Otago Regional Council

Community Presentation

Roxburgh Area Debris Flood Hazard: New Technical Findings

ORC and WSP | 18 February 2026

Otago Regional Council

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Welcome remarks

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Presentation Objectives

- Provide community with the latest technical findings
- Opportunity for questions with the consultants (WSP) and staff from Otago Regional Council, Central Otago District Council (CODC), and Civil Defence Emergency Management (CDEM)

Coal Creek flat alluvial fans (north of Roxburgh) with Slaughterhouse Creek in the foreground

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Increased understanding of debris flood hazard and risk in the Teviot Valley for 13 alluvial fans

- New findings and mapping identifies areas more likely to be affected by debris floods and possible consequences
- Milestone to inform the management of the debris flood risk in the Teviot Valley
- Key information that will be considered in the next stages of the work by decision makers in emergency planning, natural hazards mitigation, land-use planning and infrastructure management


Reservoir Creek catchment and alluvial fan

Teviot Valley looking across the Clutha River towards Dumbarton and the Old Man Range

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Agenda (6:30-8:30pm)

- Background and context (ORC)
- Current and ongoing hazard management (ORC)
- New Roxburgh Debris Flood Hazard and Risk Assessment findings (WSP)
- Next steps (ORC)
- Q&A – open discussion

➢ Refreshments and informal chats

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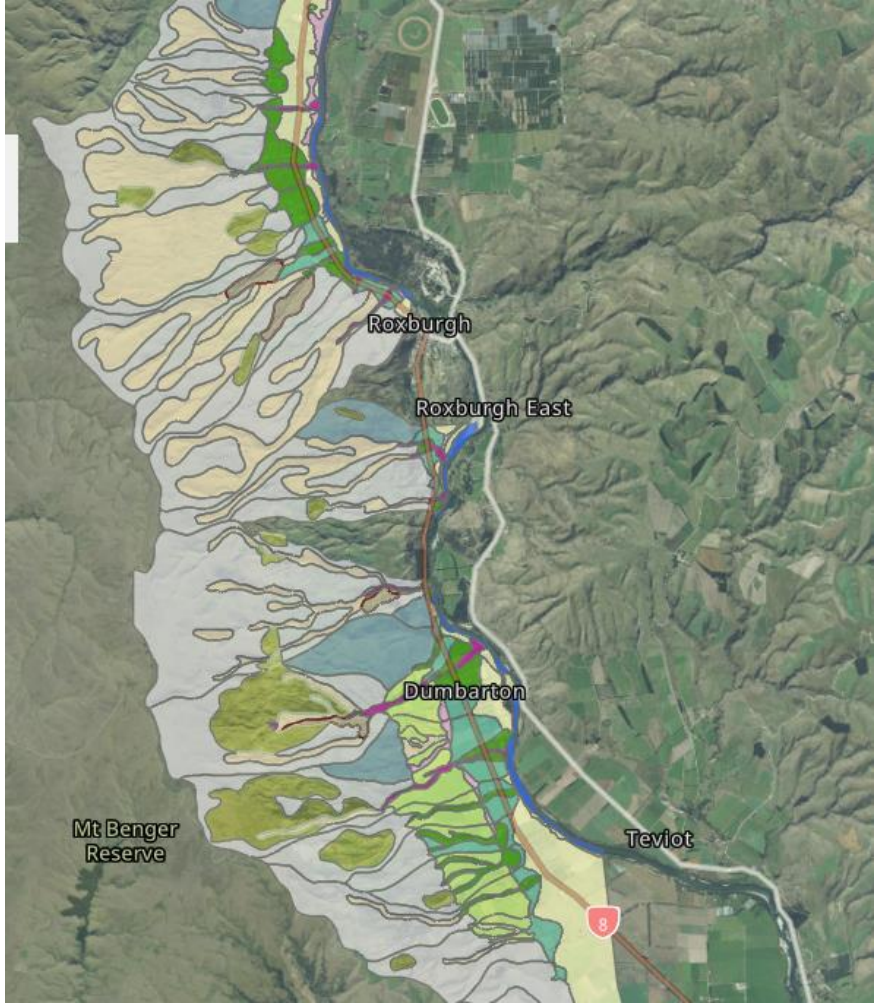
Regional Context

- GNS (2009) and Woods (2011)
- Potential alluvial fan hazard areas in Otago, including Teviot Valley
- Fan and catchment landform mapping
- Available on the Natural Hazards Database: [Alluvial Fans | ORC AGOL Natural Hazards Portal]
- Alluvial fans in Otago can have a range of hazards from clear water flooding to debris flows



Teviot Valley alluvial fan landform mapping (GNS, 2009)

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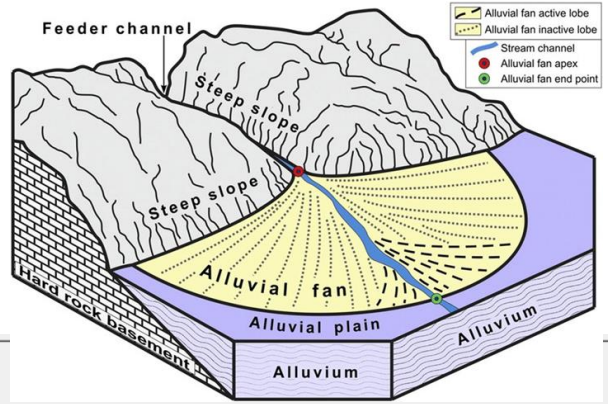
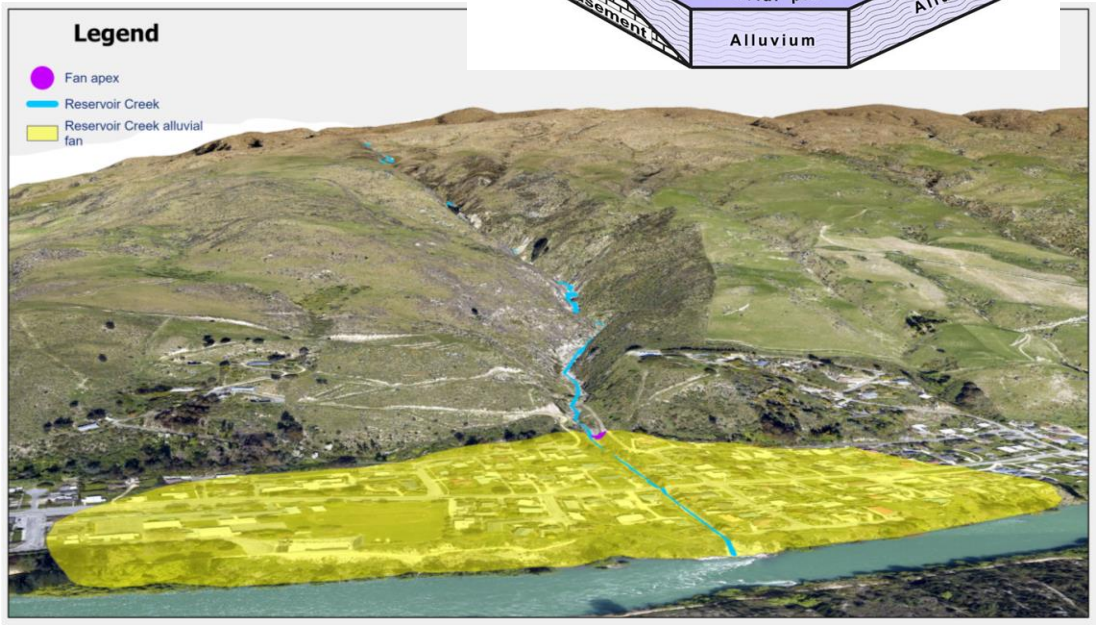
Alluvial Fan Hazards

