LIVING WITH WATER:

Designing Flood-Resilient Housing in Flood-Vulnerable Communities in Auckland

Master of Architecture Thesis of
Auckland University of Technology

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A thesis submitted to Auckland University of Technology in partial fulfilment of the requirements for the degree of Master of Architecture (Professional) (M Arch (prof.)) .

Note: all unreferenced images are produced by the author

A thesis submitted to Auckland University of Technology in partial fulfilment of the requirements for the degree of Master of Architecture (Professional) (March (Prof)).

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Abstract

Flooding is increasing in frequency and intensity in many urban regions. This thesis is driven by the 2023 Auckland Anniversary Weekend flood, which exposed the vulnerability of existing housing patterns. In many parts of Auckland, residential areas experienced severe inundation, property damage, and long recovery periods that reduced residents' well-being and caused anxiety during rainy days. The event highlights the need to rethink how housing can adapt to future weather patterns and reduce displacement.

This thesis investigates how regenerative and climate-adaptive shelter systems can reduce flood vulnerability at dwelling, neighbourhood, and community scales. The research draws on five theoretical frameworks: Floodability, Build Back Better, the 4Rs of Resilience, the Transitional Shelter Framework, and the Mauri Ora Compass. Key ideas from these frameworks are translated into five flood resilience principles: adaptation, redundancy, rapidity, self-sufficiency, and community and culture. These principles form the conceptual foundation for the design proposal.

The Clover Drive neighbourhood in West Auckland is selected as the test site because it was severely impacted by the floods. The area represents a typical suburban pattern of detached houses, private yards, and car-dependent street access. Its exposure to flooding and visible damage provides a clear context to test and develop architectural strategies for resilience.

The design-led research methodology combines literature review, theoretical synthesis, site analysis, and iterative architectural testing.

The design proposes a multi-scalar flood-adaptive housing system that allows controlled inundation while maintaining residential habitability. At the community scale, the proposal redistributes floodwater by creating level differences within a floodable landscape system integrated into public open space. At the dwelling scale, ground floors function as controlled inundation zones, while critical domestic spaces are elevated to support shelter-in-place and vertical retreat during flood events. Circulation shifts from ground-based access to layered and connected elevated walkways.

By linking spatial strategies with resilience principles, the thesis offers a framework for housing that accommodates water rather than resisting it, It demonstrates how architecture can function as part of an interconnected resilience system that reduces damage, maintains continuity of use, and strengthens long-term adaptability under increasing flood risk.

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The community I lived when I was a baby until 15 years old.

Positionality Statement

Growing up in Taiwan, an island frequently affected by natural hazards such as typhoons, earthquakes, and flooding, shaped my awareness of environmental risks and disaster preparedness. Regular exposure to hazard warnings, evacuation planning, and resilient infrastructure influenced how I understand the relationship between daily life and environmental uncertainty. This background contrasts with my observations in Auckland, where flood risks exist but public awareness and preparedness appear to be less embedded in everyday life.

This difference in hazard perception developed my interest in exploring how housing and urban design can support safer and more resilient living environments. My experience growing up in Taiwan informs my perspective on the importance of designing spaces that anticipate disruption rather than respond only after damage occurs. This positionality influences the direction of this research, particularly the focus on architectural strategies that support continuity of life during flood events.

The 2023 typhoon caused severe flooding in Kaohsiung, Taiwan. (Xuesheng Liu, 2024)

In 2022, the 6.8 magnitude earthquake in Taitung caused severe damage in Yuli Village, Hualien, Taiwan. (Junqi Wang, 2022)

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1. Introduction

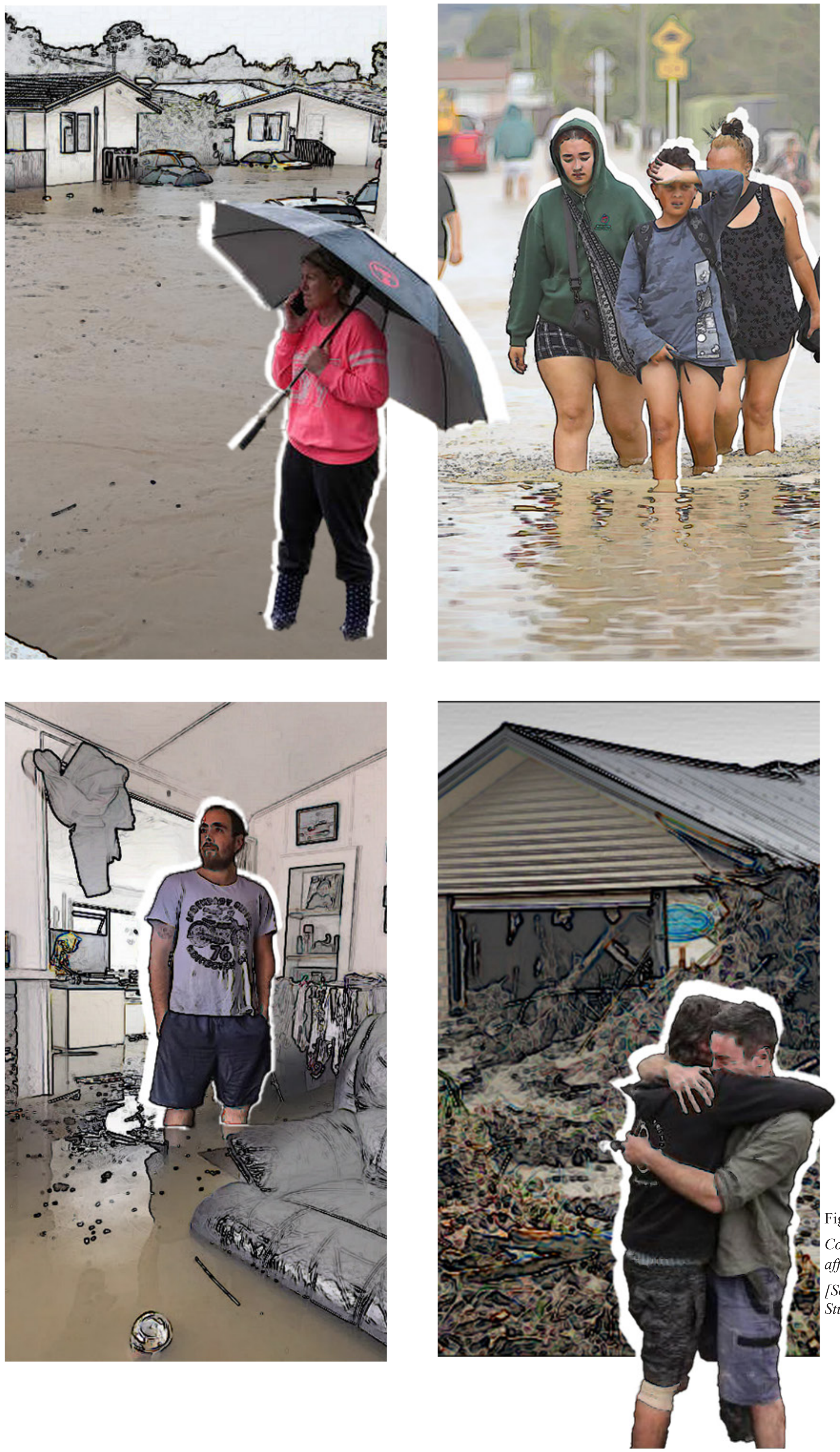


Figure 1.1
Collage of residents affected by flood.
[Source: NZherald, Stuff News]

Flooding has become an increasingly frequent condition in many urban environments, transforming what was once considered an occasional natural hazard into a persistent disruption to everyday life. Intensifying rainfall patterns, urban densification, and constrained stormwater systems mean that floods now occur more frequently, with longer durations and more complex recovery processes. In this context, flooding is no longer experienced solely as an emergency event, but as an ongoing spatial condition that shapes how cities are inhabited. The 2023 Anniversary Weekend floods in Auckland, New Zealand showed the limits of existing flood protection systems and exposed how fragile everyday living environments are when flooding lasts for long periods. For many residents, the main impact was not the physical damage to property but the disruption of daily life, the loss of psychological security, and long-term uncertainty about recovery.

Conventional flood responses primarily operate at system and policy levels. Engineering infrastructure such as stormwater networks, detention basins, and river controls seeks to reduce the likelihood or extent of inundation, while planning frameworks emphasise hazard zoning, development controls, and increasingly, managed retreat. These approaches are essential for reducing overall risk. However, they provide limited guidance on how people continue to live when floods exceed system capacity, infrastructure fails, or decisions to retreat are delayed. As a result, a gap emerges between system-level flood management and the lived realities of residential environments.

For many households, flooding does not result in immediate relocation. Instead, residents often experience prolonged periods of uncertainty in which homes remain partially usable while decisions about repair, insurance, buyouts, or retreat remain unresolved. During these extended intervals, dwellings may be neither fully habitable nor clearly uninhabitable. This condition of limbo disrupts daily routines, undermines feelings of safety, and complicates recovery. Existing flood frameworks tend to treat housing as an asset to be protected, compensated, or removed, rather than as a lived-in environment that must continue to function under uncertain conditions.

Architecture occupies a critical position within this gap. While architecture cannot prevent flooding, it shapes how flooding is experienced. Through spatial and material strategies, housing can influence whether residents are forced to evacuate, how long they can remain safely in place, and how recovery unfolds over time. Architectural design therefore has the capacity to support continued inhabitation, reduce disruption, recover during and after flood events, and provide clarity during periods of uncertainty.

This thesis focuses on residential housing because it is the primary site where flood impacts are experienced on a daily basis. The dwelling is the smallest unit of shelter, safety, and routine, and it is where decisions to stay, adapt, or leave are ultimately negotiated.

The research is situated in Auckland, where recent flood events have exposed the vulnerability of low-lying residential neighbourhoods. The Clover Drive neighbourhood in Henderson is used as a case study, representing a condition in which flooding is recurrent, retreat is discussed but not immediate, and communities continue to inhabit flood-prone environments.

The central research question is:

How can residential architecture contribute to increasing the resilience, safety, and well-being of residents impacted by floods, particularly those living in flood-vulnerable communities in Auckland?

Rather than seeking to eliminate flooding entirely, this research investigates how architecture can support life under conditions of uncertainty. The scope of the thesis is limited to community, neighbourhood, and dwelling scales. Large-scale flood engineering, emergency management systems, and policy reform are acknowledged but not directly addressed. Through a design-led research approach, the thesis uses spatial analysis, precedent studies, and scenario-based flood testing to develop and evaluate architectural strategies that complement existing flood responses by addressing the spatial and temporal conditions of everyday living in flood-prone contexts.

Research Question...

How Can Residential **Architecture** Contribute to Increasing the **Resilience, Safety, and Well-being** of Residents Impacted by Floods, Particularly Those Living in **Flood-Vulnerable** Communities in **Auckland**?

Figure 1.2

I took this photograph in July 2025. The neighbourhood was severely impacted by the 2023 Anniversary Weekend flood.

Two years later, household items removed during post-flood clean-up remain abandoned outside homes, indicating prolonged recovery and unresolved impacts on residents.

Research Aims...

To develop an architectural design proposal that enhances the physical resilience and psychological security of residents in Auckland's flood-vulnerable communities by proposing flood-resilient responses at multiple scales.

Using a specific site, the research explores how coordinated master planning of community and ecological systems, together with building-specific architectural strategies, can increase the capacity of communities to shelter in place and recover quickly from flood-related impacts.

Research Objects...

1.

To Analyse Risks and Existing Context

- Examine how flooding affects residential living conditions in flood-vulnerable communities in Auckland.
- Analyse resident dilemmas during flood events

2.

To Investigate Resilience Design Strategies

- Review architectural and urban precedents related to flood-responsive housing and flood-sensitive design in order to identify transferable spatial strategies.
- Translate extracted principles into site-specific architectural design strategies for a flood-affected residential area in Auckland.

3.

To Develop and Propose Design Solutions

- Design a housing prototype and test the proposed design strategies through staged scenarios to evaluate their performance before, during, and after inundation.
- Assess how architectural design can support continued, safe, and dignified inhabitation under flood conditions, rather than relying solely on evacuation or retreat.

Thesis Structure

PRELIMINARY RESEARCH | DESIGN-LED RESEARCH | DESIGN SYNTHESIS

Identify Problem

Literature Review →

- Organise the design principles of security and ecological resilience
- Post-Disaster Architecture and Recovery Strategies
- Ecological Architecture and Resilience Theories
- Community Participation and Sustainability
- Architectural and Infrastructure Strategies

Case Study →

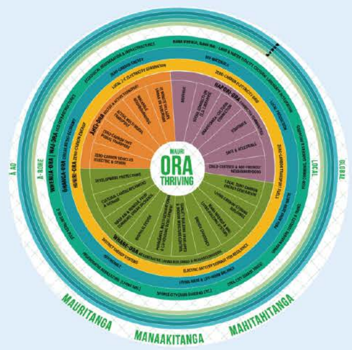
- Analysis of domestic and international post-disaster housing and precedent studies
- Analysis of success and ineffective precedents

Site Analysis →

- Field Observation (Environment, Architecture, Community)

Theoretical Framework

- Mauri Ora Compass



- Build Back Better(BBB)
- Transitional Shelter Framework
- The 4Rs of Resilience (Resilience = Robustness, Redundancy, Resourcefulness, Rapidity)

Design Process

Conceptual Designs
↓
Developed Design
↓
Refine
→

Reflect + Discuss

2. Background & Context

> ***Resilience is created by the existing connections that are there before the disaster. It's not the services coming in during the recovery.***
>
> *—Karekare resilience group member*
>
> *(Community Think, 2023)*

Globally, climate change is altering rainfall patterns, increasing the frequency and intensity of extreme precipitation, storm surges, and sea-level rise (NIWA). Urbanisation is accelerating, with cities expanding and adding impervious surfaces that hinder natural drainage. Stormwater infrastructure was largely built to previous climatic norms. These combined forces have made many urban areas more vulnerable to flooding than past designs can safely accommodate.

In New Zealand, these global trends intersect with specific regional vulnerabilities: many communities lie in floodplains or coastal zones; much of the stormwater and wastewater infrastructure is ageing; designs assume lower intensity rainfall; and insurance and governance frameworks are under strain. The floods of recent years have exposed these weaknesses. Addressing them requires analysing how building practices are adapting (or failing to adapt), and how social, cultural, and economic dimensions affect both options and outcomes.

▪ Causes of Floods

These rainfall patterns directly affect residential architecture. Heavy rainfall and flooding can expose buildings to prolonged contact with water, structural erosion, and debris impact. In Aotearoa New Zealand, recent floods have rendered hundreds of homes uninhabitable and caused billions of dollars in damage (BRANZ, 2025).

▪ Weather Patterns

Auckland has a warm and humid climate shaped by its ocean setting, with mild winters, warm summers, and rainfall throughout the year (NIWA, 2013). Average annual rainfall is about 1,100–1,200 mm, but it varies because the city sits between two harbours and volcanic highlands. Rainfall is highest in winter, with about 32% falling between June and August, and lowest in summer, at around 20%. Heavy rain often comes from north-westerly storms, and short, high-intensity rainfall events are becoming more frequent, increasing flood risk in urban areas (NIWA, 2013).

▪ Climate Change Projections

According to the Ministry for the Environment (2020), climate models project increasing frequency and intensity of heavy rainfall events in Auckland, in combination with sea-level rise, potentially up to 1.0 m by 2100 under high-emissions scenarios, and intensified risk to stormwater systems, infrastructure and coastal zones. The extreme flooding in January 2023 was already exacerbated by factors driven by climate change, which scientists estimate increased peak rainfall by 10–20% (Lorrey et al., 2018). These projections underpin the need to design with horizons such as 2050 and 2100 in mind when setting freeboard and infrastructure capacity targets.

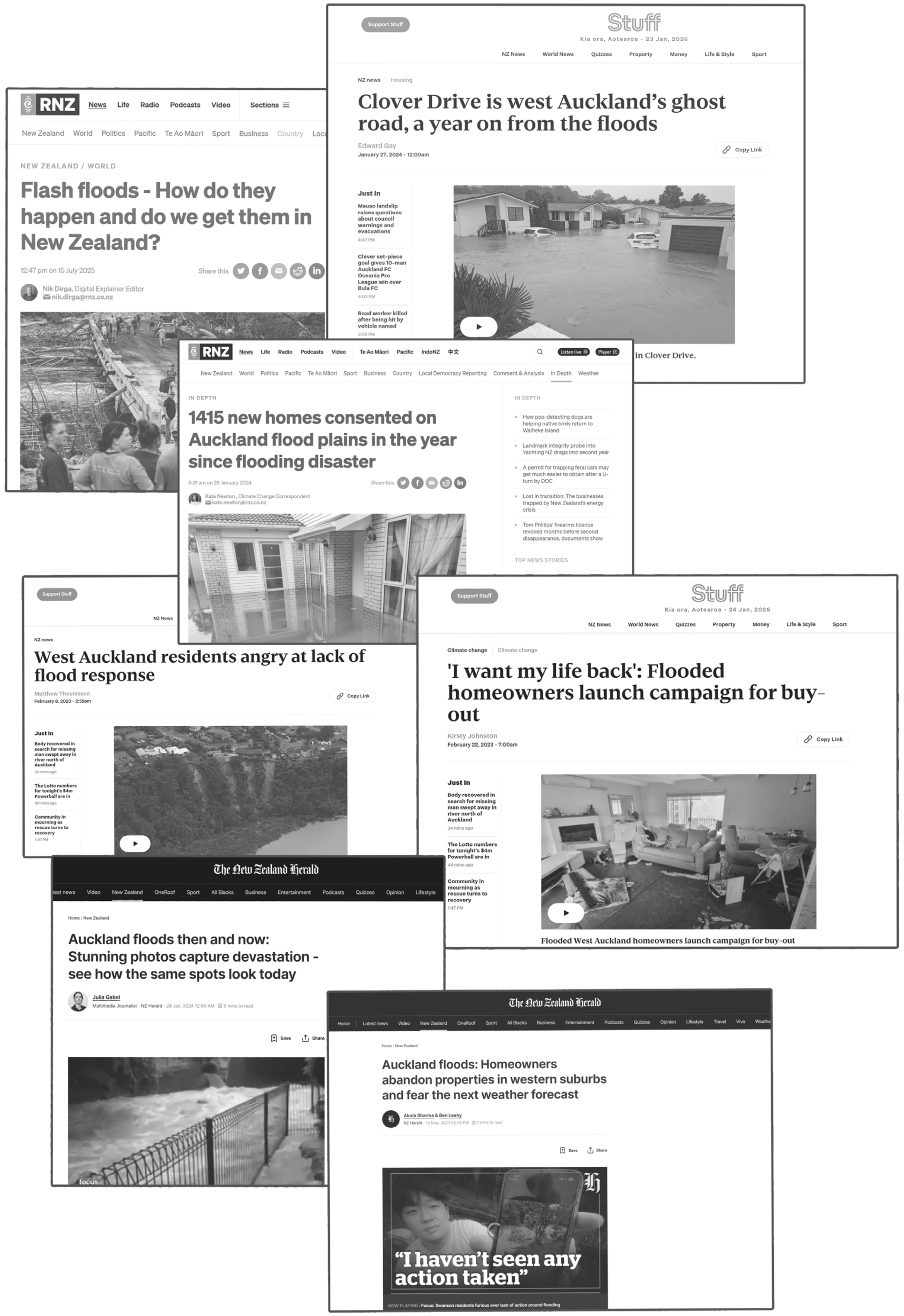


Figure 2.2

Collage of News Reports about 2023 Flood

[Source: NZherald, Stuff News, RNZ]

- ## House Type

Auckland's residential landscape has long been shaped by historical planning and land regimes (Schrader, 2013). Early urban expansion, influenced by the English country-side ideal, fostered the dominance of detached houses through expansive lots and low-density planning, a form further reinforced in the mid-to-late 20th century.

The current Auckland Unitary Plan designates mixed-use urban housing, generally allowing up to three-story detached or attached buildings to preserve established suburban architectural characteristics and neighbourhood qualities (Auckland Council, 2025). Higher-density housing types typically require resource permission or concentration in transport hubs and central areas (Auckland Council, 2025). This planning tradition and lot size, coupled with a cultural preference for detached houses, mean that even in flood-sensitive areas, the majority of housing remains low-rise detached houses, rather than higher-density or multi-story structures. This established built environment limits the possibility of large-scale redevelopment of residential areas in floodplains, which forms the problem this study addresses: adapting housing under flood conditions.

- ## Community Dilemma

Residents affected by the 2023 Auckland Anniversary Weekend floods continue to face a range of unresolved dilemmas that extend beyond the immediate loss of housing (Newton, 2023). Many homeowners remain in limbo, as property categorisation and buyout processes have moved slowly, leaving families uncertain about whether they will be able to repair, relocate, or abandon their damaged homes. Insurance claims are often tied to these decisions, meaning payouts cannot be fully accessed until the council's decisions are finalised. This has forced some residents into precarious living arrangements, such as temporary caravans or split households, as they wait for clarity on their future (Dovetail, 2024).

The prolonged delays have created a sense of instability that is compounded by the emotional strain of displacement and the visible reminders of flood damage in affected neighbourhoods (Woodhall-Melnik & Grogan, 2019). Abandoned houses continue to attract looters and vandalism, eroding community safety and trust while leaving residents fearful for their property and security (Blackwell, 2024).

Why Do Residents Feel Unsafe?

Figure 2.3
Residents' voice from News reports

▪ Mental Trauma

Several Auckland residents express growing anxiety and mental stress due to the city's prolonged and extreme rainfall, which has significantly deviated from historical norms. One social media user(@mo_mo1, 2023) shared on Reddit how the persistent rain has disrupted their sleep and triggered anxiety resembling PTSD, particularly because their room amplifies the sound and they fear potential flooding.

A therapist responded to their social media post empathetically, affirming that trauma from flood experiences is valid and recommending counseling, sound-reducing tools, and taking practical action (e.g., drain clearing, joining community groups) to regain a sense of control. Many users shared similar feelings of dread, anxiety, and sleep disruption linked to heavy rain and past flooding. Others noted how perceptions of rain have changed from cozy to fearful.

▪ Current Gap

Government research in Aotearoa New Zealand identifies housing as a central determinant of post-disaster well-being, closely intertwined with infrastructure performance, insurance processes, and psycho-social recovery (Resilience to Nature's Challenges, 2025). Damage to housing not only disrupts physical shelter but destabilises daily routines, social networks, and perceptions of safety, particularly for households already experiencing financial or social stress.

Despite this central role, housing is not formally recognised as critical infrastructure within New Zealand's disaster resilience framework (Resilience to Nature's Challenges, 2025). This classification gap reveals a structural blind spot, where large-scale infrastructural systems are prioritised, while the spatial conditions of everyday living environments remain underexplored as as potential mechanisms for building resilience.

3. Methodology

This thesis adopts a qualitative, design-led research approach based on the framework outlined by Linda Groat and David Wang in Architectural Research Methods (2013) to examine how architectural design can strengthen resilience for residents living in flood-prone communities in Auckland.

Qualitative methods are used to understand how people experience flooding in their daily lives, how they perceive risk, and what strategies they already use to cope with flood events. This type of understanding is important for developing design responses that are realistic, socially acceptable, and appropriate to local conditions.

A design-led research approach is used because the research question concerns spatial experience under conditions of uncertainty, including changes in access, use, and habitability over time, which cannot be fully evaluated through quantitative modelling or policy analysis alone. In this thesis, design functions as both the process and the outcome of inquiry. Knowledge is generated through proposing, testing, and refining architectural interventions, allowing spatial, typological, and material decisions to be evaluated through iterative cycles of drawing and scenario testing. Rather than treating flooding as a problem to be eliminated through engineering solutions, the methodology examines how architecture can support continued inhabitation, safety, and recovery under flood conditions.

Architecture is chosen as the main research medium because flooding is experienced by people in their home environments. While flood management is often addressed through engineering, planning, and emergency response, these approaches usually focus on large systems rather than everyday living environments. Architecture sits between infrastructure and daily life, shaping how people move, shelter, and adapt during flood events. Housing is especially important, as it is where decisions to stay, retreat vertically, or evacuate are made. Elements such as building section, circulation, thresholds, and material durability directly affect how residents experience flooding and recovery.

The research draws on a range of sources, including academic literature in architecture and environmental studies, government reports, news articles, and community perspectives shared through media and online platforms. Lessons from the 2023 Auckland Anniversary Weekend floods provide key contextual background for the study. International precedents related to flood-responsive housing and water-sensitive design precedents are also examined to identify useful strategies and spatial ideas.

The study is organised using a multi-scalar framework, looking at flood resilience at the community, neighbourhood, and dwelling scales. This reflects how flooding affects both large systems and individual homes at the same time. A flood-affected site in Auckland is selected for closer study, where site topography, infrastructure and housing conditions are analysed through mapping and drawing. Principles identified from literature and precedents are translated into site-specific design strategies and tested using flood scenarios that show how spaces function before, during, and after inundation.

The design process includes sketching, diagramming, mapping, modelling, and iterative design development at both housing and neighbourhood scales. Ongoing reflection and feedback from reviews are used to refine the design work. Through this approach, the thesis demonstrates how architectural design can contribute practical and context-sensitive strategies that work alongside larger infrastructural and policy responses to flooding.

4. Literature Review

What is Resilience?
How to define Resilience?

The concept of resilience has been widely adopted across disciplines, including engineering, ecology, social sciences, and architecture. Across these fields, resilience commonly refers to the capacity of a system to withstand disturbance at moments of shock while maintaining core functions(IPCC, 2012; Shams et al., 2023) In the context of this thesis, resilience is under-stood as the ability of the built environment and its associated social systems to absorb flood impacts, adapt during disturbance, and recover following flood events. This definition extends beyond structural survival to include continuity of daily life, social connection, and psychological security.

Resilience is not achieved through singular protective elements, but through interconnect-ed, multi-scalar civil and spatial strategies that allow communities to prepare for uncertainty, endure disturbance, and recover while main-taining continuity of everyday life.

Contemporary
Flood Menegement

Climate change is increasing the frequency and severity of extreme rainfall, storm surges, and flooding in many parts of world, including New Zealand (NIWA, n.d.). Urban centres, especially those near rivers, coasts or low-lying land, face growing risk from these hazards (ME, n.d.).

These Natural hazards (floods, storms) are a major cause of human displacement. In 2019 alone, approximately 24.9 million people were displaced due to extreme weather and disasters worldwide. Much of this displacement includes evacuation and relocation away from hazardous areas (UNHCR, 2019).

In 2022, the Intergovernmental Panel on Climate Change (IPCC) documents that human influence has warmed the climate system and that many regions will experience more intense short-duration rainfall events; it also summarises sea-level rise scenarios that accelerate non-linearly under higher emissions pathways. These changes increase the frequency and severity of coastal and pluvial flooding and deepen the baseline for storm surges (IPCC, 2022).

Urbanisation compounds these risks. The growth of impervious surfaces such as roads, roofs, driveways accelerates runoff, reducing natural absorption of water by soil and vegetation (NIWA, n.d.). Many waterways and streambeds have been modified, channelled, culverted, or buried, which reduce their capacity to buffer flood flows (NIWA, 2025).

Structural engineering flood defences were widely adopted historically; however, this stormwater infrastructure often reflects past climatic norms rather than future projections. Many of the pipe networks, drainage systems and treatment devices were designed for lower intensity rainfall and slower runoff amounts (Motu, 2017). When capacity is exceeded, overflow, flooding, and failures in treatment or containment are likely (NIWA, n.d.). The problem is worsened by ageing infrastructure, and by a lack of resources to upgrade or maintain systems at scale (Motu, 2017). There is also institutional inertia: policies, regulatory standards, and planning norms sometimes lag behind shifts in hazard projections (BRANZ, 2025).

In response to the consequences of flood control engineering and to address climate change, there has been a growing global emphasis on nature-based solutions (NbS) for flood risk management (Watson & Adams, 2011). Concepts such as sponge cities, green infrastructure, and water-sensitive urban design emphasise using natural processes to slow, absorb, and store excess stormwater while providing co-benefits for biodiversity, public space, and water quality.

Auckland Resilience Approaches: Nature-Based Solutions

Project Twin Streams

Figure 4.2
Project Twin Streams (2014)

Project Twin Streams (PTS) is a long-standing, community-focused environmental restoration project that began in West Auckland in 2003. Its core mission is to restore the health of the Opanuku and Oratia streams and their tributaries through ecological and social action. The project is celebrated for mobilising thousands of volunteers to plant over 880,000 native trees, creating extensive walkways and cycle paths, and integrating public art, all while naturally stabilising stream banks and protecting the floodplain. Rather than a direct flood response, PTS represents a decades-long model of community-led care for waterways, demonstrating how environmental health and public space can grow together.

Auckland's Making Space for Water programme

Figure 4.1
Making Space for Water programme (OurAuckland, 2023)

Auckland's Making Space for Water (MSW) programme is a major, ten-year infrastructure initiative launched directly in response to the devastating 2023 floods. With a budget of $760 million, its primary goal is to protect urban communities by reducing flood risk through engineered and "blue-green" solutions. This involves constructing large-scale projects like upgraded stormwater pipes, enlarged bridges, and replaned flood plains to give waterways more room during heavy rain. It is a centrally coordinated, region-wide effort focused on rapid climate adaptation and recovery, with the first construction projects beginning in 2025.

In New Zealand, Auckland's long-running Project Twin Streams has been an example of nature-based practice in the region since 2003, restoring more than 56 km of streambanks and involving community planting and ecological work that helps stabilise waterways and reduce flood impacts along the tributaries of Te Wai-o-Pareira / Henderson Creek and Huruhuru Creek (Project Twin Streams, 2014).

Auckland Council's Making Space for Water programme also reflects these nature-based principles by prioritising blue-green networks, systems of waterways and parks that give stormwater room to flow and reduce flooding in residential areas as part of broader regional flood resilience planning (OurAuckland, 2023).

Contemporary Architectural Flood Adaptation Strategies

Contemporary property-level flood mitigation strategies focus on reducing damage and maintaining habitability through architectural and material adaptation rather than relying solely on large-scale infrastructure.

Approaches include elevating buildings above projected flood levels, wet and dry flood-proofing techniques, sacrificial ground floors, and the use of water-resistant materials and detachable building compo-nents to facilitate rapid repair (Barsley, 2019).

Increasing attention is given to resilient building services, such as relocating electrical systems and utilities above potential inundation zones, as well as integrating permeable site design and on-site stormwater retention. These strategies aim to limit structural damage, shorten recovery time, and support shelter-in-place capacity (Barsley, 2019;). .

However, while effective at the individual building scale, they often lack integration with broader neighbourhood and ecological systems, highlighting the need for multi-scalar coordination in flood-prone contexts.

Global Practices

Northwest Harbor House

Figure 4.3

Bates Masi + Architects (2013)

Northwest Harbor House (2013), designed by Bates Masi + Architects, is a flood-adaptive residence in East Hampton, New York. Located about 1.8 m above sea level near wetlands and a tidal estuary, the one-storey 176 m² house is raised 2.4 m on 16 exposed glulam timber piles to meet FEMA and local zoning requirements. The piles contain bedrooms and service spaces and integrate rainwater downspouts, while voids between them improve light and ventilation. Rooftop photovoltaics and geothermal systems support energy use, and planted roof elements reduce runoff, demonstrating an integrated approach to flood resilience and ecological design (ArchDaily, 2013).

Amphibious House

Figure 4.4

Amphibious House by BACA, (2015)

The UK's First Amphibious House by BACA Architects was completed around 2014–2015 as a private 3-bedroom, 225 m² residence on an island in the River Thames, Buckinghamshire, UK. It is designed to float vertically within a dock when floodwater rises, keeping daily life uninterrupted and reducing reliance on high elevated floors. Its key points include amphibious buoyancy guided by steel posts, an intuitive terraced garden that signals rising water levels, and flexible utility connections that extend as the house moves during floods. It demonstrated how architecture can accommodate water rataher than fight it, offering a resilient model for flood-prone sites while preserving heritage context and liveability. (BACA Architects, 2015)

Local Perspectives
& Vernacular Flood Adaptation

Global flood resilience literature is increasingly complemented by local and vernacular knowledge systems that have long engaged with living alongside water. In Aotearoa New Zealand, Māori relationships to land and water emphasise co-existence rather than domination. Concepts such as awa (rivers) being living entities and whenua (land) being relational frame flooding not solely as failure, but as part of natural cycles that must be respected and accommodated (Fisher & Parsons, 2020).

Vernacular building practices in flood-prone regions globally further demonstrate how architecture has historically adapted to recurrent inundation. Elevated floors, lightweight and repairable materials, open ground levels, and flexible internal layouts are common strategies in riverine and coastal settlements across Asia and the Pacific (UNDRR, 2022). Rather than attempting to exclude water entirely, these approaches prioritise rapid recovery, continued use, and tolerance of partial flooding. Such strategies align closely with the concept of floodability, where architecture accepts periodic inundation as a design condition rather than an exception (UNDRR, 2022).

Despite growing recognition of indigenous and vernacular knowledge in landscape and infrastructure projects, these perspectives remain underexplored at the scale of everyday housing. Policy and engineering-led flood responses may incorporate nature-based solutions at the community scale, such as wetlands and restored floodplains. However, most residential buildings are still designed as sealed and static structures that rely on keeping water out. When flooding exceeds design limits, these houses have limited capacity to adapt, tolerate water, or support continued occupation.

This gap highlights the need for architectural research that translates local and vernacular flood logic into contemporary housing typologies capable of supporting continued inhabitation under uncertain conditions

Global Practices

Kompong Khleang Floating & Stilted Villages

Figure 4.5
Kompong Khleang floating & stilted villages (Tara Boat, n.d.)

Kompong Khleang is a large stilted and floating village community on the Tonlé Sap Lake near Siem Reap, Cambodia, comprising about ten villages and home to over 10,000 residents. The settlement sits on one of Southeast Asia's most dynamic freshwater systems where water levels can rise by up to 10 m seasonally, so homes are built on tall stilts or buoyant platforms that keep living spaces habitable year-round despite dramatic flooding and recession of water levels. during the wet season the lake can rise several metres, making buildings appear to float, while in the dry season stilts are fully exposed and villagers move on land. (Kompong Khleang. , n.d.)

Antohomadinka Settlement

Figure 4.6
Antohomadinka, a flood-prone informal settlement in Antananarivo, Madagascar (Mottelson J. et al., 2025)

Antohomadinka is a flood-prone informal settlement in Antananarivo, Madagascar, located on low-lying floodplain areas where rapid urbanisation and inadequate planning have concentrated vulnerable populations in places with limited infrastructure and services (Mottelson et al., 2025). Architectural responses in such settings are predominantly vernacular and incremental: residents use readily available materials to build elevated pedestrian routes and boardwalks that allow mobility during floods.

5. Theoretical Framework

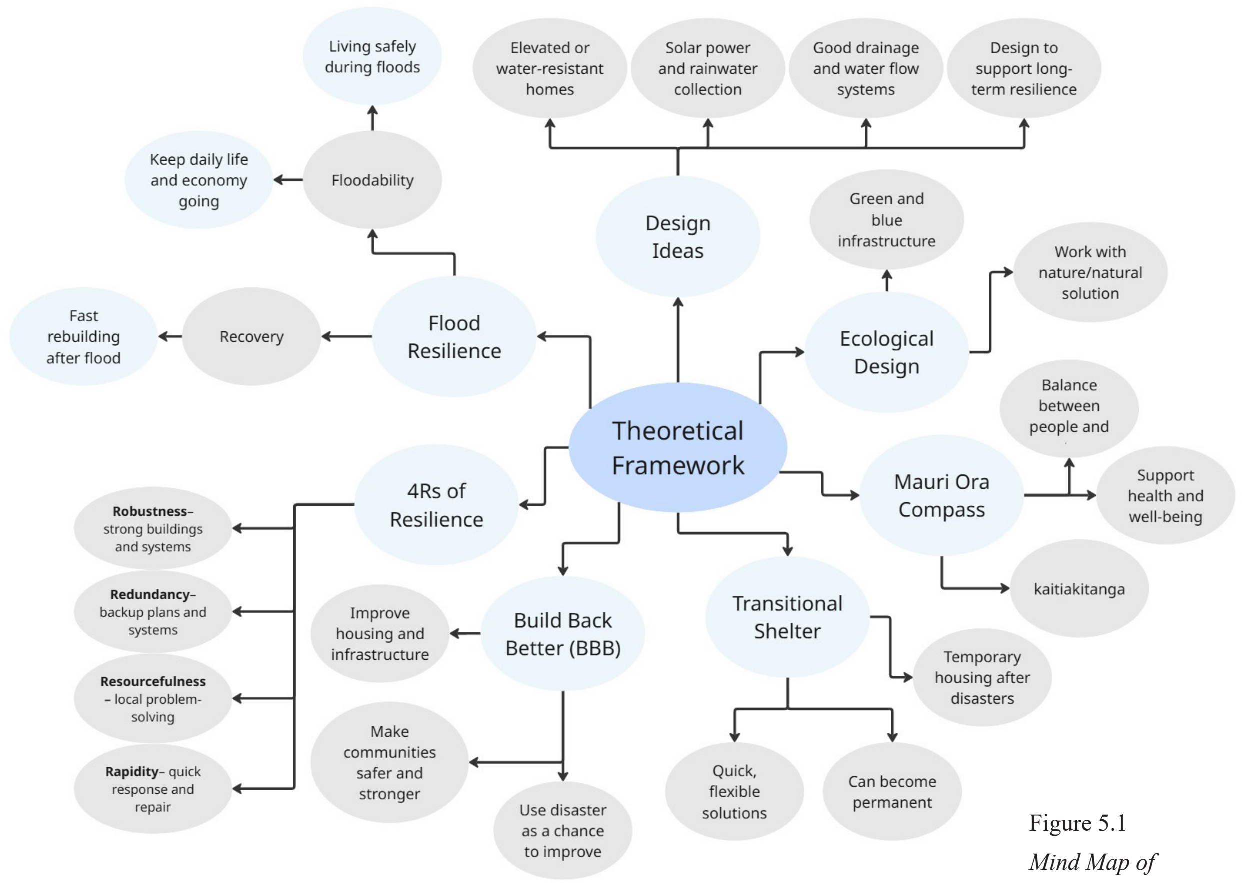


Figure 5.1

Mind Map of Theoretical Framework

Resilience Framework

This study examines how architectural design can strengthen resilience, safety, and well-being for flood-vulnerable communities in Auckland; Resilience is its central theoretical framework, understanding it not as the prevention of flooding but as the capacity of the built environment to maintain functionality, adapt during disturbance, and recover following flood events(**Shams et al., 2023**). Flood Resilience is encompasses the ability to withstand flood impacts without immediate failure, remain partially usable during inundation, and support efficient repair and recovery afterward.

This thesis establishes a theoretical framework to connect flood resilience research with architectural design. Flooding is often studied through engineering, planning, and disaster management. These fields focus on risk reduction, infrastructure performance, and policy response (Watson & Adams, 2011). However, they give limited attention to how people continue to live in their homes when flooding becomes frequent and long-lasting. As a result, there is a gap between system-level flood management and everyday residential experience. This framework addresses that gap by translating interdisci-plinary ideas into architectural and spatial thinking.

