

Ngā Ara Wātea me ngā Tūtohunga mō ngā
Tuanui Whakatipu Otaota ki Tāmaki Makaurau

Living Roof Opportunities and Recommendations for Tāmaki Makaurau Auckland

Evidence and recommendations to support the implementation
of living (green) roofs as climate resilience infrastructure

September 2026

Auckland Central
Library Living Roof

Albert Park

The University of Auckland
Living Roof

Aotea Square
Living Roof

Living Roof Opportunities and Recommendations for Tāmaki Makaurau

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Healthy Waters Department

Living roof opportunities and recommendations for Tāmaki Makaurau

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Figure 1: Auckland Central Library living roof
Source: Rachel Devine, Auckland Council

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Kupu Whakataki

Wai is at the heart of life and wellbeing. In all of its forms as it moves through the Hurihanga Wai (water cycle), Wai is a taonga for us all. All Wai has a mana and a mauri, and we all have an active role to ensure that our care and respect balances our use and demands.

There are many opportunities within our urban landscapes to recognise Wai as taonga, to implement sensitive and sensible practices that carry a broad range of positive outcomes. By providing space and time for Wai to gather, by slowing the speed which it moves through hard urban catchments, in creating reuse opportunities and providing treatment, habitat and amenity, living roof systems such as the example installed on Tāmaki Pātaka Kōrero/City Centre Library offer our built environment and our Community with a range of positive and tangible outcomes. As such, living roof systems present a powerful tool within an urban ki uta, ki tai approach to working with Wai that can simply and effectively reduce the stress on stressed urban Wai systems.

Our future generations require that we act as the best ancestors that we can be.

- Ngāti Whātua Ōrākei

***Tiakina ngā Wai e rere nei hei ora mā
ngā uri me te katoa***

***Care for the Wai that flows here, the
essence of life and wellbeing for our
people and all of Tāmaki***

Figure 2: Auckland City from Takaparawhā (Bastion Point)
Source: iStock / nazar_ab, 878205524



He Kupu Takamua | Foreword

Tāmaki Makaurau Auckland faces environmental pressures common to growing cities worldwide: more frequent extreme rainfall events, rising urban temperatures, biodiversity loss, and the challenge of maintaining environmental quality while accommodating urban development. Climate projections indicate these pressures will intensify in the coming decades.

Living roofs represent one tool within a broader suite of nature-based solutions that have the potential to address multiple urban challenges simultaneously. International experience demonstrates their potential to contribute to stormwater management, temperature moderation, biodiversity enhancement, and improved urban amenity. This report complements and builds upon Auckland's existing living roof knowledge base to help inform future decision-making.

This report presents a snapshot of key findings from the University of Auckland's living roof monitoring study - a collaboration with Auckland Council and considers the main drivers and barriers affecting living roof uptake in Tāmaki Makaurau. The primary purpose is to highlight the potential opportunities for Auckland Council to enable appropriate wider living roof adoption, and the justification for exploring these opportunities. Drawing on monitoring evidence, Auckland Council's strategic context, and international precedents to inform exploration pathways for improved outcomes.

This report investigates the potential benefits living roofs can deliver within Auckland's climate, urban context and explores a range of barriers currently limiting their uptake from upfront costs and benefit distribution, to regulatory gaps and industry confidence. We present these findings to inform ongoing policy development and design guidance, with recommendations that encourage a measured, phased approach to assessing opportunities for wider and appropriate uptake.



Craig McIlroy

General Manager
Healthy Waters and Flood Resilience

Figure 3: Auckland Central Library living roof
Source: Timescapes Limited



Te Whakarāpopoto mō te Mana Whakahaere | Executive Summary

Tāmaki Makaurau Auckland faces a set of interrelated and intensifying urban challenges - changes in intensity and frequency of extreme rainfall, rising urban temperatures, stream and river health under pressure (widespread nutrient, faecal and metal contamination) and estuaries in ecological decline, coastal and stream-bank erosion, biodiversity loss, and the pressure of accommodating growth while protecting environmental outcomes (Auckland Council, 2025). Addressing these challenges calls for innovative thinking in how we work with natural systems to deliver resilient infrastructure.

This report examines living roofs as one tool within a broader suite of nature-based solutions - not as a singular answer. Its central finding is that living roof uptake in Auckland is not constrained by the strength of the case for them: Council's strategic framework clearly supports them, the statutory framework provides partial recognition, Auckland and international evidence validates their performance, and the technical solutions exist. Uptake is constrained instead by cost-allocation, regulatory-recognition, consumer-choice and market-confidence conditions; conditions Auckland Council can positively influence using levers available within its current statutory framework. This report investigates the benefits, examines the factors affecting uptake, and sets out options for Council to support the appropriate use of living roofs.

The case for living roofs in Tāmaki Makaurau Auckland

Living roofs are a multi-functional source-control intervention. Where appropriately specified and maintained, living roofs manage stormwater at source through both retention and peak-flow attenuation, reducing runoff volumes and moderating peak flows. This can improve receiving-water health by decreasing contaminant and thermal loads, while also reducing hydrological stress that contributes to stream erosion, channel instability, and habitat degradation. Living roofs can also deliver urban heat mitigation, biodiversity habitat and ecological stepping stones, extended roof membrane life and reduced building cooling demand, alongside amenity and wellbeing benefits (Section 2).

They are best understood as source-control infrastructure rather than flood-mitigation devices: they reduce the rate, volume, and contaminant load of roof runoff at the point it leaves the building. They are most valuable where several drivers align - in combined sewer catchments, where reducing roof runoff lowers overflow frequency; in urban heat hotspots; in catchment headwaters, where slowing runoff protects downstream stream channels; and in dense centres where at-grade (i.e. planting at natural ground level) planting space is limited.

Additionally, the use of appropriate native vegetation and the application of tangata whenua mātauranga and creativity introduces additional benefits. These initiatives also contribute to the reestablishment of cultural landscapes and inscription of tangata whenua values as part of a broader network of taiao-led solutions to the challenges of increased density and increasingly impervious urban catchments.

Auckland-specific evidence

Initial findings from the University of Auckland's living roof monitoring programme (2024-25) provide locally relevant performance data (Dong et al., 2026; Soe et al., 2026):

- **Stormwater volume:** 85-92% mean reduction in runoff across the four configurations tested (90-92% for the three vegetated substrates), with rainfall events under 2 mm producing negligible runoff.
- **Peak flows:** 96-98% mean reduction in peak discharge, maintained across all seasons. In the largest event recorded (88 mm, April 2025), peak discharge was still reduced by 83-89% (University of Auckland, unpublished data).
- **Surface temperature:** peak daytime surface temperatures up to 19.7°C lower than asphalt on hot and dry days, and 2.8-3.6°C lower on average across the full monitoring period.
- **Cooling demand:** 66-82% lower annual radiation-weighted cooling degree-hours than asphalt, indicating substantial roof-level cooling-load reduction potential rather than a metered whole-building saving.
- **Biodiversity:** over 2,000 native plants from 14 eco-sourced species established on the Auckland Central Library roof, now an evolving community contributing to pollinator and habitat connectivity in the CBD, sustained by irrigation in dry periods and low-level weeding.

Together these provide locally grounded evidence of performance across stormwater, urban cooling, and biodiversity, with direct implications for Council's policy, incentive, and regulatory frameworks.

Strategic alignment

Living roof outcomes align with Auckland Council's existing strategic framework - the Auckland Plan 2050 (Focus Area 6: green infrastructure), Te Tāruke-ā-Tāwhiri (Auckland's Climate Plan), the Auckland Water Strategy's shift from end-of-pipe to at-source solutions, the Urban Ngahere Strategy, and Hīkina te Wero.¹

The AUP provides the statutory framework, recognising living roofs through the impervious area definition exclusion for all zones, while its stormwater provisions set requirements that are given effect through supporting technical guidance such as Stormwater Management Devices in the Auckland Region GD01, 2017 (GD01) and Water Sensitive Design for Stormwater GD04, 2015 (GD04). Because living roofs are excluded from the impervious area definition, the roof area is removed from a site's impervious area and potential Stormwater Management Area Flow (SMAF) triggers. The retention the roof provides can count towards the site's stormwater management rather than adding to the volume the site must otherwise manage.

¹ Each of these strategies is described in Section 3.1, with full references in the reference list.

However, this framework has not yet translated into consistent implementation. GD01 recognises the stormwater contribution of living roofs only in part, leaving applicants and consent officers without a consistent basis for assessment. The current GD01 review is well placed to resolve this.

There is no formal mechanism recognising their contribution within the development contribution framework, and alternative compliance pathways remain limited. These are examined in Sections 3 and 4.

Where tangata whenua are provided with meaningful opportunities to be embedded in the design and delivery of living roof initiatives, such initiatives align closely with the intent and ethos of partnership envisioned within Te Tiriti o Waitangi.

Barriers to adoption

Section 4 examines why uptake remains limited, grouped under three headings that frame the report's analysis:

- **Confidence.** Local performance evidence, design and installation capability, and visible precedent are all still limited, and warranty, insurance, and maintenance requirements and responsibilities remain unfamiliar to the market.
- **Risk.** GD01 recognises living roofs as at-source retention devices, allowing a roof with 100 mm of suitable substrate to be treated as fully retaining up to 25 mm of rainfall; this allowance is capped rather than scaled to substrate depth. GD01 allows detention volume requirements to be met through retention, but it is unclear how a living roof would achieve SMAF detention in practice, and no method is provided for the larger design events.
- **Cost.** Living roofs carry a higher upfront cost than conventional roofing, and the split-incentive challenge common to living (green) infrastructure means the building owner bears the cost while much of the benefit flows to tenants, the stormwater network, receiving environments, and the wider community. A small local supply chain keeps per-square-metre costs high, and uncertainty about long-term maintenance costs discourages investment, although Auckland evidence does not indicate that living roof maintenance costs more over the life of the asset (Section 4.4).

Opportunities to support wider uptake

International experience shows that cities achieving meaningful uptake pair regulatory recognition with financial incentives and capability building, adapted to local conditions (Liberalesso et al., 2020; Wilkinson, Ghosh & Pelleri, 2024). Regulation is the strongest single lever, but it reaches only the buildings it applies to and works only where technical standards and industry capacity already exist. Auckland Council has potential levers available now and, over time, through the Combined Plan, examined in Section 5 against the same three categories:

- **Confidence.** Council demonstration projects building on the Auckland Central Library, priority-catchment and feasibility mapping, capability building, knowledge sharing, and central government procurement engagement.
- **Risk.** A clear, consistent design and sizing process for living roofs through the current GD01 review, treatment train recognition, and consent pathway improvements, with planning incentives and Urban Greening Factor approaches advanced through the Combined Plan where appropriate over the longer term.
- **Cost.** Development contribution offsets, stormwater charge differentiation (variants of which Auckland has considered before without progressing), structural assessment grants, and targeted subsidies set catchment by catchment rather than as a single Auckland-wide rate. Establishing the actual cost differential for Auckland is a prerequisite to setting any rate.

Ngā Tūtohunga

Recommendations

Section 6 sets out recommended actions for Council to consider, organised as short, medium and longer term opportunities, each identifying the barrier it primarily addresses. The current GD01 review is the place to start: it is already underway, it is time-bounded, and it is the vehicle for embedding Auckland-specific monitoring evidence in the region's primary stormwater design manual.

Short term. Actions within Council's control or tied to processes already underway: updating the technical guidance in GD01 and GD04, enhancing Auckland Design Manual guidance, developing practical plain-language guidance, recognising living roofs as an acceptable solution for network capacity management, and continuing performance monitoring.

Medium term. Actions requiring Council policy or practice decisions over the next one to three years: living roofs on Auckland Council, Auckland Transport and Tātaki assets, priority-catchment mapping and a priority-catchment case study, visibility and education through published case studies and a city centre walking tour, consent pathway streamlining, and clearer recognition of living roofs in the Unitary Plan and Combined Plan.

Longer term. Opportunities that depend on future funding decisions, statutory processes including the Combined Plan, and a maturing evidence base: financial mechanisms (development contribution offsets, stormwater charge differentiation, structural assessment grants, and a targeted grant programme for priority catchments), plan provisions (planning incentives, an Urban Greening Factor, and any mandatory requirements), and wider engagement (living roofs on Crown property, and recognition in catchment and network planning).

The sequencing reflects feasibility and dependency rather than strict timing. Many actions can proceed in parallel, and actions can be brought forward where conditions permit.

1. Te Whakataki | Introduction

1.1 Purpose and Scope

This report examines the potential role of living roofs in Tāmaki Makaurau Auckland arising from the tension between continued urban growth (typically replacing permeable vegetated ground with sealed surfaces) and the protection of our natural environment. It draws on Auckland-specific research, recent University of Auckland living roof monitoring results and international examples.

It also considers the factors affecting uptake in Auckland and the options available to Auckland Council to support appropriate use of living roofs as one tool within a broader suite of nature-based solutions (NbS). The intent is to inform Council policy and design guidance, with recommendations grouped by Cost (economic), Risk (technical and regulatory) and Confidence (knowledge and market).

Detailed engineering specifications are not the subject of this report - these sit within Auckland Council's existing technical reports and guidelines, which the recommendations propose to strengthen.

The following sections cover:

- **Benefits of Living Roofs** (Section 2) - drawing on University of Auckland living roof monitoring and monitoring observations from the Auckland Central Library living roof.
- **Strategic Alignment** (Section 3) - the extent to which living roofs align with Auckland Council's strategic and statutory framework.
- **Factors Affecting Uptake** (Section 4) - examined under three headings: Confidence, Risk, and Cost.
- **The Opportunities** (Section 5) - organised against the same Confidence, Risk, and Cost framework as Section 4.
- **Recommendations** (Section 6) - actions for Council to consider, organised as short term, medium term and longer term opportunities, each identifying the barrier it primarily addresses.

The sequencing used in Section 6 reflects feasibility and dependency rather than strict timing - many actions can proceed in parallel as evidence, capability, and the central government planning reform context evolve.

1.2 What a living roof is

A living roof is a vegetated roof system - plants growing in a substrate, supported by integrated drainage and waterproofing layers built into the roof itself. It is distinct from container gardens or potted plants placed on a roof. Detailed system types are set out in Appendix 2.

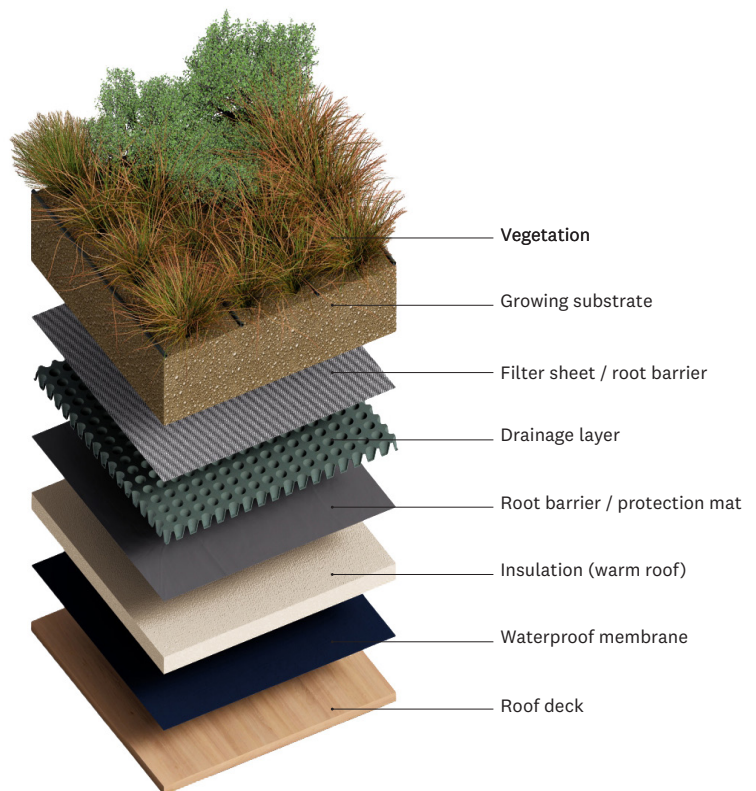


Figure 4: Typical living roof construction layers
Source: The Urbanist, 2026. Under CC BY 4.0

Indicative layers of an extensive living roof. The diagram shows an inverted build-up, with insulation above the waterproof membrane; in a conventional build-up the insulation sits below the membrane. Layer configurations vary with product system and roof type. Not to scale.

1.3 Background and Context

In 2021, Auckland Council commissioned the Central Library Roof Renewal Project. Extensive remedial works were required as the roof envelope claddings had reached the end of their serviceable life. This provided an opportunity to upgrade the roof from conventional stone ballast to a living roof within modified stone ballast, demonstrating Council leadership in sustainable infrastructure.

The living roof was installed in partnership with Ngāti Whātua Ōrākei, who developed the geometric Poutama (stepped) pattern design representing learning and intellectual achievement - appropriate symbolism for a library setting.

Ngāti Whātua Ōrākei also supplied plants through their Pourewa Nursery, including species historically present along the Waihorotiu Stream. The installation was completed in March 2022 and now supports over 2,000 plants from an original palette of 14 native species, now an evolving community with some die-back, self-establishment, and spread beyond the original planted areas.

Ngāti Whātua Ōrākei are tangata whenua and tangata moana for Te Pokapū Taone/the City Centre. Set within the Tuku Whenua the area granted by their rangatira in 1840 to welcome Governor Hobson and the relocated capital of the colony to establish Auckland, they acknowledge Tāmaki Pātaka Kōrero Auckland Central City Library as a public taonga and repository of knowledge and articles of mana that rests on their heartlands.

Ngāti Whātua Ōrākei have welcomed the opportunity to work in partnership with Te Kaunihera Auckland Council with the design, delivery, monitoring and ongoing advocacy for the Tāmaki Pātaka Kōrero Auckland Central City Library living roof. They see this initiative as a tangible example of cultural infrastructure, integrating taiao regeneration, Wai responsiveness, tribal creative practices and the re-inscription of tribal narratives back into the city to elevate their presence.

Ringatoi Hinengarangi Makoare speaks of the design being inspired by whāriki, a plaiting style of weaving used to craft mats (also named whāriki). Whāriki lay the foundations for

all aspects of life: travels from the feet of wanderers, the first breath of a newborn child or supporting the last moments of tūpapaku in their whare tūpuna before their ultimate transition from the realm of the living to the metaphysical.

Present in the planting design is a Poutama pattern, a traditional design which represents education, progress and ascension. The use of Poutama makes explicit reference to the library as a place where people seek enlightenment and education, to progress and pursue greater knowledge and understanding to help them make sense of their world. It is Ngāti Whātua Ōrākei's intention that the mōhiotanga (knowledge) and mātauranga (formal tribal knowledge) generated by this kaupapa will extend across Te Kahu Tōpuni o Tuperiri over time. The iwi welcome the opportunity to build on this successful partnership and extend this urban canopy out across the city.

The Auckland Central Library is located within the City Centre Master Plan's 'Green Link' corridor, a proposed connected network of green spaces running from Quay Park and The Domain in the east through to Victoria Park and Wynyard Quarter in the west. Living roofs have the potential to contribute to this blue-green network by providing elevated green infrastructure where ground-level space is constrained by urban development. Overlooked by surrounding buildings, the Auckland Central Library roof delivers amenity and biophilic benefits beyond the library itself.

Figure 5: Auckland Central Library living roof under construction
Source: Timescapes Limited



1.4 Environmental Challenges

Auckland faces interconnected environmental challenges with significant implications for the city's climate resilience, liveability, and ecological health. Urban development and population growth typically reduce permeable surfaces and vegetation in cities, contributing to environmental pressures that are likely to intensify with climate change.

Climate Change and Extreme Weather

In 2019, Auckland Council's Environment and Community Committee unanimously voted to declare Tāmaki Makaurau being in a climate emergency. This commitment signalled the Council's intention to put climate change at the centre of its decision making. Auckland's air temperature is projected to rise between 1.5°C and 3.75°C by 2100 depending on global emissions, with the current pathway likely to deliver a 3.5°C rise (Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan).

NIWA projections indicate that rainfall events currently classified as a 1% AEP event (i.e. 1% chance of occurring in any given year, a more extreme event than a 2% AEP) could occur more frequently (potentially 2% AEP event, 2% chance of occurring in any given year) by the end of the century, alongside an increase in short-duration, high-intensity storms that may exceed the design performance assumptions of some existing infrastructure systems (Pearce et al., 2020 - Auckland Region Climate Change Projections and Impacts, prepared by NIWA for Auckland Council, TR2017/030-3; Auckland Council, 2024 - Climate Change Scenarios Guideline Document GD15).

Recent events demonstrate urban Auckland's vulnerability. The January 2023 Anniversary Weekend storm saw parts of Auckland receive over 280mm of rain in under 24 hours, overwhelming conventional stormwater infrastructure and causing significant property damage (NIWA, 2023; Te Waihangā - New Zealand Infrastructure Commission, 2023). Less than three weeks later, Cyclone Gabrielle brought further devastation across the upper and eastern North Island, with total damage from the two North Island weather events estimated at between \$9 billion and \$14.5 billion (The Treasury, 2023). Insurance data shows severe weather claims in New Zealand have risen by 256%, reflecting both increasing frequency and growing social and economic costs (Libatique, 2026; Financial Markets Authority, 2025).

Urban Heat Island Effect

Auckland's urban areas experience significantly higher temperatures than surrounding rural areas - a phenomenon known as the urban heat island (UHI) effect - because built materials absorb solar radiation during the day and release it as heat at night. The Auckland Urban Heat Assessment (Arup, 2024) found Auckland's city centre experiences nighttime temperatures up to 3°C warmer than rural areas, with up to 3°C variation within the city centre itself creating localised hotspots. Dark roofing materials and concrete surfaces may peak at 50-60°C during hot days, with unpainted metal roofing likely higher (Dong et al., 2026).

These effects compound under climate change. Hot days over 25°C are projected to rise fourfold to over 90 per year by century's end. Heat-related deaths in Auckland are projected to increase from a current baseline of approximately 14 per year to 88 per year with a 3°C rise (Joynt & Golubiewski, 2019). Vulnerable populations - older people, young children, low-income and renter households, and those with pre-existing conditions - are disproportionately exposed.

Stormwater Management Challenges

Auckland's stormwater system faces compounding pressures. The drainage network was largely designed for historical conditions, while climate change and urban intensification are increasing pressure on the system. While around 90% of rainfall events produce less than 31 mm, and most of Auckland's annual rainfall volume falls in these small, frequent events (Shamseldin, 2010; Fassman-Beck, Voyde & Liao, 2013), larger events increasingly exceed network capacity, and continued intensification adds impervious surfaces across many catchments. Although grey infrastructure remains an essential component of stormwater management, upgrades and expansion in developed brownfield areas can be costly, disruptive, and constrained by available space. In some scenarios, complementary at-source retention approaches may help mitigate these pressures by reducing runoff volumes before they enter the network.

