Earthquake-Induced Landscape Dynamics (EILD) End-user and Stakeholder tools engagement plan

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ABSTRACT

The 14 November 2016 MW 7.8 Kaikōura Earthquake generated thousands of landslides, hundreds of significant landslide dams and damaged hillslopes that are now susceptible to failure during rainstorms and aftershocks. This debris, when further mobilised, will create new hazards, including further landslides, dams, rapid aggradation and formation of alluvial fans and floodplains, and increased river channel instability as the debris cascades from hillslope to sea. These hazards can persist for decades, requiring active management by the impacted communities and stakeholders.

The 'Earthquake-Induced Landslide Dynamics' research programme (EILD) is funded from 2018 to 2023 to investigate the impacts of the Kaikōura event and integrate field, laboratory and numerical modelling to determine how the hillslopes and rivers will respond to future forcing events, focusing on:

- forecasting landslide severity at different magnitudes of ground shaking and rain;
- quantifying post-earthquake landslide triggering and reactivation thresholds from ground shaking, rain and time;
- evaluating landslide dam longevity;
- determining how far landslide debris volumes travel downslope, once triggered;
- modelling how sediment cascades from hillslope to sea; and
- assessing the performance of earthworks infrastructure subject to landslide.

A set of tools will be developed from the research to inform landslide risk and residual risk-management methods and practices for stakeholders affected by the Kaikōura Earthquake and those that may be affected by future events.

Engagement with identified partners, stakeholders and end-users of the EILD research programme will solicit input and encourage collaboration to develop useful, useable and used tools in mitigating against earthquake-induced landslide risks. In addition, the engagement will promulgate the results of the research as widely as possible to relevant end-users.

The tools will evolve, along with end-users needs, and therefore the process will be iterative. Initial mapping of output and tools to stakeholders and end-users needs has been undertaken, and an engagement plan over the next three years (2021–2023) has been developed. Many engagement methods will be used, ranging from hui, advisory group meetings, regular programme meetings, specific invited workshops and training, special conference sessions, targeted road shows and surveys. Risks that may hinder or impact engagement and possible mitigations against these risks have been identified.

KEYWORDS

Earthquake-induced, Landscape Dynamics, Landslide, Hazard, Risk management tools, Engagement, Kaikōura

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1.0 INTRODUCTION

1.1 Programme Overview

The 14 November 2016 MW 7.8 Kaikōura Earthquake generated thousands of landslides, hundreds of significant landslide dams and damaged hillslopes that are now susceptible to failure during rainstorms and aftershocks. As the debris cascades from hillslope to sea, it will create new hazards, including further landslides, dams, rapid aggradation and formation of alluvial fans and floodplains, and increased river channel instability. These hazards can persist for decades, requiring active management by the impacted communities and stakeholders.

The Kaikōura Earthquake provides a laboratory to quantify post-earthquake landscape dynamics. Earthquake and post-earthquake landslide risk can be effectively managed using an integrated set of predictive tools guided by an evidence-based decision-making framework. The goal is to use novel and innovative methods to avoid and manage earthquake and post-earthquake landslide risk.

The 'Earthquake-Induced Landslide Dynamics' research programme (EILD) has funding from 2018 to 2023 to integrate perishable data obtained from state-of-the-art geophysical methods, mapping, ground profiling, field monitoring, laboratory testing and numerical modelling to determine how the hillslopes and rivers will respond to future forcing events, focusing on:

- forecasting landslide severity at different magnitudes of ground shaking and rain;
- quantifying post-earthquake landslide triggering and reactivation thresholds from ground shaking, rain and time;
- evaluating landslide dam longevity;
- determining how far landslide debris volumes travel downslope, once triggered;
- modelling how sediment cascades from hillslope to sea; and
- assessing the performance of earthworks infrastructure subject to landslide.

A set of tools will be developed from the research to inform landslide risk and residual risk-management methods and practices for stakeholders affected by the Kaikōura Earthquake, locally, regionally and nationally.

1.2 Aims

The aims of this engagement plan are:

1. To provide a co-ordinated and consistent approach to engagement to ensure programme success.
2. To enable tools to be developed with researchers and end-users to ensure they meet end-user needs.

The expected outcome is that stakeholders are well informed and feel they are meaningfully contributing to programme outcomes. This engagement plan is primarily for the EILD programme team, and for those researchers involved in the tool development task. The plan is aimed at engagement within the programme team (i.e. for tool development) and with external stakeholders, partners and end-users (as described in Section 2 of this report) for both research direction and tool development.

1.3 Level of Engagement

The engagement will involve different forms of engagement at different times, depending on the objectives, anticipated outcomes and context. Figure 1.1 shows the spectrum of engagement that will be used throughout the duration of the research programme.

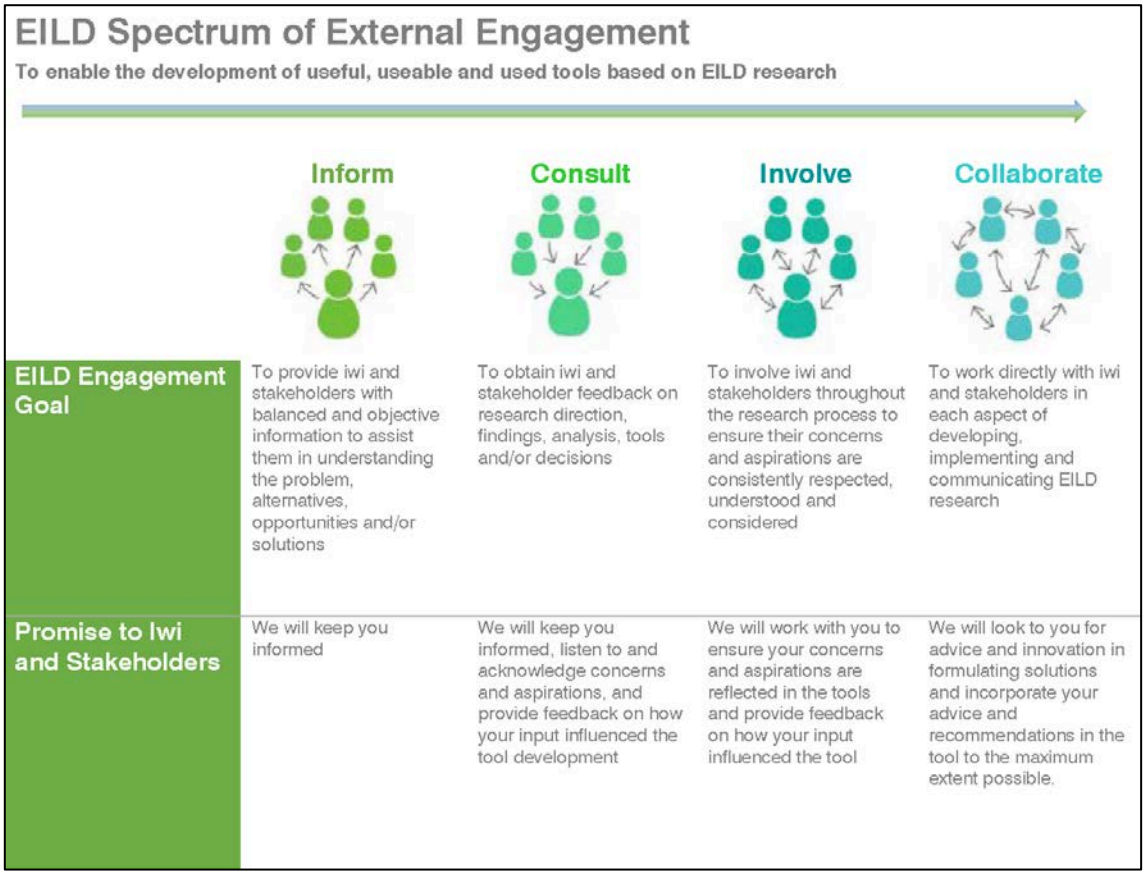


Figure 1.1 Spectrum of engagement for the EILD programme (Saunders 2019).

We will be utilising this range of engagement by:

- **Informing** researchers and end-users of progress and outputs via a website and Stakeholder Group meetings
- **Consulting** to collect feedback on progress and tool development
- **Involving** end-users in the development and direction of the project to ensure their needs are met, and
- **Collaborating** to develop tools to ensure they are fit for purpose.

2.0 STAKEHOLDERS AND END-USERS

Ngāi Tahu are a key partner to be consulted and given the opportunity to involve and shape the tool development. Te Rūnanga o Kaikōura has been identified as the mana whenua that have kaitiaki of the Kaikōura takiwā.

In addition to iwi, three other key stakeholder groups have been identified: regional stakeholders, national stakeholders and researchers. These stakeholders are represented by the Regional and National Advisory Groups and the Scientific Advisory Group. These stakeholders will be regularly informed of the progress of the outputs and tools via programmed regular meetings, where the members will be consulted and invited to opportunities to be involved or collaborate in the tool development.

The tools or output from one research aim may have significant overlap or input into tools and outputs of other research aims within the programme. Hence, the programme itself is an end-user and stakeholder.

2.1 Iwi – Ngāi Tahu as the Kaitiaki Research Partner

At the beginning of the project, initial engagement took place with representatives of Takahanga Marae, Te Rūnanga o Kaikōura, who advised that engagement should be via Mahaanui Kurataiao Ltd (MKL), based in Christchurch. MKL supports the rūnanga in achieving their objectives and aspirations for environmental management in their takiwā. They also provide environmental, cultural and consultation facilitation advisory and environmental planning to a range of local authorities, government agencies and private sector clients. In 2018, it was agreed that the project team will share GIS layers and other relevant information with MKL so they can add the information to their own GIS system. Effort continues to be made to partner and support additional iwi-led research and tool development for this project, including funding post-graduate students. MKL were to receive invitations to all advisory group meetings, as well as the agenda and minutes. Principle researchers were to meet with MKL when in Christchurch to provide updates, share new knowledge and seek advice and input when required (e.g. in the development of warning systems and other tools).

