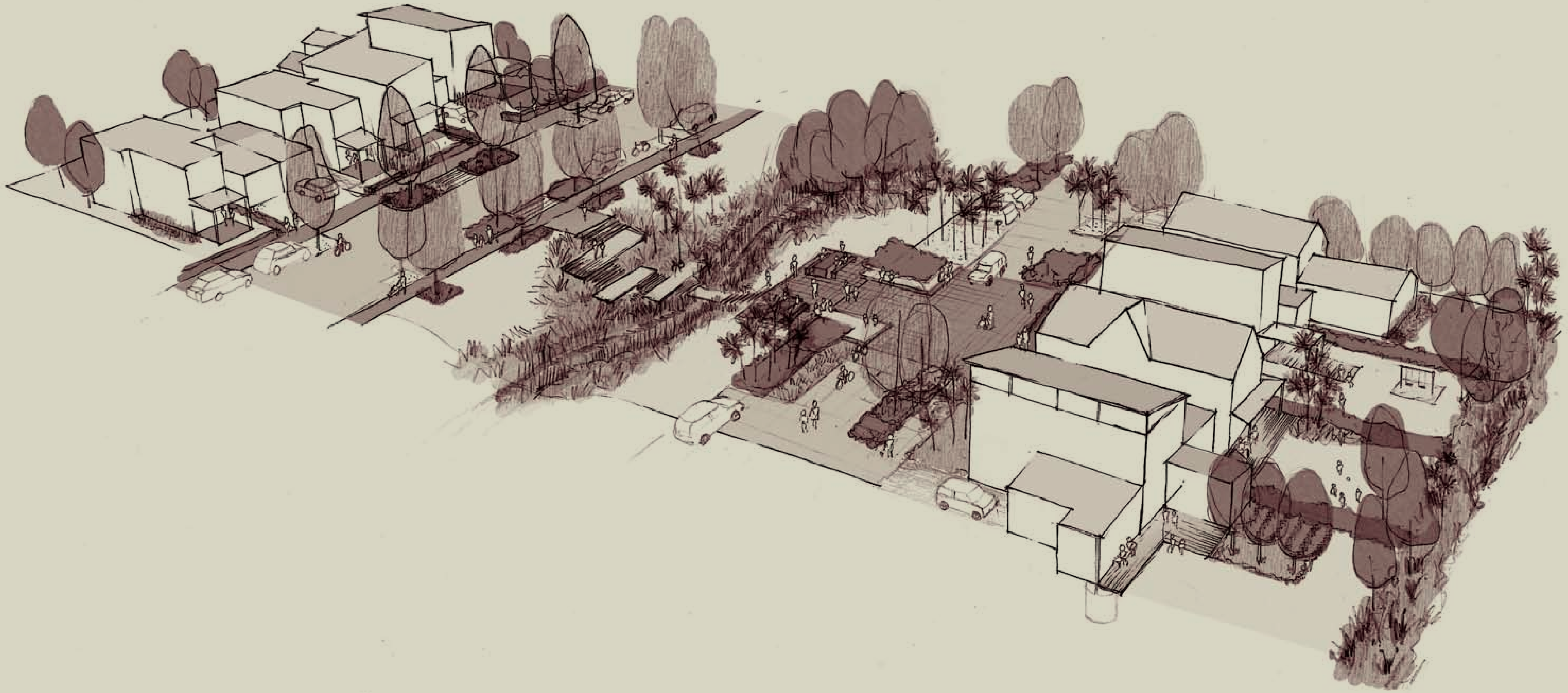
THE INTEGRATION OF LOW IMPACT DESIGN, URBAN DESIGN, & URBAN FORM



Auckland
Regional Council
TE RAUHĪTANGA TAIAO

TECHNICAL REPORT – FIRST EDITION.

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EXECUTIVE SUMMARY

The Technical Report, 'The Integration of Low Impact Design, Urban Design and Urban Form', commissioned by the Auckland Regional Council (ARC), seeks to reconcile existing approaches for Low Impact Design (LID) with urban design and urban planning objectives for the region. The TR utilized the following steps to examine this subject (refer Figure 1):

1. Comparison of accepted principles for LID and Urban Design.
2. Examination of LID approaches integrated with urban design principles.
3. A methodology or 'Toolkit' to inform integrated planning and design at a variety of scales and urban typologies.

Principles for Urban Design were based on the Ministry for the Environment (MfE) Urban Design Protocol. It was noted that urban design encapsulates a broad field of interest, with a specific bias toward socio-cultural and economic aspects of the urban environment. **Principles for LID** were based on ARC's Technical Publication (TP) 124. LID is seen as focusing primarily on the protection and enhancement of natural resources by means of managing soil and water sustainably.

Despite the divergent focus of Urban Design and LID, there is significant crossover between both practices. As a means to compare LID and urban design perspectives, the TR aligned the Seven C's of the MfE urban design protocol with TP124's LID principles in a table that depicts potential synergies and conflicts between the practices.

The most striking synergies were found to be

- An integrated design process that utilises comprehensive assessment by inter-disciplinary teams.
- Intensification of built form to protect environmental resources (as LID promotes) and to accommodate transit and mixed use commercial centres (as urban design promotes).
- Design innovation resulting from the collaboration of divergent professional disciplines.
- Design that is responsive to potential environmental and social values.
- Adherence to sustainability models, specifically the optimization of resources to achieve multiple objectives.
- Assisted by flexible planning provisions to allow responsive design outcomes.
- Quality of life and quality of environments as inter-connected goals.
- Achieving social and environmental infrastructure within legible and connected frameworks.

Potential conflicts that were identified include:

- A creative tension between the dendritic pattern of natural systems and the connective street patterns (or grid) that urban design promotes. Methods to reconcile this conflict are discussed within the text. The subject is worthy of further study.
- The impact on receiving environments through urban intensification can be remedied to the extent practicable through comprehensive planning at complementary scales (site, catchment and region) to provide for urban and environmental frameworks.
- Increase in imperviousness due to urban intensification can be mitigated by LID treatments appropriate to the relevant urban density, with a goal to disconnect stormwater from reticulated systems rather than reduce the level of imperviousness.

The integration of LID and urban design practices is already significantly developed in the Auckland region. The TR identified **contemporary LID approaches that respond to urban design objectives**. They include:

- Engagement of the public to achieve decentralized stormwater treatments on private lots (including stream restoration across multiple land owners)
- Passive stormwater treatment in open space areas.
- The use of stormwater reserves for passive recreation.
- Conservation and remediation of permeable soils in situ.
- The collective management of water services (potable, waste, storm and grey) to allow for re-use scenarios.
- Micro-grading to evenly distribute flows across urban surfaces, optimizing above ground detention, reducing erosion from laminar flows, and increasing time of concentration in catchments.
- Regional perspectives to direct stormwater management resources toward focus catchments and the most sensitive or valuable receiving environments.
- Grey water treatment and use of irrigation in the landscape.
- Opportunities for the celebration or interpretation of stormwater management in urban spaces.
- Integration of stormwater management devices with architecture (e.g. green roofs).
- Retrofit of adapted natural systems to urban environments (e.g. stream daylighting).

Streets were highlighted as an urban element where LID and urban design integration has the most significant potential. These corridors have the potential to be reinvented as shared space plazas, lineal open spaces, multi-modal transport corridors, and stormwater treatment facilities. The 'Living Street' concept blurs distinctions between public and private realms, roads and open spaces, and impervious and pervious surfaces to provide for flexibility of use and character.

A review of urban design and LID planning provisions for the Auckland Region was undertaken to identify the existing promotion of integrated practices. Opportunities were identified for:

1. Further integration of LID and urban design principles in RMA and LGA planning documents.
2. Appropriate guidance for LID and urban design objectives based on multiple planning scales.
3. Integration of LID and UD as appropriate for representative urban and environmental typologies, to provide for comprehensive (and transitional) responses across the region

The "Toolkit" for the integration of LID and urban design is a response to the opportunities identified in the planning review. Complementary scales of environmental and social orders were illustrated such as the 'region' (municipality or super-city), the 'catchment' (or community), and the 'site' (or neighbourhood) scale. For each of the three scales of region, catchment, and site, the toolkit recommended:

1. A comprehensive planning framework based on scale-specific assessment and analysis
2. Integrated design responses based on urban and environmental transitions

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INTRODUCTION

Low impact design (LID) is a development approach that utilizes natural systems and processes for the management of erosion and stormwater. In 2000 the Auckland Regional Council published the Technical Publication (TP) 124 Low Impact Design Manual for the Auckland Region, a guideline to the principles and practices of LID. The publication can be accredited with advancing LID approaches throughout New Zealand.

The primary focus of TP124 was 'greenfield' (undeveloped) sites. The TP promoted clustered urban form to reduce development effects, but otherwise did not explore aspects of urban design or urban planning.

Since the publication of TP124, LID treatments, have been advanced in urban centers and retrofitted in existing developed sites. At the same time, LID approaches have broadened to include socio-cultural aspects of stormwater and erosion management.

Auckland Councils are signatories to the Urban Design Protocol. At the same time, the Auckland Sustainability Framework, states one of its goals to be the utilisation of Low Impact Design to achieve a "unique and outstanding environment". Therefore this document seeks to assist planners, consent staff, developers, and consultants to understand the intersection of these two broad disciplines (LID and urban design), in terms of their synergies and conflicts, and the potential mechanisms to achieve their integration.

Figure 1 indicates the outline of this technical report (TR), where the following subjects are examined:

1. Comparison of accepted principles for LID and Urban Design.
2. Examination of integrated LID approaches (inclusive of urban design principles).
3. A methodology or 'Toolkit' to inform integrated planning and design at a variety of scales and urban typologies.

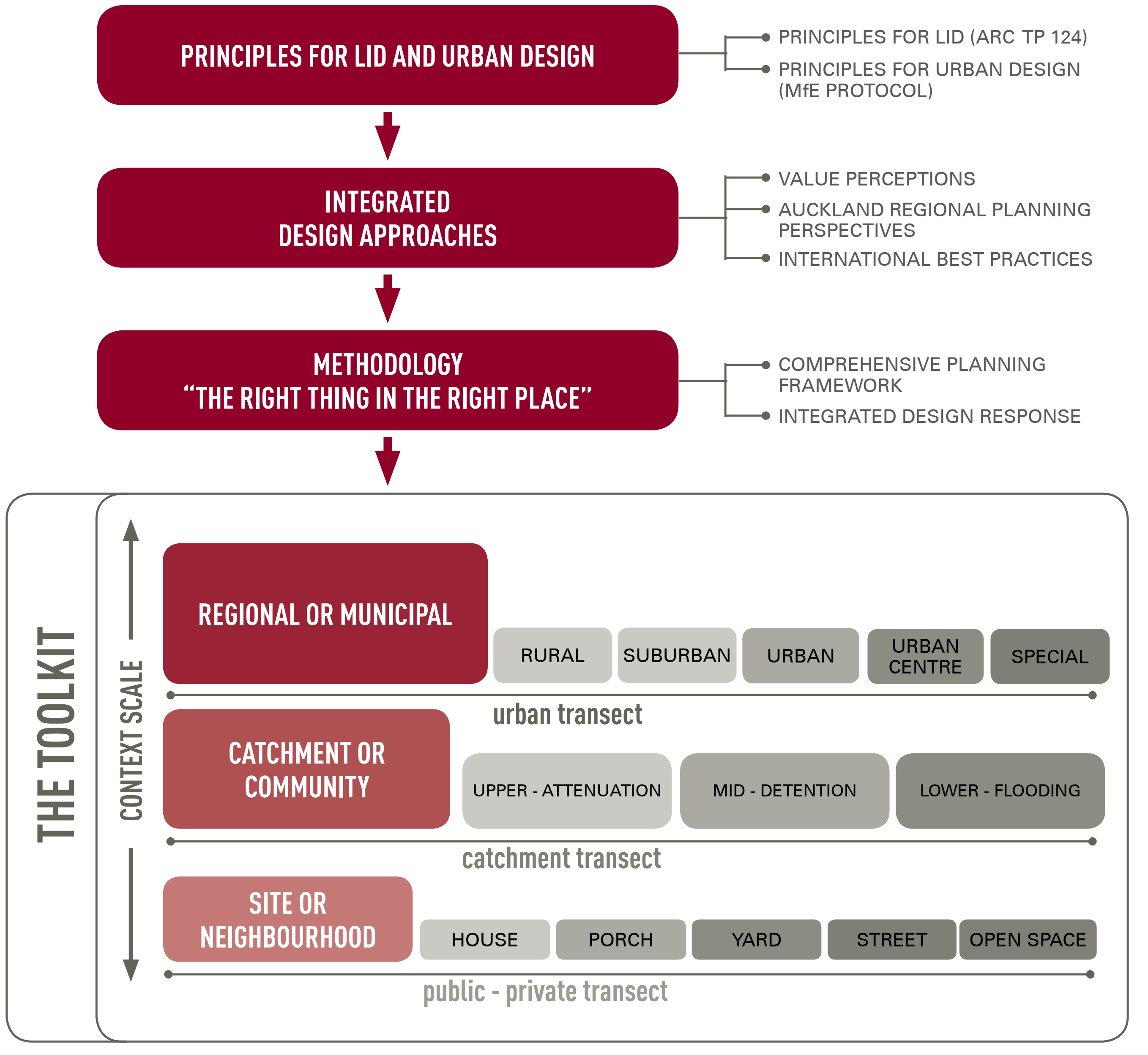
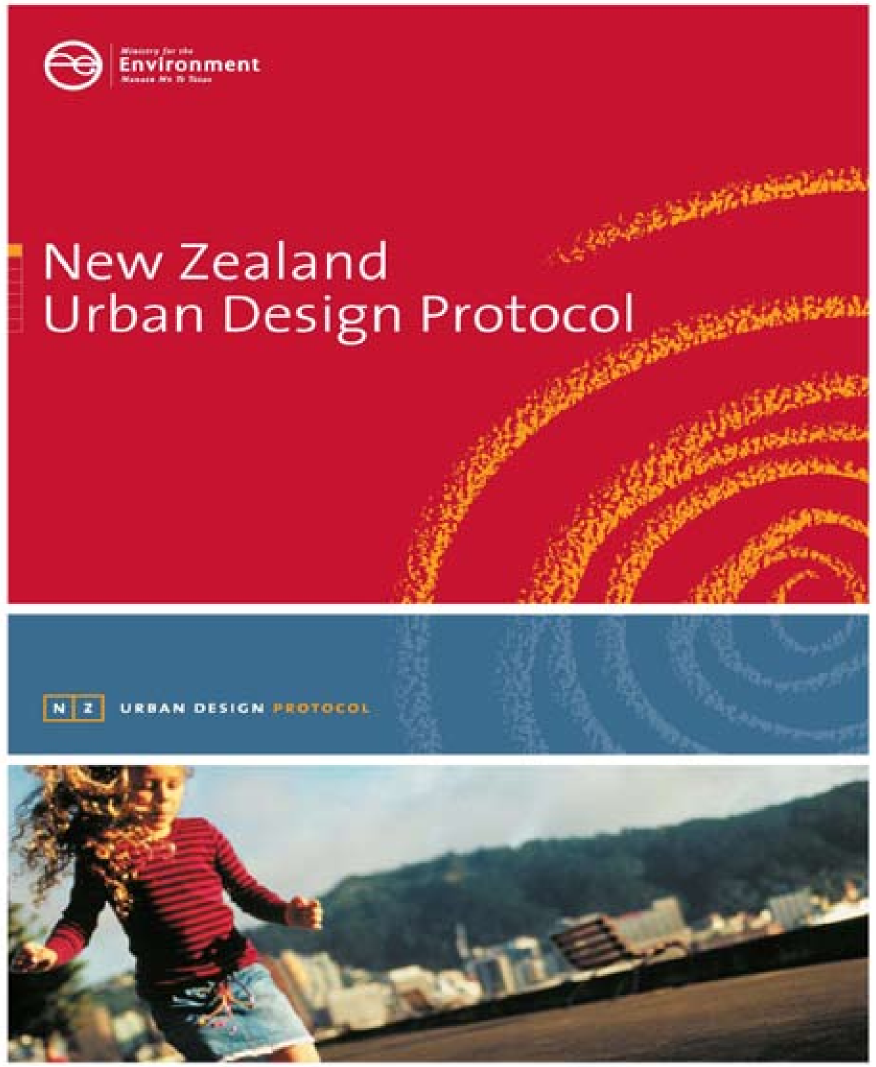


