Our Threats

Southland Water 2010: Part 4

TE AO MARAMA INC.

environment SOUTHLAND
Te Taiao Tonga

Taupara

Nā te pō, ko te ao
Tāna ko te ao mārama
Ka heke iho ko ngā ariki
Ki te whai ao
Ko tēnei tātou ngā whakatupuranga
Kua waihotia ki muri
Hei kaitiaki mō ngā taonga
Kua mahue mai ki muri
Kei ringa te ao tūroa
Ka whakamaua kia tina! Tina!!
Haumi e
Hui e, taiki e

From the realms of the night
to this world of light and understanding
the gods descended
to this environment.
All of this generation
have the responsibility
as protectors of the treasures
that have been left by our ancestors
upon this long standing world.
So they will be safe, maintained and preserved.
Bind it
Join it, let it be done.

Our Threats: How safe are we from floods, droughts and other extreme climate events?

Southland Water 2010: Part 4

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Foreword

While many of us still hold vivid memories of the 1984 floods, for young Southlanders this disaster is no more than photos and stories told by their parents and grandparents. Although on a smaller scale, the many floods and the snow last year continue to remind us that our region is prone to freshwater natural hazards.

Having farmed in northern and eastern Southland for over 20 years, I know all too well the effects of too much and also too little rain. Floods may be the most frequent form of natural hazard that we have to contend with, but drought is one of the costliest for the region, and can occur more regularly than we would like.

This report, part of the series of four written in collaboration with Te Ao Mārama Inc, represents a significant amount of work, and is one of the first reports for this region that looks at natural hazards in this way. It considers the aspects of our freshwater environment that could harm us and the things we value. It asks how we manage for natural hazards, how often we can expect one, where the most risk lies and, most importantly – how prepared are we and our communities for natural hazards.

Our great flood protection schemes and flood warning systems are highlighted in this report, but there are also areas where more can be done to ensure our region is adequately prepared for a major disaster. I hope that this report is your 'call to action' to become more prepared in your own home, at school, or at work.

Ali Timms
Environment Southland Chairman

Māori have always accepted natural hazards as inevitable events. We traditionally used signs to predict the weather, and learned from past events where to build houses and gather food. Floods were seen as the work of the atua (gods) and they increased the land's lushness, its ability to sustain us. As a result of human settlement, though, the land of Murihiku has been cleared, drained and intensively used. This will no doubt have changed some of our natural protections from these extreme climatic events.

The causes and effects of climate change continue to be recognised through planning and reporting documents like this one. This report draws attention to what we already know about climate change and highlights that there is much yet to be discovered about how this will affect our environment.

The world of our children and their children will be different, as it has always been. It is our responsibility to work towards ensuring that this report, and the others in this four-part series, contributes to our understanding of the risks and threats from natural hazards, extreme climatic events and human intervention.

As we identify and analyse the growing environmental threat from both natural events and human intervention we increase our knowledge of causes and effects but also gain opportunities to work within these confines to preserve the taonga (treasures) that have been handed down to us and ensure our own well-being and that of the generations to follow us.

Tiakina ngā taonga tuku iho o Te Aotūroa mō ngā uri whakatupu (protect the gifts of this long-standing world that have been handed down to us, for all of us today, and, for the generations that follow).

Donald Mowat
Te Ao Mārama Incorporated Chairman

At a glance

Our Threats is one of four reports which together make up *Southland Water 2010: Report on the State of Southland's Freshwater Environment*. Here we report on the aspects of the freshwater environment that have the potential to harm us and the things we value, with an overview of how safe we are from floods, droughts and other extreme climatic events. Climate variability and climate change are also discussed in terms of their influence on the frequency and intensity of freshwater natural hazards, and in turn the other themes within the *Southland Water 2010 series (Our Health, Our Ecosystems and Our Uses)*.

At different times of the year Southland is threatened by natural hazards involving both too much water, ie floods, heavy snow, rainfall and hail, and by events resulting from too little water, ie drought.

In terms of economic impact on Southland, drought is regarded as the hardest hitting.

Traditionally, Māori view natural hazards as natural processes. In this world view, everything is connected and if we mismanage our environment then events such as severe floods or droughts can result as a natural consequence of our actions.

The sporadic occurrence of natural hazards means that there is a huge amount of uncertainty in terms of predicting how frequent and how extreme they may be.

Much of developed Southland is exposed to risk from flooding and hail. The Mataura and Waimea Valleys and Lumsden are more prone to these events. We are more at risk from rain-based flooding in summer than winter, and hail damage is more common in late spring and summer than in winter.

Higher altitude coastal land in western and eastern Southland is more vulnerable to snow, which is common between May and September.

Northern Southland and the Te Anau Basin are more prone to drought conditions in summer and autumn.

A Southland residents' survey in 2010 established levels of public awareness of and preparedness for natural hazards. These results showed that although most of us understood we were at risk, very few of us were prepared for a possible natural hazard, with only 23% having an emergency kit while 66% had no emergency plan. Our community preparedness is low when compared with the measure of being self-reliant for three days.

Southland's climate is strongly influenced by large-scale changes in oceanic and atmospheric circulation in the western Pacific – these can occur over a few years (the El Niño Southern Oscillation) or over a few decades (the Interdecadal Pacific Oscillation).

The El Niño Southern Oscillation (ENSO) is characterized by two phases: El Niño and La Niña. For Southland the El Niño phase results in wetter than normal conditions while the La Niña phase leads to drier than normal conditions.

Positive phases of the Interdecadal Pacific Oscillation (IPO) result in wetter than normal conditions and more floods than the negative phases, which result in drier conditions and more droughts.

Climate change predictions suggest that Southland will experience an increased likelihood of natural hazards such as flooding and droughts. Long term climate change will be superimposed on natural variations, therefore there is potential for future climatic extremes.

Answers to the questions: 'What makes us vulnerable to natural hazards?', 'What is in place to protect our community?' and 'What we are doing to minimise our risks' are outlined in later sections of the report.

Introduction to Southland Water 2010

He oranga mou
He oranga mō matou
He oranga mō tātou katoa

A place of wellbeing for you,
For us, For all of us.

Water is of critical importance to our social, cultural, economic and environmental wellbeing. Water is also a potential threat to us through floods, droughts, and snowfall events.

The value Southlanders place on their environment is the basis of the Regional Water Plan for Southland and our Regional Policy Statement. At the same time, Ngāi Tahu ki Murihiku Natural Resource Management Plan 2008: Te Tangi a Tauira – the Cry of the People describes the manawhenua values for the freshwater environment. The values we want to protect from the threats presented by freshwater are also described within these documents.

The management outcomes for freshwater, set out in these documents, in turn provide the framework for the *Southland Water 2010: Report on the State of Southland's Freshwater Environment*. This framework enables monitoring and reporting to inform our management of Southland's freshwater resources, and help determine planning for the work programmes within the next Long-term Plan 2012–2022.

Southland Water 2010 builds and expands upon Environment Southland's first *Southland's State of the Environment Report for Water* published in October 2000, and provides a baseline to measure the success of the Water Plan which became operative in January 2010.

Southland Water 2010 consists of a series of four reports:

- Our Health
- Our Ecosystems
- Our Uses
- Our Threats

Our Threats reports on the aspects of the freshwater environment that could harm us and the things we value. This report asks how safe we are from floods, droughts and other extreme climatic events. Climate variability and climate change are also reported on because these heavily influence the frequency and intensity of freshwater natural hazards, and also have significant impact on the other themes within the Southland Water 2010 series (*Our Health*, *Our Ecosystems* and *Our Uses*). To date, no state of the environment report is planned to encompass other natural hazards such as earthquakes and tsunami. However information on these hazards and preparing for them is available from www.civildefence.co.nz or www.getthru.govt.nz.

Southland / Murihiku: Our place and our people

This section introduces our climate, patterns of past and present land use and how the identity of Southlanders has been shaped by climate – in relation to natural hazards. It provides the wider context for the discussion of freshwater threats we face in our region.

Our climate

New Zealand's climate is described as maritime and is dominated by mild temperatures and frequent rainfall. New Zealand's climate is strongly influenced by its location within a belt of relatively strong westerly winds and the large surrounding oceans. These factors mean that the air masses reaching New Zealand are humid and of moderate temperature. Average annual temperatures range from 10 degrees celsius in the south to 16 degrees in the north of the country.

Southland's climate patterns are similar and are dominated by westerly influences, which generally supply reliable and plentiful rainfall and a small annual range in temperatures. At times there are influences from the Antarctic region, bringing chilling, strong southerly winds.

The shape of the land (topography) greatly affects Southland's climate. The Fiordland mountain ranges act as a barrier to the prevailing westerlies. The mountains force air to rise up as it travels from the west to the east resulting in cloud and rain to the west. Once air reaches the eastern side of the ranges it warms and begins to descend, resulting in less cloud and lower rainfall. This is known as a rain shadow.

The existence of a rain shadow results in considerable variability in rainfall across the region. The Fiordland region receives extremely high rainfall totals, in excess of 10,000mm/yr. While the inland valleys of northern Southland are relatively dry receiving only between 800–1000mm/yr of rainfall, coastal areas such as Invercargill tend to receive greater rainfall than inland areas as there are fewer ranges in the path of the westerlies to intercept the rain. Eastern Southland typically receives around 1000mm/yr in inland areas but around 1400mm/yr in the coastal Catlins area.

Snow in Southland is generally limited to higher altitude areas (where temperatures are cooler); it is common to see snow inland, particularly on the ranges, from autumn through to late spring. However snow can fall to low levels in certain conditions at any time of year.

Southland climate variability throughout the year

Compared to the rest of New Zealand, Southland has little rainfall variation throughout the year, although there are seasonal trends. In June, July and August, more southerly air flow brings drier air resulting in less rainfall (July is the driest month). In December, January and February, westerly air flow results in wetter conditions. While Southland has less drought risk than most of the country, Figure 1 shows that northern and eastern Southland receive less rain and are more prone to drought than coastal and western Southland.

Air temperature also has a small annual range in Southland, with July being the coldest month and January the warmest. The average annual variation is about 9 degrees in Invercargill, 10 degrees in Gore and 12 degrees at Mavora and Piano Flat. Temperature variation tends to be less in coastal areas owing to the moderating effect of the sea, resulting in warmer winter temperatures and lower summer temperatures.

Weather-related records

Although the region's climate is relatively uniform, it is not without its extremes. Recent Southland weather extremes are shown in Table 1.

Figure 1: Average monthly rainfall totals in Southland since records began

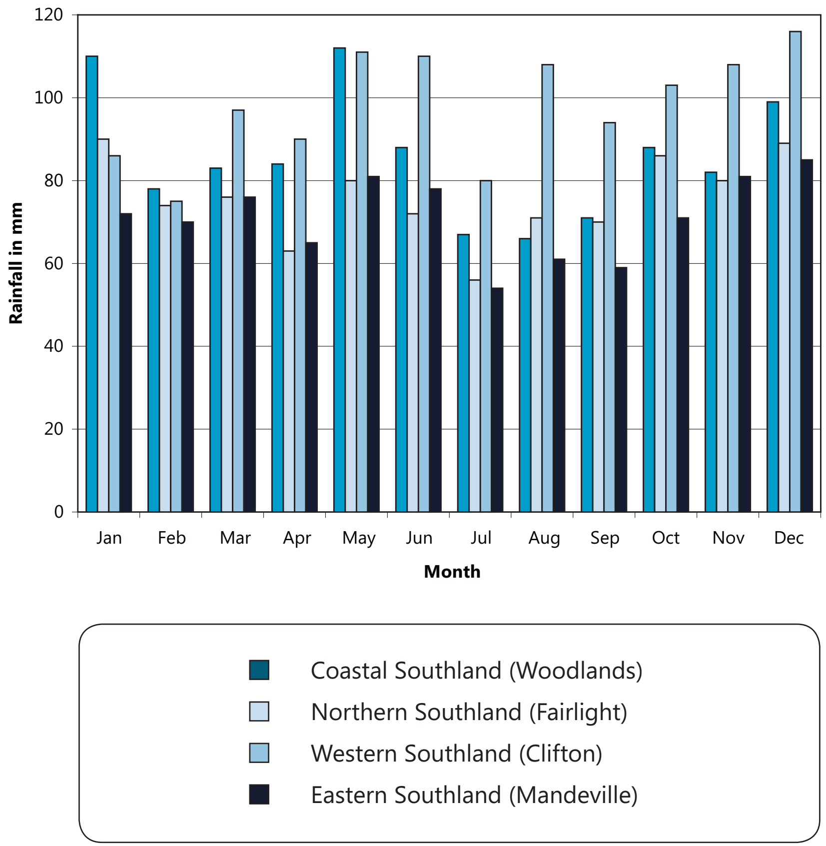

Table 1: Recent Southland weather extremes

Date	Weather	Record
July 1996	Frost	–14.2° The hardest frost on record since 1910 (snow, then 9 consecutive days of frosts).
December 2005	Rain	125–175mm in 2–3 hours at Otama Valley, 100mm in 3 hours at Riversdale, 20mm rain in 10 mins in Invercargill.
January 2008	Sunshine	287 hours – record sunshine hours for January in Invercargill.
April 2010	Rain	183mm in 24 hours – record rainfall at South West Cape, Stewart Island/Rakiura
September 2010	Snow	10cm in Invercargill and low lying areas, 20cm in hillier areas - heaviest snowfall in coastal Southland in 60 years.

Mersey Street, Gore 1913

Our people

Population and ethnicity

There are 90,873 Southlanders (2006 Census) and we make up 2.3% of New Zealand's population. In terms of ethnicity, 78.6% of Southlanders identify as of European descent, 16.5% as New Zealander, 11.8% as Māori, 1.7% as Pacific people, 1.3% as Asian and 0.2% as another ethnicity (you can identify with more than one ethnicity).

Manawhenua refers to the iwi or hapū that holds the traditional/customary authority over resources within a particular area. In Southland/ Murihiku there are four Ngāi Tahu papatipu rūnanga (traditional local Māori councils) which hold manawhenua status within the region: Te Rūnanga o Awarua, Te Rūnanga o Ōraka/Aparima, Te Rūnanga o Hokonui and Te Rūnaka o Waihopai.

Where we live and how

Southland's main urban centre is Invercargill (2006 population: 50,328). Other significant population areas are Gore (9,870), Winton (2,088), Te Anau (1,899), Riverton (1,512) and Otautau (753). Southland's 27% rural population is almost twice the national average of 14%.

