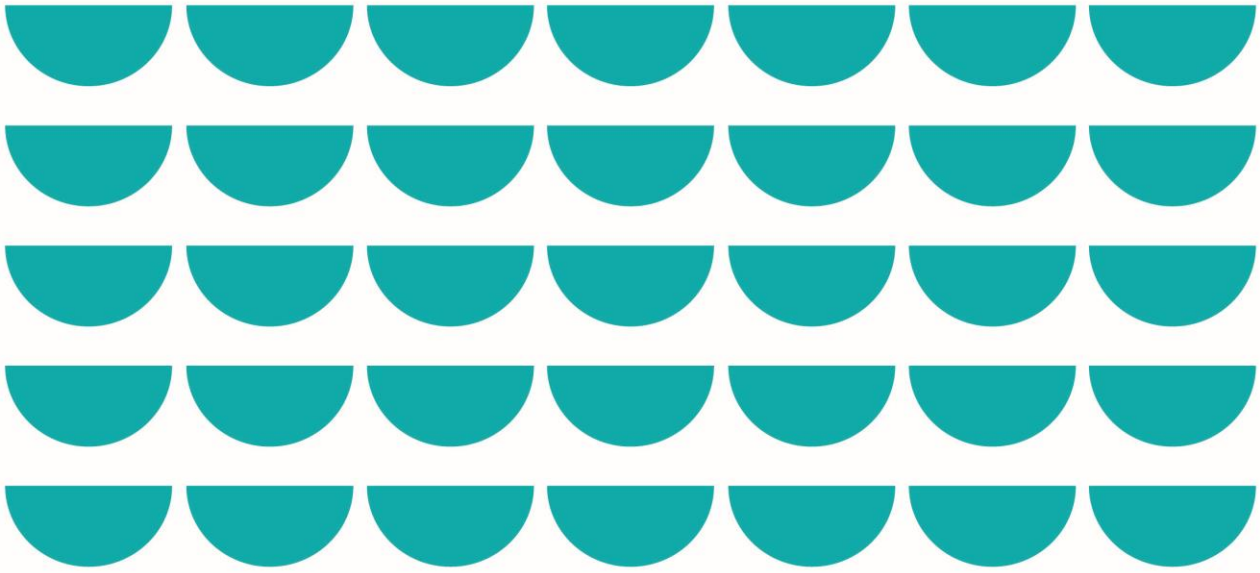
COASTAL FUTURES
SOUTHSHORE SOUTH NEW BRIGHTON

Information about the area

Southshore and South New Brighton Regeneration Strategy



REGENERATE CHRISTCHURCH TE KŌWATAWATA

Christchurch City Council

Environment Canterbury Regional Council Kaunihera Taiao ki Waitaha

Te Rūnanga o NGĀI TAHU

Introduction

The purpose of this document is to provide a comprehensive overview of existing technical information relating to Southshore and South New Brighton including:

- The natural and human (social, cultural, built, economic) environments, highlighting some of the key sensitivities of these environments to change
- The natural hazards that have, and could in the future, affect the communities of Southshore and South New Brighton
- The statutory/legislative framework for managing natural hazards which may impact on some options explored through the development of the Southshore and South New Brighton Regeneration Strategy

The purpose of this information is to build a shared understanding of information about the existing environment and natural hazards based on the best available information and science at this point in time.

It is recognised that the data will change as new and updated information becomes available, and that not everyone will agree with the science. When it comes to climate change information, there is a lot of uncertainty about when change will reach a certain threshold, and what the extent of the changes will be.

However, this information is a starting point for the conversation about actions for how this area can adapt to the effects of climate change and have a positive, viable and certain future. Coming up with the actions to address the potential effects of climate change, and working out when they need to occur is called 'adaptive planning' and it's what the Regeneration Strategy is all about.

Adaptive planning is recommended by the Ministry for the Environment and uses the four climate change scenarios as identified by the Intergovernmental Panel on Climate Change (IPCC). Using possible future scenarios means communities can plan for the 'what if' rather than the 'when'. Adaptive planning means the agreed course of action can change if need be – for example, if new climate change information becomes available. It also gives decision-makers a way to progress things and make decisions, even when there is uncertainty about the rate and effects of sea level rise.

Understanding the state of the land, and the things that might affect it, as well as its cultural significance, history and environment, will help provide context for adaptive planning.

The Regeneration Strategy Project Area

The Regeneration Strategy project area of Southshore and South New Brighton is a residential area located on the eastern edge of Christchurch along the Southshore Spit/Te Karoro Karoro. It is approximately eight kilometres from the central city but separated from the rest of the city by its geography. The area is bordered by water on three sides[1], and the suburb of New Brighton to the north. Rodney Street is the northern extent of the Regeneration Strategy project area.

The suburbs of Southshore and South New Brighton are home to approximately 2,019 households, with an estimated population of 4,830 in 2013[2]. The area is surrounded by a unique and highly valued natural environment.

As with other parts of eastern Christchurch, the area was significantly impacted by the Canterbury Earthquake Sequence in 2010 and 2011. More than six square kilometres of flat land in the Christchurch and Waimakariri Districts (approximately 7,400 properties) was red-zoned due to land damage and most of this was purchased by the Crown.[3] 195 of these properties were located in Southshore and South New Brighton, of which 192 are now owned by the Crown.[4]

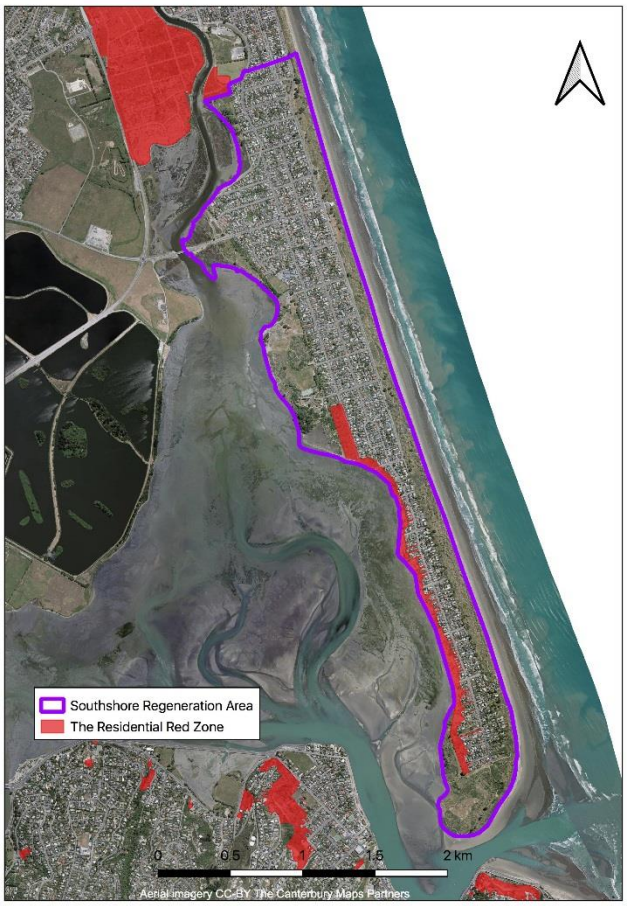


Figure 1 –Regeneration Strategy project area

The communities of Southshore and South New Brighton face the challenge of living with multiple natural hazards in a coastal environment that will be impacted by the effects of climate change, including sea level rise.

Natural Environment

The natural environment is a huge part of the appeal of this area. The coastline, saltmarshes, open spaces and reserves are highly valued by Ngāi Tahu, residents and visitors.

[1] The open coast of Te Kaikai a Waro/Pegasus Bay on the east; the Estuary/Ihutai of the Ōpāwaho/Heathcote River and Ōtākaro/Avon River to the west; and the mouth of the Estuary/Ihutai to the south

[2] When the latest census was recorded (Statistics New Zealand, 2013).

[3] (Canterbury Earthquake Recovery Authority, 2016)

[4] (Christchurch City Council, 2017b); (Canterbury Earthquake Recovery Authority, 2012)

Physical features of the area

What we know

The Regeneration Strategy project area borders the open coast of Te Kaikai a Waro/Pegasus Bay on the east; the Estuary of the Ōpāwaho/Heathcote River and Ōtākaro/Avon Rivers/Ihutai ("the Estuary/Ihutai") to the west; and the mouth of the Estuary/Ihutai to the south.

In 2015 the location of the river mouth was adjusted in regional council maps and descriptions to the north of the Regeneration Strategy project area, adjacent to Evans Ave. This reflects the change in estuary dynamics as a result of subsidence following the earthquakes. For this reason, the western coastline of the Regeneration Strategy project area is referred to as the estuary edge throughout this document.[5]

Most of the Regeneration Strategy project area is relatively low lying with ground levels less than 2 metres above mean sea level. Sand dunes, which range in height from 5 to 9 metres, act as a buffer to the ocean on the open coast and south end of the Spit. On the west side of the dunes the landscape gradually slopes towards the Estuary/Ihutai.

Figure 1 – Cross section of the Regeneration Strategy project area (indicative only).

The land is made up of sand overlying fine grained silts, peats and clays. The sands on the Estuary/Ihutai side are loose, finer and less dense than those closer to the dunes.[6]

The deeper soils and sediments are made up of coarse-grained gravels, and fine-grained silts which form a multi-layered aquifer system. [7] The water table sits within the uppermost sediments and is typically less than 10m deep across the Canterbury Plains, becoming shallower near the rivers and the coast. Within most of the Regeneration Strategy project area the water table is less than 2 metres below the ground surface. Groundwater generally becomes shallower towards the Estuary/Ihutai and the south end of the Spit, but varies with rainfall, daily tides, and drainage.[8] Groundwater depth and quality is influenced by sea water.[9]

[5] (Environment Canterbury, 2015)
[6] (Tonkin & Taylor Ltd., 2011); (Hollever & Bolton-Ritchie, 2016)
[7] (Ballegooy, et al., 2014)
[8] (Ballegooy, et al., 2014)
[9] (Ballegooy, et al., 2014)

Why this is important

The physical features of this area are important and they are part of its appeal. They also highlight some of the challenges of the location, including that:

- It is a narrow strip of land surrounded by water on three sides.
- Most of the area is low lying.
- The land is made up of fine grained, loose soils.
- Groundwater is shallow and influenced by the tides.

What we don't know

While some generalised statements can be made about the physical features of the land across the whole Regeneration Strategy project area, there are likely to be localised differences at an individual property level.

Dynamic coastal processes

The Spit was formed by, and continues to be affected by, dynamic processes of waves, wind, sea level, and currents which change the shape of the coastal environment by adding (accreting), removing (eroding) or transferring sediments.

These processes are part of a natural cycle and will change over time, depending on a combination of the movement of water (hydrodynamic processes); the physical features of the coast (geomorphology); and the availability of sediment to be deposited (sediment budget).[10]

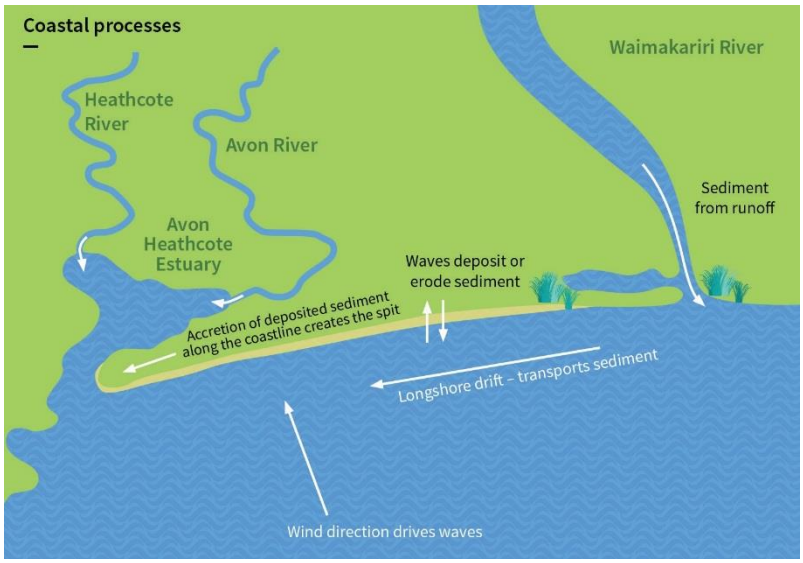


Figure 2 - Coastal processes of the Regeneration Strategy project area.

Left to themselves, sandspits naturally change over time. They constantly move and change shape, especially at estuary mouths, as the sea interacts with loose sediment (sand) rather than firm land.

[10] (Ministry for the Environment, 2017b)

What we know

Sediment Supply

Sediment, primarily from the Waimakariri River, has been transported south along Te Kaikai a Waro/Pegasus Bay and deposited along the Christchurch coast to form the dunes and the Spit. [11]

The open coast, on the eastern side of the Regeneration Strategy project area, is currently accreting, building sediment on the beach. This is largely because of the sediment continuing to discharge from the Waimakariri River. The dunes have also been increasing in volume and building seawards (accreting), mainly due to dune management and planting efforts to stabilise the dunes.[12] Despite this pattern of growth, the beach and dunes can experience short term periods of erosion because of storms. [13]

The south end of the Spit is a dynamic and constantly changing area because of the combination of effects from the open coast and the Estuary/Ihutai channel processes. This creates fluctuations in the size, shape and location of the Estuary/Ihutai mouth and end of the Spit.[14]

Figure 3 - Inlet migration curve - the most landward shoreline position of the Spit based on four historic shorelines of the dune toe in 1941 (blue), 1955 (red), 1994 (green) and 2011 (black). (Tonkin & Taylor Ltd., 2017)

Between 1940 and 1949 the Estuary/Ihutai position shifted to a more northwards position. This and several large coastal storms caused significant erosion of the end of the spit. Following this period of erosion there was a subsequent period of growth when the previously eroded foredunes were

[11] (Comfort, 1995); (NIWA, 2015a); (Avon-Heathcote Estuary Ihutai Trust, 2013); (Boffa Miskell, 2015)
[12] (Tonkin & Taylor Ltd., 2017a)
[13] For evidence of these erosion periods – see historic aerial imagery of the area https://apps.canterburymaps.govt.nz/CanterburyHistoricAerialImagery/
[14] (Comfort, 1995); (NIWA, 2015a); (Avon-Heathcote Estuary Ihutai Trust, 2013); (Christchurch City Council, 2014d); (Davis, 2000)

reformed. Some of these reformed foredunes were developed for residential purposes. [15] Figure 4 shows the range and scale of physical changes to the Spit between 1941 and 2011.

Just inside the Estuary/Ihutai mouth the channel is more stable, but the Estuary/Ihutai bed is constantly changing. Even small changes to the river or tidal currents can cause the loose, fine silty sands of the Estuary/Ihutai bed to move.

Tides

Tides are primarily caused by the gravitational attraction of the sun and moon which result in ocean long waves interacting with the sea floor to produce a rise and fall in sea levels (tides).

The sea level we see at the coast is made up of a combination of tides, storm effects (such as storm surges), wave effects, and medium and longer-term changes in sea level due to climatic and/or geological processes, and is constantly changing.[16] We have a good understanding of the tides and their influences in Christchurch. Our tides are typical of the east coast of New Zealand where the fortnightly influence of the sun on the tide is weaker than other places, and the monthly influence of the moon has a much more dominant impact on the heights of the tides. This means that on the Christchurch coast we experience a more dominant high tide period once a month (perigean tide) rather than two fortnightly spring high tide periods. Flooding usually occurs when an extreme coastal storm or other weather event coincides with these monthly perigean tide.[17]

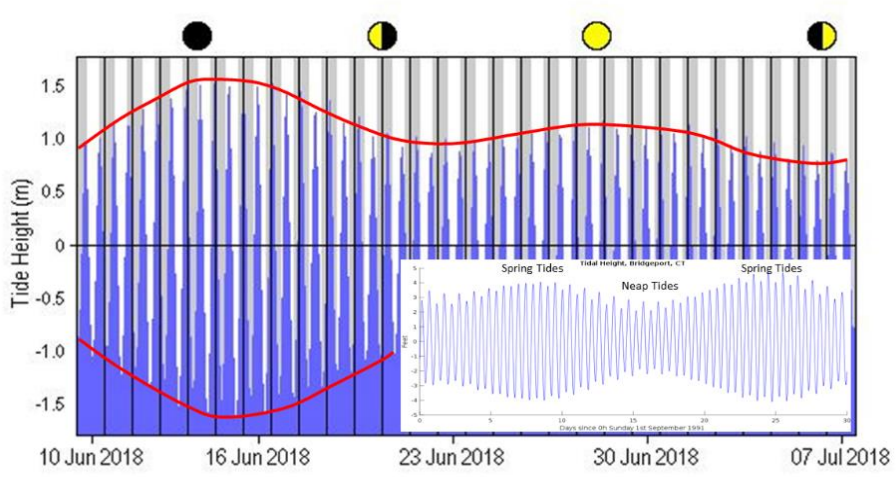


Figure 4 - Difference between spring/neap tides, and monthly perigean tides measured at Lyttelton. Adapted from NIWA tide forcaster 2018 https://niwa.co.nz/services/online-services/tide-forecaster,

The tide in the shallow water of the Estuary/Ihutai behaves differently from the tide on the open coast. It takes more time for the tide to move through the mouth of the Estuary/Ihutai and over its sand bars, into shallow water and up the rivers than it does to move up the open coast, and effects like friction distort the shape of the tidal wave. As a result, the heights and timing of the tides differ at different sites in the Estuary/Ihutai and rivers. For example, high tide at the Ferrymead Bridge is 53 minutes later and 100mm higher than at Sumner. Low tide is nearly three hours later and 700mm higher[18].

[15] (Davis, 2000)
[16] (Tonkin & Taylor Ltd., 2017a)
[17] (NIWA, 1998); (Ministry for the Environment, 2017e)
[18] (Goring D. , 2017)

Tides influence groundwater levels near the coast, causing daily and monthly fluctuations and also affects the groundwater levels adjacent to the lower reaches of the rivers and near the river mouths (for example, the area North of Bridge Street).

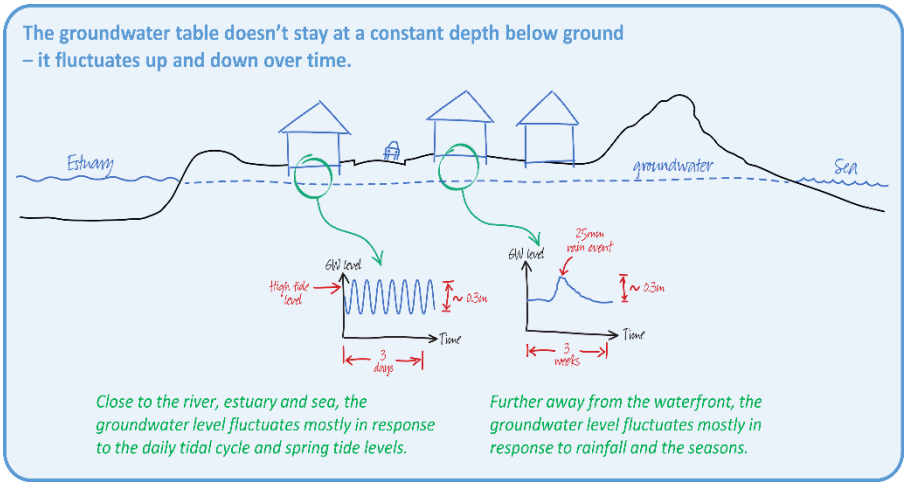


Figure 6 – Potential impacts Wave components impacting water levels (Tonkin & Taylor Ltd., 2017).

Wave dynamics and water levels

The open coast on the eastern side of the Regeneration Strategy project area is affected by deep water waves from distant offshore storms and locally generated wind waves. In Te Kaikai a Waro/Pegasus Bay prevailing waves approach from the north-east (particularly in summer), east and south-east (particularly in winter). Banks Peninsula shelters this part of the coast from the worst of the storms that come from the south[19].

On both the open coast and in the Estuary/Ihutai, water level plays an important role in shaping and changing the shoreline.[20] Water level at the coast is a component of the tide, storm surge[21], and wave run-up. Wave run-up is a combination of the elevated mean water level during the breaking process (called the 'wave set-up'), and the maximum level the waves reach on the beach (called the 'wave swash')[22].

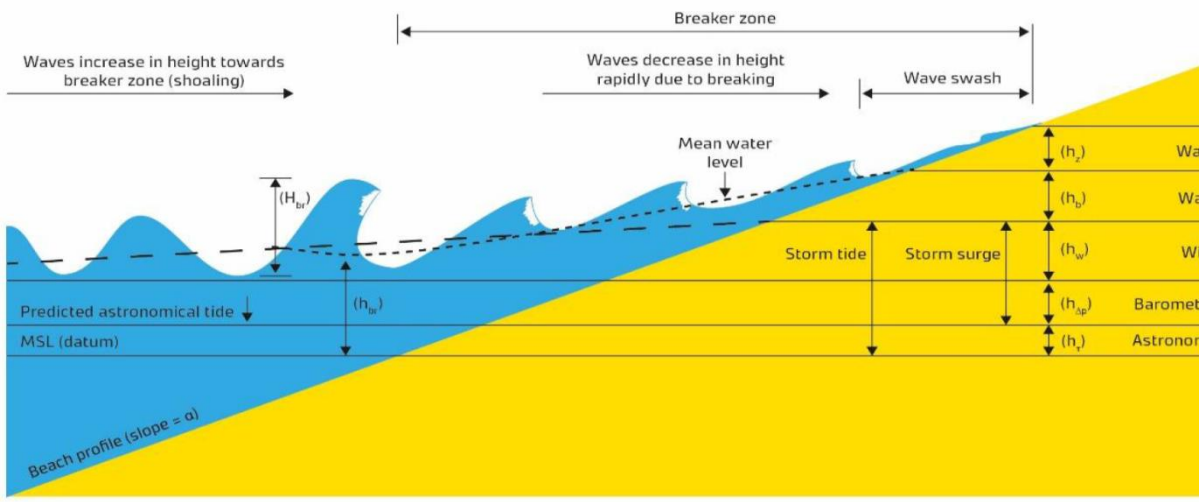


Figure 6 – Wave components impacting water levels (Tonkin & Taylor Ltd., 2017).

[19] (URS, 2004)
[20] (Tonkin & Taylor Ltd., 2017a)
[21] When strong onshore winds and low-pressure weather systems elevate sea levels.
[22] (Tonkin & Taylor Ltd., 2017a)

Why this is important

Mean High Water Springs (MHWS) is calculated differently in Christchurch. MHWS is used to describe the boundary between land and sea[23]. It is an important planning boundary and separates areas of responsibilities between the Christchurch City Council and Environment Canterbury. MHWS was previously measured at 10.40m above the Christchurch Drainage Datum (CDD) for Christchurch[24], but has recently been recalculated at 10.30m above CDD[25]. A drainage datum is a reference point used for surveying land and water levels which is typically set below lowest tide levels (see Figure 8). Any future modelling and investigations will use this updated level.

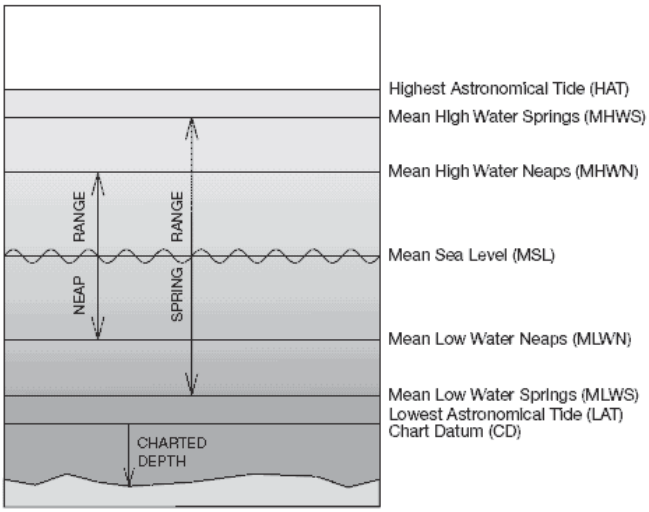


Figure 7 - Relationship between datum and MHWS (Land and Information New Zealand, n.d.)

Modelling in Christchurch reflects the local dynamic processes

The *Coastal Hazard Assessment for Christchurch and Banks Peninsula* 2017[1] estimates areas potentially at risk from coastal inundation and erosion. It uses the best currently available data on water levels and sediment budgets. Tidal fluctuations in groundwater and river levels are incorporated into modelling for shallow groundwater assessments and flood risks.

What we don't know

Long-term sediment supply

While the current cycle of accretion is stabilising the dunes, there is a risk of a cycle of erosion in the longer-term if the supply or transport of sediment from the Waimakariri River changes. There are a number of reasons why the supply of sediment could change, including climate change effects on how river sediment is transported; wind, wave and rainfall patterns; earthquakes; water abstraction from the Waimakariri River and aquifers; and gravel extraction in the lower reaches of the Waimakiriri River[26].