- The Teviot Valley is exposed to alluvial fan hazards
- Alluvial fans are dynamic depositional landforms at the base of the Old Man Range where debris floods can occur
- Debris floods are a slurry of water, rock, debris that are dense and rapid
- Triggered by high-intensity rainfall
- Damaging and difficult to predict

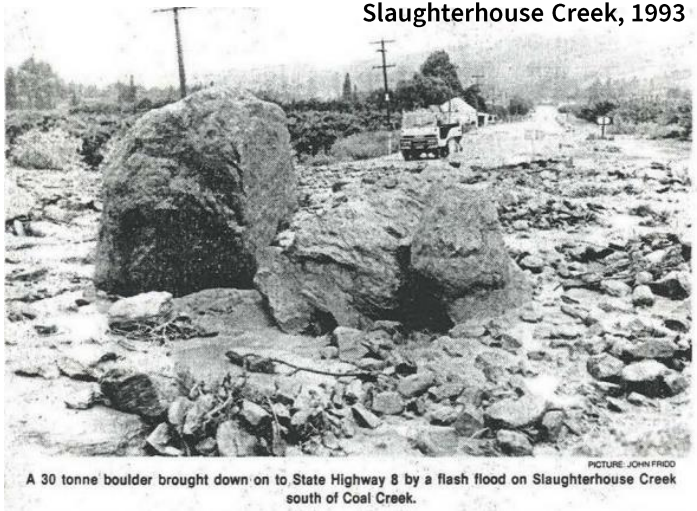




Reservoir Creek alluvial fan

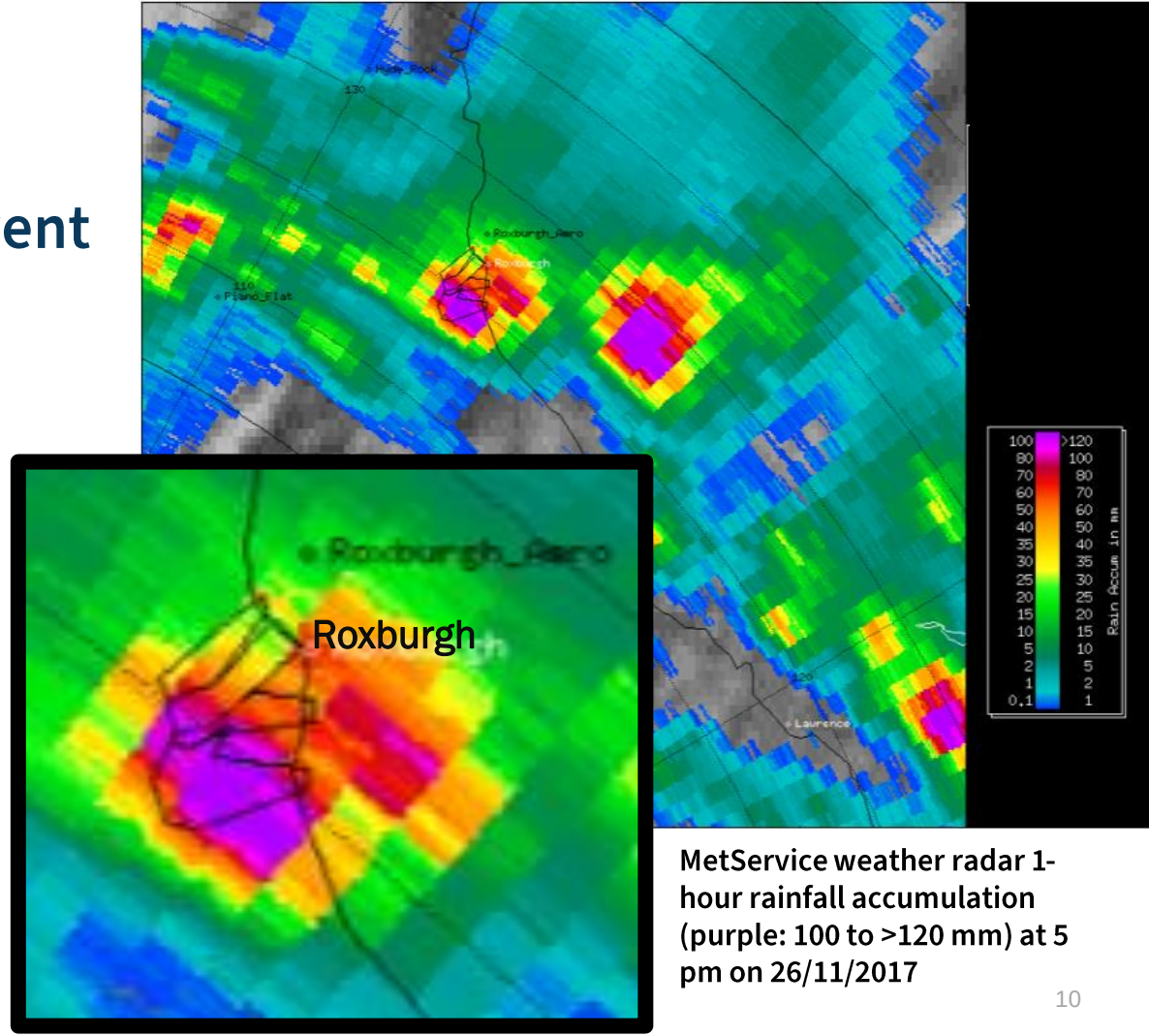
Past Events

- Large events in 1938, 1978, 1993, 2017
- As well as other smaller events
- Multiple events on different alluvial fans



