

# Impacts of Climate Change on Urban Infrastructure & the Built Environment



**A Toolbox**

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## **Tool 3.4: Investigating Urban Growth and Change to Inform the Risk Assessment Process**

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## 1. Introduction

### 1.1 Background

This document is one of a number of reference and guidance documents designed to assist Councils, and others, in taking account of long-term climate change effects in their on-going management of the urban environment. It gives details on how data on urban growth can be applied to decision-making with the aim of making the built environment more resilient to climate change effects.

Population growth is generally taken into account in making planning decisions involving the development of long design life infrastructure, such as river protection works. However, it is often assumed, for simplicity, that the urban form remains largely unchanged.

In reality, urban form may well change in the longer term (50 to 100 years hence) for many different reasons, thereby affecting risks from climate change, amongst other things. Also, the reality of changing natural hazard risk may force changes in the urban form in order to adapt to these increasing risks. For example, coastal flooding and erosion may encroach on properties to such an extent that occupants are forced to abandon them.

The tool described here sets out a method for investigating urban growth and change to inform the risk assessment process associated with climate change. It sets out steps to identify areas in future growth scenarios where climate change is likely to impact on future growth, and thus where alternatives may require greater consideration.

The urban growth and change process is a component of the Toolbox that assists in assessing climate change risks and development responses in a way that will help lead to more resilient urban areas in the face of increasingly extreme weather events.

By way of illustration, the method described in this tool has been applied to a hypothetical example based on a Wellington City suburb. While the methodology can be applied as a standalone high-level planning tool, it can also assist in informing the decision-making process that local authorities use whenever a development is proposed [refer to Tool 4.6: Overview of the Top-Down Decision Tool].

### 1.2 Purpose of Tool

The purpose of this tool is to outline an approach to investigate future urban growth so as to inform the risk assessment process in the context of managing climate change effects in the urban environment. Together with other tools, including those dealing with policy development and engineering adaptation options, this will help lead to the overall project goal of reducing climate change risk exposure and increasing community resilience.

By defining realistic future urban growth scenarios, the predicted future climate change vulnerability of these areas can be assessed more realistically. Vulnerable areas may include, for example, coastal communities exposed to significant coastal erosion, settlements in low-lying areas prone to flooding and built areas at risk from landslips.

The most effective way to reduce the impact from these hazards is through changing the nature or management of resources in areas at risk. This can be done using a range of methods, one of which is effective land use planning.

In order to plan for land usage that is sustainable and sensitive to natural processes, it is necessary both to identify and map areas at risk and have a good understanding of the potential consequences. A risk management approach has the potential to become an integral part of the planning process for climate change and help determine what responses are acceptable to local communities.

Risk assessment tools can be used to define the future risks faced by communities and to estimate the potential scale of damage should an event occur. These tools have further practical application in land use planning by assisting the formulation of policies which aim to avoid development, or to apply measures to reduce the risk of damage to the urban environment [refer to Tools 3.2 and 3.3 that describe the RiskScape tool and related case study applications in risk assessments].

To be useful in long-term planning, risk assessments also need to be representative of a potentially changing urban environment. It may not be reasonable to assume that urban growth can be represented simply by ‘more of the same’.

This tool therefore seeks to offer a method for exploring the changing natural hazard risk resulting from changes in the urban form, while at the same time indicating forms of urban development which are likely to be more resilient to these hazards. Used in this context, risk assessment may lead to an interactive process in prioritising areas for, or forms of, urban growth and change.

### 3. Methodology

The following methodology can be used by councils and others in quantifying urban growth to inform the risk assessment processes associated with the effects of climate change. The steps in the process are shown in Figure 3.1 and described below.

