**BEFORE THE HEARINGS PANEL**

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| **IN THE MATTER** | of the Resource Management Act 1991 |
| **AND** | |
| **IN THE MATTER** | of the Proposed Selwyn District Plan |

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**STATEMENT OF EVIDENCE OF GREGORY MARK WHYTE**
**ON BEHALF OF SELWYN DISTRICT COUNCIL**

**Natural Hazards-Plains Flood Modelling**

**29 September 2021**

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## 1. INTRODUCTION

**1.1** My full name is Gregory Mark Whyte. I hold the position of Managing Director at DHI Water & Environment (**DHI**). I have been in this position since February 2020 and with DHI since March 2008.

**1.2** I hold a Bachelor of Civil Engineering degree from the University of Canterbury, which I gained in 1996. I am also a Chartered Professional Engineer with the Engineering New Zealand (**ENZ**), which I have held since 2003.

**1.3** I have been engaged by the Selwyn District Council (**Council**) to give evidence of the flood modelling that was used as a basis for mapping of the Plains Flood Management Overlay as part of the Proposed Selwyn District Plan (PSDP).

**1.4** I have been providing the Council with my expertise in relation to flood modelling since 2017. We responded to a Request for Proposal from Council to use recently acquired LiDAR data to identify overland flow paths and flood depths across their district to assist the Asset Team with the prioritisation of future investigations, maintenance programmes and protection of overland flow paths. This project focused on the more frequent 10% and 2% AEP design rainfall events and modelling flooding in and around the 17 main townships across the district. Three models were built of the District named the North, South and West models and were either a 5x5 metre or 6x6 metre model grid resolution. Three models were used due to restrictions on model grid size. Having three models created some flood depth and extents anomalies at the model boundaries in the lower or downstream parts of the catchments.

**1.5** A second study was commissioned by Council in mid 2018 to refine the previous study and focus on the more infrequent 0.5% and 0.2% design rainfall events. It was decided to build one model with a 10x10 metre grid resolution to cover the entire District to remove boundary issues by having three models as for the previous study. HIRDS v.4 design rainfall was used with a more detailed infiltration method applied than for the first study. The model was validated against the July 2017 event, with some adjustments made to get a better fit against this event. Environment Canterbury (**ECan**) were a stakeholder in this study and this stage of the project was carried out in close collaboration with ECan. They effectively acted as an external peer reviewer. We supplied Council with maximum water level, water depth or and hazard results for the 0.5% and 0.2% AEP design rainfall events. Design rainfall had an allowance applied which was either RCP climate change scenario 4.5 or 8.5. These results were filtered to remove any model grid cells that had a depth of less than 50 millimetres on the basis that this depth is insignificant.

**1.6** I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014 and that I agree to comply with it. I confirm that I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express, and that this evidence is within my area of expertise, except where I state that I am relying on the evidence of another person.

**1.7** The key documents I have used, or referred to, in forming my view while preparing this brief of evidence are:

(a) Selwyn District Council – Rapid Flood Assessment, DHI, July 2017;

(b) Regional Policy Statement Modelling for Selwyn District Council – District Plan, DHI, November 2019.

## 2. SCOPE

**2.1** As mentioned above, the specific part of the PSDP that my evidence relates to is the flood modelling, that has informed the Plains Flood Management Overlay. I will specifically address:

(a) the background to Councils flood modelling;

(b) the technical integrity of the modelling;

(c) model assumptions/limitations;

(d) review of the flood modelling;

(e) the submissions received for the Plains Flood Management Overlay.

## 3. EXECUTIVE SUMMARY

**3.1** Selwyn District Council have undertaken District-Wide Flood Hazard modelling to predict flood extents and depths for the 0.5% and 0.2% AEP design rainfall events. This study involved ECan as a key stakeholder who acted as an internal peer reviewer.

**3.2** The model's physical structure is based on LiDAR data from a number of different datasets that were collected at different times ranging from 2010 to 2018.

**3.3** The model was validated against the July 2017 flood event.

**3.4** The model is expected to be updated over time with new data, methodologies and further validation to produce better resolution and accuracy.

