Earth Sciences New Zealand

Societal vulnerability to flooding: Little River/Wairewa case study

Summary of qualitative insights and description of a causal diagram

Prepared for MBIE programme: Increasing flood resilience across Aotearoa

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Executive summary

Flooding is Aotearoa New Zealand's most frequent and consistently damaging hazard. It results in injuries and death, stress, loss of property, reductions in quality of life and delays in life progress (e.g., education), as well as significant financial cost for individuals and society. An increasing frequency and intensity of extreme rainfall and floods due to climate change will increase both the tangible and intangible effects of flooding over time.

The MBIE-funded research programme *Mā te haumaru o ngā puna wai o Rākaihautū ka ora mō ake tonu: Increasing flood resilience across Aotearoa* aims to improve understanding of flood risk and increase flood resilience in Aotearoa New Zealand. Among other things, the programme seeks to improve understanding of how flood impacts cascade (flow on) through Aotearoa New Zealand's social and economic systems. This helps us understand whether and how communities can tolerate future flood risks, and what efforts might be targeted to reduce future community vulnerability to floods.

To investigate flood impacts and resilience, three case study communities subject to repeat flooding were identified: Auckland, Waikanae and Little River/Wairewa. Semi-structured interviews were undertaken with a range of participants in each area. Findings from all case studies were initially collated into a thematic analysis, identifying important issues and topics that were raised, and commonalities across the case study areas. Then for each individual case study, the cause-and-effect relationships between key interview themes were identified and supplemented with key findings on local cascading (flow-on) flood impacts emerging via media reports. Additional analysis followed to explore causal relationships. These were developed into a causal diagram to capture the dynamics of cascading flooding impacts in each case study.

This report summarises the findings for the *Little River* case study.

Five key groupings of causal relationships were identified that present the way in which the Little River community may become more or less vulnerable to flooding. These groupings, along with feedback loops that help explain their dynamics, comprise the causal diagram outlined in this report. The causal diagram demonstrates how each of the groups, loops and variables interact and influence one another over time. The five key causal groupings for Little River were:

- *Flood impacts* – how climate change is increasing the frequency and severity of flood events and associated negative impacts on the mental and physical wellbeing of the Little River community.
- *Experience of flooding and action to reduce risk* – how personal and community experience of flooding influences the degree to which actions are taken to reduce future flood risk. This includes the level of individual and collective lived memory of previous floods, and its relationship with complacency about future flood risks.
- *Desire to remain in place* – how residents' sense of community influences their desire to stay within Little River and, in turn, their tolerance of flooding.
- *Community and council relationships* – the complexity of the relationship between the Little River community and its local and regional councils, and how this affects the collective actions taken to reduce flood risk.

- *Insurance* – the relationship between insurance cover and the ability of local businesses to operate following a flood event.

Across the three case studies, we identified four high-level interactions that contribute an understanding of how flood impacts cascade through Aotearoa New Zealand's social and economic systems in ways that can increase community vulnerability to harm. These are *time*, *tolerance*, *adaptation willingness*, and *agency/hope*:

1. It takes *time* for the full consequences of floods to become apparent, and the time between events matters – if flooding occurs again before people are fully recovered, their trauma or stress accumulates, with implications for community wellbeing and relationships with councils. Time also fades memories – without knowledge of what has happened in the past, there is little motivation for change and actions to reduce the risk of future flood impacts.
2. *Tolerance* to flooding varies, particularly to the cumulative impacts from flooding. Threats to life, quality of life, property investments, and personal investments in future lifestyles all affected people's willingness to tolerate future flooding.
3. The *willingness to take adaptation measures* to reduce future flood risk is affected by both personal and collective experience or knowledge of past impacts.
4. Where there is personal, collective, and council *agency* to adapt to future flooding risk, people have *hope* for their future in place in their community. The perceived ability to manage flood risk supports, and is motivated by, connection to place and community.

Addressing these causes of vulnerability should happen across the 4 Rs of emergency management – Reduction of risk, Readiness and Response to events, and Recovery from events. This includes:

- Supporting people's ability to function in everyday life over the extended recovery period.
- Acknowledging and mitigating the trauma caused by flooding, no matter the scale of events.
- Supporting community connections and functioning before, during and after events.
- Creating and maintaining collective knowledge about flood events to increase the appetite for flood harm reduction measures.
- Building and maintaining collaborative working relationships between communities and their respective councils.
- Supporting investment and regulations that manage and mitigate flood risks.

For communities in Little River specifically, this raises questions about how to keep collective memories of previous flooding alive, how to increase understanding of individual and collective options to reduce flood risk, how to maintain community and council relationships, and how to sustain the community connections for residents' ability to tolerate and recover from flooding.

1 Introduction

1.1 Programme information

Flooding is Aotearoa New Zealand's most frequent and consistently damaging hazard. Floods can result in injuries and death (e.g., NZ Herald 2019; NZ Herald 2023; Weekes and Ryan 2015), as well as other significant impacts such as stress, loss of personal artifacts and family heirlooms, reduced quality of life and delays in formal education (Fernandez et al. 2015; NZIER 2004). At a financial level, floods in Aotearoa New Zealand regularly damage houses and infrastructure networks, causing months of disruption to communities and businesses. The Insurance Council of New Zealand (2024) estimates the annual cost of extreme weather to Aotearoa New Zealand to be generally in the order of NZD$350 million, with individual flood events being especially costly. For example, the New Zealand Treasury estimated total damages from the 2023 Auckland Anniversary floods and Cyclone Gabrielle to be NZD$9–14.5 billion (RNZ 2023). Recovery planning for the Auckland Anniversary weekend floods of 2023 is presently in the order of NZD$4 billion (Scott 2023).

Flooding around Aotearoa New Zealand reflects a variety of factors including low-lying coastlines (rendering the area susceptible to coastal inundation during storms), steep hills (contributing to flash flooding) and often urbanised environments (where absorption of overland flows is limited by the scale of the drainage systems and or available land for over wash).

As climate change is projected to increase the frequency and intensity of extreme rainfall, the effect is that floods are likely to occur more often (Ministry for the Environment 2010), increasing the scale and frequency of tangible and intangible flood impacts over time.

The MBIE-funded research programme *Mā te haumaru o ngā puna wai o Rākaihautū ka ora mō ake tonu: Increasing flood resilience across Aotearoa* aims to improve understanding of flood risk and increase flood resilience by providing better evidence for public policy (NIWA 2024). Among other objectives, the programme seeks to improve understanding of how flood impacts cascade through Aotearoa New Zealand's social and economic systems. This understanding provides the foundation for considering whether and how communities can tolerate future flood risks, and what efforts might be targeted to reduce community vulnerability to floods in the future.

This report outlines generalisable insights on the cascading nature of flood impacts across Aotearoa New Zealand. It is not intended to identify specific, prescriptive recommendations for action – this would require dedicated policy research and assessment.

To understand the cascading impacts of flooding, the following steps were taken:

- Three case study communities subject to repeat flooding were identified: Auckland, Waikanae, and Little River/Wairewa. The case study communities were consulted to identify the cascading impacts that they experience. The case studies were selected to capture a variety of flooding histories as well as data availability, community appetite for engagement, the research team's community connections, utility for meaningful change at local, regional, and national scales, and provision to increase understanding.

- Within each case study, residents, government and non-government agencies affected by flooding or involved in flood planning or response were identified for interview. Potential interviewees were identified using personal contacts, recommendations from relevant agencies, and via snowball sampling (where participants are selected based on characteristics relevant to the study, and on recommendations from other participants).
- Approval was obtained via NIWA's Human Ethics process to interview potential participants.
- Semi-structured individual or paired interviews were conducted with participants between mid-2022 and mid-2023 to discuss the cascading impacts of flooding. Most interviews were conducted online. Participants were asked about their experiences of flooding – the effects they experienced, how they coped and what they would hope to see in the future. Community members who had directly experienced flooding were also asked about their tolerance for future flooding, and how this may or may not affect their willingness to remain in place.
- Thematic analysis of the interviews was conducted to identify key themes from the interview transcripts (Braun and Clarke 2013). Comparisons between case studies allowed for the identification of commonalities and differences to how flooding impacts communities.
- To develop the causal diagram, the team reflected on the different themes from the interviews. Through a process of iterative refinement, we identified variables from these themes that could best be represented in a causal diagram (i.e., ones that can be phrased in such a way that they have a natural sense of direction – they could increase or decrease). Drawing on the interview data we then identified cause and effect relationships between these variables and collated them into a causal diagram, with a specific focus on seeking to identify feedback loops where possible.
- Each case study's draft causal diagram was supplemented with key findings on local cascading flood impacts derived from an analysis of media reports.

Causal diagrams are a tool developed under the discipline of Systems Dynamics, a conceptual framework aimed at helping us to understand the behaviour in complex systems over time. Causal diagrams are used to identify and display the various factors concerned with an issue and how they interrelate (Senge 2006; Sterman 2000). This helps us understand which parts of a system have the greatest influence and to identify areas where action might be expected to influence matters (Senge 2006).

In this context, the complex system under consideration is flooding – specifically the variety of cascading social and economic impacts of floods that communities experience and the interconnections between those impacts in communities.

1.1.1 Caveats

In this report we use the term 'community' to refer primarily to place-based communities; that is, people living or operating in a common location and geographical proximity. This definition can include residents, businesses and formal and informal organisations and groups. However,

we acknowledge that the term 'community' can mean many things to different people and that not everyone in Little River may identify as belonging to that place-based community. (For example, some may identify foremost with their local suburb.) Further, they may identify with other non-place-based communities more strongly. Some people may also live or operate in Little River but not hold the same views or participate in the collective activities that participants described to us.

In their own use of the term ‘community’, some participants may have adopted alternative or broader ‘catch-all’ meanings or identities. We have not amended or attempted to define their specific application(s) of the term, simply quoted the wording they used.

Our research was based on findings from a sample of individuals affected by flooding or involved in flood management in Little River. As well, our interviews were conducted in 2022 and 2023. Consequently, the insights gained are time bound to that period. As more floods have occurred since this time, people’s experiences, recollections, perspectives and attitudes can evolve. In view of the sampling and timing of the research, the insights gained will not reflect all the experiences, values, opinions or worldviews of people in Little River. Nevertheless, they should still provide generalisable insights of flood impacts that provide a useful basis for planning for the community.

This report sets the scene with a high-level overview of Little River in Section 2. Section 3 presents the analysis of the initial themes from the interviews. Section 4 describes the causal diagram approach used and how to read them, and Section 5 presents the causal diagram for Little River and its key feedback loops. Finally, Sections 6 and 7 discuss the implications of the findings generated by this study for the future efforts to increase flood resilience.

2 Little River/Wairewa

Little River (also referred to as Wairewa, meaning 'fast-rising water') is located on the Banks Peninsula (Figure 2-1), a 45-minute drive from Christchurch City on the eastern coast of Te Waipounamu, the South Island of Aotearoa New Zealand. Little River is one of three small rural settlements in the Banks Peninsula South area which as of 2023 had an estimated population of 1,287 (Little River Issues Working Party 2016; Stats NZ 2025). The usually resident population is primarily European/Pākehā (67.8 per cent), with those identifying as Māori at 17.8 per cent and those identifying as Asian at 17.3 per cent (Stats NZ 2025).

The Little River township is located on State Highway 75 (SH75). It is known as the 'gateway to the Banks Peninsula', providing a popular stop for tourists and regional residents on their way to other destinations such as Akaroa. SH75 provides an important link for the many Little River residents who commute to Christchurch for work (Vance 2014). Little River has several small businesses providing hospitality, accommodation, and other general services, as well as a range of important community infrastructure including a marae, school, community hall, library, and information centre.

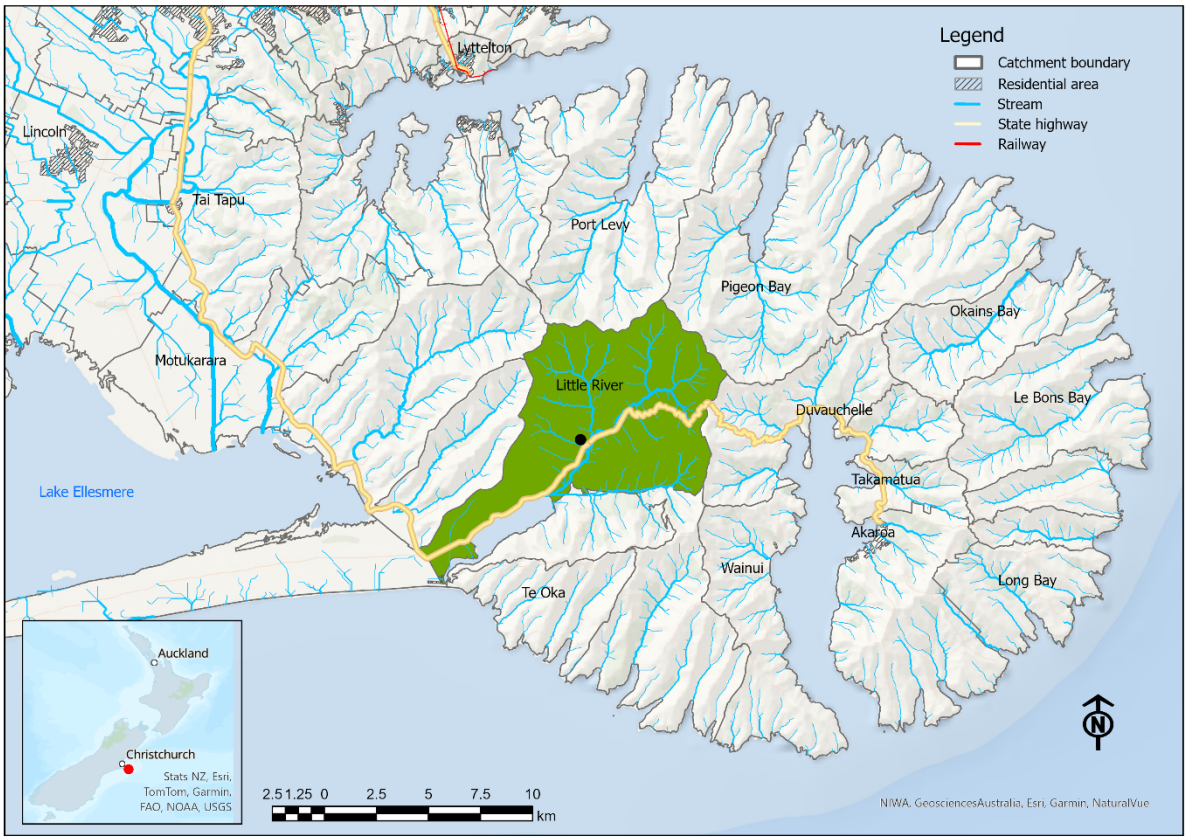

Figure 2-1: Little River, Aotearoa New Zealand. Green shows the catchment area of Te Roto o Wairewa/Lake Forsyth.

The Little River township sits within the Te Roto o Wairewa/Lake Forsyth catchment, a relatively flat valley of 85 km^2 surrounded by steep hillsides (Wild 2020), from which numerous tributaries flow into the Ōkana River. The Ōkana River runs southwest of the Little River township, meeting the Ōkuti River to form the Takiritawai River, which runs a short distance before flowing into Lake Forsyth/Te Roto o Wairewa.

Due to its location, Little River has experienced numerous floods over the course of its history. This includes significant flooding during the 1968 Wahine storm, as well as a series of large flood events which occurred over a relatively short period of time between 2011 and 2014 (Wild 2020), and more recently in 2021 (Christchurch City Council 2021), 2023 (Mathewson et al. 2023) and May 2025 (RNZ 2025a). High-intensity rain events can cause the Ōkana River to burst its bank and overwhelm local drains, resulting in significant surface flooding. This flooding occurs primarily in the township. Flooding can also occur when Te Roto o Wairewa fills up and the mouth is not open, flooding SH75 and the lake surrounds. For example, in October 2011 several businesses were flooded and SH75 was temporarily cut-off as a result of a heavy rain burst (Gorman 2011). More recently, heavy rainfall in May 2025 flooded a number of businesses in the township and SH75, cutting off access to the community and the wider Banks Peninsula (RNZ 2025a). Little River locals the research team spoke to explained that flood water tends to drain away relatively quickly once rainfall has ceased, sometimes over the course of a couple of hours.

