

# Low Impact Urban Design and Development: the big picture

An introduction to the LIUDD principles and methods framework



Marjorie van Roon and Henri van Roon  
University of Auckland

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## Glossary

**Brownfields:** areas that may be urban but landuse is changing, for example, from vacant commercial or industrial to residential, with expanding transport nodes or existing urban areas becoming intensified.

**Catchment:** also known as a drainage basin or watershed, a catchment is an area of land that collects and drains surface water runoff to a common outlet, such as a lake or the sea. Groundwater may also contribute to flow but it is not necessarily confined within catchment boundaries. A whole range of biophysical processes operate between the soil, water, air, plants and animals in the catchment as an ecosystem. Energy in the form of carbon based material as well as nutrients and water all cycle within the catchment area.

**Ecological carrying capacity:** the limits within which the biosphere can regenerate resources and provide services when exposed to human demands. See Mathis Wackernagel and William Rees, *Our Ecological Footprint*, New Society Press, 1996.

**Green roof:** roof area that is sealed, covered in substrate and vegetated; may range from partial to extensive or intensive

**Greenfields:** previously non-urban areas undergoing urban development.

**Integrated adaptive management practice:** a structured process of "learning by doing", where existing interdisciplinary experience and scientific information is fitted into dynamic models to make predictions about the impacts of alternative policies.

**Less than 15% 'effective' impervious area:** impervious surfaces that drain or discharge directly to waterways without interception by porous surfaces. For instance, paved areas or roof runoff that drains to raingardens, swales, biological filters or similar before discharging to waterways are not considered 'effective impervious areas'. In contrast, paved areas or roofs that discharge to channels, pipes or other impervious reticulation are 'effective impervious areas'.

**Life cycle costing:** the calculation of manufacture, use, maintenance and disposal costs of a product, adjusted over the expected life span of the product

**Maatauranga Maori:** traditional Maori knowledge

**Mauri:** the life force and unique personality of all things animate and inanimate

**Rain garden:** densely planted, deep porous garden bed which captures rain runoff and allows it to slowly drain away or dissipate by way of evapo-transpiration, whilst trapping contaminants.

**Rain tanks:** holding tank for rain runoff from roof areas, from small rain barrels to large commercially made tanks.

**Resilience:** the capability of development to make on going adjustment to different development pressures or unexpected events.

**Retrofitting:** urban areas undergoing landuse change in which new elements are introduced to the existing urban framework, such as construction, roading and infrastructure modification and/or maintenance.

**Riparian corridor:** vegetation alongside waterways, typically planted to the water's edge

**Sequential learning:** the transfer of learning by professionals and developers from one project or location to another, resulting in increased knowledge and implementation with each transfer.

**Stormwater runoff:** the flow of rain water after it hits the ground

**Swales and filter strips:** engineered vegetated watercourses, usually shallow linear depressions which carry and filter rain runoff.

**Treatment trains:** a series of devices linking sites in a catchment, to capture, slow and treat rain runoff.





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# PART ONE

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## Introduction

The Low Impact Urban Design and Development (LIUDD) programme is a six-year programme within the Sustainable Cities Portfolio, funded by the New Zealand Foundation for Research Science and Technology from 2003.

The idea of sustainable living emerged strongly in the late 1980s through international initiatives. Since then it has become embedded in the legislation and lifestyle of New Zealanders, from the Resource Management Act 1991 right through to community and cultural initiatives. A general definition for sustainability is:

Applying LIUDD means looking at how human activities affect the environment both now and in the future, locally and further afield, and helps assess how to work with nature's cycles to maintain ecological resources.

*Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.<sup>i</sup>*

Throughout the text Roman numerals have been used to identify references which are listed with further reading.

LIUDD looks holistically at the human impacts of development on the environment. The overriding LIUDD principle is recognising ecosystems have limitations and that human activity must work within these to be sustainable. LIUDD considers the impacts of development on wide scales, not only in area but over time. The primary document outlining LIUDD principles is attached in Appendix 1<sup>ii</sup>. Application of some of the principles at a local or neighbourhood level is shown in Appendix 2.

This three-part report offers explanation, descriptions and examples of LIUDD principles.

Part One discusses the ideas in the LIUDD programme; Part Two outlines LIUDD principles;

Part Three offers a wide-scale case study of the Hauraki Gulf and some of its catchments as an example of LIUDD principles in action.

### DEFINING LIUDD

A formal definition of LIUDD, adapted from WP051 in Appendix 1:

*LIUDD is an integrated urban design and development process using nested scales within catchments in urban and peri-urban environments. LIUDD is focused on avoiding, at little or no extra cost, a wide range of adverse effects of a physiochemical, biodiversity, social, economic and amenity nature resulting from conventional development. LIUDD aims to protect aquatic and terrestrial ecological integrity while allowing urbanisation at all densities.*

## What does Low Impact Urban Design and Development (LIUDD) mean?

The term 'Low impact' introduces the idea of reducing the effects of human activities on natural processes<sup>iii</sup> which link land, water, air, animal and plant life so that these resources are still available for future use and enjoyment. LIUDD also considers the catchment context and LIUDD processes with reference to wider scales. 'Design and development' refers to the ideas, methods and practices used to ensure human activities do not damage or destroy natural processes.

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LIUDD applies the concept of ecological carrying capacity which is a key element of sustainable development. The idea of an 'ecological footprint' will be introduced.

Ecological carrying capacity is basically a measure of the ability of an area or environment to regenerate the resources which humans consume and to handle resulting waste.

The application of LIUDD involves looking at how human activities affect the environment both now and in the future, locally and regionally, and helps assess how to work with nature's cycles to maintain ecological resources. LIUDD is a multi-dimensional decision-making process which considers various scales, over time and space.

## How does LIUDD help to fit human demands into environmental constraints?

Humans have a history of changing landscapes without understanding the consequences. The measurement of ecological carrying capacity to allow for the effects of human activities is complex. Human needs go beyond basic requirements for food, shelter and space. There is a need to create cities that are centres of innovation and economic growth, as well as cities that support social wellbeing, quality of life and cultural identities. LIUDD considers the effects generated by humans when using ecosystems and offers ways to accommodate human activities within ecosystem limitations.

Humans have a history of changing their landscapes without understanding the consequences. Measuring ecological carrying capacity to allow for the effects of human activities is complex.

In order to understand the effects of human activities, LIUDD has involved specialist researchers including scientists, engineers, planners, architects, economists, and sociologists. The aim of the LIUDD programme has been to encourage the uptake of LIUDD so that the consequences of human activity do not exceed ecological carrying capacity.

The involvement of those affected by design and development, such as community, business, and cultural groups, is critical for the success of LIUDD. Commitment and investment by regulatory agencies as well as the private sector enables LIUDD visions to be realised. The LIUDD process encourages specialists to move out of silo thinking - to think beyond the conventional uses of their

By involving a variety of researchers, government agencies, community and cultural groups, a range of activities can be accounted and planned for in low impact urban design and development

work into wider contexts. Community driven initiatives also benefit from multidisciplinary input. By harnessing the expertise and involvement of others, community groups extend their knowledge, understanding and networks to realise their goals.

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## Space, time and sustainability

As well as involving a wide variety of people, looking at the bigger picture is essential in the LIUDD process. Careful design can produce benefits on a larger scale. Potentially negative effects may not be immediately apparent - they may occur at various scales, cumulatively, or may be ultimately catastrophic.<sup>1</sup> These wider issues need considering, for instance, what will this development do to the land, water and air surrounding it? How will this affect the use of the area in the future? It is essential to think about these questions in the wider catchment scale.

Catchment management allows many factors to be considered – not only the effects on water draining from the catchment but also on the plants, animals, soils, air and on human activities within the catchment. Each is linked so that changes made to one will ultimately affect the others.

Catchment management allows many factors to be considered – not only the effects on water draining from the catchment but also the effects on plants, animals, soils, air and human activities within the catchment.

More specific questions can then be posed: What is upstream of the proposed development? What is downstream? What other developments or activities are planned for the catchment? What other activities and land uses surround the development? Would it be better to shift this development within the catchment to avoid particular issues? Is this development appropriate for this catchment at all? What was the land used for in the past, does this still affect the land, water and soil resources of the catchment, and what might that mean for development? These questions can only be thought through when thinking in a catchment context.

Time becomes a relative concept when it comes to judging what effects and consequences human activities may have on natural systems. Humans tend to judge the effects of time in terms of a decade or so, whereas natural systems vary, often working within longer time scales. For instance, groundwater may take 50 years or more to percolate to a point of extraction and can carry and concentrate contaminants previously washed off upstream land. Industries in the past such as timber treatment or farming used practices that are now recognised to be dangerous. Resultant contaminants emerge over time accumulating in waterways and groundwater. Landuses on these sites or downstream are compromised due to this previous activity. Similarly, forestry activity of over a century ago may still affect downstream waterways today through erosion

Activities, past, present and future, affect natural cycles in the long term as well as in our lifetimes. Human impacts have to operate within ecological constraints to make living sustainable.

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<sup>1</sup>“The processes through which past societies have undermined themselves by damaging their environments fall into eight categories, whose relative importance differs from case to case: deforestation and habitat destruction, soil problems (erosion, salinization, and soil fertility losses), water management problems, overhunting, overfishing, effects of introduced species on native species, human population growth, and increased per-capita impact of people.” p 5, Jared Diamond, *Collapse – how societies choose to fail or survive*, Viking, 2005: Diamond offers an assessment of human environmental impacts.

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from forest removal, creating silt layers in streams and outlets, changing harbour flows, encouraging mangrove forests to establish at the mouth of inlets.

The results of human activity were not always fully and sometimes not at all apparent during the lifetimes of those involved. Activities - past, present and future - affect natural cycles in the long term as well as in our lifetimes. Human activities have to operate within ecological constraints to make living sustainable.

### **A matter of scale**

Human activities may be considered within a range of scales, from individual lot, to catchment, to regional to national and beyond. As discussed, taking a catchment-wide view keeps options open for innovation. LIUDD requires looking beyond the scale of a development to what may be affected in the bigger picture. Table 1 and Figure 1 show a range of scales and gives examples of activities within each scale that change in effect at other scales. Using a simplified example of rainwater, considering managing this at an individual lot scale may be different from managing rain runoff for a neighbourhood and for an entire catchment. The effects radiating from an individual lot depends on whether rainfall is retained on site, for instance in tanks, rain gardens, ponds, or wetlands. If storm water is discharged into the neighbourhood, the effects depend on whether it goes into closed pipes, open channels or enters natural waterways. At a catchment scale, if all individual lots in an urban neighbourhood are discharging rainwater to reticulated systems, storm flows may cause flooding of properties and waterways, loss of soils, animal and plant life, through erosion and deposition. During these processes vegetation may be smothered and replaced by other species (succession replacement). Beyond the catchment, contaminants carried in rain runoff may build-up in the receiving waters. The cumulative effects of even the smallest sites can have negative impacts at larger scales. Undertaking LIUDD means, even at small scale developments, considering innovative solutions to manage effects at the scale of the bigger picture.

### **Resilient Development**

LIUDD is an example of integrated adaptive management practice. This means as developments evolve they are constantly refined and adapted to achieve long-term goals. During planning and development unexpected outcomes appear. These are resolved by responding appropriately, taking opportunities, and using lessons learned to feed back into the process. The learning and knowledge is shared by many people during the LIUDD process, and this helps to make the decisions made during the process resilient and to clarify the definition of goals. Resilient development is capable of on going adjustment to different development pressures or unexpected events.

The learning and knowledge shared through diverse participants during the LIUDD process feeds back to help make ongoing decisions resilient and to outline goals more clearly.

LIUDD processes consider various scales of time and space and inclusiveness, encouraging flexibility, innovation, network building and learning opportunities.

Table 1: showing a range of scales. The scales range from individual lot to ultimate receiving waters. The arrows are a reminder that decisions and activities at small scales have consequences at all larger scales.



	Individual lot		Neighbourhood		Subcatchment		Catchment		Receiving water (eg lake, harbour, river, ocean) and its catchment		Ultimate receiving environments and their catchment and ecosystems
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## PART TWO

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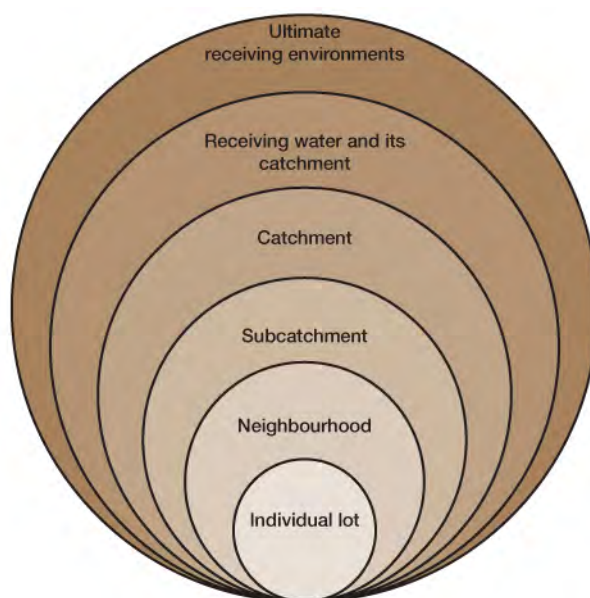
### The LIUDD hierarchy of principles

The combination of catchment management with multidisciplinary and community input offers multiple options for development and design. To combine this, priorities and guidelines are helpful. The LIUDD principles set out a hierarchy of issues and factors to consider within all scales, including catchments (Figure 1). In the simplest terms, the principles are:

LIUDD principles set out a hierarchy of issues and factors to consider within regional, catchment, neighbourhood and lot scales.

- Primary principle: Work with nature's cycles on a catchment basis to maintain the integrity and mauri of ecosystems.
- Secondary principles: Select sites for minimal impact/adverse effect; use ecosystem services and infrastructure efficiently; maximise local resource use and minimise waste.
- Tertiary principles: Promote and support alternative development forms (natural space, efficient infrastructure); 3-waters management; natural soil, water and nutrient cycles; minimum earthworks; reduction and containment of contaminants; restoration, enhancement, and protection of biodiversity; energy efficiency.

The LIUDD principles and implementation methods show how to go about the process of providing for human activities within ecological carrying capacity while considering long-term consequences. The primary reference originally outlining these principles is Working Paper 051 of the Centre for Urban Ecosystem Sustainability. A condensed version of this paper with original diagram and table is presented as Appendix 1.



**Figure 1: Scales to consider for environmental effects**

LIUDD principles require urban developers and designers to work within nature's cycles. LIUDD principles form a hierarchy. They interconnect, feeding back into one another. The LIUDD hierarchy (Figure 2) consists of principles, sub-principles and implementation actions. This framework illustrates how single LIUDD actions fit within the bigger LIUDD picture, and it consistently guides

comprehensive planning and the assessment of developments so that they work within their ecological carrying capacities.

Good LIUDD practice considers all these principles when going through the process of planning, implementing, managing and maintaining low impact urban design and development. Applying the principles helps those initiating projects and those examining decision-making processes to understand what is aimed for, and encourages innovative ways to get there.

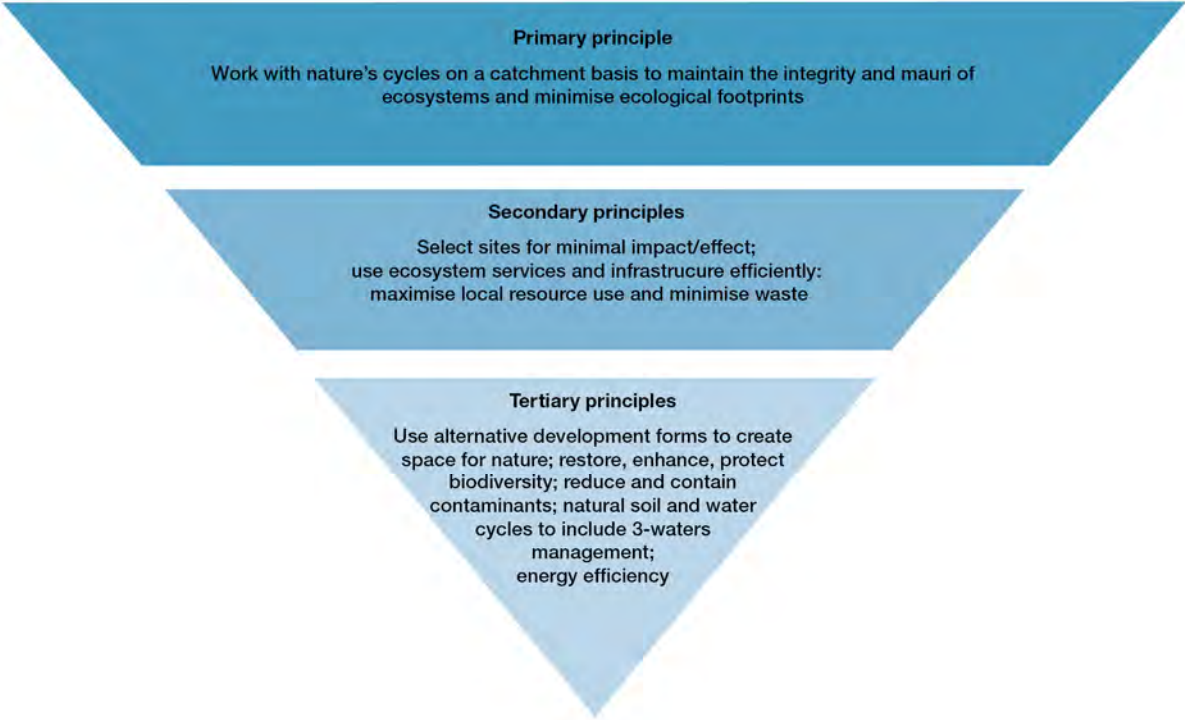


Figure 2: LIUDD principles sit in an interconnected hierarchy with the ultimate aim of working within nature's cycles and processes. The width and colour intensity at each level in this diagram show the relative importance of the principles.