November 26th 2017 Event

- Triggered by localised severe thunderstorm cell
- Rainfall intensities > 1% Annual Exceedance Probability (AEP)
- Spatially variable rainfall
- Debris floods triggered in 5 creeks: Pumpstation, Reservoir, Golfcourse, Blackjacks, and Stevensons (flow within channel)



MetService weather radar 1-hour rainfall accumulation (purple: 100 to >120 mm) at 5 pm on 26/11/2017

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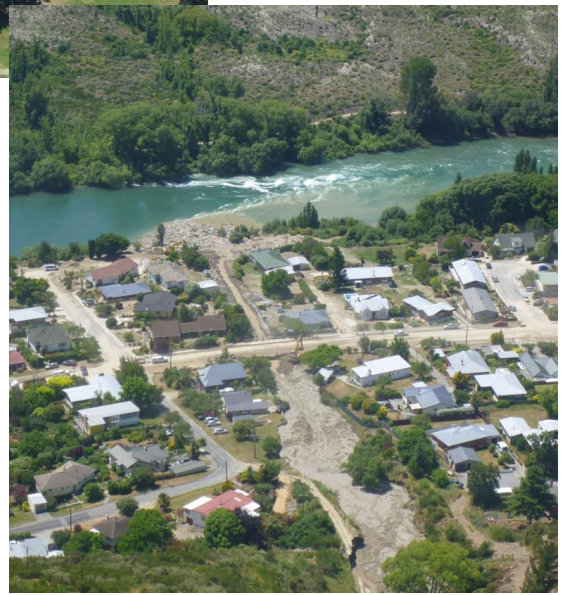
November 2017 Impacts

- Overwhelmed SH8 crossings
- Deposited debris out of channels, on roads and properties
- Concrete chute contained large debris (Reservoir Creek)
- Localised flooding, water and silt damage
- Critical infrastructure damaged

Golfcourse Creek, 2017



Reservoir Creek, 2017

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Post-2017 work completed

- Community, ORC, NZTA, and CODC cooperated on clean-up and recovery
- NZTA replaced SH8 culverts affected to increase capacity
- CODC increased resilience of pump station
- ORC conducted work under Roxburgh Natural Hazard Programme to better understand the event and potential responses (2017 to 2019).
- Increased ability to observe rain (radar & new local rain station)

Otago Rain Radar near Hindon

Current Roxburgh Natural Hazards Management Programme

Objective: identify, assess, and potentially implement, natural hazard risk management responses for debris flow hazards in the Roxburgh area.

Two concurrent technical projects by ORC

1. **Interim creek monitoring and maintenance plan (ongoing)**
2. **Roxburgh Debris Flood Detailed Hazard and Risk Assessment (NEW)**
   - in collaboration with CODC and NZTA

Supported by a community engagement plan

ORC monitoring and managing 5 creeks

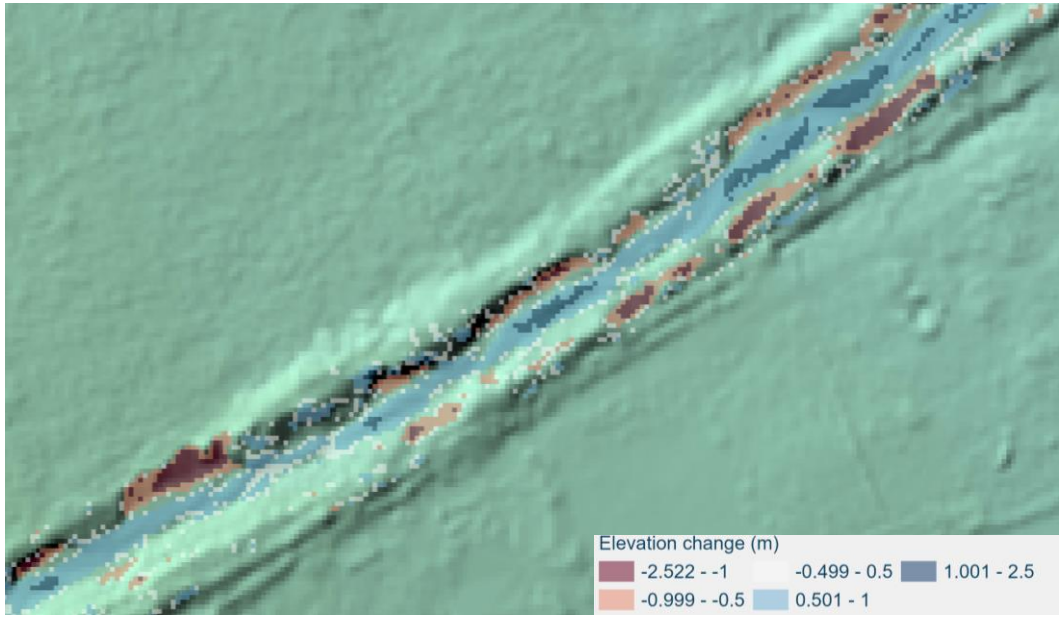
What maintenance work has ORC done since the 2017 clean up?

- 2018 – removed willows in Reservoir Creek channel, reshaped channel
- 2018 – reshaped Stevensons Creek
- 2018 – Reseeding of upper catchment
- 2019 – Removal of sediment at mouth of Reservoir Creek
- 2021 – Reshaped Reservoir Creek upstream and downstream of chute
- 2023 – Tree removal from Golf Course Creek
- 2025 – Reshaped Reservoir Creek at mouth
- 2026 – Channel reshaping work planned for Stevensons Creek in collaboration with NZTA

ORC monitoring and managing 5 creeks

How does ORC decide where to do maintenance?

- A topographic survey is conducted, such as LiDAR.
- This survey is compared to previous surveys. This provides quantitative data on where sediment is building up or where erosion might have occurred
- We have LiDAR from 2019, 2022, and 2024



Example - LiDAR change detection showing elevation change from 2022-2024 at Stevensons Creek

ORC monitoring and managing 5 creeks

How does ORC decide where to do maintenance?

- The results of the LiDAR change analysis are discussed and areas for maintenance are identified.
- Areas are identified based on changes to the creeks that may affect their ability to convey debris floods through existing infrastructure.
- Identified areas are then ‘ground truthed’ with a site visit to the creeks.
- ORC staff also undertake regular inspections of the creeks.

