Adapting to the consequences of climate change

Engaging with communities

Special Publication 2016

Te Hunga Takutai o Aotearoa
NEW ZEALAND COASTAL SOCIETY

The New Zealand Coastal Society was inaugurated in 1992 "to promote and advance sustainable management of the coastal environment". The society provides a forum for those with a genuine interest in the coastal zone to communicate amongst themselves and with the public. The society currently has over 400 members, including representatives from a wide range of coastal science, engineering and planning disciplines, employed in the engineering industry; local, regional and central government; research centres; and universities.

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Coastal erosion at Taylors Mistake, September 2013. Photo: Shane Orchard.

Adjusting to change

By Rick Liefting, NZCS Chair

At the end of 2015 the UN COP 21 climate change summit reached an agreement to attempt to limit the rise in global temperatures to less than 2°C. This monumental pact is the first to commit all countries to cut carbon emissions.

As the BBC reported following the announcement, the chair of the group representing some of the world's poorest countries noted, "We are living in unprecedented times, which call for unprecedented measures."

Unprecedented is almost an understatement. It's good news for the planet, but as those of us working as coastal engineers, scientists, planners and policy-makers know we are still in a time of great change. While limiting the temperature rise may stem the tide, the consequences of climate change are already being felt around the world.

We are no different here in New Zealand – and we are starting to see that addressed. For example, in December 2015 the Greater Wellington Regional Council moved one step closer with its flood protection plan to buy out 75 property owners in a bid to strengthen stopbanks lining the Hutt River – a move precipitated by the effects of climate change.

These types of planning decisions are going to need to become much more commonplace, but that doesn't make them any easier. As the Parliamentary Commissioner for the Environment wrote in her November 2015 report *Preparing New Zealand for rising seas: Certainty and Uncertainty*:

"Homes are much more than financial equity. Such zoning and any regulations that follow must be based on a fair process and technical assessments that are both rigorous and transparent.

"While these principles should hold for planning for any hazards under the Resource Management Act, planning for sea level rise is outside our experience – it is *terra incognita*."

For those of us who work as coastal professionals this significant shift means we need to engage with communities in new ways – we need to develop integrated planning practices that ensure communities are not only informed, but also contributing to coastal planning and decision-making.

In this New Zealand Coastal Society special publication we hope to further the discussion on engaging with communities. The publication is divided into three sections:

- Section 1 is an overview of the national landscape in addressing the consequences of climate change;
- Section 2 is a discussion on engaging with communities;
- Section 3 is a look at how Coastcare groups and communities are addressing climate change.

Much of the information in this publication is based on presentations that were given at the 2015 Australasian Coasts and Ports conference that was held in Auckland last September. I would like to recognise and thank our colleagues in New Zealand, Australia and other parts of the world who shared their experiences and learnings on adapting to climate change at the conference – they started an important conversation that we at the New Zealand Coastal Society feel it is essential to continue.

Towards climate-smart communities

By Shelly Biswell, Editor

Local government's remit for addressing climate change is multifaceted. In recognition of the complexity of local government's role, in 2009 Local Government New Zealand (LGNZ) drafted a Climate Change Position Statement to assist councils in understanding and executing their role.

Late last year, LGNZ upped the ante with the announcement of the Local Government Leaders Climate Change Declaration at the Australia-New Zealand Climate Change and Business Conference. Led by the mayors of New Zealand's larger cities, the declaration calls for immediate action to address climate change.

As LGNZ President Lawrence Yule noted when the declaration was announced, "It encourages Government to be more ambitious with climate change mitigation measures and underlines our support for Government to work with councils, communities and businesses to develop and implement an ambitious transition plan towards a low carbon and resilient New Zealand."

Earlier in 2015, the Society of Local Government Managers (SOLGM) published *Climate change – Local government can make a difference* and stated that, "Councils have opportunities to develop strategic initiatives and practical tools to support positive transitions." The report identified three overarching areas where local government can make a difference in addressing the impacts of climate change:

- building community understanding and preparedness;
- developing practical processes and tools to help New Zealanders adapt; and
- strengthening resilience against adverse impacts.

Natural hazards

While there are numerous issues for local government to grapple with addressing climate change, one area of particular concern is managing the risk associated with natural hazards. As LGNZ's 2014 think piece *Managing natural hazard risk in New Zealand – Towards more resilient communities* observes, "there is a need for a national approach to managing risk from natural hazards including principles for hazard reduction".

In the case of natural hazards, including those associated with climate change, the Government is proposing to amend the Resource Management Act 1991 to require a risk-based approach, as well as providing national direction.

Yet, as SOLGM states in its 2015 report, the Ministry for the Environment "has consistently rejected the idea of promulgating a National Environmental Standard for sea level rise, and has issued guidance with no regulatory backing".

Even with the Ministry for the Environment's current guidance (which is expected to be updated in 2016) and the objectives and policies of the New Zealand Coastal Policy Statement 2010, there remains a grey area that has left councils in the position of justifying their use of the government's guidelines and/or commissioning independent work to determine projected sea-level rise. As recent cases around the country have suggested, it's often a controversial and costly process.

In addition, a 2014 report of the Insurance Council of New Zealand (ICNZ) suggests that local authorities should take a long-term view in considering natural hazard risks. This includes denying consent applications if the long-term view suggests that natural hazards will increase. As reflected in the following article and section 2, however, risk can be subjective.

As Angus Gordon of Coastal Zone Management and Planning (New South Wales, AU) said at the 2015 Australasian Coasts and Ports Conference (see page 6), "Over the past 30 years as market values of coastal properties have escalated the potential economic and social impacts of hazard lines that cut through existing development have often resulted in scientific risk being supplanted by political risk."

In spite of (or perhaps in response to) the seemingly "rock and a hard place" position local authorities find themselves in, many have initiated spatial planning and internal guidance work to help address climate change in future strategies, policies and plans. This approach is expected to support better community engagement and decision-making.

Working collaboratively

While addressing climate change requires community- and site-specific responses there is a clear need for collaboration across both local and central government to develop and support best practice. To that end, SOLGM and the Victoria University Climate Change Research Institute have suggested the creation of a community of practice to collaborate on issues such as planning, natural hazard management, biodiversity, biosecurity and infrastructure.

As the Parliamentary Commissioner for the Environment, Dr Jan Wright, notes in her report *Preparing New Zealand for rising seas: Certainty and Uncertainty* (2015), there are several issues with how councils deal with climate change, including "problems with science assessments, with the process of engaging with the community, and with the planning and management decisions that follow". To help address some of these issues, one of her recommendations to the Minister for the Environment and the Minister of Conservation is to "take direction on planning for sea level rise out of the New Zealand Coastal Policy Statement and put it into another National Policy Statement, such as that envisaged for dealing with natural hazards".

Central government can support scientific and technical guidance. For example, the mission of the Government's Deep South National Science Challenge (Deep South NSC) is to "transform the way New Zealanders adapt, manage risk, and thrive in a changing climate". Through a five-pronged work programme, the objective of the Deep South NSC is to combine community engagement with an innovative climate prediction system.

An international perspective

In its annual *Global risks report*, the World Economic Forum identified the failure of climate change mitigation and adaptation to have the greatest potential impact in 2016. Based on a survey of 750 experts, it's the first time in the report's history that an environmental risk has been at the top of the list of threats.

While experts are aware of the potential impacts of climate change, it's harder to take specific steps to address mitigation and adaptation at the local level. In a Massachusetts Institute of Technology 2012 global study[1] on how communities are addressing climate change, researchers found that, in general, cities find it difficult to communicate their climate change work programme, or to interest political officials and business in this issue. The report notes that two global trends are "that most cities believe their national governments have limited understanding of the challenges they are facing, and most have limited access to financial support from local, regional, national, and international sources".

The international organisation ICLEI (Local Governments for Sustainability) is working to address some of these issues and has developed the Transformative Actions Program (TAP) to showcase local and regional climate action in an effort to encourage climate-smart cities.

One of the poster communities for ICLEI is Vancouver, Canada which has set for itself the ambitious goal of becoming the "greenest city in the world" by 2020.

It's a fast-track process, with Vancouver having joined the ICLEI Climate Change Adaptation Initiative pilot in 2010 with the intention of developing a climate change adaptation strategy by 2012.

While the political landscape has changed dramatically in Canada, through 2015 there was very little action on climate change at the federal level. That's meant that provinces and individual cities like Vancouver have needed to take on the brunt of the country's work in both mitigating and adapting to the impacts of climate change.

For Vancouver, that has included a complete overhaul of plans, policies, procedures and strategies with climate change now at the centre of all decision-making. As noted in their adaptation strategy, Vancouver's plans are focused on "no-regret actions" meaning actions "that build on existing plans and actions and provide community benefits regardless of the extent of climate change experienced".

It's an approach that appears to be working and has been recognised internationally as a sound climate change strategy.

Building our future

As you will read in the following pages, in preparing this publication we found many good examples of how local authorities are engaging with the public and working to create climate-smart communities. Some of this work has included a rethink on when and how to engage with communities in planning processes, as well as how to make general and site-specific information, such as estimated sea-level rise, available in a way that supports better decision-making.

The goal with this publication is to highlight some of this work, and to support the development of best practice in working with communities as they adapt to the consequences of climate change.

Greater Wellington Regional Council adopts climate change strategy

In October 2015, the Greater Wellington Regional Council (GWRC) adopted a climate change strategy focused on strengthening the long-term resilience and sustainability of the Wellington region through action and awareness.

The strategy is accompanied by an implementation plan that sets out actions GWRC will take to achieve measurable outcomes. While the strategy and implementation plan take a long-term view, the implementation plan contains actions to be completed in the near-term, which will be reviewed and updated every three years.

GWRC has been working with Wellington City Council, and both councils are keen to promote a region-wide collaborative approach.

GWRC plans to work with the community, businesses, other councils and central government in pursuing the objectives of this strategy.

The strategy and implementation plan are available at www.gw.govt.nz/climatechange/.

[1] Carmin, J; Nikhil N; and Rhie C. *Progress and challenges in urban climate adaptation planning: Results of a global survey*. Cambridge, MA: MIT. 2012.

Preparing for the consequences of climate change – current framework

By Shelly Biswell, Editor

New Zealand's climate is changing. We are already seeing indications of this change, including temperature differences on land and in our lakes, rivers and oceans. These changes are just the tip of the proverbial iceberg.

In New Zealand climate change will cause higher temperatures and more frequent extreme weather events, including droughts and flooding. It will cause an acceleration in the rate of sea-level rise.

As the Prime Minister's Chief Science Advisor Sir Peter Gluckman writes about rising sea levels, "while it is seemingly small, this rise will result in today's highest tide levels and storm surges occurring much more frequently".[2]

The consequences of climate change will be different across the country. For example, coastal areas may see increased coastal erosion, more extensive inundation and higher levels of flooding. The west of both the North Island and the South Island are expected to receive more rainfall, but the east and north will receive less. Because sub-tropical cyclones are expected to track south more often, the northern part of the North Island could see severe storms more frequently.

As Gluckman writes, "At a local level, the impact may vary as different parts of the system interact, for example an increase in sedimentation from rivers as a result of locally increased precipitation may make a channel shallower if the rate of sedimentation build-up exceeds the rate of sea-level rise. It is therefore important to assess the conditions locally rather than solely on a national or even global level."

Amanda Moran, Director of Resource Management at the Ministry for the Environment, says, "Much of New Zealand's population is located in coastal areas – and that percentage is increasing. There are unique challenges for coastal communities that will need to be planned for."

Managing risks

Managing risks from natural hazards is crucial to adapting to climate change. A central government policy is that managing hazard risk is best undertaken as close as possible to those who create or bear the risk. A framework for this policy is delivered through the Civil Defence Emergency Management (CDEM) Act 2002, and the 4Rs approach to risk:

- Reduction;
- emergency Readiness;
- Response; and
- Recovery.

Key to a risk-based approach is identifying the level of risk that is acceptable to councils and communities. All communities face unique situations and challenges which means that risks are dealt with differently across the country.

[2] Gluckman P. *New Zealand's changing climate and oceans: The impact of human activity and implications for the future*. An assessment of the current state of scientific knowledge by the Office of the Chief Science Advisor. Office of the Prime Minister's Science Advisory Committee. July 2013.

Investigating a local government risk agency

In June 2015 Local Government New Zealand (LGNZ) joined with the Government to appoint an establishment board to investigate options for a local government risk management agency. Working with both local and central government over a 12-month period, the primary task of the board is to identify risk management services that would assist councils and locally owned infrastructure.

At the same time the Government announced a review of the existing funding arrangement between central and local government to restore certain infrastructure after emergencies, such as for water, wastewater, stormwater and river flood control.

With the announcement of the establishment board, LGNZ President Lawrence Yule said, "Local government has significant expertise on managing the impacts of natural hazards and other risks but we need to work together as a sector and draw on external expertise. The ability to work together to better manage future risks is important for communities."