LIUDD principles can help identify goals and outcomes, and may be applied when undertaking design processes and the development of land, structures or infrastructure, during policy and planning activities, while managing catchments and during ecological restoration. The outcomes are not always visible - although LIUDD may result in physical structures and devices, it also includes behavioural change, collaborative learning, knowledge sharing, capacity building and maintenance strategies.

Although LIUDD may result in physical structures and devices, it also includes behavioural change, collaborative learning, knowledge sharing, capacity building and clear maintenance strategies.

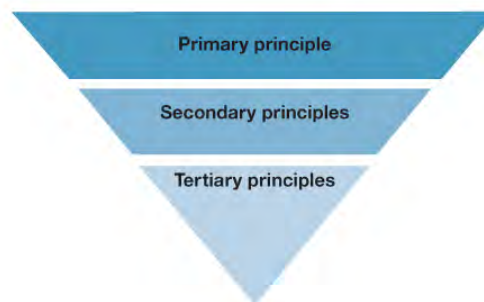
Because these outcomes are wide ranging, they are often achieved in stages.



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## **Primary Principle: Work with nature's cycles on a catchment basis to maintain the integrity and mauri of ecosystems**

This primary and overriding LIUDD principle requires human activities to support and work within cyclical ecological processes and their limits. Ecological carrying capacity needs to be respected. Designing and managing human activity in a catchment context enables impacts on processes affecting water, soil, plant nutrients, organisms and energy cycles to be minimised.



The aim is to keep the unwanted effects of resource use to a minimum, and also to contain them within the catchment.

This means managing demands on resources, and the retention of contaminants at source. Natural cycles can be long-term systems, and careful LIUDD planning, with long term results in mind, creates benefits for the physical and cultural wellbeing of the community and the environment.

LIUDD is not a one-off application – it is a strategic approach. Scales wider than the catchment may need to be considered. Some developments may have regional consequences, there may be cumulative or edge effects outside the catchment boundaries (Figure 3). Changes in circumstances during and after development may change outcomes and goals, and adjustments will need to be made to continue incorporating LIUDD principles. By relating goals and outcomes to ecological carrying capacity, sequential learning can improve the process over time.

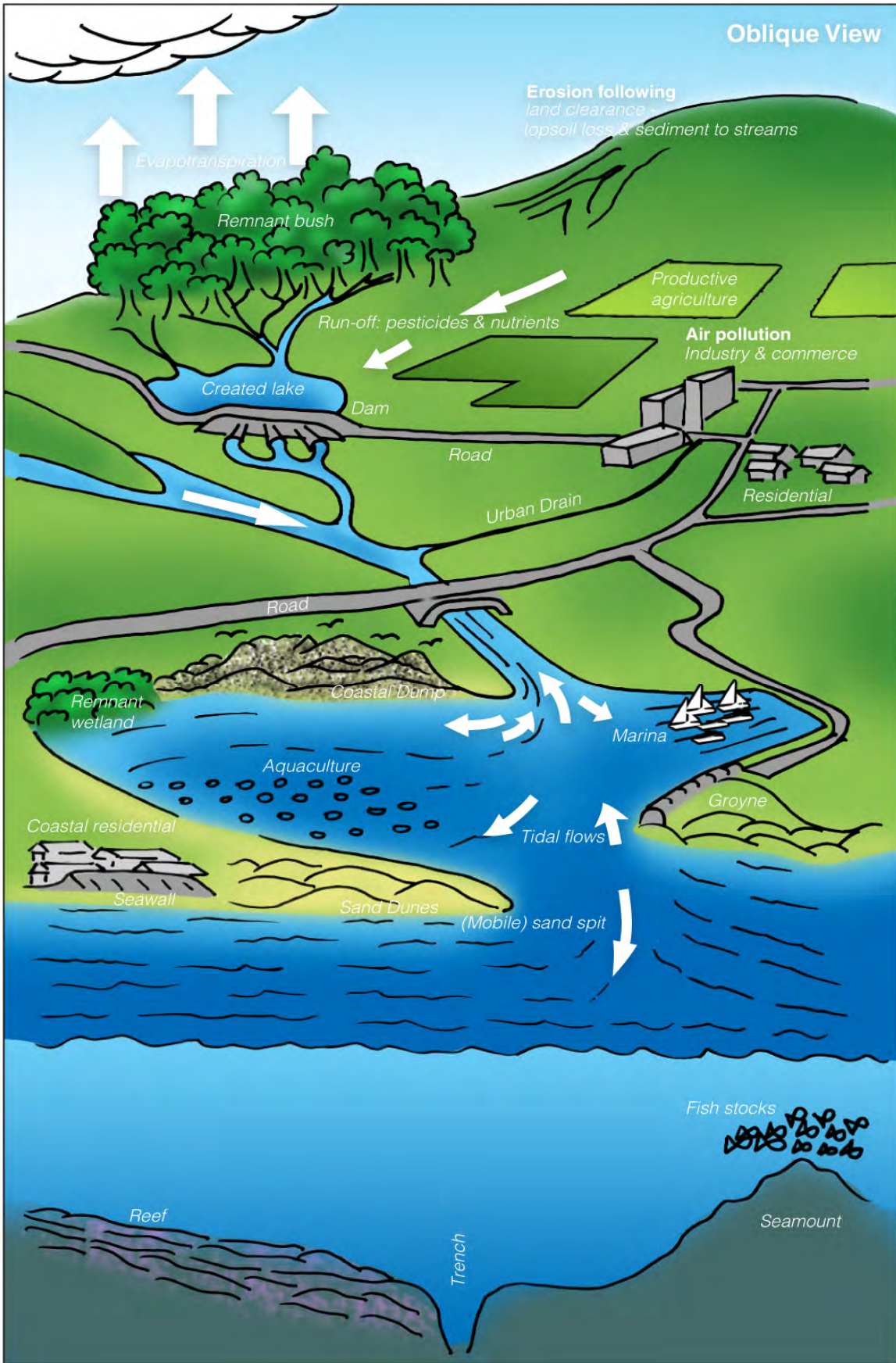


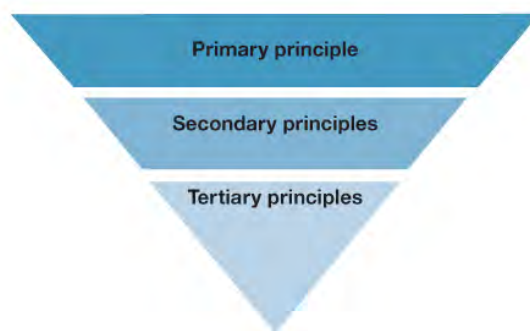
Figure 3: LIUDD requires human activities to work within ecological carrying capacity and to consider effects beyond immediate boundaries. Concept: Stephen Knight. Adapted from van Roon and Knight 2004.<sup>iv</sup>

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## **Secondary principles: Select sites for minimal impact/adverse effect; use ecosystem services and infrastructure efficiently; maximise local resource use and minimise waste.**

These principles are closely tied to the primary principle, working with nature's cycles on a catchment basis to maintain ecosystems.

### ***2.1 Select sites for minimal impact/adverse effect***



When selecting sites for LIUDD, the long-term and bigger picture needs considering. There are preferred places for development that can satisfy both human activity and environmental care. Taking a 'least regrets' approach, eliminates difficult and sensitive sites. Precious places such as significant cultural or natural areas, vulnerable ecological systems and unique landscapes are rarely acceptable locations for development (Figure 4). Using every possible protection and mitigation policy, plan or device will not replace a lost treasure. Sometimes the best LIUDD solution for a development is to go elsewhere. By screening out inappropriate areas, costs as well as risks are reduced, and unrealistic mitigation options eliminated.

When a site is appropriate for development or a specific use, ecological constraints virtually disappear and there are a wider variety of LIUDD solutions from which to choose. Nevertheless, existing urban areas undergoing intensification will still benefit from LIUDD. Development in existing urban areas can overstress the wider environment, for instance by increasing impervious flows and contaminants, and by the loss of open spaces and natural corridors. All development, whether greenfield, brownfield or the retrofitting of an existing area, can apply LIUDD practices to reduce impacts.



**Figure 4: The economic and ecological costs of developing some areas make them unlikely candidates. Photo: M. van Roon**

## ***2.2 Use ecosystem services and infrastructure efficiently***

Existing ecosystems can offer excellent LIUDD opportunities. Natural ecosystems operate by responding to conditions. Degraded or modified ecosystems lose this resilience and capacity to cope with change, for example, to act as buffer zones, process wastes or adapt to uses such as water extraction.

The wider catchment offers valuable resources. Natural waterways in the upper catchment act as a reservoir for the replenishment of riparian and aquatic animals and plants in the lower catchment. Areas of native vegetation including those in built-up areas (Figure 5), and along transport routes, act as migration corridors and patches offering shelter and food for animals.

Similarly, existing infrastructure is useful when developing areas. LIUDD in brownfield and retrofit sites may modify existing infrastructure by applying LIUDD practices and use them alongside natural ecosystems to gain economic and ecological efficiencies.

The retention and enhancement of natural processes on-site and in the wider catchment provides valuable resources. For example, green corridors – waterways, shelter belts, planted boundaries and transport verges, offer pathways for wildlife and plant dispersal<sup>v</sup>.



**Figure 5: Urban landscaping in Newton, Auckland creates visual identity as well as enhancing ecosystems by supporting biodiversity and providing evapotranspiration. Photo: M. van Roon.**

## ***2.3 Maximise local resource use and minimise waste.***

The design of developments should reduce the need to import and export resources. For instance, from the smallest lot up to entire catchments, water and contaminants should be contained to reduce both dependence upon external resources and effects upon those resources. There are many ways of doing this. For example, the capture of runoff (Figure 6) and the using of that runoff where appropriate instead of using reticulated water supply. Another example is the restoration of waterways by planting native riparian species to encourage natural filtering systems. Rather than allowing the discharge of contaminants, change how contaminants are disposed of, and include education programmes and behavioural change, as well as physical capture and treatment on site. During design and planning, encourage clustering of activities to share resources and to deal with negative effects as a whole rather than dealing with them in incremental, individual lots.

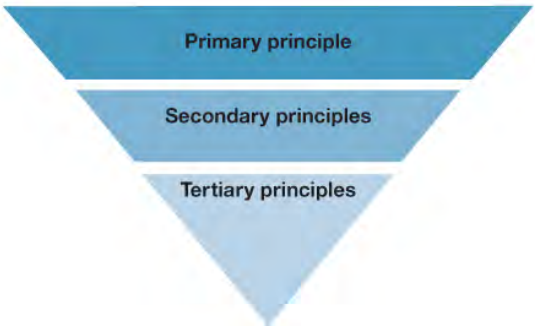


**Figure 6: Using local resources includes capturing and using rainwater where it falls. Photo: Peter Nagels**

Although outside the LIUDD programme, the reduction, reuse and recycling of goods and materials locally, along with the capture of local employment and services, is associated with other sustainability programmes. These actions reduce ecological demands and energy inputs as well as keep effects within the catchment.

To achieve the principle in practice, the focussing of resource use within developments is required.

**Tertiary principles: Promote and support alternative development forms (natural space, efficient infrastructure); 3-waters management; natural soil, water and nutrient cycles; minimum earthworks; reduction and containment of contaminants; restoration, enhancement, and protection of biodiversity; energy efficiency.**



The tertiary LIUDD principles encourage best development practices, methods and solutions to retain or restore natural cycles while reducing contaminants and increasing the efficiency of infrastructure and of water management. (Appendix 2, WP052, illustrates the implementation of many tertiary principles.)

Although many tertiary principle solutions may involve physical outputs such as ecological restoration work and the retrofitting of existing areas with innovative LIUDD devices and solutions, they also depend on vital human outputs such as capacity building, collaborative learning, knowledge and resource sharing, strategic infrastructure planning, as well as implementation and maintenance programmes. The amalgamation of these outputs links tertiary principles with the primary and secondary principles because the choice and application of tertiary principles depends on the decisions made using primary and secondary principles. Applying tertiary principles without the umbrella of the primary and secondary dominant principles cannot successfully address wider LIUDD sustainability goals.

**3.1 Alternative development forms (natural space, efficient infrastructure)**

The maintenance, enhancement or creation of natural spaces helps to maintain natural waterways and protect aquatic and terrestrial life. Open spaces (Figure 7) provide for social amenities and wellbeing, and food production, as well as protecting cultural sites. Ecologically significant areas can be identified and reserved prior to development. This can be achieved through innovative LIUDD design of form (Figure 8) as well as through regulatory devices. Examples of forms to achieve this include:

- Clustering activities while delineating and protecting significant areas or land set aside for infrastructure enhancement.
- Encouraging mixed housing that includes apartments, townhouses and compact single houses, intensifying vertically rather than horizontally, and creating



**Figure 7: LIUDD mixed housing forms differ from traditional New Zealand single lots, offering greater expanses of shared open and amenity space and conserving natural areas by clustering homes and using vertical forms. Photo: M. van Roon**

Simulated Rural Catchment  
Map 2 Conventional Rural-Residential (4ha lots)



Simulated Rural Catchment  
Map 3 Low Impact Rural-Residential Concept Plan

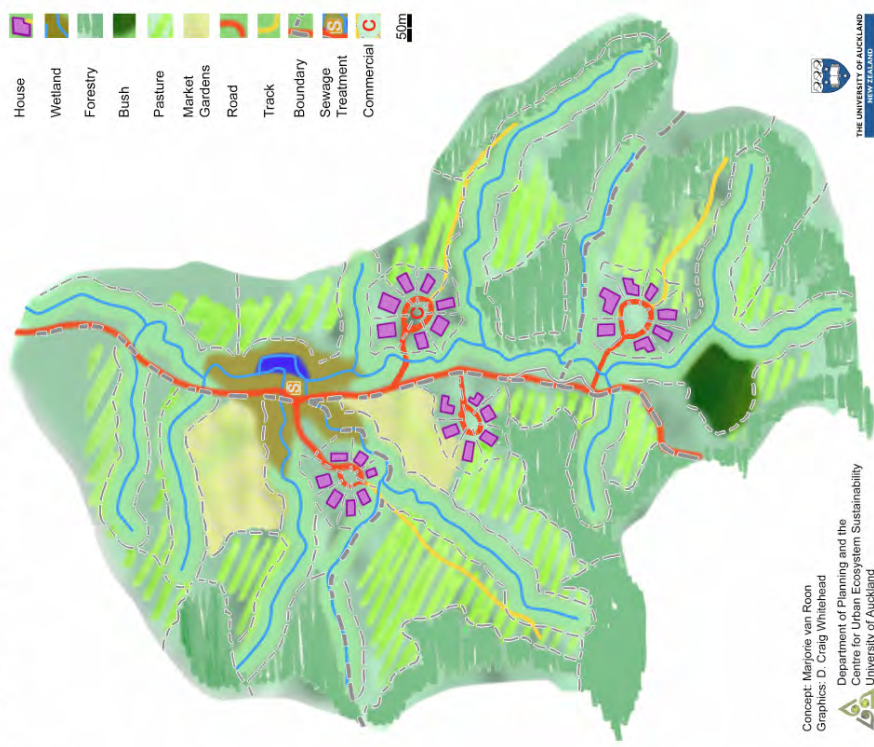


Figure 8: Alternative development form helps conserve natural values and features, and increases infrastructure efficiency. Concept: M. van Rooon. Graphics: C. Whitehead.

natural areas from the resulting space.

- Restoring and enhancing natural landscape quality and character and encouraging cultural design to support the LIUDD approach of working within natural processes and including appropriate cultural objectives.

(These are Principles 3.1A, B and Xs in WP051 Appendix 1.)

### **3.2 Three-waters management plus natural soil, water and nutrient cycles**

Human activity affects ecosystem cycles – the water, soil and nutrient cycles as well as the plants and animals depending on them. The effects of human activity can be modified to reduce impact on natural cycles, for example by retaining natural water flows and supply; ensuring flows are not contaminated; keeping waterways in natural states; encouraging recycling within natural cycles; and reducing external inputs and outputs.

Keeping cycles within catchments is also known as integrated three (or four) waters management, where stormwater runoff, wastewater and water supplies are managed and recycled within a local catchment as far as is practicable<sup>vi</sup>. Natural cycles can be restored, enhanced and protected using many solutions. The following are examples of solutions for keeping cycles in the natural state for the three waters as well as for urban earthworks.

**Stormwater** management can integrate LIUDD solutions by:

- maintaining natural hydrology (water flows, volume and variations) by using alternatives to traditional stormwater engineering solutions (Figure 9). For example, avoiding piping and channelling of stormwater within and from catchments, instead diverting to natural waterways and flowpaths as well as to natural vegetated areas and porous soils, and creating treatment trains in the catchment.
- reducing impervious areas in the catchment (to less than 15% 'effective')
- keeping zinc coated roof surfaces painted
- retaining runoff on site
- avoiding kerb and channel road design where possible, instead, using swales
- replanting riparian areas; keeping or restoring wetlands, springs, streams and forests
- keeping runoff on site by reducing road width and using porous paving, a variety of vegetated areas and biofilter systems<sup>vii</sup>
- maintaining existing LIUDD stormwater devices<sup>viii</sup>
- using stormwater as a secondary water supply and to recharge groundwater, removing contaminants if necessary.

(These are listed as Principles 3.2A-E and Xs in WP051, Appendix 1)

**Wastewater** flows can be managed using LIUDD solutions to minimise volumes, recycle and make use of nutrients. There are a variety of innovative systems that allow recycling, reduce volumes and may better account for cultural needs than conventional discharge and treatment systems. Examples include:

- strip nutrients out of sewage effluents
- composting toilets (Figure 10)



**Figure 9: Addington, Christchurch. Alternative stormwater solutions - riparian restoration in background and raingarden in traffic island in foreground. Photo: M. van Roon**



**Figure 10: Clivus Multrum compost toilet at Earthsong, Waitakere City. Photo: M. van Roon**

- wetland treatment and effluent recycling systems such as grey-water reticulation
- behaviour changes such as the use of composting or of worm farms rather than the use of wastemaster units, so that contaminants and nutrients do not enter the drainage system or receiving waters.