As part of the Christchurch City Council's Land Drainage Recovery Programme, a study on the sediment budget for southern Te Kaikai a Waro/Pegasus Bay is underway. The results of the study will help the Christchurch City Council to understand how future changes in sediment supply may affect coastal processes such as erosion, accretion and inundation on the open coast and within the Estuary/Ihutai.

Whether statistics of extreme sea levels need to be recalculated

Extreme sea levels during storms are currently defined as those that exceed 10.81m above the Christchurch Drainage Datum (at Bridge Street). Since 2010 there have been five separate extreme sea level events - four of them since June 2017. This may mean the levels currently used for extreme

[23] (Ministry for the Environment, 2017e)
[24] (Tonkin & Taylor Ltd., 2017a)
[25] (Goring D. , 2017)
[1] (Tonkin & Taylor Ltd., 2017a)
[26] (Tonkin & Taylor Ltd., 2017a); (Hicks, 1998)

sea levels in the Estuary/Ihutai are being underestimated and higher sea levels may occur more often. Christchurch City Council and Environment Canterbury are currently doing more work to review and, if necessary, update the extreme sea level statistics.

Water quality

The Ōtākaro/Avon River drains through a large part of Christchurch City before flowing into the Estuary/Ihutai, which is also fed by the Ōpāwaho/Heathcote River. Both rivers originate from groundwater springs, meaning their water quality is dependent on both the groundwater quality in the springs and the quality of discharges, stormwater and runoff which feed into them.[27]

What we know[28]

Water quality within the Estuary/Ihutai is 'poor' at the mouths of the Ōpāwaho/Heathcote River and Ōtākaro/Avon River, and 'good' close to the Estuary/Ihutai mouth and on the open coast. [29]

Since March 2010, Christchurch City's treated wastewater has been discharged via a three kilometre ocean outfall, instead of into the Estuary/Ihutai. This contributed to an improvement in the water quality in the Estuary/Ihutai.

The earthquakes had an impact on the levels of bacteria in the Estuary/Ihutai and in the lower reaches of the rivers, largely caused by untreated wastewater discharges from damaged infrastructure following the earthquakes. Once major infrastructure works were completed, levels recovered to pre-earthquake concentrations. They continue to be monitored by Environment Canterbury and the Council.

Why this is important

Changes in the water quality of the Estuary/Ihutai can have an impact on ecosystems, as has been seen with historic discharges, and recent earthquakes.

Ecology

The different environments around the edges of the Regeneration Strategy project area provide important habitats for a diverse range of plants and animals. The area has three main habitats: the coastal sand dunes and south end of the Spit; the intertidal areas adjacent to the Estuary/Ihutai; and areas of open space and reserves.

[27] (Bolton-Ritchie L. , 2017)
[28] (Bolton-Ritchie L. , 2017); (Bolton-Ritchie, 2014); (Bolton-Ritchie L. , 2015)
[29] See Environment Canterbury Recreational Water Quality map for more information http://maps.ecan.govt.nz/WaterQuality/

What we know

Range of habitats[30]

The habitat of the coastal sand dunes comprises a wide and sandy beach, foredunes, and backdunes. This habitat supports several birds, shellfish and sand-binding plants. Most of these plants are exotic species such as marram grass, although native species have been planted in a number of areas, including the Southshore Spit Reserve.

The intertidal areas of saltmarsh are mostly located north of Bridge Street, and in patches on several parts of the estuary edge in Southshore. Indigenous species include marsh ribbonwood (*Plaginathus divaricatus*), sea rush (*Juncus krausii*) and jointed rush/oioi (*Apodasmia similis*).

Figure 8 – Vegetated dunes, and adjoining development on the open coast, end of Rocking Horse Road, Southshore

Figure 9 - Saltmarsh near Penguin Street, Southshore

Some of the saltmarsh is suffering die-back because of increased tidal flooding and bed erosion following the earthquakes, particularly around Bridge Street. However, in other areas where improved habitat condition and new habitat where areas experienced some uplift, small patches of saltmarsh have expanded (for example, around Tern Street and Penguin Street).

The Estuary/Ihutai itself supports an abundant and diverse ecosystem. The importance of the Estuary/Ihutai as a bird habitat for roosting and feeding is nationally and internationally recognised.

It provides a rich food source and is a strategic location for migratory birds. The variety and abundance of migratory waders and wetland birds located in one place is particularly significant, with up to 144 bird species recorded[31].

[30] (Christchurch City Council, 2014) (Christchurch City Council, 2000) (Boffa Miskell, 2015)
[31] (Crossland, 2013); (NIWA, 2015a)

Adjoining the Estuary/Ihutai is the residential red zone, now cleared of buildings and grassed, and a number of recreation and scenic reserves. These areas are a mixture of exotic tree species, open grassed areas, and native regeneration planting.

Figure 10 - Residential Red Zone, near Heron Street, Southshore

Some areas, such as the area near the river mouth north of Bridge Street, have seen an increase in bird populations and the diversity of species over the last 30 years[32]. In other areas the existing vegetation has become increasingly stressed by the change in salinity and water levels due to subsidence as a consequence of the 2010-2011 Canterbury earthquakes, and further slight subsidence that occurred during the 2016 Kaikōura-Hurunui earthquake[33].

These ecosystems, including those on the edge of the Estuary/Ihutai adjacent to the Regeneration Strategy project area, are highly sensitive to changes in salinity, water level, moisture, sedimentation, the concentration of contaminants, temperature, and sunlight.

Why this is important

International, national, regional and district significance

The coastal margin of the Regeneration Strategy project area and the Estuary/Ihutai are recognised either nationally, regionally or at a district level for their unique ecosystems, and the amenity values. These areas are listed in Figure 12 below.

	Estuary and river mouth	Dunes and end of Spit
National recognition[1]	Wetlands of representative importance Land of national significance Site of special wildlife significance	
Regional recognition[2]	Area of significant natural value	Area of significant natural value (end of spit)
District recognition[3]	Coastal natural character Outstanding natural landscape Site of ecological significance Significant landscape feature – Jellicoe Marsh	Coastal natural character Outstanding natural landscape Site of ecological significance

[1] Department of Conservation – sourced from Canterbury maps
[2] (Environment Canterbury Regional Council, 2003)
[3] (Christchurch City Council, 2017)

Figure 11 – Significance of ecosystems and landscapes within and adjoining the Regeneration Strategy project area

See the cultural values section of the Baseline Assessment for details relating to cultural importance of these areas.

[32] (Crossland, 2013)
[33] (NIWA, 2015a); (Avon-Heathcote Estuary Ihutai Trust, 2013)

Climate change will exacerbate sensitivities

Increases in sea level and storms as a result of climate change will cause changes in salinity, water depth, and wave-affected areas, impacting the Estuary/Ihutai habitats adjacent to the Regeneration Strategy project area[34].

Opportunity to maintain and enhance values and natural protection

The habitats in the Regeneration Strategy project area provide an important buffer between the natural and built environment on both the open coast and estuary edge. For example, saltmarshes increase accretion rates by providing an erosion buffer, increasing or stabilising the marsh surface through its network of plant roots[35].

What we don't know

It is not clear whether there will be long term or irreversible impacts of climate change on the natural habitats and ecosystems, and if so what these are and when they will become apparent.

Changes to the natural environment caused by earthquakes

The 2010-2011 Canterbury earthquakes, and to a lesser extent, the 2016 Kaikōura-Hurunui earthquake, caused uplift and subsidence of land in Southshore, South New Brighton and in the Estuary/Ihutai; as well as liquefaction, lateral spread and other effects of ground shaking. This led to changes in the ground surface, physical processes, and ecosystems[36].

[34] (Avon-Heathcote Estuary Ihutai Trust, 2013)
[35] (Hunt, 2016)
[36] (Marsden, Hart, & Gomez, 2016)

What we know

Estuary bed tilt[37]

The earthquakes caused the bed of the Estuary/Ihutai to tilt, lifting in the south and subsiding in the north - particularly near the mouth of the Ōtākaro/Avon River, north of Bridge Street. The tilting has altered drainage and inter-tidal water levels within the Estuary/Ihutai.

Changes in ground levels in the Regeneration Strategy project area

Post-earthquake surveys of ground elevation indicate that the Regeneration Strategy project area has experienced subsidence and uplift in both the 2010-2011 Canterbury Earthquakes, and the 2016 Kaikōura-Hurunui earthquake. Parts of the west side of South New Brighton, north of Bridge Street experienced subsidence between 0.2-1.0m, while parts of Southshore experienced some uplift[38].

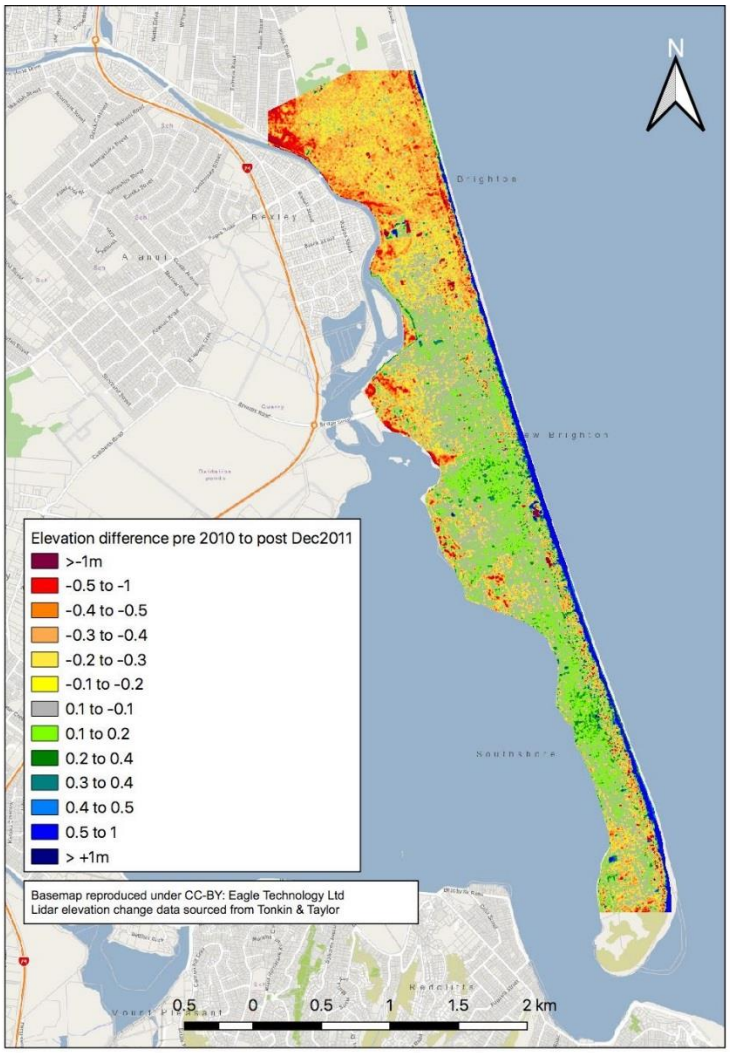


Figure 12 - Ground elevation change following the Canterbury Earthquakes. Difference between 2003 LiDAR survey undertaken by Christchurch City Council and 2012 LiDAR survey undertaken by EQC

Changing ecosystems[39]

There have been small areas of both loss and migration of saltmarsh due to subsidence and tilting of the estuary bed.

Liquefaction within the Estuary/Ihutai presented as 'sand volcanoes' caused a change of grain size distribution of the sediments in the Estuary/Ihutai[40]. However, the grain size distribution of the sediments at monitoring sites within the Estuary/Ihutai is returning to pre-earthquake conditions. As previously mentioned, sewage discharges into the rivers and the Estuary/Ihutai affected water quality in the short term.

Why this is important

Changes in the Estuary/Ihutai mouth, channels and shoreline are likely to continue as the water flowing in an out of the Estuary/Ihutai adjusts to the altered bed[41].

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[37] (NIWA, 2015a); (Avon-Heathcote Estuary Ihutai Trust, 2013); (Measures, et al., 2011)
[38] (Tonkin & Taylor Ltd, 2018)
[39] (Hollever & Bolton-Ritchie, 2016); (Avon-Heathcote Estuary Ihutai Trust, 2013)
[40] (Bolton-Ritchie L. , 2015)
[41] (Marsden, Hart, & Gomez, 2016)

Depending on the location, changes in ground levels may change the susceptibility to natural hazards such as shallow groundwater or flooding. See Natural Hazards section.

What we don't know

It is not clear at this stage how the landform changes in the Estuary/Ihutai bed, the Estuary/Ihutai mouth, and the surrounding land will affect coastal processes in the long-term, and what the implications of any changes will be.

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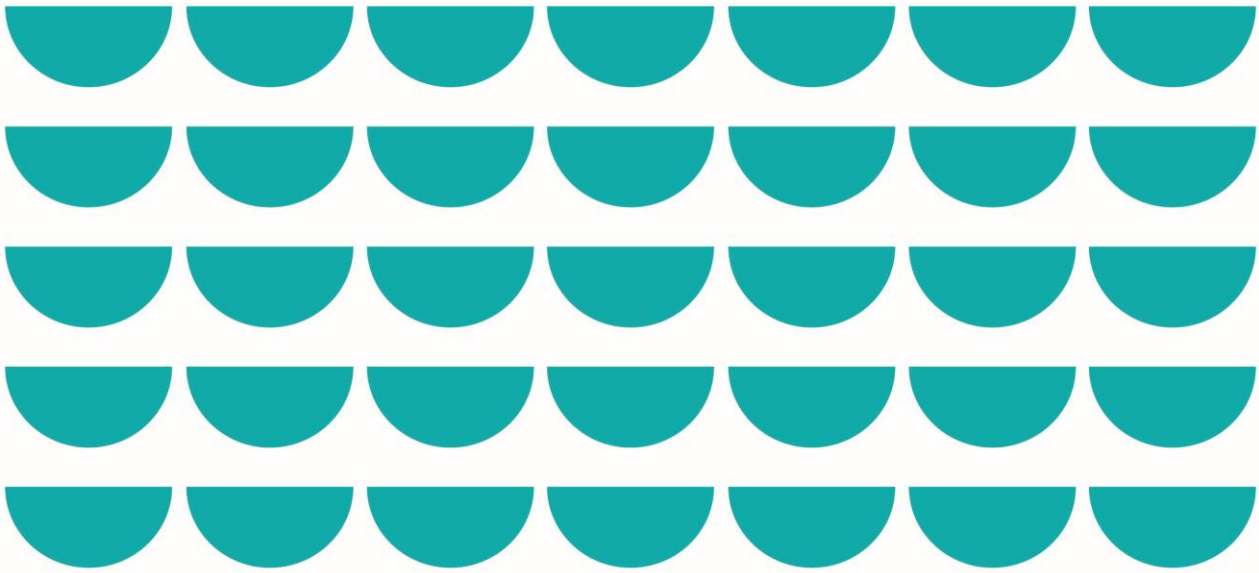

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However, this information is a starting point for the conversation about actions for how this area can adapt to the effects of climate change and have a positive, viable and certain future. Coming up with the actions to address the potential effects of climate change, and working out when they need to occur is called 'adaptive planning' and it's what the Regeneration Strategy is all about.

Adaptive planning is recommended by the Ministry for the Environment and uses the four climate change scenarios as identified by the Intergovernmental Panel on Climate Change (IPCC). Using possible future scenarios means communities can plan for the 'what if' rather than the 'when'. Adaptive planning means the agreed course of action can change if need be – for example, if new climate change information becomes available. It also gives decision-makers a way to progress things and make decisions, even when there is uncertainty about the rate and effects of sea level rise.

Understanding the state of the land, and the things that might affect it, as well as its cultural significance, history and environment, will help provide context for adaptive planning.

Human Environment

Residential development has significantly changed much of the Regeneration Strategy project area's original environment of saltmarsh and sand dunes[1].

History of settlement and development

What we know

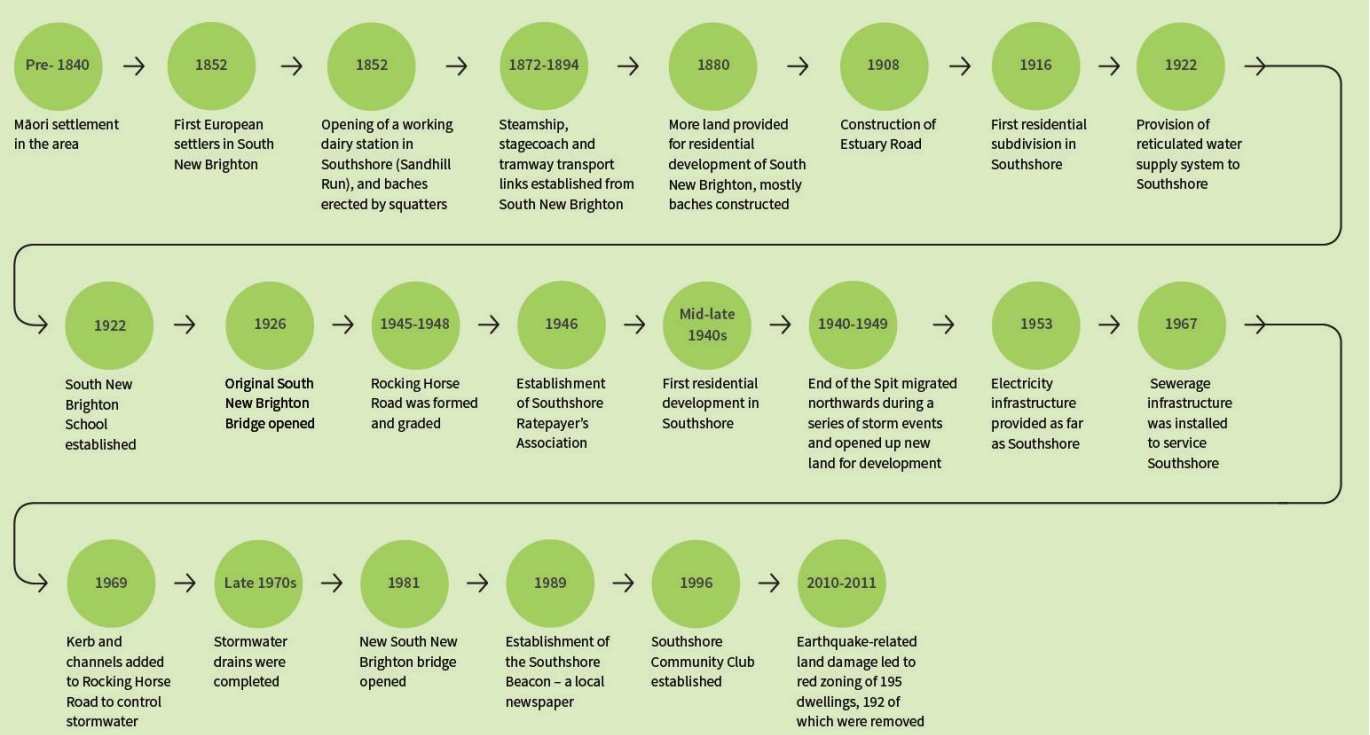


Figure 1 - History of development

European settlement of the regeneration strategy project area[2]

In 1852, after the arrival of European settlers, Southshore became part of the Sandhills Run, a dairy farm which supplied most of the milk for the new settlement of Christchurch. During this time squatters built a number of baches but no formal residential development occurred until much later[3].

[2] (Comfort, 1995); (Avon-Heathcote Estuary Ihutai Trust, 2013); (Boyd, 2010)
[3] (Comfort, 1995)

Figure 2 - Residential development in Southshore from 1945-2018. Adapted from Canterbury Maps (2018)

In comparison, South New Brighton saw its earliest settlers in 1852. Various transport links were established throughout the late 19th century, with development progressing after 1880 following subdivision, with mostly baches constructed. The South New Brighton School was established early in 1922 with 47 pupils, although it took until 1940 for permanent classrooms to be built on the current school site[4].

It was not until 1916 that any attempt was made to develop Southshore for permanent residential use. A large portion of the Regeneration Strategy project area was subdivided for housing but did not progress at this time. Instead, during World War One, the area was used for gunnery practice, as a rifle range, and later as a holiday camp which didn't succeed[5].

In the mid to late 1940s Rocking Horse Road was formed to the end of the Spit, residential development began in the Southshore area (starting with just seven houses), and the Southshore Ratepayers' Association was established. Further residential development was slow in Southshore, with services to the area not fully connected until the late 1960s. In 1953 the area received electricity 35 years after New Brighton, and in 1967, a sewage system. In 1969, after 22 years of requests, gutters were finally added to Rocking Horse Road, which had often flooded during rainy periods.

In the 1970s residential development accelerated, making the Regeneration Strategy project area one of the most developed coastal spits in New Zealand. The South New Brighton Bridge was officially opened in 1981, and the bus service to Southshore finally reached the end of Rocking Horse Road. The area continued to grow, with a population increase in Southshore from 650 people in 1972 to 1425 people in 1991. To support this community, a small local newspaper 'the Southshore Beacon' was established in 1989, and the Southshore Community Club in 1996[6].

Figure 3 - Residential Red Zone properties in the Regeneration Strategy project area

Changes in settlement patterns because of the earthquakes

The 2010 and 2011 Canterbury earthquakes caused significant damage to land and buildings in the Regeneration Strategy project area. The Crown adopted a social policy response to help people in the worst affected areas where land was not recommended for continued residential development in the short-term. This land was categorised as 'residential red zone' and voluntary offers to purchase were made to 195 property owners.[7]

As a result of this process, 192 private properties were purchased by the Crown and subsequently demolished. This has created an open grassed area of land between the estuary edge and other residential dwellings in this area. Approximately 480 members of the community

[4] (Manhire)
[5] (Comfort, 1995); (Boyd, 2010)
[6] (Boyd, 2010); (Comfort, 1995)
[7] (Canterbury Earthquake Recovery Authority, 2016)

relocated as a result.[8] In addition to the 195 red zoned properties, an unknown number of properties were damaged because of the earthquakes.

Why this is important

The history of Maori settlement in the Regeneration Strategy project area suggests the area will be culturally significant and associated values will need to be factored into any future discussions.

Southshore and South New Brighton are established suburbs with significant social and capital investment. As they are bordered by the coast and the Estuary/Ihutai, this can create challenges which will likely increase over time with the impacts of climate change. The extent of those impacts is currently unknown and this uncertainty adds to the challenges.

What we don't know

It is acknowledged that much of the research used to inform the information in this section is based on Southshore and that there will be localised differences within the Regeneration Strategy project area.

Current land use

What we know

Residential land use

Current land use in the communities of Southshore and South New Brighton is predominantly privately owned residential development with some community facilities. There is open space managed by Christchurch City Council where the dunes and reserves are located (figures 4 and 5).

In the residential red zone nearly all houses bordering the Estuary/Ihutai have been removed, creating a strip of open space between the remaining houses and the estuary edge. The residential red zoned land is mostly Crown-owned, with two privately owned properties on Rocking Horse Road.