Figure 1: Outline fo the Technical Report - The integration of LID and Urban Design

COMPARISON OF PRINCIPLES FOR URBAN DESIGN AND LID



In order to understand the potential synergies and conflicts between urban design and LID, a preliminary step compares accepted guiding principles for each. These are introduced below, as they are taken from the ARC's LID design manual TP124 (2000) and the Mfe Urban Design Protocol (2005).

URBAN DESIGN

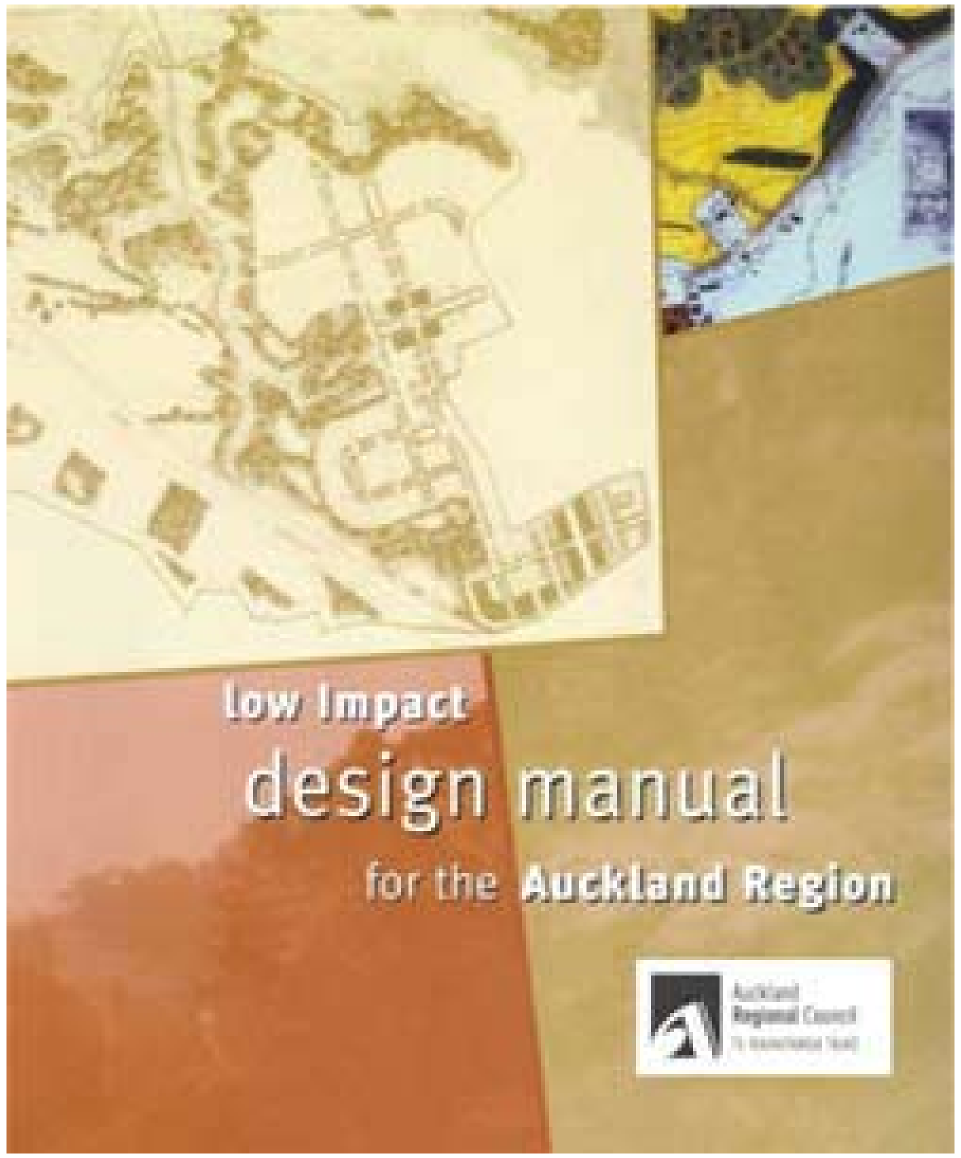
> Urban Design is concerned with the design of the buildings, places, spaces and networks that make up our towns and cities, and the ways people use them. It ranges in scale from a metropolitan region, city or town down to a street, public space or even a single building. Urban design is concerned not just with appearances and built form but with the environmental, economic, social and cultural consequences of design. It is an approach that draws together many different sectors and professions, and it includes both the process of decision-making as well as the outcomes of design.
>
> (New Zealand Urban Design Protocol, MfE 2005)

The New Zealand Urban Design Protocol is a central government initiative to improve the quality of the urban environment. The definition above would suggest that urban design is an holistic design approach, with a broad interest in environmental, economic and socio-cultural outcomes for urban environments.

To facilitate quality outcomes for urban design the MfE set out seven essential design qualities, known as the "7 C's". The 7 C's are summarised in the Executive Summary of the NZ Urban Design Protocol as:

1. Context: seeing buildings, places and spaces as part of whole towns and cities.
2. Character: reflecting and enhancing the distinctive character, heritage and identity of our urban environment.
3. Choice: ensuring diversity and choice for people.
4. Connections: enhancing how different networks link together for people.
5. Creativity: encouraging innovative and imaginative solutions.
6. Custodianship: ensuring design is environmentally sustainable, safe and healthy.
7. Collaboration: communicating and sharing knowledge across sectors, professions and with communities.

Signatories to the Protocol include central and local government agencies, developers, and design professionals. Signatories undertake to seek to achieve the design qualities outlined in the 7 C's. All the territorial authorities in the Auckland Region are signatories to the Protocol. The 7 C's represent a benchmark set of principles for the purposes of this report for comparison with principles for LID.



LOW IMPACT DESIGN (LID)

Low Impact Design is a design approach for site development that protects and incorporates natural site features into erosion and sediment control and stormwater management plans.

(ARC TP124 Low Impact Design Manual for the Auckland Region, ARC 2000)

Common to all of the approaches and practices comprising low impact design are five basic principles stated in the ARC Technical Publication 124, 'Low Impact Design Manual for the Auckland Region'. These are the following:

1. Achieve Multiple Objectives:

   Address peak rate and volume control as well as water quality control and temperature maintenance. Ideally provide for simple yet comprehensive solutions that cater for complex problems.

2. Integrate stormwater management and design early in the site planning process:

   Investigate stormwater issues during site assessment to inform land use typologies, and integrate stormwater management with developed concepts.

3. Prevent rather than mitigate:

   A paradigm shift for site planning that provides for stormwater management at-source and during conveyance rather than at the bottom of the catchment. This also relates to the construction process, reducing disturbance and therefore potential entrainment of sediment.

4. Manage stormwater as close to the point of origin as possible; minimise collection and conveyance:

   Minimise the concentration of stormwater in pipes by maintaining natural hydrology and thereby reducing the impact of flow volumes, contaminants and flow velocities on the receiving environment.

5. Rely on natural processes within the soil mantle and the plant community:

   Utilise physical processing (e.g. filtration), biological processing (e.g. microbial action), and chemical processing (e.g. cation exchange capacity) to reduce contaminants in stormwater.

Other repeated directives in TP124 include:

- Protection of the receiving environment and its habitats from potential cumulative stormwater effects.
- Clustering of development form to protect sensitive environments.
- Reduction in impervious surfaces.
- Protection of natural character and landscape amenity values.
- Provision of passive recreation in stormwater management areas.

SYNERGIES AND CONFLICTS BETWEEN URBAN DESIGN AND LID

Both the wording of the urban design protocol (inherently focused on community and people-oriented outcomes), and existing district planning provisions for urban form in the Auckland Region would suggest Urban Design has a specific bias toward socio-cultural and economic aspects of urban environments. Practitioners in Urban Design are generally aligned with the design of built environments as urban planners and architects.

LID's general focus is the protection and enhancement of natural resources by means of managing soil and water sustainably. In this way, LID appears more closely aligned with environmental and infrastructure-based professions, including engineering, landscape architecture, and ecology.

Despite the divergent focus of Urban Design and LID there is significant crossover between both practices. Both LID and urban design represent an inherently inter-disciplinary approach, which is the basis for integrated design. Their approaches take into account diverse interests, even though their specific focus may be polarized toward environmental or social outcomes (refer Figure 2).

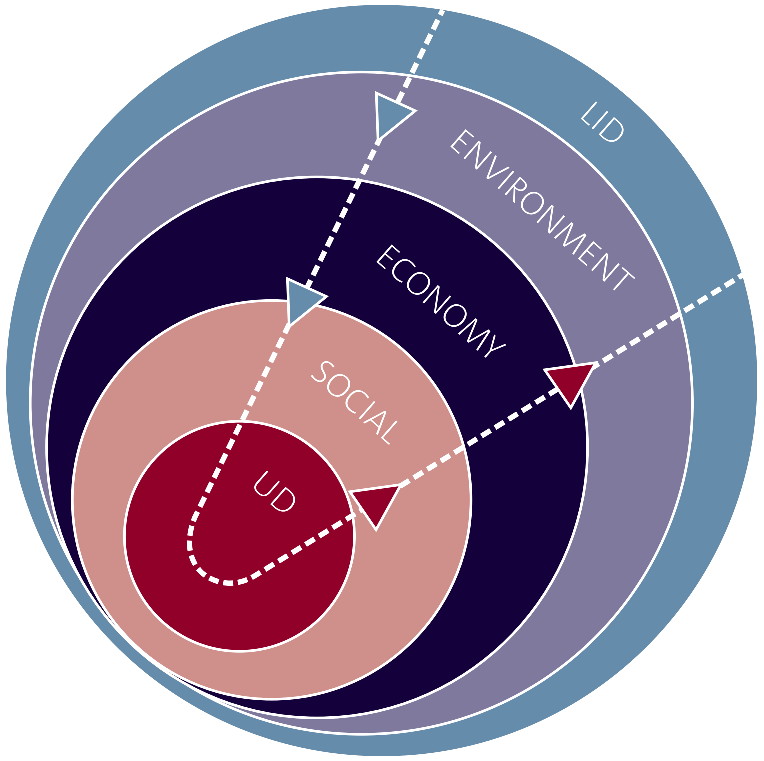


Figure 2: The sphere of influence for design approaches with an LID bias toward environmental resources and an urban design (UD) bias toward socio-cultural interests.

As a means to compare LID and urban design approaches, the MfE's Seven C's have been aligned with TP124 LID principles in Table 1. The table depicts both potential synergies and conflicts between these design approaches. The most striking synergies are as follows:

- Integrated design process based on comprehensive assessment by multi-disciplinary teams.
- Intensification of built form to protect environmental resources (as LID promotes) and to accommodate transit and mixed use commercial centres (as urban design promotes).
- Design innovation resulting from the collaboration of divergent professional disciplines.
- Design that is responsive to future potential environmental and social values.
- Adherence to sustainability models, specifically the optimization of resources to achieve multiple objectives.
- Proponents of flexible planning provisions to allow responsive design outcomes.
- Quality of life and quality of environments as inter-connected goals.
- Achieving social and environmental infrastructure within legible and connected frameworks.

There are also challenges for the integration of LID and urban design. These are primarily the counter-position of natural (organic) and urban (linear and grid-like) forms, and the conflicts of urban intensification vs protection of natural resources.

There is a creative tension between the dendritic pattern of natural stream systems and the connective street patterns (or grid) that urban design promotes. The means to reconcile these conflicting patterns occurs at the fundamental level of movement in the site. It is a matter of interlacing natural and built elements in the most appropriate ways to optimize objectives for each system. Some potential responses include:

- Adapt the urban grid in response to existing topography and landform.
- Convey water along streets, or within streetscapes as water features.
- Allow flexible rules for carriage width and riparian buffers.
- Favour pedestrian crossings in strategic locations based on travel distances.
- Provide for "shared surface" streets which integrate with riparian open spaces.
- Mitigate road crossings of streams by enhancing stream habitats elsewhere (internal to blocks).
- At road crossings provide for extended stream corridors to accommodate bridge abutments, landscape transitions, and enhanced habitat above and below culverts.
- Continue landscape connections using green elements in the built environment (e.g. planted walls, roofs, raingardens etc).

