IN THE ENVIRONMENT COURT
AT CHRISTCHURCH

I TE KŌTI TAIAO O AOTEAROA
ŌTAUTAHI ROHE **ENV-2018-CHC-290**

UNDER	the Resource Management Act 1991 (RMA)
IN THE MATTER	of an appeal under Clause 14 of the First Schedule of the RMA in relation to the Proposed Second Generation Dunedin City District Plan (2GP)
BETWEEN	**OTAGO REGIONAL COUNCIL**
	Appellant
AND	**DUNEDIN CITY COUNCIL**
	Respondent

AFFIDAVIT OF DR JEAN-LUC PAYAN FOR THE APPELLANT IN SUPPORT OF AN APPLICATION UNDER SECTION 293

ROSS DOWLING MARQUET GRIFFIN
SOLICITORS
DUNEDIN

Telephone: (03) 477 8046
Facsimile: (03) 477 6998
PO Box 1144
DX YP80015

Solicitor: A J Logan

AFFIDAVIT OF DR JEAN-LUC PAYAN FOR THE APPELLANT IN SUPPORT OF AN APPLICATION UNDER SECTION 293

I, **JEAN-LUC PAYAN**, of Dunedin, Manager, swear –

Introduction

1. I am the Manager of the Natural Hazards Team at the Otago Regional Council (ORC).

2. I have been in this position since July 2016.

3. I held the position of Investigations Engineer (hydraulic and flood hazard) at the ORC from 2008 to 2016.

4. I hold the qualification of PhD in hydrology specialising in hydrological modelling from the French Institute of Forestry, Agricultural and Environmental Engineering (AgroParisTech, Paris), and of Master of Engineering in water sciences and environment from the French School of Water and Environment Engineering (Strasbourg).

5. I have over 15 years of professional experience in river management, flood hazard mitigation and natural hazards risks management in both local government and private sector. During this time:

    5.1. I have advised the Dunedin City Council on natural hazards matters during the review of the Dunedin District Plan (Second Generation District Plan, 2GP). This included providing detailed descriptions and reporting on the flood hazard on the Taieri Plain.

    5.2. Since 2008, I have contributed to various technical investigations and assessments related to the performance of the Lower Taieri Flood Protection Scheme including the Gordon Road Spillway and Floodway.

    5.3. I contributed to the development of the joint ORC/Clutha District Council (CDC) Milton 2060 flood risk management strategy. The strategy is intended to equip the Milton community to understand and live with the effects of flooding. It is also intended to guide the style and form of land use development and redevelopment in a way that ensures that flood risk does not increase and that over time the existing risks are reduced.

    5.4. I am responsible of the provision of timely river flow and lake level forecast and likely natural hazard consequences during rainfall events across Otago. I was heavily involved in and assisted the response to several heavy rainfall events and associated flooding in the region and on the Taieri Plain in particular such as during the July 2017 event. This involved being in contact with communities within the Gordon Road Floodway.

    5.5. I have led the development of the Otago climate change risk assessment which is intended to understand potential future

JLP MJS

climate scenarios and to identify risk areas in order to assist appropriate adaptation planning.

Code of Conduct

6. I acknowledge that I have read and agree to comply with the Environment Court's Code of Conduct for Expert Witnesses, contained in the Environment Court Practice Note 2014. I have complied with the code in preparing my affidavit.

7. The data, information, facts and assumptions I have considered in forming my opinions are set out in the affidavit to follow. The reasons for the opinions expressed are also set out in the affidavit to follow.

8. Unless I state otherwise, this affidavit is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Gordon Road Spillway and Floodway

9. I am very familiar with the Lower Taieri Flood Protection Scheme (the Scheme) and with the Gordon Road Spillway and Floodway in particular. I have led or contributed to investigations and assessments related to the operation of the LTFPS and flood hazard associated with the Taieri River floodplain.

10. The Scheme is designed to reduce the risk of flooding on the Taieri Plain with varying levels of protection.

11. In addition to an extensive network of floodbanks (over 100km combined length), the Scheme relies on very large ponding areas (the East Taieri Upper Pond and the East Taieri Lower Pond) designed and used to temporary store flood water during heavy rainfall events. The ponding areas are located east of the Taieri River (left bank) between Outram and Allanton.

12. The Gordon Road Spillway and Floodway form an integral part of the Lower Taieri Flood Protection Scheme (Figure 1 attached as Exhibit "**A**"). The floodway conveys flows spilled from the Silver Stream which eventually discharges to the East Taieri Upper Pond via gated culverts through the cut-off bank.

13. The spillway is a lowered section of the true right Silver Stream floodbank between Gordon Road and Riccarton Road. This section is a designed feature of the Scheme. It is designed to mitigate the flood risk for Mosgiel (protected by the true left floodbank) by allowing preferential spilling over the true right floodbank.

14. The Gordon Road spillway and floodway, the East Taieri Upper Pond, floodbanks and overland footpaths operate as a system (part of the wider Lower Taieri Flood Protection Scheme) designed to mitigate the flood hazard in parts of the Lower Taieri floodplain combining areas of conveyance (or transfer) of floodwater and areas of ponding of floodwater. It is critical that the safe operation and integrity of the spillway and floodway are maintained and protected in order to guarantee the level of service of the flood protection scheme the Mosgiel community is relying on.

JLA MB

15. The Gordon Road Floodway receives flood waters when the Silver Stream overtops the true-right bank downstream of the Gordon Road Bridge. It also receives, flood waters from overland flows (North and East), overtopping of the drainage network and internal rainfall accumulation. Flooding can occur from any one of these sources or in combination (Figure 2 attached as Exhibit "**B**").

