

**BEFORE A HEARING PANEL: WHAKATĀNE DISTRICT COUNCIL AND BAY
OF PLENTY REGIONAL COUNCIL**

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of submissions and further submissions
on Plan Change 1 (Awatarariki
Fanhead, Matatā) to the Operative
Whakatāne District Plan and Plan
Change 17 (Natural Hazards) to the
Bay of Plenty Regional Natural
Resources Plan

**STATEMENT OF EVIDENCE OF MAURICE MCSAVENEY ON BEHALF OF
WHAKATĀNE DISTRICT COUNCIL**

ENGINEERING – DEBRIS FLOW

15 January 2020

**BROOKFIELDS
LAWYERS**

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1. EXECUTIVE SUMMARY

- 1.1. It was widely recognised soon after the 2005 event that the impact which that event had on the residents on Awatarariki fan should not be allowed to happen again.
- 1.2. It was accepted that the disaster had been caused by a large debris flow and that there was much evidence that such debris-flow events had happened there before and would happen again if nothing were done.
- 1.3. The debris-flow processes, hazard and risk distribution at Matatā were studied to currently accepted international standards, based on the recognised sparse data provided by the one confirmed event that could be investigated.
- 1.4. The 2005 debris flow at Awatarariki fan was estimated by the best available techniques to have a volume of about 300,000 m³. In my opinion this means that the volume was greater than 200,000 m³ but probably less than 400,000 m³ and unlikely to be improved on.
- 1.5. No engineering solution was found that would mitigate the impact of a 2005-sized event on fan residents.
- 1.6. A decision has been made by the Whakatāne District Council (the **District Council**) not to proceed with any mitigation work.
- 1.7. Some of the remaining residents on the fan consider that they could accept the high risk to their life of a future debris flow of undetermined magnitude. I do not support that position.

2. INTRODUCTION

- 2.1. My full name is Maurice James McSaveney.
- 2.2. My evidence is given on behalf of the District Council in relation to:
 - (a) Proposed Plan Change 1 (Awatarariki Fanhead, Matatā) to the Operative Whakatāne District Plan; and
 - (b) Proposed Plan Change 17 (Natural Hazards) to the Bay of Plenty Regional Natural Resources Plan (a private plan change request from the District Council)

(together referred to as the **Proposed Plan Changes**).

2.3. My evidence relates to the physical effects of the events which led to the Proposed Plan Changes. My evidence will cover:

- (a) The cause of the 2005 debris flows at Matatā
- (b) Debris-flow phenomena including variabilities such as size, behaviour, predictability;
- (c) Debris-flow triggering mechanisms (such as the complex inter-relationships between rainfall intensity, soil pore pressure, geology, slope angle etc.) that make it difficult to identify when a debris flow might occur;
- (d) That a debris flow is a natural hazard;
- (e) Description of the Awatarariki debris flow in 2005;
- (f) A description of the geomorphology of the Awatarariki catchment;
- (g) Analysis of the rainfall, geological and run-off processes during the 18 May 2005 storm event resulting in debris flows in the catchments behind Matatā, and in particular, the Awatarariki catchment, and that debris flows are a natural process;
- (h) Discount breakout floods from log dams or debris dams as being the initiating trigger for the May 2005 debris flows;
- (i) Preliminary estimate of 200,000 m³ as being the volume of solid material deposited on the Awatarariki fan from the 2005 debris flow (note this was subsequently increased to 300,000m³ by Tonkin and Taylor Ltd which was factored in to the risk assessment that Tim Davies and I later peer reviewed);
- (j) Evidence of previous debris flows from the Awatarariki catchment, including commentary on their size (e.g. as stated in the GNS Causes and Mitigation Report at section 2.9-2.10 and Fig 2.9.1);
- (k) Likelihood of future debris flows and area of risk;

- (l) Peer review of the Tonkin and Taylor Ltd Supplementary Risk Assessment – Debris Flow Hazard, Matatā, including confirmation of the high, medium and low debris flow risk areas delineation and conclusion that the high risk area is unsafe for residential use; and
- (m) Use of AGS (2007) as an appropriate risk management framework to assess debris flow risk from the Awatarariki catchment.

3. QUALIFICATIONS AND EXPERIENCE

- 3.1. I hold the positions of Emeritus Scientist at GNS Sciences and Visiting Professor at the State Key Laboratory of Geohazard prevention and Geoenvironmental protection, Chengdu University of Technology, Chengdu, China. Until 2015 I was a Senior Engineering Geomorphologist at GNS Sciences.
- 3.2. My qualifications include BSc (Hons) in Geology from University of Canterbury (1966) and 54 years of post-graduate research in Earth-surface processes including a PhD (1976, Ohio State University, USA).
- 3.3. I have been active in the field of Earth-surface processes research for 55 years. My expertise relates to Earth-surface processes of which debris flows are one of the many dangerous ones. My hazard research is often cited in urban and rural plans, but I do not claim expertise in District plans or plan changes. In 2007 I advised Thames District Council of the need to consider high-magnitude, low frequency debris flows in respect to planned buildings at Thames District Hospital. In China I am currently researching with colleagues the 2018 failure of debris-flow mitigation works installed after a 2010 disastrous debris flow at Yangia Gou.
- 3.3. My CV is attached to this evidence as **Appendix 1**. Previous projects and publications I have been involved with that are relevant are set out below:
 - (a) Whitehouse, I. E., & McSaveney, M. J., 1985, Debris flows at Chelsea Creek, State Highway 6: Haast River section. Report WS 1001, Ministry of Works and Development, Christchurch;

- (b) McSaveney, M. J., Whitehouse, I. E. 1986, A geomorphological appraisal of flood protection measures on Black Birch fan, Mount Cook. Report WS 1081, Ministry of Works and Development, Christchurch;
- (c) Whitehouse, I. E., & McSaveney, M. J., 1986, Arthur's Pass roading project: geology, geomorphology, and hazards assessment. Report for Ministry of Works and Development, Christchurch;
- (d) McSaveney, M. J. 1988, Appraisal of natural hazards to urban land-use in the vicinity of the proposed Glentanner Park development. Report presented to Mr Ian Ivey, Glentanner Station and Mackenzie County Council, January 1988;
- (e) McSaveney, M. J. 1988, Statement of evidence in the matter of Appeal TPC 71/87 (Town and Country Planning Act 1977) between Alpine Hotels Ltd (Appellant), and Mackenzie County Council (Respondent) and Ian K. Ivey (Applicant);
- (f) McSaveney, M.J.; Davies, T.R.H.; Gough, J.D. 1995 Natural Hazard Assessment for Mount Cook/Aoraki Village & Environs. Institute of Geological & Nuclear Sciences Client report 49500D.11. 79 p. figures;
- (g) Gough, J.; Johnston, D.; McSaveney, M.J. 1999 Community response to natural hazard risk at Franz Josef Glacier. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences science report 99/10. 35 p.;
- (h) McSaveney, M.J. 2002. Assessment of debris-flow mitigation measures at Walter Peak, Queenstown. Institute of Geological & Nuclear Sciences client report 2002/127 for Locations Management, Queenstown. 24 pp.;
- (i) Whitehouse, I.E., McSaveney, M.J., 1990. Chapter 19: Geomorphic appraisals for development on two steep, active alluvial fans, Mt Cook, New Zealand. In: Rachocki, A., Church, M.A., (editors) Alluvial Fans a field approach, John Wiley & Sons Chichester, England. p 369-384.;

- (j) McSaveney, M.J. 1995. Debris flows and bridge losses at Waterfall Creek, SH6 at Lake Wanaka, New Zealand. Institute of Geological & Nuclear Sciences Science Report 95/21. 18 p. 11 Fig.;
- (k) McSaveney, E.R., McSaveney M.J. 1998. Beware of falling Rocks - landslides. Chapter 4 In: G. Hicks and H. Campbell (eds) *Awesome Forces: the natural hazards that threaten New Zealand*. Te Papa Press, Wellington, New Zealand. p 72-97 (plus 2nd edition 1999);
- (l) McSaveney, M.J., Glassey, P.J. 2002. The fatal Cleft Peak debris flow of 3 January 2002, Upper Rees Valley, West Otago. Institute of Geological & Nuclear Sciences Science Report 2002/03. 28 p.;
- (j) McSaveney, M.J.; Beetham, R.D.; Leonard, G.S. 2005 The 18 May 2005 debris flow disaster at Matata: Causes and mitigation suggestions. Institute of Geological & Nuclear Sciences client report 2005/71. 51 p. Available at www.geonet.org.nz/landslide/report_9.pdf and also www.easternboprecovery.org.nz/pdfs/reports/IGNS_report_July05.pdf.;
- (k) McSaveney, M.J., Davies, T.R. 2005. Chapter 25: Engineering for debris flows in New Zealand. in Jakob, M., and Hungr, O. (eds). *Debris-flow hazards and related phenomena*. Praxis Press. Chichester 739 pp.;
- (l) Davies, T.R.H.; McSaveney, M.J. 2008. Principles of sustainable development on fans. *Journal of hydrology, New Zealand*, 47(1): 43-65 2012; and
- (m) McSaveney, E.; McSaveney, M.J. 2012. Landslides : beware of falling rocks. p. 62-83 In: Hicks, G.R.F.; Campbell, H.J. (eds) *Awesome forces: the natural hazards that threaten New Zealand (Second Edition)*. Wellington, N.Z.: Te Papa Press.

4. MY ROLE

- 4.1. I was the lead author of the report “The 18 May 2005 debris flow disaster at Matatā: Causes and mitigation suggestions (July, 2005)” which established that the event of 18 May 2005 had been a debris flow and a type of landslide in the then internationally recognised nomenclature. This report was instigated under a GNS Sciences contract with the Earthquake Commission to quickly gather information on major landslide events before ephemeral information is lost. As part of this investigation, we overflew the area in a helicopter in the company of Mr T Bassett of Tonkin and Taylor. The report was not written specifically as advice to Council, although it was published as a client report to Council and is distributed on the Council website.
- 4.2. I subsequently have been engaged by Council to provide review comment on a student thesis (Dan Costello, University of Auckland MSc) and several Tonkin and Taylor reports on aspects of the events at Matatā. The last of these was the “Hind” report in 2015. In 2007, I lead a Geosciences Society 1-day field trip “An introduction to sunny Matatā and its great debris flows.” On 15 August 2019, I again overflew the Awatarariki debris-flow catchment by helicopter.
- 4.3. In preparing this evidence I have reviewed the following documents and reports:
 - (a) The 18 May 2005 debris flow disaster at Matatā: Causes and mitigation suggestions (July, 2005);
 - (b) Principles of sustainable development on fans, 2008;
 - (c) Peer Review: Awatarariki debris-flow-fan risk to life and retreat-zone extent, November 2015;
 - (d) McSaveney, M.J., Davies, T.R. 2005. Chapter 25: Engineering for debris flows in New Zealand. in Jakob, M., and Hungr, O. (eds). Debris-flow hazards and related phenomena. Praxis Press. Chichester. 739 pp;
 - (e) Daniel Larson, 2005 available at the following link: <http://daniel.larsen.net.nz/daniel/stories/story.104367.html>; and

- (f) Shearer, I. 2005. Draft report to Matatā recovery projects, Part D Historical Research.

5. CODE OF CONDUCT

- 5.1. Although this is a Council hearing I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Consolidated Practice Note 2014. I also agree to comply with the Code when presenting evidence to the Hearings Panel. I confirm that the issues addressed in this brief of evidence are within my area of expertise, except where I state that I rely upon the evidence of another expert witness. I also confirm that I have not omitted to consider material facts known to me that might alter or detract from the opinions.