However, the programme was informed in 2019 that Te Rūnanga o Kaikōura are the partners for the project, and they are to receive invitations to all advisory group meetings and the agenda and minutes. At present, EILD has not been able to engage with Te Rūnanga o Kaikōura and are looking to co-ordinate consultation with ECAN and the Kaikōura District Council.

Any project researchers wanting to engage with MKL and Te Rūnanga o Kaikōura need to co-ordinate this with Tania Gerrard (t.gerrard@gns.cri.nz) prior to any contact. This is to ensure any engagement is co-ordinated, consistent and culturally appropriate.

2.2 Regional Stakeholders – Using the Research Output Locally

To ensure that the research outcomes are relevant and useable for end-users, particularly in the north Canterbury and Marlborough areas affected by the 2016 earthquake, a number of entities have been identified as regional stakeholders, including regional and district councils, entities responsible for infrastructure and networks in the area and emergency managers. These stakeholders are dealing with reconstruction and other ongoing effects of the earthquake and are having to prepare development plans and warning systems to take these ongoing effects into account.

To facilitate regional engagement, an advisory group (Table 2.1) has been established to represent the above regional stakeholders, with associated terms of reference (see Appendix 1). Representation from these stakeholder entities may vary over the duration of the programme.

Table 2.1 Regional Stakeholder Group members.

REGIONAL STAKEHOLDER GROUP		
Full Name	**Organisation**	**Role in Organisation**
Helen Jack	Environment Canterbury	Scientist and science communicator
Julie Howden	Kaikōura District Council	Deputy Mayor
Kevin Heays	Environment Canterbury	Environment Canterbury (Kaikōura) Lead
Matt Hoggard	Kaikōura District Council	Strategy, Policy and District Plan Manager
Michael Bennett**	Beef + Lamb New Zealand	Project Manager, Post-Earthquake Farming
Michelle Wild	Environment Canterbury	Senior Scientist (Water Resources)
Monique Eade	Hurunui District Council	Policy Planner
Murray Griffin	Environment Canterbury	Facilitator, Kaikōura Zone Water Management Committee
Nick Griffiths	Environment Canterbury	Science Team Leader – Natural Hazards
Nic John	Department of Conservation	Group Manager
Peter Bradshaw	Environment Canterbury	Kaikōura Land Management Advisor
Shaun McCraken	Environment Canterbury	Regional Lead, River Engineering
Kim Wright	National Emergency Management Agency (NEMA)	Senior Advisor, Hazard Risk Management
Ted Howard	-	Chair, Kaikōura Zone Water Management Committee

2.3 National Stakeholders – Implementing Outcomes for New Zealand

A Landslides National Stakeholders Group has been established, with the following terms of reference:

- To encourage inter-agency data sharing and input into the programme.
- To ensure the benefits of the research programme are fully realised and efficiently delivered.
- To help the research programme target and reach the right end-users.
- To support and promote the value of the research and facilitate the delivery of results to end-users.
- To provide government and national stakeholder-level advice on how this research programme and its outputs are upscaled from Kaikōura experience to implementation throughout New Zealand.
- To provide direction and advice on what national-scale research outcomes are needed in the landslide hazard and risk space.
- To assist in identifying opportunities to promote take-up and implementation of research outputs to gain greater value, efficiency and effectiveness of the research investment.

The National Advisory Group representation is given in Table 2.2 below. Representation from these stakeholder entities may vary over the duration of the programme. These stakeholders are responsible for maintaining national network and infrastructure, emergency management, public land management, land productivity, insurance industry and the geotechnical industry. Additional stakeholders include the Treasury Infrastructure Unit, National Infrastructure Unit and Wellington Lifelines Group (WeLG).

Table 2.2 National Stakeholder Group members.

LANDSLIDES NATIONAL STAKEHOLDER GROUP		
Full Name	**Organisation**	**Role in Organisation**
Roger Fairclough	Neoleaf Global	Chair
Don Bogie	Department of Conservation (DoC)	Regional Planning Manager
Geoff O'Malley	Land Information New Zealand (LINZ)	Principal Analyst
Graeme Blick	LINZ	Chief Geodesist and Manager National Topographic Office
Jo Horrocks	Earthquake Commission (EQC)	Head of Resilience Strategy and Research
Kiran Saligame	Ministry of Business Innovation and Employment (MBIE)	Senior Geotechnical Engineer
Paul Barker	Department of Internal Affairs (DIA)	Partnership Director, Central Local Government Partnerships Group
Philip Shackleton	Local Government NZ (LGNZ)	Principal Policy Advisor
Rebecca Beals	KiwiRail	-
Richard Smith	GNS Science	Director, Resilience to Nature's Challenges
Ross Roberts	Auckland Council New Zealand Geotechnical Society	Geotechnical and Geological Practice Lead Chair
Kim Wright	National Emergency Management Agency (NEMA)	Senior Advisor, Hazard Risk Management
Stuart Finlan	New Zealand Transport Agency (NZTA)	Lead Advisor, Geotechnical
Stuart Woods	NZTA	Lead Advisor, Resilience
Terry Jordan	Insurance Council of NZ	Operations Manager
Zoe Juniper	Ministry for Primary Industries (MPI)	National Operations Planner

2.4 Researchers as Stakeholders for Tool Development

Internal and external researcher engagement is required for the duration of the project to enable research methods, timing, engagement, outputs and outcomes to be co-ordinated.

2.4.1 EILD Programme Researchers

The project team includes researchers from WSP Opus, the University of Canterbury, Victoria University of Wellington, the University of Auckland and GNS Science. In addition, several students are involved from the universities listed above.

2.4.2 External Researchers

Engagement with other research projects will be undertaken to ensure results can be utilised by other researchers, and vice-versa. Targeted external researcher engagement includes:

- The director of Resilience to Nature's Challenges is represented on the National Landslide Advisory Group. In addition, the programme will engage specifically with the 'Rural Theme' – led by Dr Tom Wilson, University of Canterbury, and Dr Caroline Orchiston, University of Otago.
- Project AF8 – via Dr Caroline Orchiston, University of Otago.
- QuakeCore – via Prof Brendon Bradley, University of Canterbury.
- Other students – via existing student's supervisors.

2.4.3 Science Advisory Group

The Science Advisory Group meets with the programme annually and provides feedback and advice, along with liaison with international researchers. The group is made up of the members given in Table 2.3.

Table 2.3 Science Advisory Group members.

SCIENCE ADVISORY GROUP		
Name	**Organisation**	**Role in Organisation**
Joe Wartman	University of Washington	HR Berg Professor of Civil and Environmental Engineering
Jonathon Godt	United States Geological Survey (USGS)	Senior Science Advisor for Earthquake and Geological Hazards
Josh Roering	Oregon University	Department Head, Earth Sciences (Geomorphologist)
Kate Allstadt	USGS	Research Geophysicist
Pam Johnston	DIA	Principal Advisor, Community Resilience
Peter Ashmore	University of Western Ontario	Fluvial Geomorphologist

2.5 Who We are Not Engaging With

The research programme will not be engaging directly with the general public – however, they are informed via the website and through the district and regional council's engagement. The research programme will also not engage directly with specific landowners in the Kaikōura/ Marlborough districts that have been affected by the impacts of landslides or will be affected by ongoing associated hazards, such as river aggradation. Instead, they will be consulted as appropriate, and some are represented by Advisory Group members.