Another potential challenge to the integration of LID and urban design approaches is achieving urban intensification while preserving environmental resources. These seemingly divergent objectives can be reconciled in the following ways:

- Plan for urban frameworks, patterns of infrastructure, and natural systems at appropriate representative scales (region, catchment, and site) to achieve "the right thing in the right place".
- Utilise LID treatments (appropriate to specific urban typologies) to attenuate and treat stormwater prior to reticulated systems. Disconnection from reticulated systems is more important than reducing the level of imperviousness in terms of potential effects on the receiving environment.
- Where habitat is precluded, seek to achieve ecological connections, landscape amenity, environmental services, and interpretation of natural elements.
- Adapt environmental systems to account for urban constraints e.g. stream morphologies that are specific to urban environments.

These responses are represented in further detail in the methodology or "toolkit" section of this report.

Table 1: Comparison of LID and Urban Design Principles

THE SEVEN C'S	TP 124 PRINCIPLES: ACHIEVE MULTIPLE OBJECTIVES	INTEGRATE STORMWATER MANAGEMENT IN SITE PLANNING AND DEVELOPED DESIGN	PREVENT RATHER THAN MITIGATE TO IMITATE NATURAL HYDROLOGICAL PATTERNS	MANAGE STORMWATER AS CLOSE TO SOURCE AS POSSIBLE	RELIANCE ON NATURAL PROCESSES WITHIN THE SOIL MANTLE AND PLANT COMMUNITY
CONTEXT	Incremental development or re-development should contribute to a coherent overall planned environment to ensure quality outcomes e.g. the structure planning processes. Align stream and stormwater flows with open space and pedestrian networks to provide for connected reserves and permeability through neighbourhoods. Provide for 'green' infrastructure' to intercept dust, moderate noise, heat, and light, and treat water and air quality for positive outcomes to human health.	Design decisions should be informed by comprehensive planning frameworks at multiple scales of influence (the region, the catchment, and the site). Where the constraints and opportunities for a site are well understood, there is justification for seeking planning discretion to achieve flexible LID and development approaches. Designs that are responsive at the catchment scale protect aquifers and flood zones, retain natural drainage patterns to the extent possible, and provide for landscape and building typologies informed by stormwater management objectives.	Conflicts may arise between urban density objectives and preservation of natural resources and landscape elements. This may be reconciled by: • Balancing natural resource and urban design objectives from a regional planning perspective. • Providing planning flexibility to allow for site-appropriate lot size and environmental buffers. • Utilise LID treatments that are appropriate for urban typologies.	Attenuation of stormwater is a function of climate, vegetation, and geology, which are specific to a site's location and microclimate. The priority and potential for at-source stormwater management will also be based on the likely contaminant load of the proposed development, the means to convey stormwater through the site (system capacity), and the sensitivity and value of the receiving environment.	Retain and re-use a site's natural resources to the extent possible. This may require layout options to conserve permeable soils and their associated vegetation, for which detailed soils surveys may be required.
CHARACTER	Enhance natural character values associated with riparian margins, and stormwater treatment systems. Relate open space networks to a legible datum in the landscape – such as stream corridors. Bring stormwater into streets as a dynamic, audible, and reflective element to be celebrated in unique ways. Water play and water sculpture can be exciting, intriguing, and meditative for both children and adults, providing opportunities to soak and splash, cool by mist, or dampen street noise. Providing a suite of LID responses that respond to existing community character. Integrate architecture, urban form and landscape in sympathetic and responsive ways. Responses may be distinctive to emphasize contrast or provide for transitional elements to draw natural and built elements together. Interpret water treatment in the landscape for cultural values – relating to cultural health, water extraction, and habitat	The protection and enhancement of natural character, heritage, and cultural values is the basis for a community's 'sense of place'. To practically achieve development form, it may sometimes be necessary to limit character elements to priority or representative examples. It is possible to approximate the inherent character of natural systems in urban environments. For example, to imitate the hydrology of a catchment, lower catchment areas may utilize wet swales and wetland reed beds to reference water in the landscape, while upper catchment areas, may wick water away quickly in highly permeable raingardens with corresponding 'dry ridge' species. These systems may compliment natural elements retained in the landscape, such as ridgeline remnants on protected aquifers, or natural streams and wetlands in gullies.	Natural character elements may be utilised for stormwater function while contributing to neighbourhood character. For example upper catchment vegetation can integrate built form, attenuate stormwater in steep areas and provide for infiltration or filter-strip areas. Lower catchment riparian parks provide the amenity of a riparian landscape while also treating stormwater and providing flood controls. 'Street appeal' may require increased building density, and longer driveways to set garages back from building facades. The result may be an overall increase in impervious surface. However, the amount of imperviousness is not as relevant as the connection of these surfaces to reticulated systems. Therefore, the solution is to apply the appropriate LID treatment to attenuate and treat stormwater before it enters pipes. For example, stormwater runoff from highly impervious areas can be remedied through shared driveways, treepits in the streetscape, flexible road widths to increase road berms and open space, and permeable pavement materials.	LID devices can be integrated with architecture, lending the diversity of vegetation and the dynamic qualities of water to a building's character e.g. green roofs, green walls, hanging baskets, water walls, pools etc. Surface materials are also an important consideration for source control, balancing the desire for a specific materiality with a desire to control potential contaminant sources such as copper and zinc.	The preservation of natural character elements contributes to community character, natural heritage, and a 'sense of place'. This includes remnant vegetation, landform, and riparian areas, which as well as enhancing natural character and/or landscape amenity values also may act to attenuate and treat stormwater. Where existing resources are likely to be modified, allow for abstracted forms of natural systems, such as raingardens, treatment wetlands etc. These can provide targeted stormwater treatment while referencing natural character elements such as plant communities, riparian systems, and landform.

THE SEVEN C'S	TP 124 PRINCIPLES				
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CHOICE	Choice is assisted by planning flexibility, focused on achieving a "best for project" result. For example, lot boundaries are an enduring characteristic of development. Flexibility in lot size (based on an average density) allows for architectural and urban typologies that respond to environmental constraints, market choices, and urban design objectives.	LID enables "best-fit" stormwater management approaches based on physical context, project budget, and policy framework. LID is also adaptable for future development, custodianship, and maintenance. It is of benefit to the community to provide access to stormwater reserves and their associated open space areas, including for those with disabilities.	Retaining natural drainage patterns and open watercourses recognises their potential for enhancement, and their associated benefits and advantages. Correspondingly, removing open watercourses can be an opportunity cost by removing options for surface infrastructure.	Choice offers owner or tenants control of infrastructure and associated costs. In the future, a land occupier may be provided with 'future proofed' or parallel systems to choose stormwater harvest or on-site greywater systems. This is especially relevant to 'user pays' infrastructure systems such as Auckland.	Environmental buffers require a flexibility that ensures the most significant natural values are retained, without unduly compromising other development objectives. For example stream buffers can be designed to average widths, narrowing in some places to provide crossing points and an interface with the urban environment, and widening at other points to provide for larger riparian habitat areas and useable open space.
CONNECTIONS	Green networks can be integrally linked with riparian systems and stormwater management areas providing for enhanced passive recreation. Cluster development is promoted by both LID and urban design to optimize transportation nodes, encourage walkability, and reduce automobile infrastructure. An increase in pedestrian connectivity and a resultant decrease in automobile dependency has flow on benefits to both social and environmental values.	There is inevitably a creative tension between the dendritic (tree-like) pattern of natural stream systems and the connective street patterns (the grid) that urban design promotes. Some of the options to reconcile urban and natural patterns are discussed on page 4 above. Where there are objectives to reconnect or reform surface watercourses (stream daylighting), multiple alignment options are possible, including historic stream alignments, existing reticulated systems, existing overland flow paths, and open space connections.	The reduction in natural drainage patterns resulting from urban development can affect the ecological integrity and connectivity of natural systems. The means to reduce the potential impacts could include: • Protection of representative habitat types (including ephemeral watercourses) based on regional and catchment scales. • Reduce carriageways and impervious surfaces beside streams to optimise associated open space. • Provide for protected stream habitats internal to blocks with wider land management provisions. • Mitigate stream crossings by limiting culvert length, and providing for culvert habitat, and fish passage. • Recreate landscape and hydrological connections through LID and landscape treatments (raingardens, swales, streetscapes etc)	Public and private open spaces can be utilized for overland flow and to achieve treatment for filtering and attenuation. In terms of potential effects on the receiving environment, the level of imperviousness is less important than direct connections to reticulated systems. In other words, LID treatment trains have the potential to attenuate and convey stormwater to achieve a pre-development hydrology despite a high level of imperviousness in the catchment. These systems may even indirectly disperse stormwater flows to the receiving environment or to groundwater, avoiding any concentration in pipe systems.	Connections between natural and developed environments can be emphasised by transitional elements e.g. extending lighting, pedestrian paving etc into natural areas as appropriate for public access, or extending natural elements, such as water or representative plant species into streetscapes, and private yards.
CREATIVITY	Collaborative design provides opportunities to blur the lines between architecture, infrastructure, landscape, and ecology. Creative solutions for public-private transitions enhance general open space character, while retaining privacy. There are opportunities to interpret stormwater management through cultural interpretation in design work, and artwork installation. Water features can provide for enhanced public amenity and psychological well-being.	LID is inherently an innovative approach to stormwater management, a paradigm shift from reticulated infrastructure toward decentralized, passive, and dispersed systems. Creative solutions must also be robust in terms of function, requiring LID to adopt an inter-disciplinary approach to site design. Testing and designs early in the planning process will optimizes cross-benefits. There is potential at all aspects of the design process to incorporate innovative LID treatments, from responsive site layout, through grading, architectural responses, and dedicated treatment systems.	When restoring and rehabilitating natural environments in concert with development it is often possible to provide for a nett benefit, by replacing or mitigating for natural systems with rare and representative habitat types, and/or connected ecotone sequences. In an urban context and outside of the receiving environment, a site's natural resources and hydrological cycles may be abstracted in new, representative forms that retain their function while responding to built form.	Creative solutions for landscapes and architecture can capture, re-use and interpret stormwater as a resource (e.g. water source and passive cooling), a feature for delight (water walls, fountains, pools and channels), and an integrating element of the site – drawing water from architecture to landscape to open space in an understandable treatment train. New technologies and materials assist the creative process to push boundaries and provide for a unique development product.	Where areas are densely 'urbanised' it may still be possible to provide specific habitat types, and natural processes through the observation and abstraction of natural systems. This may be applied in a sustainable manner through a combination of hard and soft engineering responses. Examples include rain gardens, green roofs, reed beds, and subsurface wetlands. The abstraction and interpretation of natural systems in this way can enhance experiences of urban environments.

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CUSTODIANSHIP	LID treatment devices provide multiple benefits to a community, including landscape amenity, environmental services, and natural and cultural values. The inherent philosophy behind LID is for this management of resources in a manner that is responsive to the environment, the climate and the cultural milieu. An increasingly important objective for LID is to provide connections and open spaces that are safe from crime. This includes self-sustaining and low-maintenance designs to deter crime through the perception of well-kept infrastructure. LID is associated with environmental services that generally provide a positive impact for human health.	LID has a bias toward environmental resources. However, the integrated approaches of LID and urban design have the potential to address both social-cultural and environmental perspectives. This has a corresponding economic gain through resource optimisation and increased land values. For example, urban design responds to climate change issues through transit-oriented planning. LID works in parallel by reducing roading requirements and its associated effects to the environment via the promotion of cluster development. These forms of development have been shown to provide a level of open space amenity, flexibility, and community values that represent sustainable local economies and provide for increased re-sale value.	Custodianship is fostered by public awareness of LID benefits, which are perceived through the resulting environmental services, natural character values, and amenity values of treatment devices. Awareness of a treatment train and its impacts on the receiving environment is also important and can be interpreted in stream channels, stormwater devices, and their connecting elements. The primary means to optimize the natural heritage and natural character values for a site is the avoidance and enhancement of valuable or sensitive environments. This has added benefits through reducing the occurrence and risk factors associated with natural and human-induced hazards.	LID approaches provide for decentralized stormwater systems. This provides an opportunity for owners/occupiers to take stewardship of natural resources and stormwater devices within and adjacent to their properties. This may include individuals choosing how to harvest and dispose of water resources (with guidance of appropriate codes of practice). Decentralized management of stormwater is context-specific, with large landowners having increased opportunity for on-site stormwater systems, while dense urban areas may require some buy-in to collective centralized systems. LID encourages 'green' technology in the design and construction of buildings and infrastructure to incorporate renewable energy and passive systems.	A key objective of LID is the life supporting capacity of the receiving environment, which is highly relevant to inter-generational perspectives. This includes the appropriate design of infrastructure to enhance environmental performance. In general LID stormwater responses are concerned with 'treading lightly', through the preservation of existing resources and utilizing enhanced natural systems to mitigate urbanized stormwater inputs. Maintenance regimes for LID stormwater devices can be designed for natural succession and sustainable systems, allowing maintenance to relate more closely to stewardship.
COLLABORATION	As previously discussed, LID and urban design are both inter-disciplinary approaches that facilitate an integrated design outcome. Urban design objectives are primarily enriching community life, providing spatial legibility, and enhancing quality of life measures. LID primarily focuses on environmental resources, their ecological health, connection, and viability. A common vision between the two disciplines can be advanced through • Informed and empowering leadership • Celebration of good practice • Importance of training and research at national, regional, and local levels	LID's scope includes both natural systems and reticulated infrastructure, and therefore necessitates engagement with multiple asset management groups, including transportation, natural heritage, parks, urban design, and other 'waters' (potable, sewer, and grey water). Engagement with community groups is also important. Likewise, urban design is becoming increasingly associated with larger 'urban planning' exercises, involving multiple disciplines and sectors of government. Both practices facilitate an integrated design process based on comprehensive assessment and multiple objectives.	A collaborative approach to design provides a greater likelihood of a comprehensive site assessment. This will assist the identification of natural resources and patterns to be preserved, those that can contribute to environmental infrastructure, and areas that can accommodate built form.	Engagement with public and Iwi representatives will provide for local knowledge and will ensure natural systems, public open space, and stormwater treatment devices relate to community perspectives and objectives. The ideal outcome is a level of buy-in from the community to ensure the appropriate care and watching brief of stormwater treatment facilities. This provides opportunities for de-centralized stormwater management approaches or stream enhancements on private lots across multiple land owners. This may reduce the size and associated costs of lower catchment stormwater management responses.	Collaborative design of stormwater treatment devices introduces complementary 'hard' and 'soft' engineering approaches. In this way, robust engineering models can be complemented by a plant-soil-water interface. This provides water quality treatment utilizing the biotic, chemical, and physical processes of plant communities. Plants also act to stabilize slopes, filter and slow runoff, and moderate stormwater temperatures. Landscape treatment and open space planning that is responsive to engineering objectives and the function of natural systems can provide additional benefits to stormwater management.