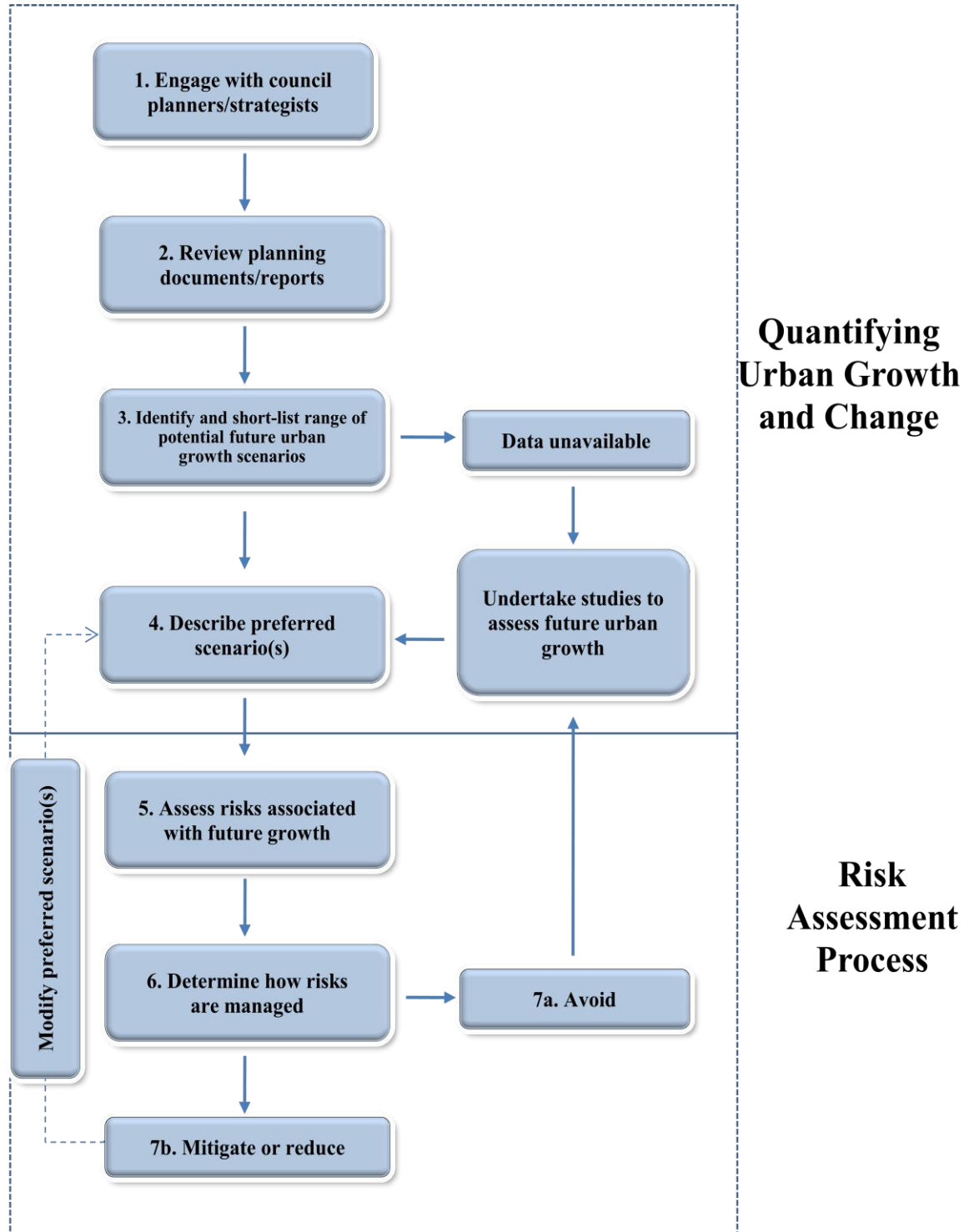


Figure 3.1: Steps for integrating urban growth and change with the risk assessment process in the context of climate change.

### **3.1 Step 1: Engage with Council Planners and Strategists**

Policy planners and strategists have an overarching understanding of the effects of policies, opportunities and rates of change in terms of trends in urban growth. They can usually provide valuable insight into where an urban area is heading in the future. They may have undertaken recent studies relating to the availability of urban land or growth assumptions to be used for council asset planning.

Increasing concerns of how climate change is likely to affect urban areas, and what adaptation measures are needed, is a challenge faced by most councils. Working with communities and interest groups such as developers (which council planners will have good knowledge of) can provide useful information on the scenarios that have been (or are being) adopted.

### **3.2 Step 2: Review Planning Documents and Reports**

Most local authorities have strategies identifying how future growth will be managed. A desktop study may be carried out to identify the documents that are available. Most of this information can be sourced from council websites.

Councils have a hierarchy of plans which set out proposals for future growth in varying levels of detail. These are prepared in accordance with the requirements of the Resource Management Act and the Local Government Act (see boxes below). Specialist studies carried out by councils are used to inform future growth proposals. Where data is lacking, councils will need to undertake further studies to fill in the gaps, particularly in areas where hazards are known (i.e. areas prone to flooding, landslides, coastal erosion etc.).

Scenarios operate on different time horizons (for example 20, 40 or 50 years). Thus, planners need to build the latest climate change projections into the strategies they use when planning urban and transport infrastructure. Climate change effects are expected to increase with time. Infrastructure at risk must therefore be assessed at future time horizons spanning the life expectancy (design life) so that measures are appropriate to manage the risk. The time horizons also need to take into account other changing factors such as population forecasts, technologies affecting lifestyle choices (e.g. internet technology), building techniques, and social and economic factors such as rising transport costs.