As Southlanders, we all have our own attachment to this place. Managing for hazards is important because our lives and livelihoods are not easily relocated, and, for Māori, cultural interests and associations cannot be substituted or relocated. This means that we need to manage the hazards we face in the areas we live – it is personal and it is specific to our place, our region.

Where Southlanders live is largely dictated by water – in its various forms, from rainwater to rivers and glaciers, water has shaped the patterns of human settlement and development in Southland/Murihiku. This is also reflected in how we talk about ourselves: in Māori terms, Ka Huika, the confluence of the Mataura and Waikaia Rivers, also denotes the various streams of peoples who have joined together in southern New Zealand.

The geography of the region ranges from towering mountains in the west to rolling hills to highly modified lowland pasture. After this land was uplifted from under the sea some 25 million years ago, it has been sculpted by glaciers (which left a chain of lakes to the west), and cut and smoothed by a network of rivers that deposited the rich sediments of Southland's plains.

Human settlement started on the coast, with Māori iwi moving inland along waterways, which were also used to transport pounamu and mahinga kai from the surrounding areas. Early European settlement followed similar patterns, beginning with coastal whaling and sealing settlements from 1829, in Fiordland, around Stewart Island/Rakiura and at Bluff and Riverton/Aparima.

The interior was opened to widespread settlement and development in 1856, from the new town of Invercargill. Those settlers noted the mud flats, dangerous creeks, peat mosses and lagoons, and began bush clearance and drainage to convert the land to pasture for cattle and sheep grazing, and crop production. Southland's rivers were scoured for gold in the 1860s, but the region's real economic boom happened in the late 1870s, when refrigeration made possible the export of dairy products and frozen mutton to Great Britain. Dairy factories and freezing works, together with other agricultural industries such as limestone fertiliser production, were soon more common than flaxmills and sawmills.

Rail and road systems opened the region further, along with the many bridges, culverts and ferries needed to connect the towns and industries that had been established close to rivers. The Port of Bluff remained a key gateway for immigrants and exports, and supported fishing and oyster fleets.

In the steep mountain country to the west, land use patterns were influenced by water in quite different ways. While the very high rainfall and glaciated landforms discouraged farming-based settlement, they formed the basis of major tourism and power generation developments. Fiordland National Park was gazetted in 1904, while the first survey of the hydroelectric potential of Lakes Manapouri and Te Anau in 1903 heralded the schemes built at Monowai in 1925, and Manapouri in 1971.

In eastern and central Southland, dairying proved a profitable venture, particularly for butter and condensed milk production, through to the 1950s when it was surpassed by the international demand for wool. This was reversed in the 1990s, when the returns on dairy commodities outstripped meat and wool prices, starting a period of sheep farms converting to dairy operations.

Agriculture, primary production and manufacturing are the main contributors to Southland's economy. Nearly 19% of Southlanders are employed in the agriculture, forestry and fishing sectors and 15% in manufacturing. Farms in Southland are predominantly involved in livestock production, with 45% involved in sheep production, 16% dairy cattle, 8% beef cattle, 10% mixed sheep and beef and 7% deer.

The climate and topography of Southland also have the potential to destroy lives and livelihoods. Rivers, which supply water to farms and settlements, have experienced disastrous floods, as in March 1913 when a number of Southlanders were killed. The 1984 flood, the most memorable in recent history, left 1,400 people temporarily homeless and caused $53m of insured damage. Heavy snowfalls have disrupted roads around Southland, particularly the tourist route from Te Anau to Milford Sound, while the 2010 snowstorm decimated new born lambs and collapsed some buildings in Invercargill.

Just as the water has shaped land, and developed patterns, it has also shaped the character of the region. Southlanders as a whole are resilient people, ready to find their own community-based solutions to difficulties – if there's a flood, local residents are more likely to be going out as part of the volunteer fire brigade than waiting for rescue. This resilience has grown out of the reality of life in a sparsely settled region with a stretched and sometimes fragile transport network, and significant repeated exposure to natural disasters, particularly flooding.

It is part of who we are, and an important part of how we face our future together.

Figure 2: Southland Region

How this report works

This report has been written to:

- Raise awareness and understanding of issues that affect our shared environment
- Tell us how effective our decisions and actions have been
- Help us set priorities for future action
- Help people and organisations make informed decisions to protect what they value in the environment
- Inspire community action.

State of the environment reporting

State of the environment (SOE) reporting is the equivalent to a report card on the environment.

SOE reports are not technical documents, although they are based on large amounts of technical information. They instead set out to show the properties of a specific aspect of our environment.

Our Threats asks 'How safe are we from floods, droughts and other extreme climate events?' Within this report we examine the 'current state' of natural hazards in the freshwater arena, by looking at risk and how prepared we are for these hazards. We also consider what makes us more vulnerable to these hazards and what we are doing to minimise the risk. As such this report extends beyond strictly 'environmental' elements.

Approach taken in this report

Southland Water 2010 focuses on the freshwater environment, but also includes the estuaries and coastal areas influenced by freshwater.

Nationwide, regional councils work together collaboratively to ensure and improve national consistency and robustness of the environmental information collected. As such, Environment Southland's monitoring programmes encompass aspects that are traditionally monitored by regional councils in New Zealand, and are consistent with current national best practice.

By reporting collaboratively, Environment Southland and Te Ao Mārama Incorporated seek to provide the people of our region with a more complete, more holistic picture of environmental and cultural health.

Report structure

The report's structure is based on the *Regional Water Plan for Southland*, the *Regional Policy Statement* and the *Ngāi Tahu ki Murihiku Natural Resource Management Plan 2008: Te Tangi a Tauira – the Cry of the People*. We report on information collected by both Environment Southland and Te Ao Mārama Incorporated.

The report is based around the following core questions:

- How often should I expect a natural hazard?
- What areas in Southland are most at risk?
- How aware and prepared (for a natural hazard) is our community?
- What makes us vulnerable to natural hazards?
- What is in place to protect the community?
- What are we doing to minimise the risks?

We also look at:

- climate change and variability, and how this affects (and is predicted to further affect) freshwater natural hazards.
- the Māori world view of natural hazards, and how this perspective requires management of freshwater ecosystems and resources be viewed as a whole.

As the purpose of SOE reporting is also to help determine future management actions, and inform the wider community on how they can help themselves, we also report on 'What we don't know and could do better', pg 42, as well as 'What you can do', pg 43.

Want more detail on SOE reporting?

Visit: http://www.es.govt.nz/environment/monitoring-and-reporting/state-of-the-environment

Managing natural hazards in Southland

Natural hazard management in New Zealand is based on an integrated and community-focused approach. In this section we describe the roles and responsibilities of Environment Southland and Te Ao Mārama Incorporated and how they work with other agencies involved in natural hazard management in Southland.

See the next section 'Introduction to natural hazards' for a description of the actual hazards we face, in terms of freshwater in our region.

Environment Southland

Environment Southland's role in managing for natural hazards is directed by our community's expectations – as set out in the Regional Policy Statement. The role is fairly comprehensive and involves many disciplines – hydrology, flood warning, catchment management (river works and engineering, land sustainability and soil conservation), and policy and planning (land use management through plans, advice, policies and hazard maps).

There are extensive works and plans in place for Southland's most frequent hazard, flooding. Our response to drought is now also more clearly defined, through the Water Shortage Standard Operating Procedure 2010, which outlines our responsibilities and procedures during a water shortage – see 'What we are doing to minimise our risk' section, pg 36.

Environment Southland, along with Invercargill City Council, and Gore and Southland District Councils, is part of the collective inter-council organisation, Emergency Management Southland, which provides all civil defence emergency management services across the region. During an emergency, Environment Southland's resources (eg staff, technology, monitoring network) play a key role – see Emergency Management Southland section of 'What we are doing to minimise our risk', pg 36.

Te Ao Mārama Incorporated

Te Ao Mārama Incorporated looks after the manawhenua interests in resource management and other aspects related to local government in Southland. It is authorised to represent the four Ngāi Tahu papatipu rūnanga in Southland/ Murihiku.

Kaitiakitanga (guardianship) is a central concept of Ngāi Tahu management of the environment. From an environmental perspective Ngāi Tahu see the world as a unified whole, where all elements, including people, are connected. As such, Te Ao Mārama Incorporated is involved in the protection of the spiritual and cultural values of the region including wahi tapū (sacred places), mahinga kai (gathering of food and resources) and other natural resources. In turn these values can potentially be impacted by climate change and natural hazards – see Michael Skerrett case study, pg 40. The *Ngāi Tahu ki Murihiku Natural Resource Management Plan 2008: Te Tangi a Tauira – the Cry of the People* describes the manawhenua values and perspectives on natural resource and environmental management issues. This planning document assists Ngāi Tahu ki Murihiku in carrying out kaitiaki roles and responsibilities.

Te Tangi a Tauira also recognises the role of communities in achieving good environmental, health and wellbeing outcomes, and thus is designed to assist others in understanding manawhenua values and policy, and is a key reference point for all natural hazards management in the region.

Te Tangi a Tauira has a policy section specific to climate change, which highlights how mismanagement of the environment and cultural protocols can result in natural hazards that threaten human communities. This is exemplified in the following policy: *'Ensure that it is understood that cultural order comes from the natural environment and that lack of respect, honour and protection of this natural order compromises Māori culture, well-being and spiritual health.'*

Ngāi Tahu ki Murihiku is concerned about the impact of global climate change on local values, particularly on the ecosystems considered taonga by iwi. Ngāi Tahu ki Murihiku promotes ongoing research on the cause and effects of climate change and the development of an appropriate policy response.

Introduction to natural hazards

Natural hazards are naturally occurring atmospheric, earth or water processes, or events that have the potential to harm people, property or infrastructure. Natural hazards include earthquakes, tsunami, erosion, volcanic and geothermal activity, snow, frost, hail, high intensity rainfall, landslips, subsidence, sedimentation, wind, drought, fire, flooding, and marine inundation.

In terms of Southland's freshwater environment and resources, several types of natural hazard can occur here, with varying degrees of likelihood. These can be categorised into events when there is too much water, ie floods and high intensity weather events such as heavy snow, rainfall and hail, and events when there is not enough, ie droughts.

The potential effects of natural hazards that we need to consider include direct and indirect impacts on our health, economy/livelihood, cultural values and ecosystems. These effects range from loss of life and livestock, to damage to infrastructure (ie roads, bridges) and homes, to impacts on aquatic ecosystems, and our communities' physical, economic, social, psychological and spiritual wellbeing.

The costs are hard to quantify. However, drought is generally regarded as the hazard that has the most economic impact in Southland, principally through its effects on pastoral production, hydroelectric power generation and urban water supplies.

The 2003/04 dry period that resulted from three months of below average rainfall in Southland caused a significant drought in northern Southland. The direct economic impact of this event was assessed in 2004 at approximately $50 million, rising to $60–70 million when indirect impacts were taken into account.[1]

Floods can be very costly, but these costs tend to come from direct damage to infrastructure, buildings, or loss of stock, rather than lost production as a result of reduced grass growth. The extent of flooding can be limited to certain parts of the catchment rather than being catchment-wide. Although the 1984 floods resulted in the fifth largest insurance loss in the world in that year, equating to $124 million in 2011 terms, this was largely because it affected so many residential and commercial buildings – see 1984 Floods case study, pg 16.

Snow can be very damaging, as the September 2010 snowfall demonstrated. The provisional cost to the insurance industry is $47 million (December 2010), $20 million of which relates to Stadium Southland alone. On top of this, there is the cost of stock losses, mostly uninsured, amounting to an estimated $20 million.

These costs demonstrate that there is much to be gained by implementing measures to prevent or mitigate the impact of freshwater-related natural hazards.

[1] SKM 2006

The Māori world view of natural hazards

Te wehenga o Ranginui rāua ko Papatūānuku – the separation of the sky father and earth mother

Māori tell various stories that explain the evolution of the universe. A familiar version starts with the Nothingness (Te Kore) at the beginning of time, and then describes the evolution of a series of nights (Te Po), and after aeons of time leads to Ranginui and Papatūānuku, the sky father and the earth mother, clinging closely together with their children between. The children are constricted by this close embrace and some decide to separate their parents. After various attempts by his other brothers, Tāne Mahuta (the god of the forest) succeeds and brings light and knowledge into the world, but in doing so he commits an act of cruelty against his parents. Another brother Tāwhirimātea (god of the wind and weather) did not agree with the separation and sought revenge upon Tāne Mahuta and his brothers. Tāwhirimātea battled his brothers and devastated the lands, forests and oceans. Tūmatauenga (the god of war) fought his brother Tāwhirimātea while others rushed to hide in safety. This made Tūmatauenga furious because his brothers did not help him. Once the battle had subsided, Tūmatauenga decided to shame his brothers by cooking and eating their children: the birds, fish, and cultivated and uncultivated foods; this lowered their prestige and established the superiority of man.

To this day the quarrels between the brothers flare up and can result in fierce storms and the natural hazards that are detailed within this report.

Natural processes and consequences of our actions

Traditionally, Māori have accepted natural hazards as inevitable natural events. They believed they were the work of the atua (gods) and as such the will of supreme entities. Various ways Māori dealt with these events was through karakia (prayer) and placing tapu, rāhui or restriction on places that may be dangerous to people. These would include rivers that were prone to flooding, and areas where natural events may have caused the death of tribal members.

Traditionally Māori would use signs to try and forecast upcoming weather events. This would include monthly, seasonal and yearly patterns. It was important to understand these, to choose the right time to collect food and resources, and to sustain their lifestyle. Changing environments and increased unpredictability and uncertainty may impact the ability of Māori to use their mātauranga (wisdom, knowledge).

Māori would learn from natural events like floods not to build houses on flood-prone areas. The hunter–gatherer lifestyle of southern Māori did not require them to farm land and most places remained in their natural state. Māori had no need to control water. Floods were seen as a natural event that increased the fertility of the land for plants and animals. For some whānau, there is concern that the construction of stopbanks prevents the replenishment of the flood plains. In some instances there is a fine line between hazard management and harming the function of the ecosystem.

The rains are seen as the tears of Ranginui, a sign of his sorrow from being parted from his wife Papatūānuku. Rain is also viewed as a way to cleanse the earth and promote new life and growth on the land. The tears and mucus that flow from mourners when a person has died are described as a great flood upon the land (Waipukepuketia te Whenua).