Current and Ongoing Hazard Management Approaches

PARA Framework – Protect / Accommodate / Retreat / Avoid

Protect

☑ Existing concrete chute for Reservoir Creek

☑ Existing SH8 road crossings structures

Accommodate

☑ Readiness, response, recovery, reduction

☑ Monitoring, forecasting and early warning

☑ Existing resilience of infrastructure

☑ Channel maintenance for 5 creeks (gravel and vegetation) and reactive delta gravel maintenance

☑ Chute maintenance for Reservoir Creek

☑ Individual and business insurance cover

☑ SH8 road crossings maintenance and repair

Retreat

Avoid

☑ Existing development rules and land use plans

Whose area of responsibility

Otago Regional Council (ORC)
Central Otago District Council (CODC)
NZ Transport Agency Waka Kotahi (NZTA)
Individual property owner
Multiple (some or all) - CODC, ORC, CDEM, NZTA, agencies, providers, community, individuals

Monitoring, forecasting and early warning

- ORC is responsible for 24/7 flood and rainfall monitoring, which includes notifying CDEM of high-risk weather forecasts for Roxburgh area.
- The advice from CDEM is: Do not wait for official warnings to take action and/or evacuate if you see the need to. Severe thunderstorms are difficult to forecast and debris floods can trigger rapidly.
- CDEM is responsible for regional emergency management planning and leading the '4Rs' (reduction, readiness, response and recovery).
- Community Response Group (CRG) support the Roxburgh community before, during and after an emergency.
- Roxburgh emergency hub: Roxburgh Memorial Hall (120 Scotland St).

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Advice for how to get ready

Sign up for CDEM alerts

- https://www.otagocdem.govt.nz/useful-stuff#emergency-mobile-alert-ema

Sign up for Metservice severe weather emails

- https://about.metservice.com/weather-emails
- Triggering rainfall for debris floods is typically associated with severe thunderstorms. Metservice provides severe weather warnings and watches, and also outlooks for the coming days.

Check out Metservice severe weather and thunderstorm outlooks

- 2-day Thunderstorm Outlook:
- https://www.metservice.com/warnings/thunderstorm-outlook
- 4-day Severe Weather Outlook
- https://www.metservice.com/warnings/severe-weather-outlook

Real-time rain radar

- Severe thunderstorms can develop very quickly and locally. Rain radar is a tool to monitor thunderstorms in real-time. Check out the Otago radar in real-time on the Metservice website:
- https://www.metservice.com/maps-radar/rain/radar/otago?range=300&tab=real-time

Update your emergency plan

- If you are in a hazard area, consider preparing your household and having an emergency plan
- https://getready.govt.nz/prepared/household/make-a-plan/household-plan

Community response group

- Check information from your local community response group
- Grab a copy of the Roxburgh community response brochure

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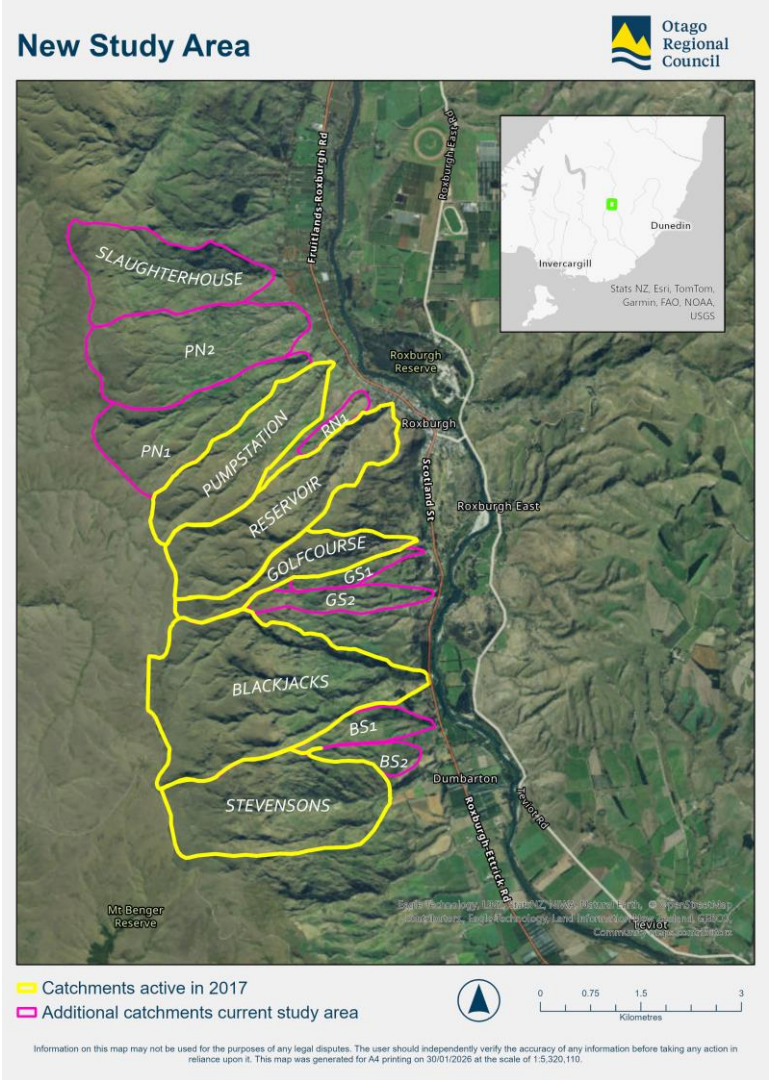
New Study Area

- 13 catchments/fans (yellow and pink)
- Catchments in yellow were active during the Nov 2017 events
- Catchments were included in the study area based on a prioritisation process
- Local names were not available for some creeks – these are identified by short labels (e.g. BS1)



New Results - Roxburgh Debris Flood Detailed Hazard and Risk Assessment

- **Follows-up on a recommendation of a previous assessment in 2019 by Golder**
- **For 13 alluvial fans (including those active in 2017 event):**
  - new detailed mapping is complementary to and refines the regional data (2009)
  - identifies areas where debris floods are more likely to occur
  - improves detail and spatial resolution of hazard and risk information
  - multi-purpose, useful background for many types further management work
  - milestone study - provides the technical basis for all further work

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WSP – Roxburgh Debris Flood Detailed Hazard and Risk Assessment findings

ROXBURGH DEBRIS FLOOD AND DEBRIS FLOW STUDY

COMMUNITY PRESENTATION

Prepared for Otago Regional Council | February 2026

ORC Debris Flood and Debris Flow Study

Project Background and Methodology

Roxburgh has been historically inundated by debris floods and flows. Debris flood modelling and risk assessment required for ORC future planning. This presentation overviews the WSP risk assessment.

Debris Flood Modelling

An overview of the methodology for the risk assessment.