16. Sections of the floodway in the vicinity of the cut-off bank are also likely to receive flows from the East Taieri Upper Pond (west) if the cut-off bank was to overtop (pond full) or to fail.

17. Large overland flows and significant ponding occur when the spillway operates. The spillway operation starts when the flows in the Silver Stream at Gordon Road exceed approximately 120-130m^3/s with the spillway fully operating when flows exceed 150-170m^3/s.

18. In the last 20 years, the spillway fully operated in April 2006, and July 2017 (Figure 3 attached as Exhibit "**C**") and was imminent or started to operate in July 2007, May 2010, April 2014, June 2015, and November 2018. The April 2006 and July 2017 are estimated to be between 2% and 1.3% and 3.3% and 2.5% Annual Exceedance Probability (AEP)[1] events respectively for the Silver Stream at Gordon Road.

19. Climate change is likely to increase the severity and frequency of rainfall events resulting in an increased likelihood of operation of the spillway.

20. By design, the level of protection provided by the Lower Taieri Flood Protection Scheme in the Gordon Road floodway area is lower than what is usually provided for urban or residential areas.

21. There are approximately 100 buildings (houses, farm buildings and sheds) in the mapped Gordon Road floodway with various exposure levels to floodwater depending on the nature and location of the properties.

22. Due to the lack of any defined path, spilled flows tend to spread out over a wide area on-route to the cut-off bank, combining with flows from the Mill Creek catchment to the east and the hill catchments to the north. The depth of water can exceed 3m in the vicinity of the cut off bank, with velocities of up to 1m/s generally, and therefore poses a hazard for people, stock, animals, vehicles, buildings, driveways, roads and other structures. Refer to paragraphs 26 to 32 for more details on the flood hazard characteristics and consequences.

23. Due to the nature of the catchment (relatively small -approximately 98km^2- with steep headwaters) and of the weather events affecting the area (relatively long duration events -over 24 hours- with often bursts of higher intensity rainfall), flows in the Silver Stream can rise quickly. This usually results in the threshold of operation of the Gordon Road spillway being quickly exceeded during a heavy rainfall event (e.g. in July 2017 the flows have risen from 100m^3/s to 150m^3/s in approximately two hours), leaving a very limited ability for residents and Emergency Services to plan a response once the spillway is operating. Early flood preparation is usually required for the residents living in the floodway, well before the flows reach the spillway operation threshold. Precautionary evacuation is also a

[1] Probability of an event occurring in any given year. i.e. a 1% AEP means there is a 1% chance in any given year of the event occurring.

JLP MWB

matter usually considered by emergency services in response to a heavy rainfall event.

24. Because of the generally subtle topography of Gordon Road Floodway, the depth, velocity and extent of flooding can also be influenced by local features, such as embankments, fences, shelterbelts and buildings, which can impede or divert flows.

25. The ORC operates, maintains and monitors the Scheme floodbanks to a high standard. Irrespective of the maintenance and monitoring regime, reliance on earth floodbanks for flood protection also means accepting some residual risk[2] exposure (i.e. failure before the design capacity is reached or for events larger than the assumed design event). Breaches in the Scheme floodbank network could potentially modify the characteristics of the flood hazard (duration and depth of inundation and water velocity) in the Gordon Road Floodway.

Flood hazard characteristics within the Gordon Road Floodway

26. Hydraulic computational modelling has been carried out to quantify the flood hazard characteristics (depth and velocity) within the floodway.

27. The modelling approach and model configuration and results are described in the report titled "Hydraulic Support for the Silver Stream and Gordon Road Floodway Modelling" completed by Bloxam, Burnett and Olliver in October 2022.

28. The modelling report was peer reviewed by Tonkin and Taylor. The peer reviewer concluded that the model is an appropriate tool for modelling the flood hazard in the Gordon Road floodway (the peer-review report is attached as Exhibit "**D**").

29. The modelling results indicate that the depth of flood water is expected to range between less than 0.5m to above 3m and the velocity is expected to range between 0.5 to 1 m/s in the floodplain for the estimated 1% Annual Exceedance Probability (AEP) event.

30. The depth and velocity calculated by the model have been used to categorise the flood hazard.

31. In the absence of specific New Zealand guidelines, the guidelines from the Australian Rainfall and Runoff (2019) have been used to categorise the flood hazard by combining the depth and velocity. The hazard categories are summarised in Table 1and presented graphically in Figure 4 attached as Exhibit "**E**".

[2] Residual risk is that part of the risk that is not mitigated, and includes risks due to events larger than the assumed design event or failure before the design capacity is reached

JLP MB

Table 1. Flood hazard categories description. From *Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia)*, 2019. https://arr.ga.gov.au/arr-guideline

Hazard vulnerability classification	Description
H1	Generally safe for vehicles, people and buildings
H2	Unsafe for small vehicles
H3	Unsafe for vehicles. children and the elderly
H4	Unsafe for vehicles and people
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure

32. The flood hazard characterisation (Figure *5* attached as Exhibit "**F**") indicates that in most of the floodway, the categories range from unsafe for small vehicles (H2) to unsafe for vehicles and people/All buildings vulnerable to structural damage/some less robust buildings subject to failure (H5).