It draws on five theoretical frameworks to form an interdisciplinary foundation for regenerative, climate-adaptive housing systems: Floodability (La Loggia et al., 2020), Build Back Better (DNS and PA, 2005), the 4Rs of Resilience (Bruneau et al., 2003), the Transitional Shelter Framework (ICLEI, 2021), and the Mauri Ora Compass (Yates, 2016).

These frameworks span disciplines such as engineering, humanitarian response, Indigenous knowledge, and disaster recovery planning. Despite their different origins, they share several core principles that can inform architectural responses to climate-induced disasters. Each framework addresses a different aspect of flooding, including water behaviour, system performance, time and recovery, and cultural values. Together, they offer a clear structure to guide design decisions at different scales. The framework does not dictate exact design forms, but it helps explain and evaluate why certain decisions are made.

Transitional Shelter Framework

Flooding affects more than physical space. It also disrupts time and the everyday lives of residents. The transitional shelter framework highlights that recovery after disaster is often slow and uncertain. The core purpose is providing safe, durable housing in the short to medium term while enabling a pathway to permanent shelter and community recovery. Defined by characteristics such as upgradability, relocatability, recyclability, potential resale value, and long-term utility beyond the initial crisis (ICLEI, 2021).

In the Auckland flood context, many residents do not immediately relocate or rebuild. Instead, they stay with family or friends, rent elsewhere, or remain in houses that are only partly usable while waiting for insurance decisions, repairs, or long-term solutions. This framework shapes the architectural approach so that housing can adapt over time and support affected households throughout the recovery and rebuilding process.

Floodability

The theory of 'Floodability' provides the starting point for this research. It challenges the idea that flooding must always be prevented. Instead, it understands flooding as a condition that can be anticipated and managed through spatial design (La Loggia et al., 2020). In this view, the key question is not how to stop water, but where water can go and what happens when it arrives. This shift is important in urban areas where stormwater systems are often exceeded.

In architectural terms, floodability directs attention to building section, ground levels, spatial hierarchy, and material selection. These elements shape how a building can coexist with periodic inundation rather than fail when water enters.

4Rs of Resilience

While floodability explains how water interacts with space, the 4Rs of Resilience help evaluate how architecture performs during and after flooding. The 4Rs include robustness, redundancy, rapidity, and resourcefulness Bruneau et al., 2003). In this research, they are used as design principles rather than technical measurements. Robustness relates to durable materials and construction that can withstand water exposure. Redundancy refers to alternative access routes, backup services, and flexible use of space. Rapidity considers how quickly spaces can be cleaned, repaired, and reused. Resourcefulness focuses on how residents can adapt when systems fail.

Build Back Better (BBB)

Build Back Better (BBB) is used to address lon-ger-term recovery and learning from flood events. The core principle is using lessons from previous events to avoid repeating vulnerabilities and unnecessary damage in future recovery. Recon-struction should aim to strengthen systems rather than restore weaknesses (DNS and PA, 2005).

Architecturally, BBB means using post-disaster reconstruction to improve buildings and communi-ties so they are safer, more resilient, and better adapted to future risks rather than simply restoring previous conditions. It emphasises inte-grating disaster risk reduction into rebuilding, improving structural performance, standards and codes, and reducing future vulnerabilities. The goal is to construct or repair in ways that minimise risk from future hazards, enhance sustainability, and strengthen overall community resilience.

Mauri Ora Compass

Mauri Ora Compass (Yates 2016) is a holistic wellbeing and action framework grounded in the Māori concept of mauri ora: the vitality or life force in people, environments, ecosystems, and built places. It integrates indigenous knowledge systems with practical indicators and actions to assess and guide transitions toward ecological, social and cultural wellbeing.

Mauri Ora Compass guides design thinking toward regenerative built environments that contribute to interconnected well-being rather than simply min-imizing harm. In architectural education and practice it encourages design decisions that consider ecological systems, community cohesion, energy systems, and cultural values as interde-pendent factors. It reframes buildings and urban form as integral parts of social-ecological systems, encouraging architecture that supports ecological health, social connection, resilient infrastructure and regenerative outcomes across place.

Within this framework, a set of shared principles can be identified: Adaptation, Self-sufficiency, Redundancy, Rapidity, and Community and Culture. These are key attributes of disaster resilience that can be translated into architectural and spatial strategies.

- **Adaptation** is positioned as a fundamental design attitude toward inevitable and recurring flooding. Rather than excluding water, adaptive design accepts inundation as a recurring condition and reduces its destructive effects through spatial configuration, constructional strategies, and adjustments to circulation and everyday use. This approach underpins rain-friendly design and provides the conceptual basis for multi-scalar flood-resilient responses across community, neighbourhood, and dwelling scales.

- **Self-sufficiency** refers to the ability of dwellings and communities to sustain basic daily life for a limited period without external assistance. In the context of flooding, this attribute supports shelter-in-place by ensuring that essential living functions, mobility, and care can be maintained locally during the initial and peak phases of a flood event. Architecturally, self-sufficiency is closely linked to spatial layout, service placement, and the provision of shared support spaces that enable collective endurance.

- **Redundancy** describes the capacity of spatial and infrastructural systems to continue operating when parts of them fail. In architectural terms, redundancy is achieved through multiple circulation routes, distributed connections, and the provision of several safe nodes rather than reliance on a single refuge or access point. At the neighbourhood scale, redundancy can be expressed through elevated connected circulation systems that preserve pedestrian continuity and social interaction during flood conditions.

- **Rapidity** refers to the length of time required for spaces and functions to return to normal use after flooding. Rapid recovery depends not only on water recession and drainage performance but also on spatial organisation and material strategies, including clear wet–dry zoning, the retention of immediately usable dry spaces, and the use of materials that can be cleaned, dried, and repaired efficiently.

- **Community & Culture** provide the psychological and social grounding necessary to sustain well-being and continuity under flood conditions. The impact of floods on residents is not only physical damage but also the disruption of familiar routines, social relationships, and a sense of identity. This study argues that familiar spatial usage patterns, visible neighborhood activities, and continuous social interaction can significantly reduce uncertainty and anxiety during disasters. Therefore, design that strengthens community connections is a spatial means of maintaining community culture and a sense of collective.

My Theoretical Framework

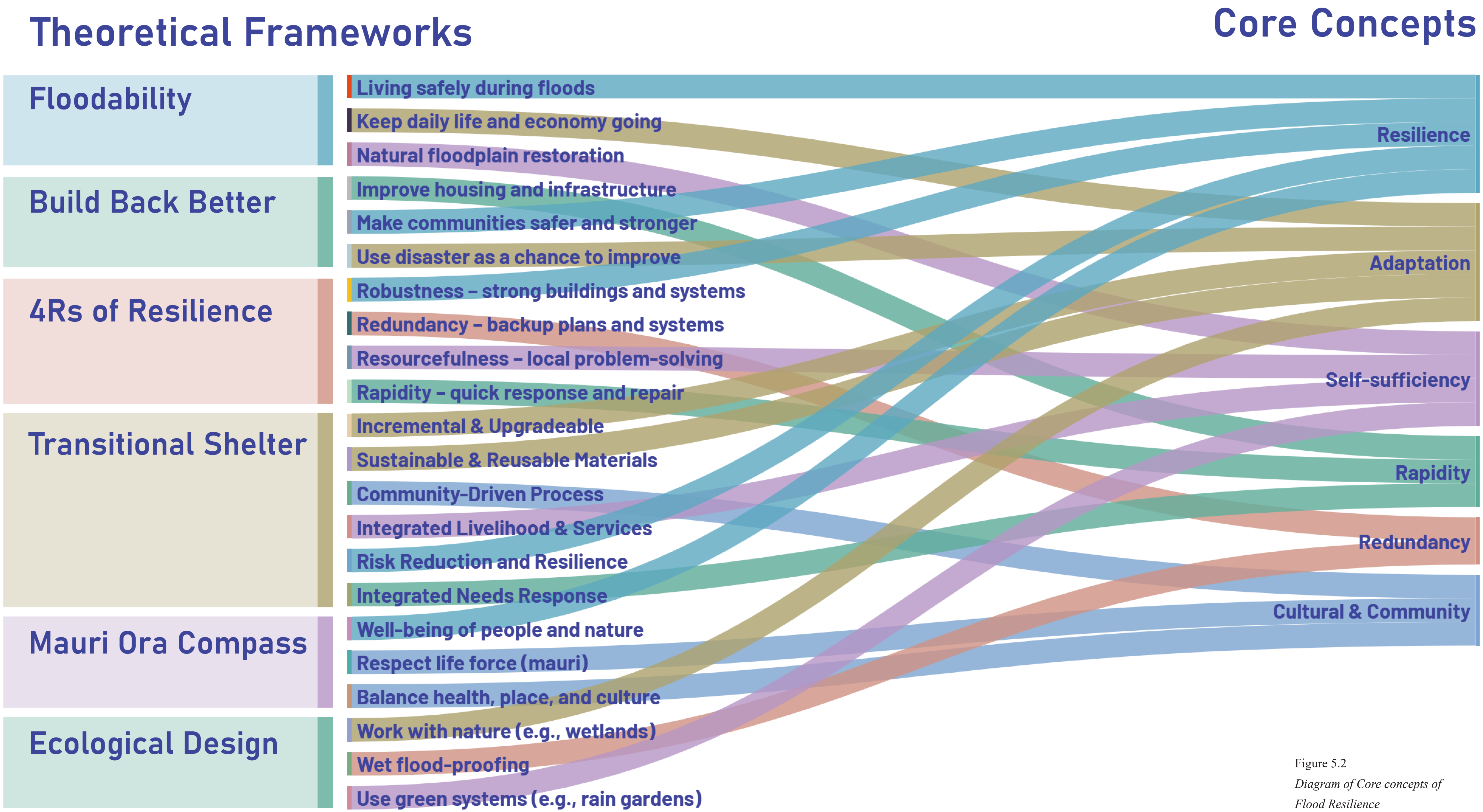


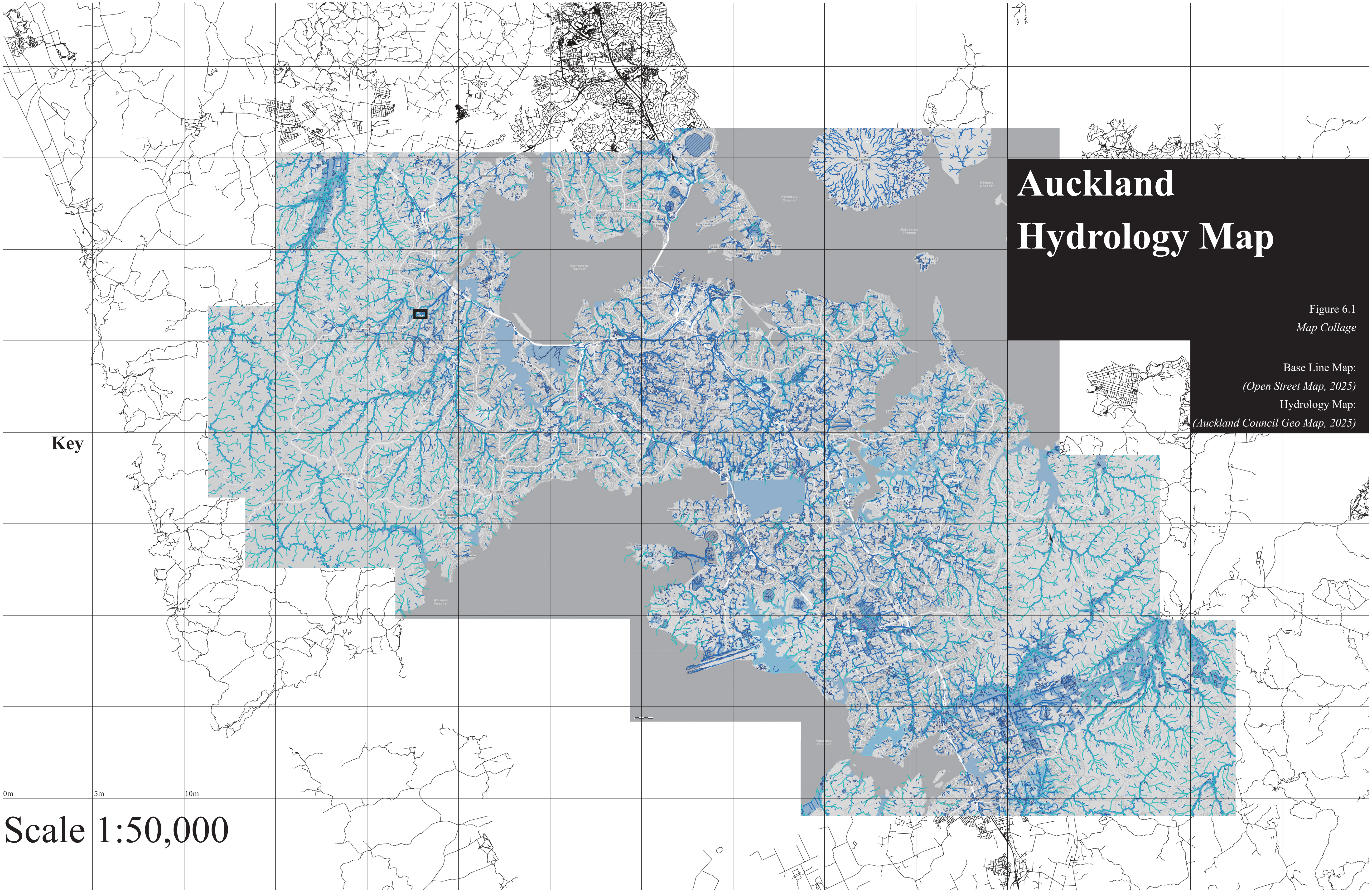
Figure 5.2
Diagram of Core concepts of Flood Resilience

6. Site Analysis

Auckland Hydrology Map

Figure 6.1
Map Collage

Base Line Map:
(Open Street Map, 2025)
Hydrology Map:
(Auckland Council Geo Map, 2025)



Key

0m 5m 10m

Scale 1:50,000

6.1 Proposed Site

Before deep in site analysis, a set of clear criteria need to be established to ensure the selected site supports the research objectives and design framework, having potential for spatial intervention.

1. The site should have documented flood risk. This may include:

- Location within an identified floodplain or overland flow path
- History of surface flooding during recent storm events
- Low-lying; near natural water systems or constrained drainage systems; reclaimed; erosion-prone areas

2. The site should contain existing flood-prone housing and able to reflect typical Auckland residential patterns. This ensures the research addresses real lived experience rather than empty land or future master-planning scenarios. This may include:

- Low- to medium-density residential fabric
- Mixed housing conditions or varied construction types
- Low floor levels housing
- Kāinga Ora housing

3. The site need to address existing community vulnerabilities. Community vulnerability affects recovery speed, relocation options, and long-term stability. Areas with constrained economic resources may experience prolonged transitional living conditions after flood events. Highly vulnerable communities may have these

characteristics:

- Low home ownership rates/high rental rates
- Residents with middle to low income levels
- Ageing building and infrastructure; inadequate drainage
- Weak transport access, unreliable utilities, poor healthcare provision, and insufficient emergency facilities.
- High proportions of vulnerable groups which require additional support during crises

- Why Clover Drive, Rānui

Clover Drive in Rānui is selected because it meets the research criteria and provides a real flood-affected context.

The site has documented flood risk, especially after the 2023 Auckland Anniversary floods, which caused severe and tragic damage in the area. News reports and official assessments documented widespread inundation, property loss, and emergency response in the neighbourhood. This confirms that flooding is an ongoing and serious issue.

The area contains existing flood-prone housing that reflects typical Auckland suburban patterns. It includes low-lying residential lots, streets that function as overland flow paths, and homes directly exposed to stream and stormwater overflow. This allows the research to focus on real living conditions rather than empty land or future development scenarios.

Clover Drive also faces social and economic vulnerability. Many households have limited financial resources and limited relocation options, which can slow recovery after flood events. These conditions affect long-term stability and highlight the need for design strategies that support continued inhabitation.

In addition, the site is part of 'Making Space for Water programme led by Auckland Council. Ongoing interventions such as blue-green infrastructure and property buyouts make it suitable for testing architectural responses within an existing planning and recovery framework.

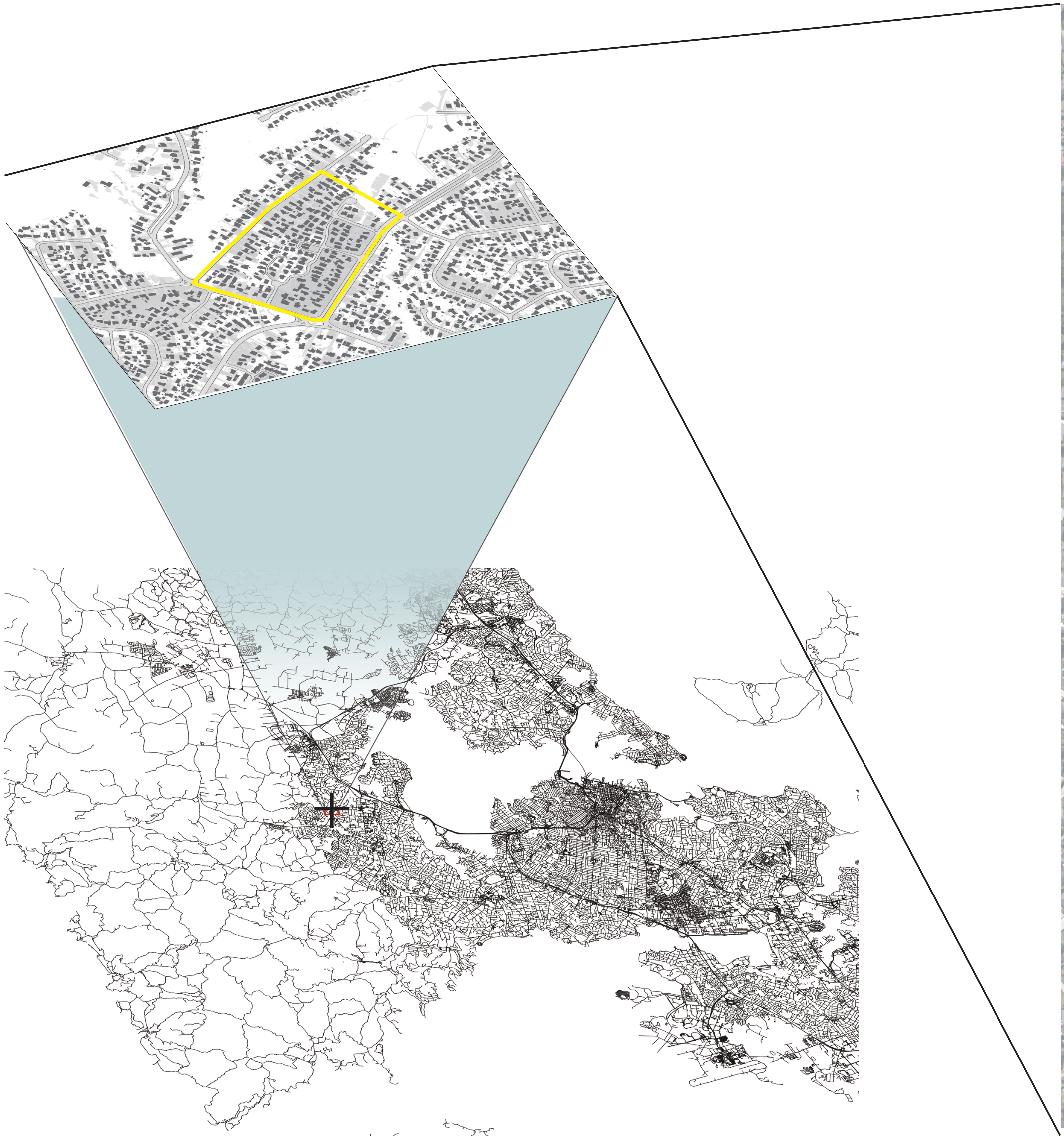


Figure 6.2
Auckland city road line map

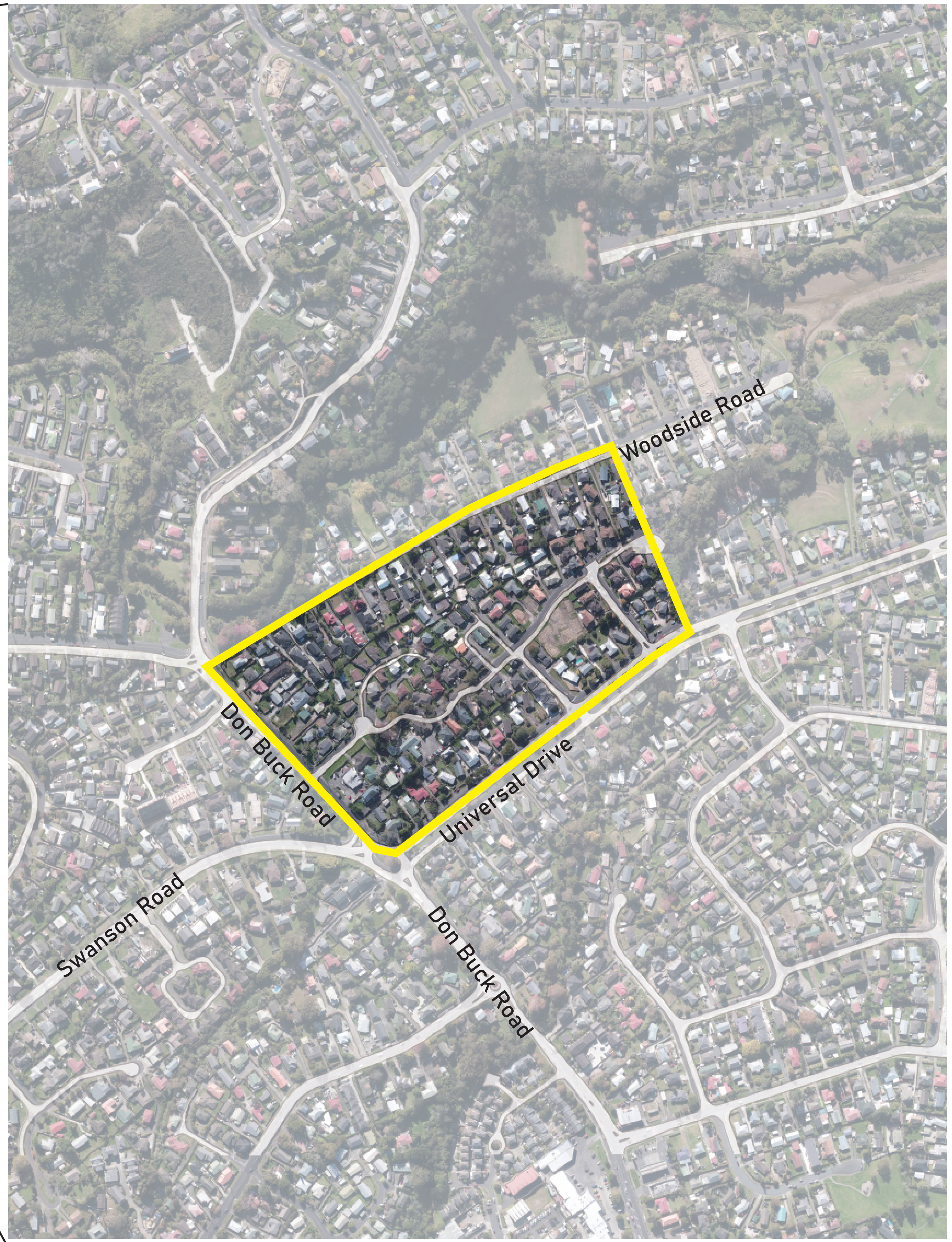


Figure 6.3
Clover Drive area Satellite Map
(Google map, 2025)

6.2 Information on the Selected Site

The Clover Drive area is a residential neighbourhood situated in the West Auckland suburb (within the Henderson-Massey Local Board).

Population (2023 Census): About **14,190** residents.

Age Groups:
23% under 15 years
22% aged 15–29
45% aged 30–64
9.4% aged 65+

Ethnic composition (Stats NZ, 2024):
37.7% European/Pākehā
21.3% Māori
26.5% Pasifika
30.3% Asian

Nearly **39%** of residents were born overseas, which contributes to the variety of languages, cultures, and religions in the community (Stats NZ, 2024). It is an established, diverse, and family-oriented community.

Historically, the area was largely rural, with land used for horticulture and poultry farming throughout the early and mid-20th century. From the 1960s onwards, like many parts of Auckland's urban fringe, it underwent significant subdivision and development to become the the residential suburb it is today (Teara, n.d.).

The community is characterised by its high proportion of families and multi-generational households. The area has a significant Māori and Pacific population, contributing to a strong and vibrant cultural identity. This is reflected in local community centres, churches, and events that serve as important social hubs. Like many similar suburbs, the area faces socio-economic challenges but is also known for its strong sense of community resilience and neighbourly support.

The community services and amenities near Clover Drive including Rānui Library, Community Centre, and Train Station. Families are supported by nearby schools such as Rānui Primary, while shopping needs are met at Lincoln Shopping Centre, Countdown, PAK'n SAVE, Fresh Choice, and the local shops (One Roof, n.d.). The area is complemented by local parks and reserves, with the Waitākere Ranges close by for outdoor recreation and scenic enjoyment.

The suburb predominantly consists of modest, detached houses built between the 1990s and early 2000s (One Roof, n.d.).

Typical House Style in the Area [Source: Author site observation]

Submerged cars on West Auckland's Clover Drive during the Auckland Anniversary weekend floods in 2023. [Source: David White, 2023]

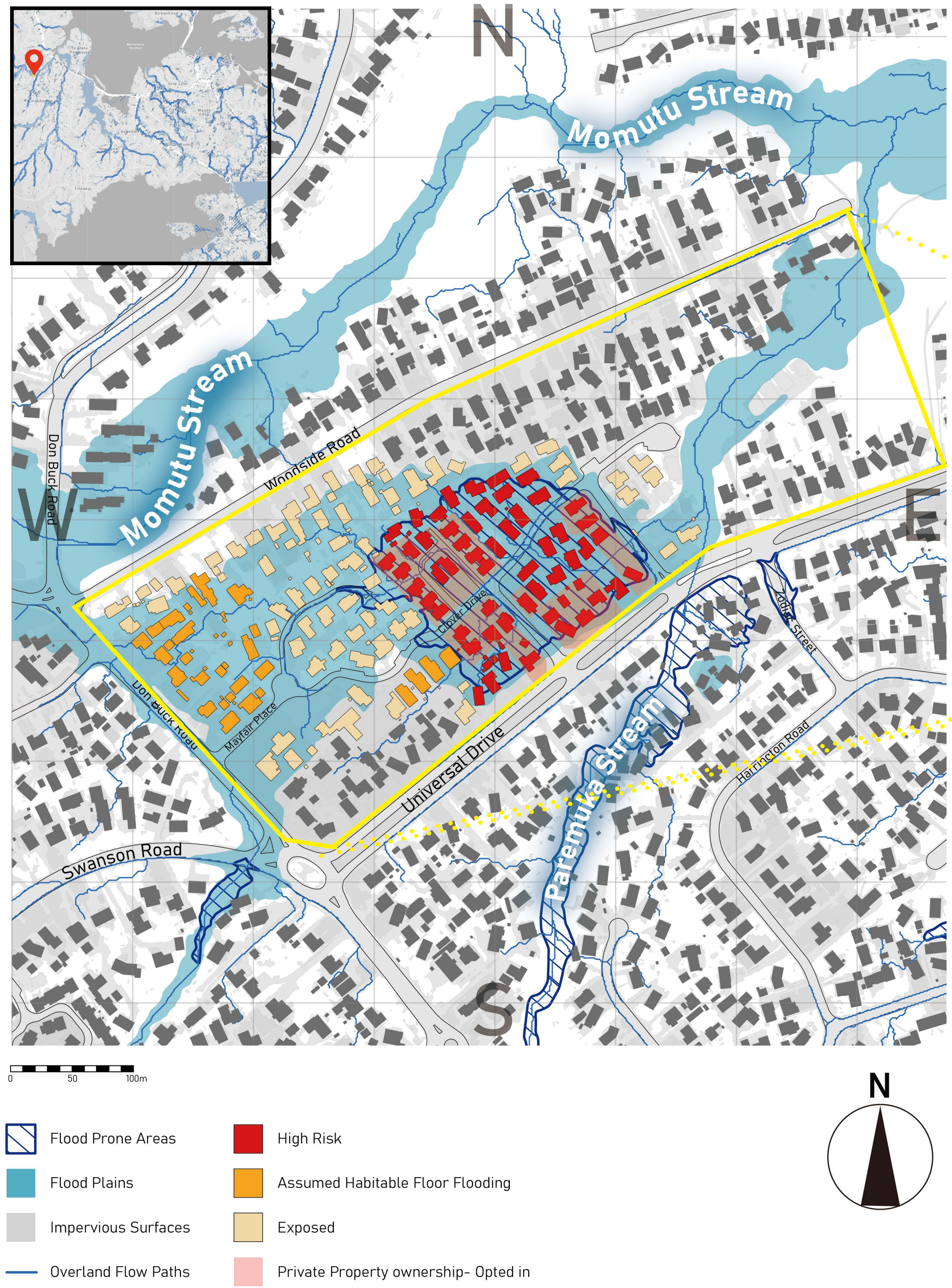
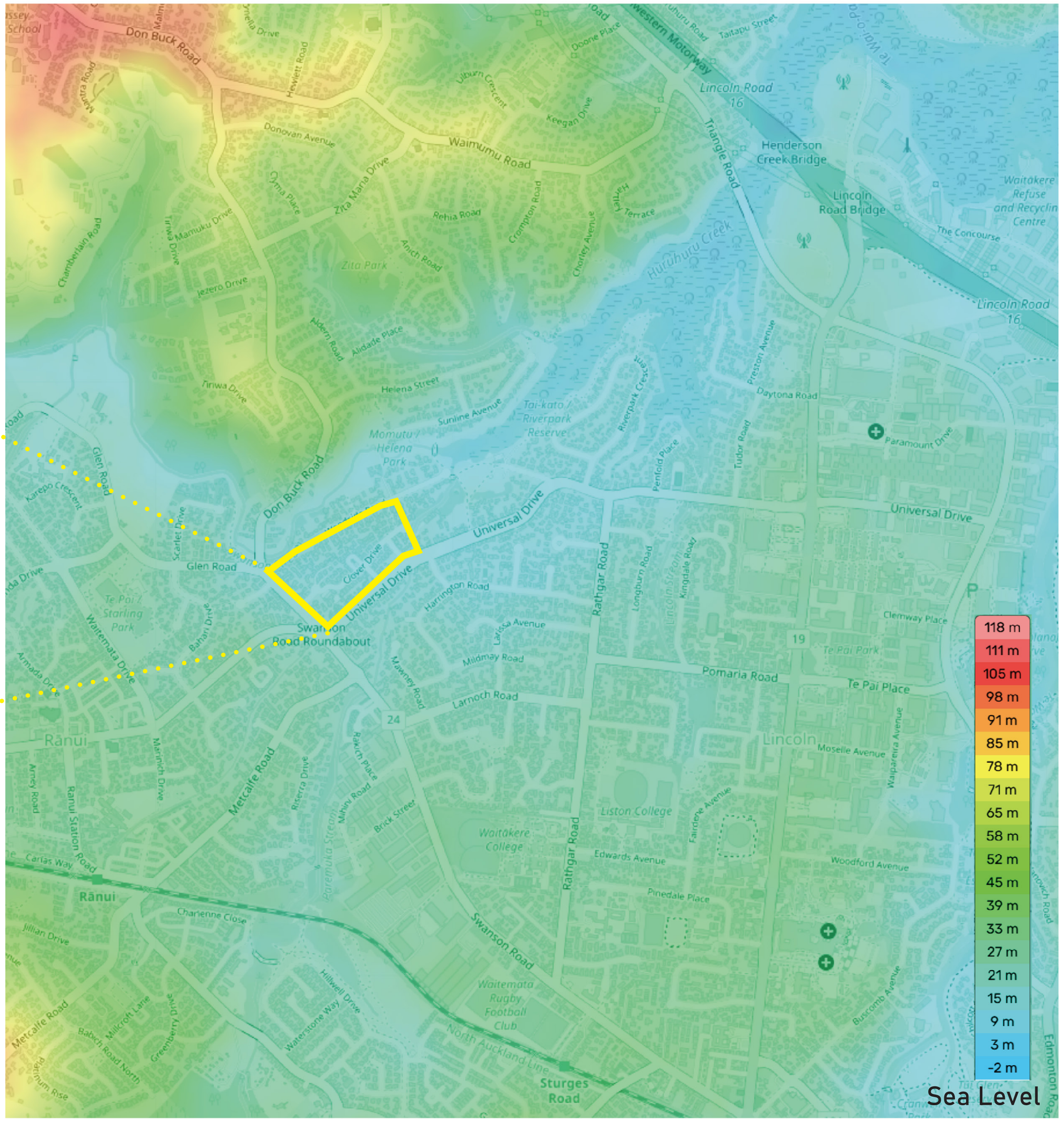
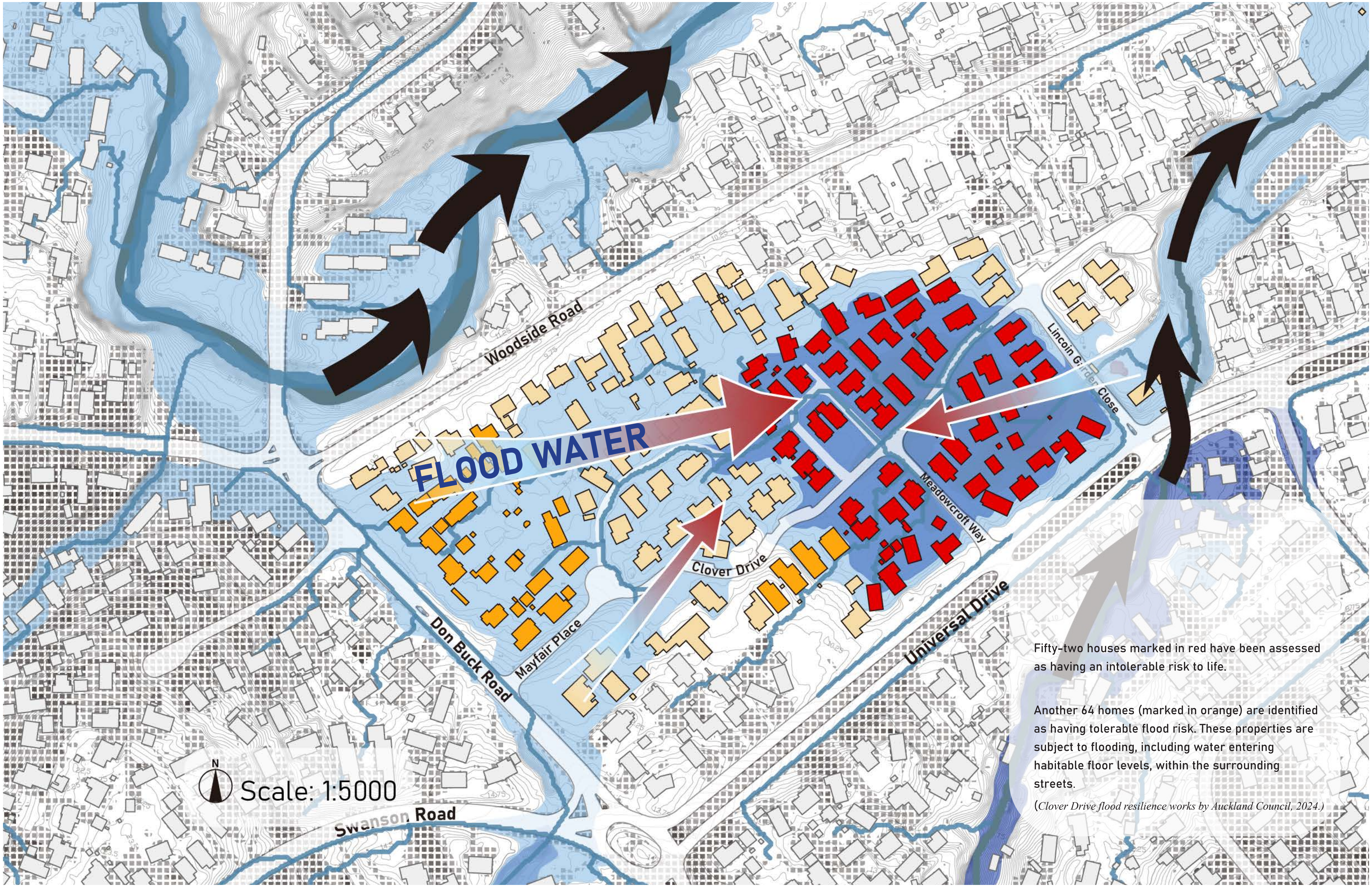


Figure 6.4
Flood prone& In risk houses Map
[Information from the report of Clover Drive flood resilience works by Auckland Council, 2024.]



The colour-coded topographic map shows that the area is located in very low-lying terrain. This means the land sits at a lower elevation than its surroundings, so water naturally flows toward and collects in this area during heavy rainfall. As a result, it has a higher risk of surface flooding and prolonged water retention.

Figure 6 .5
Colour-coded Topographic Map



Fifty-two houses marked in red have been assessed as having an intolerable risk to life.

Another 64 homes (marked in orange) are identified as having tolerable flood risk. These properties are subject to flooding, including water entering habitable floor levels, within the surrounding streets.

(*Clover Drive flood resilience works by Auckland Council, 2024.)*

Figure 6.6

Flood prone and at-risk houses

Flood Risk Assessment

[*Question from: Flood Risk: The Holistic Perspective from Integrated to Interactive Planning for Flood Resilience (Zoran Vojinovi, 2015)][Source: Clover Drive flood resilience works(Auckland Council, 2025)]*

1. Catchment Position

- The Clover Drive area is situated in an urban residential catchment in West Auckland. It is located within the mid-to-lower portion of the local stormwater catchment network, placing it in a downstream position within Rānui's urban waterway system. This topographic position inherently increases its susceptibility to collecting cumulative runoff from upstream areas.

2. Potential Sources of Flooding

Flooding at Clover Drive is a multi-source risk, primarily originating from:

- Overwhelmed Stormwater Infrastructure: Intense rainfall events exceed the capacity of the existing network, which includes undersized, ageing, or occasionally blocked pipelines and culverts.
- Waterway Overflow: High-volume events cause local streams and established overland flow paths to breach their banks.
- Surface Runoff: The prevalence of impervious surfaces in the urban landscape reduces natural infiltration, significantly accelerating and amplifying surface water flooding.

3. Flood Risk Zone Classification

The area is classified as a High Flood Risk zone.

4. Expected Flood Depths, Velocities & Return Periods

- Depth: During the January 2023 Auckland Anniversary Weekend flood event, water levels reached depths of approximately 2.0 metres within residential properties. A confidential briefing also referenced high-velocity flooding reaching 2.5 metres at a key local structure, the Don Buck Bridge.
- Return Period: The 2023 event was triggered by an extreme rainfall event with an Annual Exceedance Probability (AEP) of 0.5%, commonly termed a 1-in-200-year event.