## 4. BACKGROUND TO SELWYN DISTRICT COUNCIL FLOOD MODELLING

**4.1** Flood modelling that the Council has undertaken uses computational computer models to predict flood extents and depths across a catchment. The models use rainfall and lake level data as inputs to produce flood extent and depth outputs. A hydrological model simulates the rainfall-runoff processes in the elevated parts of the district such as the Port Hills. It is a lumped, conceptual rainfall-runoff model, simulating the overland, interflow, and baseflow components of catchment runoff as a function of the moisture contents in various conceptual storages. Flat parts of the district have rainfall applied directly to the model grid which in turn has the infiltration processes of the soil applied in the hydraulic model where excess rainfall produces runoff. These process's produce what is termed "runoff" which is then further routed in the hydraulic model via open channels, waterways and rivers. Once these primary channels are at capacity the runoff then enters the floodplain areas or the secondary flowpath areas.

**4.2** The rainfall the models use is commonly called design rainfall because it has been determined by a statistically related procedure of a certain return period. Design rainfall depths have been obtained from NIWA's High Intensity Rainfall Design System (HIRDS) v4 and use a "Chicago Storm" temporal pattern. Historical event rainfall that has been used to validate the model (July 2017) has been distributed across the catchment by a Thiessen polygon approach.

4.3 A model simulation consists of “running” the model for a certain period or window of time which could reflect the critical duration of the model or a part of the model. If you want to understand the entire flood event from the beginning to peak and the recession, then the model may have a long run time, but maybe less if you are only interested in the peak flood levels. The model run time is how long the model takes to complete the model simulation which may be faster or slower than the simulation period depending on the hardware the computer has and the model timestep used for the simulation.

4.4 DHI (formally known as the Danish Hydraulic Institute) are the producers of the MIKE software that Council uses for this district wide modelling. DHI was formed in 1964 in Denmark and released its first commercial software package "MOUSE" in 1983. DHI produce water modelling software and undertake specialist consulting projects around the world, with over 1100 staff worldwide based in over 30 countries. DHI New Zealand has 18 staff based between Auckland and Christchurch.

4.5 The mathematical equations used by the software code for flood modelling is either solving the St Venant 1-Dimensional (1-D) shallow water equations or the depth averaged Navier Stokes 2-Dimensional (2-D) equations. If the software code solves the 1-D equations it is commonly referred to as a 1D model, likewise for a 2D model. The SDC models are 2-D models.

4.6 Council has been carrying out flood modelling studies with DHI software since 2017.

4.7 The Council models consists of a rainfall runoff component and a hydraulic routing component. They makes make use of a DHI rainfall runoff model called "Model B", which is a lumped conceptual model. The rainfall runoff calculations are carried out in MIKE 11. Essentially the hydrological model produces the net runoff for each sub-catchment when a specific rainfall is applied to which some hydrological losses are removed. Runoff is also produced by applying rainfall directly to the 2-D software grid in MIKE 21, which has an integrated infiltration module.

**4.8** The hydraulic routing component of the models consist of open channels that are represented in the 2-D software MIKE 21.

**4.9** Once the model simulations are completed the model results are processed in maximum water level, water depth and hazard (only for the 0.2% events) rasters. These results were filtered where flood depths less than 50 millimetres were removed because they are insignificant.

## 5. TECHNICAL INTEGRITY

**5.1** The MIKE software tools have been used for thousands of projects around the world over the last 35+ years. They are widely accepted across the industry as tools suitable for assessing flood risk.

**5.2** DHI works in accordance with the quality management system standard: ISO 9001 as certified by Det Norske Veritas (DNV). The ISO 9001 certificate covers the following products or services within the area of water, environment, and health:

Consulting;
Software;
Research & Development; and
Laboratory Testing, Analysis and products.

DHI's quality management system requires all deliverables to be reviewed and approved by appropriately qualified staff.

**5.3** A measure of a model's ability to represent reality is how well calibrated or validated the model is. A textbook calibration/validation would consist of three or four calibration events and a validation event. The calibration events would consist of historic flood events representative of the purpose of the model. For example, if the purpose of the model was to predict large or infrequent flood events then the ideal calibration events would consist of large or infrequent flood events. Likewise for medium sized events and small or frequent flood events. A validation event could consist of a separate historical event to the calibration event that might test the overall integrity of the model using the calibrated model parameters.

**5.4** The calibration/validation of a flood model provides a degree of confidence that the model represents reality but also that it is technically robust. In order for a model to represent reality it needs to be schematised correctly and to represent the flooding processes occurring in the catchment.