AN INTEGRATED APPROACH

Urban Design and LID share an inherently inter-disciplinary design approach. Therefore the integration of LID and urban design is not only plausible, it is more likely to optimise development benefits, streamline design processes, and reduce the likelihood of unforeseen conflicts.

With the adoption of LID by diverse professional disciplines and the advent of increasing LID stormwater responses in urban environments, the integration of LID and urban design practice is already significantly developed. The following section investigates the basis by which this integration has occurred, through the following subjects:

1. Changing perceptions of stormwater in urban environments.
2. A review of national directions and international best practice in integrated LID and urban design.
3. Adoption of LID and urban planning and design practices for the Auckland Region.

PERCEIVED VALUES OF WATER IN URBAN ENVIRONMENTS

The progressive change of a city's perception of water is very effectively illustrated with the concept of the 'hydro-social contract' (refer Figure 3, Brown and Clarke 2007).

The illustration tracks a city's relationship with water along a timeline to a potential climax state where water is integrated for all its values into the urban fabric. The origin of many cities is based on a dependable water supply, navigable waterways, and water powered industries. Cities develop and water-courses become the most efficient means to remove waste, and are relegated to back lots and industrial corridors. The growth of cities leads to increased impermeable surfaces, and filled floodplains - flooded streams are channelised and piped to rapidly remove water from the city.

As cities intensify and resources become limited stormwater is again perceived as a resource, and natural systems are appreciated once more for their efficient treatment processes. Streams weave once more into the city's pattern their dynamic qualities and natural character values becoming a recognised feature of a city's amenity.

NATIONAL AND INTERNATIONAL APPLICATION

Landcare and the University of Auckland have undertaken research and case study assessments for LIUDD (low impact urban design and development), under a partnership for the Centre for Urban Ecosystem Sustainability (CUES). The CUES team promotes LIUDD as the integration of stormwater management with broader sustainability issues, including waste management, biodiversity, transportation, and energy efficiency (Ignatieva et al 2008).

Regions outside of Auckland vary in their approach to LID and urban design integration in accordance with relevant issues for that region. For example, Christchurch City Council have provided for surface water management that is integrally linked with catchment management planning, open space connectivity, and water conservation. Wellington and Kapiti coast provide discretion for activities in urban areas relating to stormwater management, with 'codes of practice' for development forms to encourage LID approaches.

LID approaches in other countries have broadened their scope to take account of socio-cultural issues relating to stormwater management. LID in the United States has become synonymous with the term 'green infrastructure' which views urban ecology as a means to provide a suite of environmental benefits within the urban framework (USEPA 2008).

SUDS (sustainable urban drainage systems) in the United Kingdom promotes sustainable outcomes from the integration of stormwater management with water quality, flooding, open space planning, landscape amenity, and urban habitat opportunities. SUDS is an attempt to balance social, economic and environmental requirements for stormwater infrastructure, while minimising potential conflicts (National SUDS working Group 2003).

WSUD (Water Sensitive Urban Design), practiced in Australia, is targeted at urban design professionals and looks at opportunities for water conservation, re-use, and stormwater best practice environmental management based on a 'best fit' for varying urban typologies (Wong 2006, Lloyd et al 2002).

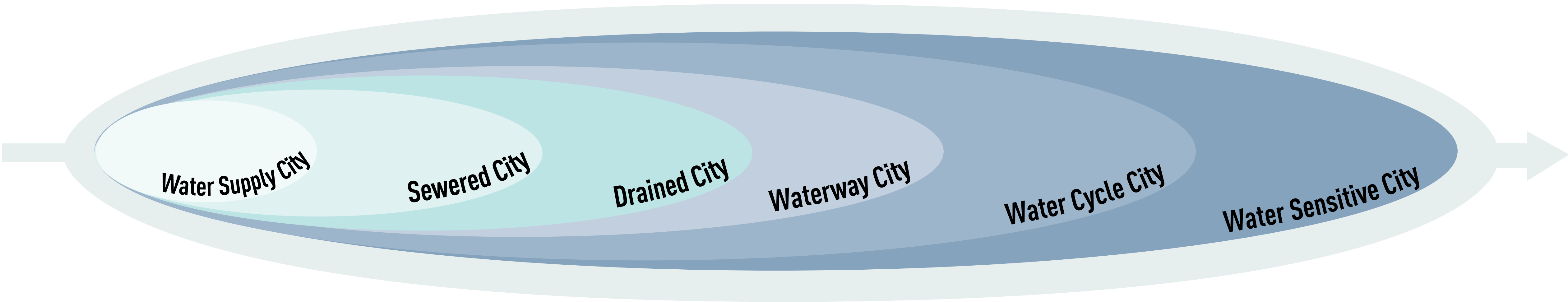


Figure 3: "The Hydro-social Contract" Adopted from Brown 2008

CONTEMPORARY APPROACHES TO LID

Local and international best practice stormwater management approaches has led to increasingly progressive approaches in urban areas, including the following:

- Engagement of the public to achieve decentralized stormwater treatments on private lots (including stream restoration across multiple land owners)
- Passive stormwater treatment in open space areas.
- The use of stormwater reserves for passive recreation.
- Conservation and remediation of permeable soils in situ.
- The collective management of water services (potable, waste, storm and grey) to allow for re-use scenarios.
- Micro-grading to evenly distribute flows across urban surfaces, optimizing above ground detention, reducing erosion from laminar flows, and increasing time of concentration in catchments.
- Regional perspectives to direct stormwater management resources toward focus catchments and the most sensitive or valuable receiving environments.
- Grey water treatment and use of irrigation in the landscape.
- Opportunities for the celebration or interpretation of stormwater management in urban spaces.
- Integration of stormwater management devices with architecture (e.g. green roofs).
- Retrofit of adapted natural systems to urban environments (e.g. stream daylighting).

One of the areas where LID and Urban design objectives frequently overlap is within the most public of spaces, the street. Streetscapes and street spaces are being continually reinvented to provide for shared space plazas, lineal open spaces, multi-modal transport corridors, and stormwater treatment facilities.

The 'Living Street' concept blurs distinctions between public and private realms, roads and open spaces, impervious and pervious surfaces, to provide for flexibility of use and optimization of infrastructure in roadways. In terms of LID, these specialized streets allows for on-site stormwater treatment that enhances streetscape amenity, contributes to community character and social infrastructure, provides other environmental services (e.g. shade), and calms and directs traffic appropriately.

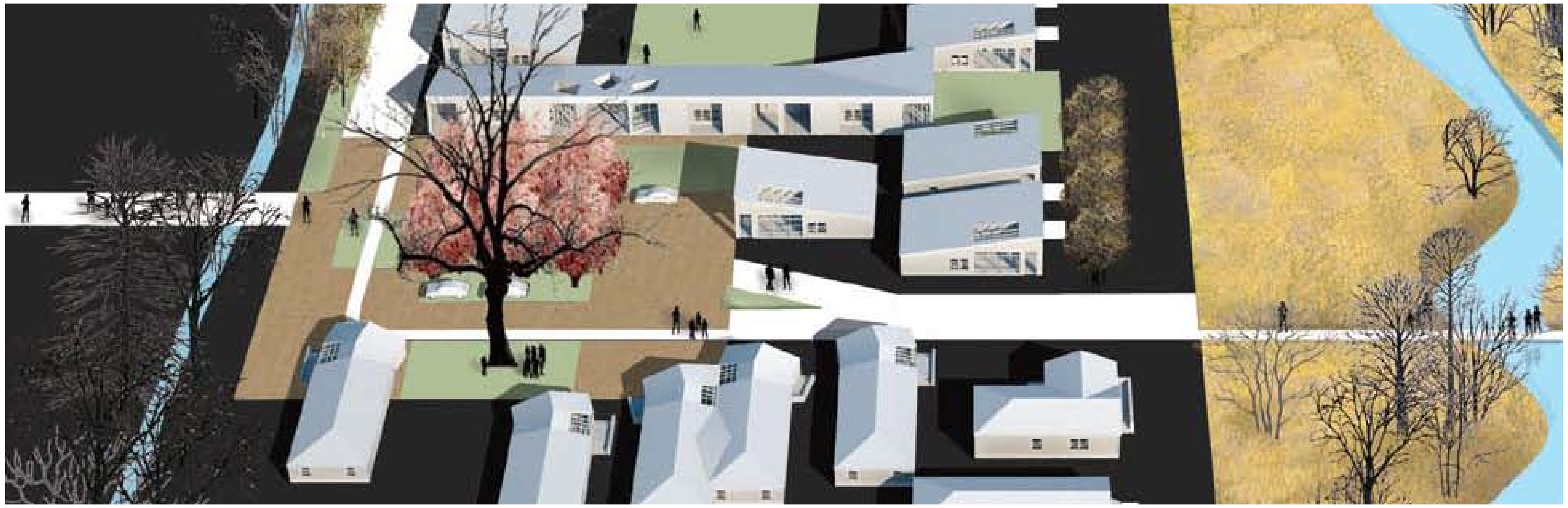


Figure 4: A study of the 'Living Street' by the University of Arkansas Community Design Centre, USA. Images courtesy of USEPA

EVOLUTION OF LID IN THE AUCKLAND REGION

LID led projects increasingly occur within Auckland's urban landscape. These approaches are often the only practical option for urban intensification and re-development projects, where existing utilities are at capacity and there is no available space for stormwater detention.

LID has been adopted by a broad range of professional disciplines in the region. This has led to LID becoming synonymous with inter-disciplinary design, focused on achieving multiple objectives for stormwater management.

Increased uptake in LID approaches in the region is also due in part to:

- Market testing of built projects and the realisation of market potential for LID treatments.
- Active promotion and education by ARC's stormwater action team.
- Publication of best practice applications and case studies.
- LID uptake across the country, providing for responses to a range of issues related to stormwater management.
- The adoption of Auckland's Sustainability Framework as means to integrate social and environmental policy.
- The preparation of guidelines by the ARC and Territorial Authorities (TA's).
- Policy adoption by TA's to protect natural hydrological systems.

Stormwater management is addressed in the Auckland Governance Royal Commission report, with specific focus on the Twin Streams project for its focus on community, sustainability, and landscape amenity objectives (Reference Vol1 8.28). The Three Waters Vision, also highlighted in the Royal Commission report, provides the framework for the future integrated management of water supply, wastewater, and stormwater services in the Auckland Region.

The proposed three waters strategic plan is guided by principles for sustainability, which extend to the co-management of air, water, land, and other natural resources as an integrated whole. The plan also calls for minimization of energy use, investigation of stormwater re-use initiatives, promotion of community engagement, and recognition of urban growth planning in the region.

As background to the preparation of this TR, a review of existing planning provisions in the region was undertaken, with specific regard to LID and urban design integration. Notable district planning provisions included:

- Structure plan alignment with hydrological catchments such as Flatbush (Manukau City), New Lynn (Waitakere City), and Long Bay (North Shore).
- North Shore City's urban design code which deals specifically with water sensitive design.
- Auckland City's urban design vision with defined environmental outcomes.
- Auckland City's urban design representation across all departments within council.
- Waitakere's Growth Management Plans that are informed by urban design goals.
- Waitakere's frequently espoused planning model of 'Twin Streams'.

However, in general it was found that there were limited policy directives that directly related urban design to LID. Urban design was addressed primarily in urban growth pressure areas and not comprehensively across all urban typologies. Following the review of planning provisions, it was determined that there were opportunities in future Auckland governance directives for

1. Further integration of LID and urban design principles in RMA and LGA planning documents.
2. Appropriate guidance for LID and urban design objectives based on multiple planning scales.
3. Integration of LID and UD as appropriate for representative urban and environmental typologies, to provide for comprehensive (and transitional) responses across the region.

These opportunities will be directly responded to in the Toolkit that follows

INTEGRATION OF URBAN DESIGN & LID – 'THE TOOLKIT'

The Toolkit is a response to opportunities identified in the previous section. It is a method to integrate LID and urban design at complementary scales, and across representative urban and environmental gradients (refer Figure 5).

Complementary scales relate to environmental and social orders such as the 'region' (municipality or super-city), the 'catchment' (or community), and the 'site' (or neighbourhood) scale (refer Figure 6). For example the significance of a stream may be its natural character values at the site scale, its connection with upstream and receiving environments at the catchment scale, and its representative values or rarity for all stream types at the regional scale. Likewise an area of flat, freely draining land may represent significant development potential for a site, but it is more likely to be an influence of growth and economic trends in the catchment, and transportation connections at the regional scale.

