miskell (2007) Dunedin LMA Review, Landscape Assessment - Final Report. Dunedin City Council Planning Department.** [www.dunedin.govt.nz](http://www.dunedin.govt.nz)

Section 6a: the preservation of the natural character of the coastal environment; section 6b: the protection of outstanding natural features and landscapes; section 6f: the protection of historic heritage; section 7c: the maintenance and enhancement of amenity values; and; section 7f: the quality of the environment

**DCC, Dunedin City Council. A Biodiversity strategy for Dunedin City. August 2007**

[http://www.dunedin.govt.nz/\\_data/assets/pdf\\_file/0020/132743/Biodiversity-Strategy-for-Dunedin-City.pdf](http://www.dunedin.govt.nz/_data/assets/pdf_file/0020/132743/Biodiversity-Strategy-for-Dunedin-City.pdf)

Biodiversity goals including wildlife habits and protection of ecosystems. Biodiversity data sheet –

[http://www.dunedin.govt.nz/\\_data/assets/pdf\\_file/0008/154628/Biodiversity-Plant-Species-Listing.pdf](http://www.dunedin.govt.nz/_data/assets/pdf_file/0008/154628/Biodiversity-Plant-Species-Listing.pdf)

**DCC, Dunedin City Council (2007) Dunedin Town Belt Management Plan** <http://www.dunedin.govt.nz/your-council/council-documents/policies/dunedin-town-belt-management-plan>

Possibility of extending the area of the town belt into South Dunedin, applying similar management rules and strategies.

2006

**DCC, Dunedin City Council (2006). 2006/07 – 2015/16 COMMUNITY PLAN, Working with you for Dunedin's future.** Mayor. Chin, P. [www.dunedin.govt.nz](http://www.dunedin.govt.nz)

*Pg7 Tahuna Outfall – The project quantum and timing has been amended for Stage One of the Tahuna Wastewater Treatment Plant upgrade. Note this change effected the 2005/06 year as well. Pg9 37% spending, \$224 Million on Environmental Wellbeing 2006 moving to 40%, \$765 Million by 2016?*

2003

**Glassey, P. Barrell, D. Forsyth, J. Macleod, R. The geology of Dunedin, New Zealand, and the management of geological hazards.** *Quaternary International Journal*, 103 23-40. Dunedin, NZ. 2003.

[https://www.researchgate.net/publication/223769598\\_The\\_geology\\_of\\_Dunedin\\_New\\_Zealand\\_and\\_the\\_management\\_of\\_geological\\_hazards](https://www.researchgate.net/publication/223769598_The_geology_of_Dunedin_New_Zealand_and_the_management_of_geological_hazards)

Geology of Dunedin and identification of hazards.

**Shannon, S., Lloyd, B., Roos, J., Kohlmeyer, J., (2003) EVH3 - Impact of Housing on Health in Dunedin NZ** World Health Organization, Cities and Health Research Program, WHO Kobe, University of Otago and Dunedin City Council. Nov 2003.

[http://www.physics.otago.ac.nz/eman/research/Dunedin\\_Housing\\_Report.pdf](http://www.physics.otago.ac.nz/eman/research/Dunedin_Housing_Report.pdf)

*Evaluates housing stock of Dunedin and the impacts on health of resi-*

dents. South Dunedin has an aging housing stock, problems of damp, cold, draughty, asbestos, poor building health exacerbates conditions such as Asthma and Pneumonia. Many buildings in south Dunedin will need to be re-built or remodelled in the near future.

1961

**Clark, W.A.V. "Dunedin in 1901" A Study in Historical Urban Geography. Master's Thesis, Department of Geography, University of Canterbury, 1961.**

<https://ir.canterbury.ac.nz/handle/10092/9152>

Geographic site conditions of historic Dunedin.

## Appendix 2 - South Dunedin in the Media

Annotated Bibliography: chronicling media stories concerning the effect of climate change/sea level rise on South Dunedin.

2012.11.30

**Elder, V. "DCC concern over rising sea levels; Houses to be built higher" Otago Daily Times. 30 Nov 2012.**

<https://www.odt.co.nz/news/dunedin/dcc-concern-over-rising-sea-levels-houses-be-built-higher>

"The threat caused by the rising sea level means new homes in some coastal areas of Dunedin will have to be built up to 1.2m higher off the ground to reduce the risk of being flooded." Changes to minimum building levels for residential and communal buildings applying for consent through the DCC, does not apply to industrial or commercial buildings. "The information, added to Land Information Memorandums (LIMs) yesterday, warned owners and purchasers houses below the new minimum levels could be subject to increased flooding risk over the next 50 years "from elevated sea-level rise associated with climate change".