Conclusion

33. The Gordon Road Spillway and Floodway form an integral part of the Lower Taieri Flood Protection Scheme. It is critical that the safe operation and integrity of the spillway and floodway are maintained and protected in order to guarantee the level of service of the flood protection scheme the Mosgiel community is relying on.

34. The flood hazard characteristics within the floodway mean that, in most of the floodway, the flood hazard categories range from unsafe for small vehicles to unsafe for vehicles and people/All buildings vulnerable to structural damage/some less robust buildings subject to failure.

Sworn at Dunedin this 16th day of December 2022 before me:-

Jean-Luc Payan

Mia Brooke
Barrister & Solicitor
Dunedin

A Solicitor of the High Court of New Zealand

"A"

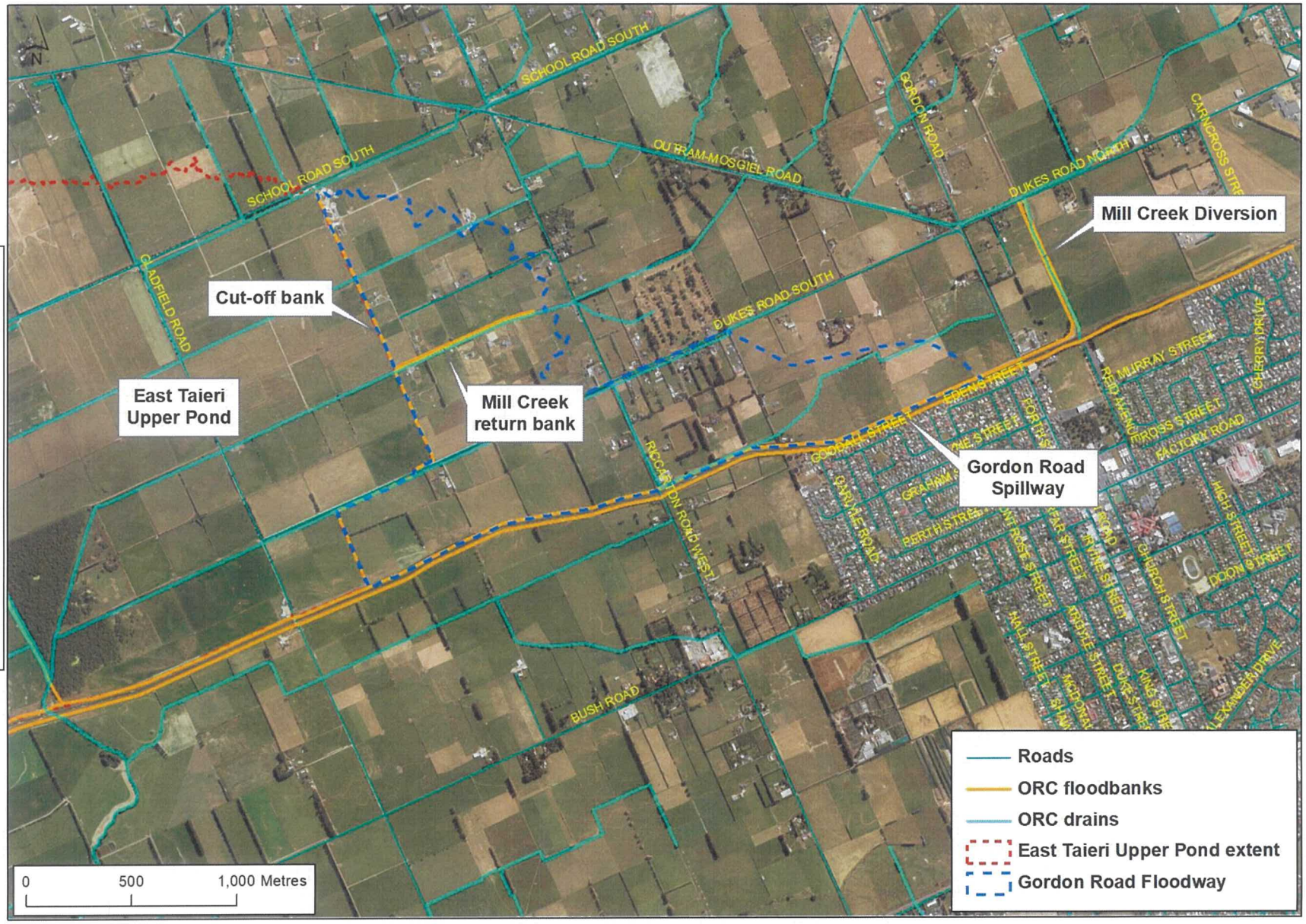


Figure 1. Lower Taieri Flood Protection Scheme and the East Taieri Drainage Scheme in the vicinity of the Gordon Road Floodway