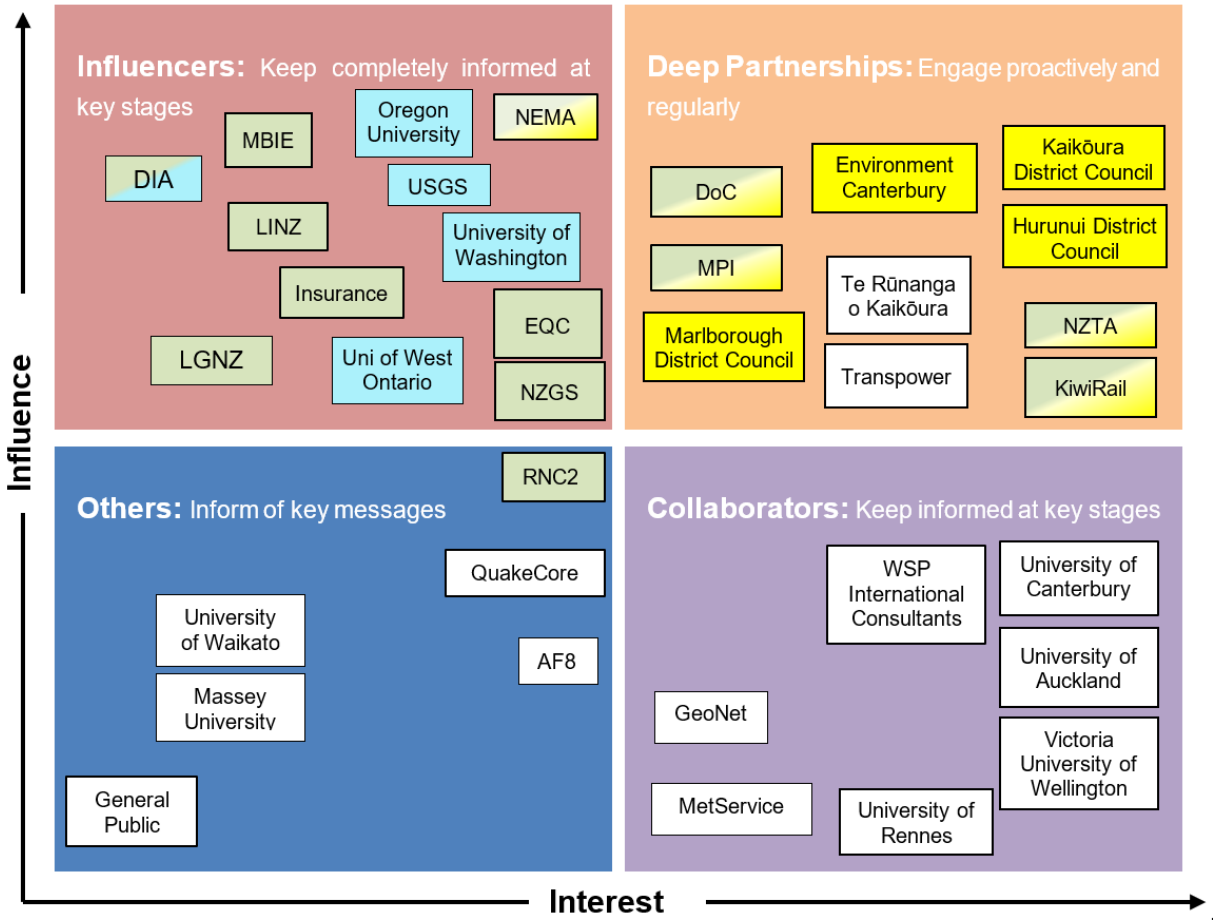


Figure 2.1 Summary of stakeholders, influence and engagement level. Landslide National Advisory Group representation is depicted by the green boxes, Regional Stakeholder Group representation is depicted by the yellow boxes and the Science Advisory Group representation is depicted by the pale blue boxes.

3.0 RESEARCH OUTPUT AND TOOLS

Internal programme-based engagement via interviews of each research aim in 2020 aided in understanding the proposed tools and outputs that each research aim envisages emanating from their research, and who might use them. These interviews are summarised into tabular form for each theme (see Appendix 2) and are used to identify tools, output, end-users and stakeholders. An example of the tabular summary for Research Aim 1 is given below in Figure 3.1. In many cases, the datasets, outputs and tools are only relevant to other researchers and modellers, both within the programme and external collaborators.

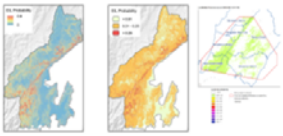
Output/Tool Description (Describe the likely output/tools from the research)	**When will it be available?**	**Stakeholder Who are they for / targeted to?** e.g. other researchers, geotechnical industry, planners, public, asset managers	**Who have you already talked to about the tools/output?**	**Who else should we talk to?**
1) Earthquake-Induced Landslide Forecast tool - Map of probability  - GIS Data? - Messaging and format - See USGS Ground Damage tool https://earthquake.usgs.gov/data/ground-failure/background.php	• Dec 2019	• GeoNet Duy Officer • Geohazards advice provider (to NEMA) • Asset/Infrastructure managers • Emergency managers • Public • Different messaging for different audiences (Sally P)	• GeoNet	• Stakeholder and advisory group • NEMA • Roger Fairclough – Lifelines • Test and talk to public Wellington (Sally P), maybe through WREMO/IOF
• Rockfall Activity Rate System (RoARS) • Likely volumes of debris from slopes • Network restoration time • Python Script	• End of 2021 • Biljana to code	• Infrastructure providers, especially road and rail users • Regional councils	• Oregon State University, Mike Olsen • University of Washington • Piggy-back on their tool	• NZTA • KiwiRail • Local Government road managers • Workshop to demonstrate?

Figure 3.1 Example of Research Aim tool summary for RA1.1.

About 19 tools and/or outputs that are considered useful to stakeholders have been identified, as listed in Table 3.1 below. It is proposed that these tools will be available via the EILD website with wrap-around text describing the tools, how they should be applied and their limitations. Links will be provided to key datasets and documents, either hosted on the site or other sites.

Table 3.1 Proposed tools and outputs from the research.

Research Theme	Tool/Output	Description	Availability of Tool
RA1.1	Earthquake-Induced Landslide Forecast tool (map)	Landslide probability maps based on earthquake shaking	Dec-19
	Rockfall Activity Rate System (RoARS)	Forecast of landslide debris generated by earthquake and estimated outage times	Dec-21
RA1.2	Post-event rainfall reactivation forecast tool (map)	Landslide reactivation map based on rainfall intensity	Sep-22
	EIL Inventory (map data)	Fully attributed earthquake-induced landslide dataset for a number of earthquakes across New Zealand	Jun-23
RA1.3	Landslide Dam Inventory (map data)	Attributed landslide Dam Inventory (database) of New Zealand	Dec-20
	Damming potential (DBI tool)	Predicts where landslide dams may form, given appropriate levels of shaking.	Jul-21
	Landslide dam longevity, breach and hydrographic prediction tool	Determines how long the dam stays in the environment; predicts breach and discharge	Jun-22
	Downstream inundation and runout empirical model	Determines downstream flow from dam breach	Jun-23
RA1.4	F-Angle tool	Use empirical data to predict runout distance on the failure of a given slope	Dec-19
	Calibrated 3D RAMMS	Numerical spatial model that models runout distance on the failure of a given slope	Jun-21
	Flow-R	Regional model giving the probability of a given runout distance of failure on slopes	Sep-22
RA1.5	Sediment Flux source to sink	Yet to be fully determined	Mar-21
	Delft 3D	Yet to be fully determined	Jun-23
RA1.6	Seismic design of slopes guideline	NZTA published guideline for slope designers	Jul-18
	Slope characterisation	Case studies / practice notes / training	Jun-23
RA1.7	Catalogue of other relevant guidelines	Website catalogue of relevant risk standards, risk assessment process, legislative framework	Jun-21
	EWS design and protocols	End-to-end warning system design	Mar-21
	Landslide Guidelines for planners, ver.2	Updated 2006 landslide guidelines to include earthquake-induced landslides and risk assessment method	Sep-22
	EILD Website and online tools	Update research progress, provide gateway to tools, databases and guidelines	Mar-21

4.0 STAKEHOLDER ENGAGEMENT

4.1 Identifying Stakeholder Needs

The outputs of the EILD research are to be 'Useful, Useable and Used'. Any output or tool must meet a purpose for the end-users and stakeholders defined and be developed in consultation with them to meet their requirements. In this regard, identifying the stakeholder needs will be ongoing and iterative to ensure that the tools and outputs are still relevant for stakeholders as their understanding of what is being developed improves and as the researchers develop and modify outputs. Each of the stakeholders will have different needs, and not all of them can be met. Hence, the engagement process will help prioritise tool development.

It must be recognised that earthquakes of the magnitude of the 2016 earthquake (M7.8) are not frequent but can re-occur within the lifetime of developments and can also occur elsewhere in the country. Outputs and tools from the programme should be designed for land development planning purposes whereby the areas at risk from earthquake-induced landslides and associated cascading hazards are recognised and avoided or mitigated against. The research advances the understanding of the processes for the benefit of decision makers and the community in general, including internationally.

In 2018, a workshop held in Christchurch identified initial issues and needs of the regional and national stakeholders, and these were mapped to programme research aims (Appendix 1). The table has since been updated following subsequent meetings with the advisory groups in 2019 and 2020 and informs the development of tools and this engagement plan.

4.2 Matching Needs to Tools

Initial mapping of stakeholder needs to tools and/or outputs has been attempted using feedback from the advisory group meetings and researcher interviews. The tools to be developed and the stakeholder needs will change as engagement continues and the research outcomes and potential tools are realised. However, initial mapping of tools to stakeholder needs has been attempted and a stakeholder engagement matrix developed, as given in Figure 4.1.

Tool	Research Theme	Availability of tool	INFLUENCERS					DEEP PARTNERS												COLLABORATORS					OTHERS					
			MBIE	EQC	NEMA	GNS/ SSUAP	NZGS/Geotech Consultants	Infrastructure Owners				EMOs	RC's	TA's	Iwi	Insurance	DoC	MPI	Land Managers	GeoNet	MetService	Research Collaborators	RAMMS Users	Geomorph Modellers	Other Universities/ Researchers					Public
								Road	Rail	Network	Asset														UoW	Massey	UoBC	RNC2	QuakeCore	
EQ Induced Landslide Forecast tool (map)	RA1.1	Dec-19			✓			✓	✓	✓	✓	✓					✓			✓										✓
Rockfall Activity Rate System (RoARS)		Dec-21						✓	✓	✓	✓		✓	✓																
Post-event rainfall reactivation forecast tool (map)	RA1.2	Sep-22		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓									
EIL Inventory (Map data)		Jun-23		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓								✓
Landslide Dam Inventory (Map data)	RA1.3	Dec-20											✓				✓					✓								
Damming potential (DBI tool)		Jul-21					✓			✓	✓	✓	✓				✓													
Landslide dam breach, longevity, hydrographic prediction tool		Jun-22								✓	✓	✓	✓				✓					✓								
Downstream inundation and run out emperical model		Jun-23					✓			✓	✓	✓	✓				✓													
F-Angle tool	RA1.4	Dec-19		✓			✓	✓	✓	✓	✓		✓	✓			✓	✓	✓			✓			✓	✓				
Calibrated 3D RAMMS		Jun-21					✓	✓									✓					✓	✓	✓	✓	✓				
Flow-R		Sep-22					✓							✓								✓		✓	✓	✓				
Sediment Flux source to sink	RA1.5	Mar-21					✓	✓	✓	✓	✓		✓	✓				✓	✓			✓		✓						
Delft 3D		Jun-23					✓	✓	✓	✓	✓		✓	✓				✓	✓			✓		✓						
Seismic design of slopes guideline	RA1.6	Jul-18					✓	✓	✓	✓	✓		✓	✓			✓					✓								
Slope characterisation - Case studies/practice notes/training		Jun-23					✓	✓	✓	✓	✓		✓	✓								✓								
Catalogue of other relevant guidelines	RA1.7	Jun-21	✓	✓			✓	✓	✓	✓	✓		✓	✓			✓	✓				✓								
EWS Design and protocols		Mar-21			✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓									
Landslide Guidelines for planners ver.2		Sep-22	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓											✓
EILD Website		Mar-21		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						✓

Figure 4.1 Engagement matrix of the outputs and tools to be developed against the stakeholders (green – available now; orange – available in next year; red – available in two or more years).

