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Calibration of runoff-routing models for the Port Hills catchments

May, 24, 2018

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Calibration of runoff-routing models for the Port Hills catchments

Sally Williams and Mark Passier

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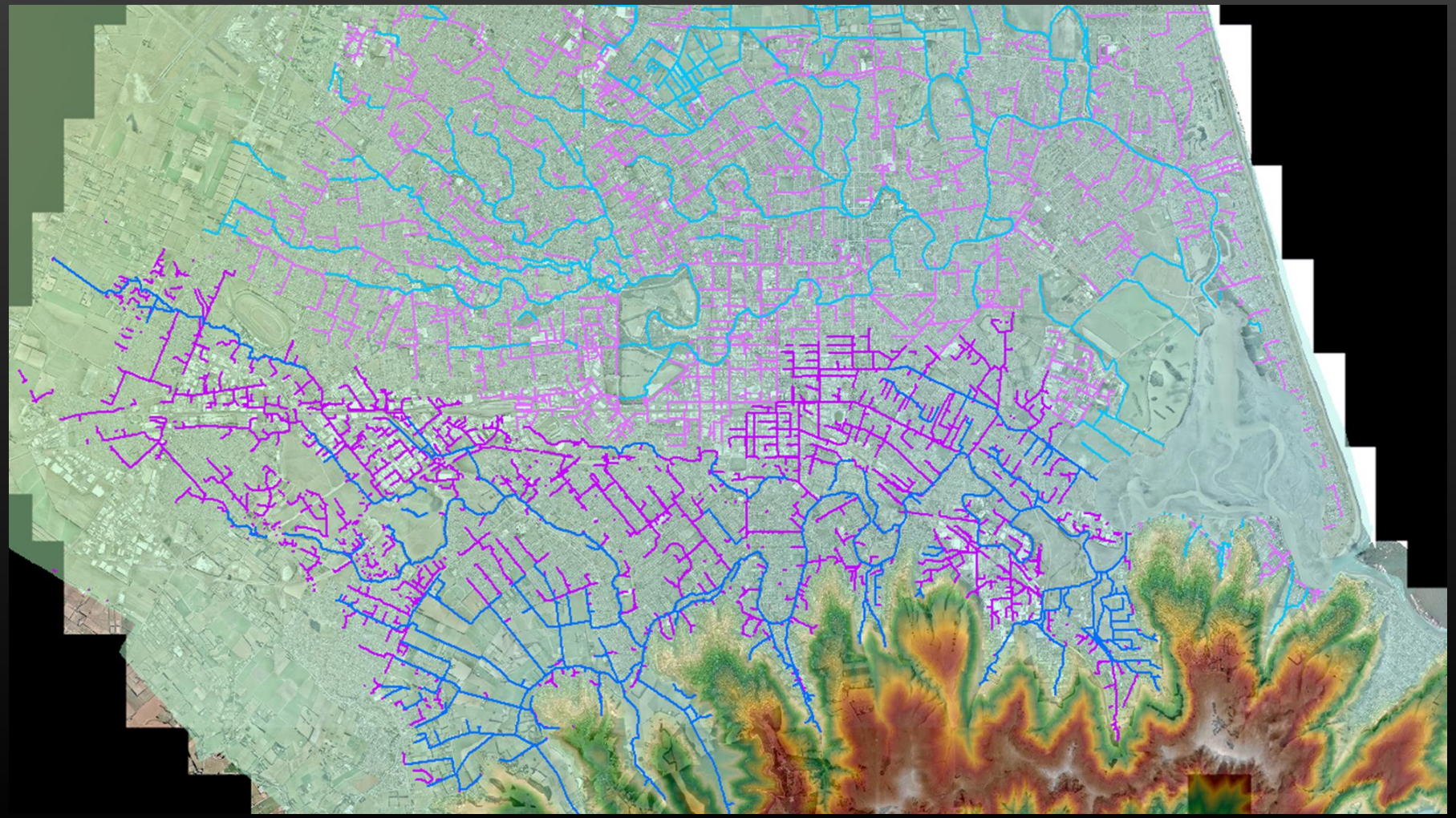
Truth