(These are listed as 3.2F-H in WP051, Appendix 1)

**Water supply** can be redesigned to suit a variety of activities. For example, not all water uses require a potable supply. Systems for collecting rainwater and using greywater can reduce wastewater discharges and their conventional reliance on a potable water supply. A range of solutions may include:

- water supply efficiency (low flow appliances and plumbing fittings)
- recycling grey water (Figure 11)
- appropriate garden design and plant species selection
- collection and treatment of rainwater.

(These are listed as 3.2I-J in WP051 in Appendix 1)

**Urban earthworks** can put natural cycles at risk. From the smallest site to the largest areas, good construction practice aims to maintain soil structure and waterways and avoid sediment and erosion issues. The design of earthworks and construction processes affect natural cycles as discussed above in 3.1 Alternative Development Forms.

Design should aim to minimise site disturbance using solutions such as:

- avoiding steep slopes and significant ecological areas
- avoiding soil compaction
- clustering buildings on suitable soils and slopes
- encouraging alternative building forms which maintain natural areas
- arranging subdivision work and construction simultaneously for efficient monitoring, compliance and remedial work.

(This is listed as 3.2K in WP051 in Appendix 1)

### ***3.3 Reduce and contain contaminants***

The most effective means of reducing contaminants, well beyond the scope of the LIUDD programme, is to limit their generation through alternative industrial practices or modes of transport. Good ecosystem health and good human health depend on preventing contaminants from entering natural cycles. Contaminants may be washed off during rain, and there are excellent opportunities to apply LIUDD solutions to avoid, reduce and treat contaminated stormwater (Figure 12) before it enters natural waterways. Similarly, changes to construction practices can stop contaminants from entering the atmosphere or being washed off by runoff. (These are listed as 3.3A, B and Xs in WP051 Appendix 1).

### ***3.4 Restore, enhance, protect biodiversity***

Biodiversity helps natural ecosystems to self-regulate and respond to changes. Local native species respond best in local natural soil, climate and water conditions. Retaining natural habitats encourages biodiversity of native species, and in turn maintains natural ecosystems to support human activities. Maori cultural aspirations to protect and enhance ecosystems often match the aims of this principle.



**Figure 11: Inkerman Estate, Melbourne. Innovative solutions for grey water treatment. Photo: M. van Roon.**



**Figure 12: Biofiltration garden in centre of road. Photo: M. van Roon.**



Biodiversity depends on the whole catchment being healthy. Although natural environments adjust to fluxes, those caused by urban activity within a catchment can reduce biodiversity. Keeping waterways natural, for instance by leaving riparian cover, can provide food, habitat, temperature control and shade as well as slowing flows, reducing erosion risks and filtering contaminants before they enter the waterway. The diversion of waterways through pipes, straightening or channelling changes flow rates, affects the variety of aquatic plants and animals which can live there. Sudden flashfloods can scour clean streambeds and habitats. Removal of riparian areas within the catchment may increase erosion and sedimentation in waterways and prevent the natural processes occurring where plants and animals recolonise downstream areas. Terrestrial areas of planting are also critical, and link with riparian planting to form natural corridors and patches where species spread and shelter.



**Figure 13: Owhanake, Waiheke Island, after restoration of forest ecosystems as part of development plan.**  
**Photo: M.van Roon.**

The best methods for promoting biodiversity are those which maintain and enhance native vegetation, features and waterways, both at development sites and within wider catchments. Environmentally sensitive areas such as riparian corridors, steep slopes and ridgelines need particular recognition with respect to restoration and protection (Figure 13). Some solutions include:

- retaining and enhancing riparian areas
- planting stormwater corridors, swales, rain gardens, biofiltration systems with locally sourced indigenous species suitable for the conditions
- encouraging indigenous planting and maintenance on private lots
- keeping natural aquatic conditions intact for native species, for instance using alternative designs mimicking natural forms for structures such as dams and culverts
- recognising and providing for aspirations by Maori groups for biodiversity protection and enhancement
- balancing vegetation cover within and throughout a catchment
- limiting greenfield developments and maintaining less than 15% 'effective' impervious areas
- using covenants or planning provisions to protect headwater aquatic and terrestrial habitats and riparian corridors.

(These are listed as 3.4A-B in WP051 in Appendix 1)

### ***3.5a Reduce need for mobility of goods and people***

Although outside the contractually-funded LIUDD programme, the need to reduce the mobility of goods and people is acknowledged. Transport is a primary driver for urban site selection. LIUDD design should encourage movement within local communities and promote public transport to reduce the dispersal of contaminants associated with transportation into air and water. Similarly, promoting the local availability of goods and services reduces transport demands. (This is listed at 3.5Xs in WP051 in Appendix 1.)

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### ***3.5b Minimise energy demands***

LIUDD solutions for energy conservation may include efficient and compact urban design to reduce reliance on vehicle use, and encourage the use of public transport, walking and cycling. LIUDD 'green building' design using alternative solutions for light, heating, cooking and washing may be incorporated into alternative building forms. (This is listed as 3.6A and 3.6Xs in WP051 in Appendix 1.)

The process of LIUDD is not linear – there are many methods or pathways to achieve LIUDD and these feed back to one another through the principles described above. The LIUDD principles hierarchy takes a holistic view, challenging urban development and design to set clear parameters, and first and foremost to work within nature's cycles. Working within these, LIUDD considers many scales, looks to future needs (Figure 14) while providing for present needs, and harnesses knowledge and participation from multiple parties.



**Figure 14: LIUDD encourages clear, long term goals for a sustainable environment.  
Photo: M. van Roon.**

## PART THREE

### Case studies

Within Part Three the Hauraki Gulf and associated catchments are used as a case study to show the application of LIUDD principles. A range of scales are used, working from the ultimate receiving environment of the Hauraki Gulf and moving up some of the tributaries feeding the Gulf to feature examples of LIUDD at the catchment, subcatchment, neighbourhood and individual lot scale (Table 2). Some of these examples, such as Twin Streams and Okura, show sustainable planning and methods put into place before the LIUDD programme came into being. LIUDD principles provide a clear framework within which these and other development or catchment management initiatives can work. This selection of examples demonstrates how LIUDD principles take a long term view, are applied holistically to include many groups and disciplines, and offer ongoing application and learning opportunities for central and local government agencies, developers and communities.

The LIUDD Principles shown in full in Appendix 1 Figure 1 have been simplified in Figure 15 below. (Note that the tertiary principles for energy and mobility are combined into one box.)

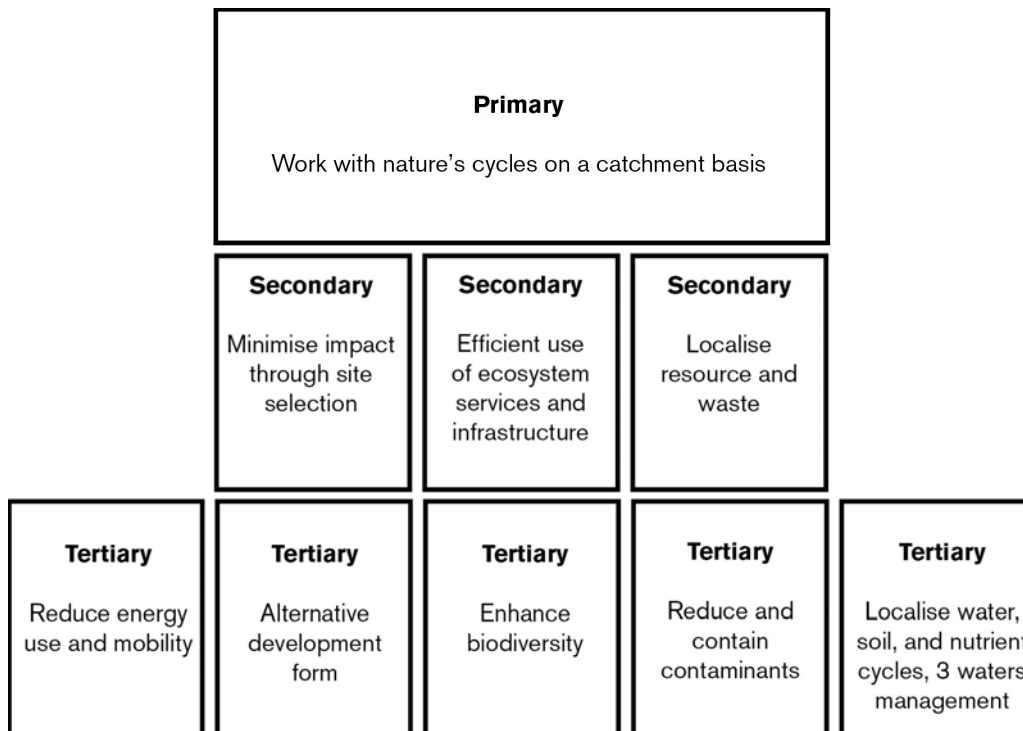


Figure 15: The Principles and Methods Hierarchy—simplified (adapted from van Roon and van Roon, 2005 Fig 1.)

The following hierarchical graphic, based on Figure 15, is included adjacent to each case study and indicates, by the intensity of the red colour, light, medium or dark red, the degree to which the authors believe each of the principles has been implemented to date. Dark red indicates the best possible result. The order of the principles in this graphic is that shown in Figure 15.

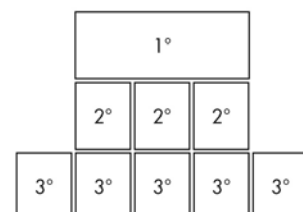



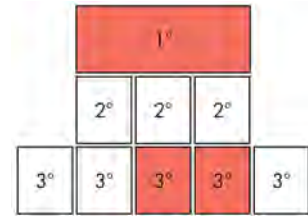
Table 2: Nested scales of LIUDD environments from Table 1 now listing the case studies at each scale that will be discussed in Part Three.



					
Individual lot	Neighbourhood	Subcatchment	Catchment	Receiving water (eg lake, harbour, river, ocean) and its catchment	Ultimate receiving environments and their catchment and ecosystems
Landcare Research Building Talbot Park	Glencourt Place Harbour View New Lynn	Tiffany Close Regis Park Mission Heights	Okura Long Bay Whau River Project Twin Streams Flatbush	Tamaki Estuary Waitemata Harbour	Hauraki Gulf

## Hauraki Gulf – developing the big picture: an ultimate receiving waters case study

Sheltered by the Coromandel peninsula, the Hauraki Gulf is a vast expanse of water which buffers the eastern coast from the Pacific Ocean, supports fisheries, and offers sanctuary to marine reserves and conservation islands. The Gulf stretches along the eastern coastline, from near Pakiri beach in the north to the Firth of Thames in the south, taking in islands (Figure 16) and the Coromandel Peninsula, and cradling catchments that house over 1 million people. Human activities on the land can threaten the ecology of the Gulf.



The Hauraki Gulf is the ultimate receiving environment for the effects of human activities in its catchment. Multiple sub-catchments (Figure 17) feed into the Gulf, and deliver effects from a myriad of human activities, including farming, and urban land uses. The greatest threat to the Gulf comes from contaminants derived from those activities, and includes the bio-accumulation of toxins in the fine sediments of the marine environment.

The Hauraki Gulf is shallow, and the sensitive enclosed waters are at risk from pollution events and gradual degradation resulting from human activities.

The Hauraki Gulf Marine Park Act 2000 emphasises the links between the Gulf, its islands and catchments, and the national importance of the ability of these interrelationships to sustain the life supporting capacity of the environment. The Park Act aims to achieve integrated catchment management of the Gulf by linking the land and the sea. (Integration is achieved by implementation of requirements of the Resource Management Act, the Auckland and Waikato Regional Policy Statements, and Regional Coastal Plans, in particular.)



Figure 16: The Hauraki Gulf viewed from Motuora Island. Photo: C. Whitehead.

Managing the Gulf holistically involves many agencies working together. LIUDD principles are now being applied in many of these catchments to change traditional urban forms and activities to those that impact on the Gulf more favourably than in the past. In the sections which follow, the different case studies (see Figure 18 for location) illustrate LIUDD principles at various levels of detail, and show the cumulative impact of human activities and development in the wide context of receiving environments. It should be emphasized that for local councils and communities the management focus is on improvement of local environments such as beaches and local streams and that this in turn serves the primary principle to manage the Hauraki Gulf holistically.

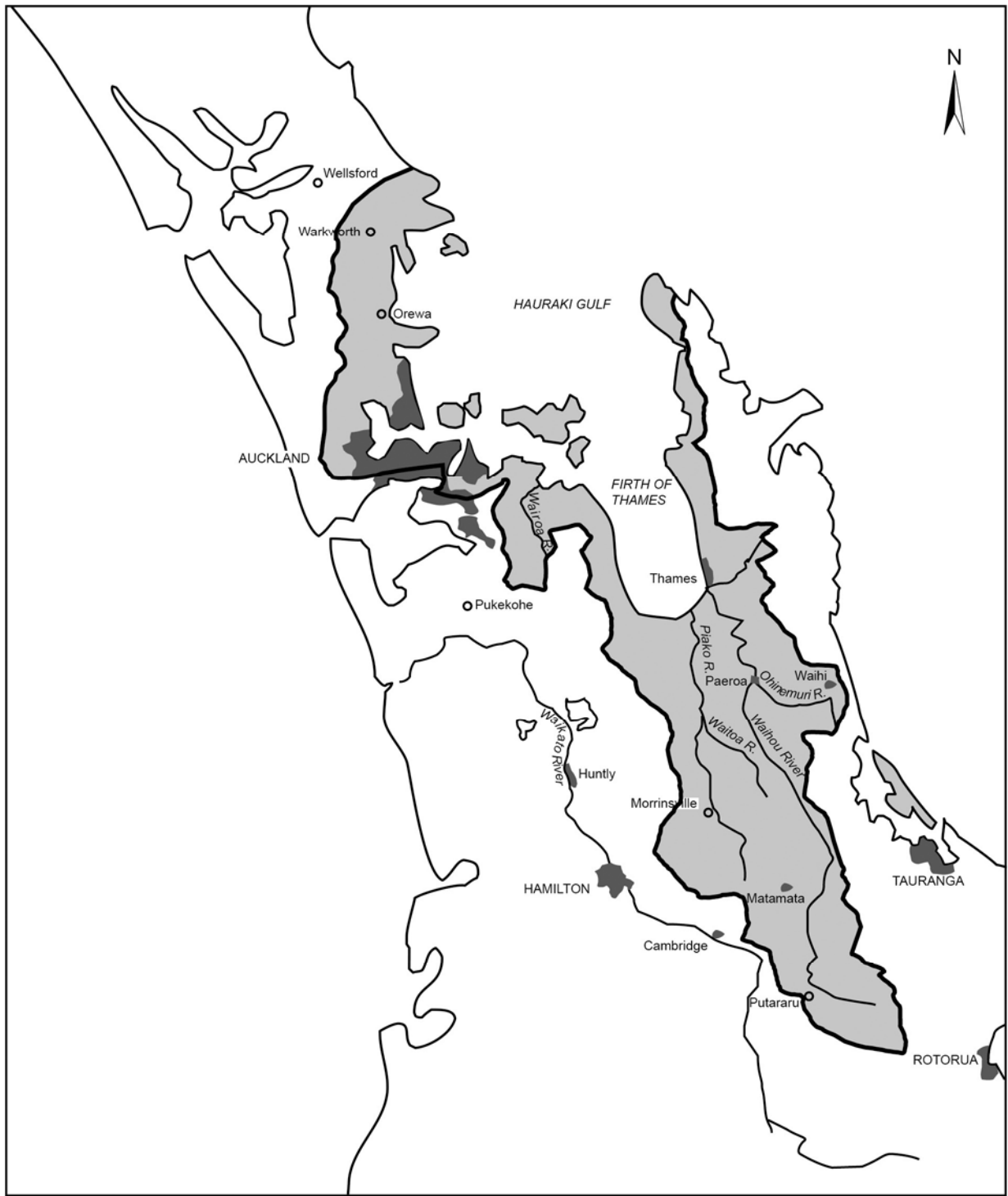


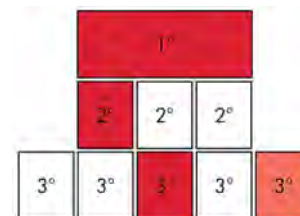
Figure 17: Map of Hauraki Gulf catchment



Figure 18: Map showing sites of case studies

### Okura – saving special sites: a catchment case study

The Okura catchment lies just outside the northern edge of the Auckland Metropolitan Area. The catchment features a four kilometre long pristine estuary flowing to the Hauraki Gulf. The Okura Estuary (Figure 19) is part of the Okura-Long Bay Marine Reserve. The study of the potential effects of urban development on this ecologically productive catchment and estuary offers an example of the LIUDD Primary Principle - the need to work within nature’s cycles on a catchment basis to maintain the integrity and mauri of ecosystems – and more importantly, reinforces the LIUDD secondary principle of wise site selection for minimal impacts from urban development.



The recent history of development plans for the Okura catchment reveals a range of issues. Although the estuary was recognised as ecologically significant, the pressure to develop the greenfields of North Shore City Council (NSCC) and Rodney District Council (RDC) grew as the population of the Auckland Region expanded. Following an Environment Court decision in 1996 the Okura catchment was zoned to remain rural, but urban development in the adjacent coastal Long Bay catchment was allowed (discussed in case study below). Development in the Okura catchment hinged on what rural development meant. Rural use could potentially mean lifestyle blocks of one hectare each, with the construction of buildings and access-ways and the possible loss of riparian planting and natural waterways which would all contribute sediment loads to the estuary.

The NSCC, RDC and the Auckland Regional Council (ARC) all realised any development - rural, urban or of transport routes – could pose risks to the ecology of the estuary. To allow development within the catchment, they needed to know what those risks might mean for the health of local streams and

other natural values, the estuary, and the marine reserve beyond. By employing the expertise of the National Institute of Water and Atmospheric Research (NIWA) to examine the sensitivity of the estuary to sedimentation from various land use scenarios, the regulatory agencies were given a better idea of the consequences of development. NIWA<sup>ix</sup> reported that all activities generating sediment posed a risk to the estuary, and although these risks could be reduced using control strategies, the level of acceptable risk should be defined. Engineering, planning and ecological consultants employed to study a range of development scenarios to define risks reported a range of outcomes. These included managing risks within specific planning and environmental controls, such as allowing limited development within defined areas while protecting the most vulnerable areas of the catchment.