2015.10.24

**Morris, C. "Planning for the city's future" Otago Daily Times. 24 Oct 2015 <http://www.odt.co.nz/news/dunedin/360580/planning-citys-future>**

Article about the release of the second generation district plan (2GP) by the Dunedin City Council (DCC). Discusses the threat of sea level rise (SLR) and climate change, "doing nothing is not an option" Mayor Dave Cull "The reality is ... they are recognised risks. We have an obligation to identify them for the benefit of not only the people who own the properties now, but anyone who might own them in the future." Summarises key points of the plan and mentions option for public input. Creation of 3 Hazard zones "At the most extreme end, new homes would become "non-complying activities", meaning resource consent would only be given in "exceptional circumstances", while lesser restrictions applied at lower levels"

2015.11.01

**Borley, C. "No need for hazard zone fear: insurers" Otago Daily Times. 1 Nov 2015. <http://www.odt.co.nz/news/dunedin/361437/no-need-hazard-zone-fear-insurers>**

Insurance industry comment following the release of the 2GP by the DCC. "Dunedin landowners whose property is in one of the 2GP's hazard zones need not fear the cold shoulder, the insurance industry says." "As more information becomes available regarding location-based potential risks to property, its likely insurers will begin to rate risk more specifically."

2015.11.19

**Gudsell, K. "sea levels like an unfolding red zone". Radio New Zealand. 19 Nov 2015. <http://www.radionz.co.nz/news/national/290105/sea-levels-like-an-unfolding-red-zone>**

The impact of rising sea levels on communities is "like a slowly unfolding red zone", according to Parliamentary Commissioner for the Environment Jan Wright. Mr Bill English "The government's dealing with all sorts of risks all the time of which this is one, it's a bit speculative, there's others that are more immediate and more costly." He said the government had more pressing issues, and thought people in South Dunedin would be reluctant to up sticks and move on the basis of what he described as "speculation about the sea level rise". "It's an area where there's inherent uncertainty, some people saying there's going to be significant sea level rise, some evidence that there might not be much, or there's been a bit so far. You know we're focussing on reducing emissions." *Env. Commissioner rightly warns government to begin preparing. English confirms that the National government are taking a hear/see/speak no evil approach and dodging responsibility. They plan to promptly do nothing about it because it is not a big concern and is too expensive?*

2015.12.23

**Johnstone, N. "Cull's flood remarks a 'mishmash" Otago Daily Times. 23 Dec 2015 <http://www.odt.co.nz/opinion/opinion/367798/cull-s-flood-remarks-mishmash>**

Following the June 15 floods storm water management expert opinion



- "For the record, the rainfall event was of the order of a 20-30 year event, depending on what is considered to be the critical rainfall duration...Such an event could normally be expected to exceed storm water infrastructure capacity and cause surface flooding...Any storm water infrastructure in poor condition, not working or subject to poor maintenance would increase the impacts of that flooding...Conversation on possible sea-level rise and impacts is to be welcomed, but the conversation needs to be held in a manner that is rational and responsible." South Dunedin community seeking honesty and accountability and fair presentation of the facts. Asking to open productive lines of communication towards a discussion on SLR.

2015.12.31

**Macfie, R. "Water Views: Rising seas will have profound effects on coastal towns and cities - and nowhere more so than in Dunedin." NZ Listener. 31 Dec 2015. <http://www.listener.co.nz/current-affairs/science/water-views/>**

Good background information into the issue of SLR in South Dunedin. "The evidence is overwhelming," says Dunedin Mayor Dave Cull. Rising sea level is not a remote future threat for his city; it is already here. "It's happening to us, and it's happening now."

2016.04.22

**Elder, V. "Millions needed for South Dunedin". Otago Daily Times. 22 Apr 2016.**

<https://www.odt.co.nz/news/dunedin/millions-needed-south-dunedin>

Council considering options for Infrastructure upgrade in South Dunedin

2016.06.10

**"Council takes flooding seriously". Otago Daily Times. 10 Jun 2016. <http://www.odt.co.nz/opinion/opinion/386269/council-taking-flooding-seriously>**

The wellbeing of South Dunedin residents and businesses is a top priority, writes Dunedin Mayor Dave Cull.