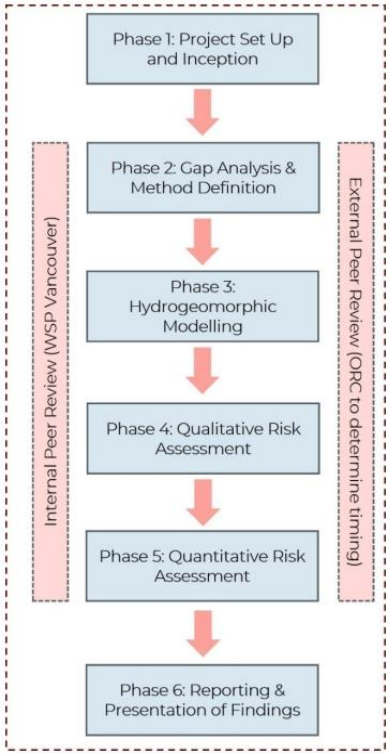
Risk Assessment Results

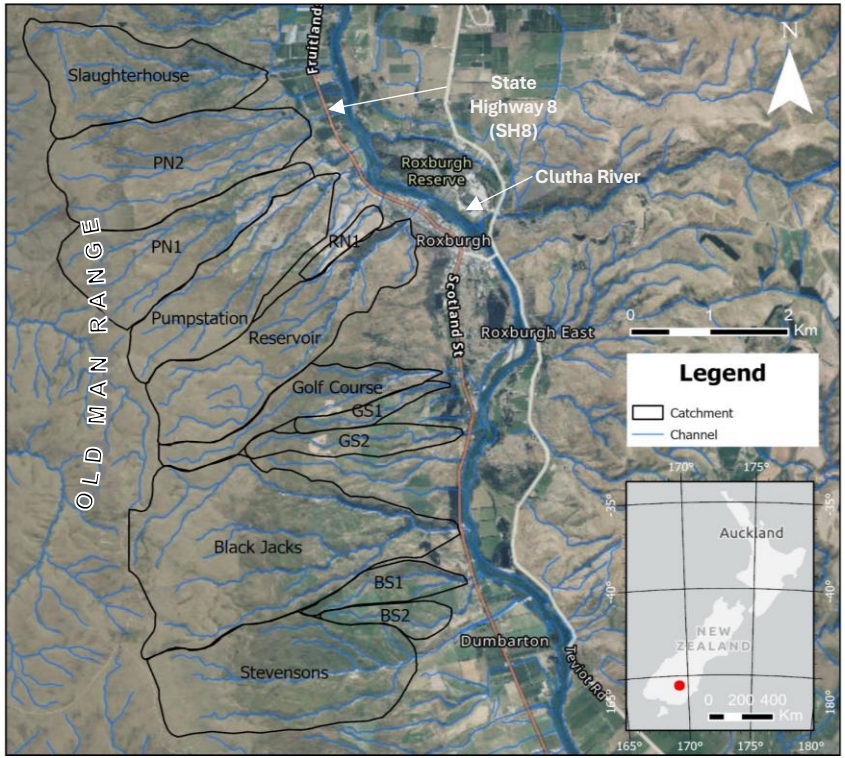
Overview of the risk assessment results including key observations and recommendations.

Implications

What did we find and what does this mean?

Background

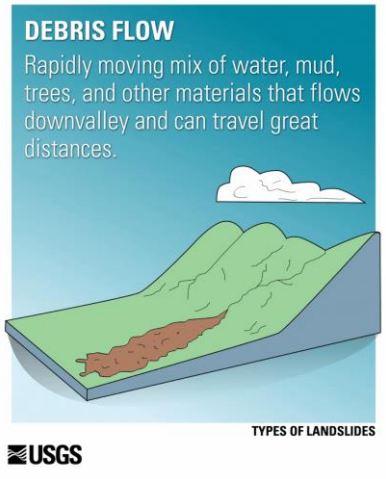

Phase 1: Project Set Up and Inception
Phase 2: Gap Analysis & Method Definition
Phase 3: Hydrogeomorphic Modelling
Phase 4: Qualitative Risk Assessment
Phase 5: Quantitative Risk Assessment
Phase 6: Reporting & Presentation of Findings
Internal Peer Review (WSP Vancouver)
External Peer Review (ORC to determine timing)

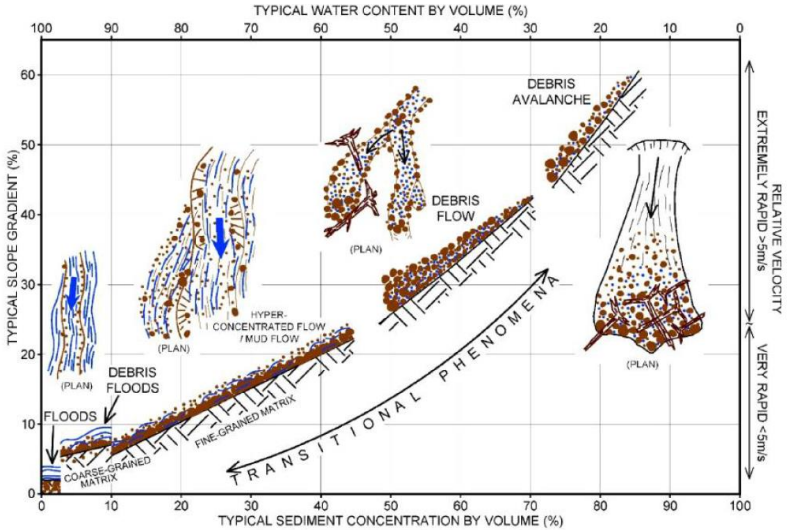

Slaughterhouse
Fruitland
State Highway 8 (SH8)
PN2
Roxburgh Reserve
Clutha River
PN1
RN1
Roxburgh
OLD MAN RANGE
Scotland St
Pumpstation
Reservoir
Roxburgh East
Golf Course
GS1
GS2
Black Jacks
BS1
BS2
Dumbarton
Stevensons
Taieri River
N
0 1 2 Km
Legend
Catchment
Channel
Auckland
NEW ZEALAND
0 200 400 Km
165° 170° 175° 180°

What are we looking at?

Hydrogeomorphic hazards refer to slope processes involving water and sediment that can have severe and wide-ranging impacts on both the human and natural environment.

They include **debris floods** (fluid-dominated) and debris flows (sediment-dominated) which are the key focus of this study.





Hydrogeomorphic hazards in Roxburgh

Why is Roxburgh and the Teviot Valley vulnerable to hydrogeomorphic hazards including debris floods and debris flows?

Hydrogeomorphic hazards in Roxburgh

What has happened in the past?