- RORB model (non-linear runoff-routing) provides good calibration following parameter fitting
- Design event magnitude is reasonable against flood frequency analysis
- Whatever surface water-groundwater complexities may exist, non-linear routing models work for the Port Hills

Dare

- Use of rain on mesh requires some caution
- Fertile ground for developing the use of RORB (and similar) non-linear routing models in New Zealand
- Gauged catchment studies plus knowledge sharing required for more widespread use

City-wide flood model



A popular history of Port Hills hydrology

4.3 Early March 2014 Storm Event

Rainfall data from the recent 04-05 March 2014 was set up and run for validation purposes. The storm had caused major flooding issues around the city, primary around the east side where the ground levels had settled due to the recent Canterbury earthquakes. The large number of surveyed flood levels and flow records makes it ideal for validating the model.

Recorded rainfall from the Mid Bowenvale rainfall gauge (HSI-325621 at Bowenvale Flume) was employed in this study. The Upper Bowenvale rainfall gauge (HSK-326616) was also modelled and examined. It was rejected as not suitable because the higher runoff generated was not considered as a good representative of the whole Bowenvale catchment. Initial infiltration rates of 10mm/hr and 5m/hr were both modelled.

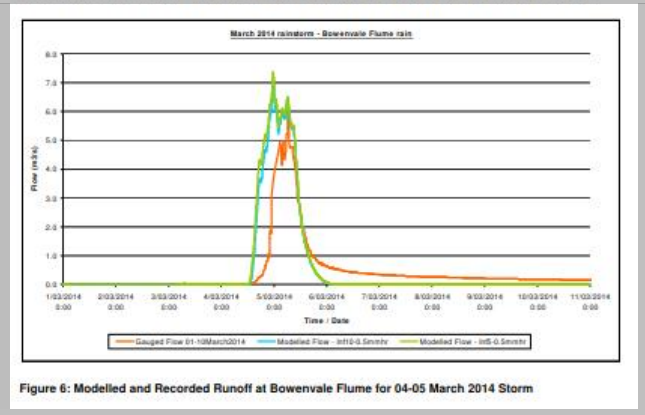


Figure 6: Modelled and Recorded Runoff at Bowenvale Flume for 04-05 March 2014 Storm

Figure 6 and Table 10 compare the recorded runoff at Bowenvale Flume to the modelled runoff. The runoff figures and resulting hydrograph show that there was little difference using different initial infiltration rates, although both sets of infiltration generated noticeably more runoff than what was recorded. The trailing edge of recorded hydrograph also suggested a slower infiltration decay than what was assumed in the model. The differences were thought to be affected by the antecedent wetness, with significant higher wetting (0.02mm modelled) and storage losses (2.0mm modelled) than what was assumed.

Table 10: Recorded vs. Modelled Flows

	Recorded flow	Modelled Infiltration rate	
	Site HSI-325621	10 – 0.5 mm/hr	5 – 0.5 mm/hr
Accumulated (m3)	345,951	406,611	432,813
Peak flow (m3/s)	5.98	7.03	7.37

DHI

For calibration, there are continuous water level records from three locations in the Heathcote River: Ferniehurst St, Buxton Terrace and the Opawa footbridge. A flow-water level rating at Buxton Terrace is regularly established from flow gaugings and provides a continuous rated flow record there. Flows are recorded at a flume in Bowenvale Stream. Bowenvale is one of several steep Port Hills tributaries of the Heathcote River, and its runoff might be expected to be representative of that from all those catchments.

The calibration process

With the model already calibrated to replicate the Buxton Terrace rating curve, calibration has comprised adjusting rainfall and runoff processes to replicate flow and water level hydrographs.