Numerous investigations and reports have been undertaken to understand the nature of the flood risk in Little River, including causes and options for flood mitigation (e.g., Blakely 2014; Harrington 2013; Vallance 2014; Wild 2020). Following flooding in 2014, the Little River community voted to establish a river ratings district in conjunction with Environment Canterbury (ECan). As part of this, residents of the Little River catchment area pay a targeted rate which ECan uses to fund maintenance of the river to reduce flood risk (e.g., clearing invasive tree species). The ratings district is still in place at the time of writing this report.

3 Thematic analysis results

Across all three case studies, 53 people were interviewed either individually or in small groups, as per their preference. The breakdown by case study is as follows:

- Little River – 12 interviews with 13 people.
- Auckland – 18 interviews with 23 people.
- Waikanae – 14 interviews, with 17 people.

In Little River, participants included residents, business owners, council staff, and members of the Wairewa Rūnanga. While some members of the Rūnanga took part in interviews for this particular project, we acknowledge that the experiences of mana whenua in Wairewa were explored more deeply within the Vision Mātauranga component of the overall research programme.

3.1 Thematic analysis summary

Once the interviews were completed across the three case studies, the issues and topics raised were reviewed by the research team. Multiple common themes were identified as well as those that were specific to one or two of the case studies. The findings below focus on themes pertinent to Little River.

Flooding negatively impacts emotional wellbeing. Experience of flooding negatively impacted the emotional and mental wellbeing of participants in all case studies, including some of those in Little River. Participants from Little River discussed how experiences of flooding had caused varying degrees of stress, frustration, anxiety, exhaustion, and fear not only for themselves but also amongst others in the community:

> *It is really exhausting. Afterwards... you're just so flat.*

> *Well, I mean, it's just ... an overarching feeling of hopelessness really, because... you know, the flooding's not going to get better. And I think even, given the nature of the valley up there, unless you removed, you know, several metres of the valley floor right out to the sea, it's always going to be a problem, I think.*

> *... we'd all done a lot of work on the [shared] property because it was... Yeah, it wasn't awesome when we got it and there's a lot of volunteer work that went into making it a really cool space. And the flood really ruined all that and it caused... like everyone just lost their mojo, and I would even suggest that some of them probably went into a bit of a, I don't know, situational depression. Like it was actually really tough.*

Other participants described the floods as being a nuisance or commented on their ability to 'get back to normal' within a short timeframe following a flood:

> *We're pretty good at just getting back into it straight away. I mean, you can't sit back and cry about it ...*

> *So yeah, I mean, it had no serious impact other than that it was a bit inconvenient, but there'd be other houses around the place who would get it much worse than that ...*

> *But it is what it is, isn't it.*

Insurance coverage for businesses, homes, and personal possessions was raised as a challenge for recovery in all case studies. In some cases, participants worried about being unable to secure ongoing flood insurance for their properties or businesses because floods had happened in the past and they had previously filed claims. In Little River, one participant described only being able to re-gain their previously lost insurance cover after they were able to demonstrate that mitigating actions had been undertaken to reduce future risk:

> *... We lost the flood insurance after the first flood. They didn't renew our flood insurance and then we didn't have any flood insurance for probably 3-4 years ... And we asked around as well. We tried to go elsewhere, but I mean, the history of three floods in the previous three or four years, no one's going to insure you are they? It's just silly ... And then the only way we got it back was to produce reports from the council and locals about the work they've done on the waterways out here. And just to show that there's been works to improve the situation and at that point we got the flood cover back.*

More broadly, *harm to businesses* was noted in all case studies. In Little River, this impact included damage to buildings and stock, impacting local businesses' ability to operate:

> *... I think it was three and a bit days before we actually got ourselves back open again. We needed some freezers and there was a lot of contamination, so we had to get that properly, commercially cleaned ...*

Community support/ help during or following flood events is common in Aotearoa New Zealand and was noted in all case studies. In Little River, community help was integral to residents' sense of community which, in turn, was integral to their *willingness to tolerate flooding* and desire to remain in place:

> *... well, from a resilience people point of view ... [flooding] brings everybody together really quickly.... I mean, we've done sandbagging and all sorts of things here at potential risk of flooding. And it's amazing how many people get in and help. It's just a great little community for that sort of thing.*

Tolerance to flooding and the question of whether residents should stay or go (and when and how) arose in all cases. The desire to stay in place was positively influenced by a number of factors, including by the sense of community residents felt and the assistance that residents received from other community members, as noted already. The desire to stay in place also reflects the natural attributes of the area. This influence was strong in shaping people's attachment to place in Little River:

> *Once you live in a place like this, you can't see yourself anywhere else ...*

As such, participants described a general tolerance of the current levels of flooding experienced thus far:

> *... The actual flooding itself hasn't deterred us from being here.*

> *... I'm not a real worrier about things like that. A part of me is like, natural disasters, you actually can't control that. So, what do you do.*

That said, it was acknowledged that there was a limit that even people who are strongly emotionally attached to an area can reach before re-evaluating their desire to stay. As one Little River participant noted:

I think if we were at that rate where we were flooded a few times in regular, you know, over that period, '13, '14, I think if that maintained I would ... yeah I wouldn't be sticking around for sure. But we've been fine since then, really. We came very close last year ...

Relationships between community and councils was commonly raised, with positive engagements being linked to increased overall satisfaction and, in turn, further positive interactions. In all case studies, greater community frustration with council services was associated with greater community action to advocate for actions that better reduce flood risk. In Little River, greater advocacy by the community for councils to reduce flood risk was linked to lower levels of frustration and improved community-council relationships:

... The community now have [a] direct line both to ECan [Environment Canterbury] and to the city council and... having more of a direct line into those places gives the chance for people to have more of a say or feel like they can be heard and yeah. It's great ...

... Some [council] staff they have been kind of bitten, I guess, you know, they've had pretty negative experiences in the old sort of town hall-type meetings ... But what I find is, the more people work with the community, closer, the more they go wow, this is great, this is really good, and this actually can really help avoid some of those negative reactions when we are communicating well... now, the [council] engagement team, they do drop-ins much more than anything else.... Yeah, we're getting much better I think at understanding effective ways of working with people and getting information to people and allowing people to ask the questions they want to ask... People don't like being talked at about their own communities. And my experience is that staff don't particularly like being the person up there talking at them.

The *legislative ability of councils to take action to reduce flood risk* was commonly raised as an issue for communities concerned about risk mitigation. In Little River, participants discussed the regulatory challenges and limitations that councils face, including how this may not always be understood by everyone in the community:

... What we're trying to do in Little River ... is to sit in a room and work together and figure it out and understand each other. So often the restrictions that are on what can happen through council are massive, they're legislative, you know, the district plan and there's just so many regulations and laws and things that have to be worked through and the community often has no understanding of that. It's not a laziness or a lack of desire. It's a really time consuming, hard work process that people have to go through.

... the National Policy Statement for Freshwater and some of the objectives set for improving water quality have placed barriers on us to do productive management and work to help alleviate flood issues... So I guess that's probably one thing, one of the barriers we struggle with as much as anything is just the constraints to doing work that benefits communities with blanket rules that are put out as policies to improve water and all this, but not necessarily thought through the unintended consequences of, oh, we'll improve this, but now our engineers can't go and do work or do what they need to do ...

The ability of councils to take action to reduce flood risk is also complicated by overlapping responsibilities between different councils and other government agencies, such as the New Zealand Transport Agency (NZTA):

> *... That's one thing that is quite interesting is just the overlapping responsibilities ... There's a lot of grey area in terms of what agency should be taking the lead or the drive on some of that.*

Community or collective memory about flooding was raised as important for influencing risk mitigation in the case studies, with stronger lived or community memories of a flood associated with a stronger drive to take mitigating actions or to better prepared for flooding. In Little River, lived memories were seen as critical for localised flood management. However, participants also suggested there was a need to maintain the memories for people to act:

> *... a lot of people move out to here, to Little River, and hopefully... there's enough of a collective memory to hold on to that 2014 flood. But I think the flood we had last year was a reminder because if it wasn't for all the [flood maintenance] work that had been done, it would... the flooding would have been, you know, quite severe ...*

The *challenges of managing flood risk in a changing climate* were raised by participants in all case studies as they reflected on the need for more action to be taken. In Little River, participants noted that a key challenge is the diverging views within the community as to the best course(s) of action. They described how there is some disagreement and confusion within the community about the cause(s) of flooding, such as whether the water levels of Te Roto o Wairewa/Lake Forsyth play a role, and whether opening the lake's outlet gate ahead of heavy rainfall would lower flood risk. Additionally, there is debate as to whether measures that increase the capacity for water to flow under the local Kinloch Bridge would be effective and financially feasible:

> *... There's a bunch of science, a bunch of modelling that says that no, the level of lake doesn't affect the flooding. There's people in the community who 100% believe that it does and there are times when the lake has been opened and they've seen levels dropped. So that's why they believe that.*
>
> *The technical people are not at all certain that doing something there [at Kinloch Bridge] would necessarily do more than a little bit more mitigation. And so you'd have to look at cost... And because there's no money anywhere for anything to happen there, what's the best way to go about getting some more data? You know, this is the complexity of it. How can we even begin to explore if maybe that's right or not, if there's no money to even begin to explore?*
>
> *There's lots of debate in the community about what the problem is and what causes the problem. And everyone's got their opinion, particularly the people who have been here for a long time because they know, yeah? And there's a bit of a battle between the experts and the people who ... do the modelling in regards to what actually causes the problem.*

Another challenge participants in Little River discussed was the cost of additional measures to reduce flood risk, beyond the river maintenance work that is undertaken through the river ratings scheme. For example, if major flood protection infrastructure was desired by residents, this is likely to come at a financial cost too high for the community to bear:

> *... And now we're sort of at that stage where it's starting to assess other options and some of the... I think some of the benefits versus cost ... Yeah, it's pretty hard to say to a small community like that, here's multi-million dollars of [flood protection] assets that you as a township need to pay for.*

As well as the wide range of impacts identified, the thematic analysis highlights the extent to which the social impacts of flooding interconnect and flow-on for communities and organisations over time. The next sections describe these causal relationships in Little River.

4 How to read the causal diagram outlined in this report

Simply put, causal diagrams are collections of variables (e.g., characteristics of places, people, environments) connected by arrows of influence. This allows us to trace influence along pathways, through multiple variables. They have a particular interest in circular pathways of influence, as these create feedback loops which influence how variables behave over time.

Causal diagrams contain two types of feedback loops that drive system behaviour. *Reinforcing feedback loops* lead to exponential growth or decline, exemplified by phenomena like compounding interest or algae blooms, while *balancing feedback loops* stabilise systems by seeking equilibrium, akin to a thermostat. Recognising these loops helps understand how variables behave and interact within a system, providing a basis for strategic interventions.

To read a causal diagram, you need to understand the below:

1. As you follow influence through a diagram, it is effectively describing to you how "more or less of this (current variable), leads to more or less of that (the next variable)".

2. *Variables* are written in such a way that they have an *inherent sense of direction*. That is, they can either go up or down. For example, 'morale' instead of 'increased morale'.

3. There are two types of arrows which denote two types of relationships between variables:

    3.1 *Solid arrows* denote a *same relationship* (variables move in the *same direction* – if one goes up, so does the other, and vice versa).

    3.2 *Dashed arrows* denote an *opposite relationship* (variables move in the *opposite direction* – if one goes up, the other goes down, and vice versa).

4. Two small lines across an arrow represents a *relative delay*. This influence will take longer to present than others represented in the diagram.

5. Sometimes a variable of particular interest is shown as a *metaphorical bathtub*. This is an analogy used to help us better understand accumulation. Some variables may influence whether the bathtub variable *increases* (things *flow into* the bathtub); while others may influence whether the bathtub variable *decreases* (things *drain* the bathtub).

6. It is important to note that *bathtubs* are used as a *metaphor*. There is no actual limit to their capacity (i.e. they will not ever overflow if they 'fill too much'). They are used as a way of highlighting with more nuance, where things accumulate or reduce.

7. *Bathtubs* can be part of *causality chains and feedback loops*.

8. Causal diagrams are agnostic in the things they describe. They simply help us describe the influences that make things go up or down. Whether changes in these variables are 'good' or 'bad' depends on the perspective of the reader.

Figure 4-1 demonstrates how the above concepts work.

While straight forward, these concepts can take some getting used to. To help with this, they are explained in more detail in Appendix A.

We are particularly interested in how various feedback loops interact and the impact this will have on the way variables of interest trend over time. Causal diagrams do not seek to quantify how these things may trend over time. They provide a valuable tool to aid understanding of the broad directions that variables may trend, in response to changes in other variables captured in the diagram.

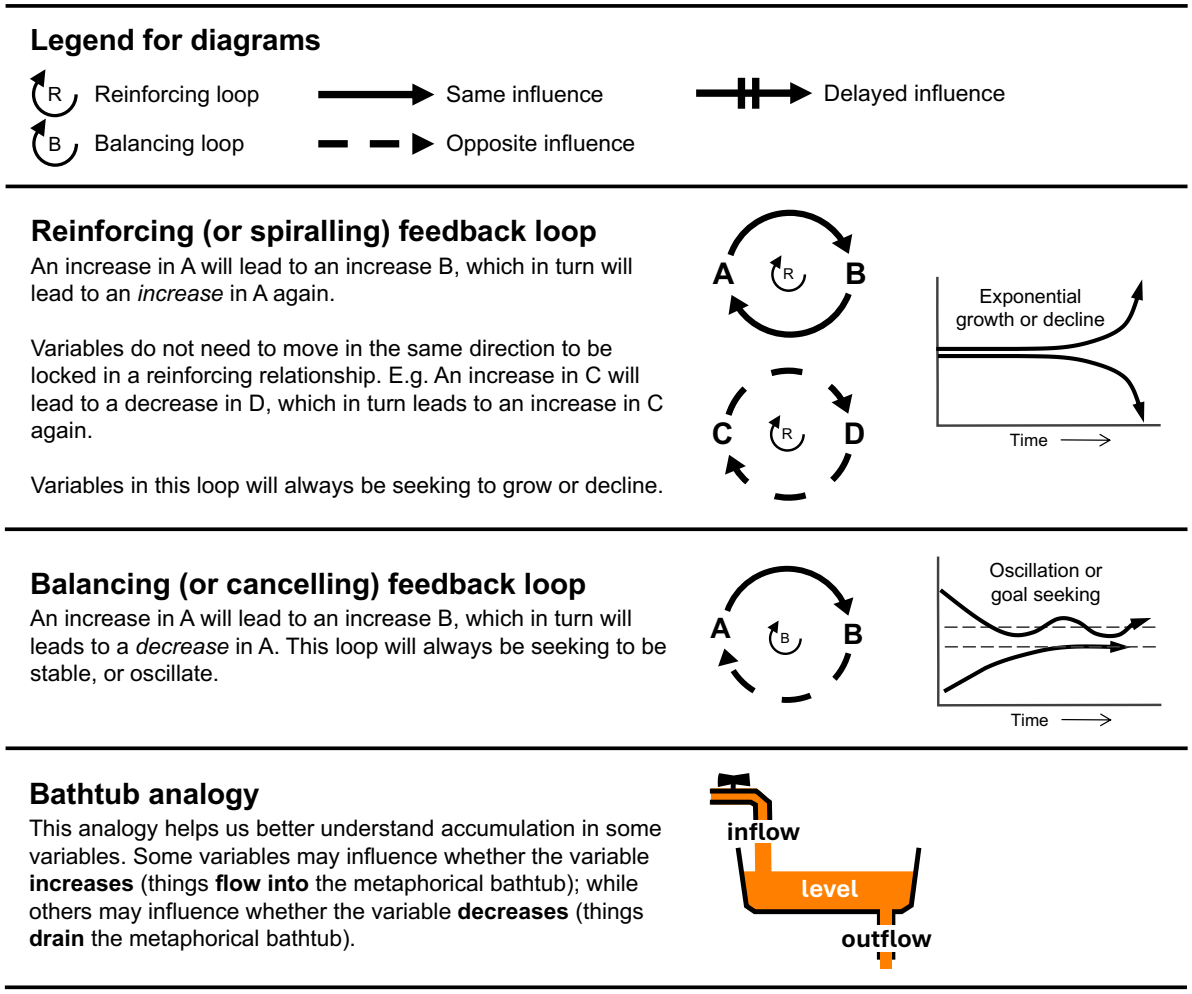

Figure 4-1: How to read a causal diagram.