A national framework for adaptation

Adapting to climate change is a complex issue that needs to be addressed consistently across different types of legislative, regulatory and non-regulatory measures. The Ministry for the Environment administers one of the key pieces of legislation for adapting to climate change: the Resource Management Act 1991 (RMA).

Section 7 of the RMA requires people to have particular regard to the effects of climate change. One place that this is done is in managing risks from natural hazards.

The New Zealand Coastal Policy Statement 2010 (NZCPS) is prepared by the Minister of Conservation under the RMA and provides direction on planning for development in the coastal environment, and includes the contribution of climate change and sea-level rise to coastal hazard risk.

Each regional council (or unitary authority) must prepare a regional policy statement, which must give effect to the NZCPS. Other regional and district plans must also give effect to the NZCPS. Under Policy 24 of the NZCPS, "Hazard risks, over at least 100 years, are to be assessed having regard to physical drivers and processes including… sea level rise…"

As part of the Resource Legislation Amendment Bill, the Government has proposed adding to section 6 as a matter of national importance "management of significant risks from natural hazards".

The Government has also signalled national guidance under the RMA, which may take the form of a national policy statement on natural hazards, with an expected 2018 release date.

As part of initial work to develop national guidance, the Government released a document, *A way forward for national direction*[3], to inform local government and other stakeholders of work in the pipeline. It's the start of an important conversation on the development of this national guidance.

"It is important that central and local government work together to manage risks from natural hazards across the country," Amanda Moran says.

Ministry for the Environment and other central government agencies frequently attend regular meetings of the special interest group of local government hazard managers to learn about both the challenges being faced and innovative practice by local government. The meetings also provide an opportunity to update local government practitioners on central government policy development.

There are also opportunities for conversations about the consequences of climate change. For example, in December 2014, the Ministry for the Environment held a workshop on sea-level rise. The workshop brought together officials from councils that have significant levels of infrastructure at risk from sea-level rise, with councils and experts who have valuable experiences in planning, consulting and responding to issues resulting from sea-level rise. The workshop also provided the ministry with valuable input into their review of the national guidance.

Planning guidance

The Ministry for the Environment's recommendations on sea-level rise are part of its guidance to assist local government decision-making in preparing for climate change. This consists of:

- *Climate change effects and impacts assessment: A guidance manual for local government in New Zealand;*
- *Coastal hazards and climate change: A guidance manual for local government in New Zealand; and*
- *Tools for estimating the effects of climate change on flood flow: A guidance manual for local government in New Zealand.*

This guidance was reviewed in 2014 and currently is being updated. New climate projections for New Zealand will be released first, followed by an update in 2016 of the guidance on coastal hazards and climate change. While the update will reflect the significant developments in international science and domestic policy relating to climate change adaptation, the core premise of the guidance remains the same. The Department of Conservation is also preparing guidance to support implementation of the NZCPS hazard policies.

Roles and responsibilities for adapting to climate change

Source: Ministry for the Environment

Central government

Central government sets the direction so that New Zealand's national infrastructure, people, environment and economy are more resilient to the impacts of climate change. It also provides the legislative framework and governance to support local councils and communities in how they adapt to climate change.

Key legislation

The RMA is the main piece of legislation for adapting to climate change and associated natural hazards.

Other legislation, policies and plans

Civil Defence Emergency Management Act 2002, the National Infrastructure Plan, 30-year local government infrastructure strategies (under the Local Government Act 2002 and the Local Government (Auckland Transitional Provisions) Act 2010), the NZCPS, and building controls under the Building Act 2004. It also includes the Local Government Official Information and Meetings Act 1987, which serves as the basis for the requirement for land information memorandums (LIMs) to include coastal hazard information.

Other support:

- provides information and guidance to local government and businesses;
- funds research and publishes information on climate change impacts; and
- prepares for, responds to, and assists with recovery from emergencies arising from major natural hazard events.

Local councils

Each part of the country will be affected differently by climate change, so preparing for and managing the risks is carried out by local councils, because they are best placed to know what is appropriate for their region or district.

Councils use the legislation, policy and guidance produced by central government to consider the risks for their region and respond appropriately through such actions as preparing adaptation strategies, building adaptation into existing plans, construction of protective works, building consents and land-use planning.

Tools of the trade

Victoria University of Wellington's New Zealand Climate Change Research Institute is focused on the connection between climate change science, policy development and decision-making. One project the institute is working on is in collaboration with Deltares, a Netherlands-based applied research institute. Deltares developed a simulation game – the Sustainable Delta Game – for policy-makers to experience making decisions under uncertain and changing conditions and a Pathways Generator for evaluating the effect of policy options. Participants develop an adaptive plan in the game and using the dynamic adaptive policy planning (DAPP) approach can test policy choices. This enables decisions to be made that can be robust when changed for whatever the climate that evolves in the future. Deltares and CCRI, working with Greater Wellington Regional Council, Wellington City Council, Tasman District Council and Ministry for the Environment, have created two new versions of the game for New Zealand decision settings – a New Zealand river and a New Zealand coastal setting.

[3] *A way forward for national direction*. Ministry for the Environment. August 2015.

Whose line is it anyway? Coastal hazard lines and considering new ways to assess risk

Compiled by Shelly Biswell, Editor

At the 2015 Australasian Coasts and Ports Conference one of the hotly discussed topics centred on how methodologies for assessing coastal hazard risk have evolved. One of the more provocative presentations was by Angus Gordon of Coastal Zone Management and Planning (New South Wales, AU) and Chair of the NSW Coastal Panel that was established under the NSW Coastal Protection Act who posited: Coastal Hazard Lines – Last Century's Thinking[4]. At the same time, New Zealand engineers presented their findings on the use of probabilistic erosion forecasts in coastal planning work[5].

Lines in the sand

In the 1970s coastal hazard lines were developed as a way to identify areas that would be affected by coastal processes. Using deterministic techniques, coastal hazard lines became the basis for coastal management and decision-making across both New Zealand and Australia.

Angus Gordon says that the coastal hazard lines of 40 years ago were vastly different than the coastal hazard lines of today.

"Initially hazard lines were based on a linear projection of historical trends, a simple, robust and readily explained concept. But as our understanding of coastal processes grew, the methodology behind calculating the location of hazard lines became more complex with the addition of storm cut, escarpment slumping, impacts of climate change and reduced foundation capacity, for example."

As the New Zealand authors of *Methods for Probabilistic Coastal Erosion Hazard Assessment* (Shand et al, 2015) note in their presentation paper, "Traditional methods of assessing coastal erosion hazard in Australia and New Zealand have typically applied deterministic techniques, separating and evaluating (largely) independent components before combining, often with an additional factor of safety or measurement error allowance, to produce an erosion hazard setback. Such techniques have advantages in being easily understood, interpreted and updated in the future as additional data is collected. However, the methods can result in conservative (large) values along with a limited understanding of the combined uncertainty range."

At the same time coastal professionals have been developing more sophisticated and nuanced methodologies for developing coastal hazard lines, in many places coastal property values have soared. The result has been that coastal hazard lines are frequently points of contention in coastal planning and management.

Angus Gordon says, "Over the past 30 years as market values of coastal properties have escalated, the potential economic and social impacts of hazard lines that cut through existing development have often resulted in scientific risk being supplanted by political risk."

Assessing risk

In recent years, in both New Zealand and Australia, there has been a move towards a more risk-based approach to coastal planning.

As Shand et al note: "New policy documents in New Zealand guiding the sustainable use of coastal resources such as the New Zealand Coastal Policy Statement 2010 (NZCPS) advocate the use of a risk-based approach to managing coastal hazard. This requires consideration of both the likelihood and consequence of hazard occurrence. Specifically, the policy statement requires consideration of areas both 'likely' to be affected by hazard and areas 'potentially' affected. Such a requirement is at odds with traditional techniques where single values are produced with limited understanding of the likelihood of occurrence or the potential uncertainty of the prediction."

The authors say that over the past 10 years the use of probabilistic methods of evaluating coastal processes have evolved. This technique uses a distribution of values for each parameter to account for expected variation, or uncertainty, rather than single values. Parameters are then combined by a Monte Carlo technique to produce a probabilistic forecast of future shoreline position.

While this method has been successfully employed for specific locations that have high-quality field data, until recently it had been relatively untested for coastal planning where available data is limited or where there are a variety of coastal types.

But working with the Northland Regional Council, Tonkin + Taylor have developed a framework for applying the stochastic simulation technique over a range of spatial scales for a variety of coastal types (see Figure 1).

Using this framework is more aligned with the risk-based approach spelled out in the NZCPS. Shand et al note that establishing generic planning rules requires specific zones or lines, so selection of the appropriate likelihood and time frame is required.

The authors write, "Ultimately, the adopted policies and rules should reflect the likelihood of hazard occurrence."

A risk-based approach has also been explored in Australia as Angus Gordon explains: "In 2007 the Australian Geomechanics Society (AGS) produced a watershed document for assessment and management of landslide risk. The methodology of the approach was based on a matrix of likelihood versus consequence to predict risk. The matrix provided a rational way to link outcomes for property and life to the probability of geotechnical hazards, and as a result the information required to determine the acceptable risks the society was prepared to take."

By 2013, investigators were experimenting with the adoption of the approach to assessment of coastal hazards. A

[4] Gordon A. *Coastal Hazard Lines – Last Century's Thinking*, Australasian Coasts and Ports Conference 2015. September 2015.

[5] Shand, T; Reinen-Hamill R; Kench P; Ivamy M; Knook P; and Howse B. *Methods for Probabilistic Coastal Erosion Hazard Assessment*, Australasian Coasts and Ports Conference 2015. September 2015.

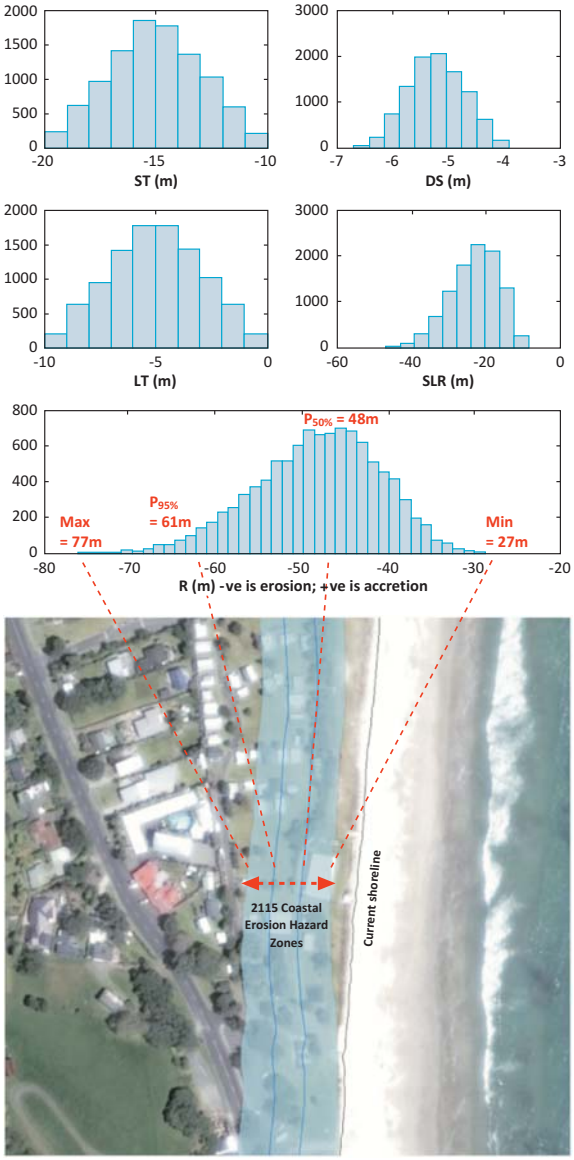

Figure 1: Sample component and CEHZ histograms with the resultant Coastal Erosion Hazard Zones width. Figure: Shand et al.

methodology was developed for establishing a probability for the potential location of a shoreline at some date in the future, the resultant consequence on property and hence the risk for coastal property, assets and infrastructure (see Figure 2).

"This approach also addresses community and political decision-making," Gordon says. "The 'consequence' area of the risk matrix requires more than just a cost-benefit approach, it requires an understanding of the affected community, its history and the potential future outcomes for its citizens and their extended families."

Conclusions

What is clear is that traditional approaches to evaluating coastal erosion hazard provide only limited understanding of the combined likelihood of occurrence or the potential uncertainty of the prediction.

Coastal professionals on both sides of the Tasman are now looking beyond traditional coastal hazard lines methodologies and incorporating methodologies that more accurately reflect risk, allow for more complexity, and take into account wider environmental, cultural and social objectives.

Likelihood	Consequence				
	Catastrophic	Major	Medium	Minor	Insignificant
Almost Certain	Very High	Very High	Very High	High	Medium
Likely	Very High	Very High	High	Medium	Low
Possible	Very High	High	Medium	Medium	Very Low
Unlikely	High	Medium	Low	Low	Very Low
Rare	Medium	Low	Low	Very Low	Very Low
Barely Credible	Low	Very Low	Very Low	Very Low	Very Low

Figure 2: Likelihood/Consequence matrix. Adapted from AGS 2007. Figure: Angus Gordon.