Ngāi Tahu ki Murihiku understand that, as all things are connected, if we mismanage our environment then events such as severe floods and droughts will be a natural consequence of our actions. In addition, the large but uncertain threat presented by global climate change (in particular to the ecosystems that support customary harvest) is of profound concern to Ngāi Tahu – see ‘Climate change predictions’, pg 20.

How often should I expect a natural hazard?

Locally, natural hazards are infrequent, and because of that they present a huge amount of uncertainty in terms of predicting how often and how extreme they may be. Since records began, people have been interested in extreme weather events, trying to devise ways of accurately predicting what will occur next. This section sets out the limitations we face even with the most up-to-date prediction systems.

Uncertainty

Uncertainty and natural hazard management go hand in hand. Typically, the most damaging natural hazard events are random, infrequent and extreme – the types of events that are often beyond an individual's past experience. There is no guarantee that such an event won't reoccur or be surpassed soon after. Even with hazard types that have a lengthy record (eg heavy rainfalls), there are often data quality or analysis issues that affect the reliability of predictions.

On top of all that, climate change affects our ability to accurately predict the effects the weather will have on the region. This means that, although past experience is a good starting point for estimating future hazards, adjustments need to be made to allow for climate change[2] (see 'Climate variability and climate change', pg 18). We also need to remember that climate change projections themselves contain uncertainty – the direction of change is reasonably robust, but there is less certainty about the magnitude of changes.[3]

Rainfall can lead to floods, but the relationship between the two is variable. Considerable effort goes into recording flood heights, converting them into flood flows and assigning probabilities to past and future flows. These probabilities may be defined as return periods, or, annual exceedance probabilities (see 'Understanding probabilities', pg 16). Their calculation always contains a degree of uncertainty, especially if the flood record is short.

There will always be a need to identify 'most likely' scenarios, but given the uncertainties that exist, there is good sense in the phrase 'expect the unexpected'. Who, in 1983, would have predicted the January 1984 rainfall in Invercargill? (See 1984 Floods case study, pg 16) Who, in 2010, would have predicted more than 100mm of snow in Invercargill? Given the risk of not acting, even with uncertain information scientists are advising the policy makers to act now and not wait for science to come up with all the answers about future trends (see Table 1: Recent Southland weather extremes, pg 8).

Predictability

Predictability varies from hazard to hazard. Some hazards and their contributing factors (such as floods resulting from heavy rain) are easier to record than others and, historically, data collection has focused on particular factors in particular areas.

Rainfall is reasonably regular and data is easy to collect. On the other hand, snow is infrequent and snowfalls vary considerably within the affected area. Furthermore, snow type and densities vary, making it difficult to compare one snowfall with another. The July 1939 snow is probably the benchmark snowfall for Southland, or at least it was until September 2010. During 1939, depths greater than 500mm were reported in places such as Mossburn and Lumsden, with falls up to 2m between Gore and Balclutha.[4]

Droughts are different again – they develop slowly and there is no way you can predict when a drought will end.

While drought indicators exist, such as monthly rainfall, sunshine hours, soil moisture, river flows and groundwater levels, there is no single measure of drought. As such, 'droughts' are not as easily identified or recorded as floods, and complete information about past droughts is difficult to locate. The complexity of droughts does not lend itself readily to the calculation of likely 'return periods', or annual exceedance probabilities.

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2 Wratt 2006

3 NIWA 2006

4 Fraser 2002

Facing up to what is possible

Even with these uncertainties and variations, it is important to look at what sorts of natural hazards are possible and what we know about the associated risks.

It would be unrealistic for us to expect that all the most extreme weather has occurred in the last 150 years. We also need to bear in mind that, due to climate change, there is potential for more frequent and more intense extreme weather events to occur than in the past – see 'Climate variability and climate change' section, pg 18.

Understanding probabilities

The chance, or probability of an event occurring (for example a flood of a certain size) is calculated by undertaking a statistical analysis of the historic records. Probabilities are often expressed in terms of 'return periods', but this can be misleading.

For example, a flood may be described as a '1-in-100-year flood'. This means that there is a 1-in-100 or a 1% chance that there will be a flood this size or greater in any year. It does not mean that if a 1-in-100-year flood occurs it will not happen again for another 100 years.

A 1% annual probability (1 in 100 year) equates to a 17% chance of it occurring at least once in the next 20 years, a 51% chance in the next 70 years, or a 63% chance in the next 100 years. Put another way, statistics tell us that there is only a 63% chance of an event with a particular 'return period' occurring within that time.

There is often a lot of uncertainty about the size of an event with a given probability, especially the lower probabilities (those with a higher return period). Factors such as the length of the record (often less than 50 years) and data quality affect the reliability of the calculated size. Climate change adds further uncertainty to size/probability relationships calculated from past weather records.

To assess the size of extreme rainfall events, meteorologists calculate what is known as the 'probable maximum precipitation' (PMP), in terms of the maximum 24-hour rainfall. On the Southland plains for example, the PMP is in excess of 300mm. That is a lot of rain, compared to the 100–150 mm rainfalls that have given rise to some of our largest floods. While we should note that PMPs represent the outer range of what's probable, they still serve as a useful illustration of what could possibly happen.

Case study: The 1984 floods – the worst in Southland's living memory

In mid-December 1983, Southland was shaping up for an unusually dry summer. River levels were getting lower, climate predictions were for a warm season and the Southland Catchment Board (Environment Southland's predecessor) took the unusual step of resolving to write to major industries to warn that they might have to scale back their discharges into the rivers, because of expected low water levels.

By mid-January 1984 the weather pattern had changed. When a slow-moving, broad band of heavy rain fell across Fiordland and southern Southland on 26–27 January, it came on top of several days of steady rain which had already left many catchments waterlogged.

Floodwarning officer Les McGraw received a heavy rain alert from the Meteorological Office in Wellington on Thursday 26 January. It heralded the worst flooding in living memory in Southland.

In the 24 hours to 9am on 27 January, 134mm of rain was recorded at Invercargill airport. This was almost twice the previous recorded 24-hour maximum of 74mm. During that period 90–150mm fell across much of the Southland plains, with even higher totals in some of the headwaters.

By Thursday night, Invercargill city's stormwater system was overloaded and by midnight the fire service had all but given up pumping water out of houses and businesses; at 3am the city's civil defence organisation was placed on full alert and at 4am Mayor Eve Poole declared a State of Emergency in Invercargill that was not to be lifted for three weeks. By mid-morning, the declaration had been extended to the Southland and Wallace County Council areas.

When dawn broke, the city was awash. Every watercourse was in flood – the Waikiwi Stream, Waihopai River, Otepuni Creek and Kingswell Creek had all breached their banks, and ponded stormwater continued to compound the problems. Invercargill was completely isolated except by air, with all road and rail links closed. The Otepuni Creek had cut the city in half, separating north from south, washing into homes and many businesses. The Kingswell Creek flooded houses in low-lying areas of South Invercargill, while the Waikiwi Stream had broken its banks, spilling across North Road and into Renfrew Street. Several properties in the suburbs of Rosedale and Gladstone were at risk both from the Waihopai River, which was near the top of its stopbanks, and from ponded stormwater that was unable to drain away.

Meanwhile, upstream at Kennington the Waihopai River had washed away timber stacks from Niagara Sawmilling's yard. The planks floated downstream and began to pile up against bridges. Shortly before midday, a logjam formed under a farm bridge a short way upstream from Invercargill. The stopbank beside the bridge was weakened and the water scoured out a 40m gap, while nearby, the top of the bank was also washed away. The floodwaters poured across Queens Drive, through Thomsons Bush and into the Prestonville industrial area, then across North Road and into Grasmere.

Many residents, at home because of the State of Emergency, had so little warning that few were able to save their belongings. Helicopters rescued several people who climbed on to rooftops to escape the water, while others were evacuated by boat. By nightfall, some 900 Invercargill homes were uninhabitable, some of them flooded to over one metre deep and contaminated by sewage.

Outside Invercargill, the Oreti River also flooded and by mid-morning, the Makarewa River was spilling into the Taramoa ponding area west of Invercargill – a natural basin which had been designated as a floodplain after severe flooding in 1978. The ponding area filled up and water flowed towards the Invercargill airport. The airport had stayed open on Friday 27 January, but Air New Zealand decided to fly its Boeing 737 to Dunedin overnight. By daybreak on Saturday 28 January, the airport was under water. Aero club planes and privately owned aircraft were swamped in their hangars and the terminal was flooded halfway to the ceiling as the Stead Street embankment acted as a stopbank, stopping the water flowing into the estuary.

Although most media focused on Invercargill's plight, Otautau and Tuatapere were also very badly hit. In Otautau, 70 percent of houses – 190 homes – were inundated by the Aparima River and the Otautau Stream. In Tuatapere, the Waiau River flooded 42 homes. Surface water affected communities all over western and central Southland. Hundreds of farmers lost stock and suffered damage to fences, bridges and crops. Only eastern Southland was spared.

The total cost of the damage arising from the floods was never fully quantified; there was no final tally that took into account losses to private property, business and agriculture, public infrastructure and the uninsured or uninsurable losses. The insurance council subsequently estimated its members had paid out claims totalling $53 million in 1984 terms, making the 1984 Southland floods the costliest natural disaster for insurers in New Zealand at that time since the 1931 Napier earthquake. The Southland Catchment Board estimated that its infrastructure cost $1 million to repair.

Spurred on by requests from the Invercargill City, Southland County and Wallace County Councils, the Southland Catchment Board designed and built comprehensive flood alleviation schemes to prevent a recurrence of similar flooding in Invercargill, Tuatapere and Otautau, and upgraded the level of protection provided to several other communities and rural areas. To date, these schemes have not been put to the test, except for the Oreti River, which successfully contained floods within its design limits in November 1999 and April 2010.

Environment Southland staff are increasingly concerned that as memories of the 1984 flood fade, complacency and lack of awareness of the region's flood hazard is increasing. As the Catchment Board's Chief Engineer, Neil McMillan, warned in the late 1980s, eventually a bigger flood must come – one which he predicted would be "of biblical proportions".

1984 floods
J. N. Easson

Climate variability and climate change

Long-term climate variability

Southland's climate is strongly influenced by large-scale changes in oceanic and atmospheric circulation in the western Pacific – these can occur over a few years (the El Niño Southern Oscillation) or over a few decades (the Interdecadal Pacific Oscillation).

The El Niño Southern Oscillation (ENSO) is a climate pattern that occurs across the tropical Pacific Ocean over a time period varying from two to seven years. It affects atmospheric pressure, winds, precipitation and sea-surface temperature.

ENSO has wide-reaching effects globally, generating extreme weather and related hazards such as floods, droughts and wildfires. A single ENSO event can last between 6 to 18 months and can have a significant impact on New Zealand's climate and in turn on agriculture and fishing, and so is an important issue for New Zealand's primary industries.

ENSO is characterised by two phases:

1. El Niño – in this phase, the oceanic temperatures of the east Pacific Ocean are warm and the air surface pressure in the western Pacific is high. In New Zealand, El Niño conditions generally lead to cooler sea temperatures and more south-westerly winds. This results in wetter than normal conditions in western and southern parts of New Zealand and drier than normal conditions in the east and north.
2. La Niña – oceanic temperatures of the east Pacific are cooler and the air surface pressure in the western Pacific is low. In New Zealand, La Niña conditions lead to warmer sea temperatures and more frequent north-easterly weather over the North Island and anticyclones in the South Island.

   For Southland, the El Niño phase results in wetter than normal conditions while the La Niña phase leads to drier than normal conditions.

The Interdecadal Pacific Oscillation (IPO) is a pattern of climate variability with a cycle of 15–30 years. It is characterised by a warm positive phase in which El Niño conditions are prevalent, and a cool negative phase, which favours La Niña conditions. During periods of positive phase IPO, Southland's rainfall total, rainfall intensity, and river figures for flood size and low flow magnitude tend to be significantly greater than during periods of negative phase IPO.[5]

The IPO was in the (cool) negative phase from 1946 to 1977. Persistent La Niña conditions in the 1970s resulted in drier than normal conditions in Southland causing a number of significant droughts. A change in the IPO to the (warm) positive phase from 1978 to 1998 resulted in wetter than normal conditions causing an increase in the number of floods in the late 1970s and early 1980s. This can be seen by looking at the flood and drought events from Mataura River data (Figure 3).

One way to see the effects of El Niño Southern Oscillation (ENSO) is by looking at past droughts in Southland, and when these occur during the El Niño and La Niña phases (Figure 4). Summer droughts typically coincide with a strong La Niña and autumn droughts generally occur when the ENSO state is normal, or in a weak La Niña/El Niño.

