Modelling Group
WATER NEW ZEALAND

Modelling Symposium

Flood storage optimisation in the Ōpāwaho / Heathcote Upper Storage Scheme

Presented by
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water NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa

What is the purpose of flood storage?

What can happen instead?

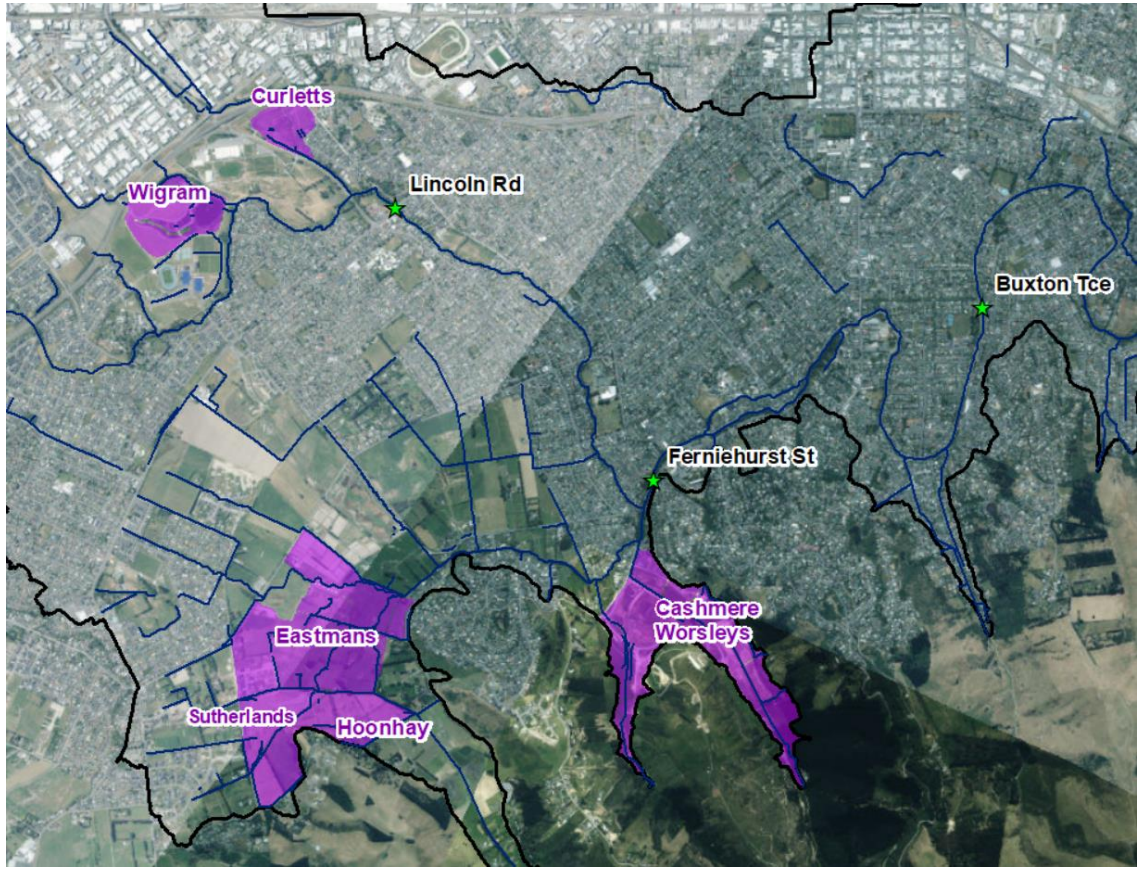
- Water is released too early – combines with flood peak
- Water is stored for too long – not ready for next event
- Blockages or failures occur causing spillways to overflow at different times
- Floods are often unpredictable – don’t follow the “design” pattern

How can we improve things?

Upper Heathcote Storage Scheme

Flood protection aims:

- To provide additional storage
- Actively control gates
  - to allow flexibility
- Improve on passive control
- Reduce flood levels



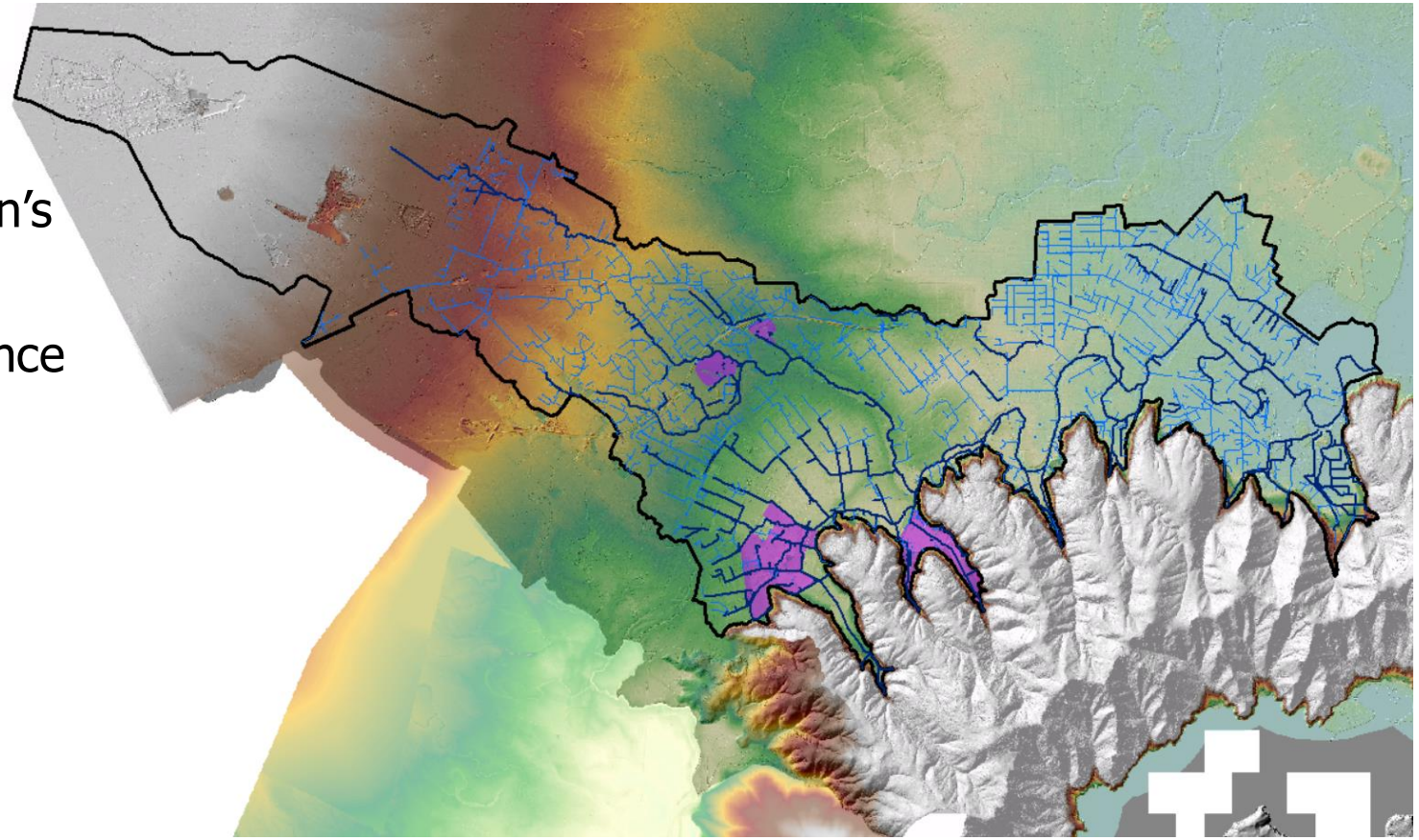
How have DHI been involved?