2016.06.29

**Gudsell, K. "Commissioner pans environment report". Radio New Zealand. 29 Jun 2016. <http://www.radionz.co.nz/news/national/307550/commissioner-pans-environment-report>**

"The country's environmental watchdog has criticised the government's landmark environmental report released last year, saying it gives no diagnosis on the health of the environment."

2016.07.06

**Heron, M. "Sea level threat: MPs told to prepare for compensation claims" Radio New Zealand. 6 Jul 2016. <http://www.radionz.co.nz/news/political/308075/sea-level-threat-homeowners-'going-to-be-very-upset'>**

Jan Wright Env. Commissioner tells Government to prepare to bailout properties damaged by SLR/Climate Change due to predicted Insurance Failure.

2016.07.11

**Mackenzie, D. "South Dunedin priority for Labour" Otago Daily Times. Mon 11 Jul 2016. <http://www.odt.co.nz/news/dunedin/389917/labour-promises-renewal>**

"The rejuvenation of South Dunedin will be a priority for an incoming Labour government, working alongside local government to develop a master plan for urban renewal. South Dunedin is among the oldest and most densely populated suburbs in New Zealand" Clare Curran said. "Significant reinvestment is needed over the coming years to improve and renew South Dunedin. More certainty is needed to encourage that investment." That would involve repurposing some open land areas, redesign of the layout of some residential, commercial and industrial areas as well as substantial housing improvement and renewal.

2016.07.16

**Morris, C. "Fears South Dunedin also sinking" Otago Daily Times. 16 Jul 2016. <http://www.odt.co.nz/news/dunedin/390570/fears-south-dunedin-also-sinking>**

"Preliminary results from GNS Science and the University of Otago's

School of Surveying pointed to potential subsidence in South Dunedin and other parts of the city...The problem was worst in reclaimed, low-lying areas of South Dunedin, near the margin of Otago Harbour, satellite data suggesting subsidence of between 2mm and 5mm a year...Other parts of the city appeared to be subsiding at slower rates, of about 1mm a year, the data showed."

2016.07.19

**"Sinking suburb: Thousands of Dunedin homes at risk". Radio New Zealand. 19 Jul 2016. <http://www.radionz.co.nz/news/national/308984/sinking-suburb-thousands-of-dunedin-homes-at-risk>**

"A report to be tabled tomorrow by the Otago Regional Council shows almost 3000 homes in the suburb of South Dunedin are just 50cm above sea level. A serious flood in June last year damaged about 1250 properties...South Dunedin is built on soft, silty soils that in the 1800s were a tidal wetland, similar to Hoopers Inlet on the Otago Peninsula. This differs from the geological landscape of the rest of the city, which is largely built on a more solid, volcanic rock.

"The time is right for a community conversation about how best to minimise the combined effects on South Dunedin of high groundwater levels, sea-level rise and land subsidence." "We believe it is critical the community understands the current and future Hazardscape of South Dunedin, and we will be presenting this information to the community over the next two months." Mr Bodeker said the key finding from this monitoring was the increased likelihood of surface flooding associated with rising sea levels. "Because there is already a shallow water table beneath South Dunedin, an increase in groundwater levels will eventually result in occasional and possibly permanent surface 'ponding' on parts of the area.

2016.07.19

**Brown, T. "Effect of sea level rise on Dunedin revealed". Otago Daily Times. 19 Jul 2016. <http://www.orc.govt.nz/PageFiles/1404/July%202016/The%20Natural%20Hazards%20of%20South%20Dunedin%20report%20-%20July%202016.pdf>**

Average sea level rise of as little as 11cm would result in many properties between Hargest Cres and Bay View Rd being flooded with

up to 20cm of water while Tonga Park and Bathgate Park would be almost entirely inundated. "The work also has to be co-ordinated between agencies and focus on the right issues, in the right sequence, at the right time.

"We believe it is critical the community understands the current and future Hazardscape of South Dunedin and we will be presenting this information to the community over the next two months.

"We are also firm in our belief that planning for South Dunedin's future management is an immediate priority."