5. Historical Flood Risk Context

The 2023 event must be understood within a historical pattern of vulnerability in West Auckland.

- Prior significant flood events in 2021 and 2022 had already stressed the region's ageing stormwater infrastructure, signalling a trend of increasing flood frequency and intensity.
- The 2023 catastrophe, during which the Clover Drive area sustained severe impacts, was unprecedented. The precipitation total for that day surpassed an average summer's rainfall and broke all previous records, overwhelming systems that were already known to be at capacity.

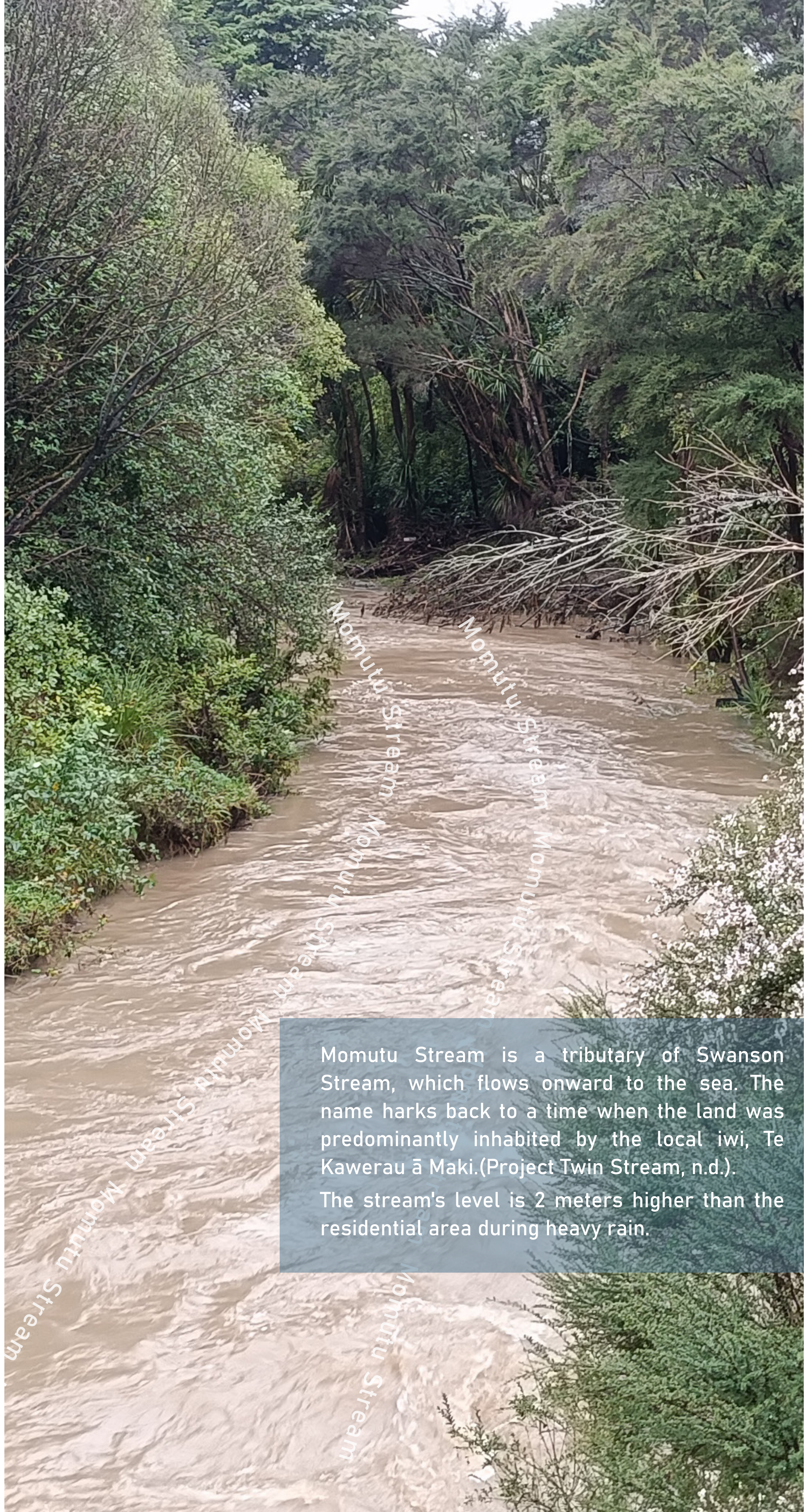
6. Future Flood Risks

Future flood risks for the Clover Drive area are projected to remain critically high due to several converging factors:

- Climate Change: Leading to more frequent and intense extreme rainfall events.
- Urban Expansion: Increasing the amount of impervious surface area and runoff.
- Ageing Infrastructure: Existing systems lack the capacity for current and future design storms.
- Mitigation Response: Auckland Council is progressing a dedicated Flood Resilience Project for Clover Drive (Auckland Council, 2024). The project is currently in the design, consenting, and funding stages, with construction anticipated to commence in late 2026 to early 2027.

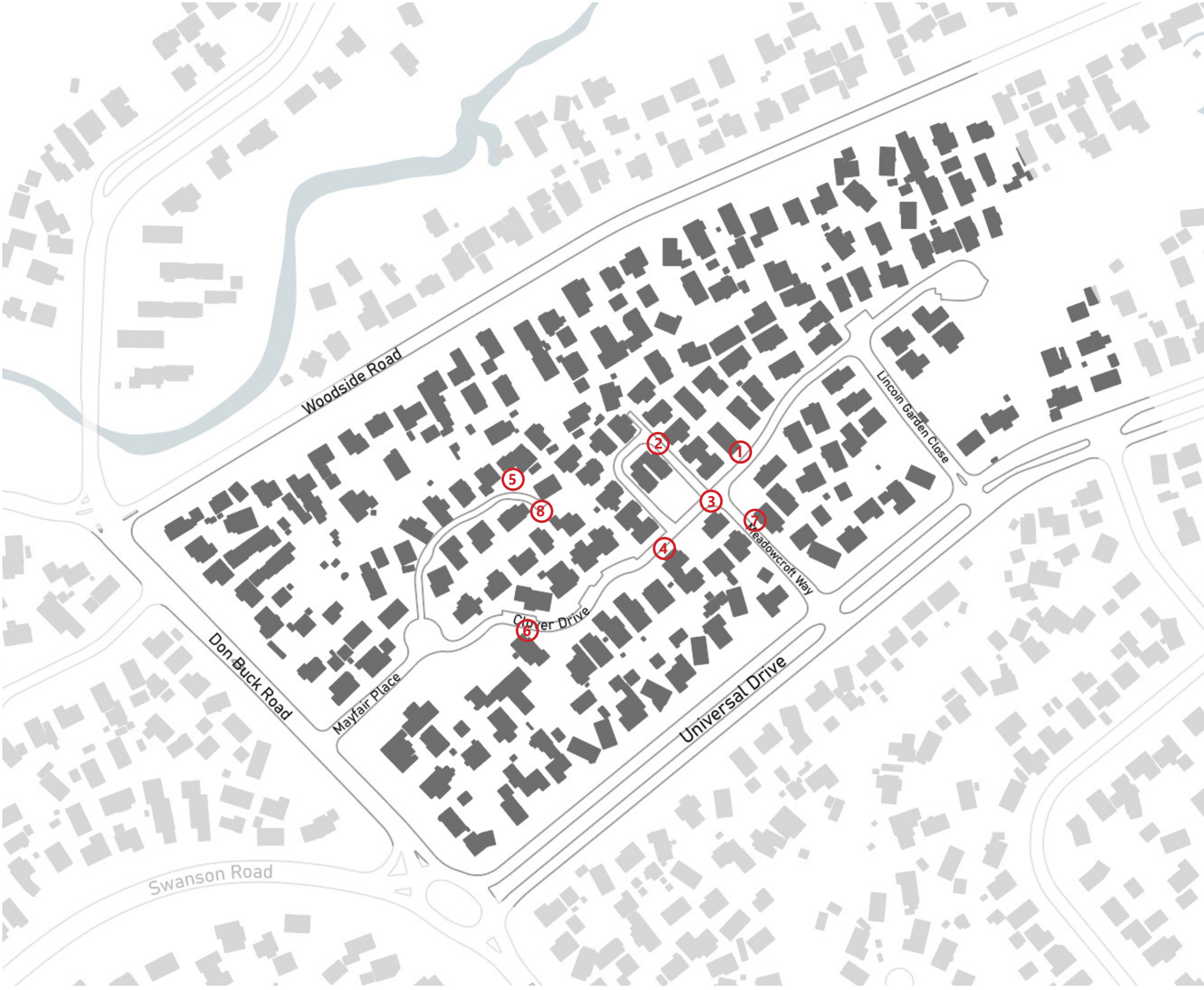
6.4 Field Observation

To enhance residents' resilience and well-being, it is necessary to identify local threats and vulnerabilities. Field observation provides a direct method for assessing physical risks, environmental conditions, infrastructure performance, and everyday living patterns.



Momutu Stream is a tributary of Swanson Stream, which flows onward to the sea. The name harks back to a time when the land was predominantly inhabited by the local iwi, Te Kawerau ā Maki.(Project Twin Stream, n.d.).

The stream's level is 2 meters higher than the residential area during heavy rain.



From my field observation, I discovered...

Left: Figure 6.7

My photos documents

Some identified issues are marked with red squares.

1. House with low floor level.

2. Floodwater could enter the building through the bottom vents.

3. These houses were severely damaged by the flood, so they were bought out by the council.

4. The bottom of the fences is enclosed, which will amplify runoff and prevent rainwater from passing freely.

5. House with low floor level; Elevation of door is not high enough; The air condition unit is placed on ground level.

6. The air condition unit is placed on ground level.

7. Elevation of door is not high enough.

8. The air condition unit is placed on ground level.

9. The scruffy dome is in the lowest point of the area.

10. Retaining wall. This house located in a higher elevation area, was not listed as damaged after the flood.

11. The ground level of this house is lower that the street surface.

12. The intersection of Clover Drive and Meadowcraft Way.

13. The ditch was blocked by fallen leaves and grass clippings.

14. This house was damaged in the flood, resulting in material leaks and mould growth; it is currently under access restrictions and vacant.

15. The lawn offers low infiltration capacity and easily accumulates water during rain.

16. This sign indicates that the stream is part of Project Twin Streams.

Clover Drive on Rainy Day

This photo shows the high proportion of imperme-able surfaces on the streets of this neighbourhood.

Observation Findings & Reflection

Typography & Street Profile

- The neighbourhood is situated in almost the lowest-lying area of the community, nestled between two streams. The two main roads (Universal Drive, Don Buck Road) are above the lowest point of the neighbourhood.
- Kerb heights are low and visually continuous, offering limited capacity to contain or redirect surface water. There is little evidence of depressed kerbs, overflow weirs, or controlled release points.
- Street surfaces are impermeable. No visible permeable paving, infiltration strips, or bio-retention elements are integrated into the carriageway or verges.

Housing

- Most dwellings are single-storey or low-rise houses typical of mid-to-late suburban development. They appear to have been built during periods when flood risk was not a primary design consideration. The housing form reflects a car-oriented, low-density model.
- Most of houses have a foundation that is raised in three or four steps. However some electrical appliances, such as air conditioning units, were not raised to the same height at the same time
- External walls are predominantly constructed with lightweight timber framing, finished with cladding or brick veneer. Internal ground-floor finishes are likely to be moisture-sensitive, making these materials prone to mould growth following flooding.

Ecology

- The stream is running high and fast, with visibly turbid brown water. This indicates recent heavy rainfall and strong upstream runoff.
- Visible rubbish, including plastic materials and discarded items, indicates informal dumping or storm-transported waste. Floodwater likely redistributes debris downstream.
- The channel width appears relatively narrow and constrained by surrounding residential development.

6.5 Historical Aerial Imagery

Figure 6.8

Series of historical Aerial imagery from Geomap

From historical aerial imagery, this neighbourhood can be traced back to before 1959. The northwestern portion of the block appears to be the earliest area of residential development.

Scope of the Site

1959

The central part of the block was formerly an open lawn with a small area of dense woodland, which may indicate the presence of an earlier ditch or stream.

Lawn

1996

2001

Over time, previously vacant lots and lawn areas were progressively infilled with residential buildings, leaving only a remnant of dense woodland.

Woodland

2010

This woodland was eventually replaced by Lincoln Garden Close, the full build-out of the block with housing.

Past Woodland

2023

In 2023, the area was severely inundated by flooding and damaged most of the homes. The coloured building footprints indicate houses that experienced varying levels of damage.

Figure 6.9
1996 Aerial imagery overlaps with the current flood zone.

Insignts from historical aerial imagery

A clear overlap can be observed between current at-risk buildings, floodplains, and flood-prone areas, and the areas identified as woodland in the historical aerial imagery in 1996.

This observation indicates a strong correlation between historical landscape features and present-day flood risk.

Areas that were formerly woodland, waterways, or un-developed land have been progressively urbanised, and these locations now correspond closely with floodplains, flood-prone zones, and buildings that suffered damage during the 2023 Anniversary Weekend flood.

This suggests that past natural drainage patterns and water-retention landscapes continue to influence flood behaviour despite later residential development, revealing a vulnerability created by building over former hydrological systems.

6.6 Community Analysis

The Henderson-Massey area has a higher proportion of middle- to low-income households, as well as larger populations of young people and minority ethnic groups. These characteristics may contribute to increased social vulnerability (EHINZ, 2023).

A higher proportion of middle- to low-income and young households reduces financial buffers. Limited savings, insecure employment, and higher debt exposure constrain the ability to prepare for, respond to, and recover from hazards. Costs associated with evacuation, temporary accommodation, insurance excess, and rebuilding disproportionately affect these households. Economic stress compounds hazard impacts, extending recovery timelines.

Data from Stats NZ (2024) indicate that home ownership in the Henderson–Massey area is below 60 percent. Data from Environmental Health Intelligence New Zealand and Massey University (2023) show that 43 percent of households live in rental housing.

This indicates substantial housing precarity. Renters typically have limited authority to retrofit dwellings for flood resilience, elevate utilities, or invest in mitigation measures. They also face higher displacement risk after hazard events if properties become uninhabitable or are withdrawn from the rental market.

Kāinga Ora

Auckland Council

Ministry for the Environment

Property Owners

Residents

Mana whenua

Renters

Community Working Groups

Stakeholders

Developers and Builders

Researchers

Insurance Companies

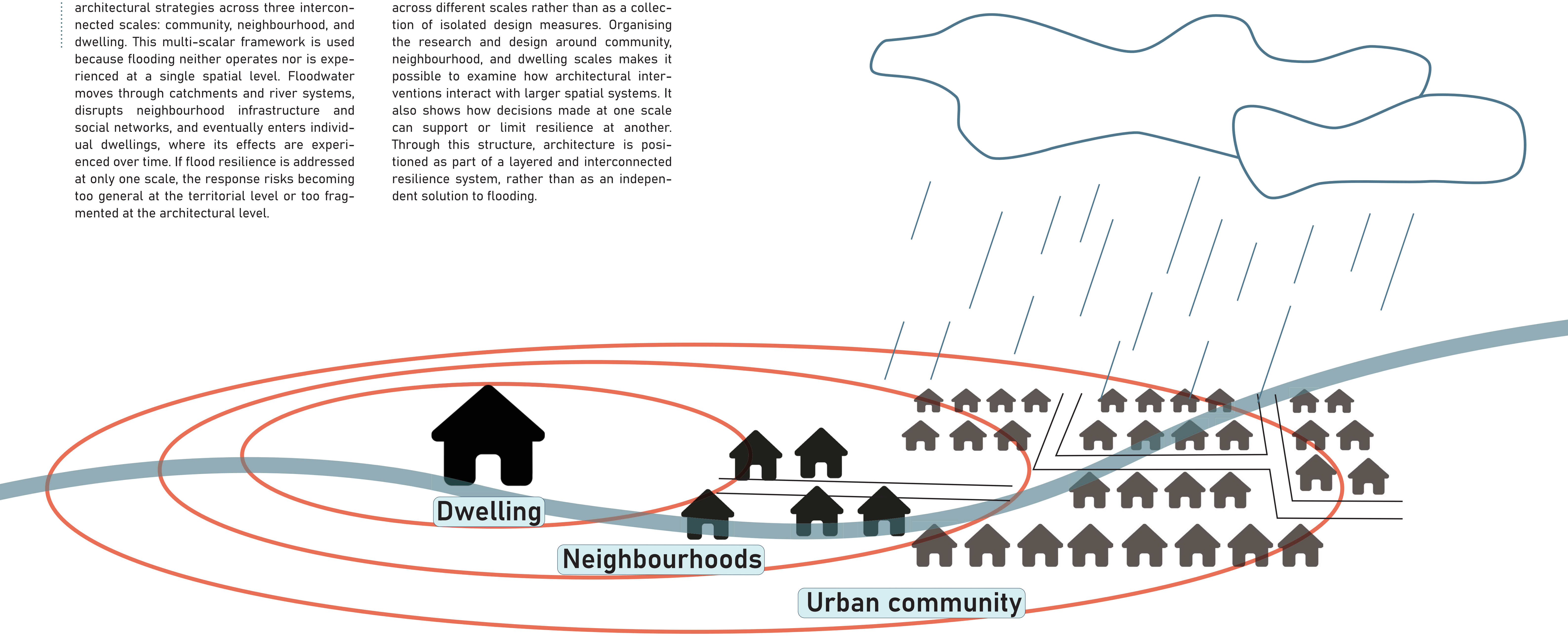
Planner, Architects & Engineers

7. Design Strategies

Multi-scalar framework

This chapter translates flood resilience principles: Adaptation, Self-sufficiency, Redundancy, Rapidity, and Community and Culture, into architectural strategies across three interconnected scales: community, neighbourhood, and dwelling. This multi-scalar framework is used because flooding neither operates nor is experienced at a single spatial level. Floodwater moves through catchments and river systems, disrupts neighbourhood infrastructure and social networks, and eventually enters individual dwellings, where its effects are experienced over time. If flood resilience is addressed at only one scale, the response risks becoming too general at the territorial level or too fragmented at the architectural level.

For this reason, a multi-scalar approach is necessary to understand resilience as a condition that emerges through coordination across different scales rather than as a collection of isolated design measures. Organising the research and design around community, neighbourhood, and dwelling scales makes it possible to examine how architectural interventions interact with larger spatial systems. It also shows how decisions made at one scale can support or limit resilience at another. Through this structure, architecture is positioned as part of a layered and interconnected resilience system, rather than as an independent solution to flooding.



7.1 Community Scale

▪ Flood Logic

At the community scale, flooding is primarily driven by catchment-wide hydrological processes, including river overtopping, surface runoff, and stormwater backflow. When water is constrained by hard infrastructure, flood depth and duration increase downstream, amplifying damage to residential areas.

Precedent Study One — *completed in* ***2022***

Te Ara Awataha & Greenslade Reserve

Te Ara Awataha in Northcote, Auckland is a 1.5 km blue-green corridor and regenerative greenway project that restores and daylights the Awataha Stream; links parks, homes, the town centre, schools, and open spaces; and manages stormwater as part of the Northcote urban regeneration programme. The regeneration programme is led by by Kāinga Ora – Homes and Communities and Eke Panuku Development Auckland with Auckland Council's Healthy Waters, mana whenua, the Kaipātiki Local Board, design partners including Isthmus and WSP, alongside community, schools, and civil and ecological partners (Auckland Council, 2023).

At the centre of Te Ara Awataha, Te Kaitaka / Greenslade Reserve was transformed into a 12 million-litre stormwater detention basin through key engineering interventions: lowering the sports field by 1–2 m (15,500 m^3 excavated), constructing floodwalls, and installing a sand-gravel base with over 2 km of drainage and irrigation pipework (Auckland Council, 2023). Ecological design added an urban wetland, daylighted stream sections, riparian planting, and terraces for recreation, effectively reinstating a functional habitat corridor and improving water quality (OurAuckland, 2023).

Grounded in the Take Mauri, Take Hono framework, the project embeds Māori cultural values and was co-developed with mana whenua, schools, and community groups. Tested during the January 2023 Auckland floods, the system reduced local flood impacts while supporting biodiversity recovery and community use, offering a scalable model of urban resilience that fuses engineering innovation with ecological restoration (Kaipātiki Project, 2023).

Left: Figure 7.3

Greenslade Reserve

(Isthmus, 2023)

Above: Figure 7.4

Greenslade Reserve during the 2023 flood

(Isthmus, 2023)

During the January 2023 Auckland Anniversary Weekend flood, Greenslade Reserve functioned as a floodplain. The open grassed area allowed stormwater to spread across the park instead of concentrating in nearby streets and houses (Isthmus, 2023).

Because the reserve sits in a low-lying area near the stream, it temporarily stored overflow when water levels rose. This reduced peak flow downstream and lowered immediate pressure on surrounding residential properties.

The absence of buildings within the reserve meant that inundation caused limited structural damage. After water levels dropped, the space could drain and recover more easily than built-up areas.

Figure 7.5

Master Plan (Isthmus, 2023)

Precedent Study Two

completed in **2022**

Kāinga Ora Development in Roskill South and Freeland Reserve

Kāinga Ora's Roskill South development and the upgraded Freeland Reserve in Mt Roskill are part of a large-scale urban regeneration project in Auckland that will deliver around 920–970 new homes, upgraded infrastructure, parks, and green stormwater management as part of the wider Roskill Development, led by Kāinga Ora – Homes and Communities with partners including Auckland Council's Healthy Waters, the Puketāpapa Local Board, mana whenua, the LEAD Alliance for civil works. Context and community stakeholders contributed to the design for the reserve and public spaces (Auckland Council, 2022; Roskill Development, 2022).

Freeland Reserve project included the daylighting of Oakley Creek (Te Auaunga Awa), restoring its natural hydrological function. Wetland capacity was expanded through the planting of native trees and plants, enhancing stormwater absorption and ecological performance. Three floodwalls were introduced to manage overflow during peak flood events. Pedestrian safety and accessibility were improved through the installation of a signalised intersection, alongside four widened walkways that strengthen connections between surrounding residential areas, the reserve, and Primary School (Auckland Council, 2022; Roskill Development, 2022; Context 2022).

During the 2023 Auckland floods, Freeland Reserve functioned as designed as a flood-adaptive green space. The restored stream corridor and expanded wetland areas absorbed and temporarily stored excess stormwater, reducing pressure on nearby properties. Water was directed along planned overland flow paths through the reserve rather than spreading into residential streets.

The three floodwalls and raised landscape elements helped control overflow and protect surrounding housing. Native vegetation and increased permeable surfaces slowed runoff and improved water retention. The reserve functioned as designed, protecting adjacent homes and supporting neighbourhood connectivity (Roskill Development, 2023).

Left: Figure 7.6

Aerial View of Freeland Reserve

Above: Figure 7.7

Freeland Reserve during the 2023 flood

Figure 7.8

Aerial view of Freeland Reserve

Identified Architectural Strategies

Community Scale Strategies: Redistributing and Holding Water

- ### Design Strategies

1. Redistribution of floodwater through widened river corridors and designated overland flow paths, reducing pressure on residential plots.

2. Retention and detention basins embedded within public open space to temporarily store floodwater during peak events.

3. Vegetated flood landscapes, including wetlands and riparian planting, to slow water velocity, enhance infiltration, and improve ecological performance.

- ### Architectural Role

Landscape at this scale does not attempt to exclude water, but instead provides spatial capacity for flooding. By shaping landform, vegetation, and public space establishes a buffer that reduces flood intensity before water reaches neighbour-hood streets and dwellings.

- ### Limitations

These strategies cannot prevent extreme flood events and depend on sufficient land availability and coordinated governance. Their effectiveness is reduced in highly constrained urban environments.

7.3 Neighbourhood Scale

- ### Flood Logic

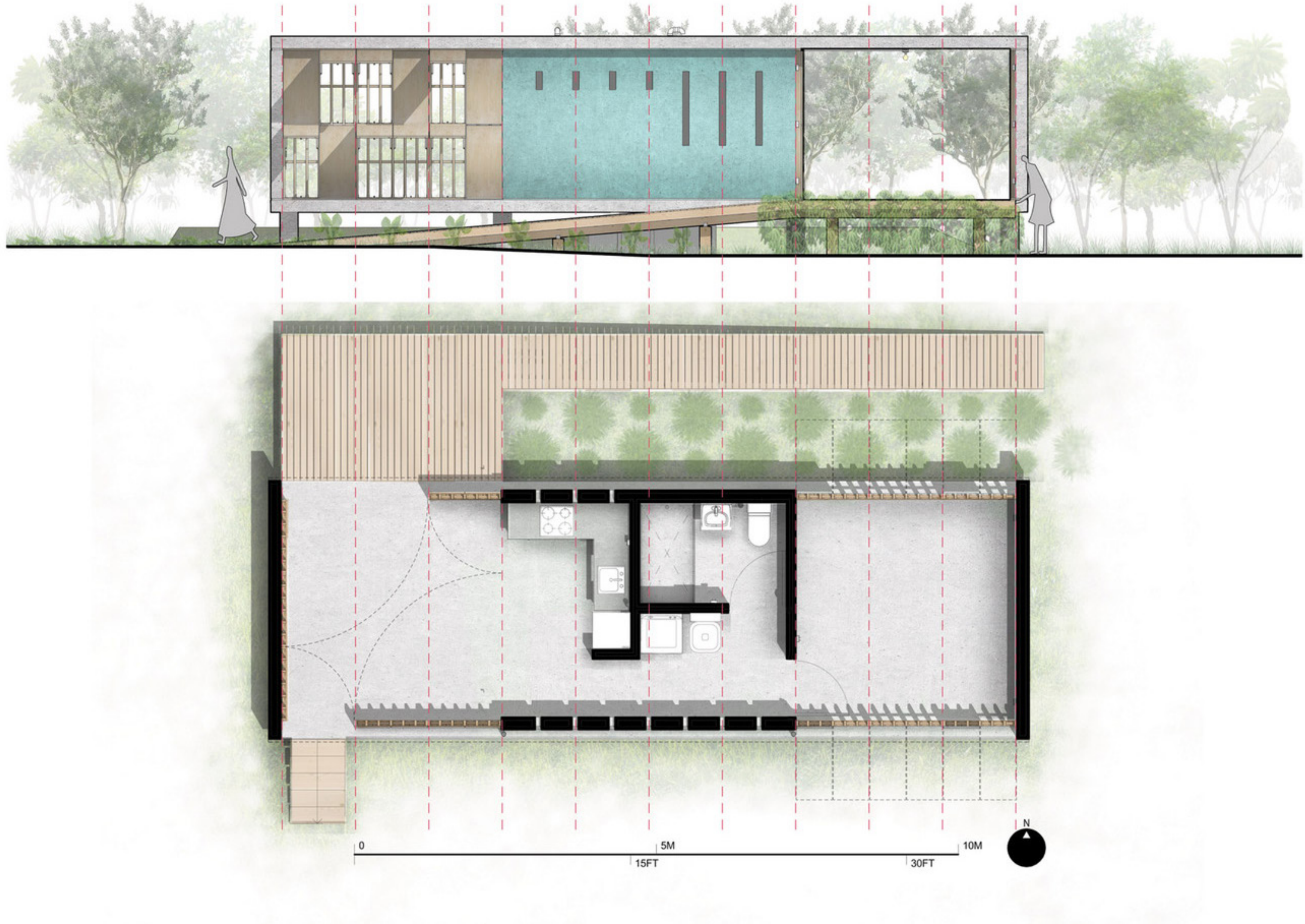
At the neighbourhood scale, flooding disrupts movement, services, and social interaction. Streets become channels for water, power outages isolate residents, and the loss of access often determines whether people must evacuate.

Precedent Study Three *completed in* ***2017***

Moriviví House: The Hurricane-Proof Project that Builds Community

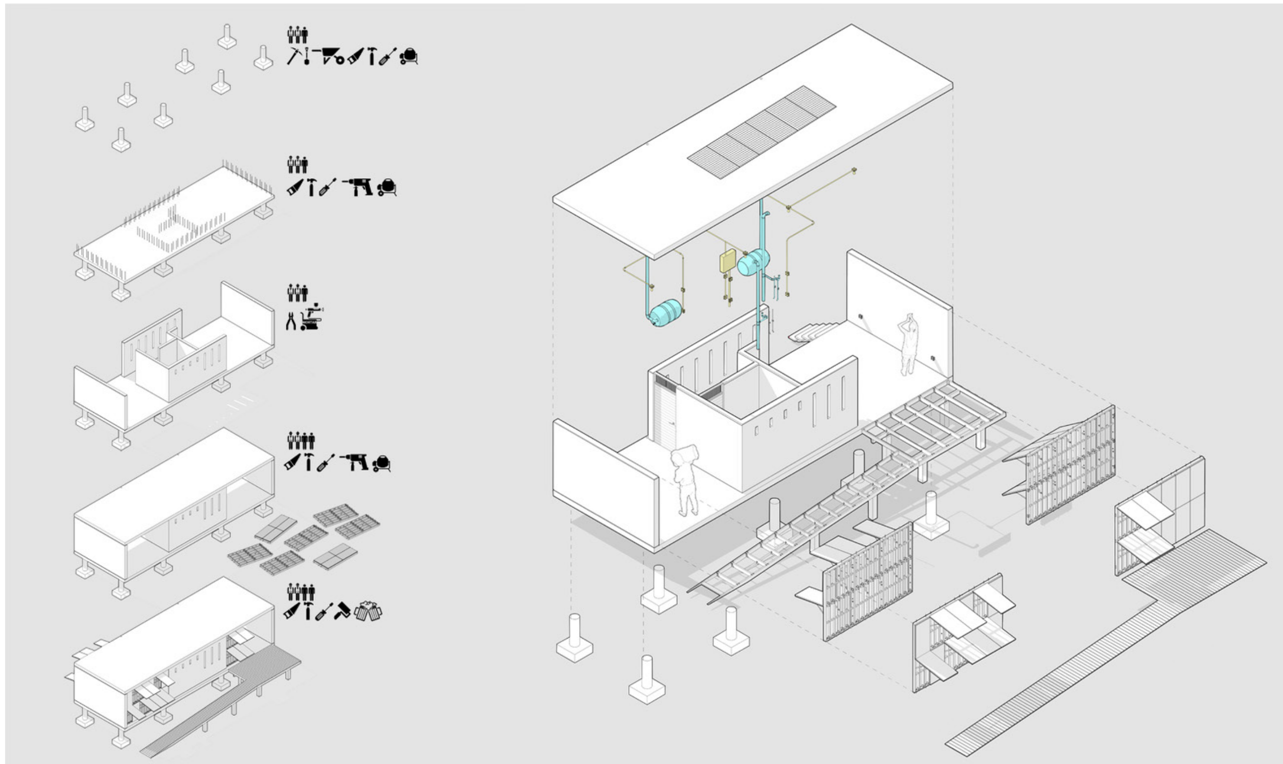
Hurricane María (2017) exposed Puerto Rico's infrastructural weaknesses, particularly in energy reliance, housing quality, and disaster preparedness. In response, Marvel Architects designed the Moriviví prototype. It is a 53m² modular, self-buildable home integrating passive and active resilience strategies. Influenced by traditional tropical design, it features elevated, flood-resistant foundations, operable wooden screens for cross-ventilation, and native landscaping for thermal comfort. Off-grid systems, including solar panels (12kWh/day), an 800L rainwater cistern, and low-energy appliances, reduce reliance on public utilities. With adaptable materials like bamboo and concrete, and communal elements such as porches and shared walkways, the prototype offers a scalable model for post-disaster housing (Hernández, D., 2019).

Figure 7.10
Moriviví House during a rainstorm



Above: Figure 7.11
Elevation & floor plan of Moriviví House

Below: Figure 7.12
Building tectonic of Moriviví House

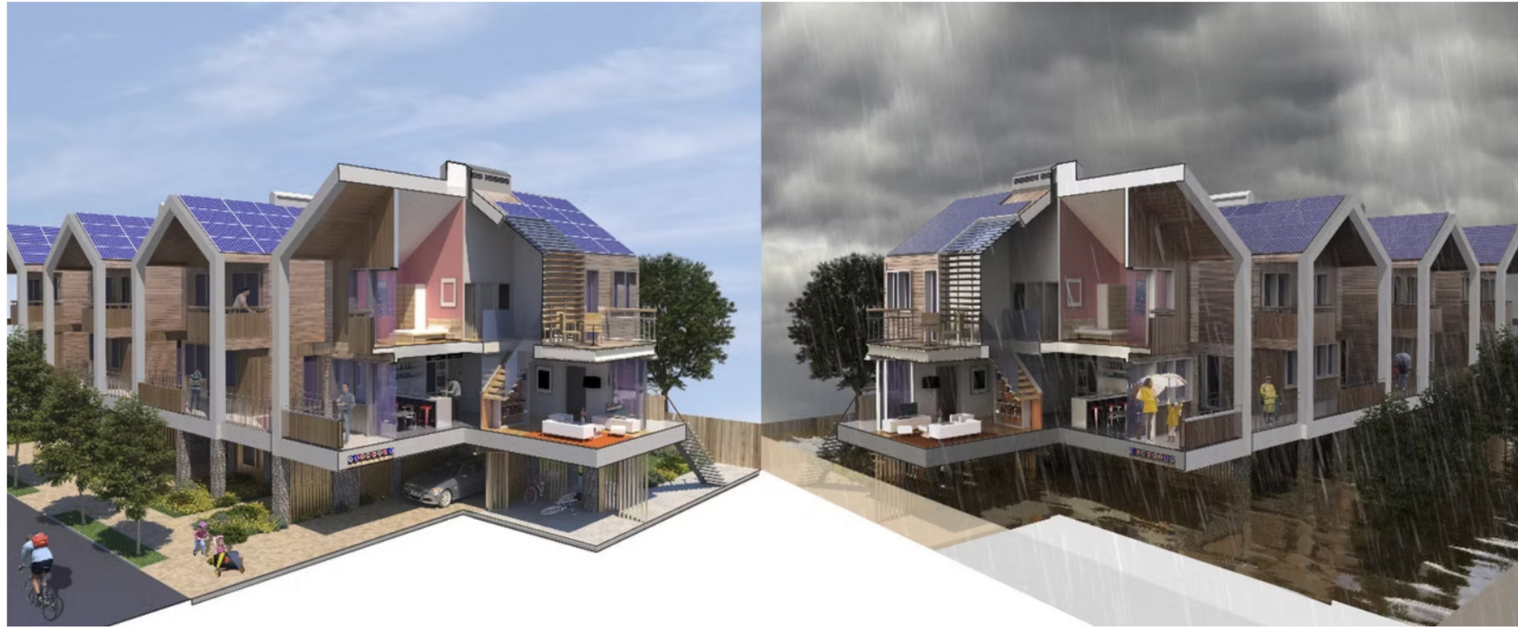


Precedent Study Four *Architectural Competition in* **2016**

The Home for All Season by TEDS and JTP

Home for All Seasons was developed by TEDS (The Environmental Design Studio) in collaboration with JTP and won the Sunday Times British Homes Awards Resilient Home competition in late 2016. The design is a residential housing concept intended for replication at new build and community scale; TEDS is currently working on testing the concept at scale to realise it in practices (TEDS, 2016).

The project is a climate-resilient housing concept that anticipates future environmental stresses such as flooding, heat waves, extreme cold, energy shortages, and broader societal change. It reframes resilience not as a compromise but as an integral design feature that enhances everyday living. The design places habitable areas and utilities above expected flood levels and includes elevated walkways so residents can maintain access during flood events. The ground level is designed as a multi-use space that can be easily cleaned and restored after flooding. Measures such as limiting the building's hardstanding footprint support sustainable drainage and reduce disruption to surrounding areas(TEDS, 2016)..



Left: Figure 7.13
Scenario in summer
(TEDS, 2016).

Above: Figure 7.14
Perspective section of sunny day and rainy day
(TEDS, 2016).

Below: Figure 7.15
Model of the houses
(TEDS, 2016).

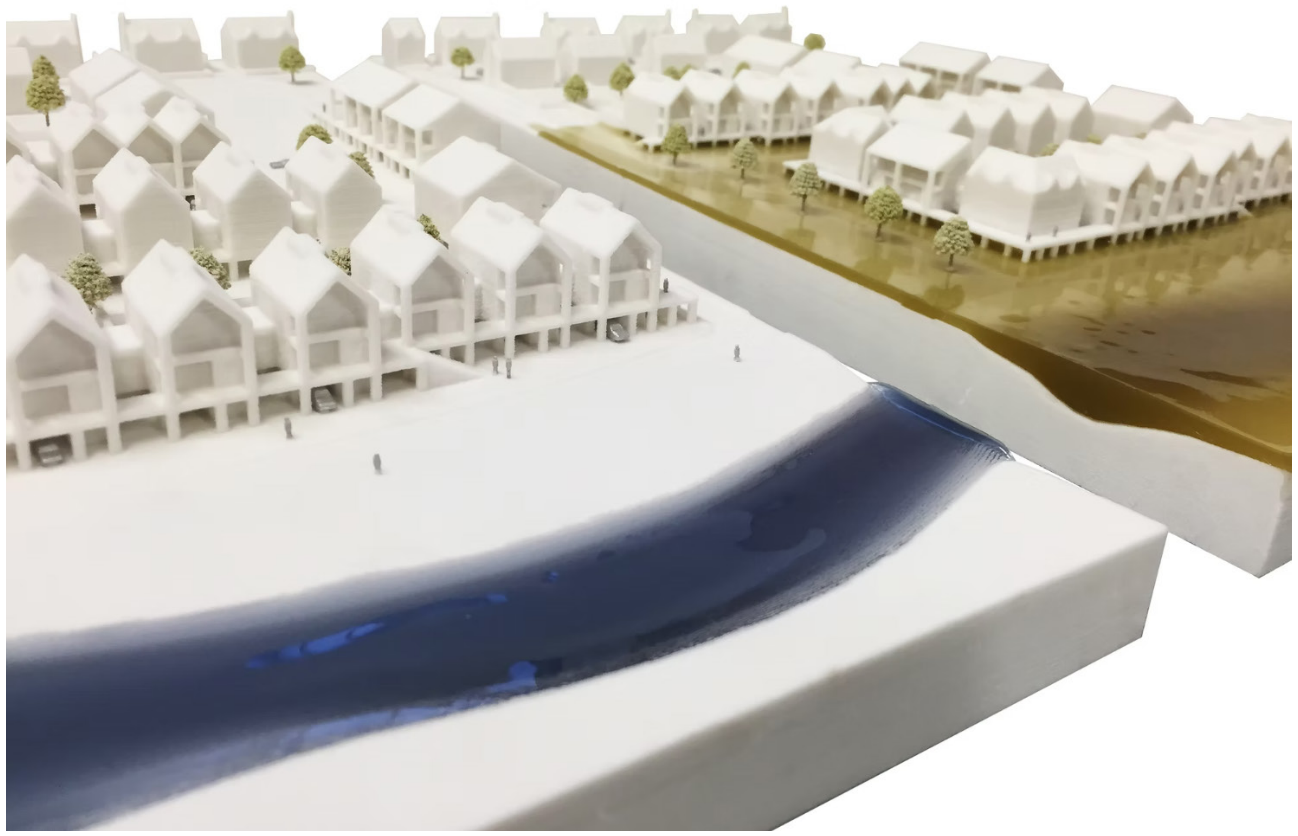


Figure 7.16

The construction process of the bridge

(Huang & Huang, 2025)

Figure 7.17

Students were walking on Dajia Street temporary steel bridge

(Huang & Huang, 2025)

Community-Built Temporary Flood Bridge After Typhoon Ragasa

In October 2025, Dajia Street in Jingxi City, Guangxi, China, experienced severe waterlogging due to continuous heavy rainfall brought by Typhoon Ragasa. The deepest floodwater reached 2.3 meters, trapping over 80 households. To facilitate travel, local villagers spontaneously used recycled scaffolding to build a temporary steel bridge in the floodwaters, approximately 82 meters long and 0.7 meters wide(Huang & Huang, 2025). This bridge became the only passage for residents to transport supplies and for children to get to school. In early November, after the waterlogging was drained and the floodwaters receded, this temporary bridge was safely dismantled(You et al., 2025).