- Modelling for the development of "Functional Description" to describe gate logic – many iterations
- Ongoing development of the flood models
- Updating models with latest basin designs – as these changed over time

The Modelling

Modelling the Heathcote catchment

- Catchment Area: 120km^2
- Free Draining soils in the West
- High groundwater in Henderson's
- Hill catchments up to RL 500m
- Flat land 70m elevation difference from west to east (24km)
- Heathcote outlets into estuary

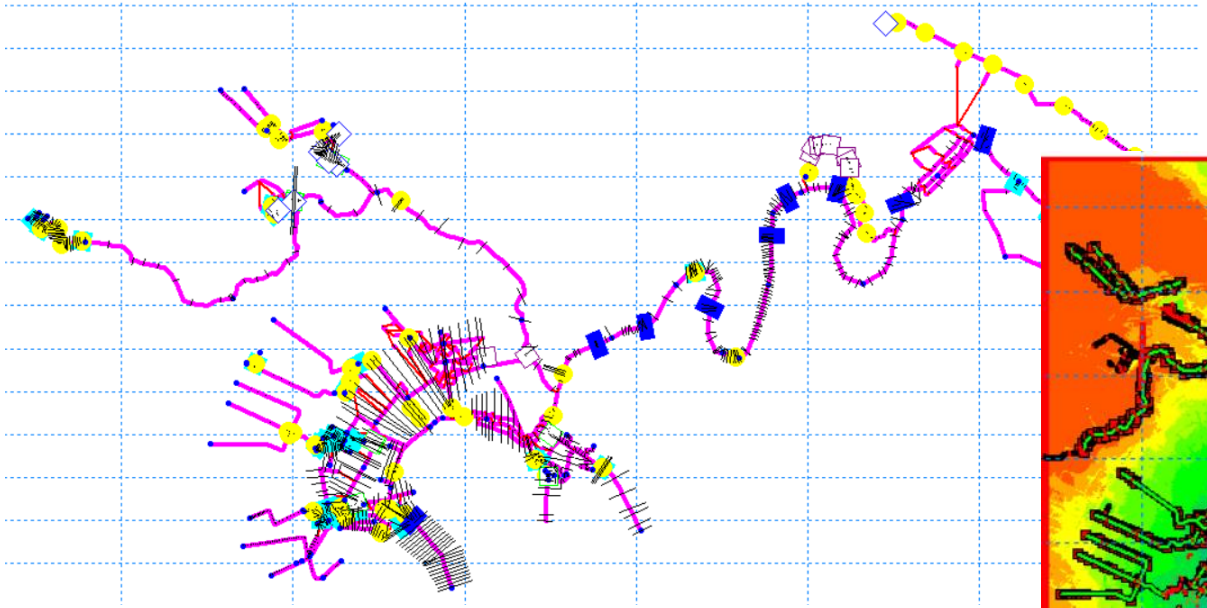


Upper Heathcote Storage Scheme

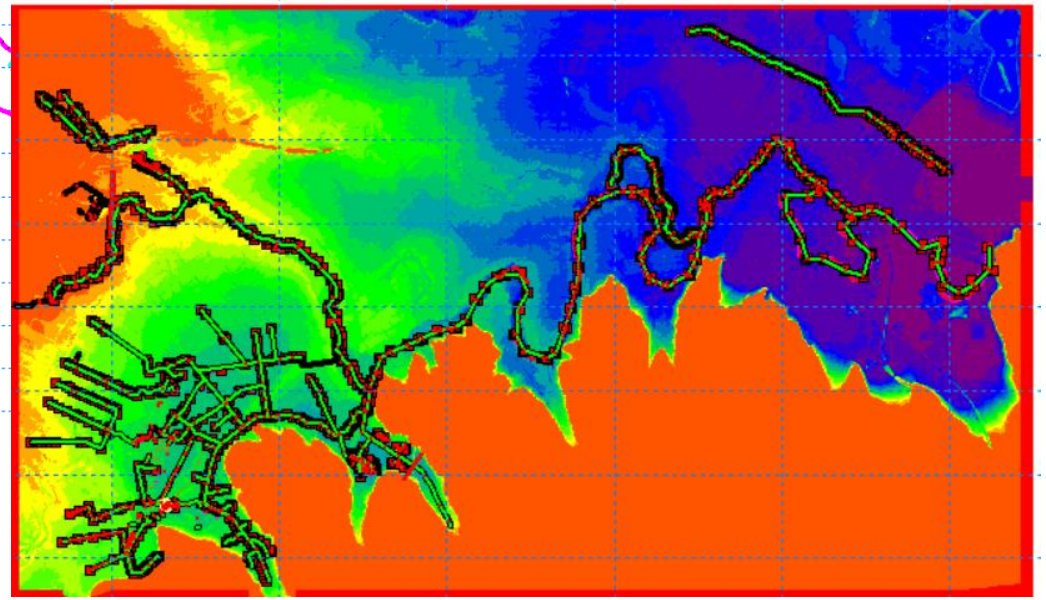
- Basin Volume: 800,000m^3
- 8 actively controlled gates

Historical Models

MIKE 11 screening model



MIKE FLOOD classic model



City Wide Model

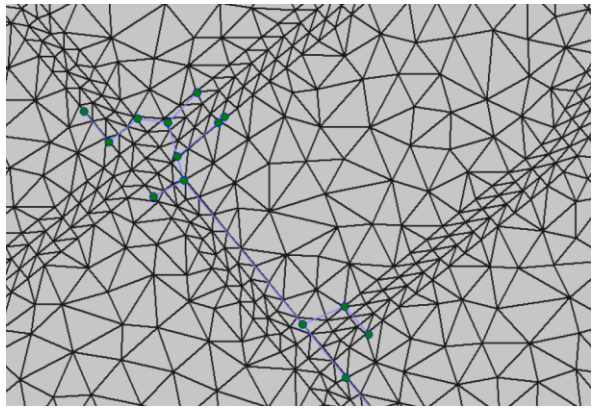
2D infiltration and Groundwater levels

Flatland - Rain on Grid

All waterways and hydraulic structures in 1D

~60 simulations with varying duration and ARI

Flexible Mesh with roads defined



Hillside - RORB runoff

Pipes >= 300mm

Calibration

The model was calibrated to 2 events and validated to 1 more

- Calibration Dry antecedent - March 2014 (~1 in 30year ARI)
- Calibration Wet antecedent - July 2017 (~1 in 14year ARI)
- Validation to June 2013 (~1 in 4year ARI)

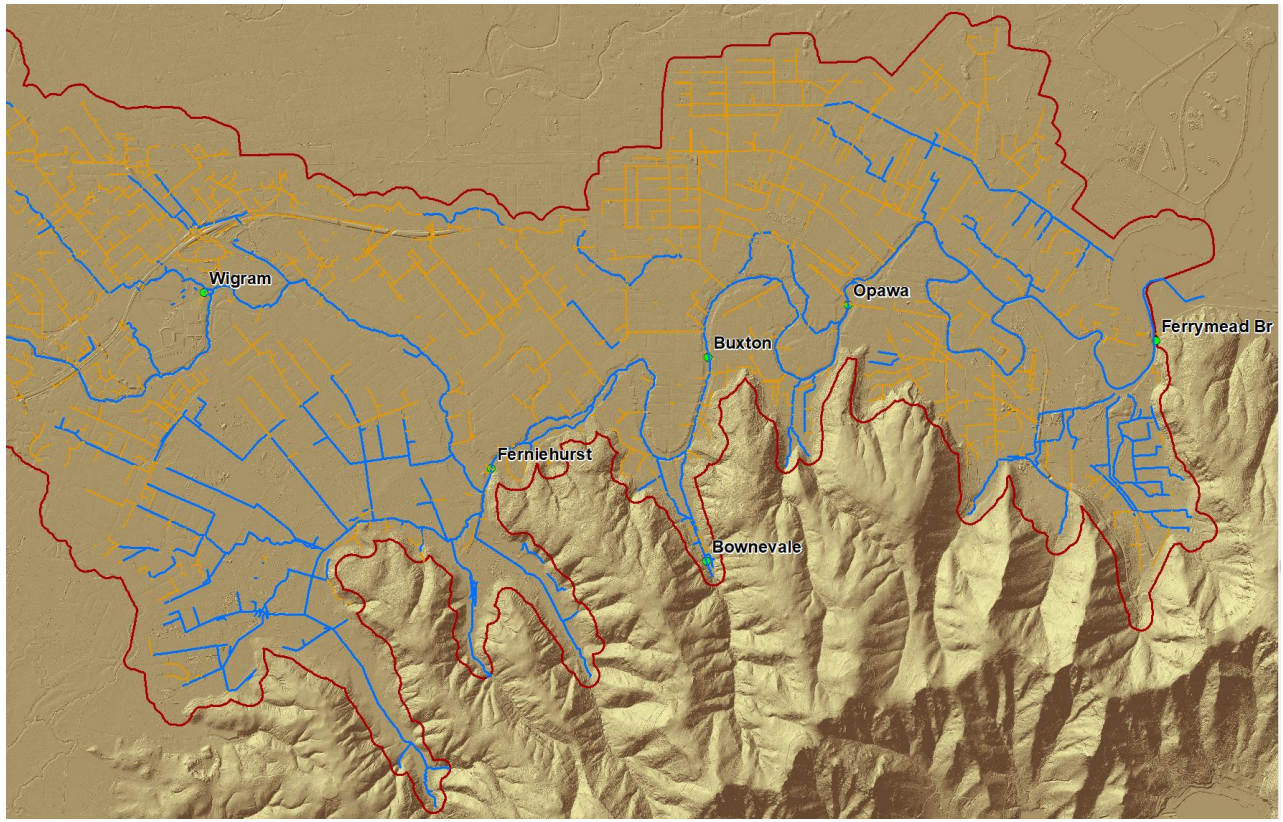
Events are reasonably small ranging from 1 in 4 year to 1 in 30 year ARI

Earlier versions of the model only calibrated against 2014 and validated against 2013.