*The Report is useful source of information, however the imaging of flooding hazard are very different to earlier BECA estimates and the severity of the Hazardscape seems to have been underplayed?*

2016.07.21

**Gibb, J. "Warning against alarmist approach to S Dunedin"; "Rising Sea levels may force up premiums". Otago Daily Times. 21 Jul 2016**

<http://www.odt.co.nz/news/dunedin/391018/warning-against-alarmist-approach-sdunedin> ; <http://www.odt.co.nz/insight/dunedin/390565/rising-sea-levels-may-force-premiums>

Otago regional councillors have emphasised the need not to overreact to environmental problems facing South Dunedin, saying solutions would eventually be found, guided partly by community dialogue. Cr Michael Deaker praised the high quality of the reports, which were based on well-researched science.

He warned against taking an alarmist approach to the problems, including the risk of surface ponding, and said the community "seriously needs" the information contained in the main 66-page report. Insurance premiums could creep up in South Dunedin along with rising sea levels, the Insurance Council of New Zealand says.

*Echoing the Global trend of downplaying the risk to avoid up-front costs of mitigation. Short-Term thinking may result in Long-term disaster.*

2016.07.21

**Loughrey, D. "Building application a test of South Dunedin's**

**future" Otago Daily Times. 22 Jul 2016. <http://www.odt.co.nz/news/dunedin/391155/building-application-test-south-d-s-future>**

*There needs to be a robust community wide development strategy to ensure building consents aren't given with good intentions but on false premises of security "You've got to put a stake in the ground and say 'Yes, we can build here'. Conrad Anderson" Applicants seeking building consent need to be fully aware of all the risks involved and the options available to them. "It was non-complying because the developer wanted to establish two houses on a 438sqm site in a zone where 300sqm per house was required. Owner Laurence Prattley has said the house was uninhabitable after being under 20cm of water during the June floods." "But if the base was engineered with reinforced steel, the foundation would remain intact."*

2016.07.25

**Telfer, I. "Labour would bring change to South Dunedin - Little". Radio New Zealand. 25 Jul 2016. <http://www.radionz.co.nz/news/national/309420/labour-would-bring-change-to-south-dunedin-little>**

*Zero-Carbon must make Clean Dry Warm Healthy homes a priority for South Dunedin redevelopment to ensure the health and well-being of its residents. Affordable to own and to live in. Design guide for redevelopment Dunedin.*

2016.07.25

**Willis, S. "Safe as Houses" Otago Daily Times. 25 Jul 2016. <http://www.odt.co.nz/lifestyle/magazine/391249/safe-houses>**

"Climate change demands a creative approach to providing warm, dry homes to live in, writes Scott Willis." Where we put our resources matters, as poor decisions now can lock in other poor investments, leading to poor economic and social outcomes. We know from home performance assessments in the city, looking at energy issues in housing, that there are a number of homes that are in very poor condition and in areas that are subject to a high water table and increased risk of flooding. This poses a dilemma for all: how much to invest in these homes, when they may have to be abandoned; sooner rather than later? Scott Willis is the project manager of Blueskin Energy Ltd. "Climate-safe housing is critical if we are to adapt to our changing environment, and it will contribute to the growing knowledge and

understanding of warm and cosy homes into the bargain." Neatly addresses the issue of housing that is discussed throughout the thesis research.

2016.07.26

**Brown, T. "Labour timeline for South renewal". Otago Daily Times. 26 Jul 2016. <http://www.odt.co.nz/news/dunedin/391532/labour-timeline-south-renewal>**

"Mr Parker said the answer was not to retreat or abandon the area, but to develop a "vision" for South Dunedin." Renewal of South Dunedin could be completed in 9 to 12 years, Mr Little said yesterday. *Regardless of which government is elected "urban renewal and vision is needed now! Although it is a positive sign that there is some acknowledgement.*

2016.07.26

**Barth, J. "'Local and national climate-change plans needed now" Otago Daily Times. 26 Jul 2016 <http://www.odt.co.nz/opinion/opinion/391523/local-and-national-climate-change-plans-needed-now>**

Call to action, cites various reports including RSNZ and talks to be held in Dunedin on 4th August by prof. J Renwick & T. Nash about Climate Change threats for Dunedin & NZ. *Yes agreed, on all points. Do articles like this reach the wider public? Do they reach the councillors and decisions makers? Is anyone listening?*

2016.07.26

**Gudsell, K. "Wave goodbye: Tide rising on Haumoana". Radio New Zealand. 26 Jul 2016. <http://www.radionz.co.nz/news/national/309437/wave-goodbye-tide-rising-on-haumoana>**

Interview video at the start, insight into opinion on options, discusses do nothing, Hard Protection, Managed Retreat (Death Knell). "Nobody wants to make a decision because the moment you step up and say 'we'll do something' then you're responsible for making sure that that happens, and I think it's about money and I think it's also nobody wants to set a precedent." "We've got two immovable objects - bureaucracy and the ocean."