5 The Little River causal diagram: Key feedback groupings and loops

The causal diagram for Little River is presented in Figure 5-1. It draws on the thematic analysis of the interviews, focusing on the cause-and-effect relationships discussed and supplemented by cascading flood impacts reported in the media. While the thematic analysis included discussion of themes directly related to flood emergency response, the causal diagram focuses primarily on cascading impacts that play out over a longer timeframe, into the recovery phase. Therefore, some of the thematic elements that relate to emergency response are not shown in the causal diagram.

Five key causal groupings, along with feedback loops and variables that comprise them, are represented in the diagram by colour. The five causal groupings are:

- Flood impacts.
- Community and Council relationships.
- Experience of flooding and action to reduce risk.
- Desire to remain in place.
- Insurance.

Within these groupings, there are three main 'anchor' variables that represent key factors of influence: *action to reduce future flood impacts*, *desire to remain in place*, and *ability of businesses to operate*. These are represented as orange boxes within the causal diagram.

- *Preventative actions to reduce future flood impacts*. The level of preventative action taken by community and councils (both city and regional) to reduce future flood risk is influenced by a large number of factors which, in turn, generate extensive knock-on effects elsewhere in the system. The level of action that the community takes is influenced by their sense of community and how much they *desire to remain in place*, the scale of previous *flood impacts*, the level of lived memory they have of those floods, and any degree of complacency they have about future flood risks (*experience of flooding and action to reduce risk* grouping). The level of action that councils take is influenced by the extent to which they are able to work collectively with communities on preventative action and the degree of pressure councils face to prioritise investments in other communities (*Community and Council relationships* grouping). The relationship between councils and the community is critical. It influences – and is influenced by – satisfaction with services and the extent of preventative works by councils, and this feeds into the degree to which communities become frustrated with councils and engage with them in joint efforts.
- The *community's desire to remain in place*. This is influenced by residents' sense of community and their tolerance of flooding. The strong sense of community and belonging in Little River means that residents are willing to tolerate a certain degree of flooding and invest in a range of actions to reduce future flood risk, to be able to remain in place.

- The *ability of businesses to operate* following a flood event. Having insurance cover is an important influence on local businesses' ability to recover following a flood event, allowing them to conduct repairs and maintain or resume operations in a timely manner. This is particularly important in a small, rural community such as Little River, which has limited retail services available locally.

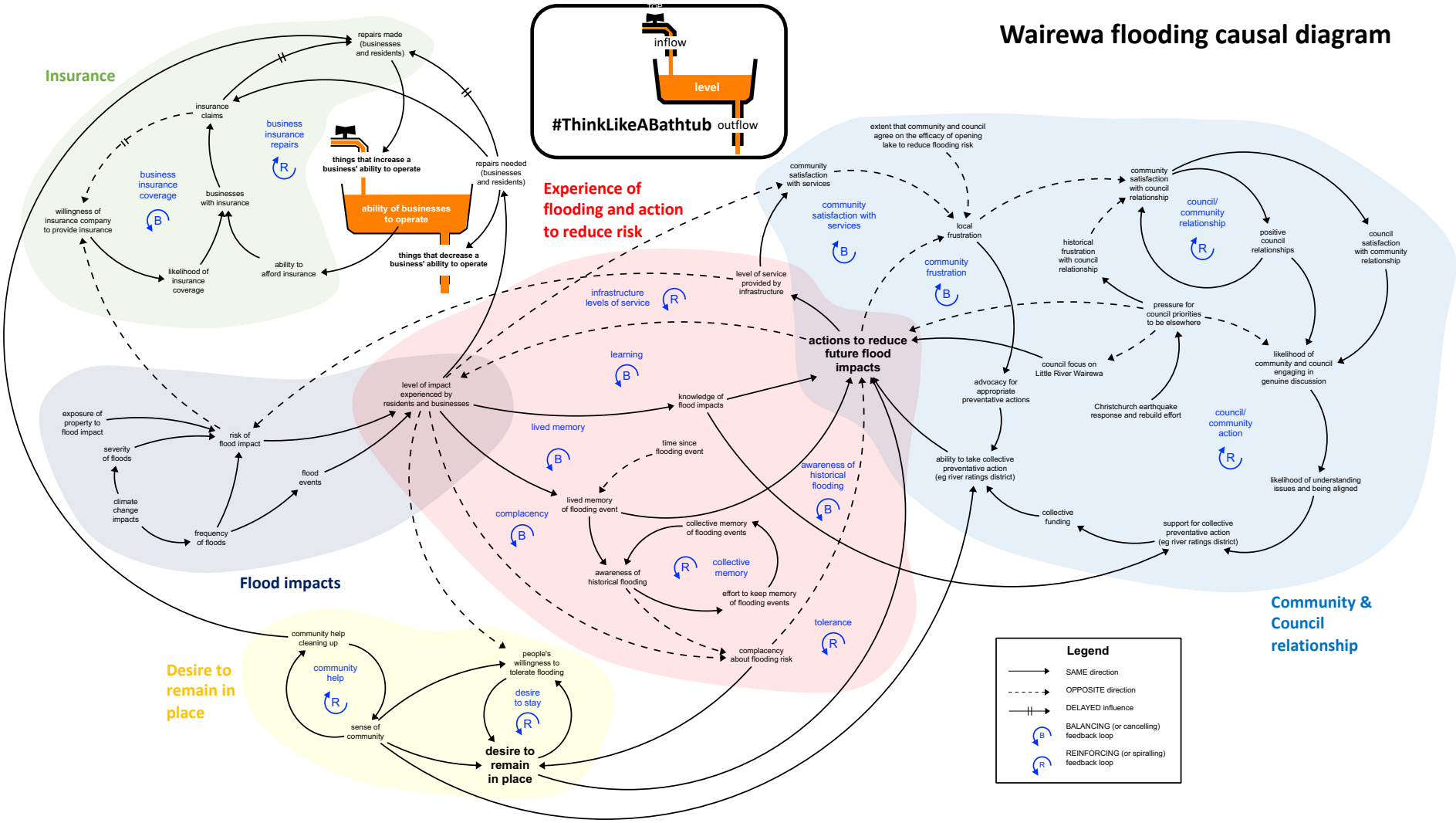

Figure 5-1: Little River causal diagram.

The feedback loops and groupings provide useful insights into how things (e.g., characteristics of places, people, environments) change over time. Therefore, they can reveal where key points of influence lie which may be targeted to reduce harmful impacts and increase resilience.

Within the five causal groupings, 15 key feedback loops were captured in the causal diagram for Little River. Eight are reinforcing, with the effect that a change in one variable results in amplifying or 'spiralling' growth or decline. Seven interactions are balancing, with the effect that the direction of change in one variable ultimately encourages a balancing or cancelling effect in that same factor (Table 5-1).

Table 5-1: Causal groupings and associated feedback loops.

Causal group	Feedback loop	Reinforcing or balancing
Flood impacts	-	-
Community and Council relationships	Community satisfaction with services	Balancing
	Community frustration	Balancing
	Council/ community relationship	Reinforcing
	Council/ community action	Reinforcing
Experience of flooding and action to reduce risk	Infrastructure levels of service	Reinforcing
	Learning	Balancing
	Lived memory	Balancing
	Complacency	Balancing
	Awareness of historical flooding	Balancing
	Collective memory	Reinforcing
	Tolerance	Reinforcing
Desire to remain in place	Community help	Reinforcing
	Desire to stay	Reinforcing
Insurance	Business insurance coverage	Balancing
	Business insurance repairs	Reinforcing

The feedback loops are described in greater detail in the following subsections. The descriptions concentrate on variables and pathways related to the feedback loops in the diagram. The contributions of other variables can be understood by following their influence across the wider causal diagram. The sequence in which the loops are presented does not imply priority or scale of influence.

5.1 Flood impacts

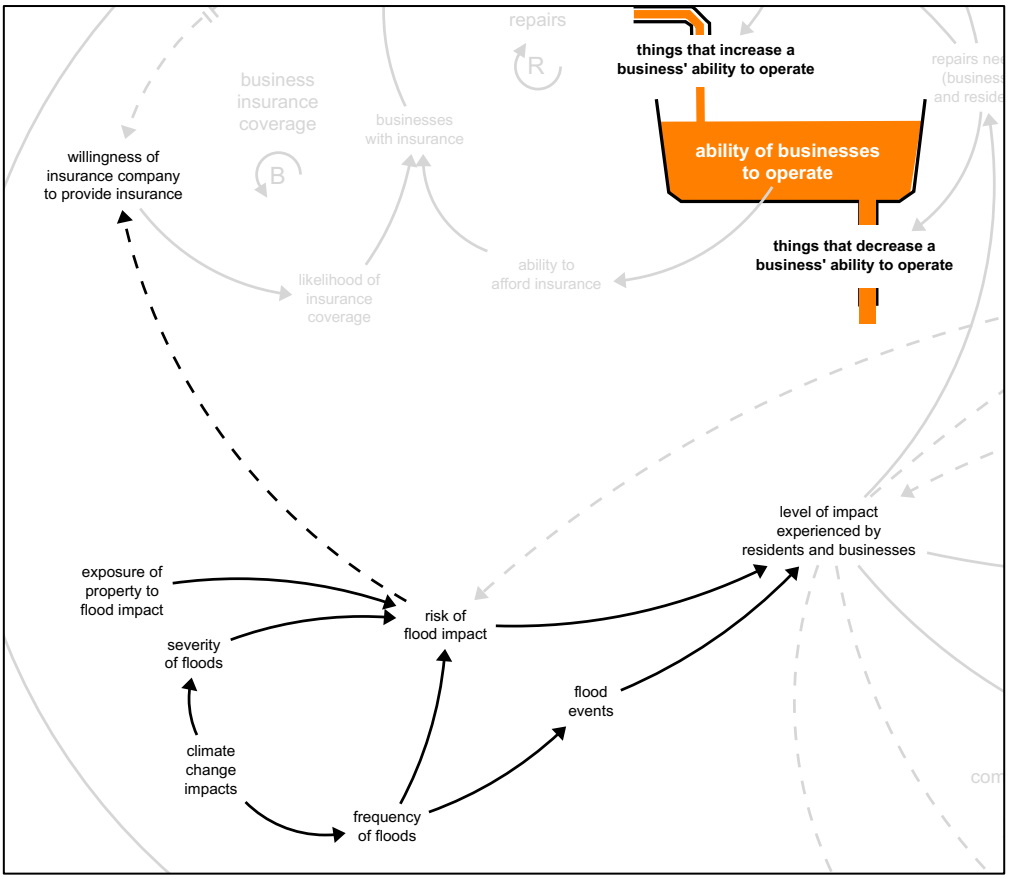

Figure 5-2: Flood impacts grouping.

While there are no feedback loops within the *flood impacts* grouping, it provides context to acknowledge that the *frequency and severity of floods* affects the *level of impact experienced by residents and businesses*, while at the same time lowering the *willingness of insurance companies to provide insurance* (Figure 5-2). As the severity of *climate change* impacts increases, so too does flood risk and severity, with cascading impacts for Little River.

Although the emotional impacts of the floods are not included in the causal diagram, they are an important influence on the general wellbeing of those living in Little River. In particular, participants discussed how flooding caused frustration, stress, and exhaustion.

If the frequency and/or severity of flood events were to increase in Little River, it can be assumed that negative emotional experiences will increase, with negative implications for the wellbeing of residents.

5.2 Council and Community Relationships

The *community and council relationships* grouping includes four feedback loops, two of which are balancing and two that are reinforcing (Figure 5-3). These loops, and the factors influencing them, help illustrate the complexity of the relationships between the community in Little River and the city and regional councils that serve them. This grouping overlaps with that of the *experience of flooding and action to reduce risk* grouping, in that both directly influence the amount of action taken (or not) to reduce the risk of future flood impacts. The grouping

described here (*community and council relationships*) focuses particularly on *collective* actions that require collaboration between the community and councils, and the factors that influence whether such actions are undertaken (such as the level of community frustration or satisfaction with their relationship with councils).

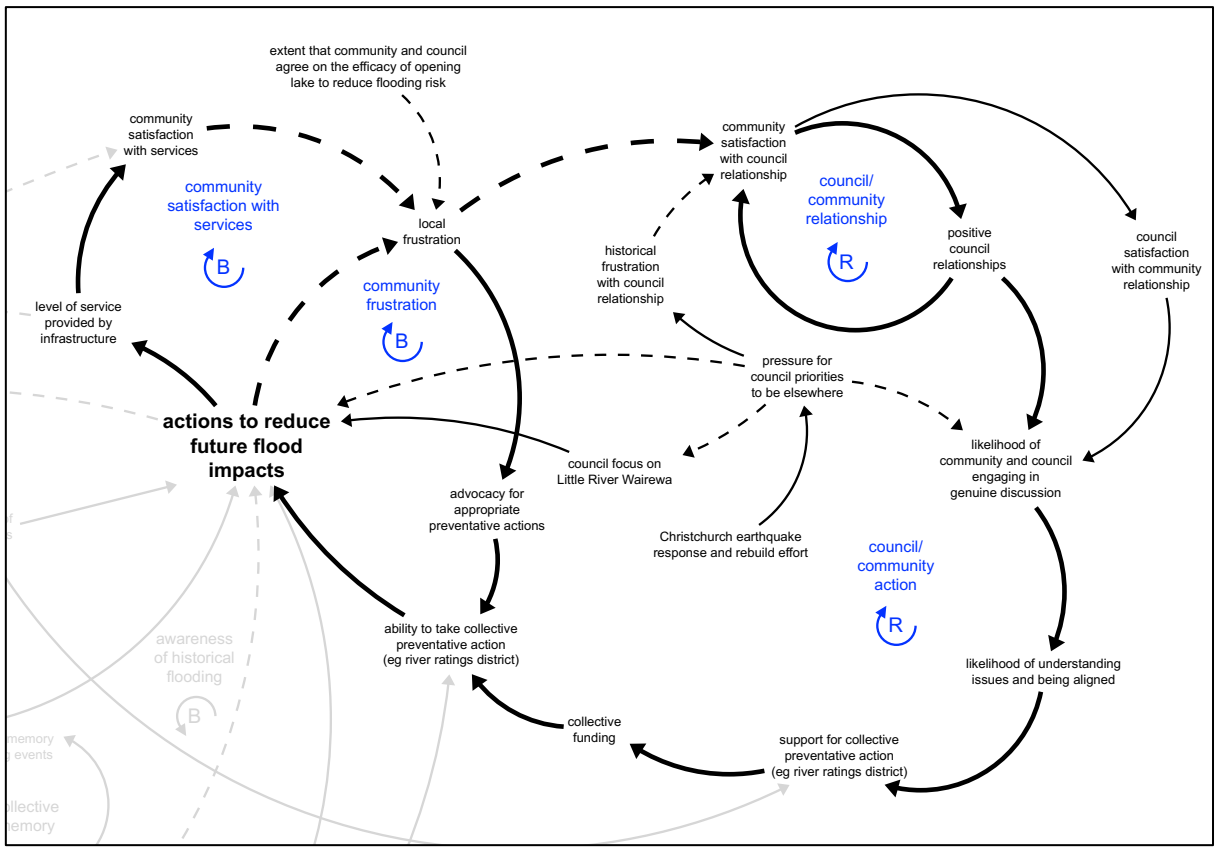

Figure 5-3: Community and council relationships grouping.