Reflection

The Dajia Street Temporary Flood Bridge shows how communities can respond quickly when formal infrastructure fails. When roads were submerged and access was cut off, they used available materials to construct a simple but functional bridge. This action restored basic mobility and allowed daily activities such as transporting supplies and attending school to continue. The bridge was narrow and temporary, yet it addressed an urgent need. Its construction demonstrates how small-scale, low-cost interventions can support survival and continuity during extreme events.

Identified Architectural Strategies

Neighbourhood-Scale Strategies: Maintaining Connection and Collective Function

- ### Design Strategies

1. Continuous elevated pedestrian connections that remain usable during flood events, linking homes to shared refuge points and higher ground.

2. Flood-adaptive street sections that accommodate water flow while maintaining safe pedestrian movement.

3. Neighbourhood-scale energy microgrids, providing partial self-sufficiency when centralised power systems fail.

- ### Architectural Role

Neighbourhood-scale architecture supports collective resilience by prioritising access, visibility, and shared infrastructure. These strategies recognise that resilience is not only about individual dwellings but also about maintaining social and functional networks during disruption.

- ### Limitations

Microgrids and elevated connections require upfront investment and long-term maintenance. They cannot fully replace centralised infrastructure and are most effective when integrated with broader community-scale systems.

7.4 Dwelling Scale

▪ Flood Logic

At the dwelling scale, flooding is experienced directly through water ingress, service failure, and loss of usable space, traditional housing typologies fail abruptly when water enters living spaces. The key challenge is not only preventing damage, but enabling residents to remain safely housed during periods of uncertainty.

Precedent Study Five

***completed in* 2017**

The Flood Resilient Repair Home by BRE

BRE (Building Research Establishment) developed the Flood Resilient Repair Home as a demonstration home in response to increasing flood risk in the UK. It is the testing house of the application of Property Flood Resilience (PFR) strategies, which aim to reduce water entry into buildings (resistance measures) and limit damage when flooding occurs (recoverability measures), enabling households to recover and reoccupy quickly.

The home is a former Victorian terraced property adapted to resist floodwater up to 600 mm deep and designed to dry out quickly after flooding, so residents can return shortly after a flood event. The design incorporates water-resistant materials such as resin-bonded kitchen units, waterproof wallboards, and ceramic flooring to minimise damage during flooding. Elevated electrical outlets and flood-resistant doors and windows further enhance resilience. An integrated sump pump system automatically removes water, ensuring the home dries quickly and remains habitable. This approach offers a scalable model for retrofitting existing homes in flood-prone areas, emphasizing cost-effective resilience and rapid recovery (BRE, 2024).

Left: Figure 7.19

Flood Resilient Repair Home

(BRE Group, 2017)

Above: Figure 7.20

Using fire hoses to flood the BRE flood house showing its resilience

(Boyd, E. H., & Bonfield, P., 2017)

Below: Figure 7.21

An automatic 'sump pump' connected to drains in the floor (BRE Group, 2017)

Precedent Study Six

completed in **2024**

The Flood Resilient Garden at Chelsea Flower Show 2024 in UK

By Flood Re, environmental expert Dr. Ed Barsley and garden designer Naomi Slade

The Flood Resilient Garden at the 2024 RHS Chelsea Flower Show in the UK addressed the increasing threat of flooding to residential areas, where one in four homes in UK faces flood risk. Designed collaboratively by garden designer Naomi Slade and environmental expert Dr. Ed Barsley, and sponsored by Flood Re, the garden demonstrates an integrative approach to urban and domestic flood resilience. It combines landscape design, water management infrastructure, and ecological strategies to provide a model that is both functional and visually appealing (Flood Re, 2024).

Inspired by natural hydrology, it features swales, elevated mounds, and a central pond to direct and store rainwater, alongside terraces and decks to create dry, usable zones. Dense, flood-tolerant planting, including ferns, pollarded willows, and Ranunculaceae, which supports biodiversity and mitigates runoff, while sustainable materials such as reclaimed timber and peat-free media enhance resilience. Smart water storage tanks and gradual drainage mechanisms reduce reliance on conventional drainage systems. By combining aesthetic appeal with functional flood resilience, the garden offers a scalable, replicable model for climate-adaptive domestic landscapes (Flood Re, 2024).

Left: Figure 7.22

The Flood Resilient Garden at Chelsea Flower Show (Flood Re, 2024)

Above: Figure 7.23

The swale/ stream & Mixed planting

Below: Figure 7.24

Rain chains & Smart Rainwater tank

Identified Architectural Strategies

Dwelling-Scale Strategies: Supporting Inhabitation Over Time

- ### Design Strategies

1. Elevated primary living floors, allowing residents to retreat vertically rather than evacuate horizontally.

2. Sacrificial ground floors, designed to flood intentionally using durable, repairable materials.

3. Clear wet-dry zoning, making flood thresholds legible and reducing psychological stress.

4. Rain gardens and on-site water management, slowing runoff and reducing localised inundation.

- ### Architectural Role

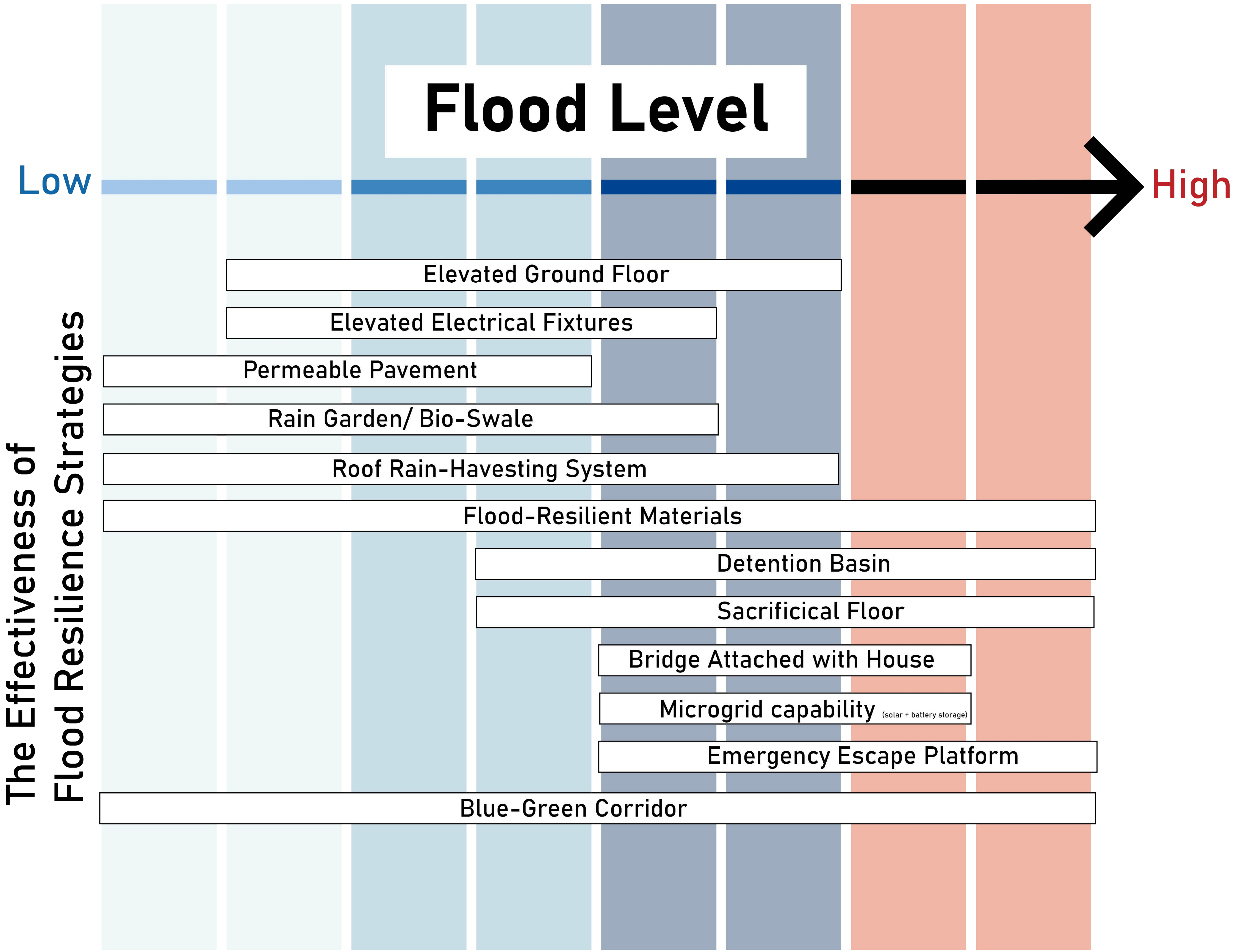
  Housing design mediates daily life during floods. Through section, material choice, and spatial sequencing, the dwelling becomes an adaptive system that supports safety, dignity, and gradual recovery rather than abrupt failure.

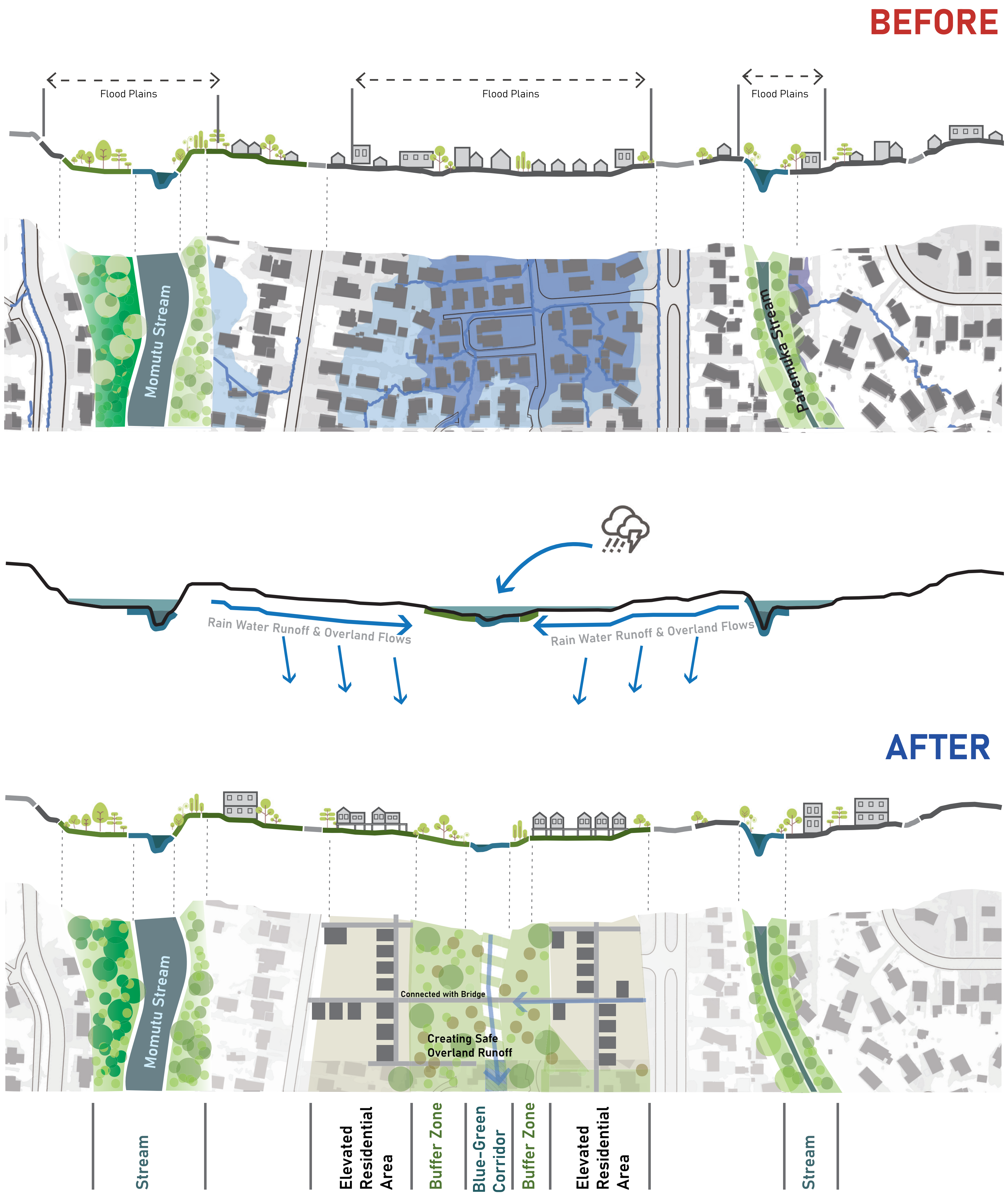
- ### Limitations

  Dwelling-scale adaptations cannot address broader catchment-level flooding alone. Without supportive community and neighbourhood infrastructure, individual housing strategies risk becoming isolated or insufficient.

8. Design Proposal

8.1 Conceptual Design


Flood Level
Low
High
The Effectiveness of Flood Resilience Strategies
Elevated Ground Floor
Elevated Electrical Fixtures
Permeable Pavement
Rain Garden/ Bio-Swale
Roof Rain-Havesting System
Flood-Resilient Materials
Detention Basin
Sacrificical Floor
Bridge Attached with House
Microgrid capability (solar + battery storage)
Emergency Escape Platform
Blue-Green Corridor



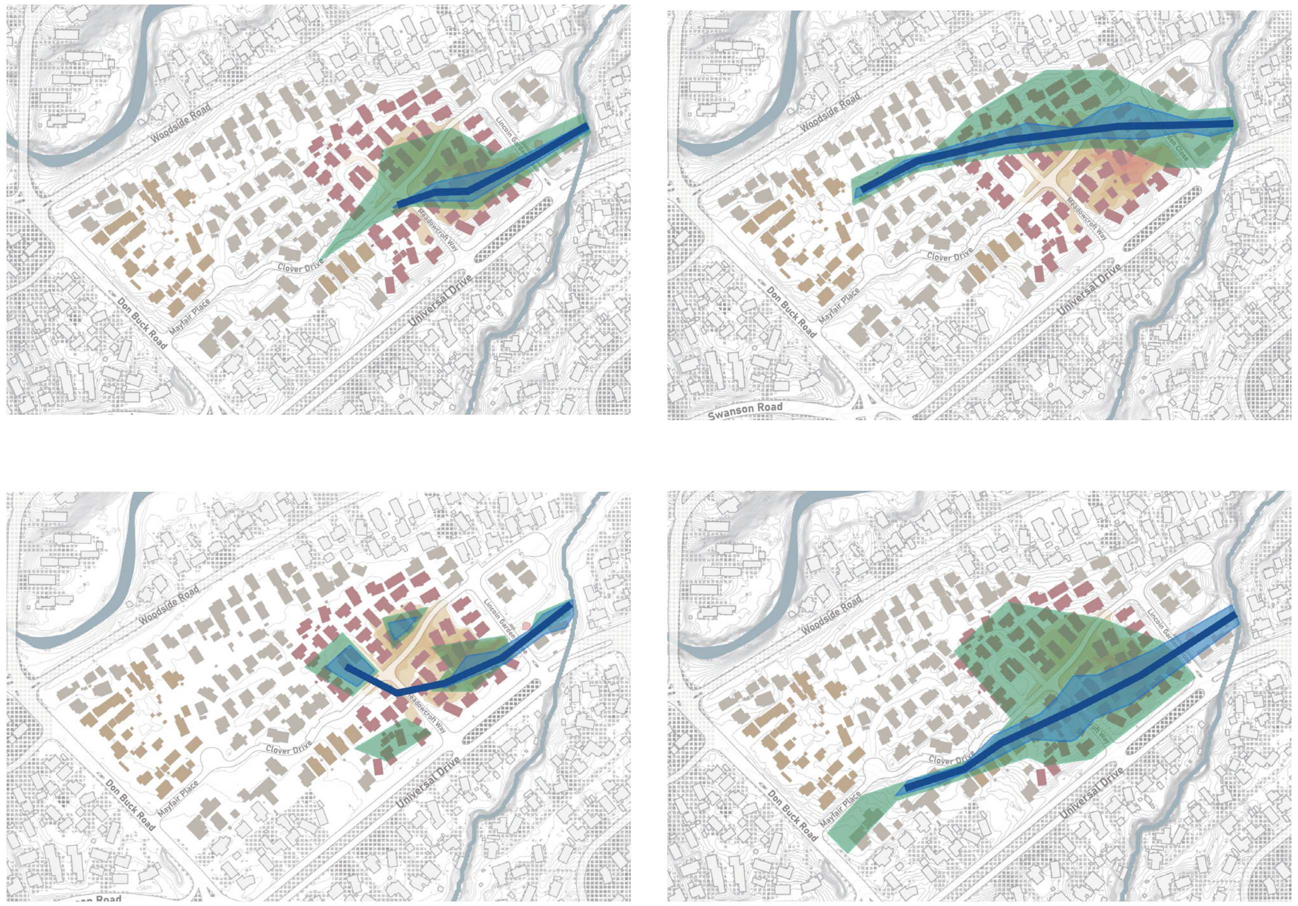
Conceptual Section of Community-Scale Master Plan

Problem

During heavy rainfall, water accelerates along asphalt surfaces and collects at low residential edges. This creates concentrated inundation zones that increase the depth and duration of flooding near housing clusters.

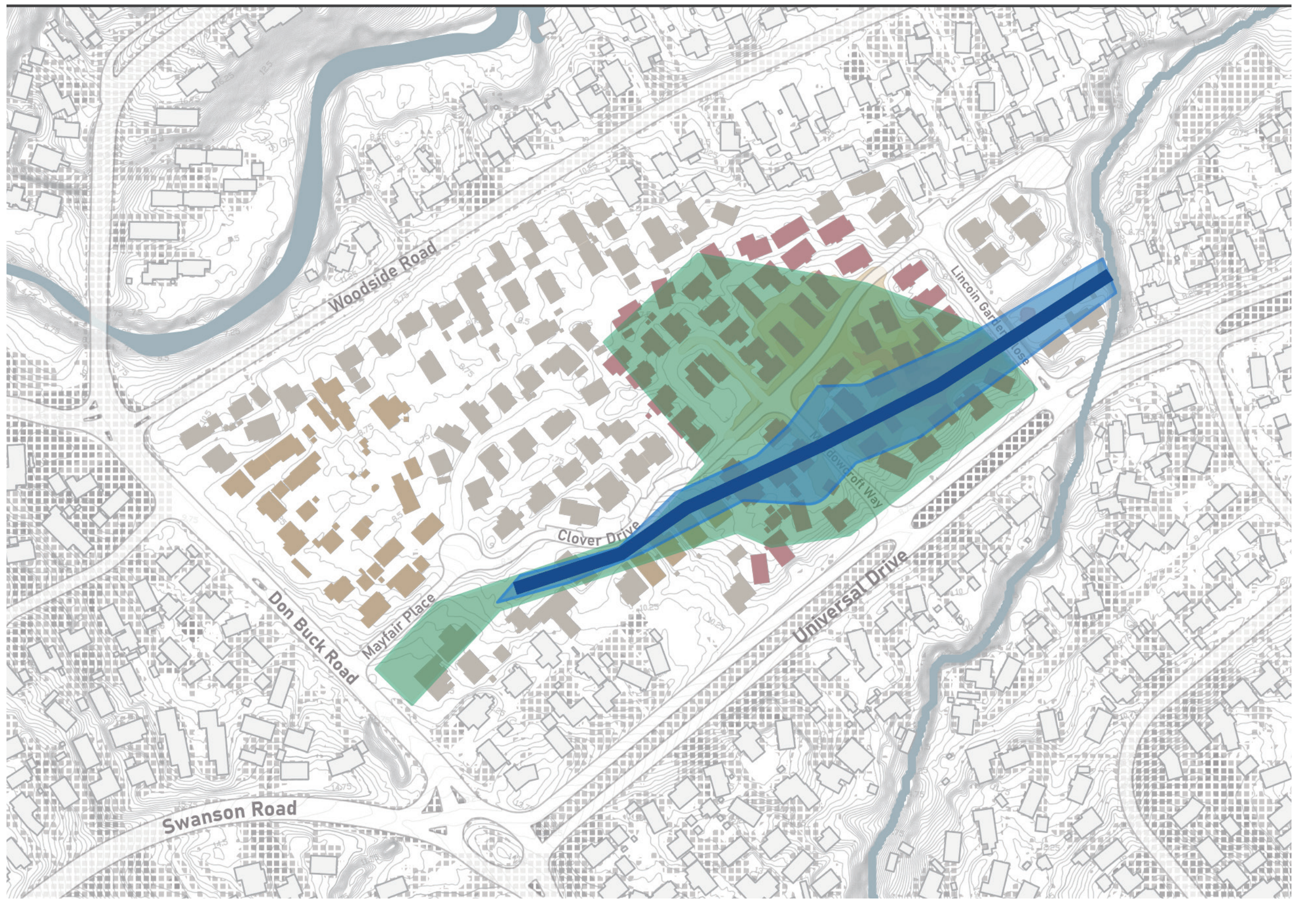
Design Move

The proposal seeks to redistribute floodwater by creating level differences within a floodable landscape system integrated into public open space. Retention basins are placed at identified low points, and vegetated corridors follow mapped overland flow paths to guide and slow water movement.



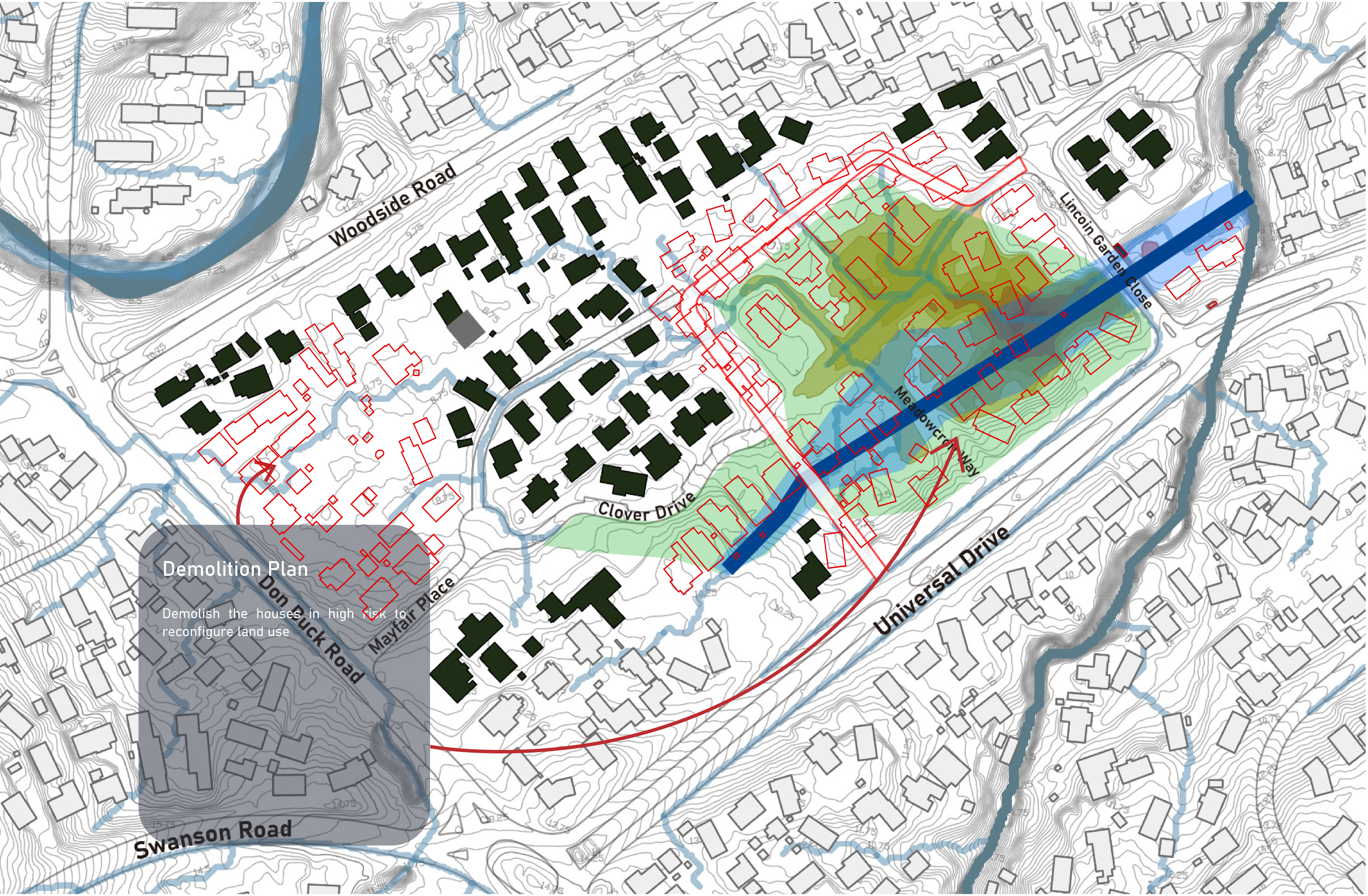
Iteration of Proposed Blue-Green Corridor

Based on the site's topography and hydrological conditions, different layout options are developed to test how water flows and how open green spaces can manage stormwater.



Chosen Plan

This plan restores the former green space and creates a safe natural buffer for floodwater. This approach guides stormwater through vegetated areas and open spaces, allowing water to slow, spread, and temporarily store during heavy rainfall.

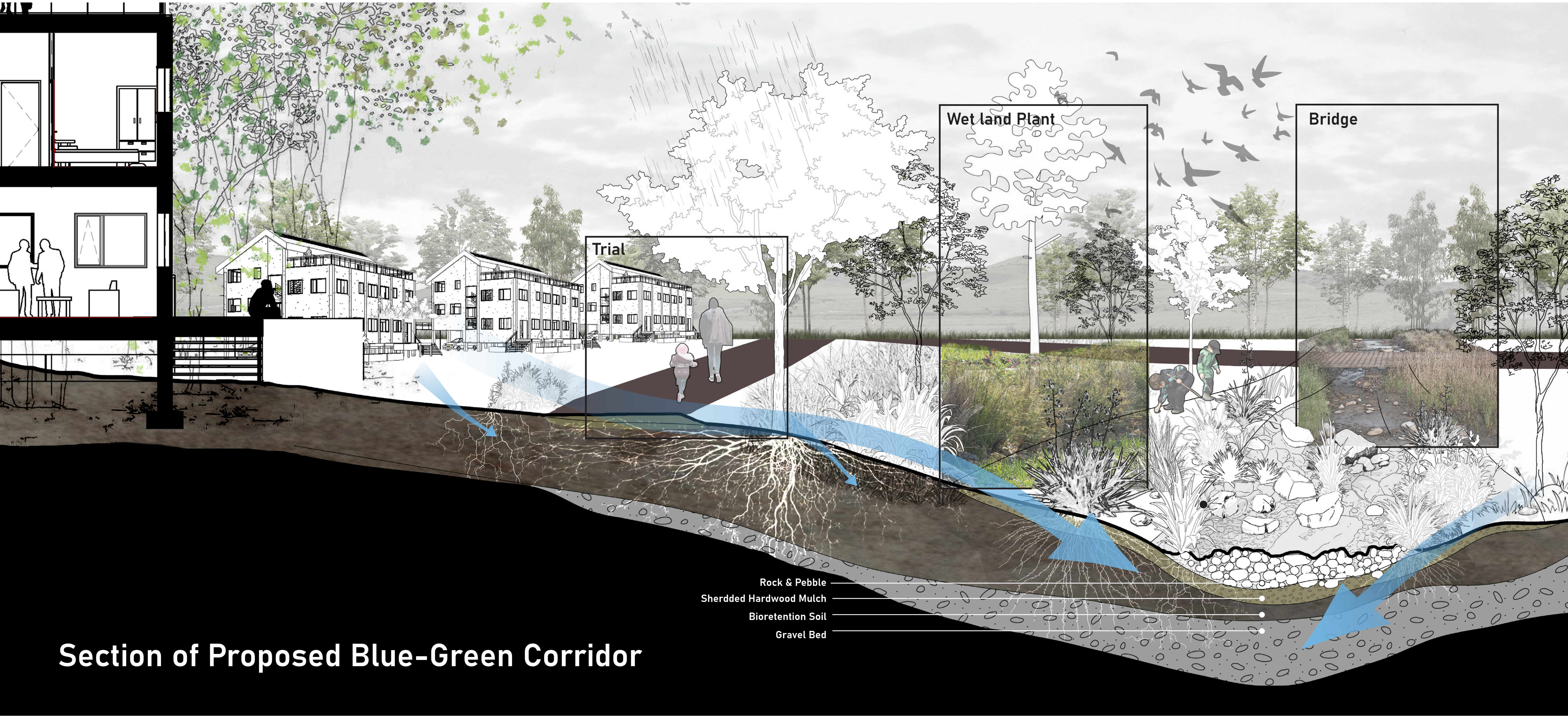


Demolition Plan
Demolish the houses in high risk to reconfigure land use
Woodside Road
Lincoln Garden Close
Meadowcroft Way
Clover Drive
Don Buck Road
Mayfair Place
Universal Drive
Swanson Road

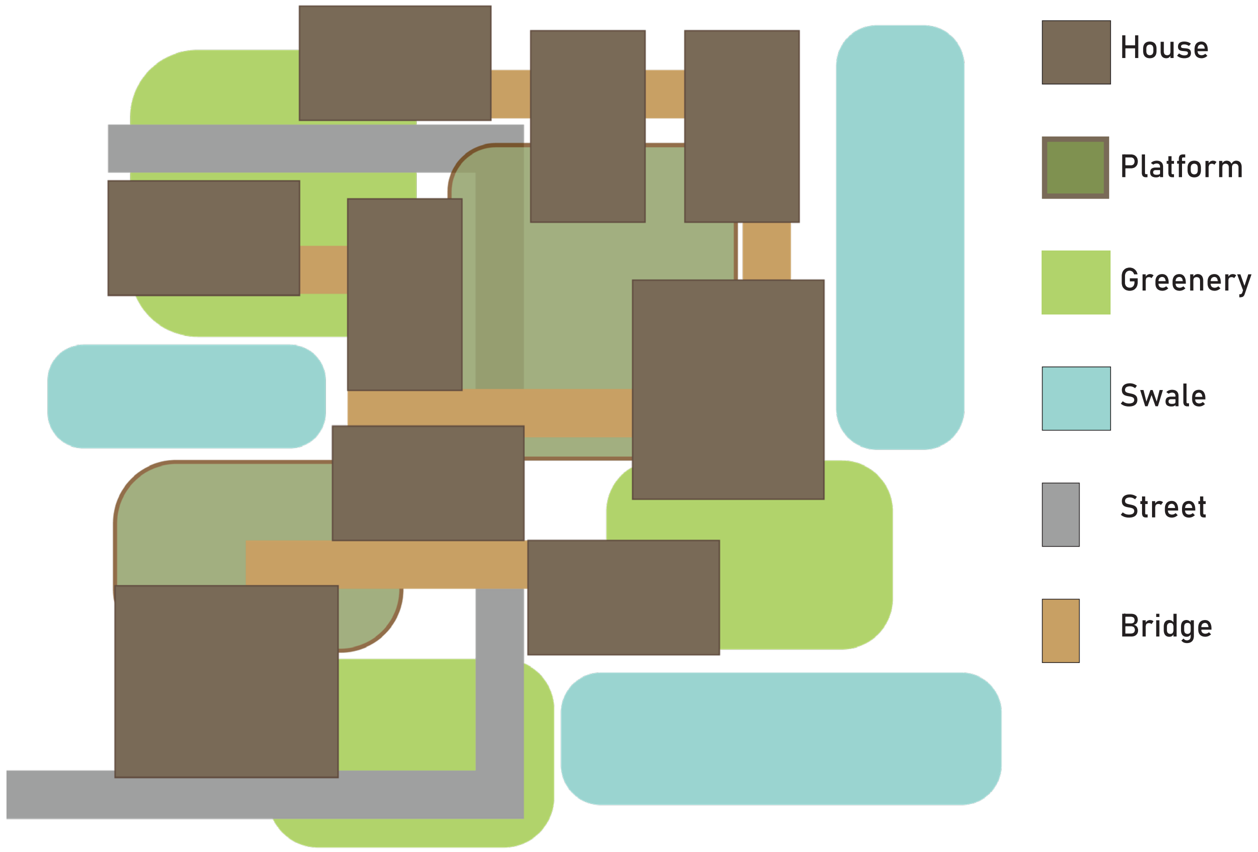
Planting native wetland or riparian plants offers significant environmental benefits. These plants help mitigate flooding by slowing overland flow, stabilising banks with dense root systems, and absorbing excess water. Their deep rhizomes bind the soil, preventing erosion during heavy rainfall. Additionally, they filter sediment and pollutants, improving water quality while reducing the speed and volume of runoff entering waterways (Auckland Botanic Gardens, n.d.).

On normal days, the bridge across the Blue-Green Corridor offers residents a scenic route to enjoy the natural landscape.

During heavy rain, when the bridge is submerged, a network of raised walkways ensures the path remains accessible.



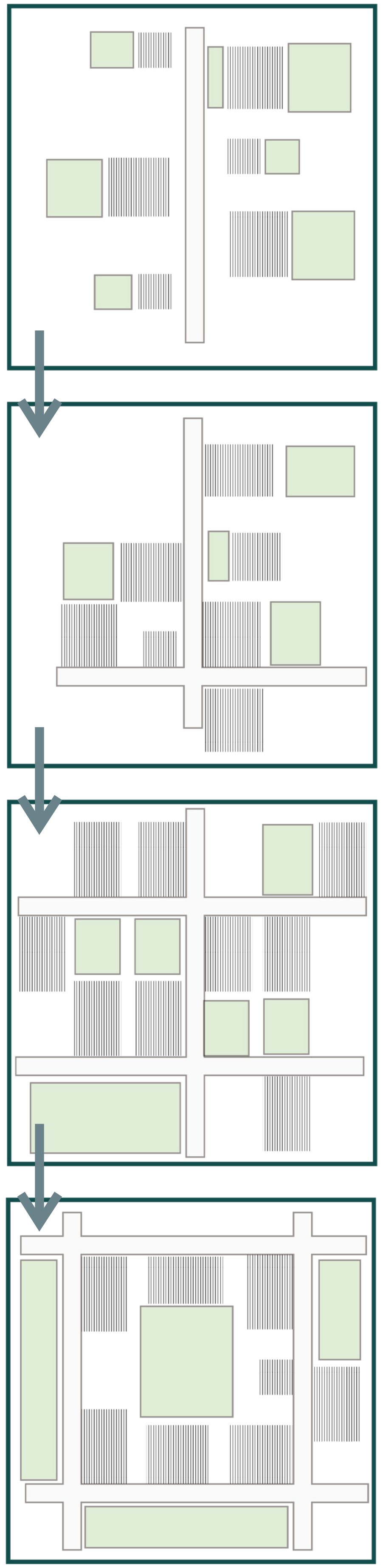
Section of Proposed Blue-Green Corridor

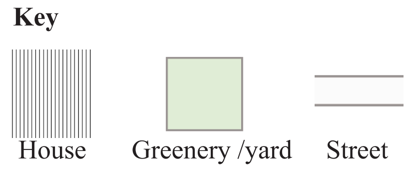


Conceptual Floor Plan

According to Watson and Adams (2011) , Distributed flood functions reduce risk more effectively than a single large system in many cases.

When green spaces, rain gardens, and small retention areas are spread across a site, they store and slow runoff near where water is generated. This reduces peak flow and lowers pressure on drainage networks. If one area fills up or fails, other areas can still hold water. This creates backup capacity and improves system stability.





Iteration of Community Fabric

The conventional suburban model of 'one house with a private yard' produces spatial separation and fragmented land use. Each dwelling manages its own boundary, drainage, and open space. While this layout provides privacy, it limits collective flood management and reduces land efficiency.

In flood-prone areas, scattered private yards do not function as coordinated retention systems. Water moves unpredictably across plot lines, and opportunities for shared infrastructure are reduced.

The proposed iteration reorganises this pattern into a clustered housing arrangement where multiple dwellings surround a shared green core. Instead of distributing small private lawns across individual plots, open space is consolidated into a central communal landscape. Houses are oriented inward toward this shared space, while service access and vehicular circulation remain at the perimeter.