2016.08.02

**Vaughan, E. "Government help sought for South Dunedin" Otago Daily Times. 2 Aug 2016.** <http://www.odt.co.nz/news/dunedin/392289/council-calls-govt-south-dunedin-help>

"The Dunedin City Council will call on the Government to help respond to the threat groundwater and sea level changes pose in South Dunedin. Councillors yesterday voted to "immediately engage" the Government over the threat the changes pose and support for urban renewal initiatives in the area."

2016.08.12

**Vaughan, E. "Former BNZ seen as ideal for hub" Otago Daily Times. 12 Aug 2016.**

<https://www.odt.co.nz/news/dunedin/former-bnz-seen-ideal-hub> ; <http://www.dunedin.govt.nz/your-council/council-projects/south-dunedin/south-dunedin-community-hub>

\$5Million dollar community hub South Dunedin proposed for old BNZ site on King Edward St. DCC funded, architects engaged from Athfield Architects Auckland office. No mention of climate change or sea level rise in the design development.

2016.08.19

**Telfer, I. "Iwi-led low-cost health centre for South Dunedin" Radio NZ. 19 Aug 2016** <http://www.radionz.co.nz/news/national/311351/iwi-led-low-cost-health-centre-for-south-dunedin>

"A major new iwi-led health centre is being launched to bring low-cost health care to South Dunedin, one of the most deprived areas in the country." It is being called Te Kāika, te reo Māori for "the village". The now disused Caversham Primary School is to be transformed into a centre which will have doctors', physiotherapy and pharmacy clinics, as well as the Māori health provider Arai Te Uru Whare Hauora and other social providers, all in one place. Dunedin's Mitre 10 Mega store is doing the full refit of the old Caversham Primary School for free as a community project. The centre's co-founder, the chair of the Ōtākou rūnanga, Donna Matahaere-Atariki, said the project was a big deal for Dunedin and for Ngāi Tahu."

2016.08.23

**"Council briefings on South Dunedin" Otago Daily Times. 23 Aug 2016** <https://www.odt.co.nz/news/dunedin/dcc/council-briefings-south-dunedin>

Public Notice of DCC & ORC meetings to be held in September regarding South Dunedin's future. "There is a great opportunity to turn some of the challenges into opportunities and give confidence for long-term investment in the area."

2016.08.24

**Vaughan, E. "Cautious approach to Dunedin development" Otago Daily Times. 24 Aug 2016**

<https://www.odt.co.nz/news/dunedin/dcc/cautious-approach-dunedin-development>

*Change of zoning to allow urban sprawl, Council may be foreseeing movement of residents out of south Dunedin and other low-lying areas to outlying suburbs. New Development as opposed to more sustainable densification.*

2016.08.25

**Brittenden, P. "Council briefings on South Dunedin" ODTv. 25 Aug 2016**

<https://www.odt.co.nz/news/odttv/odttv-council-briefings-south-dunedin>

"Pat Brittenden and Dominic George talk about meetings to be held next month by the DCC and ORC, who want to hear from you about the future of South Dunedin."

2016.08.25

**Vaughan, E. "Homelessness on the rise in Dunedin" Otago Daily Times. 25 Aug 2016** <https://www.odt.co.nz/news/dunedin/homelessness-rising-dunedin>

"The Government has been accused of avoiding its responsibilities after research showed homelessness rates in Dunedin have increased

by 70% since 2001. This comes as Social Housing Minister Paula Bennett last night said she did not read the University of Otago, Wellington, research because of "inaccurate" statements made by one of its authors in an accompanying media release. The research showed homelessness, or severe housing deprivation, in Dunedin had climbed by 70%, from 405 in 2001 to 687 in 2013. In Otago it had climbed by 67%, from 651 to 1086, in the same period."

2016.08.31

**"High level South D flood options on table" Otago Daily Times. 31 Aug 2016.** <https://www.odt.co.nz/news/dunedin/dcc/%E2%80%98high-level%E2%80%99-south-d-flood-options-table>

"The Dunedin City Council has started looking at "high level" options for significant investment in South Dunedin's storm water infrastructure."