Lessons from Christchurch – the effect of sea-level rise on liquefaction vulnerability

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This article is a summary of a presentation made at the 2015 Australasian Coasts and Ports conference. The presenters looked at liquefaction vulnerability mapping of residential areas in Christchurch, and presented vulnerability maps for different levels of earthquake shaking based on current and revised groundwater levels reflecting sea-level rise scenarios of 0.5 metre and 1.0 metre. The change in the percentage of the residential building portfolio in eastern Christchurch likely to experience moderate to major liquefaction-related damage for the different levels of earthquake shaking has been assessed for each groundwater scenario.

As presenter Peter Quilter notes, "The implications of sea-level rise are commonly considered for inundation, erosion and tsunami risk, but there has been little written about the increased level of risk that sea-level rise will have on liquefaction vulnerability in geological coastal settings. Our analysis shows that in certain areas sea-level rise significantly increases the vulnerability to liquefaction and therefore it should be taken into account when assessing this hazard."

Liquefaction and the CES

The 2011/12 Canterbury Earthquake Sequence (CES) caused both widespread liquefaction-related land damage and building damage. Liquefaction related-damage affected 51,000 of the 140,000 residential properties in Christchurch and caused approximately 15,000 residential houses to be damaged beyond economic repair as a result of liquefaction-related land damage.

The severity of the damage was primarily influenced by the earthquake motions, subsurface soil conditions and depth to the groundwater surface. Other influences included topography, proximity to rivers and streams and land use.

The CES caused regional tectonic subsidence, as well as widespread liquefaction-related ground surface subsidence. In Christchurch, 85 per cent of residential properties have subsided (both tectonic and liquefaction related) and of those properties, 60,000 have subsided by more than 200 mm. This major shift, means that Christchurch and its suburbs are now more flood prone and more vulnerable to liquefaction damage in future earthquake events as the groundwater is now closer to the ground surface.

Some Christchurch suburbs have experienced the equivalent of a 0.5 to 1 metre of relative sea-level rise as a result of the CES (see Box 2, pages 15-16). To gauge the potential effect of sea-level rise on liquefaction vulnerability in low-lying coastal environments, a dataset of 18,000 Cone Penetration Tests (CPT) in Christchurch, available from the Canterbury Geotechnical Database (CGD) was used. In the analysis, the changes in liquefaction vulnerability were examined as a result of future rises in sea-level of 0.5 metre and 1 metre rather than the changes of in depth to groundwater due to the ground surface subsidence caused by the CES.

Development of modified groundwater surfaces for sea-level rise scenarios

One-dimensional steady state backwater profile modelling of the Waimakariri, Styx, Heathcote and Avon rivers (see Figure 1a) based on the median river flow rates was done using the software HEC RAS to better understand how sea-level rise could affect river backwater profiles.

An example of a backwater profile based on the median flow rate for the Avon River is shown by the solid black line that represents the median water level of the river rising from right to left with increasing chainage upstream along the centreline of the river (see Figure 1c).

No direct modelling of the hydraulic effect or changes in the shape of river cross-sections, direction of flow, or other two and three dimensional aspects of flow were undertaken as part of the backwater profile modelling. A Mannings (roughness) coefficient (n) of 0.03 for a clean natural channel was assumed as a constant for all four rivers. Notwithstanding the simplified assumptions, general consistency was observed between the NIWA river gauge station data and the modelled HEC RAS backwater profiles.

The sea-level at existing coastal margin for each river was elevated by 0.5 metre and 1 metre and new backwater profiles were generated. The backwater profiles representing the existing median level were subtracted from each sea-level rise backwater profile to establish potential additive groundwater values in 250 millimetre increments along the chainage of each river for each sea-level rise scenario.

The maximum inland extent where the sea-level rise affects the river backwater profiles for the 0.5 metre and 1 metre sea-level rise cases are shown as points A and B respectively for each river on Figure 1a. This shows that increases in groundwater levels due to sea-level rise are generally confined to the land east of the eastern side of the Central Business District (CBD). The additive groundwater values along the chainage of each river for each sea-level rise scenario were contoured and are shown as black lines on the maps in Figures 1d and 1e.

A number of simplifying assumptions were employed for this analysis, including the assumption that river levels and surrounding shallow groundwater profiles were considered perfectly hydraulically linked with one another, and no allowance was made for future anthropogenic changes to the river levels and groundwater levels. No allowance for climatic changes in groundwater surfaces was made, nor consideration of the effects of minor river tributaries in the HEC RAS modelling.

Changes in liquefaction vulnerability for various sea – level rise scenarios

Liquefaction vulnerability evaluations in the Christchurch area have made extensive use of four CPT-based liquefaction vulnerability parameters (or indices) including; one-

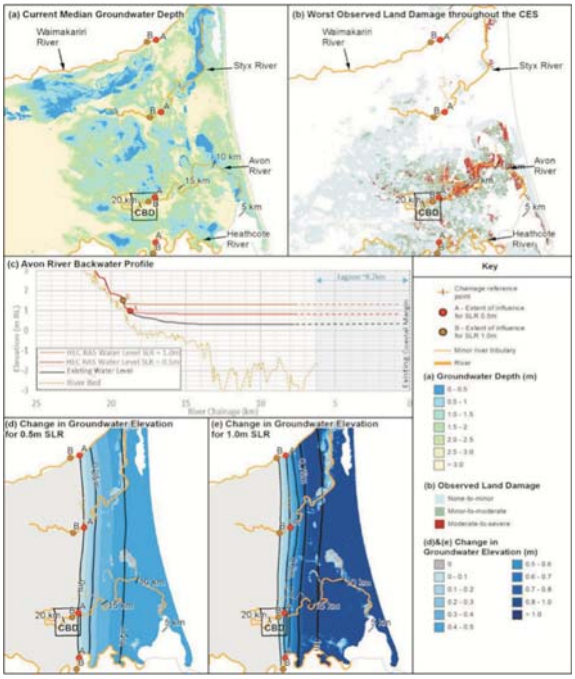

Figure 1 (a) Existing median depth to the groundwater surface; (b) Observed liquefaction related land damage as a result of the CES; (c) Avon River backwater profile modelled using HEC RAS; (d and e) Change in groundwater elevation for 0.5 metre and 1 metre sea-level rise.

dimensional (1D) post-liquefaction reconsolidation settlement (S_{V1D}), liquefaction potential index (LPI), modified liquefaction potential index (LPI_{ISH}) and liquefaction severity number (LSN). These liquefaction vulnerability parameters all use a liquefaction triggering analysis as one step in their calculation. The ability of the S_{V1D}, LPI, LPI_{ISH} and LSN parameters, in combination with some common liquefaction triggering correlations, to reasonably predict the observed liquefaction-induced damage on a regional scale was evaluated by van Ballegooy et al. (2014, 2015a and 2015b). Their conclusions included:

1. The Boulanger and Idriss (2014) liquefaction triggering procedure produced slightly better correlations with observed liquefaction-induced damage for each liquefaction vulnerability parameter compared with the other commonly used methods.
2. The LSN liquefaction vulnerability parameter provided a more consistent correlation with the observed liquefaction related damage compared with the other liquefaction vulnerability parameters.
3. Use of liquefaction vulnerability parameters in regional studies can, at best, only provide general assessments of liquefaction-induced damage patterns.

The LSN liquefaction vulnerability parameter combines many advantages, including that it is better able to analyse the complex layered soil profiles typical for natural soils, and it incorporates both the CPT tip resistance and corresponding cyclic resistance of the soil and how severely the soil reacts once it becomes liquefied. It also applies greater weighting to the liquefaction of soil layers closer to the ground surface compared to the liquefaction of soil layers at greater depths, consistent, and it considers the ratio between the non-liquefying crust thickness and the thickness and severity of the underlying liquefying soil layers.

Observed liquefaction related land damage during the CES (Figure 1b) generally correlate with the following LSN ranges: 0 to 15 indicatively correlates with none-to-minor liquefaction-related land damage, 16 to 25 indicatively correlates with minor-to-moderate liquefaction related land damage and more than 26 typically correlates with moderate-to-severe liquefaction related land damage.

For this study, the LSN liquefaction vulnerability parameter was used to assess the potential changes of liquefaction vulnerability in susceptible soils in low-lying coastal environments. The changes to the liquefaction vulnerability were assessed at the Serviceability Limit State (SLS), Intermediate Limit State (ILS), and Ultimate Limit State (ULS) design earthquake ground motions in Christchurch.

The SLS, ILS, and ULS motions for the Christchurch area are specified in the Ministry of Business Innovation and Employment (MBIE) 2014 guidelines and are all based on a reference magnitude (M) 6 earthquake with corresponding peak ground acceleration (PGA) values of 0.19 *g*, 0.30 *g*, and 0.52 *g*, respectively. For each of the sea-level rise scenarios the LSN parameter was computed at each CPT location using the respective groundwater surfaces based only on the top 10 metres of each CPT trace.

The calculated LSN values at each CPT location were interpolated between CPT investigation locations based on a natural neighbour interpolation method, which calculates thiessen polygons and weights them with proximity to CPT locations.

The analyses show that sea-level rise is likely to significantly increase the proportion of damage to residential properties in eastern Christchurch, particularly for the lower more frequent levels of earthquake shaking. With sea-level rise, the increase in the proportion of properties expected to have moderate-to-severe liquefaction-related land damage is in the order of two and four times for 0.5 metre and 1 metre sea-level rise scenarios, respectively.

Figure 2 shows coloured contour plots of the liquefaction vulnerability (LSN) maps for the current median groundwater case and the 0.5 metre and 1 metre sea-level rise scenarios (rows 1, 2 and 4, respectively) at the SLS, ILS and ULS earthquake ground motions (columns 1, 2 and 3, respectively).

Difference maps showing the increase in liquefaction vulnerability as a result of 0.5 metre and 1 metre sea-level rise scenarios are shown in Figure 2 rows 3 and 5, respectively. The maps indicate substantial increases in LSN (and consequently liquefaction vulnerability) are likely to occur in eastern Christchurch where the near surface soils typically comprise sandy non plastic sediment and where the greatest increases in groundwater levels are expected. The increases in LSN resulting from a 0.5 metre sea-level rise scenario are generally localised in effect, but at 1 metre sea-level rise scenario the increases in LSN are more continuous and widespread.

The coloured histograms in row 6 of Figure 2 provide a relative measure of the proportion of residential properties in eastern Christchurch likely to experience liquefaction related land damage.

These analyses show that sea-level rise is likely to significantly increase the proportion of damage to residential properties in eastern Christchurch, particularly for the lower more

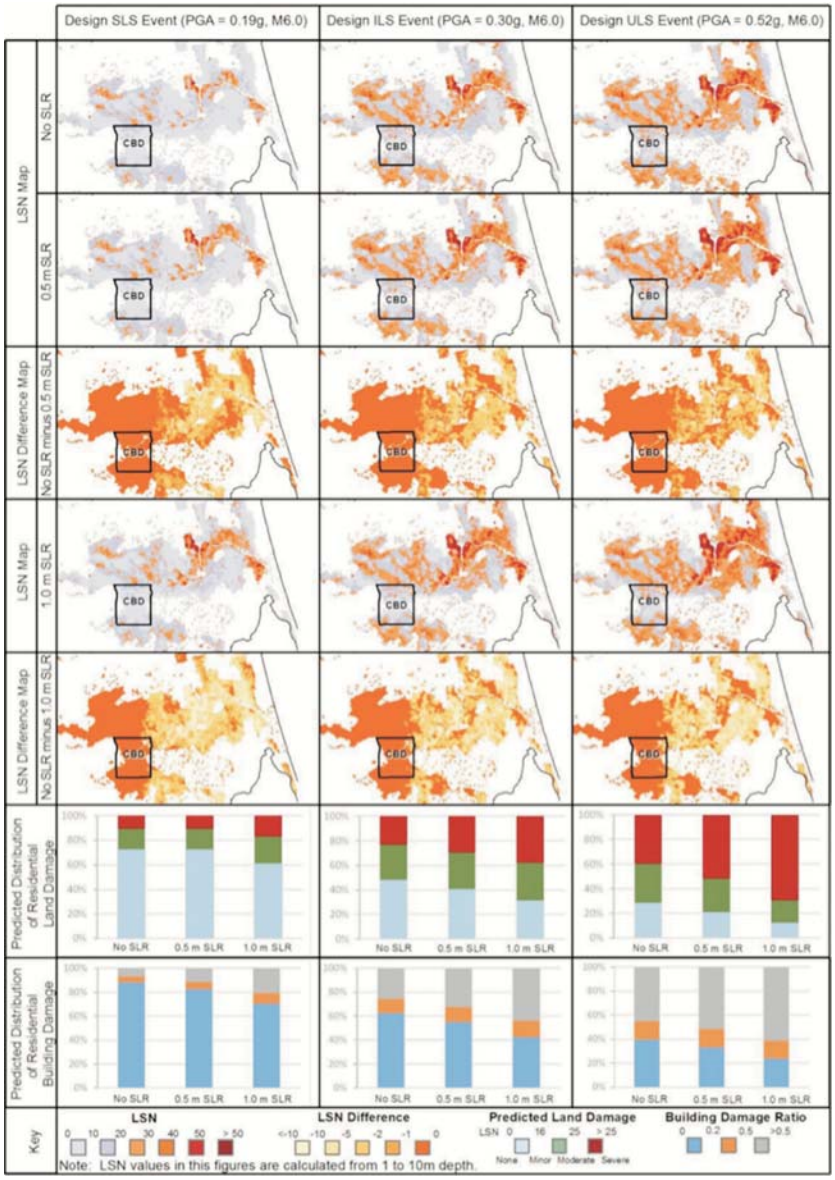

Figure 2 Spatial distribution of LSN based on the existing median groundwater surface and the groundwater surface after 0.5 metre and 1 metre sea-level rise (rows 1, 2 and 4, respectively) for the SLS, ILS and ULS earthquake shaking scenarios (columns 1, 2 and 3 respectively).

frequent levels of earthquake shaking. At the SLS ground motions, the increase in the proportion of properties expected to have moderate-to-severe liquefaction related land damage is in the order of 2 and 4 times for 0.5 m and 1.0 m sea-level rise scenarios respectively. At ULS this ratio decreases to 1.3 to 1.8 times for the 0.5 and 1.0 m sea-level rise scenarios respectively as a result of the high levels of damage that occurs anyway. The proportion of damage for the SLS case with 1.0 m sea-level rise scenario in eastern Christchurch is similar to the predicted damage at the ILS levels of earthquake shaking based on present day groundwater levels.