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4.3 Engagement Activities

Engagement activities will range from informing only (e.g. website) to collaboration (tool development); Figure 1.1. Many engagement methods will be used, ranging from hui, advisory group meetings, regular programme meetings, specific invited workshops and training, special conference sessions, targeted road shows and survey. An initial plan of likely engagement for the tools is given in Figure 4.2.

4.3.1 Hui – Ngāi Tahu

EILD Lead: Tania Gerrard

Engagement with Te Rūnanga o Kaikōura requires co-ordination with ECAN engagement regarding flood protection schemes and with Kaikōura District Council regarding natural hazard sections of the District Plan.

4.3.2 Advisory Group Meetings

Lead: Chris Massey

Annual meetings of both the Regional and National Advisory groups and other sessions as required. Members of these groups will be informed and invited to other targeted workshops or training as appropriate.

4.3.3 Researcher Meetings

Lead: Chris Massey (programme engagement) and Phil Glassey (tool development)

Programme researcher engagement includes monthly online meetings of Research Aim leaders, a bi-monthly all programme members meeting and an annual researcher meeting where the Science Advisory Group meets to be informed and to provide feedback.

4.3.4 Targeted Workshops/Training

Lead: Research Aim Leaders

Targeted workshops are planned to discuss specific research topics from the programme and can also be associated with specific tools or suite of tools. In the first instance, a River Reaction workshop is planned with regional stakeholders in March 2021, specifically to focus on the implications of sediment cascades down rivers and implications for flooding.

Once tools (or outputs) are sufficiently mature, they can be presented in targeted workshops and feedback sought while providing a training opportunity. It is intended to provide geotechnical and road construction industry training in the seismic design of slopes, including a series of practice notes and case study examples. The Earthquake-Induced forecast tool, the RoARs tool, runout tools and the dam break tools may be suitable for this type of engagement.

4.3.5 Conference Special Sessions

Lead: Brahbaharan Pathmanathan (RA1.6 leader), Chris Massey (overview) and Phil Glassey (tools)

The New Zealand Geotechnical Society (NZGS) bi-annual symposium is an opportunity to inform the geotechnical community of the outputs of the programme and the tools being

developed. A special EILD session will form part of the NZGS 2020 symposium to be held in March 2021 (postponed due to COVID-19). Similar sessions may present themselves at other conferences and symposiums.

4.3.6 Geotechnical Society Roadshow

Lead: Chris Massey and Research Theme leaders

The geotechnical industry is a key end-user of the outputs of the programme and are represented by the NZGS. There are a number of branches of the society throughout New Zealand that have regular technical sessions. These will be targeted to present the outputs of the programme and to get feedback on the tools.

4.3.7 Survey

Lead: Sally Potter, Chris Massey and Phil Glassey

End-user and stakeholder surveys may be a useful engagement tool in gathering feedback on the outputs and tools. These can be simple online surveys or more detailed paper-based surveys.

4.3.8 Website

Lead: Phil Glassey

A dedicated EILD website is being developed to inform, provide outputs and act as a platform for accessing guidelines and specific tools that are developed. The website is primarily a one-way 'inform' type of engagement. The following timeline is proposed for the website development:

Table 4.1 Website development timeline.

Oct–Nov 2020	Scope options for website development
Dec 2020	Website development company contracted
Jan–Mar 2021	Website developed and tested with researchers and stakeholders Content required from Research Aim leads
Mar 2021	Website goes live for researchers and stakeholders
Apr 2021 Onwards	Website updated with new information, tools and blogs when appropriate

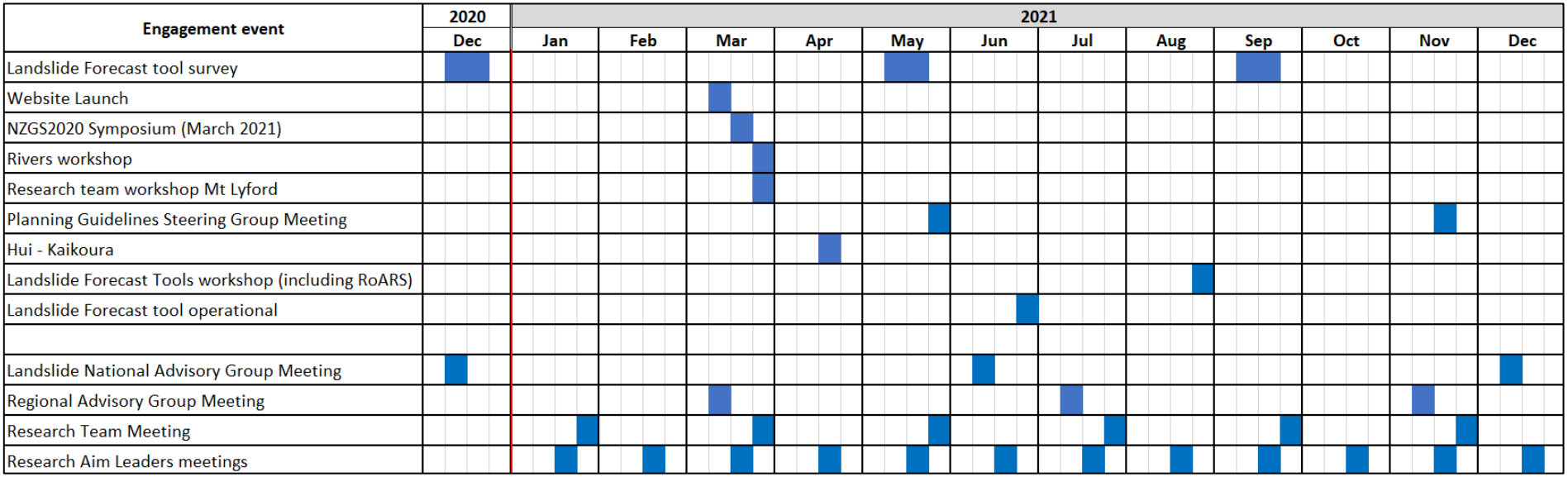

Figure 4.2 Draft of planned engagement activities in 2021.

4.4 Risks to Effective Engagement

There are several risks that could affect the implementation of this strategy, as outlined below. Mitigation measures are included.

Table 4.2 Risks to engagement.

Risk	Consequence	Mitigation
COVID-19	• Unable to travel for face-to-face meetings • Stakeholder priorities change, which decreases their engagement time • Researcher priorities change, which affects tool development	• Provide online options • Review stakeholder needs • Advise stakeholders
Changing priorities of stakeholders	Stakeholders do not have time to engage with project	• Employ various engagement methods • Review tools, needs and engagement strategy; see if other stakeholder representatives are available
Research milestones/ deliverables fall behind schedule	Delays tool development and reduces time for development and testing	• Regular project and programme team meetings
Loss of key researchers	Progress stalls while vacancies are filled	• Continue to develop skills amongst team to build capability • Clear documentation and project management to enable handovers to occur
Large-scale event occurs, e.g. major earthquake	• GNS Science staff are unable to lead tool development activities for a short to medium time period • Progress stalls while event response occurs	• Funder is informed – post-event activities take priority and are incorporated into research outputs as best as possible within time and funding constraints • Outside consultants used to develop components of tools
No co-ordination of stakeholder engagement for tool development	Stakeholder fatigue as different researchers approach the same stakeholders to engage on their tools	• Engagement Matrix and plan • Planned activities and strategic invitations • Research Aims and project personnel to report engagements

5.0 SUMMARY

Engagement with identified partners, stakeholders and end-users of the Earthquake-Induced Landscape Dynamics (EILD) research programme will solicit input and collaboration into useful, useable and used tools that will increase resistance to earthquake-induced landslide hazards. The engagement will shape the outputs and tools developed from the research. In addition, the engagement will promulgate the results of the research as widely as possible to relevant stakeholders.

The outputs and tools from the programme will evolve along with end-users needs; however, not all end-users' diverse needs can necessarily be met, and therefore the process will be iterative. Initial mapping of outputs and tools to stakeholder and end-users' needs has been attempted and an engagement plan over the next three years (2021–2023) developed. Many engagement methods will be used, ranging from hui, advisory group meetings, regular programme meetings, specific invited workshops and training, special conference sessions, targeted road shows and survey. Risks that may hinder or impact engagement, and possible mitigations against these risks, have been identified.