Calibration of Bowenvale runoff

First, the flow record at Bowenvale Flume (scaled up to account for the difference in catchment areas) was compared with the modelled runoff from the Bowenvale catchment. The comparison is incomplete, due to a gap in the flume record on 4-5 March. However, it is apparent that rainfall losses early in the event are higher than the existing model provides. An adjustment was therefore made to the initial loss in the Bowenvale catchment, an increase from 10mm to 29mm.
In addition, the maximum (i.e. initial) infiltration rate for this catchment has been increased from 5.04 mm/hr to 7.2mm/hr. These adjustments provide a reasonable match of the onset of runoff (Figure 1) and the later hydrograph, with the minor early modelled runoff attributable to impervious (urban) catchment areas downstream of the flume.

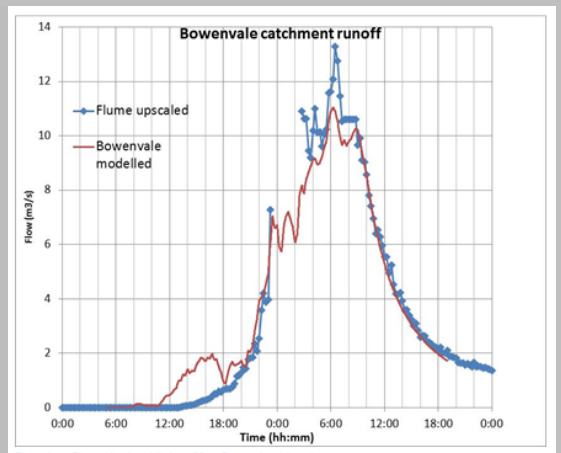
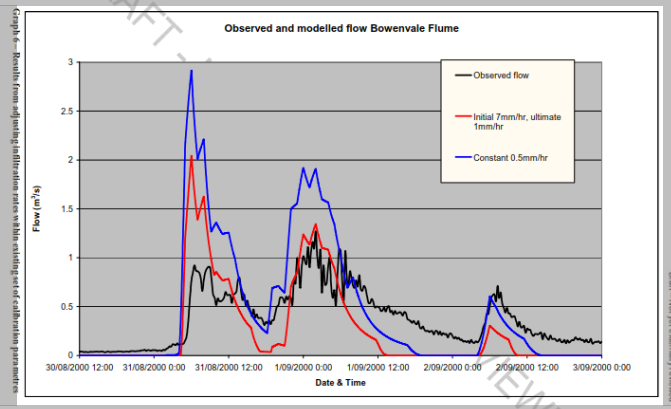


Figure 1 Observed and modelled runoff from Bowenvale catchment

This adjustment to the initial loss has also been applied to the other three Port Hills catchments upstream of Buxton Terrace. The higher initial loss applying to the March 2014 is presumed to result from dry antecedent conditions at the end of summer.