Considering sea-level rise

To date, scientists and engineers have been focusing on the direct effects of long-term, global-scale climate change effects, and the implications for existing flooding and coastal erosion hazards. The potential cumulative or indirect effects of sea-level rise on ground shaking induced hazards such as liquefaction have not been considered.

The CES and this research show that liquefaction damage following earthquake shaking will become worse as a result of groundwater levels increasing due to sea-level rise. The implications of these findings are that sea-level rise will increase the groundwater levels in low lying coastal areas and thereby increase the liquefaction vulnerability of land within coastal plains and reclaimed areas with soils susceptible to liquefaction, increasing the consequences to the built environment and increasing the financial losses of future earthquake events.

This is of particular relevance to urban areas as well as port and airports situated on coastal plains in seismically active areas. Seismic hazard assessments in liquefaction prone areas should include sea-level rise effects to ensure the risks, including climate change effects, are considered.

The complete written presentation, including references, is available through the 2015 Australasian Coasts and Ports conference proceedings.

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Section 2: Engagement

Effects of changing shoreline on infrastructure at Okariha, Port Waikato. Photo: GHD.

Engaging with communities: Conundrums for coastal adaptation

By Robin Britton, Resource Management/Planning Consultant, Focus Resource Management Group

In New Zealand we have a love affair with the ocean. Much of our prime residential and commercial development has been located very close to the coast, with little regard for the complex and naturally dynamic nature of our shorelines. Over the coming decades, climate change and sea-level rise are expected to increase both the extent and severity of the impact of natural coastal erosion and flooding on existing development.

As coastal professionals we know the complexities involved in defining hazard areas, and as planners we know the tensions of providing certainty around where and when planning provisions apply. Our national policy directs us to avoid an increase in the risk from coastal hazards and encourage changes in land use (including relocation or retreat) to achieve this. It is already clear in many locations that this adaptation will be the only way to achieve a sustainable long-term reduction in risk. Attempts to implement an adaptation approach through planning mechanisms or consenting processes, however, are generally met with great resistance from property owners, communities and councils.

Science and planning worlds often collide with property rights and emergency events; and when there's an emergency, no one really wants to talk about adaptation or the reality of how dynamic the coastal edges are in New Zealand. While such events bring these issues to front of mind, there is little time to engage wider communities into considering the long-term implications of management decisions.

Instead the go-to approach is holding the line using a range of actions. In most cases this short-term management only temporarily reduces the risk, and often degrades the public values of the coastline, potentially having flow-on effects on the local environment and economy. This approach often obliges councils into long-term commitments to maintenance and repair of expensive assets.

If we really want to make a difference for these currently and potentially affected areas, then we need to move beyond a short-term focus and beyond just engaging with coastal-edge property owners, and develop a better level of understanding within our wider communities (nationally and locally) about the risks they are or will be facing.

If we want to get some traction on coastal adaptation, do we need to think differently about coastal hazards? Do we need to engage with communities differently? How do we wrangle a sea change?

Focus on risk assessment

One of the key changes in hazards planning in recent years has been a stronger focus on risk and considering how that might better fit into Resource Management Act 1991 (RMA) plans at regional and local levels (see Box 1).

But as a general observation, coastal hazard risks are not well understood by coastal property owners, either when they are affected by RMA plan provisions or when their land is affected by a hazard event. This suggests we need to have more effective conversations about coastal hazards including risk and where the responsibility lies for risk. Any intervention decisions taken today generally come with significant upfront and ongoing economic and environmental costs, as well as creating an issue for future generations.

The insurance industry is increasingly taking a risk-averse approach for natural hazards. While this is a supporting tool for changing people's awareness of coastal-hazard risk, it is also shining the light more strongly on the work required to define risks associated with sea-level rise and future storm events.

A significant part of this shift of focus on risk management approaches is to clarify where the responsibility for taking actions and bearing the costs of protective or adaptive actions should best lie. At the 2015 Australasian Coasts and Ports Conference, Angus Gordon[6] (see article on page 6) provided an Australian perspective on the change to risk management approaches and proposed that protection works are really an individual's "insurance policy" for the future. While not advocating for hard protection works, Gordon suggests that the responsibility for finding out about a landowner's risks and enabling communities, as well as landowners, to make their own management decisions is part of this changing face of coastal hazards management.

He states:

> *The risk matrix approach allows governments and communities to analyse risk, evaluate and rank options in terms of both the social and economic benefits and costs, and determine the level of vulnerability and risk they are prepared to accept and the options they can afford to fund, or the losses they are prepared to accept at each location.*
>
> *Finally, it is important to recognise that community/political decision-making is not necessarily a clinical, rational process, but often also involves an emotional element which, if not accounted for, can frustrate attempts to implement otherwise rational, technically feasible, and clearly viable, options to manage coastal risk. Hence, the 'consequence' area of the risk matrix requires far more than just a cost/benefit approach; an understanding of the affected community, its history and the potential future outcomes for its citizens and their extended families, is essential.*

Therefore a risk management approach, by addressing not only likelihood of hazards but also consequences, reinforces the importance of engaging with communities in a different manner; involving coastal hazard conversations that talk more of vulnerability. But we also need to be clear that defining risk and consequences can be a real can of worms – it is complex and is influenced by a range of weighted components that contribute to defining the risk including, for example, considering the cost of private property, the cost of the loss of public assets such as beach amenities, and short-term versus long-term time frames.

[6] Gordon A. *Coastal Hazard Lines – Last Century's Thinking*, Australasian Coasts and Ports Conference 2015. September 2015.

This is clearly evident in Christchurch, where the effects of the earthquake have increased the risks from climate-change induced coastal hazards (see Box 2). As Ian Wright, Senior Geotechnical Engineer, Christchurch City Council comments, "To put this into context, this land has essentially undergone 100 years of equivalent sea-level rise 'overnight' if we use the IPCC latest sea-level rise rate predictions, or possibly more significantly, in the order of 500 years of sea-level rise based on historical rates."

Community consultation, engagement and collaboration

Community consultation, engagement and collaboration have a wealth of research and theoretical literature behind them, which are used to guide good practice. When it comes to coastal hazards, however, even when these community processes are undertaken effectively the results can still prove to be particularly contentious.

Effective community conversations about coastal adaptation to climate change is fundamentally dependent on the willingness of both sides to listen, have respect for differing perspectives and acknowledge the experiences and backgrounds that are brought to each side of an argument. This collaborative and interdisciplinary approach was a significant part of the Coastal Adaptation to Climate Change work led by NIWA (see Box 3), which explored engagement with different community sectors and in different ways, from localising the potential impacts of climate change, to building a school curriculum, and assessing some of the drivers behind a Māori way of dealing with hazards.

The research paper from the NIWA project identified that from a theoretical perspective, participatory approaches are seen as a means of getting people on board, understanding complex systems and achieving outcomes through consensus. But there are also challenges with this approach, such as pinpointing and engaging the community of interest, introducing technical information in a meaningful way, and making sure outcomes are locally focused.

The NIWA research also noted that, "Climate change adds an extra level of difficulty due to the complexity of climate change science, the perceived lack of scientific consensus about the likely impacts of climate change and the inter-generational enduring nature of the impacts." This, along with the political decision-making overlay, sums up some of the key barriers for gaining any traction on addressing coastal adaptation. Some recent examples of participatory approaches to engaging with communities over complex and changing issues are shown in boxes 4, 5 and 6. These cases highlight the value of taking several stages to consultation, and educating people over the complexities being addressed.

Planning time frames

Part of the difficulty in communicating hazards information and associated risks is linked to an understanding of time frames. The New Zealand Coastal Policy Statement 2010 (NZCPS) focuses on a 100-year time frame for considering natural changes in coastal processes, which is an intergenerational perspective (see Box 7). By comparison, RMA plans are valid from 10 to 20 years, which encapsulates people's more immediate experiences, and resource consents can be issued for up to 35 years. Subdivision and

land-use decisions are, however, far more permanent. In addition, there is a political overlay of three-yearly election cycles, which has a significant impact on any long-term decision-making on reducing hazard risks for future generations.

Dr Rob Bell, Principal Scientist Coastal and Estuarine Physical Processes, NIWA, has been thinking of ways to better address these differing time frames:

> *My views are changing about requiring a 100-year set-back or inundation zone to be lumbered on everyone "equally" for areas of existing development. I think there needs to be a graduated approach initially focusing on those in the more vulnerable category. So for a time frame to say 40 to 50 years, spend most of the effort and engagement on getting robust planning controls and non-statutory approaches in place for these first residents off the starting blocks. Another advantage to this approach is there is more certainty with hazard and risk predictions and climate change projections over this shorter time frame.*
>
> *Property owners likely to be affected in the longer time frames (50 to 100+ years) can be put on a "watching brief" (with some more flexible planning controls), so they can get the medium-term utility out of their assets in the meantime. Then once the frontline folk are engaged and generally accepting of the risk, then in next generation plan, the focus goes more on the second group, as well as reviewing the frontline planning controls in an adaptive management way. For example, has sea-level rise accelerated or slowed down relative to the best estimate used initially? Has erosion followed predictions or is it worse or better than previously estimated? There still, however, needs to be an overarching long-term adaptation strategy developed for the wider area based on a range of local trigger points (for example, thresholds for sea-level rise, erosion or number of coastal flooding events) to moderate any further intensification.*

This approach has been implemented through the recent Thames-Coromandel District Plan review where more flexible planning controls have been implemented to provide for reasonable ongoing use, while also not continuing to increase potential risk (see Box 8).

While this could make the risk management conversations more meaningful at a local level, there is an associated risk with only engaging with short-term affected property owners. As RMA plans are only implemented over a 10 to 20 year period, there is a risk of continuing to compound the management problems for future generations, as there is no long-term vision or acknowledgment of long-term hazard risk. In addition, land-use decisions made now can increase long-term vulnerability or risk and can impact on the economic and social well-being of the whole community. It is critical that different conversations are held with both affected property owners, as well as the wider community.

If we want to be serious about adaptation over time and adaptation that recognises long-term risks and implications of decisions, we need to involve the whole community in meaningful discussions and to seek a consensus on management options that do not just have a short-term focus.

As Bronwen Gibberd, resource consultant, Focus Resource Management Group, comments, "The biggest hurdle (to achieving adaptation) is that we don't meaningfully engage whole communities in decision-making about hazards, including education about long-term effects; consideration of social, economic, cultural and environmental effects; consideration of future generations; and implications of management options, in a way that addresses not only private benefits but also public interests."

Where are we heading and what's on the horizon?

There's no doubt that managing the risk of coastal hazards is a key challenge for the future. The work that science providers, such as GNS Science and NIWA, have done in this space provides a strong lead on how to progress a New Zealand approach to incorporating risk management into the way we plan for our coastal areas. Fundamental to this is engaging in conversations locally, regionally and nationally. Public participation enables a wider understanding of coastal hazard risks and the implications of any management decisions will occur; and that will then better inform people's decisions on management options.

Bay of Plenty Regional Council and Auckland Council through their recent RMA plans have taken a risk-based management approach, and this has assisted in moving the discussions forward on the link between the RMA and risk.