6. THE CAUSE OF THE 2005 DEBRIS FLOWS AT MATATĀ

- 6.1. The 18 May 2004 debris flow at Awatarariki Stream, Matatā was triggered by exceptionally heavy rain falling on already saturated ground over much, if not all of the upper catchment area. Although the rain was the trigger, the cause of the debris-flow event was the many slope failures which were triggered by the rainfall which caused landslides to fall into already flooded stream channels. The evidence for widespread slope failures is two-fold:
- (a) Debris flows occurred more-or-less simultaneously in almost every tributary stream in the catchment area, and in most adjacent catchments in the Matatā area; and
 - (b) There are a great many debris-avalanche scars on the steeper slopes after 2005 than were present before 2005 as shown by space imagery available on Google Earth.
- 6.2. Measured rainfall at Awakaponga: 302 mm in 24 hr, 94.5 mm in 1 hr, 30.5 in 15 minutes. The 30.5 mm in 15 minutes fell close to the end of the storm. It is not unusual for storm rainfalls to peak near the end of a storm. Such rainfalls would be widely expected to trigger many slope failures on steep slopes anywhere in the world. They are not threshold values at which one or two failures might occur: they are values at which many failures would be expected, as indeed occurred.

- 6.3. There is a pattern discernible in the distribution of debris avalanches on steep slopes around the catchment of Awatarariki Stream. There are fewer avalanche tracks in the northeast corner and at the southwestern head of the catchment. The abundant avalanche tracks form a wide band which crosses from the escarpment immediately west of Awatarariki, and extends to south east of Awakaponga. In the western Southern Alps, I have seen similar patterns of debris avalanches tracks that have arisen from the passage across the landscape of high-intensity convective rain showers.

7. DEBRIS-FLOW PHENOMENA INCLUDING VARIABILITIES SUCH AS SIZE, BEHAVIOUR, PREDICTABILITY

- 7.1. A debris flow is a dense mixture of sediment and water which flows under the influence of the mass of sediment that it contains. The most common analogy is to liken the flow to that of wet concrete. The proportion of sediment to water in debris flows is highly variable. There is no characteristic ratio of water to sediment, even in a single debris flow, and the ratio does not remain constant during the flow. The flow characteristics of a natural debris flow are determined by the interactions between the sediment particles and the proportion of water present.
- 7.2. The quantity of sediment in a debris flow developed from a debris avalanche is determined both by the amount of debris in the avalanche, and by the amount of loose sediment in the stream channel that is able to be eroded by the growing debris flow. There is no necessary relationship between the amount of rain and the size of a triggered debris avalanche. There are however crude relationships between the amount of rain and the number of debris avalanches, and the number of debris avalanches and the total volume of debris contributed to the stream channel by debris avalanches. The amount of water flowing in the stream channel at the time is another variable, as is the amount of erodible material in the channel. All of these quasi-independent variables go to make it impossible to predict the size of a debris flow in a natural channel where none of these variables are known even though the qualitative circumstances under which a debris flow is likely to occur is easily predictable (as has been described above).

8. DEBRIS FLOW IS A NATURAL HAZARD

- 8.1. Debris flows are globally recognised as dangerous and therefore by definition they are a hazard. Not all debris flows are natural: a recent debris flow with multiple fatalities in Brazil was initiated by the collapse of a mine-tailings dam and therefore should be considered as an anthropic hazard.
- 8.2. The treatment of debris flows as a type of landslide hazard is not globally universal. In the Russian Federation debris flows are treated as a flooding hazard for historical reasons that arose from the government ministry that dealt with them in the former Soviet Union. In Japan, debris flows are regarded as a sediment hazard.
- 8.3. The 2005 report on the Matatā debris flows summarised the then-extant New Zealand statutes and regulations concerning debris flows among New Zealand natural hazards. Since I retired from employment in GNS Science in 2015 I have spent considerable time outside of New Zealand and have not had need to closely follow trends in New Zealand legislation and regulations relating to hazard and risk. I have read the evidence submitted by Dr Saunders dealing with the current thinking on debris flows as an element of natural hazard risk in New Zealand. It has evolved substantially for the better since 2005, and along the lines that I hoped that it would evolve.

9. DESCRIPTION OF THE AWATARARIKI DEBRIS FLOW IN 2005

- 9.1. I did not witness the 2005 debris flow, but I have read several accounts written by people who were present on the Awatarariki fan while the event was occurring. The independent accounts written by Neville Harris and Daniel Larsen are very informative. Mr Harris makes no reference to time during what was evidently a very significant event in his experience. Mr Larsen provides several mentions of time which indicate a duration of more than an hour during which the flow behaviour varied, but remained dangerous. Both refer to serious flooding of rushing dirty brown water carrying logs and boulders. Mr Harris refers to the railway bridge being blocked by logs several times before the bridge was swept away. Both refer to pulsing flows. Neither of these two witnesses appears to have been familiar with the concept of debris flow, and refer throughout their accounts to a flood with logs and boulders.

- 9.2. When I visited the area on 23–25 May and 9–10 June, 2005, the evidence for the recent passage of a debris flow in the Awatarariki Stream was unequivocal to me, both in the nature of the huge boulders transported in the event, and in the presence of a U-shaped stream channel scoured in bedrock in the catchment upstream of the fan. In preparing my evidence, I have repeatedly read the evidence of the eyewitnesses in an attempt to discern if there might have been a moment in the events described when a true flood might have transformed to a debris flow. Mr Harris's description of the railway bridge becoming clogged with trees which then broke free and moved as a block to lodge at the culvert under the highway, suggests to me that debris avalanches had already occurred in the Awatarariki catchment, and that debris flows were already occurring. This interpretation is in accord with the times mentioned by Mr Larsen and the unambiguous times recorded for the torrential rain at Awakaponga.
- 9.3. There are two very remarkable features of the debris flow at Awatarariki Stream. As is noted also in the evidence of Professor Davies, the Awatarariki debris flow moved in a very low gradient channel. Professor Davies offered no explanation, but I note that the principal source of sediment for the debris flow was deeply weathered Matahina ignimbrite and weakly consolidated weathered pumice sand. These water-saturated materials are easily crushed and abraded to yield a fine sandy slurry which would have facilitated continued movement of the debris flow on a lower than usual gradient, and the debris flows gradual transition near the seaward edge of the fan to a thick sandy debris flood. In effect, the break-down of water-saturated pumice continues to add water to the debris flow.
- 9.4. The second remarkable feature of the debris flow of 2005 was the absence of fatalities or even injuries. None of the people carried by the flow on the Awatarariki fan were exposed directly to the debris: they were inside homes or vehicles. Through much of the event there was heavy rain falling at Matatā and consequently few people moving about outdoors on foot other than a few people alerted to danger and checking on the safety of neighbours. The State highway had been closed by bridge washouts earlier in the day, so the only reported traffic on the highway across the fan was a heavy truck which crossed the highway

culvert before the culvert was destroyed. This was early in the debris-flow event.

10. A DESCRIPTION OF THE GEOMORPHOLOGY OF THE AWATARARIKI CATCHMENT

- 10.1. The steepland catchment of Awatarariki Stream consists of an upland plateau which has been deeply dissected by the Awatarariki Stream in a box canyon. The canyon is cut into mantling tephra deposits and Matahina formation, down to and into soft, weakly cemented sandstone and siltstone. The soft siltstone appears to be somewhat resistant to erosion and forms the bed and banks of the stream channel from where loose sediment has been scoured by the debris flow. This probably is because the siltstone is more cohesive than many of the other units, and its softness allows it to absorb impacts without fracturing. Boulders of siltstone were carried long distances in the debris flows, even though they fall apart on drying.
- 10.2. The weakly to moderately welded ignimbrites and their associated interbeds of the Matahina Formation range widely in erodibility. They stand in high, steep, to very steep slopes above the deep narrow stream channels which are floored mostly on soft siltstone. The more strongly welded components of the ignimbrites are columnar jointed (with regularly spaced cracks) from contraction during cooling from high temperature. These vertical cracks promote ready failure of the strongest rock in the catchment, and the formation of many large to very large boulders in the stream bed. Most of these boulders are too large to move in normal stream flood flows and are moved only by debris flows.
- 10.3. It is the steep slope angles more than the character of the rocks that make the catchments so prone to debris flows. The steep slope angles arise because the catchments are small, but large enough that their streams have cut to the foot of the ancient sea cliffs. The larger coastal catchments further to the west of Matatā are too large for debris flows in them to propagate to the coastal plain.

11. DISCOUNT BREAKOUT FLOODS FROM LOG DAMS OR DEBRIS DAMS AS BEING THE INITIATING TRIGGER FOR THE MAY 2005 DEBRIS FLOWS

- 11.1. What we know of the rainfall intensities on 18 May 2005, and what we know of the distribution of landslips, debris avalanches and multiple debris flows in the Awatarariki catchment are quite sufficient to explain the cause and severity of the event that occurred on the Awatarariki fan. I know of no evidence to support a hypothesis that this event was caused by breakout floods from debris dams, although elsewhere such breakout floods have caused debris flows. I am familiar with one such site at Yangjia Gou in China where two large fatal debris flows have occurred in the last 10 years from break-out floods from the same debris dam (see paragraph 16.1 below).
- 11.2. I do not dispute the presence of so-called debris dams in the catchment: I only dispute that they caused the event. It is characteristic of steepland streams for sediment to be irregularly stored along the course of the channel behind accumulations of large boulders and ephemeral debris dams (in forested catchments). It also is typical for large debris flows to entirely scour their channels to bed rock. Hence, a traverse up any of the streams in the upland area around Matatā between debris flow occurrences would always encounter a series of alternating alluvial flats and torrent areas around rotting fallen tree trunks. It has been suggested that perhaps the size of future debris flows from Awatarariki Stream could be reduced by maintaining a channel clear of debris dams in the upper catchment. To do so, however, would require the maintenance of a roadway along the channel to provide access and the roadway itself would provide ample debris to feed a growing debris flow.
- 11.3. I note also the evidence of Prof. Davies and Dr Phillips that catchment management practices will not significantly diminish the life safety risk to residents on the Awatarariki fan.

12. PRELIMINARY ESTIMATE OF 200,000 M³ AS BEING THE VOLUME OF SOLID MATERIAL DEPOSITED ON THE AWATARARIKI FAN FROM THE 2005 DEBRIS FLOW

- 12.1. In the 2005 report, I wrote “We have only crudely estimated the volumes of solid material. For Awatarariki Stream, the fan length is about 300 m and width, about 300 m. An average sediment depth of about 2 m leads

to a volume estimate of about 100,000 m³. Some 10% of this is “large woody debris” – the larger remnants of the trees. Perhaps about as much again of sediment and woody debris did not stop on the fan and is now in the lagoon and beyond.” This “crude estimate” summed to 200,000 m³. Subsequently, T & T used LIDAR and aerial photography to obtain a much less crude estimate of about 350,000 m³. I have reviewed the evidence used to make this estimate, and compared it with the much larger Costallo thesis estimate. In my opinion the T&T estimate is well founded and unlikely to be improved upon.

- 12.2. In view of the very real uncertainty in gaining an accurate estimate of the volume of debris delivered onto the fan head by the 2005 debris flow, I am particularly reassured by the numerical modelling work described by Mr Hind which suggests that the true volume of debris on the fan makes very little difference to the risk to life on the fan.

13. EVIDENCE OF PREVIOUS DEBRIS FLOWS FROM THE AWATARARIKI CATCHMENT

- 13.1. There is irrefutable evidence for previous debris flows at Matatā. The evidence shows that large prehistoric debris flows built the land beneath Matatā over the last 7000 years. One of the previous debris flows delivered the huge boulders that were used as landscaping features on the fan of Awatarariki Stream before 18 May 2005.
- 13.2. Dr, The Honorable Ian Shearer (Shearer, 2005) lists 28 floods that have occurred in the eastern Bay of Plenty in the last 137 years. Some of these have affected Matatā. Several of these can be confirmed as debris flows. One in 1869 destroyed a flour mill on what we presume to be the fan of Awatarariki Stream. The boulders from another in 1950 were illustrated in the Whakatāne Beacon of 1 June 2005. This is likely to have been from Waitepuru Stream because historical vertical aerial photographs held by GNS Sciences bracketing this time show evidence of a debris flow in that stream between 26.9.44 and 18.4.61. Floods in 1906 and 1939 may also have been associated with debris flows, although we are unable to see features on 1944 aerial photographs consistent with a large debris flow in 1939.
- 13.3. Drainlayers installing underground pipes for dwellings on the Awatarariki fan reported encountering large boulders below the fan surface prior to

the 2005 debris flow. T&T attempted to excavate into the fan in an attempt to obtain organic material that could be radiocarbon dated. No organic material was found. It is assumed that past organic material as was deposited in 2005 had been completely oxidized in the freely draining fan deposits.