It is important to note that the planning process and the district plan create opportunities for development and are not 'blueprints' for future development. While the district plan will provide for certain standards such as residential densities, it is the owners of land and the development community who will take up the opportunities to develop. This is largely driven by economic factors.

### **Resource Management Act**

The Resource Management Act 1991 (the RMA) is the primary statute setting out how the environment should be managed, and especially how the environmental effects of activities should be managed. The RMA is based on the concept of managing natural and physical (built) resources in a sustainable way, and at a sustainable rate. It encourages communities to plan for the future environment.

District and regional plans are amongst the most important aspects of the RMA. Councils have responsibilities to prepare plans to help them manage the environment in their areas. Regional policy statements set the basic direction for environmental management in the region, which may include objectives, policies and other provisions on urban growth and change. Regional plans tend to concentrate on particular parts of the environment such as the coast, soil, a river or the air. They set out how discharges or activities involving these resources will be managed to limit the risk of resource degradation or pollution. District plans concern the use and development of land. They set out the issues and objectives for the community, and the policies, rules and other methods a council will use to manage the use of land in its area. They also identify what needs to be taken into account if a development is not a permitted activity and can only proceed subject to a resource consent.

The regional policy statement is the overarching document, and its objectives and policies must be “given effect to” by councils through district and regional plans. Every district or regional plan is different and reflects the desires and aspirations of the local community. Non-statutory documents in the form of area plans, urban development strategies and other informal plans can also be used to provide guidance to communities on future development.

### **Local Government Act**

The Local Government Act 2002 (the LGA) provides the general framework and powers under which New Zealand's local authorities operate. Part 6 of the Act promotes greater accountability between local authorities and their communities, and a long-term focus for the decisions and activities of the local authority. The Act includes a requirement for local authorities to facilitate a process with their communities, at least every six years, and to identify community outcomes for the intermediate and long-term future of the district or region. The role of the local authority is to facilitate the process, with the community having ownership of the identified outcomes. Part 6 also requires local authorities to prepare a Long Term Plan (LTP), which is to cover at least the next ten years, and which must be reviewed every three years. The LTP describes the community outcomes and priorities, and the activities the local authority will undertake to contribute to the outcomes. The plan is designed to integrate decision-making and include information on the key policies of the local authority. It also describes linkages between activities and how they are funded.

### 3.3 Step 3: Identify and Shortlist Future Urban Growth Scenarios

In terms of land use planning, the process quantifying urban growth needs to assess the balance between population growth (or decline) and land capacity.

The theoretical distribution of growth between different parts of an urban area, along with assumptions of changes in existing areas, provides for a range of growth scenarios. Population statistics and forecasts are updated 5-yearly and urban growth scenarios need to be reviewed at regular intervals. Land capacity can be quantified by applying various criteria relating to ecological, cultural, physical and economic aspects.

Through these processes, a number of scenarios can be developed and a number of areas of potential change can be identified in urban areas. Planning studies can identify one or more preferred scenarios and, for example, define where higher residential densities are envisaged through infill or redevelopment and the locations of new areas of fringe urban growth.

The information described above is a useful basis for the development of a risk assessment tool. While the areas identified within the scenarios are most likely to see significant change in the future, the extent and exact location and rates of change cannot be reliably known or predicted. The areas will, however, provide a realistic basis to explore preferred future urban growth scenarios, and the risks to which communities in these areas may potentially be exposed.

The above analysis may define several different urban growth scenarios, depending on the level of detail for which the effects of changing urban form are to be investigated. In situations where multiple scenarios are defined, the Multi-Criteria Analysis (MCA) methodology [refer to Tool 4.5] could be used to shortlist the most appropriate scenario(s) for consideration.

Using the MCA approach, a long list of alternative urban growth scenarios will be the *options* in the MCA. The *criteria* in the MCA will be the factors that determine the desirability of a future urban environment, where resilience to potential climate change effects is at least one of these criteria. This is explained in more detail using the example shown in [Tool 4.5: Overview of an MCA-Based Decision Tool].

### 3.4 Step 4: Describe Preferred Scenario(s)

The next step in further understanding how risks for climate change are associated with urban growth scenarios is to fully describe the likely future urban form associated with each scenario. This step is achieved by applying planning principles or ‘rules of thumb’, or other methods such as structure planning. It is possible to apply different assumptions to different climate change-related scenarios, and thus to describe a range of scenarios for further investigation.