Another critical report that contributes to adaptation discussions is the recent report by GNS, which assesses how existing use rights are managed by natural hazards. This report[7] found that:

> *...regional councils are generally not taking responsibility for reassessing existing use rights. This has the implication of existing use rights being allowed to continue, even in high-risk areas. There is an opportunity to scope the options on how existing use rights can be further managed, and regional powers implemented, to reduce future risks.*

The report also noted that while the NZCPS takes a risk-based approach, currently the RMA does not in any explicit manner. Nevertheless, the case studies presented show that planning practice is becoming more innovative and risk based.

The Minister for the Environment has also identified natural hazards as a priority to be addressed in 2018, through a national policy statement, national environmental standard or regulation. The scope of this and how it will mesh with or override the existing NZCPS, however, is yet to be seen.

New Zealand currently has several sites where coastal hazards are a major problem. The effects of sea-level rise will potentially exacerbate them and create new hazard-prone areas. If we want to be serious about coastal adaptation, we need to be proactively educating our wider communities and involving them in decision-making based on risk and consequences, within a long-term vision.

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[7] GNS Science, 2015. *Natural Hazards: RMA plan analysis to manage existing use rights and implementation of the New Zealand Coastal Policy Statement 2010.* Prepared for the Ministry for the Environment.

Box 1: A toolbox for risk-based land-use planning for natural hazards

Wendy Saunders, Natural Hazards Planner, GNS Science (W.Saunders@gns.cri.nz)

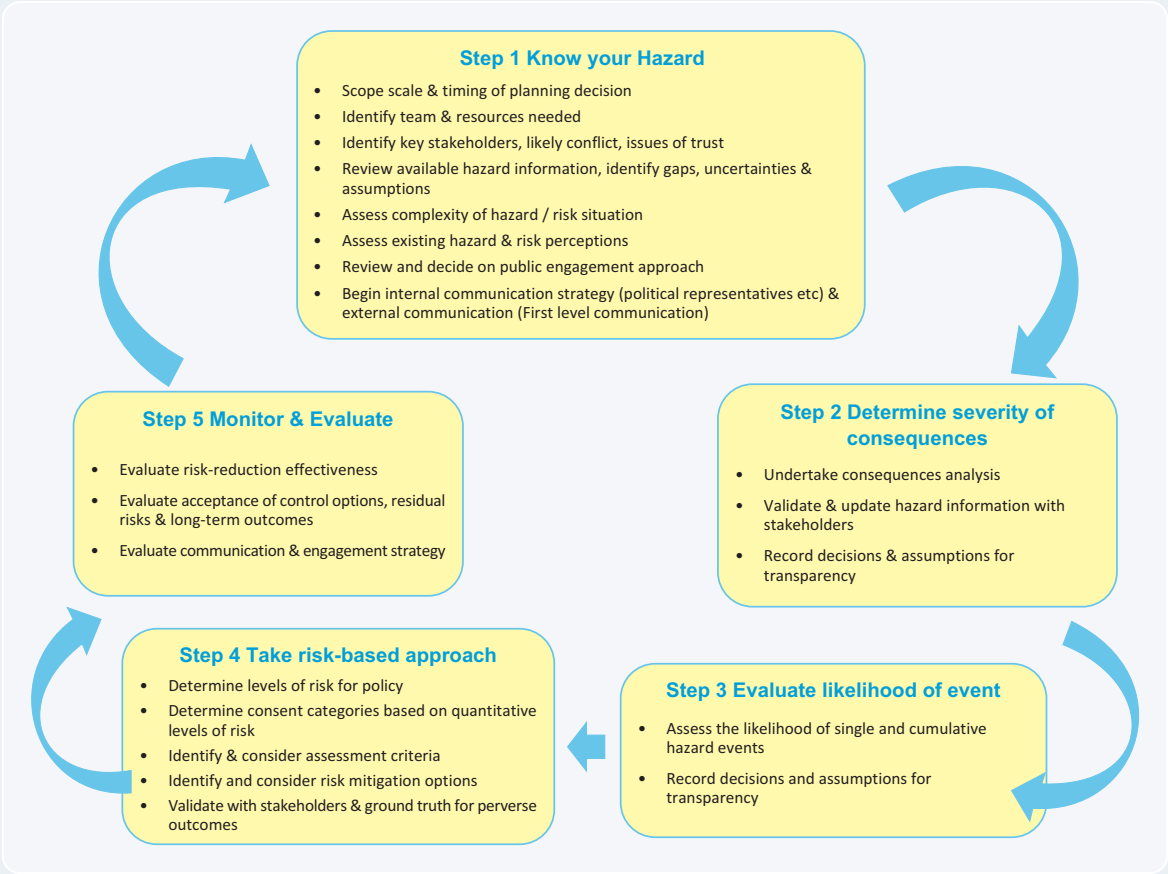
GNS has developed a toolbox for local government to use as a resource to assist them in implementing risk-based land-use planning for natural hazards. It offers a new approach where consequences of natural hazard events are the focus. It presents techniques, practice steps and options for enabling local government to review multiple natural hazard risks, both within councils and with external stakeholders.

The toolbox is an online tool that covers three key themes:

- setting the scene for why this approach is important;
- the five-step risk-based approach for natural hazards and;
- examples of implementation.

The report accompanying this tool notes many land-use planning approaches are based on a likelihood assessment of a natural hazards, such as a 1-in-100 year event. But likelihood alone does not give the full picture of the impact or consequences of a hazard event, and with increasing development (in coastal areas) there is increasing levels of risk to people and property. Therefore the GNS tool provides for a way to define levels of risk and to include them into planning documents.

For more information: GNS Science at www.gns.cri.nz/Home/RBP/Risk-based-planning/A-toolbox.



This framework provides a useful reference point, but should not be necessarily considered a template. In practice the steps may require feedback loops or be revisited as the complexity of the project unfolds. Figure: GNS Science.

Box 2: Impacts of the Canterbury earthquake sequence on Christchurch's coastal hazards

Ian Wright, Senior Geotechnical Engineer, Christchurch City Council (ian.wright@ccc.govt.nz)

The 2010/11 Canterbury earthquake sequence devastated large portions of Christchurch. The Eastern Suburbs were particularly heavily impacted by land damage, not only by the direct ground shaking effects, but more importantly the consequences of the secondary effects of liquefaction and basin subsidence. These effects have made the area more susceptible to other hazards, which include fluvial, pluvial and coastal flooding particularly by marine inundation.

The earthquake sequence has provided the trigger for multiple hazards that have had a cascading effect. Cascading events are events that occur as a direct or indirect result of an initial event.

Ground shaking is the trigger (also causes direct damage to structures and ground), which leads to:

- liquefaction that contributes to ground-cracking deformation, lateral spreading and ground settlement;
- global settlement caused by liquefaction, basin subsidence (due to sediment compaction and consolidation) and tectonic adjustment;
- increased liquefaction vulnerability (as the water table has risen in a relative sense making more of the shallow sediments susceptible to liquefaction and crust thinning according to the Earthquake Commission);
- increased fluvial and pluvial flooding by creating additional low areas;
- a diminished stormwater discharge to ground management capacity;
- increased susceptibility to coastal hazards (erosion and inundation) in the back-barrier lagoonal environment of the Avon-Heathcote Estuary – exacerbated by sea-level rise; and
- an increase in salt water intrusion leads to:
  - contamination of shallow aquifers,
  - engineering issues pertaining to foundations (salt water has corrosive effects on concrete, including foundations, pilings, sidewalks and structural walls),
  - engineering constraints on flood mitigation measures, particularly water ingress under stopbanks, loss of structural strength and ponding, and
  - ecological die-back and transformation which may cause increased coastal erosion.

It is important to note that there is often an overlap or continuum across these areas; some processes act as a feedback loop, which exacerbates the original process.

LiDAR (Light, Detection And Ranging) mapping of Christchurch's eastern suburbs has shown the land change associated with the earthquake sequence land damage has been significant. Large areas have lowered by more than one metre. To put this into context, this land has essentially undergone 100 years of equivalent sea-level rise "overnight" if we use the IPCC latest sea-level rise rate predictions, or possibly more significantly, in the order of 500 years of sea-level rise based on historical rates. At first glance, these changes are not that obvious (in that they are not catastrophic events in themselves), but the April 2014 floods gave us an inkling into the problems and those that lie ahead.

Climate change has provided us with an additional challenge. We are faced with a double-barrelled scenario where in the one barrel we have the slow and almost imperceptible creep of accelerated sea-level rise loaded, and in the other we have large and catastrophic storms, which are expected to increase in size and frequency. The true nature of this dilemma will only be realised when both barrels are discharged.

Christchurch is unique – with its double whammy of a large earthquake causing considerable ground damage

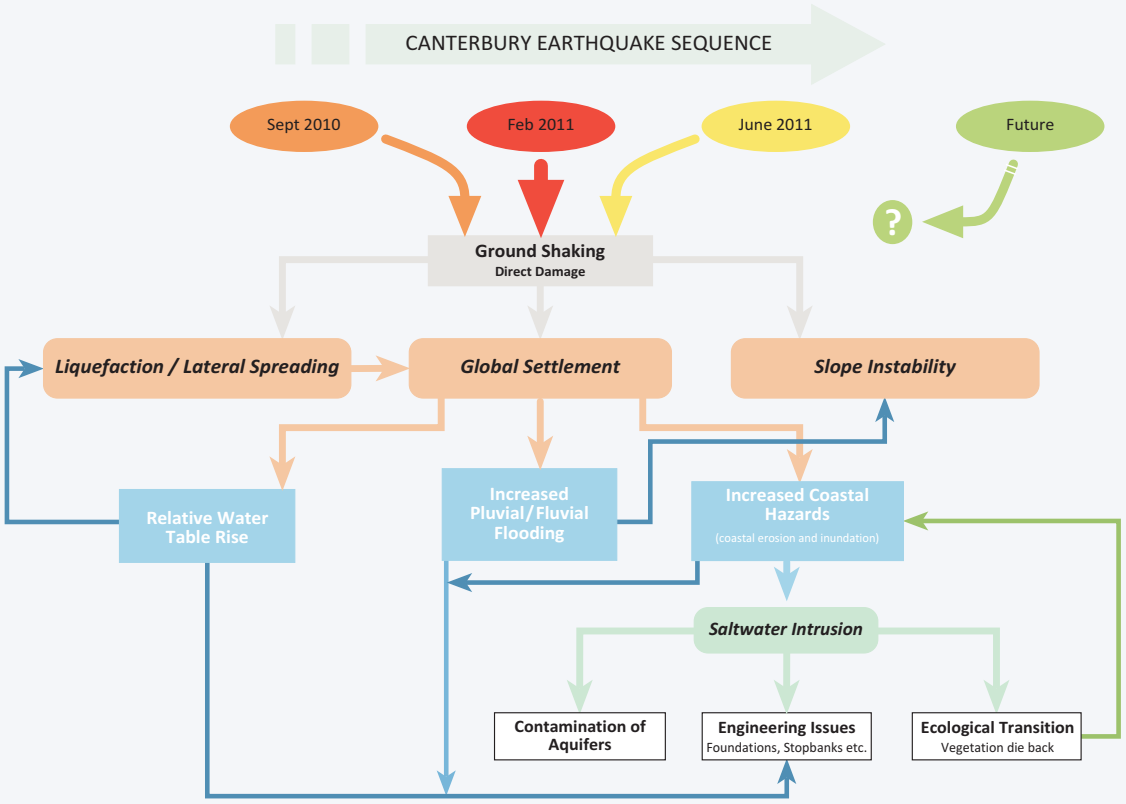
Red-zoned house facing the Avon-Heathcote Estuary – severe coastal erosion and inundation has damaged the seawall, swimming pool and house. Photo: Ian Wright, Christchurch City Council.

Stressed stormwater infrastructure: The erosion scarp gives an indication of how far the coast has retreated since the construction of the outlet. The image also illustrates how low the roading and housing infrastructure is (notice the ad hoc riprap infill). Photo: Ian Wright, Christchurch City Council.

to an area at increasing risk from climate change-induced coastal hazards. This provides the Christchurch City Council and the Christchurch community with an urgent challenge; we do not have the luxury of time to assess what these future scenarios will mean to us as we are already well immersed in this battle. In many respects, we are on borrowed time as we are already incredibly vulnerable to another catastrophic event, particularly a large coastal storm thanks to the recent earthquake effects. Expected sea-level rise is just going to increasingly compound this risk over time.

The east of Christchurch, particularly the Brighton Spit area and low-lying land close to the estuary, is subject to cumulative risk from several natural hazards – coastal erosion, coastal inundation, fluvial and pluvial inundation, tsunami, earthquakes and liquefaction. Residents of these areas are well aware of the risks associated with these natural processes and there is a range of views on the most appropriate responses – across the spectrum of adaptation, defence and retreat.