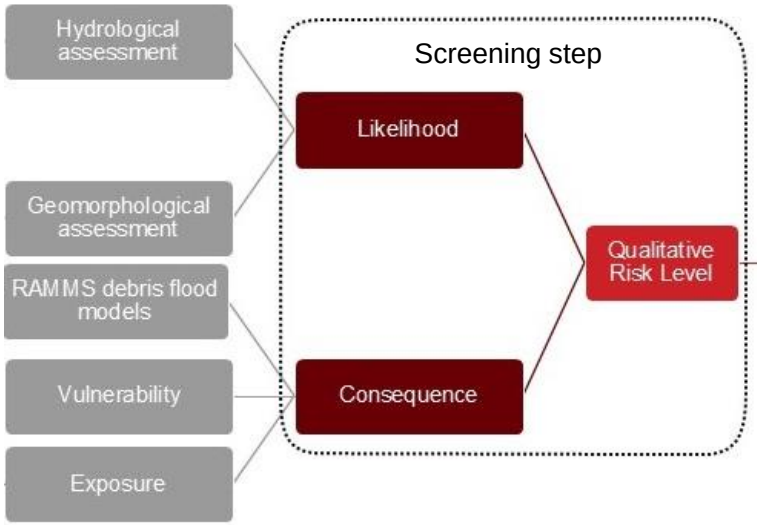
Historical records

- Seven documented events since 1938.
- 1978 and 2017 the most recent and notable events.

October 1978 Debris Flood Reservoir Creek

November 2017 Debris Flood Reservoir Creek

Our Study



1. *What is the annual debris flood risk for **people?***

2. *What is the annual debris flood risk for **buildings?***

DEBRIS FLOOD MODELLING

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Debris flood modelling

INPUTS

Topographical data

Where are the flow paths and debris source areas?

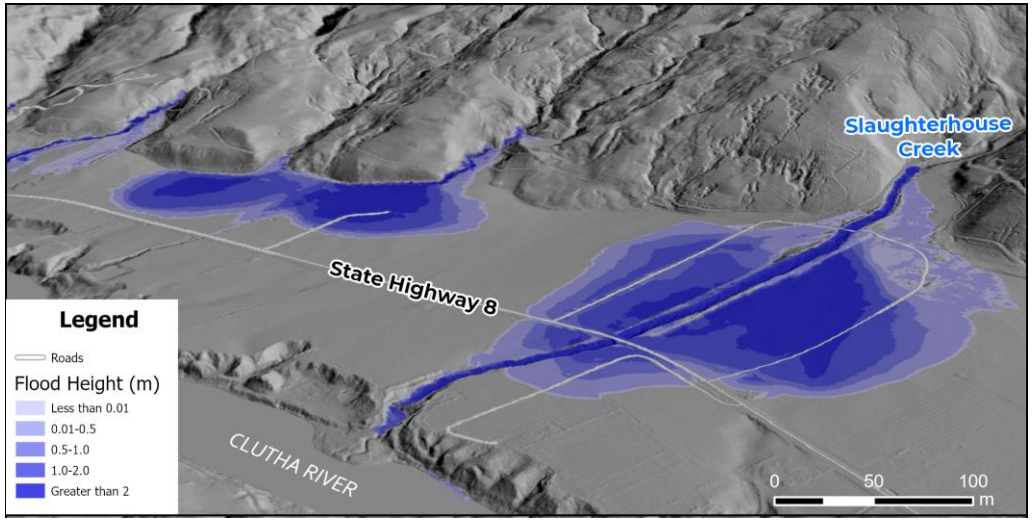
Hydrological Model

How do streams react to rainfall events?

Geomorphological assessment

What can we expect from future events?

OUTPUTS

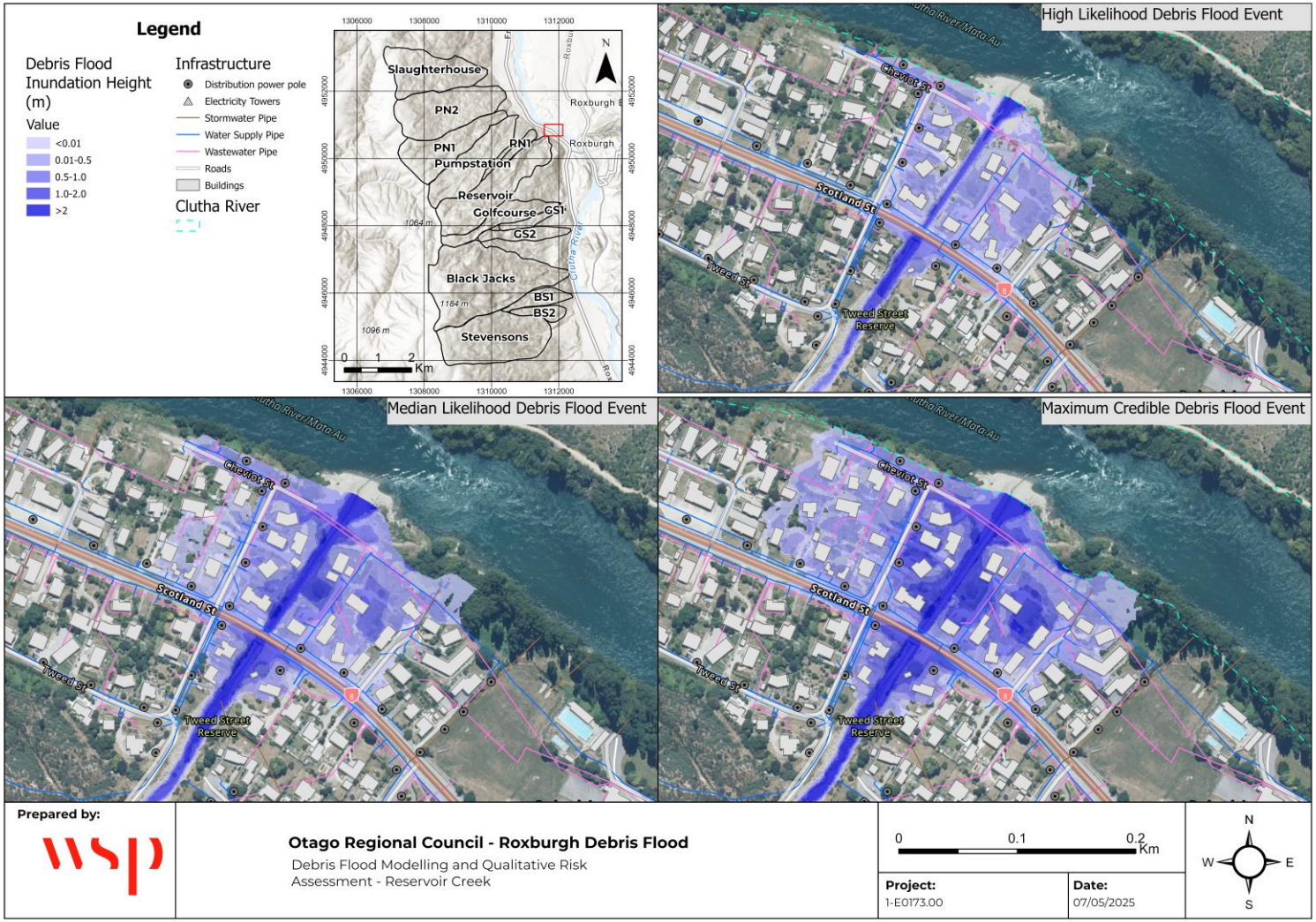


Debris flood modelling

Over the history of an alluvial fan, smaller debris floods are more common, and very large debris floods are rare. Therefore, the area affected by any one debris flood event will vary.