5.2.1 Community frustration and satisfaction with services

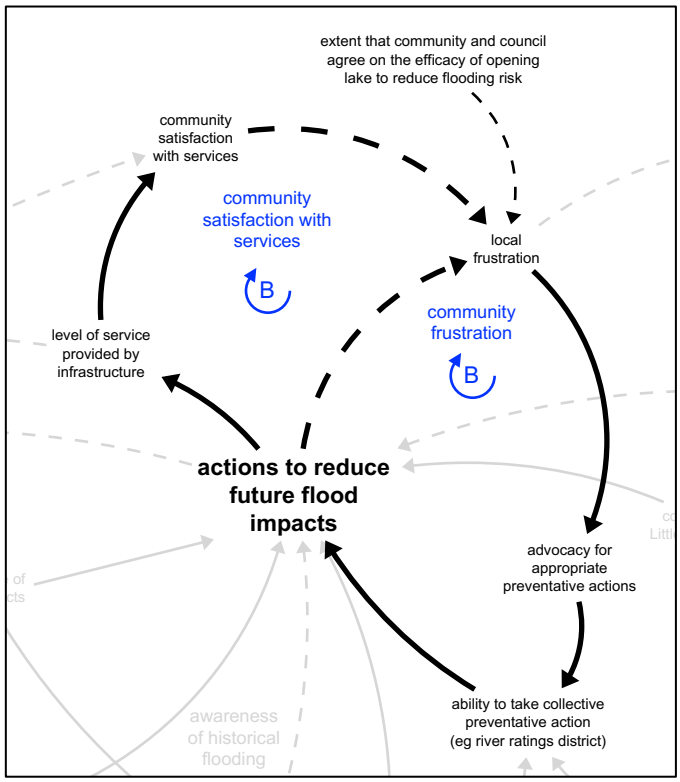

Figure 5-4: Community satisfaction with services and community frustration loops.

There is a balancing relationship in Little River between actions taken to reduce future flood risk, and *community frustration and satisfaction with infrastructure services* (Figure 5-4).

The greater frustration there is with council services, the more residents advocate for preventative actions to reduce flood risk and the more those actions tend to be undertaken (*community frustration* loop). This in turn reduces local frustration. Over time, the lower the level of frustration, the less residents may advocate and the lower the level of preventative actions taken. This balancing relationship means that the level of local frustration with services and the extent of preventative action taken to reduce future flood impacts can be expected to oscillate ('seesaw') over time.

Closely related, the greater the number of actions taken in Little River to reduce future flood impacts (such as improving drainage, installing bigger culverts, etc.), the greater the level of infrastructure service and the higher the level of community satisfaction with services (*community satisfaction with services* loop). In this respect, Little River participants described positive reductions in flood impacts due to work undertaken to improve infrastructure. They also discussed additional infrastructure solutions they believed may further reduce future risk of flooding (e.g., lifting an at-risk bridge or installing culverts on either side).

However, because greater community satisfaction with services is associated with lower levels of frustration, over time, this may mean that community advocacy for further action declines. Consequently, greater community satisfaction with services may prevent further efforts to proactively reduce future flood impacts. Over time, this balancing relationship means that the extent of future actions to reduce future flood impacts and the level of community satisfaction with services may oscillate.

5.2.2 Council and community relationship

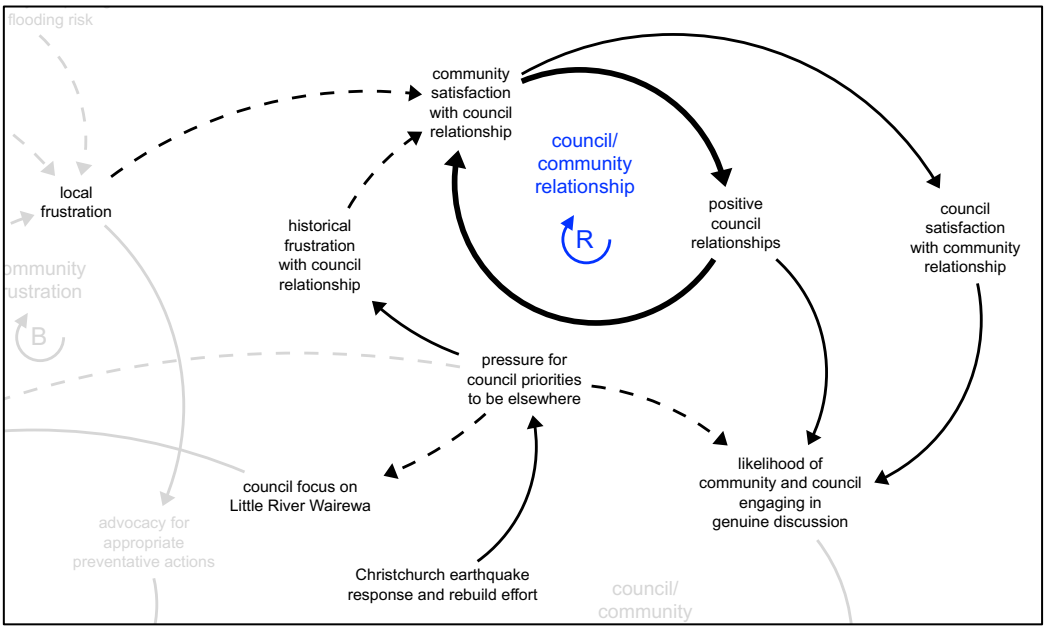

Figure 5-5: Council/community relationship loop.

There is a reinforcing relationship between community satisfaction with its relationship with councils, and the degree to which the *council-community relationship* is a positive one (Figure 5-5). The more positive the relationship with councils, the higher the level of community satisfaction with said relationship. In turn, the higher the level of community satisfaction with the community-council relationship, the more positive the relationship is. Over time, this could be expected to result in ever improving relations. Conversely, declines in the level of community satisfaction with councils could be expected to result in a downward spiralling of relations.

Other influences on the community's degree of satisfaction with their relationship with councils include *community frustration* and *historical frustration* with councils. Some participants noted that the Little River community felt somewhat ignored by the Christchurch City Council following the 2010–2011 Canterbury earthquakes, as the council focused on recovery within Christchurch city itself (*pressure for council priorities to be elsewhere*, *Christchurch earthquake response and rebuild effort*). This lowered residents' satisfaction with the community-council relationship. For example:

> *... The flooding in 2014 damaged our local tennis courts ... those courts weren't able to be used. At the end of 2014, I sort of brought it to the community board going, we know this was a natural event, we know that there's insurance for things like that. When are we going to get these replaced? And they said it's not a priority because, of course, 2014 was only a few years after the earthquake. So earthquakes took priority over flooding...*
>
> *... [The flood] was also three years after the earthquake. So people were still trying to sort their lives out after the earthquake and then they also got flooded as well. So a lot of the... In a sense, there was a lot of focus from city council in Christchurch itself. And kind of Little River was the unfortunate... kind of the poor cousin.*
>
> *... Even now they're still saying, oh, 'we're still trying to work out what infrastructure needs more funding, more upgrades'. Because... the city had to deal with the earthquakes. And so, of course,*

there was a big distraction for ten years. And it has taken ten years to get where we are, pre-earthquake times. They are now finally being able to deal with or making that more of a priority now because, of course, they've dealt with post-earthquake stuff that they can now deal with, okay, what else is screaming at us? What else is a higher priority now that we've dealt with the other priorities in the city?

However, more recently, relationships between the community, the Christchurch City Council and ECan were reported to have become much more positive and mutually productive over time:

... Some people in council had no idea that there was issues in the area, let alone land drainage issues in the area, let alone infrastructure problems. And so when they started putting cameras down the culverts and go, oh, they're completely not there or completely blocked or ... They decided, yes, it was warranted because, you know, the community made a fair point. There was an issue. There was infrastructure that needed to be repaired. And yeah, so everyone's quite pleased to see that kind of work being done.

... There's a lot of interaction with the council that's made us a trusted partnership... enough that they've got a representative with an office out here. And we have a good relationship with the community board as well. So usually we get what we want. It does take its time and things are a bit slow and the wheels turn slowly. But generally speaking ... once [the Community Trust have] got the support from the community, the council sort of look at it and say, Oh, yeah ok, everybody wants this, let's make it happen.

5.2.3 Council and community action

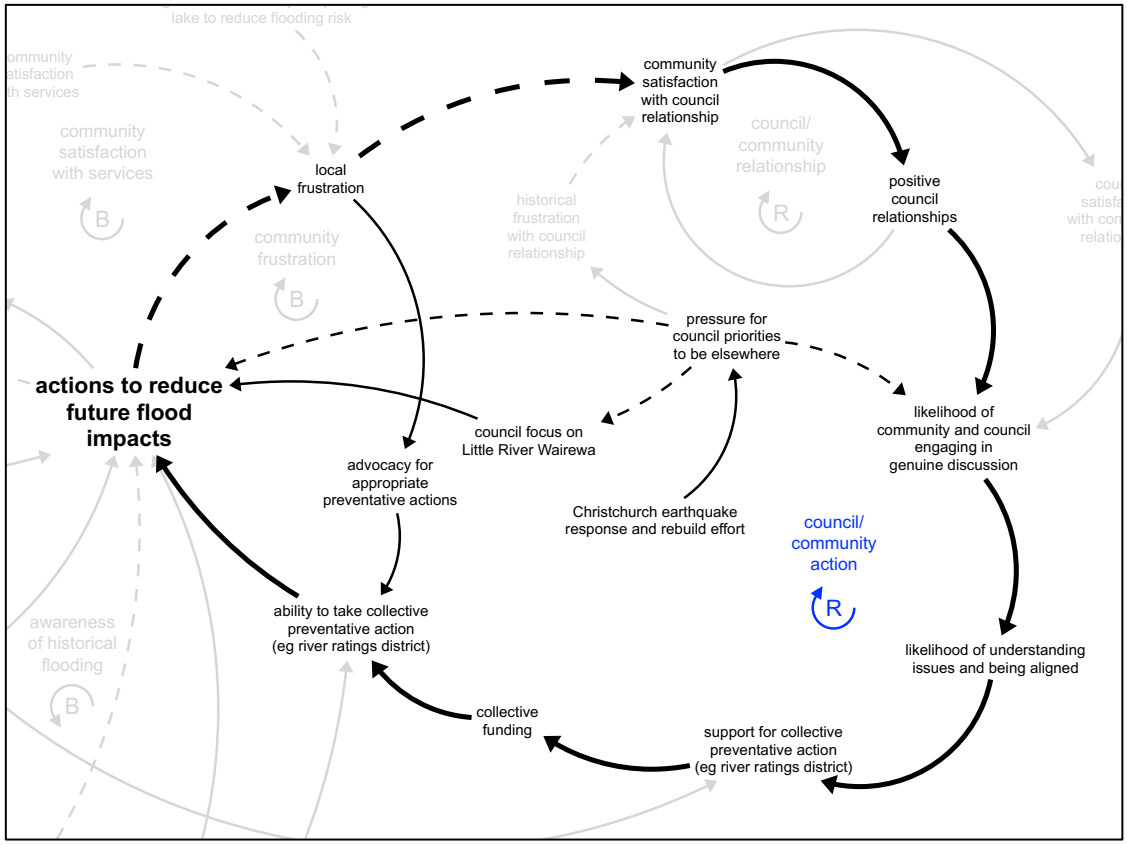

Figure 5-6: Council/community action loop.

There is a reinforcing relationship between council-community relationships and the level of preventative actions taken to reduce future flood impacts (Figure 5-6). The greater the amount of action taken to reduce future flood impacts, the greater the community's satisfaction with their relationship with councils and, likewise, the greater the satisfaction councils have with their relationship with the community. This increases the likelihood of community and councils engaging in open discussion, a higher likelihood of issues being understood and aligned, and greater support for collective preventative action. Increased support and funding for collective actions (such as the river ratings district) reduces future flood impacts. Over time, this reinforcing relationship could be expected to result in ever-improving relations and increasing levels of preventative works. This, of course, may be mediated over time by the aforementioned balancing loops that also sit within this grouping.

Additionally, local community frustration is influenced by the level of disagreement between community and councils over the effectiveness of different preventative actions. In particular, a point of contention for many residents (though not all) is disagreement with councils over the role of opening Lake Forsyth during heavy rainfall, and whether this would reduce the amount of flooding in Little River. Recent flooding in May 2025 saw some residents expressing frustration towards councils that the lake had not being opened prior to the event, while the councils have stated that opening the lake earlier would not have prevented flooding in the town (Brown 2025).

5.3 Experience of flooding and action to reduce risk

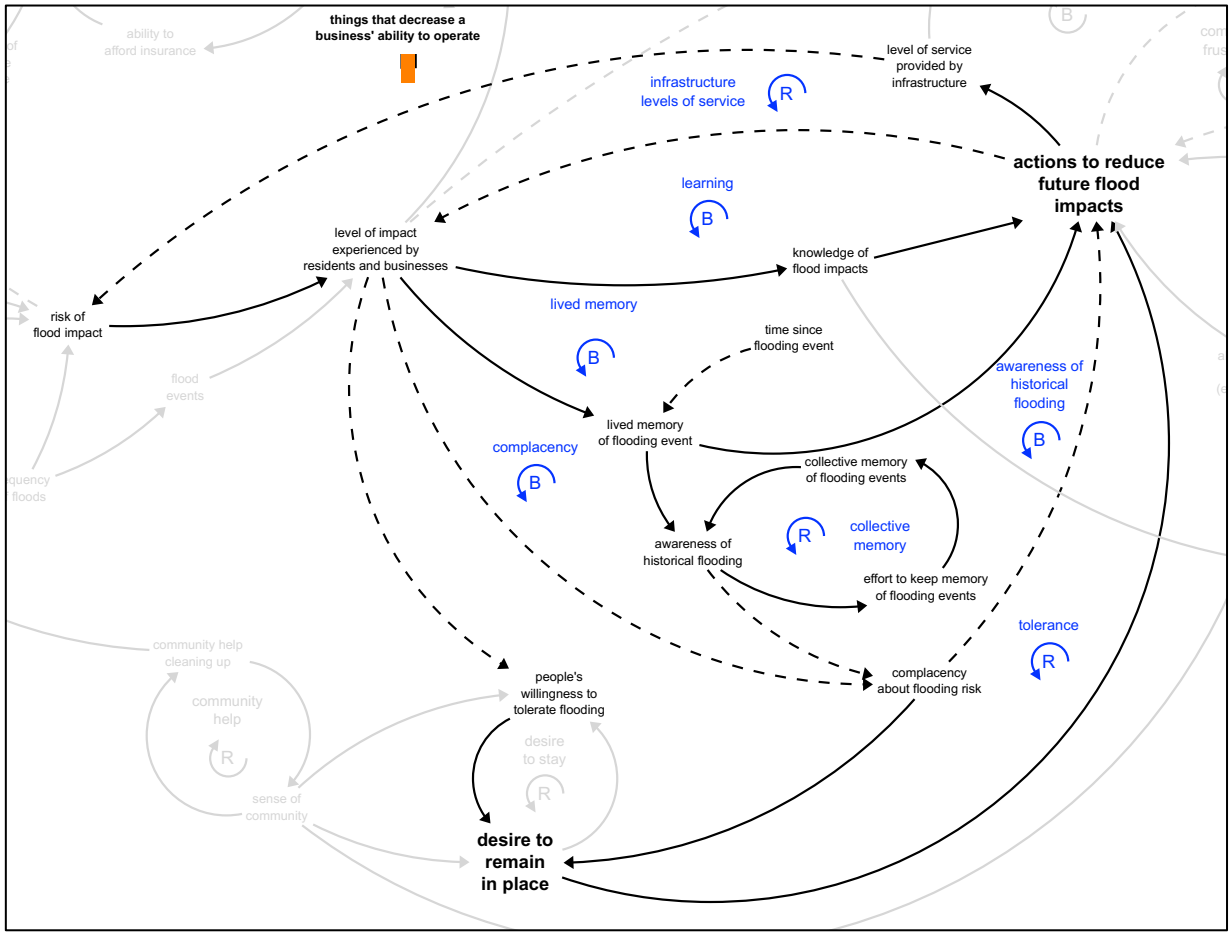

Figure 5-7: Experience of flooding and action to reduce risk grouping.