2014 Calibration

Data included

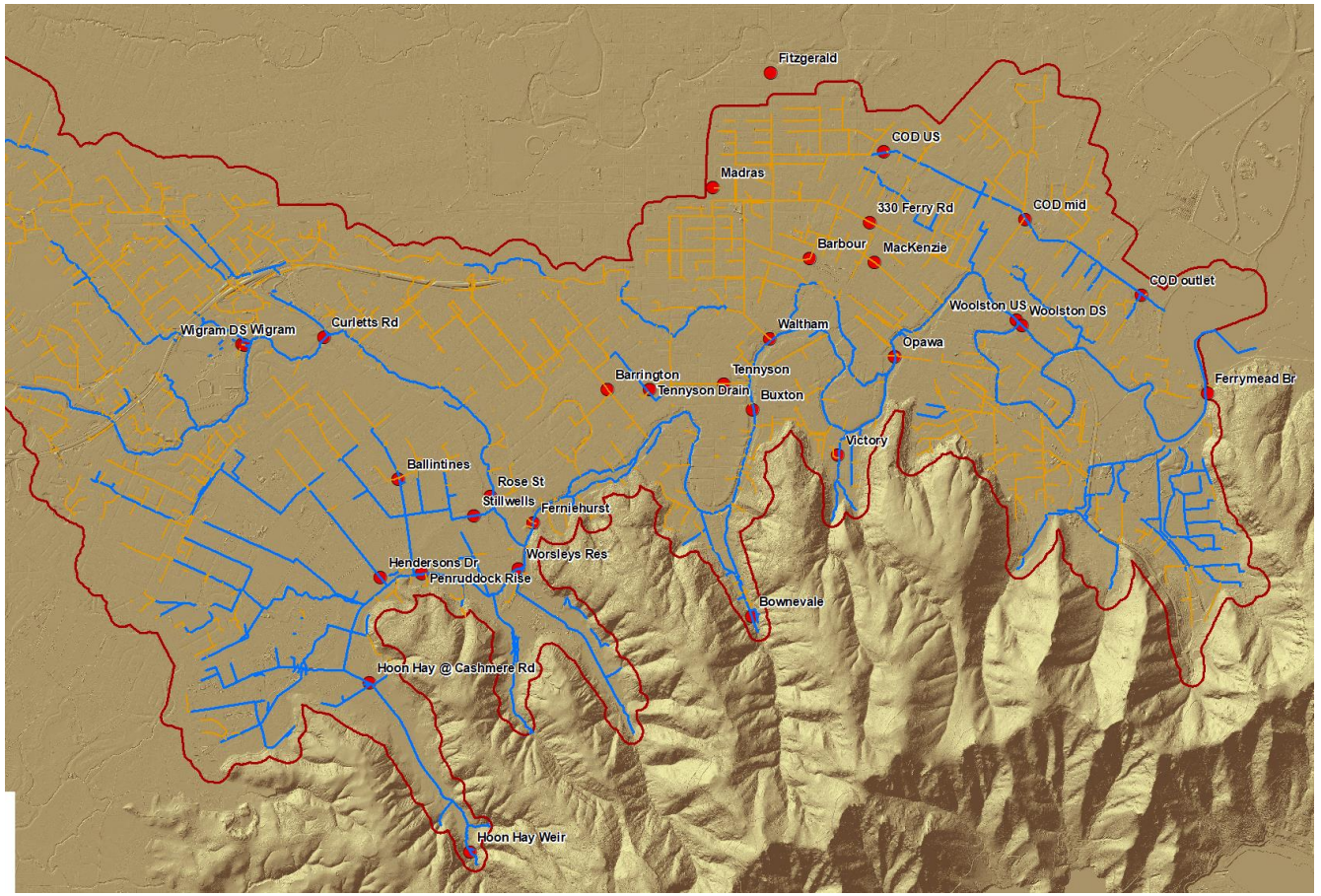
- 6 water level gauge locations
- 3 with rated flow
- Derived flow at Wigram
- Flood Extents
- Spot levels
- Aerial Photography
- Gauge Rainfall only



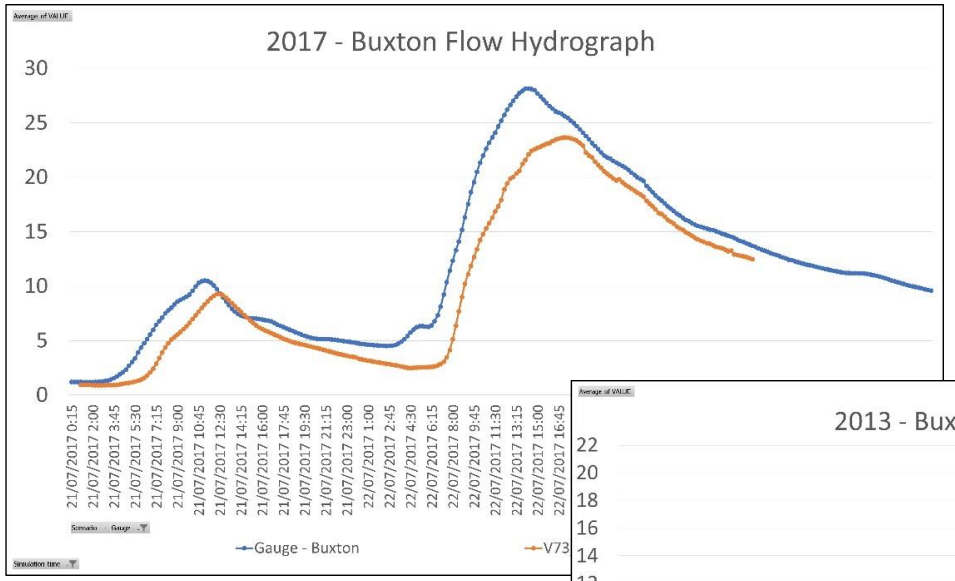
2017 Calibration

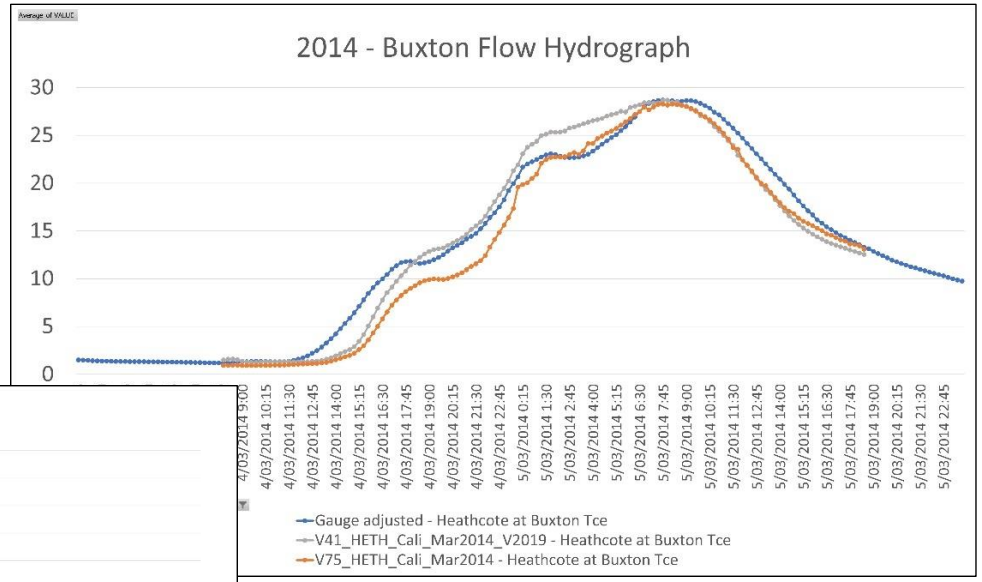
Data included

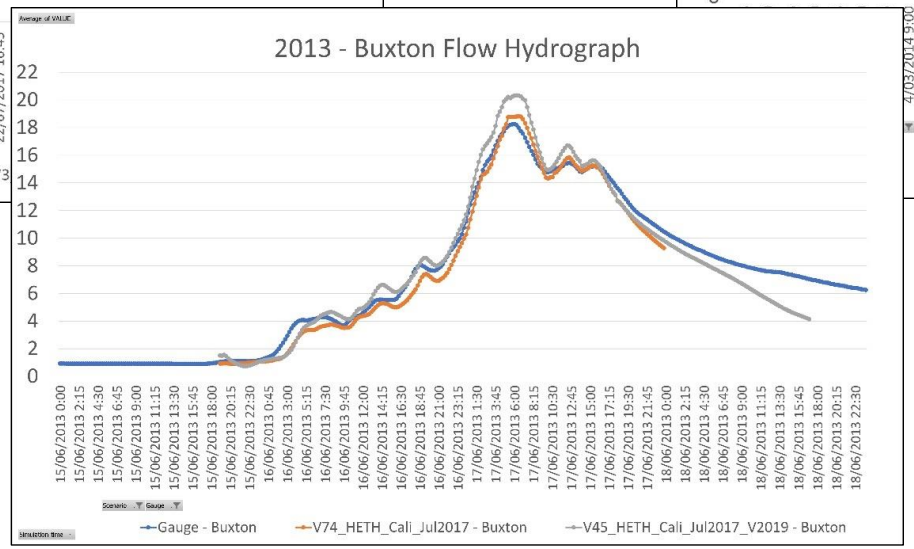
- 22 Water Level gauges
- 11 of which include flow
- +6 pipe gauges covering depth and flow
- Debris marks
- Flood snapshots
- Radar rainfall used