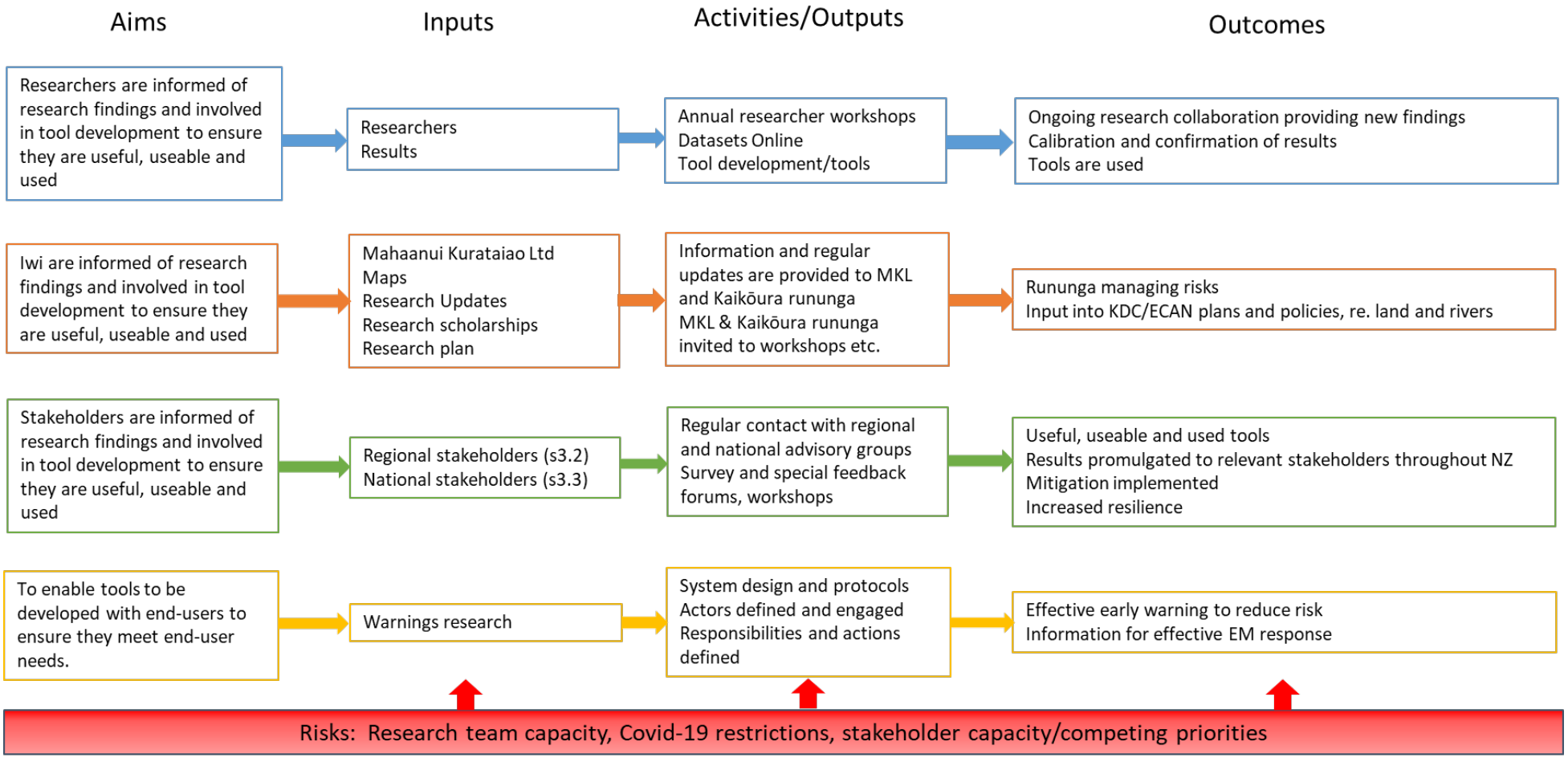

Figure 5.1 Aims to outcomes logic model and risks to engagement.

6.0 ACKNOWLEDGMENTS

The EILD work is funded by the MBIE Endeavour Fund under research contract C05X1709. The authors wish to thank the partners, end-users and stakeholders that have already had input into the programme. Scott Kelly and Sally Potter, both of GNS Science, reviewed the report and provided feedback that has improved the report.

7.0 REFERENCES

Saunders WSA. 2019. Principles of project-based engagement. Lower Hutt (NZ): GNS Science. 42 p. (GNS Science miscellaneous series; 129).

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APPENDICES

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APPENDIX 1 STAKEHOLDER NEEDS

Table A1.1 2018 stakeholder needs and issues.

<table>
<tr><th colspan="3">The Issues</th></tr>
<tr><th>In the Next Year from Now</th><th>In the Next 2 to 3 Years</th><th>In the Next 4 to 5 Years</th></tr>
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Main Post-Earthquake Natural Hazard Issues (Kaikōura District Council)

- **Kaikōura District Council District Plan change:** Not yet sure whether the change is a rolling versus full review. The Natural Hazards chapter of the Plan is likely to be reviewed. Currently, there is no provision for earthquakes in the Plan. As part of the Plan review/change, flooding and landslides are going to be major issues.
- **Identification of flood-prone areas:** Some land post-earthquake is now unsuitable for building on. Flood modelling is currently being carried out using the post-earthquake LiDAR ground models (by Environment Canterbury [ECan] and along State Highway 1 by NCTIR [North Canterbury Transport Infrastructure Recovery] by Aurecon). The Kowhai and Mt Fyffe areas/catchments are of big concern, as these could affect the Kaikōura urban area.
- **Identification of rockfall and landslide areas:** Across the entire region, at a more detailed scale in urban areas and less detailed (more granular) across the rural areas. Rockfall hazard assessments have been carried out at the house-specific scale (by Golder Associates) for those houses impacted by rockfalls triggered by the earthquake.

Main Post-Earthquake Natural Hazard Issues (ECan)

- **Thresholds for landslide triggering**, e.g. rainfall magnitude/duration thresholds and earthquake shaking thresholds.
- **Particle size distributions (PSD) of the sediment in the main rivers**. What is the PSD of the bed load, suspended load and the amount of fine-grained sediment that is and will be transported from source to sea? What are the bed load transport thresholds (i.e. remobilisation of sediment)?
- **Hapuku dam failure models – an update**. What effects would a further dam failure from, for example, a landslide sourcing from the upper slopes entraining the dam material (that is left), have on the catchment? Could such a large landslide and further dam failure lead to a significant debris-flood wave downstream? What river flood(flow)-return period would such a debris-flood be equivalent to?
- **Bridge scour and aggradation**. Five bridges are currently being reviewed by Beca for Kaikōura District Council and NZTA, including those on the Clarence, Kowhai and Wharekiri streams.

Main Post-Earthquake Natural Hazard Issues (NZTA)

- **Most short-term issues covered by NCTIR**. GNS Science is currently engaged by NCTIR to help with their ‘Resilience Study’ for State Highway 1 and the South Island Main Trunk railway. This work is helping to define longer-term issues that would need to be monitored/addressed once NCTIR dissolves.

Main Post-Earthquake Natural Hazard Issues (MCDEM)

- As per Kaikōura District Council and other councils (affected) via the National Recovery Office (NRO). GNS Science has already been involved with this work via the Information and Research Working Group established by the NRO. These meetings and workshops have included all of the main stakeholders.

Main Post-Earthquake Natural Hazard Issues (MPI)

- The main opportunity for the Endeavour Programme to work with the rural sector is via the *Primary Industries Earthquake Recovery Fund* projects. GNS Science has already met with the Kaikōura Dairying project group and the Beef + Lamb NZ-led Land and Farm Business representative, but we have yet to meet with them to discuss their recovery projects, which will run across three different areas. We understand that these projects are close to being contracted by MPI and so will engage with them once contracted.

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Main Post-Earthquake Natural Hazard Issues and Needs (Kaikōura District Council)

- Policy help and/or advice with respect to planning issues and case studies from elsewhere in New Zealand, e.g. Whakatāne, Christchurch City Council, etc. Needs to link with the National Science Challenge work in this area. Kaikōura District Council will provide specific areas of need via the planned programmes engagement meetings (to be held every three months, face-to-face).
- Risk-based tool kit (case studies and background data collated).
- Landslide hazard zones defined for selected areas.
- Basic catchment-scale sediment volume versus time estimates at the fan heads to aid with understanding aggradation/erosion rates. For example, can aggradation be managed, or is it going to be too rapid. If so, could the Kowhai break out of its channel and affect Kaikōura township?

Main Post-Earthquake Natural Hazard Issues and Needs (ECan and MCDEM)

- Response thresholds; processes established (e.g. lists of consultants that can respond rapidly to events).
- Damage reports from landowners – can these be done like a ‘GeoNet Felt Report’ for earthquakes?
- Collate legal opinions and examples of challenges.
- District level roles and responsibilities defined from a planning perspective but at the national scale.

National-Scale Needs

Main Post-Earthquake Natural Hazard Issues and Needs (NZTA)

- Long-term monitoring of slope performance post-NCTIR.
- Current resilience framework is underdone with respect to hazards. Limited community involvement.
- Help with the development of their government policy statement on natural hazards (landslides).

AF8 Project

- Updated landslide and landslide dam scenarios for an Alpine Fault M8 earthquake.

Enhance Geohazard Monitoring Project

- Landslide forecast models for earthquakes (initially) and later for rain events.

Risk-Based Tool Kit (Other New Zealand Councils, LGNZ)

- Guidelines for landslide hazard and risk assessment and design of earthworks.
- Planning-related case studies and legal opinions / environment court decisions.

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Main Post-Earthquake Natural Hazard Issues and Needs

- Regional-scale landslide hazard / risk zone methodologies are developed.
- Physics-based flood models for the areas of study established, including aggradation and erosion rates and how they vary per catchment with time post-earthquake.

National-Scale Needs

- Landslide forecast system (developed by EGM and GNS Science SSIF) to incorporate data from this programme.
- Decision support tools to help communities work out what resilience means in order to help define investment and outcomes.