**5.5** The modelling methodology is essentially the same as used for the Waimakariri District Council (WDC), for their district wide flood mapping. We started this type of modelling with WDC back in 2009 and have worked with WDC either carrying out the modelling or acting in a peer review capacity to the present day.

## 6. MODEL ASSUMPTIONS/LIMITATIONS

**6.1** A flood model is a simplified representation of reality and hence there are many assumptions and approximations made when building and using a flood model. The "Regional Policy Statement Modelling for Selwyn District Council – District Plan, DHI, November 2019" report endeavours to limit and document the assumptions required in building and running the flood models.

**6.2** The following limitations were identified from the study:

a) Only some calibration/validation has been carried out for the July 2017 event and no other storm events were assessed.

b) The ground levels are of varying LiDAR resolution throughout the model domain. Some care should be taken especially when interpreting results across different data sets.

c) Infiltration is based on estimated rates based off spatial soil data. Thus, the accuracy of the rates is dependant both on the accuracy of the soil data, and the estimated rates assigned to each soil type.

d) In channel routing for water courses smaller than the grid size of 10m will not be accurately resolved in the model.

e) The location of hydraulic structures, such as culverts, was not estimated or included in this modelling. Ponding may be overestimated in some areas that, in reality, would allow some through flow to occur.

f) It is expected that the 10m resolution of the grid will be adequate enough to pick-up flow obstructions such as road embankments, however structures such as fences or walls will not be resolved in the model, although some consideration is made for this in the "built up area" roughness value.

g) Stormwater reticulation networks were not included in this model.

h) It expected that the more detailed ECan Selwyn River MIKE FLOOD model would be used to analyse the area in and near the Selwyn River.

i) The rainfall used is a 72 hour nested storm, this assumes that the critical duration for the models is at or less than 72 hours. It is possible that in some areas the critical duration may be longer than this, in which case flood levels may be underestimated.

## 7. REVIEW OF FLOOD MODELS

**7.1** DHI routinely peer review other consultants' models and have our models reviewed by other consultants. Peer review at the end of a project can be of limited use if some fundamental aspect of the model are wrong. We find a better approach is to be involved at key stages of a modelling project to minimise any reworking or time taken to correct the model for any errors/omissions or modifications required.

**7.2** ECan were involved in a review capacity from the beginning of the Regional Policy Statement modelling study and were closely involved during the validation of the model against the July 2017 event.

## 8. CONSIDERATION OF SPECIFIC SUBMISSIONS

### R Christie [DPR-0133]

**8.1** Model cell land levels are based on LiDAR data that was obtained in 2016-2017 for this area.

**8.2** The flood cells shown for both 3 Zabeel Street, Lincoln and 9 Wallace Crescent, Prebbleton are connected to other flood cells in the area but any depths less than 50 millimetres have been removed from the results. So, the cells shown are not isolated cells but are cells that are deeper than 50 millimetres of flood water.

### Ascot Park Limited (APL) [DPR-0428]

**8.3** The modelling has been reviewed at key stages by ECan and in particular against the July 2017 flood event.

**8.4** The modelling taken does of course have some uncertainty as all modelling does. The current model gives a district wide spatial overview of flooding. The model is expected to be updated over time with new data, methodologies and further validation to produce better resolution and accuracy.

**West Melton DRAI [DPR-0360]**

**8.5** The model has a practical resolution used in terms of LiDAR data resolution and model simulation time.

**8.6** The model is expected to be updated over time with new data, methodologies and further validation to produce better resolution and accuracy.

**RIHL [DPR-0374] & RIDL [DPR-0384]**

**8.7** The model is based on LiDAR data points which are averaged over a 10 metre grid across the model domain. Topographical features that are larger than 10 metres in size may be represented in the model grid, but finer features may not be represented in the model grid because of the averaging effect.

**8.8** The modelling has been reviewed at key stages by ECan and in particular against the July 2017 flood event.

**R Potts [DPR-0256]**

**8.9** The modelling taken does of course have some uncertainty as all modelling does. The current model gives a district wide spatial overview of flooding. The model is expected to be updated over time with new data, methodologies and further validation to produce better resolution and accuracy.

**Gregory Mark Whyte**
**29 September 2021**