[8] (Christchurch City Council, 2017b); (Canterbury Earthquake Recovery Authority, 2012)

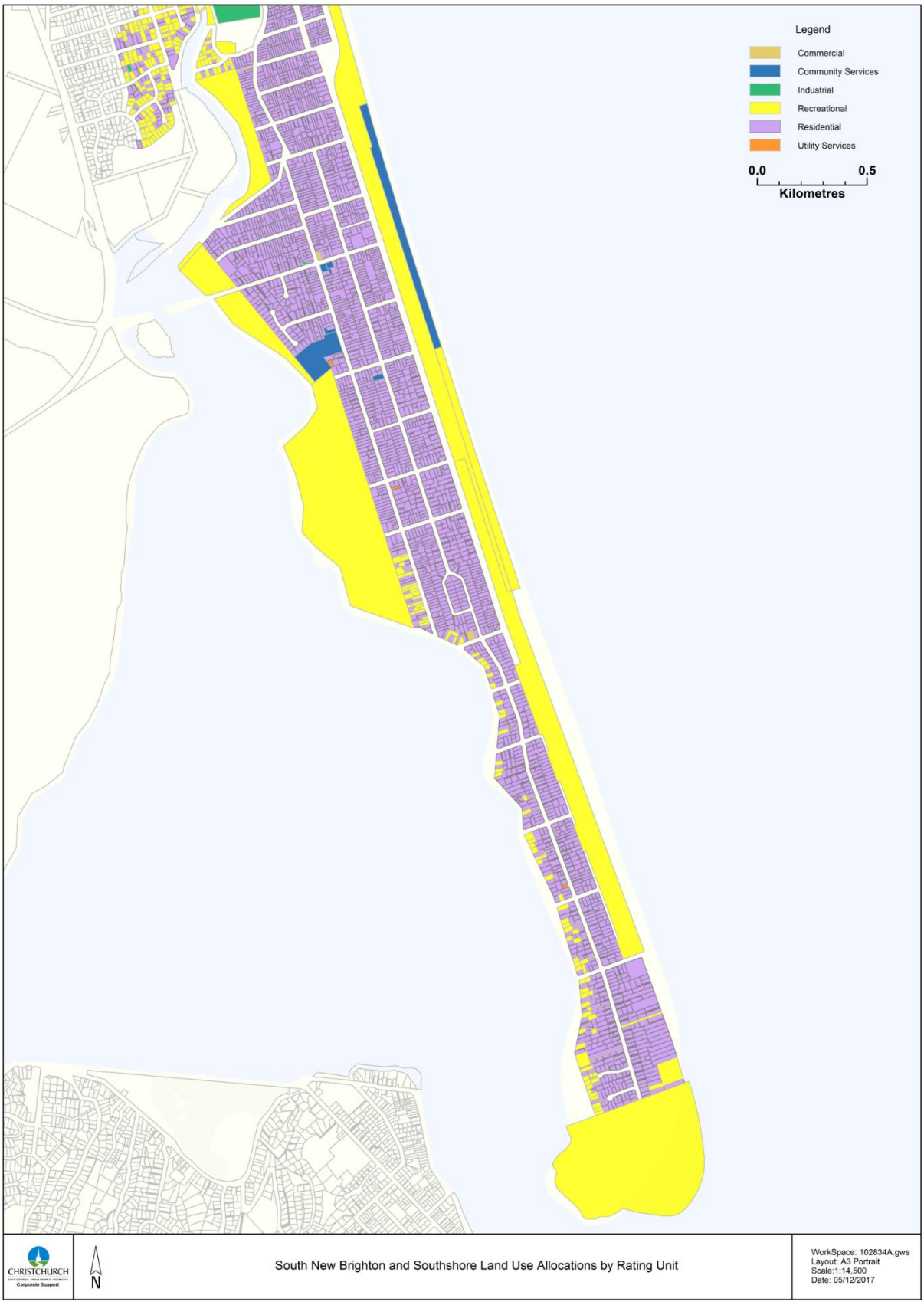


Figure 4 – Land use in the Regeneration Strategy Project Area (CCC 2018)

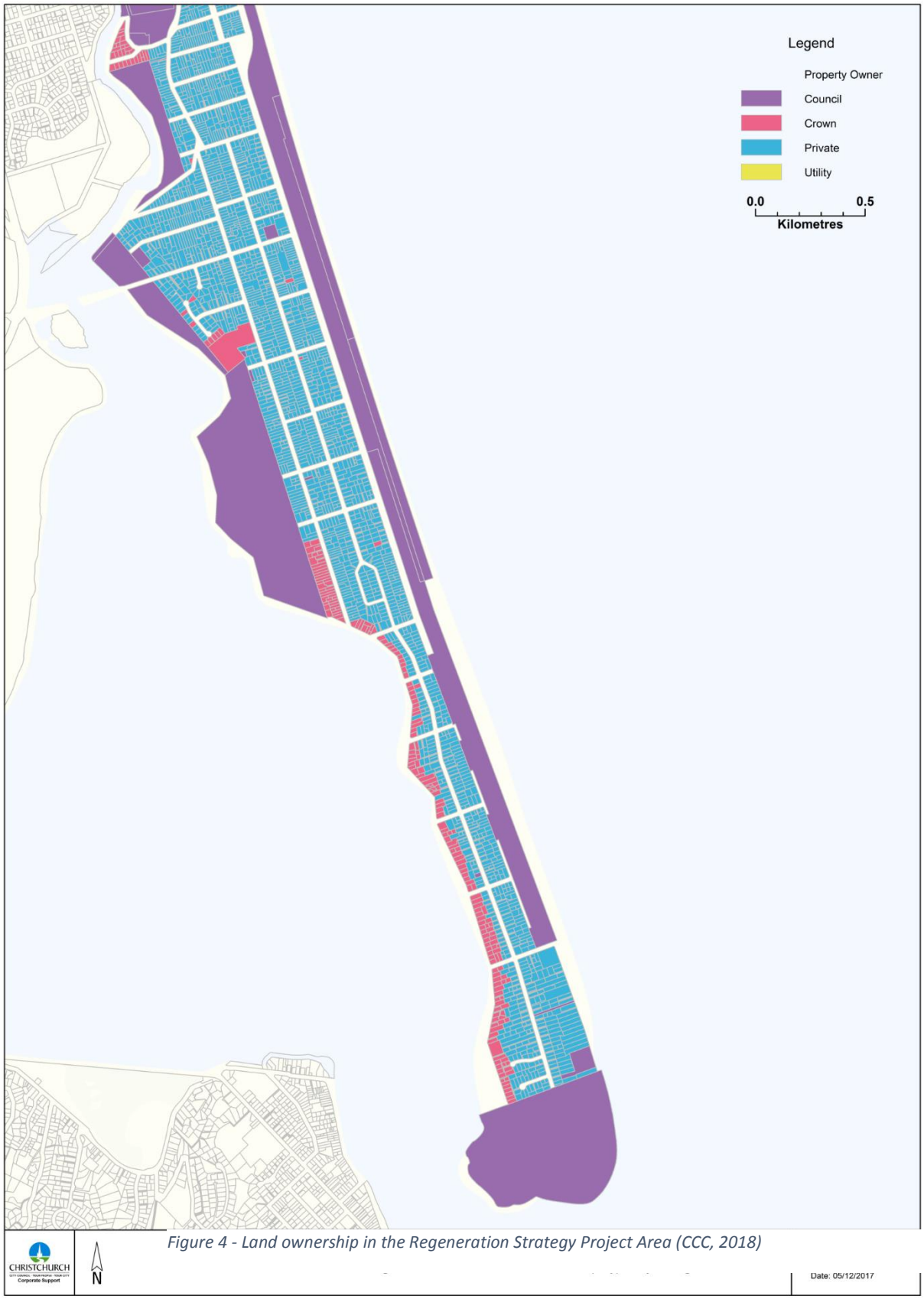


Figure 4 - Land ownership in the Regeneration Strategy Project Area (CCC, 2018)

Figure 6 below outlines the age of buildings in the Regeneration Strategy project area. In South New Brighton around 60% of the houses were built between the 1940s and the 1970s. In Southshore, 70% of the houses were built between 1950s and the 1970s. Approximately 166 new houses have been constructed since 2010, most of which were rebuilt because of earthquake damage.

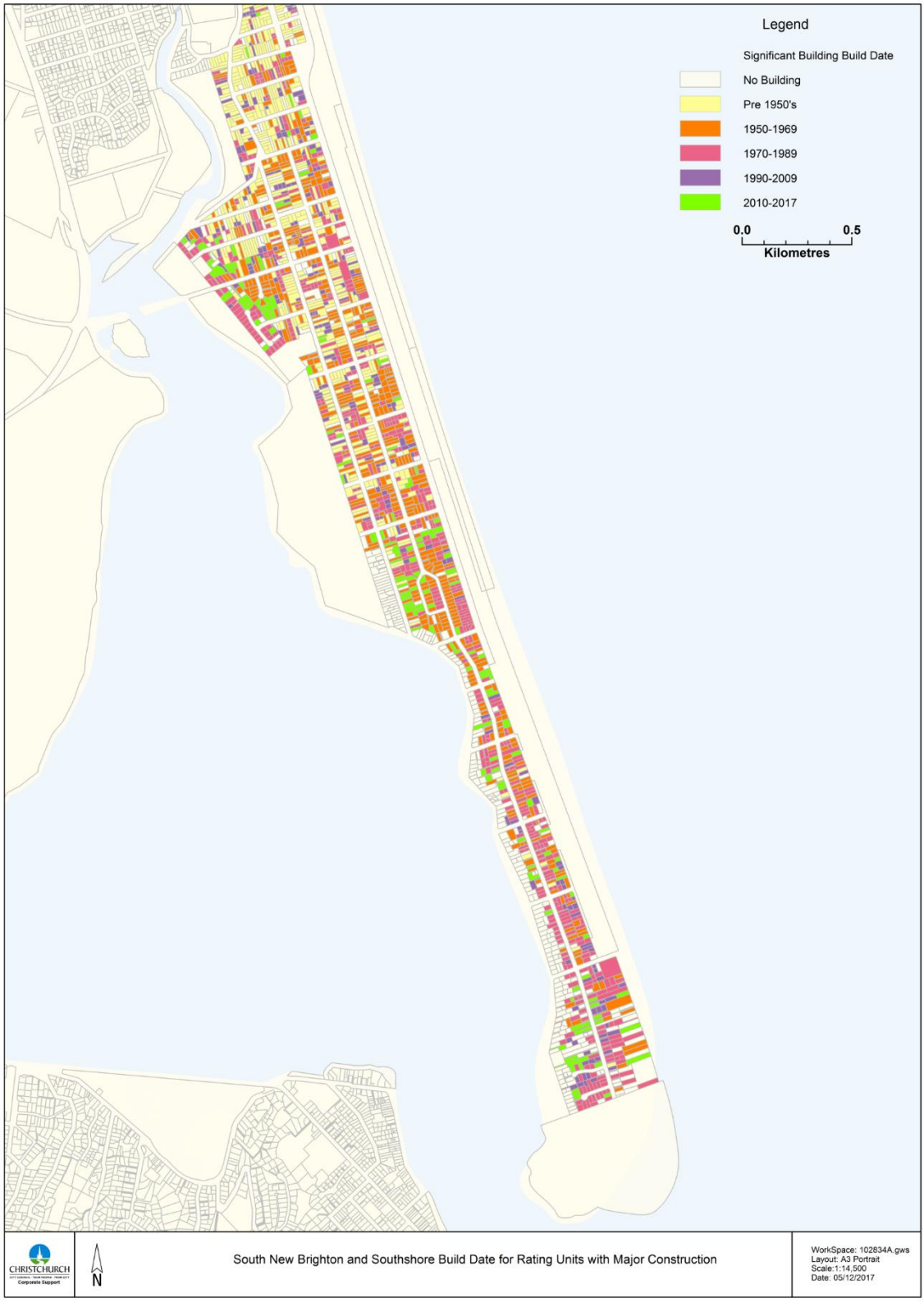


Figure 6 - Building ages in the Regeneration Strategy Project Area based on rating information (CCC 2018)

Housing market

Property values in the Regeneration Strategy project area dropped slightly following the earthquakes, consistent with city-wide trends, but have since stabilised and property is still being sold and bought.[9] The average property value (land and improvement value) at (insert date) was $377,876 for South New Brighton and $449,354 for Southshore. The total value of residential properties and assets in the Regeneration Strategy project area is $790 million.

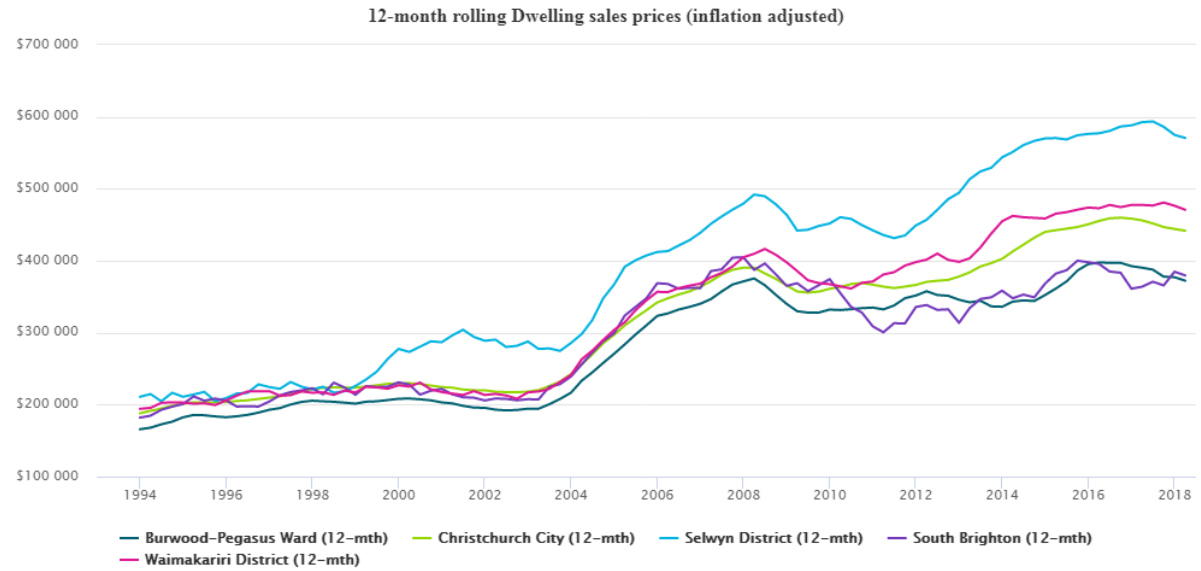


Figure 8 - Dwelling sales prices for South Brighton census area, in relation to wider district and surrounding areas. (Ministry of Business, Innovation and Employment (MBIE), 2018)

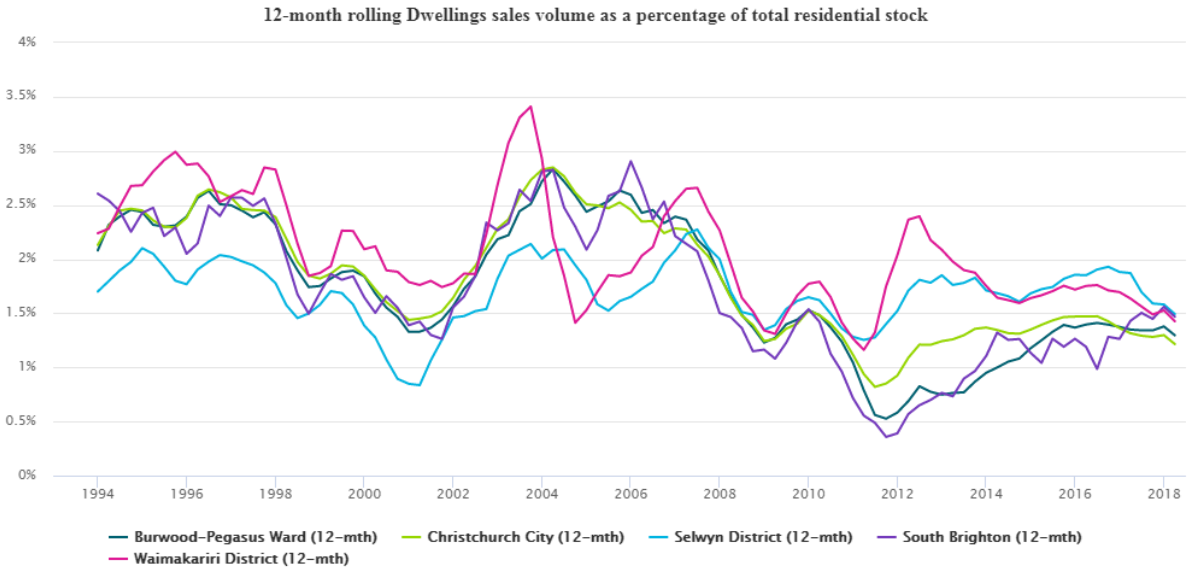


Figure 7 - Dwelling sales volume for South Brighton census area, in relation to wider district and surrounding areas. (Ministry of Business, Innovation and Employment (MBIE), 2018)

[9] (McDonald, Housing demand pushes price growth east in Christchurch, 2016); (McDonald, Beach suburb home values bouncing back, 2016)

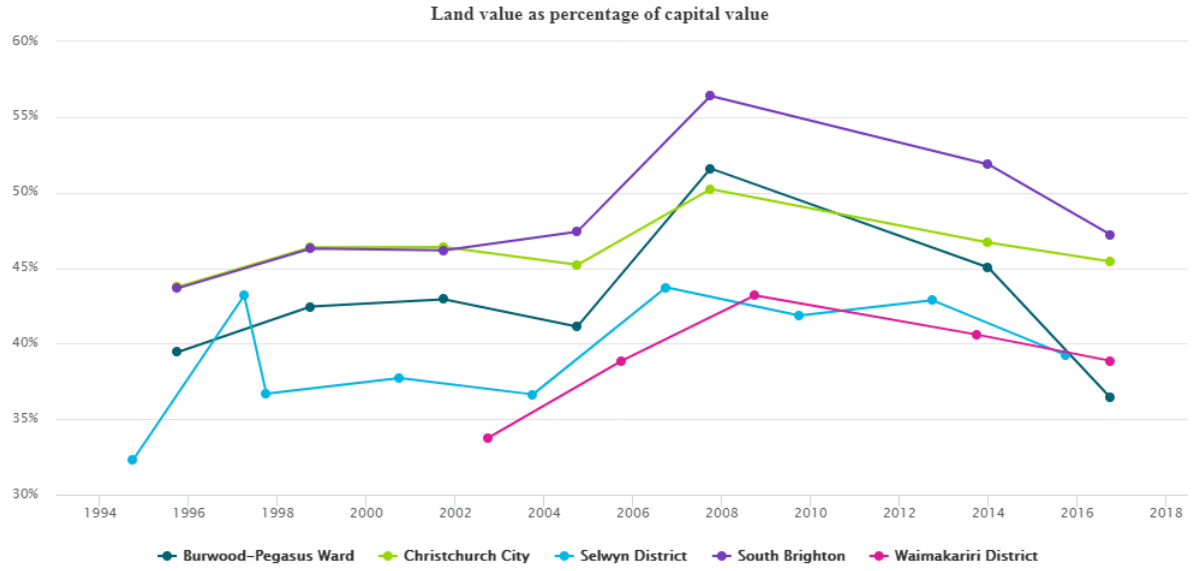


Figure 9 – Land value for South Brighton census area, in relation to wider district and surrounding areas. (Ministry of Business, Innovation and Employment (MBIE), 2018)

Residential catchment for nearby commercial centre

The Regeneration Strategy project area is part of the residential catchment for the commercial area of New Brighton. Once a thriving district centre, the commercial core of New Brighton has been in decline since the 1980s and suffered significant damage during the Canterbury Earthquakes. The New Brighton Regeneration Project led by Development Christchurch Ltd (DCL)[10] builds on the New Brighton Suburban Master Plan[11] and seeks to deliver key projects to support the revitalisation of New Brighton.

The Council has allocated capital investment for the revitalisation of New Brighton in its 2018-28 Long Term Plan (LTP). Following a recently completed $8M beachside playground upgrade, the Council has allocated over $16M to street and open space improvements over the next 10 years, and has allocated another $9.7M for a 'Phase One Hot Salt Water Pool' development over the next year[12].

Local shopping areas and community spaces

Prior to the 2010/11 earthquakes the Regenerate Strategy project area had two distinct local shopping areas. The first at the Bridge Street, Estuary Road corner and the second on Caspian Street. Both were significantly impacted in the earthquakes. The shops at Caspian Street, which had included a cafe/bar, dairy, takeaway shop and hairdresser all closed, and the buildings remain unrepaired. At the Bridge Street, Estuary Road corner only one dairy and the local garage remain from a once thriving retail area that included a café, takeaway shops, bottle store, dairies, chemist and doctors' surgery. There is a dairy on Union Street and a café and hairdresser on Rodney Street.

The local community hall on Beatty Street, which was also the school hall and used as the toy library, was demolished and replaced with a smaller community centre relocated from the old QE11 site. Since then the school has been without a hall and has to assemble outside, winter and summer. This means the school cannot

[10] DCL is the Urban Development Agency for Christchurch City Council tasked with providing commercial advice, and in some instances leading projects, where Council funds have been committed to regeneration projects.
[11] (Christchurch City Council, 2015c)
[12] (Christchutrch City Council, 2018c)

hold whole school gatherings in bad weather. Though the new community centre is widely used, it is recognised by the community as inadequate for their needs.

The South Brighton Bowling Club was demolished after the earthquakes, as was the local yacht club - Pleasant Point Yacht Club. The Yacht Club currently operates out of containers near the recently repaired jetty and has plans to rebuild a club in the area. The South Brighton Bowling Club was not rebuilt.

The South Brighton Surf Lifesaving Club and South Brighton Tennis Club were also both significantly damaged. The South Brighton Surf Lifesaving Club is currently sourcing funding to rebuild their club. Both clubs remain highly supported in the community. The South Brighton Tennis Club has the largest junior numbers in all tennis clubs registered with Canterbury Tennis. The South Brighton Surf Lifesaving Club has a large junior programme and won the 2018 Canterbury Junior Surf Champs and the Southern Regional Junior competition. Both the South Brighton Surf Lifesaving Club and the South Brighton Tennis Club have grown substantially, particularly in the last 2-3 years.

Despite the lack of gathering places in the project area a keen sense of community remains. The Bridge South Brighton Trust (TBSBT) was established by a group of residents who saw an opportunity to repair the badly damaged church on the corner of Bridge Street and Estuary Road and create a replacement for some of the lost spaces. In 2016 Christchurch City Council approved TBST $325,000 to buy the building for the community "as is" (unrepaired). TBST are currently repairing the building to create a multi-use community hub, which will include a cafe, gallery, office space, wellness centre, information centre and a community hall to house the toy library, and provide a performance venue and event space.

Open space

Most of the land on the open coast and the estuary edge is public open space used as scenic and recreation reserves, and in some instances for flood protection (for example, near the mouth of the Ōtākaro/Avon River north of Bridge Street). In addition the residential red-zone land is currently operating as open space having been cleared of buildings, providing access to the estuary edge along the southern end of the Spit.

These open spaces provide local residents, and the wider Christchurch population, with a wide range of recreational opportunities. Established and informal walkways provide access to the beach, the Estuary/Ihutai and Southshore Spit Reserve.

The beach and estuary also provide residents with a wide range of recreational activities, including swimming, paddleboarding, yachting, fishing, surfing, surf lifesaving, windsurfing, canoeing and kayaking.[13]

Figure 10 - Open space and Residential Red Zone land in the Regeneration Strategy project area

[13] (Christchurch City Council, 2014b); (Boffa Miskell, 2015)

Why this is important

This area is highly valued as a place to live, and for its amenity, recreational opportunities and access to open spaces.

The residential red zone and reserves along the estuary edge and open coast provide an almost continuous area of open space between existing development and the coastal environments.

The two key stages of residential activity, the first from the 1940s to 1980s and the latter since the Canterbury earthquakes, have created two very different characteristics of residential development based on building materials, practices and codes at each time. This will have implications for the resilience of the building stock in the Regeneration Strategy project area.

What we don't know

It is not clear whether or when the property market or provision of insurance may be impacted by increasing hazard risk. Ongoing research by Motu[14] as part of the Deep South National Science Challenge on insurance, housing and climate adaptation has suggested that in areas recognised as especially vulnerable to climate change risks, there will be properties that become difficult to sell or insure. Evidence from international markets suggests that when insuring a risk becomes uneconomic, insurers can decide to change their insurance offering which can mean increasing premiums, bringing in risk-based pricing on policies, or withdrawing insurance altogether[15].

There is not a record of floor levels for all properties in the Regeneration Strategy project area, although those that have been rebuilt since 2010 are likely to be at the higher levels currently required to protect buildings from a 1-in-200-year flood. Knowing the scale of resilience of existing buildings will help improve understanding of the potential consequences of natural hazard risks, and at what point flooding, coastal inundation and groundwater hazards may become unacceptable risks.

There is also no definitive record of how many properties remain unrepaired and have been on-sold, 'as is, where is'.

Implications of past land use – potentially contaminated land

What we know

As Southshore/South New Brighton have developed some of the current land uses will have replaced past land use that may have involved storage, use or disposal of hazardous substances or chemicals. Such land uses could include landfill, bulk storage/use of pesticides, manufacture or disposal of asbestos. These sites are now considered likely to cause land contamination.

Where these sites are known they are identified on the Listed Land Use Register (LLUR), a publicly available database maintained by Environment Canterbury. The LLUR identifies 26 sites within the Southshore/South New Brighton Regeneration Strategy area. The property owners will have received a letter when they were added to the LLUR.

The LLUR uses Ministry for the Environment's Hazardous Activities and Industries List (HAIL), which is a compilation of activities and industries that are considered likely to cause land contamination resulting from

[14] Motu is a non-for-profit New Zealand independent economic research institute.
[15] (Storey et al., 2017)

hazardous substance use, storage or disposal. The requirement to assess and manage contaminated land is part of the Resource Management Act.

Why this is important

Potentially contaminated land can have adverse effects on the natural environment and human health. Disturbance of the soil occurs as land is developed or changes use. It is important to know where contaminated land is located so people are not exposed to contaminants that may affect their health.

Development on properties identified on the LLUR will need to follow guidance from Environment Canterbury and Christchurch City Council. This may include engaging an expert to undertake a detailed site investigation to find out if the land is actually contaminated, managing or remediating contaminated land or limiting the type of land use.

What we don't know

There are 26 sites that we are currently aware of. There may be additional HAIL activities or sources of contamination in the Southshore/South New Brighton Regeneration Strategy area that will need to be considered. We don't know how the impacts of climate change, such as rising groundwater or inundation, will affect these properties and potential leaching of contaminants.

Infrastructure

What we know

River and Estuary edge structures[16]

A range of formal and informal structures along the estuary edge, provide some short-term protection to infrastructure and development from inundation and erosion.

Temporary stopbanks along the narrow section of the estuary edge at the Pages Road end are being reinforced and stabilised. When this work is completed the temporary stopbanks will provide continuous protection as far south as Bridge Street. At the time of construction the temporary stopbanks were designed to protect the surrounding area from a 1 in 50-year flood which range in height up to 11.4m above the Christchurch Drainage Datum for Christchurch, and will have a design life of 20 years. There has also been a range of activities undertaken as part of the Christchurch City Council's temporary stopbanks project North of Bridge Street such as rock work, terramesh baskets, pipe replacement, tree removals and planting, building paths and trails, and top soiling.