For each of the three scales of region, catchment, and site, the toolkit will recommended a methodology for:

1. Comprehensive planning frameworks based on scale-specific assessment and analysis
2. Integrated design responses based on urban and environmental transitions

Urban and environmental transitions are referred to as 'transects' in the toolkit. These relate to urban density and land use transitions at the regional scale, topography for the catchment scale, and public-private transition for the site scale (Refer figure 5)

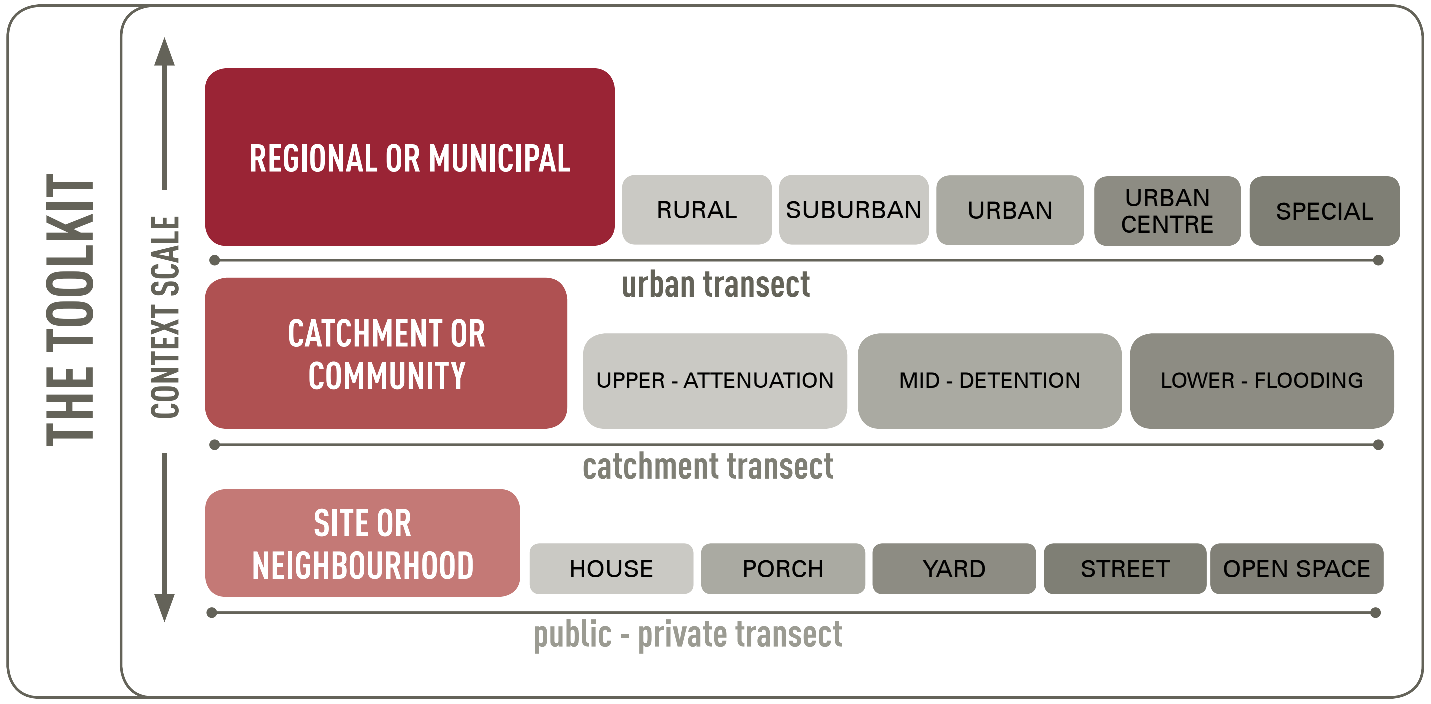


Figure 5: "The Toolkit" framework illustrating the three focus scales (region, catchment, and site) with associated environmental and urban transitions (the transects)

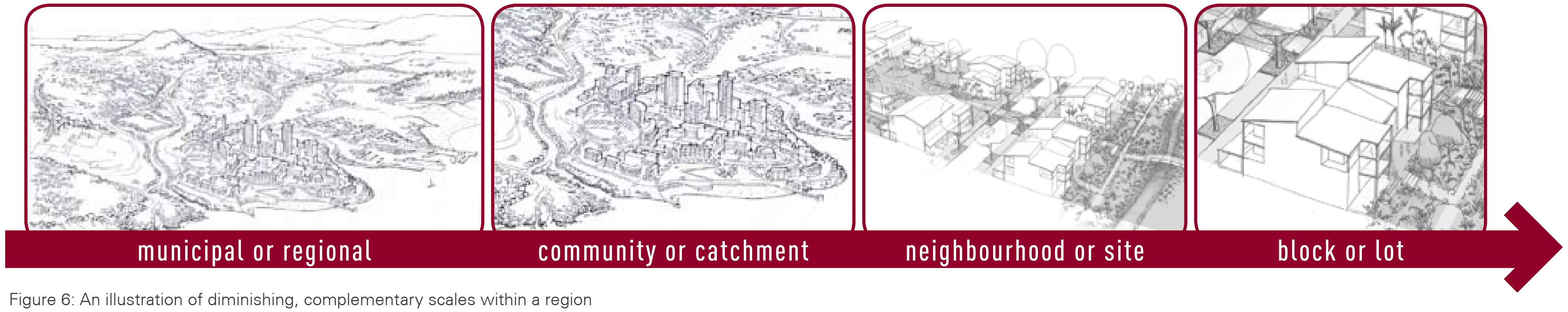


Figure 6: An illustration of diminishing, complementary scales within a region

REGIONAL SCALE

Comprehensive Planning Framework

From a regional perspective, environmental and social goals are not in competition with economic prosperity. The four strands of well-being identified in the Local Government Act 2002, social, environmental, cultural, and economic well-being, are inextricably linked and highly interdependent. All of these objectives can be achieved through a parallel planning process to optimize values for Auckland environments.

The Royal Commission findings for Auckland Governance, called for robust, considered, and consistent planning to support the region's ongoing growth and development. LID and urban design benefit this process by inter-relating environmental and social infrastructure in terms of spatial planning and prioritization.

Figure 7 below represents a potential planning process to facilitate the integration of LID and urban design perspectives in a regional model. The process is described in further detail below:

1. Data Analysis:

   In order to accurately inform the planning process, it is necessary to work with comprehensive, compatible, and accurate data, which combines modeling and ground-truthing. Information gathering could be prioritized by a gap analysis for focus areas such as geology, hydrology, ecology, the built environment, cultural and heritage mapping, and demographic data. The information would be of greatest benefit as compatible format and scale, and accessible to publicly available software.

2. Spatial analysis and Interpretation

   Information can be presented, or extracted in such a way as to reveal relationships between patterns and elements of Auckland's environments. For example ecological gradients can be determined from topography, aspect, existing vegetation, and predicted natural vegetation. Urban form can be read as a function of landscape and transport connections, natural and human-made barriers, land use capability, and landscape typologies. Opportunities to intersect open space and stormwater systems could be through the coincidence of open space with aquifers, streams, aging pipe networks etc.

REGIONAL SCALE – COMPREHENSIVE PLANNNING FRAMEWORK Based on Auckland Governance Royal Commission Recommendations

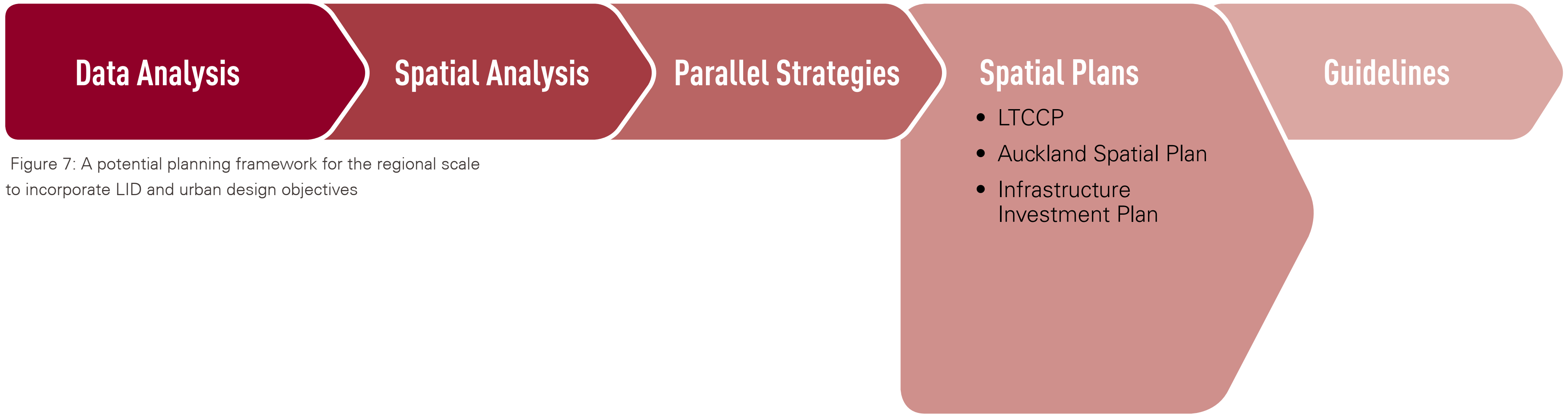


Figure 7: A potential planning framework for the regional scale to incorporate LID and urban design objectives

3. Parallel strategies

   Priorities for urban growth, open space, and infrastructure in the region can be examined in parallel through multi criteria analyses. This identifies shared objectives, parallel timeframes, combined budgets, and the optimization of existing resources. Parallel strategy is an opportunity to promote inter-disciplinary design in regional government, reconcile land capability and landscape character with land use, and integrate natural and built infrastructure.

   Tangata whenua is an essential partner in this process with specific regard to water relationships and their relative cultural value, Waiora (water in its most 'pure' form); Waimaori (water for consumption); Waimate (water that has lost its mauri and is no longer able to sustain life); and Waitai (seawater, the surf or the tide) (Douglas 1981).

4. Spatial Planning

   The combined Auckland Council will have an opportunity to develop transport and land use strategies in a single agency. There is expected to be a single long-term council community plan, a spatial plan for the region which coordinates plans for growth, economic, and social development, and an infrastructure investment plan to guide growth management and public works investment.

   A spatial plan is the ideal platform to recognise synchronicity between urban patterns of built form, landscape and ecology, infrastructure services, transport, and open space.

5. Guidelines

   This allows for context specific planning provisions with flexibility, discretion and specialized zoning that relates to site-specific values and constraints. Examples of planning structures include ICMP's, structure plans, codes of practice, development plans, and design guides. This planning scale relates more specifically to the sections that follow.

The regional landscape supports diverse natural, productive, and development patterns. The challenge for urban planners is to protect and enhance representative values for the region while catering for landscape change.

An LID approach to landscape modification traditionally responds to physical constraints, differentiating development areas from protected environments, with specific management responses at their transition. Regionally-based issues that would inform this LID approach are depicted in Figure 8 and could include:

- Policies to protect and enhance high value or highly sensitive receiving environments. Values might relate to natural heritage, urban habitat, and environmental goods and services. The most at-risk and valuable resources may require protection and buffering including dune lakes, bogs, spring seepages, inland water bodies, and wetlands.
- Groundwater processes capture stormwater as infiltration and deliver year-round flows to stream environments. Therefore, it is important to identify recharge areas and hydrological soil groups for the region to respond with appropriate development typologies (and target levels of imperviousness). Knowledge of groundwater 'break-out' areas (springs) will provide for appropriate management responses including associated habitats.
- The Auckland region has 68% of its waterways as first order streams and 90% as first and second order streams combined. Therefore, the retention of headwaters requires special attention for their representative character values.
- Region-wide floodplain management. Flood volumes relate to combined groundwater saturation and breakout, localised precipitation rates, stormwater-sheds, and water extraction. Large order streams (3rd order or greater) receive flow from many subcatchment areas, requiring comprehensive approaches to stormwater management including appropriate urban typologies.
- Coastal settlement planning requires the review of sensitive coastal and estuarine environments, looking at non-point and diffuse stormwater outputs from coastal settlement, and land use typologies that impact coastal erosion.
- Provide appropriate protective buffers and connections between habitat types within the region. Hydrological systems are a convenient way to connect habitat types across longitudinal zones (headwaters to coastal environments) and latitudinal zones (aquatic to terrestrial). Cross catchment connections provide for linkages to wider ecological areas of the region.
- Public access to stormwater management areas provide for interpretation, passive recreation, and to navigate through urban areas along traffic free routes
- Geology is an important determinant of stormwater management approaches and land use decision-making. Geotechnical considerations are at constant balance with the protection of headwater streams, coastal cliffs, and arable landscapes
- Stream characteristics vary for urban typologies, but can be provided sufficient protection to accommodate their inherent systems and processes while optimising their value as a resource and a contiguous element in the landscape. Stream reserves are also a means to link urban neighbourhoods to provide for recreational and amenity corridors

Integrated Design Response

At the regional scale, urban design and LID are primarily concerned with social and environmental systems, such as community boundaries, transport grids, ecosystems, and stream patterns. The planning framework, discussed previously, provides a means to integrate LID and urban design objectives through a parallel planning process.

However, to comprehensively address the urban landscape and its variation, LID approaches must consider the impacts of population density and land use change across the region, from the rural hinterland to the urban core.

The diversity of urban form is illustrated in Figure 9, as a conceptual transect through the region, with variation in population density, land use, and open space treatment. The transect is a means to consider appropriate LID responses to representative urban typologies. Ideally LID responses will find synergies with urban design objectives specific to these urban areas and assist in their transition from one to the other.

Specific urban typologies are discussed in greater detail in the section 'site scale' that follows. However, as can be seen in Figure 9, the potential pattern for stream and stormwater systems across the urban transect is:

- Catchment and stream protection, and reinforced ecological transitions in the rural environment
- Generous open space buffers and natural systems interpretation in suburban areas
- Environmental buffers to protect streams in urban environments
- Functional and often linear integration of open water within the industrial grid
- The utility, appearance and disappearance of water as an element within the urban centre.

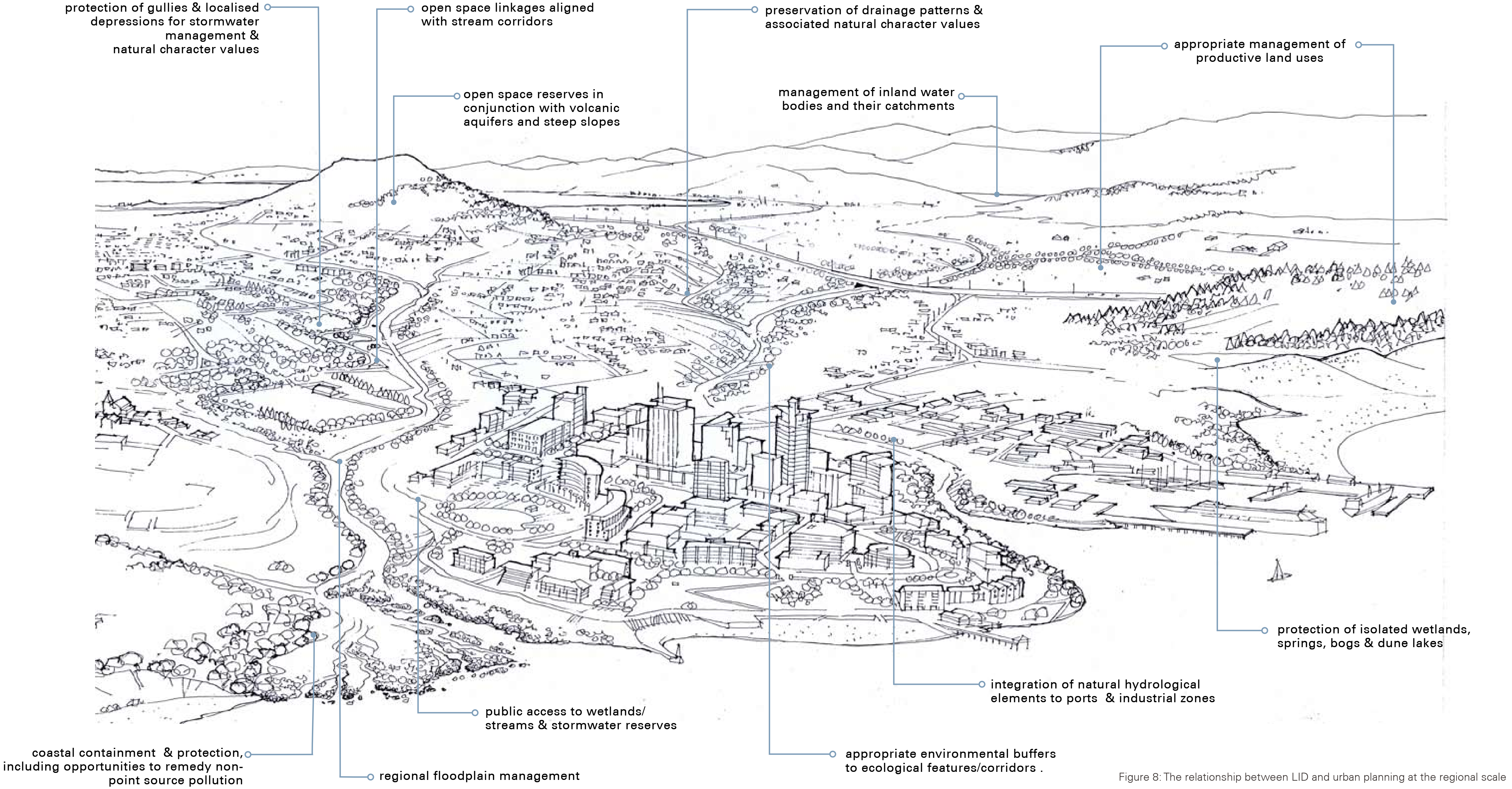


Figure 8: The relationship between LID and urban planning at the regional scale

Figure 9: The Urban Transect illustrating representative population densities and land uses within the regional scale

CATCHMENT SCALE

Comprehensive Planning Framework

At the catchment scale there is alignment between urban design and LID outcomes through the preparation of integrated catchment management plans (ICMP) and structure plans at the same extent (the stormwater catchment).