Figure 19: The southern coastline of Okura Estuary. Photo: M. van Roon

The Okura catchment requires ongoing comprehensive consultation and planning. The Okura catchment has a variety of stakeholders, including residents, cultural groups, environmental groups, developers and government agencies. The stakeholders actively support a range of interests, from supporting the establishment of the Marine Reserve in 1995, to being heard at Council and Environment Court hearings. In 2000 NSCC produced comprehensive catchment management plans for the southern subcatchments of Okura including provisions aimed to protect the estuary on an ongoing basis.

The Okura catchment shows how integrated catchment management can use analysis and scientific research to demonstrate the ecological consequences of alternative development scenarios. Scientific knowledge was sought and promptly responded to by Regional and District Councils with positive ecological outcomes to date. Lessons learned, from this and the following case study, illustrate good application of the LIUDD principle that prioritises site selection for positive ecological outcomes. The management of the Okura catchment now goes well beyond the Environment Court decision to allow rural development in the catchment, and is a good example of the application of LIUDD primary and secondary principles.

**Long Bay – planning vision: a catchment case-study**

The coastal settlement of Long Bay abuts the Okura catchment, which is discussed above. Long Bay contains highly valued and fragile ecological areas, especially the upper reaches, which are still in bush cover with waterways in natural states. The lower reaches are mostly in pasture and include the Long Bay Regional Park on Long Bay beach (Figure 20). The catchment includes the ecologically significant Vaughan and Awaruku streams which feed the Okura-Long Bay Marine Reserve and the open waters of the Hauraki Gulf. The urban design for this catchment demonstrates examples of the implementation of many LIUDD principles and methods.



The catchment includes the



Figure 20: A view from the centre of Vaughans Stream catchment out to sea off Long Bay. Photo: North Shore City Council



ecological value of the Long Bay catchment itself, the establishment of the Long Bay-Okura Marine reserve in 1995, and the awareness of environmental issues brought about through the 1996 Environment Court decision meant development in this catchment could not occur in a piecemeal or ad hoc fashion. The interests of multiple parties, including community, cultural and environmental groups as well as industry and developers encourage all decision makers to carefully consider what will be lost and gained as urban development continues in this catchment.

Key factors for stakeholders include the maintenance and restoration of water quality in streams and marine areas; landscape features; bush and stream habitats; and protection of cultural and historical features of this and the adjacent Okura catchment. NSCC has had the challenge of providing for residential development within the constraints of ecological, historical, cultural and amenity values of the catchment.

From 1999, NSCC began devising a long term comprehensive plan for the catchment. Over the next seven years a structure plan was formulated using integrated catchment management planning. Using statutory planning tools to ensure public consultation, NSCC devised a comprehensive development plan which was incorporated into the District Plan and illustrates many LIUDD principles. The Interim decision from the Environment Court in 2008 has significant implications for LIUDD and it provides some important case law.<sup>x</sup>

The overall goal of the District Plan Change (Figure 21) is to protect the Long Bay natural environment, while permitting residential development to meet anticipated growth in North Shore City. This matches the LIUDD primary principle of working within nature’s cycles to maintain ecosystem integrity, and providing decision makers with a specific goal to work towards. (It also matches the LIUDD definition of achieving ecological objectives while allowing for development at all densities – see LIUDD definition in Part One.)

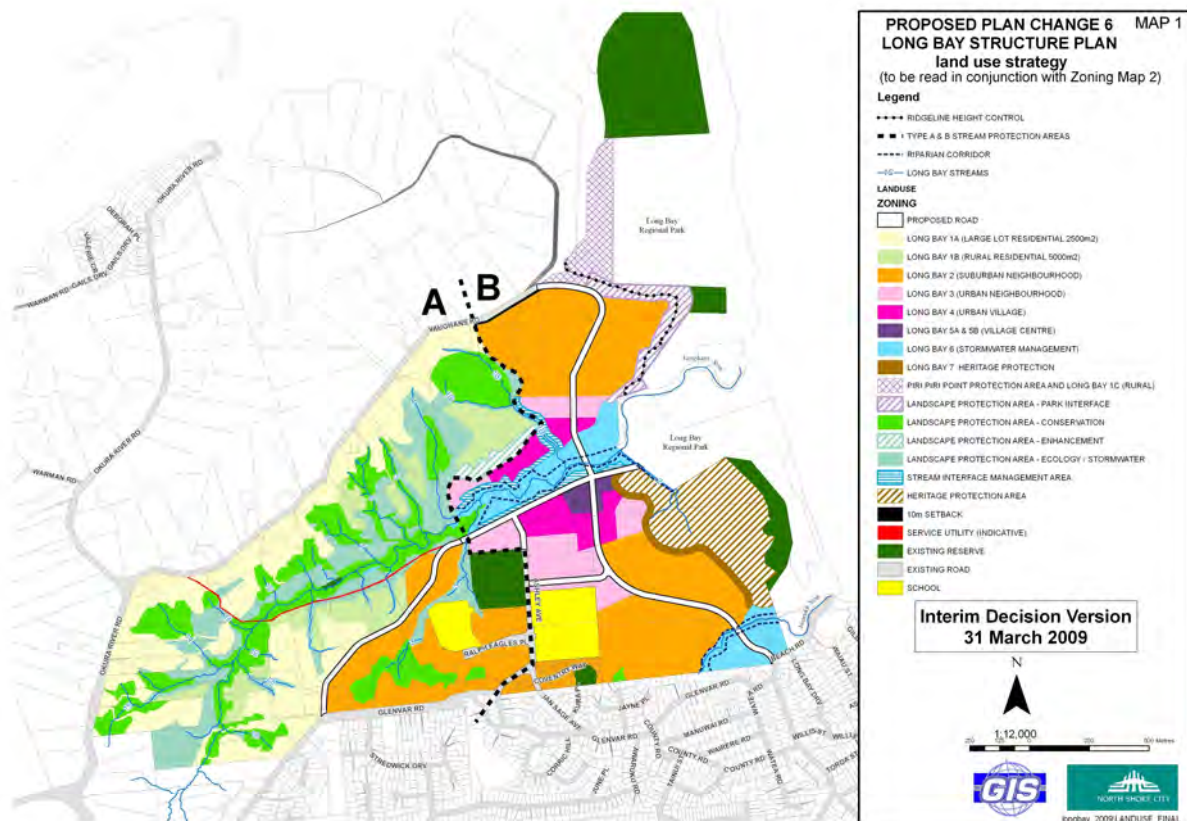


Figure 21 Proposed Plan Change 6 to the North Shore City District Plan. North Shore City Council

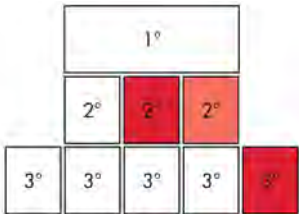
The structure plan for the Long Bay catchment adopts many LIUDD principles and incorporates secondary as well as tertiary principles, including: using a catchment scale for design purposes; minimising earthworks in catchment headwaters (LIUDD secondary and tertiary principles); protecting and revegetating stream riparian corridors and land in the upper catchment; capturing and treating stormwater at source (aiming to achieve pre-development discharge levels of stormwater); minimising impervious areas in the upper catchment; locating and clustering buildings in least fragile and ecologically valuable areas; reducing potable water use (mandatory rain tanks); and decreasing urban density in upper catchments to retain, natural landforms, ecosystems and reduce stormwater impacts or changes in hydraulic response<sup>xi</sup>.

Features such as these in the structure plan not only ensure LIUDD occurs at a design level. These features ensure the involvement of owners and residents by incorporating LIUDD into behaviour and activities. The structure plan actively encourages residents to be involved in three-water management (water supply, wastewater and stormwater) through the use of rain gardens, water tanks, and the reduction of reticulated water use. It also fosters an appreciation and responsibility for the surrounding ecosystems by encouraging biodiversity through native planting and pest and weed control, and by delineating and celebrating the natural areas in the catchment.

From the outset NSCC recognised the development of the Long Bay catchment required a holistic and long term development plan. The restoration of ecologically important areas within and alongside the Long Bay catchment were identified early, and provisions were made to protect these while providing for urban development. From the development concepts to implementation, and from future needs such as maintenance and individual participation, the comprehensive management for the Long Bay catchment has offered and continues to offer excellent examples of primary, secondary and tertiary LIUDD principles.

**Glencourt Place – economies of scale: a neighbourhood and individual lot case study**

The hilly suburb of Windy Ridge in Glenfield lies to the north of the Waitemata Harbour. In the last few years increasing urban development in the area led to flooding on properties below 25 homes in Glencourt Place. Traditional engineering solutions would have involved installing and upgrading stormwater reticulation to drain runoff to the tributaries feeding the harbour and eventually to the Hauraki Gulf. LIUDD solutions have provided alternative options.



The NSCC recognised stormwater could be contained on the individual lots in Glencourt Place. These established properties already had soak pits, but these now swamped the properties below. Rather than investing in reticulation in the upper area and upgrading the infrastructure below to take greater flows, the Council installed on-site collection devices including rain tanks (Figure 22), trenches and contoured flow paths to slow flows to the properties below. Plumbers connected the rain tanks for toilet flushing, laundry and garden use, saving property owners water rates costs.



Figure 22: Rain water tanks installed at Glencourt Place Photo: Eva Veseley

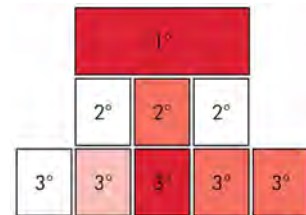
Retrofitting existing areas can offer innovative opportunities for LIUDD, however, apparent costs can be a barrier. The NSCC wanted to know how much LIUDD solutions cost when compared to traditional infrastructure. LIUDD researchers<sup>xii</sup> investigated the life-cycle costing for the project in association

with the NSCC. Life cycle costing considers manufacture, use, maintenance and disposal costs of a product, adjusted over time. The product in this case was the use of LIUDD solutions over conventional reticulation. Although results showed overall costs were very similar, the exercise highlighted environmental benefits as well as learning opportunities. Council staff, contractors and researchers gained valuable experience.

Exchanging the old soakpits for methods to contain rather than discharge the stormwater to new reticulation, fits in with the LIUDD secondary principle of using existing infrastructure efficiently. Containing stormwater on site for reuse is an example of the LIUDD tertiary principle of three-waters management. Of greater importance is the excellent opportunity created by this small scale neighbourhood LIUDD example to provide lessons for residents, local government and researchers on how LIUDD practices can be implemented while still being financially viable.

### Project Twin Streams – flow on effects: a catchment case study

Over half the area of Waitakere City Council (WCC) - 10,000 hectares - feeds the Oratia, Waikumete, Opanuku, Pixie and Swanson streams and it is home to over 100,000 people. These streams have a total length of 56 kilometres of stream banks, and flow into the upper reaches of the Waitemata Harbour before reaching the Hauraki Gulf. In 2003, WCC initiated Project Twin Streams with the aim of riparian restoration through community involvement. The Council soon recognised that this project could also address the effects of urban growth on foothills that are part of the catchment feeding these streams. Project Twin Streams is a good example of integrated catchment management which achieves LIUDD outcomes<sup>xiii</sup>.



By 2004 WCC expanded Project Twin Streams to include integrated sustainable urban planning and low impact stormwater management. Collaboration with the Auckland Sustainable Cities Programme provided planning and policy input. This became a community development model which considered sustainable social, spiritual, environmental, economic and cultural elements.

Aquatic and terrestrial ecologists<sup>xiv</sup> examined the areas to investigate issues such as why streams were not repopulating with native species, and provided recommendations. Water quality and stream ecosystem monitoring is ongoing. Surveys identified the area’s environmental and social characteristics. Residents, tangata whenua and school groups are involved as well as local businesses and industries. Established community groups are being provided with resources through a dedicated Council coordinator so that they can undertake hands-on management of the ecosystems of the catchments, including stream care, riparian planting, education, and biodiversity restoration and enhancement (Figure 23). These actions link to the LIUDD secondary and tertiary principles. Activities by developers, industry and local businesses have become integrated into the project.

The ongoing success of the project is due to the active partnership and commitment occurring between the Council and community organisations, along with the inclusion of wider research and planning expertise. Monitoring during the LIUDD programme has shown that the most successful LIUDD practice emerges when a wide variety of people are included. Involving many people not only encourages innovative solutions to emerge, but



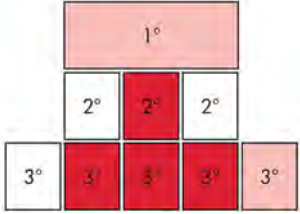
Figure 23: Community group volunteers planting native trees. Photo: M. van Roon

by investing time and resources, people can better understand the project and commit to it, long-term. By combining the knowledge and input of experts and community, aims and issues can be identified and managed from the outset.

Project Twin Streams embraces the primary LIUDD principle of working with nature’s cycles within catchments to maintain the integrity and mauri of ecosystems. By initiating methods to implement secondary and tertiary principles, it achieves this goal.

**Harbour View – treading lightly: a neighbourhood case study**

The suburb of Harbour View commands spectacular views, stretching along the coastal edge of Te Atatu peninsula, and lies adjacent to the western entrance of the Whau Estuary (Figure 24). Harbour View enjoys vistas over the nearby Pollen Island Marine Reserve and east, up the Waitemata Harbour and back towards the central Auckland city skyline, with iconic Rangitoto Island set in the Hauraki Gulf beyond. In this small settlement LIUDD principles have been put into action.



In the mid-1990s WCC recognised that the greenfields that would later become Harbour View had excellent ecological, landscape and amenity values. They set out to preserve and enhance this environment using innovative design. Collaboration between planners, architects, landscapers, engineers and ecologists has resulted in clustered mixed medium density housing, with maximisation of open space and the preservation of conservation and heritage areas.

The development manages stormwater runoff through a range of controls including narrow streets, permeable surfaces and green corridors. The newest streets have flush kerbs, which direct runoff to a biofiltration garden. Excess runoff discharges to a large conservation wetland, where contaminants are contained rather than flowing towards Pollen Island marine reserve. As well as achieving these ecological goals and retaining heritage features, each home in the development was designed to occupy a small ground footprint, to be energy efficient and to connect visually with the local community.

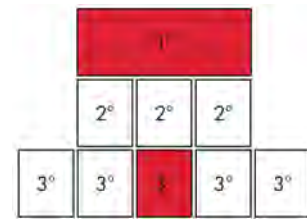


Figure 24: Harbour View looking back towards city. Photo: Stephen Knight.

Although small scale compared to larger developments in surrounding catchments, Harbour View manages to integrate many secondary and tertiary LIUDD principles. These include efficient design and use of ecosystem resources, the reduction and containment of contaminants, and the use of alternative development forms as well as the protection and enhancement of natural features.

## Whau River and Estuary – community care: a catchment case study

The Whau River and Estuary (Figure 25) feeds into the Waitemata Harbour not far from Auckland Harbour Bridge, inside the Hauraki Gulf. The busy north-western motorway bridge passes over the mouth of the River, separating it from Pollen Island Marine Reserve on the harbour side. The wide tidal river catchment has important historical and cultural values, as it was an important home, food source and transport route for both Maori and European settlers. The many tributaries of the River traverse industrial, commercial, residential land, but over the years the effects of urban life have degraded the ecologically rich waterway. Concerned locals continue to work hard to improve the state of the Whau, applying LIUDD-type principles.



The catchment of the Whau covers almost 30 square kilometres and contains over a dozen large stream tributaries which traverse many suburbs, some of which are undergoing urban intensification. The catchment sits within both WCC and Auckland City Council (ACC) jurisdiction and is a mixture of brownfields and retrofitting opportunities.



**Figure 25: The Whau Estuary downstream of the commercial centre of New Lynn.**  
Photo: M. van Roon.

Since approximately the year 2000 councils and community groups such as the Friends of Whau have worked to improve the ecological health of the Whau river catchment, concentrating in particular on the stream-side bush<sup>xv</sup>. The group have funding through ACC and WCC with a brief to organise riparian and river clean up programmes, including pest and weed control.

From 2006 Friends of The Whau took a strategic approach to managing the Whau catchment. They devised an integrated catchment management plan with the goal of raising awareness of issues within the catchment, and of motivating efforts to sustain the natural values. Many of the members were not used to working in a planning role, so the experience of developing the plan built the group's knowledge and capacity.

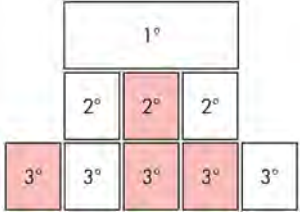
By taking a catchment wide strategic approach, the group increased local knowledge, activated the community, and became involved in governance and political decisions relating to the Whau River. They collaborated with government agencies, business and industry to gain funding and support. A range of LIUDD principles were applied by Friends of The Whau to achieve their goals. They wanted those living on the Whau to work within integrated catchment management principles to maintain the integrity and mauri of ecosystems - the LIUDD primary principle. To make this happen they implemented LIUDD tertiary principles, including protection, restoration and care of the stream corridors of the catchment.

## New Lynn Town Centre – urban constraints: a neighbourhood case study

The population of New Lynn is expected to double in the next 20 years. This suburb, perched far up the wide Whau where the estuary becomes a river, has generated industry and commerce from the late 1800s. Along with the ecological values of the Whau, New Lynn historically has provided employment through the development of manufacturing industries such as timber, tanneries,

clothing, glass, brick, clay and pottery, including Crown Lynn pottery. Rail and road connections have helped New Lynn to become a bustling retail centre, and home to New Zealand’s first shopping mall.

In 1999 New Lynn was identified as an intensification node for the Auckland Region. However New Lynn’s ageing transport, drainage and commercial services will not sustain the expected growth, so it is undergoing infrastructure upgrades to support the expected influx of people.