Planning principles that are commonly applied to many urban areas, and which can be quantified, relate to aspects such as increasing residential densities, concentrating activities along transportation corridors, and creating open spaces within built environments. While there are many more principles that may be applied, the above ones are of particular relevance to climate change risk assessment.

The risk assessment process needs to be adjusted to take account of these changes in the urban environment so that the changes can be factored in. For example, changes in residential density can be represented by increasing the population at risk in appropriate areas. Concentrating activities along transport corridors can be represented by increasing numbers, size and values of assets at risk, while creating open spaces in high hazard areas will reduce populations and infrastructure at risk.

The application of planning principles or ‘rules of thumb’ in describing possible growth scenarios can assist in expanding asset data and therefore management of risk. It can also highlight areas where other methods (such as public education) may be needed to increase community resilience. Three particular planning considerations are briefly highlighted below.

#### **3.4.1 Increasing Residential Densities**

In all but the smallest of urban centres, areas close to central business districts – and other commercial nodes where land values tend to be higher – tend to attract greater intensity of land uses and residential development (sometimes with more apartment-style buildings). These areas have benefits of short journeys to work and proximity to a wide range of social, cultural and recreational opportunities.

Increased land use intensity (with more hard surfaces) generally leads to increased stormwater run-off with increased potential for flooding. Risks can be exacerbated by increasing residential densities from growing numbers of people in those areas, resulting in increasing potential damage to property and human life should an extreme weather event occur.

#### **3.4.2 Transportation Corridors**

The efficient use of transport infrastructure (for example, train, road and bus) can be achieved through creating nodes and/or corridors where high land use intensities are encouraged. This leads to improved connectivity, and effective and safe movement of people and goods. Efficiencies should result in reducing carbon emissions and in contributing to a more sustainable environment. Protecting this infrastructure from hazards will be critical to achieving these efficiencies.

#### **3.4.3 Open Spaces**

Open spaces are important in urban areas for environmental, social and physical reasons. Not only are they increasingly considered ‘green lungs’ in cities, they can

also be used as part of sustainable stormwater management practices to prevent or reduce flooding, and enhance urban stormwater quality. Furthermore, leaving natural buffer zones between the sea and new buildings and structures means that the risks from storm surge and flooding are reduced, if not eliminated. The role of open spaces therefore goes further than that of the recreational and aesthetic.

#### **3.4.4 Overall Description of Preferred Scenario(s)**

Once ‘rules of thumb’ planning principles or other methods have been applied, the resultant scenario elements (e.g. expected areas of residential intensification, different types of land use, open spaces and key infrastructure) should be mapped and described in relation to characteristics in different areas such as numbers of people and typical forms of development.

#### **3.5 Step 5: Assess Risks Associated with Preferred Scenario(s)**

A number of ‘rules of thumb’ that seek to characterise urban growth need to be defined in order that climate change risk assessments can be adjusted to take account of possible urban change in the longer term. These are generally applied on a case-by-case basis. A hypothetical illustration of the use of ‘rules of thumb’ to take account of different urban growth scenarios is given in the synthetic case study for the suburb of Kilbirnie in Wellington, outlined in Section 4.

There are many different techniques which can be used to assess risk, ranging from qualitative methods (which purely describe the risk exposure), through to fully quantitative methods from which absolute measures of risk can be derived [see Tool 1.3 for an introduction on this topic]. All of these methods have their advantages and disadvantages depending to some degree on the detail with which the effects of climate and urban change are to be evaluated.

A GIS-based approach to mapping the spatially varying hazard and risk is commonly used in land use planning. Various urban planning parameters can be applied and spatially mapped using quantitative measures e.g. land can be quantified in hectares or m<sup>2</sup>; population in numbers and/or rate of increase; and residential density in dwelling units per hectare. An example risk assessment tool that uses this GIS method is Riskscape [see Tools 3.2 and 3.3 for further details and case study examples].

#### **3.6 Step 6: Determine How Risks are Managed**

Areas identified as being vulnerable to climate change will need to be assessed to determine what practical course of action can be taken. Coastal communities are increasingly under threat. Many are vulnerable not only to erosion of the coastal environment but also to inundation of lower-lying areas due to storm surge and tidal effects aggravated by sea-level rise.

Adaptation options can include a variety of measures ranging from abandoning the area (e.g. creating ‘sacrifice zones’ under managed retreat) to protection of at-risk

assets by, for example, the construction of costly sea wall / flood protection structures. Policies that restrict new buildings on floodplains and encourage or require the restoration of wetlands are two examples of planning adaptation measures. A further example is provision of more open spaces (discussed above) to provide temporary increased stormwater storage capacity (i.e. ponding areas) as an effective means of controlling flooding.