The *experience of flooding and action to reduce risk* grouping includes seven feedback loops, four of which are balancing and three that are reinforcing (Figure 5-7). This grouping captures the different ways in which experience of flooding influences the degree to which actions are taken to reduce future flood risk. This includes the level of impact experienced by individuals and local businesses, which in turn influences the level of lived memory they have of those floods, and any degree of complacency about future flood risks. This grouping also influences, and is influenced by, *people's desire to remain in place* and their tolerance for flooding.

5.3.1 Learning

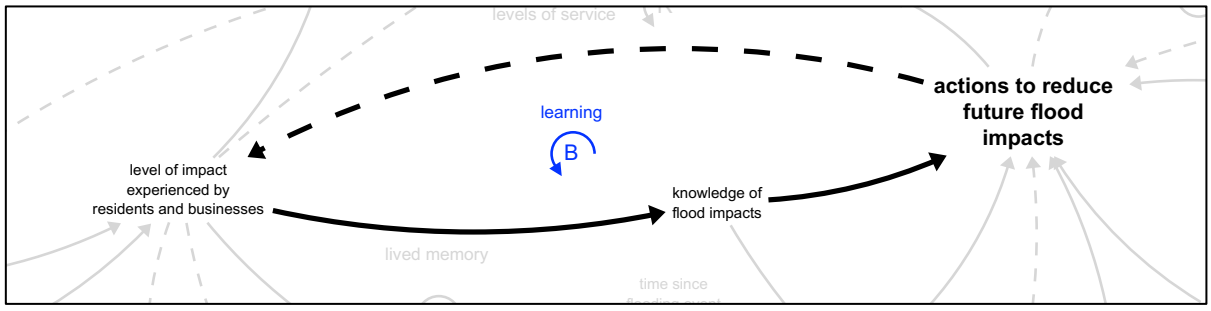

Figure 5-8: Learning loop.

The extent of flooding experienced by communities affects their knowledge of flood impacts, and in turn the efforts they make to reduce future impacts (Figure 5-8). This forms a balancing feedback relationship.

More frequent or severe flood impacts are associated with improved knowledge of flooding, which in turn is associated with increased efforts by residents to reduce the effects of future floods. This includes learning what individual actions are most effective for reducing risk (e.g., clearing blocked drains on one's property, elevating personal items to a certain height, watching the river levels more closely during a rain event):

> *... Two years later, we got flooded again. And I knew the signs then. So my first priority was: get the greyhound; walked out the back; get the chickens shut up; make sure I got all the cats in and all the living things because I've been there before... I could see the culvert at the front was overflowing the road... I knew the signs.*

> *... We're more proactive ... Christchurch Council have an app that's called Snap Send Solve... and one of the drains was starting to block up at the back so I sent through a thing, and to be fair within a few days they had people around clearing the drains.*

Learning extends beyond individual households to include what collective actions are effective at the community level. For example, experience of flooding led the Little River community to form a river ratings district, where residents pay a targeted rate which ECan uses to fund maintenance of the river to reduce flood risk (e.g., clearing willows). At the time of our interviews, this had shown to be effective in reducing flood risk in Little River:

> *... Since the ratings district has been in place ... Huge difference. So when we have a rain event, the rain does kind of drain away a lot faster rather than getting caught up behind willows that are down or, you know... there's more bank stabilisation that needs to be done. But heck, just what's happened already has already made an improvement, and people can see on the ground how much that's improved.*

We haven't had any significant flooding events in that township, in Little River, since that time. And I completely believe that that's largely attributable to the rating district doing the work on the streams and that people do not remember that they don't have floods. They remember when they do have them. And that's a big difference.

Because greater efforts to reduce flooding are associated with lower impacts, over time this may lower the community's knowledge of how to best reduce flood risk, ultimately resulting in fewer preventative actions being taken.

The balancing relationship captured in this loop means that the level of knowledge about flood impacts that the community hold, and the extent to which they attempt preventative actions to reduce future flood impacts, can be expected to oscillate over periods of time.

5.3.2 Lived memory

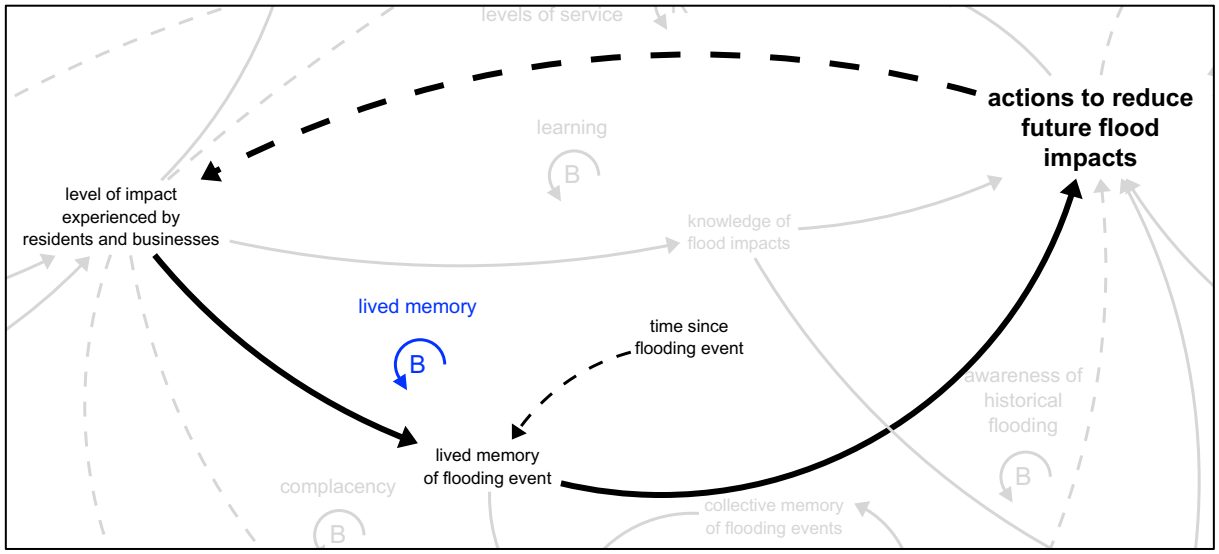

Figure 5-9: Lived memory loop.

There is a balancing relationship between the level of impact that residents and businesses experience from flooding, the *lived memory* they have of flooding events, and the actions they take to reduce future flooding (Figure 5-9). The greater the impacts that people experience, the greater their lived memory of floods, and the higher their efforts to reduce future impacts.

However, effective preventative actions reduce the severity of future impacts experienced by residents and businesses. Over time, the lower the level of impact they experience, the weaker their lived memory of flood events, and the fewer preventative actions they may take to reduce future flood impacts.

This balancing relationship means that extent of flood impact on residents and businesses and the lived memory they have of flooding events may be expected to oscillate over long periods of time.

5.3.3 Complacency

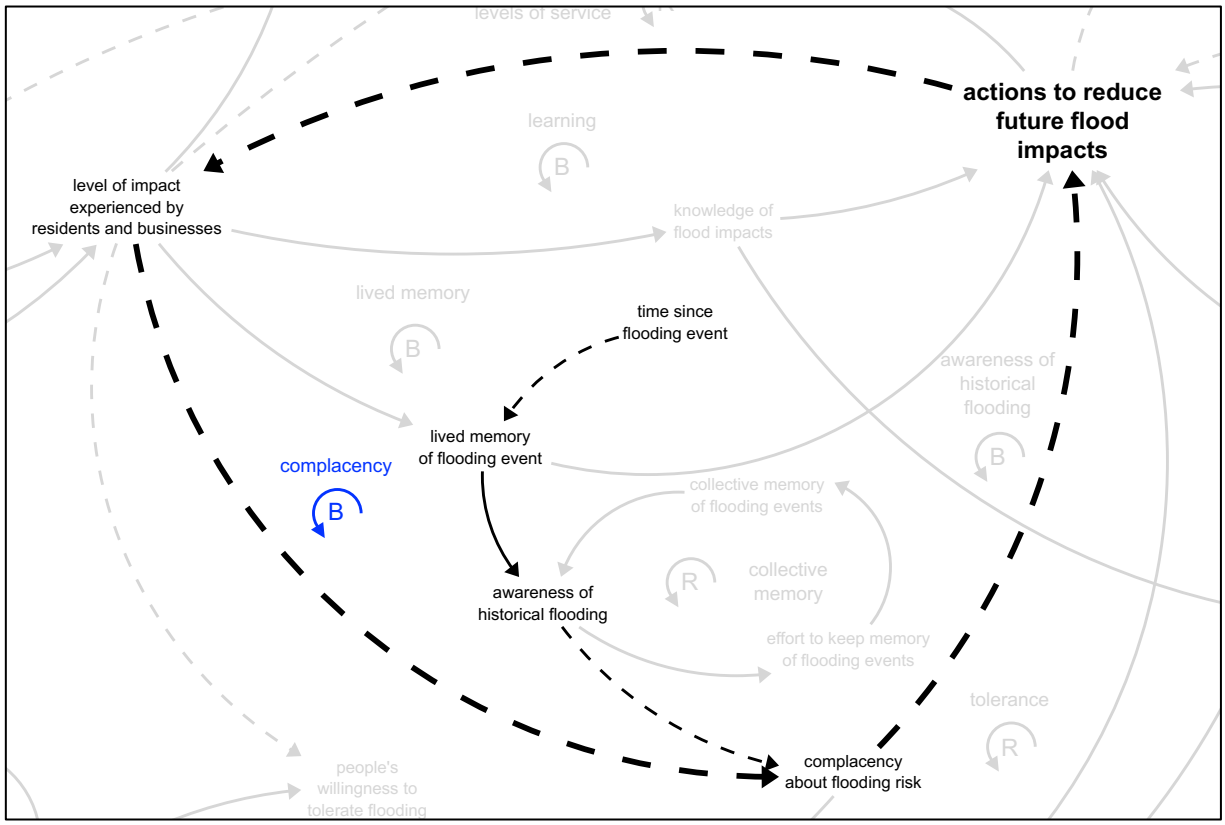

Figure 5-10: Complacency loop.

There is a balancing relationship between the extent of *flood impacts* on residents and businesses and their degree of *complacency* about taking preventative actions to reduce future flood impacts (Figure 5-10). The higher the level of *impact* people experience from floods, the less complacent they are, and the more likely they are to act to reduce the impact of future floods. This is evident in the Little River community voting to establish the river ratings district following a major flood event in 2014:

> *... After the last significant flood [in 2011], we campaigned for a rating group to be formed and in the first instance, after one flood, we failed when people... they primarily didn't want their... the thought of their rates to go up. But after the next flood, people were... there's a degree of shock. But one of the things that came out of that was that people then agreed to set up a rating district for this basin.*
>
> *As far as Wairewa is concerned ... It's like, they're kind of getting ready for flooding. That's kind of where their heads are at. They're not saying, 'oh, no, we'll be fine'. They're like, 'well, we better actually...' Because they know. So I think that there is that kind of... I don't want to say that the community is on edge, but there is certainly a much more heightened sense of alarm these days than... this is my perception, than there would have otherwise been.*
>
> *They're still wary of flood events ... There is still a flood risk and they acknowledge that. And I guess because of that, the Little River community board have ... Work quite closely with our team ... to try and work through this. So yeah, there is quite an active community presence trying to make sure things are worked through or acknowledged at least.*

However, preventative actions reduce the level of flood impacts people sustain. The lower the subsequent levels of flood impact, the more complacent people may become about flood risks over time, and the fewer preventative actions they may take to reduce future flood impacts. This was a concern for some participants:

> *... if it wasn't for the 2014 flood, we probably still wouldn't have a rating district in our area... It was a workplan for the next ten years. And so... What we have to do is go back to the community next year and then get them to agree to continue, because if they don't, [a large flood event] could happen again. So hopefully people think, 'okay, we still need it'.*

The balancing relationship in this loop means that the extent of flood impact on residents and businesses and the degree to which they attempt preventative actions to reduce future flood impacts may be expected to oscillate over time. This may be especially true if the make-up of the community changes to include newer residents who have not experienced flooding in Little River and may be unaware of the potential risk.

5.3.4 Awareness of historical flooding and collective memory

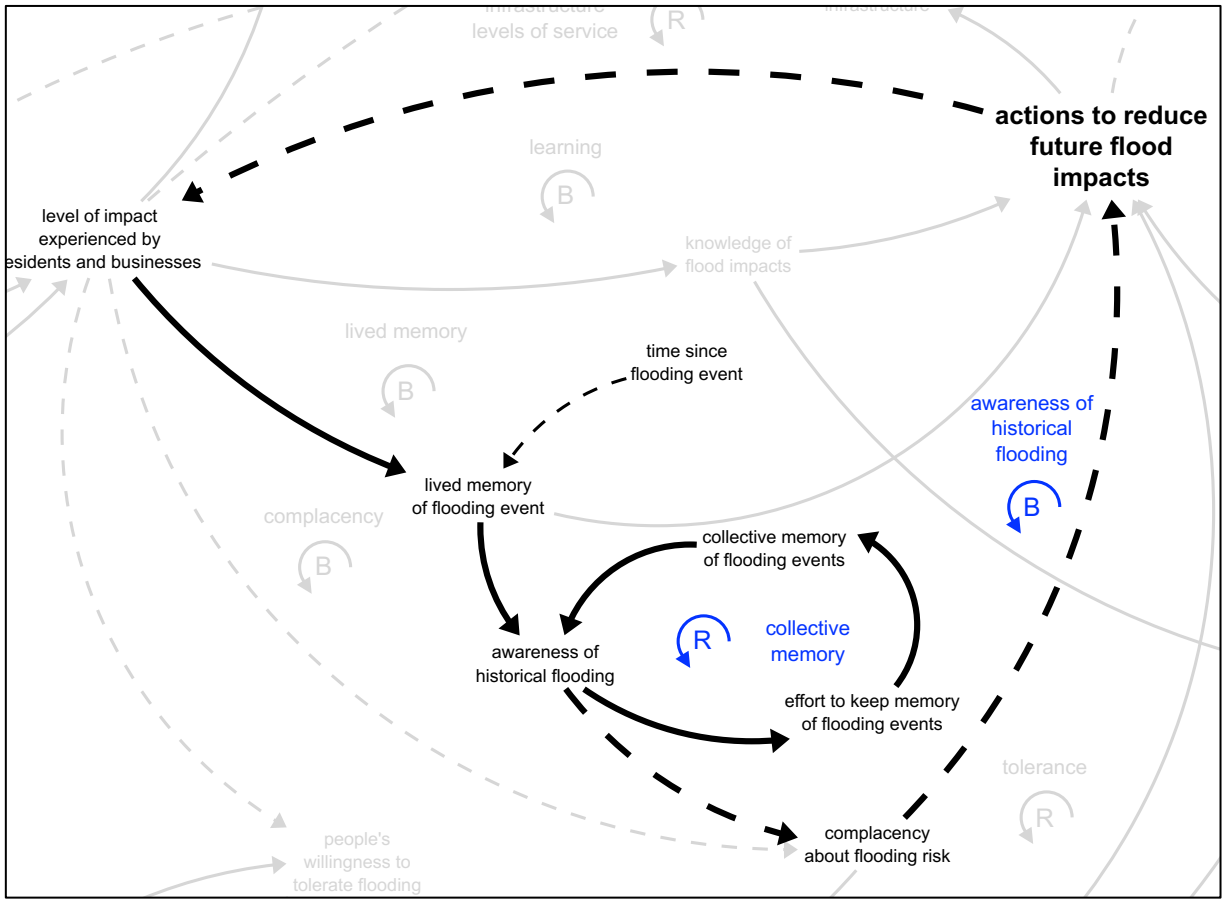

Figure 5-11: Awareness of historical flooding and collective memory loops.