- 13.4. The name “Awatarariki” translates as “Goose pimples” which may imply that the fan area at the time of Maori arrival had an appearance somewhat similar to the area of “goose-pimpley” surface which it has had since 2005. Oral tradition of the use that an invading Maori group made of a lone Pohutukawa tree on the upper fan implies that the fan has always been an open area with isolated trees. All of this is consistent with the occurrence of past debris flows in the last 1000 years or so.
- 13.5. There are anecdotal reports of large boulders on the sea floor offshore of Awatarariki fan that provide a favourable habitat for crayfish. The only source of large boulders on the sea floor in this area is from past large debris flows. Since the current coastal landform forms a barrier to the passage of debris flows, the presence of boulders offshore likely relates to debris flows occurring at times of lower sea level.
- 13.6. The steep escarpment which forms the backdrop to Matatā is the remnant of an ancient sea cliff which was last trimmed by the sea around the time that modern sea level rose and stabilised around its current height with respect to the land. This roughly constrains all of the current coastal landforms in the area to the last 6000 years or so, which implies a high rate of delivery of sediment from the catchments behind the range front.
- 13.7. The highly dendritic development of the box-canyon landscape of the Awatarariki catchment is diagnostic of a geomorphology developed mostly by repeated sapping of steep slopes by very many debris avalanches such as occurred in 2005 (and with associated debris flows to remove the fallen solid materials from the channel). The circumstances which led to the development of this geomorphology were not altered by the occurrence of the 2005 debris flow. Hence future occurrences of large debris flows issuing from the catchment are a certainty, without a radical change in the catchment morphology.

14. LIKELIHOOD OF FUTURE DEBRIS FLOWS AND AREA OF RISK

- 14.1. Key to development of an estimate of the likelihood of future debris flows on the fan is development of a history of past debris flows and their magnitudes. In the time since 2005 there has been no progress in this development. However, through the use of numerical modelling the Hind report suggests that the area of high risk on the fan is somewhat insensitive to the magnitude of debris flows at low return periods.

15. PEER REVIEW OF THE TONKIN AND TAYLOR LTD SUPPLEMENTARY RISK ASSESSMENT – DEBRIS FLOW HAZARD, MATATĀ,

- 15.1. I was a party with Prof Davies to a peer review of the T&T “Hind” report. We accepted that the report made good use of the available data using internationally accepted quantitative analysis techniques. We accepted that in modified form it depicted significant areas of adequately quantified high risk to life.

- 15.2. However, I endorse the opinion of Dr Massey that it is not the role of the technical expert to conclude that any area is fit or unfit for any particular use.

15.3. USE OF AGS (2007) AS AN APPROPRIATE RISK MANAGEMENT FRAMEWORK

- 15.4. I accept that AGS (2007) presents a framework for risk management of an area at risk of a known and quantifiable hazard. It is not the only framework for risk management. Like all such frameworks, implementation of the risk assessment arrived at, is subject to a public policy decision which involves elected officials deciding on the level of risk at which they will tolerate the death of other people. Some people are reluctant to make such decisions, and would rather they were made by others

16. LESSONS FROM SOME DEBRIS-FLOW MITIGATION STRUCTURES IN CHINA

- 16.1. A large mountain area of Sichuan Province in China was severely affected by the M8 Wenchuan earthquake in 2008 which triggered tens of thousands of landslides. Subsequently, the debris from many of these

landslides has given rise to some immense debris flows. Some cities were abandoned because of this debris-flow damage. The monsoon rains of 2010 gave rise to some particularly disastrous debris flows when the 2008 landslide deposits were mobilised. As a result many roads and bridges which had been quickly replaced after they were destroyed by the earthquake had to be rebuilt. Below Wenjia Gou, much of the rebuilt town of Qingping was destroyed by a 2010 debris flow originating from the deposit of the Wenjiagou rock avalanche of 2008. This debris flow destroyed a debris-flow detention dam built across the river post-2008. This large debris-flow detention dam was grossly under-designed for the event which occurred. Subsequent to 2010 a new and substantially larger dam was built, much of the catchment runoff is now intercepted above the landslide deposit and diverted into another catchment, and the landslide deposit morphology has been very substantially modified to make for a likely more stable channel. The lower portion of the rock avalanche is now cropped for soy beans, and the debris-flow fan from 2010 is now in large-scale Kiwifruit orchards.

- 16.2. Another river subject to recurrent debris flows from a 2008 landslide deposit is at Yangjia Gou which I visit yearly. After a large fatal debris flow in 2010, a series of 8 massive concrete pile structures were installed across the river to stabilise the channel bed from further scour. The bases of these 1-m diameter piles were installed to a depth of about 5 m in the landslide debris forming the channel bed and stood about 5 m high in the channel. By 2017 coarse sediment had built up against the upstream side of these debris retention structures as it was supposed to do. A severe storm in the summer of 2018 triggered another fatal debris flow in Yangjia Gou and the lower three of these structures were destroyed by debris-flow scour on the downstream side of the structures to below the bases of the piles which then fell over. The engineering design of the structures had underestimated the required depth of the piles. Other mitigation structures further downstream also failed but they were cut through by the continual passage of abrasive sand in the water over a period of 8 years. These debris-flow mitigation works were all well-constructed, but grossly under-designed for the environment in which they were placed. They have been repaired and replaced with more robustly constructed structures, and telemetering flow-monitoring

equipment has been installed to eventually provide more robust data for engineering design should they fail again.

- 16.3. The Chinese engineers responsible for the design of debris-flow mitigation work have much experience but little quantitative data for the particular area of Sichuan affected by the 2008 Wenchuan earthquake. Their knowledge is growing quickly, but lives have been lost while they gain it.
- 16.4. There are other areas of China where debris flows occur annually each wet season. The local peoples do not live on the areas subject to debris flows, but they are experienced at using such areas for cropland growing mostly legumes such as soy beans and peanuts.
- 16.5. Applying what I have learned from my China experiences to Matatā, It is very easy to underestimate the size and power of a debris flow. I would be very wary of letting a group of even experienced debris-flow engineers conduct experiments that place lives at risk while they “fine-tune” a mitigation structure to get it to work. This is the situation that has been proposed repeatedly for Awatarariki.

17. RESPONSE TO SUBMISSIONS

- 17.1. With reference to the submission by Awatarariki Residents Incorporated I make the following responses.
- 17.2. New Zealand is a signatory to the UN-supported Sendai Declaration of 2015 (see Prof. Davies’ evidence), which is why New Zealand supports a risk-based approach to disaster reduction. In my past role as Editorial advisor to the Board of Representatives of the International Consortium on Landslides I helped draft the Sendai declaration. PC1 is a significant contribution of disaster risk reduction on Awatarariki fan.
- 17.3. Managing hazard risk is accomplished by managing risks to people and property. It is not achieved by managing hazards.
- 17.4. The adopted approach has been an event-based approach: it is intended to prevent such disasters as happened in 2005 from happen again.
- 17.5. There have been a great many, extensively reviewed, cost-benefit analyses of the engineering options for mitigation of the risk on the

Awatarariki fan at all levels of government. The option of foregoing engineering mitigation solutions was not taken up lightly.

- 17.6. Historic land uses (such as the adjacent Council operated quarry, farming and logging) did not contribute to the 2005 event in any way. Nor could catchment maintenance assist to avoid or mitigate risk. It is scientifically inappropriate to try to manage the hazard: hazards are unmanageable.
- 17.7. The precision of the modelling of risk of landslide and debris flow, the modelling of probability of fatality or injury; and the science as to assessment of risk properties identified as “high risk” have been detailed at great length in numerous reports (which are on the Council website). The analyses of probability and consequence have been conducted to internationally very high standards. The risk assessments have been shown to be robust to a large range of input values. No assertions of risk of fatality to Society members and their families have been made. The risk assessment has been shown by Mr Hind to be robust. In our professions we are prohibited by law from conducting the experiments that would demonstrate the fragility of Society members or anyone else on the Awatarariki Fan.
- 17.8. We all agree that risk involves probability and consequence. The Residents Society claim that a different approach to acceptability of risk is required in relation to existing residential activity, as distinct from land use planning for future residential use however is flawed. Prior to 2005 Council and purchasers of property on the fan were reliant on some technical expert’s opinion that the land was suitable for residential use (ie that there were no unacceptable risks associated with the land). Unfortunately, at a very early point in the process of deciding to offer the land for residential use, someone made a critical mistake, probably in ignorance, of not recognising what to me are clear signs of past debris-flow activity on the fan. I commend Council for bravely attempting to rectify that person’s mistake through PC1.
- 17.9. The Australian Guidelines on risk assessment are the most appropriate standard to apply. The Guidelines are fit for purpose and widely used. Their use in New Zealand for the purpose of land-use changes requiring mandatory withdrawal from high-risk lands has been tested in New

Zealand courts with respect to land-use changes in the Port Hills area of Christchurch.

Submission by the Matatā Residents Association

- 17.10. The Matatā Resident's Association's belief that a combination of engineering mitigation, partnered with connected early warning systems would enable the majority of Awatarariki residents to stay where they are is not backed by any evidence.

Council has commissioned investigations of early warning systems and a combination of bunding on the Awatarariki Stream coupled with an early warning system. No suitable combination has been found. This is reported on further in the evidence of Prof. Davies.

Submission by Mr Sutton

- 17.11. I have much sympathy with Mr Sutton and his mother. In terms of "acceptability" and "tolerability" the 15 –year delay between the event and a mutually agreeable settlement yet to be reached is neither acceptable nor tolerable. I can accept that Mr Sutton may see that Council has let his mother down. It may be more than 15 years late, but in my opinion the Proposed Plan Changes are the right decision. A debris flow fan is not a place to bring up children or to spend one's retirement years.

18. CONCLUSION

- 18.1. There are very sound technical reasons why there are no guidelines on how to design safe homes on a debris-flow fan.
- 18.2. Debris flows are a type of landslide and can involve very large quantities of coarse sediment arriving and depositing very rapidly, but in unpredictable ways.
- 18.3. Although the triggers of debris flows are qualitatively well understood, there is no deterministic relationship between the size of trigger and the size of the resultant debris flow. In the case of Awatarariki Stream, very heavy rain triggered many debris avalanches which turned into debris flows when they fell into the already flooded stream. These debris flows coalesced before reaching and depositing on the Awatarariki fan.

- 18.4. Much of the very fine material which made the debris flow of 2005 so mobile continued beyond the fan where it mixed with fine sediment from other sources and some went out to sea. This made it impossible to determine the true volume of the 2005 event.
- 18.5. We can be certain that if rainfall of the intensity that triggered the debris flows of 2005 were to occur again, there would be further debris flows, but they would not be of similar size to the debris flow of 2005; they might be smaller and they might be larger. This natural uncertainty creates great difficulty in developing a successful engineering design, if engineering measures are to be undertaken to mitigate future debris flow damage.
- 18.6. A well accepted technical method of coping with such uncertainty is to use numerical modelling (as has been documented in Mr Hind's evidence). Numerical modelling is a very useful way of testing the sensitivity of one's decisions to various necessary assumptions about debris-flow behaviour. Numerical modelling has been used extensively in investigating possible solutions for risk reduction at Awatarariki.
- 18.7. On reflection about my contribution to the technical background about the debris flow at Awatarariki in May 2005, I have asked myself two hypothetical questions which I comment on as follows:

What if the 2005 debris flow had been a bit larger?

- 18.8. My report on the event would not have been the least bit different. The true volume and return period of the 2005 debris flow and the areas affected by the debris flow were not in the least bit relevant to any of the subsequent engineering analyses. The analyses would have been based on different input values but would have reached the same conclusions – possibly in just as much inordinate time.

What if some of residents had been killed in the 2005 event?

- 18.9. The entire legal process would have been very different. Maybe, some decisions would have been made quicker. Fan residents would have been very sad about the fatalities but maybe not so annoyed about the Proposed Plan Changes.