The ARC is preparing an update of ICMP guidelines and also prepared a catchment study across jurisdictional boundaries for the Papakura Stream in 2008. The study determined a comprehensive assessment method to inform ICMP decision-making, applying aspects of landscape, culture, recreation, and ecology to stormwater infrastructure and freshwater environments (Bull et al 2008).

Figure 10 below, represents a potential planning process to facilitate the integration of LID and urban design at the catchment scale:

1. Resource Inventory:

An inventory of the catchment requires a combination of modelling and ground-truthing sufficient for validation of data. The benefits of a stream walk, and physically viewing the catchment from the ridgeline can not be underestimated, though the walking of tributaries may be selected for representational sites by modelling. The use of stream ecological valuations (SEV) vs physical habitat scores is dependant on the land use and the scale of the catchment. The formation of complete GIS datasets is a first step to determine the extent of stormwatersheds and existing infrastructure.

2. Spatial Analysis

Interpretation of datasets is optimised by using inter-disciplinary teams. This will reveal issues and opportunities in the landscape that are relevant to all disciplines. Interpretation of data, through multi-criteria analysis can identify public works that provide the most benefits - to manage or buffer the greatest concerns, or enhance sites of value, significance, or multiple function.

Urban streams may be identified as a flood risk, a hazard, or as visually unappealing. If managed appropriately they can be transformed to form connected open space, environmental services, and enhanced natural character and cultural values. Where aging reticulated pipes, detention basins, and floodplains coincide with open space and low valley gradients, there may be opportunities to enhance water quality treatment, retain water volumes and restore habitat, while contributing to an overall increase in landscape amenity.

Public interpretation can be fostered by urban habitat restoration, and the retrofit of LID treatments in urban centres, key nodes, or in close proximity to wetlands and streams. A spatial analysis based on multiple criteria will optimise LID treatments for stormwater controls, streetscape amenity, traffic calming, and landscape connectivity.

3. Engage Public

The process of engaging with the public can awaken the community to the value of their forgotten streams. Changes in the catchment over time are important considerations for forward planning and can often be provided by those who have lived in an area for a time. The planning process is given value and priority through matauranga Maori, anecdotal local information, and the determination of issues specific to the community.

4. Spatial Plans

As mentioned previously, the potential impact of development on the catchment, and the appropriate form of development contribution or otherwise can be determined through the parallel planning process of ICMP's and structure plans. These will inform the LTCCP and annual plans and prioritise existing and potential future catchment issues.

5. Guidelines

Guidelines such as management plans, development plans, practice notes and codes of practice are important tools for non-point source pollution, pollution prevention, and decentralised LID stormwater approaches. It can ascribe appropriate land management and/or urban design responses to stream management areas, upper catchment sources, and floodplain and coastal areas. In this way there is potential to improve on existing stormwater management targets through public/private and rural/urban interface within the catchment.

CATCHMENT SCALE – COMPREHENSIVE PLANNNING FRAMEWORK

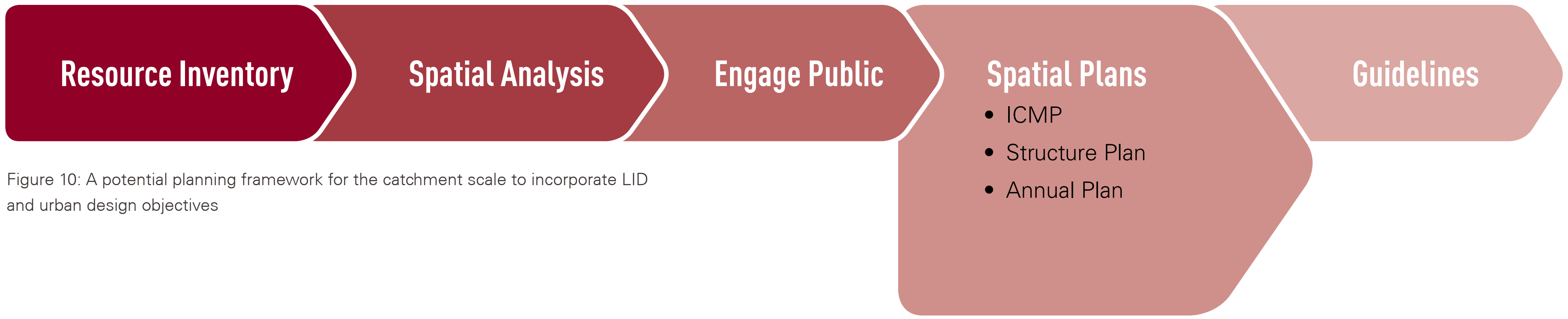
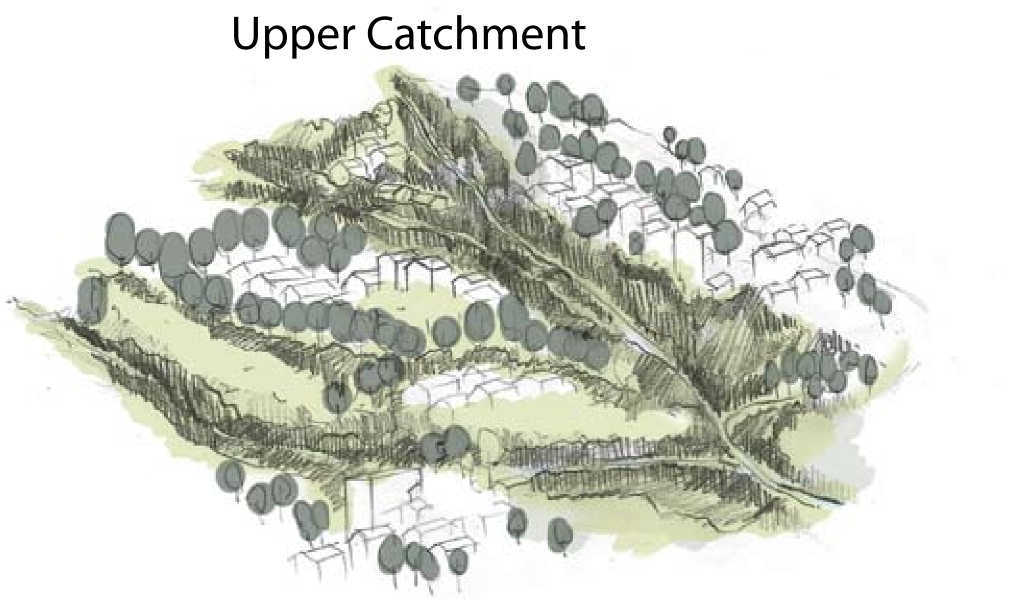
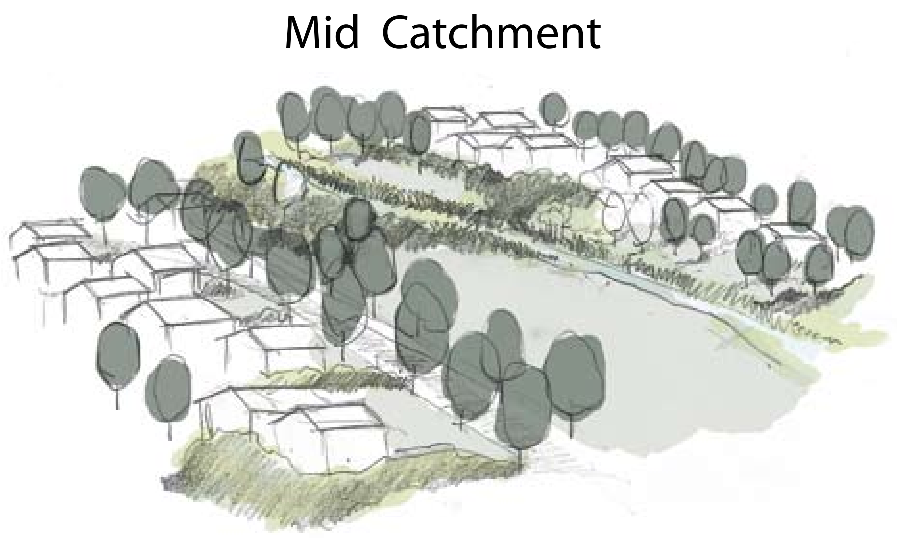


Figure 10: A potential planning framework for the catchment scale to incorporate LID and urban design objectives





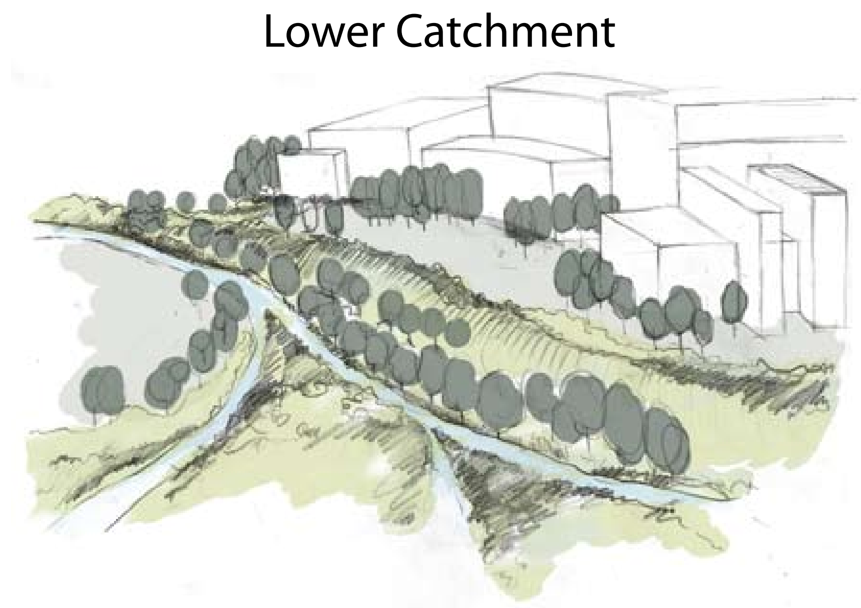


Figure 11: The Catchment Transect, representing environmental gradients within the catchment scale

Integrated Design Response

At the catchment scale the synergy between LID and urban design is based on the hydrological cycle in terms of rainfall collection and conveyance. The catchment can be broadly divided into three system-based areas, the upper, middle, and lower catchment (refer Figure 11).

- Upper Catchment

The upper catchment represents a significant proportion of Auckland stormwater due to the prevalence of low order streams and ephemeral gullies within the volcanic region. The steep and ephemeral nature of these stream systems require there be a level of protection to prevent erosion and contaminant loads from travelling to receiving environments. The upper catchment is often the steepest and therefore the most vulnerable to erosion in the catchment. Here water collects swiftly and vegetation in gullies and overland flow paths must withstand the inundation of swiftly-flowing water.

The upper catchment is therefore (from an LID perspective) focused on source control and infiltration to groundwater. Groundwater infiltration is especially pertinent above Auckland's volcanic aquifers. Auckland is fortunate for parks associated with volcanic cones, since these open spaces provide a vegetated backdrop for the city as well as protecting steep slopes and broad aquifer areas. Stormwater can also be attenuated through bioretention devices, infiltration fields, and/or the capture and re-use of rainwater.

Slope protection and erosion control is also important in headwaters and can be managed through reserving bush, forestry, and applying appropriate pastoral regimes.

The steep nature of headwaters, as well as the need for resource protection, lends itself to a clustered form of urban development, where dense residential or institutional buildings are dominated by planted slopes and generous open space.

- Mid Catchment

The mid-catchment is generally associated with detention or conveyance as stormwater coalesces to form streams and wetland areas. An appropriate urban response is to protect these systems with suitable buffers of native vegetation or open space, which often leads to ribbon like fingers of green through the mid slopes and upper valleys of cities.

These connected open space areas are ideal candidates to enhance urban connectivity, with pedestrian and recreational pathways along valley gradients. These are especially relevant in terms of legibility, as citizens can read the landscape and determine the means to find valleys and therefore open space connections. Stream and wetlands vary according to urban density, with densely buffered narrow stream corridors in dense urban areas, and wider open spaces in suburban zones. The integration of LID and urban design at the mid catchment is primarily a function of interlaced urban and environmental patterns such as the urban grid and natural drainage patterns.

- Lower Catchment

The primary LID issue in the lower catchment is protection of coastal and estuarine environments, and the prevention of flooding impacts. In terms of urban form, lowland environments are usually undulating to flat areas, which provide optimal site conditions for large scale, dense, and specialised urban typologies such as commercial centres, ports, and industrial zones.

The resulting land use pattern is a dichotomy between built and natural landscapes, with wide open spaces in association with floodplains, estuaries, and recreational open space, side-by-side with dense development of high rise, civic spaces, and specialised zoning.