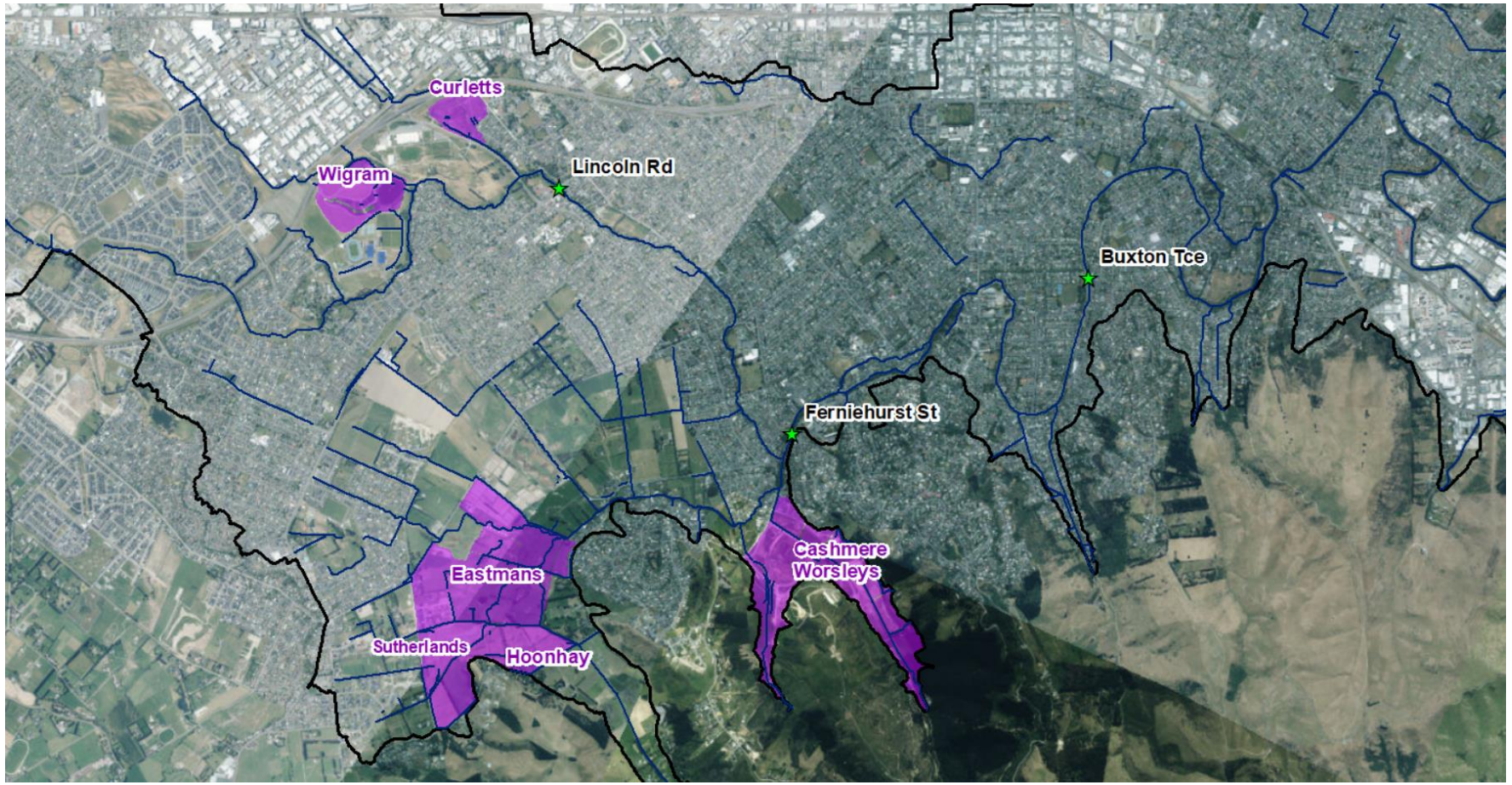
Calibration at Buxton Terrace





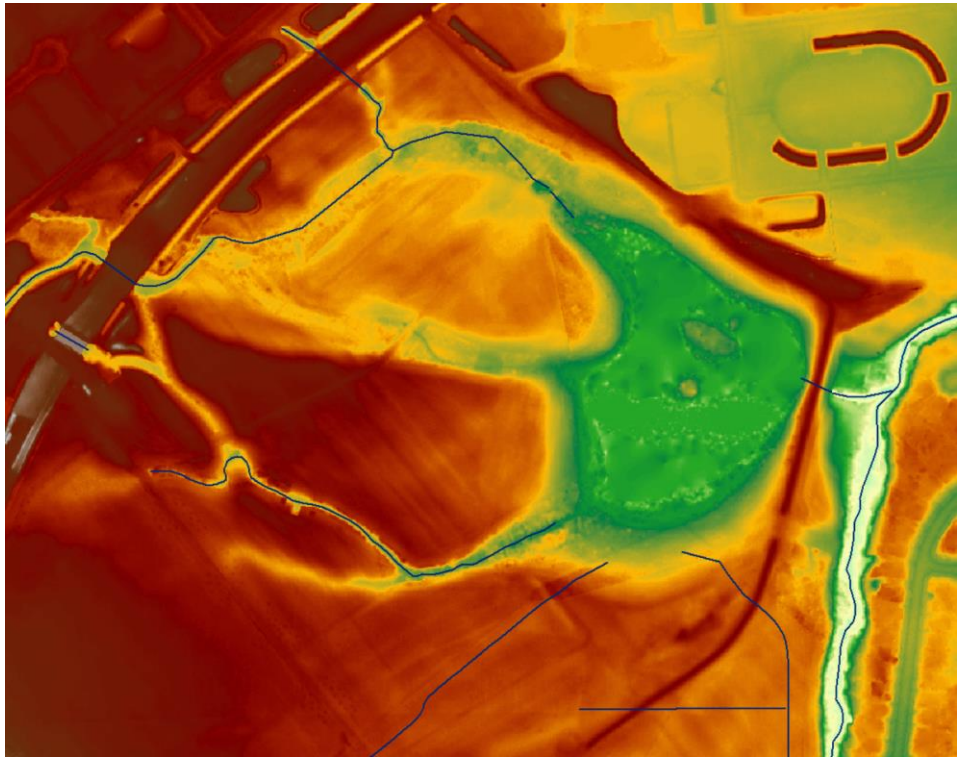


The Basins

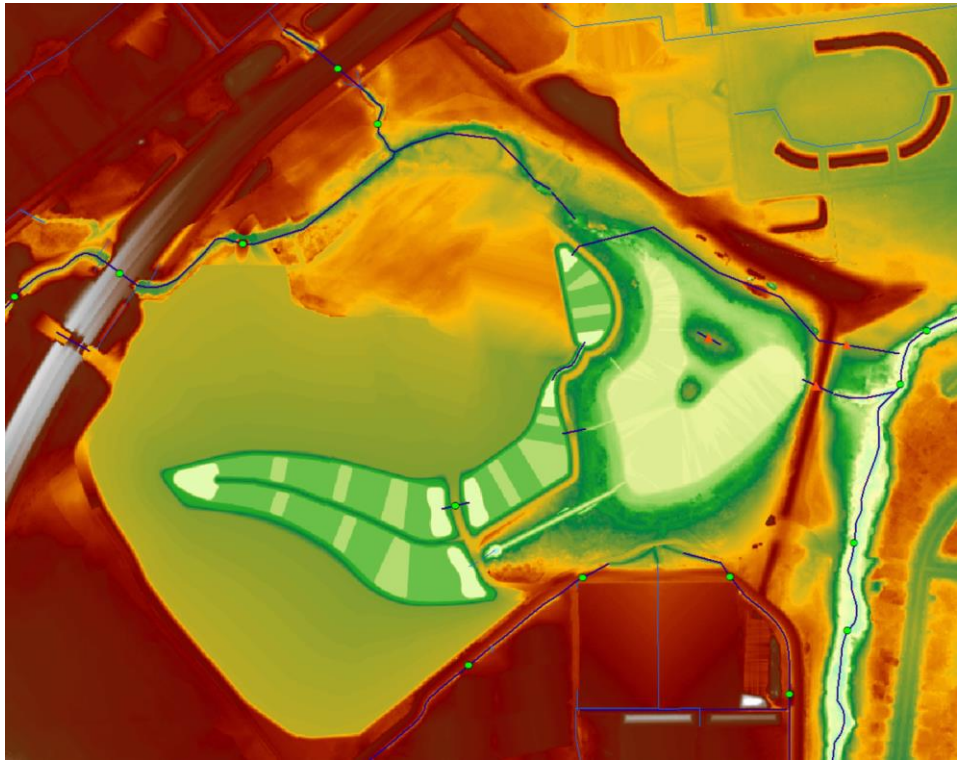

Curletts
Wigram
Lincoln Rd
Buxton Tce
Ferniehurst St
Cashmere
Worsleys
Eastmans
Sutherlands
Hoonhay