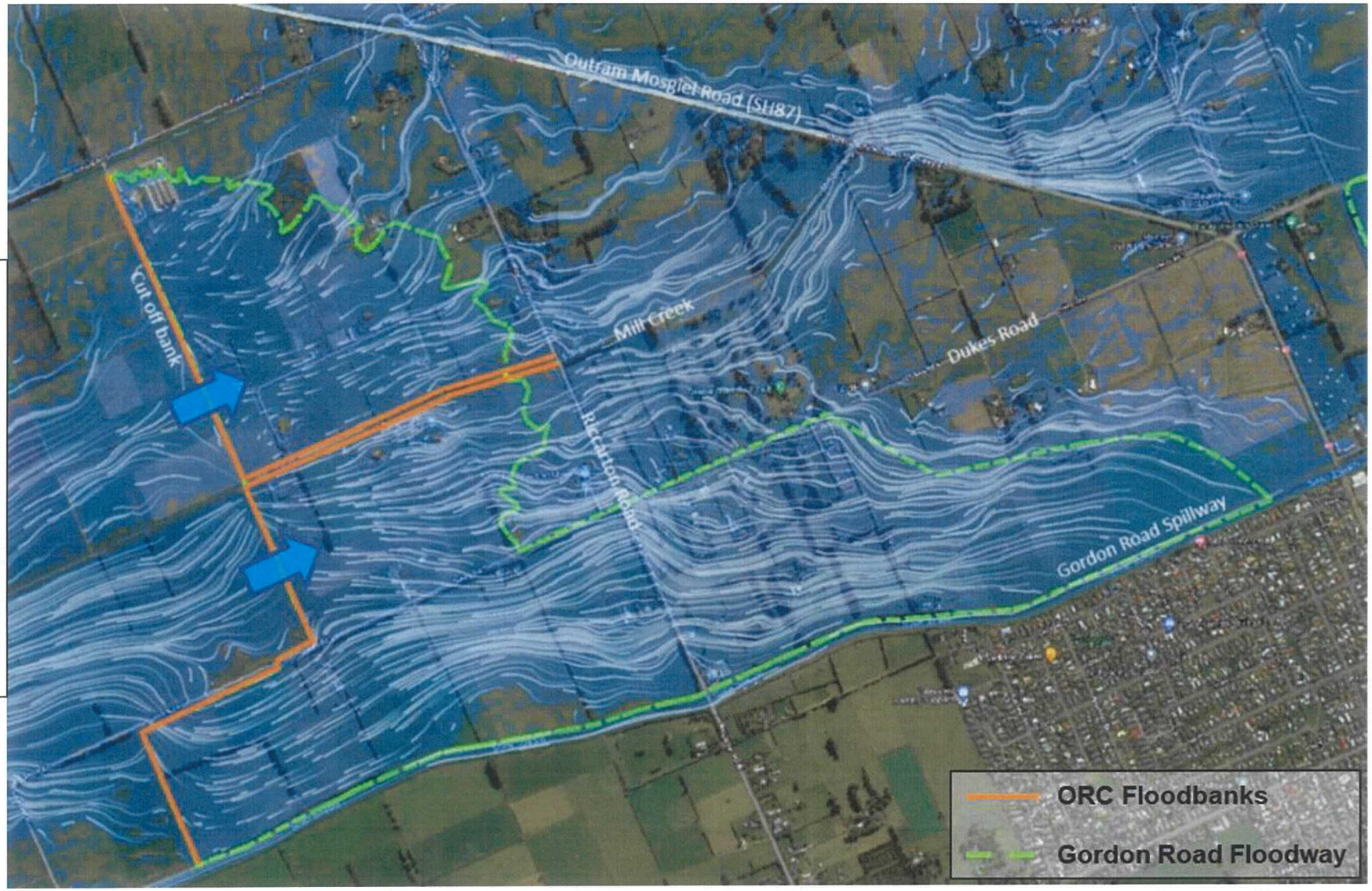
This is the document marked with the letter "A" and referred to in the annexed affidavit of JEAN-LUC PAYAN of Dunedin, Manager, sworn at Dunedin this 16th day of December 2022 before me:

Mia Brooke
Barrister & Solicitor
Dunedin

A Solicitor of the High Court of New Zealand

AJL-266090-1013-1280-V1

"B"



This is the document marked with the letter "B" and referred to in the annexed affidavit of JEAN-LUC PAYAN of Dunedin, Manager, sworn at Dunedin this 16th day of December 2022 before me

Mia Brooke
Barrister & Solicitor
Dunedin

A Solicitor of the High Court of New Zealand

Figure 2. Sources of floodwater contributing to the Gordon Road Floodway. The blue arrows indicate flows from the East Taieri Upper Pond if the cut-off bank was to overtop (pond full) or to fail. Source report: Silver Stream Modelling Report, Bloxam Burnett & Olliver (October 2022)

"C"

Figure 3. (a) Section of the Gordon Road Spillway and Floodway operating during the April 2006 flood event. Looking south toward the lower section of the Silver Stream right bank. Mosgiel urban area in the distance. (TVNZ footage)
(b) Section of the Gordon Road Floodway in the vicinity of the cut-off bank (the cut-off bank is the earth bank in the middle of the image) during the July 2017 flood event. Looking east (photo: ORC).

This is the document marked with the letter "**C**" and referred to in the annexed affidavit of **JEAN-LUC PAYAN** of Dunedin, Manager, sworn at Dunedin this 16th day of December 2022 before me:

Mia Brooke
Barrister & Solicitor
Dunedin

A Solicitor of the High Court of New Zealand

"D"

Tonkin+Taylor

This is the document marked with the letter "D" and referred to in the annexed affidavit of JEAN-LUC PAYAN of Dunedin, Manager, sworn at Dunedin this 16th day of December 2022 before me:

Mia Brooke
Barrister & Solicitor
Dunedin

A Solicitor of the High Court of New Zealand

8 December 2022
Job No: 1001453.0156

Otago Regional Council
70 Stafford Street
Private Bag 1954
Dunedin 9054

Attention: M J-L Payan

Dear Jean-Luc

North Taieri flood hazard: Silver Stream modelling review

In accordance with our Letter of Engagement dated 20 September 2022, we are pleased to report on our review of the Hydraulic Support for Silver Stream and Gordon Road Floodway Modelling project report.