Awareness of historical flooding and *collective memory* influence the degree to which people are complacent about taking actions to reduce future flood risk (Figure 5-11).

There is a balancing relationship between the level of flood impact that residents and businesses experience, their awareness of historical flooding, and the level of actions they take to reduce future risk (*awareness of historical flooding* loop). The greater the flood impacts

experienced, the greater people's lived memory of the event and awareness of what, over time, comes to be classified as historical flooding. This in turn lowers people's complacency about flood risk and increases the level of preventative actions they take to reduce future flood impacts.

As previously described, experience of flooding motivated Little River residents to take individual and collective actions to reduce future risk. In the future, it is possible that the effectiveness of those preventative actions may lower the community's lived memory and awareness of historic flooding and increase complacency towards flood risk. If this were to eventuate, residents may reduce the number of preventative actions they take or invest in. For example, in Little River there was some concern that new residents might not be aware of previous floods and therefore be less aware of the need for investing in actions such as the river ratings district.

The balancing relationship in this loop means that the level of awareness people have of historic flooding and the level of actions they take to reduce future flood impacts may be expected to oscillate over time.

Closely related to this is the reinforcing relationship between awareness of historical flooding and a collective memory of flood events held within the community (collective memory loop). The greater awareness people have of historical flood events, the greater the efforts made to remember those events, and the stronger the collective memory of flooding.

In Little River, several participants (including non-Rūnanga members) pointed out how the area's name 'Wairewa' holds important historical information about its flood risk, but that many new arrivals are not aware of this until locals share that knowledge with them:

> *... a lot of the people who moved into Little River, to Wairewa, thought 'oh, yeah, this place doesn't flood'. And when you explain to people that 'Wai- rewa' ... So water, wai, rewa kind of means 'to float'. But in this sense it means like to rise quickly, because we're in the catchment in these hills, we have quite a steep hill catchment. So when people say Wairewa, what does it mean, it means 'fast-rising water'.*

Explaining the meaning of the name 'Wairewa' to new residents is itself an important action that helps to ensure that knowledge of local flood risk endures. Conversely, the lower the lived memory and awareness people have of historical flood events, the lower the efforts made to remember those events, and the weaker the collective memory of flooding becomes over time.

5.3.5 Tolerance

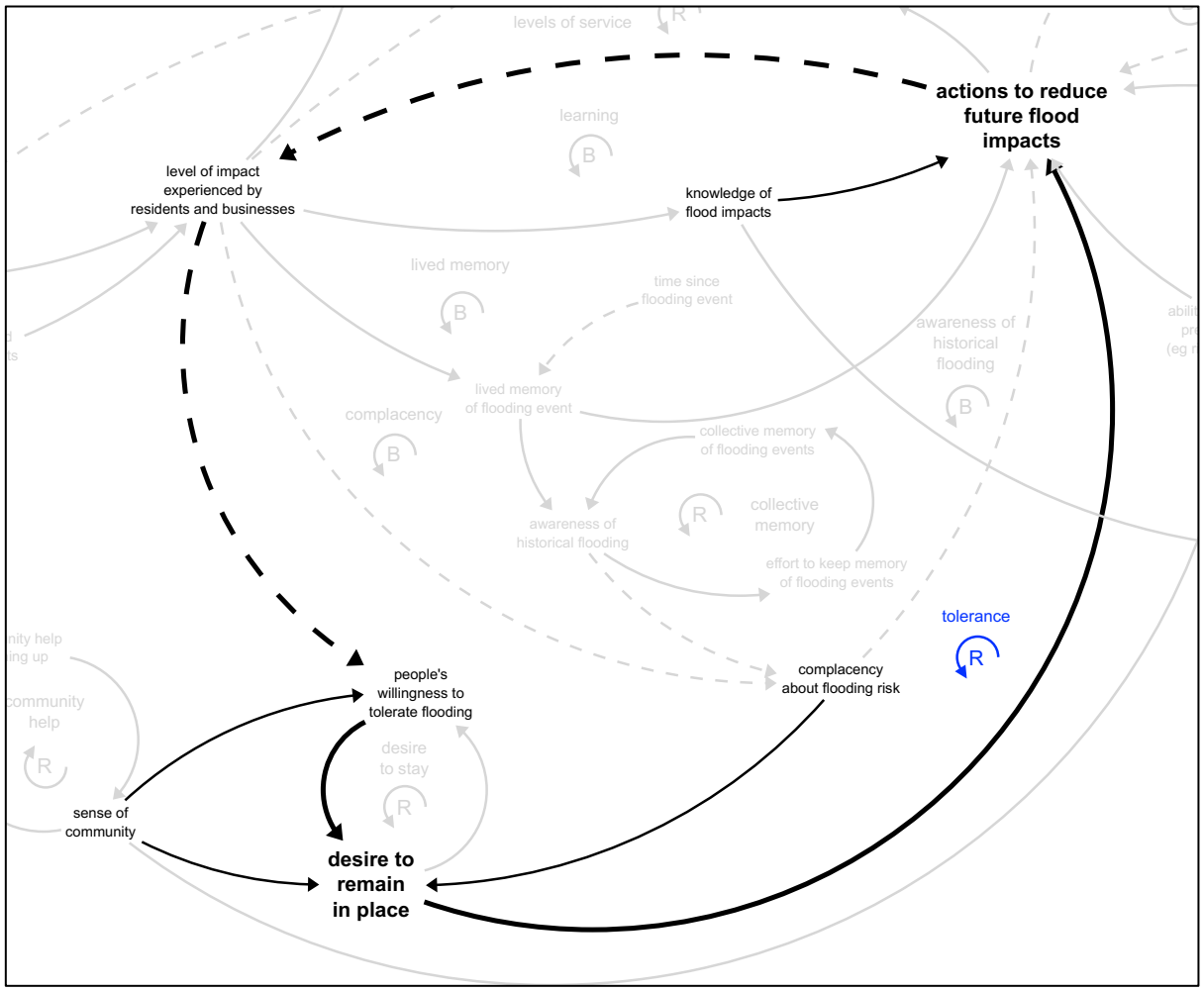

Figure 5-12: Tolerance loop.

The *tolerance* loop directly connects into the *desire to remain in place* grouping, capturing the reinforcing relationship between the desire to remain in place and amount of preventative *action taken to reduce future flood impacts* (Figure 5-12). The greater the desire people have to stay in place, the more they invest in actions to reduce flood risk, and the lower the level of impacts experienced. The lower the level of impacts experienced, the greater the tolerance to flooding and the higher the desire to stay in place. This reinforcing relationship means that, over time, the desire to stay in place can be expected to strengthen if actions to reduce future flood impacts increase.

Due to the strength of their connection to place and community, many Little River residents currently experience high levels of tolerance to flooding and willingness to stay:

> *... I'm fairly resilient. It'll take quite a lot to get me out of here I think. And like the kids are at school here now and all the rest ... so this is definitely home. So it would take a lot to get us up and out.*

Rather than move, residents have undertaken individual flood mitigation measures and advocated strongly for community-level actions to reduce risk:

> *... No, I don't get a sense that [flooding is affecting people's tolerance to staying]... I get kind of the opposite sense, right. My sense is that the community are almost like digging deeper. There is kind of that community spirit where they ... You know, like 'we can beat this'.*

Conversely, the higher the level of flood impacts experienced, the lower the tolerance to flooding. Over time, this may lower the desire to stay in place. As previously noted, despite expressing a strong desire to remain in Little River, it was suggested that some residents could reach a limit if flood frequency became too high:

> *... I think if we were at that rate where we were flooded a few times in regular, you know, over that period, '13, '14, I think if that maintained I would ... yeah I wouldn't be sticking around, for sure. But we've been fine since then, really. We came very close last year. But yeah. I think if it was a constant, ongoing, persistent thing, then yeah, that would ... a significant event every couple of years would be giving me the s**ts, absolutely.*

If people's desire to stay declines, the less likely they are to invest in actions to reduce flood risk, and the higher the level of impacts they may experience. The higher the level of impacts experienced, the lower the tolerance to flooding and the lower the desire to stay in place. This reinforcing relationship means that, over time, the desire to stay in place can be expected to dwindle if actions to reduce future flood impacts decrease.

5.3.6 Infrastructure levels of service

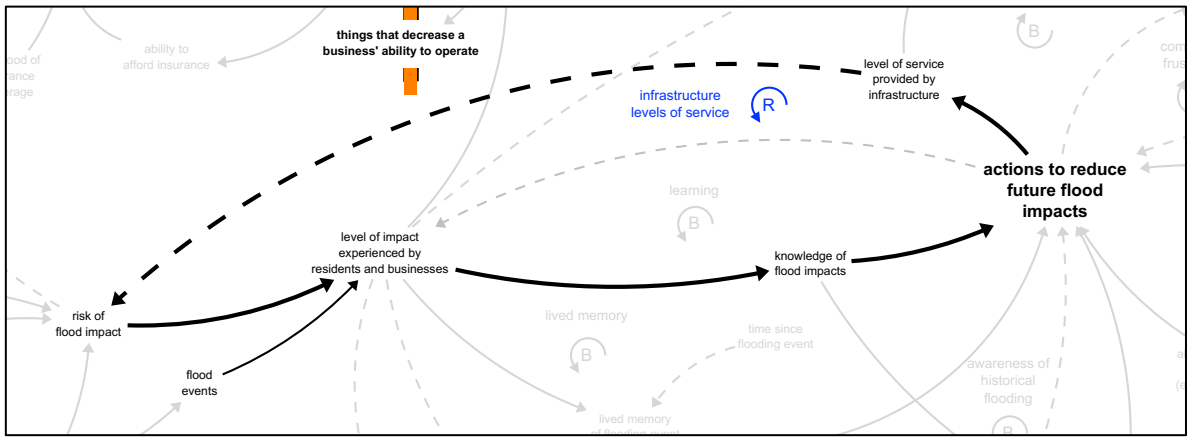

Figure 5-13: Infrastructure and flood impacts loop.

There is a reinforcing relationship between the *level of service provided by local infrastructure* (e.g., stormwater infrastructure) and the level of *flood impact* experienced by residents and businesses (Figure 5-13). When infrastructure levels of service are insufficient to deal with the amount of rainfall received, the level of flood impacts experienced increases. This lowers people's willingness to tolerate flooding. Over time, this could reduce their desire to remain in place, which in turn may lower the number of actions taken to reduce future flood impacts. While the *tolerance* loop (Section 5.3.5) captures individual and collective actions taken to reduce flood risk (e.g., community-funded river maintenance), this loop more specifically accounts for those actions which focus on installing or improving infrastructure (e.g., culverts, pipes).

The *infrastructure levels of service* variable may also influence the balancing loops previously described (*learning* loop, *lived memory* loop, *complacency* loop, *awareness of historical*

flooding loop). This means that over long periods of time, the level of service provided by infrastructure in the future may oscillate due to changes in complacency, knowledge, lived memory and awareness of flood risk. Similarly, this also works to reinforce the existing *tolerance* reinforcing loop previously described. The greater the *infrastructure levels of service*, the lower the impacts and greater the *willingness to tolerate flooding* and *desire to remain in place*.

5.4 Desire to remain in place

The community's *desire to remain in place* grouping captures the relationship between residents' sense of community, their tolerance of flooding, and their desire to stay within Little River (Figure 5-14). The grouping is comprised of two reinforcing loops (*community help* loop, *desire to stay* loop) and is directly connected to all the other causal groupings in the diagram.

5.4.1 Community help and desire to stay

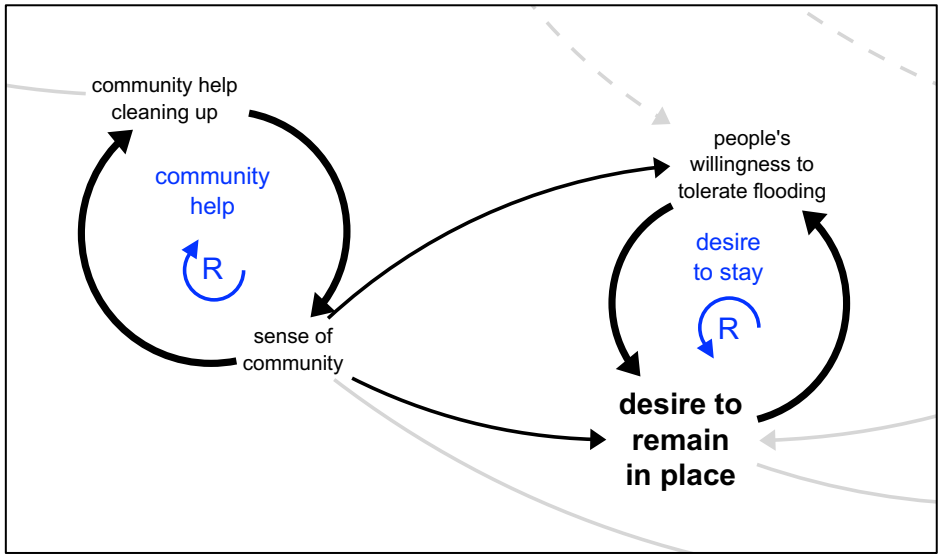

Figure 5-14: Community help and desire to stay loops.

A strong sense of community and belonging in Little River increases residents' desire to stay and the extent of flooding they are prepared to tolerate in order to remain in place:

> *... It's the community as well as where we live, isn't it? That's why we moved here, that's what we got stuck into, and we're part of the community and enjoy the community. So if they came to us in five years' time and said, you have to move, we would be really devastated, no discussion.*

In turn, the greater residents' willingness to tolerate flooding, the higher their desire to stay in place (*desire to stay* loop). This produces a reinforcing relationship, in which people's preparedness to tolerate flooding and desire to stay in place can be expected to increase over time. Conversely, if people's tolerance for flooding was to decline (perhaps due to an increase in the frequency or severity of flooding), this would likely lower their desire to remain in place, further reducing their tolerance for future flooding.

An important influence on the sense of community in Little River is that residents help one another out during and after a flood event (*community help* loop). This forms a reinforcing relationship, where the greater the sense of community, the more that community members

assist each other; the greater the assistance, the stronger the sense of community. Over time, this sense of community can be expected to strengthen as support increases.

A strong sense of community support was reflected in comments from interviewees, for example:

> *... Yeah, it's just a big clean-up job, but there's so many people out here like so many locals turn up and just muck in. It's quite amazing. They just turn up with trailers and tools and wheelbarrows and, you know, mops and whatever and just get into it ... It's small-town mentality. Everyone gets in there and just clean things up.*

Conversely, the weaker the sense of community, the less community members might assist each other. The less assistance community members receive, the weaker the sense of community. Over time, the sense of community as expressed by research participants could be expected to erode if residents were to stop supporting and assisting each other.