Combined stormwater and wastewater networks in older parts of Auckland activate during rainfall events as small as 2-4mm in some catchments, discharging contaminated overflows into streams, harbours and coastal waters. Contaminated overflows also occur from other parts of the network. SafeSwim publishes near real-time recreational advisories following these events. Stormwater runoff from impervious surfaces also carries pollutants - sediments, heavy metals, hydrocarbons, nutrients, thermal load (with discharges over 25°C identified as a stormwater contaminant of concern in Auckland), pathogens, and microplastics - into the Waitematā, Manukau and Kaipara Harbours and coastal waters.

Intensification compounds these pressures. Soils in earth-worked areas store less water (typically ~30mm compared to 100-200mm in undisturbed soils), increasing runoff (MfE & Auckland Council urban soil compaction study; Manaaki Whenua - Landcare Research, Keeping urban soils spongy; Ira, 2025). The resulting higher and more frequent runoff progressively erodes stream banks, a dynamic at the core of 'urban stream syndrome', and disrupts urban stream ecology.

Flood risk is a long-standing feature of Auckland's urban landscape, particularly in low-lying areas and historical floodplains. Improved flood-hazard identification and recent severe weather have heightened understanding of this existing risk, rather than revealing a new risk. Surface flooding, exacerbated stream-channel erosion and property damage are increasingly evident, with severe weather claims in New Zealand having risen by 256%, reflecting both increasing frequency and growing social and economic costs (Libatique, 2026).

Biodiversity Loss and Habitat Fragmentation

Auckland's natural environment supports a rich diversity of plants and animals, many of them found nowhere else in the world. Auckland Council's 2025 State of the Environment reporting shows indigenous forest and scrubland cover has grown by more than 5,500 hectares since 2018, now making up 27 per cent of the region (Auckland Council, 2025). Urban development has nevertheless progressively replaced natural habitats with buildings and infrastructure, fragmenting the habitat that remains and enabling the spread of invasive plant and animal pests (Auckland Council, 2025; PCE, 2023).

Remaining green spaces are dominated by mown non-native grasses - around half of Auckland's urban green space is grass - which provides "only a relatively meagre suite of environmental services: limited cooling, no shade provision, low diversity and little support for native species" (PCE, 2023). Edge effects, isolation, and urban barriers limit species movement and gene flow. Bird, lizard, and invertebrate populations have broadly declined in urban areas, though some generalist pollinators persist (Auckland Council, 2025). Loss of vegetation also reduces the ecosystem services the city relies on - pollination, pest control, nutrient cycling, air filtration, and carbon sequestration (PCE, 2023).



Figure 6: Nature-based Solutions
Source: The Urbanist, 2026. Under CC BY 4.0

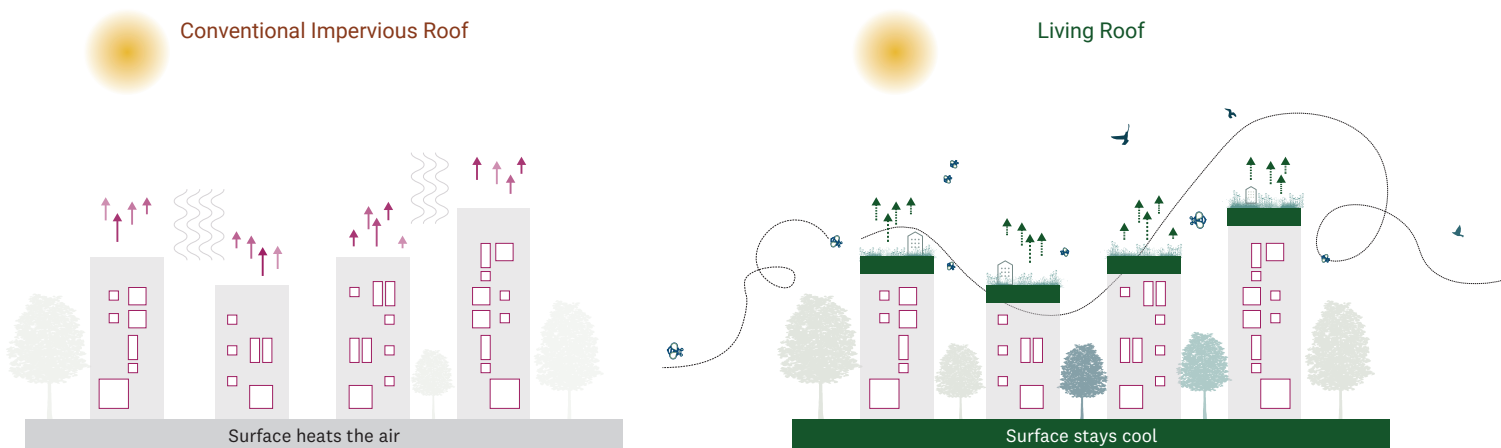


Figure 7: Conventional impervious roof versus living roof
Source: The Urbanist, 2026. Under CC BY 4.0

Development Pressure and Green Space Loss

Auckland's population is projected to reach 2 million by 2033 (Stats NZ, 2026), with growth to approximately 2.2 million planned for by 2052 (Auckland Council, 2023). The Future Development Strategy (FDS) provides for this growth through a combination of quality compact, multi-nodal intensification within the existing urban area and greenfield expansion at the urban edge. In 2023/2024, 82% of dwelling consents were within existing urban areas, with 68% for intensive typologies such as townhouses and apartments, and the balance accommodated through greenfield growth (Auckland Council, 2024). The AUP enables greater building heights and densities to support housing supply and public transport, but both forms of growth reduce permeable, vegetated ground: intensification adds impervious surfaces and reduces per-capita green space within established suburbs (PCE, 2023), while greenfield development converts rural and vegetated land to urban use. Auckland Council's 2025 Open Space, Sport and Recreation Strategy, Manaaki Tāmaki Makaurau, responds directly to this pressure, proposing the creative use of rooftops and small pockets of land to sustain green space in higher-density areas and to make the city greener and better able to absorb rainfall. In already-developed areas, opportunities for ground-level (at-grade) stormwater management retrofit are increasingly constrained by competing land uses and high land values.

Ultraviolet Radiation (UV)

New Zealand experiences some of the highest UV radiation levels in the world due to its latitude and naturally thinner ozone layer, with levels having stabilised since the early 2000s but remaining high by global standards. High UV exposure highlights the need for materials and surfaces that withstand UV and reduce heat gain, and for integrating nature-based solutions into the built environment.

Conventional roofs face accelerating performance pressure. UV exposure and temperature cycling shorten membrane life: Canadian field research recorded daily temperature fluctuations of 45°C on a conventional roof compared with approximately 6°C beneath a living roof (National Research Council Canada, 2013), and Auckland monitoring shows the same effect: asphalt roof surfaces reached up to 76°C on hot days, while vegetated roofs were up to 20°C cooler (Dong et al., 2026). Conventional roof membranes typically require periodic replacement over a building's life. years (Dong et al., 2026). Limited roof insulation contributes to heat gain in summer and loss in winter, increasing energy consumption for cooling - pressures that will intensify as the climate warms and as building stock ages.

1.5 A strong case, low uptake

Auckland's environmental challenges are interconnected - climate change, stormwater pressures, urban heat, biodiversity loss, and the loss of permeable ground through intensification compound one another. Living roofs are unusual in that a single intervention has the potential to respond to many of these at once: a roof installed primarily for stormwater retention also moderates urban heat, creates habitat, extends membrane life, enhances building energy efficiency, and adds amenity. They are a multifunctional source-control intervention that is well suited to dense urban environments when implemented in appropriate locations.

Despite a growing local evidence base demonstrating the multi-benefits of living roofs to address a number of urban challenges, their uptake in Tāmaki Makaurau remains relatively low. Section 2 explores the benefits in the context of urban challenges referenced in Section 1. Section 4 examines the factors affecting uptake under three headings, Confidence (knowledge and market), Risk (technical and regulatory) and Cost (economic), and Section 5 outlines the corresponding opportunities available to Council.

2. Ngā Hua o ngā Tuanui Whakatipu Otaota | Benefits of Living Roofs

Living roofs deliver multiple cultural and environmental benefits. Typically, from a single integrated system rather than as separate interventions, these benefits may include stormwater management, urban heat mitigation, biodiversity, building performance, and public health and amenity. This section sets out each benefit, drawing on international evidence and Auckland-specific monitoring. Table 1 summarises this evidence. Living roof types and substrate options are described in Appendix 2.

2.1 Monitoring Programme

Direct, ongoing data collection from the Auckland Central Library roof was not feasible due to health and safety constraints, ease of accessibility, and the library's legacy internal drainage system. Auckland Council instead partnered with the University of Auckland to establish replica test beds at the University's Faculty of Engineering and Design rooftop, approximately 400 metres from the library, where similar environmental conditions could be monitored.

The monitoring programme tracks four substrate configurations:

- Natural Habitats Eco-Pillow systems - replicating the Library installation.
- Stone ballast - an unvegetated control of river pebbles and bark mulch over a stone ballast base, representing a conventional ballasted roof.
- Daltons Pinegro Mix - a second nature-based substrate at 120 mm depth.

- Proprietary media systems - nature-based living roof substrates with conventional drainage layers.

Monitoring commenced in June 2024, with initial findings now available from the first 12 months of data collection. Further data is anticipated over the coming years, subject to University of Auckland capacity, enabling analysis of performance variation across climate cycles and seasonal conditions, and expansion of the parameters (e.g. invertebrate use) and configurations measured (e.g. a conventional ballast control, and varied tray slopes, which may influence the balance between retention and detention) through additional trays. Ongoing research will continue to build the local evidence base for Auckland conditions.

2.2 Stormwater Management

Living roofs replicate natural drainage patterns and reduce stormwater runoff at source. Rainfall is intercepted by vegetation, absorbed into the growing media (substrate), and released back to the atmosphere through evaporation from the substrate surface and transpiration by plants. Runoff only enters the drainage layer once the substrate's field capacity is reached.

University of Auckland 2024-2025 monitoring of the Auckland Central Library replica test beds (120-150 mm substrate, with more than 90% native plant cover averaging over 200 mm in height); demonstrates strong stormwater performance under local conditions (Soe et al., 2026):

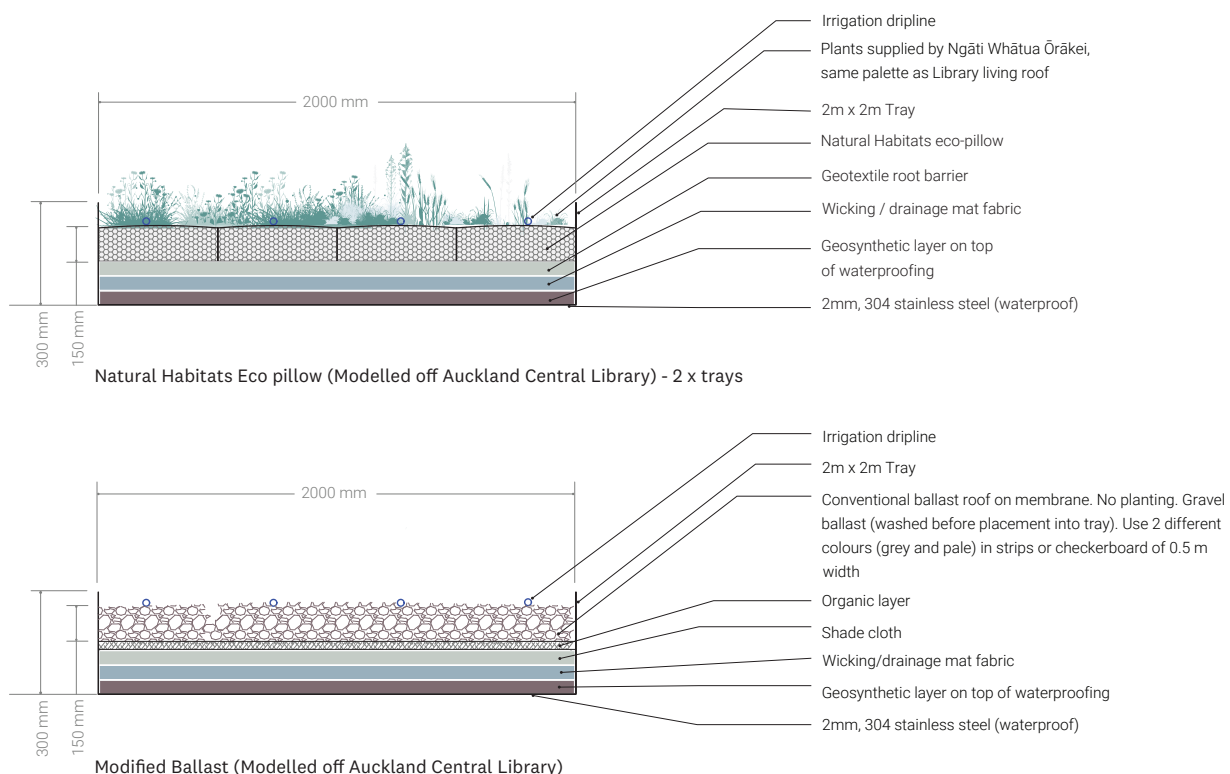


Figure 8: Substrate configurations
Source: The Urbanist, 2026. Under CC BY 4.0

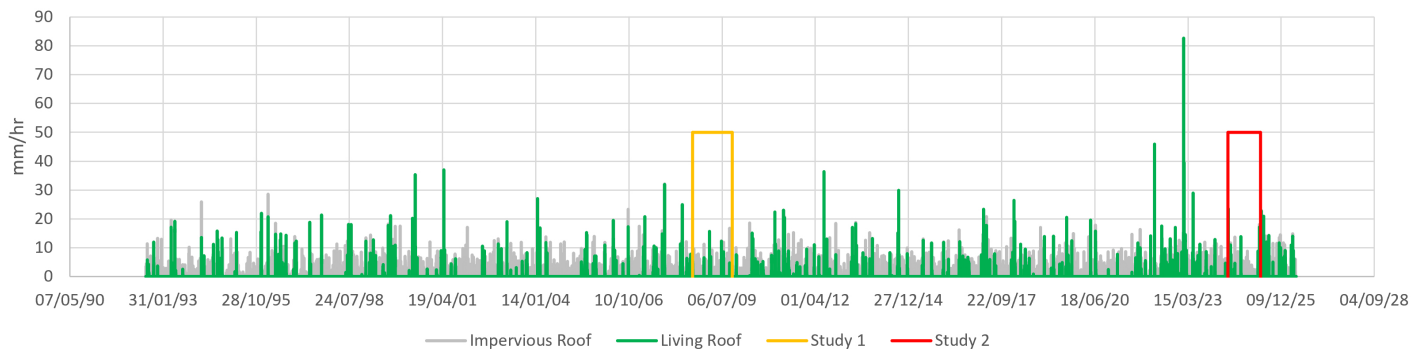


Figure 9: Continuous analysis of living roof performance against the historic Albert Park rainfall record (150 mm substrate; 38 mm retention capacity; 7-day drying interval; runoff compared with a conventional impervious roof). Source: Tektus Consultants Limited

85-92% mean runoff reduction across the four configurations tested (90-92% for the three vegetated substrates)

- 96-98% mean reduction in peak discharge, maintained across all seasons.
- A modelled retention capacity of about 38 mm for 150 mm of substrate with seven days of drying (Figure 9), which would retain more than 95% of events in Auckland's long-term rainfall record.

Living roofs deliver their greatest benefit during the small-to-medium rainfall events that make up the majority of Auckland's annual rainfall. The most frequent events are fully absorbed - events under 2 mm produced negligible runoff during monitoring (Soe et al., 2026) - and never reach the piped network. It is the cumulative volume of these frequent small events, rather than occasional large storms, that drives much of the annual pollutant runoff load on Auckland's stormwater system.

These findings extend earlier Auckland Council research (Fassman, Simcock, Voyde & Hong, 2010 - TR2010/018), which monitored four living roofs over 8-28 months and found cumulative runoff reductions of 39-57% compared to conventional roofs at the same sites, with median retention of 56-76% across all events and complete retention of individual events up to 25 mm. The lift in retention performance reflects deeper substrates (100-150 mm versus 50-70 mm in the 2010 work), differences in rainfall event distribution across the two monitoring periods, and substrate moisture-storage characteristics - with configuration (substrate composition, depth and plant cover) shown internationally to be the principal driver of variation in living roof runoff mitigation (Fassman-Beck, Simcock, Voyde & Hong, 2013).

Extrapolating conservatively from these two studies, 150 mm of planting media can retain up to 38 mm of rainfall given seven days of drying time between events - consistent with the monitored event retention above. Modelled continuously

against the historic rainfall record from the Albert Park rain gauge, this illustrates the sustained reduction in runoff a living roof achieves relative to a conventional impervious roof (Figure 9).

As an at-source intervention, living roofs reduce the volume of runoff entering the piped stormwater network - particularly valuable in intensified urban areas where surface-level blue-green infrastructure such as ponds and wetlands is space-constrained. While living roofs do not substitute for network upgrades in catchments where the existing network is undersized for current or projected demand, they can reduce the footprint of downstream stormwater management devices and lower overall pressure on the network.

This is especially relevant in Auckland's older combined sewer catchments, where stormwater and wastewater share a single network and contaminated overflows to streams, harbours and coastal waters can be triggered by relatively small rainfall events. Because living roofs retain these frequent small events at source, their benefit is greatest in the headwaters of these combined catchments, where reducing the volume entering the network can lower the frequency of contaminated overflows and the associated public-health and environmental impacts. Living roofs complement, rather than replace, major network capacity interventions such as the Central Interceptor.

Living roofs provide a unique opportunity to achieve extended retention/detention without the risk of oversized orifices or blocked infrastructure, resulting in device failure. The ability for living roofs to drain via both evapotranspiration and percolation ensure a more resilient device when compared to underground or tank-based infrastructure. Ngāti Whātua Ōrākei set clear stormwater management outcomes for their rohe in their iwi management plan, Te Pou o Kāhu Pōkere (2018). The plan acknowledges the challenges involved and points to nature-based solutions such as living roofs as a way of meeting these outcomes.

Streambank erosion and urban stream health

By slowing rainfall event peak runoff to a fraction of conventional roof levels, living roofs in catchment headwaters can materially mitigate the streambank erosion at the heart of ‘urban stream syndrome’ (Fassman-Beck, Simcock, Voyde & Hong, 2013). The effect is most pronounced where multiple living roofs are concentrated in the headwaters of small urban catchments, where peak runoff reduction translates directly into reduced erosive force on downstream channels.

2.3 Membrane Protection

Living roofs protect the roof membrane from ultraviolet radiation, temperature extremes, and weather damage, which can extend roof life (Porsche & Köhler, 2003; Kosareo & Ries, 2007; Dong et al., 2026). Studies have shown that membrane temperature fluctuations during spring and summer on a conventional roof can reach 45°C, whilst under a living roof the fluctuations are in the order of 6°C (National Research Council Canada, 2013). Auckland-based monitoring recorded instantaneous asphalt roof-surface temperatures as high as 76.3°C during summer peaks, compared with a maximum of approximately 55.0°C on vegetated surfaces (Dong et al., 2026). This reduction in thermal stress, combined with UV shielding, can extend membrane lifespan.

- **UV radiation protection** - vegetation and substrate completely shield the membrane from ultraviolet radiation, the primary factor in membrane degradation.
- **Temperature stabilisation** - reduced thermal cycling from expansion and contraction reduces membrane fatigue.
- **Physical protection** - the multi-layered system provides a barrier against mechanical damage from maintenance activities, debris, and weather events.
- **Extended lifespan** - Conventional roof membranes typically require periodic replacement over a building’s life. By shielding the membrane from ultraviolet radiation, temperature fluctuations, and physical wear, a living roof may help reduce membrane exposure to degradation mechanisms, although the extent of any associated lifespan benefit will depend on site-specific conditions, design, installation quality, and maintenance. Examples exist of membranes protected by living roofs lasting 40-50+ years (Kosareo & Ries, 2007; US General Services Administration, 2011; Dong et al., 2026). At the Moos water filtration plant in Zurich, built in 1914, the membrane beneath the vegetated roof remained fully functional after 90 years, with repairs needed only at the exposed edges (Brenneisen, 2006). Extended membrane life remains an identified benefit for which project-specific replacement data are not yet available (Ira, 2026).

In the case of the Auckland Central Library living roof, an electrical vector conductor wire was included as part of the installation to allow for easy leak detection after the substrate was installed. Using non-invasive techniques like this regularly can help identify potential membrane integrity issues early, supporting the overall membrane maintenance programme.

2.4 Building Energy Efficiency

Living roofs enhance building energy efficiency by moderating heat transfer through the roof. The substrate’s thermal mass stores heat and slows its transfer into and out of the building fabric: University of Auckland monitoring shows vegetated roof surfaces peaking later in the day than asphalt and retaining modest warmth overnight, flattening the daily thermal cycle that drives heating and cooling demand (Dong et al., 2026):

- 66-82% reduction in annual radiation-weighted cooling degree-hours compared with asphalt - a roof-level indicator of substantial cooling-load reduction potential, rather than a metered whole-building saving (Auckland monitoring; Dong et al., 2026).
- 10-30% reduction in winter heat loss through the roof, with the greatest benefit on older buildings with little existing insulation - a particular advantage for retrofit applications (Castleton et al., 2010).

Research in Toronto estimated that citywide living roof implementation, across all eligible flat roofs, could deliver direct building energy savings of 4.15 kWh/m² per year - approximately \$21 million annually - together with a 114.6 MW reduction in peak electricity demand and around 56,300 tonnes per year of avoided carbon dioxide emissions from electricity generation (Banting et al., 2005).

2.5 Urban Heat Island Mitigation

Living roofs are commonly used to mitigate the effects of the urban heat island effect through two mechanisms: introducing more vegetation into the urban environment, providing shading and cooling through evapotranspiration; and increasing the reflectiveness of roofs to reflect a higher amount of solar radiation into the atmosphere (Dong et al., 2026).

Auckland monitoring (Dong et al., 2026) confirms significant thermal performance benefits:

- Up to 19.7°C lower peak daytime surface temperature than asphalt during heatwave and drought days (12.0-19.7°C across the three substrates).
- 2.8-3.6°C lower whole-day mean surface temperature than asphalt across the full monitoring period, and 1.2-1.3°C lower than stone ballast.
- 3.6°C lower whole-day mean surface temperature for Daltons Living Roof Mix, the best-performing substrate (Source: Dong et al., 2026).

The Auckland Urban Heat Assessment (Arup, 2024) identified urban heat impacts as a significant climate risk for Auckland. Heatwave periods often coincide with poor air quality episodes and intense urban heat island conditions, which collectively exacerbate health problems, especially among the elderly, young, and vulnerable populations. Living roofs provide a quantifiable mitigation response, but meaningful citywide cooling requires implementation at scale: international modelling indicates 0.1-0.8°C citywide cooling from greening around half of a city's roofs, up to ~2°C in targeted or irrigated areas (Liu & Bass, 2005; Rosenzweig, Solecki & Slosberg, 2006; Imran et al., 2018).