When charged with revitalising New Lynn, WCC involved many parties in developing a long term vision for the New Lynn neighbourhood. In 1996 WCC ran a community charette – a five day public design workshop - to address the planning of social, economic and environmental elements for the neighbourhood. A second charette was run ten years later. Working with the results of the charettes, over the last decade WCC has developed a long-term vision for the neighbourhood, and generated funds from private developers and infrastructure agencies to support the upcoming growth.

As part of the ongoing management of growth, WCC and the ARC initiated a study to integrate low impact approaches to stormwater during brownfield and retrofitting development in the neighbourhood (Figure 26). Part of this study is attached as Appendix 2 and shows there are excellent opportunities to put LIUDD tertiary principles into place in a myriad of innovative ways in New Lynn. However, the key limitation for New Lynn is its location. Convergent transport routes at New Lynn may make it ideal for intensification in some ways, but it is doubtful whether this can be justified when the potential consequences for the Whau estuary and Pollen Island Marine Reserve are considered.

New Lynn is adjacent to and discharges into the ecologically fragile Whau Estuary which in turn drains to the low-flushing, confined waters of the Upper Waitemata Harbour. Historical industrial discharges into the Whau have compromised the health of this river and estuary. These are now better understood and controlled, and the Whau is undergoing catchment restoration programmes as previously discussed. The main LIUDD challenge for the redevelopment of New



**Figure 26: New Lynn edge between medium-density housing and stormwater retention and restoration.**  
Photo: M. van Roon

Lynn is the control and containment of stormwater runoff carrying contaminants from urban activities to the Whau and beyond.

Stormwater from roads and roofs is a major source of urban contaminants. The Whau estuary mouth is near the ecologically valuable Pollen Island Marine Reserve in the Waitemata Harbour. The low flushing capacity of the Waitemata Harbour means contaminants discharged into these waters accumulate, affecting marine and bird life, and potentially compromising human health before eventually discharging to the Hauraki Gulf. The big picture for New Lynn involves the catchment of the Whau Estuary and the receiving environments this river feeds, which are the Marine Reserve, the harbour and ultimately, the Hauraki Gulf.

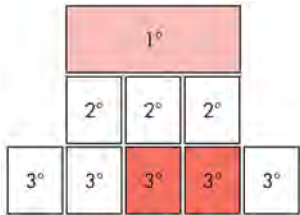
The decision making processes which realise intensification are akin to those required for greenfield developments. Minimising impacts through site selection applies to these just as it would for a greenfield situation. The primary LIUDD principle of working with nature’s cycles to maintain the integrity and mauri of ecosystems is unlikely to be achieved during the redevelopment of New Lynn even with stringent stormwater controls, including reduced impervious areas, containment, re-use, treatment, and a priority for education and behaviour modification. No matter what the scale of development activity is, LIUDD implementation attempts to comply with the primary, secondary and at least some tertiary LIUDD principles.



**Figure 27: The Rewa Rewa footbridge across the Whau River connects the public with efforts to maintain the integrity of this ecosystem as sought through LIUDD principles and methods. Photo: M. van Roon**

**Tamaki Estuary – capturing catchments: a receiving waters case study**

The Tamaki Estuary (Figure 28) has 50 km of coastline, from the sandy beaches of the Waitemata Harbour at the mouth of the Estuary to mangrove forests and saltmarshes in the upper reaches. From there four major streams extend throughout the catchments. The Estuary crosses the boundaries of Auckland and Manukau City Councils, flowing under motorways and railroads and adjacent to industrial areas, as well as hospitals, golf courses, long established suburbs and greenfields.



Forty years ago the community group Tamaki Estuary Protection Society was formed to address the pollution of the estuary. The Society recognised that pollution originated from the increasing activity and land use changes in the surrounding catchment. This group understood that the health of an estuary is affected by human activities. Today this group collaborates with infrastructure providers, industry, business, and local government as well as with community and cultural groups, to monitor the management of the catchments of the estuary and to actively promote good practices in these catchments.



**Figure 28: Tamaki Estuary viewed from Panmure Wharf. Photo: M. van Roon**

The Society is actively involved in planning and policy formation as well as in resource consent implementation. They have links with many interested parties in the area, and provide a strong voice and a good resource base for the implementation of action. They work with researchers and regulatory bodies which monitor the health of the waterways. On the ground, they advocate for the establishment of ecologically and historically significant reserves, undertake weed and pest control, and co-ordinate ecological and water quality monitoring and education programmes.

Integrated Catchment Management is used by some territorial local authorities to monitor waterway health and to document resource use. However, catchment management is also a useful context for

groups with particular environmental and social interests, and fits in with LIUDD primary and secondary principles. The Tamaki Estuary Protection Society recognised the benefits of catchment-wide and holistic planning before it became mainstream. Using a long-term vision and expertise, involving others, and applying a catchment-wide approach to their interests, the Tamaki Estuary Protection Society extended their networks and knowledge to achieve their goal of working to maintain the ecosystems of the Tamaki Estuary.

**Flatbush – greenfield palette: a catchment case study**

The 1700 hectares of rolling green hills and partially forested upper ridgelines of Flatbush at the south-eastern boundary of the Auckland Region will house around 40,000 people by 2020. This large mainly greenfields catchment is divided by many tributaries which feed back into the Otara stream, and then into the Tamaki estuary before flowing out into the Hauraki Gulf. The Otara stream and Tamaki estuary are already suffering from urban pressure, and the Manukau City Council (MCC) recognised that upstream urban development would further compromise these waterways. The MCC used a low impact approach by developing a structure plan for development around the Otara stream and its tributaries.



The MCC began the formal planning process for Flatbush in 1997. Integrated catchment management planning was merged with structure planning, leading to a variation and changes to the District Plan (Figure 29) which specified rehabilitation and the protection of the waterways of the catchment, along with stormwater containment and treatment within the catchment. Over 45 kilometres of waterways and gullies – almost all those in the catchment - are protected under the plan, and a substantial area is now in MCC ownership. The waterways and gullies become ecological features in the landscape by linking green corridors, with urban development clustered between them. High density and commercial development is restricted to the lower reaches of flatter land, while the steep and more fragile upper reaches are divided into larger lots. In the upper reaches there are restrictions on impervious cover and earthworks, as well as requirements for the maintenance of vegetation cover. All stormwater runoff is directed to 48 council owned and maintained ponds throughout the catchment. Subcatchment and neighbourhood case studies within Flat Bush catchment show some LIUDD principles in action at a smaller scale.



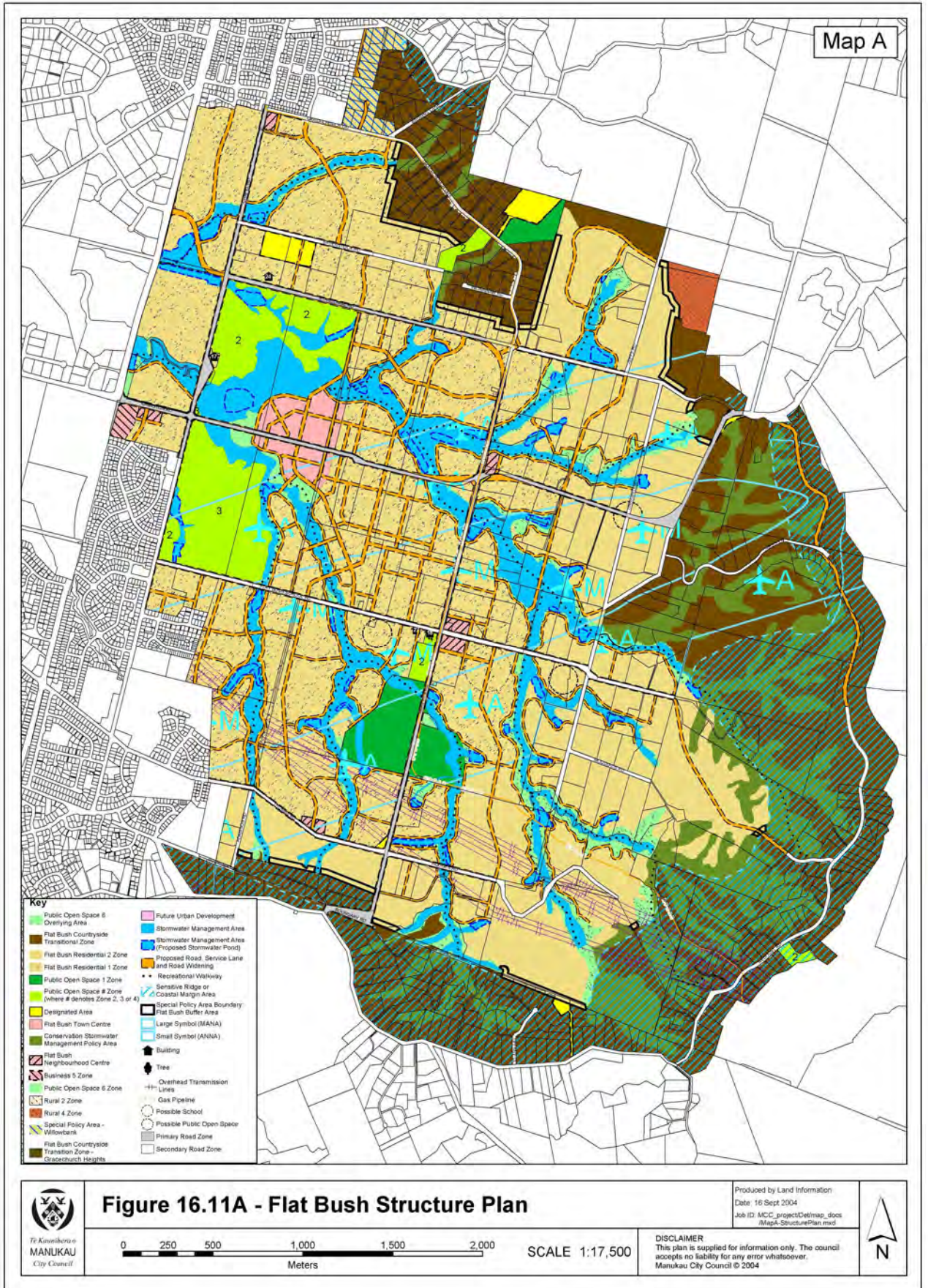


Figure 29: Flatbush Structure Plan: Manukau City Council

### Regis Park subcatchment of Flat Bush

District Plan density requirements for countryside living areas limit lot sizes to around 5000 square metres, in some cases averaged across a site. The subcatchment of Regis Park (Figures 30 and 31) in the upper reaches of Flat Bush has 66 clustered lots, all much smaller than 5000 square metres, with more than sixty percent of the land in privately owned communal open space. This open space is now planted with native forest and wetland species, to be managed by residents. A shared sewage plant on communal land treats wastes from the lots and disperses treated effluent to an area of the new forest. Streets are narrow and the clusters of lots are set away from watercourses. A raingarden in every lot will in future provide stormwater detention, evapotranspiration, and contaminant removal, with overflows to planted areas and wetlands. By containing and treating stormwater on site, and nurturing a reservoir of plants and animals in the upper reaches of the catchment to feed the lower reaches, Regis Park development actively contributes to the protection and enhancement of the wider catchment.



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**PROPOSED SUBDIVISION CONCEPT PLAN**  
REGIS PARK, FLAT BUSH MARCH 2003



Figure 30: Regis Park concept plan. DJScott Associates Ltd



Figure 31: View of Regis Park subcatchment in March 2009 showing revegetation areas and new housing. Photo: M. van Roon

### Tiffany Close sub-catchment of Flat Bush

Tiffany Close (Figure 32) is also in the upper reaches of the Flat Bush catchment. This established countryside living sub-catchment has traditional lots, and many contain stream reaches and forest areas.

Tiffany Bush Care group formed in 2000, and twenty-two property owners now protect their bush and streams. As well as weed and pest control and understorey planting, the group plan to control stormwater runoff from their properties. Like Regis Park, this small sub-catchment protects and enhances the ecosystems within and beyond their properties.

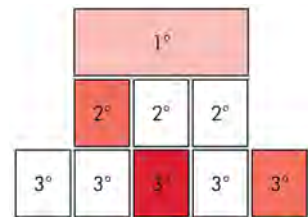
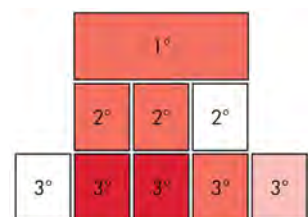


Figure 32: Tiffany Close sub-catchment of Flatbush. Photo: M. van Roon

### Mission Heights subcatchment of Flat Bush

Still near the upper reaches and further west from Regis Park in Mission Heights sub-catchment, housing densities of this development increase resulting in lots of around 500 square metres. By traditional New Zealand subdivision standards, these homes are clustered, being two-storey and in close proximity. This allows for extensive open space and preserves stream corridors which are filled with mature native forests and reaches



of natural stream bed interspersed with Council stormwater ponds and wetlands (Figure 33).

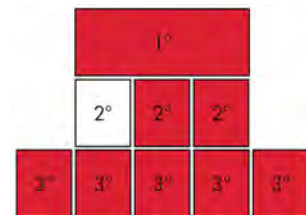


**Figure 33: Mission Heights residential estate including reserved mature forest and stormwater treatment wetland. Photo: M. van Roon**

The management of the Flatbush catchment is a good example of catchment wide design with the priority to protect ecological values during urban growth. The MCC identified the valuable resources of the headwater ridgelines and waterways within and beyond the catchment. By creating a structure plan with the clear goal to protect these resources, the Council has implemented the LIUDD primary principle, and some secondary and tertiary principles. Developers and residents within the catchment have acknowledged these values and, like the Council, have put various LIUDD methods and practices into place.

### **Landcare Research Sustainable Building practice: individual lot case study**

When Landcare Research began designing their new premises in Tamaki (Figure 34), Auckland, they committed to sustainable design. The vision was a demonstration of comprehensive LIUDD within a commercial building. They aimed to balance economics, the natural environment, and the needs of people using the building through innovative design and long term sustainability.



An architect specialising in sustainable design worked with an ecological manager at Landcare Research to devise a general design, but the challenges of integrating LIUDD also called upon the expertise of builders, landscapers, planners, economists, biologists, sociologists, as well as specialist soil, hydrology, energy and mechanical scientists and engineers. LIUDD features on this commercial site include raingardens, swales, compost toilets, water tanks, a wind turbine, thermal efficiency and waste reduction.



**Figure 34: Landcare Research building at Tamaki with raingarden in the entranceway. Photo: M. van Roon**

Challenges were not limited to integrating LIUDD practices - the building lodges office staff, laboratories and biological specimen collections which require climate controls, along with specialist

earthquake and fire protection, so innovation extended well beyond LIUDD techniques for managing energy, waste and water.

The LIUDD research team readily shares their learning experiences from this multidisciplinary project. From the evaluation and monitoring<sup>xvi</sup> of technical, ecological and economic efficiency, to the assessment of the health and well being of the staff working in the building, this project benefited from a wealth of combined expertise and worked successfully to achieve LIUDD outcomes at all levels.

### Sustainability features in a brownfield redevelopment at Talbot Park, Tamaki: an individual lot and neighbourhood case study

Between 2002 and 2007, the Housing New Zealand Corporation refurbished the 5 hectare Talbot Park medium-density housing estate. This provided an opportunity to incorporate a wide diversity of LIUDD practices into streetscapes, house lots and the neighbourhood park<sup>xvii</sup>. Stormwater infiltration, evaporation and trapping of contaminants, were maximised by the use of streetside raingardens, the retention of large trees, and the incorporation of permeable paving on some properties. On some dwelling sites the installation of solar hot water systems and raintanks has increased the self-sufficiency of residents (Figure 35). This refurbishment has been undertaken with an awareness of the need to minimise the effects of housing intensification upon the Tamaki Estuary and its tributaries, at the same time as providing sustainable and affordable social housing.

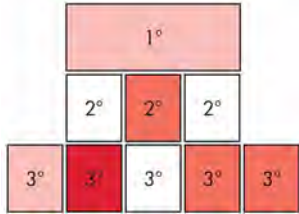


Figure 35: Small tenanted houses at Talbot Park with solar power, raintanks, and street-side raingardens. Photo: M. van Roon

### Closing Comment

The LIUDD Principles and Methods Framework, is a hierarchy of practical methods and not merely an untested theory. An understanding of the catchment context of every action, when designing retrofitting, building and managing in urban and countryside living areas, is the key to successful LIUDD. Spatial scales are nested and every action or decision at lot or neighbourhood scale has consequences for the catchment and region. Natural processes can have long gradual time frames

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and cumulative change over time and space takes time, which must be taken into account in any decision making process aiming at long term sustainability.

The sequence of case studies in the Hauraki Gulf is just one example of nested co-dependent scales. A parallel sequence could be described for the Avon-Heathcote estuary and catchment in Christchurch. The estuary is the receiving water for the South East Area, within this catchment, comprehensive urban planning and development is progressing and most LIUDD principles are being implemented.

This report has provided a framework for the LIUDD process and principles together with case studies to illustrate these. Appendix 1 details the principles, the underlying rationale and methods of implementation. Appendix 2 provides a visual presentation of some tertiary principles and the various ways of implementing these in a specific case study.

Extensive further reading on LIUDD in New Zealand in terms of economic efficacy, the incorporation of it into plans and practices, technologies and environmental performance is available at <http://www.landcareresearch.co.nz/research/built/liudd/> (accessed 2 June 2009).