Bloxham Burnett Olliver (BBO) has prepared a report of the flood hazard assessment of the North Taieri/Gordon Road floodway to the north and west of Mosgiel. More specifically the assessment has considered the area between Silver Stream, the cut-off banks to the west, and State Highway 87 to the north and east. The assessment has investigated how this flood plain area is impacted in flood events using the Taieri hydraulic model originally developed by the Otago Regional Council (ORC). A significant contributor to flows in the floodway during extreme events is overflow from the Silver Stream, conveyed across the Gordon Road spillway on the true right bank in the Mosgiel reach.

The model has been used to simulate various historical flood events to calibrate and validate the model, to simulate the flooding experienced in the July 2017 event, and to determine the flood hazard in the 100 year Average Recurrence Interval (ARI) event.

We received by email (Payan/Bassett) on 25 October 2022 a copy of the report prepared by BBO (ref 147460, Version 1 dated 25 October 2022), and an amended Version V2 dated 21 November 2022.

Our technical specialist, Tom Bassett, discussed aspects of this review with Bikesh Shrestha of BBO by phone on 10 November 2022 and variously by email through November and December 2022.

The scope of the review essentially comprises two questions:

1 Does the ORC hydraulic model adequately represent the flood hazard (including inundation extents, depths and velocity) for spills over the Gordon Road spillway?

2 Do the hydrological scenarios considered by ORC adequately communicate the flood hazard for District Plan purposes?

Tonkin & Taylor Ltd | 1 Fanshawe St, Auckland Central, Auckland 1010, New Zealand
PO Box 5271, Victoria Street West, Auckland 1142 P +64-9-355 6000 F +64-9-307 0265 E akl@tonkintaylor.co.nz

Modelling assumptions

The model for the Taieri system has been developed using HEC RAS software, incorporating 2016 LIDAR survey data of the terrain as well as available Silver Stream cross section survey data (2003, 2011, and 2017). The model is a coupled one dimensional/two-dimensional model, representing the Silver Stream and Taieri River channels and the wider flood plain area respectively. This is a conventional approach to developing a computational hydraulic model for a river and flood plain system, and is based on widely used software.

Hydraulic resistance in the model domain has been represented by assigned roughness coefficients depending on land cover in the flood plain, and in Silver Stream based on calibration against observed water levels in historical flood events.

We understand that hydrology input data to the model have been provided ORC, i.e. with regard to:

- Historical event monitoring information from the Silver Stream gauge at Gordon Road
- Silver Stream flood frequency data
- Normalised hydrograph profiles.

These inputs have not been scrutinised as part of this review.

Model calibration and validation

Observed flood level data (in the form of surveyed debris levels) were available for the Silver Stream from a kilometre upstream of the Gordon Road bridge to the mainstream Taieri River system 8 km downstream. These data are from four flood events, viz. 2006, 2010, 2015 and 2017. Observed data were also available for 2017 event in the flood plain between Silver Stream and Mill Creek to the north.

BBO reports that the model was calibrated using the 2015 flood data, and validated for the 2006, 2010, and 2017 flood events:

- Modelled peak water level profiles as presented in the report show generally good agreement with the observed levels along the stream channels. In the lower reaches some of the simulated event levels are generally higher than the observed data (up to several hundred millimetres). However, upstream in the Silver Stream reaches past Mosgiel the agreement is much closer.
- In the flood plain the simulated 2017 water levels are generally in the range of -0.25 m to +0.25 m compared to observed data. However, along the north-south alignment of the downstream cut-off bank the simulated water levels are consistently approximately 0.5 m higher than observed debris data. The model initially did not include culverts/waterways (except for Mill Creek) through the cut-off bank which contribute to conveyance capacity across the bank, but has been revised to incorporate these
- In discussion with BBO we understand several factors may influence the higher modelled water levels at this location:
  - Given overtopping of the cut-off bank during the event, it is considered that the surveyed debris levels may not represent an accurate identification of the peak water level during the event
  - The uncertain influence and timing of Taieri River overflows to the ponding area and the effect on upstream water levels in the North Taieri Area
  - Nonetheless the agreement between simulated and observed levels 250 m and more upstream of the cut-off bank is generally close, as well as levels along the east-west

alignment of the cut-off bank where the modelled water levels are similar to those along the north-south cut-off bank.

We have compared mapping of the flooding in the flood plain to aerial photographs and video recorded during the 2017 event, provided by ORC. While the timing of the imagery in relation to the peak of the flooding is uncertain, the extent of flooding indicated is generally consistent with the 2017 event modelling results.

We consider that the modelling approach, and parameters selected in development of the model, are soundly based and reflect conventional professional practice. Furthermore, simulation results compared to available monitoring data for the 2006, 2010 and 2017 events provide validation of the model as a tool to investigate flooding processes and present-day flood hazards in the North Taieri/Gordon Road floodway area.

Flood hazard modelling

The model was used to investigate the flood hazard for the 100 year ARI event. We understand that this scenario is based on present day climate data, i.e. no provision for climate change effects on rainfall.

As for the July 2017 event, the 100 year ARI modelling results indicate widespread flooding on the flood plain between Silver Stream, State Highway 87 and School Road South. Although the 100 year ARI peak Silver Stream flows are significantly higher than the July 2017 event (296 m^3/s and 229 m^3/s respectively), the extent of flood plain inundation is not significantly greater. This is likely due to the wide flood plain overland flow path (generally greater than 500 m) and the significant increase in conveyance capacity for modest increases in flood depth.