[5] SKM 2006

Figure 3: IPO versus Mataura River at Gore – flood and droughts

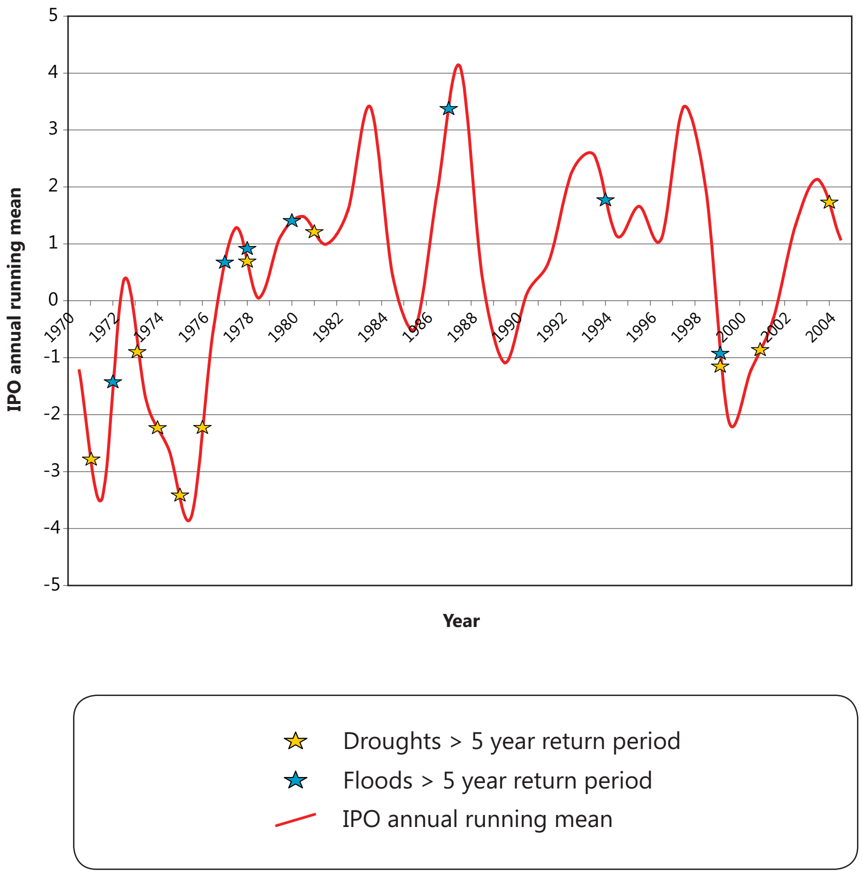
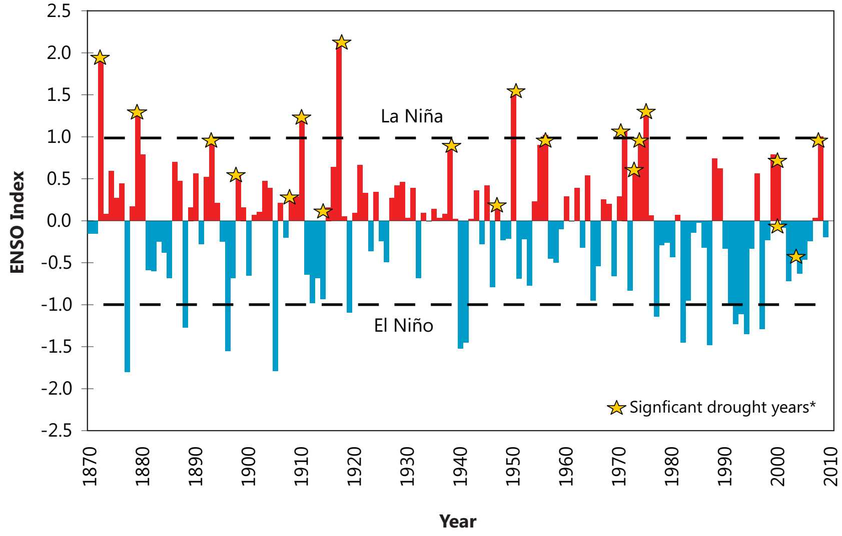


Figure 4: Time-series plot of ENSO and significant droughts in Southland from 1870 to 2010[6]



[6] Drought years sourced from numerous publications including SKM (2006), Mosley and Pearson (1997), Riddell (1984) and Southland Times articles in Issues 1971, 1563 (in 1872), 1692 (1873), 3571, 3594 (1879), 12825, 12491 (1893), 13698, 13949, 13705 (1897) and NIWA CliFlo database (http://cliflo.niwa.co.nz/). *nb: data pre-1970 is limited.

Much of Environment Southland's hydrological network (ie stream flow and rainfall measuring sites) was established in the 1970s and this data is used as the statistical basis for our understanding of 'normal' conditions. However, much of this data comes from an identified wet phase in the long-term climate pattern corresponding to a positive phase in the IPO. This means that our 'norm' is perhaps too wet compared to a long term mean, and droughts may in fact be more likely than current analysis suggests. While that is another uncertainty we have to live with, it does indicate that it is prudent to take climate variability into account in our long-term planning for management of Southland's water resources.

Climate change predictions

The National Institute of Water & Atmospheric Research (NIWA) has looked at likely climate scenarios based on a number of greenhouse gas emission scenarios from the Intergovernmental Panel on Climate Change (IPCC). Using the mid-range of these scenarios, NIWA predicts a temperature increase of about 1 degree Celsius by 2040 and 2 degrees Celsius by 2090. A warmer atmosphere can hold about 8% more moisture for every 1 degree Celsius increase in temperature. Rainfall is projected to rise and heavy rainfall events are likely to become heavier and more frequent. Strong winds are also predicted to increase.

Should these predictions play out, Southland would be exposed to an increased likelihood of natural hazards such as flooding and drought (Table 2).

Table 2: Climate change predictions for 2040, relative to 1990 for Southland (from MfE guidelines, May 2008)

Climate aspect	Prediction for 2040	Comments	Natural hazard this contributes to
Daily temperature	↑	Higher temperatures, less frosts	Drought
Annual temperature	↑	Higher temperatures (0.8–0.9˚C increase) on an annual average	Drought
Rainfall events	↑	More frequent heavy rainfall events; increase in size of the event	Flood
Annual rainfall	↑	Higher (3–5%) average annual rainfall	Flood
Wind	↑	Increase in annual westerly wind flow and peak wind speeds	Drought
Tropical cyclones	↑	More storms	Flood
Sea temperature	↑	Higher sea temperatures, similar to increase in annual temperature	Flood/drought (sea temperature warms air temperature which drives climate system)
Sea level	↑	Increase in sea levels (0.2m)	Flood

Cataclysmic events are not the only negative effects of climate change. Even slight changes in temperature and rainfall patterns present major challenges to ecosystems and the individual species within. For Ngāi Tahu this presents a particularly significant threat, because of the value placed on ecological integrity, and the indigenous flora and fauna that Māori consider as taonga. Particularly concerning are changes to habitat of species used for traditional customary purposes.

New Zealand climate varies significantly from year to year and from decade to decade. Long-term climate change will be superimposed on these natural variations, and it is this combination that will provide the future climate extremes, 'Our threats', to which Southland will be exposed.

Not all climate change will be a 'threat'; some changes will be welcome and some will present opportunities. Either way it will require adaptations and adjustments at a regional and local level.

What areas in Southland are most at risk?

Figure 5: Potential flood-prone areas in Southland (based on actual and potential flooding areas)

What we are most at risk from, and where and when

Flooding

Rainfall, drainage and flooding are all interconnected. When rainfall is greater than the amount that land and natural waterways can absorb the land becomes either water-logged or flooded. This can happen as a result of heavy, widespread rain over one or two days, or intense localised rainfall over a period of hours or even minutes.

While we create drainage works to reduce the likelihood of flooding, long or intense rainfall can still overwhelm drainage systems, and during the heaviest rain, even the stopbanks we build to contain swollen waterways can be overwhelmed – see 'What is in place to protect the community', pg 32.

Much of the developed part of Southland is located on floodplains and many of our populated areas have flooded previously and remain under threat – although the likelihood is reduced through current flood management measures. Even previously unflooded areas of historic floodplains are potentially at risk (Figure 5).

Our weather patterns mean we are more at risk from rainfall based flooding in summer than in winter – see 'Our climate', pg 7.

There are also flooding risks resulting from other weather events that create storm surges and high waves in coastal areas – particularly when these coincide with high tides.

Case study: Gore – Living with hazards

Gore is a district covering some 1,250 sq km, with a population of approximately 13,000. The district extends to Arthurton in the east, Waitane in the west, north to Mount Wendon and as far south as Waiarikiki, and includes the main townships of Gore, Mataura and Waikaka.

The town of Gore was first known as Longford, for its Mataura River crossing. Like many early European settlements, its site was dictated by the demands of transport of the day – it sits at the point in the valley where hills meet, meaning people could travel north and south without a hill climb, and at a long ford suited to horses. The land around was highly productive for farming and forestry, and so the town grew, and grew further when it became a railway junction.

Gore's location in the valley makes it particularly prone to extreme weather events including flooding, snowfall and drought.

A number of natural hazards feature in the district's written record, which began in 1836. Flooding presents the main risk, as it creates problems for all forms of transportation, and access to the area can be cut off completely. Newspaper reports of the time suggest floods in 1896 and 1913 were the most devastating the area had seen; damage to houses and shops, massive stock losses and even loss of life was reported.

Stopbanking in Gore has been largely in response to the various floods, as well as requests from the community to improve the system to safely carry larger volumes of water. The first stopbanks were completed in 1918. The first major upgrade of these banks was done in 1963 in response to the 1957 flood. Since then, sections have been strengthened following subsequent events.

Flood schemes were also improved around Mataura following the 1978 floods, when much of the township was inundated.

The flood protection schemes in Gore principally protect the central business district, homes and some major industry. If a large flood was to overtop the stopbanks, there is a particular risk to the west side of town, as floodwater entering this area would be prevented from returning to the Mataura River by the railway embankment or stopbanks. The floodwater then would have to flow through the town to the Cronin and Charlton Creeks before it could exit to the river.

Regional industry and services based in the Gore district include the Alliance Freezing Works, Alliance Pelthouse, Ngahere Sawmill at Mataura, Clover Meats and the Gore Hospital. Many of these industries have put measures in place to reduce their risks, such as raising flood-sensitive equipment. The Gore Hospital has been rebuilt in a new location, inside the protection of the stopbank system.

Drought is also a concern for the district. Northern parts of the catchment typically receive less rainfall and are more prone to drought than coastal and western Southland. Summer droughts particularly impact the dairying industry and the production of milk solids, while autumn droughts have a greater impact on the health of stock and the ability to grow winter feed supplies.

Another important natural hazard for the Gore district is snow and ice. Frozen, snow-covered country roads become impassable to traffic, including emergency services, creating particular challenges for elderly and those living alone. This was an issue for the side roads out of the Mataura Valley during the 'big freeze' of 1996, when night temperatures remained below zero for most of two weeks.

Today, flood alleviation schemes, forward planning and the community's own preparedness are helping to mitigate much of the risk associated with our freshwater natural hazards. However, as the community changes, other things can reduce the value of existing risk reduction measures. For example, public halls and small rural schools, which have traditionally been used as welfare centres, are starting to close down. This poses a greater risk for local families potentially affected by natural disasters. They will either have to fend for themselves for longer in an emergency, or attempt to travel further for support. Complacency among the community is also a risk, as many begin to take the stopbanks and other warning systems for granted, and fail to prepare themselves, their homes and their families for natural hazards on a larger scale.

Figure 6: Gore district

Catchment-wide rainfall

Historically, we have been mainly concerned with floods that result from widespread rainfall that affects all, or significant parts of large catchments, like those of the Oreti, Mataura and Aparima Rivers. These have set our benchmarks: the 'old man floods' of 1878, 1913, 1978 and 1984. Of these, the 1913 flood was the first to affect established townships – Gore, Mataura, Wyndham, Lumsden, Winton and Otautau all flooded for the first time, while the 1984 flood was the most severe to date, flooding more than 900 homes in Invercargill, along with almost all of Otautau and much of western Tuatapere.

All of those townships are now 'protected' from floods of those historic proportions. That does not mean there is no risk: due to flood protection schemes, the likelihood of flooding is considerably less than it was, but if there was a larger flood, the potential consequences would be very high.

Rural areas, where there is less infrastructure in the form of built structures, generally have a lower standard of protection from flooding, reflecting a cost/benefit assessment which takes into account the probability of an event, its consequences and the cost of protection and improvements.

Localised rainfall

Flooding from short duration, intense, localised rainfall, often accompanied by hail and thunderstorms, is not a new phenomenon. However, it is a type of flooding that is likely to become more common. This is partly because historically it has attracted less risk management effort than widespread flooding, and partly because climate change means it is likely to occur more frequently – see 'Climate variability and climate change', pg 18, also 'Hail' later in this section, pg 24.

Records show the Mataura and Waimea valleys and Lumsden are more prone than most Southland areas to extremely intense rain, although these events can occur in any location. With rainfall intensities of around 50mm in 15–30 minutes, even the slightest hollows can become streams and streams can become torrents. Often guttering and stormwater drains cannot cope, causing internal flooding, especially to commercial buildings in urban areas.

The localised nature of such storms means that they are often missed by rain gauge networks. It is only when the storms strike centres of population or disrupt transport systems that they come to the attention of authorities. Records of floods from such events are patchier than our records of widespread floods, often because the streams they affect are small, and are not part of the wider flood-warning network.

Lakeside flooding

Another kind of flooding risk that has not been paid much attention to historically is lakeside floods. Development around Lakes Te Anau and Manapouri makes these areas the most at risk, but lakeside huts around remote lakes, such as Lake McKerrow, have been flooded in the past.

What is 'risk'?

The 'risk' associated with natural hazards is a combination of the probability, or likelihood, that an event will occur, and the degree of harm, or consequences, that it may cause. The level of harm can range from inconvenience to catastrophe.

Understanding risk is important for two reasons. First, knowing how risk comes about helps identify ways of reducing it and, secondly, being able to calculate risk helps with setting priorities for reducing the risks.

The current level of risk associated with any particular hazard reflects identification based on past experience, and the risk management done subsequently to reduce that risk to acceptable or tolerable levels.

To a large extent, especially with flooding, we are now dealing with a residual risk. That is the risk that remains beyond the primary flood alleviation measures already in place.

For example, stopbanks and detention dams are a primary measure, but usually they are not designed to protect against all floods. There is always a risk of overtopping once their protection limit is reached. Minimum floor heights are an example of a method that is used to reduce the 'residual' flood risk, ie when overtopping occurs.

The risk associated with some hazards is more manageable than others, for example it is often easier to manage flood risk than drought risk.

Flooding from storm surges

Southland's freshwater systems include our estuaries, which can be significantly affected by storms involving high winds and/or major drops in air pressure. The resulting storm surges can swamp low-lying coastal areas and estuaries. This is particularly relevant to the New River Estuary – two successive storm surge events in May and June of 1958 are the highest recorded to date at the estuary.

The lift in sea level attributable to storm surge can further increase water levels, which can threaten coastal stopbank systems, especially Invercargill.

Sea level rise

Southland's flooding risks are increasing as a result of sea level rise. This effect of global climate change is already happening and is predicted to increase. Its main effects are accelerated coastal erosion, increased marine inundation (flooding by seawater) and impeded drainage. The last two effects can heighten the risks associated with freshwater-based flooding, especially around estuary areas; their likelihood is directly related to height above sea level – any land below 3–5m above mean sea level can generally be considered to be threatened by sea level rise effects.

Hail

While small hail (less than 5mm in diameter) may be associated with snowfall, larger, damaging hail is most common in late spring and summer, often in association with thunderstorms. It is usually very localised, but can cause considerable direct damage to crops, buildings and vehicles and indirectly contribute to flooding by blocking downpipes and drains. Damaging hail storms are reported every 2–3 years somewhere in Southland, but many probably go unreported. Hailstones the size of hen's eggs, and billiard, golf, or cricket balls have variously been reported, along with a continuous deafening noise.