A minor extension to the temporary stopbanks is planned for the first 185m immediately south of Bridge Street, although the rest of the extension to the jetty has been deferred and will be considered as part of the range of options explored in the Regeneration Strategy[17].

Along the estuary edge in Southshore there is a mix of natural edge, Christchurch City Council-owned structures, old sea walls and informal protection structures. Many structures were installed by private landowners along the estuary edge. It is not known whether these were consented or engineered to a particular design standard, and some structures have deteriorated or been displaced by the earthquakes.

[16] (Hunt, 2016); (Christchurch City Council, 2018a)
[17] (Christchurch City Council, 2017a)

In 2016 central government agencies constructed an informal landscaping bund along the estuary edge of the residential red zone. This may have reduced the risk of inundation in the short term. The Christchurch City Council filled in gaps in the bund and extended the bund in Jellicoe Marsh and around the South Brighton Holiday Park as part of a series of emergency works during flood events. Other recent works include rebuilding of the rock structures in front of the boardwalk in South New Brighton Reserve, and maintenance on the Ebbtide Street rockwall.

Short term and temporary stabilisation works as part of ongoing monitoring and maintenance may occur in front of the landscaping bund in Southshore and other bunds along the estuary edge in the interim of a long term strategy for the area. In addition pump setdown areas are planned to facilitate future temporary pumping in identified locations.

The difference between a stopbank and a bund

A stopbank and a bund can perform the same function, but a bund is generally a structure that might not be constructed to the same engineered standard as a stopbank, and may be more temporary or informal in nature.

Stormwater

The majority of stormwater services run the along Rocking Horse Road and Estuary Road, with outflows into the Estuary/Ihutai. Because some of the roads in the Regeneration Strategy project area are located below the high tide level, In order to allow them to drain, the stormwater outlets discharge into the Estuary also below high tide level.

This means the outflows are restricted when the tide is high and can lead to water flowing back through the system in dry weather if there is leakage in the backflow prevention. In order for this system to work effectively they need to be able to both open and close as required. CityCare manages this issue by clearing these drains of any silt build up before significant rain events.

The stormwater pipe network is designed to deal with a 1 in 5-year rainfall event, and can manage around a 1 in 10-year event through secondary flow paths including flooding on roads. Where heavy rain coincides with a high tide, temporary pumps may be needed and are deployed in the locations in shown in figure 11 as necessary[18].

Stormwater ponds at the end of Blake Street were built in 2014/2015 by SCIRT as part of a wider stormwater system including a pump station, designed to discharge stormwater into the estuary at all tide levels. The work also included a stormwater pipe network involving a large chamber and outlets, and an overland flow path.

[18] (Christchurch City Council, 2018a)

Wastewater

The SCIRT programme introduced the use of pressure and vacuum sewer systems to improve resilience in areas with high risk of liquefaction, including across the Regeneration Strategy project area[19]. In the Southshore area the old sewer system has recently been abandoned altogether and the pipes sealed because every property now has its own pressure sewer tank and pump. The tanks discharge into new pipes in the streets, flowing through other pumping stations to Bromley for treatment.

The ocean outfall, which passes under the estuary and Jellicoe street, takes the city's treated wastewater from the oxidation ponds and transports it three kilometres out into Te Kaikai a Waro/Pegasus Bay. This was completed in December 2009 and cost $87 million[20].

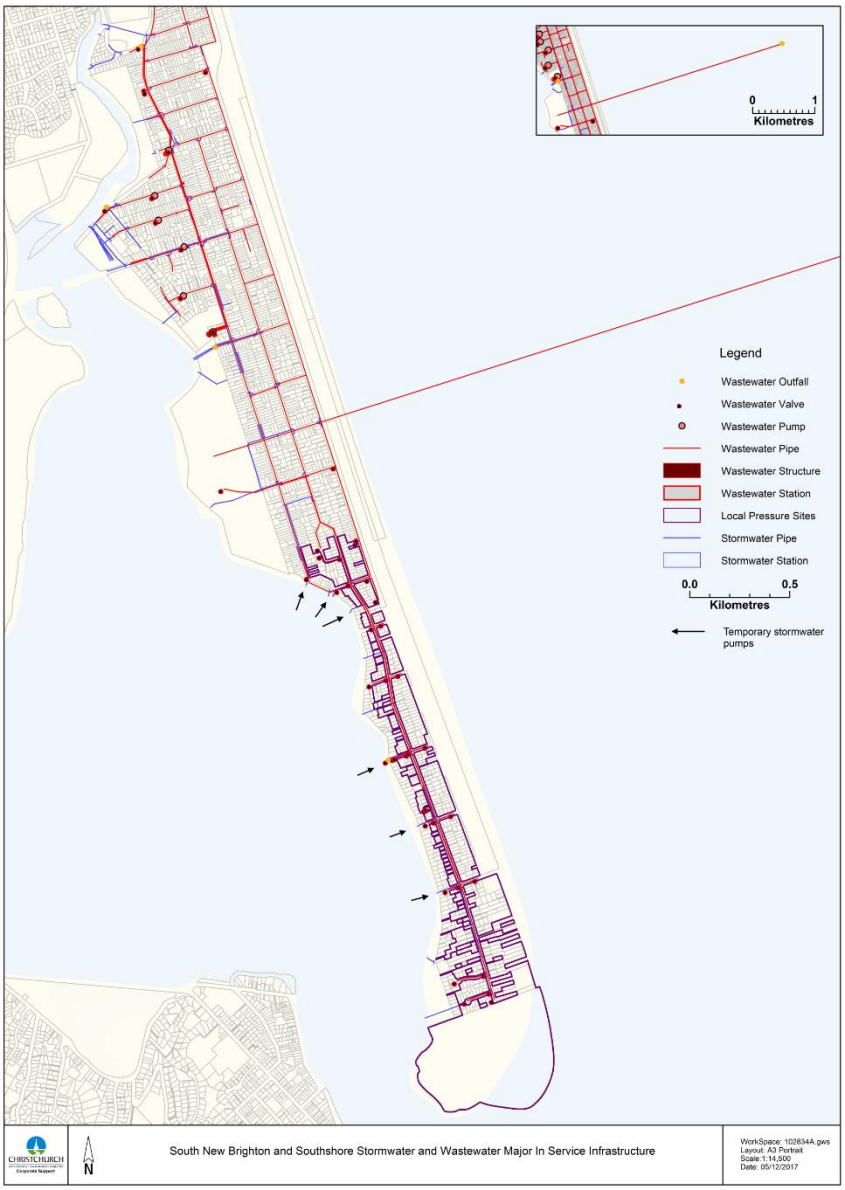


Figure 11 - Stormwater and wastewater infrastructure (CCC, 2018)

Water Supply

The water supply for the Regeneration Strategy project area is fed from groundwater sources beneath Christchurch. The local pump stations are not subject to the temporary chlorination that much of the rest of the city is still experiencing, as the below-ground well heads have been checked and cleared of the risk for contamination. Water treatment by chlorination is not part of the long-term strategy for water supply as outlined in the Christchurch City Council 2018 Infrastructure Strategy.

Transport

Estuary Road, Union Street, Marine Parade (north of Bridge Street), and Rocking Horse Road (to the south of Caspian Street) provide the main transport routes within South New Brighton and Southshore. Bridge Street, including the Bridge Street Bridge, is classified as a minor arterial route in the Christchurch Transport Strategic Plan, highlighting its importance as the key connecting route to the rest of the city.

[19] (Christchurch City Council, 2018a)
[20] (Winstone Aggregates, 2009)

Why this is important

All infrastructure is vulnerable to the effects of climate change. Various upgrades following the earthquakes have improved the resilience of some systems, such as the wastewater, at least in the short to medium term. However, other systems, such as stormwater is highly vulnerable to the effects of climate change as the discharge points are often at the lowest elevation near the coast. These services are likely to experience increased failures and decreases in levels of service over the coming decades as sea level rises[21].

To date, responses to improve the resilience of infrastructure in the Regeneration Strategy project area have been ad hoc and reactionary, such as the response to the earthquakes, or individual flood events. The Regeneration Strategy provides an opportunity to take a strategic and adaptive approach to infrastructure management and investment that recognises future uncertainties, and the impacts of climate change.

What we don't know

In its *30 Year Infrastructure Strategy 2018-2048*, the Christchurch City Council has made no long-term commitments to defend areas and services from the effects of climate change. However, many asset management programmes now take climate change effects into account, such as design guidance for new infrastructure which adds allowances for increased rainfall intensity and sea level rise. The Council is also carefully considering how and when it constructs new infrastructure in areas affected by climate change[22].

[21] (White, 2017); (Christchurch City Council, 2018a)
[22] (Christchurch City Council, 2018a)

The Communities of Southshore and South New Brighton

What we know

The 2013 census recorded 4,830 people living in Southshore and South New Brighton in 2,019 dwellings.[23]

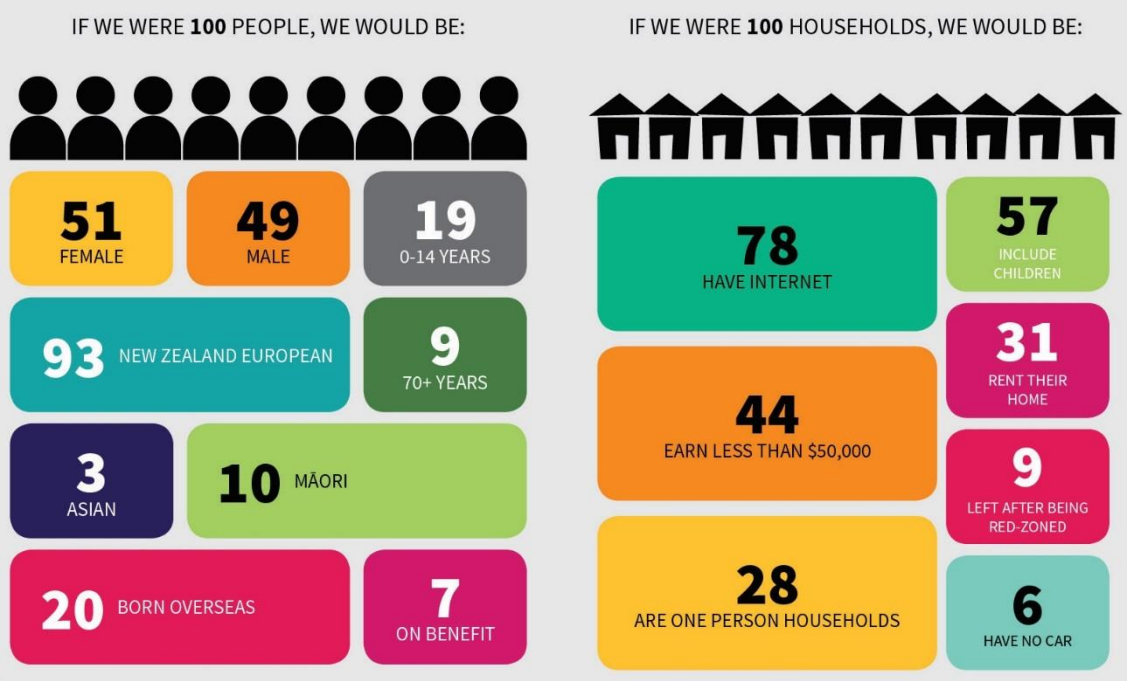


Figure 12 - Household composition

This data relates to the Southshore and South New Brighton Regeneration Strategy project area based on the 2013 Census, Ministry of Social Development, and Residential Advisory Service statistics. Note - denominators differ by Census question because some cells were suppressed due to small sample sizes, ethnicity data does not equal 100 percent due to people identifying with multiple ethnicities.

Sense of place

Feedback from submissions on a range of Christchurch City Council plans and projects[24] from members of the Southshore and South New Brighton communities following the earthquakes highlight the strong sense of community in these areas, along with a feeling of disconnection from the rest of Christchurch. The submissions show that local amenities, events and surrounding natural environment are highly valued, as well as intangible aspects of the communities such as the "beachy pace" and "friendliness of locals".

Community involvement in decision-making

Trends in submissions between 2011 and 2017[25] show that residents and community representatives are becoming increasingly involved in participatory processes, and that they want faster response from agencies. The submissions also demonstrate a heightening awareness of the issues and policy implications for home

[23] (Statistics New Zealand, 2013)

[24] Annual Plans (CCC) 2011 – 2017, Long Term Plan (CCC) 2015, District Plan Review & Independent Hearings Panel, the South New Brighton Reserves Plan – 2014 and the Te Waka Aroha – Bridge Project consultation

[25] On a variety of Christchurch City Council Plans including; Annual Plans (CCC) 2011 – 2017, Long Term Plan (CCC) 2015, District Plan Review & Independent Hearings Panel, the South New Brighton Reserves Plan – 2014 and the Te Waka Aroha – Bridge Project consultation

owners, with the focus shifting from earthquake legacy issues to include future-focused issues such as estuary edge and flood protection, and the effects of sea level rise on the existing flood hazard.

Mental health and wellbeing

Research indicates that the mental health and wellbeing of residents of the wider coastal and east Christchurch communities[26] appears to have been more significantly affected than for residents in other parts of Christchurch.

This is particularly the case for youth. A higher proportion of respondents in these communities continue to experience the top four stressors of 'distress or anxiety associated with ongoing aftershocks', 'being in a damaged environment surrounded by construction work', 'additional financial burdens' and the 'loss of recreational, cultural and leisure pursuits'[27].

While these mental health indicators reflect the wellbeing for a wider area than Southshore and South New Brighton, it is possible that many of these issues are also true for individuals and families in the Regeneration Strategy project area.

Why this is important

Southshore and South New Brighton have a very strong sense of community, with a wide network of community groups and support networks. This is important for understanding the adaptive capacity of the communities – their ability to respond to change over time.

What we don't know

While the population data used for this study was accurate in 2013, the effects of Canterbury earthquakes created population relocation, particularly from the eastern suburbs of Christchurch. Updated data from the 2018 census, available in late 2018, will confirm whether this trend is still occurring, has ceased, or has reversed.

The movement of people to and from the Regeneration Strategy project area outside the residential red zone following the earthquakes is not well documented. It is possible that residents relocated away from the area because of stresses following the earthquakes. Likewise, others may have relocated within the area, or moved into the area for other reasons.

In most of the statistical data used to identify social issues and demographic information, South New Brighton and Southshore are grouped together.

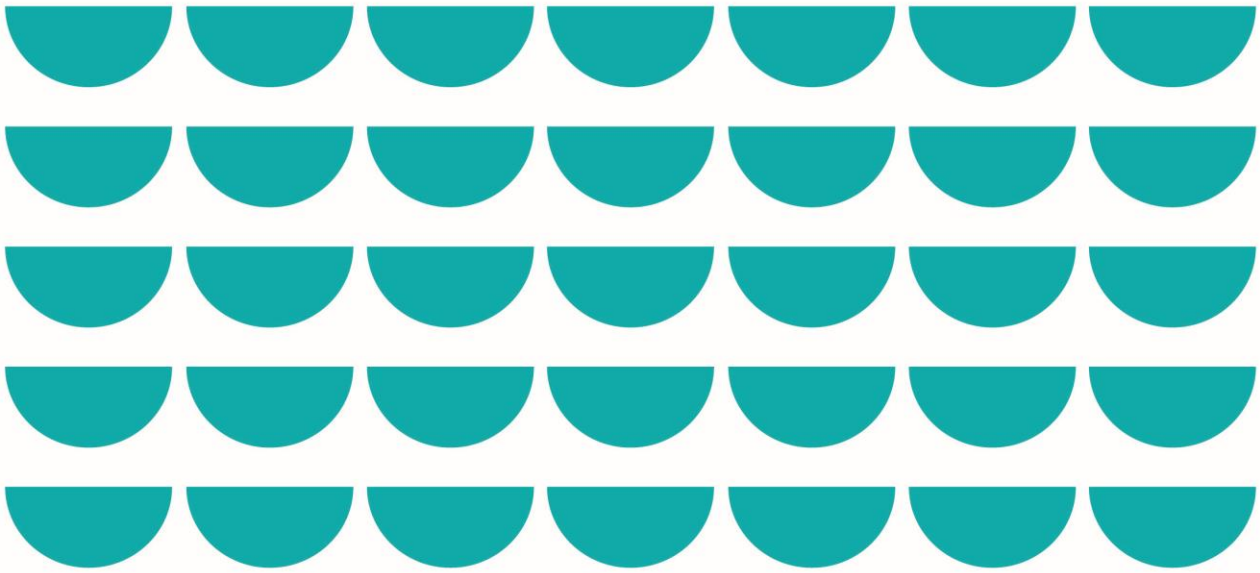
[26] New Brighton or South Brighton Census Area, the Coastal-Burwood Ward, and the 'North East' catchment used in the Canterbury Wellbeing Index

[27] (Canterbury District Health Board, 2016); (Colmar Brunton, 2016); (Social Policy Evaluation and Research Unit, 2016)

COASTAL FUTURES
SOUTHSHORE SOUTH NEW BRIGHTON

Information about the area

Southshore and South New Brighton Regeneration Strategy



REGENERATE CHRISTCHURCH TE KŌWATAWATA

Christchurch City Council

Environment Canterbury Regional Council Kaunihera Taiao ki Waitaha

Te Rūnanga o NGĀI TAHU

Introduction

The purpose of this document is to provide a comprehensive overview of existing technical information relating to Southshore and South New Brighton including:

- The natural and human (social, cultural, built, economic) environments, highlighting some of the key sensitivities of these environments to change
- The natural hazards that have, and could in the future, affect the communities of Southshore and South New Brighton
- The statutory/legislative framework for managing natural hazards which may impact on some options explored through the development of the Southshore and South New Brighton Regeneration Strategy

The purpose of this information is to build a shared understanding of information about the existing environment and natural hazards based on the best available information and science at this point in time.

It is recognised that the data will change as new and updated information becomes available, and that not everyone will agree with the science. When it comes to climate change information, there is a lot of uncertainty about when change will reach a certain threshold, and what the extent of the changes will be.

However, this information is a starting point for the conversation about actions for how this area can adapt to the effects of climate change and have a positive, viable and certain future. Coming up with the actions to address the potential effects of climate change, and working out when they need to occur is called 'adaptive planning' and it's what the Regeneration Strategy is all about.

Adaptive planning is recommended by the Ministry for the Environment and uses the four climate change scenarios as identified by the Intergovernmental Panel on Climate Change (IPCC). Using possible future scenarios means communities can plan for the 'what if' rather than the 'when'. Adaptive planning means the agreed course of action can change if need be – for example, if new climate change information becomes available. It also gives decision-makers a way to progress things and make decisions, even when there is uncertainty about the rate and effects of sea level rise.

Understanding the state of the land, and the things that might affect it, as well as its cultural significance, history and environment, will help provide context for adaptive planning.

Natural Hazards

Overview

Natural events make up the atmospheric, earth or water-related processes that shape the environment in which we live. Natural events become a 'hazard' when they cause damage or change to the environment on which people depend such as people, property, natural systems and the economy.

Figure 1 - When a natural event becomes a hazard (Auckland Council, 2014)

What we know

Multiple hazards could affect the area

There are a range of hazards which could affect the Regeneration Strategy project area such as flooding (from rainfall, higher sea levels, or rising shallow groundwater), land damage (from liquefaction, vertical displacement or coastal erosion) or risk to life from tsunami. Many of these could occur at the same time and can lead to combined or cumulative effects.

Flooding, coastal inundation and shallow groundwater are the main risks

Flooding from rainfall, coastal inundation (during extreme tide events or coastal storms), or below the ground (due to shallow groundwater) pose the main risks to the Regeneration Strategy project area, and are most likely to affect the largest proportion of land. Coastal flooding is primarily from the Estuary/Ihutai.

Estuary edge most exposed

Low lying areas around the estuary edge are the most exposed to these hazards. This exposure will increase over time with sea level rise.

Why this is important

Range of potential risks and effects

Because of the multiple hazards and cumulative hazard risks, any responses need to consider the range of potential risks and effects. For example, edge protection of the Estuary/Ihutai will not mitigate the risk from rainfall flooding or shallow groundwater.

Combined effects can increase the hazard

While the hazards the Regeneration Strategy project area is exposed to can and do occur independently, when they occur at the same time or in close succession, the combined effect of multiple hazards and their interactions can increase the hazard. Examples include:

Coastal inundation and rainfall

Extreme sea levels and inundation caused during a storm or an extreme tide can hinder drainage of low lying areas by producing flood backwater effects in stormwater systems and rivers. This restricts flood discharge from rivers or through the stormwater system and exacerbates flooding.

Shallow groundwater and liquefaction

Shallow groundwater is a key component in creating susceptibility to liquefaction. As groundwater levels rise, along with rising sea level, further areas may become susceptible to liquefaction. In addition, the effects of increased soil saturation, and ponding in low areas, decreases the land's storage capacity in high rainfall, which can lead to flooding.

Tsunami and flooding

A large tsunami could change the shape and size of the Estuary/Ihutai mouth and south end of the Spit, breach the sand dunes, or damage infrastructure on either side of the Regeneration Strategy project area. If natural and physical structures and protection are damaged or removed, it could increase the risk of coastal flooding.

What we don't know

When and how often events will occur

Despite being able to model hazard risk, this is still an estimate of likelihood and has a level of uncertainty regarding when and how often events will occur. Some hazards such as those influenced by sea level rise will increase in likelihood over time, while others such as liquefaction caused by earthquakes or flooding from rainfall events could occur at any time. Even if a hazard event has not occurred in recent memory or has not occurred at the same time as another event, this does not mean it will not occur in the future. The purpose of modelling susceptibility is to determine what reasonably could occur so that the risk can be managed.

Climate change

Climate is changing and will continue to change in the future. While the extent and rate of change is dependent on the extent that greenhouse gas emissions are reduced globally, some change to our climate is already in motion and inevitable. The Ministry for the Environment (MfE) recognises the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report[1] provides the most up-to-date climate science outlining what New Zealand can expect because of climate change[2].

[1] The IPCC is the international body which assesses the science related to climate change to provide policy makers regular updates on its impacts and future risks, and options for adaptation and mitigation.

[2] (Intergovernmental Panel on Climate Change (IPCC), 2014)

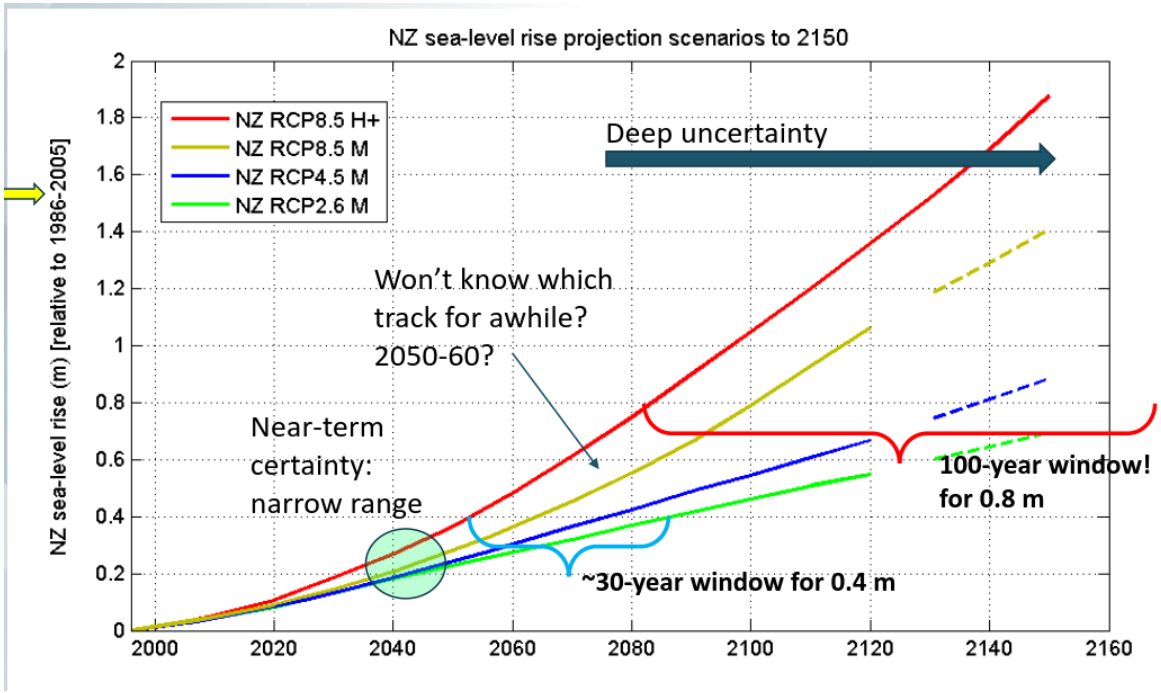
What we know

Climate change will worsen other hazards

Climate change is not a natural hazard. It does, however, lead to increasing the risk from hazards such as floods from rivers, rainfall and rising groundwater, liquefaction potential where some types of soil are presently close to the ground surface, and coastal erosion and inundation.