The modelled flood velocities and velocityxdepth distributions are also similar for the 2017 validation event and the 100 year ARI flood hazard event.

We consider that the modelling results for the 100 year ARI event provide useful guidance to ORC regarding flood hazard in various locations on the North Taieri/Gordon Road flood plain. However, we recommend that in terms of hazard planning, ORC might consider:

- Likely effects of climate change on 100 year flows
- Possible uncertainty in terms of statistical flow frequency estimates.

Conclusions

In terms of the *questions* posed by ORC

1 *Does the ORC hydraulic model adequately represent the flood hazard (including inundation extents, depths and velocity) for spills over the Gordon Road spillway?*
   - Based on comparison of simulated water levels and historical flood data presented in the report we consider that the model is an appropriate tool for modelling the flood hazard in the North Taieri/Gordon Road floodway
   - Modelled flood levels are consistent with available historical monitoring data, and thus presuming that the ground survey data are accurate the flood depths will have been appropriately determined. While there are no available data regarding historical flood plain velocities, it is reasonable to assume that the derivative velocities are a reasonable representation of the values to be expected for the events modelled.
   - We note that the model is reliant on accurate ground survey data, that is representative at the time of the historical events modelled and the future events investigated. This is also the case for land use and ground cover assumed in the modelling scenarios.

- The flood hazard is dependent also on the integrity of the hydraulic controls in the system at the time of the extreme events, i.e. the flood control assets in the system such as stopbanks, spillways, etc and assuming that they will function as designed without failure.

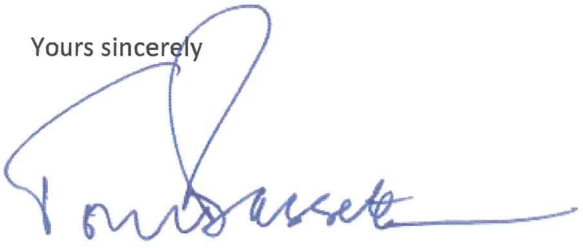
2 *Do the hydrological scenarios considered by ORC adequately communicate the flood hazard for District Plan purposes?*

- The principal hydrological scenario modelled (i.e. 100 year ARI event) is consistent with the design standard for the Silver Stream flood control scheme, noting that flow over the spillway can be expected to commence at a much smaller recurrence interval - maybe between 2 year and 5 years frequency based on modelling results
- As noted above, the flood hazard modelling to inform planning could also consider:
  - Likely effects of climate change on design flows
  - Possible uncertainty in terms of statistical flow frequency estimates
  - And also, acceptable event frequency and risk in terms of planning for safe and sustainable communities in the future.

We trust that this meets your requirements. Please contact Tom Bassett at tbassett@tonkintaylor.co.nz if you require clarification or elaboration of this review report.

This T+T review is a form of peer review, undertaken on a level-of-effort basis, to provide additional assurance to Otago Regional Council as to the quality of the modelling. The responsibility for the modelling remains fully with the Principal Consultant (BBO), and T+T's review does not constitute a means by which that modelling responsibility can be passed on to T+T. This report has been prepared on behalf of, and for the exclusive use of ORC, and is subject to, and issued in accordance with, the provisions of the contract between T+T and ORC. T+T accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