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Programme Outputs/Tasks to Fulfil the Current Needs (All Stakeholders Listed Above)		
In the Next Year from Now	**In the Next 2 to 3 Years**	**In the Next 4 to 5 Years**
• **Area-wide landslide hazard zones defined**. There were some discussions as to whether these should be defined using a risk-based approach (using international best-practice methods), given that such an approach provides quantifiable and defendable risk estimates (with uncertainty) that can be used to underpin hazard zonation. *Mapped to Research Aims 1.1.5, 1.1.6 and 1.2.6 but cannot be achieved until Year 2.* • **Landslide-sediment budgets estimated, at the catchment scale**. This could be done quickly and relatively easily to define those catchments most likely to produce large volumes of sediment downstream. *Mapped to Research Aim 1.1.1 and can be achieved in Year 1.* • **Hapuku dam failure scenarios explored**, including volume-flood models to define the 'worst case' and 'most likely case', as previously done by GNS Science immediately post-earthquake. *Mapped to Research Aim 1.3.8 and can be achieved in Year 1.*	• **Policy help and/or advice with respect to planning issues**. Scene setting and collation of case studies and legal opinions. Hosted on website specifically set up for the programme. *Mapped to Research Aims 1.7.2, 1.7.3 and 1.7.5.* • **Landslide hazard maps developed for specific areas of Kaikōura District Council**. These areas will need to be defined by Kaikōura District Council and others and the scale of the maps will need to be agreed. *Mapped to Research Aims 1.1.5, 1.1.6 and 1.2.6.* • **Landslide forecast models developed**. Use new landslide models developed by this programme in the landslide forecast system currently being developed by GNS Science under the EGM projects and the landslide SSIF programme. *Mapped to Research Aims 1.1.5 and 1.1.6.* • **Preliminary landslide response thresholds established**. For earthquakes and rain. *Mapped to Research Aims 1.1.5, 1.1.6 and 1.2.6* • **Landslide and landslide dam scenarios updated for AF8**. Re-run landslide and dam failure scenarios for the AF8 project using new landslide and dam models developed via this programme. *Mapped to Research Aims 1.1.5, 1.1.6 and 1.3.7.*	• **Policy help and/or advice with respect to planning issues**. Scene setting and collation of case studies and legal opinions. Hosted on website specifically set up for the programme. *Mapped to Research Aim 1.7.* • **Landslide forecast models updated and incorporating a rainfall-induced landslide model**. Provide new landslide models developed by this programme in the landslide forecast system currently being developed by GNS Science under the EGM projects and the landslide SSIF programme. *Mapped to Research Aims 1.1 and 1.2.*

Missing stakeholders with issues and needs yet to be included and mapped to the programme Research Aims:

- The lines companies, e.g. Transpower
- Iwi
- EQC
- First Gas
- NZTA
- Treasury Infrastructure Unit
- Local Government NZ
- KiwiRail.

Table A1.2 Updated stakeholder needs in 2020, mapped to programme research aims. Updates in blue.

~~Current Year~~ **Updated in March 2020**
Engagement Strategy • More targeted engagement for designing tools will be carried out later in the programme. • Tools can be defined as having an input and an output, e.g. an app, decision-making framework. Distinct from reports, maps. • Terms of reference for this group have been circulated, agreed and are now in place. • ~~CM, WS and SP are meeting with Tania Wati from Ngāi Tahu on 17 April. Local rūnanga decided that their involvement should be resourced from Christchurch.~~ **This has now changed. We were informed in September that Te Rūnanga o Kaikōura now manage their environmental portfolio through Clint McConchie (clint.mcconchie@ngaitahu.iwi.nz). We have tried several times to contact Clint, but there has been no response to date.** • MB said that on-ground support for the farming community would be useful, e.g. around tool delivery. • **CM talked about the tools development and the process going forward with respect to the Research Theme leaders developing the outline ideas for the tools and with stakeholder engagement to identify other tools or show support for those proposed by others.** ***Early Warning Systems for Landslides*** • Need to determine scope, scale, delivery mechanism and other variables as a group. **This was done at the meeting in March. SP to disseminate the research plan.** • Need to determine desired outcomes. Life safety? Property damage? • Need to consider thresholds for activity, e.g. moving freedom campers. ✓ AP: SM to give SP the Group CDEM contact details. ✓ AP: SP to set up a meeting with a smaller group to discuss further. ***AP: ALL: Let Sally know what engagement you would like for tool development: 1:1 meetings per organisation or sector; 1–2 workshops with the whole group?*** ***Main Post-Earthquake Natural Hazard Issues (Kaikōura District Council)*** • **Kaikōura District Council District Plan change** Not yet sure whether the change is a rolling versus full review. The Natural Hazards chapter of the Plan is likely to be reviewed. Currently, there is no provision for earthquakes in the Plan. As part of the Plan review/change, flooding and landslides are going to be major issues. *The District Plan change is a rolling review, and natural hazards are first up.* *GNS Science was planning to prepare a brief proposal for MH and Helen Jack outlining the methodology for landslide hazard zonation. The idea is to start simple – identify landslide hazard-prone areas (source and runout), then discuss these regional-scale maps before identifying areas that require closer investigation. This proposal has been put on hold until after the Stage 1 draft hazard maps are ready (end of June 2018).*

~~Current Year~~ Updated in March 2020

MH said that simple prohibited area maps would be acceptable for rural properties but are less palatable where prohibited polygons coincide with or exclude potential building sites.

CM suggested a staged approach: Stage 1 hazard maps, with detailed risk-based maps in later stages.

MW asked where alluvial fans sit – in the landslide hazard space or the river flooding hazard space?

The District Plan change is looking to introduce 'prohibited areas' for comparison with flooding.

AP: GNS Science to provide the group with Otago Regional Council alluvial fan report, provisional on permission from the ORC and report authors.

~~AP: GNS Science to provide draft maps to Kaikōura District Council by the end of June, these will then be used to scope the future work and proposal.~~

~~AP: DS to schedule a July workshop to discuss maps.~~

The first stage of this work was completed in Feb 2020, with the second stage being discussed now. This second stage would be done under a commercial contract for ECan / Kaikōura District Council?

- **Identification of flood-prone areas**
  - Some land post-earthquake is now unsuitable for building on. Flood modelling is currently being carried out using the post-earthquake LiDAR ground models (by ECan and along State Highway 1 by NCTIR by Aurecon). The Kowhai and Mt Fyffe areas/catchments are of big concern, as these could affect the Kaikōura urban area.
    - ✓ JH: Airborne LiDAR has been flown for the Kowhai and Hapuku channels. The programme plans to fly thrice-yearly surveys (channel) plus annual/event-based catchment-scale surveys.
  - NCTIR surveys will continue every six months for the coast.
    - ✓ AP: MW to share details of her modelling software with JH.

AP: DS to write up a data-sharing agreement for the group, e.g. LiDAR would not be for redistribution – not yet done.

AP: DS to ask Katie Jones (GNS Science / PhD student) whether satellite imagery can be shared with the group – this is fine, but how best to deliver as the data is not to be shared, given the significant research interests from others.

These two APs need to be discussed.

- **Identification of rockfall and landslide areas**
  - Across the entire region, at a more detailed scale in urban areas and less detailed (more granular) across the rural areas. Rockfall hazard assessments have been carried out at the house-specific scale (by Golder Associates) for those houses impacted by rockfalls triggered by the earthquake.

Not much progress has been made towards this (MH). Some post-Gita re-assessments of properties have been made, none resulted in further action.

Kaikōura District Council has a business case under consideration for funded retreat from ~27 properties (life safety risk).

- ✓ AP: MH to share the location of those properties and associated reports with CM.

This was completed and used in the Stage 1 hazard analysis work GNS Science did for Kaikōura District Council / ECan.

~~Current Year~~ Updated in March 2020

Main Post-Earthquake Natural Hazard Issues (ECan)

- **Thresholds for landslide triggering**, e.g. rainfall magnitude/duration thresholds and earthquake shaking thresholds

  Warning systems – see item 3.

- **Particle size distributions (PSD) of the sediment in the main rivers**. What is the PSD of the bed load, suspended load and the amount of fine-grained sediment that is and will be transported from source to sea? What are the bed load transport thresholds (i.e. remobilisation of sediment)?

  Field work is underway. JH talked about a proposed radio-tracking study by a student from the University of Canterbury that would complement the PSD data and facilitate model validation.

  JH suggested co-funding an upgrade to the Orange Grove stage recorder.

  - ✓ AP: MW to let JH know who oversees the Orange Grove stage recorder.

- **Hapuku dam failure models – an update**. What effects would a further dam failure from, for example, a landslide sourcing from the upper slopes entraining the dam material (that is left), have on the catchment? Could such a large landslide and further dam failure lead to a significant debris-flood wave downstream? What river flood(flow)-return period would such a debris-flood be equivalent to?

  Seepage analysis and sieving has been written up and can be shared with the group.

  Several trash line maps have been compiled.

  All of this data has been used to calibrate and re-run models. The uncertainty in the models maps well to channel complexity.

  - ✓ AP: CM / Jon Tunnicliffe to share reports with SM.
  - ✓ CM asked who is archiving the Harvest data – it is not at ECan.
  - ✓ AP: SM to find out who their contact at Harvest is.

  We now have a data-sharing agreement in place with NZTA and KiwiRail and so have access to this data for the project team.

- **Bridge scour and aggradation**. Five bridges are currently being reviewed by Beca for Kaikōura District Council and NZTA, including those on the Clarence, Kowhai and Wharekiri streams.

  Increased to more than 30 bridges under review. Clarence and Wharekiri are subject to business case (with NZTA).

  This is not part of the research programme, but it is acknowledged that the LiDAR data and river erosion rate models would be useful – would they be available in time?

  - ✓ ***AP: JT and JH to discuss.***

~~Current Year~~ Updated in March 2020

Main Post-Earthquake Natural Hazard Issues (NZTA)

- **Most short-term issues covered by NCTIR**. GNS Science is currently engaged by NCTIR to help with their 'Resilience Study' for State Highway 1 and the South Island Main Trunk railway. This work is helping to define longer-term issues that would need to be monitored/addressed once NCTIR dissolves.
  This is now completed and NCTIR is handing over to KiwiRail and NZTA. We have access to their data (past and future).