Wigram

2011 LiDAR

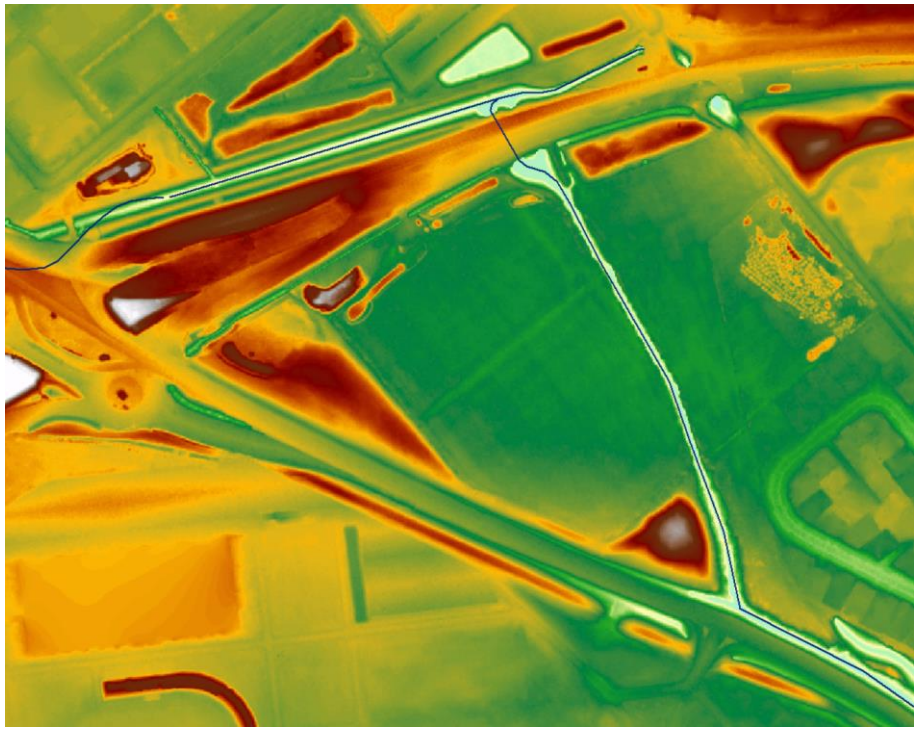


2023 model

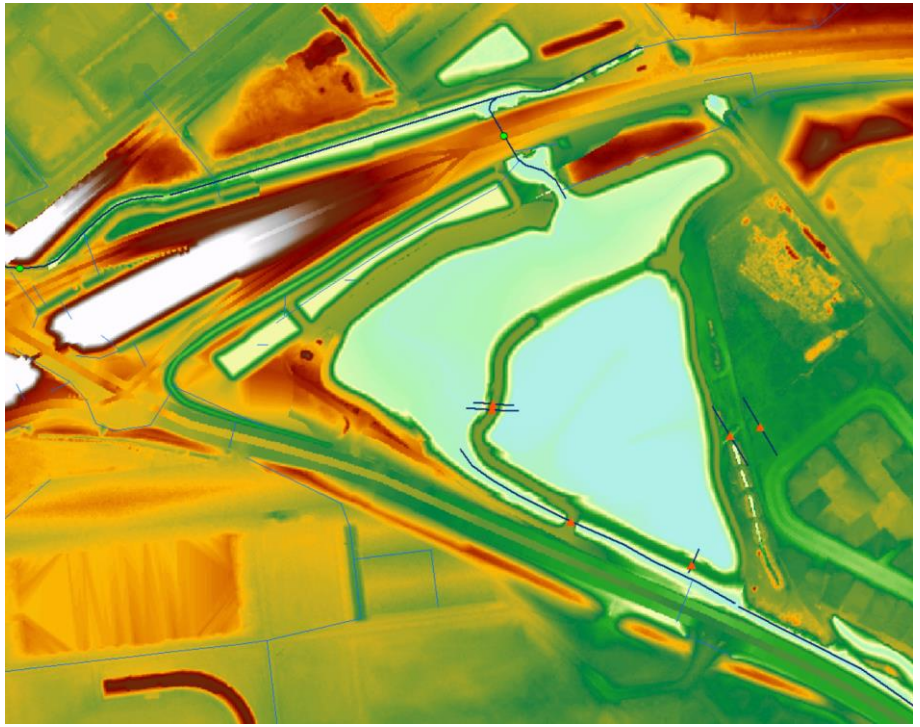


Curletts

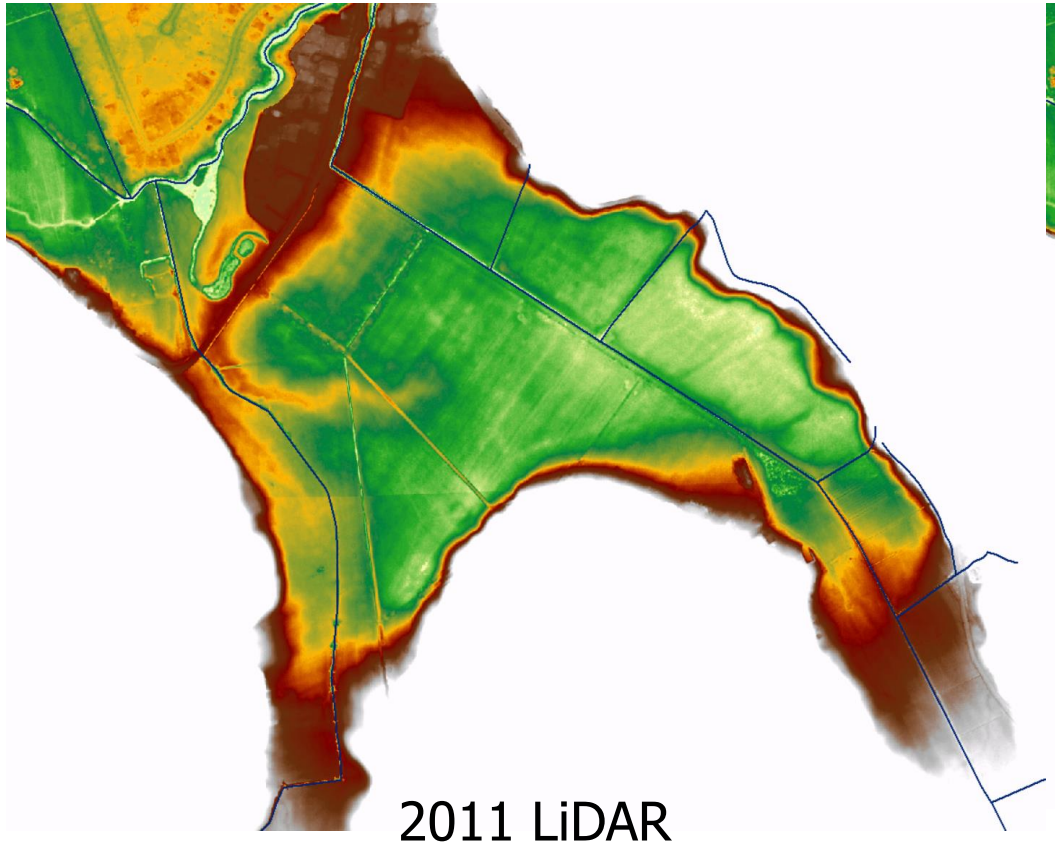
2011 LiDAR



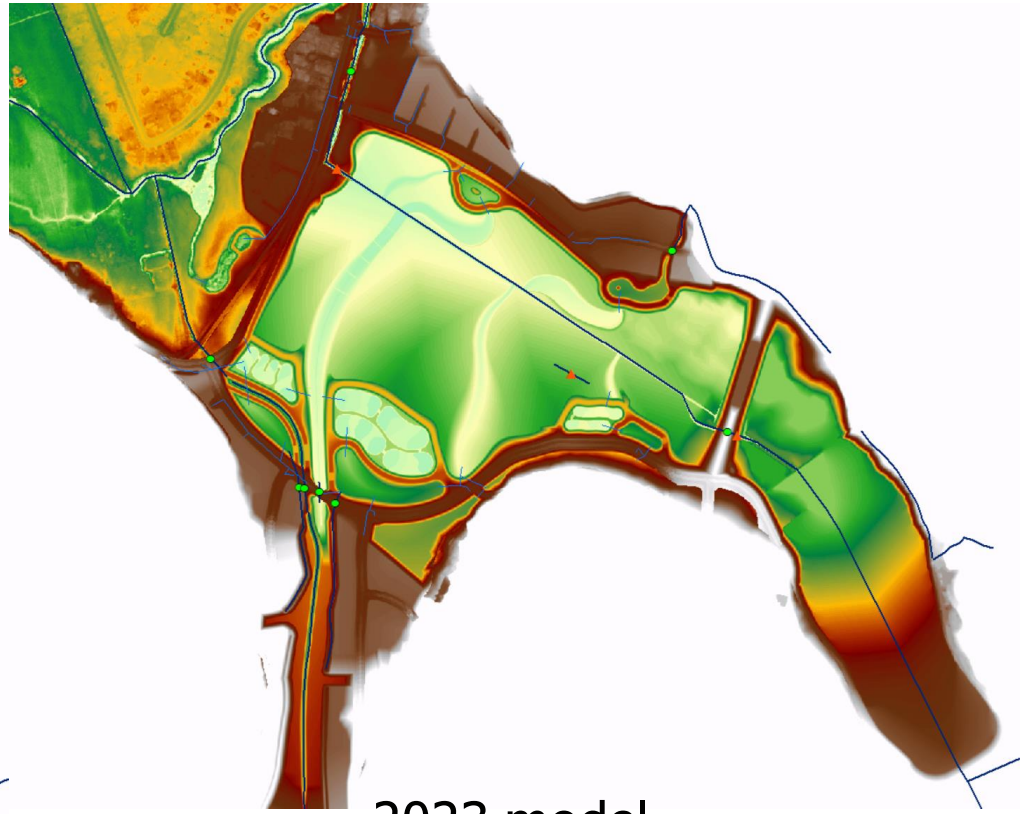
2023 model



Cashmere Worsleys

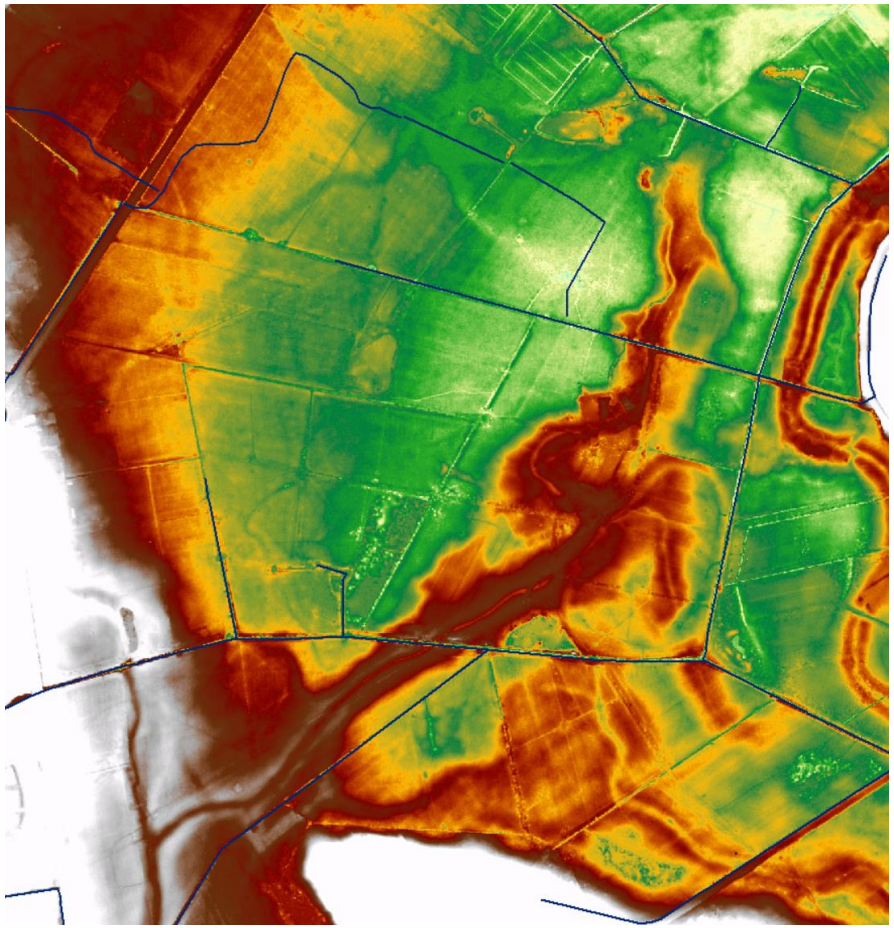


2011 LiDAR

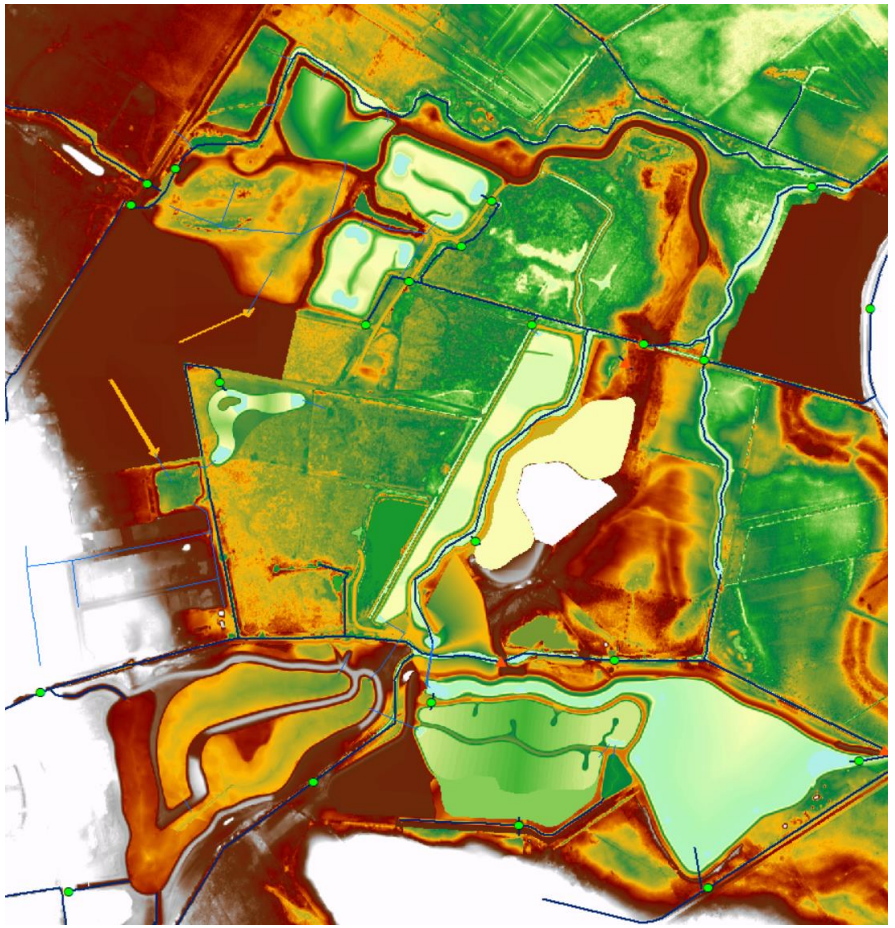


2023 model

Eastmans/Sutherlands/Hoonhay



2011 LiDAR



2023 model

Active Basin Management

Active management - Objectives

- Scheme based on a "Functional Description" document (Jacobs/CCC)

- Reduce flooding downstream, by specific levels for at risk properties and roads
- Reduce basin spillway overflows
- Avoid rapid changes in water level / flow
- Recover storage within a specific time
    - ~4 day limit for vegetation