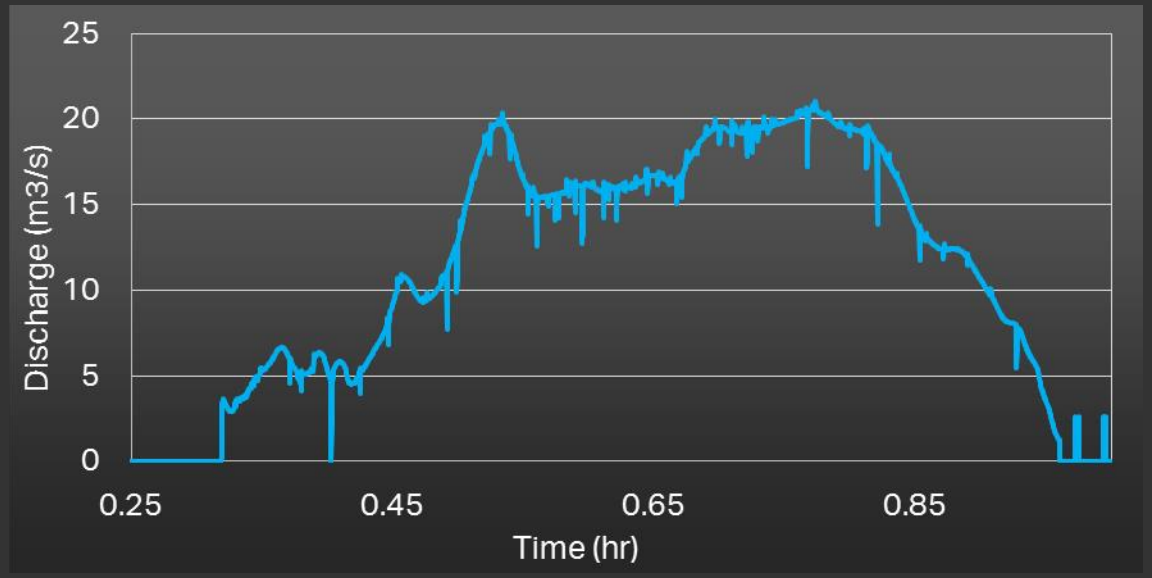


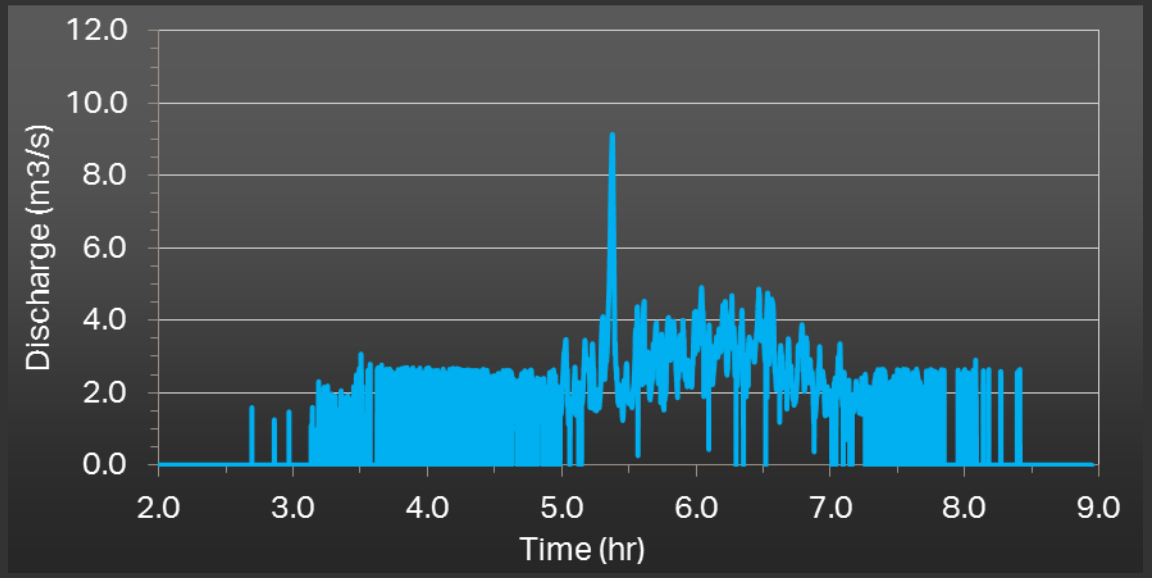
Using rain on mesh hydrology

- Excellent representation of physical catchment variables

…but initial outcomes not so good

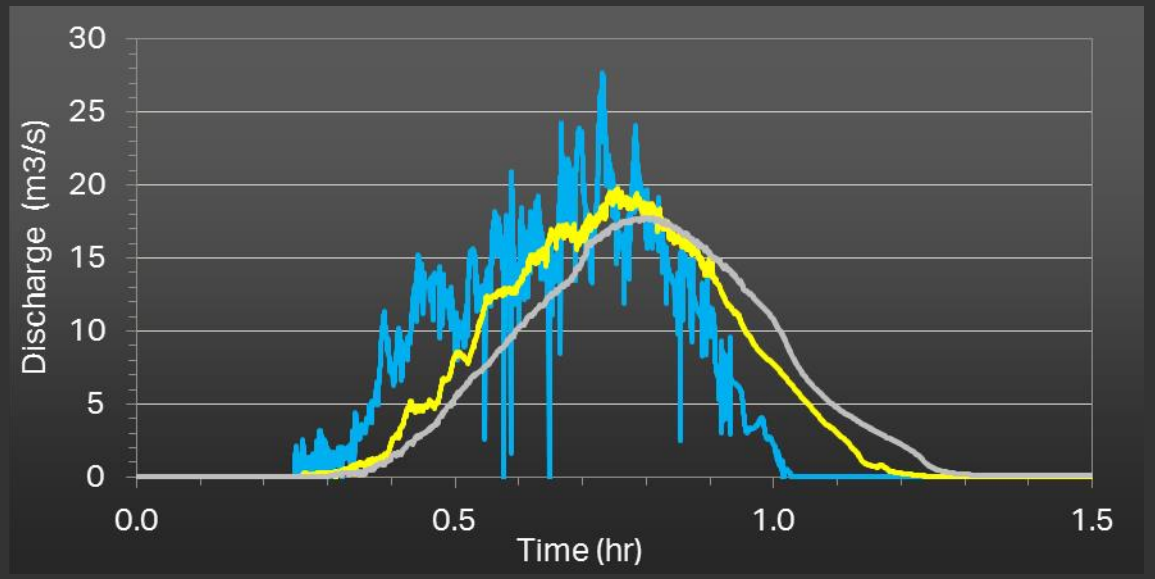
- Surface roughness the only variable with connection to hydrological theory