Maurice James (Mauri) McSaveney

15 January 2020

APPENDIX 1 – CV

PROFESSOR MAURI MCSAVENEY: CURRICULUM VITAE AND PUBLICATIONS



Dr Maurice (Mauri) James McSaveny
Quaternary & steepland geomorphologist
Engineering geomorphologist

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Education:

B.Sc.(Hons) Geology, 1966, University of Canterbury, New Zealand
Ph.D. Geology, 1975, The Ohio State University, Ohio, U.S.A.

Professional memberships:

Member of the Geological Society of New Zealand
Member of the New Zealand Hydrological Society
Member of the New Zealand Society for Earthquake Engineering
Member of the New Zealand Geotechnical Society
Member of the editorial boards of "Landslides" and "Engineering Geology"

Languages

English

Countries of work experience

New Zealand, Antarctica, China, Japan, Europe, North America, Papua New Guinea, India

Fields of special competence:

Engineering geomorphology, steepland geomorphology, geomorphic mapping, dating of geomorphic surfaces, Quaternary geology, glacial geology, steepland hydrology, landslide seismology, coastal geomorphology and tsunami studies, natural-hazard assessment including earthquakes, coastal, river and slope processes, quantitative erosion assessment, erosion processes, rheology of earth materials, landslide kinematics, environmental-impact assessment, palaeoseismicity, scientific editing, post-doctoral research mentoring

Experience:***2015-Present***

Emeritus Scientist, GNS Sciences, New Zealand and Visiting Professor, State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, Chengdu, Sichuan, China.

In these roles, Dr McSaveney devotes his energy to mentoring young professionals in the continuing pursuit of scientific excellence, innovation and creativity.

1988 to 2015

Pure and applied geomorphological research on diverse topics in New Zealand and overseas, GNS Sciences (Institute of Geological and Nuclear Sciences Ltd, formerly DSIR Geology & Geophysics, and before that New Zealand Geological Survey, transfers through continuing restructuring).

Dr McSaveney wrote, spoke, consulted and provided expert opinion on a wide range of topics involving the development of New Zealand's landscapes, making use of his established reputation for applying innovative techniques to quantitative research in Earth Surface processes.

1976 to 1988

Research in alpine hydrology and erosion processes, Water and Soil Division, DSIR. (formerly Water & Soil Directorate, Ministry of Works & Development) Research into climate, hydrology and erosion processes of the Southern Alps. Dr McSaveney guided a multidisciplinary team of scientists investigating factors influencing erosion in the Southern Alps. The group's studies measured the exceptionally high rates of natural erosion there, and were part of research that has forced a major reappraisal of the extent to which humans have modified erosion in New Zealand. Specific studies have included: the distribution of rainfall across the Southern Alps; the distribution of catastrophic landslides in the Southern Alps; the role of large landslides in modulating sediment supply of Shotover River; hydrology and erosion in an area receiving more than 12,000 mm annual rainfall; earthflow deformation, rates of rock weathering for age determination; natural hazards to urban development in mountainous terrain.

1967 to 1976

Research Associate, Institute of Polar Studies, The Ohio State University, Columbus, Ohio: Glaciological, glacial geological and geomorphological research in Colorado, Alaska, and Antarctica. Dr McSaveney's most lasting research accomplishment here was his analysis of the mechanics of the now classic Sherman Glacier rock avalanche, triggered by the Great Alaska Earthquake of 1964.

1967 (April to June)

Glacial Geologist, Lime & Marble Ltd, New Zealand Review of Mines Department records of sluicing claims, Central Westland

1963 to 1966

Student, University of Canterbury, New Zealand, majoring in geology,

Track record

- Natural hazard assessments including flooding, debris flow and earthquake hazards, review of performance of existing protection works, and recommendation of further protection options in New Zealand and India.
- International contributions to understanding the mechanics of long-runout landslides.
- Geomorphic overviews for major engineering projects in New Zealand
- Geomorphic reviews of engineering failures in New Zealand
- Tsunami hazard studies and tsunami research in New Zealand and the south Pacific
- Authored and coauthored numerous research papers and conference presentations.

Professional positions held

2016-present	Visiting Professor, SKLGP, Chengdu University of Technology, Chengdu, Sichuan, China
2015-present	Emeritus Scientist, GNS Science, Lower Hutt, New Zealand
1990 - 2015	Engineering Geomorphologist, GNS Science, Lower Hutt, New Zealand
1988 - 1990	Geomorphologist, DSIR Geology and Geophysics, Christchurch, New Zealand
1976 - 1988	Group leader, Hydrology Centre, Ministry of Works and Development, Christchurch, New Zealand
1967 - 1976	Research Associate, Institute of Polar studies, Columbus, Ohio, USA

Present research/professional speciality

Geology: Hazard Assessment; Landslide Risk Assessment; Paleoseismology; Hazard mapping; Lahars and debris flow; Geomorphology; Fluvial Processes; Geomorphic Hazards; Engineering Geomorphology; Erosion Processes; Alpine Slope Processes; Landslide Processes; Earthquake effects

Total years research experience

54 years

Professional distinctions and memberships (including honours, prizes, scholarships, boards or governance roles, etc)

2016 – present	Visiting Professor, State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology
2013 – present	Vice-chairman, International Research Network on giant landslides
2012 - 2015	International Consortium on Landslides Board of Representatives: Editorial advisor
2012	The International Consortium on Landslides: Best Paper Award for 2010
2012	Japan Society for the Promotion of Science (JSPS): 2012 Invitation Fellow for research in Japan
2011	The Second World Landslide Forum: 1st Place - "Landslides of the World" photo contest: Impacts of Landslides
2010	Kyoto University: Invited Guest Landslide Researcher, DPRI
2010 - present	Department of Geological Sciences, University of Canterbury: Adjunct Associate Professor
2008	American Geophysical Union: Editor's citation for excellence in refereeing - JGR Earth Surface
2005	4th International Conference on Debris-Flow Hazards Mitigation International Advisory Committee: Member

2004 NATO Advanced Research Workshop, Bishkek, Kyrgyzstan: Invited
Keynote Speaker

2004 American Geophysical Union: Editor's citation for excellence in refereeing
for JGR-Planets

2003 - present Editorial Board, Landslides: Member

2002 - present International journal "Landslides" Editors-in-Chief: Member

2002 NATO Advanced Research Workshop, Celano, Italy: Invited Keynote
Speaker

2000 - present New Zealand Geotechnical Society: Member

2000 - present IAEG: Member

2000 International Gravelbed Rivers Workshop: Invited speaker

1998 - present New Zealand Society for Earthquake Engineering: Member

1989 - present Geosciences Society of New Zealand: Member

1977 - present NZ Hydrological Society: Member

1974 Geological Society of America: North Central Section, Best Student
Paper

Total number of <i>peer reviewed</i> publications and others	Journal articles	Books, book chapters, books edited	Conference proceedings	Citations
	78	12	23	1799

Research publications
Peer-reviewed journal articles
2018 Zhang, Ming ; McSaveney, MJ. (2018). Is air pollution causing landslides in China?. Earth and Planetary Science Letters. 481. 284-289. 10.1016/j.epsl.2017.10.045.
2018 Shugar, DH; Clague, Jj; McSaveney, MJ. 2018. Late Holocene activity of Sherman and Sheridan glaciers, Prince William Sound, Alaska. Quaternary Science Reviews 194: 116-127
2018 Sassa, Kyoji ; Guzzetti, Fausto ; Yamagishi, Hiromitsu ; Arbanas, Zeljko ; Casagli, Nicola ; McSaveney, MJ ; Dang, Khang. (2018). Landslide Dynamics: ISDR-ICL Landslide Interactive Teaching Tools, Volume 1: Fundamentals, Mapping and Monitoring. 10.1007/978-3-319-57774-6.
2018 Hu, Wei ; Huang, Runqiu ; McSaveney, MJ ; Zhang, Xiang-hui ; Yao, Lu ; Shimamoto, Toshi. (2018). Mineral changes quantify frictional heating during a large low-friction landslide. Geology. 46. 10.1130/G39662.1.
2018 Carey, J.M. ; Crutchley, G.J. ; Mountjoy, Joshu ; Petley, Dave ; McSaveney, M.J. ; Lyndsell, B. (2018). Slow episodic movement driven by elevated pore-fluid pressures in shallow subaqueous slopes. Geomorphology. 329. 10.1016/j.geomorph.2018.12.034.
2017 Zhang, Ming; McSaveney, MJ. (2017). Rock-avalanche deposits store quantitative evidence on internal shear during runout. Geophysical Research Letters. 10.1002/2017gl073774.
2017 Zhang, Ming ; McSaveney, MJ ; Shao, Hai ; Zhang, Chenyang. (2017). The 2009 Jiweishan rock avalanche, Wulong, China: Precursor conditions and factors leading to failure. Engineering Geology. 233. 10.1016/j.enggeo.2017.12.010.
2017 Hu, Wei ; Xu, Qiang ; Wang, Gonghui ; Scaringi, Gianvito ; McSaveney, Mauri ; Hicher, Pierre-Yves. (2017). Shear Resistance Variations in Experimentally Sheared Mudstone Granules: A Possible Shear-Thinning and Thixotropic Mechanism. Geophysical Research Letters. 44. 10.1002/2017GL075261.
2017 Hu, Wei ; Xu, Qiang ; Wang, Gonghui ; Scaringi, Gianvito ; McSaveney, MJ ; Hicher, Pierre-Yves. (2017). Supporting Information for "Shear resistance variations in experimentally sheared mudstone granules: a possible shear-thinning and thixotropic mechanism".
2016 Massey, C.I., Abbott, E., McSaveney, M, Petley, D.N., Richards, L. 2016. Earthquake-induced displacement is insignificant in the reactivated Utiku landslide, New Zealand. 11th International Symposium on Landslides, Naples, Italy June 2016.
2016 Massey, C.I. ; Petley, Dave ; McSaveney, M.J. ; Archibald, Garth. (2016). Basal sliding and plastic deformation of a slow, reactivated landslide in New Zealand. Engineering Geology. 208. 10.1016/j.enggeo.2016.04.016.
2016 Massey, C ; Della Pasqua, F ; Francois-Holden, Caroline ; Kaiser, Anna ; Richards, L ; Wartman, J ;. McSaveney, MJ ; Archibald, Garth ; Yetton, M ; Janku, L. (2016). Rock slope response to strong earthquake shaking. Landslides. 14. 10.1007/s10346-016-0684-8.
2016 Massey, C ; Abbott, E ; McSaveney, M ; Petley, Dave ; Richards, L. (2016). Earthquake-induced displacement is insignificant in the reactivated Utiku landslide, New Zealand. 10.1201/b21520-5.
2016 Jiang, Yao ; Wang, Gonghui ; Kamai, Toshitaka ; McSaveney, MJ. (2016). Effect of particle size and shear speed on frictional instability in sheared granular materials during large shear displacement. Engineering Geology. 210. 10.1016/j.enggeo.2016.06.005.
2016 Davies, Tim; McSaveney, MJ. (2016). Comment on "The Reduction of Friction in Long-Runout Landslides as an Emergent Phenomenon" by Brandon C. Johnson,