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## Appendix 1

# Low Impact Urban Design and Development Principles for Assessment of Planning, Policy and Development Outcomes

Marjorie van Roon and Henri van Roon

## Working Paper 051

CUES Working Paper Series



**CUES** | centre for urban ecosystem sustainability

A collaborative research partnership between  
the University of Auckland and Landcare Research Ltd



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# Appendix 1: Low Impact Urban Design and Development Principles for Assessment of Planning, Policy and Development Outcomes

Marjorie van Roon and Henri van Roon, Centre for Urban Ecosystem Sustainability

27 June, 2005

*This is a shortened version of Working Paper 051 of the Centre for Urban Ecosystem Sustainability.*

*The full working paper is available (March 2009) on the LIUDD website at*

[www.landcareresearch.co.nz/research/built/liudd](http://www.landcareresearch.co.nz/research/built/liudd)

## Introduction

An essential element of making LIUDD into mainstream practice is providing clarity to all stakeholders on what the principles of LIUDD are and the methods that can be used to implement those principles. This paper has three main objectives. The first objective is to define what LIUDD is and what it is not, by defining principles and sub-principles (Table 1). The second objective is to show the relationship between the principles and implementation actions. The third objective is to code principles and implementation actions, thereby enabling a stakeholder to create a checklist of implementation achievements using these codes. Stakeholders will thereby be able to assess the degree to which their planning documents, policies, guidelines, codes of practice, and actual practices incorporate LIUDD. The paper elaborates on Table 1, which is the primary tool to do this, but it should not however be used in isolation. The application of LIUDD principles requires the reformulating of planning tools to promote and implement those principles (van Roon *et al*, 2005).

LIUDD is a term unique to New Zealand. Contributing philosophies, principles and practices are, however, common to many countries and cluster under diverse labels. The LIUDD approach uses ecological carrying capacity as a starting point. In New Zealand (Eason *et al*, 2004; van Roon, 2005) concepts and practices evolving since the late 1990s have reached beyond alternative stormwater management to an integrated urban design and development process now termed LIUDD, which deliberately embraces LID as well as other elements. LIUDD aims to avoid a wide range of adverse effects of a physiochemical, biodiversity, social, economic and amenity nature, resulting from conventional urban development, protecting aquatic and terrestrial ecological integrity (van Roon and Knight, 2004) while allowing urbanisation at all densities. Not all LIUDD begins with the urban environment. Case studies under pressure for peri-urban growth, in for example Taupo, Manukau and Waiheke, have provided additional lessons some of which are reported in the appendix to the Proposed Taupo West Rural Structure Plan (TDC, 2004 Appendix 4).

LIUDD planning processes highlight the externalities, which have tended to be ignored or under-rated in design and development. With appropriate planning, funding and management, it is possible to have different patterns of development and intensities of development, whilst still meeting environmental standards and economic aspirations. In the past externalities have often been down played with the result that development has been subsidised by the environment to its detriment.

## Principles of LIUDD

The principles, sub-principles and implementation tasks that we consider central to LIUDD are summarized in Table 1 (Columns 1, 2 and 4 respectively). A detailed description of and rationale for each principle is presented in column 3 of the Table. The numerical codes, which follow implementation alternatives in the far-right column of Table 1, are provided to enable ease of reference to these tasks in future publications and checklists of LIUDD achievement. The inter-relationship of principles and sub-principles is also demonstrated in Figure 1. Note that in this figure,

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box outlines are differentiated to demonstrate the core focus of the LIUDD programme, which is shown in bold text. Complementary tertiary principles and sub-principles, that are outside the LIUDD programme brief, are boxed-in by broken lines.

Table 1 includes some principles, which for the sake of completeness have been included, even though their implementation is beyond the scope of this LIUDD programme. By including these extraneous sub-principles (XX) in the table we wish to convey the fact that we have not overlooked their importance in achieving objectives that arise from these principles. Instead we are acknowledging that their implementation belongs in other programmes. Maori values and practices have been incorporated throughout Table 1 as a first step in reframing development to create more sustainable forms of design from an indigenous/New Zealand perspective.

Note many of the principles can be mutually reinforcing or overarching. Each can be elaborated on in various ways and the implementation of one has spillover effects on the others. These spillover effects can be both positive and negative. There will be instances in implementation situations where trade offs will be required and where more weight will have to be given to one principle over another. Table 1 is a work in progress and is expected to change, but change is expected to be least in the main principles. However, the implementation alternatives listed are the beginning of an evolving task.

#### *Primary Principle*

The principles in the left column of Table 1 form a hierarchy of importance. The single primary principle seeks recognition that human activity should respect and operate within natural cycles (van Roon and Knight, 2004) in order to minimize negative effects and optimize catchment internalisation of materials, contaminants and energy. This principle is embedded in all other principles in Table 1. The ecological carrying capacity concept, as part of resilient natural cycles, is central to the LIUDD approach.

#### *Secondary Principles*

Principle 2.1, concerning site selection, emphasises the fact that the greatest achievements in LIUDD result from choosing the optimum location within a region for urban development. Without this essential step, even if the tertiary principles are applied consistently, there are unlikely to be acceptable outcomes. All principles in Table 1 provide useful guidance to this fundamental strategic planning approach. Sub-principle 2.1B articulates the ‘least-regrets’ approach as a component of site selection. It keeps options open and avoids actions which pre-empt alternatives or which incur major costs. Principle 2.2 recognises past infrastructural investment and seeks to optimize return on this. It also addresses the services provided to society by healthy functional ecosystems and the need to ensure their ongoing capacity. The overarching secondary principle 2.3, concerning minimisation of imports and exports to a catchment, is generic to almost all tertiary principles.

#### *Tertiary Principles*

Figure 1 demonstrates the hierarchical links between secondary principles, tertiary principles and sub-principles. Note that although we have demonstrated the increasing complexity of interactions with distance down the figure, there are numerous horizontal interactions at the tertiary and sub-principle levels that are not readily illustrated.

Principle 3.1 encourages alternative development forms so as to retain open space and enhance infrastructure efficiency. Clustering is not the only means of implementing Principle 3.1. For example, the concentration of titles (residential, commercial or industrial) within multi-level buildings instead of spread across a site can free-up open space between buildings that will then need to be protected from construction and re-vegetated to implement principles in Table 1. Such a change in site layout has as one of its primary objectives support for natural processes and biodiversity. This contrasts

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with the usual objective of maximizing human use and impervious surfaces on the site by covering it in buildings and car-parks. This approach has major implications for the implementation of LIUDD principles on all greenfield and redevelopment sites.

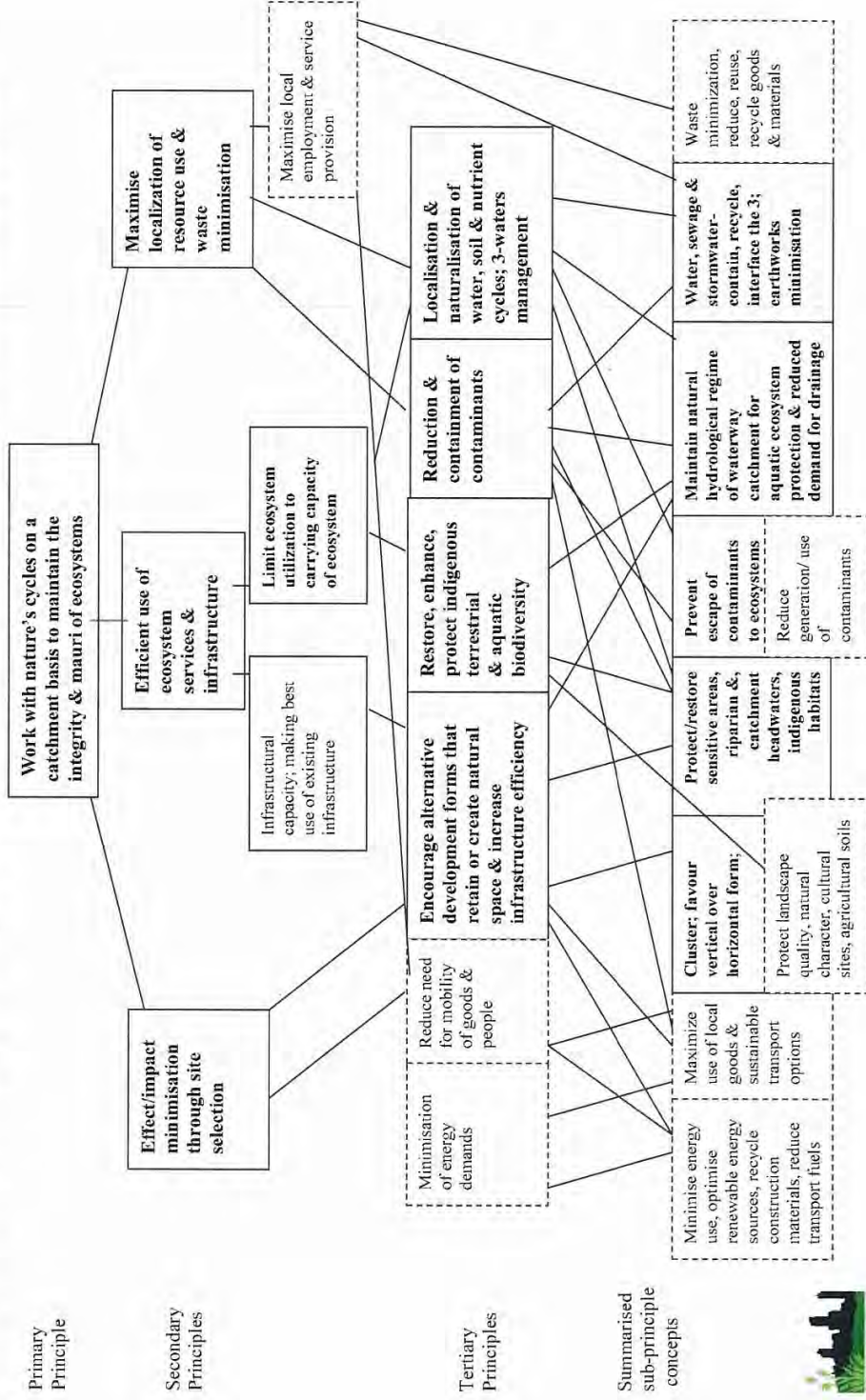
The stormwater sub-principles 3.2A to 3.2D inclusive and their implementation are the traditional focus of low impact approaches. Conviction of the need for and methods (NSCC, 2002) to achieve less than 15% 'effective' imperviousness, to ensure hydrological neutrality within a catchment, is a major challenge for all stakeholders but particularly those involved in redevelopment. Re-vegetation of riparian corridors is mainstream practice but there is less awareness of the need to protect terrestrial and stream ecosystems in catchment headwaters so that these can function as a reservoir of stream biota for re-colonisation of streams that become inadvertently degraded downstream. Principle 3.2 emphasises the importance of 'integrated three waters management'. Linear once-through systems are minimized when water supply, wastewater and stormwater systems are designed and costed simultaneously to maximize opportunities for water recycling and the minimisation of natural water takings and effluent discharges. Through naturalization of the water cycle and support for green construction, LIUDD aims to contribute to the reduced use, mobility and ecosystem availability of contaminants.

LIUDD (Principle 3.4) contributes to fulfillment of the objectives of New Zealand's Biodiversity Strategy (DoC and MfE, 2000) by encouraging protection and re-vegetation of both urban and rural-residential areas and by reducing hydrological and aquatic biological changes brought about by urbanization. Direct habitat management that is embodied in tertiary principle 3.4 is just a minor component of the all-encompassing ecological objective encapsulated in LIUDD. LIUDD addresses the optimum functioning of ecosystem processes and cycles.

Transport management at the regional scale (Principle 3.5X) and waste minimisation are beyond the scope of this Programme. However transport management is acknowledged as a primary driver for site selection for urban use (Principle 2). Transport planning and management at the neighbourhood or catchment scale can comfortably be aligned with achievement of stormwater, biodiversity and neighbourhood containment objectives. Also aligned with these are energy conservation actions (Principle 3.6) implemented at neighbourhood and individual site scales.

In Table 1 principles and methods relevant to brownfield as well as greenfield developments have been provided. Adoption of these methods for greenfield sites is easier and faster than for brownfields. The retrofitting of existing New Zealand urban areas has typically only been achieved over many decades as individual sites have been redeveloped and infrastructure has required replacement.

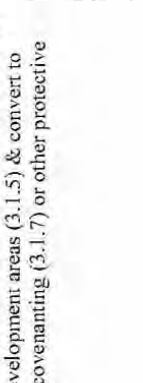
**Figure 1: Hierarchy of Principles of LIUDD. Principles in bold are the dominant focus of this LIUDD, FRST funded, programme. Principles in dashed boxes are complementary, but outside this programme. Figure 1 is a partial representation of Table 1 (van Roon and van Roon, 2005)**





**Table 1: CUES FRST funded LIUDD programme: checklist of LIUDD principles for assessment of planning, policy and development outcomes** (van Roon, M. & van Roon, H. 2005)  
 Sub-principles denoted by X or XX, rather than A - K, are not the focus of the LIUDD programme. By including these extraneous sub-principles in the table we wish to convey the fact that we have not overlooked their importance in achieving objectives that arise from these principles.

Principles	Sub-principles	Detailed description & Rationale	Examples of Implementation Alternatives
<b>Primary principle</b> 1 Work with nature's cycles on a catchment basis to maintain the integrity & mauri of ecosystems & minimise ecological footprints.	<b>Cycles &amp; catchments</b> 1A Support cyclical ecological processes. 1B Use catchment context as design & management framework. 1C Recognise & provide for the long-term nature of natural cycles.	Use integrated knowledge systems including scientific and matauranga Maori as bases to manage cyclical processes that determine distribution & influence of water, soil, plant nutrients, contaminants, organisms & energy. Human & cultural wellbeing are a significant by-product of the above being done effectively. Functionality of cyclical processes is essential for internalisation of effects & reduction of resource demand, that together make urban or rural-residential developments 'low impact'. Design within catchment context provides opportunities to support natural cycles (van Roon & Knight, 2004).	Use guidelines, district plan provisions, covenants, & the promotion of collaborative projects between, e.g. local government, community groups, tangata whenua, and private agencies that support natural ecosystem function, and promote effective management. Encourage recycling of water, wastes, materials & energy through co-location of complementary activities (1.1), innovative infrastructure (1.2) & technologies (1.3) preventing discharges to ecologically sensitive environments. Use catchment context for design & management (1.4).
<b>Secondary principle</b> 2.1: Effect/Impact minimisation through site selection.	<b>Spatial/Strategic Planning Approaches</b> 2.1A Site selection used to avoid /minimize negative impacts thereby removing need for mitigation. 2.1B Adopt 'least regrets' strategy to minimise risk. 2.1X Protect sites of cultural significance. 2.1XX Protect landscape quality & natural character.	Select areas for development & screen out inappropriate areas with avoidance of sensitive areas to minimise ecological, cultural & economic costs, as this is more effective than remedial work. The 'least regrets' approach provides a basis for remedial action, as a type of insurance policy, in case there are unforeseen consequences resulting from development. These are essential components of appropriate site selection for development.	Prior to development or re-development identify & delineate areas that are ecologically sensitive (2.1.1) & define limitations or constraints at a regional scale (2.1.2). Develop criteria for assessment & basis for decision-making in selection of development areas & convert to Regional Plan provisions (2.1.3) or District Strategic Plan provisions (2.1.4). Ensure the protection of culturally significant or culturally sensitive landscapes or sites for appropriate forms of design and development, where these values converge with or enhance natural processes or cycles (2.1.5). Whilst an integral part of wise site selection these are not elements of LIUDD FRST-funded programme. They may, however, benefit indirectly from the application of Principle 2.1 & other LIUDD principles. They are in fact key elements to achieving successful outcomes of the overall LIUDD process. Therefore, encourage appropriate forms of development and design in culturally and visually significant areas.
<b>Secondary principle</b> 2.2 Efficient use of ecosystem services & infrastructure	<b>Efficiency</b> 2.2A Maintain ecosystems in optimum condition to ensure ongoing capacity to support human needs. 2.2B Maximise use of existing infrastructure.	Degraded ecosystems lack the resilience & capacity to process wastes, accommodate resource extraction or otherwise cope with human use. The use of existing infrastructure is maximised so as to make best possible use of prior capital investment.	Develop & use economic instruments which price ecosystem services fairly and on an ongoing basis, taking account of all externalities including life cycle pricing (2.2.1). Provide comparative costing of ecosystem services versus conventional infrastructure, to achieve the same outcomes (2.2.2). Use this approach as a basis for the design & construction of alternative infrastructure (2.2.3).


<sup>1</sup> It could be argued that this could be generalised to 'plans and policy documents' but Regional and District are the 'spatial context'.