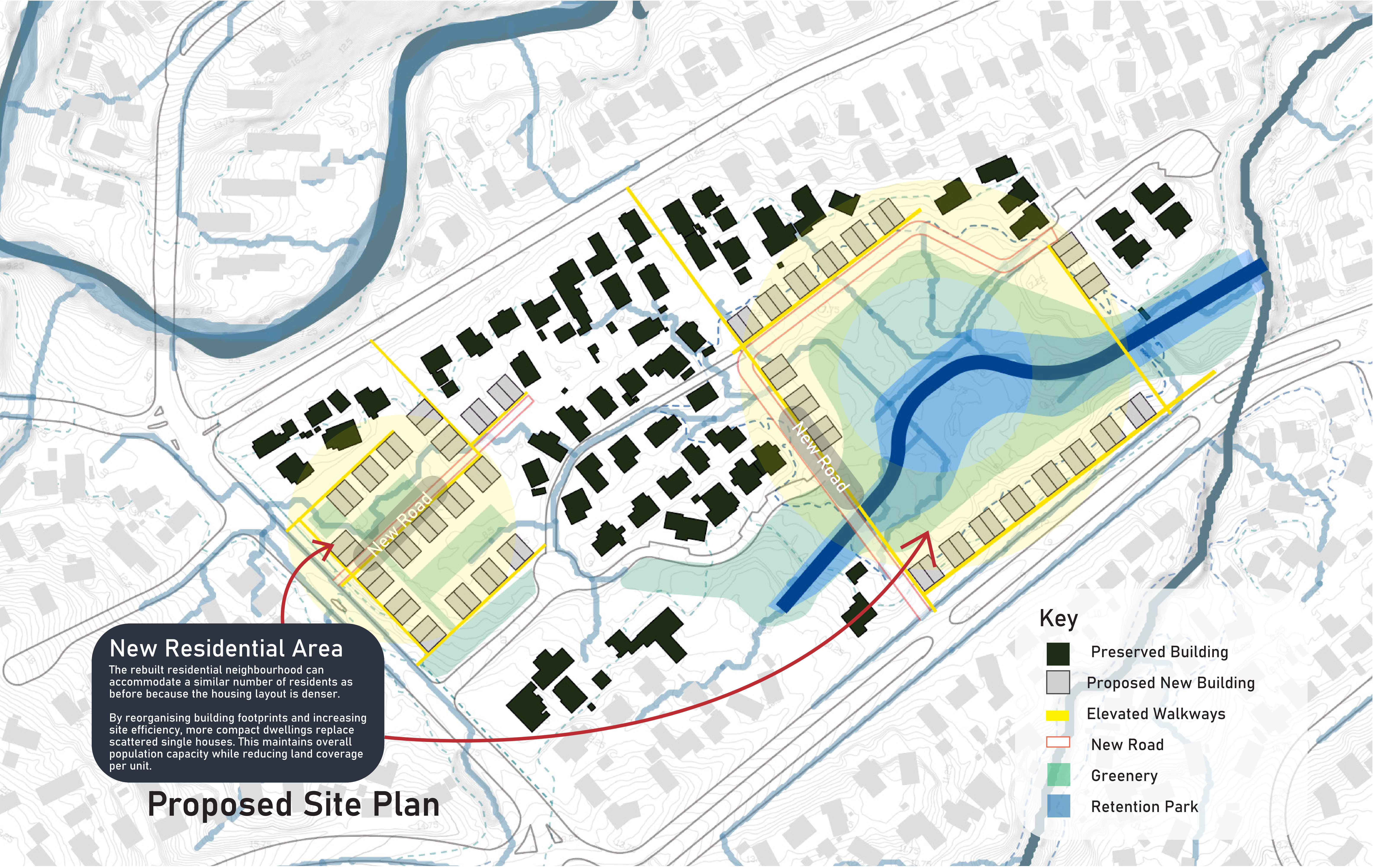
Spatial Logic

The shared green core performs multiple roles:

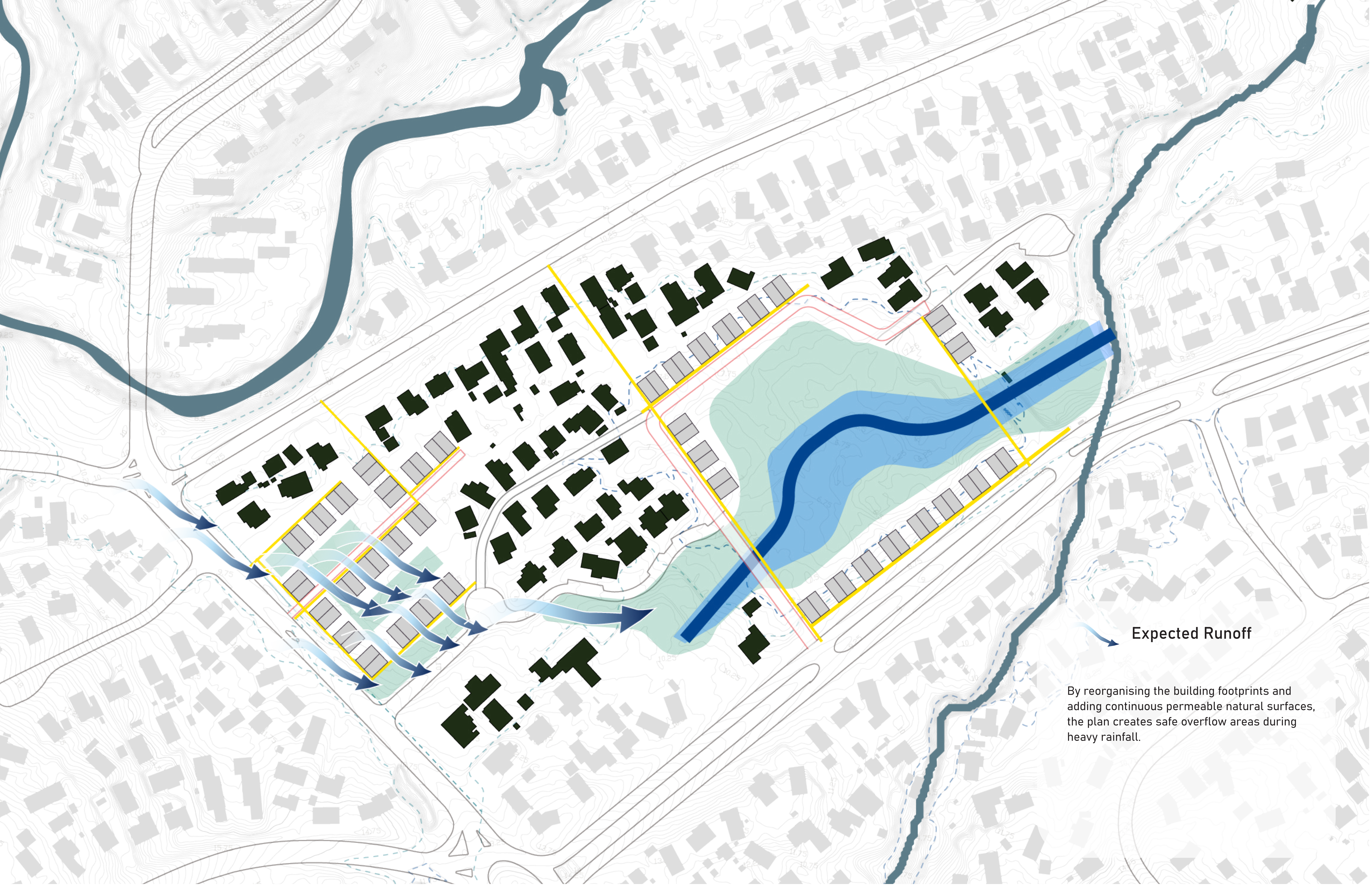
- Stormwater retention basin
- Social gathering space
- Visual and environmental buffer
- Ecological corridor

By lowering the central landscape slightly below surrounding floor levels, it becomes a controlled flood-receiving zone. During heavy rainfall, runoff from paved surfaces is directed toward this shared space rather than flowing randomly across individual yards. The central green acts as a distributed detention area that reduces peak runoff pressure on street infrastructure.

Housing clusters create a defined edge around the green core. This arrangement increases passive surveillance and strengthens social connection. Openings and elevated verandas face the shared space, encouraging interaction while maintaining defensible boundaries.



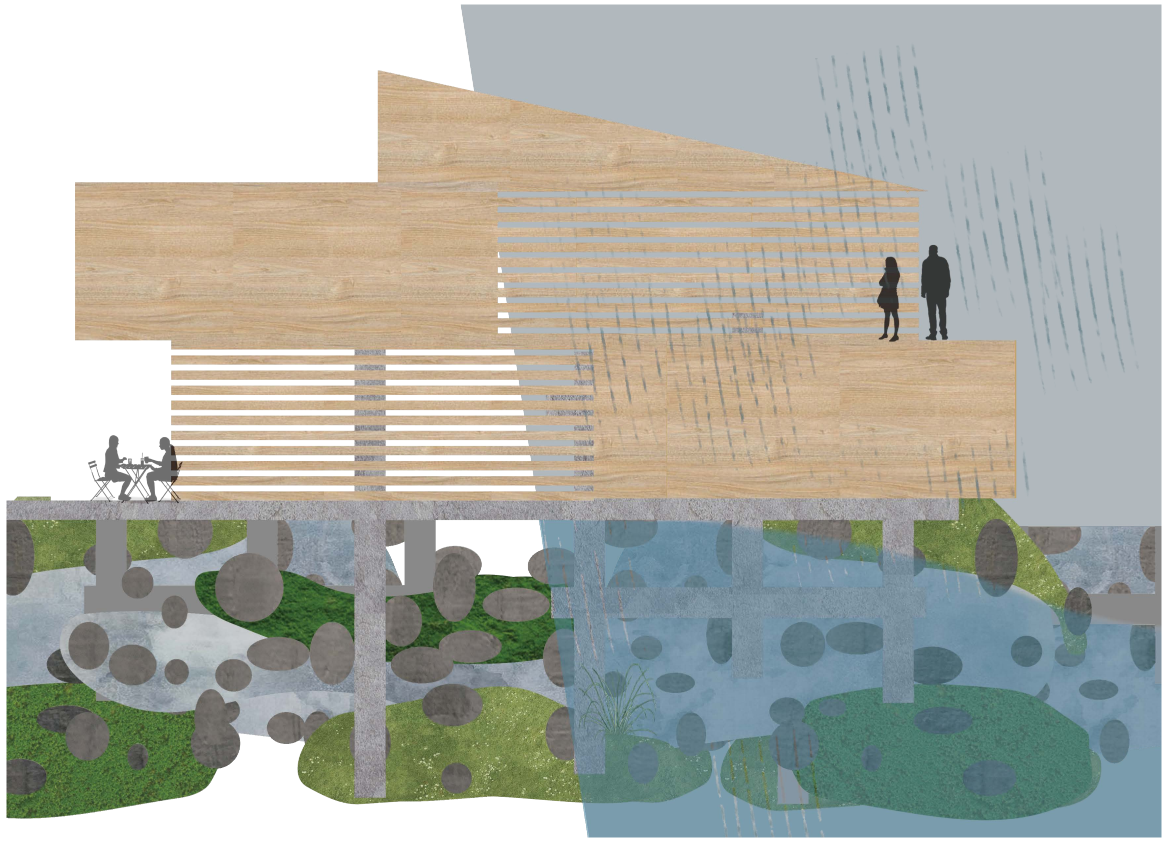
New Road
New Road
New Residential Area
The rebuilt residential neighbourhood can accommodate a similar number of residents as before because the housing layout is denser.
By reorganising building footprints and increasing site efficiency, more compact dwellings replace scattered single houses. This maintains overall population capacity while reducing land coverage per unit.
Proposed Site Plan
Key
Preserved Building
Proposed New Building
Elevated Walkways
New Road
Greenery
Retention Park



By reorganising the building footprints and adding continuous permeable natural surfaces, the plan creates safe overflow areas during heavy rainfall.

Risks and Solution

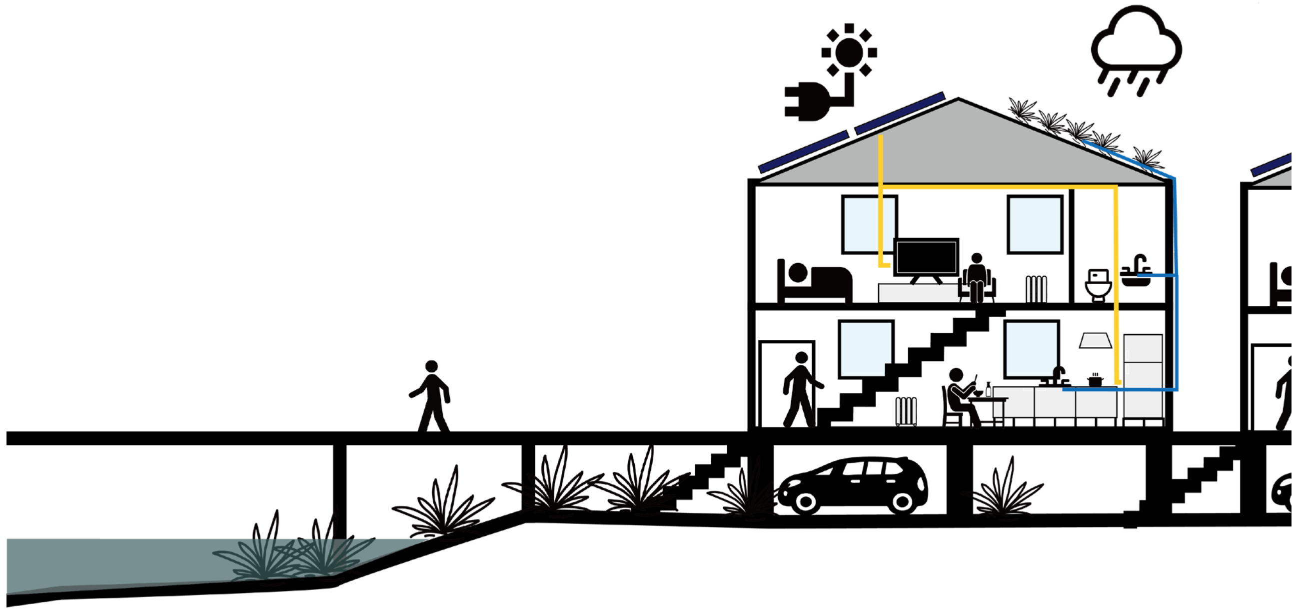
Risk of Flood	Spatial Issue	Impacts	Solution
Damage to Home Appliances	Flooding of facilities located below flood level.	Water damage to equipment caused power outages, contamination, and corrosion of components, which required costly replacements.	Raise HVAC units, electrical panels, and water heaters above the predicted flood level (PFL).
Ground Floor Interior Damage	The use of absorptive materials in flood-prone zones.	Saturated walls, mould growth, and a decline in long-term structural strength.	Use moisture-resistant materials at ground level; Avoid plasterboard and carpet below PFL; Design ground floor as a sacrificial or flood-tolerant zone.
Prolonged Standing Water Around Houses	Poor site grading and lack of drainage .	Foundation instability, material decay and mosquito breeding.	Use water pumps for drainage; Introduce permeable pavements and vegetated swales; Divert water toward retention basins.
Power Outage	Fallen trees and debris can damage power lines and poles, and substations or electrical equipment may be flooded.	Loss of lighting, communication, and refrigeration, disrupt basic living conditions.	Install community microgrid with battery storage; Elevate energy infrastructure above PFL; Integrate rooftop solar for partial self-sufficiency.
Slow Post-Flood Recovery	Non-repairable finishes and concealed damage.	Long periods of displacement and significant financial strain.	Use removable wall panels and modular cabinetry; Detail ventilation gaps for rapid drying; Elevate main living spaces above PFL.

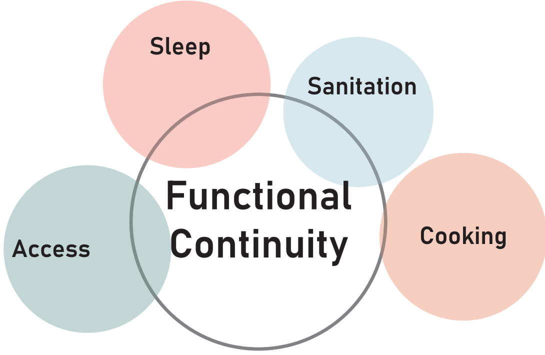


Conceptual Drawing

Spatial Logic

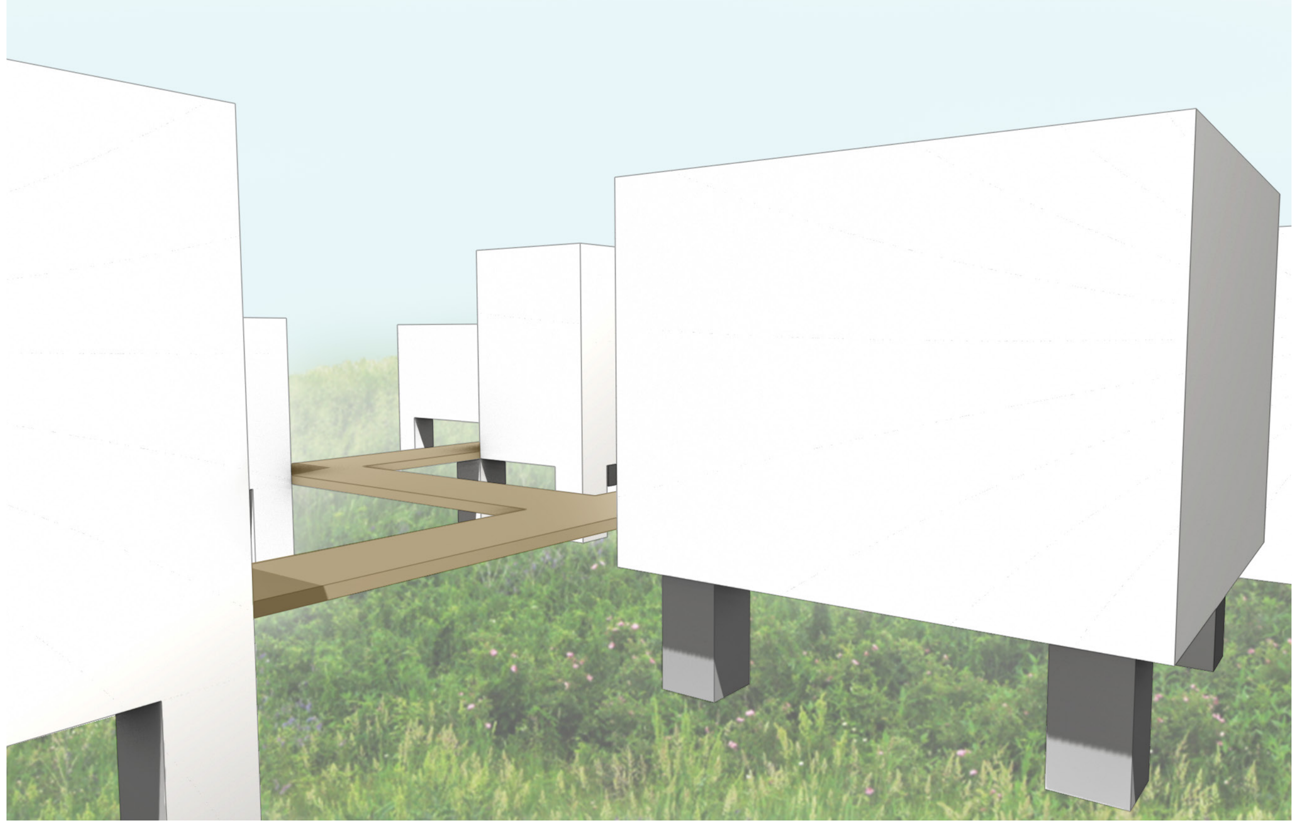
- Reduce building footprint by building two or three-storeys.
- Elevated floor that higher than the flood water level.
- Allow vertically retreat
- Create open space in ground floor.





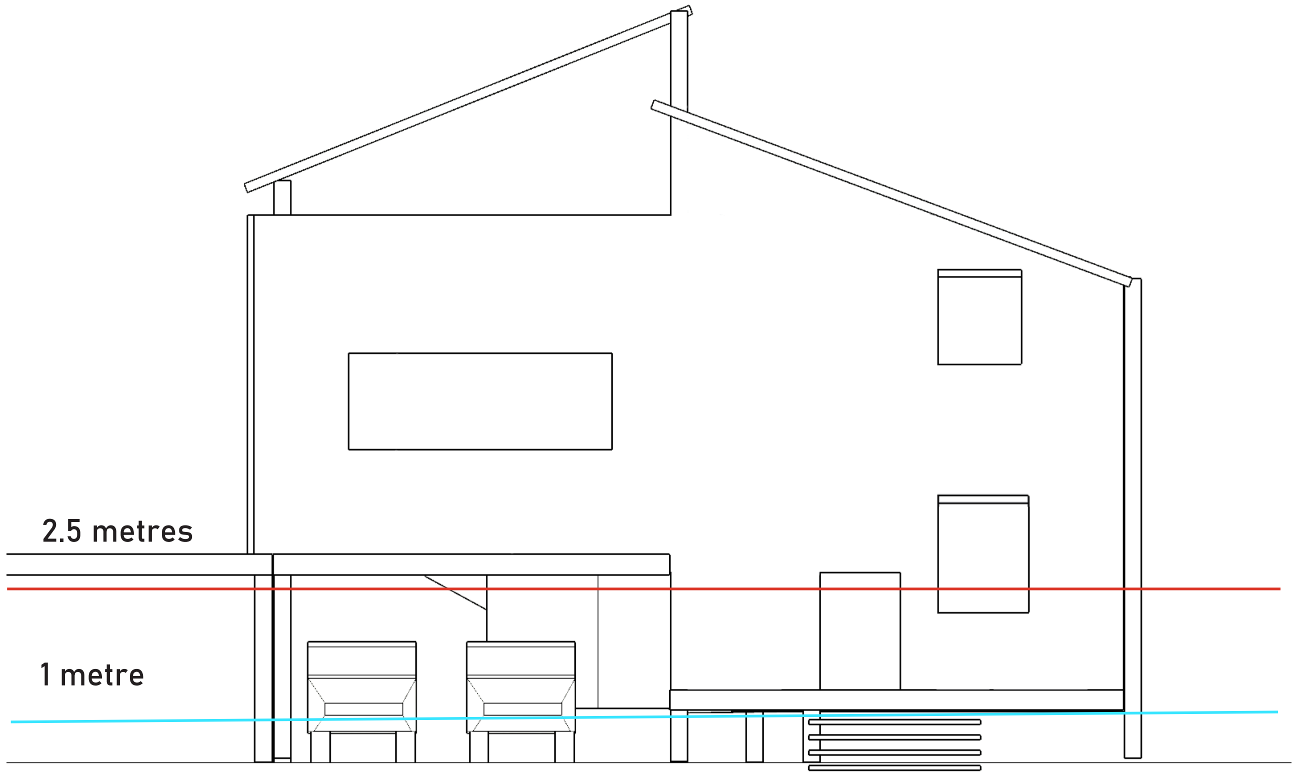
Spatial Logic

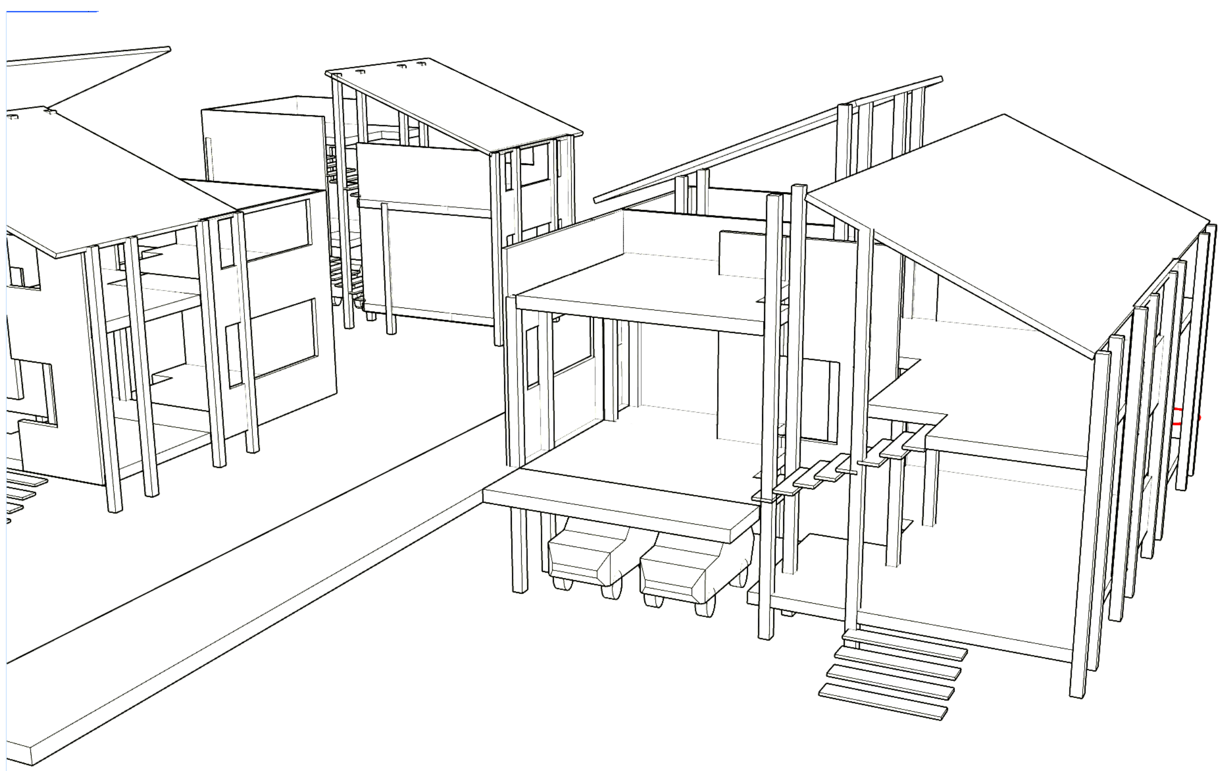
- **Elevated House and connection that are higher than predicted flood level, enhance the functional continuity.**
- Solar panels for on-site energy generation.
- Green roof to absorb and slow rainfall runoff.
- **Rain harvesting system**
- Open ground floor designed to function as car parking.



Iteration Drawing

- Elevated walkway connects the houses

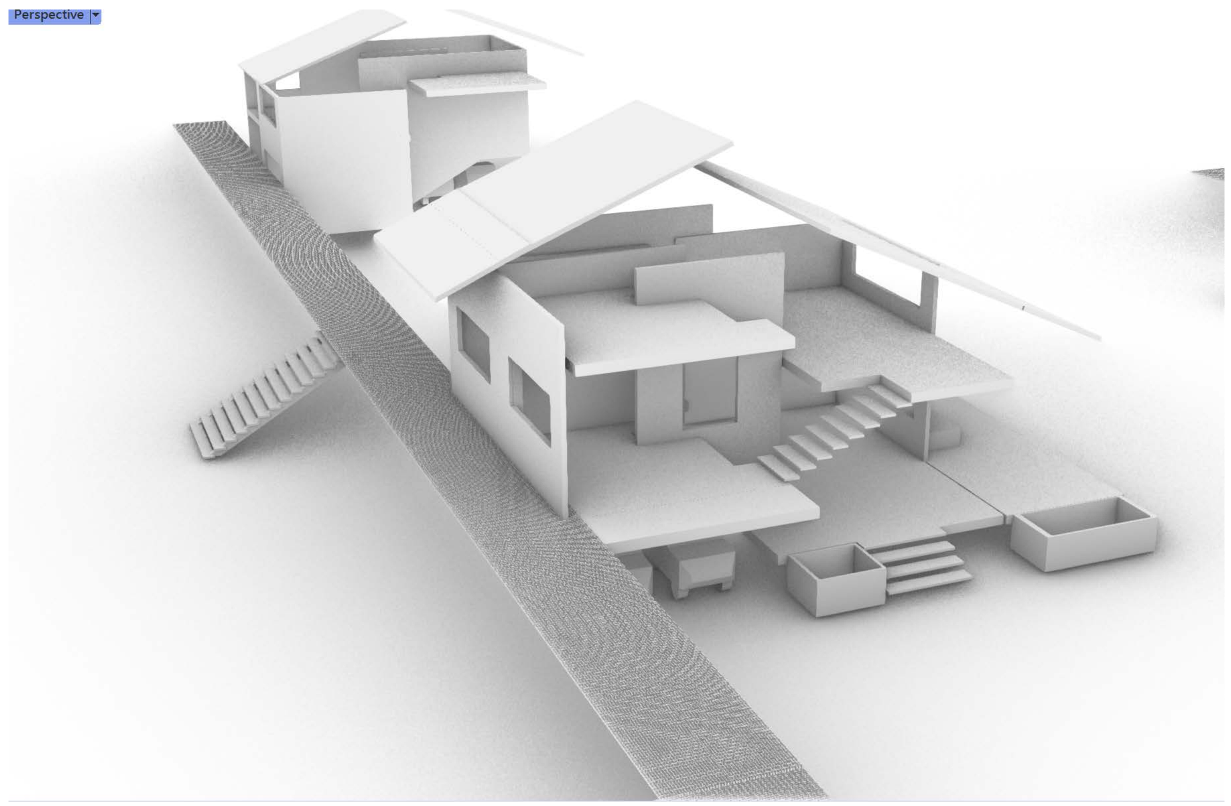


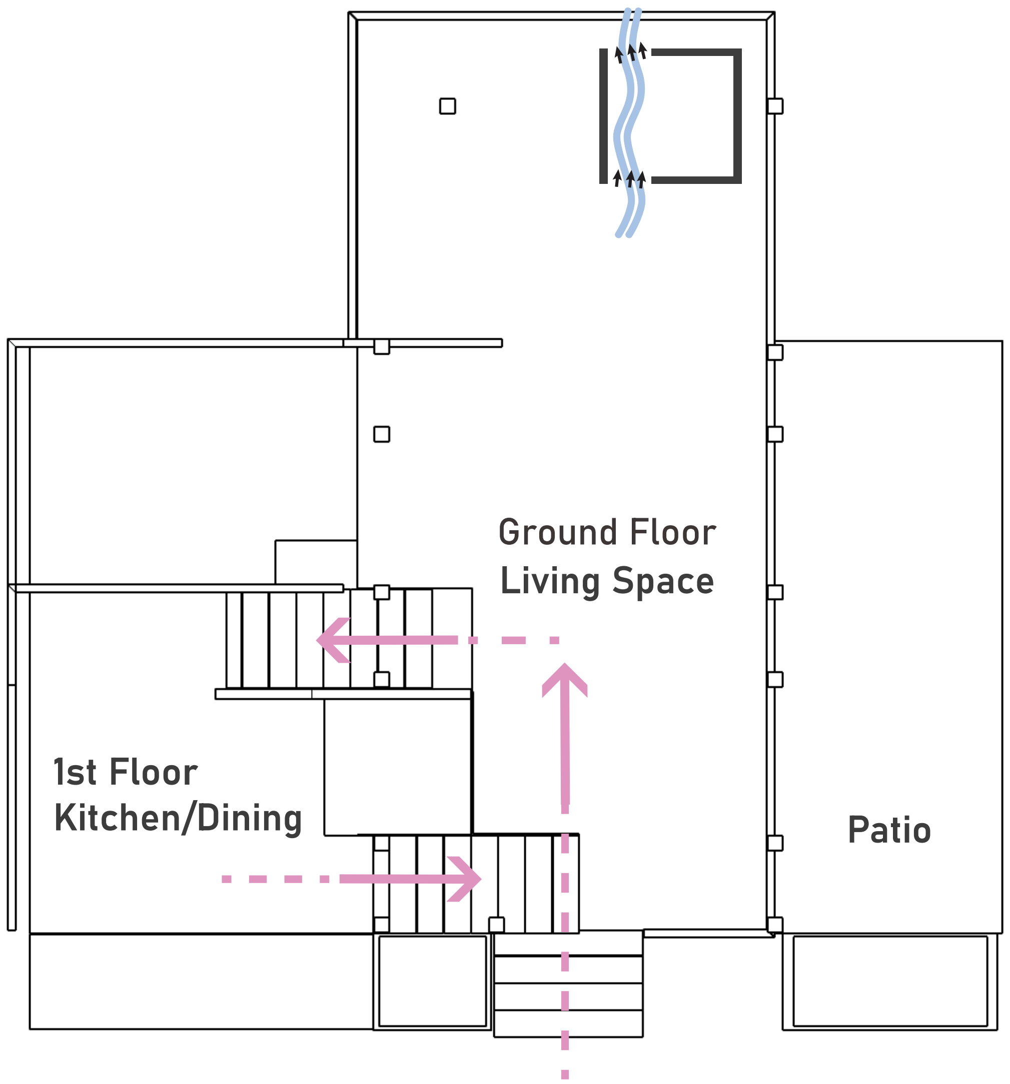


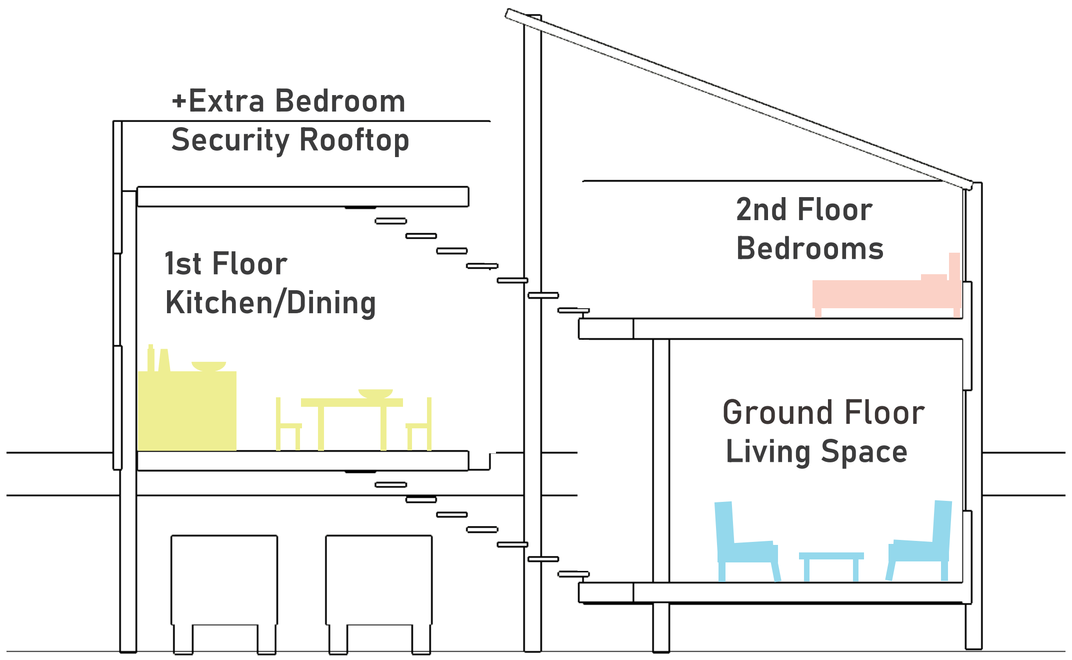
Split Levels

Split-level design divides the house into staggered floor heights, creating vertical differentiation that reduces risk and improves functional flexibility.

Split levels design can create height differences for different functions: raised heights can prevent floodwaters from entering the main living spaces and damaging expensive equipment.







Spatial Layout Strategies

- ### Living Room

The living room is located on the ground floor as a flexible social space. It is designed with flood-resilient materials and layouts that allow quick cleaning and recovery after inundation.

- ### Kitchen

The kitchen is planned to be positioned on a higher floor to protect essential assets from the risk of flooding.

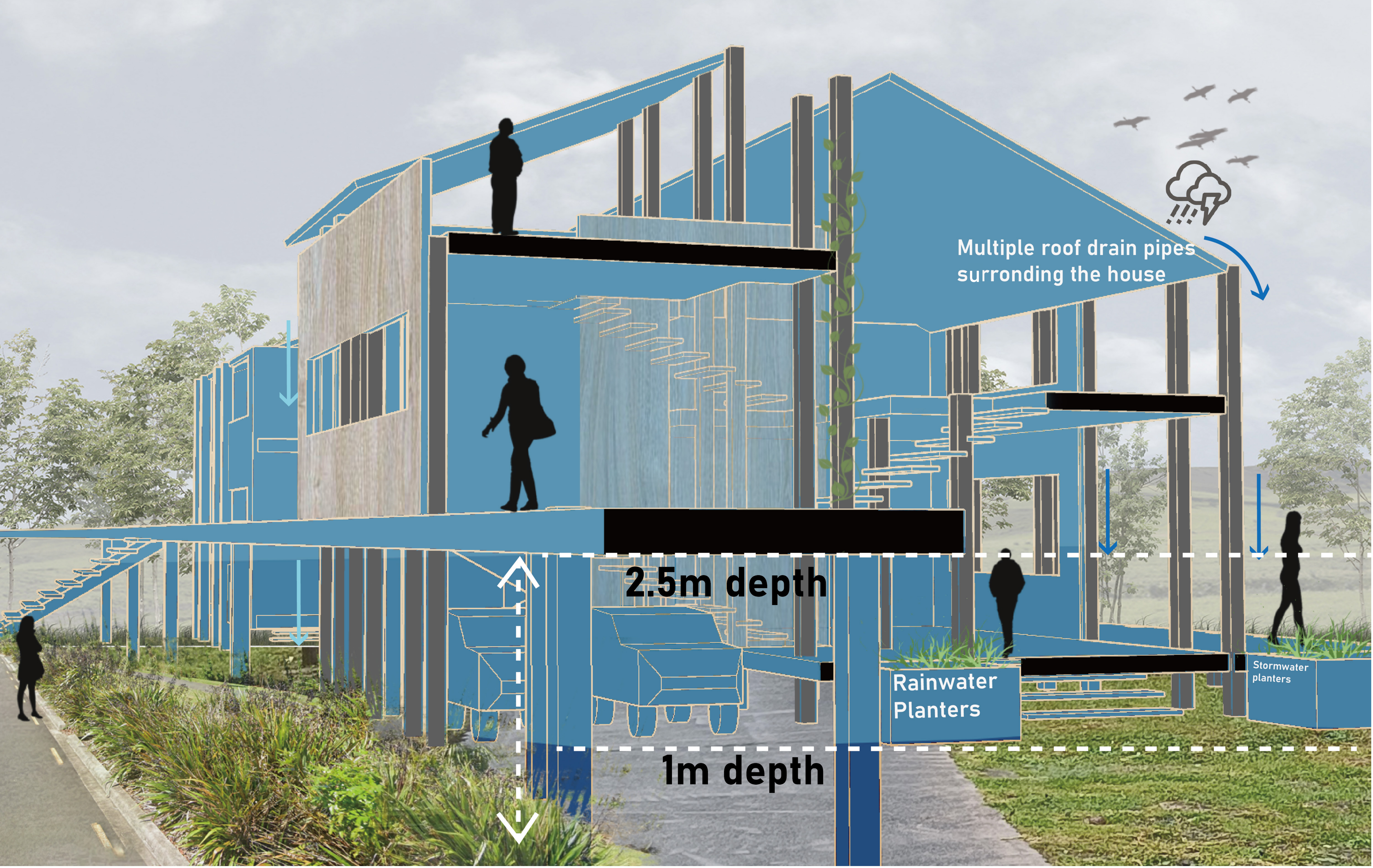
Kitchen appliances are typically among the most expensive and infrastructure-dependent components in a house. They require electrical connections, gas supply, plumbing, and drainage. Once submerged, repair costs are high and replacement is often unavoidable.

- ### Bathroom

Two bathrooms are provided, one on the lower floor and one on the upper floor, to ensure basic hygiene and functionality during flooding. If the ground floor becomes unusable, residents can still access essential facilities above flood level.

- ### Rooftop Terrace

A rooftop terrace is included as an elevated refuge space. It provides temporary safe access during extreme flood events and functions as an emergency gathering or shelter area.


Multiple roof drain pipes surrounding the house
2.5m depth
1m depth
Rainwater Planters
Stormwater planters

8.2 Developed Design

Elevated Walkway

Drawing from previous precedents, I apply an elevated walkway in my design concept. It avoids floodwater by lifting circulation above expected flood levels and increases access across the site. It also strengthens community connection.

The walkway links houses at an upper level. It provides safe pedestrian movement when ground paths are submerged. Residents can move between homes, shared spaces, and refuge areas without entering floodwater.