There is some evidence to suggest that areas more at risk of torrential rain are also more at risk of damaging hail; indeed the two often occur in tandem – see earlier section 'Localised rainfall', pg 23.

Snow

Historic snow records are incomplete and accurate measurements are lacking – this means we rely on records in old newspapers and local history books to build a picture of what could happen. These include an 1878 account of deep snowdrifts in the Gore district, with severe frosts for the following fortnight (cold enough for the Mataura River to freeze over at Mataura). There are also reports of a widespread deep snowfall in July 1939, especially in inland Southland, and a week later a snowfall of up to 150mm in Invercargill – similar to that which fell in September 2010 affecting most of coastal and eastern Southland.

Even with the slight warming of regional temperatures expected with climate change, we need to allow for the possibility of snowfalls like these in the months between May and September. The higher coastal land in western and eastern Southland is more vulnerable than elsewhere, because snowfalls often arise from slow-moving deep depressions embedded in cold south-westerly or south-easterly airstreams. The actual effects of each snowfall ultimately depend on its depth and persistence.

The most common snow threat to Southland infrastructure is snow avalanches on the Milford Road. However, this threat is closely monitored and actively managed by the New Zealand Transport Agency and its contractor, Works Civil, to reduce the risk of loss of life and road closures.

Debris avalanches

One other hazard associated with too much water is debris avalanches. These are rapidly flowing mixtures of broken rock and water. In Southland they are usually associated with steep slopes and heavy rain. Mid Dome is a notable source of debris avalanches in Southland, with one known as the Jobs Ford slip having temporarily blocked the Mataura River in the Nokomai Gorge on at least three occasions since the 1960s. The avalanche material in the river is gradually scoured away over a period of days or weeks as the river bed returns to its former level.

Landslides of various types, including debris avalanches, are common in Fiordland and frequently close the Milford Road for periods of time ranging from hours to days. Generally speaking, however, areas in Southland with high population densities are flat, and landslides are not a significant threat.

Case study: Significant Southland droughts

1956 – The 1956 drought appears to be regarded as the most significant drought in both Southland's and New Zealand's recorded history. Because there were no flow-gauging measurements taken then, it is not known exactly how low many rivers became. However, it is estimated that the Mataura River at Gore reached a low flow of 6 cubic metres/second (cumecs). For large parts of Southland, January 1956 still remains one of the warmest months on record.

1971 – According to locals at the time, the lakes and rivers fell to their lowest levels since the 1956 drought, as a result of minimal rainfall between December and February. Generally, it appears river flows were still above 1956 levels, with the Mataura River at Gore reaching 7.03 cumecs. On the Oreti River, the Alliance Freezing Works Company was forced to bulldoze a small weir across the river downstream of the Riverton–Invercargill highway bridge, in order to raise the water level enough to be able to pump water.

1999 – The 1999 drought is regarded as one of the most severe in recent times, although most river levels were still above the minimums recorded/estimated in 1956 and 1971. The most severely impacted areas were northern and western Southland; however, river flows across the entire region were affected (Figure 7). Great numbers of stock were transported out of the region as pastures dried up and killing space at freezing works was at a premium. This drought prompted Environment Southland to establish a drought response group, to form at the onset of any drought events, with the aim of making sure communications with key user groups is quick and informed and appropriate response options are taken.

2003/04 – Three months of below average rainfall from November 2003 to January 2004 resulted in a relatively significant drought event in northern Southland. This extended to central and western areas as the event proceeded (Figure 8). Major rivers were not reduced to significantly low flows, due to the relatively short duration of the event, and localised thunderstorm activity in catchment headwaters. Significant rainfall in February 2004 alleviated the drought conditions.

Figure 7: River flows at the height of the 1999 drought, 22 February 1999[7]

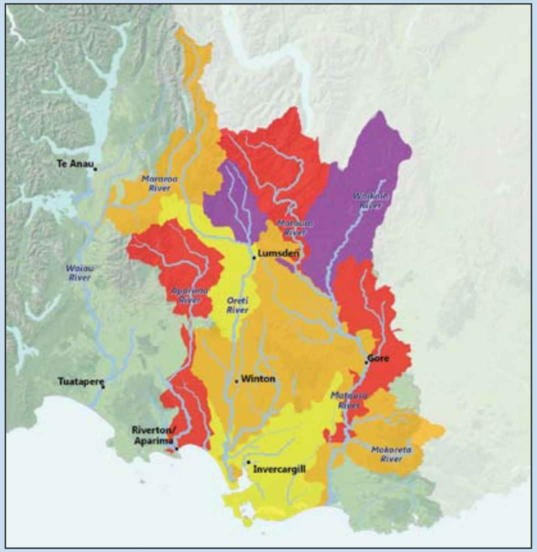
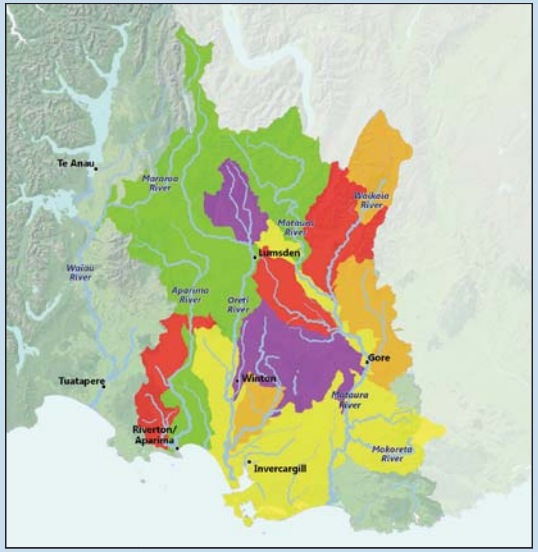


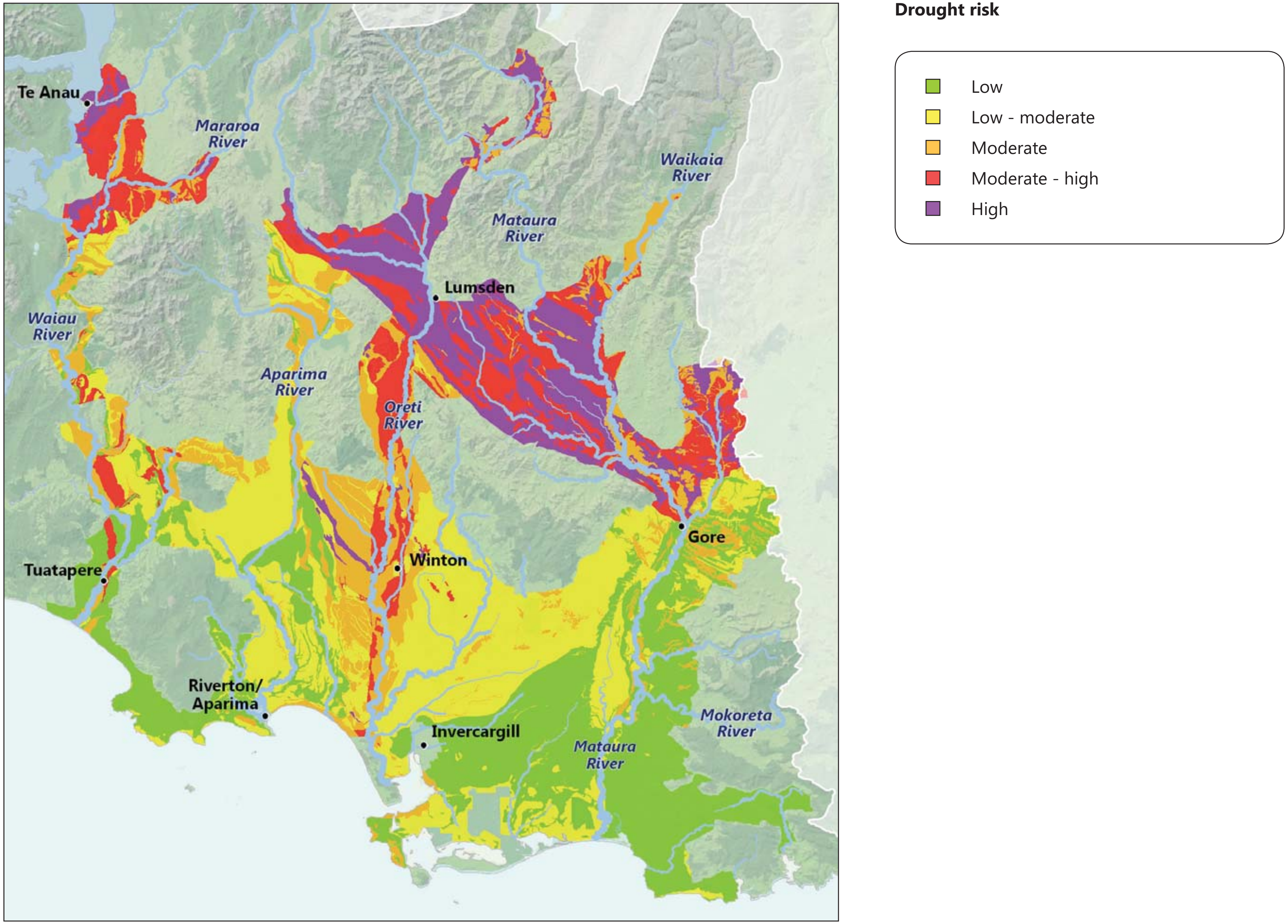
Figure 8: River flows at the height of the 2003/04 drought, 19 January 2004[7]



- Extremely low
- Severely low
- Very low
- Moderately low
- Normal

[7] Figure 7 & 8 data is based on return periods. Normal is < 2 year return period, Moderately Low is a 2 to 5 year return period, Very Low is a 5 to 10 year return period, Severely Low is a 10 to 25 year return period and Extreme Low is > 25 years return period.

Figure 9: Drought-prone areas in Southland, based on climate and soil type



Case study: Living with drought – Rohan and Zella Horrell

Rohan and Zella Horrell own and operate a 400ha sheep and beef property on the Mataura river flats at Ardlussa, near Riversdale. Rohan has lived on the property for nearly all of his life, taking over the property from his father. Living in what he calls 'drought-prone' land, Rohan has experienced many droughts and is very aware of how best to prepare. Rohan says you have to expect there will be a drought any year.

There are many ways Rohan has readied his farm for drought, starting with breed selection. Rohan runs Kelso Composites, a very hardy sheep breed which originated in the dry North Canterbury region.

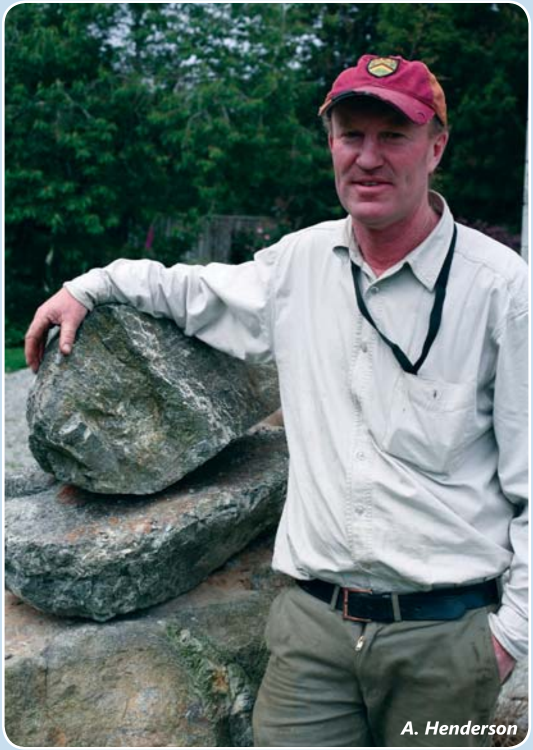
Contrary to most sheep farming operations, Rohan rotates his ewes and lambs around the farm once tailing is over. This means more weight is put on the ewes and they are in better condition going into a dry spell. Feed is grown and it is easier to tell how much feed is available. Rohan tries to have 1000 tonnes of silage on hand just in case of a drought – the silage can be stored for up to 10 years before it is fed out.

If Rohan suspects a dry spell is coming he tries to send his ewes out to grazing before the grass supply gets too low to fatten the lambs left behind. Rohan sends his stock out to areas such as Tokanui, which usually have higher than average rainfalls and therefore plenty of feed during a drought. Rohan has a good relationship with his graziers and uses the same farms each time.

Rohan always tries to get his winter swede crop sown early. By doing this the swedes get a good head start before the dry periods.

Rohan and Zella's farm is very well sheltered, with 95% of the paddocks having some sort of shelter. The shelter belts are side trimmed but never topped. Rohan believes that having tall shelter belts certainly stops the drying nor-west winds from sucking the moisture out of the paddocks, keeping the grass healthy.

When asked whether he believes a drought or flood is more costly to the farm, Rohan says definitely a drought. With a flood you may have some fence damage and stock losses, but the event is over pretty quickly. With a drought there are a number of costs which all mount up, including buying in feed, sending stock away, killing lambs at lower weights, poor winter crops, and stock more prone to health issues.


A. Henderson

Drought

The Southland region generally experiences a temperate climate with reliable rainfall evenly distributed throughout the year and modest evapo-transpiration rates (loss of moisture from plants through evaporation). However, some parts of the region, northern Southland and the Te Anau basin in particular, occasionally experience drought: 'extended periods of below average rainfall, during which agricultural production is adversely impacted by resulting soil moisture deficits' (Figure 9).[8]

In general, droughts in Southland tend to be of limited duration, and have an impact on only part of the growing season. There are two typical drought scenarios that affect agricultural production in the region: summer droughts which impact significantly on stock finishing and peak milk solids production, and autumn droughts which have a greater impact on winter feed supplies and reproductive health of stock.[9]

[8] SKM 2006

[9] SKM 2006

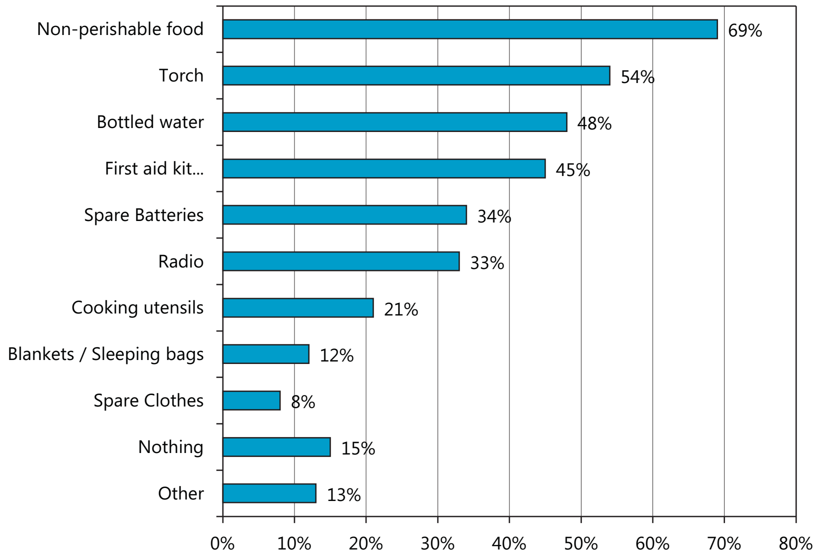
How aware and prepared (for a natural hazard) is the community?