2016.09.08

**Scoop. "South Dunedin to grill election candidates this week" 08 Sep 2016.** <http://www.scoop.co.nz/stories/AK1609/S00597/south-dunedin-to-grill-election-candidates-this-week.htm>

South Dunedin elections candidates' public meeting.

2016.09.09

**Vaughan E. "work on South D issues" Otago Daily Times. 09 Sep 2016.**

<https://www.odt.co.nz/news/dunedin/dcc/work-south-d-issues>

Mayor Dave Cull too early to make formal approach for help to government.

2016.09.10

**Morris, C. "Civil Defence chief steps aside, changes loom" Otago Daily Times. 10 Sep 2016** <https://www.odt.co.nz/news/dunedin/civil-defence-chief-steps-aside-changes-loom>

Defence Chief Steps Aside, given option to restructure/sidestep into different role or retire.

2016.09.14

**TVNZ. “Dunedin first city to have university and council make stand against fossil fuels” 14 Sep 2016**

<https://www.tvnz.co.nz/one-news/new-zealand/dunedin-first-city-have-uni-and-council-make-stand-against-fossil-fuels>

In May 2014, Dunedin City Council became the first local authority in New Zealand to divest from fossil fuels to highlight their impact on climate change. Otago University has followed the local council in committing to a policy of no longer investing in companies engaged in the exploration and extraction of fossil fuels.

2016.09.19

**Vaughan E. “DCC votes on hub site today” Otago Daily Times. 19 Sep 2016.** <https://www.odt.co.nz/news/dunedin/dcc/dcc-votes-hub-site-today>

“Dunedin City councillors will today vote on the preferred location for a \$5.25 million library and community hub for South Dunedin.”

2016.09.20

**Vaughan, E. “South D hub site caution” Otago Daily Times. 20 Sep 2016.**

<https://www.odt.co.nz/news/dunedin/south-d-hub-site-caution> ; <https://www.youtube.com/watch?v=wdUQaU0dRrw>

“Cr David Benson-Pope said the issue had been on the books for as long as 40 years and putting the discussion off risked months of further delay. After the council narrowly voted in favour of discussing the item, all the councillors, including those who most vehemently argued the issue should be left on the table, agreed with a resolution which had been put together by Cr Jinty MacTavish, which took into account concerns over a lack of consultation.”

2016.09.21

**Loughrey, D. “Crowd fired-up over flooding” Otago Daily Times. 21 Sep 2016.** <https://www.odt.co.nz/news/dunedin/dcc/crowd-fired-over-flooding>

“Community anger over last year’s flooding was in evidence last night as Dunedin City Council candidates fronted up to a South Dunedin audience.”

2016.09.22

**Loughrey, D. “Meeting Challenges Priorities” Otago Daily Times. 22 Sep 2016.** <https://www.odt.co.nz/news/dunedin/dcc/meeting-challenges-priorities>

“In response to concern about changes to the bus system that audience members said had badly affected South Dunedin, candidates said they were supportive of the council taking over the system from the Otago Regional Council.”

2016.09.23

**Loughrey, D. “Tenants complicate South D hub plan” Otago Daily Times. 23 Sep 2016.** <https://www.odt.co.nz/news/dunedin/tenants-complicate-south-d-hub-plan>

Current tenants of the old BNZ building, the proposed South D hub site have no intention of moving. DCC states that part of the development plan is to accommodate or relocate existing tenants.

2016.10.21

**“Dunedin pump upgrade aims to combat floods.” Radio New Zealand. 21 Oct 2016.** <http://www.radionz.co.nz/news/national/316220/dunedin-pump-upgrade-aims-to-combat-floods>

New filter installed at pumping station in south Dunedin to help drain away storm water in the event of a flood.

2016.10.27

**Vaughan, E “Detailed map of dangerous poles”. Otago Daily Times. 27 Oct 2016.** <https://www.odt.co.nz/news/dunedin/detailed-map-dangerous-poles>

Maintenance map of power poles in need of repair around the Dunedin area.