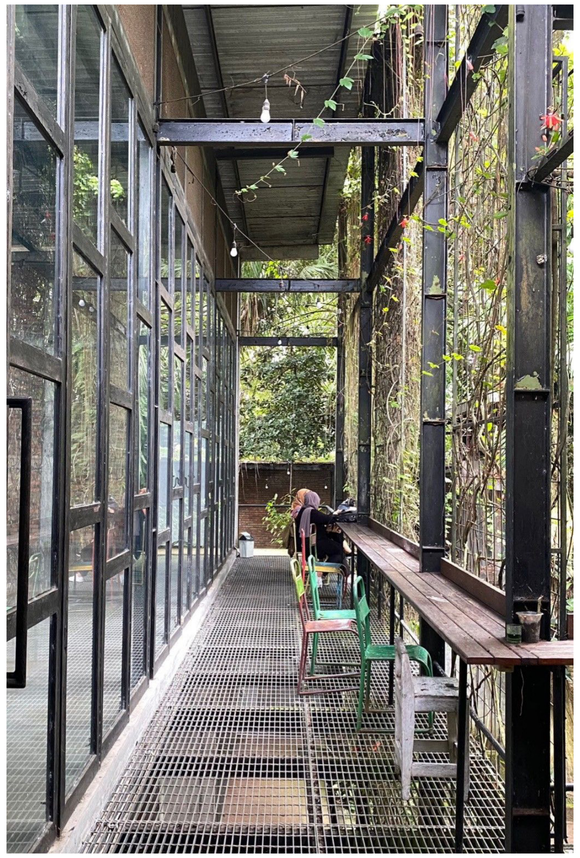
In normal conditions, the walkway supports daily circulation. During heavy rainfall, it becomes critical infrastructure. By separating movement from ground-level flooding, it reduces disruption and improves safety across the neighbourhood.

Lightweight coated steel is selected as the primary structural material. It has a low self-weight and reduces load on foundations. The protective coating improves resistance to rust and weathering, which is important in wet and flood-prone conditions.

Metal grating is used for the walkway surface. The open grid allows rainwater to pass through, so water does not collect on the deck. It also improves ventilation and reduces moisture retention, which helps limit corrosion. The panels are relatively light and can be installed or replaced easily.

Together, these materials create a lightweight, durable, and well-drained elevated walkway system suited to flood conditions.

Precedent



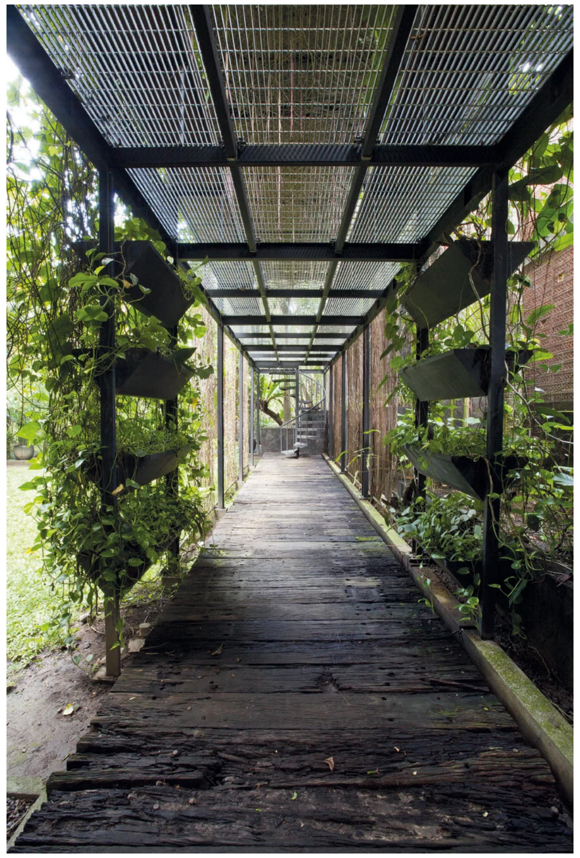
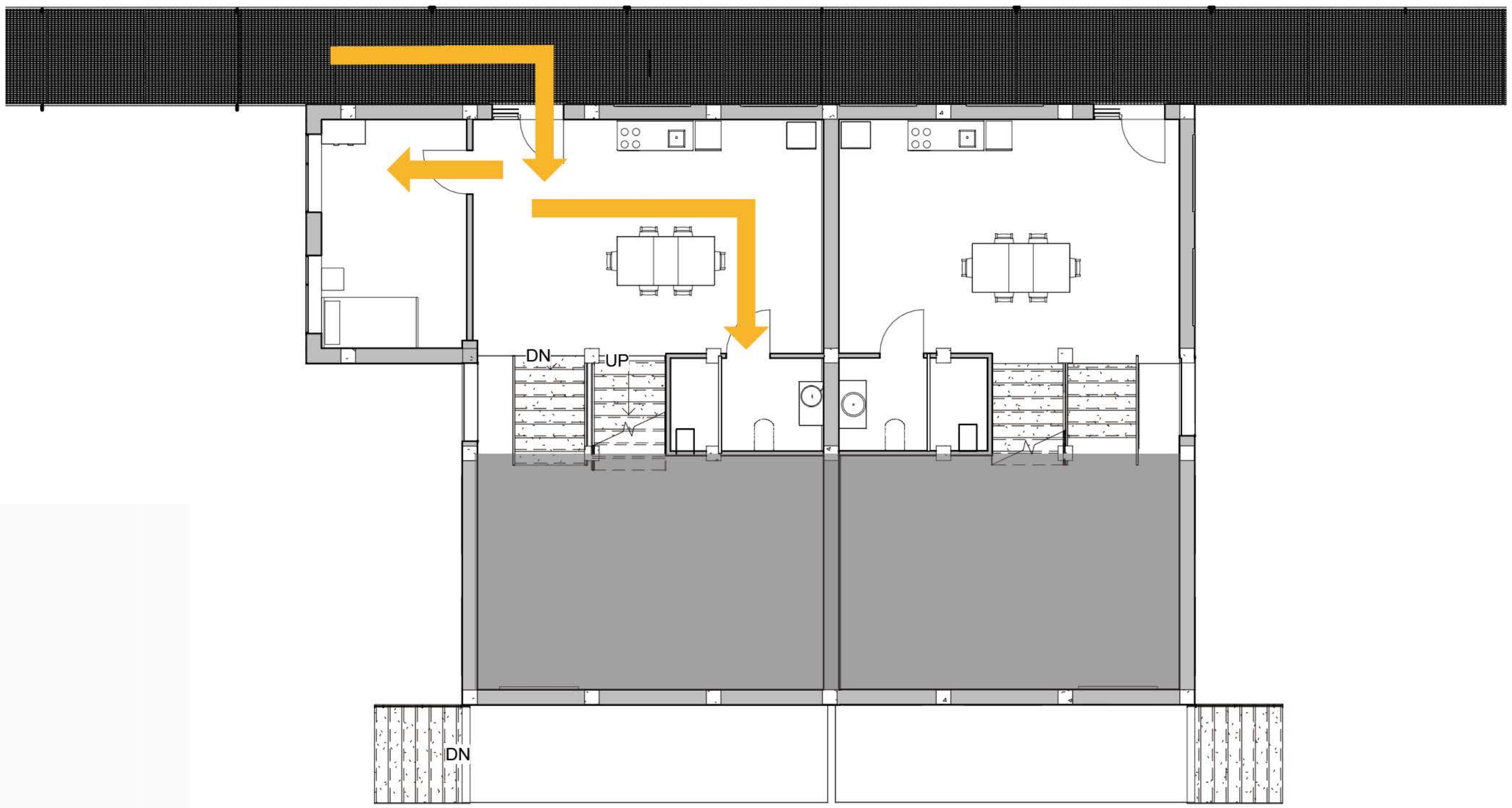
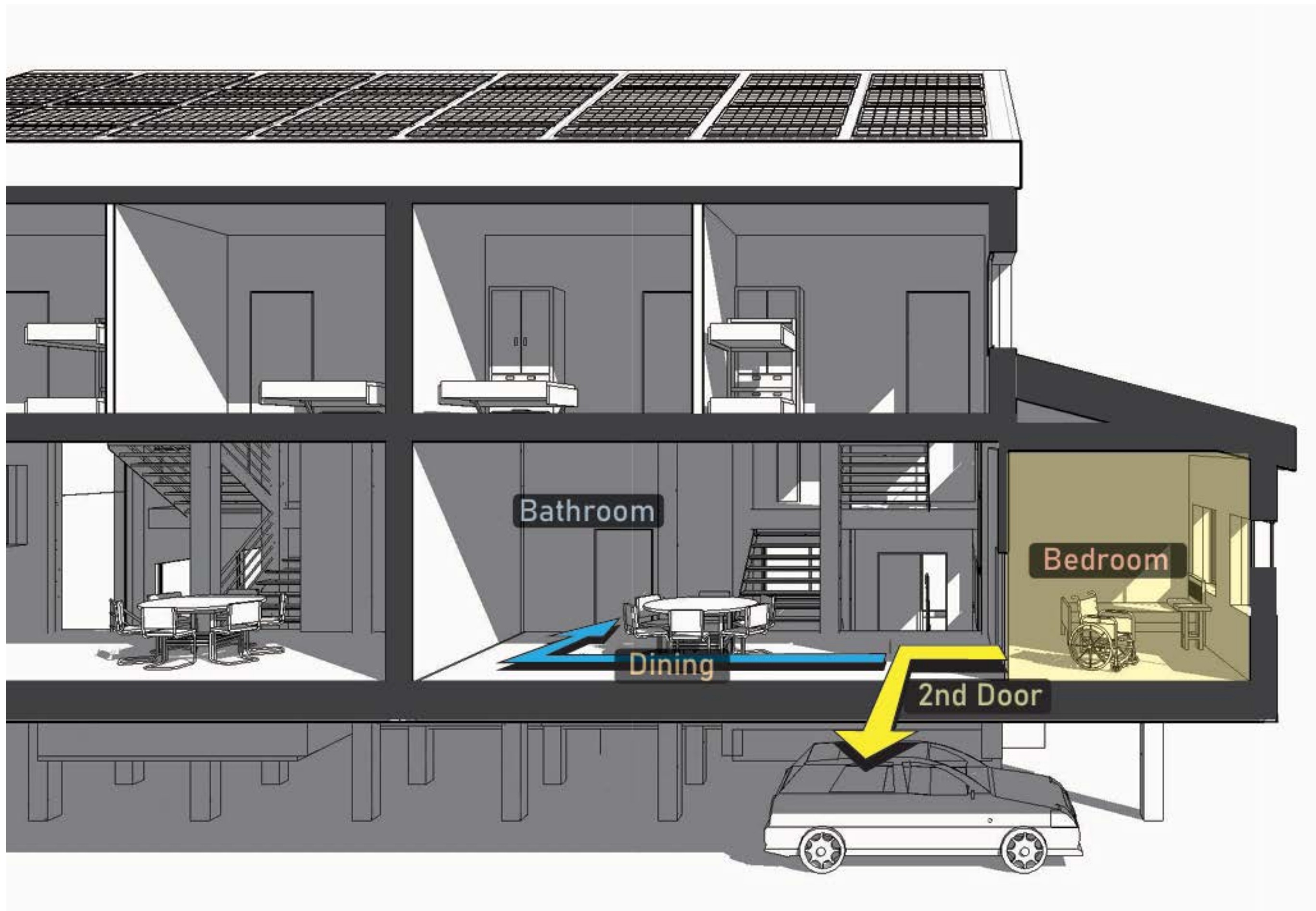


Figure 8.1
SaRanG building by Jumaldi Alfi (Laksono, 2015)

Imagination of the walkway

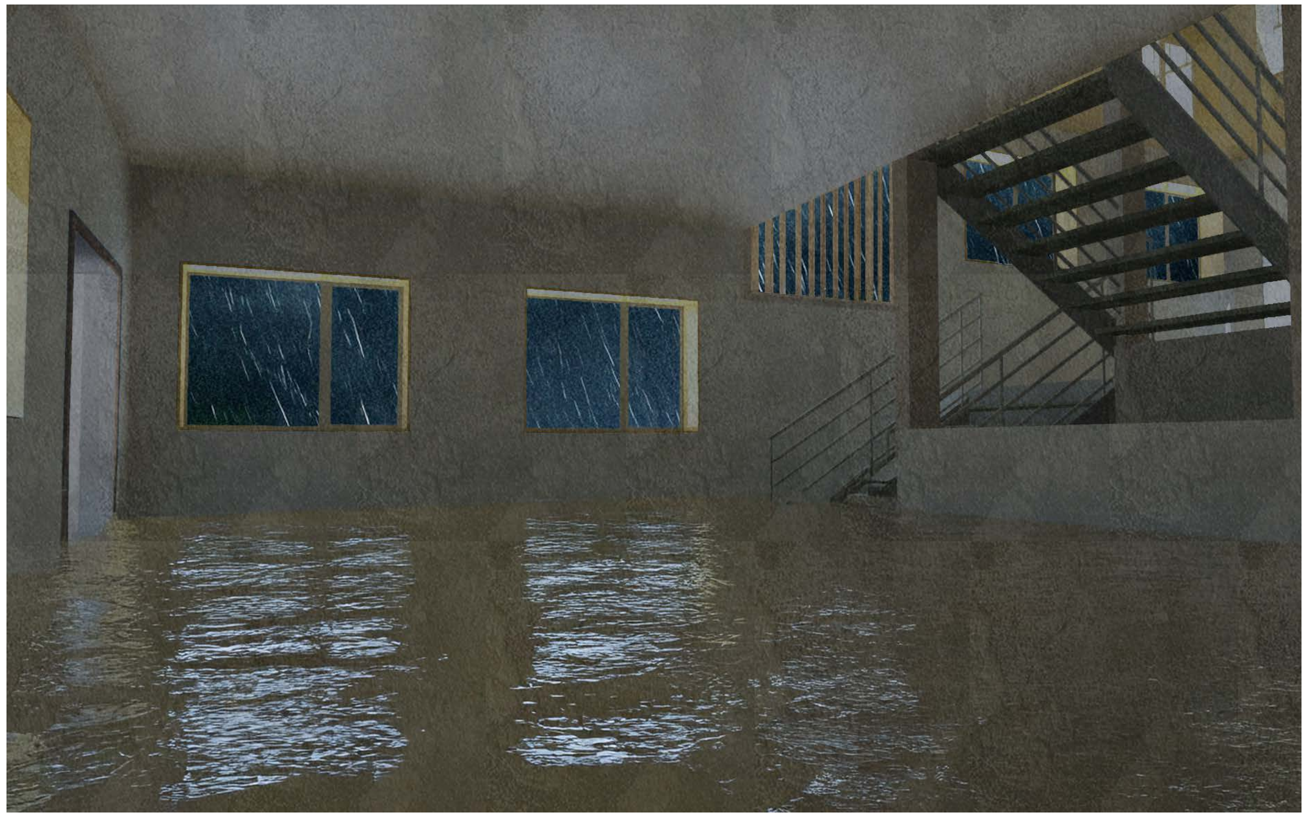
Vulnerable Groups in Floods





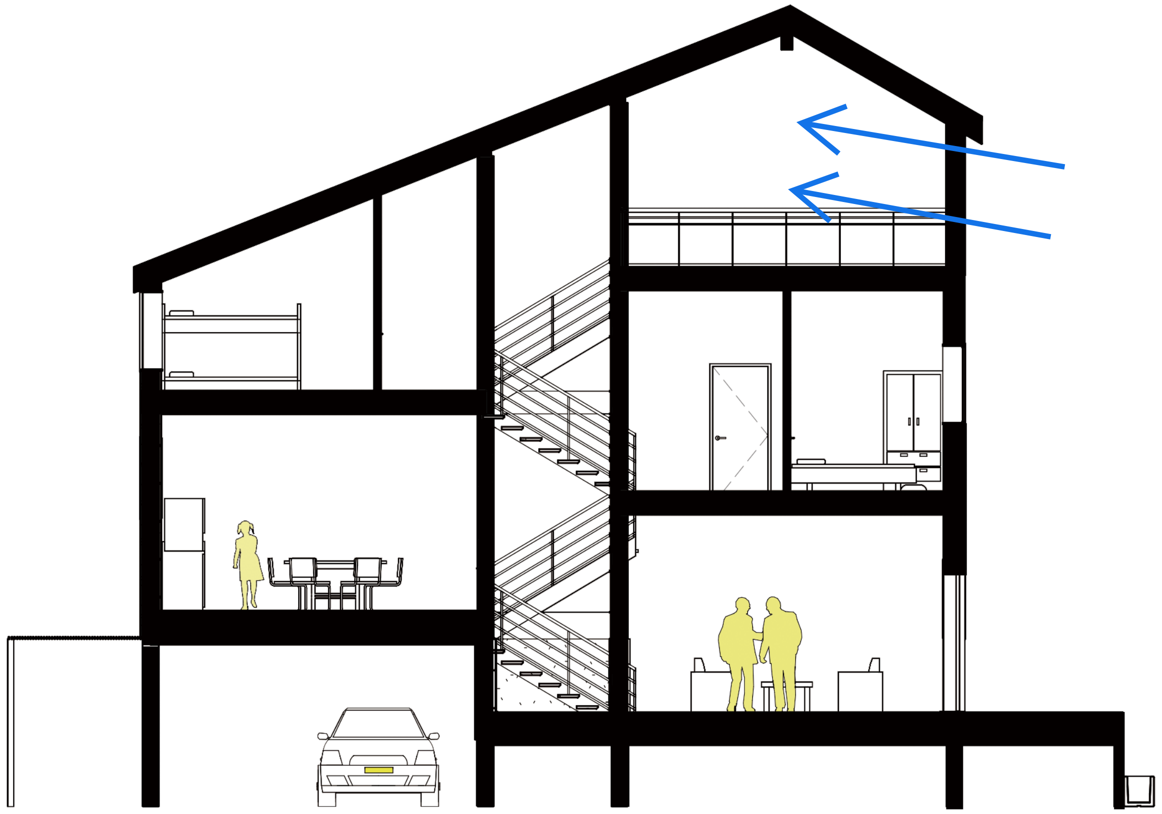
People most vulnerable during floods include elderly and disabled residents who cannot move independently and require assistance to evacuate.

In the design process, this condition is addressed by placing a bedroom on the first floor with direct access to a second door connected to the elevated walkway. On the same level, the kitchen, dining area, and a bathroom are provided to support daily living. This layout allows essential functions to remain accessible without using stairs during flood events.



Sacrificial Ground Floor

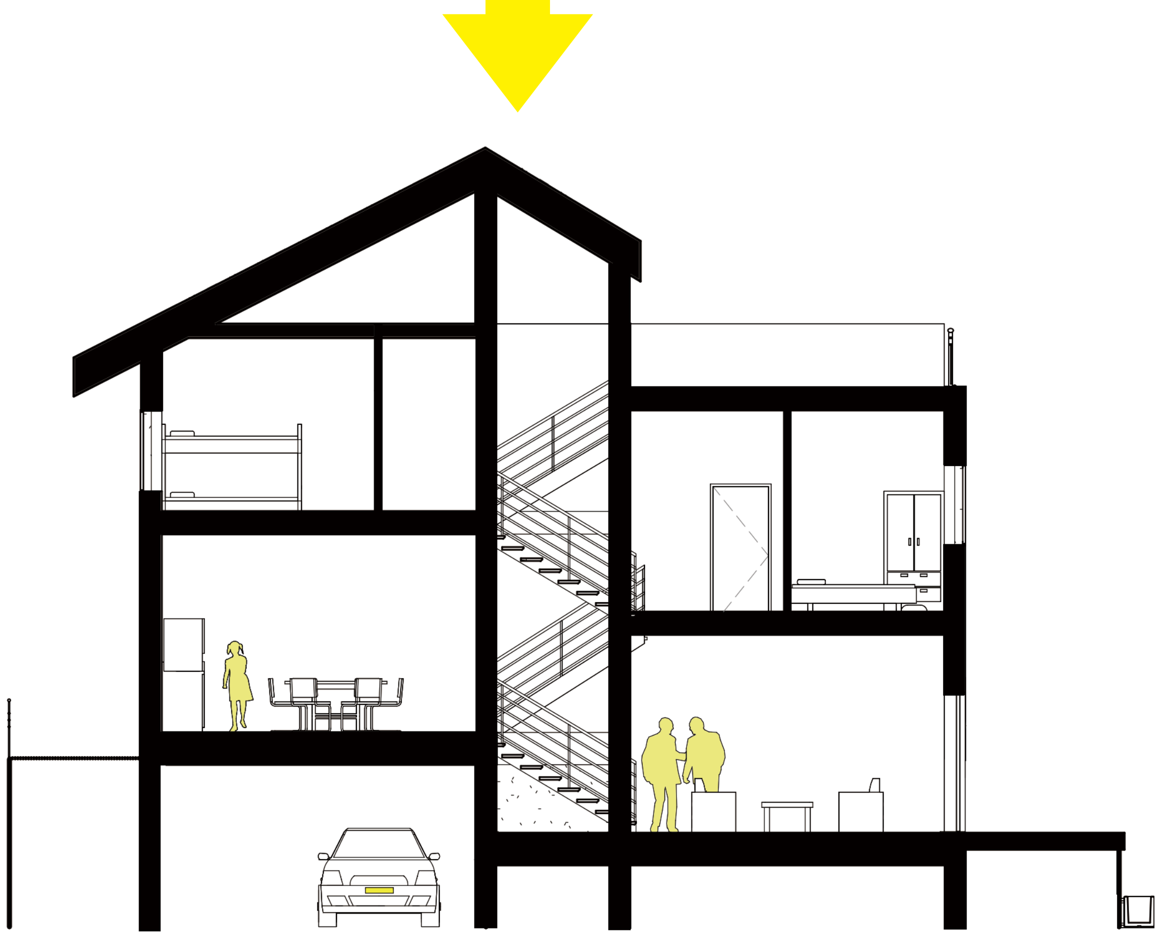
Although the ground-floor living room is raised, it may still be submerged during floods exceeding two metres, as seen in previous events. By treating this level as a sacrificial ground floor with water-tolerant materials and limited critical functions, damage can be reduced and essential living activities can continue on the upper levels.



Roof Design

This roof design was selected for performance reliability rather than visual expression.

Having shorter eaves reduce vulnerability to wind-driven rain entering **softs**, reduces wind exposure and uplift pressure during storms.



Material Strategies for Flood-Adaptive Housing

Material strategy determines how a building performs during inundation, how quickly it recovers, and how much repair is required. In flood-prone housing, materials can be selected based on the five resilience principles.

Criteria of Material Selection:

- **Adaptation**
  Materials need to tolerate periodic water exposure.
- **Redundancy**
  Layered assemblies prevent total system failure if one component is damaged; combine dry flood-proofing and wet flood-proofing.
- **Rapidity**
  Durable finishes and removable layout that can shorten repair time.
- **Self-sufficiency**
  Locally available materials support repair without complex supply chains; standardised panel dimensions for easy replacement.
- **Community & Culture**
  Material choice that reflects local construction practices while improving flood performance; integration of native planting within landscape design.

- ## Foundation

Concrete that is well-anchored and heavy enough to resist buoyancy and lateral water forces.

Concrete blocks or reinforced masonry that tolerate water immersion without loss of strength.

Reinforced concrete must prevent the steel bars from being exposed to avoid corrosi

Pile foundation (concrete, steel, or treated timber piles) to lift the structure above ground water and reduce direct contact with floodwater.

- ## Structure

Pressure-treated timber and cold-formed steel framing that resist decay when wet.

Concrete and masonry structural elements that can withstand short-term inundation with minimal repair.

Design for easy drying and cleaning after flood exposure.

- ## Roof

Water-resistant and durable roofing materials such as metal roofing, clay tiles, or composite shingles.

Ensure secure connections and water-tight flashings to prevent water entry.

Use roof designs that shed water quickly to reduce ponding. (general practice)

- ## Walls

Water-resistant exterior materials such as concrete block, brick, metal panels, PVC panels, or glazed tiles.

Avoid materials that absorb water like standard gypsum board or untreated wood below flood levels.

Consider sealed masonry or waterproof coatings on lower wall sections.

- ## Flooring

Waterproof or water-tolerant floors such as ceramic tile, porcelain, concrete tile, vinyl tile on concrete slab, recycled plastic lumber, or terrazzo.

Install waterproof membranes between structural deck and finishes to prevent moisture damage.

Avoid plywood or organic wood flooring where floodwater is likely.

- ## Doors & Windows

Flood-resilient doors such as fibreglass, metal, or reinforced frames that resist water impact and decay.

Use water-sealed thresholds and consider removable or breakaway panels below expected flood levels.

Glass block elements can be used as water-tight infill where needed.

- ## Insulation

Closed-cell foam insulation that resists moisture penetration and dries quickly if wet.

Avoid insulation that absorbs water (e.g., fibreglass batts) below flood levels.

Place insulation above anticipated inundation depths where possible.

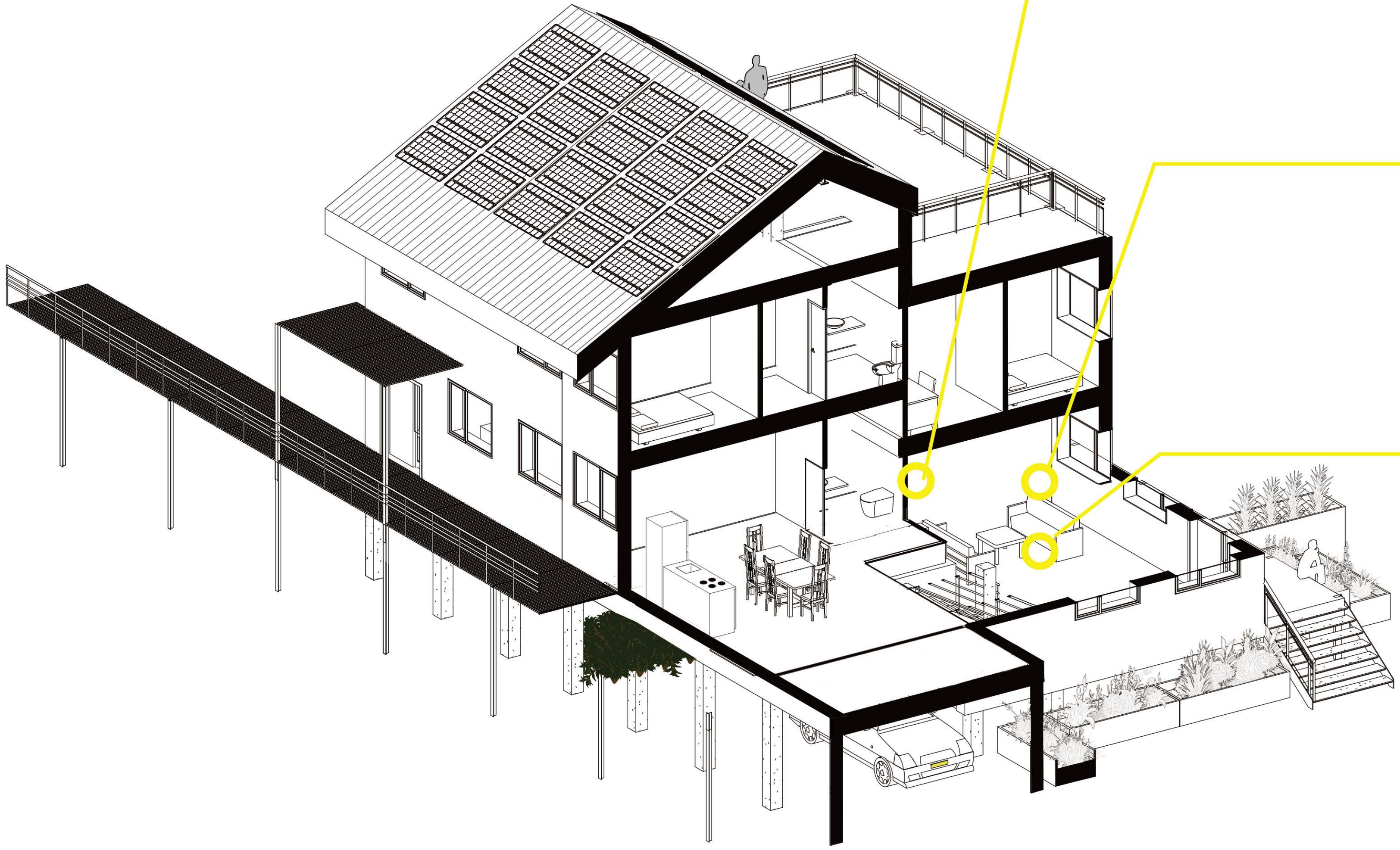
- ## Finishing

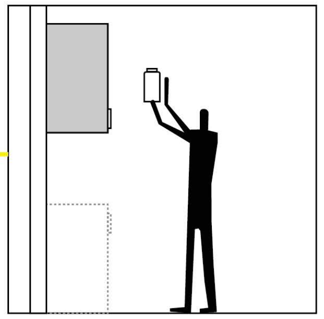
Water-resistant interior finishes like tile, sealed concrete, epoxy resin, or water-proof paint in lower areas.

Avoid organic finishes, MDF, and carpets in zones prone to flooding.

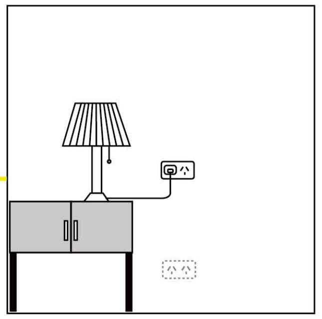
Use sealants and waterproof grouts on all wet-area surfaces.

8.3 Detailed Design

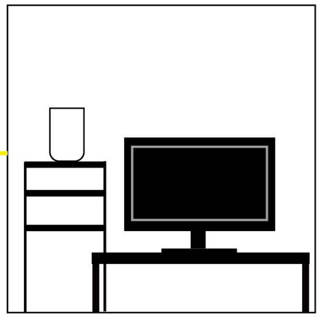




Move the storage to a higher location to avoid flood.



Sockets and switches placed higher up the wall to prevent water ingress.

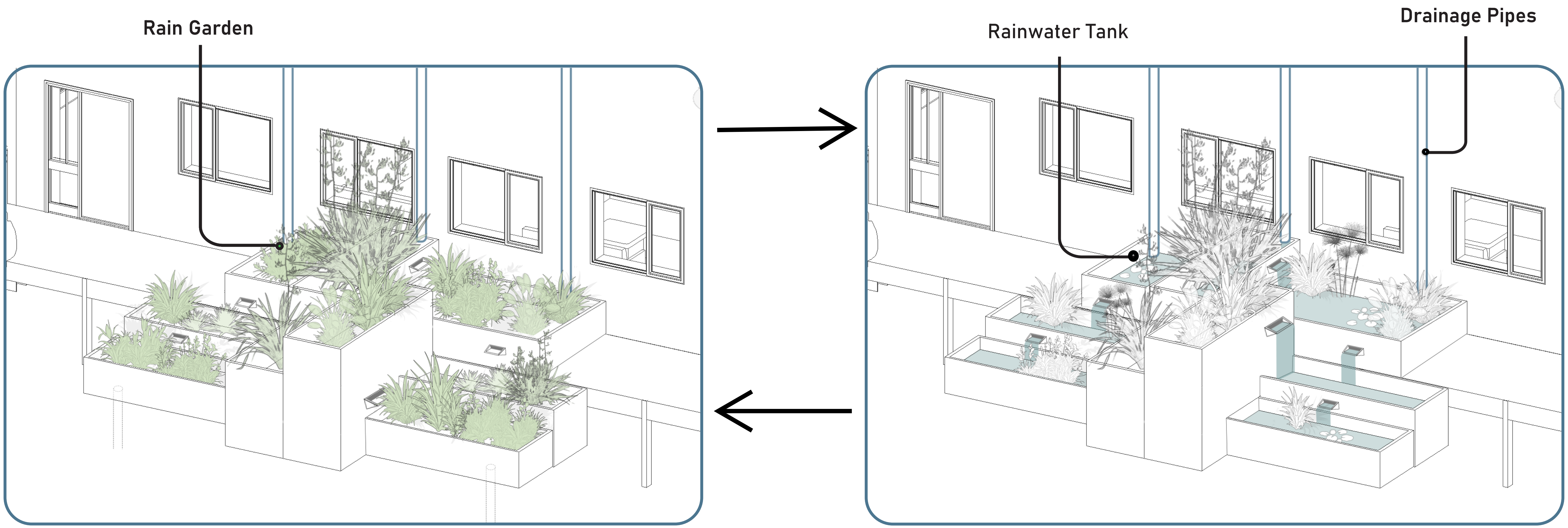


Use furniture with high legs to reduce water damage, or lightweight pieces that can be moved to higher levels before flooding.

Small steps to increase flood resilience

Rain Garden

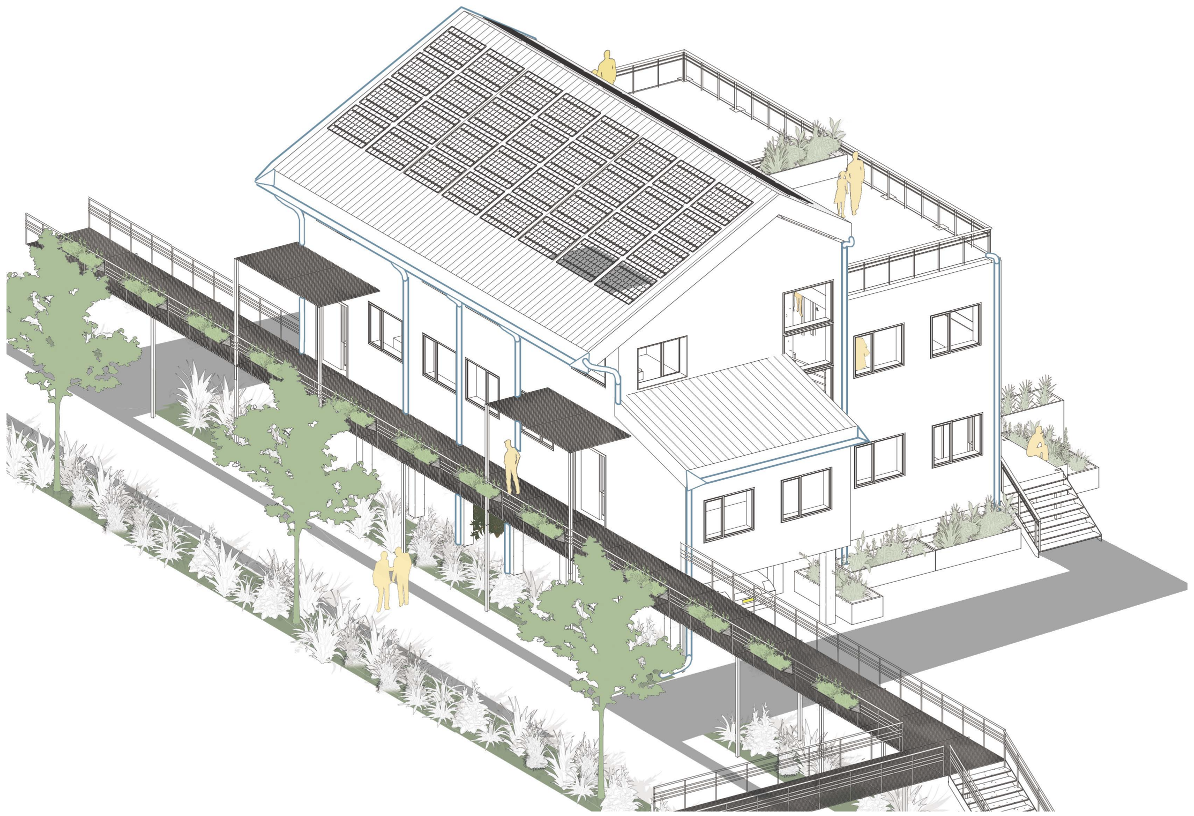
The design proposes modular rain garden boxes that function as both planting beds and rainwater storage tanks. The system allows components to shift between water retention and vegetation use depending on rainfall conditions. During heavy rain, the boxes collect and temporarily store stormwater to reduce runoff. When water levels decrease, the stored water can either infiltrate into the soil or be reused for irrigation.

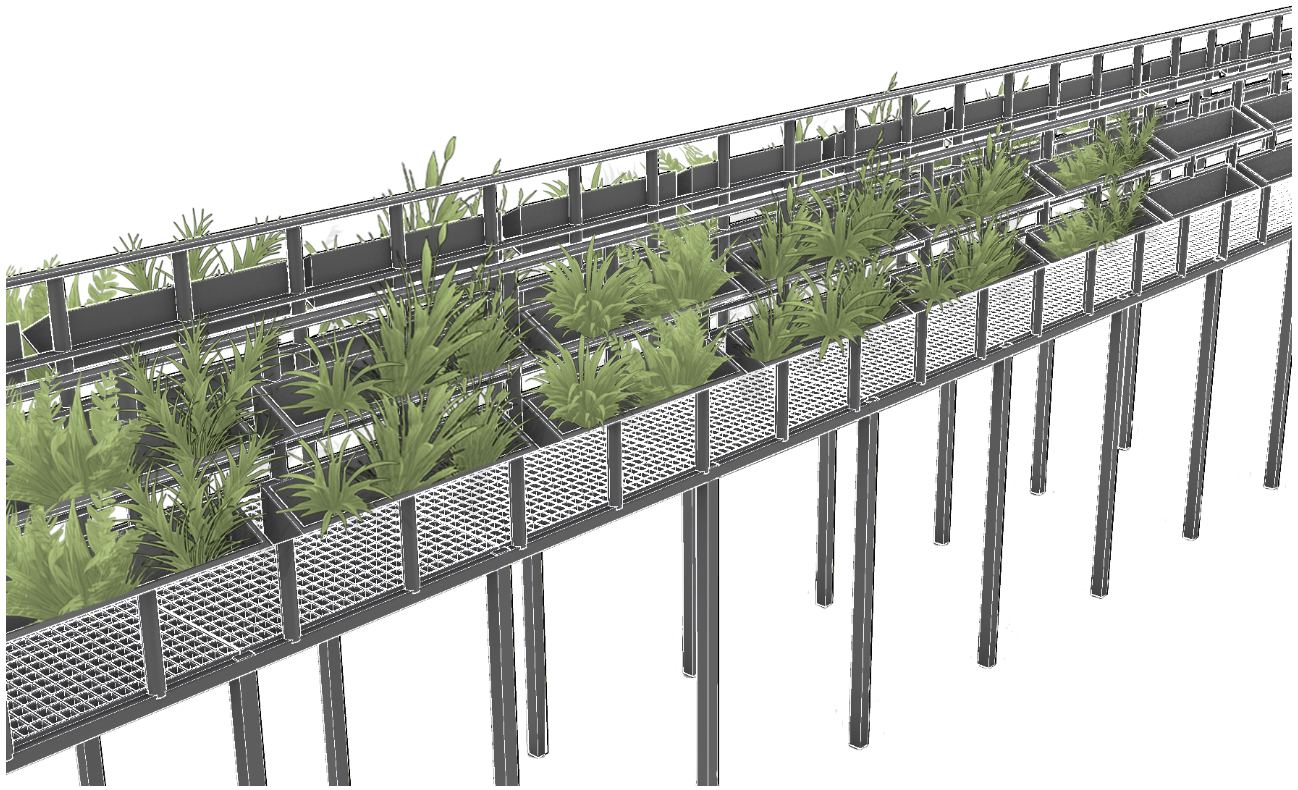


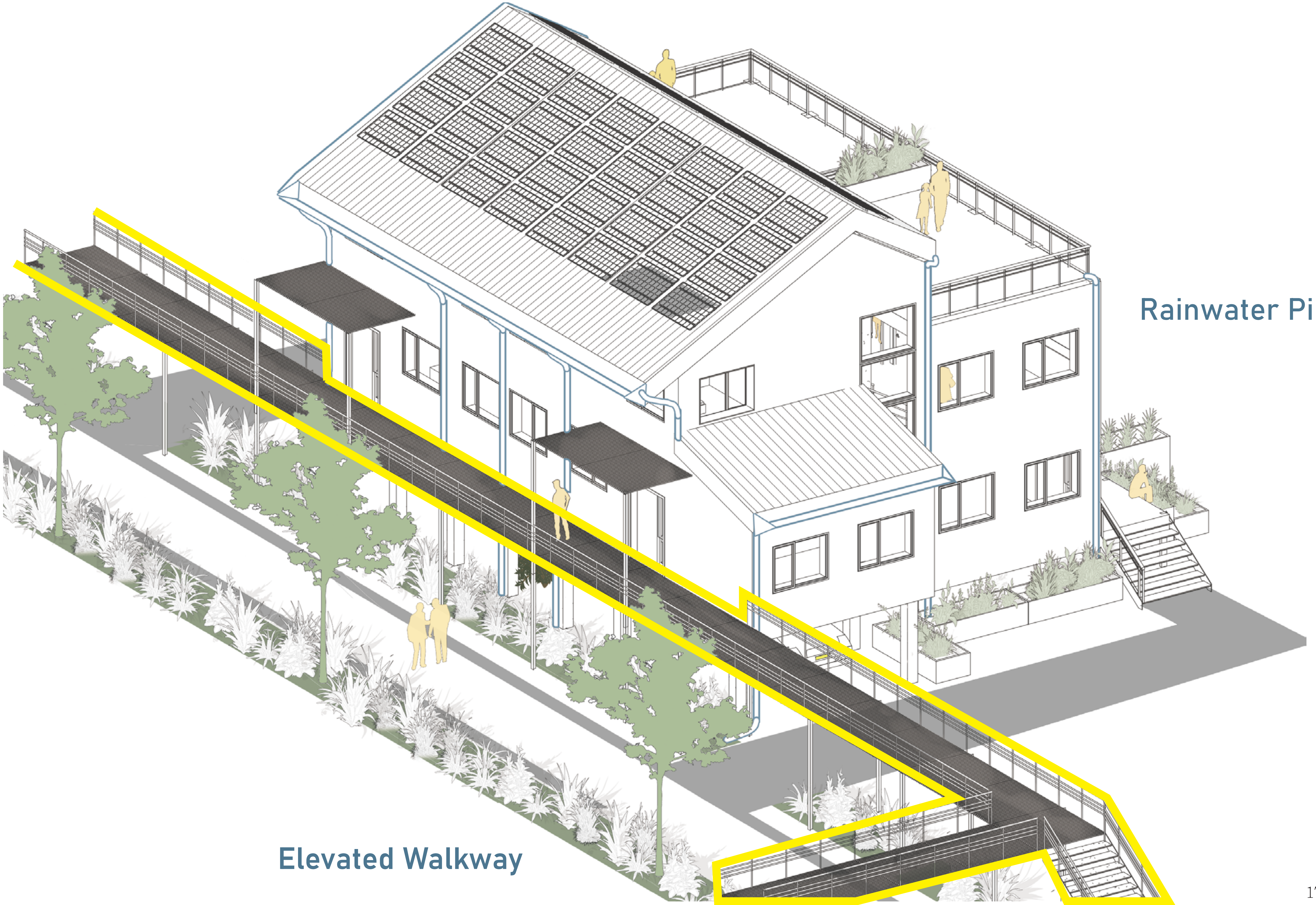
Planters

Planters are integrated along the rails of the elevated walkway. They add greenery, reduce the cold appearance of metal,and reduce surface heat gain on exposed steel railings. This improves comfort during non-flood conditions.