Choices of response depend on a detailed understanding of local conditions, how much has been invested in the community and what is an acceptable level of risk. For example, managing coastal erosion requires input from the whole of the affected community. In areas with extensive infrastructure (e.g. commercial development, ports, industries and housing), adaptation through asset protection is likely to be the best choice. This might include strengthening buildings against potential damage, raising roads and railway lines above expected flood levels, and increasing the height of stopbanks [for example, as discussed in Tools 4.2 and 4.4]

### **3.7 Step 7: Mitigate, Reduce or Avoid Effects**

#### Mitigate and Reduce

One of the most obvious uses of a risk management process in urban areas relates to increasing the resilience of communities through identification of a range of prudent mitigation measures. A risk assessment model will be capable of defining the risks to which communities are currently exposed.

As additional hazards are added through ongoing dialogue, the importance of individual risks to the community will become apparent and measures to reduce risk can be prioritised on the basis of cost benefit and community needs i.e. for which hazard do we get the best benefit in return for funding spend on risk reduction?

The process of climate change adaptation may involve a range of practical steps to mitigate or reduce the risk so as to make communities more resilient and better prepared for future risks – either on a community basis through infrastructure planning, or on a site-by-site or building-by-building basis.

In the context of this tool, one obvious risk mitigation or reduction measure is to ensure that increasing numbers of people are not exposed to hazards due to an adverse change in the population distribution e.g. leading to intensification in at-risk areas. Thus the risk assessment process may suggest that there is a need to revise the preferred scenario(s) and to encourage different forms of urban growth and change.

#### Avoid

Areas known to be prone to hazards should, where possible, be avoided in future growth scenarios for urban areas. This can easily be achieved for prospective ‘greenfield’ developments but becomes more difficult with ‘brownfield’ sites where existing infrastructure may need to be relocated.

In the longer term, planning restrictions and proactive measures to encourage the relocation of vulnerable property and assets can be effective, although long-term planning approaches and consistent administration of these plans is essential to achieve the intended outcome.

#### **4. Example: Urban Growth Scenarios for Wellington City**

Parts of Wellington City are particularly prone to climate change and related risks of flooding and landslips. In defining various scenarios for consideration and analysis in the context of this tool, the higher concentrations of population and the use of marginal infill land (low-lying or high slope) resulting from implementing policies to increase residential densities need to be taken into account.

This section works through the steps shown in Figure 3.1 using a hypothetical example to show the implications of a growth scenario for part of the Wellington suburb of Kilbirnie.

This example is based on a more detailed paper prepared under this research study (MWH, 2010) that looks at urban growth scenarios for Wellington City for use in the Riskscape risk assessment tool.

##### **4.1 Step 1: Engage with Council Planners and Strategists**

Greater Wellington Regional Council (GWRC) has a strategic planning role and is responsible for formulating strategies for regional land transport and thus also for regional urban growth and change. Wellington City Council (WCC) has a land use planning role for its area (as do other territorial authorities within the region).

With the focus of this project on Wellington City, details on urban development were obtained primarily from the Principal Advisor Urban Strategy and Centres in the City Planning Team at WCC. Much of this information sought to update population projections and reprioritise growth areas based on the Council's current and developing policy. WCC planners pointed out that, in any application, growth scenarios must be viewed as a broad guide only and that details may change over time based on a number of unknown factors such as population forecasts and land availability.

##### **4.2 Step 2: Review Planning Documents and Reports**

Numerous policy documents set out strategies for future growth in Wellington City's boundary. Policies and strategies give high level guidance and direction on developing and implementing a vision, and an integrated framework to achieve sustainable growth of the Wellington region. A list of plans and policies reviewed for this project is

included in the reference section at the end of this document. Some of the key documents relevant to this tool are summarised in the box below.

**Wellington Regional Strategy:** The Strategy (2006) seeks to mature a number of identified sub-regional centres throughout the region. Action areas include completing a centre vision for each of the sub-regional centres; developing a transport investment programme for these centres; and developing regionally consistent principles for the management of ‘big-box’ retail.

**Northern Growth Management Framework:** The Framework (2003) seeks to strengthen the existing town centres by consolidating land use and expanding park and ride facilities. An extensive community consultation exercise was undertaken as part of the development of the Framework in 2002-03. One of the key conclusions of this consultation was that there should be no new town centre and that new growth should be directed to strengthen existing centres.