Environment Southland is part of the Southland Civil Defence Emergency Management (SCDEM) Group, which educates about natural hazards and promotes preparedness in the community.

Southland is generally perceived as a resilient community. Community resilience is the overall goal of the SCDEM Group, which works with the Ministry of Civil Defence and Emergency Management to promote awareness and preparedness. Nationally the aim is for people to be able to survive with little assistance after an emergency for at least three days.

In 2010, Environment Southland and the SCDEM Group commissioned a Residents' Opinion Survey to determine how well people understand the risks and how well they are prepared. The questions related to civil defence, likely hazards and the general preparedness of the Southland public.

Figure 10: Emergency supplies Southlanders have ready for use in a civil defence emergency (Versus Research 2010, N= 600)



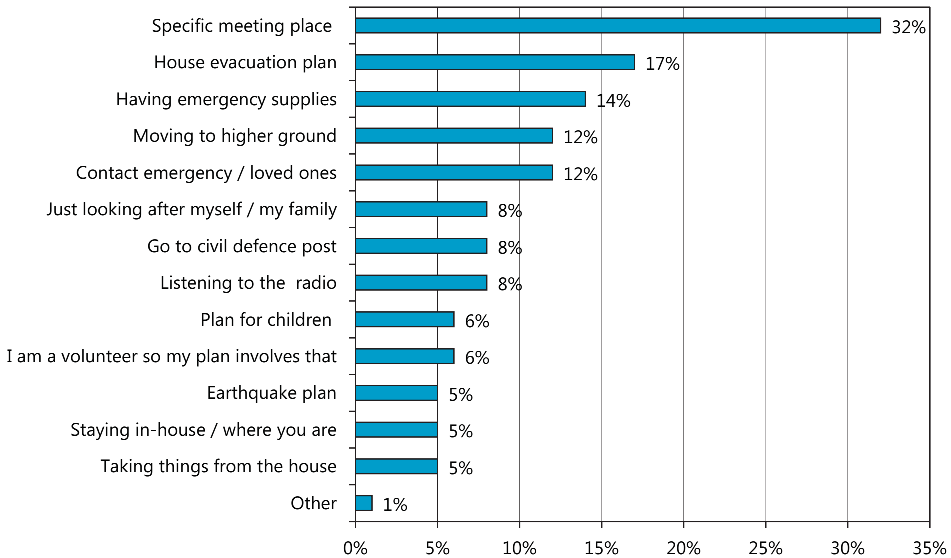
Most Southlanders have some supplies like food and water, although less than a quarter have these in a prepared kit. Only one third have a plan as to how they would deal with an emergency as a household. The region's population is generally perceived as being resilient, but actual preparedness is low (compared to the measure of being self-reliant for three days).

Three-quarters of residents mentioned floods and earthquakes as the main hazard they are likely to face in Southland. Rural residents are more likely to say storm/hurricane/cyclone (21%) and urban residents are more likely to say tsunami (26%). Farmers are more likely to recognise infrastructure failure as the main hazard that could affect them and their families (20%).

Most residents (85%) had some form of emergency supplies ready, although only 23% had these in a prepared emergency kit. The most common items residents had prepared were non-perishable food, a torch and bottled water (Figure 10). Farmers are more likely to say they have a prepared emergency supply kit (35%).

Just over a third (34%) of residents have a plan for coping in a civil defence emergency. Having a specific meeting place (32%) and a house evacuation plan (17%) were commonly mentioned as part of household emergency plans (Figure 11).

Figure 11: For Southlanders who have household emergency plans – what their plans involve (Versus Research 2010, N= 205)



The majority of residents (66%) have no emergency plan (this is not the same as having an emergency supply kit) and the most common reason given for this was not having thought about it (43%). Fifteen percent said they had no plan because they don't think disaster will strike, and 15% have had no time to prepare one.

Just over a third of residents said an expected emergency would spur them into developing a plan, while 13% said an actual disaster striking would make them have a plan for next time.

The SCDEM Group says that the primary way residents will receive information in an emergency is from the radio. According to the survey, 63% of residents expect to receive emergency messages by radio, and it is the most preferred way to receive emergency messages (68%).

What makes us vulnerable to natural hazards?

Throughout the history of Southland/Murihiku we have had to live with natural hazards. We are, as a region, more vulnerable to these events because of where we have developed our towns and infrastructure – in areas prone to flooding and/or drought, and because of our limited preparedness for these events.

Region-wide development

Southland's population is concentrated on its floodplains as it is prime agricultural land: fertile alluvial soils, easily cultivated and irrigated. Townships were formed in support of these farms.

Towns were often built on very small areas of localised high ground. Due to growth in some parts of our region, there has been pressure to develop outside the historic urban areas. In some instances, new development has occurred on lower areas around the original township, greatly increasing the risk of flooding.

Region-wide engineering work on streams and rivers has alleviated some of the issues associated with the periodic flooding of valuable production land, but also created some new issues. This engineering, including the straightening of rivers and extensive drainage enhancement work, has changed the way Southland experiences freshwater hazards. Floodwaters now move down the catchment a lot more quickly. Decreased travel time of flood peaks can have the side effect of increasing the level of flooding at the bottom end of the catchment, although this is generally for a shorter period of time.

Southland is seen as a region with abundant freshwater resources. However, region-wide development of more intensive farming operations has put pressure on these resources. These operations tend to use more water, particularly if irrigation is required, and seek to modify natural watercourses to suit their needs. The increased use of irrigation allows more intensive farming in areas of the region susceptible to droughts, such as the north. These developments actually increase the risk of drought in these areas, as more farms are using the common groundwater and river water resources. In times of low rainfall, minimum level cut-offs will be triggered more often in areas where the water resource is more heavily developed, with the result that water takes will be restricted and farming operations left short of the water supply they depend on.

Lack of knowledge

New Zealanders in general have a low awareness of natural hazards: 21% have no knowledge of what disasters could occur in their area. Southland's population historically had a relatively high level of awareness of freshwater hazards, but as the region goes through generational and population change, the community is beginning to lose this knowledge. Homebuyers born between 1960 and 2000 have little or no memory of previous natural disasters such as floods. New immigrants to the region also often lack this historical knowledge, as well as having little or no understanding of how water can affect the land locally.

Dams, stopbanks and early warning systems can give a false sense of security to people with respect to freshwater natural hazards. While technological advances may have reduced the risk to our communities, there is a lack of understanding of the systems, and their capabilities and limitations. Over reliance on technology, and our community's increasing inability to cope with conditions out of the ordinary means we are less resilient.

Apathy and complacency

Some Southlanders know and accept there are freshwater hazards associated with living in Southland and are prepared accordingly. For many others, the hazards are viewed as unlikely to occur, and they are not motivated to take action ahead of time.

In order to cope with natural hazards we rely on the community to be resilient and self-sufficient. Apathy about preparing for an emergency, or complacency that protection and response systems will provide all the answers, actually increases the risks that natural hazards present.

A 2010 survey shows 15% of Southlanders have nothing prepared for an emergency (not even informal emergency supplies), and many (66%) do not have a household emergency plan – see earlier section 'How aware and prepared (for a natural hazard) is the community?', pg 28. The main barrier to developing a plan appears to be complacency, with most who had no plan stating that they would develop a plan only if an emergency was immediately expected.

Complacency and apathy in the community can result in loss of resources and potentially lives. People who have not prepared for an emergency require a greater level of assistance at the time of a hazard event. When there are more people overall needing help, the response time is longer for those community members most in need. This adds to the community's overall vulnerability to freshwater natural hazards.


K. McGraw

What is in place to protect the community?

In this section we report on the infrastructure that is in place to protect us from natural hazards related to freshwater. Southland has suffered several large flooding events in the last 50 years and many smaller floods and, as a result, the community has generally insisted that priority be given to flood alleviation works to protect them and the things they value. These works are, however, only part of a wider package of measures that are used to manage flood risk.

Detention and retention dams, stopbanks and drainage have been used as the main defence against flooding in Southland. However, these flood alleviation works are not designed to prevent all flooding – as such, there is a significant residual risk to be managed.

While no major community works are in place to protect against drought, there are some small community stock water schemes, eg the Five Rivers Stock Water Scheme. Some individual farmers, mainly in northern Southland, also have their own irrigation systems. There is a considerable response effort that comes into play around droughts when they occur – see 'What we are doing to minimise our risks', pg 36. And there are also a number of mitigation measures that individuals can take – see 'Living with drought' case study, pg 27.

Detention and retention dams

Detention and retention dams are flood control structures which reduce flood flows in a stream by storing water to spread the total flow over a longer period. Retention dams store some water behind the dam indefinitely and this area can be utilised as a wetland and/or wildlife area. A detention dam is designed to temporarily hold water, draining slowly so as to minimise flooding downstream from heavy rain.

Environment Southland maintains four detention and three retention dams on behalf of the community (Figure 12). Waihopai, Otepuni, Kingswell and Winton dams are detention dams which protect urban areas from surface flooding. Clayton's, Lagoon Creek and Dawson City are retention dams in northern Southland protecting rural areas from flooding and reducing the channel and bridge/culvert damage downstream of the structures.

Stopbanks

Environment Southland maintains 448km of stopbanks for flood protection on behalf of the community (Figure 12). These stopbanks are a mixture of urban and rural structures giving an agreed level of protection for these communities.

There are also stopbanks which are maintained by private land owners for their flood protection.

From the late 1970s to mid 1990s, Environment Southland purchased a number of low-lying flood-prone properties as these areas could not be offered flood protection. This land (4598ha) is leased back to farmers for stock grazing.

Drainage

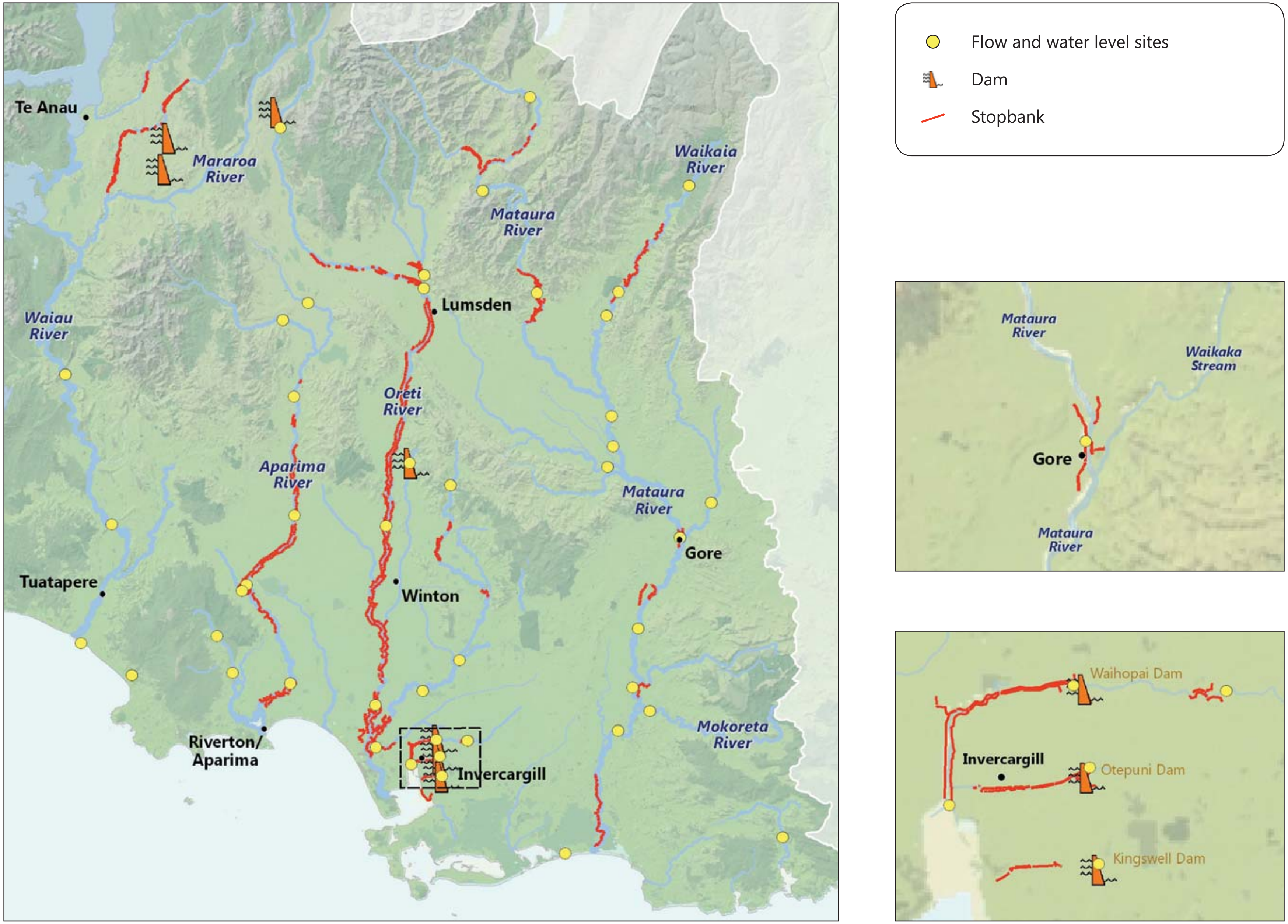
The construction of good drainage systems in Southland has supported the development of a productive agriculture industry. Environment Southland maintains about 1360km of drainage channels on behalf of ratepayers – this is likely to be less than 10 percent of all the drains in Southland. Good drainage is important in managing floodwater as it assists with the draining of heavy rainfall from the land and therefore reducing the flooding potential. The Lower Makarewa River is a good example of this type of drainage works.