- Charles S. Campbell, and H. Jay Melosh: Comment on Johnson et al. 2016. *Journal of Geophysical Research: Earth Surface*. 121. 10.1002/2016JF003954.
- 2016 Carey, JM ; McSaveney, M ; Petley, Dave. (2016). Dynamic liquefaction of shear zones in intact loess during simulated earthquake loading. *Landslides*. 14. 10.1007/s10346-016-0746-y.
- 2016 Carey, J M; McSaveney, M ; Lyndsell, B ; Petley, Dave. (2016). Laboratory simulation of a slow landslide mechanism. 10.1201/b21520-61.
- 2015 Zhang, Ming ; Yin, Yueping ; McSaveney, M.J. (2015). Dynamics of the 2008 earthquake-triggered Wenjiagou Creek rock avalanche, Qingping, Sichuan, China. *Engineering Geology*. 200. 10.1016/j.enggeo.2015.12.008.
- 2015 McSaveney, MJ. (2015). Fragmenting Granular Flow: A Personal Account of the Concept. 1741-1744. 10.1007/978-3-319-09057-3_308.
- 2015 Engl, Daniela A ; Massey, Chris ; McSaveney, MJ. (2015). CrEAM Modelling of Groundwater-Triggered Landslide Acceleration at the Utiku Landslide (New Zealand). 583-586. 10.1007/978-3-319-09057-3_96.
- 2015 Della Pasqua, F ; Massey, C ; McSaveney, M. (2015). Geotechnical characterization and seismic slope stability of rock slopes in the Port Hills during the New Zealand 2011 Canterbury Earthquakes. 10.1201/b18897-45.
- 2015 Cox, S.C., McSaveney, M.J., Spencer, J., Allen, S.K., Ashraf, S., Hancox G. T., Sirguey P., Salichon, J., Ferris B. G., 2015. Rock avalanche on 14 July 2014 from Hillary Ridge, Aoraki/Mount Cook, New Zealand. *Landslides* DOI 10.1007/s10346-015-0556-7
- 2015 Carey, J M. ; Hancox, GT ; McSaveney, M. (2015). The January 2013 Wanganui River debris flood resulting from a large rock avalanche from Mt Evans, Westland, New Zealand. *Landslides*. 12. 10.1007/s10346-015-0607-0.
- 2014 Van Dissen, R.J. McSaveney, M.J. Townsend, Dougal; Hancox, G.T. ; Little, T.A. ; Ries, William ; Perrin, N.D. ; Archibald, Garth ; Dellow, G.D. ; Massey, C.I. ; Misra, Santanu. (2014). Landslides and liquefaction generated by the Cook Strait and Lake Grassmere earthquakes: a reconnaissance report. *Bulletin of the New Zealand Society for Earthquake Engineering*. 64. 196-200.
- 2014 Massey, CI; McSaveney, MJ ; Taig, Tony ; Richards, Laurie ; Litchfield, NJ ; Rhoades, D ; Mcverry, Graeme ; Lukovic, Biljana ; Heron, David ; Ries, William ; Van Dissen, RJ. (2014). Determining Rockfall Risk in Christchurch Using Rockfalls Triggered by the 2010–2011 Canterbury Earthquake Sequence. *Earthquake Spectra*. 30. 155-181. 10.1193/021413EQS026M.
- 2014 Heron, David ; Lukovic, B ; Massey, C ; Ries, William ; McSaveney, M. (2014). GIS modelling in support of earthquake-induced rockfall and cliff collapse risk assessment in the Port Hills, Christchurch. *Journal of Spatial Science*. 59. 10.1080/14498596.2014.913509.
- 2014 He, Bin ; Sassa, Kyoji ; McSaveney, MJ ; Nagai, Osamu. (2014). Development of ICL landslide teaching tools. *Landslides*. 11. 10.1007/s10346-013-0460-y.
- 2013 Sassa K, He B, McSaveney M, Nagai O. 2013. *ICL Landslide Teaching Tools*. ISBN: 978-4-9903382-2-0. ICL Press, 405 pages
- 2013 Massey, Chris; McSaveney, MJ; Davies, Tim. (2013). Evolution of an Overflow Channel Across the Young River Landslide Dam, New Zealand. 10.1007/978-3-642-31319-6_7.
- 2013 Massey, C.I. Petley, Dave ; McSaveney, M.J.. (2013). Patterns of movement in reactivated landslides. *Engineering Geology*. 159. 1–19. 10.1016/j.enggeo.2013.03.011.
- 2012 McSaveney, E.; McSaveney, M.J. 2012. Landslides : beware of falling rocks. p. 62-83 In: Hicks, G.R.F.; Campbell, H.J. (eds) *Awesome forces : the natural hazards that*

- threaten New Zealand (Second Edition). Wellington, N.Z.: Te Papa Press.
- 2012 McColl, Samuel; Davies, Tim. McSaveney, M.J. (2012). The effect of glaciation on the intensity of seismic ground motion. *Earth Surface Processes and Landforms*. 37. 1290-1301. 10.1002/esp.3251.
- 2012 Davies, T.; McSaveney, M.J. 2012. Mobility of long-runout rock avalanches. p. 50-58 In: Clague, J.J.; Stead, D. (eds) *Landslides : types, mechanisms and modelling*. Cambridge: Cambridge University Press.
- 2011 Davies, T.R.H.; McSaveney, M.J.; Boulton, C.J. 2011. Elastic strain energy release from fragmenting grains : effects on fault rupture. *Journal of structural geology*, 38: 265-277
- 2011 Davies, T.; McSaveney, M.J. 2011. Bedload sediment flux and flood risk management in New Zealand. *Journal of hydrology, New Zealand*, 50(1): 181-189
- 2010 Dufresne, A.; Davies, T.R.; McSaveney, M.J. 2010. Influence of runout-path material on emplacement of the Round Top rock avalanche, New Zealand. *Earth surface processes and landforms*, 35(2): 190-201; doi: 10.1002/esp.1900
- 2010 Davies, T.; McSaveney, M.J.; Kelfoun, K. 2010. Runout of the Socompa volcanic debris avalanche, Chile : a mechanical explanation for low basal shear resistance. *Bulletin of volcanology*, 72(8): 933-944; doi: 10.1007/s00445-010-0372-9
- 2009 Massey, C.I.; Manville, V.R.; Hancox, G.T.; Keys, H.J.; Lawrence, C.; McSaveney, M.J. 2009. Out-burst flood (lahar) triggered by retrogressive landsliding, 18 March 2007 at Mt Ruapehu, New Zealand: a successful early warning. *Landslides*, 7(3): 303-315
- 2009 Davies, T.R.H.; McSaveney, M.J. 2009. The role of rock fragmentation in the motion of large landslides. *Engineering geology*, 109(1/2): 67-79
- 2009 Chevalier, G.; Davies, T.R.; McSaveney, M.J. 2009. The prehistoric Mt Wilberg rock avalanche, Westland, New Zealand. *Landslides*, 6(3): 253-262
- 2009 Boulton, C.; Davies, T.; McSaveney, M.J. 2009. The frictional strength of granular fault gouge : application of theory to the mechanics of low-angle normal faults. p. 9-31 In: Ring, U.; Wernicke, B. (eds) *Extending a continent: architecture, rheology and heat budget*. London: Geological Society. Geological Society special publication 321
- 2008 McSaveney, M.J., Davies, T.R., 2008. Surface energy is not one of the energy losses in rock comminution, *Engineering Geology* (2008), doi: 10.1016/j.enggeo.2008.11.001
- 2008 Davies, T.R.H.; McSaveney, M.J. 2008. Principles of sustainable development on fans. *Journal of hydrology, New Zealand*, 47(1): 43-65
- 2008 Davies, T.R., McSaveney, M.J., (2008) The role of rock fragmentation in the motion of large landslides, *Engineering Geology*. doi:10.1016/j.enggeo.2008.11.004
- 2007 Mitchell, W.A.; McSaveney, M.J.; Zondervan, A.; Kim, K.; Dunning, S.A.; Taylor, P.J. 2007. The Keylong Serai rock avalanche, NW Indian Himalaya : geomorphology and palaeoseismic implications. *Landslides*, 4(3): 245-254; doi:10.1007/s10346-007-0085-0
- 2007 McSaveney, M.J.; Davies, T.R.H. 2007. Rockslides and their motion. p. 113-133 In: Sassa, K.; Fukuoka, H.; Wang, F.; Wang, G. (eds) *Progress in landslide science*. Berlin: Springer.
- 2007 McSaveney, M.J., Page, M.J. 2007. The Totara Reserve Regional Park cliff collapse of 15 December 2006. *GNS Science report 2007/11*. 14 p.
- 2007 Hinton A.C., McSaveney, M.J. 2007. Lithology and hardness of shore platforms and surficial large boulders at Turakirae Head, New Zealand. *New Zealand journal of geology and geophysics* 50: 27-32
- 2007 Davies, T.R., McSaveney, M.J., Deganutti, A.M. 2007 Dynamic fragmentation causes low rock-on-rock friction. In Eberhardt, E., Stead, D. & Morrison, T. (eds) *Rock Mechanics: meeting society's challenges and demands*. Taylor Francis Group, London

p. 959–966

- 2007 Becker, J.S.; Johnston, D.M.; Paton, D.; Hancox, G.T.; Davies, T.R.; McSaveney, M.J.; Manville, V.R. 2007 Response to landslide dam failure emergencies : issues resulting from the October 1999 Mount Adams landslide and dam-break flood in the Poerua River, Westland, New Zealand. *Natural hazards review*, 8(2): 35-42
- 2006 Smith, G.M.; Davies, T.R.; McSaveney, M.J.; Bell, D.H. 2006. The Acheron rock avalanche, Canterbury, New Zealand : morphology and dynamics. *Landslides*, 3(1): 62-72
- 2006 McSaveney, M.J., Graham, I.J., Begg, J.G., Beu, A.G., Hull, A.G., Kim, K., Zondervan, A. 2006. Late Holocene uplift of beach ridges at Turakirae Head, south Wellington coast, New Zealand. *New Zealand journal of geology and geophysics* 49: 337–358.
- 2006 McSaveney, M.J., Davies, T.R.H. 2006. Rapid rock mass flow with dynamic fragmentation: inferences from the morphology and internal structure of rockslides and rock avalanches. In Evans, S.G., Scarascia Mugnozza, G., Strom, A., and Hermanns, R.L. (eds) *Landslides from massive rock slope failures. NATO Science Series IV: Earth and environmental sciences Vol. 49.* 285–304
- 2006 Davies, T.R., McSaveney, M.J., Beetham, R.D. 2006. Rapid block glides: slide-surface fragmentation in the Waikaremoana landslide, North Island, New Zealand. *Quarterly journal of engineering geology and hydrogeology*, 39:115–129.
- 2006 Davies, T.R.; McSaveney, M.J. 2006 Rock avalanche size and runout implications for landslide dams. In: Abdrakhmatov, K.; Evans, S.G.; Hermanns, R.; Mugnozza, G.S.; Strom, A.L. (eds) *Security of natural and artificial rockslide dams : [Bishkek]: NATO ARW.*
- 2005 Power, W., Downes, G., McSaveney, M.J., Beavan, J. Hancox, G. 2005. The Fiordland earthquake and tsunami, New Zealand, 21 August 2003. in Sataki, K. (ed) *Tsunamis: Case Studies and recent developments*, Springer, p31-42.
- 2005 McSaveney, M.J.; Davies, T.R.H. 2005. Making a grain-bridge connection between two rocky planets.p. 73-74 In: *Workshop on the Role of Volatiles and Atmospheres on Martian Impact Craters*, July 11-13, 2005, Laurel, Maryland. Houston, Tex.: Lunar and Planetary Institute. LPI contribution 1273
- 2005 McSaveney, M.J.; Davies, T.R.H. 2005. Dynamics of high-speed blockslides. in Senneset, K.; Flaate, K.; Larsen, J.O. (eds) *Landslides and Avalanches ICFL 2005 Norway. Proceedings of the 11th International conference and field trip on Landslides, Norway, 1-10 September 2005.* Taylor & Francis/Balkema, Leiden, The Netherlands. p 257–263.
- 2005 McSaveney, M.J.; Beetham, R.D.; Leonard, G.S. 2005 The 18 May 2005 debris flow disaster at Matata: Causes and mitigation suggestions. Institute of Geological & Nuclear Sciences client report 2005/71. 51 p. Available at [www.geonet.org.nz/landslide/report 9.pdf](http://www.geonet.org.nz/landslide/report%209.pdf) and also www.easternboprecovery.org.nz/pdfs/reports/IGNS_report_July05.pdf.
- 2005 McSaveney, M.J., Davies, T.R. 2005. Chapter 25: Engineering for debris flows in New Zealand. in Jakob, M., and Hungr, O. (eds). *Debris-flow hazards and related phenomena.* Praxis Press. Chichester 739 pp
- 2005 Larsen, S.H., Davies, T.R.H., McSaveney, M.J. 2005. A possible coseismic origin of late Holocene moraines of the Southern Alps, New Zealand. *New Zealand journal of geology and geophysics* 48: 311-314.
- 2005 Korup, O., Schmidt, J., McSaveney, M.J. 2005. Regional relief characteristics and denudation pattern of the western Southern Alps, New Zealand. *Geomorphology* 71(3-4): 402–423
- 2005 Hancox, G.T.; McSaveney, M.J.; Manville, V.R.; Davies, T.R. 2005. The October