**Urban Development Strategy:** This Strategy (2006) sets out the Council’s stated approach to managing growth and change for Wellington City. It is built around a 50-year growth concept that reinforces the physical characteristics that make Wellington distinctive. The Strategy seeks to concentrate additional development along a ‘growth spine’ from Johnsonville through the CBD to the Airport. This will be supported by promoting a high quality public transport system as the main means of movement along the growth spine. Improvements to the quality of development as well as better integration with supporting facilities and services are also key objectives.

**North Wellington Public Transport Study:** This study (2002-06) reviewed the provision of passenger transport services in Wellington. It considered four options including retaining and enhancing rail; creating a busway on the rail corridor; running buses on the street and replacing the rail line with a walking and cycling track; and light rail on an extended rail line through the CBD. The final preferred option was the retention and improvement of rail.

**District Plan:** At the implementation level is the Wellington City District Plan which is the primary document that manages land use and development within the Wellington City Council's territorial boundaries. It contains rules that set parameters for development or land use proposals. The District Plan sets out a vision of a sustainable city, while also identifying areas for economic growth. The operative District Plan identifies the central area as a significant intensification opportunity. In addition, sub-regional centres within the City have a Suburban Centre zoning. This is a permissive zone that allows a range of activities to occur, including retail, industrial and residential. A plan change is proposed for the Suburban Centre Zone and the Residential Zone.

The **LTCCP** (2009/19 – now the LTP): This sets out the Council’s outcomes for the next 10 years and defines the aspirations for the City. It has been developed in response to the City and regional community outcome processes and reflects the community aspirations set down in those processes. To guide the Council in achieving the outcomes, the Council has developed strategies for each of the key activity areas: governance, environment, economic development, cultural wellbeing, social and recreation, urban development and transportation.

The **Annual Plan** deals with community assets and sets out the short-term goals for the community.

**Centres Policy:** In August 2008, the Council adopted a Centres Policy with the intent of maintaining and strengthening centres as primary places for shopping, living, employment growth and services. The Policy defines the hierarchy and function of various centres, provides guidance on how they should be managed and developed, and assists in coordinating Council investment in and around the centres. The policy defines a hierarchy of centre types: the central city, sub-regional, town, district and neighbourhood centres.

**Urban Character Assessment (2008):** The City Council commissioned a comprehensive citywide assessment of urban character and townscape. This has been followed by a more detailed assessment of the Johnsonville area. Extensive analysis documented natural character elements (topography, open space, and green structure such as trees and bush) and built character elements (development patterns, housing character and landmarks). The reports identified areas sensitive to change due to natural and built character elements.

**Infill Housing Review:** This project is examining where new intensive housing development would best meet the needs of the future. The work on housing intensification has been coordinated with the Centres Policy.

### 4.3 Step 3: Identify and Short-list Future Urban Growth Scenarios

Wellington City has no ‘hard and fast’ urban growth scenario, although some areas have been identified for greenfield growth (e.g. the Northern Corridor) and for significant intensification in general terms (e.g. Johnsonville to Newtown spine). Some intensification is enabled in most parts of the urban area.

In the absence of such scenarios, it is necessary to develop and apply planning principles or ‘rules of thumb’ (as discussed in the following step) in order to describe the urban future of any particular area in sufficient detail.

### 4.4 Step 4: Describe Preferred Scenario

The planning policies and strategies for Wellington City identify a series of agreed principles for future growth. These principles have been prepared by both WCC and GWRC in consultation with the wider community and civic leaders to guide the City and region into the future.

These planning principles are recognised as ‘rules of thumb in identifying trends in urban growth in general for Wellington City (MWH, 2010). Many of these principals could apply to other urban areas and are considered planning good practice:

- Maintain the City’s compactness
- Focus development along a “growth spine”
- Better integrate land use and transport
- Improve quality of urban design
- Foster “sense of place”
- Create better housing choices
- Promote commercial activities



- Establish “Areas of Change”
- Identify risk prone areas

The above principles are expanded upon in Table 4.1.