The plants absorb and temporarily store rainwater, improving drainage and ecological performance. They also strengthen the connection between circulation and landscape.

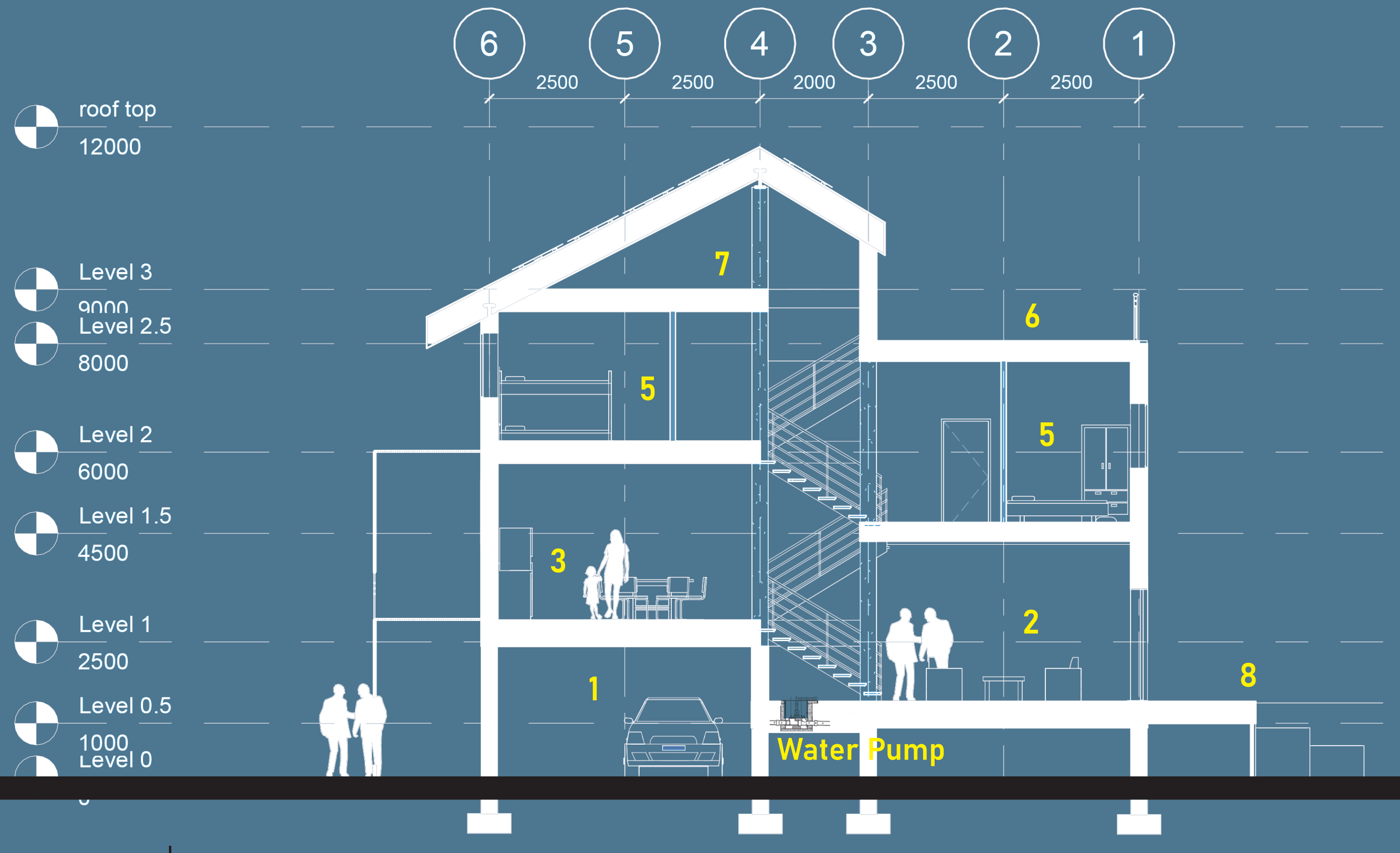


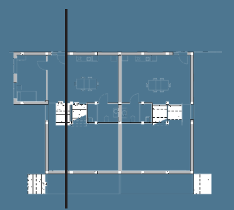



Rainwater Pipes
Elevated Walkway

9. Design Results

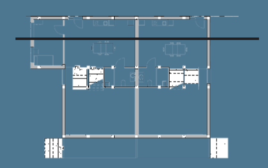

ROAD
N
0
5
10
20m
Scale: 1:500
Permeable Pavement
Tall grasses and meadow vegetation
Grassland
Outline of Building Footprint
Gravel Ground
Site Plan of Building

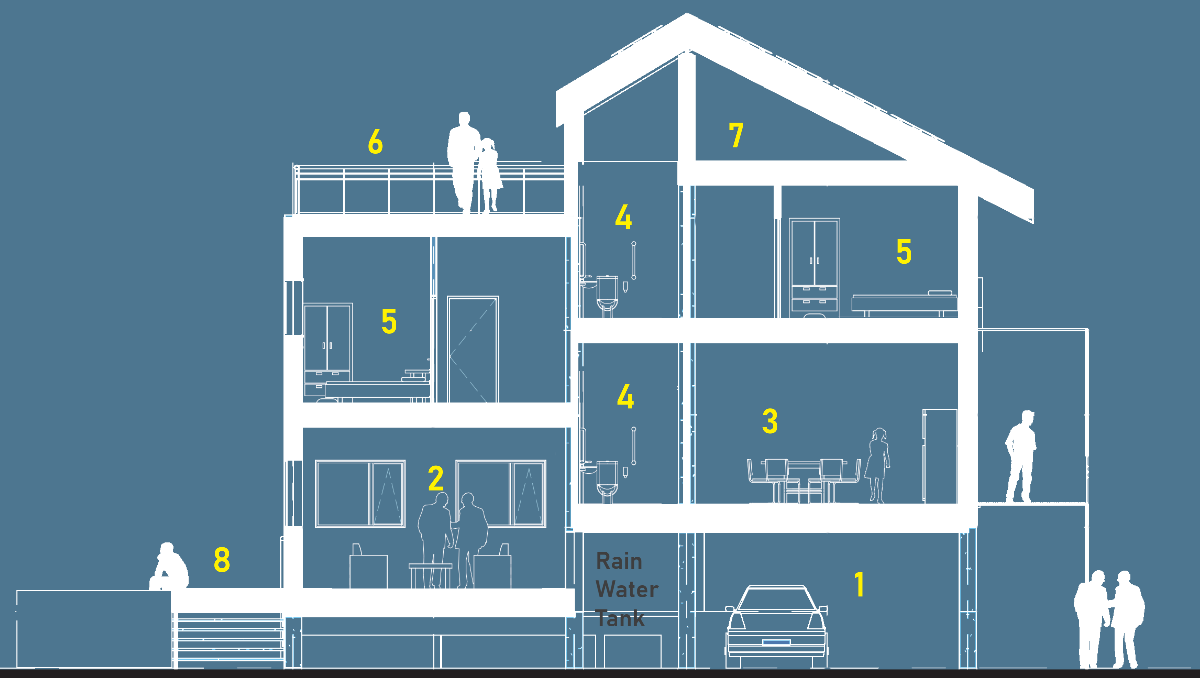


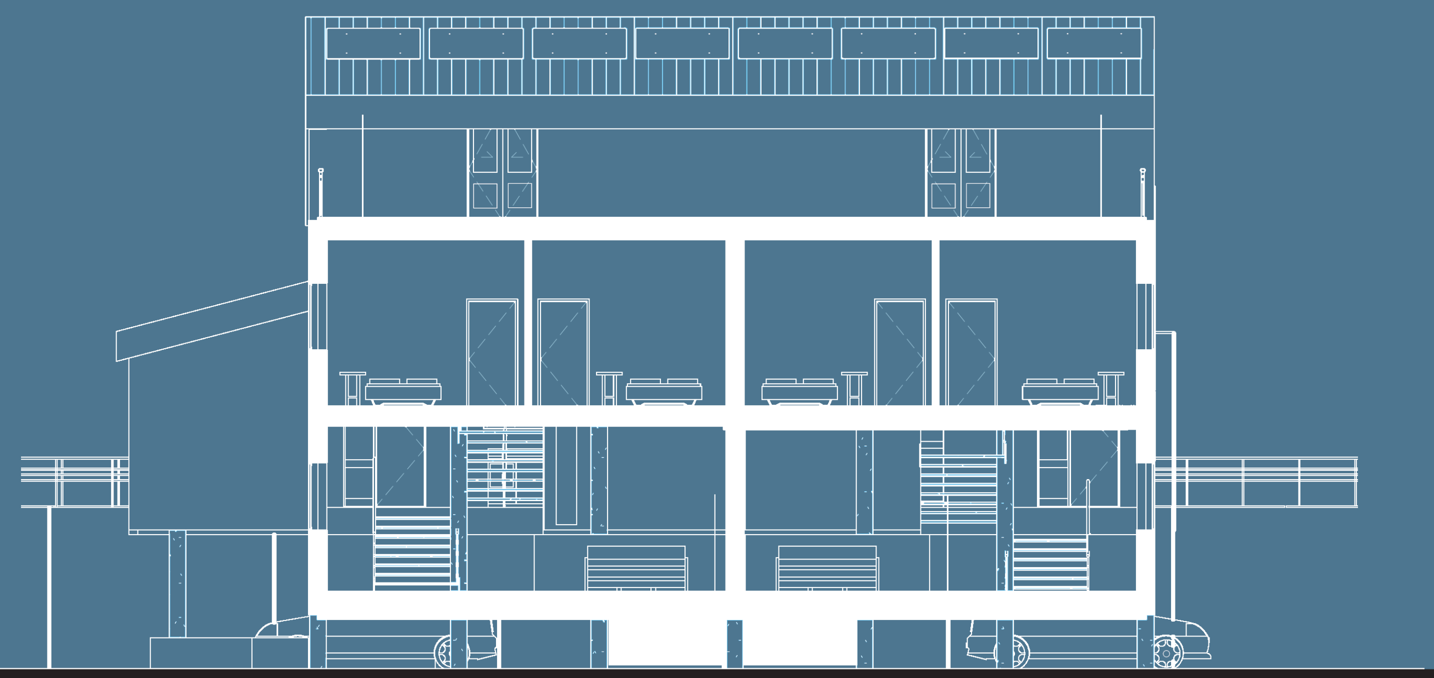


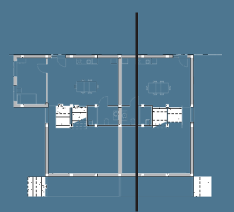
1. parking
2. living room
3. kitchen/dining room
4. bathroom

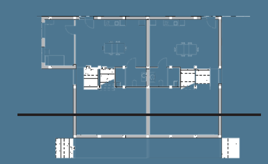
5. bedroom
6. rooftop terrace
7. equipment room
8. patio



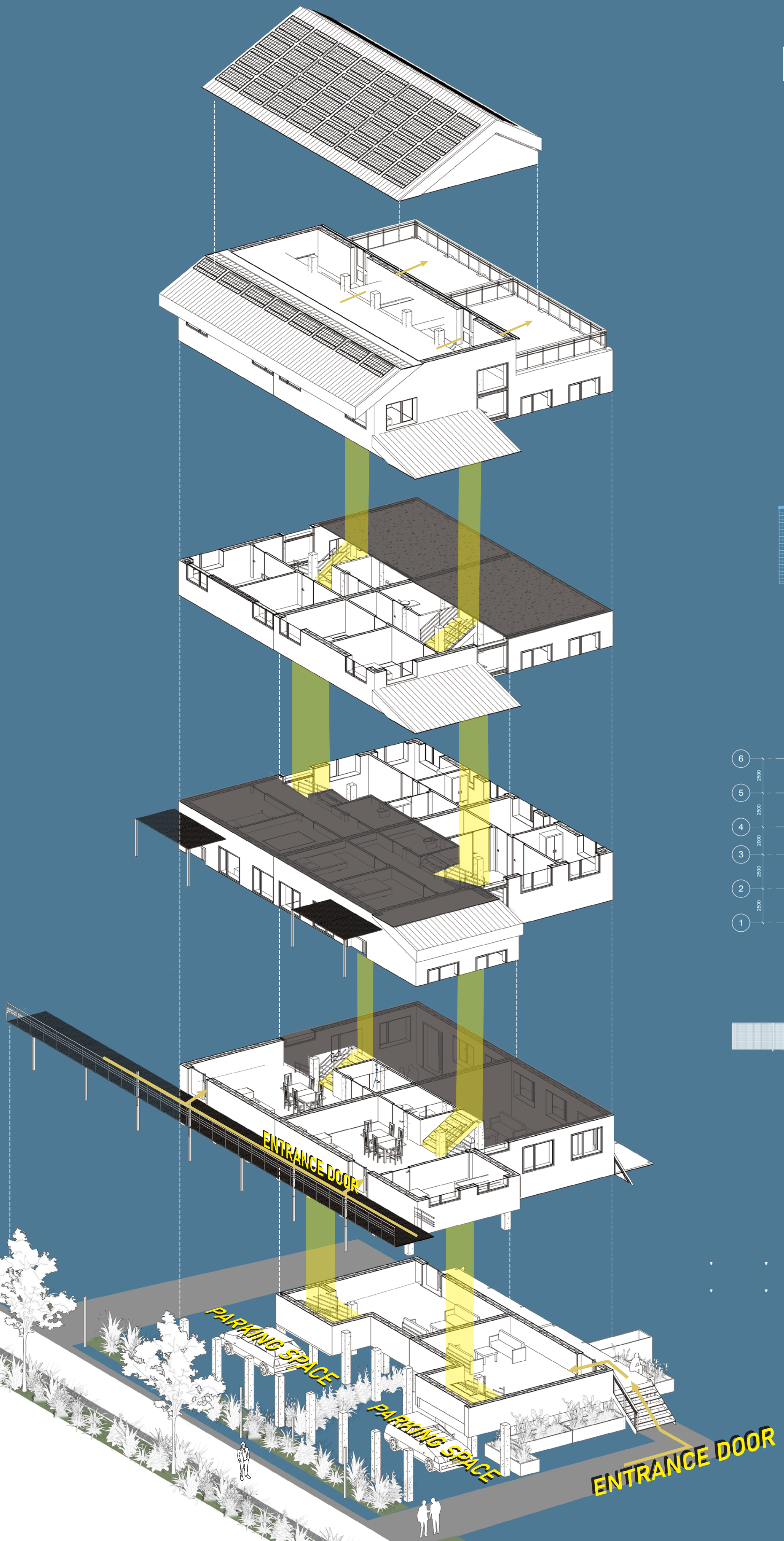




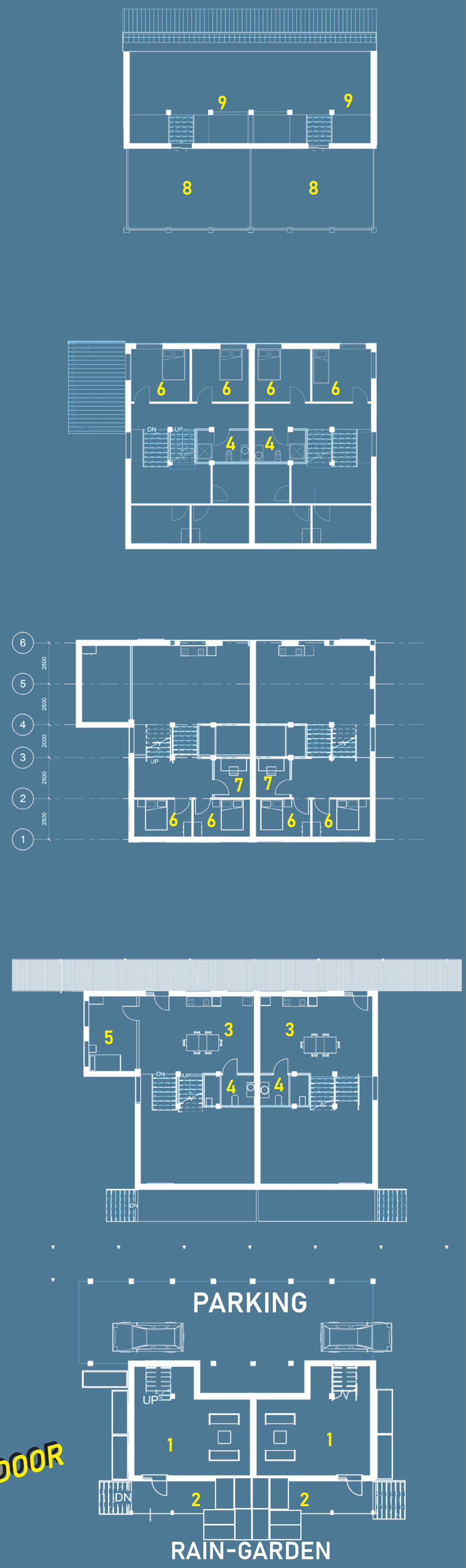




Sections



FLOOR PLANS



SOLAR PANELS

TOP FLOOR

8. ROOF TOP TERRACE 9. EQUIPMENT ROOM

THIRD FLOOR

6. 2 BEDROOMS 4. BATHROOM

SECOND FLOOR

6. 2 BEDROOMS 7. STUDY ROOM

FIRST FLOOR

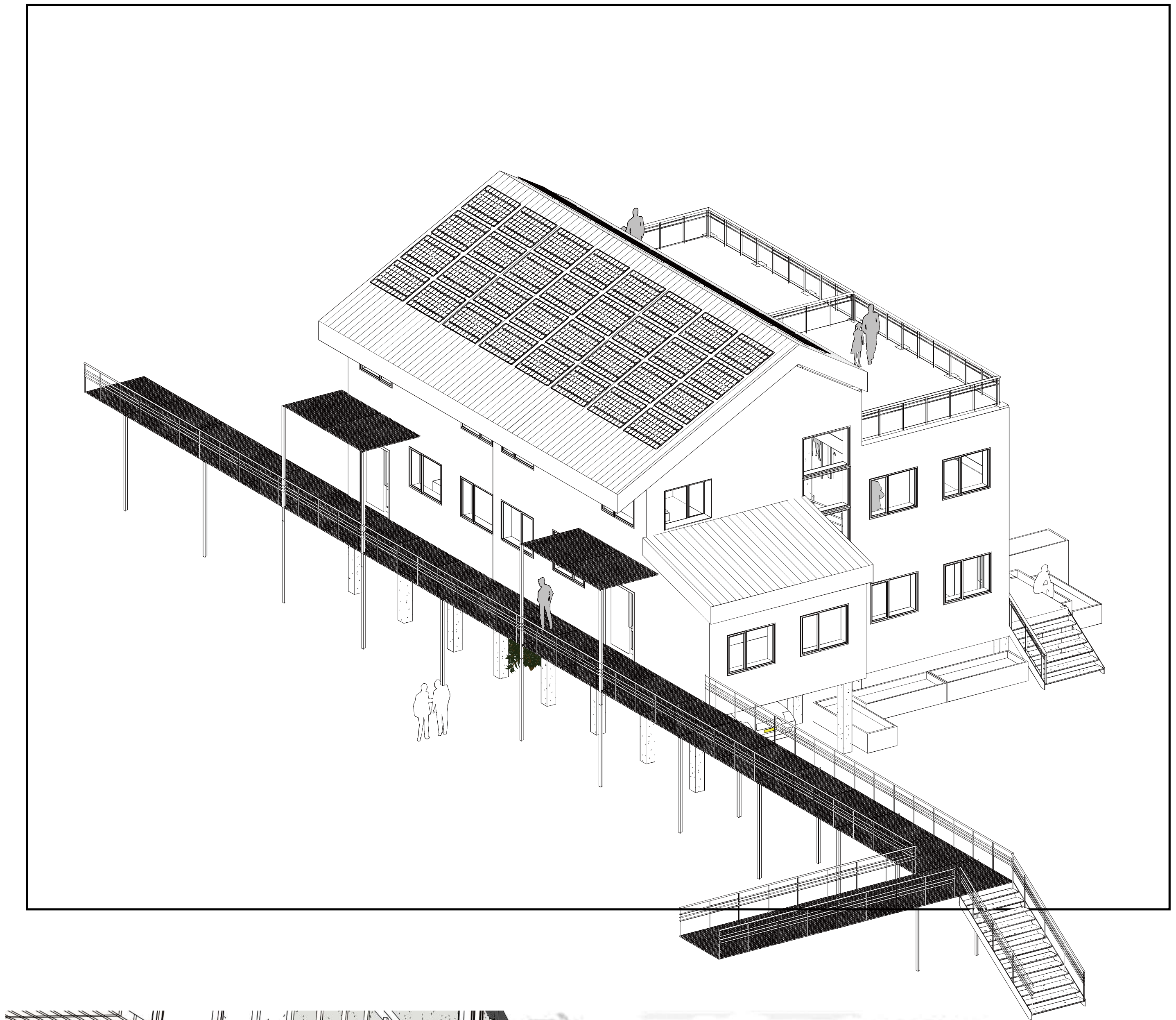
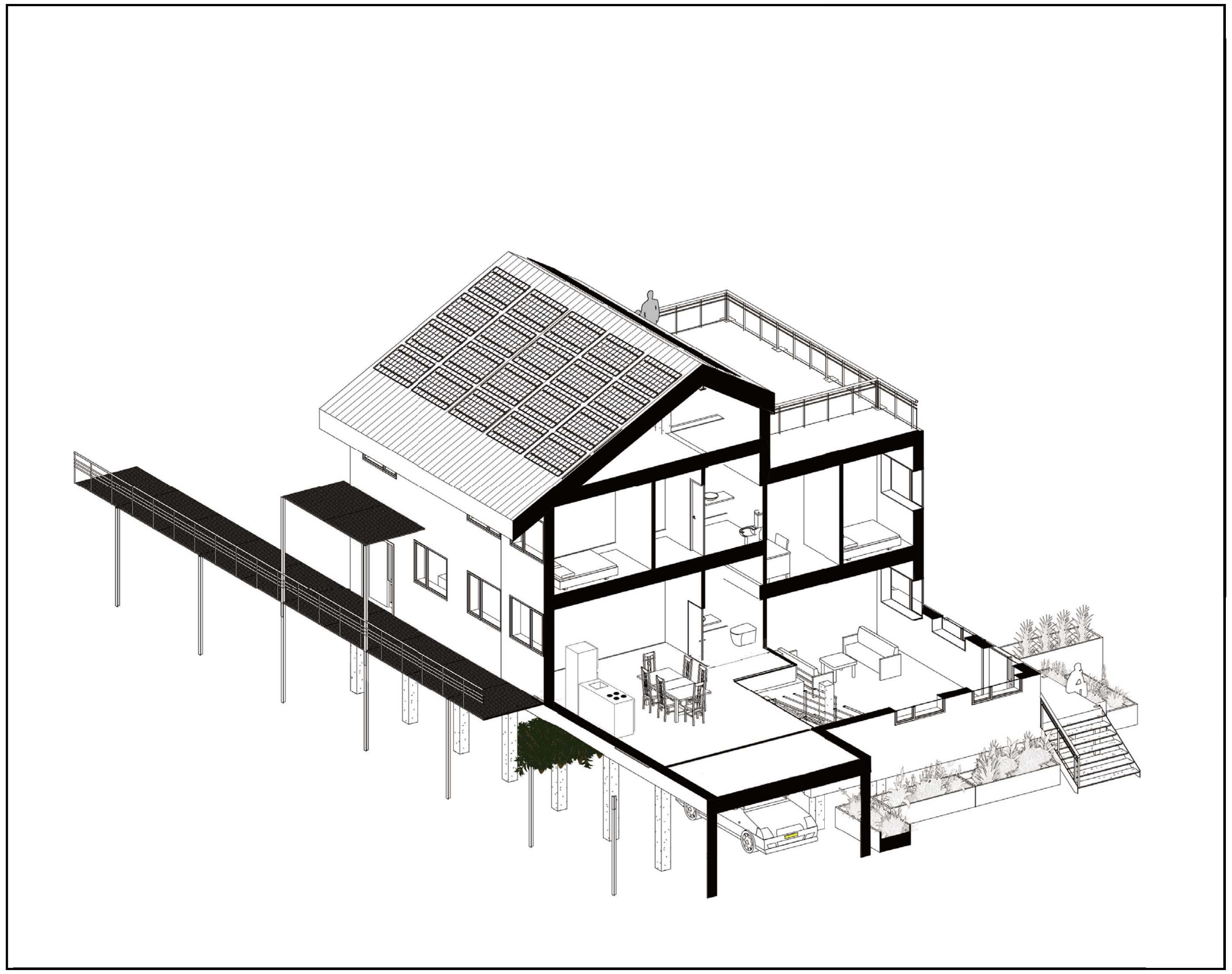
ENTRANCE DOOR CONNECTING WITH BRIDGE