2.6 Biodiversity Enhancement

Living roofs can enhance biodiversity benefits by providing habitats and 'green links' (connecting points). Switzerland and London introduced living roof systems that mimic natural habitats found locally. Living roofs can provide connections across cities that short-range species would not be able to cross otherwise, which is important in ensuring populations do not become isolated. Urban greening opportunities such as living roofs are an important way for mana whenua to reintroduce species to areas they have been displaced from.

Auckland Central Library demonstrates successful native habitat creation with 14 indigenous plant species sourced from Ngāti Whātua Ōrākei's Pourewa Nursery. Species include those historically present along the original Waihorotiu Stream shoreline and other culturally and environmentally appropriate species. Species selection drew on a decade of plant monitoring at Auckland Botanic Gardens, where trial living roofs established in 2010 identified native species suited to Auckland's rooftop conditions (Bodley, Simcock & Stanley, 2022). The planting design, developed in collaboration with Tangata Whenua, uses a poutama (stepped) pattern representing education, progress, and

ascension - paying homage to the library as a place where people seek knowledge and understanding.

- **Habitat creation** - living roofs designed with native species can support local fauna including lizards, and invertebrates, and sometimes birds (gulls). Specific habitat features, such as coarse wood, refugia (e.g. deep leaf litter layers) and temporary or permanent water, can enhance invertebrate biodiversity (Davies et al., 2010). Most living roofs support a range of generalist invertebrate species that include some mobile native species.
- **Ecological connectivity** - living roofs can provide stepping stones connecting fragmented urban habitats, creating movement corridors for birds and insects.
- **Pollinator support** - living roofs can specifically support native bee species and other pollinators currently under pressure in urban environments, with plants typically flowering earlier on living roofs than on the ground helping extend foraging. Noting taller roofs (over ~10 floors) are less accessible for invertebrates.
- **Ecosystem services** - pollination services, natural pest control through beneficial insects, and carbon sequestration in plant biomass and growing media.

Research on New Zealand living roofs demonstrates that a minimum 100-150 mm substrate depth is needed to support a reasonable range of native plants in Auckland's climate without afternoon shade, and that the capacity to irrigate in times of severe moisture stress is important for maintaining diverse native plant communities with different heights and growth forms (Fassman, Simcock & Voyde, 2010; Fassman-Beck & Simcock, 2013; Bodley, Simcock & Stanley, 2022). Media depths as thin as 50 to 70 mm can support a narrow range of native species (including mosses and summer-

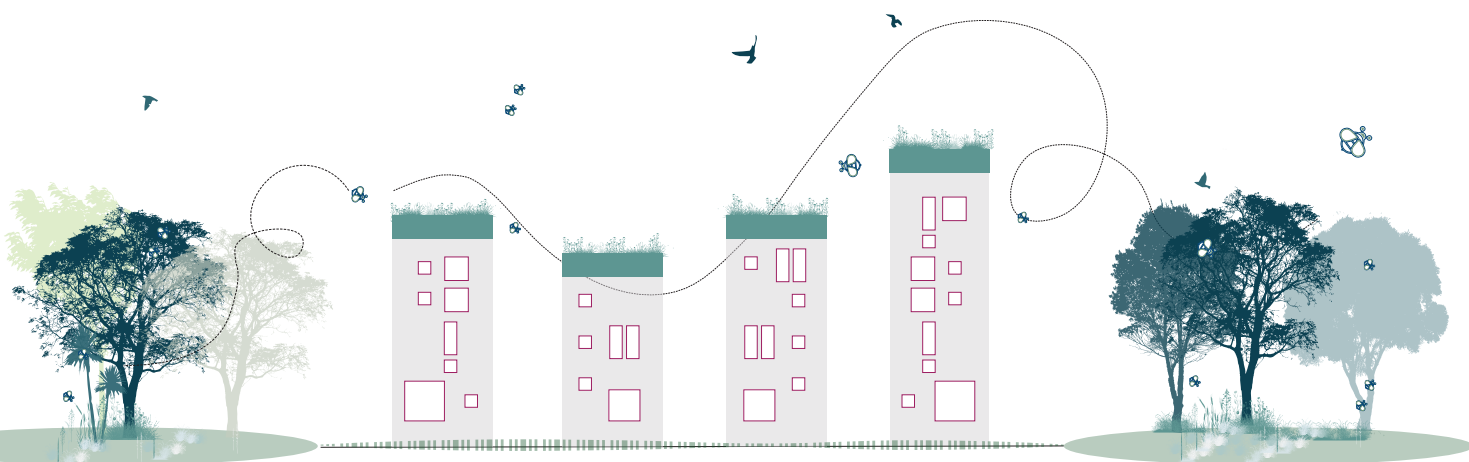


Figure 10: Living roofs as stepping stones for biodiversity
Source: The Urbanist, 2026. Under CC BY 4.0

dormant orchids) and a wider range of non-native plants (particularly succulents, bromeliads and short-lived winter or spring annuals). Native species can still persist on thinner substrates, as observed on living roofs at the University of Auckland, but the range of species that will thrive is narrower and the planting has a correspondingly narrower aesthetic.

2.7 Human Health and Wellbeing

Biophilia is the innate affinity that human beings have with the natural world. A substantial body of research shows that contact with nature provides significant benefits to human health and wellbeing: exposure to green space has been associated with reduced stress and measurable physiological benefits, including lower heart rate and blood pressure (Ulrich, 1984; Twohig-Bennett & Jones, 2018; Willis, 2024). Many of these benefits flow from visual access to greenery, not only physical access; even a view of vegetation has been shown to aid recovery and wellbeing (Ulrich, 1984). While the Auckland Central Library roof is not publicly accessible, it is overlooked by numerous surrounding buildings and so delivers biophilic and amenity benefits to those with views over it.

- **Cultural connection** - the Auckland Central Library demonstrates how living roofs can integrate mātauranga Māori and strengthen cultural connections to place through iwi partnership in design and plant sourcing. Living roofs also give whānau the opportunity to connect and engage with taonga species in a highly urbanised environment.
- **Mental health benefits** - visual access to vegetation improves mental health outcomes, reduces stress, and enhances satisfaction with living and working environments (Ulrich, 1984; Twohig-Bennett & Jones, 2018).
- **Workplace productivity** - biophilic design research links contact with nature, including visual access, to improved workplace productivity, wellbeing and reduced absenteeism (Cooper, 2015). Realisation of these benefits depends on physical or visual access to the roof, which is a design decision rather than an automatic feature of a living roof. Future accessible living roofs may realise greater social and productivity value where site context, building function and safety requirements permit.
- **Noise reduction** - the soil, vegetation and drainage layers of a living roof absorb, reflect and deflect sound, improving the acoustic insulation of the building envelope; extensive systems have been shown to improve sound insulation by several decibels (Van Renterghem & Botteldooren, 2011). This works in both directions: it reduces external noise entering the building (as at Remarkables Primary School in Queenstown, where a living roof was installed partly to absorb aircraft noise from the nearby airport), and it reduces noise escaping from noisy interiors such as bars and music venues where windows are kept closed.
- **Fire resistance** - a well-maintained living roof, with a moist substrate and managed, low-fuel vegetation, can slow the spread of fire across a roof. Recognised standards such as the German FLL guidelines set out substrate, vegetation and firebreak requirements for fire performance (FLL, 2018). Conversely, unmaintained roofs with dry vegetation can increase fire risk, so design (firebreaks, irrigation) and maintenance are important.

Table 1 - Summary of Living Roof Benefits with Auckland Evidence

Benefit Category	Performance Measure	Auckland/NZ Evidence
Stormwater retention	Annual volume reduction	85-92% (UoA monitoring)
Stormwater retention	Event retention threshold	~38 mm modelled retention capacity (Tektus)
Peak flow attenuation	Mean peak discharge reduction	96-98% (UoA monitoring)
Temperature reduction	Surface temperature vs bare roof	Up to 19.7°C lower peak; 2.8-3.6°C lower mean (UoA monitoring)
Membrane protection	Extended lifespan	Extended (international)
Energy savings	Cooling energy reduction	20-30% (international)
Native biodiversity	Species establishment	14 native species (ACL)

Source: University of Auckland Living Roof Monitoring Programme (2024-2025); Auckland Council TR2010/018 (Fassman, Simcock & Voyde, 2010); Fassman-Beck, Simcock, Voyde & Hong (2013); National Research Council Canada (2013); Environment Canada; Auckland Urban Heat Assessment (Arup, 2024); Dong et al. (2026).

3. Te Whakahāngai Whai Rautaki | Strategic Alignment

Living roofs sit within an established Auckland Council strategic framework. The Auckland Plan 2050 and its subsidiary strategies reference green infrastructure, nature-based solutions, or living roofs directly, giving strong strategic support. The statutory framework, however, provides only partial recognition: the AUP excludes living roofs from the impervious area definition, while the supporting design guidance (GD01) provides a pathway limited to a single credited configuration, without the alternative substrate depths, worked examples or standalone detention recognition available to other devices. This section summarises the alignment, the statutory framework that gives effect to it, and the gap between strategic intent and statutory implementation.

3.1 Strategic framework

- **Te Tiriti o Waitangi.** Te Tiriti provides the primary and enduring basis for the relationship between ngā iwi/hapū o te motu and the Crown recognising the rights of tangata whenua and establishing a point of legitimacy for the establishment of settlers as tangata tiriti. This initiative has been undertaken in an ethos of partnership consistent with the intent captured in the 1840 document, with Ngāti Whātua Ōrākei (as tangata whenua) partnering with Te Kaunihera o Tāmaki Makaurau (as agent of the Crown). See also Te Pou o Kāhu Pōkere: Iwi Management Plan for Ngāti Whātua Ōrākei (Ngāti Whātua Ōrākei, 2018).
- **Auckland Plan 2050.** The region's long-term spatial plan. Direction 3 calls for development that protects and enhances the natural environment, including embedding sustainable design principles across buildings and infrastructure. The 2022 Auckland Plan Evidence Report Update identifies living roofs explicitly as a nature-based solution responding to intensification pressure.
- **Te Tāruke-ā-Tāwhiri - Auckland's Climate Plan.** Commits Auckland to net zero emissions by 2050. Action Area B6 directly supports the uptake of productive roofs - an umbrella term covering food production, biodiversity enhancement, biosolar energy generation, and rainwater harvesting - with committed pilots on public assets, barrier removal, and incentive investigation. Action Area B1 commits to reviewing AUP provisions from a climate and natural hazards perspective.
- **Te Rautaki Wai ki Tāmaki Makaurau - Auckland Water Strategy (2022).** The strategy embodies a fundamental change in direction across three fronts: end-of-pipe to at-source, grey to integrated blue-green-grey, and centralised to distributed water management. Living roofs support all three. These directions are given effect through the strategy's eight Strategic Shifts, two of which are especially relevant: Strategic Shift 4 (Regenerative Water Infrastructure) seeks

infrastructure that is regenerative, resilient and mauri-enhancing, and Strategic Shift 6 (Integrated Land Use and Water Planning) supports integrated planning at regional, catchment and site scale, including a regional blue-green network.

- **Urban Ngahere (Forest) Strategy.** Explicitly includes living roofs within the definition of Auckland's urban forest. Targets 30% canopy cover by 2050, with no local board below 15% (current 18%; some boards below 10%). 61% of canopy is on private land, making private-sector uptake material to the target.
- **Indigenous Biodiversity Strategy.** Vision of Auckland's indigenous biodiversity flourishing and treasured (*He taonga, ka whaihua ngā rerenga kē o te Ao Tūroa i Tāmaki Makaurau*). Living roofs can contribute as habitat stepping stones - particularly for invertebrates and pollinators, given low disturbance and predator exclusion potential.
- **Hikina te Wero - Auckland Transport's Environmental Action Plan.** Commits AT to "increase pervious surfaces along corridors that connect areas of high ecological value by 10% through planting, living roofs and paving". AC carpark buildings, bus stations, shelters, and maintenance facilities present implementation opportunities.

3.2 Statutory and technical framework

The principal statutory instrument for living roof recognition in Auckland is the AUP, supported by Council technical guidelines and reports which set the engineering basis for stormwater device acceptance and design. Separate Building Act 2004 and Building Code requirements may apply where a living roof installation involves building work, such as structural modifications, waterproofing or drainage works. These requirements relate to building compliance rather than the stormwater management function of the living roof.

Auckland Unitary Plan

- **Definitions (Chapter J) and zone controls (chapter H).** The definition of impervious area explicitly excludes "porous or permeable paving and living roofs". This means living roofs are not counted toward impervious area standards - though the exclusion does not in itself unlock additional building coverage, which is governed by a separate standard. Where impervious area is the binding constraint, a development can incorporate living roofs without triggering non-compliance; where building coverage is the binding constraint, the exclusion offers no benefit. Whether living roofs might in future be recognised within building coverage or height controls is considered as a potential lever in Section 6, where it is noted such an approach would likely be appropriate only in particular zones, such as the city centre. The AUP does not itself define 'living

roof’, which creates uncertainty at the margins about what qualifies for the exclusion (for example, minimum substrate depth or vegetation coverage); the guidance recommended in Section 6 would address this definition gap.

- **Stormwater provisions (Chapters E1, E8 and E10).** These chapters set the framework for managing the effects of land use and development on freshwater and coastal water quality, including hydrology mitigation requirements in mapped Stormwater Management Area - Flow (SMAF 1 & 2) catchments, and rules regulating the diversion and discharge of stormwater runoff from impervious areas. These regional provisions are given effect at the zone level through the district plan provisions in Chapter H, including maximum impervious area standards and, in some zones, matters of discretion that call for an integrated stormwater management approach (for example the Business - Mixed Use Zone). The Plan does not specify which devices satisfy these requirements; device-level guidance sits in the supporting technical documents below. Because living roofs are excluded from the impervious area definition, they do not count towards

the maximum impervious area standards in the zone provisions (Chapter H), so a greater proportion of a site can be built on where a living roof is used. The regional stormwater rules in Chapter E8 (diversion and discharge of stormwater runoff from impervious areas) and Chapter E10 (development of impervious areas) apply only to impervious areas, so a living roof does not itself trigger them, and the roof area is likewise excluded from what would trigger the Stormwater Management Area Flow (SMAF) provisions. Rather than adding to the impervious area a site must manage, the retention a living roof provides can count towards the site’s stormwater management.

- **Plan Change 120 - deep soil and canopy tree standard.** Plan Change 120 was notified in 2025 to enable additional residential intensification. Proposed residential standards include a deep soil and canopy tree standard for residential development, which would have stormwater infiltration and urban heat reduction benefits on intensified residential sites. Living roofs could complement rather than substitute for ground-level requirements, including the deep soil and canopy tree standard.

Figure 11: Auckland Central Library living roof
Source: Rachel Devine, Auckland Council



Building Act 2004 and Building Code

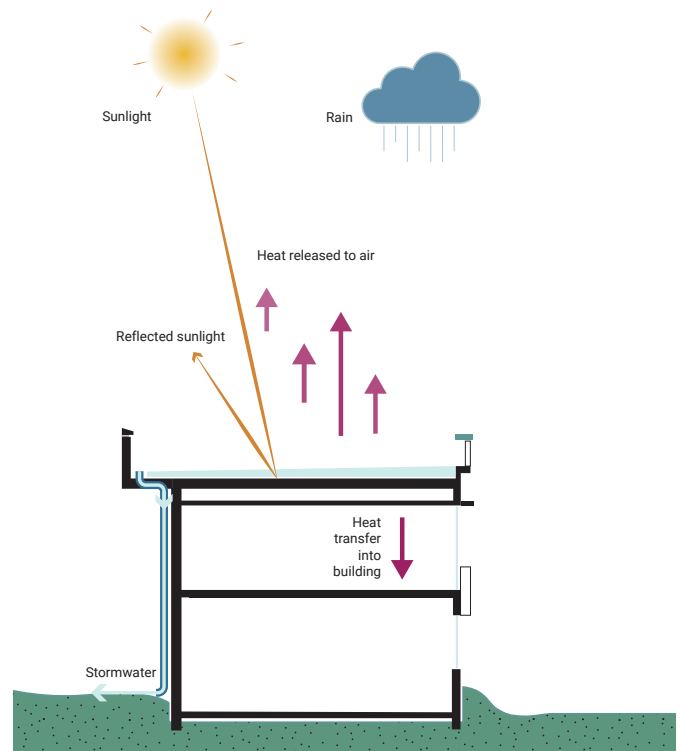
- **Building consent.** While GD01 identifies Building Code compliance requirements for elements such as roof structure, waterproofing and drainage (Section C4.2.1, Table 56), these matters are addressed through the building consent process rather than the resource consent process, noting that GD01 is a guidance document. The building consent process is concerned with compliance of the building work itself, including any structural modifications to the roof. This is a separate consenting process from the resource consent process.

Supporting technical guidance

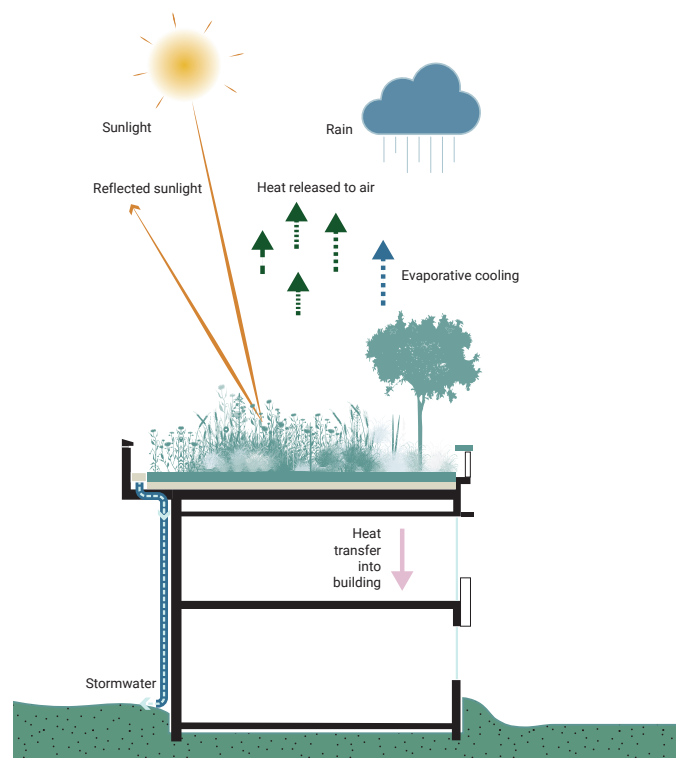
- **GD2017/001 (GD01) - Stormwater Management Devices in the Auckland Region.** Identifies living roofs as an acceptable at-source retention device, requiring a minimum substrate depth of 50–100 mm depending on design, and providing that a roof with 100 mm of suitable substrate may be credited with fully retaining 25 mm of precipitation for consenting purposes (Section C4.2.3). GD01 is the principal document consent officers refer to when assessing stormwater device proposals against AUP requirements.
- **GD2015/004 (GD04) - Water Sensitive Design for Stormwater.** Sits alongside GD01 and provides concept-level guidance for water sensitive design, including a dedicated section on living roofs and living walls covering stormwater performance, wider benefits and common design challenges. The current GD01 review is incorporating GD04's content into a single integrated guideline, which is intended to improve the uptake of water-sensitive design guidance in practice.
- **TR2010 evidence base - Extensive Green (Living) Roofs for Stormwater Mitigation.** GD01's living-roof guidance draws on Auckland Council Technical Reports TR2010/017, Part 1: Design and Construction (Fassman, Simcock & Voyde, 2010) and TR2010/018, Part 2: Performance Monitoring (Fassman, Simcock, Voyde & Hong, 2010), and the supplementary review TR2013/045 (Fassman-Beck & Simcock, 2013). This evidence base largely predates later-generation system types - modular trays, proprietary pillow systems, biosolar configurations - which are addressed in Appendix 2.

3.3 Alignment summary

Across Auckland Council's strategic framework, living roofs align with multiple policy directions. The Auckland Plan 2050 sets the overarching direction; the Climate Plan provides the most explicit support through Action B6; the Water Strategy positions living roofs within a fundamental shift toward regenerative, distributed, at-source infrastructure; the Urban Ngahere and Indigenous Biodiversity Strategies include them within their respective definitions of green infrastructure and habitat; Hīkina te Wero translates the strategic direction into transport-network targets.



Conventional impervious roof



Living roof

Figure 12: Living roofs: stormwater and thermal performance
Source: The Urbanist, 2026. Under CC BY 4.0

Evolving terminology

Council’s strategic documents use evolving language - *green infrastructure* (Urban Ngahere), *regenerative infrastructure* (Water Strategy), *productive roofs* (Climate Plan), *nature-based solutions* (Homes and Places Evidence Report), *water sensitive design* (GD01/GD04). By contrast, the AUP uses the term - *integrated stormwater management* - which does not fully capture the broader multi-benefit outcomes living roofs deliver.

This reflects a structural difference rather than an oversight: Council’s strategies are non-statutory and can be updated through Council’s own review cycles, whereas the AUP is a statutory document that can only be amended through a formal Schedule 1 process under the RMA (for example, a plan change). Some of this ground is intended to be covered through the Freshwater Plan Change’s water sensitive design workstream. The more significant opportunity sits with the Combined Plan: the new planning framework replacing the RMA (comprising a Spatial Plan, a Land Use Plan and a Natural Environment Plan, not simply a plan change to the AUP) gives Council the opportunity to define water sensitive design more explicitly and move toward an outcome-focused approach, giving developers the ability to draw on a wider suite of tools - including living roofs - to meet those outcomes.

Table 2 summarises how living roof benefits align with each strategic document. Primary alignment (●) indicates the benefit is explicitly addressed or targeted in the strategy; secondary alignment (○) indicates the benefit supports broader strategic objectives. The alignments assume a typical living roof with 100 mm or greater substrate depth; some benefits depend on specific design choices.

Table 2 - Strategic Alignment Matrix

Strategy	Stormwater	Heat	Biodiversity	Carbon	Amenity
Auckland Plan 2050	●	●	●	○	●
Auckland Unitary Plan	●	○	○	○	○
Te Tāruke-ā-Tāwhiri: Auckland Climate Plan	●	●	●	●	○
Te Rautaki Wai ki Tāmaki Makaurau: Auckland Water Strategy	●	○	○	○	○
Te Rautaki Ngahere ā-Tāone o Tāmaki Makaurau: Auckland’s Urban Ngahere (Forest) Strategy	○	●	●	●	●
Indigenous Biodiversity Strategy	○	○	●	○	○
Hīkina te Wero: Auckland Transport Environmental Action Plan	●	○	●	●	○

● Primary alignment ○ Secondary alignment

The strategic-statutory gap

Auckland Council’s section 35 monitoring report on the AUP’s water provisions (Auckland Council, 2022, TR2022/14, p. 11) acknowledges that the Plan “includes many of the stormwater components of water sensitive design within policies relating to integrated stormwater management” but notes “scope for refining the provisions to place a greater emphasis on water sensitive design and to have more explicit linkages to related guidance material”, and that “further work is required to require or incentivise rainwater tanks, clustered development and green infrastructure”. The opportunity to align the statutory framework with the evolving strategic language is examined in Sections 4-6.