**Table 4.1: Planning Principles for Wellington City**

<b>Principles</b>	<b>Comment</b>
<b>Compact City</b>	Encourage a city with a contained urban form and more intensive development focused on the city centre, key suburban centres and major transport corridors.
	Allow intensive development of some areas while protecting others from development.
	Encouraging commercial, office, residential and industrial uses in the central area and suburban centres adjacent to main transport routes.
<b>Growth Spine</b>	Focus development along a “growth spine” running from Johnsonville through the city centre to Newtown and Kilbirnie, to ensure that growth occurs where the benefits are greatest and the harm least.
	Promote development focusing on Adelaide Road precinct and Kilbirnie.
	Reinforce and improve compact corridor form.
<b>Land Use and Transport</b>	Ensure that land and infrastructure are integrated and used efficiently.
	Focus growth close to existing transport networks.
	Provide a safe and efficient transport network.
	Encourage a transition towards public transport and other alternatives by providing infrastructure – that that supports buses, cycling and walking.
	Improve public transport connections.
	Design major roads to support our centres.
<b>Urban Design and Sense of Place</b>	Foster a ‘sense of place’ through the development of public spaces (e.g. the Waterfront, Lambton Quay).
	Improve the quality of urban design and improve connections between green spaces in and near centres.
	Protect places that have a citywide character and heritage value.
	Preserve and protect neighbourhood character.
	Build on culture and place.
	Strengthen green belts and open space corridors.
<b>Housing Choice</b>	Encourage growth in housing and employment in key centres with good infrastructure and public transport.
	Promote housing choice.
	Promote infill housing by increasing numbers of apartments and townhouses.
	Northern area will be the prime location for ‘greenfield’ residential development and largely residential with a mix of densities – higher near transportation nodes.

	Build on and strengthen existing communities.
<b>Commercial</b>	Maintain and strengthen the city's centre to provide accessible shopping, facilities and services.
	Promote the central area and main centres as ideal locations of commercial activity.
	Mature our sub-regional centres.
	Reinforce a strong regional CBD.
<b>Identify 'Areas of Change'</b>	Identify 'Areas of Change' in suburban centres and promote bus lanes, walking and cycle plans.
	Criteria used for 'Areas of Change' – areas less than 20 minutes walk from the Golden Mile (CBD); areas less than 10 minutes walk from town centres (Tawa, Johnsonville, Karori, Newtown, Kilbirnie, Miramar); areas less than 5 minutes walk from smaller centres; areas best served by public transport; areas with good carrying capacity (infrastructure and support services); avoid areas with environmental hazards (flooding and earthquake risks and significant resource values such as bush remnants).
	Rates of growth in rural areas will continue to be low and there is no proposal to amend the rules to facilitate intensive rural lifestyle development.
	There will be some reduced capacity for residential infill development and medium/high density housing in outlying residential areas that are not well provided for in terms of public transport.
	There is capacity for a small amount of medium density housing within existing inner residential areas and a small amount of high density apartment living in Oriental Parade.
	Some of the expected demand for medium density development will be directed to areas surrounding Johnsonville town centre and Kilbirnie town centre.
	The majority of demand for medium density development will be directed to Suburban Centres on the growth spine, in particular, Johnsonville, Kilbirnie and Adelaide Road; there will be some demand for high density in Adelaide Road, and to a lesser extent Johnsonville and other dispersed centres.
	Residential development will be discouraged in Suburban Centres where these centres are industrial-based employment centres or 'work centres'.
	The majority of high density apartment style residences will be located in the Central Area, with the remaining occurring in Adelaide Road, and a small amount in Johnsonville and other areas such as Oriental Parade.
	The majority of student accommodation will be provided off-campus and there will be minimal residential development within institutional precincts.
<b>Identify Risks associated with Future</b>	Identify areas with landslide hazards - areas of moderate and high landslide (slope failure) susceptibility; steep cut slopes (>45°) are often susceptible to failure under wet conditions and



<b>Growth</b>	earthquake loading, and it is important to consider slope instability in future development.
	Identify areas with flood hazards - areas of land known to be, or predicted to be, inundated during a significant rainfall event; this information has been grouped into three categories - high flood hazard; moderate flood hazard; and residual flood hazard.

**Scenario for Kilbirnie Town Centre**

Kilbirnie has been identified as an ‘Area of Change’ in Wellington City. A description of the area’s future under the scenario can be drawn from the above principles. This example has been prepared on a hypothetical basis to illustrate the risk assessment process using readily available data from council planning documents.

**Existing study area**

- Area: 22ha
- Existing dwelling density: 18 dwellings/ha (gross)
- Public transport: high frequency bus route
- Centre type: major town centre

**Description of possible outcome**

- Apartment living above ground floor level in commercial areas
- Medium density townhouse and terrace housing in areas immediately adjacent to the centre
- Proposed dwelling density: 40 dwellings/ha

**Comments**

- The location and function of Kilbirnie town centre means there is benefit in locating additional population here
- While there is scope for increased residential in commercial areas, there are few options for intensification in surrounding residential areas without major redevelopment and land amalgamation
- This form of development is a high priority for the City, particularly in commercial areas
- Staging - the planning is for growth to occur after Adelaide Road (which is a higher priority) as resources become available; there needs to be a wider area study to confirm boundaries of the intensification area
- The intensification will need coordination with transport infrastructure improvements.

