**IN THE ENVIRONMENT COURT**
**AT CHRISTCHURCH**

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

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|---|---|
| **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 |

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# AFFIDAVIT OF TOM BASSETT FOR THE APPELLANT IN SUPPORT OF AN APPLICATION UNDER SECTION 293

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**AFFIDAVIT OF TOM BASSETT FOR THE APPELLANT IN SUPPORT OF AN APPLICATION UNDER SECTION 293**

I, **TOM BASSETT**, of Auckland, Engineer, swear –

**Introduction**

1. I am an Advanced Water Engineering Specialist with Tonkin & Taylor Ltd (T+T).

**Statement of Professional Qualifications and Experience**

2. I am a Chartered Engineer (CEng) with the qualifications BE (Hons) and ME from the University of Auckland, and MBA from the University of Otago.

3. I have nearly 40 years post-graduate experience, principally in the water resources disciplines of hydrology and catchment management. I am a member of the British Institution of Civil Engineers and the New Zealand Hydrological Society, and a past Committee member of the Engineering New Zealand Rivers Group.

4. Since 1994, I have been employed by T+T as a Water Resources Engineer. I was for two years the Resource Group Manager of the T+T Water Resources Group, and subsequently for two years the Discipline Manager of the Water Engineering sub-Discipline.

5. I am a Principal of T+T and have wide experience in water resources engineering including hydrological analysis, computational modelling, catchment management investigations and reporting.

6. Specific project experience related to catchment management and river engineering includes:

    6.1. Hydrological analysis, hazard assessment, engineering design and specialist technical support for the Matata Risk Mitigation and Recovery Project;

    6.2. Hydrological analysis, hydraulic modelling and river control works on the Tongariro River;

    6.3. Hydraulic modelling and design of river control works on the Tauranga-Taupo River;

    6.4. Integrated Catchment Studies for Metrowater and Auckland City;

    6.5. Hydrological analysis of extreme event flows in the Sibulan River, Mindanao, The Philippines;

    6.6. Hydrological analysis and runoff modelling, and hydraulic modelling in relation to the Sarawak River barrage in East Malaysia;

    6.7. Hydraulic modelling of the Manawatu River; and

6.8. Peer review of hydrological analyses on flood statistics and hydraulic modelling of the Rees River and investigation of flood hazard in Glenorchy, Otago.

**Code of Conduct**

7. 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 evidence.

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

9. Unless I state otherwise, this evidence 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.

**Materials Considered**

10. I have not visited the Silver Stream.

11. In preparing this evidence I have reviewed the Hydraulic Support for Silver Stream and Gordon Road Floodway Modelling report, Version 1, 25 October 2022, and Hydraulic Support of Silver Stream and Gordon Road Floodway Modelling report, Version 2, 21 November 2022 prepared by Bloxam Burnett & Olliver (BBO).

12. I provided my feedback to Dr Bikesh Shrestha of BBO during the course of the peer review. I am satisfied that the matters raised by me have been taken into account in the updated modelling report.

**Scope of Evidence**

13. This evidence relates to my review of the reports.

14. The scope of the review essentially comprised of two questions posed by the Otago Regional Council (ORC):

    14.1. Does the hydraulic model accurately represent the flood hazard (including inundation extents, depths and velocity) for spills over the Gordon Road Spillway?

    14.2. Do the hydraulic scenarios considered adequately communicate the flood hazard for District Plan purposes?

**Assumptions**

15. The review did not include scrutinising the hydraulic input data.

**Model Calibration and Validation**

16. I consider that the modelling approach, and parameters selected in the development of the model, are soundly based and reflect conventional professional practice. Further, simulation results compared to available monitoring data for the 2006, 2010 and 2017 flood events provided validation of the model as a tool to investigate the flooding processes and

present-day flood hazards in the North Taieri/Gordon Road Floodway area.

**Flood Hazard Modelling**

17. I consider that the modelling results for the 100-year ARI (annual recurrence interval) or "*return period*" provide useful guidance regarding flood hazard in various location on the North Taieri/Gordon Road flood plain.

18. However, I recommended that in terms of hazard planning, the Otago Regional Council might consider the likely effects of climate change on 100-year flows and possible uncertainty in terms of statistical flow frequency estimates.

**Conclusion**

19. In terms of the questions posed:

    1 *Does the 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 I 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 I consider that the flood depths will have been appropriately determined. While there are no available data regarding historical flood plain velocities, I also consider that it is reasonable to assume that the derivative velocities are a reasonable representation of the values to be expected for the events modelled.

    - I 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.

    - I note that 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?*

    - I understand that the principal hydrological scenario modelled (i.e. 100 year ARI event) is consistent with the design standard for the Silver Stream flood control scheme, though 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

- In my opinion 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.

**Attachment**

20. My reporting letter provided to ORC by T+T is **attached** as Exhibit "**A**".

**Sworn** at Auckland this 15th day of December 2022 before me:-

Tom Bassett

**A Solicitor of the High Court of New Zealand**

MICHELLE LAPWORTH LL.B
Solicitor
Auckland

"A"

This is the document marked with the letter "A" and referred to in the annexed affidavit of TOM BASSETT of Auckland, Engineer, sworn at Auckland this 15th day of December 2022 before me:

A Solicitor of the High Court of New Zealand

MICHELLE LAYWORTH LL.B
Solicitor
Auckland

Tonkin+Taylor

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?



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## 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.

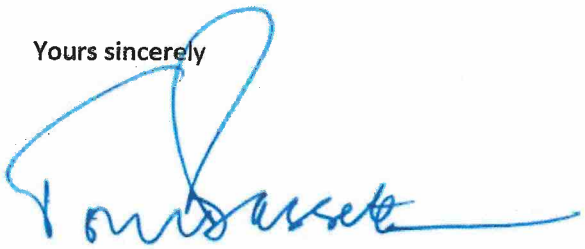
2 *Do the hydrological scenarios considered by ORC adequately communicate the flood hazard for District Plan purposes?*

- 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
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