National guidance recommends considering four possible scenarios

In 2017 Ministry for the Environment released guidance for councils to manage and adapt to the increased coastal hazard risks posed by climate change and sea-level rise[3]. This guidance includes four future climate scenarios, known as Representative Concentration Pathways (RCPs)[4], which reflect how much solar radiation the earth would receive (warming) based on different concentrations of emissions. These include RCP 2.6 which represents a low to eventual net-zero emissions scenario, to RCP 8.5+ which represents a continuing high emissions scenario and accounts for possible instabilities in polar ice sheets.



Likely pathways	RCP 2.6	RCP 4.5	RCP 8.5	RCP 8.5+
Sea level rise 2065	0.30m	0.33m	0.41m	0.55m
Sea level rise 2120	0.55m	0.67m	1.06m	1.36m

Figure 2 – Sea level rise projections based on the four representative concentration pathways (RCP) scenarios. Adapted from Ministry for the Environment workshop on Coastal Hazards and Climate Change guidance (2018)

[3] (Ministry for the Environment, 2017f)

[4] Further information on the RCPs can be found in (Ministry for the Environment, 2016a) section 2.1 http://www.mfe.govt.nz/publications/climate-change/climate-change-projections-new-zealand

Expect changes in temperature rainfall and storms

Climate change is expected to have a range of effects on natural processes including higher temperatures, changes in rainfall patterns, more intense storms, changes in airflow patterns, and rising sea levels. What this means for the Canterbury region is higher average temperatures and temperature extremes, increased intensity of rainfall and changes to seasonal patterns, increased frequency and intensity of dry days, drought, and storms, small-scale wind extremes, and ex-tropical cyclones[5].

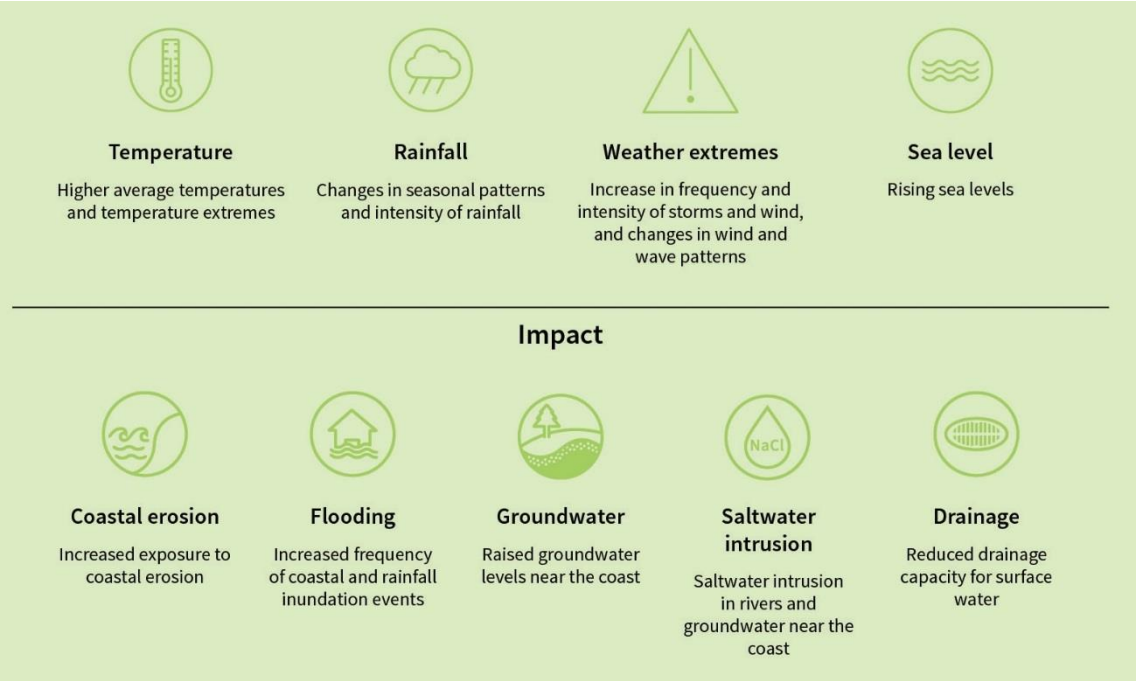


Figure 3 - Potential effects of climate change in Canterbury

Why this is important

The RCP 2.6 scenario is globally accepted as inevitable[6], meaning that even if emissions are reduced immediately, and some of the greenhouse gases are able to be extracted back out of the atmosphere and stored, we have already set in motion a sea level rise of at least 0.2-0.4m by 2065[7]. This can be considered our baseline, or new normal.

The current track is the RCP 8.5 scenario in which a sea level rise of 0.41m by 2065 and 1.06m by 2120 is a likely outcome for New Zealand. If emissions increase at faster rates, a sea level rise is likely to be greater than these predictions.

[5] (Ministry for the Environment, 2017f);
[6] The Fifth Assessment Report (AR5) involved over 830 scientific authors from 85 countries and processed 142,631 review comments, with 42 governments providing reviews of the Synthesis Report. (Ministry for the Environment, 2017g)
[7] (Ministry for the Environment, 2017i)

What we don't know

When these changes will occur

The key uncertainty in climate change projections is not if, but when changes will reach a certain threshold. This uncertainty is based not only on the natural processes themselves, but the human behaviour that influences them.

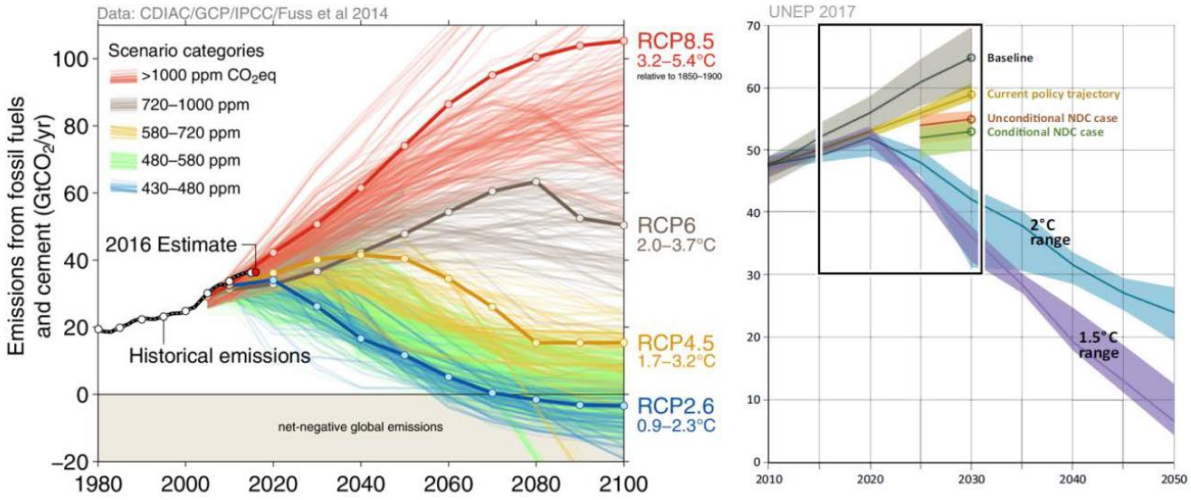


Figure 4 – Global emissions scenarios and the four RCPs compared with Paris agreement and current global policies. Ministry for the Environment workshop on Coastal Hazards and Climate Change guidance (2018)

Effects of less conservative projections

The IPCC scenarios are based on the current emissions pathway continuing or on emissions being reduced or mitigated[8]. They do not consider significant increases in emissions practices, or non-linear polar ice sheet and ice shelf responses, such as irreversible collapse of the ice sheets in Antarctica and Greenland which could cause sea level to rise at a much faster rate[9].

Fluvial and Pluvial Flooding

Flooding from rainfall (pluvial) and rivers (fluvial) is the most common natural hazard in Canterbury. The low-lying characteristics of Christchurch, and the Regeneration Strategy project area, mean that there have always been some areas prone to flooding during heavy rainfall.

The magnitude of a flood depends on many factors including the intensity and duration of rainfall, the shape of the land and surface features, the plants and soil characteristics, how saturated the area is before a rain event, and evaporation.[10] The impact of a flood is a combination of the ability of the water to drain away, and the vulnerability of the assets and people exposed to the floodwaters.

[8] Although the RCP 8.5 H+ scenario allows for increased emissions based on high population growth
[9] (Ministry for the Environment, 2017i); (Ministry for the Environment, 2017g)
[10] (Ministry for the Environment, 2010a)

What we know

Flooding in the regeneration strategy project area is primarily from rainfall and tides

The Regeneration Strategy project area most commonly experiences local runoff flooding. This is flooding from localised high intensity, short duration rainstorms or more prolonged, lower intensity rainfall events. The flooding is caused where the water in smaller rivers or streams, or flowing over land, is unable to drain away and collects in low lying areas.

The tides also have a strong influence in and around the Regeneration Strategy project area. If a high tide occurs with localised heavy rainfall or higher than normal river flows from rainfall further up the catchment, it can restrict drainage and cause backflow up the river or the stormwater infrastructure, or flood low lying areas around the estuary edge.

See the Environment Canterbury website for more information on flood dynamics in Canterbury https://www.ecan.govt.nz/your-region/your-environment/natural-hazards/floods/causes-of-flooding/

Flood risk will increase over time with climate change

The risk of flooding is likely to be exacerbated by climate change and sea level rise (in tidally affected areas) which will likely increase the extent and intensity of flooding[11]. Longer duration rainfall predominantly comes from low-pressure systems to the east of Christchurch, with highest rainfall more likely to occur during late autumn through winter. Current climate change projections suggest that there will be lower annual average rainfall in eastern Canterbury, but that the intensity of extreme rainfall events will increase[12].

Different sized flood events

In Christchurch the stormwater drainage network, flood ponding areas and overland flow paths are designed to manage the effects of flood waters in frequent and small flood events, while flood risk to new buildings is managed through requiring floor levels to be raised above the height of flood waters expected in large and rare flood events. The expectation is that flood mitigation schemes will provide a reduction in street flooding in more frequent events but would be overwhelmed or fail in larger events. Floor levels will need to manage this risk.

The Council is legally required to assess and manage areas most at risk of flooding, in particular the Canterbury Regional Policy Statement requires assessment and management of areas most at risk from damaging and dangerous flooding, where in a major flood event the velocity or depth of water could be damaging to people or property. In these areas restrictions on new development apply.

[11] (Ministry for the Environment, 2008)

[12] Current Government projections estimate Christchurch could see a 16% increase in overall rainfall volume by 2100 (Ministry for the Environment, 2008); (Ministry for the Environment, 2016a)

ARI (in any 1 year period)	AEP	In any 10 year period	In any 50 year period?	In any 80 year period (average lifespan of NZer)	Current thresholds for management
1 in 10	10%	1 chance in 1.54 (65%)	99%	99%	CCC flood intervention policy[4]
1 in 50	2%	1 chance in 5.5 (18%)	64%	80%	Building code floor level requirements[5]
1 in 200	0.5%	1 chance in 20 (5%)	22%	33%	District Plan floor level requirements[6]
1 in 500 + depth/ velocity[7]	0.2%	1 chance in 50 (2%)	9%	15%	District Plan development restrictions[8]

[4] The Christchurch City Council will help property owners who've had frequent above-floor flooding, where their flooding has been worsened by the earthquakes, and planned flood mitigation schemes will not offer a timely reduction to their flood risk ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/policies/sustainability-policies/flooding-intervention-policy/

[5] For new developments, a minimum finished floor level must provide protection from a one-in-50-year flood event to get a building consent, even if relying on existing use rights

[6] For properties in the Christchurch District Plan Flood Management Area new developments or additions need to meet a minimum floor level to provide protection from a one-in-200-year flood event

[7] High Flood hazard as defined by the Regional Policy Statement (Policy 11.3.1) as a 1 in 500 year where the flood water is deeper than 1m or the product of velocity and depth is greater than 1

[8] New development in the Christchurch District Plan High Flood Hazard Management Area is discouraged and consent may not be granted.

Figure 5 - Flood probabilities and frequencies for different magnitude events

Flood probabilities can be described as AEP (Annual Exceedance Probability) which is the probability of a certain size of flood occurring in a single year (or being exceeded), or ARI (Average Recurrence Interval) which is the average period between floods of a certain size. This does not mean that a 1-in-200-year flood will happen regularly every 200 years, or only once in 200 years. In any given 200-year period, a 200-year event may occur once, twice, more, or not at all. While the probability of a major flood occurring in any one year is relatively low, the probability of a flood of that size occurring over the lifetime of a person (or building) is much higher.

Widespread exposure to flooding

Figure 6 indicates that most of the residential area of Southshore and South New Brighton is at risk from flooding in a large flood event. Areas around the estuary edge and along the Rocking Horse Road where the lowest lying land is located are at risk from potentially damaging depths or velocities of flooding in a major event. These areas are also susceptible more regular flooding in smaller events.

Figure 6 - Flood hazard extents managed through the Christchurch District Plan. 1) Flood Management Area (based on 1 in 200 year flood event) and 2) High Flood Hazard Management Area (based on 1 in 500 year flood event where the water depth is greater than 1 metre, or the depth x velocity is greater than or equal to 1)

Why this is important

Complex interactions of rainfall and tides are accounted for in modelling

Flood hazard is measured by calculating the probability of a flood of a particular size happening in any given period.

The modelling of areas at risk of flooding are based on a combination of rainfall (including predicted increase in rainfall intensity of 16% because of climate change)[13] and tides[14], with an allowance for 1 metre sea level rise[15]. These reflect the influences on flooding which can occur separately, cumulatively, or over time (100 years) to increase the risk. All models are also run on the assumption that there are no stopbanks (i.e. that they have failed in an extreme event)[16].

In addition, to calculate the High Flood Hazard Management Area, only those areas with flood depths or velocities which meet the Canterbury Regional Policy Statement definition are modelled[17].

Likely effects of flooding

Flooding can have significant consequences for communities and individuals. These include community trauma and disruption, damage to property and infrastructure, changes to the natural environment, business losses and economic hardship. These effects will be different depending on the source of flooding; the depth and location of the water on a property (i.e. above floor flooding affecting the interior of the house, underfloor flooding affecting the building footprint, and flooding on the section); the velocity (i.e. whether the water flows through a property or ponds); and the duration of flooding[18].

What we don't know

Exposure to small scale, regular flooding

Christchurch City Council is doing more work to identify areas at risk of flooding during smaller scale, more regular flood events. This work involves combining assessments of the risk of flooding of more frequent events (such as a 1 in 10-year event) and whether this would be expected to flood above floor levels for each site.

Coastal inundation and erosion

Coastal processes can create hazards onshore either by flooding from the sea (coastal inundation) or wearing away or removing sediment from the coastline (coastal erosion).

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[13] Consistent with Ministry for the Environment guidelines for estimating the effects of Climate Change on Flood Flow (Ministry for the Environment, 2010b)

[14] Either a 1 in 200-year rainfall event combined with a 1 in 20 year tidal event, or a 1 in 200 year tidal event combined with a 1 in 20 year rainfall event (for the 1 in 200 year flood extent); and Either a 1 in 500 year rainfall event combined with a 1 in 50 year tidal event, or a 1 in 500 year tidal event combined with a 1 in 50 year rainfall event (for the 1 in 500 year flood extent)

[15] Consistent with Ministry for the Environment recommended minimum transitional value of sea level rise to use in planning instruments for managing existing coastal development (Ministry for the Environment, 2017f)

[16] (Christchurch City Council, 2015a); (Christchurch City Council, 2015b); (Christchurch City Council, 2016)

[17] Where the flood water is deeper than 1m or the product of velocity and depth is greater than 1 (Environment Canterbury, 2013)

[18] (Ministry for the Environment, 2016b); (Ministry for the Environment, 2010a)

What we know – coastal inundation

Factors contributing to coastal inundation

Coastal inundation is primarily caused by storm surges[19], high or extreme tides raising sea levels, and larger than normal waves or swell.

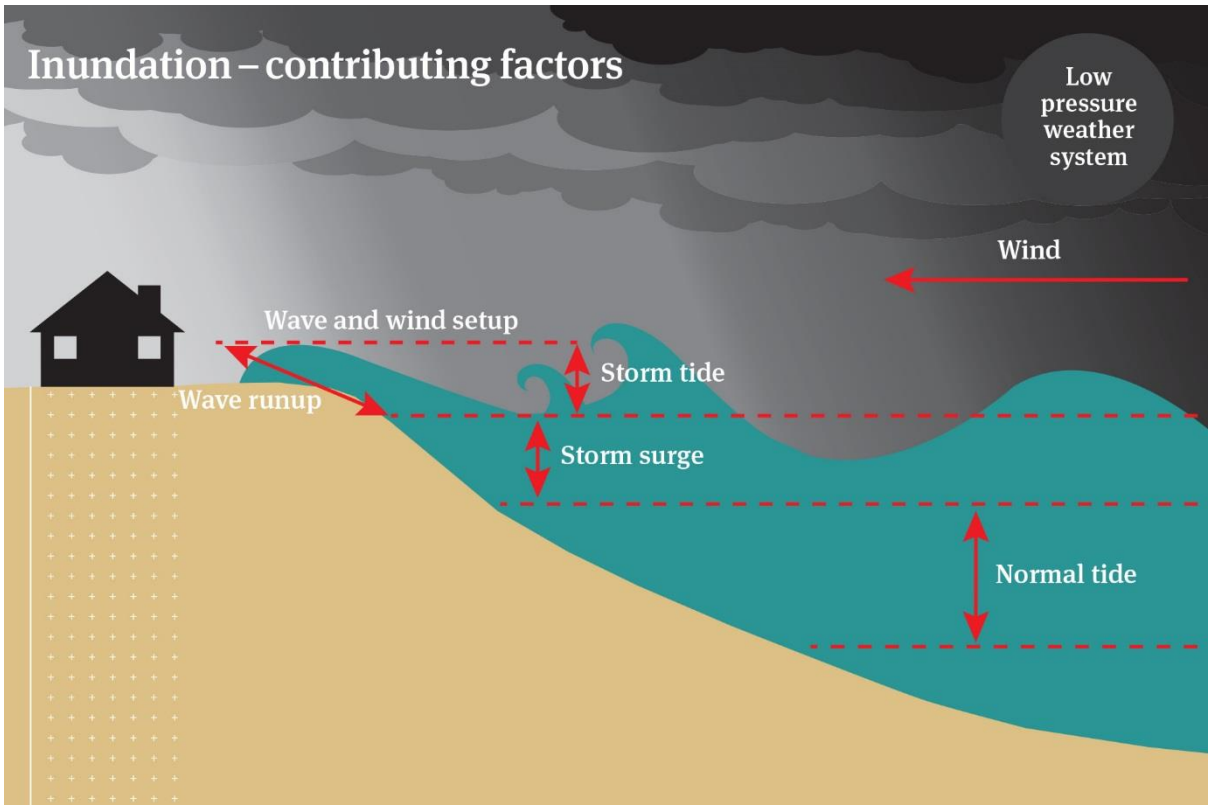


Figure 7 - Factors contributing to inundation (Tonkin & Taylor Ltd., 2017)

These effects can be exacerbated when these storms occur at the same time as extreme tides. The extent and depth of flooding is also influenced by the physical characteristics of the land adjoining the coast[20]. Further information on the process of coastal flooding in outlined in the Ministry for the Environment Fact Sheet:

http://www.mfe.govt.nz/sites/default/files/media/MFE_Coastal_Fact%20Sheet%202.pdf

[19] When strong onshore winds and low-pressure weather systems elevate sea levels

[20] (Tonkin & Taylor Ltd., 2017a); (Ministry for the Environment, 2017c)

Sea level rise will increase the frequency of coastal inundation[21]

As sea levels continue to rise the frequency, duration and extent of coastal flooding will increase. This will cause king tides, storm surges and waves to reach higher up the shore than they used to, and increase the likelihood of cumulative effects.

While coastal inundation from a 1 in 100-year event is considered rare in todays' terms, this can be expected to occur once a year in Christchurch with as little as 0.3m of sea level rise. If sea level continues to rise, the same inundation event can be expected to occur every tide.

The four RCPs recommended by the Ministry for the Environment are used to estimate future sea level rise for a range of possible futures. [22]

SLR	Christchurch
0cm	Every 100 years
10cm	Every 22 years
20cm	Every 5 years
30cm	Once a year
40cm	Every 3 months
50cm	Twice a month
60cm	Twice a week
70cm	Every day
80cm	Every tide
90cm	Every tide
100cm	Every tide

Figure 8 - Exceedances of today's '100-year events' occur more often as sea level rises (Parliamentary Commissioner for the Environment, 2015)

Exposure to coastal inundation

Coastal inundation which would flood from the Estuary/Ihutai will likely affect a large percentage of the Regeneration Strategy project area with as little as 0.3m sea level rise (the minimum likely to occur in the next 50 years).[23]

Timeframe	RCP 2.6	RCP 4.5	RCP 8.5	RCP 8.5+
Out 50 years to 2065				
South New Brighton (SNB)	1,016	1,057	1,099	1,133
Southshore (SS)	501	501	503	505
Percentage of properties affected in SNB and SS (% affected)	70%	72%	74%	75%
Out 100 years to 2120				
South New Brighton (SNB)	1,133	1,174	1,316	1,348
Southshore (SS)	502	506	506	507
Percentage of properties affected in SNB and SS (% affected)	75%	77%	84%	85%

Figure 9 – Coastal Inundation – number of properties affected

[21] (Ministry for the Environment, 2017f); (Parliamentary Commissioner for the Environment, 2015); (Tonkin & Taylor Ltd., 2017a)

[22] Further information on the RCPs can be found in (Ministry for the Environment, 2016a) section 2.1 http://www.mfe.govt.nz/publications/climate-change/climate-change-projections-new-zealand

[23] (Tonkin & Taylor Ltd., 2017a)

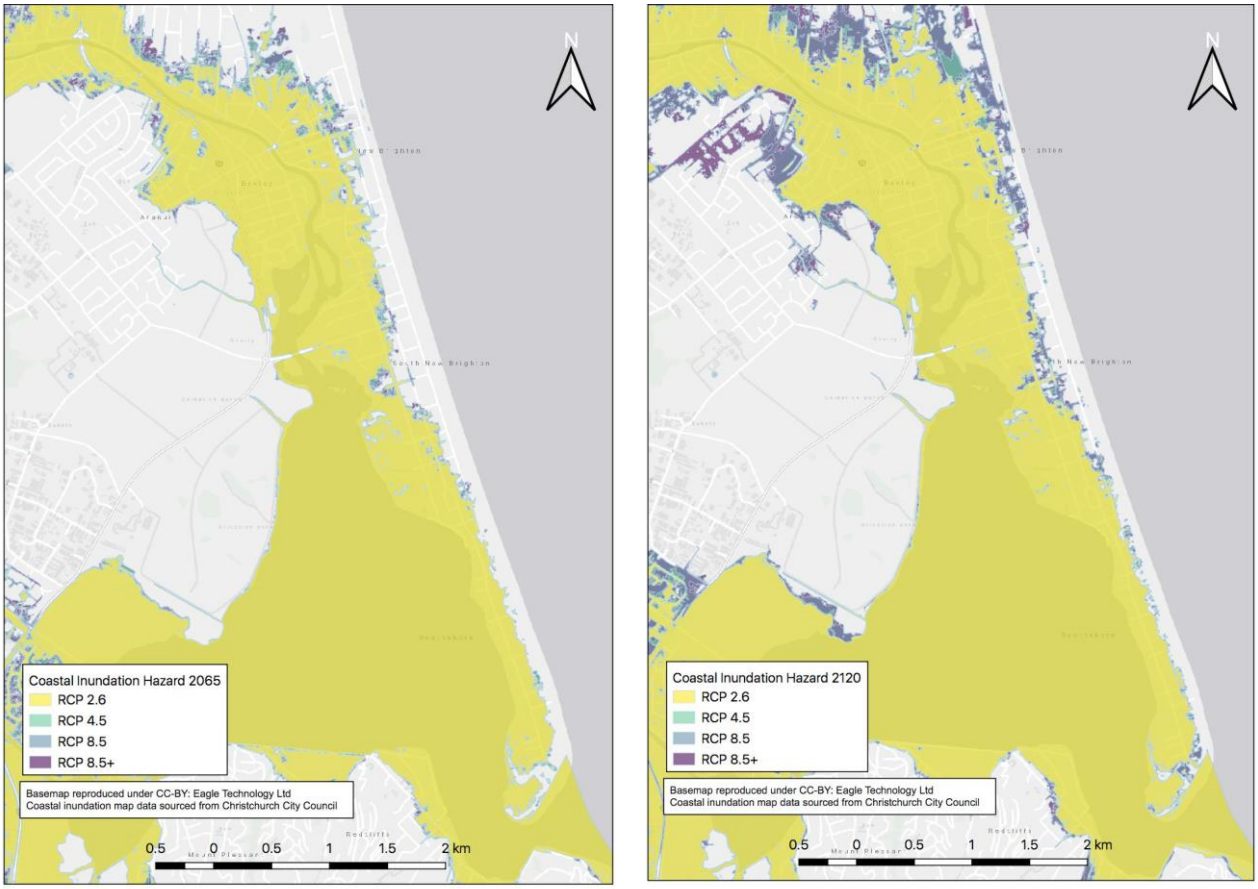


Figure 10 - Coastal inundation hazard for the years 2065 and 2120 for all four RCP scenarios, based on the Coastal Hazard Assessment for Christchurch and Banks Peninsula (Tonkin & Taylor Ltd., 2017)

What we know – coastal erosion

Factors contributing to coastal erosion

Coastal erosion can be a long-term or a short-term process. In the longer-term erosion is largely caused by an imbalance in sediment supply, but in the short-term erosion can occur as a result of dynamic wave run-up during high tide or storm events, and is heavily influenced by the shape of the coastline. This is part of a natural cycle where coastlines erode during storms and recover by accretion between them[24]. Further information on the process of coastal flooding in outlined in the Ministry for the Environment Fact Sheet:

http://www.mfe.govt.nz/sites/default/files/media/MFE_Coastal_Fact%20Sheet%201.pdf

Short term erosion events can occur despite pattern of long term accretion[25]

While the open coast of the Regeneration Strategy project area is currently in a cycle of long-term accretion, storm events will cause localised erosion. Increased intensity of storms could cause worsening of short-term erosion, and increased frequency of storms would result in less time for the beach to recover between storms. This changes the balance in the short-term cycle of erosion and accretion.