Main Post-Earthquake Natural Hazard Issues (MCDEM)

- As per Kaikōura District Council and other councils (affected) via the National Recovery Office (NRO). GNS Science has already been involved with this work via the Information and Research Working Group established by the NRO. These meetings and workshops have included all the main stakeholders.

  We continue to hold national stakeholder meetings – the next is planned for 11 December 2020.

Main Post-Earthquake Natural Hazard Issues (MPI)

- The main opportunity for the Endeavour Programme to work with the rural sector is via the *Primary Industries Earthquake Recovery Fund* projects. GNS Science has already met with the Kaikōura Dairying project group and the Beef + Lamb NZ-led Land and Farm Business representative, but we have yet to meet with them to discuss their recovery projects, which will run across three different areas. We understand that these projects are close to being contracted by MPI and so will engage with them once contracted.

  MB: Big question – what will the land look like in 20 years? Farmers need to know whether to commit resources to farming infrastructure, stabilisation projects.

  Post-quake Farming are starting individual farm mapping projects.

  GNS Science should attend hill country group meetings – good opportunity for two-way information exchange.

  - ✓ AP: MB/Amelia to talk to Stu Ford about GNS Science involvement ***– ?***
  - ✓ AP: GNS Science to send the paper and field guide to the group ***– Done.***

Other Business

- *MH updated the group on ex-tropical Cyclone Gita. No re-assessed properties raised concerns.*
- *MW talked about the exaggerated return periods that were reported in the media. The storm was very localised, as was damage. Focus on Rosy Morn.*
  - ✓ AP: MH to send aggradation report to CM and JH ***– ?***
  - ✓ AP: CM to send GeoNet report (draft) for comment ***– Done.***
- *Discussed additional invitees to these meetings:*
  - *Ian Wright – consulting, would need $.*
  - *James Brassington – already in the loop through Jon Tunnicliffe.*
  - *Rob Langridge – doing paleoseismic research in the Clarence.*

In the Next 2 to 3 Years (2017–2020) – New COVID-19 Extension, so 2021

Main Post-Earthquake Natural Hazard Issues and Needs (Kaikōura District Council)

- Policy help and/or advice with respect to planning issues and case studies from elsewhere in New Zealand, e.g. Whakatāne, Christchurch City Council, etc. Needs to link with the National Science Challenge work in this area. Kaikōura District Council will provide specific areas of need via the planned programmes engagement meetings (to be held every three months, face-to-face).

  This has not been done, although GNS Science did complete Phase 1 of the landslide hazard mapping. Phase 2 is now being discussed.

- Risk-based tool kit (case studies and background data collated).

  This is ongoing.

- Landslide hazard zones defined for selected areas.

  Done as Phase 1 work.

- Basic catchment-scale sediment volume versus time estimates at the fan heads to aid with understanding aggradation/erosion rates. For example, can aggradation be managed or is it going to be too rapid? If so, could the Kowhai break out of its channel and affect Kaikōura township?

  Jon and Jamie to update – interested to arrange a river-specific workshop (1.5 years from March 2020) with the RA1.5 team and others, with stakeholders to discuss results and future projections? Does something need to be done sooner, i.e. in March 2021?

  Link with NIWA (Richard Measures) with respect to river modelling (1-, 2- and 3D) – Niraj on sabbatical at NIWA.

Main Post-Earthquake Natural Hazard Issues and Needs (ECan and MCDEM)

- Response thresholds; processes established (e.g. lists of consultants that can respond rapidly to events) and thresholds developed.
- Damage reports from landowners – can these be done like a ‘GeoNet Felt Report’ for earthquakes?
- Collate legal opinions and examples of challenges.
- District level roles and responsibilities defined from a planning perspective, but at the national scale.

National-Scale Needs

Main Post-Earthquake Natural Hazard Issues and Needs (NZTA)

- Long-term monitoring of slope performance post-NCTIR.
- Current resilience framework is underdone with respect to hazards. Limited community involvement.
- Help with the development of their government policy statement on natural hazards (landslides).

AF8 Project

- Updated landslide and landslide dam scenarios for an Alpine Fault M8 earthquake ***– is this dead?***

In the Next 2 to 3 Years (2017–2020) – New COVID-19 Extension, so 2021
Enhanced Geohazard Monitoring Project
• Landslide forecast models for earthquakes (initially) and later for rain events ***– this work is well advanced via EGM and GeoNet.***
Risk-Based Tool Kit (Other New Zealand Councils, LGNZ)
• Guidelines for landslide hazard and risk assessment and design of earthworks.
• Planning-related case studies and legal opinions/environment court decisions.
In the Next 4 to 5 Years (2017–2022) – Now June 2023
Main Post-Earthquake Natural Hazard Issues and Needs
• Regional-scale landslide hazard / risk zone methodologies are developed.
• Tools identified and developed.
• Physics-based flood models for the areas of study established, including aggradation and erosion rates and how they vary per catchment with time post-earthquake.
National-Scale Needs
• Landslide forecast system (developed by EGM and GNS Science SSIF) to incorporate data from this programme.
• Decision support tools to help communities work out what resilience means to help define investment and outcomes.

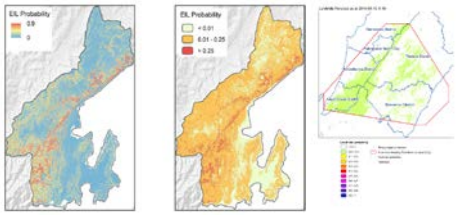
Table A1.3 Programme outputs/tasks to fulfil the current needs (all stakeholders listed above).

In the Next Year from Now	In the Next 2 to 3 Years	In the Next 4 to 5 Years
• **Area-wide landslide hazard zones defined**. There were some discussions as to whether these should be defined using a risk-based approach (using international best-practice methods), given that such an approach provides quantifiable and defendable risk estimates (with uncertainty) that can be used to underpin hazard zonation. *Mapped to Research Aims 1.1.5, 1.1.6 and 1.2.6 but cannot be achieved until Year 2.* • **Landslide-sediment budgets estimated at the catchment scale**. This could be done quickly and relatively easily to define those catchments most likely to produce large volumes of sediment downstream. *Mapped to Research Aim 1.1.1 and can be achieved in Year 1.* • **Hapuku dam failure scenarios explored**, including volume-flood models to define the 'worst case' and 'most likely case', as previously done by GNS Science immediately post-earthquake. *Mapped to Research Aims 1.3.8 and can be achieved in Year 1.*	• **Policy help and/or advice with respect to planning issues**. Scene setting and collation of case studies and legal opinions. Hosted on website specifically set up for the programme. *Mapped to Research Aims 1.7.2, 1.7.3 and 1.7.5.* • **Landslide hazard maps developed for specific areas of Kaikōura District Council**. These areas will need to be defined by Kaikōura District Council and others, and the scale of the maps will need to be agreed. *Mapped to Research Aims 1.1.5, 1.1.6 and 1.2.6.* • **Landslide forecast models developed**. Use new landslide models developed by this programme in the landslide forecast system currently being developed by GNS Science under the EGM projects and the landslide SSIF programme. *Mapped to Research Aims 1.1.5 and 1.1.6.* • **Preliminary landslide response thresholds established**. For earthquakes and rain. *Mapped to Research Aims 1.1.5, 1.1.6 and 1.2.6.* • **Landslide and landslide dam scenarios updated for AF8**. Re-run landslide and dam failure scenarios for the AF8 project using new landslide and dam models developed via this programme. *Mapped to Research Aims 1.1.5, 1.1.6 and 1.3.7.*	• **Policy help and/or advice with respect to planning issues**. Scene setting and collation of case studies and legal opinions. Hosted on website specifically set up for the programme. *Mapped to Research Aim 1.7.* • **Landslide forecast models updated and incorporating a rainfall-induced landslide model**. Provide new landslide models developed by this programme in the landslide forecast system currently being developed by GNS Science under EGM projects and the landslide SSIF programme. *Mapped to Research Aims 1.1 and 1.2.*

APPENDIX 2 RESEARCH THEME ENGAGEMENT SUMMARIES

RA1.1: Landslide Initiation – Tools/Outputs, End-User and Stakeholder Engagement (August 2020)

Jon Carey, Saskia de Vilder, Sally Dellow, (Brenda Rosser)

Output/Tool Description (Describe the likely output/tools from the research)	**When will it be available?**	**Stakeholder** **Who are they for / targeted to?** e.g. other researchers, geotechnical industry, planners, public, asset managers	**Who have you already talked to about the tools/output?**	**Who else should we talk to?**
1) Earthquake-Induced Landslide Forecast tool - Map of probability  - GIS Data? - Messaging and format - See USGS Ground Damage tool https://earthquake.usgs.gov/data/ground-failure/background.php	• Dec 2019	• GeoNet Duty Officer • Geohazards advice provider (to NEMA) • Asset/Infrastructure managers • Emergency managers • Public • Different messaging for different audiences (Sally P)	• GeoNet	• Stakeholder and advisory group • NEMA • Roger Fairclough – Lifelines • Test and talk to public Wellington (Sally P), maybe through WREMO/IOF
• Rockfall Activity Rate System (RoARS) • Likely volumes of debris from slopes • Network restoration time • Python Script	• End of 2021 • Biljana to code	• Infrastructure providers, especially road and rail users • Regional councils	• Oregon State University, Mike Olsen • University of Washington • Piggy-back on their tool	• NZTA • KiwiRail • Local Government road managers • Workshop to demonstrate?