4. Ngā Take Whai Pānga ki te Whakamahinga | Factors Affecting Uptake

Despite strong strategic alignment, living roof uptake in Auckland remains limited. No comprehensive inventory of installations exists, but industry survey responses and the small number of documented examples indicate that living roofs remain the exception rather than routine practice, and uptake lags well behind cities such as Toronto, London and Singapore that have used the mechanisms described in Section 5. This section examines the factors that have constrained adoption, grouped under three headings: Confidence, Risk and Cost. The grouping reflects both Auckland-specific industry survey findings (set out in 4.1) and international evidence.

4.1 Industry perspective: Auckland survey findings

In May 2026, a survey of architects, developers, landscape architects, structural engineers, stormwater consultants, contractors, suppliers and asset owners was undertaken to understand the factors affecting living roof uptake in Auckland. Key themes include:

- **Cost is consistently named as the leading barrier** but is typically framed as upfront cost premium rather than whole-of-life cost - reflecting the split-incentive dynamic discussed below. The Auckland Central Library assessment illustrates the distinction: although there was a higher initial investment, it is anticipated that this may be partly offset by lower projected maintenance costs over the life of the asset (Section 4.4).
- **Risk aversion** features strongly - including warranty and liability concerns, leak risk and membrane durability, perceived complexity, and concerns about maintenance responsibility in multi-tenanted buildings.
- **Regulatory uncertainty** is a barrier commonly raised internationally - particularly GD01's exclusion of living roofs from standalone detention credit for larger flood-mitigation design storms (50%, 10% and 1% AEP), even though they are recognised for SMAF detention via the retention pathway. Auckland respondents echoed this theme, though it featured less prominently in local feedback than cost.
- **Supply chain and capability gaps** - are repeatedly named, with respondents noting the small number of experienced practitioners, limited plant material availability in commercial quantities, and reluctance among structural engineers to size for living-roof loading without precedent.
- **International evidence alone is not enough to build confidence:** respondents placed more weight on Auckland-specific monitoring data than international references, and identified visible local demonstration projects as the single most effective way to reduce perceived risk.

- **Lack of Auckland specific guidance and evidence** - feedback includes the desire for worked design examples suitable for Auckland conditions, standard construction information, performance calculators, maintenance specifications and pricing indicators as well as updated formal guidance documents (e.g. GD01).

4.2 Confidence: Knowledge and market barriers

Local evidence base

Few New Zealand case studies and performance data exist beyond Auckland and Canterbury, leaving designers and building owners uncertain about outcomes in different contexts. The Auckland Central Library monitoring programme presented in Section 2 begins to close this gap for one substrate type and configuration, but does not yet cover thinner sedum-mat systems, biosolar configurations, modular trays, or amenity-grade intensive systems. Targeted research on water-quality contribution and SMAF-specific performance is identified as a substantive gap.

Industry capability and supply chain

The scale of New Zealand's living roof market is small, as confirmed by the industry survey. A limited number of suppliers and installers constrains competition and keeps prices elevated; suitable plant material is not always available in commercial quantities; and substrate components may require specialised sourcing. The result is a self-reinforcing dynamic - limited demand constrains supply-chain development, while limited supply-chain capacity keeps costs elevated and constrains demand. This was a defining feature of London's pre-policy market (Greater London Authority, 2008) and has been resolved in cities where deliberate demand-side policy - mandates, incentives, or a public-sector demonstration pipeline - has built supplier confidence to invest.

Designer, specifier, and asset-owner familiarity

Risk aversion within the construction industry favours proven, conventional approaches over novel systems. Warranty and liability concerns deter designers and contractors from recommending or undertaking living roof projects without precedent (industry survey). Perceived complexity - integrating waterproofing, drainage, growing media, planting, and irrigation - discourages adoption even where the technical challenges are manageable. Asset-owner familiarity with ongoing maintenance regimes is particularly low; in multi-tenanted commercial buildings, the question of who is responsible for living roof maintenance (and its budgeting) is often unresolved.

The visibility-and-precedent gap

A consistent theme across the survey findings, international literature, and the strategic-alignment analysis in Section 3 is the absence of a visible, accessible portfolio of completed

living roof projects in Auckland. Many existing roofs are private or rooftop-level and not visible from the street, and there is no current inventory of installed living roofs in the region. This visibility gap means that designers, developers, and building owners cannot easily learn from precedent - a structural barrier that demonstration projects on Council-owned and CCO assets are particularly well-suited to address. Establishing an Auckland living roof inventory is identified as a recommendation candidate in Section 6.

4.3 Risk: Technical and regulatory barriers

Regulatory framework gaps

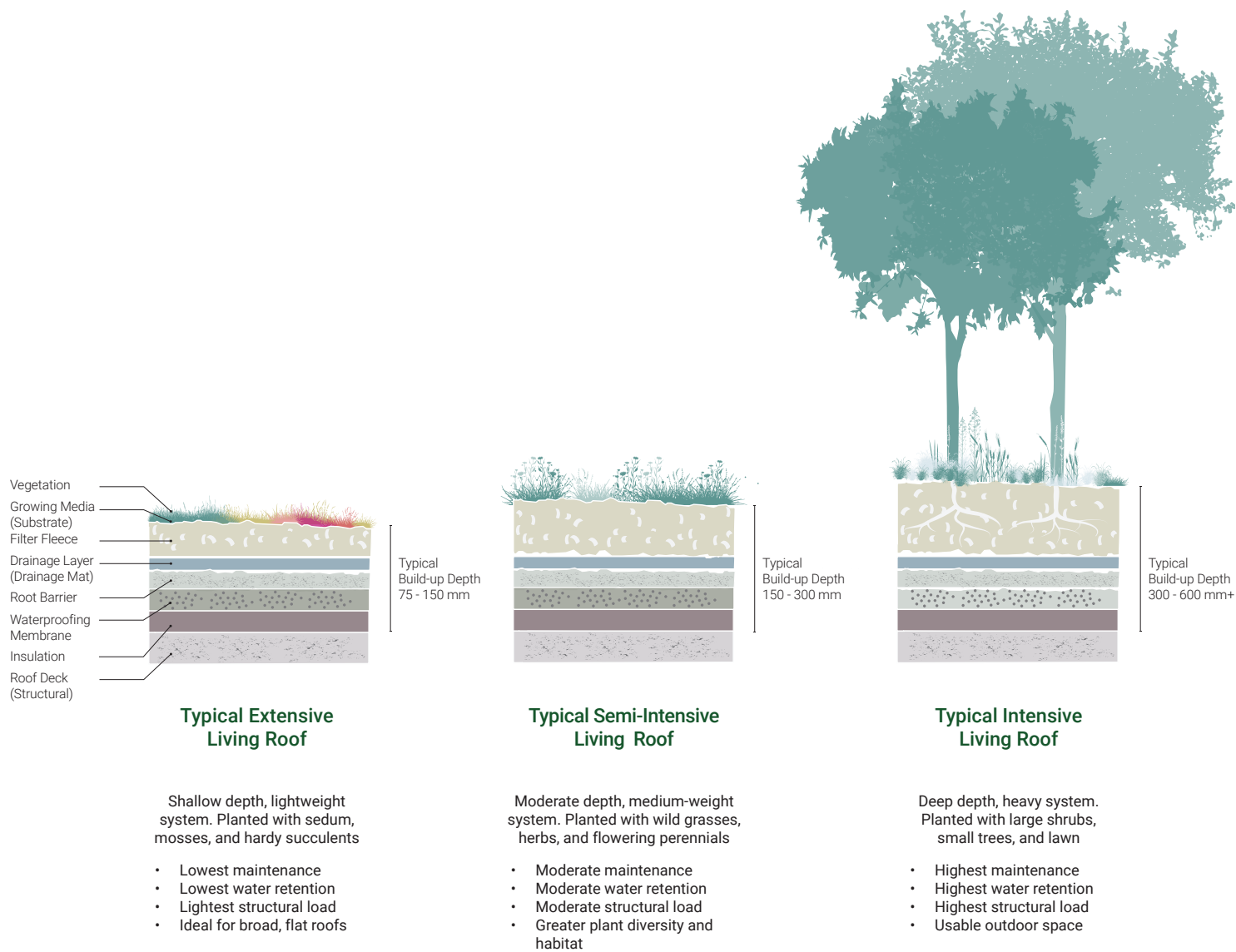
New Zealand has few regulatory drivers, financial incentives, or simplified consent pathways specifically supporting living roof uptake (Moores et al., 2018; Ira, 2022). GD01 lists living roofs as an acceptable stormwater management practice, but the way their retention, extended-detention, and water-quality contributions are recognised within the design framework would benefit from clarification. In particular:

- how the retention a living roof provides relates to the hydrology mitigation outcomes sought in SMAF events;
- whether a living roof area can be treated as effectively pervious when sizing downstream water-quality devices; and
- how living roof parameters should be modelled to account for runoff volume reduction.

Consent officers and applicants alike are left with minimal guidance on how living roofs should be assessed against plan requirements. Auckland Council's section 35 monitoring report goes further, recommending more explicit linkages to guidance material to promote green infrastructure as an option for meeting plan requirements, rather than guidance confined to assessing such devices once they are proposed (Auckland Council, 2022, p. 11). The GD01 review currently underway provides an opportunity to make these points explicit and consistent. The development of the Combined Plan under the legislation replacing the Resource Management Act presents a further opportunity, and sequencing matters: completing the GD01 review first would allow the updated guideline to be referenced in the new plan. If plan provisions are drafted before the review concludes, these gaps – in sizing, metrics and plan linkages - risk being carried into the new statutory framework for a further plan cycle.

Figure 13: Auckland Central Library living roof
Source: Rachel Devine, Auckland Council





Note: Build-up depths are typical and can vary based on design, plant palette, and project requirements

Figure 14: Living Roof Systems: Comparison of three primary systems
Source: The Urbanist, 2026. Under CC BY 4.0

Performance metric mismatch

GD01 does not recognise living roofs for detention in the 50%, 10% or 1% AEP design events, nor for standalone extended detention for stream protection in SMAF 90th to 95th percentile events, where detention is accepted only as a substituted retention volume (Section C4.1). This reflects what the guideline currently recognises rather than an assessment of individual systems: some proprietary systems, particularly blue-green roof configurations incorporating a dedicated detention layer, may provide attenuation, but no pathway exists within GD01 for that performance to count toward compliance.

University of Auckland monitoring study documents strong mean runoff reduction (85-92%) (Soe et al., 2026) and peak-flow attenuation in smaller events (96-98% mean peak discharge reduction - see Section 2.2), but these benefits are expressed in different metrics than those within GD01 and the earlier Stormwater Management Devices Design Guidelines Manual (TP10, Auckland Regional Council, 2003). This means living roofs cannot clearly substitute for conventional extended detention devices within current assessment frameworks, even where their overall stormwater performance is equivalent or superior. Living roofs can also form part of an integrated stormwater management system, for example, reducing the volume that a downstream detention tank or rain garden must manage, or incorporating an engineered storage layer with a controlled-flow outlet (a blue-green roof) to provide detention at roof level. Neither configuration is supported by a sizing methodology in current design guidance, so designers cannot readily credit the living roof's contribution when sizing the rest of the system.

A further limitation is that, because living roofs sit on top of buildings, additional catchment area cannot generally be routed through them. They can only manage the rain that falls directly on them, which limits their use for offset mitigation where a development needs to manage runoff from elsewhere on the site.

Structural and consenting requirements

Structural assessment requirements add complexity and cost, particularly for retrofits. Extensive systems typically weigh 100–150 kg/m² when saturated and require structural evaluation, which adds to project timelines. On existing buildings, conservative engineering assessments can rule out installation in some cases. Safety requirements can also add disproportionate cost, particularly balustrades where roof access is not part of the design intent.

Building consents. Where a living roof installation involves building work, compliance with the New Zealand Building Code may need to be demonstrated. The most relevant provision within the Building Code is B1 Structure, which addresses the ability of the roof structure to withstand potential additional loads imposed by the living roof. However, this will only apply where a living roof installation affects the structural loading of

a roof. If so, it requires demonstration that the roof structure can safely withstand all imposed loads throughout its service life. B2 Durability and E2 External Moisture may also need to be addressed. Consideration may also need to be given to Building Code requirements relating to D1 Access Routes and F4 Safety from Falling, where relevant to the roof design, access arrangements, and intended use. Due to the additional novelty and the lack of established precedent, complexity and processing times for living roof assessments may be extended compared to a conventional roofing system. The main exception is minor structures such as bus and bike shelters, where retrofitted living roofs have been assessed as Exempted Building Works under Schedule 1 of the Building Act 2004, subject to Council discretion (Shamrock and Jones, 2022). Further exploration to better understand how living roof applications could be improved is identified as an opportunity in Section 6.

Perceived versus real technical barriers

The Greater London Authority's 2008 review (the equivalent technical report supporting the London Plan's living roof policy), found that several barriers that appear technical - fire risk, leakage, maintenance, and limited industry expertise, were substantially reduced or resolved where established standards (such as the German FLL standards, from the Landscape Research, Development and Construction Society) and appropriate warranties were in place.

Evidence presents that living roofs can reduce exposure of waterproofing membranes to ultraviolet radiation and thermal stress, which may extend membrane service life; while established suppliers and system designers commonly operate in accordance with FLL or equivalent recognised industry standards (Greater London Authority, 2008).

The genuine residual technical barriers were structural loading on existing buildings (an issue for retrofit but not new build) and the cost premium where the building owner is not the long-term operator.

Auckland remains at an earlier stage of living roof market development than London was in 2008. As a result, several "perceived but misleading" barriers identified in the London review (for example, fire, leakage, maintenance) continue to influence market confidence locally. Addressing these barriers is therefore likely to depend less on further technical research and more on demonstration projects, industry capability development, and wider adoption of recognised standards.

Implementation gap

Auckland's environmental aspirations relevant to living roofs sit largely within non-statutory strategies (for example, the Climate Plan, Urban Ngāhere Strategy, and Water Strategy), while the provisions that give them effect operate through the AUP.

Because changes to the AUP are made through an independent statutory process, Council cannot unilaterally translate these aspirations into statutory provisions. The barrier is therefore one of consistency between strategy and

the statutory framework rather than a failure to implement, and it is most readily addressed through potential future Combined Plan provisions.

4.4 Cost: Economic barriers

The split incentive challenge

The defining economic barrier is systemic to green infrastructure broadly, not unique to living roofs. Building owners bear the full installation cost while a substantial share of the quantified benefits accrues to tenants, local government and the wider community. A Helsinki study found private benefit to cost ratios of 0.5 to 1.1 for extensive living roofs, rising to 0.9 to 2.2 when social benefits such as reduced stormwater infrastructure needs, air quality improvements and urban heat island mitigation are included (Nurmi et al., 2016). Studies from Czechia and Portugal report total benefit to cost ratios of 4:1 to 6:1 when all ecosystem services are valued, although these benefits are distributed across multiple beneficiaries rather than concentrated with the investing owner (Teotónio et al., 2020). The same dynamic applies to rain gardens, swales and other source control devices that deliver public good stormwater functions (Moore et al., 2018; Ira, 2022).

The Auckland Central Library assessment shows the same pattern locally, finding that the organisation funding a living roof is not necessarily the primary beneficiary of the value it creates. Benefits comprise private benefits such as reduced energy consumption and extended roof life; shared benefits such as improved stormwater management and visual amenity; and public goods such as biodiversity, urban cooling and climate resilience. Because Auckland Council is a publicly funded organisation, the wider community benefits are returned to the Aucklanders who funded the project, reflecting Council's multiple roles as building owner, infrastructure provider, environmental steward and representative of the public interest. Council therefore realises a greater proportion of the value generated than a private building owner would typically achieve (Ira, 2026). For a private developer, by contrast, investment decisions are generally based on returns that can be directly captured by the asset owner, so benefits accruing beyond the property boundary are unlikely to be reflected in conventional appraisal. This mismatch between those who incur the costs and those who receive the benefits is a classic public good problem, and is precisely the condition that justifies policy intervention.

Figure 15: Living Lab, Living Roof Monitoring, Faculty of Engineering and Design, University of Auckland
Source: The Urbanist



Why other green infrastructure devices get built

Other green infrastructure devices face the same split-incentive economics in principle but get installed more readily than living roofs in Auckland. Rain gardens, swales, and bioretention devices appear in two contexts: as components of public infrastructure (road corridor, vested reserves, public stormwater network), where they are funded and maintained by Auckland Transport or Auckland Council; and as consent-driven devices within private developments, where they meet AUP Chapter E1 and E10 performance requirements for hydrology mitigation, water quality, or stream protection.

In both contexts, four factors make them more workable than living roofs:

- **A defined compliance pathway.** GD01 provides design specifications and worked design examples for rain gardens, swales and bioretention devices, which can be consistently referenced by consent officers and applicants as the established means of demonstrating that performance requirements are met.
- **Lower whole-of-life cost per unit of catchment treated than roof-level devices.** GD01 sizes bioretention devices providing retention and detention at approximately 3.5 to 5 per cent of the impervious catchment they treat, so a ground level device manages runoff from an area many times larger than its own footprint, whereas a living roof's contributing catchment equals its own area (GD01, Section C3 and Table 48). These cost comparisons exclude land costs, which sit outside the underlying life-cycle cost model (Ira, 2017).
- **A mature design and supply-chain industry.** Civil contractors install rain gardens routinely; landscape architects specify them as standard; structural input is not typically required.
- **Straightforward maintenance and amenity access.** Ground level devices are inspected and maintained from grade by standard landscape crews, and their amenity value is available to passers by without further provision. Living roof maintenance requires designed roof access, whether by internal shaft or external caged ladder, together with fall protection such as perimeter parapets, guardrails and roof edge restraint systems, all of which must be provided for at design stage (GD01, Section C4.2.2). Amenity and wellbeing benefits are similarly conditional on access: the Auckland Central Library assessment notes that its benefit distribution analysis assumes roof access for the public or tenants, identifies the provision of public and staff access as a design choice that materially affects the value delivered, and records that physical access to the Library roof is itself limited (Ira, 2026).

Where these devices sit in the road corridor or in vested public space, ownership lies with Auckland Transport or

Auckland Council on completion, with ongoing maintenance managed as part of the public stormwater network - the developer's involvement ends at handover. Where they sit on private land, they remain as private assets, but the maintenance regime typically sits within the landscape contract rather than as a building-fabric liability.

Living roofs face the same split incentive without these compensating conditions. They sit on the building owner's roof and remain on the building owner's books for the life of the asset, with capital cost, structural integration, maintenance and renewal all staying with the owner as a building fabric liability. The Auckland Central Library assessment confirms that the principal cost drivers occur during the initial establishment phase, including structural integration, specialist materials and vegetation establishment (Ira, 2026). Industry feedback also identifies competition with revenue generating roof uses such as plant rooms, photovoltaics, terraces and services (Section 4.1). On top of these factors, the supply chain is limited.

Living roofs do, however, hold a distinct advantage in land terms. Because they occupy existing roof area they impose no land cost and do not compete for developable site area, which is itself increasingly constrained given that landscaped area required under the Plan, for example 40 per cent of net site area in the Single House Zone under H3.6.11, must also serve amenity planting. On constrained sites this is a material economic advantage, yet it is not identified among the advantages listed in GD01 (Section C4.1), and a living roof earns no credit toward the Plan's landscaped area standards, which apply to ground level planting only.

Roof area is not costless, however. It is contested space, and GD01 notes that services such as heating, ventilation and air conditioning should be minimised and clustered where a living roof is provided, because protrusions and perforations compromise the waterproofing membrane (GD01, Table 55). On buildings with high plant and services demand, or where photovoltaics are proposed, the roof area available for a living roof is reduced accordingly. The advantage is therefore one of land rather than of space: a living roof avoids consuming developable site area, but it competes for roof area with uses that may generate revenue or serve building function.

The recognition of living roofs within GD01's stormwater framework is addressed in Section 4.3. The split incentive is therefore not unique to living roofs, but the compliance pathway, cost, supply chain and access conditions that make other green infrastructure typologies workable in Auckland do not yet exist for roof level devices.

Upfront cost versus whole-of-life value

Living roofs carry a higher initial capital cost than conventional roofing, although the magnitude of the difference varies with design, structural requirements, scale and choice of product. For the Auckland Central Library, where approximately 1,100 m² of conventional ballast roof

was replaced with extensive native vegetation, the additional construction cost represented a modest premium on the total roof construction cost. Projected maintenance costs over the subsequent 49 years were lower for the living roof under both scenarios modelled, by 43 per cent under the low cost scenario and 23 per cent under the high. Over 50 years the living roof's total life cycle cost was 2.8 to 3.3 per cent higher, with costs discounted at 4 per cent and sensitivity testing at 2 and 6 per cent not changing the relative result (Ira, 2026).

This qualifies a common assumption. On the Auckland evidence, maintenance is the component that improves the comparison rather than the one that undermines it. The ballast roof requires regular weed spraying, periodic stone redistribution, partial stone replacement and drainage maintenance, whereas an established living roof functions as a comparatively self sustaining vegetated system whose corrective maintenance consists mainly of selective vegetation management and localised repairs. Because acquisition costs represent 80 to 90 per cent of the living roof's net present value, the whole of life comparison is driven principally by the initial investment rather than by ongoing costs. The maintenance result is also a function of the conventional roof's renewal profile, which includes ballast stone replacement at ten year intervals and membrane renewal within the assessment period, rather than of lighter routine maintenance for the living roof, which in fact requires more frequent routine care.

Some international studies have found that extensive substrate-based living roofs outperform both conventional and inverted-roof options once membrane longevity and energy savings are accounted for (Greater London Authority, 2008). The Auckland assessment did not find a lower net present value for the living roof, and the difference between the two results warrants further local analysis. In either case, the whole of life logic only operates where the building owner is also the long term operator, and much Auckland development is built for sale rather than for long term ownership.

Benefit distribution in Auckland

Benefits are distributed across multiple beneficiaries:

- Direct or private benefits may include reduced building energy consumption, improved thermal comfort, potential extended roof membrane life, enhanced environmental credentials and, in some cases, increased property values or rental premiums.
- Wider public benefits include reduced pressure on the public stormwater network, improved receiving water quality, urban heat mitigation, biodiversity enhancement and increased climate resilience.
- Visual amenity may benefit occupants, neighbouring buildings and the wider community, and benefits from green or natural views may be captured entirely by

adjacent properties and the wider community rather than by the building owner.

In relation to stormwater, retention and peak flow reduction can reduce pressure on public stormwater infrastructure. The Auckland Central Library economic assessment recognised avoided hard infrastructure and pipe costs, and avoided public infrastructure delivery, as potential avoided cost pathways, although no project specific network upgrade deferral was monetised (Ira, 2026).

Current Auckland and New Zealand policy settings provide relatively few mechanisms through which these wider public benefits are translated into direct financial value for the asset owner. Many overseas jurisdictions, by contrast, apply stormwater utility charges based on impervious area, stormwater fee credits, green infrastructure incentives or Green Factor requirements that explicitly reward investment in living roofs, so that a greater proportion of the value generated is internalised by the developer or building owner (Ira, 2026). The economic value realised from an identical living roof may therefore differ substantially between cities despite similar environmental performance. Without such mechanisms, building owners may face unfavourable project economics even where the environmental and social return is strongly positive. Potential mechanisms for the Auckland context are considered in Section 5.5.