2016.10.27

**“Accommodation standards” Editorial. Otago Daily Times. 27 Oct 2016.** <https://www.odt.co.nz/opinion/editorial/accommodation-standards>

“Dunedin is risking being labelled a “slum city” if landlords continue to flout government standards, Mayor Dave Cull says...Last year, under proposed changes to the Residential Tenancies Act, landlords were told to make sure the property they rent out has ceiling and underfloor insulation to meet the new standard and is fitted with smoke alarms.”

2016.11.06

**Martin, R. “Homes under threat from climate change” Radio New Zealand. Taranaki. 6 Nov 2016.** <http://www.radionz.co.nz/national/programmes/insight/audio/201822351/insight-homes-under-threat-from-climate-change>

“Weather-related emergencies in Dunedin, the Kapiti Coast and Whanganui have brought into sharp relief the challenge New Zealand faces from the effects of climate change.”

2016.11.16

**Mcneilly, H. “South Dunedin is a ‘litmus test for the nation’ in regards to climate change” Stuff.co.nz 16 Nov 2016.** <http://www.stuff.co.nz/national/86516374/south-dunedin-is-a-litmus-test-for-the-nation-in-regards-to-climate-change>

“The June 2 floods cost an estimated \$140 million, but the future costs would be greater unless local and central government worked together on climate change and the impact on coastal communities, Dunedin South MP Clare Curran said. Curran was the keynote speaker at the New Zealand Coastal Society annual conference in Dunedin on Wednesday morning.”

2016.11.20

**Yeoman, G. “New routes hurting business: retailers” Otago Daily Times. 20 Nov 2016.** <https://www.odt.co.nz/news/dunedin/new-routes-hurting-business-retailers>

“Changes to Dunedin’s southern bus routes are affecting business in South Dunedin, shop owners say. The changes to the Mosgiel-Taieri



bus routes in June last year led to buses from Green Island being re-routed to travel along the Southern Motorway into the Octagon rather than through South Dunedin. Grey Power Otago president Jo Miller said the new routes meant it was more difficult for customers to get to South Dunedin."

2016.12.16

**Loughrey, D. "Ire over cycleway changes" Otago Daily Times. 16 Dec 2016.**

<https://www.odt.co.nz/news/dunedin/ire-over-cycleway-changes>

In the design, the cycle-ways were described as "shoulder" areas of the road.

"It was so far below NZ Transport Agency standards they're not actually allowed to call it a cycle lane.

"They know it doesn't meet any kind of minimum standard."

*Cycleway continues to experience roll-out difficulties*

2017.01.16

**Simons-Smith, T. Taylor, M. "Notches help stop erosion" Otago Daily Times. 16 Jan 2017.**

<https://www.odt.co.nz/news/dunedin/notches-help-stop-erosion>

University of Otago master of science student Tom Simons-Smith studied the effect of notches in sand dunes for fighting erosion. "In the long term, it's not going to save the South Dunedin area, but it will buy time." DCC very supportive of the study, public lecture planned and a proposal to install notches along the whole coast line.

## Appendix 3 – ZC Building Materials

**Macrocarpa Timber:** Framing, Interior Finishes, Decking & Exterior Timber. Timber Direct Otago. Saw Mill: Lot 3, 20 Chadwick St, Fairfield, Dun—edin. <http://www.timberdirectotago.co.nz/products.php>

Due to the direct contact with seawater and estuarine ground timber used in construction would require H6 exterior treatment and H5 interior treatment, the most commonly used treatment method is CCA. An organic non-leaching alternative would be preferable and further research into this is needed, floating villages in Malaysia are reportedly made of wood that is resistant to the influence of seawater (wonderful Malaysia 2016)

Timber construction was chosen for: lightweight construction, if sourced locally has a comparatively low-carbon footprint, renewable resource, trees are a natural carbon sink, and if properly treated has a long lifespan. Steel was considered but decided against due to high-cost, vulnerability to rust and current manufacturing methods which have a much higher carbon footprint than timber. Some structural components such as brackets could be made of steel if protective coatings were applied. An alternative would be to manufacture these components out of high-strength recycled plastic, which would be buoyant, long lasting and impervious to water. All steel fixings must be galvanised steel due to water exposure.

**EPS Polystyrene Blocks.** EPS Foam Chch Ltd, expanded polystyrene manufacturers. 3/70 Shortland St, Aranui Christchurch. <http://www.epsfoam.co.nz/page20/blocks.html> .