<p><b>Secondary principle</b> 2.3 Maximise localisation of resource use &amp; waste minimisation.</p>	<p><b>Localisation</b> 2.3A Maximise containment of local water &amp; contaminant cycles 2.3X Reduce, reuse, recycle goods &amp; materials locally. 2.3XX Maximise opportunities for local employment &amp; service provision</p>	<p>Minimises impact on areas adjacent to catchment, reduces ecological footprint. Minimises downstream effects such as bioaccumulation in receiving waters.</p>	<p>Maximise use of local water (see below). Minimise contaminant export from catchment (2.3.1).</p>
<p><b>Tertiary (3<sup>b</sup>) principle</b> 3.1: Encourage alternative development forms that retain, restore or create natural space &amp; increase infrastructure efficiency</p>	<p><b>Plan in catchment context</b> 3.1A Cluster activities whilst absolutely &amp; permanently prohibiting intensification or structures on "balance" land. 3.1 B Retrofit brownfield developments to encourage vertical over horizontal form &amp; naturalise the resultant open space.</p>	<p>Concentration of compatible activities through clustering or vertical intensification can reduce capital costs, lowers ongoing maintenance &amp; operating costs, whilst allowing for increased densities overall. It also facilitates the maintenance or restoration of natural hydrological regimes thereby protecting the integrity of aquatic ecosystems and reducing the demand for drainage construction and upgrading. Creation or retention of open space caters for amenity and recreational needs, human wellbeing needs, food production areas, catchment runoff protection and provides opportunities to protect and maintain culturally significant sites (e.g. wahi tapu, mahinga kai, habitat of flora and fauna taonga).</p>	<p>Not part of LIUDD programme brief.</p>
<p><b>3.1X</b> Restore or enhance landscape quality &amp; natural character.</p>	<p><b>3.1XX</b> Encourage appropriate forms of development &amp; design in culturally significant areas where cultural values converge with natural cycles</p>	<p>As LIUDD principles are founded on working within nature's processes, improved landscape quality &amp; natural character are certain byproducts of LIUDD approaches.</p>	<p>3.1X is not part of the LIUDD programme in its own right but its protection &amp; enhancement are an integral byproduct of LIUDD approaches. In effect adequate provision for protection of landscape values will facilitate the effectiveness of the core programme.</p>
		<p>For example, convergence of LIUDD principles with Maori values &amp; concepts leads to a convergence of LIUDD structure plans &amp; preferred development styles of urban Maori &amp; tangata whenua groups. Culturally appropriate forms of LIUDD 'style' should be encouraged &amp; followed in culturally sensitive areas (e.g. pa, marae, papa kaitiaki, mahinga kai, and ngahere).</p>	<p>3.1XX is only indirectly aligned with the LIUDD programme but the inseparability of ecological &amp; Maori cultural objectives means that in most such developments LIUDD principles will largely be adhered to.</p>

<p><b>3<sup>o</sup> principle</b></p> <p><b>3.2: Localisation &amp; naturalisation of water, soil &amp; nutrient cycles.</b> Optimise recycling, minimise external demand &amp; discharges. Optimise 'integrated three (or four) waters management' within local catchment.</p>	<p><b>Stormwater</b></p> <p><b>3.2A</b> Minimise generation of stormwater, localise at source. <b>3.2B</b> Reduce 'effective' impervious surface area to less than 15% of catchment. <b>3.2C</b> Maintain/ re-create catchment flow characteristics as if under previous 'natural vegetation' (hydrological neutrality). <b>3.2D</b> Utilise stormwater wherever possible as a secondary water supply <b>3.2E</b> Maximise groundwater recharge with stormwater following contaminant removal.</p>	<p>To identify what constitutes healthy waters based on scientific &amp; cultural values. To ensure the natural functioning of healthy receiving waters, maintain the hydrological regime and water quality, minimize effects on the mauri, &amp; avoid nutrient enrichment &amp; contamination of kaimoana areas. Avoid capital costs &amp; maintenance of reticulated systems. Minimize downstream surge &amp; scour effects as well as trap contaminants &amp; nutrients. Aim at zero discharge from properties. No development on upper &amp; riparian catchment areas so as to ensure maintenance of the environment &amp; water quality. Minimisation of runoff from catchment headwaters. Upper catchments act as reservoir for species to allow ongoing re-colonisations of habitat effected by development. Supported by sub-principles 3.2F to 3.2K</p>	<p>Use "natural processes" streams &amp; wetlands as infrastructure (3.2.1). Avoid curb &amp; channel storm water reticulation systems (3.2.2) &amp; provide pipes only for overflows, not for base flow (3.2.3). Protection (3.2.4) &amp; re-vegetation (3.2.5) of the riparian corridors. Identification, protection or re-creation of indigenous habitats, including wetlands, forests, springs, &amp; streams - both perennial &amp; ephemeral (3.2.6). Identification, protection, rehabilitation, re-creation, &amp; maintenance of culturally significant natural areas e.g. mahinga kai, kaimoana, taonga (3.2.7). Provide financial, rating or other incentives to encourage developers &amp; land owners to retain or create these natural features (3.2.8). Re-vegetate upper catchments (3.2.9) &amp; all erosion prone areas (3.2.10). Encourage high biomass vegetation systems to trap rain &amp; species with high evapo-transpiration capability (3.2.11). Adopt narrow roads (3.2.12), swales (3.2.13), rain gardens (3.2.14), biofiltration (3.2.15), porous paving (3.2.16), onsite detention tanks (3.2.17), ecoroofs (3.2.18). Provide for ongoing maintenance of stormwater control devices (3.2.19). Camber all impervious surfaces, including roads, to direct run-off to above devices or to natural vegetation areas on pervious soils (3.2.20). Use organic soils &amp; compost to optimise function of rain gardens (3.2.21). Protect &amp; enable overland flow paths (3.2.22) &amp; flood plains (3.2.23).</p>
<p><b>Wastewater</b></p> <p><b>3.2F</b> Minimise volume &amp; recycle for dual water supply <b>3.2G</b> Nutrient strip sewage <b>3.2H</b> Encourage adoption of dry waste systems &amp; reduced use of water-born systems.</p>	<p>Provide reticulated waste water systems or advanced treatment package plants. Adapt for improved environmental &amp; cultural simultaneous outcomes, including waste water management sensitive to the values of Maori groups such as tangata whenua &amp; urban Maori &amp; by avoiding gradual cumulative unwanted effects of nutrient &amp; contaminant buildup in waterways &amp; soils, degradation of aquatic ecosystems, &amp; loss of mauri.</p>	<p>Use of modern systems of Clivus multirum (3.2.24), compost: toilets with flush pan (3.2.25), wetland treatment systems (3.2.26) as well as large scale sewage treatment plants with effluent recycling to land (3.2.27) or to dual water supply (3.2.28). Consider reticulated grey water systems (3.2.29) in lieu of full sewage reticulation.</p>	<p>Use of modern systems of Clivus multirum (3.2.24), compost: toilets with flush pan (3.2.25), wetland treatment systems (3.2.26) as well as large scale sewage treatment plants with effluent recycling to land (3.2.27) or to dual water supply (3.2.28). Consider reticulated grey water systems (3.2.29) in lieu of full sewage reticulation.</p>
<p><b>Water supply</b></p> <p><b>3.2I</b> Minimise potable water usage &amp; demand, reduce extraction from natural waterways. <b>3.2J</b> Harvest or recycle water</p> 	<p>Reduce overall water use &amp; utilize rainwater &amp; recycled water for appropriate purposes as part of an overall approach. This provides the potential for savings in both treatment costs and the exposure of the human population &amp; receiving water ecosystems to treatment chemicals.</p>	<p>Dual Water supply (3.2.30), use of water tanks (3.2.31) &amp; water efficient appliances (3.2.32). Low flow tap fittings (3.2.33), recycle grey water for toilet &amp; outside use 3.2.34). Gardens designed to favour indigenous vegetation adapted to local climate conditions (3.2.35). Provide systems which treat/sterilise rainwater for hot water use (3.2.36). Use of tailored plumbing systems to prevent cross-connection of potable &amp; non-potable systems (3.2.37).</p>	<p>Dual Water supply (3.2.30), use of water tanks (3.2.31) &amp; water efficient appliances (3.2.32). Low flow tap fittings (3.2.33), recycle grey water for toilet &amp; outside use 3.2.34). Gardens designed to favour indigenous vegetation adapted to local climate conditions (3.2.35). Provide systems which treat/sterilise rainwater for hot water use (3.2.36). Use of tailored plumbing systems to prevent cross-connection of potable &amp; non-potable systems (3.2.37).</p>

	<p><b>Urban earthworks management</b>  <b>3.2K</b> Minimum site disturbance.</p>	<p>Respect the intactness of whenua (land). Avoid detrimental earthworks or management practices related to development, which have a significant (to be defined) impact on soil structure &amp; the functioning of adjacent receiving waters &amp; ecosystems. Minimum site disturbance; sediment containment - building sites. Minimise site works to reduce development costs &amp; compaction problems. Carrying out subdivision &amp; building site earthworks simultaneously is more economic, reduces compliance costs &amp; facilitates monitoring &amp; remedial work if needed.</p>	<p>Restrict earthworks on slopes identified in planning documents as unsuitable for development (3.2.38), and on significant ecological areas (3.2.39).</p> <p>Use techniques such as clustering to concentrate buildings on suitable soil types &amp; slopes leaving areas naturally unsuitable for construction in a vegetated &amp; undisturbed condition (3.2.40).</p> <p>Implementation of Principle 3.1 is supportive of these actions.</p>
<p><b>3<sup>0</sup> principle</b>  <b>3.3:</b> Reduction &amp; containment of contaminants</p>	<p><b>3.3X</b> Minimise generation of transport &amp; industrial contaminants.</p> <p><b>3.3XX</b> Prevent /minimise escape of contaminants via atmosphere.</p>	<p>This would require changes in: transport modes &amp; fuels: industrial processes, sustainable business, industrial ecology. This is the most effective means of reducing air, soil &amp; stormwater contamination. Subprinciples 3.5X and 3.5A are supportive.</p> <p>This is the most effective means of reducing air, soil &amp; stormwater contamination.</p>	<p>Not part of LIUDD programme brief.</p> <p>Not part of LIUDD programme brief.</p> <p>This is implemented under the requirements &amp; provisions of the Resource Management Act, 1991.</p> <p>Strip contaminants from stormwater before discharge to natural waterways (3.3.1).</p>
	<p><b>3.3A</b> Prevent escape of contaminants via water cycle.</p> <p><b>3.3B</b> Reduce contaminant-loaded materials used in construction industry.</p>	<p>Damage to ecosystems &amp; human health reduced by containment.</p> <p>Damage to human health &amp; ecosystems reduced by lower exposure to toxins in buildings/construction waste</p>	<p>Encourage the construction of 'green buildings' (3.3.2)</p> <p>Comply with requirements of the Building Act, 2004 (3.3.3), building code (3.3.4) &amp; council development construction guidelines (3.3.5).</p>
<p><b>3<sup>0</sup> principle</b>  <b>3.4:</b> Restore, enhance, protect indigenous, terrestrial &amp; aquatic biodiversity.</p> 	<p><b>3.4A</b> Protect existing, restore or recreate indigenous habitats. No net loss of habitat.</p> <p><b>3.4B</b> Protect &amp;/or revegetate environmentally sensitive areas within catchment i.e. riparian corridors, steep slopes, ridgelines.</p>	<p>This supports the objectives of the NZ Biodiversity Strategy: promote natural ecosystem functioning within development catchments (e.g. by maintaining &amp; enhancing water &amp; soil cycles), maintain &amp; enhance indigenous flora, fauna &amp; habitats, recognise Maori aspirations to protect, rehabilitate &amp; enhance indigenous ecosystems, reduce development pressures on indigenous biota.</p>	<p>Favour indigenous revegetation of stormwater management corridors with locally appropriate stocks (3.4.1).</p> <p>Priority use of indigenous species when planting rain gardens, biofiltration systems &amp; trees in swales (3.4.2).</p> <p>Provide incentives for indigenous vegetation planting (3.4.3) &amp; retention on private lots (3.4.4). Maintain instream values to protect aquatic ecosystems from damage by structures (3.4.5) e.g. dams &amp; culverts</p> <p>Promote biodiversity protection &amp; restoration by Maori organisations including iwi &amp; hapu (3.4.6) with support from local government and Nga Whenua Rahui (3.4.7).</p>



	<p><b>3.4C</b> Maintain or restore natural hydrological regime of waterway catchment for aquatic ecosystem protection.</p>	<p>Volumes &amp; periodicity of discharges from catchments are determinants of habitat conditions in receiving water ecosystems including rivers, wetlands, lakes &amp; estuaries. Changes to hydrological regime are determinants of major changes in aquatic ecosystem composition &amp; function.</p>	<p>Retain (3.4.8), restore (3.4.9) or recreate (3.4.10) natural balance of vegetation cover, especially proportion of catchment in forest. Limit (greenfield, 3.4.11) or revert to (brownfield, 3.4.12) 'effective' impervious surface areas to &lt;15% of catchment. Achieved also through implementation of principle 3.2A – E.</p>
	<p><b>3.4D</b> Protect or restore appropriate riparian vegetation. Protect reservoir of species in catchment headwaters for stream recolonisation.</p>	<p>Riparian vegetation filters contaminants, provides shade for temperature control, bankside habitat &amp; carbon supply. Headwaters terrestrial &amp; stream habitats required for different life cycle stages.</p>	<p>Use covenants (3.4.13) or district plan provisions (3.4.14) to protect riparian strips. Use covenants (3.4.15) or district plan provisions (3.4.16) to protect headwater terrestrial-aquatic habitat combination.</p>
<p><b>3<sup>0</sup> principle</b> <b>3.5:</b> Reduce need for mobility of goods &amp; people.</p>	<p><b>3.5X.</b> Maximise proximity of residential &amp; employment bases. Optimise regional transport flows &amp; public transport</p>	<p>Security, cost &amp; availability of transport fuels are questionable. In addition to costs there is concern about air pollution &amp; run-off quality. Favour rail &amp; water-borne transport over road transport on environmental &amp; economic efficiency grounds – low import of hydrocarbons to catchment.</p>	<p>Not part of LIUDD programme brief</p>
	<p><b>3.5XX</b> Maximise local availability &amp; use of goods, services &amp; neighbourhood sustainable transport options.</p>	<p>The sourcing of construction materials &amp; food locally, reduces transport demand for goods &amp; people. Compost generated locally could be input to raingardens for stormwater treatment (see 3.2.14). Riparian corridors protected or restored under sub-principle 3.4B provide space for cycling &amp; walking paths. Note that implementation of these measures would achieve sub-principle 3.5 whilst supporting achievement of sub-principle 3.2B.</p>	<p>Not part of LIUDD programme brief</p>

<p><b>3<sup>rd</sup> principle</b></p> <p><b>3.6:</b> Minimisation of energy demands</p>	<p><b>3.6A</b> Minimise Energy use</p>	<p>Improve building design for solar heat capture, insulation &amp; use of passive solar energy &amp; wind. Reduce imbedded energy in materials.</p>	<p>Double glazing (3.6.1) &amp; high level insulation (3.6.2) for new &amp; existing structures. Thermal mass/ materials in buildings for heat storage (3.6.3). House design to use (3.6.4) or avoid (3.6.5) solar input. Skylights (3.6.6) with or without link to fibre optics (3.6.7) for light transfer to other parts of building. Protect sunlight sight lines (3.6.8) for solar hot water, solar voltaics &amp; passive solar heating.</p>
<p><b>3.6X</b> Optimise renewable energy sources <b>3.6XX</b> Reduce use of transport fuels <b>3.6XXX</b> Recycle construction materials</p>	<p>Reduces running costs to end user of energy. Reduces need to generate electricity &amp; environmental impact thereof as well as transmission issues. Reduces travel costs. The sub-principles could be met by providing a residential access layout that minimizes the need for car travel &amp; encourages non-mechanised transport options such as walking &amp; cycling. This necessitates the creation of compact &amp; functional urban areas with good public transport. Other provisions might include outside laundry drying areas, wind power generation as a permitted use, firewood tree cropping as an integral part of design/layout, local recycling depots/collection &amp; composting areas as part of reducing energy-mobility requirements.</p>	<p>Not part of LIUDD programme brief</p>	<p>Not part of LIUDD programme brief</p>

**Maori terms used in Table 1 and this paper:**

- Maori: Indigenous people of New Zealand
- tangata whenua: people of the land, used in reference to Maori associated with particular parts of New Zealand
- mauri: The life force and unique personality of all things animate and inanimate.
- rahui: a form of restriction set up over a resource by a hapu or its chief for spiritual, social, or economic reasons.
- tikanga: customary correct ways of doing things
- maatauranga Maori: traditional knowledge
- whenua: land
- wahi tapu: sacred place
- urupa: burial ground



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## Conclusions

We have attempted to define the principles and actions that make possible the implementation of LIUDD. We have therefore created the means, by which all stakeholders involved in development processes can generate checklists using the codes we have provided, to document implementation achievements. It is hoped that this will bring greater clarity to stakeholders wishing to introduce LIUDD into everyday practice.

## Acknowledgements

We would like to express our thanks to other members of the CUES LIUDD team who provided constructive comments on the draft, in particular Garth Harmsworth, Michael Krausse and Jenny Dixon.

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## Appendix 2

# The Case for a “Low Impact” Approach in the Re-development of New Lynn

Marjorie van Roon and Henri van Roon

30 August, 2005

Working Paper 052

CUES Working Paper Series



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## Appendix 2: The Case for a “Low Impact” Approach in the Re-development of New Lynn

Marjorie van Roon and Henri van Roon, CUES and Department of Planning, University of Auckland

This report was prepared for the Auckland Regional Council in response to the Proposed Waitakere District Plan Change 17

### **Summary: The Case for a “Low Impact” Approach in the Re-development of New Lynn**

Five detailed charts illustrate a “Low Impact” approach in the area of the New Lynn Proposed Plan Change 17 (PPC17). Each chart details existing environments with possible changes using this approach for re-development or retrofitting. The charts mostly emphasise Low Impact Design (LID) approaches to stormwater management but have been prepared in the wider framework of Low Impact Urban Design and Development (LIUDD). LIUDD takes an integrated approach to urban design and development so that benefits go well beyond those of stormwater management (van Roon and van Roon, 2005).

The handling of stormwater runoff is a major issue in intensification and re-development of the PPC17 area. Our overall approach is driven by the need to strive for hydrological neutrality and optimum stormwater quality and is based on our knowledge of local and international best practice to date. Hydrological neutrality aims to retain or recreate flow characteristics of a pre-development situation. It is important to note that New Lynn has several constraints such as its division by roads and railway. However, the upgrading of these links could provide new opportunities for stormwater and re-vegetation by possible under-grounding of the rail line.

The PPC17 area is part of a larger catchment and functions both as a conduit and receptacle for stormwater from elsewhere and incoming flows may limit proposed low impact solutions. The catchment drains to enclosed harbour waters. As a result of urbanisation streams and estuaries of the Whau are amongst the most contaminated in the Waitemata Harbour. While point source pollution is controlled, storm water is not, with road and roof water runoff the main sources of contamination.

As noted, the key to effective storm water management is to implement the concept of hydrological neutrality. For ecosystem protection, effective impervious cover should not exceed 15% of a catchment. PPC17 allows for up to 70 % site coverage in the Living 6 environment and 100 % in the Community environment. There is then a challenge for Waitakere City to provide directions and incentives for an urban form which achieves hydrological neutrality and ways in which effective impervious areas are compensated for by ‘low impact’ solutions. Our charts illustrate some common themes as summarized below.