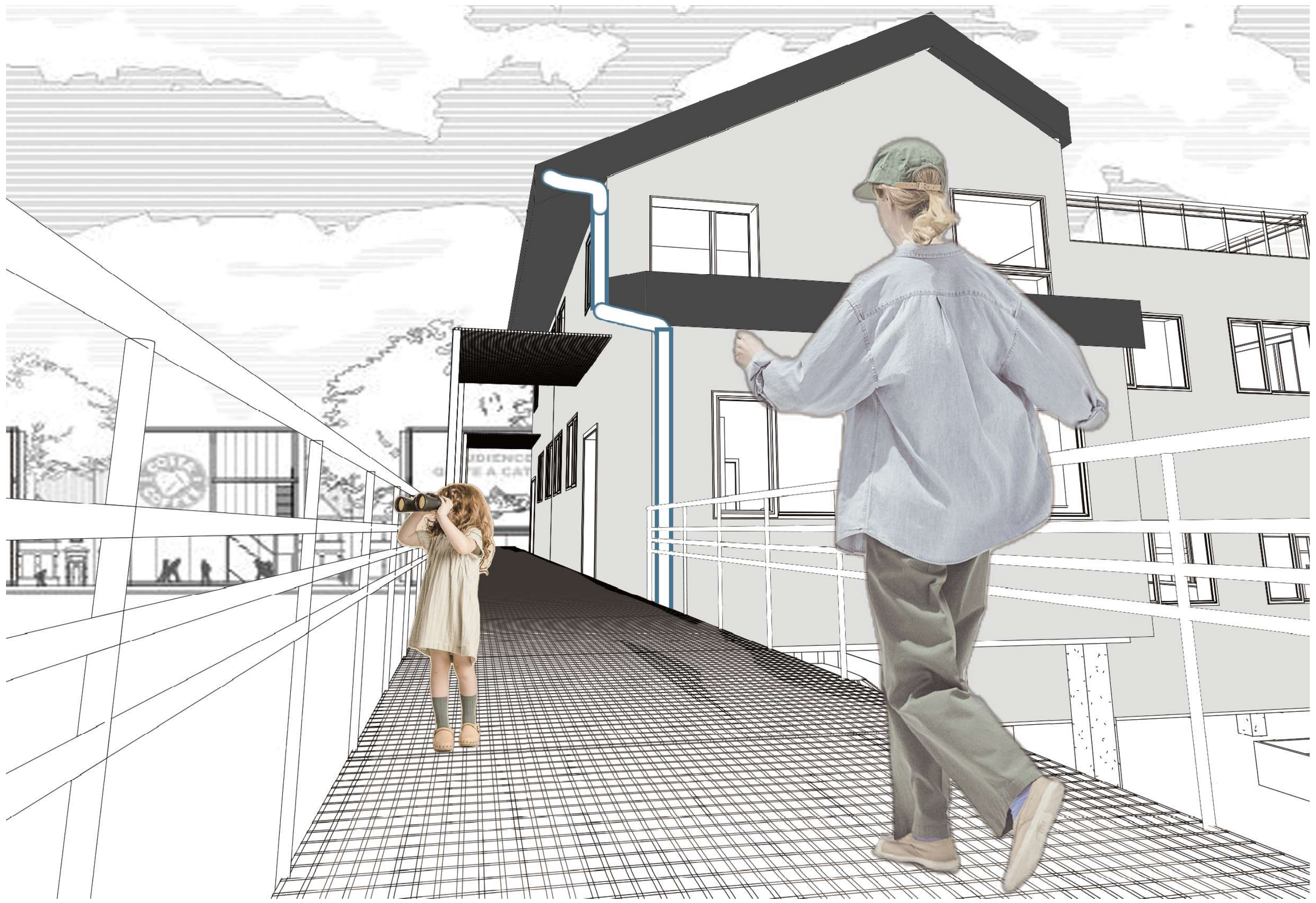
3. KITCHEN/DINING 4. BATHROOM
5. EXTRA ROOM FOR DISABLED AND ELDERLY PEOPLE

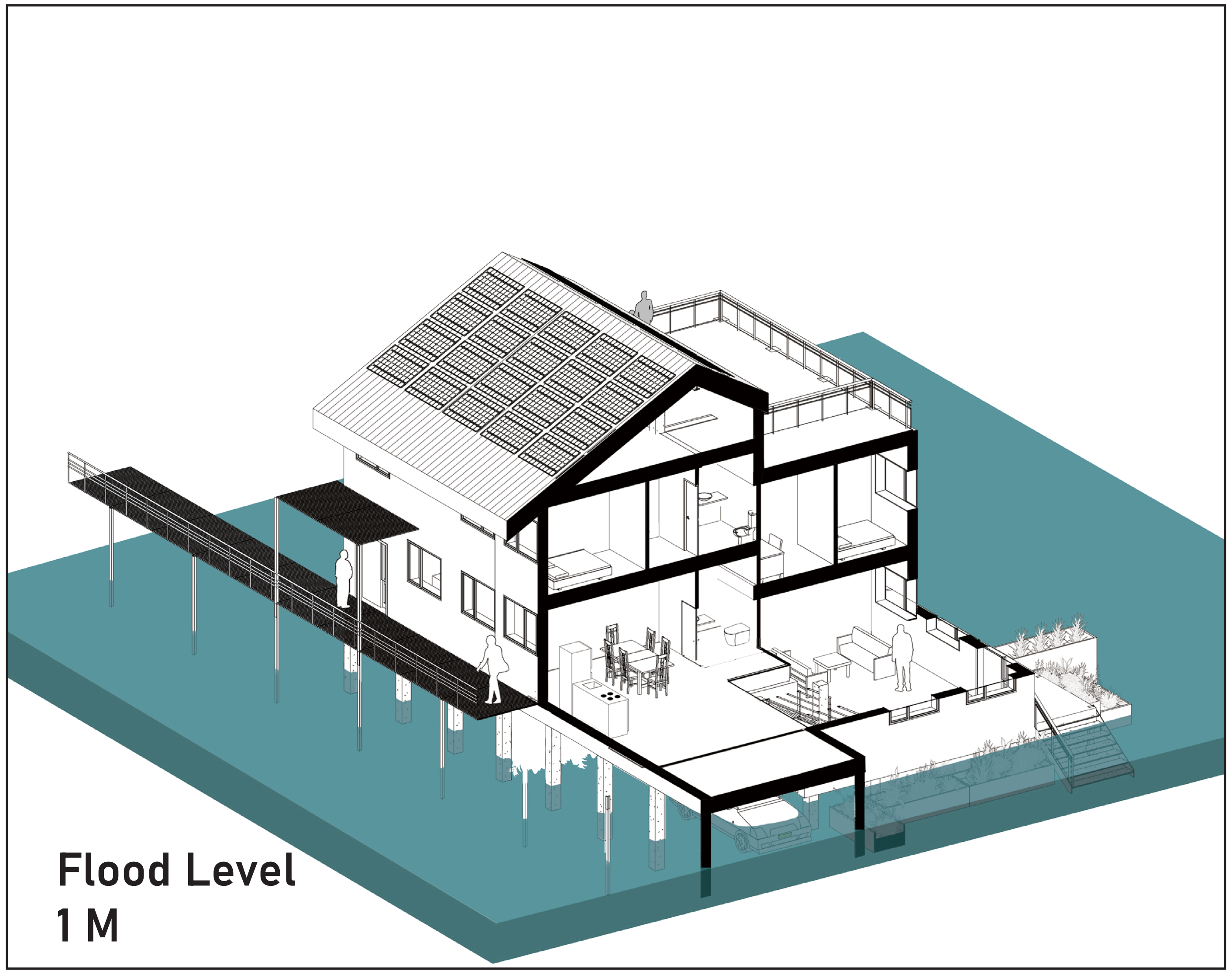
ELEVATED GROUND FLOOR

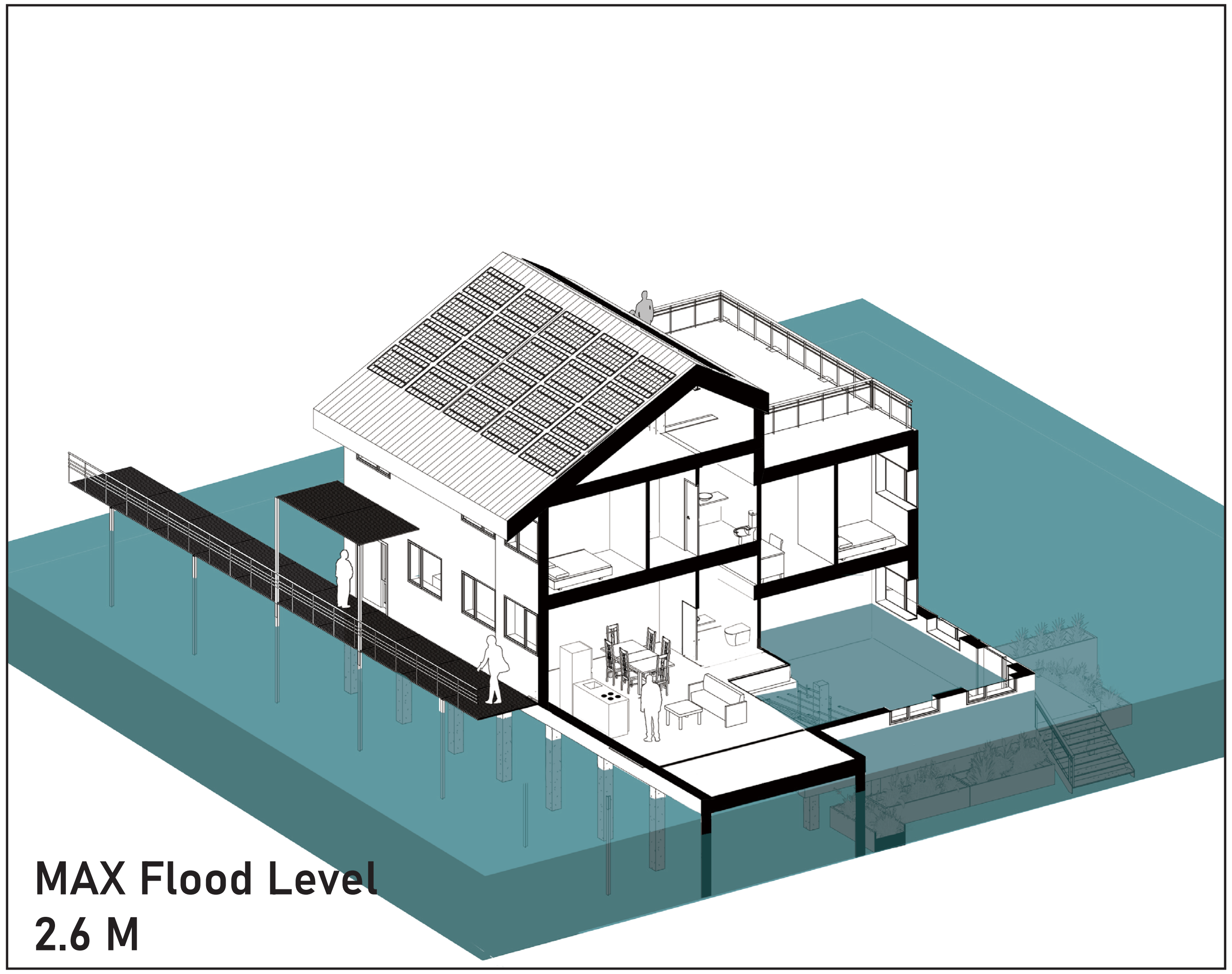
MAIN ENTRANCE DOOR

1. LIVING ROOM 2. OUTDOOR PATIO

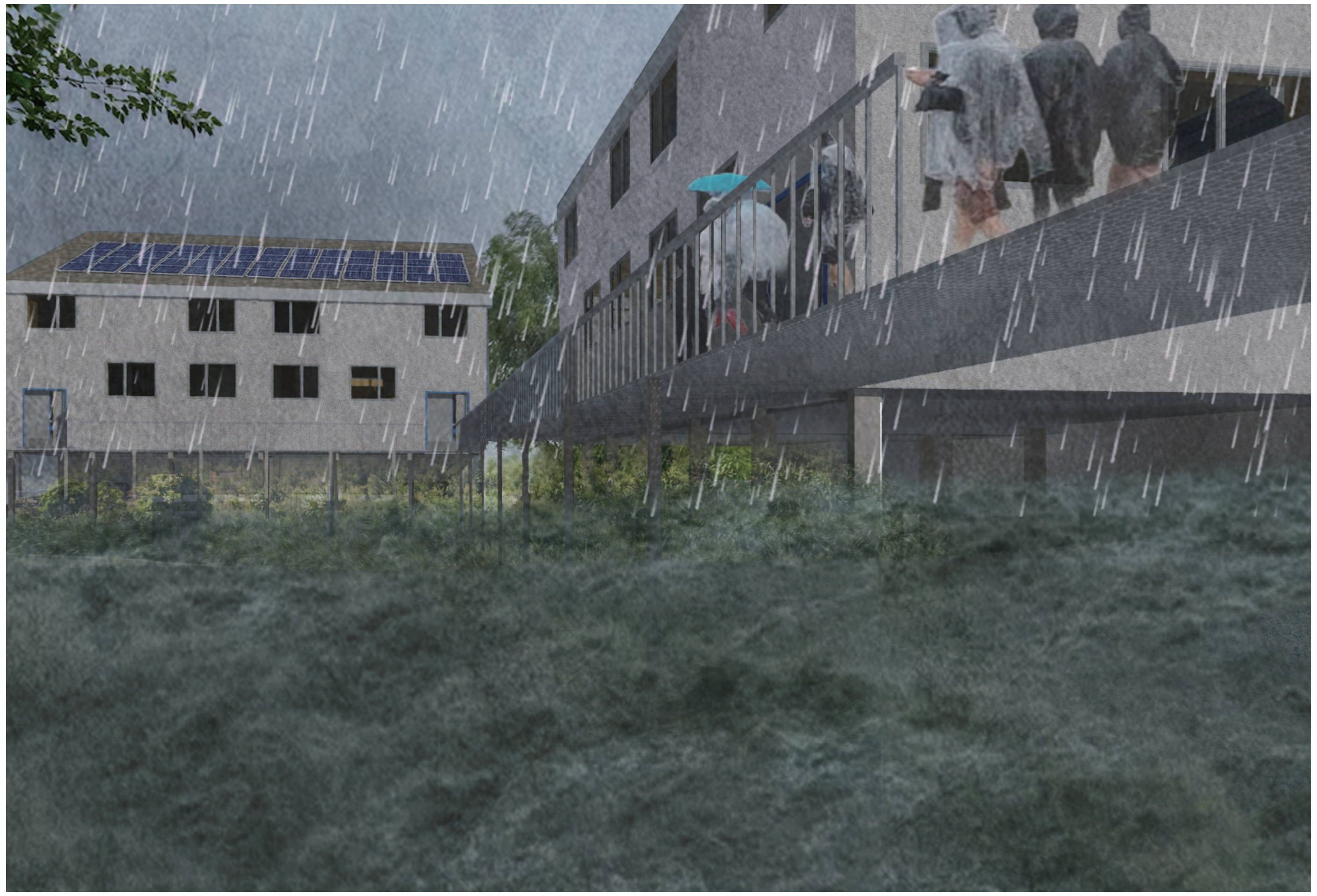



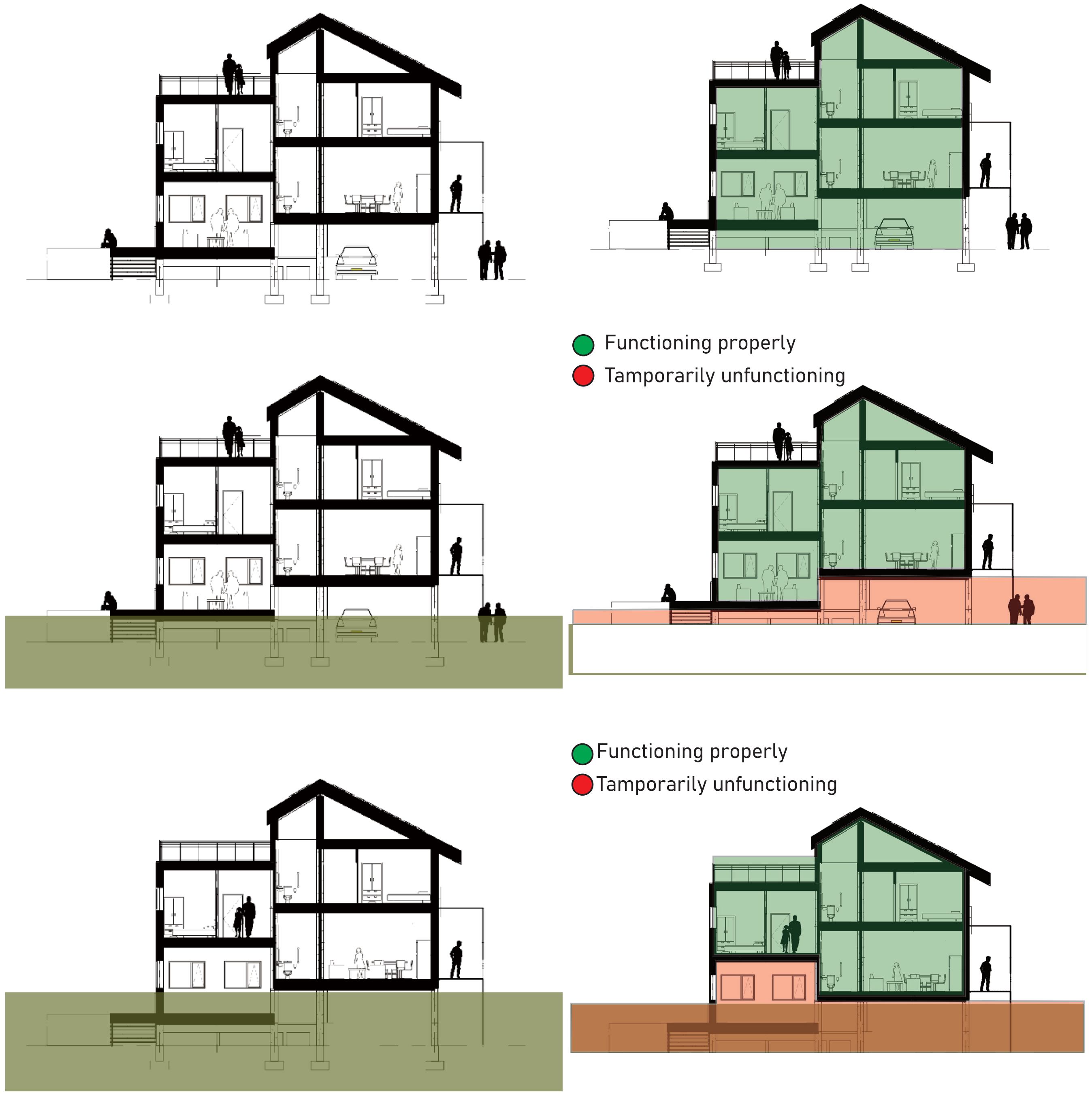



Flood Level
1 M


MAX Flood Level
2.6 M


THE LOEWE SHOW HAS BEEN CANCELLED
FASHION TURNS A PAGE





Living Room

The furniture is carefully selected with tall legs, lightweight structure, and flood-tolerant materials to reduce damage during flooding and allow easy cleaning and recovery.

Bed Room

The bedroom is oriented to face the central green area, providing visual connection to nature and shared open space. Large windows in upper floor improve daylight and create a sense of openness while maintaining privacy.

Kitchen & Dining Room

A split-level layout and open staircase connect the kitchen and dining area with the living and upper floors. This design improves visual connection, creates openness between spaces, and strengthens family interaction and spatial continuity.

Neighbourhood Street View

10. Conclusion

10.1 Key Insights & Critical Reflection

This research shows that flood resilience works best when addressed across community, neighbourhood, and dwelling scales together. At the community scale, floodable landscapes, retention areas, and overland flow paths redistribute water and protect residential clusters. At the neighbourhood scale, connected elevated walkways, layered circulation, and shared open spaces improve movement and social support during flood events. At the dwelling scale, elevated critical spaces, split-level layouts, and controlled ground-floor inundation allow homes to remain usable while managing water. These strategies function as a system rather than separate solutions.

The study also shows that resilience includes both physical protection and psychological security. Protecting buildings from damage is important, but residents also need stability, safety, and the ability to maintain daily routines. Design principles such as adaptation, redundancy, rapidity, self-sufficiency, and community support help address both material and emotional needs. This approach expands flood design beyond technical protection toward everyday living conditions.

However, applying these frameworks to a real site requires adjustment to context, budget, and construction limits. Design ideas may not fully translate without technical testing and policy support. Future work should include deeper engagement with residents and further testing through pilot projects to improve practical outcomes and ensure the design responds to lived experience.

- While the elevated circulation improves pedestrian access, it does not remove reliance on vehicular evacuation during extreme floods. If water depth exceeds walkway height or affects surrounding roads, residents may still depend on cars or external rescue. This shows a limit in full mobility resilience.

- The design protects key interior spaces by placing kitchens and electrical systems on upper floors. However, the ground floor remains vulnerable. Even with water-resistant materials, repeated flooding may weaken finishes and increase maintenance cost. Controlled inundation reduces pressure, but it does not remove long-term material fatigue.

- The light steel structure supports modular construction and fast assembly. At the same time, steel requires ongoing corrosion protection, especially in humid conditions. Without regular inspection, structural durability may decline over time.

- The shared raised walkway strengthens community connection. Yet shared infrastructure depends on collective management. If maintenance responsibility is unclear, the system may deteriorate. Social cohesion cannot be assumed, and governance structures must support long-term care.

10.2 Recommendations for Future Research & Practice

Future research can expand by directly involving residents who have experienced flooding to strengthen the relevance and effectiveness of flood-adaptive housing design. Field interviews, surveys, and participatory workshops would provide detailed insight into how households live through flood events, including evacuation patterns, coping strategies, and challenges with temporary displacement. Understanding daily routines, household priorities, and psychological impacts would help tailor architectural interventions to support both physical safety and emotional well-being.

Collaboration with residents during design testing would allow for iterative adjustments based on practical feedback, such as usability of elevated circulation routes, accessibility of critical spaces, and suitability of shared green infrastructure for community needs. This approach ensures that proposed solutions are not only theoretically sound but also grounded in lived experience. It would also reveal site-specific limitations, such as material availability, construction feasibility, and maintenance requirements, that could affect the long-term resilience of housing systems.

Further research should incorporate pilot implementation of proposed housing models in selected flood-prone neighborhoods. On-site monitoring of water flow, structural performance, and material response under actual flood conditions would provide empirical data to refine design strategies. Post-occupancy evaluation over multiple flood seasons would capture user behavior, satisfaction, and adaptation strategies, helping to assess whether homes function as intended in both routine and extreme conditions.

Comparative studies across other flood-prone regions in New Zealand or internationally would test the transferability of the design principles, revealing which strategies are context-specific and which can be generalized. Additional research could examine integration with broader community infrastructure, including stormwater networks, emergency access, and shared ecological landscapes, to ensure that flood-adaptive housing contributes to systemic resilience.

10.3 References

IPCC. (2012). Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate, Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 555-564

Groat, L. N., & Wang, D. (2013). Architectural research methods (2nd ed.). Wiley.

NIWA. (n.d.). Climate change and stormwater. https://niwa.co.nz/freshwater/stormwater-management/climate-change-and-stormwater

Lorrey, A.M., Pearce, P.R., Barkus, C., Anderson, S.J., and Clement-Jones, A. (2018). Auckland Region climate change projections and impacts: Summary report. Revised January 2018. Prepared by the National Institute of Water and Atmospheric Research (NIWA) for Auckland Council. Auckland Council Technical Report, TR2017/031-2.

Ministry of Environment. (2025). Our Environment 2025 – 7. Impacts on people, society and the economy. https://environment.govt.nz/publications/our-environment-2025/impacts-on-people-society-and-the-economy/

Motu. (2017). NZ water systems particularly vulnerable to climate change. https://www.motu.nz/about-us/news/nz-water-systems-particularly-vulnerable-to-climate-change

Schrader, B. (2013, June 17). Housing. Te Ara – the Encyclopedia of New Zealand, https://teara.govt.nz/en/housing

Barsley, E. (2019). Retrofitting for flood resilience: A guide to building and community design. RIBA Publications.

Community Think. (2023). Waitākere Ranges Resilience Planning A report.

Blackwell, F. (2024, January 25). Auckland Anniversary floods a year on: Outstanding insurance claims, properties yet to be categorised. RNZ. https://www.rnz.co.nz/news/national/507477/auckland-anniversary-floods-a-year-on-outstanding-insurance-claims-properties-yet-to-be-categorised

Watson, D., & Adams, M. (2010). Design for flooding: Architecture, landscape, and urban design for resilience to flooding and climate change. John Wiley & Sons.

Charlesworth, E., & Fien, J. (2022). Design and disaster resilience: Toward a role for design in disaster mitigation and recovery. Architecture, 2(2), 292–306. https://doi.org/10.3390/architecture2020017

Resilience to Nature's Challenges. (2025). Housing and disaster recovery (Policy Brief). Resilience to Nature's Challenges National Science Challenge, Extreme Weather Research Platform, Ministry of Business, Innovation and Employment. https://resiliencechallenge.nz/outputs/housing-and-disaster-recovery/

Auckland Council, & Arup. (2019). Climate change risks in Auckland: Auckland Council technical report (TR2019/019). Auckland Council. ISBN 978-1-98-858959-6; ISSN 2230-4525 (print); ISSN 2230-4533 (online).

Woodhall-Melnik, J., & Grogan, C. (2019). Perceptions of mental health and wellbeing following residential displacement and damage from the 2018 St. John River Flood. International Journal of Environmental Research and Public Health, 16(21), Article 4174. https://doi.org/10.3390/ijerph16214174

Building System Performance branch. (2025). The Resilient homes - Flooding quick guide. Ministry of Business, Innovation and Employment (MBIE). ONLINE: ISBN 978-1-991316-04-2

BRANZ. (2021). Bulletin666 Restore home after flooding. ISSN 1178-4725 (print); 2537-7310 (online).

One Roof. (n.d.). 20 Clover Drive, Henderson, Waitakere City. https://www.oneroof.co.nz/property/auckland/henderson/20-clover-drive/obUes

Stats NZ. (2024, October 3). Home ownership increases and housing quality improves. https://www.stats.govt.nz/news/home-ownership-increases-and-housing-quality-improves/

Environmental health Intelligence New Zealand & Massey University. (2023). Social Vulnerability Indicators for New Zealand 2023 (SVI2023), Auckland local board areas

Fisher, K. T., & Parsons, M. (2020). River co-governance and co-management in Aotearoa New Zealand: Enabling Indigenous ways of knowing and being. Transnational Environmental Law, 9(3), 455–480. https://doi.org/10.1017/S204710252000028X

United Nations Office for Disaster Risk Reduction. (2022). Words into Action: Using traditional and indigenous knowledges for disaster risk reduction. https://www.undrr.org/words-into-action/traditional-and-indigenous-knowledges-drr

Newton, K. (2023, February 17). For sale: new, warm and dry homes. The catch? They're in a flood plain, and the flood is coming sooner than you think. Stuff News. https://www.stuff.co.nz/national/131196837/for-sale-new-warm-and-dry-homes-the-catch-theyre-in-a-flood-plain-and-the-flood-is-coming-sooner-than-you-think

@mo_mo1. (2023). Is Ranui a bad area to buy house? Reddit. https://www.reddit.com/r/auckland/comments/1d6nvzc/is_ranui_a_ bad_area_to_buy_house/

Welch, T. (2023, January 29). Auckland floods: Even stormwater reform won't be enough – we need a 'sponge city' to avoid future disasters. The Conversation. https://theconversation.com/auckland-floods-even-stormwater-reform-wont-be-enough-we-need-a-sponge-city-to-avoid-future-disasters-198736. https://doi.org/10.64628/AA.n37vncsqp

Nguyen, C. N. (2020). Homeowners' choice when the government proposes a managed retreat. International Journal of Disaster Risk Reduction, 47, 101543. https://doi.org/10.1016/j.ijdrr.2020.101543 https://ourauckland.aucklandcouncil.govt.nz/media-centre/2025/april/ground-broken-on-the-first-making-space-for-water-flood-resilience-projects/

Bruneau, M., Chang, S. E., Eguchi, R. T., Lee, G. C., O'Rourke, T. D., Reinhorn, A. M., ... & von Winterfeldt, D. (2003). A framework to assess and improve the seismic resilience of communities. Earthquake Spectra, 19(4), 733–752.

UNESCO. (2019). Science, technology and innovation for resilience. UNESCO. https://en.unesco.org/disaster-risk-reduction/science-technology-resillience

ICLEI (2021). Guide on Connecting Green Recovery and Resilience in Cities. Resilient Cities Action Package 2021 (ReCAP21)

Yates, A. M. (2016). Mauri-Ora: Architecture, indigeneity, and immanence ethics. Architectural Theory Review, 21(2), 261–275.

Sandeeka Mannakkara, Suzanne Wilkinson, (2014). Re-conceptualising "Building Back Better" to Improve Post-Disaster Recovery, International Journal of Managing Projects in Business, Vol. 7 Iss: 3. Pre-print version.

La Loggia, G., Puleo, V. & Freni, G. (2020). Floodability: A New Paradigm for Designing Urban Drainage and Achieving Sustainable Urban Growth. Water Resour Manage 34, 3411–3424. https://doi.org/10.1007/s11269-020-02620-

CIRIA. (2007, May). Improving the flood performance of new buildings: Flood resilient construction. Department for Communities and Local Government.

Auckland Council Healthy Waters. (2025, June 6). Framework for assessing flood risk at the property level (Version 3.0).

United Nations Office for Disaster Risk Reduction. (2017). The Sendai Framework Terminology on Disaster Risk Reduction. https://www.undrr.org/terminology/resilience.

Comfort, L. K., Boin, A., & Demchak, C. C. (2010). Designing resilience: preparing for extreme events. University of Pittsburgh Press. https://ci.nii.ac.jp/ncid/BB07157158

Auckland Council. (2025, November). Making space for water: Year in review 2024/2025. ISBN 978-1-991415-42-4 (Print) ISBN 978-1-991415-43-1 (PDF)

Bates Masi + Architects. (2019, December 21). Northwest Harbor. ArchDaily. https://www.archdaily.com/562527/northwest-harbor-bates-masi-architects

BACA Architects. (2015). Amphibious house. https://www.baca.uk.com/amphibioushouse

Kompong Khleang. (n.d.). About the village. https://kompongkhleang.org/the-village/

Isthmus. (2023). Northcote's landscape infrastructure in action. https://isthmus.co.nz/thinking/northcotes-landscape-infrastructure-in-action/

Freeland Reserve- Roskill Development. (2023). First off the ground: civil construction completed in Roskill South. https://roskilldevelopment.co.nz/news/first-off-the-ground-civil-construction-completed-in-roskill-south/

Freeland Reserve in flood- Roskill Development. (2023). Freeland Reserve does its job in Auckland's floods. https://roskilldevelopment.co.nz/news/freeland-reserve-does-its-job-in-aucklands-floods/

Hernández, D. (2019, July 15). Moriviví House: The hurricane-proof project that builds community. ArchDaily. https://www.archdaily.com/920913/morovivi-house-the-hurricane-proof-project-that-builds-community

BRE Group. (2017). Flood resilient repair house. https://bregroup.com/about/science-park/flood-resilient-repair-house

Boyd, E. H., & Bonfield, P. (2017, February 17). Building flood resilience into the fabric of Britain. Environment Agency. https://environmentagency.blog.gov.uk/2017/02/17/building-flood-resilience-into-the-fabric-of-britain/

Kāinga Ora, (2022, November 8). Celebrating the opening of Freeland Reserve in Roskill South. https://kaingaora.govt.nz/sm_WS/news/celebrating-the-opening-of-freeland-reserve-in-roskill-south

DNS & PA. (2005). Tackling the Tides and Tremors: South Asia Disaster Report 2005. Colombo: Duryog Nivaran Secretariat & Practical Action - South Asia Programme.

Shams, S., Barton, A.,Fox, A., Hsu, J. (2023). Resilience Design Toolkit, Resilience Design Integration for Architectural Projects. AIA, HKS Inc. aia.org/resiliencedesigntoolkit.

10.4 List of Figures

Figure 4.1 Project Twin Stream

Figure 4.2 Auckland Council. (2025, November). Making space for water: Year in review 2024/2025.

Figure 4.3 Bates Masi + Architects. (2019, December 21). Northwest Harbor. ArchDaily. https://www.archdaily.com/562527/northwest-harbor-bates-masi-architects

Figure 4.4 BACA Architects. (2015). Amphibious house. https://www.baca.uk.com/amphibioushouse

Figure 4.5 Kompong Khleang. (n.d.). About the village. https://kompongkhleang.org/the-village/

Figure 4.6 Mottelson, J., Chilaule, R., & Venerandi, A. (2025). Aquatic informal settlements: Vernacular design strategies for flood-resilient built environments. Habitat International, 169, Article 103708. https://doi.org/10.1016/j.habitatint.2025.103708

Figure 6.1 Auckland Council. (2025). Auckland Open Street Map.

Figure 6.2 Auckland city road line map

Figure 6.3 Google Map (2025). https://www.google.com/maps/

Figure 6.4 Auckland Council. (2024). Clover Drive flood resilience works

Figure 6.6 Auckland Council. (2025). Auckland Open Street Map.

Figure 6.8 Google Map 1959, 1996, 2001, 2010, 2023 Aerial imagery (2025). https://www.google.com/maps/

Figure 6.9 Google Map 1996 Aerial imagery (2025). https://www.google.com/maps/

Figure 7.3-5 Isthmus. (2023). Northcote's landscape infrastructure in action. https://isthmus.co.nz/thinking/northcotes-landscape-infrastructure-in-action/

Figure 7.6 Freeland Reserve- Roskill Development. (2023). First off the ground: civil construction completed in Roskill South. https://roskilldevelopment.co.nz/news/first-off-the-ground-civil-construction-completed-in-roskill-south/

Figure 7.7 Freeland Reserve in flood- Roskill Development. (2023). Freeland Reserve does its job in Auckland's floods. https://roskilldevelopment.co.nz/news/freeland-reserve-does-its-job-in-aucklands-floods/

Figure7.8 Context NZ. (2025, September 30). Freeland Reserve. https://context.nz/portfolio/freeland-reserve/

Figure7.10-12 Hernández, D. (2019, July 15). Moriviví House: The hurricane-proof project that builds community. ArchDaily. https://www.archdaily.com/920913/morovivi-house-the-hurricane-proof-project-that-builds-community

Figure 7.13-15 The Environmental Design Studio. (2016). The Home for All Seasons. https://www.t-e-d-s.com/home-for-all-seasons

Figure 7.16-17 黄腾, & 黄业倩. (2025, October 20). 科学应对内涝 携手共建家园. 百色新闻网. http://zhuanti.bsyjrb.cn/content/2025-10/20/content_240678.htm

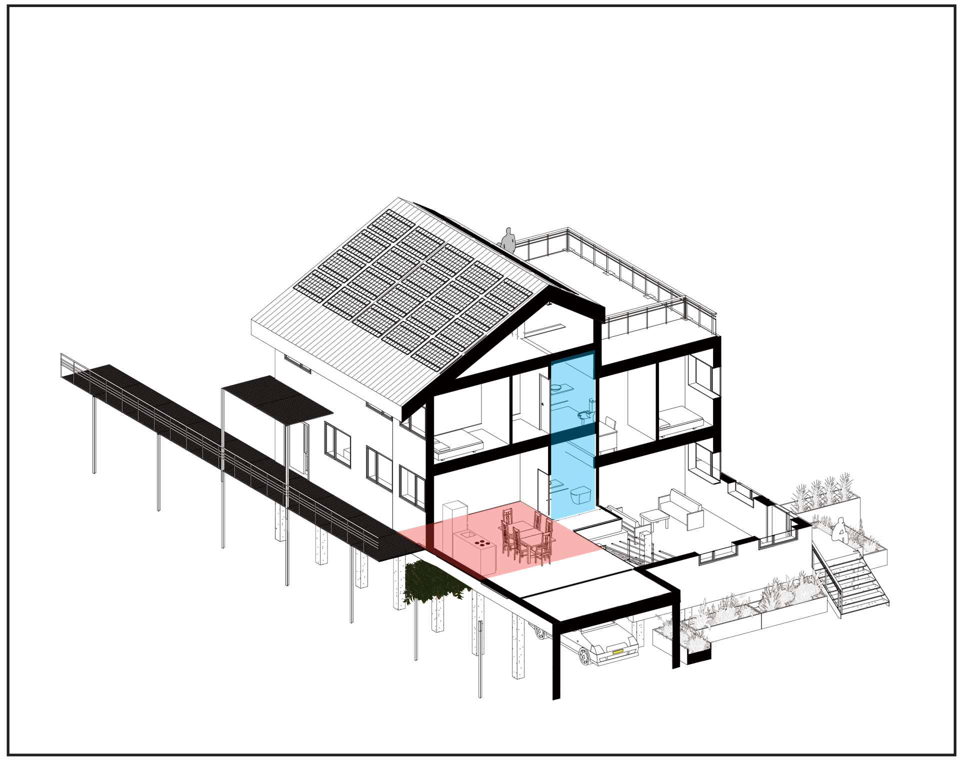
Figure 7.19-7.21 BRE Group. (2017). Flood resilient repair house. https://bregroup.com/about/science-park/flood-resilient-repair-house

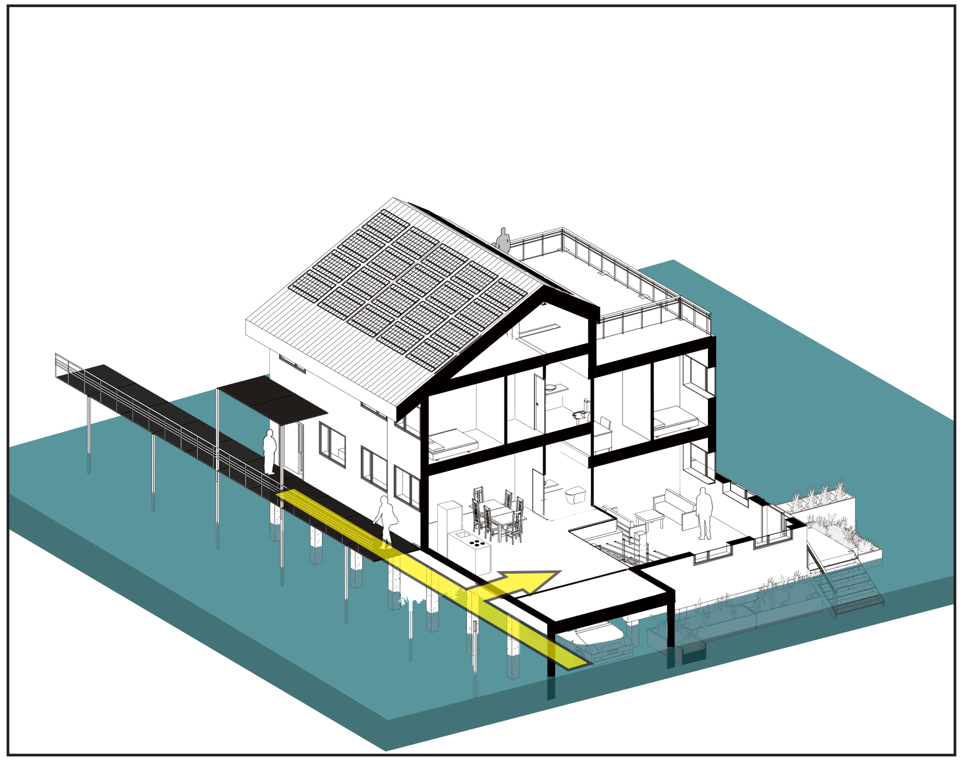
Figure 7.22-7.24 Flood Re. (2025, November 13). The Flood Resilient Garden. https://www.floodre.co.uk/flood-resilient-garden/

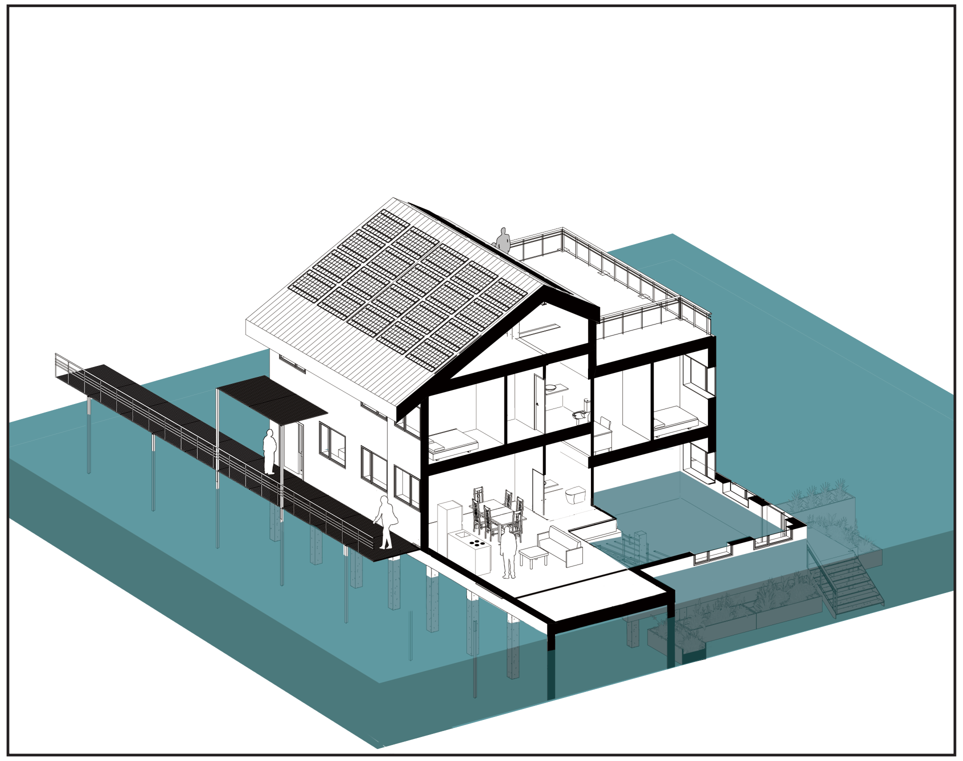
Figure 8.1 Laksono, B. T. (2018). [The balcony] [Photograph]. In B. Hahijary, SaRanG Building: A nest for artists. Indonesia Design. https://indonesiadesign.com/story/sarang-gallery-a-nest-for-artists/

Appendix:
Required Amendments by Examiners

▪ Relationship between elevated systems and sacrificial ground floor approaches







Critical functions
The elevated house is designed to protect living spaces from **more frequent, low-level flooding** caused by increasingly intense rainfall events, which are becoming more common.

Critical functions, including the kitchen, bathroom, bedrooms, and electrical infrastructure, are located on upper floors above predicted flood levels. This reduces damage to expensive household equipment and allows residents to maintain essential daily activities during flood events.

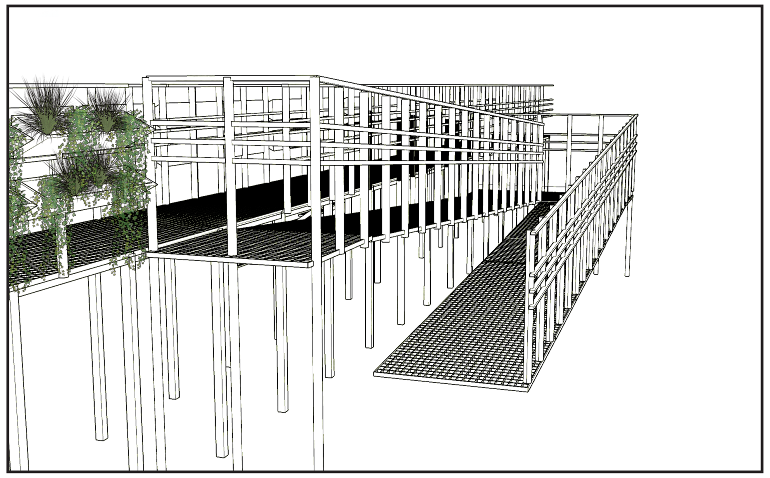
The elevated circulation network serves as an **alternative access route when roads and ground-level paths are flooded.** It maintains pedestrian connectivity, supports safe movement during flood events, and reduces the risk of community isolation.

During non-flood conditions, the walkway also acts as an elevated community garden corridor. Planters integrated into the railings introduce native vegetation, improve visual amenity, support biodiversity, and create opportunities for residents to participate in small-scale gardening and stewardship activities. This helps transform the walkway from purely emergency infrastructure into an active social and ecological space.

However, elevation alone cannot eliminate flood risk. Flood levels may exceed design predictions, particularly under future climate uncertainty and increasingly extreme rainfall events. For this reason, the proposal incorporates a sacrificial ground floor designed to accommodate flood depths exceeding 1000 mm. Rather than resisting water entirely, the ground floor allows controlled inundation, enabling floodwater to enter and flow through the space. This approach reduces hydrostatic pressure on walls and foundations, helping to protect the overall structural integrity of the building during severe flood events.

The sacrificial ground floor also supports faster and more efficient recovery following extreme flooding. Water-resistant materials, raised services, and open structural systems allow floodwater to enter and recede with minimal long-term damage. As critical living functions are located on upper levels, the impact of flooding on everyday habitation is significantly reduced. This strategy lowers repair requirements, shortens recovery time, and improves the building's ability to remain functional after inundation compared with conventional housing, where floodwater directly affects primary living spaces.

▪ Inclusive circulation strategies for elderly & mobility-impaired users.



Ramps for elderly
& mobility-impaired users

Planters in the railings

Flood-resilient environments need to remain accessible to residents of different ages and mobility levels. While elevated walkways and raised living spaces improve safety during flood events, they may create barriers for elderly residents, wheelchair users, and people with temporary or permanent mobility impairments if access relies solely on stairs.

To address this issue, the elevated circulation network is designed as an accessible route rather than an emergency-only pathway. Gentle ramps are incorporated where possible to provide step-free access between key community destinations.

During non-flood conditions, the walkway also acts as an elevated community garden corridor. Planters integrated into the railings introduce native vegetation, improve visual amenity, support biodiversity, and create opportunities for residents to participate in small-scale gardening and stewardship activities. This helps transform the walkway from purely emergency infrastructure into an active social and ecological space.

▪ Cost and Feasibility

A network of elevated walkways is a key component in supporting elevated housing systems by maintaining connectivity between homes during flood events. However, achieving full accessibility poses significant challenges in terms of space requirements and construction costs, especially where long ramps or large spans between houses are required to connect to elevated levels.

While these measures enhance resilience and connectivity during flooding, they also increase overall project cost. To improve feasibility, future development could consider the use of lower-cost, water-resistant materials such as aluminium. For example, a 20-metre aluminium pedestrian bridge is estimated to cost approximately $65,000 (Monkeytoe Group, 2024). Composite decking systems may also provide a durable and cost-effective alternative.

A phased implementation strategy could further enhance feasibility by prioritising elevated circulation infrastructure in the most flood-prone areas before expanding the network across the wider community. The modular design of the bridge network further supports this approach, allowing for the incremental addition or removal of units in response to changing needs and conditions.

Reference:

Monkeytoe NZ. (2024, September 21). Standard pedestrian bridge (flyable). https://www.monkeytoe.co.nz/products/bridges/standard-flyable-bridge/

▪ Technical considerations of the elevated walkway & their implications for liveability.

◦ **Noise:**
The elevated walkway is made from a lightweight metal frame and grating, which may create noise when people walk across it. Footsteps and vibrations may be heard inside nearby homes, especially where the walkway passes close to bedrooms or living areas.

To reduce this issue, future designs could add rubber connections between structural elements, use planting along the walkway to help absorb sound, or explore other low-noise material combinations suitable for elevated walkway .

◦ **Privacy:**
The elevated walkway improves movement and connection between residents, but it may also increase overlooking into neighbouring homes. This could reduce privacy for some residents.

Planter boxes, hedges, and careful placement of windows can help screen views and create a better balance between community interaction and personal privacy.

◦ **Maintenance:**
The walkway, rain gardens, and planted areas require regular maintenance. Steel components need protection from corrosion, while vegetation must be managed to prevent overgrowth and blocked drainage.

Although maintenance creates additional responsibilities, it may still be less costly than repairing repeated flood damage to buildings and infrastructure.

◦ **Safety:**
During wet weather, walkway surfaces may become slippery. Handrails, non-slip materials, adequate lighting, and proper drainage are important to ensure safe movement, particularly for children, older adults, and people with mobility difficulties.

▪ Critical reflection on the design

Among all strategies tested, elevated living spaces emerged as the highest priority. Locating critical functions such as kitchens, bathrooms, and electrical systems above expected flood levels provides the greatest reduction in flood damage and enables residents to continue occupying their homes during frequent flood events. This strategy directly protects the most vulnerable and costly-to-replace components of domestic infrastructure.

The raised pedestrian walkway network also plays an important role in maintaining community connectivity when ground-level routes become inaccessible, while also functioning as essential access infrastructure supporting the elevated living system. At the community scale, retention landscapes, rain gardens, and vegetation-based water management systems contribute to reducing localised flood impacts, while also providing environmental and social benefits during non-flood conditions. However, their effectiveness is dependent on available space, soil conditions, and ongoing maintenance requirements.

Water-resistant materials and adaptive construction strategies are another key design of resilience. Even with elevated living spaces, extreme flood events may still affect parts of the building. The use of durable, flood-tolerant materials helps reduce repair costs and shortens recovery time following inundation. Compared with large-scale structural interventions, material-based strategies are relatively straightforward to implement and can be applied to both new and existing housing stock.

However, several trade-offs between resilience, affordability, and practicality must be considered. For example, the inclusion of split-level arrangements increases construction complexity and cost. In lower-budget housing contexts, a simpler floor configuration may offer a more practical balance between resilience and affordability. Similarly, increased spacing between dwellings improves privacy and allows greater water permeability across the site, but it also increases the length and cost of the elevated walkway network. Reducing the distance between houses could improve cost efficiency while still maintaining the core resilience benefits of the proposal.