[24] (Ministry for the Environment, 2017b)
[25] (Tonkin & Taylor Ltd., 2017a)

Long-term increases in sea level elevation will exacerbate both long-term and short-term erosion, and any changes in the sediment budget of the Waimakariri River could also change this balance over short and long term.

Erosion is different across the Regeneration Strategy project area due to the shape of the land[26]

The south end of the Spit is subject to erosion/accretion cycles because it is affected by both open coast processes (breaking waves, tides and ocean currents) and estuarine processes (freshwater drainage, river flooding, sedimentation). The interactions of these two processes can be unpredictable.

Waves, and therefore wave energy, are highest on the exposed open coast and can undergo more dramatic erosion events during coastal storms than the more sheltered the Estuary/Ihutai. However, erosion of the Estuary/Ihutai shorelines is often very slow to repair naturally as, unlike the open coast, the more sheltered wave conditions in estuaries are not conducive to the movement of sediments onshore which can help a shoreline naturally recover from storm events.

Exposure to coastal erosion

Coastal erosion within the Regeneration Strategy project area is largely confined to open space areas directly adjacent to the coastline, with a maximum of 73 properties affected by 2120 in the highest RCP 8.5+ scenario[27].

Timeframe	RCP 2.6	RCP 4.5	RCP 8.5	RCP 8.5+
Out 50 years to 2065				
South New Brighton (SNB)	16	16	16	22
Southshore (SS)	0	0	0	2
Percentage of properties affected in SNB and SS (% affected)	0.7%	0.7%	0.7%	1.1%
Out 100 years to 2120				
South New Brighton (SNB)	16	19	26	70
Southshore (SS)	0	0	2	3
Percentage of properties affected in SNB and SS (% affected)	0.7%	0.9%	1.3%	3.4%

Figure 11 – Coastal Erosion – number of properties affected

[26] (Tonkin & Taylor Ltd., 2017a)
[27] (Tonkin & Taylor Ltd., 2017a)

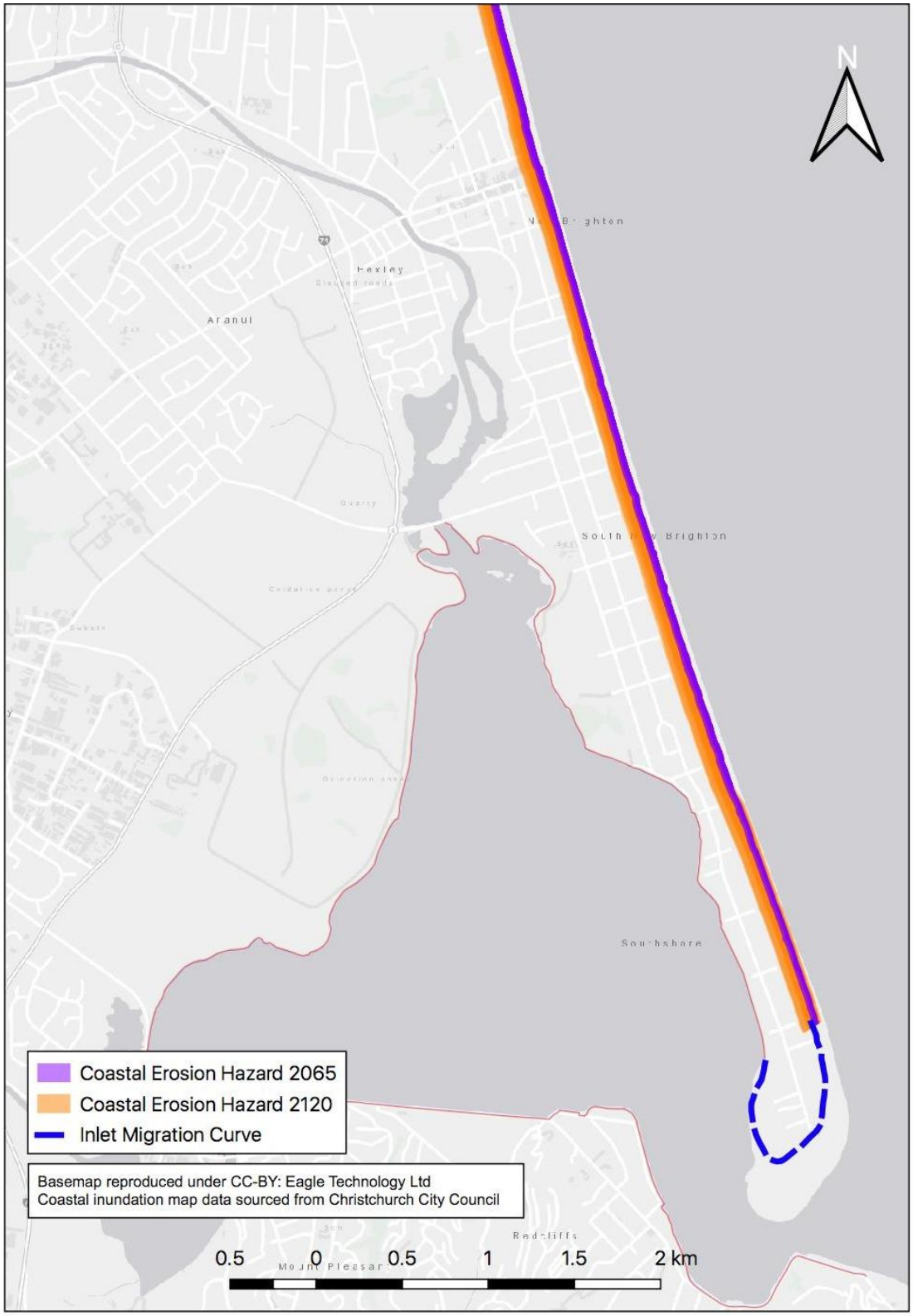


Figure 12 - Coastal erosion hazard for the years 2065 and 2120. Each time period includes all four RCP scenarios, and two sediment budgets (average and reduced) for the open coast, based on the Coastal Hazard Assessment for Christchurch and Banks Peninsula (Tonkin & Taylor Ltd., 2017)

Why this is important

Requirement to identify areas potentially affected by coastal hazards

National direction through the New Zealand Coastal Policy Statement (NZCPS) requires councils to identify areas potentially affected by coastal hazards over at least the next 100 years, particularly areas at high risk of being affected[28].

Modelling reflects best available information

Tonkin and Taylor modelled coastal inundation and erosion risk on the open coast and harbour coast (the Estuary/Ihutai) on behalf of the Christchurch City Council in the *Coastal Hazard Assessment for Christchurch and Banks Peninsula (2017)*[29] using two time horizons:

- 50 years - which reflects the likely extent of hazards based on a more certain estimate of sea level rise, and
- 100 years - which reflects the possible extent in the longer-term future.

For both timeframes and processes, sea level rise estimates for all four RCP scenarios recommended in the Ministry for the Environment guidance[30], and two sediment supply scenarios (for the open coast erosion models) were mapped.

Coastal erosion modelling[31]

Separate methodologies, recognising the different coastal processes have been used to assess and map coastal erosion along the open and harbour (the Estuary/Ihutai) coast.

- For the open coast, a probabilistic model is used to map erosion where the rate of erosion for small sections of the coastline is calculated and averaged for stretches of the coast that exhibit similar characteristics. This means that within the line indicating the potential erosion, there may be localised differences in the potential erosion risk. Two different sediment budget scenarios were used for the long-term erosion or accretion patterns. The 'average sediment budget' reflects the current pattern of accretion on the open coast, and a 'reduced sediment budget' reflects a potential future pattern if changes in the Waimakariri River sediment supply were to occur.
- For erosion within the Estuary/Ihutai, one value of potential erosion is used for the whole area for each time horizon. This is largely due to uncertainties with the modified shoreline and the effects this will have on future erosion. The lower energy environment is accounted for in the inputs of storm cut, sea level rise effects, and long-term erosion rates. However, existing estuary edge protection structures were not factored into the modelling as many are damaged or not engineered to specific design standards. Instead the erosion lines represent potential erosion effects if these structures are not retained in good working order. It is recognised that there will be localised differences in erosion along the estuary edge.

Erosion at the end of the Spit was not modelled due to the complex dynamics in this area. Instead the inlet migration curve is used. This represents the most landward extent that each section of the Spit

[28] (Department of Conservation, 2010)
[29] (Tonkin & Taylor Ltd., 2017a)
[30] (Ministry for the Environment, 2017f)
[31] (Tonkin & Taylor Ltd., 2017a); (Tonkin & Taylor Ltd., 2017b)

has been during recent recorded historical events, and is a conservative estimate of the area potentially at risk of erosion in the future.

Coastal inundation modelling[32]

Modelling of coastal inundation is a combination of estimating changes in water levels because of various coastal processes, and the topography of the land which affects the extent and depth of flooding.

Two approaches are used to assess inundation. On the open coast a bath tub method is used to map the extent of flooding inland to the same level as at the coast. This assumes even displacement of water across the inundated area. In the Estuary/Ihutai, a hydrodynamic model method uses flood and tide simulation software (called TUFLOW) that defines inundation more accurately in low lying and wide flat areas and factors. This factors in flow paths and the interaction of different hydrological processes.

National, regional and district context

The National Institute of Water and Atmospheric Research (NIWA) undertook a national overview of exposure to hazards in coastal areas in 2015[33] as part of a wider project by the Parliamentary Commissioner for the Environment on Preparing New Zealand for rising seas[34]. This work looked at the potential exposure of people and assets based on elevation above MHWS, which is a simplified approach but provides high level context of the national distribution of risk.

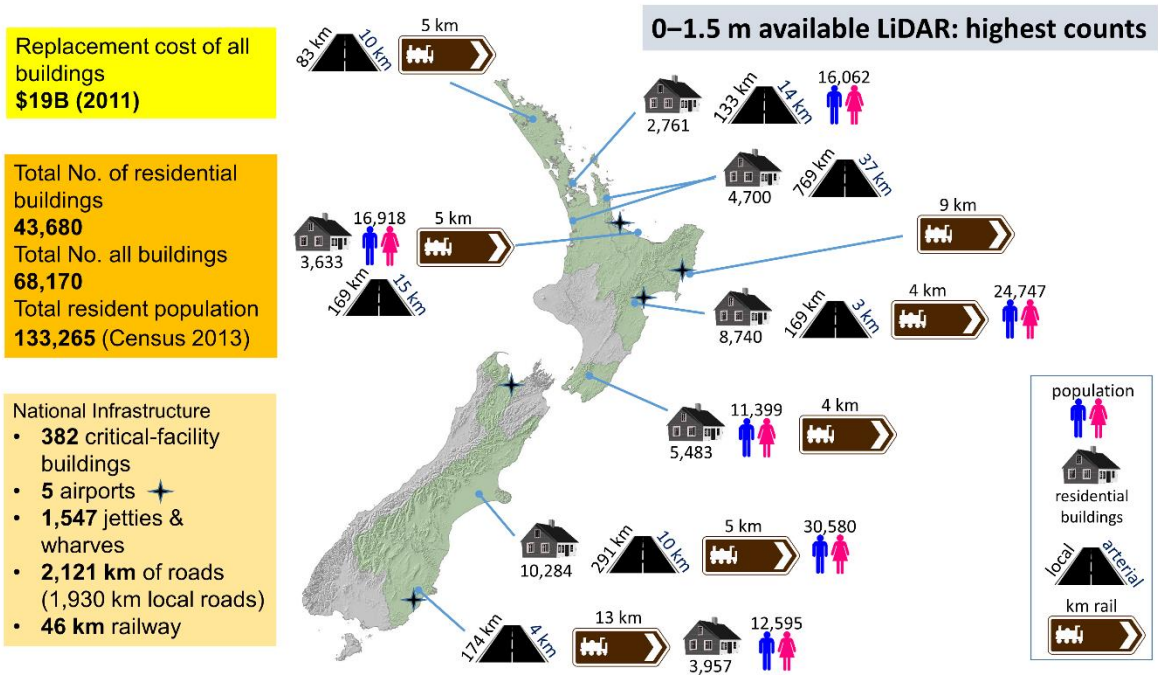


Figure 13 - National coastal inundation exposure (NIWA, 2015)

[32] (Tonkin & Taylor Ltd., 2017a); (Tonkin & Taylor Ltd., 2017b)
[33] (NIWA, 2015c)
[34] (Parliamentary Commissioner for the Environment, 2015)

National and regional exposure and potential effects

The analysis summarized in figure 13 found that nationally, there is significant population (133,265 residents) and assets (with an estimated replacement cost of $19 billion for all buildings) potentially at risk from inundation due to their location within 1.5m elevation of the coast[35]. Canterbury is the most exposed region in regards to residential buildings (10,284)[36] and residential population (30,580), with an estimated replacement cost of residential buildings of $2.5 billion[37].

District exposure

The *Coastal Hazard Assessment for Christchurch and Banks Peninsula (2017)*[38] provides a more detailed analysis of risk to Christchurch city. While it doesn't specifically calculate assets at risk, it highlights the extent of the city likely to be affected by inundation, shown in Figure 14, which could potentially affect (either in part or fully) around 13,600-24,800 properties in the District by 2120.

Implications of wider area at risk

The wider modelling of coastal inundation risk highlights the scale of potential impacts nationally, regionally and across the city. While there is evidentially a large area potentially affected by coastal inundation within the regeneration strategy project area, the hazard is not isolated to this area and is an issue that will need to be dealt with in the broader context.

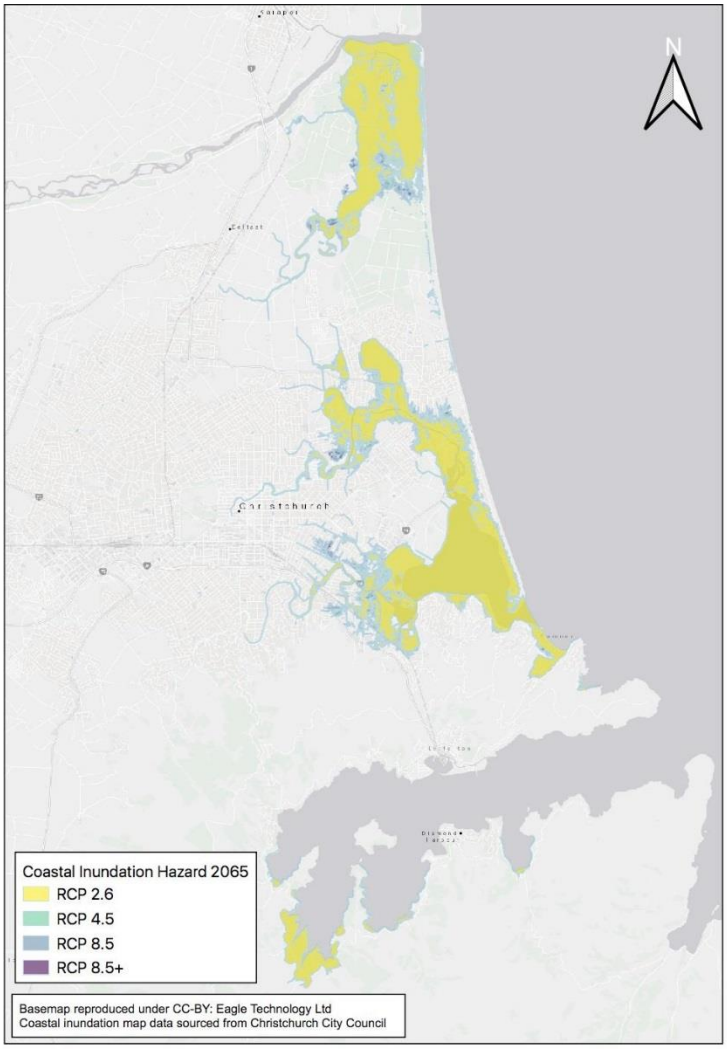


Figure 14 - Coastal inundation hazard for the Christchurch District for the years 2065 for all four RCP scenarios, based on the Coastal Hazard Assessment for Christchurch and Banks Peninsula (Tonkin & Taylor Ltd., 2017)

What we don't know

Modelling of hazard risk is not a static process, but a reflection of the best available estimates at any point in time. Further work currently being undertaken on groundwater levels, extreme sea levels, and future sediment budgets will inform the assessment of coastal hazard risk in the future and may

[35] This is equivalent to areas which could be at risk over at least the next 100 years, based on the range of RCP scenarios for New Zealand, and only applies to those regions modelled where LIDAR data was available (NIWA, 2015c)
[36] Excluding buildings standing at the time of the study in the residential red zone
[37] (NIWA, 2015c)
[38] (Tonkin & Taylor Ltd., 2017a)

require modelling to be recalculated as the understanding of these processes develops. Despite this, as the 2017 Coastal Hazard Assessment reflects the best currently available information it is appropriate to use this for the purposes of the regeneration strategy project.

Groundwater flooding

Groundwater becomes a hazard when it is close to or above the ground surface for long periods of time as it causes rising damp, saturation of subsurface structures or the ground surface[39]. Groundwater flooding could occur during large and/or prolonged rainfall events, seasonally, daily because of tides, or more permanently as a result rising sea levels.

What we know

Extent of hazard

As shown in figure 15, areas adjacent to the estuary edge north of South New Brighton Park and along Rocking Horse Road in Southshore have the shallowest groundwater at less than one metre below the ground surface. These areas are therefore the most susceptible to current and future flooding from groundwater. Much of the rest of Regeneration Strategy project area may be susceptible from future groundwater flooding because of sea level rise.

[39] (Zhang, 2010)

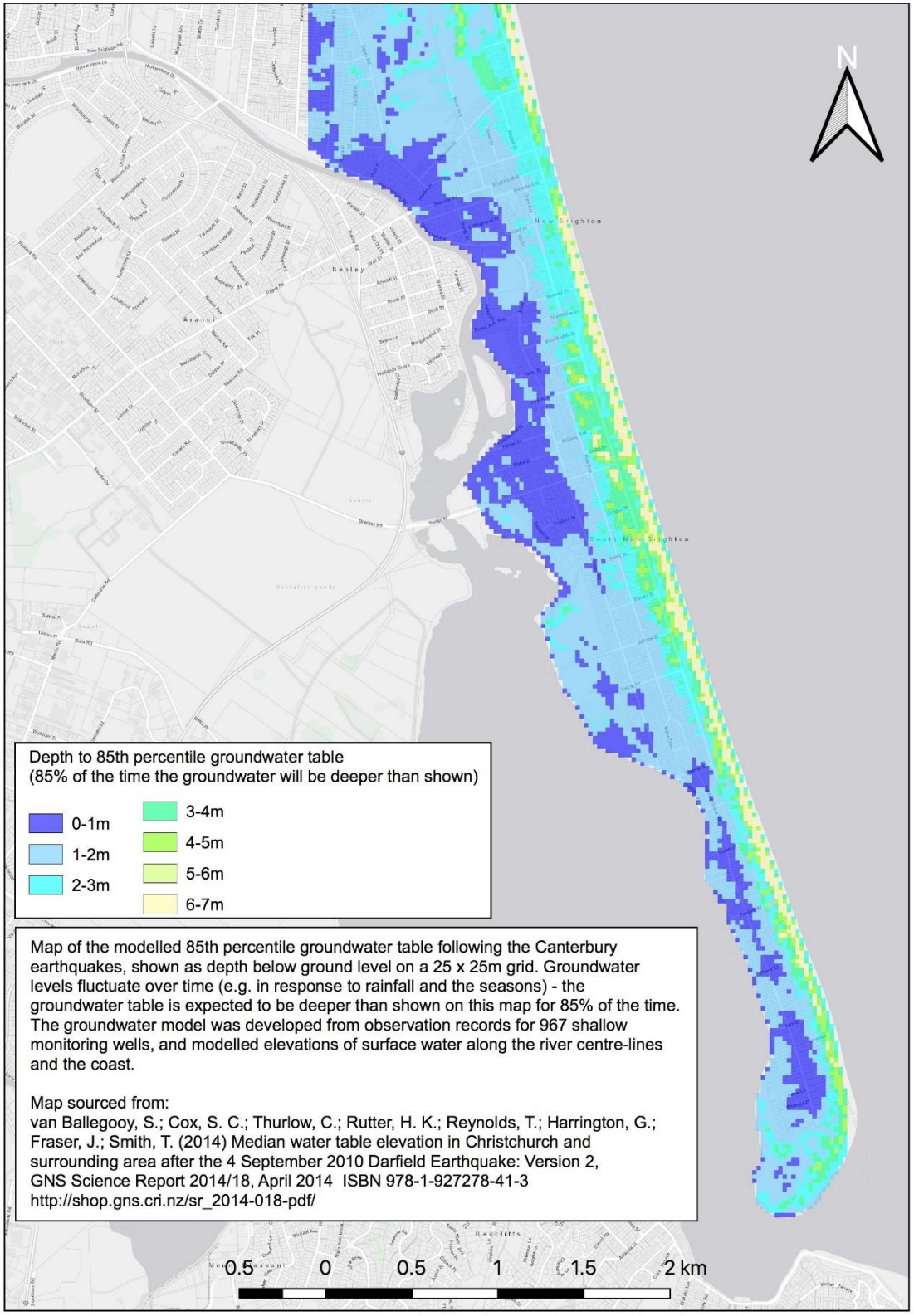


Figure 15 - Depth to groundwater table, based on 85th percentile (average peak levels). (van Ballegooy, et al., 2014)

Coastal processes influence groundwater

Fluctuations with tides add a twice daily peak in groundwater levels at the coastal margin and close to the tidal reaches of rivers, which can increase the occurrence of dampness and saturation, and slow or not allow for drying out. Rising sea level will raise the groundwater level where influenced by the tide, such as areas close to the Estuary/Ihutai. This could also increase the salinity and have consequences for water quality, vegetation and structures. As the groundwater levels across the Regeneration Strategy project area are already shallow, it is likely that more properties will begin to experience hazardous levels of shallow groundwater with sea level rise.

Likely effects of shallow groundwater

Shallow groundwater may have visible effects such as ponding above the ground surface, or invisible effects such as rising damp and impacts on infrastructure below the ground. These can lead to physical damage, but also affect health and wellbeing, particularly if people are exposed to it over longer periods of time or on a regular basis.