Environment Southland also administers a consent for the artificial opening in Waituna Lagoon to the sea, which was created to minimise flooding of farm land. The resource consent for the opening is held by the Lake Waituna Control Association.

Tide gate structures

There are two large tide gate structures which Environment Southland maintains on behalf of the Matarua Rating District: the Titiroa and

Figure 12: Flood protection structures and flood monitoring sites



Gorge Creek structures. These tide gates keep out tidal waters, preventing salt water intrusion into freshwater systems. This also provides drainage benefits to the surrounding land.

Stead Street pumping station

Environment Southland has one pumping station at Stead Street, which assists with the drainage of the Lake Hawkins drainage area and the Invercargill Airport. These areas are low lying land barely one metre above mean sea level. Lake Hawkins was originally a low lying tidal estuary area until the construction of the Stead Street embankment. Due to the land being near sea level, the station pumps water into the Invercargill estuary when required.

Flood-warning network

The history of flood warning in Southland dates back to 11 July 1947 when the Southland Catchment Board issued its first radio broadcast.

The procedure followed has remained largely unchanged, although it is enhanced by the use of automatic rain gauges and water level recorders with radio and cellphone communications, and computer modelling to assist in predicting flood peaks.

Data is collected and automatically relayed to the Invercargill base as frequently as every 15 minutes where it is stored on a computer database. If rainfall or river levels exceed certain 'trigger' levels, the Flood Duty Officer is automatically contacted and begins to personally monitor the situation. If the situation meets critical levels, the Flood Duty Officer contacts Emergency Management Southland and Environment Southland's Communications Officer to start pre-recorded radio broadcasts directing listeners to the Environment Southland website and the Environmental Data Information (EDI) phone-in system.

Technology such as the internet and phone-in systems allows the public to access the data by demand. These systems can also provide users with graphs and historic comparisons, to support their own decision-making. They are now the emergency services' preferred method for giving the public information about flooding risks: interpretation of the data and decision-making about actions such as moving stock are, as they have always been, left up to the public – see 'Communications' in the section on 'What we are doing to minimise our risk', pg 38.

The monitoring network

Environment Southland currently monitors rainfall and river levels.

Rainfall is measured at 36 sites (this includes rain gauges for the soil moisture network installed from 2005–2011). Data is automatically sent in hourly, but updated every 15 minutes when trigger levels are reached.

River levels are measured at 44 sites, 18 of which are flood-warning sites. Flood-warning sites are placed in strategic areas such as the headwaters (to increase warning time) or around populated areas where there is increased risk to life and property. The river level sites in the headwaters of the Oreti, Aparima, Mataura, Waikaia, Waiau and Pourakino Rivers send data back every 15 minutes. Other sites are automatically sent hourly, but updated every 15 minutes when trigger levels are reached.

Flood forecasting

Environment Southland uses two types of flood model to predict flows and levels on Southland's major rivers. Flood predictions are made available to emergency management staff to assist in decision-making and preparing for floods. These models allow us to better prepare for an emergency and give timeframes in which to warn the public of likely river level peaks and potential damage to infrastructure.

1. Flow routing models

Environment Southland uses these models for the Aparima, Oreti, Mataura and Waikaia Rivers.

The flow at a particular site is estimated by combining the flow from two or more sites upstream from that point. A time delay is applied to each of these sites to allow for the time the flood peak takes to arrive at the downstream site.

2. Rainfall runoff models

Environment Southland uses these models for the Oreti, Mataura, and Waihopai Rivers and the Otepuni Stream and Kingswell Creek.

The flow at a particular site is estimated by taking rainfall measurements in the headwaters and calculating how much will run off into the rivers and when the resulting peak will arrive downstream. These models give up to 10 hours earlier warning than the flow routing models can – however, the estimates are less accurate because of the wide variety in rainfall and runoff conditions within a catchment. This is why they are often used in combination with methods based on experience with earlier floods.

The rainfall runoff models are early warning models and are used in the upper reaches of the catchment. In larger catchments we have flow sites in upper and lower reaches. We can measure actual flow in the upper reaches. This is used to model the lower reaches because it is more accurate.


M. Poole

What we are doing to minimise our risk

Environment Southland and Te Ao Mārama Incorporated prepare, plan and implement a variety of approaches that help Southland communities minimise their risk from natural hazards, particularly floods and droughts. We carry out joint work with a number of agencies through the inter-council organisation Emergency Management Southland (see pg 39).

The management of risks associated with natural hazards has evolved over time as our knowledge increases and public expectations change. Risk management is now a lot more formalised, integrated and structured than in the past.

Risk minimisation actions are implemented at government, community and individual levels. This section outlines what happens at a regional and national level – see 'What you can do' for community and individual action, pg 43.

Planning and policy development

Land use is managed under the Resource Management Act 1991 (RMA), and one of the stated goals is to avoid or mitigate the effects of natural hazards. In broad terms, the measures used include hazard maps, avoidance of development of the most hazard-prone areas, separation or set back distances (for example minimum floor heights in flood-prone areas, or buffer zones along the coastline or river banks) and property-specific hazard information that informs individuals and enhances preparedness. The measures take into account climate change predictions and advice contained in Guidance Manuals for Local Government produced by the Ministry for the Environment.

The Building Act 2004 requires new buildings to be able to cope with snow, wind and flooding. As such, the vulnerability of buildings to flooding is considered during the building consents process. In some cases, notices are placed on the title to record the existence of the hazard and absolve the territorial authority of liability in the event of subsequent damage.

Environment Southland maintains a significant amount of hazard information, including photos and reports on historic flood events. The territorial authorities therefore forward relevant, building, subdivision and land use consent applications to Environment Southland for comment. Environment Southland also handles many direct requests for information from landowners or people looking to purchase property.

Hazard mapping

Hazard maps show the areas that could be affected by a hazard. Some hazard maps show the existence of a hazard, as shown in Figure 5, while others map the degree, occurrence, or likelihood of the hazard, as shown in Figure 9. Some may be event specific like those in Figures 7 and 8.

Territorial authorities also often include some hazard information on maps in their District Plans.

At a local level, considerable effort goes into refining past work that identified flood prone areas and the size and potential extent of flood events.

Information and education

Hazard maps are a useful starting point, as they flag the existence of a hazard, but more detailed information is required before the hazard can be managed.

Information is the cornerstone to planning for the occurrence of natural hazards. That planning occurs at all levels, from individuals purchasing a property to infrastructure managers looking to build a resilient network.

Territorial authorities are required to supply natural hazard information that is known to them via the Project Information Memorandum process under the Building Act 2004, or when such information is requested through the Land Information Memorandum process under the Local Government Official Information and Meetings Act 1987.

Regulation and enforcement

Environment Southland and the territorial authorities are responsible for applying laws and regulations. In the area of hazard management this can include:

- Restricting (or declining) commercial, residential and industrial developments if the building is on hazard-prone land. For example, subdivisions may be declined if they are planned for flood-prone lands. Alternatively, in areas of less risk, developments may have minimum floor height restrictions imposed, to reduce the likelihood of buildings being flooded in the future.
- Restricting water takes from surface and groundwater in the region – minimum flow and level restrictions/cut-offs apply to the region's water resources, and need to be enforced during dry conditions to maintain the necessary water levels to avoid the adverse effects of drought.

Environment Southland plans and procedures

Local authorities are required to produce long-term plans every three years that specify community outcomes and identify issues of significance, including the maintenance, upgrade or building of strategic assets, eg stopbanks, retention and detention dams and the drainage network.

Southland's Regional Policy Statement is currently being reviewed by Environment Southland. This review has highlighted Southland's susceptibility to natural hazards. As the Regional Policy Statement provides direction to all other planning documents, the review is likely to direct other plans to include a greater emphasis on hazard risks.

The Southland Flood Control Management Bylaw makes provision for the protection and management of flood control works undertaken by the council. The bylaw applies to all flood control works that are intended to stop, control or restrict the flow or spread of floodwater in some way.

Flooding is also considered in a limited way in the Regional Water Plan for Southland, the Regional Land Transport Strategy, and the Solid Waste and Effluent Plans (the last two of which are also currently under review).

The Regional Water Plan for Southland provides specific flood protection work rules to help minimise the risk of natural hazards. These include rules specifically allowing flood protection works such as erosion control structures and drainage maintenance activities, as well as controls to prevent impacts on flood flows within the activities regulated by the plan.

The Water Shortage Standard Operating Procedure is one means to giving effect to Environment Southland's responsibility, under the RMA, to manage the adverse effects of water resource use. This document complements other plans by outlining Environment Southland's standard operational procedures during a water shortage. It provides a framework for decision-making; maintains open communication with water users; supports the fair treatment of water users during a water shortage; and enables Environment Southland to fulfil its function under the RMA.

Te Ao Mārama Incorporated planning

The *Ngāi Tahu ki Murihiku Natural Resource Management Plan 2008: Te Tangi a Tauira – the Cry of the People*, specifically identifies climate change as a key issue for Māori. Māori see the world as a unified whole, where all elements are connected. Emphasis is placed on maintaining the balance of cultural and spiritual values in the environment. The changes brought on by a warming global climate caused by human interference directly affect this balance. Climate change has the potential to change the indigenous flora and fauna that Māori consider as taonga. There are currently no established tribal policies with respect to climate change; however, the plan outlines areas for advocacy as well as areas for engaging and actively contributing to a range of local and national policy and planning initiatives. Examples of such policies are to 'Support sustainable energy systems (for houses, water and transport) to meet social and cultural needs while minimising environmental impact' and 'Support Māori ownership of climate change issues through more active involvement of Māori in science, environmental management and policy development.'[10]

[10] Ngāi Tahu ki Murihiku 2008

Investigations and research

Flood modelling

Environment Southland uses computer flood models to predict magnitudes and arrival times of flood peaks – see 'Flood-warning network', pg 34.

Engineering Lifelines study

'Lifeline utilities' are defined as organisations that provide vital infrastructure services to the community, such as water, wastewater, transport, energy and telecommunications. A lifelines study compares the asset information from each utility with known and potential hazards to predict likely failure areas in an emergency. This allows planning for risk reduction, and for recovery following an emergency. Lifeline utilities share information on their assets and work together to reduce the risks to the community from any emergency.

The Southland Engineering Lifelines Group is developing a vulnerability study of the region's lifeline assets. The group is formed under Emergency Management Southland and is made up of representatives from Environment Southland, the region's territorial and road controlling authorities, and power and telecommunication companies.

Longer term, the group will look at the action plans developed by utilities to help reduce the risks associated with identified problem areas. These plans will incorporate measures to protect vital services from the predicted effects of climate change.

Maintenance of infrastructure

Environment Southland continues to maintain structural protection from floods, such as stopbanks, and retention and detention dams, to protect local communities. We also conduct a drainage maintenance programme.

From the late 1970's, all the main rivers in Southland had their designated flood fairways cleared of vegetation and an annual programme of physical and chemical works keeps flood fairways, the central part of the river bed, clear of major obstructions.

The Lower Mararoa River was the last river to have the flood fairway clearance work completed which entailed the removal of willow and vegetation. This has restored many of the original natural values to this section of the river.

Over the next 10 years, Environment Southland will review all its flood alleviation schemes to see if the schemes still provide the level of flood protection the community desires. This review will take into account the predicted rainfall increases due to climate change.

Communication

Radio

- During floods, if the situation reaches critical levels, pre-recorded radio messages are broadcast directing listeners to the Environment Southland website and the Environmental Data Information phone-in system.
- If the flood escalates, Environment Southland will issue regular flood-warning messages and river level bulletins to all radio news media in Southland.
- Due to the limited local coverage during weekends and week-nights, Environment Southland and the two main radio stations (Classic Hits and More FM) have an agreement that the station will activate if an emergency warrants it.
- You can find the frequencies of the stations to listen to on www.es.govt.nz.
- Emergency Management Southland may also use radio in cases where evacuations are necessary.

Telephone services (Environmental Data Information system)

- As part of the technology at a number of our river monitoring sites, Environment Southland has an automated telephone service that allows people to find out the current river level at a given site. These telephone numbers are available in all areas that may be affected by flooding.
- The phone number for this service is 03 211 5010.

Internet

- Flood warnings, river levels, rainfall and other weather-related data are available on the Environment Southland website. The rainfall and river level information is the most popular part of the Environment

Southland website, receiving more than half of all visits to the website. When not in flood, the data is still used by farmers and recreational river users.

- Environment Southland's Soil Moisture Network and Groundwater Monitoring Application provide online information to farmers to help them make informed decisions about their farming practices. This information can be useful to help indicate possible drought, or to measure saturated soils.
- Environment Southland's website is www.es.govt.nz. You can use the search to find 'river levels' or 'rainfall'. If there is a flood warning on, you will see this displayed clearly on the homepage.

Printed materials

- Environment Southland produces river catchment information brochures for the main river systems in Southland containing detailed information such as flood-warning information, flood peak travel times and historical peak flood heights.
- We encourage preparedness through articles in our regular publications, EnviroSouth, Enviroweek and Enviromoos, the Squawk and Brucie's Buddie's Bulletin.
- We publish preparedness messages regularly in newspapers.
- During an emergency, we work closely with print journalists to ensure timely and accurate reporting of the situation.

Working with the community

- Land sustainability officers provide advice on:
    - reducing risk of flooding through retaining vegetation cover on upland catchments and maintaining wetlands in mid-catchment areas
    - promoting natural flood mitigation measures
    - planting and maintaining of shelterbelts for drought protection and soil conservation.
- Call 03 211 5115 to talk to a Land Sustainability Officer. They can come and visit you on your property.
- Environment Southland works with several communities that have chosen to live with flooding, eg Mataura Island, rather than build stopbanks to lower the flood risk. These communities have made a conscious decision to respond differently, choosing to rely on Environment Southland's flood-warning system and their own contingency plans.

Emergency Management Southland

Emergency Management Southland is the collective inter-council organisation (incorporating Environment Southland, Invercargill City Council, Gore and Southland District Councils) that provides all civil defence emergency management services across the region.