3 different size events were simulated to show the possible range.

Event	Description	Trigger	Return Period (including climate change)
High likelihood event	More frequent but smaller scale debris floods. Similar in size to Pumpstation/Golf course 2017 events.	40-60 mm of rainfall in 1 hour	100 – 300 years
Median likelihood event	Larger debris flood volume and extent, less frequent that high likelihood event.	60-100 mm of rainfall in 1 hour.	500 – 1,400 years
Maximum credible event	Large scale but very infrequent debris flood events. Not observed in human records.	>140 mm of rainfall in 1 hour.	10,000 - 12,000 years.


Legend
Debris Flood Inundation Height (m)
Value
<0.01
0.01-0.5
0.5-1.0
1.0-2.0
>2
Infrastructure
Distribution power pole
Electricity Towers
Stormwater Pipe
Water Supply Pipe
Wastewater Pipe
Roads
Buildings
Clutha River
Slaughterhouse
PN2
PN1
RN1
Pumpstation
Reservoir
Golfcourse
GS1
GS2
Black Jacks
BS1
BS2
Stevensons
Roxburgh
1064 m
1184 m
1096 m
0 1 2 Km
N
High Likelihood Debris Flood Event
Median Likelihood Debris Flood Event
Maximum Credible Debris Flood Event
Chevior St
Scotland St
Tweed St
Tweed Street Reserve
Prepared by:
Otago Regional Council - Roxburgh Debris Flood
Debris Flood Modelling and Qualitative Risk Assessment - Reservoir Creek
0 0.1 0.2 Km
Project: 1-E0173.00
Date: 07/05/2025
N
W
E
S

Initial qualitative risk screening

- A qualitative risk screening was completed to identify the highest risk fans for further assessment.

- Qualitative risk calculated as:

$$Risk = Hazard\ Likelihood \times Consequence$$

- Consequence determined using existing criteria for buildings, people, and lifelines:
  - Physical damage, injuries/fatalities, lifeline damage and outages.
  - Summarized in Appendix G of the detailed report

- Uses partially-operative Otago Regional Policy Statement APP6 framework.

- Useful screening tool

➢ 12 catchments carried forward to quantitative risk assessment (all except Black Jacks Creek where the qualitative risk is “acceptable”)

QUANTITATIVE RISK ASSESSMENT

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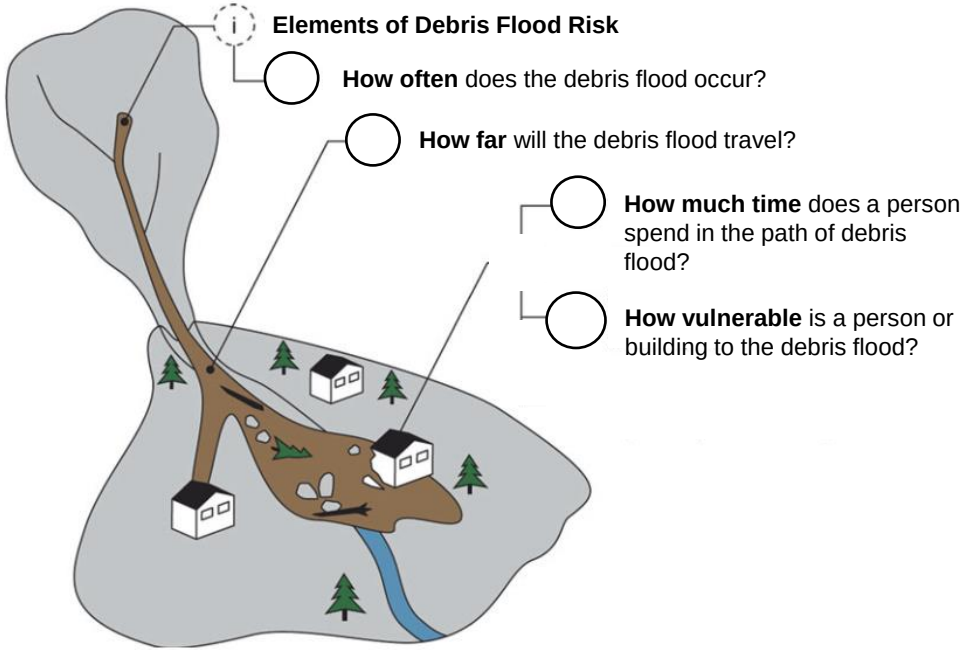
How is risk calculated?

- We are to assess life risk using AGS Guidelines for Landslide Risk Assessment.

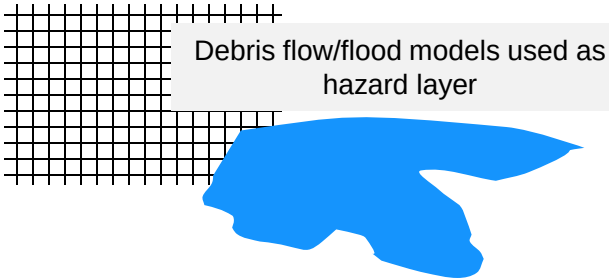
- **For people**, risk calculated as **annual individual fatality risk (AIFR)**
- AIFR means in any given year what is the likelihood of fatality of the most exposed individual in the study area.

- **For buildings**, risk calculated as **annual property risk (APR)**
- APR means in any given year what is the likelihood of a building being damaged.



How do we determine risk spatially?

Each fan divided into 1 by 1m grid cells.