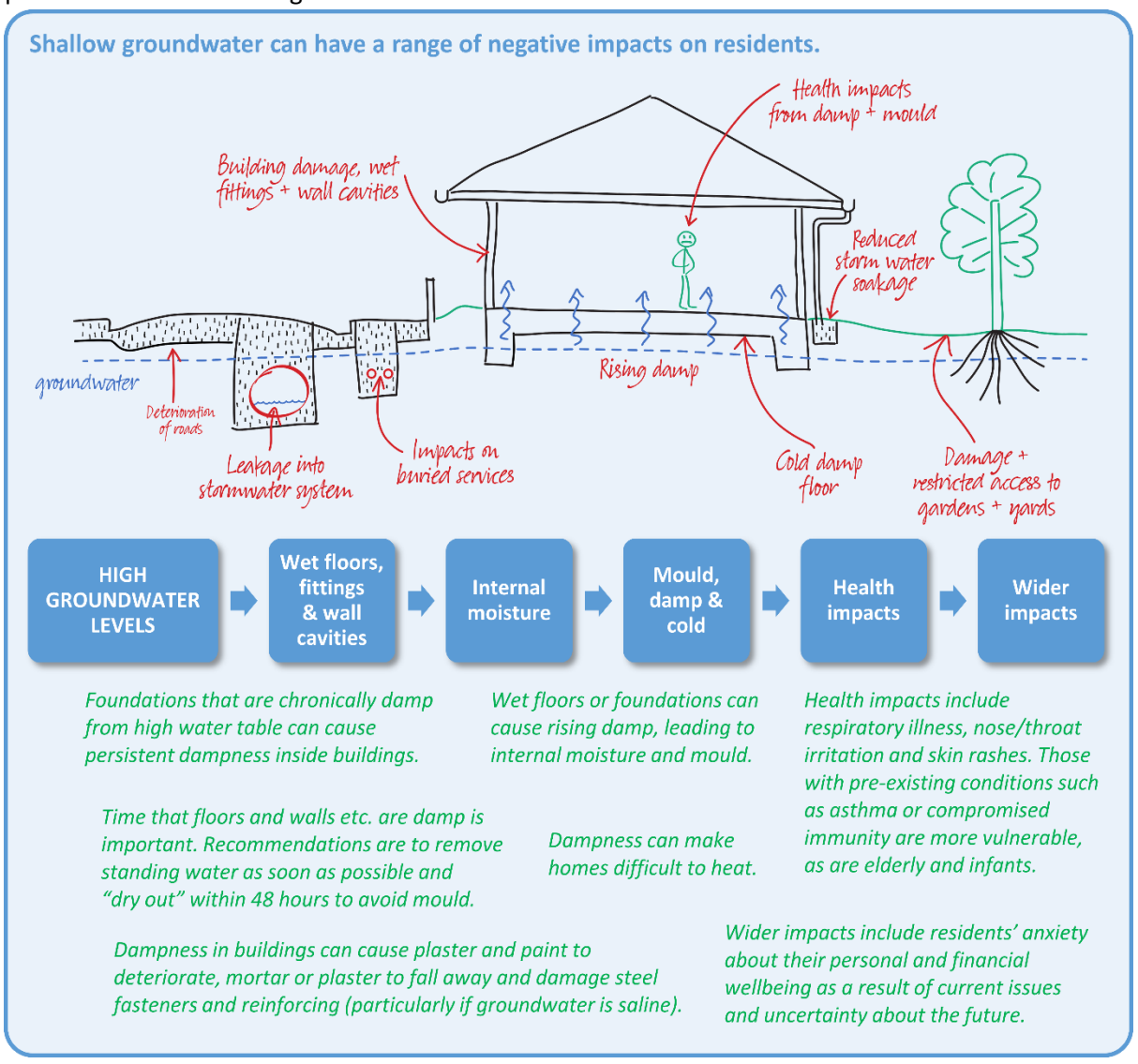


Figure 16 - Potential impacts of shallow groundwater on property and households (prepared by Tonkin & Taylor on behalf of Christchurch City Council 2018).

Why this is important

As groundwater levels fluctuate over time and to some extent within regular tidal cycles, statistical averages are used to calculate the groundwater level. Guidance from the Netherlands suggests groundwater levels in gardens and parks shallower than 0.5m below ground, and below houses and roads shallower than 0.7m below ground, should be managed.

High groundwater is also likely to exacerbate the effects of flooding in a rainfall event, as there will be less capacity for infiltration into the soils, resulting in increased surface runoff and more pressure on stormwater and secondary drainage pathways.

As much of Christchurch city has shallow groundwater, this is not an isolated problem. However, in the Regeneration Strategy project area the additional influence of tidal fluctuations and future sea level rise create issues of exacerbated hazard risk in areas close to the coast, which will only increase over time.

What we don't know

While testing of groundwater monitoring wells confirms the influence of coastal water on the groundwater system in the regeneration strategy project area, the timing and scale of climate change and sea level rise effects is not known.

Liquefaction

Liquefaction occurs when loose silts and sands below the water table become suspended in the groundwater as the ground shakes during earthquake shaking. The sediment grains are then no longer supporting the ground above, but the weight of that ground falls back upon a layer that has now basically become a liquid. With continued ground shaking pressure builds up and forces the water to the surface through cracks and crevices in the ground. The water carries with it the suspended sediment and ejects it at the ground surface, and can lead to subsidence as this material settles, and lateral spreading, where stretch or translation of land occurs adjacent to waterways.

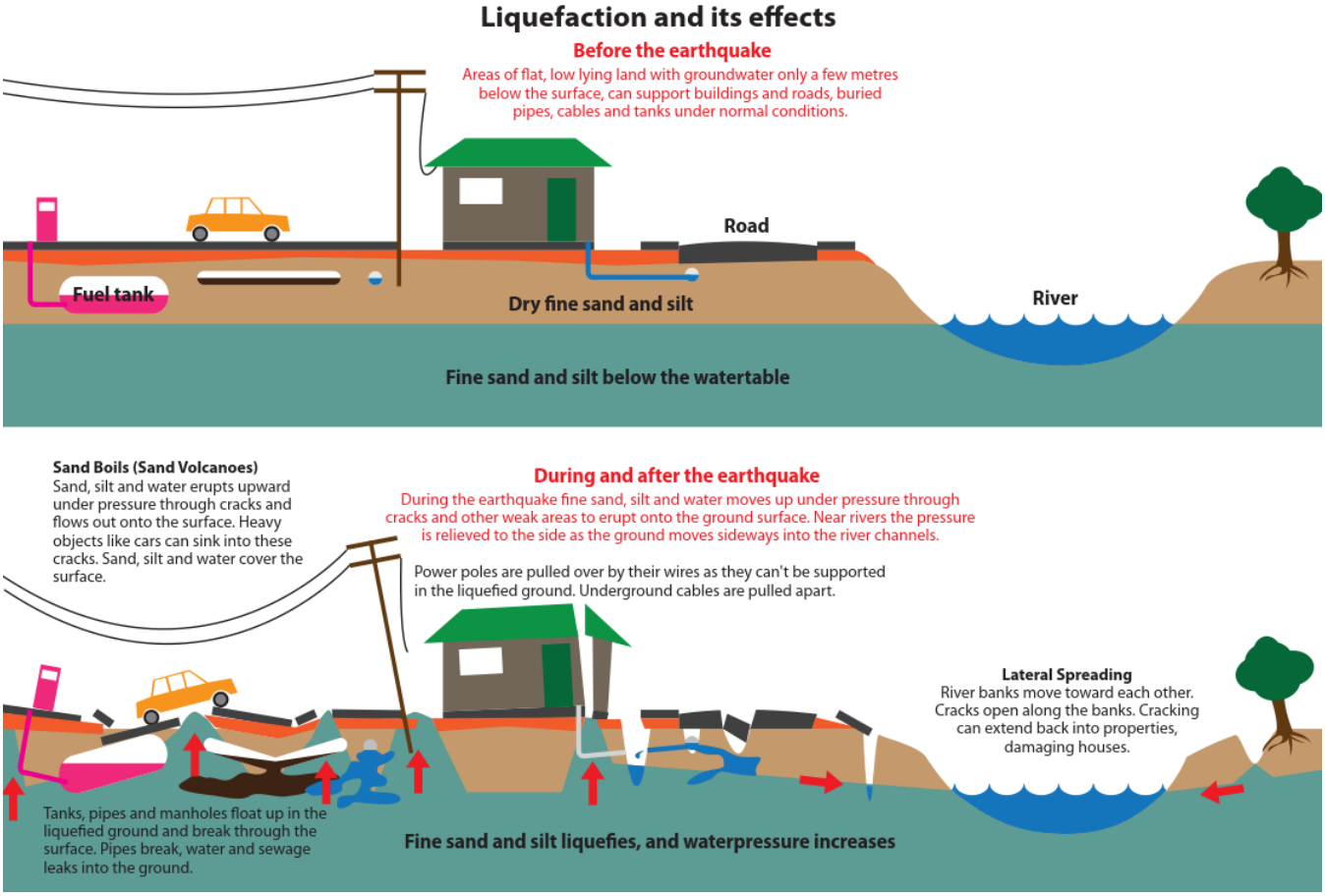


Figure 15 - Liquefaction and its effects. IPENZ (now Engineering New Zealand) (2011)

What we know

Actual and likely effects of liquefaction

Recent earthquakes have demonstrated vulnerability of the land in the regeneration strategy project area to liquefaction and its effects.

Observed effects of liquefaction and subsidence or uplift following the 2010 and 2011 Canterbury earthquakes included damage to property, stormwater and wastewater infrastructure, roads, changes in river and coastal processes and ecosystems because of uplift and subsidence, and changes in overland drainage patterns, as outlined in figure 19.

Extent of hazard

Figure 20 categories the liquefaction and lateral spreading observations following the February 2011 earthquake which outlines the differences in liquefaction vulnerability across the area.

The worst affected areas of observed liquefaction were generally red zoned after the earthquakes[40]. However, most of the land along the estuary edge in Southshore, and either side of Bridge Street has also experienced ejected material during the earthquake and is more vulnerable to future events then the rest of the Regeneration Strategy project area[41].

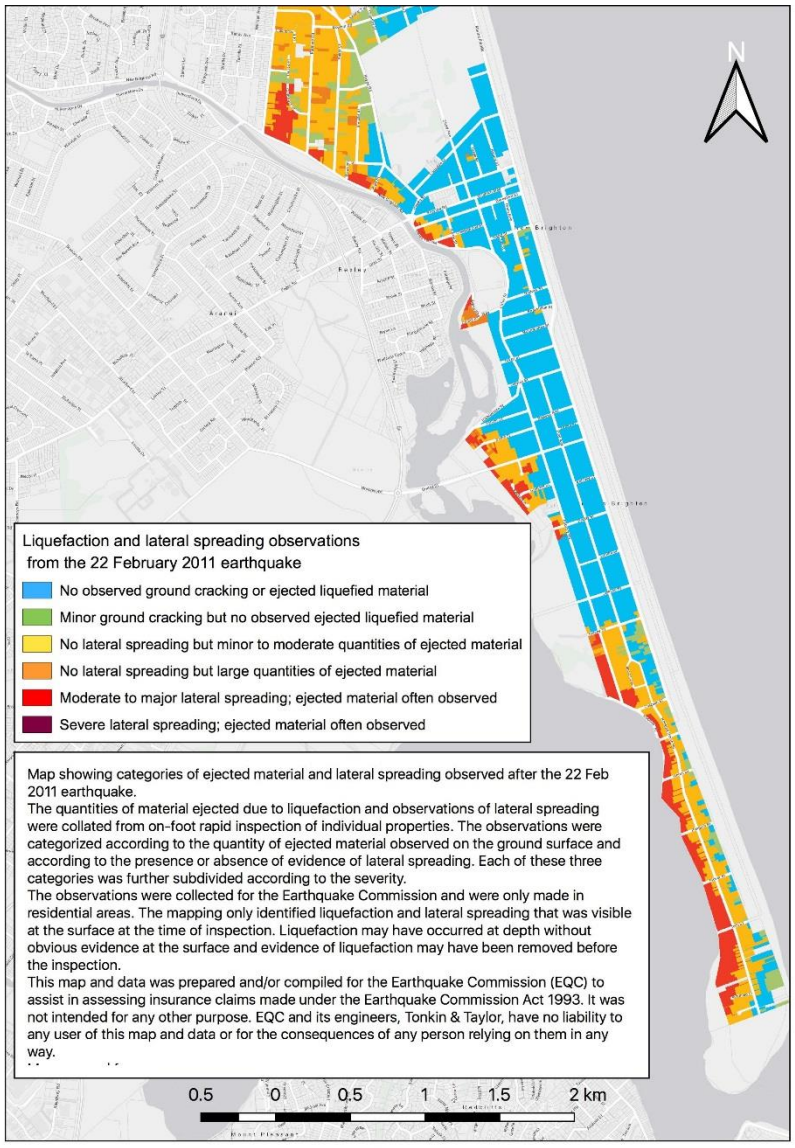


Figure 16 - Observed liquefaction and lateral spreading from the 22 February 2011 earthquake (Tonkin & Taylor Ltd. , 2012)

Why this is important

The widespread liquefaction in the Canterbury earthquakes has resulted in an extensive amount of research and guidance, developed locally and nationally, on past occurrence of, and future vulnerability to liquefaction[42].

There is also a broad understanding of the effects, and how to mitigate these. As a result of this awareness, building constructed after the earthquakes are likely to be built to the latest standards for liquefaction-prone land[43] and more resilient than older building stock.

[40] Where the land was so badly damaged that it was considered unlikely it could be built on over the short to medium term

[41] (Tonkin & Taylor Ltd. , 2012)

[42] (EQC, MBIE and MfE, 2017); (Tonkin & Taylor Ltd., 2013); (GNS Science, 2012); (Ministry for Business, Innovation and Employment (MBIE), 2012);

[43] (EQC, MBIE and MfE, 2017)

What we don't know

While the observed liquefaction is currently the best available information on future susceptibility of land, Christchurch City Council has commissioned more detailed investigations on liquefaction risk which will provide further clarity which will be used to inform this project when available at the end of 2018.

Tsunami

Tsunamis are waves created when the ocean floor is displaced by earthquakes, landslides or volcanoes. The size of the wave, extent of inundation or erosion caused by a tsunami vary hugely and depend on the source, tide and meteorological conditions, and topography of the shore. Most tsunamis are so small that they are barely noticed. Small tsunamis can disrupt currents in the sea and within harbours. Occasionally there is a tsunami that is large enough to cause flooding of land.

What we know

Christchurch is most likely to get a distant source tsunami

Tsunami scientists have shown that the coastline of Pegasus Bay is different from the rest of the New Zealand coast in that a tsunami large enough to cause flooding of land is most likely to come from a distance source (i.e. an earthquake off the coast of South America) than from local or regional sources[44]. This is because a distant source tsunami travels directly towards our coast, as opposed to the oblique angle created by a regional source wave. Tsunami scientists use the physics of earthquakes, wave generation and wave travel to model the likely effects of tsunamis.

Extent and consequence of tsunami could be severe

The latest tsunami modelling undertaken on behalf of Environment Canterbury maps areas susceptible to inundation from a distant source tsunami originating from a magnitude 9.485 earthquake at the Peru subduction zone. This indicates in a large tsunami, if the wave arrived at high tide, all the Regeneration Strategy project area could be inundated with a wave height of up to 12m at the coast. Most flooding would come from the Estuary/Ihutai side with about 14 hours of warning

[44] The source is the largest influence in determining the scale of potential effects. The terms "local, regional and distant source tsunami" are a useful way for responders to recognise how long they have to get people to safety- i.e. how long it takes the tsunami to travel from where it was generated to the affected shoreline. See (NIWA, 2015b) for further information on regional source tsunami

time[45]. Note that the effects are significantly less if the tsunami arrives at low tide, which has been the case in past tsunami events in 1960[46] and 2010[47].

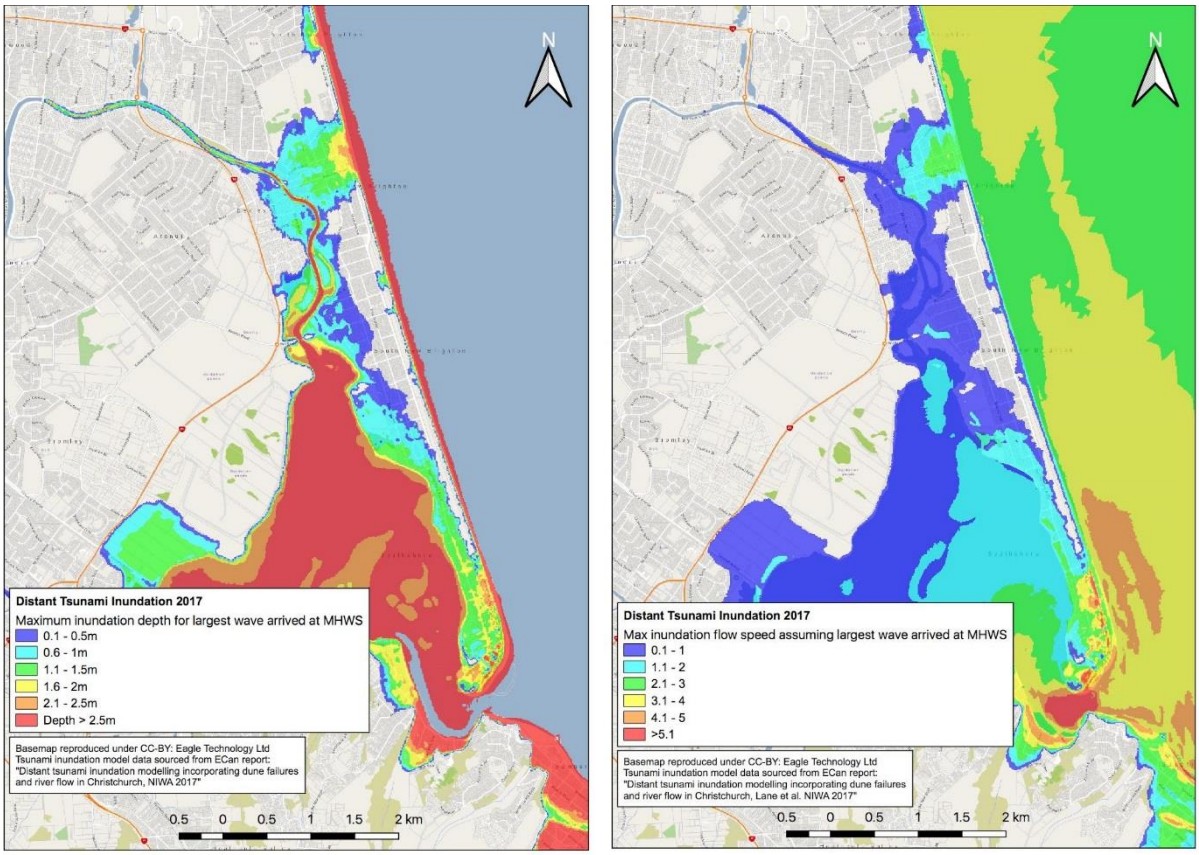


Figure 17 - Distant source tsunami from a M9.485 earthquake off Peru a) flooding assuming high tide arrival and b) wave height at coast (NIWA, 2017)

Sea level rise increases the potential effect

Changes in long term sea level will have no impact on the occurrence of tsunamis, so will not affect the likelihood of a tsunami occurring. However, increases in the underlying water level that the tsunami is superimposed on could mean the impacts of tsunami are greater in the future.

Why this is important

Source and potential effects dictate management response

As the primary tsunami risk to the regeneration strategy project area is a distant source tsunami, there would be sufficient warning time to allow organised evacuation but with the potential effects much more damaging and severe. For this reason, tsunami risk is primarily managed in Christchurch through civil defence response and evacuation.

[46] May 1960 (Mw9.4-9.6 Central Chile)
[47] Feb 2010 (Mw8.8 Central Chile)

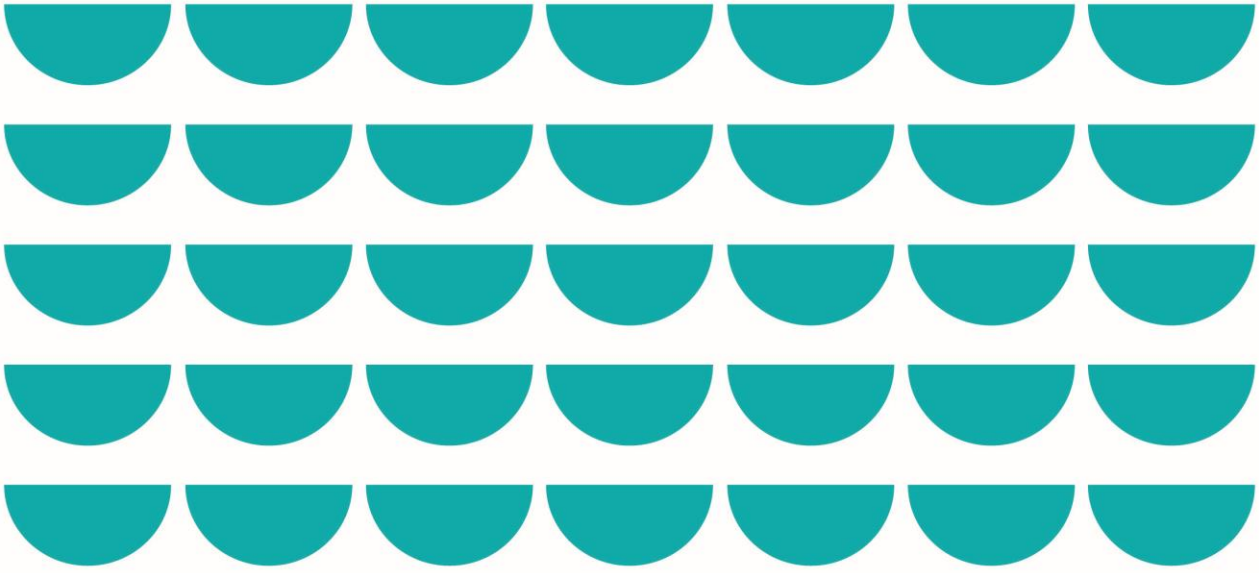
What we don't know

As sea level rises, coastal scientists consider it is possible that the end of the spit could erode back. This would result in a wider Estuary/Ihutai mouth so that more water could flow in and out of the Estuary/Ihutai not only with tides, but also with storm surge and waves, and rarer events such as tsunamis. Because the Estuary/Ihutai coast is lower than the open coast, it is more vulnerable to flooding with such events, and this is expected to worsen with erosion of the spit, widening of the Estuary/Ihutai mouth and more water being able to enter the Estuary/Ihutai. How much this will affect future flooding in such events depends on many unpredictable factors and therefore cannot be fully defined.

COASTAL FUTURES
SOUTHSHORE SOUTH NEW BRIGHTON

Information about the area

Southshore and South New Brighton Regeneration Strategy



REGENERATE CHRISTCHURCH TE KŌWATAWATA

Christchurch City Council

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

Te Rūnanga o NGĀI TAHU

Introduction

The purpose of this document is to provide a comprehensive overview of existing technical information relating to Southshore and South New Brighton including:

- The natural and human (social, cultural, built, economic) environments, highlighting some of the key sensitivities of these environments to change
- The natural hazards that have, and could in the future, affect the communities of Southshore and South New Brighton
- The statutory/legislative framework for managing natural hazards which may impact on some options explored through the development of the Southshore and South New Brighton Regeneration Strategy

The purpose of this information is to build a shared understanding of information about the existing environment and natural hazards based on the best available information and science at this point in time.

It is recognised that the data will change as new and updated information becomes available, and that not everyone will agree with the science. When it comes to climate change information, there is a lot of uncertainty about when change will reach a certain threshold, and what the extent of the changes will be.

However, this information is a starting point for the conversation about actions for how this area can adapt to the effects of climate change and have a positive, viable and certain future. Coming up with the actions to address the potential effects of climate change, and working out when they need to occur is called 'adaptive planning' and it's what the Regeneration Strategy is all about.

Adaptive planning is recommended by the Ministry for the Environment and uses the four climate change scenarios as identified by the Intergovernmental Panel on Climate Change (IPCC). Using possible future scenarios means communities can plan for the 'what if' rather than the 'when'. Adaptive planning means the agreed course of action can change if need be – for example, if new climate change information becomes available. It also gives decision-makers a way to progress things and make decisions, even when there is uncertainty about the rate and effects of sea level rise.

Understanding the state of the land, and the things that might affect it, as well as its cultural significance, history and environment, will help provide context for adaptive planning.

Framework for managing natural hazards and climate change

A complex framework of international, national, regional and local regulatory and non-regulatory requirements and tools apply to the management of natural hazard risks (figure 1). This provides the legal foundation for building sustainable, hazard-resilient communities and the toolbox to implement any response to avoid and mitigate hazard risks and adapt to the exacerbation of these risks due to climate change.[1]

Figure 1 - Framework to manage natural hazard risk and climate change

International programmes

International programmes, research, agreements and guidance highlight the importance of natural hazard risk reduction and adaptation and mitigation[2] to climate change.

New Zealand's role as a signatory of international agreements provides an obligation to collectively contribute towards achieving the outcomes sought. This may lead to or influence national legislation and guidance. Relevant international programmes include:

- The **Sendai Framework**, under the United Nations International Strategy for Disaster Reduction (UNISDR), sets out seven targets and four priorities for action including investing in

[1] (Local Government New Zealand (LGNZ), 2014); (Ministry for the Environment, 2017g); (Saunders, Beban, & Kilvington, 2013); (Tonkin & Taylor Ltd., 2016); (Glavovic, Saunders, & & Becker, 2010)

[2] Climate mitigation is about actions to reduce greenhouse gas emissions.

disaster risk reduction for resilience[3]. In committing to the Sendai Framework, the New Zealand government is reviewing the National Civil Defence and Emergency Management Strategy to align with the four priority areas of the Sendai Framework, and giving more weight to a risk-based approach in planning processes with recent changes to the Resource Management Act 1991 (RMA)[4].

- The **Paris Agreement** was signed by 175 countries (including New Zealand) at the end of 2015. It recognises that climate change is an urgent and potentially irreversible threat to human society and the planet, and requires both mitigation and adaptation.[5] In response to the Paris Agreement, the New Zealand government has established a programme of work to transition to a low-emission and climate-resilient future including a proposal for new legislation, the Zero Carbon Bill.

- New Zealand is a participant in the **Intergovernmental Panel on Climate Change (IPCC)** which provides a scientific view on the current knowledge on climate change, its potential impacts, and guidance on adaptation and mitigation. The fifth assessment report 2015[6] (5AR) has been used to inform recent national guidance on climate change and coastal hazards.[7] The sixth assessment is scheduled for release in 2021.