Emergency Management Southland employs four staff who are responsible for the planning and preparation of our community for an emergency. During an emergency they set up a dedicated Emergency Operations Centre, and can call on volunteer assistance across the region from the Red Cross, Salvation Army, and civil defence sector volunteers. Emergency Management Southland is also supported by and works with the police, fire and ambulance services, as well as the district health board and other key agencies. Staff from Environment Southland and from the other councils will take on key roles within the operations centre during an emergency, such as controller, public information manager, operations manager, and logistics manager. During a flood, Environment Southland's Flood Duty Officer also plays a key role – see 'Flood-warning network' on pg 34.

Case study – Michael Skerrett, Kaupapa Taiao Manager, Te Ao Mārama Incorporated

Michael is the Kaupapa Taio Manager at Te Ao Mārama Incorporated and has many of the same responsibilities as other small business managers: looking after finances, staff and compliance with business legislations.

What sets his role apart from other managers is his responsibility to facilitate Ngāi Tahu iwi input into the processes required by the Resource Management Act 1991 (RMA) and other relevant legislation. This often involves consultation between the councils and the papatipu rūnanga (traditional marae-based communities), and arranging workshops to provide input or develop submissions on plans, policies or other people's submissions.

Michael has an extensive knowledge of Ngāi Tahu matters, local issues and environmental processes, both in New Zealand and around the world. He also takes a keen interest in the harvests of oysters (tio) and mutton birds (tītī). He has been going to the tītī islands for approximately 57 years – since he was a child.

Michael is particularly interested in climate change and climate variability, particularly the El Niño Southern Oscillation, and the El Niño and La Niña cycles and their effects on the environment. He acknowledges that climate variability occurs naturally, but has also observed changes in intensity over time. Michael believes climate-related issues need good leadership and strong will from politicians.

Over many years of harvesting, Michael has observed changes in the abundance and health of the tio and tītī and the correlations between the two. He has also observed tītī and tio numbers crash during the El Niño Southern Oscillation cycle, coinciding with poor breeding and lack of food. Another observation is the mass seeding, or good flowering years of cabbage trees (tikouka) and flax (harekeke), coinciding with good tītī seasons.

The tītī harvest has strict rules in place to sustain the population. But the biggest threat to our tītī is climate change, Michael says. The fact that this mahinga kai harvest is unbroken is very special, as most others have either been lost, or at least been broken or not continuous. Being able to offer tītī and tio is also a special part of manaakitanga or hospitality when visitors come to marae in Southland.

Climate change, beyond existing long-term patterns of natural variability, could be devastating to families for hundreds of years to come. Michael says: "The ability to harvest (especially tītī) is a big part of their life and it can affect their feeling of being at home and being able to walk in ancestors' footsteps."

A. Henderson

Case study – Dallas Bradley, Senior Planner (Hazard Mitigation), Environment Southland

Dallas started as a hazard mitigation planner at Environment Southland in 1987, coming from a background in surveying and overseeing construction of new stopbanks. He began by preparing floodplain management plans that looked at how the flood-prone areas around Invercargill would be managed in the future.

Hazard mitigation planning is about providing information, advice and recommendations around land use development (like buildings, subdivisions) to members of the public, and city and district councils. Recommendations might include minimum floor heights (to avoid floodwaters) or the density of housing in hazard-prone areas. Dallas's role is to raise people's awareness about historical or potential hazards on their property, aiming to minimise their risk of being affected by a hazard. He also records information on hazard events that occur, to inform future advice. "Unless a concerted effort is made to record such events in a structured way, it is amazing how quickly such events are completely forgotten," Dallas says.

Anyone can contact Dallas. Usually people contact him when purchasing new property, or are looking to construct a new building or undertake subdivision. Dallas uses a variety of historic photos, reports and anecdotal information to provide people with a report of what has happened there in the past and may happen in the future. While most people enquire about flood risk, some situations also require him to consider coastal erosion, land instability, marine inundation and tsunami risks. "It is difficult to provide an absolutely accurate assessment of risk," Dallas says, "as past records are often incomplete or the 'ideal' information is simply unavailable. On top of that, climate change adds to the uncertainty and potential magnitude of future events."

Dallas finds that attitudes towards natural hazard risk are extremely variable and are changing. Some people are extremely cautious, others accept the risk and manage it accordingly, but many never seek information at all. After the 1984 flood, Southlanders were very aware and concerned about flooding, but since then, with people moving to Southland and new generations coming along, awareness is diminishing. "We can't be complacent and we have to take a long-term view. History is characterised by the infrequent occurrence of big and bigger floods or other natural hazards. We are constantly setting new weather-related records of some sort – the snow in 2010 for instance."

One of the rewarding aspects of Dallas' role is providing people with information and advice that enables them to make more informed decisions. A recommendation of floor height, or where to put a hay shed, can make all the difference to people and animals when the area is in flood. The ultimate aim is to be able to experience a flood and carry on life as normal, he says – in other words 'sustainable management'.

K. Yardena

What we don't know and could do better

What we don't know

- We know little about the full extent the impacts of climate change or hazards will have on things we value in cultural terms.
- We have very little natural hazard information for smaller coastal catchments outside our rating districts. We also have limited hazard information on many of the catchments in Fiordland and Stewart Island/ Rakiura, for example the Hollyford River and Lake McKerrow.
- There is a lack of historic natural hazard information or historic rainfall information for some areas, which means that the data recorded may not be representative of what has happened in the past. This makes it difficult to calculate accurate probabilities about what may happen in the future.
- We are not able to accurately predict future major land use changes and how this might affect river flows due to changes in drainage channels.

What we can do better

- Environment Southland has a wealth of information on hazards that could be made more available to the public. This could include more detailed information on the Environment Southland website.
- Technology is available to support more precise flood modelling, which would improve our flood-warning system. Long term, flood modelling could also be improved by having a rainfall radar which is calibrated to our own field rain gauges – providing more accurate rainfall data to help better predict flood peaks. Extending the flood-warning network would also assist in more precise flood modelling.
- Nationally, Civil Defence encourages people to be able to survive for three days on their own. In conjunction with Emergency Management Southland, we could direct further efforts into educating and promoting ways that people can prepare themselves for three days on their own.

What you can do

While this report deals with freshwater hazards, much of the information about what you can do applies to other hazards, including earthquakes and tsunamis. More information on these can be found at www.getthru.govt.nz.

At home

- Prepare your household emergency plan. Determine where your household and/or family would meet if you were not together when an emergency occurred. See Emergency Management Southland's website, www.civildefence.co.nz for more information for your plan.
- Keep important documents together and include them in your plan of what you would take with you if you had to leave your home.
- Prepare an emergency supplies kit and store at least three days' supply of water per person. Power may be a problem, so make sure you have a battery powered radio to get the most up-to-date information. Go to www.getthru.govt.nz for a list of suggested items.
- Keep extra prescription medication in your emergency supplies kit. Remember to keep it 'fresh'.
- Find out from previous owners, neighbours, or the council if your property has flooded in the past. District Plans contain maps identifying land that may flood, or you can contact your local council or Environment Southland for property-specific information.
- Have adequate insurance.
- Before you buy or build, check with Environment Southland or your local council on what hazards there are to be aware of in the area, and if this could affect your consent application.
- To learn more about climate change, go to www.climatechange.govt.nz.

At work

- You can get road closure information on the local radio stations but it is also available from the AA and Southland District Council websites (www.aa.co.nz and www.southlanddc.govt.nz).
- Discuss with your household and/or family where you would meet if you were not together when an emergency occurred.
- Prepare a workplace emergency kit and store at least three days' supply of water per person.

On the farm

- Get familiar with the Environment Southland website, so you know where to get up-to-date information on river levels near you. This information will help you to plan for future floods, eg knowing when to move stock (www.es.govt.nz).
- Prepare flood and drought contingency plans.
- Prepare your stock and land for drought, especially if you live in a drought-prone area. Refer to the 'Living with drought' case study, pg 27, for examples of measures you can take to prepare for drought.
- Consider your location before building and seek advice from Environment Southland regarding the possible hazards in the area and how these may affect your consent application.
- Get advice from Environment Southland before planting, building, or clearing within a floodway or on flood-prone land.

Glossary

Annual exceedance probabilities: the probability of a particular size flood occurring in any given year.

Debris avalanche: a mass of rock fragments and soil that moves rapidly down a steep mountain slope or hillside. It may also incorporate water, snow, trees, bridges, buildings, and anything else in its way.

Detention and retention dams: flood control structures that hold back flood waters for a planned period to take the peak off the downstream flow.

El Niño: surface waters in the eastern Pacific Ocean along the western coast of South America are warm and the air surface pressure in the western Pacific is high. El Niño promotes increased rainfall and flooding for the South American countries while New Zealand experiences generally drier than usual, and in some cases, drought conditions.

El Niño Southern Oscillation (ENSO): is a climate pattern that occurs between El Niño and La Niña conditions across the Pacific region. The Southern Oscillation is the see-saw pattern of reversing surface air pressure between the eastern and western Pacific; when the surface pressure is high in the eastern Pacific it is low in the western Pacific, and vice-versa.

Evapo-transpiration: is the loss of moisture from plants through evaporation.

Flood modelling: is the computerised method of predicting the timing and site of flood peaks on a particular river. It includes flow routing models and rainfall runoff models.

Floodplain: a typically flat area near a river or a stream that floods easily. Natural floodplains slow the flow of the water, help prevent flooding further downstream and reduce damage caused by debris.

Hazard: poses a level of threat to life, health, property, or environment.

Hazard map: a map highlighting areas that are affected or vulnerable to a particular hazard. They are typically created with respect to natural hazards such as floods, earthquakes and tsunamis.

Hydrology: the study of the movement, distribution, and amount of water.

Interdecadal Pacific Oscillation (IPO): an oscillation in the ocean–atmosphere system that shifts climate variables such as sea temperature in the Pacific region. The cycle has been observed over time periods ranging of up to 30 years.

Kaitiaki: is the Māori concept for guardianship of the sky, the sea, and the land.

Kaitiakitanga: means the act of guardianship exercised by the tangata whenua over an area in accordance with Māori beliefs relating to natural and physical resources. It also includes the ethic of stewardship.

La Niña: a cooling of surface waters in the eastern Pacific Ocean with stronger than average trade winds. These force warm surface water to be blown across towards the western Pacific. La Niña has the opposite effect to the El Niño system.

Manawhenua: traditional/customary authority or title over land, and the rights of ownership and control of usage on the land, forests, rivers etc. Manawhenua is held by an iwi or hapū rather than individuals.

Manaakitanga: support, caring and hospitality, as shown towards guests.

Papatipu Rūnanga: Traditional local Māori Councils. Papatipu Rūnanga in Southland are Waihopai Rūnaka, Te Rūnanga o Awarua, Te Rūnanga o Oraka/Aparima and Hokonui Rūnaka.

Probable maximum precipitation (PMP): theoretically the maximum depth of rain for a given duration that is meteorologically possible over a certain area, at a particular time of year.

Rāhui: is a restriction imposed on an area for gathering food or resources. Rāhui may be placed on land, sea, rivers, forests, gardens, fishing grounds, and other food resources.

Residual risk: the risk, or danger of an action or an event that remains, even after other known risks have been countered, factored in, or eliminated.

Return period: the average interval of time until the re-occurrence of a defined event.

Storm surge: a storm surge is an offshore rise of water associated with a severe weather system. Strong winds, low atmospheric pressure and contours of the ocean floor cause water to pile up forming waves much higher than usual. The surges of water that result, have the potential to flood and cause damage to low lying land.

Tapu: a Māori term for sacred or forbidden. Places, people or objects which are tapu must be left alone. They should not be approached or interfered with, and in some cases, they should not even be spoken of.

Wahi tapu: a place sacred to Māori in the traditional, spiritual, religious, ritual or mythological sense.

G. Carnie

References

Fraser, A. 2002. *Weather Hazards, Invercargill City Lifelines Project Hazard Report.*

Ministry of Agriculture and Forestry (MAF). 2009. *Drought Guide – Drought definition, recognition and assistance measures.* Accessed 4/02/2011 online http://www.maf.govt.nz/news-resources/publications.aspx.

Ministry of Civil Defence & Emergency Management. 2010. *Campaign Monitoring Research 2010*, Colmar Brunton, 25 July 2010.

Ministry for the Environment. 2008. *Climate Change Effects & Impact Assessment – a Guidance Manual for Local Government in New Zealand,* 2nd edition. ME number 870.

Ministry for the Environment. 2001. *Kyoto Protocol – Ensuring our future, Climate Change Consultation Paper.* A document prepared by the New Zealand Climate Change Programme. ME number 416.

Ngāi Tahu ki Murihiku. 2008. *Te Tangi a Tauira: Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan.* Te Ao Mārama Incorporated. Invercargill. Available at www.es.govt.nz.

NIWA. 2003. *The Climate Update*, October 2003.

Officials' Committee for Domestic and External Security Coordination (ODESC). 2007. *National Hazardscape Report.* ODESC, Department of the Prime Minister and Cabinet, Wellington.

Cyclopedia Company Limited. 1905. in *The Cyclopedia of New Zealand [Otago and Southland Provincial Districts]* Vol. 4, pp. 776–778. Published by The Cyclopedia Company Limited, Christchurch, N.Z.

Our Way Southland. 2009. *Southland's Community Outcomes: monitoring report for the period 2005 – 2009.* Published by Environment Southland, Invercargill City Council, Southland District Council and Gore District Council, June 2009. Available on the Our Way Southland website: www.ourwaysouthland.org.nz

Sinclair Knight Merz (SKM). 2006. *Southland Water Resource Study Stage 4.* Report Prepared For Venture Southland.

Sorrell, P. (editor).2006. *Murihiku – The Southland Story.*

Tait, A., Burgess, S., Mullan, B., Reid, S., Thompson, C. 2006. *Meteorological Hazard Assessment Report for the Southland Engineering Lifelines Project.* Prepared for Southland District Council. NIWA client report WLG2006-52. Wellington.

Versus Research Ltd. 2010. *Environment Southland: Residents' Opinions Survey 2010.*

Wratt, D. 2006. *Natural Disasters in our Changing Climate – a Look at the Major Risks Affecting NZ Civil Defence & Emergency Management,* Emergency Management.

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For further information, see www.es.govt.nz

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Protection of ecosystem services for flood management	Land sustainability officers, Environment Southland
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