Active Management

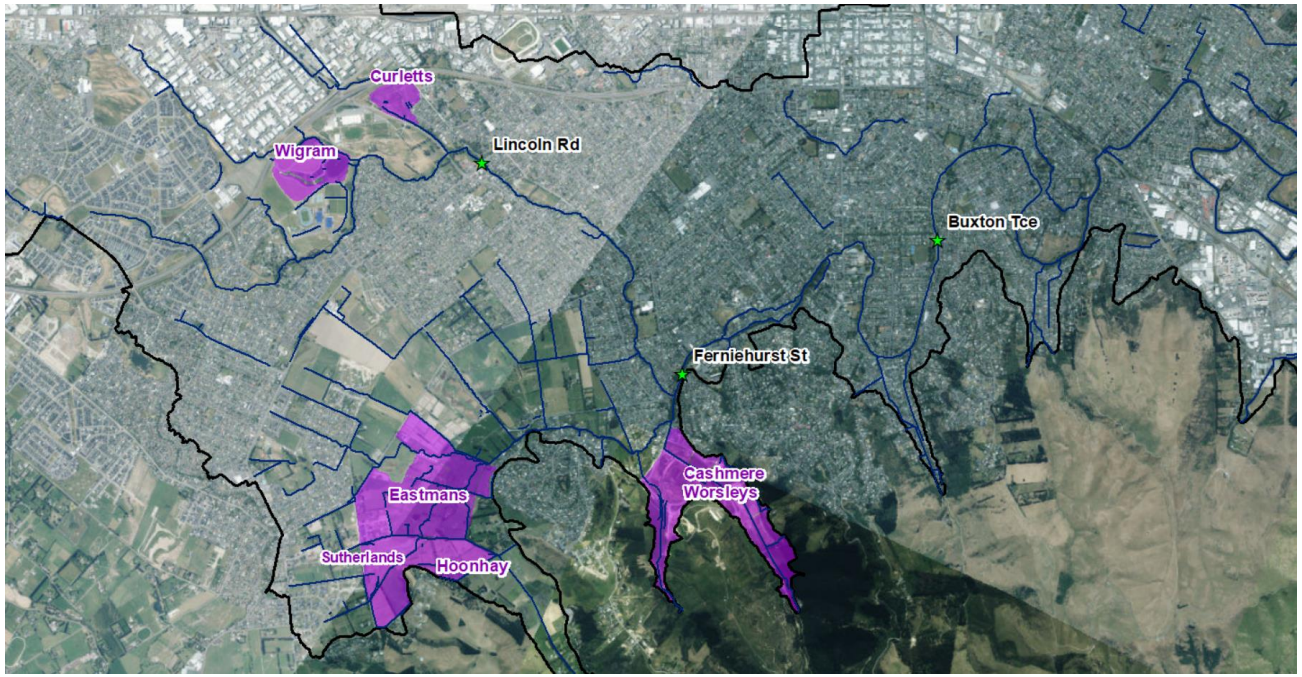
Standard Operating modes:

- Normal Operation – default operating mode.
- Storage Activation – gate closure is activated on high river level.
- Storage Management – gate position control to prevent overflows/flood.
- Storage Recovery – the controlled basin discharge sequence.

Active Management

Sensor Locations

- In basins
- Directly downstream of basins
- Ferniehurst St
- Buxton Terrace
- Lincoln Road



Active Management

How we modelled it?

- Control gates with “if-else” statements
- Links gate operation to the water level sensors
- For complex rules we used special variables
- At each timestep the model makes checks to change gate levels or variable states

Example: Wigram Gate 1

If-Else Statement

Storage management + Emergency control

1. If the Wigram pond WL > 25.5 then apply 50% scaling to the outlet Qh relationship – Table A.

Note when Table A reaches 25.6m, the Emergency control activates, which opens the gate fully.

Example: Wigram Gate 1

Storage activation

2. If Heathcote - Downstream of Wigram gate >22.5 & **Lincoln trigger** = 0 then close the gate - stops this priority from working after the flood activation, so it won't occur during recovery
3. If Lincoln > 21.3 then close the gate

Lincoln Trigger Variable

Initial value = 0

1. If Lincoln WL > 21.3 then value = 1
2. Else value = 1

This trigger will only activate once, the first time Lincoln rises above 21.3m.

Example: Wigram Gate 1

Storage Recovery

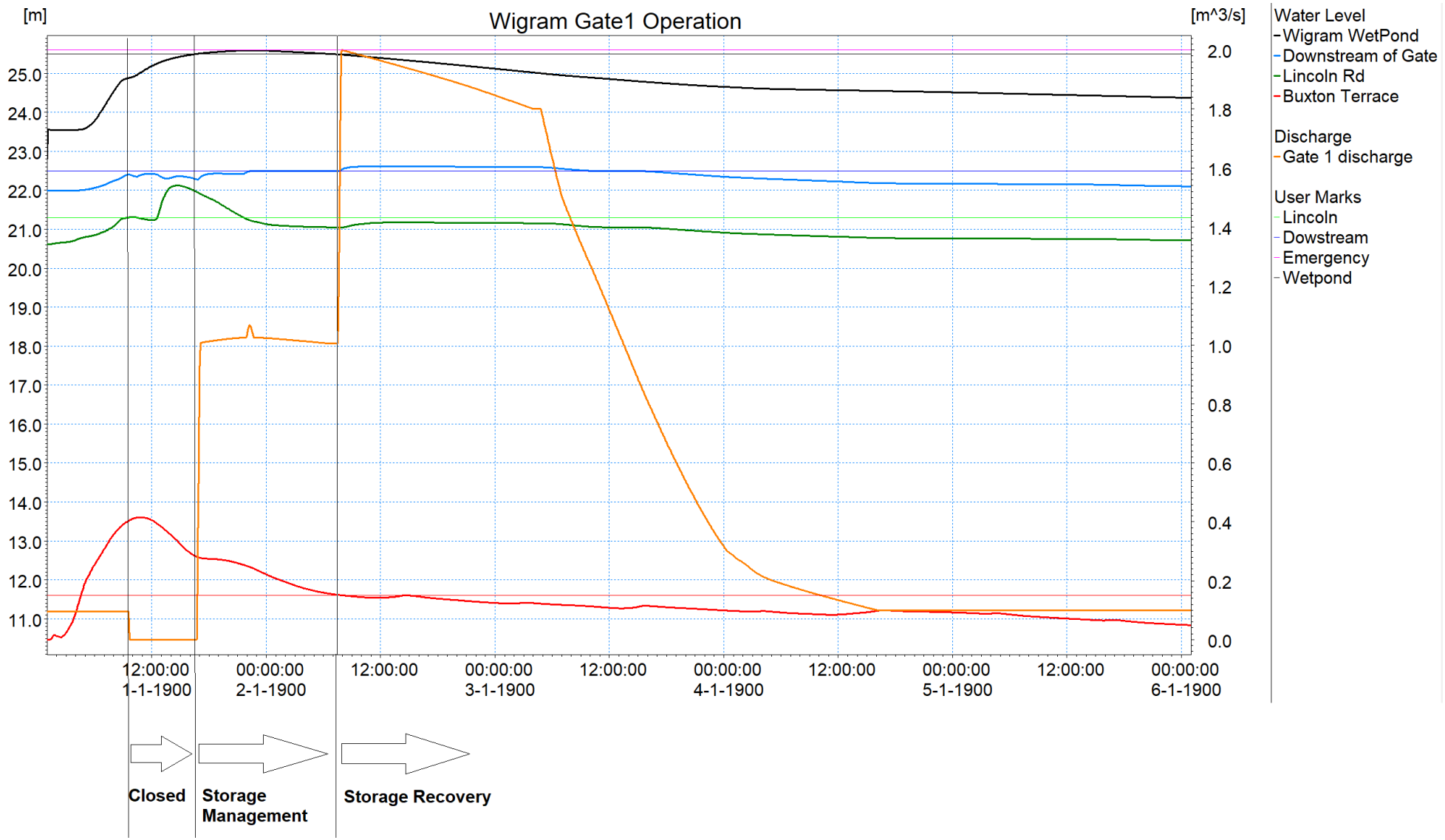
4. If Lincoln <21.3 and Wigram WL < 25.5 AND Buxton <11.6 and then

   Multiply the **Wigram Scale Factor** by the Qh relationship for this outlet, Table B.

Else Unchanged

Wigram Scale Factor Variable – This is scale factor which is used for the main gate logic. Values 0-1 represent the scaling factor.