**Common themes:** Retrofit in areas unlikely to change in the next 20 years, such as Ambrico Place. Avoid piecemeal infill redevelopment. Encourage large-scale re-development in areas which are ripe for change or already vacant, such as around Crown Lynn Place. Increase vegetation (urban forest style) and green the urban area, both horizontally at ground level and roof tops, and vertically as in and on building walls to maximise evapo-transpiration. Minimise site coverage in impervious areas and link to pervious areas either directly adjacent or downstream, to filter and improve water quality, as well as providing detention and slowing discharges into streams. Minor/local roads could be narrowed with provision of swales and/or raingardens in the verges. Encourage the use of shared pervious driveways and strips rather than solid driveways. Create open space by clustering development and encouraging higher rise housing. Link open spaces such as parks to the estuary.

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Encourage minimum footprint buildings and permanently protected open space around them. Make car-parking spaces/areas at all scales effectively pervious or underground.

**Benefits to the Whau estuary and New Lynn Town area of applying a 'low impact' approach:**

- Improved water and sediment quality, lower contaminant load in streams and in the Whau estuary.
- Improved ecological conditions (natural flow and quality) for freshwater and marine life that therefore has a better chance -this maintains biodiversity.
- Reduced sediment load and siltation with associated mangrove spread in the Whau estuary.
- Reduction in peaking of storm water flows and flooding as well as channel stability, scouring/collapse.
- Air pollution reduces as vegetation absorbs gasses; filters and traps dust as well as providing oxygenated air.
- Reduced capital costs for piping, smaller sizes and lower maintenance costs over infrastructure lifespan.
- Amenity, streetscape and overall physical environment become more diverse and attractive; places become a destination rather than spaces to endure in transit.



**New Lynn Brownfield: Preliminary Options<sup>1</sup> for LID<sup>2</sup> Applications Based on Waitakere City District Plan Change 17  
Guide to the Relationship Between Charts and Plan Change Map of Human Environments**

Marjorie van Roon

Centre for Urban Ecosystem Sustainability (CUES), and Department of Planning, University of Auckland

**Chart 1: Living to Living 5 + Hierarchy of Roads**

**Legend**

- Area of Plan Change
- Community (New Lynn)
- Living 1
- Living 2
- Living 3
- Living 4
- Living 5
- Living 6
- Living 8
- Open Space
- Special Areas
- Working (New Lynn)

**Chart 3: Carparks and Ecoroof Opportunities**

**Chart 4: New Community Areas**

**Proposed Plan Change 17  
Waitakere District Plan: Human  
Environments.**



**Chart 2: Ambrico Place Working to Living 5**

**Chart 5: Crown Lynn Place Working to Living 6**

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- Options depicted in these charts reflect a 'first cut' assessment of LID application. This assessment is mostly focused on stormwater and has not been undertaken as part of an integrated catchment management process.
- LID (Low Impact Design) is a subset of what the CUES research team has defined as LIUDD (Low Impact Urban Design and Development). For further explanation see CUES working paper 051 by van Roon and van Roon, 2005.

# New Lynn Brownfield: Preliminary Options for LID Applications Waitakere City District Plan Change 17, Human Environments. Living in Transition to Living 5 (Caspian Close) and Hierarchy of Road Types Marjorie van Roon

Centre for Urban Ecosystem Sustainability, and Department of Planning at the University of Auckland, August 2005.

**Local Streets** could have improved amenity and biodiversity and also treat and recycle stormwater



**Fig.1 Caspian Close**, New Lynn, a residential street in the north-west of the Proposed Plan Change area, has conventional form and stormwater conveyance.



**Fig.2 Neighbourhood streets** (Reid, Upper Delta, Caspian) might be retrofitted with raingardens, meandering street form and no curbs or stormwater drains.

**Caspian Close** design approximates a desirable LIUDD urban layout with 2 storey houses and sufficient open space. Both here and in a more conventional housing area east of the Whau Estuary (Fig.7) increased revegetation and source control of stormwater is needed, e.g., porous paving (Fig.6) and sharing instead of splitting (Fig. 7) of driveways or installation of water tanks Figs.10 and 11.

**Fig.8 New Lynn Hierarchy of Roads**  
 Map from Waitakere City Council PPC17



**Codes:** These applications would apply methods identified by the following LIUDD codes (van Roon and van Roon, 2005):  
 favour vertical over horizontal form 3.1B, swales 3.2.13, raingardens 3.2.14, biofiltration 3.2.15, porous paving 3.2.16, contaminant removal 3.3.1, water tanks 3.2.31, priority use of indigenous species 3.4.2, re-vegetation of private lots 3.4.4.

**Fig.3 Caspian Close:** The tree and grass enclosed parking bays in this turning circle island could equally well accommodate a raingarden (Fig.4) or verges might accommodate grass swales (Fig.5) to decontaminate uphill road runoff.



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**Fig.9 Conventional housing and paving** in the north-west sector of the Proposed Plan Change area.  
 Photo: City of Vancouver

**Fig.7 Three separate parallel driveways**  
 Reference: van Roon, M. and van Roon, H., 2005. Low Impact: Urban Design and Development Principles for Assessment of Planning, Policy and Development Outcomes. Centre for Urban Ecosystem Sustainability Working Paper 051. This chart was peer reviewed by Jennifer Dixon and Ilan van Roon, CUES and University of Auckland.



**Fig.10 Residential water tank**  
 Left above: Fig.12 shows a biofiltration basin on side of busy main street and Fig.13 above right, shows a biofiltration strip in the centre of the street



**Fig.11 Water tank** (left) beneath back deck of house (right)



**Fig.14 Great North Road** has high traffic volumes



**New Lynn Brownfield: Preliminary Options for LID Applications**  
**Waitakere City District Plan Change 17, Human Environments Working in Transition to Living 5. An example: Ambrico Place Housing Estate**  
**Marjorie van Roon**  
 Centre for Urban Ecosystem Sustainability, and Department of Planning, University of Auckland, August 2005

Ambrico Place 2005



Fig.1 Ambrico common area



Fig.5 Vacant land at Ambrico



Fig.9 Ambrico back street slope to right could be retrofitted with a bioinfiltration garden as in Fig.16



Fig.16 Bioinfiltration garden

Ambrico Commons (1) could be re-landscaped to cater to water recycling in addition to recreation and amenity. Examples include stormwater and greywater wetlands (2, 3 and 6), greywater subsurface treatment (3) for re-use in toilets, raingarden (4) or bioinfiltration gardens (14 and 16) to process roof or path stormwater, store water in underground detention beneath commons to supply a water feature (7). Similarly, yet to be developed areas of Ambrico (5) could be designed to incorporate features shown to right (2 to 16). Stormwater volume and contaminants from roads (9, 11, 17, 18) could be reduced. A back street (9) slopes to the car-line at the right of photo where porous paving (12) or a narrow bioinfiltration trench (16) could be retrofitted. The low-point gutter-line between road and garage aprons on Ambrico Place (18) might be retrofitted with infiltration groove (13) and on left side of the same street there is opportunity for porous paving (13 and 15) under carparks. The garage entry side alley (11) might be resurfaced with porous paving (12) or incorporate infiltration grooves (13).

**Codes:** These applications would apply methods identified by the following LIUDD codes (van Roon and van Roon, 2005): swales 3.2.1.3, raingardens 3.2.1.4, bioinfiltration 3.2.1.5, porous paving 3.2.1.6, onsite detention 3.2.1.7, greywater system 3.2.2.9, wetland 3.2.2.6



Fig.10 Ambrico playground



Fig.11 Ambrico garage entry side-alley

Fig.18 Ambrico Place



Fig.2 Wetland gardens



Fig.3 Wetland gardens and greywater treatment system



Fig.6 Wetland in housing estate common area has slab stepping - stones



Fig.7 Water feature in housing estate common area



Fig.8 Swale greenway between and to rear of row houses



Fig.15 Grass parking medium



Fig.13 Infiltration groove in street (Photo: www.waterbest.nl)



Fig.12 Porous paving parking area



Fig.14 Bioinfiltration style front-yard gardens



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**Reference:** van Roon, M. and van Roon, I., 2005. Low Impact Urban Design and Development Principles for Assessment of Planning, Policy and Development Outcomes. Centre for Urban Ecosystem Sustainability Working Paper 051  
**This chart was peer reviewed** by Jennifer Dixon and Henri van Roon, CUES and Department of Planning, University of Auckland.

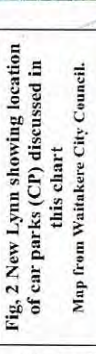
## Waitakere City District Plan Change 17, Human Environments, Carparks and Ecoroof Opportunities in Commercial Areas

Marjorie van Roon

Centre for Urban Ecosystem Sustainability, and Department of Planning, University of Auckland, August 2005.



**Fig. 1** The Lynnmall shopping centre carpark is shown in Fig. 1 and located as CP1 in Fig. 2. Extensive impervious surfaces are segmented by raised and curbed islands of lawn. Redevelopment of some of the lawn areas as biofiltration strips (Fig. 4 and 5) or basins (Fig. 5 and 6) with cut curbs would enable stormwater volume and contaminant reduction. Other lawn areas should be revegetated as explained on the right of this chart.



**Fig. 2** New Lynn showing location of car parks (CP) discussed in this chart  
Map from Waitakere City Council.



**Fig. 10**



**Fig. 11**



**Fig. 12**

Both Ecoroof construction (Fig. 13 and 14) and the landscaping of carpark areas with shrub ground cover (Fig. 11 and 12) rather than mown grass increases leaf mass and surface area thereby increasing rain interception and evapotranspiration. If priority is given to indigenous species this will contribute to reducing the decline of New Zealand biodiversity. Carpark buildings Fig. 10 can be covered in vegetation. If half of the site of CP1 (Fig. 1) or of CP2 (Fig. 9) were used to build such a building the other half could be re-landscaped. This would further increase biodiversity and permeability without a decline in parking lots. There are economic implications and the re-landscaped areas would require protection.



**Fig. 3**

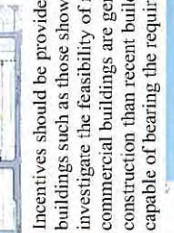
Ponding or carpark flooding is prevented during large storm events by overflow drains as seen in Fig. 3 and 6.



**Fig. 4**



**Fig. 5**



**Fig. 6**

Incentives should be provided for owners of commercial buildings such as those shown in Fig. 9 and Fig. 15, to investigate the feasibility of retrofitting Ecoroofs. Older commercial buildings are generally of heavier construction than recent buildings and may therefore be capable of bearing the required weight.



**Fig. 13**

**Fig. 14** Ecoroof



**Fig. 7** The demonstration above showed the speed and efficiency of porous paving, laid on an appropriate base substrate, for infiltrating stormwater.



**Fig. 9** Extensive carpark areas between commercial buildings in Delta Street (CP2 Fig. 2) and the banks of the Whau Estuary provide opportunities for contaminant capture and stormwater runoff reduction as discussed above.



**Fig. 15**

Fig. 15 Existing buffer of vegetation against walls and throughout riparian zone to right provide protection to the adjacent Whau Estuary where it passes under Great North Road



**Fig. 16** Ecoroof on Reid St. garage

**Codes:** These applications would apply methods identified by the following LIUDD codes (van Roon and van Roon, 2005): biofiltration 3.2.15, porous paving 3.2.16, contaminant removal 3.3.1, ecoroofs 3.2.18, priority use of indigenous species 3.4.2, riparian protection 3.2.4, urban form 3.1B.

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**Reference:** van Roon, M. and van Roon, H., 2005. Low Impact Urban Design and Development Principles for Assessment of Planning, Policy and Development Outcomes. Centre for Urban Ecosystem Sustainability Working Paper 051  
This chart was peer reviewed by Jennifer Dixon and Ilan van Roon, CUES and University of Auckland.

**New Lynn Brownfield: Preliminary Options for LID Applications**  
**Waitakere City District Plan Change 17, Human Environments. An example: New Community Areas**  
**Marjorie van Roon**  
 Centre for Urban Ecosystem Sustainability, and Department of Planning, University of Auckland August 2005



**Fig.1** New Lynn library under construction with planter boxes in foreground



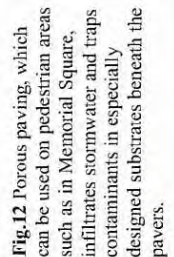
**Fig.2** Appropriately designed gardens can disperse, treat, evaporate stormwater from roofs.



**Fig.3** Appropriately designed planter boxes can treat stormwater from patios and roofs.



**Fig.4** Entry to Memorial Square, New Lynn. The grassed areas in Figures 5 and 6 are on the right of this view.



**Fig.5** Memorial square retrofit opportunity for a swale, grass swale or raingarden. This grass verge is adjacent to the swale in Fig. 6.



**Fig.6** Memorial square existing swale, grass swale or raingarden. This maintenance at an optimal length is a management challenge.



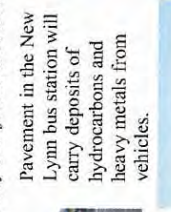
**Fig.7** Back of New Lynn Community Centre



**Fig.8** A water feature that uses recycled water



**Fig.9** Green the walls



**Fig.10** Green the roof



**Fig.11** Memorial Square pillars some of which have a water feature that could use recycled stormwater from the roof of the library or adjacent bus shelters as in Fig. 14.



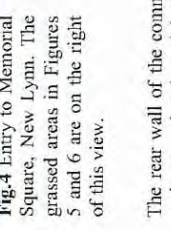
**Fig.12** Porous paving, which can be used on pedestrian areas such as in Memorial Square, infiltrates stormwater and traps contaminants in especially designed substrates beneath the pavers.



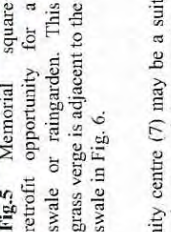
**Fig.13** The garden on the down-slope of the New Lynn bus station may be suitable for a rain garden. The tree planter to right (14) might be replaced by a mini wetland (16) receiving runoff from the bus shelter roof above.



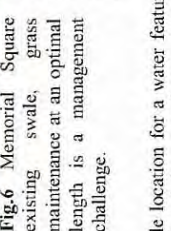
**Fig.14** Pavement in the New Lynn bus station will carry deposits of hydrocarbons and heavy metals from vehicles.



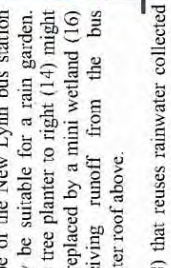
**Fig.15** Artificial wetland series in paving



**Fig.16** Miniature artificial wetland embedded in busy pedestrian promenade



**Fig.17** Parking area behind New Lynn community centre



**Fig.18** Cut curb

The rear wall of the community centre (7) may be a suitable location for a water feature (8) that reuses rainwater collected from the centre roof and stored either underground or in a slab shaped water tank between the wall and the water feature. The parking area behind the community centre (17) requires changes to improve functionality of the biofiltration strip. Solid wheel blocks should be broken (18) to enable stormwater entry. The parking area on the right side of the carpark (17) requires re-sloping towards, not away from, the biofiltration strip.

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## New Lynn Brownfield: Preliminary Options for LIUDD Applications Working in Transition to Living 6. An example: Crown Lynn Place Marjorie van Roon

Centre for Urban Ecosystem Sustainability, and Planning Department at the University of Auckland

As only a small proportion of the proposed Living 6 Environment near Crown Lynn Place has as yet been redeveloped there is an opportunity to implement some of the LIUDD principles (van Roon and Roon, 2005) relating to urban form. That is, requirements relating to Living 6 in the District Plan might be crafted to facilitate the achievement of both 15% effective impervious surface ratios along with high levels of biodiversity and amenity. This could be done through the control of building footprints, revegetation of grounds, roofs and walls, and installation of biofiltration devices, water tanks and water recycling systems. The images on this chart demonstrate examples from elsewhere of the application of these methods within high density housing estates which could be created in the Living 6 Environment of New Lynn. In addition, the existing apartment complex in Crown Lynn Place could be retrofitted with alternative stormwater devices discussed in other charts.



**Fig.1** Apartment building in Crown Lynn Place



**Fig.2** Further apartments in Crown Lynn Place, adjacent to those in Fig.1



**Fig.3** Extensive grounds of apartment complex with shrub to tree height re-vegetation and biofiltration strip in road centre in foreground



**Fig.4** Wetland gardens between apartment buildings. Wetlands are irrigated by recycled water.



**Fig.5** Biofiltration gardens adjacent to back wall of apartment block



**Fig.6** Street verge infiltration galleries under construction



**Fig.7** Abundant shrub to tree height vegetation to facilitate rain interception, and evapotranspiration, and opportunities to infiltrate rain and greywater, is demonstrated



**Fig.8** Use of locally sourced indigenous plants (unlike the ivy around an Auckland high rise as shown in Fig.18) is necessary for biodiversity enhancement.



**Fig.9** Pile of demolition rubble on vacant Living 6 site next to apartments shown in Figs.1 and 2



**Fig.10** Artificial hills of the grassed open space Fig.11 overlay a vast stormwater storage reservoir supported by the matrix shown in Fig.12



**Fig.11** Stormwater is used for irrigation. Tanks, fenced from view (Figs.16 and 17) store rainwater from the roofs of apartment buildings.



**Fig.12** Stormwater storage reservoir



**Fig.13** Matrix supporting the reservoir



**Fig.14** Matrix supporting the reservoir



**Fig.15** Vacant Living 6 site next to Monier: special area



**Fig.16** Stormwater tanks



**Fig.17** Stormwater tanks



**Fig.18** Ivy around an Auckland high rise

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Reference: van Roon, M. and van Roon, Il., 2005. Low Impact Urban Design and Development Principles for Assessment of Planning, Policy and Development Outcomes. Centre for Urban Ecosystem Sustainability Working Paper: 051  
 This chart was peer reviewed by Jennifer Dixon and Henri van Roon, CUES and Department of Planning, University of Auckland.



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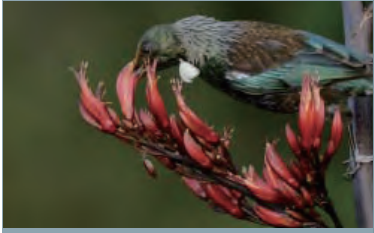
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