- 1999 Mt Adams rock avalanche and subsequent landslide dam-break flood and effects in Poerua River, Westland, New Zealand. *New Zealand journal of geology and geophysics*, 48(4): 683-705
- 2005 Begg, J.G.; McSaveney, M.J. 2005 Wairarapa fault rupture: vertical deformation in 1855 and a history of similar events from Turakirae Head. p. 21-30 In: Townend, J.; Langridge, R.M.; Jones, A. (comps) *The 1855 Wairarapa Earthquake Symposium : 150 years of thinking about magnitude 8+ earthquakes and seismic hazard in New Zealand : 8-10 September 2005 : proceedings volume*. [Wellington, NZ]: Greater Wellington Regional Council.
- 2004 Korup, O., McSaveney, M.J., Davies, T.R.H. (2004). Sediment generation and delivery from large historic landslides in the Southern Alps, New Zealand. *Geomorphology*, 61, 189-207.
- 2003 McSaveney, M.J., Downes, G. 2003. The 1855 earthquake and tsunami around Wellington, New Zealand. Notes for an excursion from Wellington City to Turakirae Head, 27 September 2003. Institute of Geological & Nuclear Sciences Information Series 57. 15 pp.
- 2003 McSaveney, M.J., Davies, T.R., Ashby, G. 2003. The fatal Ramsay Glacier rockfall of 9 November 2002. Institute of Geological & Nuclear Sciences science report 2003/02. 16 p.
- 2003 McSaveney M.J., Glassey, P.J. 2003. GeoNet Landslide Response: the fatal Cleft Peak debris flow of 3 January 2002, Rees Valley, West Otago. In Crawford, S. and Hargraves, S. (eds) *Geotechnics on the volcanic edge*. Proceedings of the Geotechnical Society symposium, Tauranga, March 2003. IPENZ Proceedings of Technical Groups vol 30(1): 301-310.
- 2003 Davies, T.R.H., McSaveney, M.J., Clarkson, P.J. 2003. Anthropogenic aggradation of the Waiho River, Westland, New Zealand: microscale modelling. *Earth Surface Processes and Landforms* 28: 209-218.
- 2002 McSaveney, M.J., Glassey, P.J. 2002. The fatal Cleft Peak debris flow of 3 January 2002, Upper Rees Valley, West Otago. Institute of Geological & Nuclear Sciences Science Report 2002/03. 28 p.
- 2002 McSaveney, M.J., Downes, G. 2002. Application of landslide seismology to some New Zealand rock avalanches. In Rybar, J., Stemberk, J., Wagner, P. (Eds) *Landslides. Proceedings of the first European conference on landslides*, Prague, Czech Republic, June 24-26, 2002. Balkema, Lisse. p. 649-654.
- 2002 McSaveney, M.J., Davies, T.R. 2002. Rapid rock-mass flow with dynamic fragmentation: - Inferences from the morphology and internal structure of rockslides and rock avalanches. In Evans, S.G., Martino, S. (eds) *Abstracts Volume, Massive rock slope failure: New models for hazard assessment*. NATO Advanced Research Workshop, Celano (AQ), Abruzzo, Italy, June 16-21, 2002. p. 89 – 92. (Full paper [18 pp] in press for 2006).
- 2002 McSaveney, M.J., 2002. Recent rockfalls and rock avalanches in Mount Cook National Park, New Zealand. Chapter 2 in Evans, S.G., and DeGraff, J.V. (eds). *Catastrophic landslides: occurrence, mechanisms and mobility*. Geological Society of America Reviews in Engineering Geology 15: 35-70.
- 2002 McSaveney, M.J. 2002. The next great West Coast earthquake. *Tephra*, 19: 36-41
- 2002 McSaveney, E.; McSaveney, M.J. 2002 Beware of falling rocks! : landslides. p. 72-97 In: Hicks, G. (ed.); Campbell, H.J. (ed.) *Awesome forces : the natural hazards that threaten New Zealand*. Wellington, NZ: Te Papa Press. (Revised and reprinted 1st published 1998)
- 2002 Davies, T.R.; McSaveney, M.J. 2002 Dynamic simulation of the motion of fragmenting rock avalanches. *Canadian geotechnical journal*, 39(4): 789-798

- 2002 Beetham, R.D.; McSaveney, M.J.; Read, S.A.L. 2002. Four extremely large landslides in New Zealand. p. 97-102 In: Rybar, J.; Stemberk, J.; Wagner, P. (eds) Landslides : proceedings of the First European Conference on Landslides, Prague, Czech Republic, June 24-26, 2002. Lisse, The Netherlands: A.A. Balkema.
- 2001 Downes, G., Webb, T., McSaveney, M., Darby, D., Doser, D., Chague-Goff, C., Barnett, A. 2001. The 26 March and 17 May Gisborne earthquakes and tsunami: implications for tsunami hazard for east coast, North Island, New Zealand. In Proceedings of the joint IOC-IUGG International Workshop Tsunami Risk Assessment beyond 2000: Theory , Practice and Plans - In memory of Professor Sergey L. Soloviev, Moscow, 14-16 June, 2000. p.55-67.
- 2001 Davies, T.R.; McSaveney, M.J. 2001 Anthropogenic fanhead aggradation, Waiho River, Westland, New Zealand. p. 531-553 In: Mosley, M.P. (ed.) Gravel-bed rivers V. Wellington, NZ: New Zealand Hydrological Society.
- 2000 McSaveney, M.J.; Goff, J.R.; Goldsmith, P.; Barnett, A.; Elliott, S.; Nongkas, M. 2000. The 17th July 1998 tsunami, Papua New Guinea: evidence and initial interpretation. Marine Geology Vol 170: 81 – 92.
- 2000 McSaveney, M.J., Davies, T.R; Hodgson, K.A. 2000. A contrast in style between large and small rock avalanches in Bromhead, E., Dixon, N, and Ibsen, M-L. (Eds) Landslides in research, theory and practice (proceedings of the 8th international symposium on landslides, Cardiff 26-30 June 2000) vol 2: 1053-1058.
- 2000 Davies, T.R., McSaveney, M.J. 2000. Anthropogenic fanhead aggradation, Waiho River, Westland, New Zealand. Proceedings of Gravel-bed rivers 2000, 27 August - 2 September 2000, Christchurch, New Zealand. Gravel-bed Rivers 5. Mosley, M.P. (ed.) P. 531-553.
- 1999 McSaveney, M.J. 1999. Tsunami: the experience. Tephra, 16.
- 1999 McSaveney, M.J. 1999. 2.3: Raised marine terraces and beach geology, Turakirae Head. In Speden, I., Skinner D.N.B. (editors) Field Trip Guides. 8th International Symposium on Antarctic Earth Sciences 5-9 July 1999. The Royal Society of New Zealand, Wellington. ISBN: 0-908654-93-5. Pp. 85-92.
- 1999 Hancox, G.T., McSaveney, M.J., Davies, T.R., Hodgson, K.A. 1999. Mt Adams rock avalanche of 6 October 1999 and the resulting landslide dam and lake in Poerua River, Westland, New Zealand. Institute of Geological & Nuclear Sciences Science report 99/19.
- 1999 Goldsmith, P.; Barnett, A.; Goff, J.R.; McSaveney, M.J; Elliott, S.; Nongkas, M.1999. Report of the New Zealand reconnaissance team to the area of the 17th July 1998 tsunami at Sissano Lagoon, Papua New Guinea. Bulletin of the New Zealand Society for earthquake engineering 32(2): 102-118.
- 1999 Goldsmith, P., Barnett, A., Goff, J., McSaveney, M., Elliott, S., Nongas, M. 1999. Immediate report - New Zealand National society for earthquake engineering technical reconnaissance of the area of the 17 July 1998 tsunami at Sissano Lagoon, Papua New Guinea. Conference technical papers of the New Zealand Society for Earthquake Engineering annual conference 19-21 March 1999 p. 6-13.
- 1999 Davies, T.R.; McSaveney, M.J.; Hodgson, K.A. 1999 A fragmentation-spreading model for long-runout rock avalanches. Canadian geotechnical journal, 36(6): 1096-1110
- 1999 Davies, T.R., McSaveney, M.J. 1999. Runout of Dry Granular Avalanches. Canadian geotechnical journal 36: 313-320.
- 1999 Davies, T.R, Hancox, G.T., Hodgson, K., McSaveney, M.J. 1999. Landslide dam-break flood in the Poerua River, Westland. Current, 14: 29-31
- 1998 McSaveney, M.J., Davies, T.R. 1998. Natural hazard assessment for the township of Franz Josef Glacier and its environs. Institute of Geological & Nuclear Sciences client

- report 43714B.10. 58 p.
- 1998 McSaveney, M.J., Davies, T.R. 1998. A Hazard assessment for Aoraki/Mount Cook Village. in Johnston, D.M., Kingsbury, P.A. (compilers) Proceedings of the natural hazards management Workshop, Christchurch 28-29 November 1998. Institute of Geological & Nuclear Sciences information series 45 p. 70-75.
- 1998 McSaveney, E.R., McSaveney M.J. 1998. Beware of falling Rocks - landslides. Chapter 4 In: G. Hicks and H. Campbell (eds) Awesome Forces: the natural hazards that threaten New Zealand. Te Papa Press, Wellington, New Zealand. p 72-97 (plus 2nd edition 1999).
- 1997 McSaveney, M.J. 1997. Beach geology at Turakirae Head, Wellington. 5 p. In: Campbell, H.J. (ed.); Grapes, R.H. (ed.) Geological Society of New Zealand Inc 1997 Annual Conference : 25-27 November ... Wellington : field trip guides. Wellington: Geological Society of New Zealand. Geological Society of New Zealand miscellaneous publication 95B
- 1996 McSaveney, M.J., Kawachi, Y. 1996. Mt Cook rock avalanche of December, 1991. Chikyu monthly, 18(9): 608-614
- 1996 Barrell, D.J.A.; Forsyth, P.J.; McSaveney, M.J. 1996. Quaternary geology of the Rangitata Fan, Canterbury Plains, New Zealand. Institute of Geological & Nuclear Sciences Science report 96/23. 67 p.
- 1995 McSaveney, M.J. 1995. Managing slope instability hazards. p. 73-76 In: Hull, A.G. (comp.); Coory, R. (comp.) Proceedings of the Natural Hazards Management Workshop '95, Auckland, 28-29 November 1995. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences information series 38
- 1995 McSaveney, M.J. 1995. Debris flows and bridge losses at Waterfall Creek, SH6 at Lake Wanaka, New Zealand. Institute of Geological & Nuclear Sciences Science Report 95/21. 18 p. 11 Fig.
- 1993 Ricker, K.E., Chinn, T.J., McSaveney, M.J. 1993. A late Quaternary moraine sequence dated by rock weathering rinds, Craigieburn Range, New Zealand. Canadian journal of earth sciences, 30(9): 1861-1869
- 1993 McSaveney, M.J. 1993. The Mount Fletcher rock avalanche of 2 May 1992. New Zealand Alpine Journal. 7 pp.
- 1993 McSaveney, M.J. 1993. Rock avalanches of 2 May and 17 September 1992, Mount Fletcher, New Zealand. Landslide News 7. Japan landslide Society p. 2-4.
- 1992 Whitehouse, I.E., McSaveney, M.J., 1992. Assessing the likelihood of natural hazard damage to an alpine highway. New Zealand Geographer 48(1): 27-32.
- 1992 McSaveney, M.J., Stirling, M.W. 1992. Central Otago basin and range country: Chapter 22 in Soons, J. M., and Selby, M. J., editors, Landforms of New Zealand 2nd edition. Auckland, New Zealand, Longman Paul. p 482-504.
- 1992 McSaveney, M.J., Chinn, T.J., Hancox, G.T. 1992. Mount Cook rock avalanche of 14 December 1991, New Zealand. Landslide News 6. Japan landslide Society. p. 32-34
- 1992 McSaveney, M.J. 1992. A manual for weathering-rind dating of grey sandstones of the Torlesse Supergroup, New Zealand. Institute of Geological & Nuclear Sciences Science Report 92/4 Institute of Geological & Nuclear Sciences Limited, Lower Hutt, New Zealand. 52 pp. ISBN 0478070063.
- 1992 Chinn, T. J., McSaveney, M. J., McSaveney, E. R. 1992. The Mount Cook Rock Avalanche of 14 December, 1991. New Zealand Geological Survey [Guide to ... brochures]. 6 p. DSIR Geology & Geophysics; Lower Hutt.
- 1991 McSaveney, M.J., Thomson, R., Turnbull, I.M. 1991. Timing of relief and landslides in Central Otago, New Zealand. in Bell, D. H. Editor. Landslides Volume 2: Proceedings of the 6th International symposium on landslides, February 1992, Christchurch, New Zealand, Balkema, Rotterdam,: p 1451-1456.