4.5 What this tells us

Across all three groupings, a consistent finding emerges. Living roof uptake is not constrained by the strength of the case for them - the strategic framework supports them, the Auckland and international evidence base demonstrates their performance, and the technical solutions are available. Uptake is constrained by the cost-allocation, regulatory-recognition, and market-confidence conditions that determine whether a designer or developer can specify a living roof with reasonable certainty about its consenting pathway, its financial return, and its long-term operational support.

Internationally, cities that have achieved substantial living roof uptake - London, Toronto, Copenhagen, Portland, Basel, Berlin - have done so through deliberate policy intervention that addresses multiple barrier categories simultaneously (Greater London Authority, 2008; Zhang & He, 2021). Section 5 examines the potential levers available to Auckland Council.

Several mechanisms discussed in this section, including impervious area based stormwater charges, have been examined by Auckland Council and related agencies previously, reaching different conclusions under the policy and regulatory settings applying at the time (Ira, 2014). This report does not revisit those decisions. It sets out the international evidence and the Auckland-specific monitoring data now available, against a statutory and strategic context that has since changed, including the current GD01 review, the development of the Combined Plan, and the intensification and climate pressures described in Section 1.

5. Ngā Ara Wātea | The Opportunities

5.1 Lessons from International Policy Approaches

International research comparing living roof policy approaches indicates that neither purely mandatory nor purely voluntary approaches are unequivocally superior (Wilkinson, Ghosh & Pelleri, 2024). A comprehensive review of 143 incentive policies across 113 cities in 19 countries found that financial subsidies and statutory obligations are the most common mechanisms worldwide, though regional approaches vary significantly based on local conditions and priorities (Liberalesso et al., 2020).

International practice identifies six categories of incentive policies for promoting green infrastructure (Liberalesso et al., 2020):

1. Tax or developer contribution reductions, stormwater fee discounts, and other tax incentives - typically insufficient on their own to fully offset the cost premium.
2. Financing via direct subsidies for installation costs and reduced interest rates on loans for green infrastructure.
3. Construction permit bonuses with density bonuses allowing additional floor area in exchange for living roof installation.

4. Sustainability certification with recognition through rating systems such as Green Star or local equivalents.
5. Mandatory requirements for living roof installation on certain building types or sizes.
6. Priority processing for developments incorporating green infrastructure.

5.2 Regional Patterns

International evidence reveals distinct regional approaches. In Europe, 85 percent of incentives are financial subsidies, reflecting strong government investment in direct support. North America shows a more balanced distribution across subsidies (23%), statutory obligations (18%), stormwater fee discounts (15%), and sustainability certifications (15%). In South America, where municipal budgets are typically more constrained, incentive policies focus on property tax reductions (31%) and statutory obligations (23%) - mechanisms that do not require direct government expenditure (Liberalesso et al., 2020). For Auckland, this suggests that a mix of direct and indirect mechanisms is likely to be more appropriate than reliance on any single instrument, with the balance determined by funding capacity and policy priorities.

Figure 16: Oasis Terraces, Singapore
Source: iStock / zdl, 1164925286



The leading international examples illustrate how different combinations of levers operate in practice.

Singapore: Voluntary Approach with Strong Incentives

Singapore has achieved the greatest documented uptake of living roofs through a programme combining substantial financial incentives with sustained public-sector leadership. The Skyrise Greenery Incentive Scheme funds up to 50 percent of installation costs, supporting over 110 retrofitted buildings and an 80 percent increase in living roof coverage (Wilkinson, Ghosh & Pelleri, 2024; National Parks Board, 2025). Singapore markets itself as a ‘garden city’, and the Housing and Development Board - as a major property owner - plays an influential role in driving uptake through public-sector procurement.

Toronto: Mandatory Requirements with Financial Support

From 2010 to 2025, Toronto operated North America’s first mandatory living roof bylaw, alongside parallel financial incentives. The Toronto Green Roof Bylaw required living roofs on new developments exceeding 2,000 m² gross floor area, covering 20–60 percent of available roof space on a sliding scale (Wilkinson, Ghosh & Pelleri, 2024). The mandatory policy was complemented by the Eco-Roof Incentive Program, which provided installation grants of

CA\$100/m², structural assessment grants of up to CA\$1,000 for retrofit projects, and a cash-in-lieu provision of CA\$200/m² where on-site provision was not feasible - with cash-in-lieu funds recycled into voluntary-installation grants. The bylaw supported the installation of more than 1,200 living roofs across Toronto (City of Toronto, 2025) before being repealed by the Ontario provincial government on 3 November 2025, returning Toronto to a voluntary regime.

German Cities: Long-standing Mandatory Policies

German cities have the longest experience with mandatory living roof policies, operating since the 1980s. In Munich, all suitable flat roofs over 100 m² must include a living roof; in Stuttgart, all new developments with flat or pitched roofs up to 12 degrees must be greened to specific standards. Hamburg initiated a comprehensive Green Roof Strategy in 2014 aiming to install or retrofit at least 70 percent of new and existing buildings, supported by stormwater-fee reductions and installation subsidies up to 60 percent (European Environment Agency, 2021a). These cities also require maintenance for specified periods ranging from 5 years (Leiden, Netherlands) to 15 years (Merelbeke, Belgium), supporting long-term performance (Liberalesso et al., 2020).

Figure 17: London living roofs, Tower Bridge
Source: iStock / Manoj Soundararajan, 2239126268



London: Voluntary Planning Policy

London increased its living roof area substantially through a voluntary approach embedded in planning policy, achieving a reported 360 percent increase over eleven years (Wilkinson, Ghosh & Pelleri, 2024). The Greater London Authority's 2008 Living Roofs and Walls technical report, which underpinned London Plan Policy 5.11, framed living roofs as a multi-objective intervention: biodiversity (including habitat for the black redstart, a rare bird associated with London's post-industrial brownfield sites being one of the original impetus for the policy), urban heat mitigation, sustainable drainage, and amenity (Greater London Authority, 2008). The London Plan 2021 expresses the policy through an Urban Greening Factor, with intensive living roofs scoring 0.8 and extensive living roofs 0.7. Uptake has been reinforced by London's underlying infrastructure economics - in many central catchments, retrofitting living roofs is materially less costly than upgrading the combined sewer network. The relevance for Auckland is highest where multiple drivers align with infrastructure constraints, particularly in combined sewer catchments and headwaters where downstream network capacity is the binding constraint.

While neither the London Plan nor borough Local Plans mandate living roofs directly, their cumulative effect at borough level makes them close to unavoidable on many developments. For example, in the London Borough of Tower Hamlets, the borough's Local Plan 2031 policies S.ES1 and D.ES3 require development to maximise the provision of living building elements and deliver biodiversity enhancement on major applications, with sustainable drainage required under the plan's water and flood policies. Read together with supporting documents such as the borough's Local Biodiversity Action Plan, and applied to sites where ground-level space is severely constrained, these requirements can in practice only be satisfied at roof level. Non-compliance may result in planning permission being refused or financial contributions being sought through legal agreements. The mechanism is therefore not voluntary adoption, but cumulative outcome-based requirements that living roofs are well placed to satisfy.

This is directly relevant to Auckland. It indicates that uptake can be achieved without a living roof mandate, provided outcome-based requirements are set at a level that constrained sites cannot meet at grade, and provided developers retain flexibility over the tools used to meet them. This is the mechanism underlying the Urban Greening Factor approach discussed in Section 5.4.

Implications for Auckland

The international evidence suggests several considerations for Auckland.

- **Integrated policy packages.** The most effective approaches combine multiple levers that reinforce each other, rather than relying on a single mechanism

(Liberalesso et al., 2020; Zhang & He, 2021).

- **Phased implementation.** Beginning with incentivised measures to develop market capacity before considering mandatory requirements, once industry capability exists.
- **Right-sized incentives.** International experience shows that subsidies and tax incentives are most effective when set against the actual cost differential in the relevant context (Nurmi et al., 2016; Teotónio et al., 2020). In Auckland this varies by zone. Where on-site stormwater mitigation is required for the development - for example within SMAF areas or under specific consent conditions - the relevant comparison is between a living roof and a conventional roof plus the mitigation that would otherwise be installed, a materially smaller gap than the gross premium. Where on-site mitigation is not required (parts of the city centre, some industrial and business zones discharging directly to the public network), the gross premium applies, but the public benefit case may still be strong - for example in combined sewer catchments where roof-runoff reduction lowers overflow frequency. This argues for catchment- and zone-specific incentive rates rather than a single Auckland-wide rate. Beyond subsidies, two mechanisms could reinforce this. An impervious area based stormwater charge would create an automatic incentive for living roofs without requiring a separate rule, since the AUP already excludes them from the impervious area definition (Chapter J). Such charges, and the reasons previous variants have not progressed in Auckland, are discussed in Section 5.5. Separately, the point at which a flat roof's waterproofing membrane reaches the end of its life presents a strategic opportunity: where membrane replacement is already planned, a living roof could be installed concurrently, avoiding many of the costs associated with a standalone retrofit while also supporting an extended service life of the new membrane, although the size of that difference has not been quantified for Auckland (Section 2.3).
- **Public sector leadership.** Council demonstration projects serve dual purposes - building evidence and industry capability, while signalling commitment. Comparable international precedents include the US federal programme, which now maintains over 80 buildings and approximately 20 hectares of living roofs across the General Services Administration portfolio, supported by whole-of-life cost analysis and a 2011 review of benefits, costs and challenges (US General Services Administration, 2011). Comparable precedent exists at central government level: section 438 of the United States Energy Independence and Security Act 2007 requires federal development and redevelopment projects with a footprint exceeding 5,000 square feet to maintain or restore predevelopment hydrology, in respect of temperature, rate, volume and duration of flow, to the maximum extent technically feasible

(US EPA, 2009). The requirement is outcome-based rather than device-specific: agencies may demonstrate compliance either by managing the 95th percentile storm on site or through site-specific hydrologic analysis, with living roofs among the practices explicitly identified. Combined with life-cycle costing applied through GSA's facilities standards, this underpinned the subsequent expansion of the federal living roof portfolio. Central government leadership of this kind amplifies market signalling beyond what a single city authority can achieve alone.

- **Local adaptation.** Policy effectiveness depends on local conditions. Auckland's particular combination of catchment characteristics (combined sewer overflows in older networks; high topographic relief and elevated enclaves with limited at-grade planting space), climate exposure (increasing rainfall intensity, summer heat), and statutory framework (AUP, GD01, the upcoming Plan Change 120 deep soil requirements) means that living roofs may be the most appropriate intervention in some catchments and zones, while other green infrastructure types are better suited elsewhere.

A consistent message from the international literature is that overcoming barriers to living roof uptake requires coordinated action across policy, technical, economic, and social dimensions; addressing any single barrier category in isolation is unlikely to shift market outcomes significantly (Zhang & He, 2021). Auckland's approach should therefore integrate technical guidance, financial mechanisms, regulatory pathways, and market development initiatives within a coherent implementation framework.

5.3 Knowledge levers: responding to confidence barriers

Confidence-building levers aim to address knowledge and market confidence - the conditions under which designers, contractors, building owners, and consent officers can specify, install, and assess ongoing living roof requirements (e.g. maintenance) with reasonable certainty.

Technical guidance and standards

Updated technical guidance is needed to support consistent assessment and to build industry capability with the current GD01 review presenting a timely opportunity (see section 5.5). It is recommended that updated guidance should incorporate Auckland Central Library and University of Auckland monitoring findings alongside earlier research (TR2010/018; Fassman-Beck & Simcock, 2013), species selection for Auckland conditions (Bodley, Simcock & Stanley, 2022), and relevant international evidence (Greater London Authority, 2008; Liberalesso et al., 2020). Key elements include design methodologies and calculation procedures, substrate specification requirements, maintenance and monitoring protocols, and quality assurance and verification procedures for installation and establishment. The Auckland

Central Library and University test beds could be used as case studies, supported by worked examples showing structural assessment approaches, sizing calculations, and consent application requirements.

Training, capability, and supply chain

Confidence is influenced by both the maturity of the local design and installation supply chain and the market understanding of risks, costs, responsibilities and benefits. Targeted capability-building measures, including Auckland Design Manual guidance, industry training, and structured knowledge sharing drawing on Council and University of Auckland monitoring, can strengthen market confidence and supply-side capability. These measures address capability directly. The volume of work needed to sustain a mature supply chain will come from private development responding to the cost and regulatory levers in Sections 5.4 and 5.5.

Demonstration and public-sector procurement

Demonstration projects build evidence, contribute to industry capability, and signal Auckland Council commitment. Council-owned living roofs generate Auckland-specific monitoring data, give designers, engineers and contractors direct local experience, and provide visible precedent that private applicants and their consultants can point to. The Auckland Central Library illustrates the value a single well-documented project can carry, particularly where project specific monitoring is combined with whole of life cost analysis (Ira, 2026). The number of Council buildings suitable for a living roof in any year is limited by roof form, structural capacity and renewal timing, so the contribution of Council's own portfolio is to evidence and precedent rather than to the volume of work needed to sustain a supply chain. The international experience described in Section 5.2 indicates that public portfolios of scale follow regulatory requirements rather than procurement decisions. International precedent supports this approach: the US General Services Administration maintains approximately 20 hectares of living roofs across more than 80 federal buildings, supported by whole-of-life cost analysis (US General Services Administration, 2011). Central government leadership in New Zealand - for example through specification on new government-owned buildings and on Crown infrastructure programmes - would amplify the market signal that local Council procurement alone can provide.

Auckland-specific opportunities

Auckland has specific opportunities to advance living roof implementation through existing frameworks and upcoming policy processes. These are set out below in approximate order of availability, from those already underway to those dependent on the new planning framework.

GD01 review. The current review of GD01, which is incorporating GD04 into a single integrated guideline, is the most immediate opportunity available. It can address the design and sizing matters identified in Section 4.3 and

provide the worked design example that living roofs presently lack. As noted in Section 5.4, the review needs to be completed in time for the updated guideline to be referenced in the Combined Plan.

Freshwater plan change and water sensitive design

workstream. Council has been investigating how greater uptake of water sensitive design could be encouraged or required through a freshwater plan change to the AUP, including the development of a water sensitive design rating system. That work provides a foundation for living roof provisions and will need to be updated to fit the new planning regime.

Building consent practice. Where a living roof installation involves building work, compliance with the New Zealand Building Code may need to be demonstrated, most relevantly B1 Structure where the installation affects the structural loading of the roof (see Section 4.3). Opportunities to support efficient processing, including standardised structural and weathertightness details and guidance for processing staff, are available to Council without statutory change.

Council asset renewal. Waterproofing membrane replacement on Council buildings presents a recurring and predictable opportunity to consider the feasibility and

appropriateness of installing a living roof, as the works can be integrated with planned asset renewal activities (Section 5.3). The Auckland Central Library assessment could inform future assessment of living roofs as an option across Council's property portfolio, particularly for flat-roof structures with membrane and/or ballast roofs (Ira, 2026).

Water services regulatory framework. The Local Government (Water Services) Act 2025 includes provisions governing charges for stormwater services, and Taumata Arowai may in future develop stormwater environmental performance standards and national engineering design standards. Both may affect the mechanisms available to Council (Sections 5.4 and 5.5).

Auckland Unitary Plan (AUP) review/Combined Plan.

The AUP is due for review as required by the current Resource Management Act. The government is progressing resource management reform through two bills expected to receive royal assent in 2026, the Planning Bill and the Natural Environment Bill. These will replace the RMA and require Council to develop a new statutory planning framework, replacing the AUP with the Combined Plan, which will comprise a Spatial Plan, a Land Use Plan and a Natural Environment Plan.

Figure 18: Hundertwasser Art Centre with Wairau Māori Art Gallery living roof, Whangārei, Northland
Source: Zoë Avery, The Urbanist



The development of the Combined Plan via RM Reform presents an opportunity in the short to medium term to strengthen living roof recognition through explicit plan provisions, performance-based standards, and incentive mechanisms. Climate Plan Action Area B1 commits to reviewing AUP provisions from a climate change and natural hazards perspective; living roof requirements or incentives could be advanced through this process. However, due to the signalled national standardisation of RM Reform Council will face statutory hurdles in deviating from national standards and applying local policies.

Plan Change 120 implementation. Plan Change 120's deep soil and canopy standard for residential zones has the purpose of building climate resilience, including increasing stormwater infiltration and reducing urban heat in intensified sites. The implementation of this standard may create future opportunity for living roof recognition in the AUP review, including in business and mixed-use zones that have higher building coverages and greater parking requirements where ground level deep soil requirements cannot be met. In residential zones, living roofs could complement rather than substitute for ground-level requirements, including deep soil.

Stormwater Network discharge consent. Auckland's regional network discharge consent framework provides a pathway for recognising living roof contributions to stormwater management at catchment scale. Integration of living roofs into consent obligations present the opportunity to recognise their contribution to stormwater volume reduction targets, peak flow management objectives, water quality improvement goals, and source control best practice. This would support prioritising headwaters of catchments, particularly those in combined sewer catchments where the catchment economics most closely resemble the London case.

Implementation sequencing

International experience suggests a sequenced approach to policy implementation. Early-stage markets benefit from demonstration projects, technical guidance, and voluntary incentives that build industry capability and market confidence before mandatory requirements are introduced (Wilkinson, Ghosh & Pelleri, 2024; Zhang & He, 2021). Section 6 sets out a potential implementation pathway, organised by Opportunity Area, that flows from the lever analysis in this section.

Figure 19: Living roof Basel, Switzerland
Source: Zoë Avery, The Urbanist



5.4 Technical levers: responding to risk barriers

Risk-mitigation levers address the technical and regulatory uncertainty that discourages adoption. International evidence shows that, when designed with appropriate exemptions and alternatives, regulatory mechanisms drive rapid market development and cost reduction (Wilkinson, Ghosh & Pelleri, 2024). The following mechanisms respond to the risk barriers identified in Section 4. Each would require assessment against Auckland’s statutory framework and consenting practice before it could be adopted.

Consent pathway improvements

Resource consent. GD01 recognises living roofs as at-source retention devices. A roof providing 100 mm of suitable substrate may be credited with fully retaining a maximum of 25 mm of precipitation, with larger events calculated using a curve number of 98 (GD01, Section C4.2.3), the value GD01 applies to impervious surfaces (Section C1.4.5). On this basis living roofs are recognised as providing retention, including toward SMAF requirements, and detention for stream protection achieved as retention volume. They are identified as not providing detention for the 50%, 10% or 1% AEP events, and are not to be used as water quality treatment devices (Section C4.1). The credit is capped rather than scaled, with no additional recognition for substrate deeper than 100 mm, despite GD01 identifying settled depth as a primary determinant of retention. The opportunity is that a strengthened GD01 chapter, supported by Auckland Design Manual guidance and worked examples, would scale the retention credit to validated substrate depth and water-holding capacity, and provide a sizing basis for the controlled-release detention available where an engineered storage layer is included (Section 4.3). This would reduce both the applicant’s evidential burden and the scope for differing interpretations between consent officers.

Building consent. Where a living roof installation affects the structural loading of the roof, compliance with B1 Structure of the New Zealand Building Code will need to be demonstrated, supported by a structural assessment from a suitably qualified and experienced person (see Section 4.3). Complexity arises from structural loading, weathertightness and membrane durability beneath vegetation, fire performance, and safety where roof access or fall protection is involved. The absence of established precedent compounds this, extending processing relative to a conventional roof. The opportunity is standardised structural and weathertightness details, worked examples, and guidance for processing staff. These measures are available to Council without statutory change, and reduce cost and uncertainty for applicants rather than altering statutory timeframes.

Green Factor and biotope-area approaches

Berlin pioneered the Biotope Area Factor (BAF), which expresses the ratio between ecologically effective surfaces and total site area. Target values are set for different

development types 0.6 for new housing, 0.3 for commercial development - with different surface treatments receiving weightings for compliance calculation. A conventional sealed roof scores 0, while an intensive living roof with more than 80 cm of soil depth scores 0.7. Seattle’s Green Factor, effective from 2007, requires the equivalent of 30 percent vegetated coverage in neighbourhood business districts, with bonus weightings for elements including living roofs.

A Green Factor approach could be investigated to be integrated into Auckland Council’s planning framework through a future AUP review (i.e. the new Combined Plan). Weightings would need tailored to local conditions. A Green Factor approach would provide flexibility for designers while ensuring environmental outcomes, with living roofs providing a pathway to partial compliance on sites where ground-level planting is constrained.

The feasibility of incorporating such an approach into the Combined Plan will also depend on stormwater standards developed by Taumata Arowai, whose oversight of the environmental performance of wastewater and stormwater networks commenced in October 2023 under the Water Services Act 2021. No stormwater environmental performance standards have been made to date, and national engineering design standards covering stormwater are still being developed with the sector.

Where a rating system cannot be given statutory effect, it may still deliver value as a non-statutory instrument. A voluntary rating applied and promoted by developers, comparable to established green building rating tools, would provide market recognition for higher-performing developments without relying on plan provisions, and would not be contingent on the outcome of reform.

Floor area and built-form bonuses

Floor area ratio bonuses incentivise uptake without regulatory mandate by allowing additional development capacity in exchange for living roof installation. Portland offers floor area bonuses for developments with living roofs covering at least 70 percent of roof area. The bonus value can be calibrated to offset implementation costs while maintaining planning integrity, creating market pull for high-performance systems. This mechanism is particularly effective in high-value locations where additional floor area has substantial economic value.

In Auckland, the equivalent levers could potentially be modest increases to AUP Building Coverage or Maximum Height controls for developments providing a living roof over a defined proportion of roof area in specific zones or via specific controls at either an Auckland wide or overlay level. The design of any such bonus would need to ensure that the increased development yield does not erode the planning purposes of the underlying controls, and the bonus value should be sized to the actual cost differential identified in Section 4.4 rather than the gross cost premium.

Building Coverage and Maximum Height are zone standards, and reform is expected to introduce standardised planning zones nationally. Depending on how that standardisation is given effect, Council may have limited scope to vary these controls, or may be able to do so only through a substantial amendment process.

Mandatory requirements

Toronto's Green Roof Bylaw (Canada), adopted in 2009 and taking effect in 2010 (2012 for industrial development), required living roof coverage on new developments exceeding 2,000 m² gross floor area, with coverage ratios scaled by building size (Wilkinson, Ghosh & Pelleri, 2024). Exemptions applied to residential buildings under six storeys and to tower floor plates under 750 m². A cash-in-lieu alternative at CA\$200/m² was available where on-site provision was not feasible. Over its fifteen years of operation the bylaw supported more than 1,200 living roofs in Toronto (City of Toronto, 2025) before it ceased to apply on 3 November 2025. The repeal did not follow from any assessment of the bylaw's performance, but formed part of a provincial programme to accelerate housing and infrastructure delivery: the province signalled the change in Bill 60 (Fighting Delays, Building Faster Act 2025) and gave effect to it through provincial action revoking the enabling provision of the City of Toronto Act 2006 (section 108) under which the city had made the bylaw.