1. Unchanged – only initiate a change in the scale factor every 15 minutes
2. If Lincoln WL > 21.25, reduce scale factor by 5%
3. If Lincoln WL < 21.2, increase scale factor by 5%
4. Else Unchanged


Wigram Gate1 Operation
[m]
[m^3/s]
25.0
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12:00:00 1-1-1900
00:00:00 2-1-1900
12:00:00
00:00:00 3-1-1900
12:00:00
00:00:00 4-1-1900
12:00:00
00:00:00 5-1-1900
12:00:00
00:00:00 6-1-1900
Closed
Storage Management
Storage Recovery
Water Level
Wigram WetPond
Downstream of Gate
Lincoln Rd
Buxton Terrace
Discharge
Gate 1 discharge
User Marks
Lincoln
Dowstream
Emergency
Wetpond

Challenges

Main challenge was to match the model to the Functional description and what is being built on the ground

- Switching between modes was often done implicitly in the logic
- Models may respond more efficiently than real controllers
- Considering all possible scenarios of relative flood timing
- Feedback loops – gate hunting

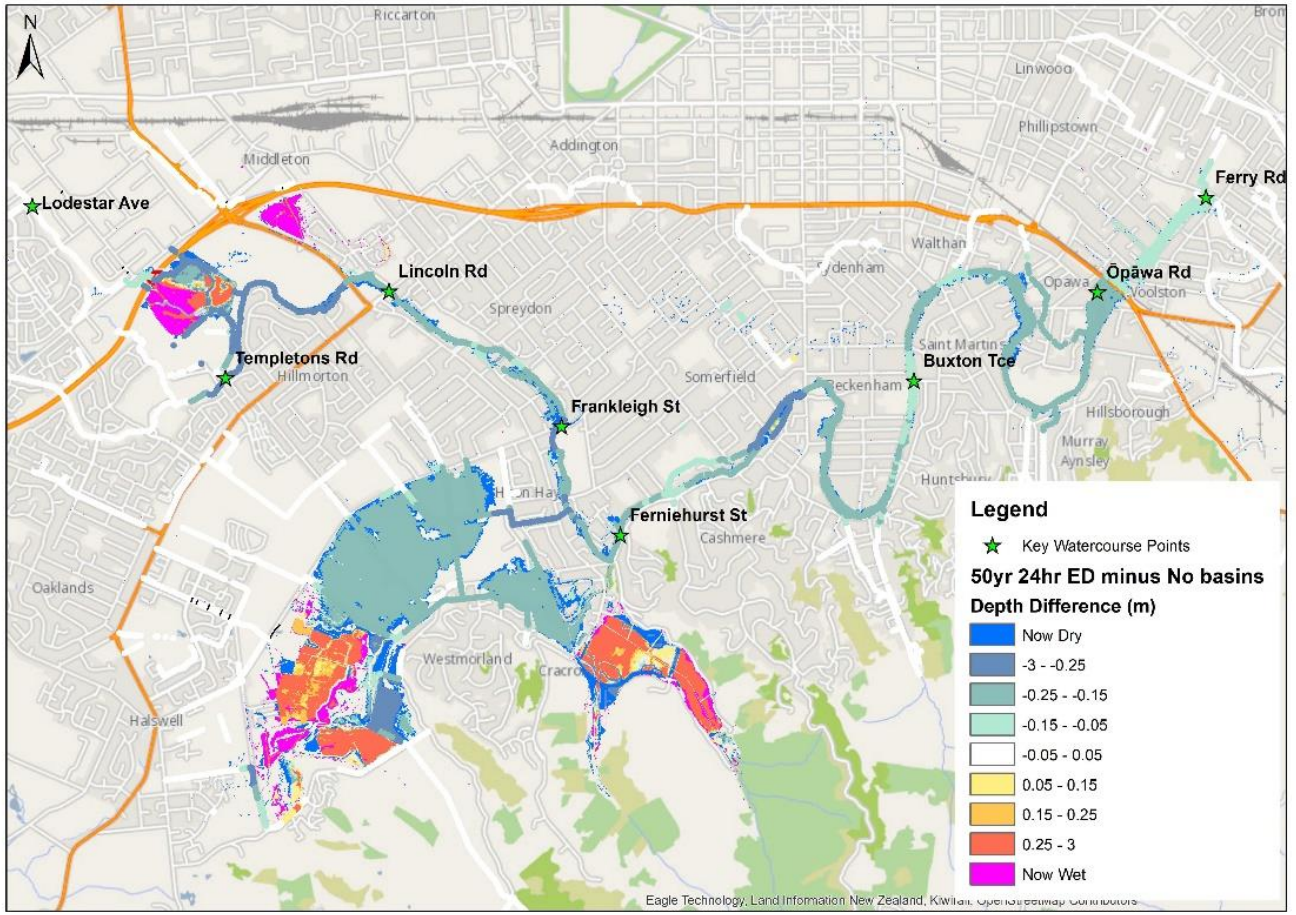
Benefits

Showing overall benefits of scheme

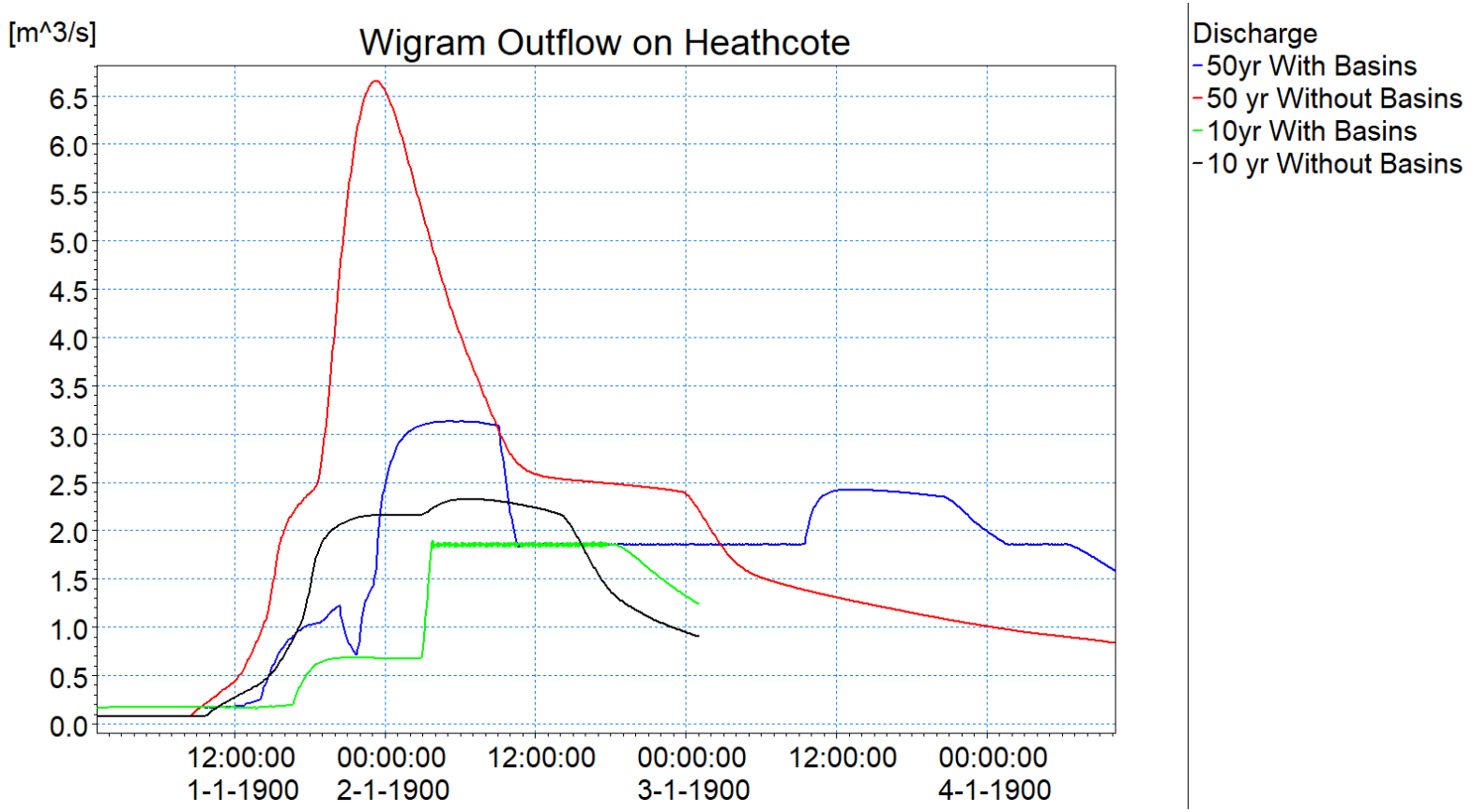
- Setup a model with the key 4 basins reverted to a "pre-development" state
- Run for the 24hour duration for the 10 year and 50 year ARI's
- Results show reduced peak flow and water levels in the Heathcote between Wigram and Opawa
- Benefits were similar to those predicted using the older models

Results

	Difference (mm)	
Location	Diff 50yr	Diff 10yr
Templetons Road	-490	-80
Lincoln Road	-230	-520
Frankleigh Street/Sparks Road	-340	-330
Ferniehurst Street	-220	-530
Buxton Terrace	-140	-240
Opawa Road Bridge	-190	-100
Ferry Road upstream of Radley Street	-60	-30



Comparison at Wigram



Future work

- Further optimisation of scheme
- Testing alternate scenarios – i.e. different rainfall patterns
- Improving gate hunting, and other undesirable features
- Ongoing model improvements

Conclusions

- Modelling predicts that the basins improve flood levels significantly along the Heathcote
- Active management was setup in the model to replicate a real life gate operation
- Having a modelling tool has allowed CCC to make many decisions on the layout and setup of these gates
- The model can be used in the future to further optimise the system and test alternate rainfall scenarios and gate settings

Acknowledgements

Special thanks to

Christchurch City Council (Martin Densham PM)

Peter Christensen (Storm Environmental / CCC consultant)

Damian Debski (Jacobs)

All consultants working on the basin designs and other things behind the scenes

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Thank you!
Questions? Patai?

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