5.5 Insurance

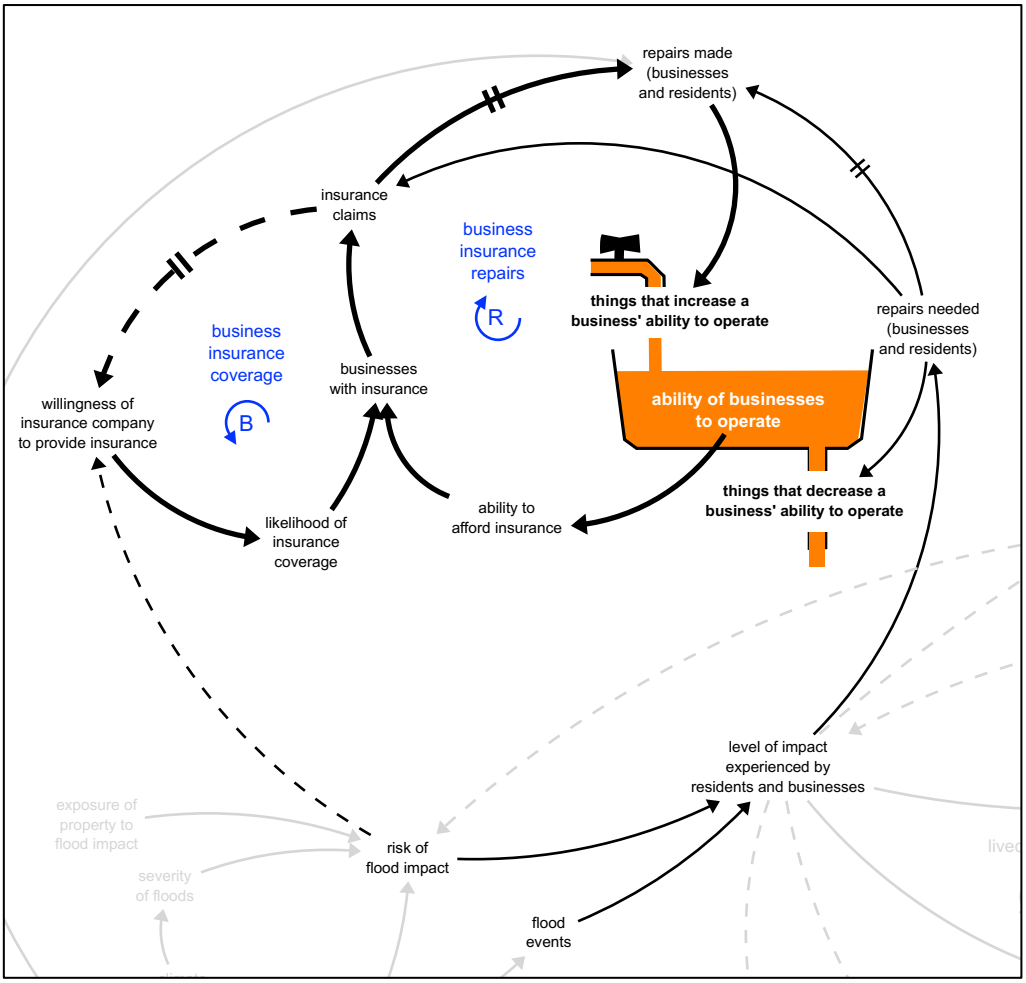

Figure 5-15: Business insurance loops.

At the centre of the *insurance* grouping is the relationship between insurance cover and the *ability of businesses to operate* (Figure 5-15). Having insurance is a significant influence on local businesses' ability to recover following a flood. Insurance cover provides the financial means to

conduct repairs and maintain or resume operations in a timely manner. This is particularly important in a small, rural community such as Little River, which has limited retail services available locally. Businesses in Little River have experienced loss of insurance cover due to flooding and some participants expressed concerns that future flooding would further reduce their ability to afford or be eligible for insurance.

5.5.1 Business insurance coverage and repairs

There is a balancing relationship between the frequency of insurance claims made following a flood event and the ability of businesses to maintain their insurance (*business insurance coverage* loop). The more insurance claims that are made for flood-related damages and repairs, the less willing insurance companies are to provide insurance coverage, particularly if future flood risk remains unchanged or increases. Businesses face reduced cover and/or loss of cover entirely. The fewer businesses that have coverage, the fewer insurance claims that are made following future flood events.

Conversely, the fewer claims that are made, the more likely insurance companies may be willing to provide coverage. Another important influence on insurance companies' willingness to provide cover is whether flood risk is declining. For example, one business owner described taking actions to reduce flood risk, to ensure continuity of cover:

> *... The major building had a big concrete base so you can't lift a concrete base. But we had to do other mitigating actions so that we could continue to be insured.*

Closely related to the *business insurance coverage* loop is the reinforcing relationship between business insurance and the ability to undertake the repairs that allows businesses to operate (*business insurance repairs* loop).

Included in the *business insurance repairs* feedback loop is a 'bathtub' analogy which allows us to better understand how the level of a variable can accumulate (filling the bathtub) or reduce (draining the bathtub) over time. In this case, the bathtub demonstrates how a business's ability to operate is increased by factors that 'fill the tub' (e.g., having insurance, the community helping to clean-up post-flood) and decreased by things that 'drain' the tub (e.g., needing to make and pay for repairs). The reinforcing relationship in this loop captures how the less insurance coverage that businesses have, the lower their ability to repair damages and operate in a usual manner after a flood. Where compromised ability to operate reduces a business's income, this may reduce their ability to afford insurance (particularly if the frequency of flooding is relatively regular or increasing), and in turn their ability to operate after a future event. Over time, this could be expected to result in a downward spiral in business resilience.

Flood damage to local businesses presents a significant challenge for residents in Little River, given its small and relatively isolated nature. Participants discussed how local businesses provide local employment, and how residents come together to help clean up in order to support business owners and ensure their timely re-opening:

> *... 'cause we're the one stop shop for everybody. People have supplies they need out here. And if we're closed... Whether candles and water and whatnot, then they have to go town and it's an hour and a half round trip. So, it's quite important to get back open again.*

> *... you need to be open to make a living. And we had people that work for us and they needed their jobs not to be disrupted and stuff.*

6 Future-focused impacts

As well as the loops developed from the data analysis, several future-focused themes were identified. These were developed from commentary on what the future might hold for Little River, given projected climate change and future flood risk. It is intended that they will be more fully explored in subsequent publications.

6.1 Connection to place in a changing climate

Participants described a strong connection to place and community in Little River. This appears to influence their willingness to accept a certain degree of flood risk in return for the ability to remain in the area. Participants did describe having heightened awareness of flood risk, and some also expressed being somewhat concerned about future flooding. However, most also appeared to find the current risk of flooding to be tolerable, rather than something that caused a great deal of anxiety or stress on a day-to-day basis.

It should be noted that the participants we interviewed are those who continue to live in Little River, rather than those who have left. It is therefore possible, though no inferences can be made, that flood risk has been a factor in influencing previous residents to leave.

Due to the continuing strength of participants' connection to place, there is a strong focus on taking actions to further reduce flood risk. While participants acknowledged there are limits to how much flood risk can be reduced in Little River ("*... there's gotta be some point where it [infrastructure] doesn't work*"), those we spoke to were confident that there was currently still more which could be done in this regard. This included suggestions of continued pest tree removal, riparian planting to stabilise riverbanks, potentially elevating homes, and potentially implementing larger flood protection infrastructure works. This confidence appeared to be bolstered by the success of river maintenance measures undertaken via the rating district scheme with ECan, which participants described as having noticeably reduced flood risk. It is likely that this confidence in risk reduction measures has contributed to participants' ability to recover following previous experiences of flooding, and their continued desire to remain in the community.

If proposed actions are insufficient to deal with future flood risk (or unable to be implemented e.g., due to financial limitations), it is likely there would be negative implications for residents' wellbeing, and potentially even implications for their desire to remain in place. Some participants reflected on whether there may be a tolerance threshold at which they, or members of the wider community, may no longer be willing to accept flooding in Little River. However, all those residents we spoke to affirmed their desire to remain in the community under present conditions. It is therefore important for the community that measures to reduce flood risk (including maintaining support for the river ratings district that funds such actions) continue to be undertaken.

6.2 Maintaining community-council relationships

An important factor that has allowed flood mitigation measures to be successfully implemented in Little River has been the ongoing development of productive community-council relationships, instigated by community advocacy action.

Over time, investment by both community and council in relationship-building and collaborative decision-making has led to the successful implementation of flood mitigation measures in Little

River. According to participants, an ongoing commitment to working with one another, while not easy, has reaped rewards in terms of supporting community aspirations and building trust between the council and community.

Maintaining these engagement processes, managing disagreements, and ensuring strong communication channels are likely to be essential for the continued success of flood risk reduction activities and for maintaining productive community-council relationships. Conversely, if these processes are allowed to deteriorate, this is likely to undermine relationships and future efforts to reduce local flood risk. Renewed anger and frustration towards Christchurch City Council following recent flooding in May 2025 highlights that community-council relationships can remain fragile when flooding continues to occur, as disagreements arose once again over the potential role of water levels in Lake Forsyth exacerbating the severity of the flooding (RNZ 2025b).

7 Where do we go from here?

The causal diagramming exercise highlights a number of flooding effects on the wellbeing of the Little River community. Many of the experiences of flood impacts in Little River were broadly similar to those in Auckland and the Waikanae Catchment. For instance, all cases identified stress and trauma within the community, the role of community in supporting one another, and the influence of flooding and flood risk upon community relationships with councils.

Across our three case studies, including Little River, the impacts of floods go well beyond the inundation and damage experienced during and immediately after an event. They affect trauma levels within the community, the ability to function in everyday life, how communities connect and function, the capacity of communities to adapt to flood risk, and the ability of the investment and regulatory environment to manage flood risk. We identified four mechanisms for understanding how flood impacts cascade through Aotearoa New Zealand's social and economic systems in ways that, if not addressed, can increase community vulnerability to harm (Figure 7-1).

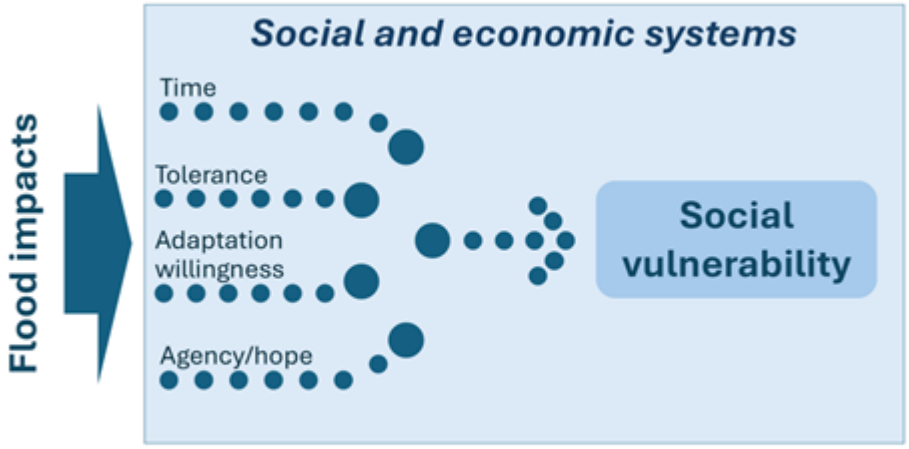

Figure 7-1: How flood impacts cascade through social and economic systems to increase social vulnerability.

Time plays an important role in understanding how impacts from flood events develop. Firstly, the full consequences of floods take time to become apparent and often the consequences only become apparent when things are well into post-event recovery phase. Secondly, time between events matters – without sufficient time to fully recover and experience life as normal, the trauma from flooding accumulates. And thirdly, time fades memories – without knowledge of what has happened in the past, there is little motivation for change in terms of actions to reduce the risk of future flood impacts.

Tolerance to flooding varies, particularly to the cumulative impacts from repeated historical events, or the threat of repeated future flooding. Threats to life, property investments, quality of life, and personal investments in future lifestyles all affects people's willingness to tolerate future flooding.

We found that the willingness to take adaptation measures to reduce future risk and trauma was affected by knowledge of past impacts. This included both personal experiences and

collective memories held within the community. Greater knowledge of previous events motivates adaptive change at the personal property level and supports willingness within the community to collectively address risks. Conversely, where there is less willingness to adapt (perhaps because of few memories), people are inadvertently less able to reduce their future flood risks and will be more vulnerable to harm.

Where there is personal, collective, and council agency to manage and adapt to future flooding risk, people have hope for their future in their community. This belief in the ability to manage flood risk supports, and is motivated by, connection to place and community. Where flood risk mitigations are no longer possible or sufficient, desire to remain in place can weaken and negative implications for wellbeing can emerge.

Addressing these influences on vulnerability should happen across the 4 Rs of emergency management – Reduction of risk, Readiness and Response to events, and Recovery from events. Examples include:

- Supporting people's ability to function in everyday life over the extended recovery period.
- Acknowledging and mitigating the trauma caused by flooding, no matter the scale of events.
- Promoting community connections and functioning before, during and after events.
- Creating and maintaining collective knowledge about flood events to increase the appetite for flood harm reduction measures, so those who do not have direct experience are also better protected in the future.
- Building and maintaining collaborative working relationships between communities and their respective councils.
- Supporting investment and regulations that manage and mitigate flood risks.
- Supporting the adaptive capacity of communities.

7.1.1 What does this mean for people in Little River?

Although the purpose of this research was only to provide insights on the nature of cascading social impacts of flooding, information from the causal diagramming exercise could be used by the community and councils to draw on themes emerging from the diagram (e.g., community relationships with councils or insurance companies) to achieve better outcomes. To do this, Wairewa councils and communities could ask themselves a number of questions:

- How can we ensure over time that the community does not forget what has happened before? How can collective memory be kept alive? For example, are there community spaces where images and memories can be kept?
- How can learnings be shared with others in the community about what actions can be taken to reduce one's future flood risk?

- How can productive working relationships between the community, councils and government agencies be maintained and improved, to ensure continued collaboration to reduce flood risk?
- Community connections are an important factor influencing residents' desire to stay in Little River and an important source of support during and following a flood. How does the community ensure that those connections are sustained?

These questions can help to frame thinking about actions and interventions to reduce future flood vulnerability in Little River.

8 Acknowledgements

We wish to acknowledge the contributions of the late Dr. Benita Wakefield to this work including her work connecting us with the Little River community, supporting the data collection process, and providing guidance by drawing on her deep local knowledge.

We also wish to thank all participants who shared their stories and knowledge with us as part of this project. We are incredibly grateful for the time you took to provide us with your insights and lived experiences.

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Appendix A How to read a causal diagram (detailed)

This appendix provides a more comprehensive explanation for how to read a causal diagram.

Causal diagrams help us visualise the relationships between different related variables and how they influence each other. This visual articulation of inter-connected relationships is called the 'causal structure'. This causal structure helps us understand how the behaviour of variables in the diagram will change over time will change (or not), in response to changes (or not) in factors within the wider causal structure.

This section outlines important fundamental elements of causal structure. These are:

- The bathtub analogy.
- Feedback loops – the basic building blocks of a causal diagram.
- How feedback loops and causal diagrams are annotated.
- Goals and gaps – driving individual loop dominance.
- How influence operates differently upstream and downstream of a change in flow.

Reading this section will help the reader understand and navigate the causal diagram in this report.

The bathtub analogy

Causal diagrams often draw on the analogy of a bathtub. A metaphorical bathtub has been used in the diagram described in this report. The analogy of the bathtub (Figure A-1) represents an accumulated level or amount of something (also called a stock) that is of interest to the issue you are seeking to understand. It may even be the central feature of the issue you are seeking to better understand.

The level of the bathtub (stock) can only be increased by adding more through a metaphorical tap (also called an inflow); and it can only be decreased by removing some of what is in the bathtub through a metaphorical drain (also called an outflow).

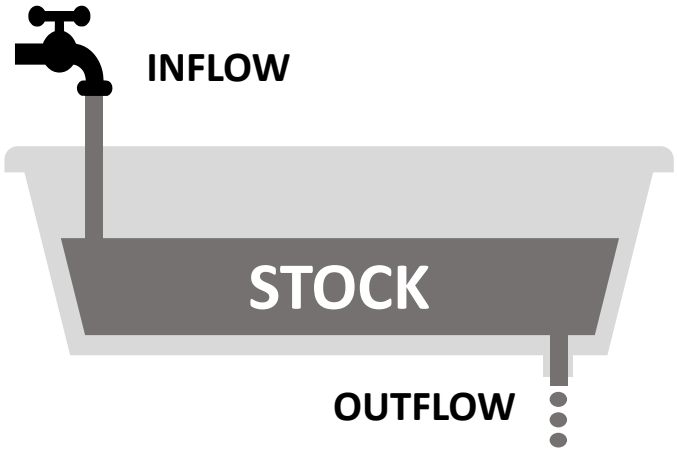


Figure A-1: The bathtub analogy.

This simple analogy can provide powerful insights. For example, an action may stop an issue being added to by reducing or stopping the inflow (the tap). This will stop the level of the bathtub increasing but will not reduce it. To demonstrate this, think of greenhouse gas emissions into the atmosphere. If all greenhouse gas emissions were to stop tomorrow, this would not cause their level in the atmosphere to reduce, it would simply stop them increasing.