Basel's building regulations (Switzerland), introduced in 2002, require living roofs on new buildings over 1,000 m² and specify design parameters including the use of native soils and flora, minimum growing medium depth, and mounding requirements to encourage insect habitat (Wilkinson, Ghosh & Pelleri, 2024). Tokyo compels developers of new private buildings with footprints larger than 1,000 m² and new public buildings over 250 m² to green 20 percent of their roof areas or face annual fines, stimulating construction of approximately 50,000 m² of living roofs annually (Liberalesso et al., 2020).

Any mandatory living roof provision would need to be progressed through a Plan Change or the Combined Plan, and would need to be defensible against the broader purposes of the AUP, including built form, impervious surface area, urban amenity and development feasibility. Public consultation and stakeholder engagement would inform any policy direction before formal statutory mechanisms are advanced. In practice, an Auckland approach would likely combine plan provisions, performance (technical) standards, consenting pathways, and incentive structures, implemented through the statutory framework as it evolves.

That framework is itself in transition. The Combined Plan will be required to implement the new Planning Act and Natural Environment Act replacing the Resource Management Act, and new national directions are expected in relation to freshwater and coastal receiving environments. Reform is also intended to introduce extensive national direction

governing plan making and plan provisions, which may limit the extent to which councils can adopt provisions departing from standard national versions; the scope of that constraint is not yet settled. Auckland Council has been investigating how greater uptake of water sensitive design could be encouraged or required through a freshwater plan change to the AUP, and that work will need to be updated to fit the new planning regime.

The reform framework also raises the importance of this evidence. Both the Planning Act and the Natural Environment Act will require evaluation and justification reports addressing, among other matters, the costs and benefits of proposed provisions. The ability to quantify long-term benefits will therefore bear directly on whether a living roof provision can be justified. Several of those benefits remain difficult to monetise, which is itself an argument for the evidence-development actions identified in Section 6. Auckland Council's own economic assessment framework addresses this by combining qualitative, semi-quantitative and whole of life cost methods rather than relying on a single monetary ratio, on the basis that outcomes such as climate resilience, biodiversity, urban cooling and amenity cannot all be robustly monetised (Ira, 2026).

5.5 Economic levers: responding to cost barriers

Economic levers improve the financial case a designer or developer considers when specifying a living roof. International experience suggests that self-funding mechanisms can be particularly effective, as they return a portion of the public benefit value to the building owner at the point of investment decision rather than requiring ongoing budget allocations. Policy and regulatory settings can influence how much of the value generated by a living roof is internalised by the building owner. The following mechanisms are drawn from international practice. Each would require assessment against Auckland's cost structures, statutory settings, and funding context before it could be adopted.

Integration into GD01 - design and sizing pathway

GD01 currently lists living roofs as an acceptable stormwater management practice but provides insufficient detail to support consistent design and consent assessment. The gap to be closed is not a special 'credit' mechanism, but a clear, GD01-aligned design and sizing process - consistent with the way other green infrastructure devices in GD01 (raingardens, swales, bioretention) are specified and assessed. The GD01 review currently underway is considered an appropriate vehicle for this work.

A strengthened GD01 chapter on living roofs could incorporate Auckland-specific monitoring evidence (University of Auckland and Auckland Central Library), define substrate, depth, and vegetation parameters by typology, set out a sizing process aligned with the AUP's stormwater management objectives, and provide worked design examples.

It would ideally provide a consenting pathway for living roofs that is consistent with other GD01 devices, while also recognising, where supported by evidence, the additional co-benefits they can provide, without implying that living roofs operate outside the GD01 framework or require fundamentally different assessment criteria. Maintenance and monitoring provisions would ideally be specified in line with other GD01 devices, with ongoing vegetation cover and substrate condition as the principal performance indicators (Fassman-Beck & Simcock, 2013).

Development contribution offsets

Development contribution offsets recognise that living roofs can support onsite stormwater management and contribute to reducing pressure on existing network infrastructure. TR2013/045 establishes that living roofs with appropriate substrate retain meaningful proportions of rainfall (Fassman-Beck & Simcock, 2013), enabling quantified offsets against stormwater development contributions. This directly addresses the split-incentive challenge by returning a portion of public benefit value to the investing building owner at the point of development decision-making. It should be acknowledged however, that living roofs would not remove

the ongoing need for public stormwater networks to be maintained and upgraded over time.

A development contribution offset for living roofs would likely, for consistency, need to sit within a broader framework that recognises other GD01 stormwater management devices delivering equivalent stormwater outcomes – it is recommended that living roofs be treated as one option within a suite of acceptable interventions, not a uniquely privileged one. Where differentiation is justified, it rests on attributes specific to living roofs rather than on benefits shared with other vegetated devices. Air quality, amenity and biodiversity benefits are delivered by ground-level planting as well, and at-grade vegetation sits closer to the pedestrian exposure zone. The attribute that distinguishes living roofs is that they deliver stormwater retention without consuming developable land, which is most valuable on constrained sites where at-grade devices are not practicable. In some contexts, however, the underlying drivers – limited at-grade planting space (notably on elevated enclaves and dense centres), co-benefits in energy use and urban heat, or catchment-specific water-quality and overflow constraints – may justify weighting or prioritising living roofs as the most appropriate device for a particular zone, catchment, or development

Figure 20: Auckland residential living roof
Source: Zoë Avery, The Urbanist



typology. The offset calculation methodology would ideally recognise equivalent stormwater detention volume, peak flow reduction, water quality improvement, and long-term infrastructure capacity contribution. Auckland Council's development contribution policy provides a framework for implementing such offsets without requiring legislative change.

Structural assessment grants

Structural assessment grants reduce a specific barrier for retrofit projects. Toronto's Eco-Roof Incentive Program provides structural assessment grants of up to CA\$1,000 to establish whether an existing building can support a green roof (City of Toronto, 2026). This recognises that uncertainty about structural adequacy, rather than actual inadequacy, often prevents retrofit consideration. Given that extensive systems typically weigh relatively modest additional loads of around 70–170 kg/m² when saturated, streamlining structural assessment processes could help identify and unlock retrofit opportunities on suitable buildings. The Auckland Central Library provides a local example: structural assessment confirmed that no strengthening was required, as the existing roof could support the proposed extensive system (Ira, 2026).

Appropriate funding sources could be investigated, including both public and private options, and the potential for integration into existing building resilience programmes.

Direct subsidies and grants

Direct subsidies address the gap between private costs and private benefits during the period in which the market is developing. Singapore's Skyrise Greenery Incentive Scheme provides up to 50 percent of installation costs, capped at S\$200/m², with a mandatory five-year maintenance commitment and pro-rata recovery for early removal. As of 2023, over S\$10.2 million had been disbursed across more than 200 buildings, supporting 155 hectares of skyrise greenery (National Parks Board, 2025). Toronto's Eco-Roof Incentive Program, operating since 2009, provides grants of CA\$100/m² for living roof installations, up to CA\$100,000 per project. From 2013 the programme was self-funded through cash-in-lieu payments collected under the Green Roof Bylaw; that funding stream ended with the bylaw's repeal in 2025 (see Mandatory requirements, below), though the grant programme itself remained open in early 2026 (City of Toronto, 2026).

Figure 21: Toronto City Hall podium living roof, Toronto, Canada
Source: iStock / Orchidpoet, 184373580



Direct subsidies sit in tension with the polluter pays principle that underpins fee differentiation: subsidies are typically funded from general rates or a targeted rate, spreading the cost across all ratepayers, while fee differentiation recovers cost from the properties generating the runoff, in proportion to the burden they place on the network. The international evidence suggests these mechanisms are not mutually exclusive but operate at different points in market development. Subsidies are most useful during market formation, when supply chains and design capability are still maturing and uncertainty discourages first-mover investment. As the market matures, subsidies can taper and the policy emphasis can shift to durable, self-funding mechanisms such as fee differentiation, regulatory recognition, and statutory requirements.

Auckland cost evidence is currently project specific rather than general. For Auckland, living roofs are typically understood to involve a cost premium relative to conventional roofing, although the extent of that premium varies by project (see Section 4.4). No general Auckland cost range has been established, and establishing that differential is a prerequisite to setting any subsidy rate. The relevant economic comparison also varies by zone. Where on-site stormwater mitigation is required - typically within SMAF areas or under specific consent conditions - the comparison is between a living roof and a conventional roof plus the mitigation that would otherwise be installed, a materially smaller gap than the headline premium. Where on-site mitigation is not required (parts of the city centre and some business and industrial zones discharging directly to the public network), the gross premium applies; here, a stronger public benefit case may still justify a higher per-square-metre subsidy - for example in combined sewer catchments where roof-runoff reduction lowers overflow frequency, or in urban heat hotspots. Appropriate funding sources could be investigated, including both public and private options. The appropriateness of the funding structure would need to be analysed, including the costs and benefits of a catchment-by-catchment model versus a single Auckland-wide rate, and the merits of sunset provisions tied to market maturity rather than open-ended commitments.

Stormwater fee differentiation

Stormwater fee differentiation aligns with the German model and could in principle be implemented through Auckland's existing targeted rates framework. Following a 1985 Federal Administrative Court ruling establishing the polluter pays principle in Germany, approximately 73 percent of German cities with populations over 100,000 now charge separate fees based on impervious surface area, with reductions of 50 percent or more for properties meeting runoff coefficient thresholds (Bundesverband GebäudeGrün, 2020). Hamburg's combination of fee reductions with subsidies up to 60 percent of installation costs delivered 44 hectares of new living roofs between 2014 and 2020 (European Environment Agency, 2021a); Münster offers an 80 percent reduction in stormwater

drainage charges for properties with living roofs. In several German jurisdictions the fee structure is paired with retrofit obligations on existing flat-roofed buildings that fall below current performance standards, providing a route to bring the existing stock into the framework rather than only new development.

Variants of an impervious area based stormwater charge have been investigated several times in Auckland over the past two decades and have not progressed to implementation (Ira, 2014). The reasons include equity concerns across the ratepayer base, the administrative cost of property-level impervious-area assessment, and the political difficulty of introducing a new charge structure. Separately, and at a more fundamental level, the scenarios in which living roofs are most practically and appropriately applied have not yet been systematically identified for Auckland. Any charge or incentive mechanism would need to be tested against that evidence, which is the purpose of the priority-catchment and feasibility mapping recommended in Section 6. The international evidence does not by itself overcome these objections, but the German experience demonstrates that, where political and administrative conditions support it, fee differentiation can be self-funding, durable, and effective. This area may be an opportunity for Auckland Council to revisit when the necessary foundation exploration work regarding appropriateness has been carefully analysed. (Examples may include further reviews of network discharge consent options and the broader Water Strategy implementation).

This context is changing. The Local Government (Water Services) Act 2025 establishes enduring arrangements for drinking water, wastewater and stormwater services, including specific provisions governing charges for stormwater services. In Auckland, water and wastewater services sit with Watercare, while stormwater remains a Council responsibility funded through general rates and the Water Quality Targeted Rate. The Act's stormwater charging provisions may alter the framework within which any future impervious area based charge would be assessed, and earlier conclusions should therefore be read against the settings that applied at the time rather than as settled positions.



Figure 22: Living roofs Copenhagen, Denmark
Source: iStock / Westersoe, 2244461768

6. Ngā Tūtohunga | Recommendations

This report identifies potential levers for Auckland Council to enable wider, appropriate uptake of living roofs across Tāmaki Makaurau. Drawing on local monitoring evidence, Auckland’s strategic context, international precedents, and the analysis in Sections 4 and 5, the recommendations are organised into short term, medium term and longer term opportunities.

Each focus area sets out the context, the potential actions to progress it, and the barrier it primarily addresses being cost, risk or confidence (identified in section 4 and shown by icons). Actions are deliberately framed as steps to develop or investigate: they identify where to start, while leaving decisions on specific mechanisms to Council’s own processes as the evidence base builds.

The sequencing reflects feasibility and dependency rather than strict timing. Short term actions are within Council’s control or tied to processes already underway; medium term actions require Council policy or practice decisions; longer term opportunities depend on future funding decisions, statutory processes (including the Combined Plan) and a maturing evidence base. Many actions can proceed in parallel, and the framework is designed to be robust where actions can be brought forward where conditions permit.

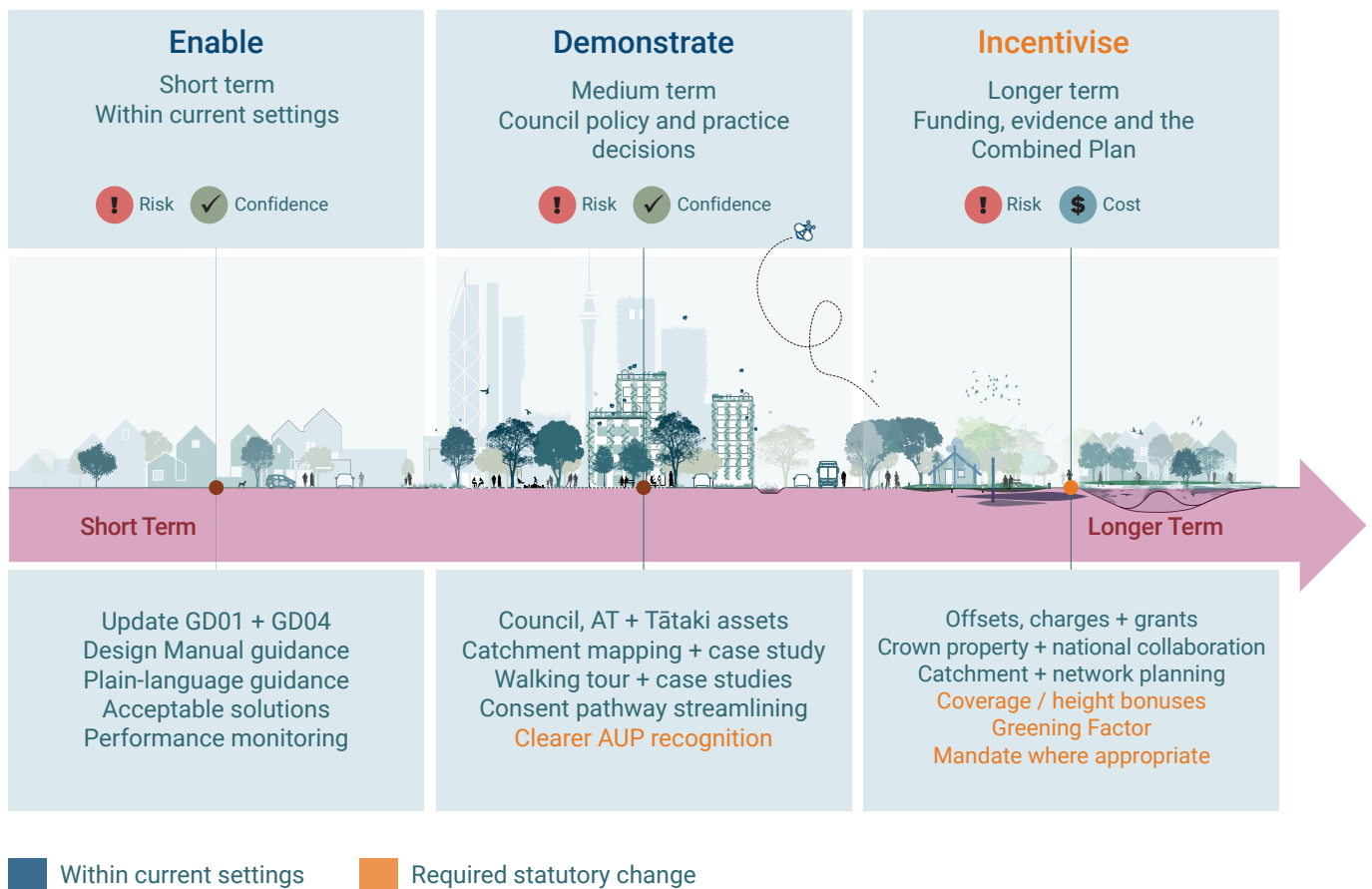


Figure 23: Indicative Strategic Road Map
Source: The Urbanist, 2026. Under CC BY 4.0

Short Term Opportunities

These actions are within Council's control or aligned with processes already underway, principally the current GD01 review, the most concrete near-term opportunity. Several are expressed as contributions to that review rather than as new standalone workstreams, so their timing is set by the review programme.

Barriers addressed:  Confidence  Risk  Cost

Focus Area	Potential Actions	Barriers Addressed
Update Technical Guidance in GD01 and GD04 As part of the GD01 review, update the technical and engineering guidance in the "Living Roofs" chapter.	- Review the adequacy of current living roof chapter (GAP analysis). - Incorporate local evidence and monitoring data. - Include design, assessment, maintenance and performance outcomes. - Emphasise living roof benefits in device selection sections of GD01. - Formalise how living roof contributions are recognised within 'treatment train' approaches, consistent with other GD01 devices, providing certainty for applicants and consent officers.	 
Auckland Design Manual Guidance enhancement Enhance information within the Auckland Design Manual to provide more detailed guidance, including case studies to support a range of industry specialists with practical application.	- Review the adequacy of current living roof inclusions (GAP analysis). - Align Auckland Design Manual content with GD01 guidance and updates. - Include additional guidance to support industry specialists (e.g. case studies).	
Practical Living Roof Guidance Develop plain-language Auckland Council guidance for building owners, developers and designers on living roofs suited to Auckland conditions.	Develop practical plain-language guidance on living roof design aligned with Auckland Council technical documents. <i>(Including substrate selection, planting approaches and design considerations).</i>	 
Acceptable Solutions Recognition of living roofs as an acceptable solution for stormwater network capacity management.	- Develop implementation guidance on the use of living roofs where stormwater or combined sewer networks are at capacity, recognising the volume and flow control benefits of living roofs. - Consider advocating for incorporation into National Engineering Design Standards as these are developed.	 
Performance Monitoring Monitoring living roof designs to assess water quality, hydrology, planting and substrate effectiveness.	- Continue monitoring living roof devices on Council-owned roofs and University of Auckland or other research roofs, to verify water quality and hydrology performance and to confirm plant and substrate suitability and improvements. - Use monitoring results to inform future updates to guidance documents.	 

Medium Term Opportunities

These actions require Council policy or practice decisions over the next one to three years. They focus on building visible local precedent, market confidence and consenting certainty, being the foundations on which any later mechanisms would rely.

Barriers addressed:  Confidence  Risk  Cost

Focus Area	Potential Actions	Barriers Addressed
Priority-catchment mapping Undertake a priority-catchment and feasibility mapping exercise to identify where living roofs deliver maximum impact.	- Undertake a region-wide opportunity and feasibility assessment to identify locations, catchments and building typologies where living roofs are expected to deliver the greatest environmental, infrastructure and community benefits. - Develop a spatial prioritisation framework that identifies priority catchments/ areas. - This may include, but is not limited to, combined sewer catchments, urban heat hotspots, areas of limited at-grade planting space, areas of large impervious space coverage, elevated enclaves, building typologies (industrial, commercial, multi-residential), and spatial / density patterns).	 
Priority Catchment Case Study Undertake a catchment-scale assessment of the wide-scale use of living roofs.	- For an identified priority catchment, investigate the use of living roofs compared to construction of major infrastructure as part of an integrated catchment approach. - Investigate and model how much of the catchment would need uptake to achieve the effect, and compare the cost-benefit outcomes. - This work could be used as the basis for developing evidence for future financial and planning incentives, as set out in the long-term opportunities.	 
Auckland Council / Auckland Transport / Tātaki assets Lead by example by delivering living roofs on Auckland Council, Auckland Transport and Tātaki assets (buildings and infrastructure), building industry capacity and the local evidence base.	- Identify opportunities to incorporate living roofs into Auckland Council building and infrastructure projects. In particular focusing on integrating with already programmed upgrades and on new buildings and infrastructure. - Identify locations where they are technically feasible, cost-effective and expected to deliver demonstrable public benefits. - Share opportunities and assess implementation on a case-by-case basis.	
Living infrastructure walking tour Enhance living infrastructure visibility and education within the Auckland CBD.	- Develop a living infrastructure walking tour of the city centre, showcasing visible examples and incorporate QR codes to link to photos of those not accessible such as the Auckland Central Library living roof. - Provide supporting signage and online information to build public and industry awareness.	

Focus Area	Potential Actions	Barriers Addressed
Publish case studies Visible local examples are among the most effective forms of confidence-building, and these outputs would coordinate with the priority-catchment mapping above.	• Develop and maintain a register and map of existing living roofs across Tāmaki Makaurau. • Publish Auckland case studies, including the Auckland Central Library. • Share case studies locally and nationally, such as through national industry conferences (e.g. Water NZ) • Prepare plain-language communication resources for designers, developers, building owners and consent officers.	
Consent Pathway Streamlining Investigate the opportunities to optimise or enhance resource and building consent processes for living roofs	• Investigate streamlined resource consent pathways for living roofs that meet GD01 performance standards, focusing on retrofit projects (drawing on the existing streamlined pathway for rainwater tanks). • Investigate improvements to building consent processing, such as standardised structural and weathertightness details and guidance for processing staff.	 
Recognition of living roofs in the Auckland Unitary Plan / Combined Plan Use the Combined Plan process to make the treatment of living roofs in the Unitary Plan clearer and more consistent, ahead of any incentives or requirements.	• Investigate how living roofs can be more clearly recognised in Unitary Plan provisions through the Combined Plan process, for example in stormwater management, impervious area and landscape provisions. • Clarify how existing rules apply to living roofs (such as the Chapter J impervious area exclusion) and how they are assessed, so applicants and consent officers have certainty.	

Long Term Opportunities

These opportunities warrant investigation only as the evidence base, market maturity, funding context and statutory framework (including the Combined Plan) allow, and are included here to show possible future pathways to increasing uptake of living roofs drawing on the analysis in this report.

Barriers addressed:  Confidence  Risk  Cost

Focus Area	Potential Actions	Barriers Addressed
Auckland-specific planning incentives Encourage living roofs through planning provisions in zones where this is appropriate.	- Investigate planning incentives for living roofs through the Combined Plan process, such as building coverage or maximum height bonuses, or alternative ways of meeting planning requirements. - Identify the zones where extra height or coverage is acceptable in planning terms, such as the city centre. - Align any bonus to the actual additional cost of providing a living roof, so the extra development allowed does not undermine the purpose of the planning controls being relaxed.	 
Urban Greening Factor A flexible, performance-based approach to urban greening through a future plan review.	- Investigate an Urban Greening Factor approach (a points based system that scores the different types of greening on a site, such as trees, ground-level planting and living roofs, against a minimum target) approach as part of a future AUP review, with weightings based on local performance evidence. - Weight deep-soil, ground-level planting materially higher than extensive living roofs, providing flexibility for designers while securing environmental outcomes.	
Living roofs on Crown property and national collaboration Engage with central government and national industry organisations to support wider uptake of living roofs. Central government leadership would strengthen the market signal beyond what Council procurement alone can provide.	- Engage with central government to promote awareness of the potential benefits of living roofs on public buildings and infrastructure, using international case studies to inform decisions. Any adoption within Crown property portfolios would be subject to central government priorities and decision-making processes. - Work with national industry organisations, such as Water New Zealand, to share Auckland's evidence and experience and support wider uptake of living roofs nationally.	
Targeted grant programme for priority catchments Support living roof uptake in locations where they deliver the greatest public benefit.	- Assess the case for a targeted grant programme in priority catchments, such as SMAF areas, combined sewer catchments and urban heat hotspots. - Investigate grant rates set by catchment or area rather than a single region-wide figure. Any funding mechanism would require further investigation to determine its suitability, scale and targeting criteria, taking into account regulatory requirements, project costs and the public benefits expected, with a clear end point once the market matures.	