- 1990 Whitehouse, I.E., McSaveney, M.J., 1990. Chapter 19: Geomorphic appraisals for development on two steep, active alluvial fans, Mt Cook, New Zealand. In: Rachocki, A., Church, M.A., (editors) *Alluvial Fans a field approach*, John Wiley & Sons Chichester, England. p 369-384.
- 1990 Hicks, D.M., McSaveney, M.J., Chinn, T.J.H. 1990. Sedimentation in proglacial Ivory lake, Southern Alps, New Zealand *Arctic and Alpine Research*.22(1) 2642.
- 1989 McSaveney, M.J., Whitehouse, I.E. 1989. Anthropoc erosion in Canterbury mountain land. In: Rudge, M. R. (editor) *Moas, mammals and climate in the ecological history of New Zealand*. New Zealand Journal of Ecology 12: Special Supplement: p 151-163.
- 1989 McSaveney, M.J., Whitehouse, I.E. 1989. An early Holocene glacial advance in the Macaulay River valley, central Southern Alps, New Zealand. *New Zealand Journal of Geology and Geophysics* 32(2):217-223.
- 1989 McSaveney, M.J., Whitehouse, I.E. 1989. 15 The influence of wild-animal browsing on soil and water in New Zealand in *Proceedings of Seminar 2000 The future of New Zealand's Wild animals*. 21 22 November, 1988. Ministry of Forestry, Christchurch, for the New Zealand Deerstalkers Association. p. 57-63.
- 1989 Basher, L.R., McSaveney, M.J., 1989. An Early Aranuian glacial advance at Cropp River, New Zealand. *Journal of the Royal Society of New Zealand*.19(3):263-268.
- 1988 Whitehouse, I.E., McSaveney, M.J., 1988. Climate change and erosion. In *Climate Change: the New Zealand response*. Proceedings of a workshop held in Wellington, /March 29 30, 1988. Wellington, New Zealand, Ministry for the Environment. p. 252.
- 1988 Whitehouse, I.E., Chinn, T.J., Von Höfle, H.C., McSaveney, M.J., 1988. Radiocarbon contaminated penguin bones from Terra Nova Bay, Antarctica. *New Zealand Antarctic Record* 8(3):11-23.
- 1988 Basher, L.R., Tonkin, P.J., McSaveney, M.J., 1988, Geomorphic history of a rapidly uplifting area on a compressional plate boundary: Cropp River, New Zealand. *Zeitschrift für Geomorphologie N. F. Suppl. Bd 69*: 117131.
- 1987 McSaveney, M.J., Griffiths, G.A. 1987. Drought, rain and movement of a recurrent earthflow complex in New Zealand. *Geology*. 15:643-647.
- 1987 Chinn, T. J., McSaveney, M. J., 1987. On the Flooding of Vanda Station. *New Zealand Antarctic Record* 7(3):2331.
- 1986 Whitehouse, I.E., McSaveney, M.J., Knuepfer, P.L.K., Chinn, T.J., 1986. Growth of weathering rinds on Torlesse Sandstone, Southern Alps, New Zealand. Chapter 17 in Colman, S.M., & DeThier, D.P., editors, *Rates of Chemical Weathering of Rocks and Minerals*. Academic Press, New York. p. 419-435.
- 1986 Griffiths, G.A., McSaveney, M.J., 1986. Sedimentation and river containment on Waitangitaona alluvial fan, South Westland, New Zealand. *Zeitschrift für Geomorphologie N. F.* 30(2):215230.
- 1984 Burrows, C.J., McSaveney, M.J., Scarlett, R.J., Turnbull, B., 1984. Late Holocene forest horizons and a Dinornis Moa from an earthflow on North Dean, North Canterbury. *Records of the Canterbury Museum* 10(1): 18.
- 1983 Whitehouse, I.E., McSaveney, M.J., Horrell, G.A., 1983. Spatial variability of low flows across a portion of the central Southern Alps, New Zealand. *Journal of Hydrology (New Zealand)* 22(2):123-137.
- 1983 Whitehouse, I.E., McSaveney, M.J., 1983. Diachronous Talus Surfaces in the Southern Alps, New Zealand, and their implications to talus accumulation. *Arctic and Alpine Research* 15(1):53-64.
- 1983 Griffiths, G.A., McSaveney, M.J., 1983b. Hydrology of a basin with extreme rainfalls, Cropp River, New Zealand. *New Zealand Journal of Science* 26(4):293-306.
- 1983 Griffiths, G.A., McSaveney, M.J., 1983a. The distribution of mean annual precipitation across some steepland regions of New Zealand. *New Zealand Journal of*

- Science 26(2):197-209.
- 1980 Whitehouse, I.E., McSaveney, M.J., Chinn, T.J., 1980. Dating your scree. Tussock Grasslands and Mountain Lands Institute Review 33:15-24.
- 1979 McSaveney, M.J. 1979. An effective antifreeze for storage raingauges: Journal of Hydrology (New Zealand) 18: 52-54.
- 1978 McSaveney, M.J. 1978. The magnitude of erosion across the Southern Alps: Proceedings of the Conference on Erosion Assessment and Control in New Zealand, 21st-23rd August 1978. New Zealand Society of Soil Conservators, Christchurch, p.7-24.
- 1978 McSaveney, M.J. 1978. Sherman Glacier rock avalanche, Alaska, USA: Chapter 6 in Voight, B. ed. Rockslides and Avalanches 1, Natural Phenomena. Developments in Geotechnical Engineering 14A:197-258.
- 1975 McSaveney, M.J. 1975. The Sherman Glacier rock avalanche of 1964: its emplacement and subsequent effects on the glacier beneath it: Ph. D. dissertation, The Ohio State University, Columbus, Ohio, 403 pp, 21 tables, 121 figures.
- 1974 McSaveney, M.J. 1974. Buckling of the Meserve Glacier surface: Antarctic Journal of the United States 9(4):164-166.
- 1974 McSaveney, M.J. 1974. A 3.1-meter recession of Meserve Glacier, Wright Valley: Antarctic Journal of the United States 9(4):166-167.
- 1973 McSaveney, M.J. 1973. Spatially discontinuous shear in the "semirigid" zone of an ice cliff: Antarctic Journal of the United States 8(5):311-313.
- 1973 McSaveney, M.J. 1973. Relative yearly totals of solar radiation incident on various slopes for latitude 77° 30'S: Antarctic Journal of the United States 8(6):347-348.
- 1973 McSaveney, M.J. 1973. Recession of Meserve Glacier, Wright Valley, between 1966 and 1972: Antarctic Journal of the United States 8(6):346-347.
- 1973 McSaveney, M.J. 1973. New data for a Cenozoic history of Wright Valley, southern Victoria Land: Antarctic Journal of the United States 8(5):266-268.
- 1973 McSaveney, M.J. 1973. Geographic orientation of wave ogive systems: Journal of Glaciology 12:149-150.
- 1973 McSaveney, M.J. 1973. Folding of cold ice: Antarctic Journal of the United States 8(6):344-346.
- 1972 McSaveney, M.J., McSaveney, E.R. 1972. A reappraisal of the Pecten Glacial Episode, Wright Valley, Antarctica: Antarctic Journal of the United States 7(6):235-240.
- 1972 McSaveney, M.J. 1972. Ogive systems on polar alpine glaciers: Antarctic Journal of the United States 7(4):101-102.
- 1972 McSaveney, E.R., McSaveney, M.J. 1972. Ancient ice wedges in Wright Valley, Antarctica: Antarctic Journal of the United States 7(4):102-103.
- 1968 McSaveney, M.J., Gage, M. 1968. Ice flow measurements on Franz Josef Glacier, New Zealand, in 1966: New Zealand Journal of Geology & Geophysics 11:564-592.

Letters

- 1982 Griffiths, G. A., McSaveney, M.J. 1982, Comment on editorial: Units Coefficients and Dimensions, by S. M. Thompson. Journal of Hydrology (New Zealand) 21:7677.
- 1982 McSaveney, M. J. 1982, Comment on Eroding the base of civilisation by L. Brown. Journal of Soil and Water Conservation 1982: 66.
- 1982 McSaveney, M. J. 1982, Lake Christabel. Soil and Water 18(2): 2.

Book Reviews

- 1989 McSaveney, M. J. 1989, "Modelling snowmelt-induced processes" edited by Morris,

- E. M. IAHS Publication No. 155. Royal Society of New Zealand Bulletin 19(1):117
- 1985 McSaveney, M. J. 1985, "Till and related deposits, Genesis / Petrology / Application / Stratigraphy " edited by Evenson, Schluchter, & Rabassa. Earth Science Reviews 22:169170.
- 1983 McSaveney, M. J. 1983, "Earth's pre-pleistocene glacial record" edited by M. J. Hambrey & W. B. Harland. Cambridge University Press, Cambridge 1981, XV + 1004 pp. Earth Science Reviews 19(1):8283.
- 1981 McSaveney, M. J. 1981, "Submarine permafrost on the Alaskan Continental Shelf" by M. E. Vigdorchik. Westview Special Studies in Earth Sciences, Westview Press, Boulder, Colorado. 1980. 118 p. Sedimentary Geology 32:158159.
- 1981 McSaveney, M. J. 1981, "The Human Impact: Man's role in environmental change" by Andrew Goudie, 1981, Basil Blackwell Publishers, Oxford, 313pp. Journal of Hydrology (New Zealand) 20:152153.
- 1981 McSaveney, M. J. 1981, "Arctic Pleistocene history and the development of submarine permafrost" by M. E. Vigdorchik. Westview Special Studies in Earth Sciences, Westview Press, Boulder, Colorado. 1980. 286 pp. Sedimentary Geology 32:157158.
- 1979 McSaveney, M. J. 1979, "Elements of Geographical Hydrology" by B. J. Knapp. George Ellen & Unwin, London. Journal of Hydrology (New Zealand) 18:5960.
- 1975 McSaveney, M. J. 1975, "Icefield Ranges Research Project: Scientific Results 4" Earth Science Reviews 11(4):367368.

Unpublished Reports

- 2005 Hancox, G.T., Dellow, G.D., Perrin, N.D., and McSaveney M.J., 2005. Western Corridor Transportation Study: Review of Geological Hazards affecting the proposed Coastal Highway Upgrade and Transmission Gully Motorway route. GNS Science Consultancy Report 2005/161 – Client report
- 2004 Beetham, R.D., McSaveney, M.J., Dellow, G., Rosenberg, M., Johnston, D., Smith, W. 2004. A review of natural hazards information for Northland region. Institute of Geological & Nuclear Sciences Science report 2004/06. 25 p.
- 2003 Smith, W.D.; McSaveney, M.J.; Cousins, W.J. 2003 Earthquake, Volcano and Tsunami risks to property of Wellington City Council. Institute of Geological & Nuclear Sciences Client report 2003/129. 38 p.
- 2003 Cousins, J., Smith, W., McSaveney, M., Johnston, D. 2003. Earthquake, volcano and tsunami risks to property of Christchurch City Council. Institute of Geological & Nuclear Sciences client report 2003/33. 39 pp.
- 2003 Cousins, J., Smith, W., McSaveney, M., Johnston, D. 2003. Earthquake, volcano and tsunami risks to property of Auckland City Council. Institute of Geological & Nuclear Sciences client report 2003/36. 40 pp.
- 2002 McSaveney, M.J. 2002. Assessment of debris-flow mitigation measures at Walter Peak, Queenstown. Institute of Geological & Nuclear Sciences client report 2002/127 for Locations Management, Queenstown. 24 pp.
- 2002 Cousins, W.J.; Manville, V.; Smith, W.D.; McSaveney, M.J.; Johnston, D.M. 2002. Environment Bay of Plenty Flood protection assets risk assessment. Institute of Geological & Nuclear Sciences Client Report 2002/129. 48 pp.
- 2001 McSaveney, M.J., Davies, T.R.H. 2001. The former Mid Dome Soil Conservation Reserve, Southland: likely consequences to land stability of removal of wilding trees. Institute of Geological & Nuclear Sciences client report to Ministry for the Environment. February 2001. 15 pp.