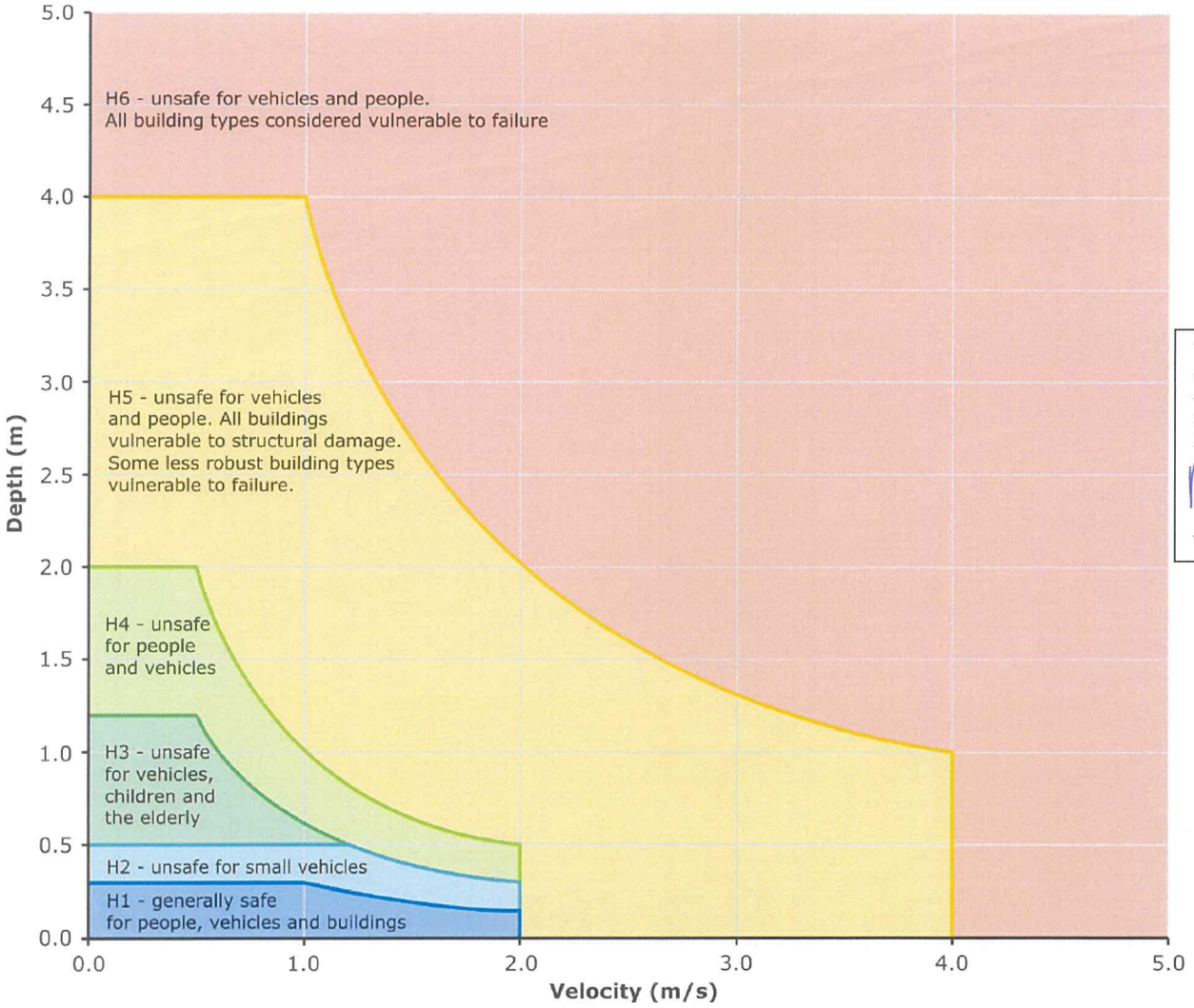
Yours sincerely



Tom Bassett
ADVANCED WATER ENGINEERING SPECIALIST
PROJECT DIRECTOR

9-Dec-22
t:\christchurch\tt projects\1001453\1001453.0156\workingmaterial\1001453.silver stream modelling review.112022.docx

"E"



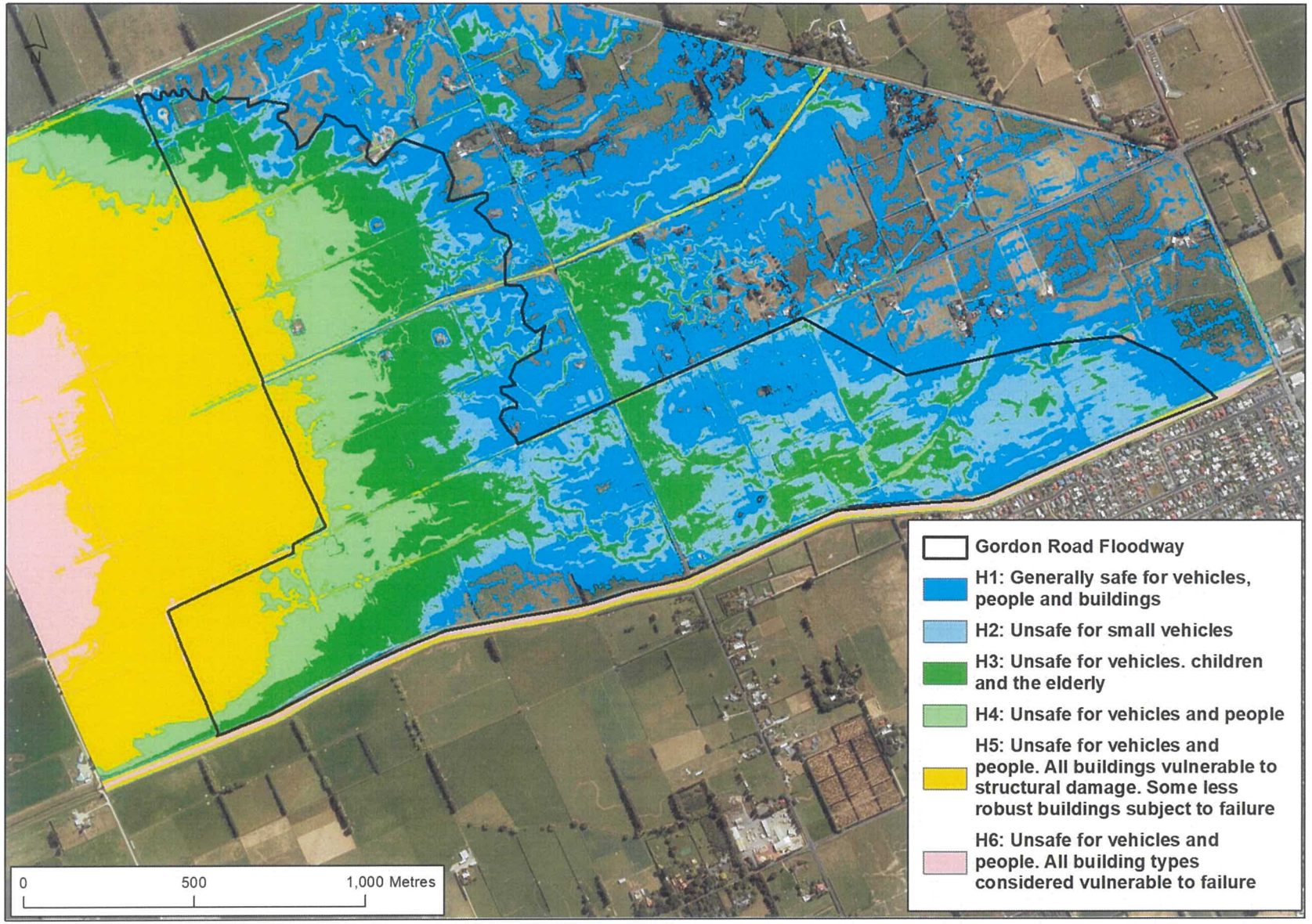
This is the document marked with the letter "**E**" and referred to in the annexed affidavit of **JEAN-LUC PAYAN** of Dunedin, Manager, sworn at Dunedin this 16th day of December 2022 before me:

Mia Brooke
Barrister & Solicitor
Dunedin

A Solicitor of the High Court of New Zealand

Figure 4. Flood hazard curves combining depth of flooding and velocity. The combined flood hazard curves set hazard thresholds that relate to the vulnerability of the community when interacting with floodwaters. The combined curves are divided into hazard classifications that relate to specific vulnerability thresholds. From *Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors)Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia)*, 2019.
https://arr.ga.gov.au/arr-guideline

"F"



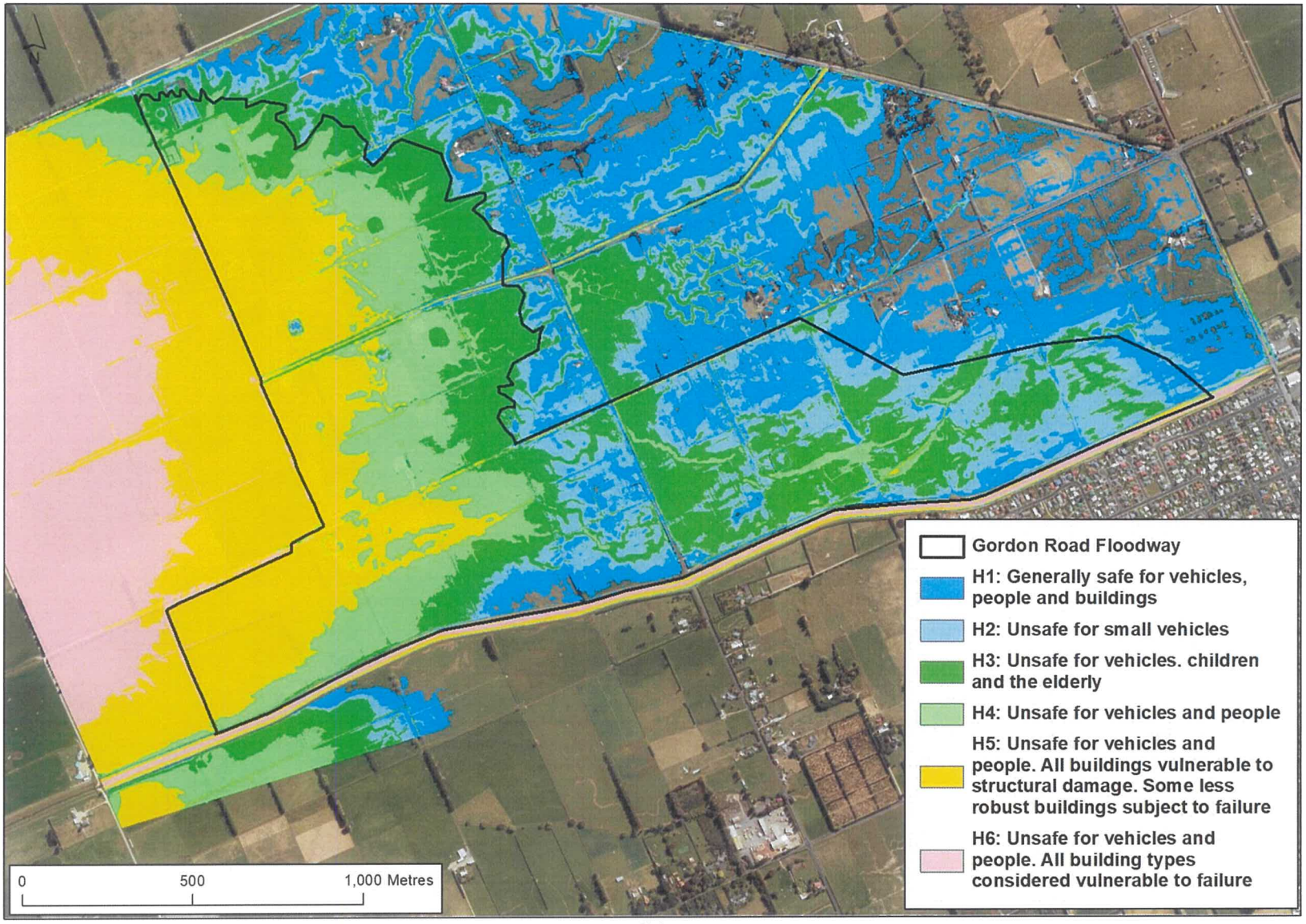
(a)

This is the document marked with the letter "F" and referred to in the annexed affidavit of **JEAN-LUC PAYAN** of Dunedin, Manager, sworn/affirmed this 6th day of December 2022 before me:

Barrister & Solicitor
Dunedin

A Solicitor of the High Court of New Zealand

AJL-266090-1013-1280-V1



(b)

Figure 5. Modelled flood hazard categories based on the Australian Rainfall and Runoff guidelines (https://arr.ga.gov.au/arr-guideline) (a) July 2017 flood event – (b) 1% AEP flow event in the Silver Stream