Used as buoyancy blocks and interior insulation, floor, wall, roof. Entirely recyclable product that does not emit greenhouse gases, during production or throughout its lifetime. Testing would need to be done around leeching, and exterior casing or coating applied to protect it from the elements. Manufactured in Christchurch, New Zealand. Although the opening of a company in Dunedin would be beneficial.

**Recycled Plastic Corrugated Roofing.** Light-weight Plastic Corrugate roofing that would perform the same way as a metal corrugate roof but made entirely from recycled plastic. Not currently available in New Zealand, however similar products are available from companies like Supreme Plastics in Onehunga. <http://supremeplastics.co.nz> ; Reclaim recycling recycles plastics otherwise headed for the landfill although their business model is focused on economic gain rather than an environmental ethos <http://www.reclaim.co.nz/values.php>

**Solar Panels.** Power Smart – Solar Electricity. 18 Tukorako Drive, Mount Maunganui, Tauranga 3116, New Zealand. [south-island@powersmartsolar.com](mailto:south-island@powersmartsolar.com); <http://powersmartsolar.co.nz/residential-off-grid-solar>

Solar Panels connected to a community grid, power used and stored collectively, in a combined system could contribute to the power usage of the buoyant community.

**RePlast Block.** ByFusion PBC 2016. Dunedin, New Zealand. <http://www.bymfusion.com/#replast> ; Morris, C. Otago man makes plastic fantastic. Otago Daily Times. 30 Aug 2010. <https://www.odt.co.nz/news/dunedin/otago-man-makes-plastic-fantastic>

Operating from the Green Island Landfill in Dunedin, backed by the DCC Lewis manufactures recycled plastic building blocks. Currently used underutilised in retaining walls and landscaping, testing of strength, insulation and buoyancy capacity would be beneficial.

**Waterless Composting Toilets.** WCT. <http://wctnz.co.nz/> Auckland, New Zealand.

Self-sufficient sustainable toilet system which could be installed on mass and supported/serviced by the DCC.

**Plastic Rain Water Tanks.** Devan. <http://www.devan.co.nz/online/welcome.csn> New Zealand.

Not currently made of recycled plastic but this could be developed. Installed on mass to provide individual building water supply and increase site water carrying capacity reducing flood risk. Used in combination with waterless composting toilets and grey water recycling greatly reducing water usage and reliance on civic water supply.

## Appendix 4 – Environmental management plant listing

Selection from the DCC “Biodiversity Plant Species Listing” to aid in Environmental management of South Dunedin during Dry and Wet Land phases of SLR.

### Dunedin/Coastal

*Leptospermum scoparium manuka* ● M,H tolerant of both wet and dry sites

*Myrsine australis mapou* ● M ● slow growing but very hardy

*Plagianthus divaricatus saltmarsh ribbonwood* ● F salt water tolerant, ideal for estuary margins etc

*Fuchsia excorticata fuchsia*, kotukutuku ● M,H ● damper sites preferable, deciduous

*Coprosma acerosa sand coprosma* ● M spreading ground cover, very hardy

*Apodasmia(=Leptocarpus) similis jointed wire rush*, oioi ● F estuary margins

*Austrofestuca littoralis* (R) sand tussock ● F fore-dunes only

*Bolboschoenus caldwellii purua grass* ● F

*Carex litorosa* (R) sea sedge ● F estuary margins

*Cortaderia richardii toetoe* ● F,M useful in retaining steep banks

*Desmoschoenus spiralis pingao, pikao* ● F fore-dunes and rear dunes, excellent sand binder

*Euphorbia glauca* (R) shore spurge ● F dunes

*Libertia peregrinans* (R) sand iris ● F,M dunes and sand flats

*Phormium tenax flax, harakeke* ● F most suitable for lowland swamps and wetlands

*Poa cita silver tussock* ● M. *Schoenoplectus pungens three-square* ●

*F suitable for salt marshes and estuary margins*

### Northeastern Areas

*Schoenoplectus pungens three-square* ● F

*Typha orientalis bulrush, raupo* ● F can dominate shallow waterways and ponds

### Inland/Central

*Chionochloa rubra red tussock* ● F,M attractive, large red-coloured tussock, well adapted to wet soils

*Pseudopanax ferox* (R) fierce lancewood ● M,H ● important plant of lakeshore and islands

*Schefflera digitata seven-finger, pate* ● M ● damp shady gullies preferred

*Olearia bullata* (R) ● F,M ideal for damp gully bottoms



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