Boardwalk adjacent to the South New Brighton Community Centre. The gap in the boardwalk has been bridged where the structure has been pulled apart by liquefaction-induced lateral spreading. The entire structure has sunk, warped and been pulled apart by more than 2 metres by this earthquake-induced process. Photo: Ian Wright, Christchurch City Council.



Impacts of the Canterbury Earthquake Sequence on Christchurch. Figure: Christchurch City Council.

Box 3: Coastal adaptation to climate change

Helen Rouse, Christchurch Regional Manager, NIWA (Helen.Rouse@niwa.co.nz)

A NIWA-led team published a range of guidance in 2011/12 relating to coastal communities adapting to potential effects arising from climate change. Three key outputs from the project are outlined below.

Engaging and informing communities

The project team explored different ways for engaging with local communities about coastal climate change and how to adapt to it. There were four main threads to this work area, and a wealth of information on communicating with different communities:

- a case study undertaken in Whitianga, involving an interdisciplinary approach to engaging with the community;
- a case study undertaken with Ngāti Whanaunga in Manaia, which sought to better appreciate the conditions that shape and determine community vulnerability and resilience (endurance) to climate risks and change;
- cross-curricular work undertaken with Year 10 students at Mercury Bay Area School, building knowledge and understanding; and
- a research paper which draws together the theory from international literature, overseas experiences and the above case studies to build a recommended approach to engaging communities in coastal adaptation issues.

Encouraging best practice planning

This part of the project started in 2009 with an evaluation of the planning, policy and institutional processes of 30 councils, in respect to coastal adaptation. Resulting from this review and the identified needs and gaps, the project team developed a guidance toolbox and four-step process called *Pathways to Change*, to assist local authorities and communities in preparing for climate change impacts at the coast. This includes guidance on dealing with communities and people's sceptical views along with other barriers commonly faced by councils.

Building a national coastal sensitivity profile

This part of the project built a national picture of the relative sensitivity of New Zealand's coastline to coastal hazards and the potential impacts of climate change. This coastal sensitivity index (CSI) provides a snapshot of the potential sensitivity of New Zealand's non-rocky coastline to coastal inundation (flooding) and coastal erosion. The CSI maps are a first step in understanding where the impacts of climate change on the coast may be most significant, and where adaptation activities would be most usefully targeted.

For more information: NIWA at www.niwa.co.nz/climate/research-projects/coastal-adaptation-to-climate-change

Pathways to Change – 4 steps on the adaptation journey towards a resilient community. NIWA.

Box 4: Collaborating in a catchment setting

Michelle Lewis, Harbour and Catchment Management Coordinator, and Emily O'Donnell, Hauraki Coromandel Catchment Management Team Leader, Waikato Regional Council (Michelle.Lewis@waikatoregion.govt.nz)

Presented at the 2015 Australasian Coasts and Ports Conference, this paper outlined a non-statutory approach to taking action within a harbour and catchment context. Harbour and catchment planning provides for a combined agency, iwi and community approach to natural resource management, in a holistic mountains-to-the-sea approach within a local catchment setting.

A key aspect of this approach was to bring people together to discuss and identify environmental issues, learn about what technical information is already available to inform these issues and to focus on actions that would make a difference for the future. By involving other agencies, community groups and individuals there is the opportunity to promote actions that are aligned with and allow for joint contributions to be made, but it also builds a collaborative vision for the future.

The approach to engaging with the community includes the following.

- **Co**nnection – having meaningful discussions, across boundaries, addressing people's perceptions about environmental issues, and recognising those linkages between the mountains and the sea.
- **Co**-design – having no set plans, but providing a pathway for meeting community expectations.
- **Co**llective – recognising that there is a shared pool of knowledge within the community and agency staff, and seeking a shared input into solutions.
- **Co**mplex – acknowledging that the environmental issues are complex, the solutions challenging, and there will be conflicting views in plan design.
- **Co**ordination – providing opportunities and space for input from iwi, community members and agencies to ensure a coordinated and strategic approach focused on actions.
- **Co**llaboration – this is required if the plan is to be meaningful and accessible and able to be implemented.

Early engagement and promoting community ownership is fundamental to enabling environmental change to take place, as there is no simple or quick answer to many of the problems.

The authors described it as being a bit like a recipe ... take:

- a dash of science and research;
- combine with lashings of local knowledge experience and mātauranga Māori; and
- serve with a dollop of implementation and a sprinkle of goodwill.

Box 5: Community engagement – the *Rena* experience

Cushla Loomb, Technical Director Planning, Beca Ltd (cushla.loomb@beca.com)

The container ship *MV Rena* grounded off the coast of the Bay of Plenty in October 2011. Beca was commissioned by the owners and insurers to investigate the potential options for the fate of the wreck, which included an extensive consultation programme with the public and key stakeholders.

The engagement process used for the *Rena* can help inform good practice for working with communities on issues associated with climate change.

In considering the best approach to the consultation, the project team had to consider and plan for a number of challenges:

- The grounding was a high-profile event that received national (and international) media coverage. This initially made identifying potentially affected or interested parties difficult.
- There were many highly technical considerations involved in the various options that limited what options could be practically explored. Communicating these complex messages to the public required careful management.
- The nature of the wreck and debris was constantly changing as a result of salvage operations and weather events.
- The reef that the ship grounded on is known to be a taonga and culturally significant for a number of iwi, all with different values and interests in the reef.

The above considerations required an adaptive approach to consultation. The team undertook the consultation in stages with the first round being very extensive and involving nationwide advertisements to inform the general public on the process and draw out those parties that wished to continue to be directly engaged throughout the project.

This was very successful in narrowing the scope of consultation and enabled more targeted and focused engagement in subsequent stages around the more complex technical issues.

Ongoing consultation with iwi was undertaken commencing with an apology (appreciating many parties were still hurting from the original grounding incident) and involving factors such as rangatira ki te rangatira (chief to chief) and kanohi ki te kanohi (face to face) to give the issues the mana they deserve.

Over 150 individual meetings were held with the various iwi and hapū groups over the course of the project. The mutual respect built up between iwi and the owner and insurer representatives, despite the different viewpoints, is a testament to the success of the consultation programme.

Box 6: Adaptive management responses on a sediment dynamic coast in Auckland

Sam Morgan, Senior Coastal Scientist, Auckland Council; Paul Klinac, Team Manager – Coastal Management Services, Auckland Council; and Jamie Boyle, Coastal Scientist, Auckland Council (sam.morgan@aucklandcouncil.govt.nz)

This paper was presented at the 2015 Australasian Coasts and Ports Conference and emphasised that the key to successful adaptation is in communicating the science results effectively.

The paper presented a case study of North Piha, a site on the west coast of the Auckland region, which is subject to large-scale fluctuations or pulses in sediment supply. This results in management issues ranging from erosion to accretion, water quality, wind borne sand drift and coastal-hazard setbacks.

Works were undertaken three times between 2004 and 2014, and included stream realignment, dune reshaping and planting. An adaptive management approach was taken to minimise future risk to infrastructure, whilst addressing some of the outstanding concerns within the local community.

Because the environment is so dynamic, and little is known about the nature of sediment supply and transport, the responses to arising problems (erosion threatening coastal infrastructure and access to community facilities; impounding of water resulting in water quality and access issues) have to be flexible and options for addressing them may change over time.

In conjunction with historical data, detailed monitoring of the area was initiated in 2011 and trigger levels were set to allow the stream to meander naturally for as long as possible. These triggers were met in 2012 resulting in physical works and replanting. In 2013, the works programme was revised when there was community opposition to the acceptance of regular dune loss. Further investigations were then undertaken. This determined that high rainfall events, wave climate and sand drift were three factors influencing dune stability at the site. As a result, further trigger levels were set and a revised monitoring plan was also put in place.

The amended monitoring plan sought to provide an increased width of dune retention, with an agreement that trigger levels could then be adjusted following an improved understanding of beach morphology. The introduction of new monitoring techniques (GPS dune toe mapping) presented an opportunity for more effective communication of data.

The rationale for revised trigger levels and monitoring was communicated to the wider Piha community via the distribution of an information package to key stakeholders and through the local board.

Stakeholders were given time to access and discuss the information amongst their respective groups and provide feedback through the local parks department. Evaluation of feedback confirmed that on balance, the proposed trigger levels satisfied the majority of substantive concerns raised.

As the authors noted in their presentation, a key lesson learned is that as the project evolves, “monitoring observations and revised objectives should always be communicated clearly amongst key stakeholders and decision-makers so there is no confusion around the direction of the project and limitations of outcomes being sought. Informing key stakeholders with this level of information appears to be a critical part of maintaining the momentum of these types of approaches.”

Box 7: Planning for coastal-storm inundation and sea-level rise

Dr Scott Stephens, Coastal and Estuarine Physical Processes Scientist and Dr Rob Bell, Principal Scientist – Coastal and Estuarine Physical Processes, NIWA (Scott.Stephens@niwa.co.nz or Rob.Bell@niwa.co.nz)

This presentation on planning for coastal-storm inundation and sea-level rise was given at the 2015 Australasian Coasts and Ports Conference. High storm tides and large waves combine to cause property flooding and damage, the impact of which is expected to worsen with future sea-level rise. This study used joint-probability methods to model the likelihood of high coastal-storm inundation events, which were mapped into potential coastal-hazard areas in the Auckland region as part of the Proposed Auckland Unitary Plan process. The coastal-storm inundation maps are proposed to be included in regional and district plans to control development as part of a risk-reduction strategy, and have been debated within a Hearing under the Resource Management Act 1991 (RMA) and Local Government (Auckland Transitional Provisions) Act 2010.

The joint-probability methods stood up well to Hearing scrutiny in providing a robust and flexible framework to calculate coastal-storm inundation elevations. The static inundation mapping method provided maps that efficiently defined the coastal-storm inundation risk at a regional scale, but were less accurate at individual property scale.

The panel issued interim guidance recommending that the plan provisions should deal with a 1 per cent annual exceedance probability coastal-storm inundation event plus 1-metre sea-level rise by 2115 for coastal areas. The panel acknowledged uncertainties in the current mapping and welcomed suggestions on how the maps could be improved. The final recommendations of the panel are due by July 2016.

The panel was "not convinced of the need for a 2-metre sea-level rise to be identified as a statutory requirement for greenfields development in the plan or maps". The panel indicated a preference for stronger and new subdivision-scale policies in coastal-hazard areas, including at the regional policy level, rather than management at the scale of building controls, for example, on minimum floor levels.

The Hearings process identified a tension between the different way in which planning time frames and risk have been addressed under the RMA and the Building Act 2004 (Building Act).

There are two key variables which come into play when looking at either a 50-year or 100-year time frame:

1. the likelihood of an event occurring (independently of sea-level rise), which directly relates to risk (together with the consequences); and
2. the effects of climate change over this period, and a resulting increase in sea-level rise (which compounds risk).

The RMA and the Building Act deal with time frames in different ways. The RMA does not directly specify a particular planning time frame to be considered for hazard risk, but under the RMA district and city plans covering the coastal environment need to give effect to the New Zealand Coastal Policy Statement 2010 (NZCPS). The latter provides a directive of at least 100 years. As a result, case law points to a 100-year time frame being considered appropriate for coastal hazards such as coastal erosion. A 50-year time frame is usually considered for building works when applying the Building Act based on the minimum intended life of a building under the Act.

Further, the Building Regulation (1992) and the mandatory Building Code associated with the Building Act contains clause E.1.3.2 that states that surface water, resulting from an event having 2 per cent probability of occurring annually, shall not enter buildings. This clause is applied in the form of a minimum floor level for habitable buildings, and it is a minimum standard – some councils have adopted a 1 per cent annual exceedance probability floor-level standard for surface waters. Applying a 2 per cent annual exceedance probability to a 50-year building design life means that the likelihood of such an event exceeding this level is quite high at 63 per cent.

The 1 per cent annual exceedance probability and 100-year planning time frame were adopted for coastal-storm inundation maps within the Proposed Auckland Unitary Plan, with a 1-metre sea-level rise component added on top of this. The 1 per cent annual exceedance probability event has a 63 per cent chance of occurrence over 100 years and is thus considered likely to occur, whereas over a 100-year period a 2 per cent annual exceedance probability event has an 86 per cent likelihood of occurrence and so is almost certain.

The risk-reduction directives of the NZCPS suggest it is appropriate to plan for low-probability, high-magnitude events, and thus 1 per cent annual exceedance probability is more appropriate. Given the short data records we have in New Zealand, it is difficult to accurately assess the magnitude of coastal-storm inundation events at probabilities lower than 1 per cent annual exceedance probability.

A related observation during a workshop with Auckland Council engineers was that although the Building Act (or Building Code) does not consider climate change and sea-level rise, there was a perceived need that good practice would be to include a 50-year sea-level rise allowance in minimum floor level requirements when implementing building development controls under the Building Act, unless otherwise required under district or regional plans under the RMA.

The Hearing panel's interim guidance suggests the adoption of the 100-year planning time frame (NZCPS) as appropriate for managing coastal hazards.