RA1.2: Landslide Reactivation – Tools/Outputs, End-User and Stakeholder Engagement (August 2020)

Jon Carey, Saskia de Vilder, Sally Dellow, (Brenda Rosser)

Output/Tool Description (Describe the likely output/tools from the research)	**When will it be available?**	**Stakeholder** **Who are they for / targeted to?** e.g. other researchers, geotechnical industry, planners, public, asset managers	**Who have you already talked to about the tools/output?**	**Who else should we talk to?**
1) Earthquake-induced landslide (EIL) inventory • Provides online maps, data • Point data v1 available to public already, BSSA paper. • Located on DesignSafe site • Geospatial Dataset • EIL could be included in the Auckland Council Landslide database	Polygon data (embargoed until 2023)	• Network infrastructure • Regional and local councils • Land management • Insurance • DoC, MPI • EQC • Other researchers	• KiwiRail, NZTA • NCTIR • Kaikōura, Hurunui • Marlborough, ECan • Ngāi Tahu (MKL) • DoC • MPI	• KiwiRail, NZTA • NCTIR • Kaikōura, Hurunui • Marlborough, ECan • Ngāi Tahu (MKL) • DoC • MPI • Other researchers • Ask if they have tried to use it and feedback (ask Chris M)
2) Post-event rainfall reactivation forecast map? • Geospatial map of landslide probabilities based on rainfall – GeoNet/MetService • Cyclone Gita paper – landslides	Talk to Brenda	• GeoNet Service delivery to NEMA • Maybe MetService product (Sally P)	• MetService • GeoNet	• MetService
3) Lab testing • Paper (soil – reactivation focus; rock – damage focus). • Data for potential tool development	2022	• NZGS – practice guideline • Geotechnical • Other researchers	• Researchers – New Zealand and international • Academic, e.g. Dave Pettley	• NZGS – practice guideline • Geotechnical • Other researchers • Planners?

Note: Levels of stakeholder user engagement from ‘Active Engagement’ to ‘Push notification’ only.

RA1.3: Landslide Dams – Tools/Outputs, End-User and Stakeholder Engagement (August 2020)

Andrea Wolter, Chris Massey, Saskia de Vilder

Output/Tool Description (Describe the likely output/tools from the research)	**When will it be available?**	**Stakeholder** **Who are they for / targeted to?** e.g. other researchers, geotechnical industry, planners, public, asset managers	**Who have you already talked to about the tools/output?**	**Who else should we talk to?**
• Landslide Dam Inventory • Paper and dataset • Contributes to global data	End 2020	• Other researchers • Regional council • DoC	• GNS Science • German researchers	• Don Bogie (DoC) • Regional council • Italians, German, Canadian researchers
• Damming potential (DBI Tool) and failure • Paper? • Where in the landscape	July 2021	• Geotechnical • Regional council • Emergency managers • Asset managers • DoC	• Geotechnical • Chinese University	• Geotechnical • Regional council • Emergency managers • Asset managers, networks • DoC • WREMO
• Landslide dam breaching, Longevity, Critical Hydrograph prediction tool • Time to failure / How long it will last • Failure mechanism • Paper	June 2022	• Regional Council • Emergency managers • Asset managers • DoC • Consultants • Other researchers	• GNS Science • Staff only – unique	• Regional council
• Downstream inundation and runout empirical model. Prediction tool breach runout distance – simpler than flood modelling • Connected with RA1.4 runout	June 2023	• Regional council • Emergency managers • Asset managers • DoC	• No one at present	• Regional council • Emergency managers • Asset managers • DoC, NZGS

RA1.4: Landslide Runout – Tools/Outputs, End-User and Stakeholder Engagement (March 2020)

Marc-André Brideau

Output/Tool Description (Describe the likely output/tools from the research)	**When will it be available?**	**Stakeholder** **Who are they for / targeted to?** e.g. other researchers, geotechnical industry, planners, public, asset managers	**Who have you already talked to about the tools/output?**	**Who else should we talk to?**
• Empirical Methods • GNS Science runout method published – CR2019/102: Deterministic mapping of potential landslide debris inundation	2019	• Consultants • Researchers	• Wellington City Council metro pilot • University of British Columbia • Stakeholder / Steering Groups	• New Zealand Geotechnical Society • University of Auckland • Massey University • University of Waikato • NZTA
• Paper – Landslides, Oct 2020 • Database – Link to paper, data, graphs and relationships available on DesignSafe	Oct 2020	• Consultants • Researchers	• Wellington City Council metro pilot • University of British Columbia • Stakeholder / Steering Groups	• New Zealand Geotechnical Society • University of Auckland • Massey University • University of Waikato • NZTA
• F-Angle tool • Python script and interface • Release data	Sep 2022	• Consultants • Researchers • Infrastructure owners • Territorial authorities / regional council?	• Wellington City Council metro pilot • University of British Columbia • Stakeholder / Steering Groups	• New Zealand Geotechnical Society • University of Auckland • Massey University • University of Waikato • NZTA

Output/Tool Description (Describe the likely output/tools from the research)	**When will it be available?**	**Stakeholder** **Who are they for / targeted to?** e.g. other researchers, geotechnical industry, planners, public, asset managers	**Who have you already talked to about the tools/output?**	**Who else should we talk to?**
• Other tools • Flow-R (distributed empirical model for regional susceptibility assessments of debris flows, developed at the University of Lausanne. Uses Matlab; free) • University of British Columbia – PRE-RA predictive tool: path analysis and point analysis for site specific cases published in *Landslides*: Rock avalanche runout prediction using stochastic analysis of a regional dataset	-	• Researchers • Specialist consultants • Modelling specialists	-	• Specialist geotech consultants
• Physics-based models • Calibration 3D RAMMS (Rapid Mass Movement Simulation) https://ramms.slf.ch/ramms/ • Site specific – not quite probabilistic • Refined BC method published	Sep 2022	• Researchers • Specialist consultants • Modelling specialists • Specific infrastructure assets	• University of British Columbia	• University of British Columbia • RAMMS users • Geotech
• Empirical methods • GNS Science runout method published – CR2019/102: Deterministic mapping of potential landslide debris inundation	2019	• Consultants • Researchers	• Wellington City Council metro pilot • University of British Columbia • Stakeholder / Steering Groups	• New Zealand Geotechnical Society • University of Auckland • Massey University • University of Waikato • NZTA

RA1.5: Post-Earthquake Sediment Cascade – Tools/Outputs, End-User and Stakeholder Engagement (November 2020)

Jon Tunicliffe, Jamie Howarth, Phaedra Upton

Output/Tool Description (Describe the likely output/tools from the research)	**When will it be available?**	**Stakeholder** **Who are they for / targeted to?** e.g. other researchers, geotechnical industry, planners, public, asset managers	**Who have you already talked to about the tools/output?**	**Who else should we talk to?**
• Sediment Flux source to sink • Temporal maps or movies • 3D time series • Interactive 3D model – SketchPad (embedded in a web page) • Point cascade maps (are they useful – engagement tool only; illustrative) • Workflow tool/roadmap about what is needed to estimate changes in sediment budget – flow diagram (links to processes, methods, examples, etc. decision tree)	• 2021? • Feb 2021 • 2020 • Future/2022	• Emergency managers • Infrastructure managers • Planners • Geotech • Other researchers • River ECan	• ECan • Kaikōura District Council – how much aggradation and when? • Regional Stakeholder Group	• ECan • Kaikōura District Council • DoC • NZTA • KiwiRail • Landowners (utilise the riverbed)
• **Papers** • Hapuku Paper	• 2021	• Other researchers (geomorphic dynamics)	• University of Washington (collaborators)	-
• Kowhai Paper • Compare and contrast between Hapuku and Kowhai	• 2021	• Other researchers, ECan river management	• Neil Hovius (GFZ Postdam) • Chengdu University • NIWA	-

Output/Tool Description (Describe the likely output/tools from the research)	**When will it be available?**	**Stakeholder** **Who are they for / targeted to?** e.g. other researchers, geotechnical industry, planners, public, asset managers	**Who have you already talked to about the tools/output?**	**Who else should we talk to?**
• Initiation paper • Katie Jones – connectivity to *Landslides*	• 2021	• Other researchers	-	-
• RiverLab • Dimitri (Post-Doc) – 2D multi-grainsize functionality tool, morphodynamic model. • Timeframe and amplitude of change at range front	• 2022	• Other researchers to educated stakeholders (feeds into 6)	• Philippe Davy – Rennes	-
• Delft 3D • Flooding patterns change with aggradation	-	• Emergency managers • Infrastructure managers • Planners	• NIWA (generally, not specifically)	• KiwiRail • NZTA

RA1.6: Performance of Earthworks – Tools/Outputs, End-User and Stakeholder Engagement (November 2020)

Brabha Pathmanathan, Doug Mason

Output/Tool Description (Describe the likely output/tools from the research)	**When will it be available?**	**Stakeholder** **Who are they for / targeted to?** e.g. other researchers, geotechnical industry, planners, public, asset managers	**Who have you already talked to about the tools/output?**	**Who else should we talk to?**
• Seismic design of slopes 	2018	• Infrastructure managers • Geotech • Other researchers • NZTA • Construction industry	• Who knows about them? Who uses them? • NZTA have published and on website • Summary in Geomechanics news	• Referred to when bridge manual updated.
• Papers? • Impacts Infrastructure corridors of Kaikōura in *Landslides*?	Mar 2021	• Infrastructure managers • Geotech • Other researchers • NZTA • Construction	• University of Canterbury	-
• Characterising and assessments of specific slope failures; design recommendations • Reports and papers, case studies • Design notes / practice advice for various types? • Practitioner training including aspects of other Research Aim outputs	Jun 2022	• Infrastructure managers • Geotech • Other researchers • NZTA • Construction	• New Zealand Geotechnical Society • Doug's PhD, University of Canterbury	• New Zealand Geotechnical Symposium • NZTA – engage with them in design of output; Geotech forum, also in association with bridge manual
• Contribution transport network resilience outcomes?	Sep 2022	• All	-	-

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