SITE SCALE

Comprehensive Planning Framework

At the site scale, potential development is generally a function of regulatory frameworks, site constraints, and a developer's objectives. Objectives for LID and urban design can be tailored to specific outcomes, such as enhancing identity and character values for a site, providing a marketing advantage for 'sustainable design', achieving low cost solutions to environmental services, efficient use of the site, and achieving multiple objectives to reduce operational costs.

The comprehensive planning framework in Figure 12 lays out a procedure for site analysis and concept development to integrate LID and urban design. It has previously been presented in the ARC TR 2008/20, 'The Application of LID to Brownfields' (Lewis and Seyb 2008) and is summarised here:

1. Site Inventory

A site is generally assessed for three focus areas, environmental, social, and regulatory. Environmental issues include services, soils, surface water and groundwater, flooding, landscape and natural character values, ecology and landscape connections, and any significant physical feature or element.

Social concerns involve preemption of potential community concerns, and optimisation of market demand for the product and/or service that development seeks to provide. Some of the common social and cultural issues associated with development include landscape character values, community amenity, landscape connectivity, health and safety, and cultural values.

SITE SCALE – COMPREHENSIVE PLANNNING FRAMEWORK Based on ARC TR Application of LID to Brownfields

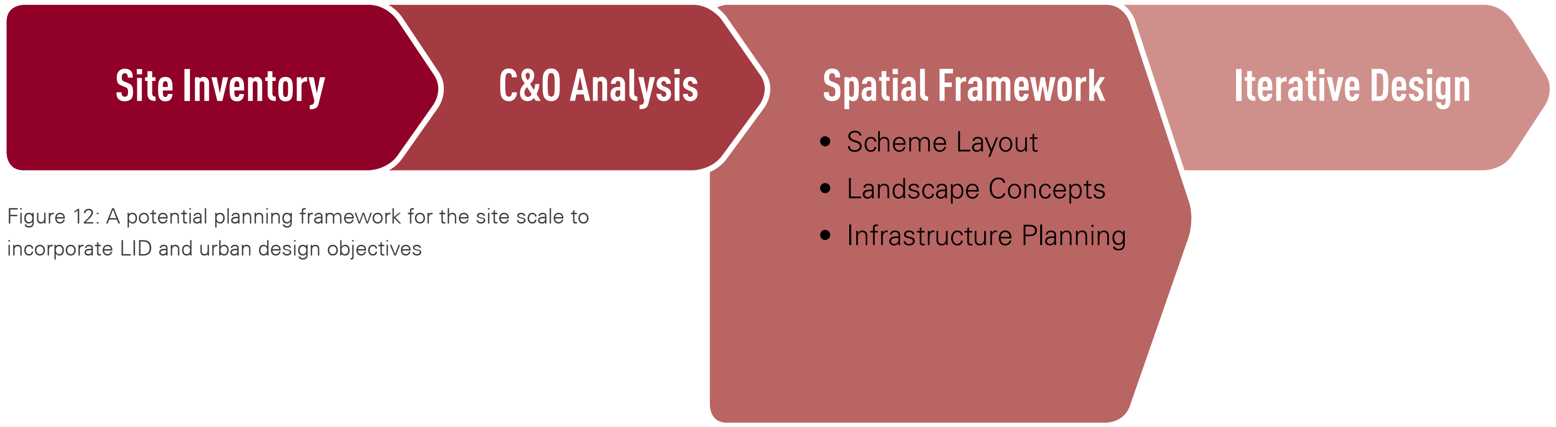


Figure 12: A potential planning framework for the site scale to incorporate LID and urban design objectives

Early discussions with regulators is vital to determine potential issues with infrastructure and services, transportation, and the flexibility/discretion around planning provisions to assist LID and urban design outcomes.

2. C&O Analysis

Following a comprehensive site inventory, a design team will have sufficient information to accurately describe the constraints and opportunities inherent to the subject site.

Constraints and opportunity analysis identifies absolute constraints (such as protected watercourses), areas appropriate for specific land use, and areas that can be utilised for infrastructure.

LID and urban design approaches would seek to realise the appropriate placement and scale of inherent design features, while considering overlapping land uses. In this way, there is opportunity for passive recreation in ecological areas, ecological planting in private yards and combinations of infrastructure and environmental services within roading right-of-ways.

3. Spatial Framework

The "spatial development framework" is a means to represent the built development pattern supported by an integrated framework of unbuilt landscape elements. The process for developing a spatial framework includes the following steps:

3.1 Identify dominant features that determine development form

Dominant features are those that define and/or connect various elements of a site and therefore dictate a distinct development form, such as landform, drainage patterns, aspect and slope. These features often contribute to a 'sense of place' and a unique environmental outcome.

3.2 Determine relative density and building coverage from SWOT analysis

As previously discussed the SWOT analysis determines optimal areas for development and potential constraints to be remedied or avoided. Flexibility in layout and building typology can provide for a diverse product that is responsive to the site. This should be discussed with regulators early in the process to achieve the best outcome for the site and the development product. It may also be important to engage community stakeholders at an early stage to ensure their concerns are adequately addressed and project viability is not compromised.

3.3 Integrate the site through an environmental enhancement framework

Areas that represent neither optimal development nor absolute constraints may represent opportunities for both social and environmental infrastructure. For example, a gully that acts as an overland flow path may connect open spaces within the site, provide for landscape amenity when planted, and treat stormwater quality..

In this way, stormwater management and open space areas can be based in marginal land areas (gullies, ephemeral streams, roadside verges, lower catchment slopes etc) yet contribute to the overall environmental enhancement framework of the proposed development, including streetscapes, mitigation planting, and structure planting.

4. Iterative Design

The process of integrating LID methods into concept design is likely to be iterative because it requires compromise between competing objectives and constraints. Through design re-iterations the proposed development, environmental enhancement framework, and transitions between different areas within the site can be tested. An investment in project coordination meetings will ensure that multiple objectives are considered in design decisions . In this way resources of the site will be utilised to their fullest potential, with overlapping benefits for urban design and LID.

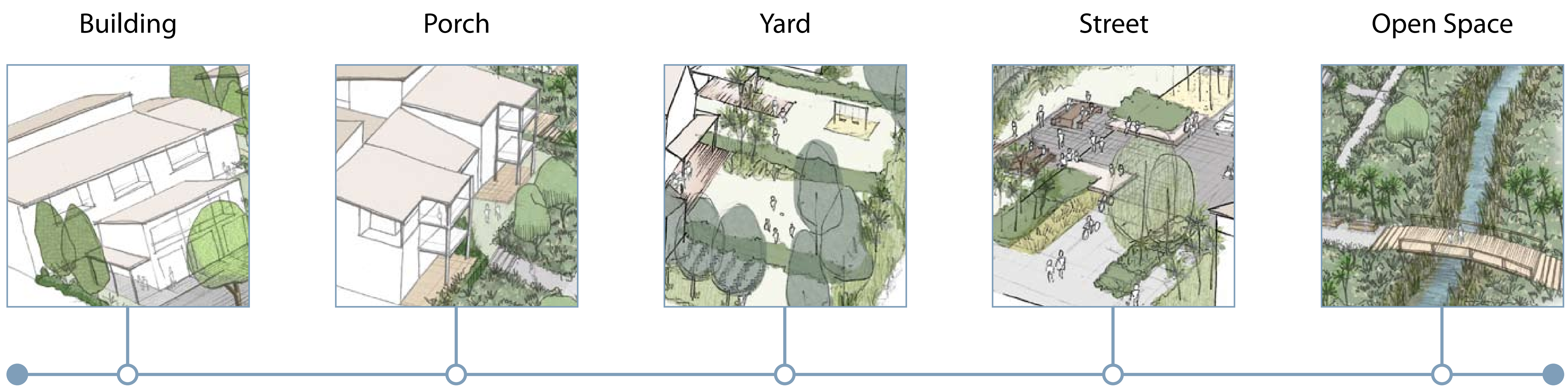


Figure 13: The public-private transect through the site or neighbourhood scale

Integrated Design Response

The development framework for a site can be divided into open space, built form, and transitional areas. These areas are illustrated above in a transect through the block from private buildings to public open space, including transitional areas such as porches, yards, and the street (refer Figure 13). The transect through the block is a well understood pattern for urban designers. Some of the key aspects of the public-private transect include:

- Public-Private Transitions

Distinctions between public and private spaces can be blurred or strengthened as appropriate. LID treatments can provide structural elements in these transitions with specific stormwater management devices as appropriate. For example greenroofs in buildings for private open space, raingardens to screen private yards, and tree pits to define public streetscapes.

- Architectural responses

Architecture can provide a specific design response to environmental constraints such as steep slopes and poor aspect. Responsive architecture can also reduce impervious surfaces and capture stormwater for re-use as appropriate. A flexible internal layout in a building can provide for increased occupancy, mixed use, and compact urban environments.

- Street Typologies

As discussed previously, the street not only acts as a transport corridor, but also provides public open space, landscape amenity, and environmental services. The use of reduced street carriageways such as 'homezones', lane ways etc provides greater opportunities for LID interface within streetscapes.

- Open Space Connections

The quality and accessibility of open space is significant to urban design outcomes. Homezones, stormwater reserves, and stream systems may be utilised for open space amenity and function. Open space alignment with streams also provide for a linear park systems that connects communities along a recognisable feature in the landscape.

- Site Layout Flexibility

Lot layout is often the most enduring legacy for a design. Flexible planning provisions provide opportunities to achieve dense community character around transport and commercial areas, reduce impacts on natural resources, and increase open space areas for the balance of the site.

- Mixed Use Facilities

Multi faceted communities allow residents to be close to work and shops, and ultimately reduce the need for transportation infrastructure and its associated effects on the receiving environments.

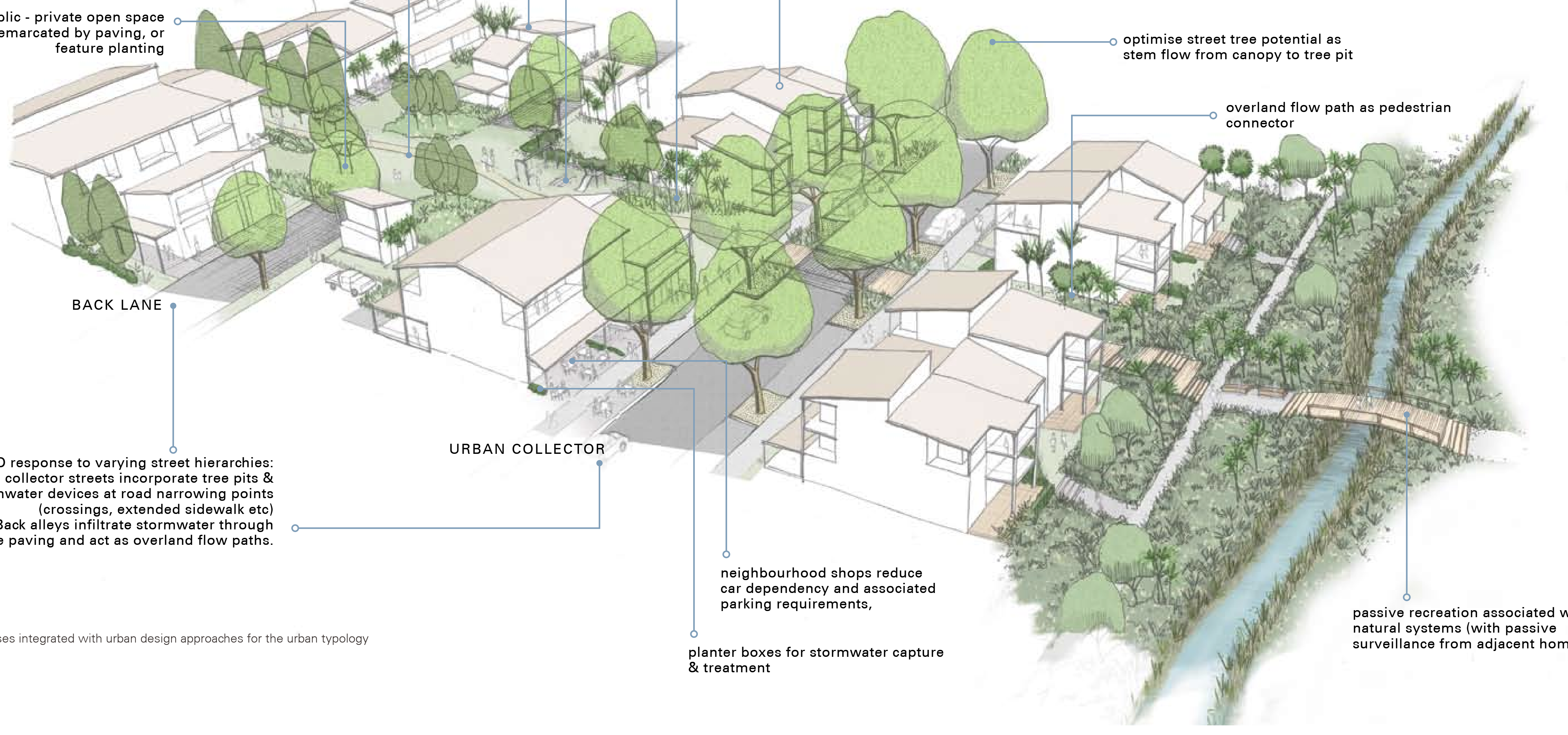
Table 2 evaluates opportunities within the public-private transect for LID approaches. This is applied across representative urban typologies (taken from the urban transect), and some of the outcomes are illustrated in Figures 14-17 that follow. The table is not intended as an exhaustive list of LID approaches for urban typologies or public-private areas, but is intended as a means to engender discussion.