This summary was first published in Coastal News *(November 2015).*

Box 7 (continued)

Top: Aerial photograph of Mission Bay. Centre: Mission Bay with present-day 1 per cent annual exceedance probability storm-tide plus wave set-up elevation superimposed (purple shading). Bottom: Mission Bay with present-day 1 per cent annual exceedance probability storm-tide plus wave set-up elevation superimposed (purple shading), plus 1-metre sea-level rise (light shading), and plus 2-metre sea-level rise (orange shading). Photos: NIWA.

Box 8: Managing coastal erosion hazards on Coromandel Beaches – achieving more by asking for less?

Bronwen Gibberd, 4D Environmental Ltd (fourdenvironmental@ihug.co.nz)

When designing and implementing coastal erosion setbacks, it is generally good practice for coastal hazard practitioners to include all possible components that may contribute to erosion, with sufficient precaution to ensure predictions will not be exceeded. This approach seems intuitive and keeps the insurers happy, but it can cause unintended impacts on early progress towards adaptation.

When evaluating the multiple components of erosion, the area at immediate risk from current natural processes can be quantified with much more certainty than the medium- to long-term response of the shoreline to future sea-level rise and climate change. In most cases, both of these components of erosion are combined into a single setback. In effect, we are treating property we think might be at risk in the future with the same controls as areas we know to be at risk now.

By including areas of future potential hazard, the proposed setback becomes much wider and has a much greater impact on property use. In some cases, the resistance from landowners is so strong that proposed planning provisions are watered down or setbacks are discarded. This can result in huge cost to councils with very little meaningful change in the coastal erosion risk.

Over the last 10 to 15 years, the Thames-Coromandel District Council (TCDC) and the Waikato Regional Council have worked with members of Focus Resource Management Group to better define coastal erosion hazard using site-specific data, and (more recently) to implement development setbacks and associated planning controls through the district plan review process[8]. Two setbacks are proposed:

- CCEL (Current Coastal Erosion Line): the area at risk from existing natural shoreline change, with no allowance for sea-level rise effects; and
- FCPL (Future Coastal Protection Line): the additional area landward of the CCEL that could be affected by erosion driven by a SLR of 0.9 metres.

The CCEL is based on measured data and historical observations, with only very small safety factors. This makes the setbacks believable and easily understood by all those affected; and as a result, very difficult to dispute. The CCEL is essentially applied as a building exclusion zone. In the area between the CCEL and FCPL there are more flexible controls on use, with provisions that require relocatable buildings and limit subdivision to avoid increasing risk over time.

In most locations, there is still space on beachfront properties to allow for the construction of a residential dwelling. By minimising the width of setback to include only the area vulnerable to known (and current) hazards, TCDC has been able to implement these lines to achieve a first (albeit small) step toward adaptation by shifting houses landward on their sections and reducing immediate risk. This also helps limit the demand for coastal protection structures.

By asking for less, TCDC is achieving initial adaptation and signalling to and preparing their community for further adjustment in the future, if and when required.

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[8] The TCDC has not yet released its decisions on submissions (due April 2016) so the proposed district plan provisions are subject to change.

Section 3: How communities are addressing climate change

Council-community partnership projects have proven a successful formula for restoring coastal margins. Photo: Shane Orchard.

Community-led approaches and climate change: Perspectives from coastal restoration projects

By Shane Orchard, University of Canterbury

This article and the related case studies have been prepared in collaboration with the Dune Restoration Trust.

The design of shoreline protection initiatives is a cornerstone topic in the discourse on coastal climate change. Projects to restore degraded coastal margins are an important aspect of this field, and looking ahead, the avoidance of similar degradation issues is an important topic for planning.

In recent years, there has been considerable progress achieved in many parts of New Zealand in relation to degraded dune ecosystems, and with an increasing focus on estuaries. Many of these projects are referred to as Coastcare initiatives and are often led by, or have benefited from, local community-based approaches[9]. As such, they are an important area of activity within the wider opportunities for local community input into coastal management.

Dune conservation provides a range of benefits for people that may include protection from inundation and short-term erosion events, and risk-reduction benefits in larger magnitude natural disasters. These benefits have not escaped the attention of coastal communities, most notably where dune ecosystems occur seaward of populated areas and provide a tangible barrier to tsunami, storm surge and related periodic events. Such benefits may be reflected in coastal inundation assessments and the like, as was the case recently in Christchurch[10]. In the absence of dunes, equivalent coastal protection in these locations would require extensive lengths of seawall or other physical structures. Additionally, the conservation of indigenous dune ecosystems is an urgent biodiversity issue. Communities also derive considerable benefits from indigenous dune biodiversity that encompass cultural values, natural character and landscape values, to name a few.

As we move towards more specific actions for climate change adaptation, engagement with coastal communities will be increasingly important and there is a need to consider the issues and opportunities for locally driven initiatives. These activities will have a direct bearing on the perception and thus adoption of effective solutions for coastal management issues. Intuitively, Coastcare-style initiatives may be a useful component of climate change adaptation, especially where a greater degree of coastal protection is afforded through activities such as dune rebuilding. The sites involved,

[9] For a summary see Dahm, J; Jenks G; and Bergin D. *Community-based dune management for the mitigation of coastal hazard and climate change effects. A guide for local authorities*. Report prepared for Ministry for the Environment. Wellington. 2005.

[10] Tonkin + Taylor. *Coastal Hazard Assessment. Stage Two*. Report prepared for Christchurch City Council. July 2015.

Work underway on a new restoration area at Clifton Beach in Christchurch. Photo: Shane Orchard.

however, may also be adversely affected by climate change, with the impacts of sea-level rise being of particular concern.

Despite offering benefits in periodic events, dunes are susceptible to longer-term erosion trends, including the shoreline retreat processes associated with sea-level rise. Impacts on dunes may be especially pronounced where attributes important to their persistence are affected, such as the maintenance of dune vegetation. Understanding the effects of climate change on projects seeking to restore and protect coastal ecosystems is therefore important, along with possible actions. Conversely, the potential contribution of natural ecosystems to achieving wider climate change adaptation goals is a related and useful topic. Both are important aspects of planning for climate change.

This article describes a preliminary exploration of these issues gained by seeking climate change perspectives from representatives of Coastcare groups in three parts of New Zealand. For each group a case study was prepared based on semi-structured phone interviews and document analysis in relation to four questions as follows:

- What are the key objectives in your group's project?
- What are motivations and drivers behind these objectives?
- How has the project changed your coastal community to date, particularly in relation to climate change?
- Has climate change influenced your objectives and activities to date, and how might it influence them in the future?

Some of the important unknowns at the outset were the degree to which Coastcare objectives incorporate climate change, if at all, and whether specific steps have been taken to address issues and opportunities related to sea-level rise in the context of these projects. A summary of each case study is presented here.

CASE STUDY

Case Study 1: Waitohu Stream and Dune Care Group, Kāpiti Coast

Background

This project began in 1999 as a community response to the level of pollution in the Waitohu Stream. It is led by a volunteer group who devote considerable effort to ensuring that members feel valued and can contribute to the project according to their abilities. The formula has been very successful and has resulted in 15 years of work to restore an area of Kāpiti Coast District Council reserve land on the west and south banks of Waitohu Stream close to the beach. The project receives very good support from the Greater Wellington Regional Council Biodiversity Unit and Kāpiti Coast District Council that between them provide funding, technical information and a support worker.

Key objectives and activities

The Waitohu Stream and Dune Care Group is an incorporated society and its objectives are to:

- Protect and enhance the natural values of the Waitohu Stream estuary and associated dune system so that in time there will be an intact native coastal vegetation sequence and habitat link for indigenous wildlife.
- Provide opportunities for the local community to understand and appreciate the diversity and importance of this part of the local ecosystem and contribute to its maintenance.

Progress towards restoration objectives has been considerable and is ongoing. The group's current goal is to maintain the previous plantings and to grow new plants from seed of species endemic to the area. The group is involved with several community and national initiatives including working with local schools and kura, supporting internships and work placements, providing inputs to other council programmes that involve the site, and conducting backdune trial plantings for the Dune Restoration Trust.

Dune system at the Waitohu Stream mouth in 2010 following a period of accretion associated with dune restoration activities. Photo: Sue McIntosh.

Dunes at the Waitohu Stream mouth in 2014 following a high-tide storm surge event and movement of the stream mouth. Photo: Sue McIntosh.

Members are also involved in outreach activities further afield, including attending the annual Dune Trust conference and regional events.

Changes associated with the project

An early initiative of the project was to establish a nursery for coastal plants. Initially, many plants were donated to the nursery, but in recent times the operation has moved to collecting and growing from seed with a focus on the local indigenous species. The nursery also serves as a base for the wider project.

Historically, there was an intact *spinifex* foredune along this section of coastline which has been invaded by marram grass to varying degrees. Foredune restoration activities have progressively replaced marram with native sandbinders. The project area also includes a considerable backdune system dominated by marram and lupin that is also being restored with native species.

Dune and streamside sites for new plantings are carefully chosen to optimise the chances of survival. Over the life of the project, however, the Waitohu Stream has frequently affected dune plantings as its estuary meanders across the beach. Although long-term efforts to repair blowouts and extend the dune have been reasonably successful, at times the stream cuts into the restored dune system and there is a loss of plants and sand.

Outreach activities have had considerable influence within the local community. A particular focus has been to introduce youth to the restoration project and emphasise the ecological values and protective roles of coastal ecosystems. One initiative has been to fence off a large marram dune for kids to play on, as a separate feature of the beach where disturbance is encouraged in contrast to the more sensitive restoration areas.

Climate change perspectives

Until recently the group has been mainly concerned about erosion processes related to the behaviour of the stream. Over the last few years, however, there has been an increasing awareness of storm surges and king tides as a cause of erosion of the foredune. To address this the group has made a conscious decision to retreat. This strategy is being implemented in both planning for new restoration areas, and maintenance of existing areas. At this stage, the *spinifex* and pingao on the foredune are regrowing as the sand is replenished, but the group won't be doing any more planting in that area. It is hoped that the earlier plantings may have built insurance for the future and in the coming years this will be put to the test. The ability of these foredune species to naturally adapt to any change in sea level or storm-surge conditions will be monitored going forward, whilst new restoration work will focus increasingly on the backdune system.

CASE STUDY

Case Study 2: Sumner Coastcare Project, Christchurch

Background

The Sumner Coastcare Project began in 2010 when a group of local people established the Sumner Environment Group with the aim of assisting the restoration of natural environments in the area. The key strategy was to tackle one site at a time. Restoring the degraded local dune system and revegetating erosion-prone gullies and riparian areas above the village were the two areas selected for local action. Contact was made with other groups who might be interested in those areas, and with local authorities with management responsibilities and existing work programmes in place. Over time a collaborative but community-led vision for these sites has evolved which has been gaining increasing buy-in from the wider community. Alongside this a shared work programme has developed, particularly between key community groups and the local council, which is underpinning real progress in restoring these sites.

Key objectives and activities

At the local beaches, the Christchurch City Council (CCC) Coastal Park Rangers had already begun dune restoration activities many years prior with considerable progress achieved. The Coastcare project therefore represents extra involvement by the community. Since 2010, the Coastcare project has involved an active council-community partnership approach to the restoration of degraded dune sites in a way that also accommodates a wide range of community interests. This has been important since the beach and dune environments are high-use areas in close proximity to the city.

Changes associated with the project

The initial focus has been dune restoration at Clifton Beach and Taylors Mistake, both sites at which the historical dune system had largely disappeared due to a progression of foreshore developments and exotic plant invasions over several decades. Managing the dunes and their restoration for multiple values has been one of the hallmarks of the project. Some of the aspects to cover off early were to ensure access and also views in some parts of the beach. Positive results were achieved alongside dune restoration by upgrading the existing beach access and selection of appropriate plants for reintroduction. At some sites the backdune area had been relatively neglected for many years. This has been turned into a positive by including new recreation facilities, such as picnic tables, in the backdune restoration plan. These areas are now getting considerable use by the community whereas not long ago they were largely overlooked.

The restoration plans themselves are an evolving process with the implementation steps being scheduled only when feedback indicates widespread support. This strategy has had the added advantage of promoting collaborative opportunities with other groups who may be developing projects that involve the site. In this case, synergies have been found with both the local surf lifesaving club and Coastal Pathway group. These groups are now assisting the dune restoration effort and conversely, the restored dunes are expected to add value to their initiatives. These are just some of the components that have assisted the project in generating positive outcomes across multiple values important to the community.

Climate change perspectives

To date, restoration of a native dune system to improve biodiversity and cultural values in a way consistent with other values has been the main driver, with climate change considerations being of less importance for current activities. An important strategy, however, has been to ensure consistency with council and iwi management plans that

Photos taken December 2011 (top) and May 2013 (bottom) showing the successful re-establishment of dunes at Clifton Beach using spinifex. *Photos: Shane Orchard.*

do address climate change. Two key documents that have provided considerable guidance are the *CCC Coastal Parks Strategy 2000* and the *Mahaanui Iwi Management Plan 2013*. On the ground, these aspects have led to an emphasis on mahinga kai values and re-introduction of Ngāi Tahu taonga species, for example. Progress towards the initial restoration goals at the two main sites is also well advanced. Once the dunes have been restored, ongoing management and maintenance will become the key activities.