- 2000 Smith, W.; McVerry, G.; Cousins, J.; Hancox, G.; Downes, G.; McSaveney, M.; Rattenbury, M. 2000 GAPQuake NZ New Zealand earthquake loss modelling. Institute of Geological & Nuclear Sciences Client report 2000/109. 63 p.
- 2000 McSaveney M.J., Rattenbury, M. 2000. Tsunami impact in Hawke's Bay. Institute of Geological & Nuclear Sciences client report 2000/146. 15 p
- 2000 Downes, G.; McSaveney, M.; Heron, D. 2000 Integrated risk assessment for Wellington City Council Phase III, Tsunami inundation. Institute of Geological & Nuclear Sciences Client report 2000/39 A. 49 p.
- 1999 Villamor, P; McSaveney, M.; Johnston, D.; Stirling, M.; Rosenberg, M. 1999 PHASE 1, Probabilistic seismic hazard assessment and review of volcanic and tsunami hazards for the Malampaya onshore gas plant, Luzon, Philippines. Institute of Geological & Nuclear Sciences Client report 1999/113. 39 p. - + 17 figs
- 1999 Hancox, G.T.; McSaveney, M.J.; Davies, T.R.; Hodgson, K. 1999. Mt Adams rock avalanche of 6 October 1999 and the subsequent formation and breaching of a large landslide dam in Poerua River, Westland, New Zealand. Institute of Geological & Nuclear Sciences science report 99/19. 33 p.
- 1999 Gough, J.; Johnston, D.; McSaveney, M.J. 1999 Community response to natural hazard risk at Franz Josef Glacier. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences science report 99/10. 35 p.
- 1998 Graham, I.J.; Kim, K.J.; Zondervan, A.; McSaveney, M.J. 1998 Establishment of ¹⁰Be surface exposure dating methods at GNS. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences science report 98/22. 15 p.
- 1997 McSaveney, M.J.; Read, S.A.L. 1997 Mid-Waitaki power stations : Waitaki River terrace profiles, Interim report. Institute of Geological & Nuclear Sciences Client report 43626-B.10.
- 1997 Graham, I.J.; Kim, K.J.; McSaveney, M.J.; Zondervan, A.; Webb, P. 1997 Establishment of surface exposure dating methods using ¹⁰Be and ²⁶Al at GNS : progress report. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences science report 97/30. 17 p.
- 1996 Hull, A.G.; McSaveney, M.J. 1996 A 7000-year record of great earthquakes at Turakirae Head, Wellington, New Zealand. Institute of Geological & Nuclear Sciences Client report 33493B.10. 14 p. figures
- 1995 McSaveney, M.J.; Davies, T.R.H.; Gough, J.D. 1995 Natural Hazard Assessment for Mount Cook/Aoraki Village & Environs. Institute of Geological & Nuclear Sciences Client report 49500D.11. 79 p. figures
- 1992 Paterson, B. R., McSaveney, M. J., Reyners, M. 1992, The hazard of rock fall and rock avalanches at the Zig Zag, SH73 Arthurs Pass. DSIR Geology and Geophysics Contract Report No. 1992/14, prepared for Transit New Zealand, February 1992, 17 pp.
- 1992 McSaveney, M. J., Chinn, T. J.; Coates, G. F. 1992, The Mount Fletcher rock avalanche of 16 September 1992. Immediate report. Institute of Geological & Nuclear Sciences, Christchurch. 10 pp.
- 1992 McSaveney, M. J. 1992, The Mount Fletcher rock avalanche of 2 May 1992. Immediate report. DSIR Geology & Geophysics. 22 p. DSIR Geology & Geophysics, Christchurch.
- 1992 Hull, A. G.; Anderson, H. J.; Dowrick, D. J.; McSaveney, M. J.; Paterson, B. R.; Zhao, J. X. 1992, Seismotectonic hazard assessment of the Highbank power station site, Canterbury. Contract report 91/104, DSIR Gology and Geophysics for Electricity Corporation of New Zealand Ltd. 66 pp.
- 1992 Coates, Glen; McSaveney, Mauri. 1992. Slope stability assessment of proposed

- radio repeater site at Malcolms Knob, Cook River, South Westland. Institute of Geological and Nuclear Sciences Contract Report 1992/54. 14 pp.
- 1991 Hancox, G. T., Chinn, T. J., McSaveney, M. J. 1991, Mt Cook rock avalanche, 14 December 1991. Immediate report. DSIR Geology & Geophysics. 15 p. DSIR Geology & Geophysics, Lower Hutt.
- 1990 McSaveney, M. J., Griffiths, G. A. 1990, Landform life expectancy in evolving landscapes. Manuscript in preparation.
- 1990 McSaveney, M. J. 1990, Reconnaissance weathering-rind dating of boulder deposits along the trace of the Irishman's Creek at Balmoral Station, Lake Tekapo. Report to Earth Deformation Section for Waitaki Seismotectonics Review for Electricorp.
- 1990 McSaveney, M. J. 1990, Hazard assessment for Clinton Forks Hut, Milford Track. Report to Department of Conservation, Invercargill, February 1990.
- 1990 McSaveney, M. J. 1990, Clyde Power Station Reservoir, Cromwell Gorge, Right Bank: geomorphological evaluation for slope stability. New Zealand Geological Survey Engineering Geology Report EGI 90/002
- 1990 Macfarlane, D. F., McSaveney, M. J., 1990, Clyde Power Station Reservoir Landslide Investigations General Information . New Zealand Geological Survey Engineering Geology Report EGI 90/001.
- 1990 Grocott, G. G.; Bell, G. M.; Stirling, M. W.; McSaveney, M. J.; Manning, P. A.; Salt G. 1990, Clyde Power Station Reservoir Brewery Creek Slide Area, landslide geotechnical assessment. New Zealand Geological Survey Engineering Geology Report EGI 89/016. 3 Volumes.
- 1989 McSaveney, M. J., Whitehouse, I. E., Barringer, J. R. F. 1989, Environmental impact assessment for snowmaking project at Porter Heights Skifield. A report prepared for Porter Heights Skifield Ltd, Christchurch. 23 pp, 2 appendices.
- 1989 McSaveney, M. J., Whitehouse, I. E. 1989, Environmental impact assessment for snowmaking project at Mt Hutt. A report prepared for Leisureland Corporation Ltd, Methven. 18 pp, 5 appendices.
- 1989 Franks, C. A. M.; Salt, G. A.; Friday, R.; McSaveney, M. J. 1989, Clyde Power Station Reservoir Engineering geological and geotechnical assessment of the Nine Mile Creek Slide area: Upstream section BL 3600 to 5000. New Zealand Geological Survey Engineering Geology Report EGI 89/014. 3 Volumes.
- 1988 McSaveney, M. J., Whitehouse, I. E. 1988, Snow tussocks and water yield: A review of the evidence. Report for Mr John Miller, Central Otago High Country Runholders association. 15pp.
- 1988 McSaveney, M. J. 1988, Uplift at Hokitika. Report to the Hokitika Borough Council, October, 1988. 3 pp.
- 1988 McSaveney, M. J. 1988, Statement of evidence in the matter of Appeal TPC 71/87 (Town and Country Planning Act 1977) between Alpine Hotels Ltd (Appellant), and Mackenzie County Council (Respondent) and Ian K. Ivey (Applicant).
- 1988 McSaveney, M. J. 1988, Appraisal of natural hazards to urban land-use in the vicinity of the proposed Glentanner Park development. Report presented to Mr Ian Ivey, Glentanner Station and Mackenzie County Council, January 1988
- 1988 Basher, L. R., Hicks, D. M., McSaveney, M. J., & Whitehouse, I. E., 1988, The lower Waimakariri River floodplain a geomorphological perspective. Report for the North Canterbury Catchment and Regional Water Board. 36pp and 3 maps.
- 1987 Whitehouse, I. E., Howard, G., & McSaveney, M. J., 1987, Hydrological overview: Ryton Station, Lake Coleridge. Report prepared for Boffa Miskell Partners, Christchurch.
- 1986 Whitehouse, I. E., & McSaveney, M. J., 1986, Arthur's Pass roading project: geology, geomorphology, and hazards assessment. Report for Ministry of Works and

Development, Christchurch.

- 1986 McSaveney, M. J., Whitehouse, I. E., Williman, E. B. 1986, An appraisal of flood protection for campground development at Glentanner. Report prepared for Truebridge Callender Beach Ltd, Wellington.
- 1986 McSaveney, M. J., Whitehouse, I. E. 1986, A geomorphological appraisal of flood protection measures on Black Birch fan, Mount Cook. Report WS 1081, Ministry of Works and Development, Christchurch.
- 1986 McSaveney, M. J. 1986, Climate Hydrology and Erosion Processes of South Westland, report for New Zealand Forest Service. Report WS 1173, Ministry of Works and Development, Christchurch.
- 1985 Whitehouse, I. E., & McSaveney, M. J., 1985, Geomorphological comment on the general problems of bridging on State Highway 6 : Hokitika to Wanaka. Report WS 1002 Ministry of Works and Development, Christchurch.
- 1985 Whitehouse, I. E., & McSaveney, M. J., 1985, Debris flows at Chelsea Creek, State Highway 6: Haast River section. Report WS 1001, Ministry of Works and Development, Christchurch.
- 1983 McSaveney, M. J. 1983, Estimating seasonal contributions of snow to runoff in regions of high annual precipitation. Report WS 768, Ministry of Works and Development, Christchurch.
- 1982 McSaveney, M. J. 1982, Systematic errors in the rated flow of Rakaia River at Gorge. Report WS 847, Ministry of Works and Development, Christchurch.
- 1981 McSaveney, M. J., Whitehouse, I. E. 1981, Sediment Sources and Sediment yield of Little Hopwood Burn, Lake Hawea, New Zealand, Report WS 492, Ministry of Works and Development, Christchurch.
- 1981 McSaveney, M. J. 1981, Performance of a recording storage raingauge based on the Foxboro waterlevel recorder. Report WS 305, Ministry of Works and Development, Christchurch.
- 1980 Whitehouse, I. E., & McSaveney, M. J., 1980, Assessing the influence on rock lithology and structure on location and magnitude of erosion features in the Dry Acheron Catchment, Canterbury, New Zealand. Report WS 306, Ministry of Works and Development, Christchurch, 20 pp.
- 1980 Basher, L. R.; Hicks, D. M.; Hunter, G. G.; Griffiths, G. A.; McSaveney, M. J., & Whitehouse, I. E., 1980 Dry Acheron Water and Soil Research. Report WS 226, Ministry of Works and Development, Christchurch. 6 pp.
- 1979 McSaveney, M. J. 1979, Progress results from high-country research within the Christchurch Science Centre. Ministry of Works and Development, Christchurch.
- 1978 McSaveney, M. J. 1978, Shotover River: Aspects of its erosion history relating to control of siltation in the Clutha Valley Development. Report WS 1, Ministry of Works and Development, Christchurch.
- 1978 McSaveney, M. J. 1978, Report to the Marlborough Catchment Board on the distribution of loess along the Mount Fyffe Floodway, Kaikoura.