**Table 4.2: Forecast Population Increases for Kilbirnie (hypothetical)**

Suburb	2006 to 2026		2026 to 2051		Density (dwelling/ha)		Natural hazards
	People	Dwellings	People	Dwellings	Existing	Potential	
Kilbirnie	1,257	706	984	675	18	40	Earthquake, flooding

How this data can be applied to the risk assessment process is discussed in Section 4.5.

#### 4.5 Steps 5 and 6: Assess Risks and Determine How to Manage

The planning and demographic information described above for the hypothetical example for Kilbirnie may provide input into a risk assessment tool such as Riskscape [see Tools 3.2 and 3.3]. By defining realistic future urban growth scenarios for parts of Wellington City, areas of growth within the urban area can be identified and mapped. The risk assessment tool can then be used to define the risks that future communities in these areas may potentially be exposed to, and to estimate the potential scale of damage should a natural hazard event occur.

The effect on risk from the implementation of different planning policies can be quantified by combining spatial mappings of the natural hazards with the demographic information, with and without the planning policy implemented. The ‘rules of thumb’ can be used as a basis for modifying the demographic information to reflect different planning policies.

Using the hypothetical example for Kilbirnie to illustrate the risk assessment process, it can be shown that the area around Kilbirnie Town Centre is potentially at risk from flooding (as well as the non-climate change related risk of earthquakes).

The forecast changes in population and dwellings in Table 4.2 are presented for two time horizons (20 years and a further 25 years, or 45 years in aggregate), using 2006 population as a baseline. It can be seen that a reducing rate of population increase is predicted. This could be due, in part, to a policy to increase green space. However, a simultaneous predicted increase in dwelling density results from the policy to provide more intensive forms of development (including multi-storied) in this area.

#### 4.6 Step 7: Mitigate, Reduce and Avoid Effects

In earlier steps, different urban scenarios have been determined based on future growth and how development is likely to occur over time. Decisions are then made in this step on whether to mitigate, reduce or avoid the adverse effects of climate change in the affected areas.

In the chosen example, adaptation strategies responding to the effects of sea-level rise in Kilbirnie could include measures aimed at increasing the height of ground-floor levels in buildings or constructing a sea wall. Measures to reduce the impact of flooding could involve creating large tracts of open spaces (parks, permeable parking areas, playing fields) which will allow water to collect and permeate, and act as temporary retention ponds. An alternative strategy to avoid the effects could be as significant as relocating large parts of the suburb.

The policy to provide more green space may well in itself reduce flood risk if the open areas are located in flood prone areas, and more especially if these areas are designed to accommodate occasional flooding. This policy can be represented by changing the

land use and assigning appropriate flood damage and recovery costs for the land use change.

Likewise, a policy to encourage multi-storey buildings will reduce the population exposed to the direct damaging effects of flood waters. The effects of this policy can be represented by appropriate adjustment of the number of occupants at risk to only those directly impacted by flooding (i.e. at ground level). In both cases, the wider social costs and other impacts, such as transport and services disruption, would be applied to the full population.

Application of flood-resilient building design, in flood prone areas, could also be explored to reduce risks further. For example, the ground floor level could be reserved for flood-resilient land use, such as car parking and landscaping, with commercial and living areas raised above the 1 in 200 year (0.005 ARI) flood level.

Complications could arise, however, if risk reduction measures conflict with other urban design principles. For example, raising the building floor substantially above flood levels, while effective, may not be seen as an acceptable option as it conflicts with the policy to provide retail facilities on the ground level of multi-storey apartment blocks.

In such instances, it is clear that mitigating risk is not the only basis for making a decision. Other tools, such as the Multi-Criteria Assessment [Tool 4.5] could be useful in this context to assess the preferences amongst different future urban growth scenarios from a variety of tangible and intangible perspectives.

## 5. Conclusion

To date, the Kilbirnie example has not been tested in Riskscape or any other risk assessment within this research study. However, the processes described in this tool are based on well known risk methodologies.

The challenge is largely in adjusting risk models in suitable ways to represent the effects of different policies. This adjustment will be based on applying different growth and change scenarios. Studies need to be based on relatively simple and localised policy considerations, and risk assessments can then be applied to help determine the most appropriate policies on a case-by-case basis.

It may take a number of iterations, including community input, to determine the most appropriate future for parts of urban areas. The risk assessment process assists in achieving an understanding of whether an appropriate balance can be achieved through mitigation of risks in an area, or whether additional future risk should be avoided.

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