In relation to climate change, community perspectives on shoreline management are becoming increasingly important in Christchurch and there is considerable need for strategic planning. An associated aspect is the need to ensure flood management from rain events.

At Clifton Beach there has been periodic flooding of backdune areas associated with the modification of a local stream mouth and lack of a flood path. This would naturally exit through the dune system, but the potential role of a self-maintaining stream mouth versus backdune ponding is unknown. At this site, protection against coastal inundation hazards would be improved by avoiding low spots in the dunes. Some sort of flood engineering or coastal ponding area will continue to be needed, however, to accommodate flood events. Combining these aspects with the benefits of a restored dune system will be an interesting process and will be important to the future of the project over the longer term.

Case Study 3: Long Beach Coast Care Group, Northland

CASE STUDY

Background

The Long Beach Dune Restoration project, started in 2011, was the result of Melanie Jones, a local Kerikeri High School student's need for a science fair project. Following conversations with Russell Landcare Trust members, Jones started to investigate ways of controlling kikuyu grass without damaging native coastal plants by using concentrated saltwater rather than herbicides. Together with others in the local community, the Long Beach Coast Care Group was formed to lead restoration activities in partnership with Northland Regional Council and the Russell Landcare Trust.

The restoration site is a lengthy but narrow piece of reserve land between the shoreline and a local road. Prior to restoration, only small remnants of native sand-binding vegetation remained at the site, which was dominated by kikuyu grass. Being a pocket beach within a relatively closed coastal system, the incoming sand supply is small and, in its degraded state, considerable sand loss through wind erosion was evident. To address this the group has been actively re-establishing *spinifex* and pingao together with other indigenous dune vegetation species.

Key objectives and activities

Key objectives for the group include restoring the naturally occurring Long Beach foredune vegetation to as close to original state as possible, and to reduce the erosion along the beach to protect Long Beach Road from being undermined. Another priority is to retain the goodwill of the people living along the beach, many of whom are part-time summer residents. An important aspect is to provide for sufficient and appropriate access to the beach for a wide range of users including swimmers, boaties, dog walkers, runners and sunbathers.

Motivations and drivers behind these objectives include an eroding beach with a reduced parking area between the beach and the road. Steepening of the beach profile and progressive erosion has also led to parts of the beach becoming less usable for recreation. The enthusiasm of local people for combining science with a community initiative also played a considerable role at start-up and continues to provide motivation for the group as the project has progressed.

Changes associated with the project

Although the project started with a short length of the beach to gauge the wider community response, nearly one-third of the beach has now been restored. Several thousand plants have been successfully established at Long Beach,

Results of dune restoration activities at a Long Beach site as seen in 2011 (top) and 2015 (bottom). Photos: John Gallie.

accompanied by regrading of the foredune profile in some areas. The plantings have helped to disperse storm surges and reduce erosion. Observations indicate there is less sand blown across the road in storm events and more sand is being trapped in the dune system, especially in the areas where *spinifex* has been established.

Importantly, there have been no negative comments on the initiative, even when a digger was used to reshape the beach before planting could occur. Designated access points using sand ladders are well used and there have been no vandalism or issues with the temporary fencing around the plantings. There is also an increasing number of new people getting involved with the project, demonstrating that it has been well received and has strong local ownership.

Climate change perspectives

In the lead up to the project, the group had not consciously thought about climate change. A major driver for its initiation, however, was the observation of erosion and a change in the beach profile over a 10-year period prior. In addition, Russell Landcare Trust members had noted dune restoration with *spinifex* at nearby Tapeka Point beach and were interested in achieving similar improvements in natural environment values at Long Beach.

The project provides an interesting case where a well-organised and informed group that is aware of climate change implications is linking science with on-the-ground action. As is common elsewhere, the restoration site is geographically constrained and would be undoubtedly affected by sea-level rise. Project members are unsure whether the community understands the connections between the dune restoration and countering the impacts of climate change despite being confident that the more natural appearance of the beach is being appreciated. In the near future, the group is planning to install interpretation boards at the restoration site and an aspect of these will be to raise awareness and encourage the community to make those connections.

Conclusions

The three case studies involve similar restoration initiatives yet differ in local context. Only the Waitohu group has made a specific change to their strategy in relation to potential climate impacts at the project level. The project area in that case, however, includes an extensive backdune area which is available to accommodate system dynamics and potential long-term changes in shoreline position. In comparison, the other two sites are geographically constrained by built infrastructure with the Long Beach site being particularly narrow. Despite this, both projects are producing clear benefits for coastal hazard management in addition to biodiversity and other gains versus the pre-restoration state. All of these benefits are relevant to objectives for climate change adaptation and even at small sites such gains may play a useful role.

Repeat plantings perhaps supplemented by beach nourishment activities could, in theory, be used to counter periodic losses from erosion events. At sites that do not currently accommodate the possibility of dune migration inland, this provides a possible means for maintaining some natural shoreline values, together with a degree of protection for landward built structures under climate change. Despite this, return on investment considerations may become a barrier to the sustainability of these projects. If sea-level rise continues there will obviously come a time when such initiatives are no longer viable even if the enthusiasm of volunteers remained to offset costs of maintenance.

Looking ahead, the potential to reimagine the role of Coastcare-style community-led initiatives is intriguing. Restoration of biodiversity and natural environment values can be identified as a common driver behind most current initiatives and considerable innovation may be required to meet these objectives in a changing landscape. Possibilities include looking outside the range of current Coastcare activities and the potential to combine regional and local-level interests within a more strategic approach.

There is clearly a need for strategic planning to ensure integration of shoreline restoration and biodiversity conservation objectives alongside other priorities for climate change adaptation. The context for these objectives has a bearing on cost-benefit considerations when evaluating managed retreat strategies and also points to the likely role of off-site mitigation strategies, such as assisted migration or purposeful restoration of natural ecosystems, at new sites where retreat is not a feasible or preferred option. Finding the right solutions and committing to investments in the many different contexts, however, will be undoubtedly complicated by variable timelines over which responses are needed, and the spatial arrangement of resources to be protected and the affected communities themselves. As the story unfolds it is likely that the thinking on shoreline conservation will need to become more firmly embedded in the wider discussion on climate change adaptation.

Seeing is believing: King Tides Auckland

By Shelly Biswell, Editor

A community citizen science initiative to record changes along Auckland's coasts provides people with a glimpse of what daily tides might look like in the future as a result of sea-level rise.

King Tides Auckland is a community citizen science initiative that encourages people from around the Auckland region to photograph the highest tides (known as king tides) that naturally occur along the Auckland coastline each year. A visit to the initiative's Facebook page shows just how engaged the community has become in creating a living record of how our coastline is affected by king tides.

Ben Sheeran of Recreation Solutions Ltd, who is one of the forces behind King Tides Auckland, says the initiative gives people an opportunity to engage in an important conversation on climate change.

"Discussions about climate change often seem 'too big' or 'too distant' for people to connect with. The king tides initiative offers the public an opportunity to see how sea-level rise could affect our infrastructure, our landscape and our way of life. Not only that, but people get to share their perspective on these changes by uploading images to the King Tides Auckland website, Facebook and Instagram sites," he says.

King Tides Auckland is part of the Global King Tides movement and reflects growing international awareness to the consequences of climate change.

"The visual aspect of the initiative makes it much easier to have discussions about appropriate development, for example. It gives communities a chance to share information with each other and with government," Sheeran says.

For Auckland Council's Coastal Management Services Team Manager Paul Klinac the initiative is part of a wider programme to engage with communities about storm inundation and sea-level rise.

"It's not enough to show up to a community meeting and put up maps with lines on them to illustrate how sea-level rise might affect an area. That style tends to result in community push back with respect to the process that has been followed, why the community hasn't been involved or consulted with from the beginning, and ultimately brings into question how decisions are being made.

King tide at Bucklands Beach on 22 March 2015. Photo by Craig Thomson and courtesy of King Tides Auckland.

What is a king tide?

The term "king tide" is a common term for the highest tides that occur over the course of the year. These high tides happen when a new or full moon falls at the same time as the moon is at its closest to the Earth (in its perigee).

"The King Tides Auckland initiative, on the other hand, is a way for communities to really engage – and over a sustained time. People are witnessing changes and starting to question what this might mean for them personally and the wider community. They are also sharing that information with the council and with each other. It's a much more constructive approach," Klinac says.

He adds that while the engagement aspect of the initiative is important, the images also provide scientists, local and central government, along with businesses and individuals with information that can assist with planning for the future.

Klinac and Sheeran are now talking with other councils around the country in an effort to roll out the initiative nationally.

"In establishing the initiative, we did it with the intention that other councils could develop similar initiatives within their own communities. It's a commitment of resources – both time and staff – but the pay-off is huge in terms of community engagement and better decision-making," Klinac says.

Ben Sheeran says people from around the country are already uploading photos to the Auckland King Tides sites during king tide events.

"It is clear people want to be part of this national conversation. The important thing is to give them the communication channels to do that," he says.

Want to learn more? Visit http://auckland.kingtides.org.nz/ or Facebook/kingtidesakl or Instagram/kingtidesakl

Low tide and king tide at Mangere Inlet on 21 February 2015. Photo by Stella Wilson-Staab and courtesy of King Tides Auckland.

Planned retreat at Okariha, Port Waikato

By Maurice Hoban, Senior Manager, GHD

Okariha or Sunset Beach is located on the west coast of the North Island and forms a section of the 3-kilometre spit on the southern mouth of the Waikato River. High-wave energies, storms and fluctuating volumes of sand have contributed to a prolonged period of erosion and a rise in sea-level points to this trend potentially continuing. The beach is a constantly changing environment due to these natural processes and the influence of human activities on the shape and form of the beach.

Over the last two years, the Waikato District Council and GHD have led a collaborative community and multi-organisation approach to engaging the community of Port Waikato on coastal hazards and the options to manage ongoing risk. This was driven by community concern as Sunset Beach has eroded more than 30 metres over the last six years resulting in the loss of community assets.

Waikato District Council commissioned GHD to identify options to manage ongoing risk from erosion to community facilities, including the community hall, houses, surf lifesaving club, car parking facilities and toilets that formed the hub of the community. Rather than presenting engineering solutions, a process of community engagement to inform the development of options was recommended. This involved two-way communication, where the community was informed about the science and the consequences of the different management options and the community informed the important values they wanted to protect and the vision of how they saw their community in the future.

Transparency needed to play an important role in this process. A focus group of stakeholders was set up to help guide the process that included Waikato District Council, Waikato Regional Council, Department of Conservation, Residents and Ratepayers Association, iwi, local business owners and the Sunset Beach Surf Lifesaving Club. Open dialogue was encouraged to determine the community's stance on managing uncertainty, acceptance of risk and options to manage risk.

Effects of changing shoreline at Okariha, Port Waikato. Photo: GHD.

Map showing changes in the shoreline at Okariha, Port Waikato. Photo: GHD.

Defence was the primary solution being sought by the community prior to the assessment of options. Stakeholders and the community were asked to help define criteria that would be used to assess options for risk. It became evident that the community valued easy access to the beach, access and use of a community hall, and the protection of the natural character of Port Waikato.

Community workshops were held to map the community's criteria against the range of management options, including options to defend, adapt, retreat or do nothing. Managed retreat ranked highest against the community's criteria and was seen as the most pragmatic and cost effective way to manage ongoing risk.

The community wanted to be actively involved in planning for managed retreat. Workshops were held to help design what managed retreat could look like and the opportunity this could provide to the community if managed well.

Questions still remain about the science, including uncertainty around rates of erosion, timing, possible accretion and sea-level rise. Having all known information in one form proved invaluable for engagement, as did direct access to experts who were on hand to help answer any questions. Outputs from this process are being used to develop options for planned retreat. They are also being used to inform the regional and district plan reviews as well as long-term investment plans.

"As we move towards more specific actions for climate change adaptation, engagement with coastal communities will be increasingly important and there is a need to consider the issues and opportunities for locally driven initiatives."

Shane Orchard,
University of Canterbury

"...we need to move beyond a short-term focus and beyond just engaging with coastal-edge properties, and develop a better level of understanding within our wider communities about the risks they are or will be facing."

Robin Britton, Resource Management/Planning Consultant, Focus Resource Management Group

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Front cover: Milford Beach. Photo: Ben Sheeran, Auckland King Tides Initiative.

Inside cover: Dotterels nesting at Clifton Road Reserve Whitford. Photo: Ben Sheeran, Auckland King Tides Initiative.

Back cover: Bucklands Beach. Photo: Ben Sheeran, Auckland King Tides Initiative.

Te Hunga Takutai o Aotearoa
NEW ZEALAND
COASTAL SOCIETY