Focus Area	Potential Actions	Barriers Addressed
Development contribution offsets Recognise living roof stormwater retention within the development contributions framework.	- Investigate development contribution offsets that recognise living roof stormwater retention, within a framework. - Assess where living roofs may warrant priority, such as sites with limited ground-level planting space (such as central city or areas with high impervious surfaces, i.e. >70%), or catchments with combined sewer overflow, urban heat or energy-use pressures.	
Stormwater charge differentiation Vary stormwater charges for properties with verified living roof performance.	- Investigate stormwater charge differentiation for properties with verified living roof performance, alongside network discharge consent reviews and Water Strategy implementation. - Take account of previous Auckland investigations and the changing legislative context, including the Local Government (Water Services) Act 2025.	
Structural assessment grants Reduce uncertainty for owners of existing buildings considering a living roof retrofit.	- Investigate small grants to help building owners assess whether an existing building can structurally support a living roof. - Investigate potential funding sources, including public, private and blended options.	
Recognition in catchment and network planning Integrate and recognise living roofs in Council's catchment and stormwater network planning, building on the priority-catchment mapping (medium term).	- Investigate how living roof contributions can be recognised in catchment management and network planning, including whether they could count towards Council's regional stormwater network discharge consent obligations. - Use the priority-catchment mapping to identify where living roofs could contribute most to network outcomes.	
Mandatory living roof requirements through Combined Plan A potential future requirement, if market readiness, evidence and support mechanisms are established.	- Investigate mandatory living roof requirements for developments above a defined floor area, advanced through the Combined Plan and subject to the national direction framework. - Develop any requirement as a coordinated package of plan provisions, performance standards and incentives suited to Auckland.	



He Āpitihangā 1 | Appendix 1

Case Studies

Figure 24: Auckland Central Library Living Roof
Source: Rachel Devine, Auckland Council

Auckland Central Library Living Roof

Project Overview:

Location:	44-48 Lorne Street, Auckland CBD
Completion:	March 2022
Type:	Extensive living roof using Natural Habitats Eco-Pillow system
Coverage:	Approximately 560 Eco-Pillows achieving 50% roof coverage
Substrate:	150mm
Design:	Poutama (stepped) pattern representing learning progression
Designer:	Ngāti Whātua Ōrākei, Babbage (design), Legacy Construction (lead contractor), Sansom (waterproofing)

Cultural Partnership:

- Partnership with Ngāti Whātua Ōrākei throughout design process
- All 14 native species eco-sourced from Pourewa Nursery
- Species selection includes those historically present along Waihorotiu Stream
- Design symbolism appropriate for library setting

Ngāti Whātua Ōrākei have welcomed the opportunity to work in partnership with Te Kaunihera with the design, delivery, monitoring and ongoing advocacy for the Tāmaki Pātaka Kōrero living roof. Kaupapa like this green roof are examples of cultural infrastructure. It integrates nature into our city and allows us to actively elevate the mauri of our taiao.
- Ngāti Whātua Ōrākei (2026)

Performance Outcomes:

- Successful establishment of all 14 native species
- Strong plant health and coverage after three growing seasons
- Observable biodiversity enhancement including native insects and birds
- Visual amenity improvement for surrounding high-rise buildings

Lessons Learned:

- Importance of detailed structural assessment for retrofit applications
- Value of early Tangata Whenua engagement in design development
- Need for clear maintenance protocols and responsibilities
- Benefits of modular systems for ease of installation and future maintenance
- Value of early design workshops to address client risks and concerns
- Need to protect the membrane from damage during construction
- Electric field vector mapping (EFVM) wire beneath the substrate to simplify ongoing membrane integrity testing
- Monolithic membrane that can be patch repaired, with a polyethylene root barrier for added protection



Figure 25: Auckland Central Library living roof
Source: Timescapes Limited

Living Roof Monitoring Facility



Figure 26: Living Labs, living roof monitoring, University of Auckland
Source: The Urbanist

Project Overview:

Location:	University of Auckland, Faculty of Engineering and Design, Symonds Street, Auckland CBD
Installation:	2022
Type:	Extensive living roof
Coverage:	Seven test beds, 2-4m ² each
Substrate:	150mm
Design:	Test beds (2-4m ² each)
	Data Collection: 3-minute interval measurements across 106 rainfall events
Designer:	University of Auckland and The Urbanist

Test Bed Configurations:

- DL1, DL2: Daltons Living Roof Mix (150mm depth)
- EP1, EP2: Natural Habitats Eco-Pillow system
- DP1, DP2: Daltons Pinegro Mix (120mm depth)
- ST1: Stone/Ballast control (no vegetation)

Key Findings:

- Natural material mix substrates (Daltons Living Roof Mix) achieved highest performance (92.4% mean runoff reduction)
- Peak discharge control maintained even during extreme events (83-89% peak reduction during the 88 mm event; University of Auckland, unpublished data)
- 5-8 percentage-point variation between seasons (highest in summer, lowest in autumn)
- Up to 19.7°C lower peak and 2.8-3.6°C lower mean surface temperature than asphalt

Plants supplied from Ngāti Whātua Ōrākei's Pourewa Nursery include: *Arthropodium cirratum* (rengarenga, NZ rock lily), *Phormium cookianum* (wharariki, mountain flax), *Carex trifida* and *Carex secta* (tātaki, mutton-bird sedge), *Apodasmia similis* (oioi, jointed wire rush), *Coprosma acerosa* (tātaraheke, sand coprosma), *Libertia peregrinans* (mīkoikoi, NZ iris), *Pratia angulata* (pānakenake), *Fuchsia procumbens* (creeping fuchsia), *Disphyma australe* (NZ ice plant), *Acaena novae-zelandiae* (piripiri, red bidibid), *Muehlenbeckia complexa* (pōhuehue), *Muehlenbeckia astonii* (tororaro), *Astelia banksii* (kōwharawhara, coastal astelia) and *Chionochloa flavicans* (miniature toetoe).

Hundertwasser Wairau Māori Arts Centre, Whangārei

Project Overview:

Location:	Dent Street, Town Basin, Whangārei
Completion:	2021
Type:	Intensive living roof
Area:	Approximately 980m²
Client:	Whangārei Art Museum Trust
Designer:	Concept: Friedensreich Hundertwasser, Living Roof Designers: Zoë Avery & Renée Davies, 4Sight Consulting
Substrate:	600-700mm substrate depth

Design Philosophy:

The living roof afforestation embodies Hundertwasser’s philosophy:

“When one creates living roofs, the houses themselves become part of the landscape. People must use the roofs to return to nature what we unlawfully took from her by constructing our homes and buildings - the layer of earth for grasses and trees.”

The design brief centered on giving space back to nature, creating a forest environment where people enjoy as guests of nature. The aim was to create a forest using New Zealand native Northland-specific plants including offshore island, threatened, endangered or rare species, integrated with exotic fruiting trees.



Project Drivers:

- Habitat creation for rare and endangered species
- Giving space back to nature in urban Whangārei
- Creating aesthetic green space for community, visitors, and workers
- Recreation space integrated with sculpture park
- Stormwater management and water quality improvement
- Energy conservation through insulation for galleries below
- Roof longevity through membrane protection

Vegetation:

The planting palette includes:

- Native Specimen Trees: Tītoki (*Alectryon excelsus*), Three Kings Island Tītoki, Karaka, Elingamita, Fairchild’s Kōhuhu, Heart-leaved Kōhuhu, Three Kings Kaikōmako, Tawāpou, Coastal maire, Chatham Island Nīkau, Kōwhai, Three Kings Milk tree
- Exotic Fruit Trees: ‘Doyenne du Comice’ Pear, ‘Beurre Bosc’ Pear, ‘Billington’ Plum, ‘Burbank’ Plum, ‘Sunrise’ Apple, ‘Egremont russet’ Apple, ‘Monty’s surprise’ Apple, ‘Nani’s Nectarine’, ‘Caravan peacharine’
- Native Shrubs and Groundcovers: Various *Hebe* species, *Coprosma* ‘Poor Knights’, Puka, *Arthropodium*, *Asplenium*, *Astelia*, *Apium*, *Blechnum*, *Carex* species, *Chionochloa*, *Dianella*, *Festuca*, *Lepidium*, *Pimelea*, *Selliera*, *Xeronema*, *Pachystegia*, *Hibiscus* species

Significance:

As the last Hundertwasser building in the world, this project showcases living roofs as integral architectural elements. The intensive forest-like design demonstrates the potential for creating meaningful habitat and recreation space on building rooftops while honouring indigenous ecosystems. The roof is publicly accessible: visitors can walk through the rooftop forest, linking it to the sculpture park and Town Basin and the integration of food-producing trees reflects Hundertwasser’s vision of human harmony with nature.

Figure 27: Hundertwasser living roof, Whangārei, Northland
Source: Zoë Avery, The Urbanist



Figure 28: Hundertwasser Art Centre with Wairau Māori Art Gallery living roof, Whangārei
Source: Zoe Avery, The Urbanist

Waitakere Civic Building, Auckland



Figure 29: Waitakere Civic Building living roof, Henderson, Auckland
Source: Zoë Avery, The Urbanist

Project Overview:

Location:	Henderson, Auckland
Client:	Former Waitakere City Council (now Auckland Council)
Designer:	Renée Davies & Landcare Research
Architect:	Architectus
Type:	Extensive living roof
Area:	500m ²
Completion:	August 2006

Project Vision:

- Demonstrate range of sustainable benefits of living roof technology
- Create living roof specific to New Zealand context, reflective of Waitakere plant species
- Create organic patchwork of plants that moves and changes over years
- Provide colour variation through leaf colour, texture, and seasonal flowering
- Ensure multiple outcomes for stormwater, habitat, and amenity
- Provide well-researched and documented process for plant selection specific to New Zealand

Native Vegetation:

Original planting palette (2006), all native New Zealand species adapted to harsh rooftop conditions:

Acaena microphylla (NZ bidibid), *Calystegia soldanella* (Sand convolvulus), *Coprosma acerosa* (Sand coprosma), *Dichondra repens* 'piha' (Mercury bay weed), *Disphyma australe* (NZ iceplant), *Festuca coxii* (native tussock), *Leptostigma setulosa*, *Libertia peregrinans* (NZ iris), *Muehlenbeckia* species, *Pimelea prostrata* (NZ daphne), *Selliera radicans*. Twenty years on, the roof is dominated by *Astelia*, illustrating the succession that occurs on thin, unirrigated substrates (E. Simpkins, pers. comm. 2026).

Significance:

The Waitakere Civic Building received a coveted NZILA Sustainability Excellence Award, recognising pioneering work in living roof design specific to New Zealand conditions. This project established precedents for native plant selection, substrate formulation, and design approaches that informed subsequent New Zealand living roof projects. The focus on ecological authenticity and biodiversity outcomes demonstrated Council leadership in sustainable infrastructure.

NZI Building, Auckland CBD



Figure 30: Living roof, NZI Centre, 1 Fanshawe St, Auckland
Source: Zoë Avery, The Urbanist

Project Overview:

Location:	1 Fanshawe Street, Auckland
Client:	IAG
Designer:	Greenroofs Ltd
Architect:	Jasmax
Type:	Extensive living roof
Area:	350m ²
Completion:	May 2009
Installation Cost:	~\$200/m ² (everything above waterproofing)

Project Drivers:

- Rooftop garden adjacent to staff outdoor area
- Stormwater runoff reduction with roof water used for toilet flushing
- Support 5 Star Green Star rating for sustainable design
- Workplace productivity enhancement
- Recreation and client entertainment space

Design Features:

- Exotic sedum mix (seven species) for low maintenance
- Substrate depth: 50-75mm
- Below-ground drip irrigation for establishment
- Permanent staff access for work and entertainment

Significance:

This commercial office living roof demonstrates integration of stormwater management with building water reuse systems, contributing to Green Star certification. The roof provides staff amenity in Auckland’s CBD, showcasing how living roofs can enhance workplace quality and support employee wellbeing in high-density commercial environments.

Potter Children's Garden, Auckland Botanic Gardens



Figure 31: Living roof, Potter Children's Garden, Auckland Botanic Gardens
Source: Zoë Avery, The Urbanist

Project Overview:

Location:	102 Hill Road, Manurewa, Auckland
Client:	Auckland Botanic Gardens
Designers:	Jack Hobbs and Ed Snodgrass
Completion:	July 2010

Two Demonstration Living Roofs:

1. Children's Garden Entrance (12.9m²):

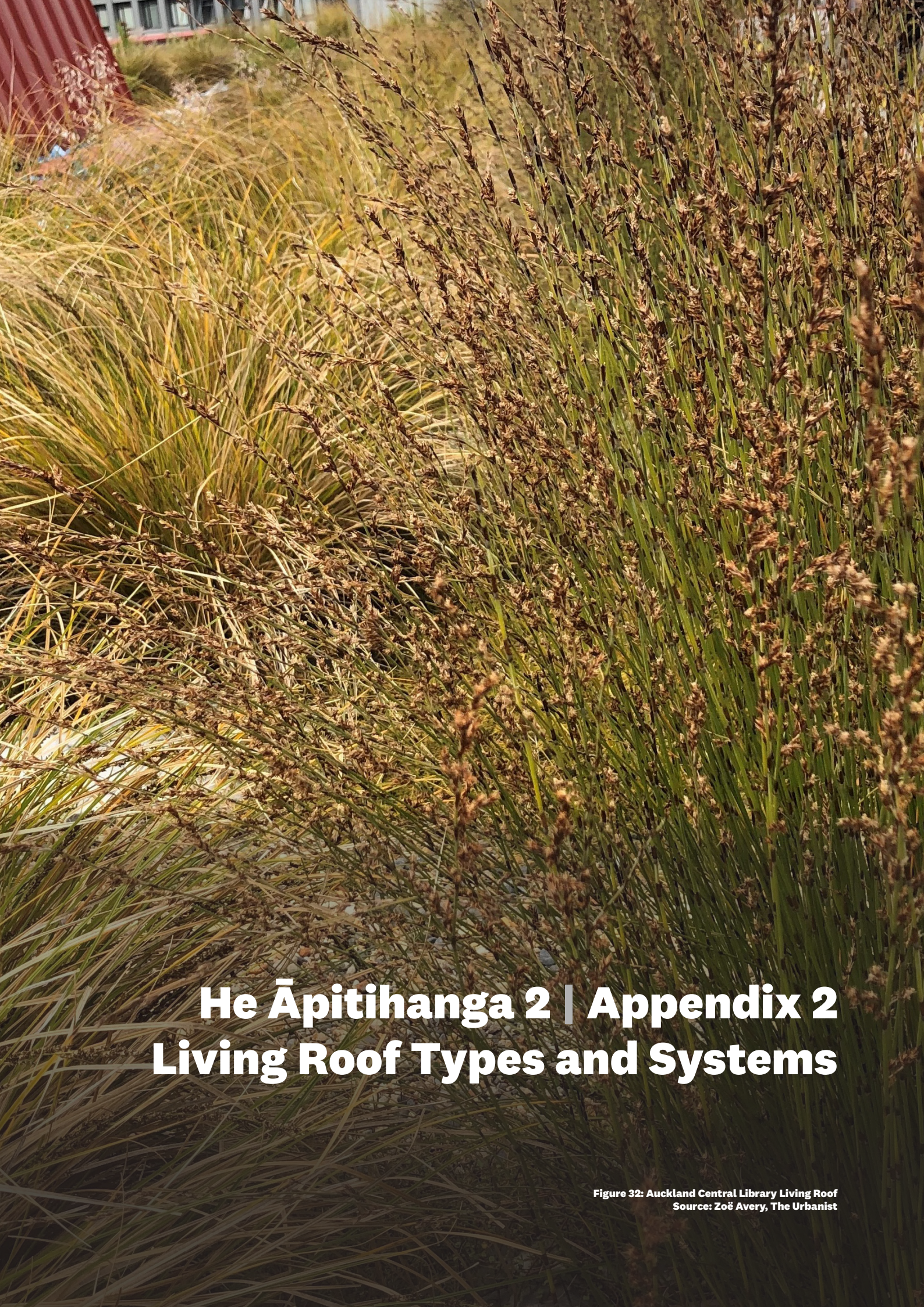
- Designed for maximum visual impact with colourful exotic species
- Plants of outstanding form and colour to attract children
- Species include *Aloe*, *Echeveria*, Bromeliad, *Gazania*, *Lampranthus*

2. Children's Garden Toilet Block (29.9m²):

- Native plant showcase complementing adjacent native landscaping
- Species include native tussocks (*Austrofestuca*, *Chionochloa*, *Poa*), *Coprosma*, *Libertia*, *Muehlenbeckia*, *Xeronema*
- Part of treatment train discharging to swale and pond

Significance:

These demonstration projects showcase both exotic and native living roof approaches in a public educational setting. The side-by-side comparison allows visitors to understand different design philosophies and plant palettes. The native roof required less maintenance than the exotic entrance roof, providing valuable lessons for future projects. Both roofs demonstrate living roof potential on timber structures with 15-degree slopes.



He Āpitihianga 2 | Appendix 2

Living Roof Types and Systems

Figure 32: Auckland Central Library Living Roof
Source: Zoë Avery, The Urbanist

Living Roof Types and Systems

Living roofs are purpose-built roof systems designed to support vegetation. Unlike container gardens or potted plants placed on roofs, they are integrated building elements constructed to specific technical standards, incorporating waterproofing, drainage, growing media, and vegetation layers that work together as a functioning ecosystem. The term also encompasses living roofs, roof terraces, ‘landscape over structure’ (e.g. Aotea Square) and roof gardens which may be accessible by workers or residents, and intensively or extensively vegetated. None of these terms are mutually exclusive, although particular types may be more appropriate for certain uses.

A typology has been adopted internationally, largely based on construction method and intended use. Performance characteristics vary depending on system type, and selection involves trade-offs between stormwater retention, biodiversity value, structural requirements, maintenance commitment, and cost. They have typically been classified into three main types based on substrate depth, structural requirements, and intended use.

Table 3 - Living Roof Typologies

Type	Substrate Depth	Saturated Weight	Maintenance	Retrofit Suitability
Extensive	50-150mm	60-150 kg/m ²	Low	High - suitable for most existing structures
Semi-intensive	150-500mm	150-300 kg/m ²	Moderate	Moderate - requires structural assessment
Intensive	500mm+	300-1000+ kg/m ²	High	Low - typically new build only

Source: FLL Green Roof Guidelines (2018)

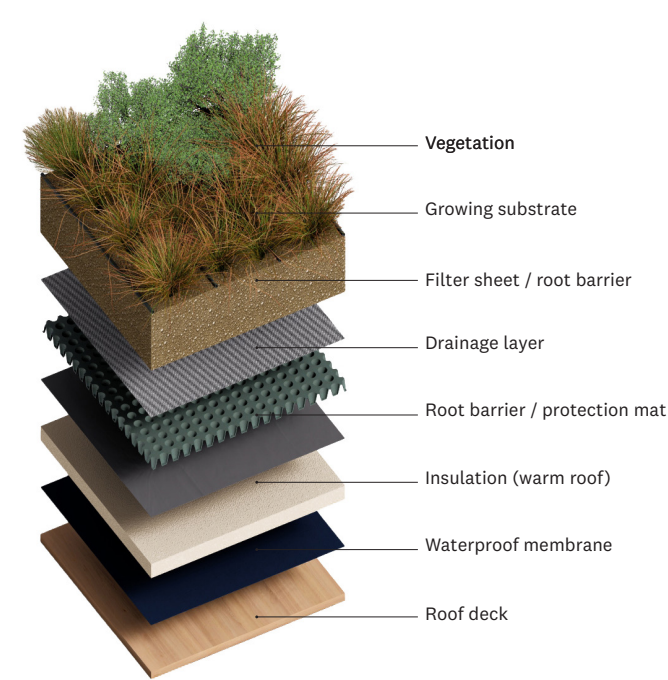


Figure 33: Relationship and Potential Use of Various Types of Living Roof
Figure 33 illustrates the relationship between living roof types, showing the spectrum from extensive to intensive systems and their primary applications.
Source: The Urbanist, 2026. Under CC BY 4.0

Extensive Living Roofs

Extensive living roofs feature shallow growing media (50-150mm depth) and are designed to be lightweight and low-maintenance. They typically receive minimal management and usually no irrigation or fertilisation after establishment, although this may be required initially until plants become established. Due to their light weight, extensive systems are well suited for retrofitting onto existing buildings.

According to the German FLL Guidelines, extensive greening represents natural forms of vegetation that are largely self-sustaining (but still regularly maintained). Plants with special adaptation to extreme site conditions are used including some species with high regeneration capacity. Plants present and their dominance usually change over time due to natural succession of planted and self-establishing plants, small-scale micro-climate variations across the roof, and response to maintenance.

Many recommended, readily-available native plant species require a minimum substrate depth of 100 to 150mm or site-specific microsite (e.g. afternoon shade) or supplementary irrigation to establish and thrive in Auckland. (Bodley, Simcock & Stanley, 2022; Fassman-Beck & Simcock, 2013) This means that in Auckland, traditional extensive systems (50-100 mm) that do not have shade or irrigation will typically be planted largely with non-native species. Non-native species can facilitate native plant establishment and persistence by lowering drought stress (for example bromeliads, which provide shade and shelter with low water use, and sedums, which down-regulate quickly under water shortage; both help cool the substrate surface). While these systems still deliver stormwater and thermal benefits, they probably provide limited indigenous biodiversity outcomes. Further, non-native species should be screened in sensitive locations such as near coastal cliffs to avoid the potential for spread from roofs to cliffs. For projects where native biodiversity is a priority, semi-intensive systems with at least 100 mm substrate depth and/or afternoon shade and/or irrigation are recommended. Auckland monitoring data supports a minimum substrate depth of 100mm for extensive systems to ensure consistent year-round performance in terms of thermal regulation, moisture retention, and plant growth with 150 mm depth providing more resilience and planting options.

Two main construction approaches exist for extensive systems:

- Proprietary Mat-based systems: shallow substrates with a blend of natural and artificial minerals, recycled or waste materials (sometime plastics), and organic matter. These are pre-grown to provide instant cover. These are often the lightest weight option but storm water retention varies as does thermal mass. In New Zealand these can be planted with a mix of exotic or native species.
- Substrate-based systems: with depths generally

75-150mm consisting of porous substrate or similar aggregates. These support a greater variety of species, hold significantly more rainfall, have greater thermal mass, and offer higher evapotranspiration properties. In New Zealand, substrates at the upper end of this range (approaching 150mm) can support a selection of hardy native species.