Table 2 - LID Responses to urban typologies

	URBAN DESIGN ELEMENT					
URBAN TYPOLOGIES	ARCHITECTURAL	STREET TYPOLOGY	OPEN SPACE	LAYOUT	MIXED USE FACILITIES	PRIVATE-PUBLIC TRANSITION
RURAL	• Combine building footprints • Potential for greywater systems an appropriate distance from receiving environments • Provide for stormwater capture and re-use	• Swale profiles to prevent erosion. • Placement of parallel wetlands at the end of swales prior to entering streams. • Planting of tree production species along roadway lengths	• Buffer streams from nutrients, sediments, and pesticides • Investigate opportunities for public access to watercourses and coastal areas	• Review countryside living approaches to apply rural centres within productive landscapes • Place contaminant sources (e.g. dairy sheds) away from receiving environments	• Integrated approaches between rural industries (horticulture, forestry and pasture) • Co-operative infrastructure between farms	• Investigate opportunities to utilise landform and vegetation for screening of buildings from roads • Restore wetland and stream linkages across property boundaries
SUBURBAN	• Stormwater capture and re-use • Efficient housing typologies to increase occupants per dwelling • Use of appropriately inert materials for impermeable surfaces	• Street hierarchy to inform the appropriate character and extent of rain gardens, tree pits, or permeable paving • Street typologies specific to the edge of open space • 'Home zones' to combine open space, traffic, and stormwater systems	• Optimise natural systems for open space amenity and stormwater management potential, including interpretation • Use of 'home zone' streets for public open space and stormwater treatment • Amenity treatment wetlands with facilities for passive recreation	• Optimise natural systems for open space amenity and stormwater management potential • Integrate topography and natural patterns with a connected network of streets • Provide for average densities in-line with environmental constraints • Use proposed topography for laminar stormwater flows and above ground detention	• Flexible house design for multiple living arrangements (shared and sub-lease etc) to increase population densities and diversity and reduce roading and parking requirements • Neighbourhood shops at inter-modal transport nodes or at the intersection of traffic-safe walking routes to reduce parking requirements and provide more opportunities for shared surface streets.	• Utilise front yards for attenuation of driveway runoff, overflowing to streetscape stormwater systems • Allow backyard communal overland flow paths to wick away flooding and filter stormwater prior to reticulated systems • Utilise boundary hedges for stormwater attenuation
URBAN	• Stormwater capture and re-use • Compact and attached housing typologies to increase occupants per dwelling • Use of appropriately inert materials for impermeable surfaces • Green roofs and planter boxes as attenuation and treatment of stormwater	• Street hierarchy to inform the appropriate character and extent of rain gardens, tree pits, or permeable paving • Rear lanes as permeable conveyance systems • Optimise street tree potential for stormwater capture (stemflow to tree pits) • Above ground temporary detention	• Passive recreation associated with natural system networks • All open space areas utilised for passive stormwater attenuation and treatment	• Provide for average densities in-line with environmental constraints and diversity of built forms • Reconcile street alignment with natural hydrological patterns • Use proposed topography for laminar stormwater flows and above ground detention	• Permeable back lane drives to provide access to retail • Street widths reduced for shopping precincts potentially using raingardens and permeable paving • Neighbourhood shops at inter-modal transport nodes to reduce road carriage and parking requirements	• Combine public and private spaces for stormwater management zones, while demarcating private areas using spatial cues (e.g. ground plain changes) • Provide for overflow of rain tanks to public areas for temporary above ground attenuation
URBAN CENTRE	• Stormwater capture and re-use • Use of water for passive cooling • Use of appropriately inert materials for impermeable surfaces • Green roofs as additional open space	• Use of permeable paving and below ground detention • Optimise street tree potential for stormwater capture (stemflow to tree pits)	• Green roofs as open space, intensive for physical access and extensive for visual amenity • Potential for interpretation or abstraction of stormwater treatment processes as part of open space areas	• Provide for strategic open space areas for water quality treatment and urban habitat • Balance roading right-of-way and lot coverage to incorporate LID devices • Provide for greenroof potential on covered car parks etc	• Mixed use urban configuration to provide resident population without the need for private transport • Centralised transport nodes and associated open spaces	• Potential for terraces, green roofs and balconies to be used for stormwater management
URBAN CORE	• Stormwater capture and re-use • Use of water for passive cooling • Use of appropriately inert materials for impermeable surfaces • Application of green wall technologies • Inclusion of atriums and terraces irrigated and cooled by stormwater • Green roofs as additional open space	• Street hierarchy to inform the appropriate character and extent of rain gardens, tree pits, or permeable paving • Use of permeable paving and below ground detention for irrigation or water features • Optimise street tree potential for stormwater capture (stemflow to tree pits)	• Green roofs as open space, intensive for physical access, and extensive for visual amenity • Use of 'shared space' streets for public open space and stormwater treatment	• Provide sufficient civic space to incorporate LID devices • Provide for greenroof potential on covered car parks etc	• Mixed use urban configuration to provide resident population without the need for private transport • Centralised transport nodes and associated open space	• Potential for terraces, green roofs and balconies to be used for stormwater management
SPECIAL INDUSTRIAL	• Strengthen frame-construction to hold intensive green roofs or filter strips • Stormwater capture and re-use • Use of appropriately inert materials for impermeable surfaces • Planter boxes to attenuate and treat stormwater flows • Underground detention beneath carparks etc	• Daylight large pipe infrastructure within roading right-of-ways as lineal streams • Optimise street tree potential for stormwater capture • Provide for central swales as practical for turning circles • Pollution control devices as spill safe-guards	• Employee pocket parks optimised for stormwater attenuation • Pedestrian connections in association with lineal streams where landscape connections are appropriate • Amenity treatment wetlands with facilities for passive recreation	• Combined curb cuts and shared access to back lots • Combined building footprints • Sharing of boundary devices such as swales and treatment wetlands	• Mixed use configuration to provide commercial frontage (associated with industrial use).	• Shared filter-strip and wetland areas between properties • Incorporate security fences into vegetated areas or within hedges to reduce their visual impact and attenuate for stormwater

Location of suburban land use within the theoretical urban transect

Figure 14: LID responses integrated with urban design approaches for the suburban typology



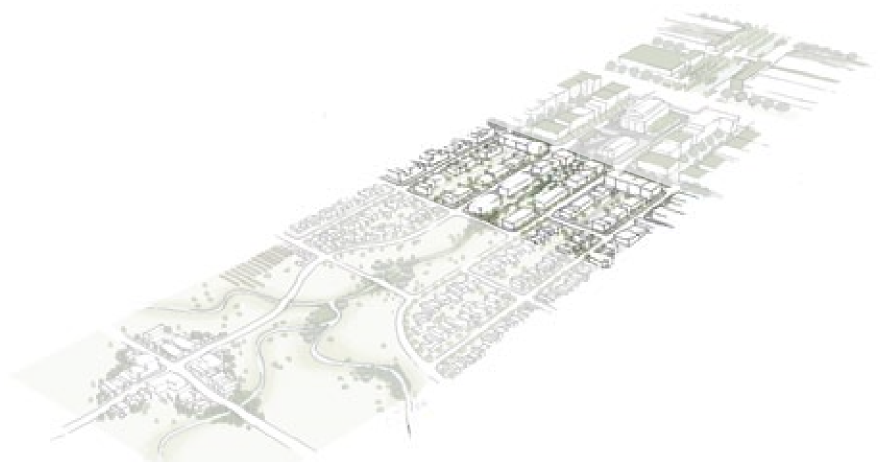


Figure 15: LID responses integrated with urban design approaches for the urban typology

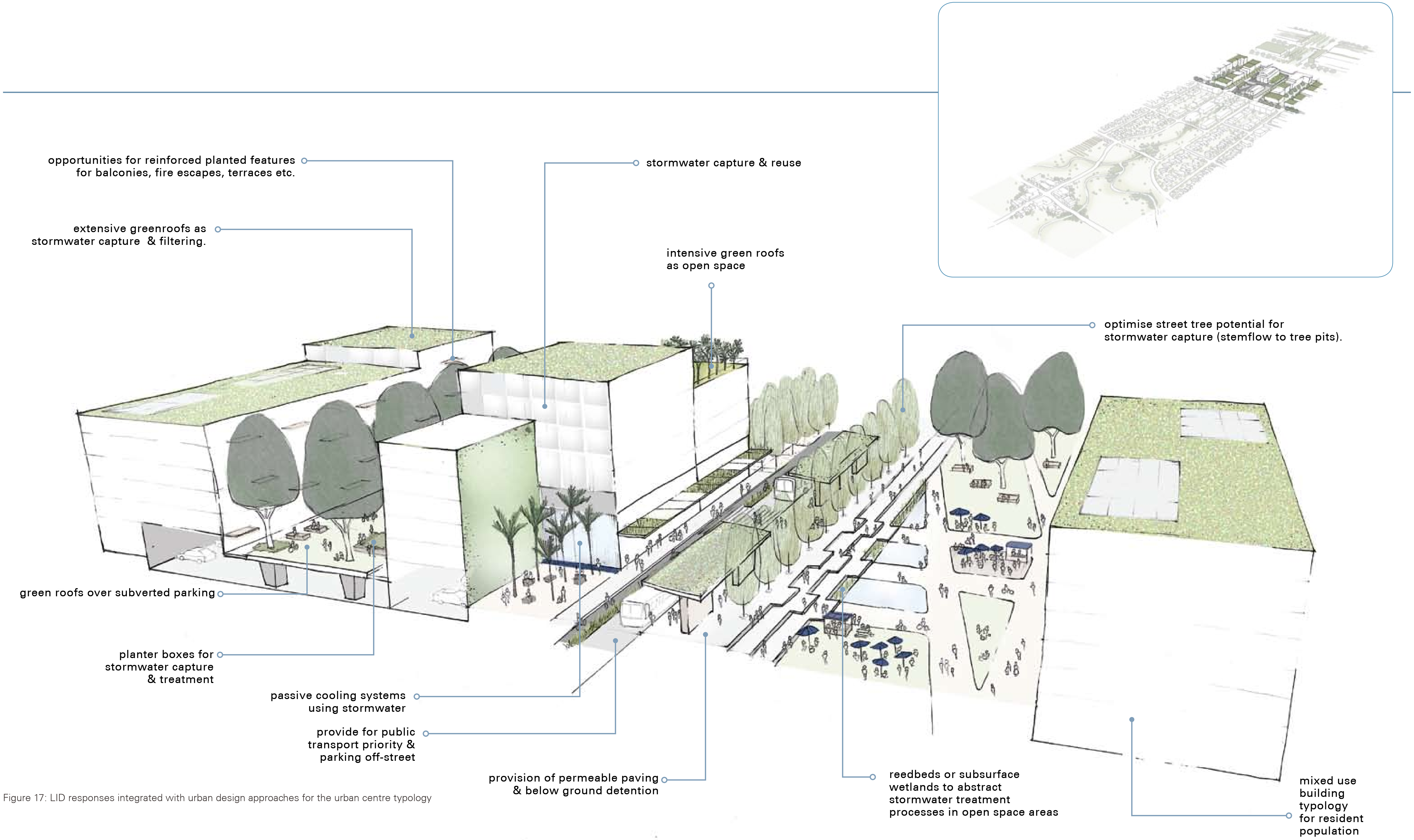


Figure 17: LID responses integrated with urban design approaches for the urban centre typology

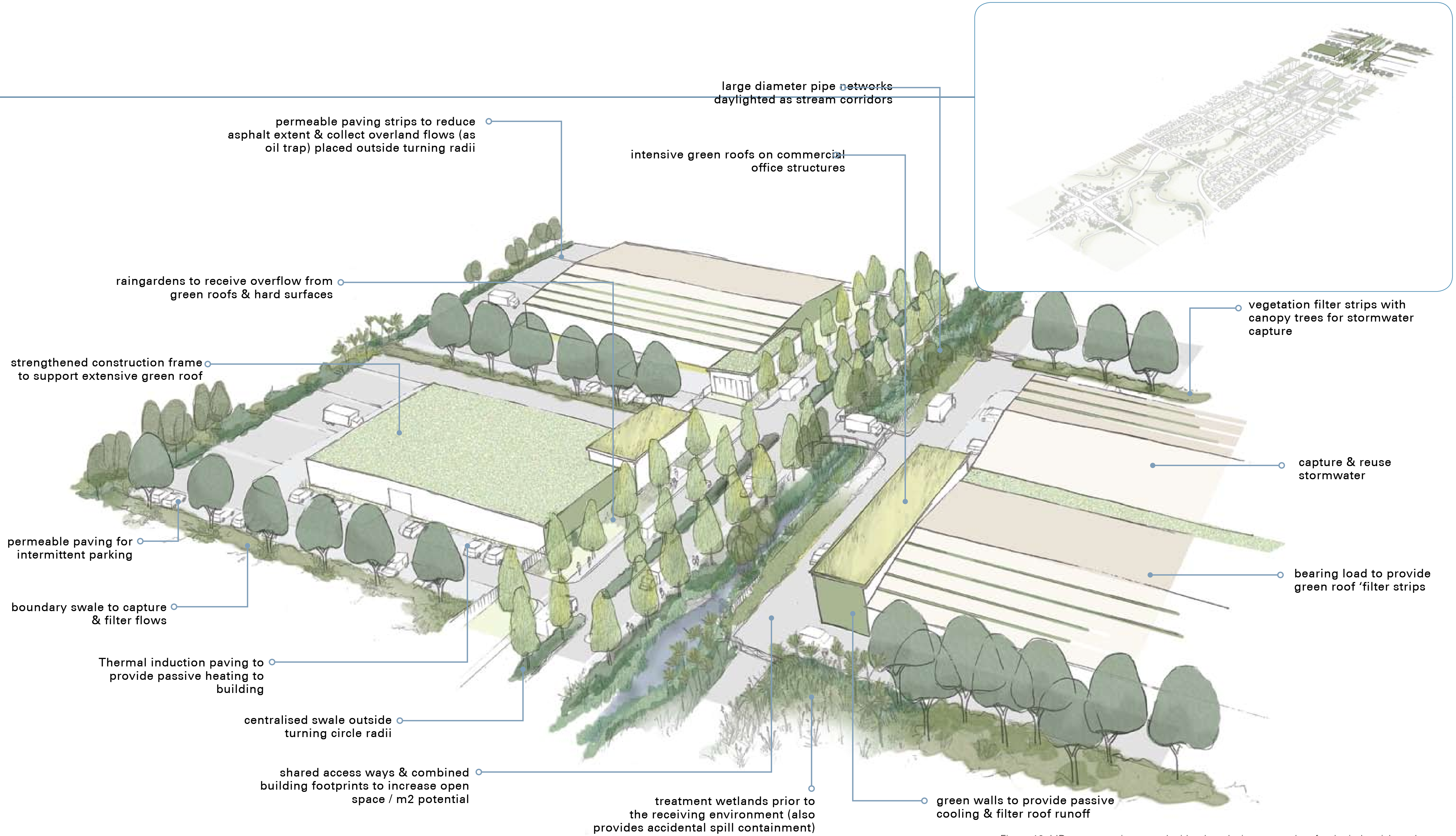


Figure 16: LID responses integrated with urban design approaches for the industrial typology

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