- **ISO 31000 2009 is the international standard** setting out principles and guidelines for risk management processes.[8] It is used to inform and guide risk-based planning approaches, including the definition of risk in the New Zealand Coastal Policy Statement.

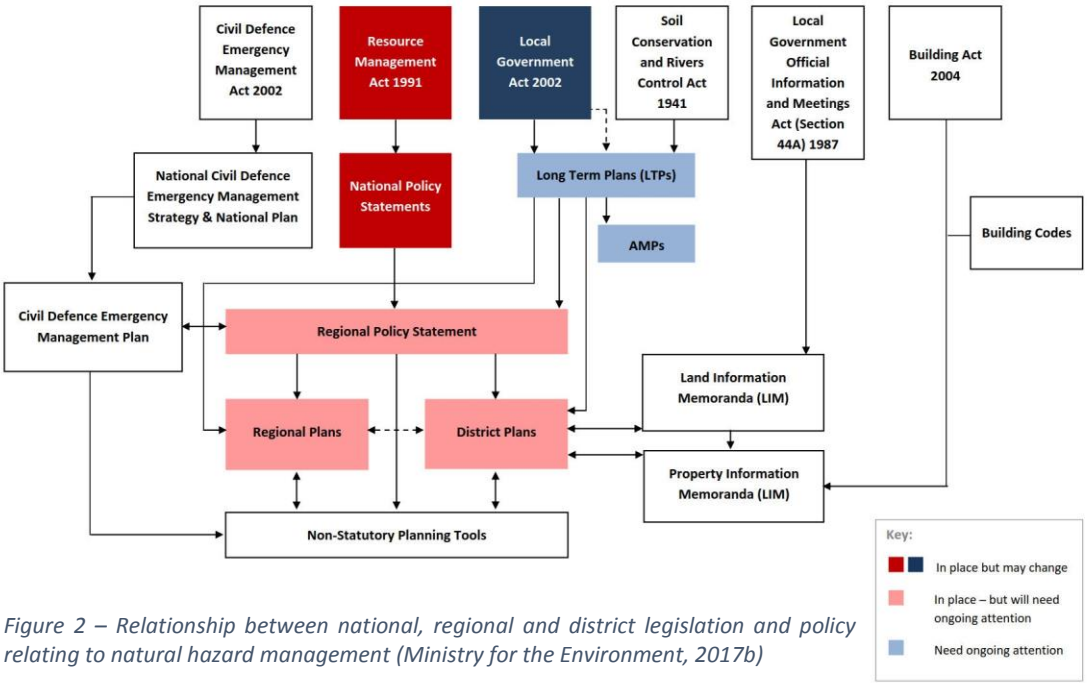


Figure 2 – Relationship between national, regional and district legislation and policy relating to natural hazard management (Ministry for the Environment, 2017b)

[3] (United Nations Office of Disaster Risk Reduction, 2015)
[4] (Ministry for the Environment, 2017a); (Ministry for the Environment, 2017d); (Ministry for the Environment, 2017c)
[5] (United Nations Framework Convention on Climate Change, 2016)
[6] (Intergovernmental Panel on Climate Change (IPCC), 2014)
[7] (Ministry for the Environment, 2017f)
[8] (AS/NZS ISO 31000, 2009)

Management framework

The international programmes New Zealand has committed to sets the context for national policy and direction for managing natural hazards and adapting to climate change, which councils then implement. In addition, there are some overarching legislative responsibilities and requirements which councils (both regional and city) must comply with.

One way of looking at these responsibilities is how and when local government uses various national policies and legislation. More than one piece of legislation or national policy can apply when local government is undertaking its role or function, as shown below.

Role/function	Legislation and national policy	Tool/action
Decision making	Local Government Act 2002 (LGA)	• Decision making responsibilities • Financial planning
Communicating	Local Government and Official Information and Meetings Act 1987 (LGOIMA) Building Act 2004	• Land Information Memoranda (LIM) • Project Information Memoranda (PIM) • Land Information Request (LIR)
Regulation of buildings	Building Act 2004 Building Code	• Building consents • Performance standards
Regulation of land use	Resource Management Act 1991 (RMA) New Zealand Coastal Policy Statement 2010 (NZCPS)	• Canterbury Regional Policy Statement (CRPS) 2013 • Regional Coastal Environment Plan (RCEP) 2003 • Land and Water Regional Plan (LWRP) 2016 • Christchurch District Plan (CDP) 2017
Financial, asset management, and community planning	Local Government Act 1974, 2002 (LGA) Local Government (Rating) Act 2002 Soil Conservation and Rivers Control Act 1941 Christchurch Drainage Act 1951 Public Works Act 1981 Reserves Act 1977	• Long Term Plan (LTP) 2018 • Infrastructure Strategy 2018 • Bylaws • Stopping roads • Special rating areas • Flood protection and control works • Land acquisition • Reserve management and development plans
Emergency management planning	Civil Defence and Emergency Management Act 2002 (CDEM) National Civil Defence and Emergency Management Strategy	• Canterbury Civil Defence and Emergency Management (CDEM) Group • Canterbury CDEM Group Plan 2014 • Community resilience plans
Earthquake Regeneration	Greater Christchurch Regeneration Act 2016 (GCR Act)	• Decisions on future use of Residential Red Zone land • Powers relating to works and ownership of land • Regeneration Plans and Section 71
Adaptation	Zero Carbon Bill	• MfE Coastal Hazards and Climate Change guidance

Figure 3 –Tools available for councils to undertake their roles and functions relating to natural hazards and climate change

Decision making

The Local Government Act 2002 (LGA) provides a general framework, obligations, restrictions and powers for councils to operate. The LGA requires councils to give regard to the avoidance or mitigation of natural hazards when performing its role in making decisions[9] and undertake financial planning for risk reduction activities.[10] These requirements encompass both present and anticipated future circumstances[11], with a need to take into account the foreseeable needs of future generations[12]. There

[9] Section 11A of the Local Government Act 2002
[10] Sections 93-97 of the Local Government Act 2002
[11] Section 10(2)(c) Local Government Act 2002
[12] Section 10(1)(b) of the Local Government Act 2002

is no statutory responsibility under the LGA for councils to protect property from encroachment from the sea, but councils may choose to do so as part of this decision-making process.

Any decision making undertaken under the LGA, or the Resource Management Act 1991 (RMA), needs to take into account the principles of the Treaty of Waitangi. This includes the need to consult with Māori to meet the principle of partnership.

Communicating known hazard information

Under the Local Government and Official Information and Meetings Act 1987 (LGOIMA) district councils are obliged to issue Land Information Memoranda (LIM) on request. This must include information known to the council on (amongst other things) the potential hazards related to the site.[13]

Sections 31-35 of the Building Act 2004 also requires councils to issue Project Information Memoranda (PIM) on request. A PIM must include information likely to be relevant to the building work that identifies each special feature of the land concerned including potential natural hazards.

Regional councils also provide a Land Information Request (LIR) as requested. LIRs are not prepared under any legislation, but like LIMs and PIMs provide known natural hazard information that is held by the Regional Council on a particular site.

Regulation of buildings

The Building Act 2004 regulates building work and can be used to manage natural hazard risk through:

- performance standards in the building code[14];
- refusal of building consent where the land is exposed to multiple hazards, or will accelerate or worsen adverse effects, unless the building can be adequately protected[15].

Section 72 of the Building Act offers a solution to the Council refusing a building consent by allowing, in certain situations, an owner to take the risk of building on such hazardous land but requires that a warning is placed on the legal title. This warns future property owners of the potential hazard, and reduces the liability for the Council and for EQC if there is damage to the land as a result of that hazard.

Regulation of land use and subdivision

The RMA is the key tool for managing natural hazard risk. The management of significant risks from natural hazards must be recognised and provided for, and all decisions must have particular regard, among other things, to the effects of climate change.[16] This is achieved through the regional and district policies and plans, and the associated resource consent process.

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[13] Section 44A of the Local Government and Official Information and Meetings Act 1987

[14] Includes requirements for foundation design in areas prone to liquefaction (Ministry of Business, Innovation and Employment (MBIE) , 2011), and raising floors above the level of flooding predicted to occur in a 1 in 50 year flood event (Ministry of Business, Innovation and Employment (MBIE), n.d.)

[15] Sections 71- 73 of the Building Act 2004

[16] Sections 6(h) and 7(i) of the Resource Management Act 1991

The NZCPS states objectives and policies to achieve the purpose of the RMA while managing the coastal environment. This includes managing coastal hazard risks, taking climate change into account, by locating new development away from areas prone to such risks, considering responses, including managed retreat, for existing development and protecting or restoring natural defences to coastal hazards[17]. The NZCPS is required to be 'given effect to' in district or regional plans, and must be had 'regard to' in decisions on resource consent applications. Regional policy statements, regional coastal plans and district plans must give effect to the NZCPS (sections 62(3), 67(3) and 75(3) of the RMA).

The Canterbury Regional Policy Statement 2013 (CRPS) [18] provides direction, priorities and outlines responsibilities for natural hazard management. In some instances it directs district and regional plans to include rules relating to either Environment Canterbury or Christchurch City Council functions. The Regional Coastal Environment Plan for Canterbury (RCEP)[19] manages activities in the coastal marine area (CMA), while the e Christchurch District Plan[20] manages new development, subdivision and land use.

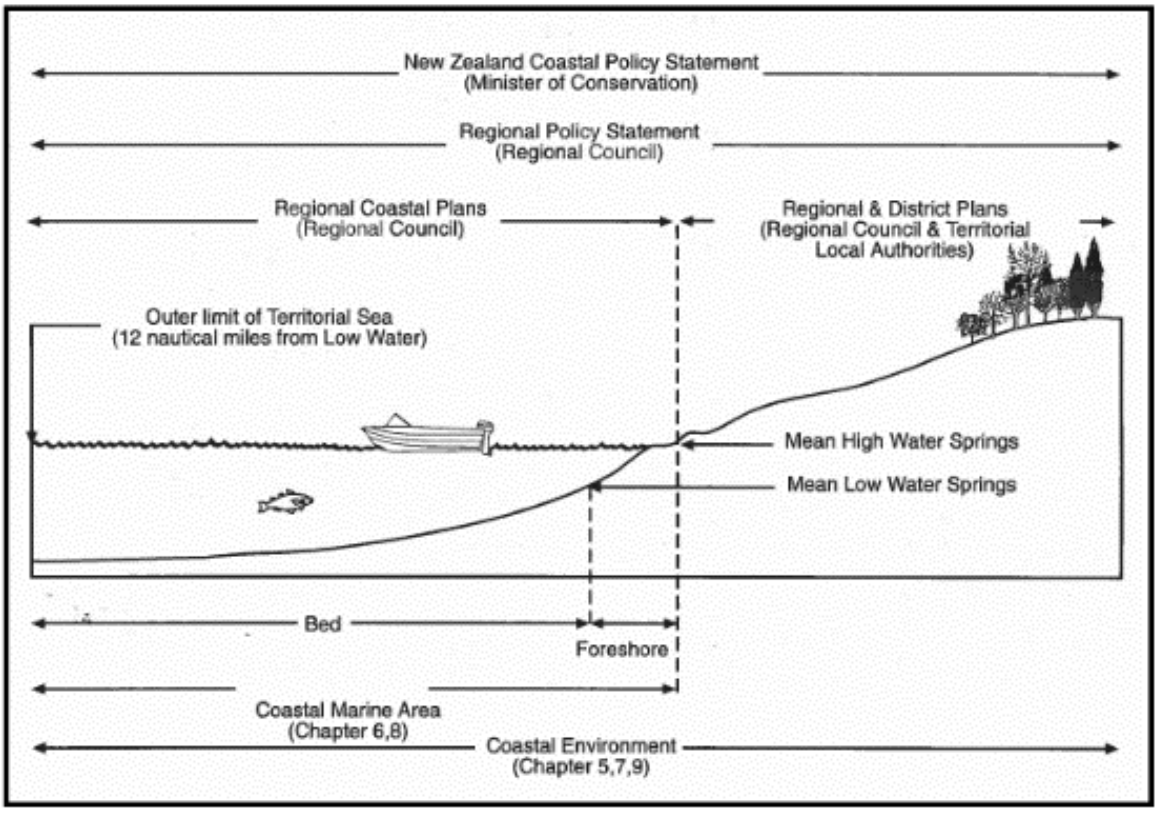

Figure 4 - The coastal environment (Environment Canterbury Regional Council, 2003)

Figure 4 shows where the different RMA plans apply to the coast and land. The coastal marine area (CMA) is the area below Mean High Water Springs. This line changes over time depending on how coastal processes change the land and coast interface.

[17] Objective 3 of the New Zealand Coastal Policy Statement (Department of Conservation, 2010)
[18] (Environment Canterbury, 2013)
[19] (Environment Canterbury, 2003)
[20] (Christchurch City Council, 2017c)

Under the RMA, Council RMA planning documents must be reviewed every 10 years[21], but because of the permanence of buildings and development regulated through these tools, they often seek to achieve strategic outcomes for the next 50-100 years.

Financial, asset management planning

Through the Long Term Plan (LTP) and asset management planning process (covering 10 years), councils must make decisions about:

a. what level of natural hazard protection will be provided (in the case of flood protection works); or
b. what level of event assets are to withstand (in the case of network infrastructure) in the next 10 years.

An infrastructure strategy is prepared as part of an LTP (every three years). While the LTP and asset management planning only plans for the next 10-years, the infrastructure strategy is required to plan for at least 30 years which includes consideration of the resilience of infrastructure in the event of natural disasters, sea level rise and climate change[22].

In addition, various tools are available to manage council assets and services, and to protect communities from natural hazards. These include:

- Using powers under the LGA to make bylaws, and stop roads[23]
- Establishing special rating areas under the Local Government (Rating) Act 2002[24]
- Using powers under the Soil Conservation and Rivers Control Act 1941[25] and Christchurch Drainage Act 1951[26] for flood protection and control works
- Using the Public Works Act 1981 which allows central government or councils to acquire private land for public purposes[27]
- Development of reserve management and development plans under the Reserve Act 1977[28]

Emergency Management Planning

The Civil Defence and Emergency Management Act 2002 (CDEMA) [29] requires councils to co-ordinate and participate in risk reduction, readiness, response and recovery through regional Civil Defence and Emergency Management Groups.

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[21] Section 79 of the Resource Management Act 1991
[22] Section 101A of the Local Government Act 2002
[23] Section 345(3) of the Local Government Act 1974, and Part 8 of the Local Government Act 2002
[24] Sections 16 to 18 of the Local Government (Rating) Act 2002
[25] Section 10 of the Soil Conservation and Rivers Control Act
[26] Christchurch District Drainage Act 1951
[27] Guidelines for the acquisition of land under the Public Works Act 1981 can be found on the Land and Information New Zealand website https://www.linz.govt.nz/regulatory/15703
[28] (Christchurch City Council, 2014b); (Christchurch City Council, 2014a)
[29] Civil Defence Emergency Management Act 2002

Civil Defence and Emergency Management group plans[30] are developed at the regional level and focus on co-ordination, having systems in place, and encouraging communities to achieve acceptable levels of risk. These can be supplemented by community resilience plans which can apply to a specific area or group outlining how they as communities and individuals will support each other, and how the Canterbury Civil Defence and Emergency Management Group will support them during reduction, readiness, response and recovery. There is no community resilience plan for Southshore and South New Brighton as yet, however there is an opportunity to develop one in future with the Christchurch Civil Defence Emergency Management Team.

Regeneration

The Greater Christchurch Regeneration Act 2016 (GCRA) [31] aims to facilitate the regeneration of the Greater Christchurch area following the 2010 and 2011 Canterbury earthquakes and provides additional powers to central government and councils to expedite this process where necessary, and to manage and make decisions regarding the future use of residential red zoned land.[32]

Regenerate Christchurch is responsible for determining the future use of the red zone. For the Ōtākaro Avon River Corridor red zone land this is being undertaken through the development of the Ōtākaro Avon River Corridor Regeneration Plan. The future of the red zoned land at South New Brighton and Southshore will be influenced by the Southshore and South New Brighton Regeneration Strategy, and ideas for its use will be gathered through the process.

Adaptation

There has been a recent push nationally among researchers, practitioners and agencies for a more coordinated approach and better tools to assist with adapting to climate change.[33]

The discussion document on the Zero Carbon Bill[34] was recently consulted on, and proposed a number of tools to support adaptation decision making including providing more national direction through a national adaptation plan and national climate change risk assessment, and reporting requirements.

The Ministry for the Environment guidance on coastal hazards and climate change[35] provides councils with a recommended best practice process to undertake adaptation with communities. This process is being used to develop the Regeneration Strategy for Southshore and South New Brighton.

[30] (Canterbury Civil Defence and Emergency Management Group , 2014)
[31] Greater Christchurch Regeneration Act 2016
[32] These powers include (1) developing and amending planning instruments relating to greater Christchurch through the development of regeneration plans or s71 of the Act; and (2) undertaking works, restricting access, acquiring property or amending property boundaries in accordance with subpart 2 of the Act
[33] (Climate Change Adaptation Technical Working Group, 2018); (Local Government New Zealand (LGNZ), 2017)
[34] (Ministry for the Environment, 2018)
[35] (Ministry for the Environment, 2017f)

Guidance

There is a range of best practice guidance for councils to manage natural hazards (such as potentially liquefaction prone land[36]), preparing for climate change,[37] and to implement the NZCPS coastal hazard objectives and policies, [38] [It is anticipated that more guidance will be provided in future as understanding of natural hazard risk and adaptation for climate change in the New Zealand situation improves.

How are we currently managing natural hazard risk

Roles and responsibilities

The Christchurch City Council is responsible for managing the effects of land use and subdivision activities, issuing building consents, communicating hazard risk, planning, delivering and maintaining infrastructure, and participating in regional civil defence groups.

Environment Canterbury (the regional council) provides direction for managing hazards through the regional policy statement. It also co-ordinates and oversees the management of natural hazards through the Regional Canterbury Civil Defence and Emergency Management Group[39], the regional approach to managing natural hazard risk and the Greater Christchurch Partnership[40]. Environment Canterbury manages activities in the coastal marine area (CMA).

There are many pieces of overlapping and interacting legislation that govern drainage and flood protection within the region and the district. Both the regional and city council are able to undertake drainage and flood protection works. Simplistically, Environment Canterbury manages river control and drainage schemes across the region, such as the Waimakariri stopbanks. While Christchurch City Council generally looks after drainage and floodplain management within urban Christchurch.

Land use and buildings

Risk to buildings, people and property are currently managed through a combination of Building Act regulations, and regional and district policies and plans.

Building consents

Building consents are generally required for new buildings, additions, alterations and repairs to manage building design and safety for the life of a building (50 years).

Regional planning requirements

The Canterbury Regional Policy Statement (CRPS) 2013[41] sets out the framework and priorities for resource management in the Canterbury region, including managing natural hazard risk. It also sets

[36] (Ministry for the Environment, 2017h);
[37] (Ministry for the Environment, 2008);
[38] (Department of Conservation, 2017)
[39] (Canterbury Civil Defence and Emergency Management Group, 2018)
[40] (Greater Christchurch Partnership, 2017)
[41] See the following link for more information on the CRPS https://www.ecan.govt.nz/your-region/plans-strategies-and-bylaws/canterbury-regional-policy-statement/

out the responsibilities and functions of local authorities in the control of land-use to avoid or mitigate natural hazards. The CRPS further reinforces direction in the NZCPS, including:

- Avoiding increasing risk in areas subject to hazards which are unacceptable[42], such as areas likely to be subject to coastal inundation or erosion over at least the next 100 years, or flood waters of high depth and velocity which pose a risk to life[43];
- Reducing reliance on hard protection structures[44];
- The importance of protecting critical infrastructure[45]

The Regional Coastal Environment Plan 2005 (RCEP) [46] sets out how Environment Canterbury will carry out its resource management responsibilities in the coastal marine area, including those related to coastal hazards. The RCEP includes some rules relating to activities in coastal erosion zones directly adjacent to the coast, which may apply to the land side of the CMA.

Any district planning documents must give effect to the CRPS, and not be inconsistent with the RCEP. While the current direction and rules in the regional planning documents sets the framework for regional land use, both the CRPS and RCEP are due for review in 2021.

District planning requirements

The Christchurch District Plan (CDP) 2017 includes floor level requirements and controls on development in areas at risk of flooding[47], controls in areas directly adjacent to the coastline[48], assessment requirements for areas at risk of liquefaction[49], and an overarching policy approach to avoid unacceptable risk to natural hazards[50]. The Christchurch District Plan contains limited management of development in areas at risk from coastal hazard, but requires assessment of coastal hazard risk within the coastal environment, consistent with the requirements in the New Zealand Coastal Policy Statement. The extent of the coastal environment is defined on the planning maps and supporting policies in the Christchurch District Plan. The Christchurch City Council has statutory direction to develop coastal hazard provisions "as soon as practicable".[51]

The Christchurch City Council also has a flood intervention policy[52] for frequent above floor flooding. Assistance will be provided to landowners of properties meeting the policy criteria where flooding experienced has been worsened by the earthquakes, and planned flood mitigation schemes will not offer a timely reduction to the flood risk. Flockton is the first area where this policy has been applied, having been through a long process of investigation and flood mitigation design, and understanding

[42] CRPS objective 11.2.1 and policies 11.3.1, 11.3.2, 11.3.5 (Environment Canterbury, 2013)
[43] These are defined as "high hazard areas" in CRPS policy 11.3.1 (Environment Canterbury, 2013)
[44] CRPS objective 11.2.2 and policies 11.3.1(3), 11.3.7 (Environment Canterbury, 2013)
[45] CRPS policies 11.3.1(7), 11.3.4 (Environment Canterbury, 2013)
[46] (Environment Canterbury, 2003)
[47] Rules in High Flood Hazard Management Area and Residential Unit Overlay 5.4.6, and the Flood Management Area 5.4.1, 5.4.2, 5.4.3 (Christchurch City Council, 2017c)
[48] (Christchurch City Council, 2015d)
[49] Policy 5.2.2.3.1, Rule 5.5.2 C1 (Christchurch City Council, 2017c)
[50] Policy 5.2.2.1.1 (Christchurch City Council, 2017c)
[51] The Canterbury Earthquake (Christchurch Replacement District Plan) Amendment Order (No 2) 2015, clause 6 inserted new Clause 5A(2) stating "*As soon as is reasonably practicable after the commencement of this clause, the council must amend the Natural Hazards (part) Stage 3 proposal accordingly (without applying the process in this order)*" http://www.legislation.govt.nz/regulation/public/2015/0235/latest/whole.html.
[52] (Christchurch City Council, 2017)

which properties will benefit from timely area-wide mitigations, and which won't. The Heathcote is the other area where the policy is currently being applied. Up to seven properties were identified in Flockton and up to 35 in Heathcote to which the policy could be applied.

Council infrastructure and floodplain management

The Christchurch City Council 30-year Infrastructure Strategy 2018-2048[53] explains how the Council will deliver and manage infrastructure to support core services to meet the needs of current and future generations. The strategy outlines the levels of service for the provision of infrastructure, flood protection commitments and resilience of infrastructure.

Various projects relating to increased flooding because of the earthquakes are being undertaken through the Christchurch City Council's Land Drainage Recovery Programme.[54] A number of studies have also been commissioned by both the Christchurch City Council and the community, investigating different flood protection options for Southshore and South New Brighton.[55] The South Brighton Reserves Management Plan outlines how the three South Brighton Reserves along the estuary edge will be managed. This includes a number of aims focusing on ecological, cultural and landscape values, natural defences of the estuary edge to improve resilience to the effects of climate change and erosion, and recreation activities.[56] The South New Brighton Reserves Development Plan 2014 includes additional requirements for Council and must be complied with under the Reserves Act. This includes landscape and concept plans and a prioritised list of development projects.[57]

Community resilience

Christchurch is part of the 100 Resilient Cities network, an international initiative dedicated to helping cities around the world become more resilient to the physical, social and economic challenges that cities face in the 21st century. As part of this, the Christchurch City Council, along with other partners in Greater Christchurch[58] prepared a Resilient Greater Christchurch Plan[59]. This Plan acknowledges seismicity, flooding, tsunami and climate change, including sea level rise, as some of the key shocks and stresses that the Greater Christchurch needs to build resilience.

The Resilient Greater Christchurch Plan has four goals, including a goal on understanding risks to be better prepared for future challenges. Part of the 'understand' goal includes a specific programme on securing a future in the eastern parts of Christchurch.

[53] (Christchurch City Council, 2018-2048)
[54] (Christchurch City Council, 2018b)
[55] (NIWA, 2015); (Beca Ltd., August 2017); (Aurecon, 2017); (OCEL Consultants NZ Ltd., 2016)
[56] (Christchurch City Council, 2014b)
[57] (Christchurch City Council, 2014a)
[58] Selwyn District Council, Waimakariri District Council, Te Rūnanga o Ngai Tahu and Environment Canterbury
[59] (Greater Christchurch Partnership, 2015)