Typical vegetation seen in New Zealand extensive systems include Sedum species (multiple varieties), Sempervivum species, Lampranthus and other ice plants, Echeveria and similar succulents, Selliera radicans (one of few natives suitable for shallow substrates).

New Zealand example: The NZI Building in Auckland CBD features an extensive living roof with exotic sedum mix at 50-75mm substrate depth, demonstrating integration of stormwater management with building water reuse systems.



Figure 34: Extensive Living Roof Cross-Section and Example

Figure 34 shows typical extensive living roof construction layers and an example installation.

Source: The Urbanist, 2026. Under CC BY 4.0

Semi-Intensive Living Roofs

Semi-intensive systems incorporate moderate depth growing media (150-500mm) supporting diverse vegetation including shrubs, perennial grasses, and small woody plants. Saturated weight is typically 150-300 kg/m², requiring structural consideration in design. These systems offer greater plant diversity and visual interest than extensive roofs while requiring less structural capacity than intensive systems.

Simple intensive greening is usually designed with ground cover plants, grasses, perennials and shrubs. The variety of uses and design is limited in comparison to intensive living roofs, but the plants used make lower demands on the layer structure as well as on the supply of water and nutrients. Production costs are lower than for intensive systems, and maintenance measures are required to a reduced extent.

A semi-intensive native living roof can be designed to mimic the natural ecosystem of the local area using native plant species.

Vegetation forms (FLL classification):

- Grass-herbaceous planting
- Wild perennials-shrub planting
- Woody shrubs-perennial planting
- Woody plants (small shrubs)

These systems offer greater plant diversity and visual interest than extensive roofs while requiring less structural capacity than intensive systems. Collaboration and co-design with local iwi can create appropriate design and species selection that can be eco-sourced from local and iwi-led nurseries.



Figure 35: Semi-Intensive Living Roof Cross-Section

Figure 35 shows typical semi-intensive living roof construction layers with native grasses, sedums, herbs and perennials over 150-500mm growing substrate. Source: The Urbanist, 2026. Under CC BY 4.0

Intensive Living Roofs

Intensive living roofs are principally designed to provide amenity and are normally accessible for recreational use. They may be referred to as roof gardens or terraces. Generally, intensive living roofs comprise lush growth of vegetation and are based on relatively nutrient-rich and deep substrate (500mm or more). They allow for the establishment of large plants and conventional lawns.

Intensive greening may consist of perennials, grasses, shrubs, and in some cases trees. They can be flat or height-differentiated. They are comparable with ground-based open spaces in the possibilities of use and design diversity with appropriate equipment. The plants used place high demands

on the layer structure, and this type of living roof can only be sustained through intensive care, especially regular water and nutrient supply.

Intensive roofs traditionally require higher levels of maintenance, regular irrigation and applications of fertiliser. Due to the plants used and the combined growing and drainage properties of the substrate, the weight of an intensive living roof system can be considerable, typically 300-1000+ kg/m² when saturated. Substantial reinforcement of an existing roof structure or inclusion of extra building structural support may be required. The benefits of intensive systems include maximum biodiversity and ecosystem services, usable green space and amenity, highest stormwater retention (70-95% annual retention), and significant cooling effects.

Vegetation forms (FLL classification):

- Lawn and turf areas (for games, sports and amenity)
- Low perennials and ground covers
- Perennials and bushes to 150cm height
- Large shrubs to 3m height
- Small trees to 6m height
- Medium trees to 10m height
- Kitchen gardens (a special form allowing regular recultivation by non-professionals)

New Zealand examples include the Hundertwasser Art Centre in Whangārei with 600-700mm substrate depth supporting native forest species.



Figure 36: Intensive Living Roof Cross-Section and Example

Figure 36 shows typical intensive living roof construction layers and an example installation demonstrating park-like landscape treatment. Source: The Urbanist, 2026. Under CC BY 4.0

Design Options

Beyond the three main categories, there are additional design options that can be combined with any system type to achieve specific outcomes:

Biodiverse Living Roofs

Biodiverse living roofs are specifically designed to maximise ecological outcomes rather than aesthetic appeal alone. The design and type of living roof installed will dictate the amount of biodiversity achieved. These roofs typically feature:

- Varying substrate depths to create differing microclimates
- A variety of different substrates, including clay, sand and specialised mixes
- Habitat features such as logs, rocks and gravel drainage corridors
- Design consideration for the extreme rooftop environment including temperature extremes, sunlight, high winds and limited access

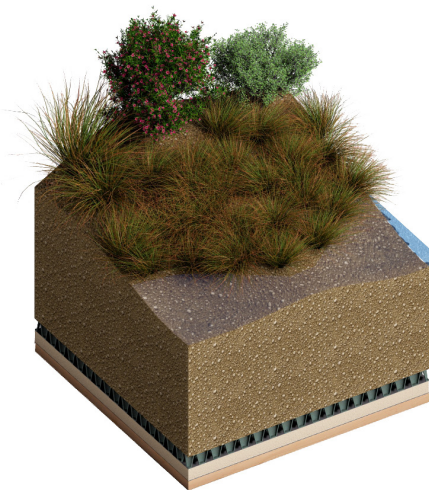


Figure 37: Biodiverse Living Roof Cross-Section and Example

Figure 37 shows typical biodiverse living roof construction layers and an example installation demonstrating biodiversity additions.
Source: The Urbanist, 2026. Under CC BY 4.0

Biosolar Living Roofs

Biosolar living roofs combine the use of solar panels and vegetation. They are designed to provide stormwater mitigation and biodiversity benefits while producing more electricity by keeping the photovoltaic panels at an ambient temperature, thereby increasing the working efficiency of the panels. Key design considerations include:

- Plant species selection to avoid shading panels while maximising ground cover
- Panel setting and height to enable light and water to reach the vegetation beneath
- Integration of the living roof and solar systems at the design stage for optimal performance

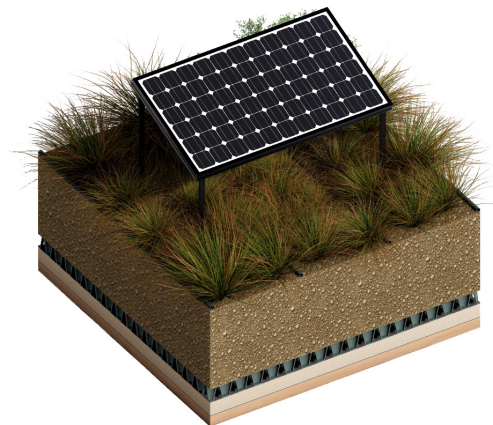


Figure 38: Biosolar Living Roof Cross-Section and Example

Figure 38 shows typical biosolar living roof construction layers and an example installation demonstrating solar panel integration.
Source: The Urbanist, 2026. Under CC BY 4.0

Modular Living Roofs

Modular systems such as the proprietary pre-planted modular pillow system used at the Auckland Central Library offer installation flexibility and are particularly valuable for retrofit applications. These tray or modular systems are vegetated (usually plastic) trays planted close together on the roof. They are pre-planted and grown off-site then brought onto the roof for an instant vegetated cover effect.

- Pre-grown modules provide instant cover and reduce establishment risk
- Individual modules can be lifted for roof membrane inspection and maintenance
- The monitoring programme at Auckland Central Library confirms modular systems achieve comparable performance to built-in-place systems
- Particularly advantageous for partial coverage where structural or budget constraints exist



Figure 39: Modular Living Roof Cross-Section and Example

Figure 39 shows typical modular living roof construction, with pre-planted modules (trays) set close together over the waterproofing and drainage layers, and an example installation.

Source: The Urbanist, 2026. Under CC BY 4.0

Blue-green Living Roofs

Blue-green living roofs add an engineered water storage layer beneath the growing substrate, with a controlled-flow outlet that releases stored rainfall slowly over 24 to 48 hours. This combines the retention and evapotranspiration of a living roof with the detention of a conventional blue roof, so the roof can attenuate peak flows in larger events as well as retain the small, frequent ones. Key design considerations include:

- Storage capacity and outlet sizing matched to the design events the roof is intended to manage
- Structural loading, as stored water adds to the saturated weight of the system
- Overflow provision so the roof drains safely when the storage layer is full
- Maintenance access to the outlet to prevent blockage

No sizing pathway currently exists for this configuration in GD01 (see Section 4.3); the current GD01 review provides the opportunity to establish one (Section 5.4).



Tohutoro | References

Figure 40: Auckland Central Library Living Roof
Source: Zoë Avery, The Urbanist

- Auckland Council. (2012). Auckland Council Indigenous Biodiversity Strategy. Auckland Council.
- Auckland Council. (2016). Auckland Unitary Plan Operative in part (updated). Auckland Council. <https://unitaryplan.aucklandcouncil.govt.nz/>
- Auckland Council. (2017). Stormwater management devices in the Auckland region (Guideline Document GD2017/001). Auckland Council.
- Auckland Council. (2018). Auckland Plan 2050. Auckland Council.
- Auckland Council. (2019). Te rautaki ngahere ā-tāone o Tāmaki Makaurau: Auckland's urban ngahere (forest) strategy. Auckland Council.
- Auckland Council. (2020). Te Tāruke-ā-Tāwhiri: Auckland's climate plan. Auckland Council.
- Auckland Council. (2022a). Auckland Plan 2050 evidence report update 2022: Homes and places. Auckland Council.
- Auckland Council. (2022b). Auckland Unitary Plan RMA section 35 monitoring: B7.3 Freshwater systems and B7.4 Coastal water, freshwater and geothermal water (Technical Report TR2022/14). Auckland Council.
- Auckland Council. (2022c). Te rautaki wai: Auckland water strategy 2022-2050. Auckland Council.
- Auckland Council. (2023). Future development strategy 2023-2053. Auckland Council.
- Auckland Council. (2024a). Auckland future development strategy 2023-2053: Monitoring report December 2024. Auckland Council.
- Auckland Council. (2024b). Climate change scenarios (Guideline Document GD15, November 2024). Auckland Council.
- Auckland Council. (2025a). Manaaki Tāmaki Makaurau: Auckland open space, sport and recreation strategy. Auckland Council.
- Auckland Council. (2025b). Te ora o te taiao o Tāmaki Makaurau: The health of Tāmaki Makaurau / Auckland's natural environment in 2025. Auckland Council.
- Auckland Council & Arup New Zealand Limited. (2024). Auckland urban heat assessment: Technical report. Auckland Council. <https://knowledgeauckland.org.nz/publications/auckland-urban-heat-assessment-technical-report/>
- Auckland Regional Council. (2003). Stormwater management devices: Design guidelines manual (Technical Publication 10, 2nd ed.). Auckland Regional Council.
- Auckland Transport. (2021). Hīkina te Wero: Environment action plan 2020-2030. Auckland Transport.
- Banting, D., Doshi, H., Li, J., Missios, P., Au, A., Currie, B. A., & Verrati, M. (2005). Report on the environmental benefits and costs of green roof technology for the City of Toronto. Ryerson University.
- Bebelman, C., Ira, S., Simcock, R., & Shamrock, L. (2023, May). Going green: Costs and benefits of living roofs on bus shelters in Auckland. Water New Zealand Stormwater Conference 2023. https://www.waternz.org.nz/Article?Action=View&Article_id=2450
- Bodley, E., Simcock, R., & Stanley, R. (2022). Plant evaluations for living roofs in Auckland, New Zealand. *Sibbaldia*, (21), 57-74. <https://doi.org/10.24823/Sibbaldia.2022.377>
- Bundesverband GebäudeGrün. (2020). BuGG market report building greening 2020. BuGG.
- Castleton, H. F., Stovin, V., Beck, S. B. M., & Davison, J. B. (2010). Green roofs: Building energy savings and the potential for retrofit. *Energy and Buildings*, 42(10), 1582-1591. <https://doi.org/10.1016/j.enbuild.2010.05.004>
- City of Toronto. (2025). Green roofs [Web page]. Retrieved 23 September 2026, from <https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/green-roofs/>
- City of Toronto. (2026). Eco-Roof Incentive Program [Web page]. Retrieved 23 September 2026, from <https://www.toronto.ca/services-payments/water-environment/environmental-grants-incentives/green-your-roof/>
- Cooper, C. (2015). Human spaces: The global impact of biophilic design in the workplace. *Interface*.
- Davies, R., Simcock, R., Ussher, G., de Groot, C., Boulton, M., & Toft, R. (2010). Elevated enclaves: Living roof biodiversity enhancement through prosthetic habitats. *CitiesAlive! Green Roof and Wall Conference*, Vancouver.
- Dong, S., Soe, A. N., Shamseldin, A. Y., Zorn, C., Latu, K., Simcock, R., Avery, Z., Chen, M., & Devine, R. (2026). Optimizing green roof substrates for coastal resilience: Thermal performance and energy implications under extreme weather in Auckland. *Building and Environment*, 298, 114610. <https://doi.org/10.1016/j.buildenv.2026.114610>
- Energy Independence and Security Act of 2007, Pub. L. No. 110-140, § 438, 42 U.S.C. § 17094 (2007).
- European Environment Agency. (2021). Four pillars to Hamburg's green roof strategy: Financial incentive, dialogue, regulation and science [Climate-ADAPT case study]. <https://climate-adapt.eea.europa.eu/en/metadata/case-studies/four-pillars-to-hamburg2019s-green-roof-strategy-financial-incentive-dialogue-regulation-and-science>

- Fassman, E. A., Simcock, R., Voyde, E., & Hong, Y. S. (2010). Extensive green (living) roofs for stormwater mitigation: Part 2 Performance monitoring (Technical Report TR2010/018). Auckland Regional Council.
- Fassman, E. A., Simcock, R., & Voyde, E. (2010). Extensive green (living) roofs for stormwater mitigation: Part 1 Design and construction (Technical Report TR2010/017). Auckland Regional Council.
- Fassman-Beck, E., Simcock, R., Voyde, E., & Hong, Y. S. (2013). 4 Living roofs in 3 locations: Does configuration affect runoff mitigation? *Journal of Hydrology*, 490, 11-20. <https://doi.org/10.1016/j.jhydrol.2013.03.004>
- Fassman-Beck, E., Voyde, E., & Liao, M. (2013). Defining hydrologic mitigation targets for stormwater design in Auckland (Technical Report TR2013/024). Auckland Council.
- Fassman-Beck, E., & Simcock, R. (2013). Living roof review and design recommendations for stormwater management (Technical Report TR2013/045). Auckland Council.
- Financial Markets Authority. (2025). Weather events claims insights: Insights from the insurance claims response to the 2023 North Island weather events. FMA. <https://www.fma.govt.nz/assets/Reports/Weather-Events-Claims-Insights.pdf>
- Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau. (2018). Green roof guidelines: Guidelines for the planning, construction and maintenance of green roofs (English ed.). FLL.
- Greater London Authority. (2008). Living roofs and walls: Technical report supporting London Plan policy. Greater London Authority.
- Imran, H. M., Kala, J., Ng, A. W. M., & Muthukumaran, S. (2018). Effectiveness of green and cool roofs in mitigating urban heat island effects during a heatwave event in the city of Melbourne, Australia. *Journal of Cleaner Production*, 197, 393-405. <https://doi.org/10.1016/j.jclepro.2018.06.179>
- Ira, S. (2014). A review of alternative funding solutions for stormwater management (Technical Report TR2014/008). Auckland Council.
- Ira, S. (2025, September 26). The construction problem beneath our feet. Newsroom. <https://newsroom.co.nz/2025/09/26/the-construction-problem-beneath-our-feet/>
- Ira, S. (2026). Auckland Library living roof: Multi-benefit performance and economic evaluation [Final report]. Koru Environmental Consultants for Auckland Council.
- Ira, S. J. T. (2017). Summary of life cycle costs for stormwater infrastructure solutions. Koru Environmental Consultants for Greater Wellington Regional Council.
- Ira, S., & Simcock, R. (2019). Understanding costs and maintenance of WSUD in New Zealand. Building Better Homes, Towns and Cities National Science Challenge.
- Joynt, J. L. R., & Golubiewski, N. E. (2019). Development of the Auckland heat vulnerability index (Technical Report TR2019/012). Auckland Council.
- Kosareo, L., & Ries, R. (2007). Comparative environmental life cycle assessment of green roofs. *Building and Environment*, 42(7), 2606-2613. <https://doi.org/10.1016/j.buildenv.2006.06.019>
- Lewis, M., Simcock, R., Davidson, G., & Bull, L. (2015). Water sensitive design for stormwater (Guideline Document GD2015/004). Auckland Council.
- Libatique, R. (2026, April 21). Storm frequency rises as claims climb 256% in New Zealand. Insurance Business. <https://www.insurancebusinessmag.com/nz/news/catastrophe/storm-frequency-rises-as-claims-climb-256-in-new-zealand-572467.aspx>
- Liberalesso, T., Oliveira Cruz, C., Matos Silva, C., & Manso, M. (2020). Green infrastructure and public policies: An international review of green roofs and green walls incentives. *Land Use Policy*, 96, 104693. <https://doi.org/10.1016/j.landusepol.2020.104693>
- Liu, K. (2003). Engineering performance of rooftop gardens through field evaluation (NRCC-46294). Proceedings of the 18th International Convention of the Roof Consultants Institute, Tampa, FL. National Research Council Canada.
- Liu, K., & Bass, B. (2005). Performance of green roof systems (NRCC-47705). National Research Council Canada.
- Local Government (Water Services) Act 2025 (NZ).
- London Borough of Tower Hamlets. (2020). Tower Hamlets local plan 2031: Managing growth and sharing the benefits. London Borough of Tower Hamlets.
- Manaaki Whenua - Landcare Research. (n.d.). Keeping urban soils spongy. Retrieved 23 September 2026, from <https://www.landcareresearch.co.nz/news/keeping-urban-soils-spongy>
- Mayor of London. (2021). The London Plan: The spatial development strategy for Greater London. Greater London Authority.
- National Parks Board. (2025). Skyrise greenery incentive scheme [Web page]. Retrieved 23 September 2026, from <https://skeyrisegreenery.nparks.gov.sg/incentive-scheme/about/>
- New Zealand Infrastructure Commission / Te Waihangā. (2023). The 2023 Auckland Anniversary weekend storm: An initial assessment and implications for the infrastructure system. <https://tewaihang.govt.nz/our-work/research-insights/the-2023-auckland-anniversary-weekend-storm>

Ngāti Whātua Ōrākei. (2018). Te Pou o Kāhu Pōkere: Iwi management plan for Ngāti Whātua Ōrākei. Ngāti Whātua Ōrākei Trust.

NIWA. (2023). Auckland suffers wettest month in history [News release]. <https://niwa.co.nz/news/auckland-suffers-wettest-month-history>

Nurmi, V., Votsis, A., Perrels, A., & Lehvävirta, S. (2016). Green roof cost-benefit analysis: Special emphasis on scenic benefits. *Journal of Benefit-Cost Analysis*, 7(3), 488-522. <https://doi.org/10.1017/bca.2016.19>

Parliamentary Commissioner for the Environment. (2023). Are we building harder, hotter cities? The vital importance of urban green spaces. PCE.

Pearce, P., Bell, R., Bostock, H., Carey-Smith, T., Collins, D., Fedaeff, N., Kachhara, A., Macara, G., Mullan, B., Paulik, R., Somervell, E., Sood, A., Tait, A., Wadhwa, S., & Woolley, J.-M. (2020). Auckland region climate change projections and impacts (revised September 2020; Technical Report TR2017/030-3). Auckland Council.

Porsche, U., & Köhler, M. (2003). Life cycle costs of green roofs: A comparison of Germany, USA and Brazil. RIO 3 - World Climate and Energy Event, Rio de Janeiro.

Rosenzweig, C., Solecki, W. D., & Slosberg, R. B. (2006). Mitigating New York City's heat island with urban forestry, living roofs, and light surfaces. New York State Energy Research and Development Authority.

Shamseldin, A. Y. (2010). Review of TP10 water quality volume estimation (Technical Report TR2010/066). Auckland Regional Council.

Soe, A. N., Dong, S., Shamseldin, A. Y., Latu, K., Zorn, C., Simcock, R., Devine, R., & Avery, Z. (2026). Climate-adaptive performance index for green roof substrates: Year-round assessment in Auckland. *Hydrological Sciences Journal*. Advance online publication. <https://doi.org/10.1080/02626667.2026.2689660>

Stats NZ. (2025). Subnational population projections: 2023(base)-2053. Stats NZ. <https://www.stats.govt.nz/>

Tektus Consultants. (2025). Living roofs: Status quo, stormwater and hydrology (Memo T20002.251204.M03, 4 December 2025). Tektus Consultants for Auckland Council.

Teotónio, I., Silva, C. M., & Cruz, C. O. (2021). Economics of green roofs and green walls: A literature review. *Sustainable Cities and Society*, 69, 102781. <https://doi.org/10.1016/j.scs.2021.102781>

The Treasury. (2023). Impacts from the North Island weather events (27 April 2023). The Treasury. <https://www.treasury.govt.nz/sites/default/files/2023-04/impacts-from-the-north-island-weather-events.pdf>

Twohig-Bennett, C., & Jones, A. (2018). The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. *Environmental Research*, 166, 628-637. <https://doi.org/10.1016/j.envres.2018.06.030>

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science*, 224(4647), 420-421. <https://doi.org/10.1126/science.6143402>

United States Environmental Protection Agency. (2009). Technical guidance on implementing the stormwater runoff requirements for federal projects under Section 438 of the Energy Independence and Security Act (EPA 841-B-09-001). US EPA.

United States General Services Administration. (2011). The benefits and challenges of green roofs on public and commercial buildings. GSA.

Van Renterghem, T., & Botteldooren, D. (2011). In-situ measurements of sound propagating over extensive green roofs. *Building and Environment*, 46(3), 729-738. <https://doi.org/10.1016/j.buildenv.2010.10.006>

Water Services Act 2021 (NZ).

Werthmann, C. (2007). Green roof: A case study. Princeton Architectural Press.

Wilkinson, S. J., Ghosh, S., & Pelleri, N. (2024). Mandatory or voluntary approaches to green roof implementation: A comparative study among some global cities. *Journal of Environmental Planning and Management*, 67(2), 334-355. <https://doi.org/10.1080/09640568.2022.2113768>

Willis, K. J. (2024). Good nature: The new science of how nature improves our health. Bloomsbury.

Zhang, G., & He, B.-J. (2021). Towards green roof implementation: Drivers, motivations, barriers and recommendations. *Urban Forestry & Urban Greening*, 58, 126992. <https://doi.org/10.1016/j.ufug.2021.126992>



Figure 41: Neighbourhood Living Roofs, Germany
Source: iStock / Nikada, 2234302536

Wynyard Central
Living Roof

The Parc Apartments
Living Roof

1 Fanshawe Street
Living Roof

Victoria Park