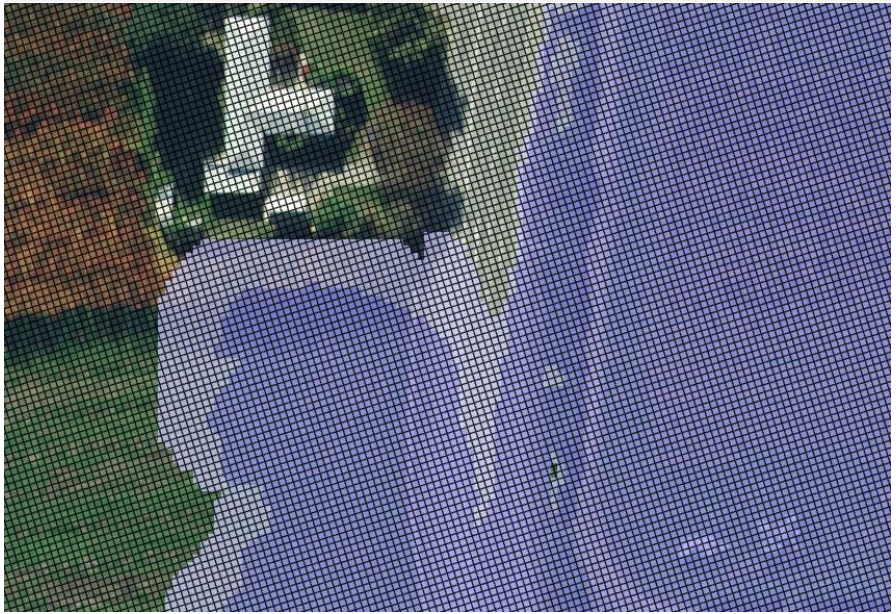


Debris flow/flood models used as hazard layer

For each grid cell assign:

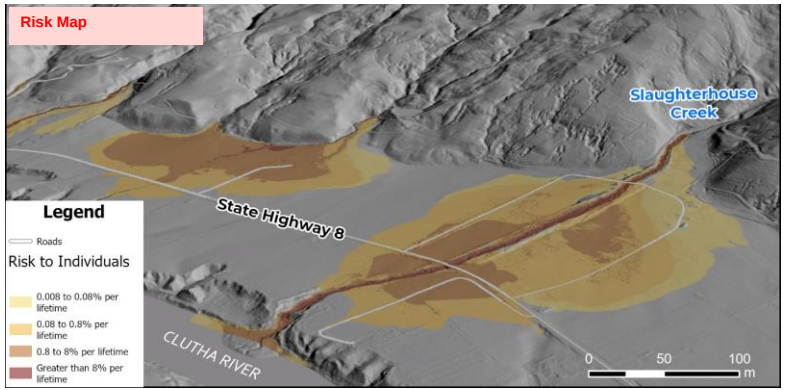
- Probability of hazard occurring
- Probability that hazard reaches exposed element
- Probability that exposed element is present at the time of the event
- Vulnerability of exposed element given the depth of inundation and velocity of the event.
- AIFR and APR

Debris flood model inundation (purple), grid cells (black)



Risk mapping and tolerability

Colour	Risk Value	Risk Tolerability - Existing Development	Risk Tolerability - New Development
	1E-06 to 1E-05	Acceptable	Tolerable
	1E-05 to 1E-04	Tolerable	Significant
	1E-04 to 1E-03	Significant	
	>1E-03		



- Partially operative Otago Regional Policy Statement risk tolerability criteria applied to calculated risk values.
- Both present day and severe climate change scenario mapped.
- Risk values (i.e. 1E-03) expressed as annual risk of fatality or property risk.
- Very small values so scientific notation used in maps.
- See below table for what notation means.

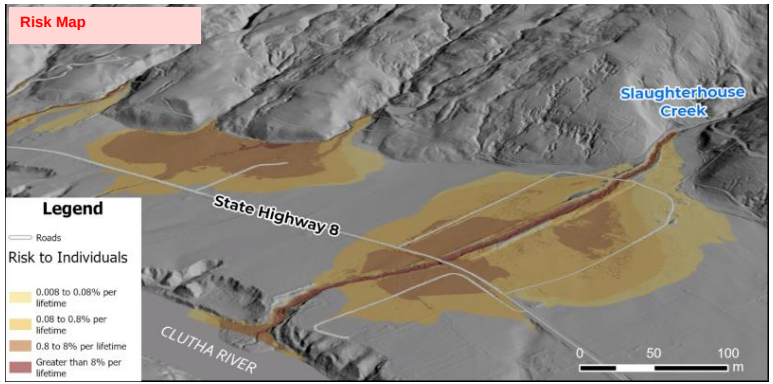
'10 to the negative ...per year'	Is the same as...(per year)	Is the same as once in...	Is the same as...(80-year lifetime)
10^{-2}	1%	100 years	55% per lifetime
10^{-3}	0.1%	1,000 years	8% per lifetime
10^{-4}	0.01%	10,000 years	0.8% per lifetime
10^{-5}	0.001%	100,000 years	0.08% per lifetime
10^{-6}	0.0001%	1,000,000 years	0.008% per lifetime


AIFR - Present Day
APR - Present Day
AIFR - RCP8.5
APR - RCP8.5
Cheviot St
Scotland St
Tweed St
Tweed Street Reserve
Roxburgh Area School
Prepared by:
Otago Regional Council - Roxburgh Debris Flood
Quantitative Risk Assessment- Reservoir
Colour
Risk Value
Risk Tolerability - Existing Development
Risk Tolerability - New Development
<1E-06
Acceptable
Acceptable
1E-06 to 1E-05
Tolerable
1E-05 to 1E-04
Tolerable
Significant
1E-04 to 1E-03
Significant
>1E-03
0
0.1
0.2
Km
Project:
1-E0173.00
Date:
30/07/2025
N
W
E
S

What did we find?

- All fans in the assessment have areas of significant risk.
- Spatial analysis reveals that areas within close proximity to main channels – typically within 200–300 m – are most vulnerable, with risk decreasing with distance and elevation.
- Refer to the maps in Appendix H of the report for more information.

- Report and maps on ORC webpage: https://www.orc.govt.nz/get-involved/projects-in-your-area/roxburgh-hazard-management/



How to reduce future debris flood impacts?

There are a range of different options available to help manage debris flood impacts:

- Physical structures
- Non-structural measures
- Planning tools
- Long-term adaptation and resilience

Debris flow barrier - Geobrugg

SUMMARY

- The Teviot Valley is exposed to hydrogeomorphic hazards including debris floods.
- These hazards can cause damage to buildings, infrastructure, and are public safety concerns.
- We modelled debris floods in 13 catchments to identify high risk areas on each alluvial fan.
- Analysis shows all fans have areas of significant risk.
- Higher risk areas are proximal to channels and within topographical depressions on each fan.
- Hazard and risk maps help guide mitigation including regulatory planning and engineering design.

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Maps

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Next Steps from 2026

- **Early March - loop back to community with any follow-up (e.g. Teviot Bulletin)**
- **Consider councillor feedback, community and mana whenua concerns, and carry forward into planning.**
- **Continue working closely with NZTA, CDEM and CODC:**
  - Investigate the need for additional or more extensive channel management (2026)
  - Shortlist potential mitigation options (structural and non-structural options) (2026)
  - Integrate into long-term decision-making and funding processes (e.g. Long Term Plans) (from 2027)
- **Open to additional community engagement activities in 2026**
- **CDEM will update the Teviot Valley Emergency Response Plans to reflect the new findings and to raise awareness of facilities identified to support the community's welfare needs.**

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Thank you