Another example is an action that may increase the outflow (the drain) from the bathtub in an attempt to reduce the level of the bathtub. But if there is still a significant inflow through the tap into the bathtub, this will reduce the impact of the increased outflow from the drain. Or if the inflow was to increase more than the outflow, the level of the bathtub will still continue to rise, but at a slower rate due to the increase in the outflow (drain). Greenhouse gases are another good way of demonstrating this point. Even though there are many increased efforts to remove greenhouse gases from the atmosphere (e.g., increasing the flow from the drain (i.e. sequestering carbon) by planting trees or using direct carbon air capture technology), if the emissions (the tap) increase by more than the drain, the level of the bathtub will still increase.

Simply put, if more flows in through the tap than out the drain, the level of the bathtub increases. If more flows out than in, it decreases. It is noted that the bathtub is a metaphor – it will never overflow as it does not technically have a specific capacity. However, it may be fully exhausted (drained).

Feedback loops – the basic building blocks of a causal diagram

Causal diagrams focus on moving away from thinking of causality as linear, to circular. That is, a linear way of thinking about causality might be that A influences B, whereas a circular way of thinking about causality might be that A influences B, and then B also influences A (Figure A-2). This means the causality 'feeds back' on itself, so where this is identified it is known as feedback loops.

Figure A-2: From linear to circular causality.

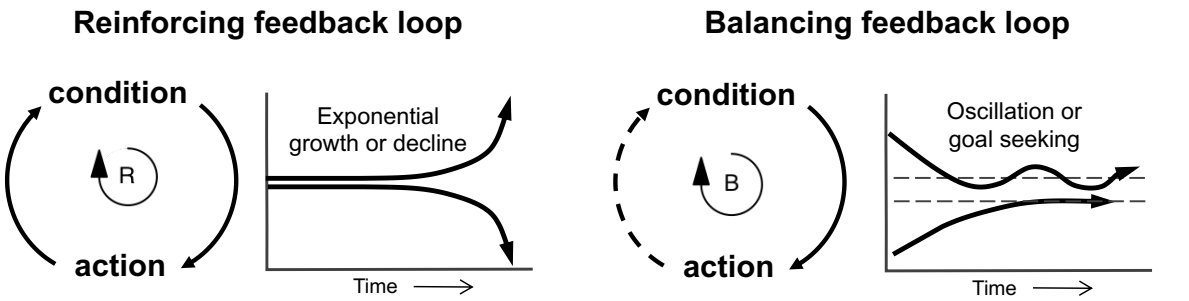
There are two types of feedback loops, reinforcing and balancing (Senge 2006).

Reinforcing loops seek to spiral in the direction they are already heading (hence reinforcing). They can spiral up or spiral down, and they tend to drive growth or decline (see Figure A-3). They can also change direction and spiral the opposite way, in response to influences from outside the feedback loop (i.e. how they interact with other influences). But the influence from within the loop will always seek to continue spiralling it in the same direction that it is heading.

A simple example of a reinforcing loop is money in a bank account earning interest. Assuming no withdrawals, the more money in the bank then the more interest earned, thus resulting in even more money in the bank. This influences back on itself in the same direction and has the effect of compounding on itself.

Balancing loops seek to cancel or balance themselves out. They tend to create control, restraint or resistance (Figure A-3). Depending on how they interact with other loops they may not always manage to cancel themselves out or come back into balance, but this is what the influences within them will be seeking to do.

A simple example of a balancing loop is thermostat-controlled heating. Let's say that the room temperature drops so the thermostat clicks on and generates heating, this increases the room temperature, so the thermostat clicks off, stopping the heating. This has the effect of cancelling itself out.



Adapted from Senge (1990) & Ford (2010)

Figure A-3: The two types of feedback loops.

Feedback loops can be made up of more than two variables and can be linked together to form a causal diagram. How these interact in a wider network of loops and influences provides insight into the influences that may be causing a change in the system over time.

How feedback loops and causal diagrams are annotated

This section describes how feedback loops and causal diagrams are annotated.

Labelling variables

As noted in the bathtub analogy section, an important concept within causal diagrams is demonstrating where things build-up (accumulation) or decrease (decumulation). Not all variables need to be represented using the bathtub analogy, but all variables in a causal diagram should be labelled in such a way that they can increase or decrease. This means that they should be described as nouns; have a clear sense of direction, therefore making it obvious that it could increase or decrease; and/or have a normal sense of direction that is positive (or at least when a change in direction is included, it does not become a double negative – e.g., instead of more or less unhappiness we have more or less happiness). 'Positive' here refers to an increasing direction of change over a decreasing one, rather than a qualitatively positive thing. Examples to demonstrate this are shown in Figure A-4. In this report, when factors from the diagram are referenced in the text, they are italicised.

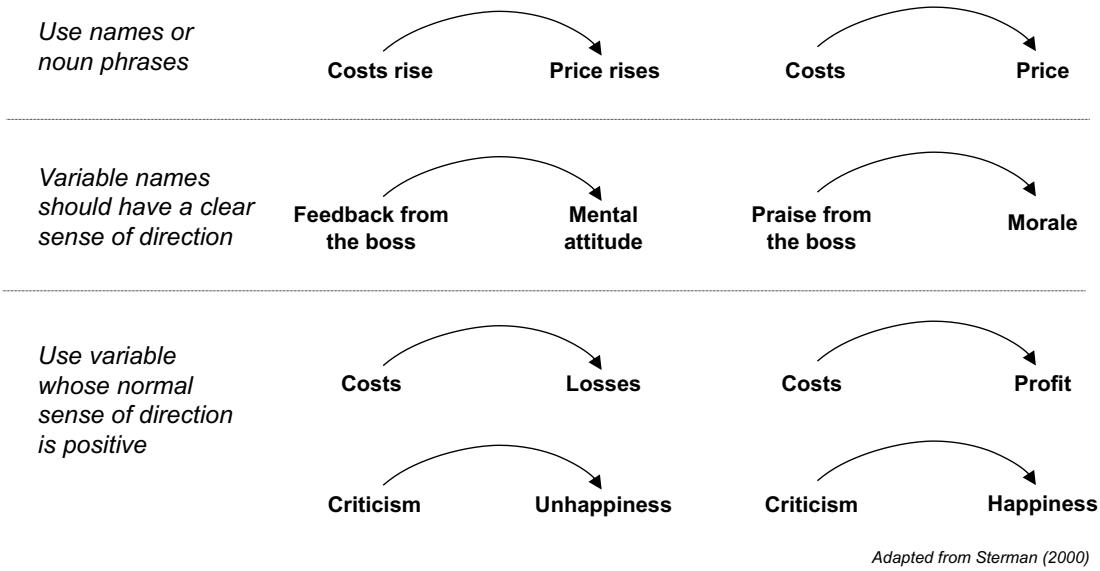


Figure A-4: Labelling variables.

Annotating loops

Variables within causal diagrams are connected (and made into feedback loops) by arrows, indicating that one factor has a causal relationship with the next. These arrows are solid or dashed lines, because they work in either the 'same' or 'opposite' direction. These terms correspond to the direction of change caused by one variable on another (Figure A-5).

For example, if change in one variable leads to change in the next variable in the same direction, it is a same relationship (solid line). Likewise, if the second variable changes in the opposite direction, it is an opposite relationship (dashed line).

Relative delays in the cause-and-effect influence between two variables, when compared to other influences outlined in the causal diagram, are annotated as a double line crossing the arrow. An example of this is shown in Figure A-5.

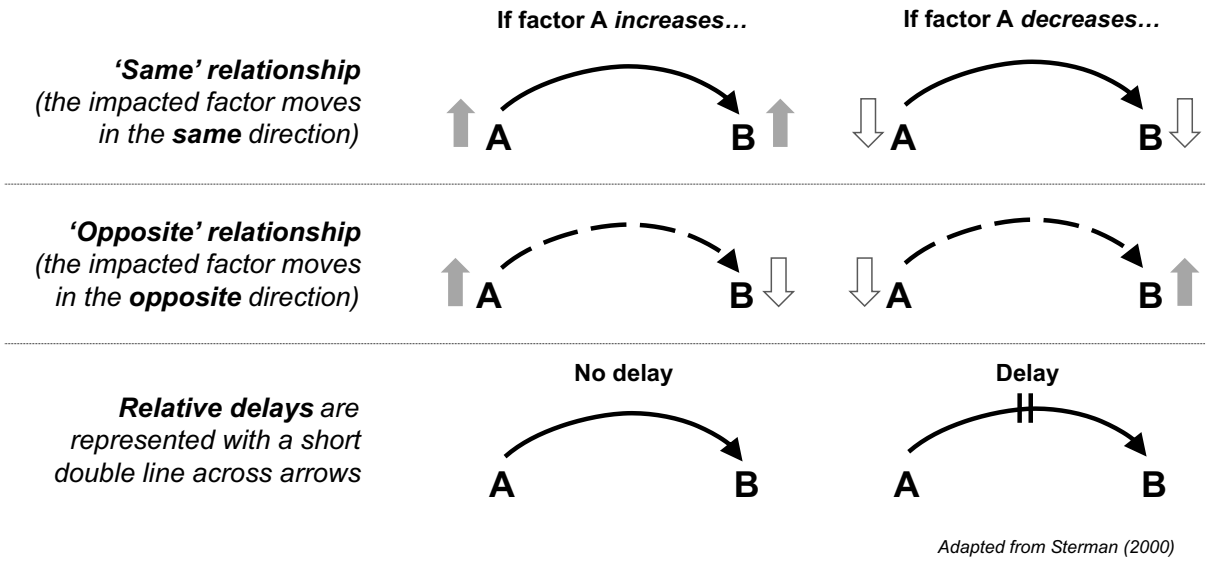


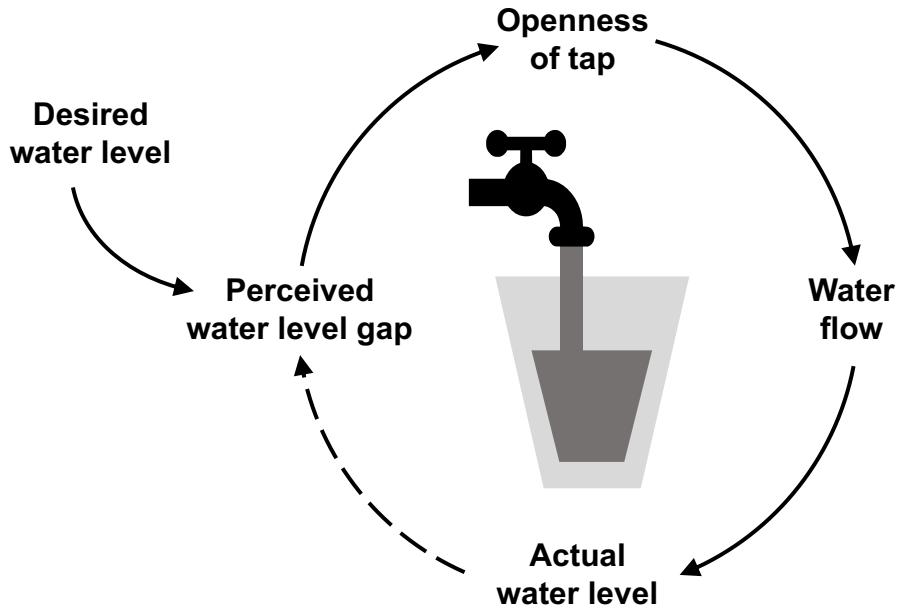
Figure A-5: How arrows and delays are labelled in causal diagrams.

Goals and gaps – driving individual loop dominance

Realising that multiple loops are operating together to generate the behaviour you are trying to understand is the first useful insight of a causal diagram. A further useful insight is understanding that not all loops operate at the same strength all the time. Different loops can dominate at different times. For example, the behaviour generated in a causal diagram might be dominated by a period of growth, but when a physical limit is approached (e.g., the available space in a pond for algae to grow) a balancing loop will start to dominate, therefore slowing the rate of growth.

One useful mechanism for gaining insight into the strength of a balancing loop is '*goal/gap' structure*. This is a feature within the causal diagram that combines both the *desired or aspirational* level for something (a 'goal'), with its *actual* level. The difference between these – aspiration versus actual – is the 'gap'. The higher the desired level and the lower the actual level, the greater the 'gap'. The result is movement towards activities/decisions that narrow the gap between desired and actual. The lower the desired level and the higher the actual level, the lower the 'gap'. This usually leads to decreases in activity because it is nearer its goal.

An example of filling a glass of water is shown in Figure A-6. Initially, while the gap/difference between the desired and actual water level is high, the tap will be opened more. As the desired level of water is approached the gap/difference reduces, so the tap is closed further, until it is fully closed when the water level reaches the desired amount.



Adapted from Senge (2006)

Figure A-6: Example of a 'goal/gap' structure in a system map – filling a glass of water. Adapted from Senge (2006).

How influence operates differently upstream and downstream of a change in flow

When a diagram is made up partly of variables and arrows of influence, as well as a visual bathtub analogy (stock and flows - as this report has), then the flows in or out of a stock

themselves often form pathways of influence within feedback loops. When this occurs, the influence can be either same or opposite, depending on which way along the flow the influence is travelling.

When a flow forms part of a feedback loop and the influence is travelling *with the flow* (i.e. downstream), then that is a same influence. That is, if the flow was to increase (or decrease), then the stock to which it is flowing would also increase (or decrease), all other things being equal.

When a flow forms part of a feedback loop and the influence is travelling *against the flow* (i.e. upstream), then that is an opposite influence. That is, if the flow was to increase (or decrease), then the stock from which it is flowing would decrease (or increase), all other things being equal.

For example, imagine a stock of 'students' at a university and a stock of 'students that have graduated' from that university, joined by a flow of 'students graduating'. An *increase* in the flow of people graduating will *increase* the number of people in the 'graduated' stock – a same influence. At the same time, an *increase* in that flow will *decrease* the number of people in the 'students' stock – an opposite influence.

The flow structure and the variable/arrow influence structure are compared below in Figure A-7.

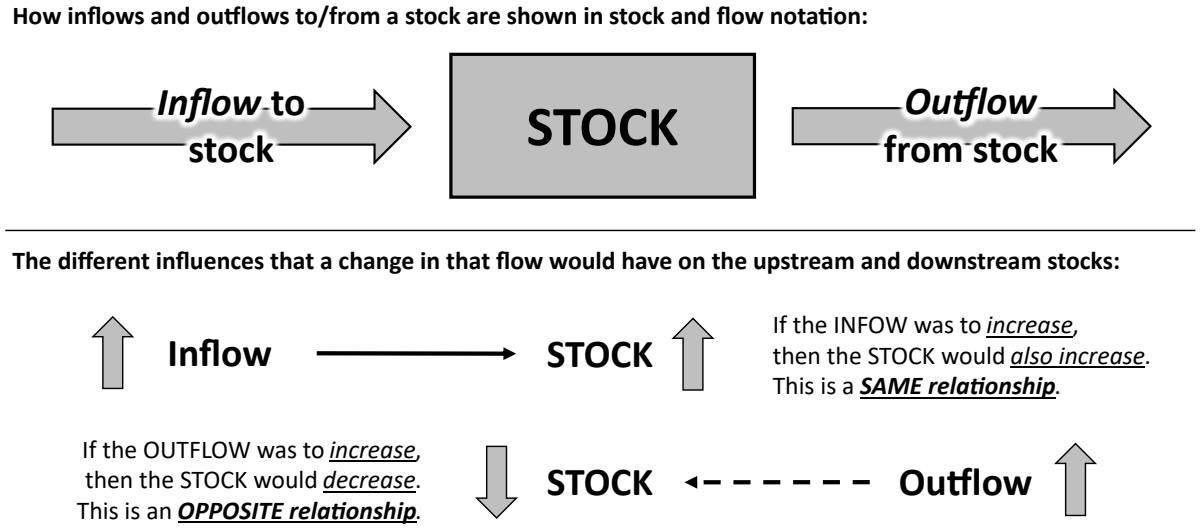


Figure A-7: How influence operates differently upstream and downstream of a change in flow.