- Questionable rainfall runoff response plus oscillatory behaviour
- Rainfall characteristics very influential, so outcomes variable

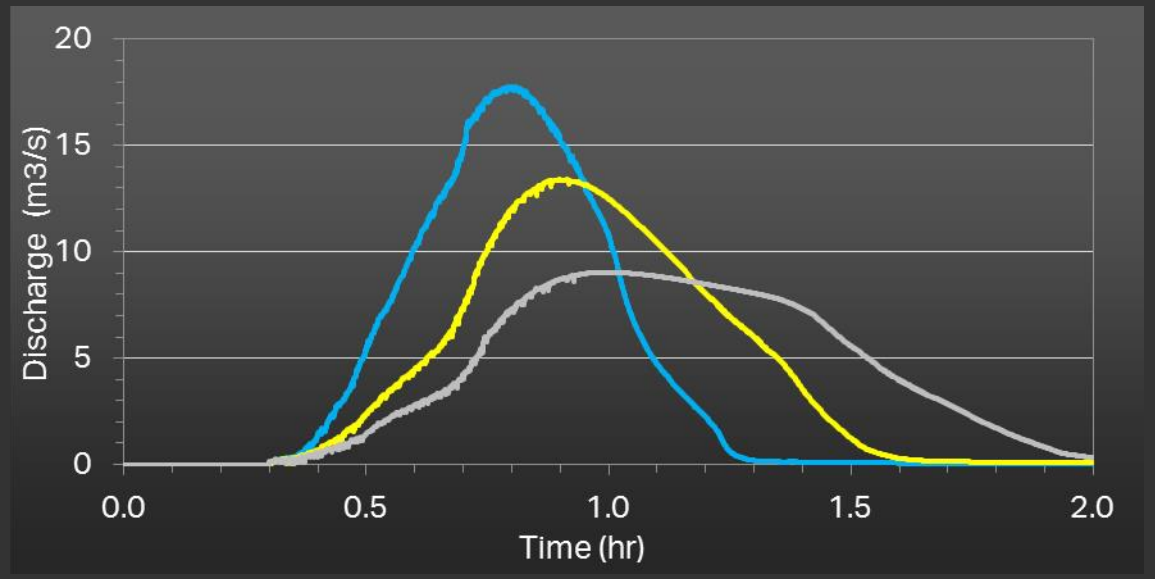




Using rain on mesh hydrology

- If you break the rules, life gets a little easier!



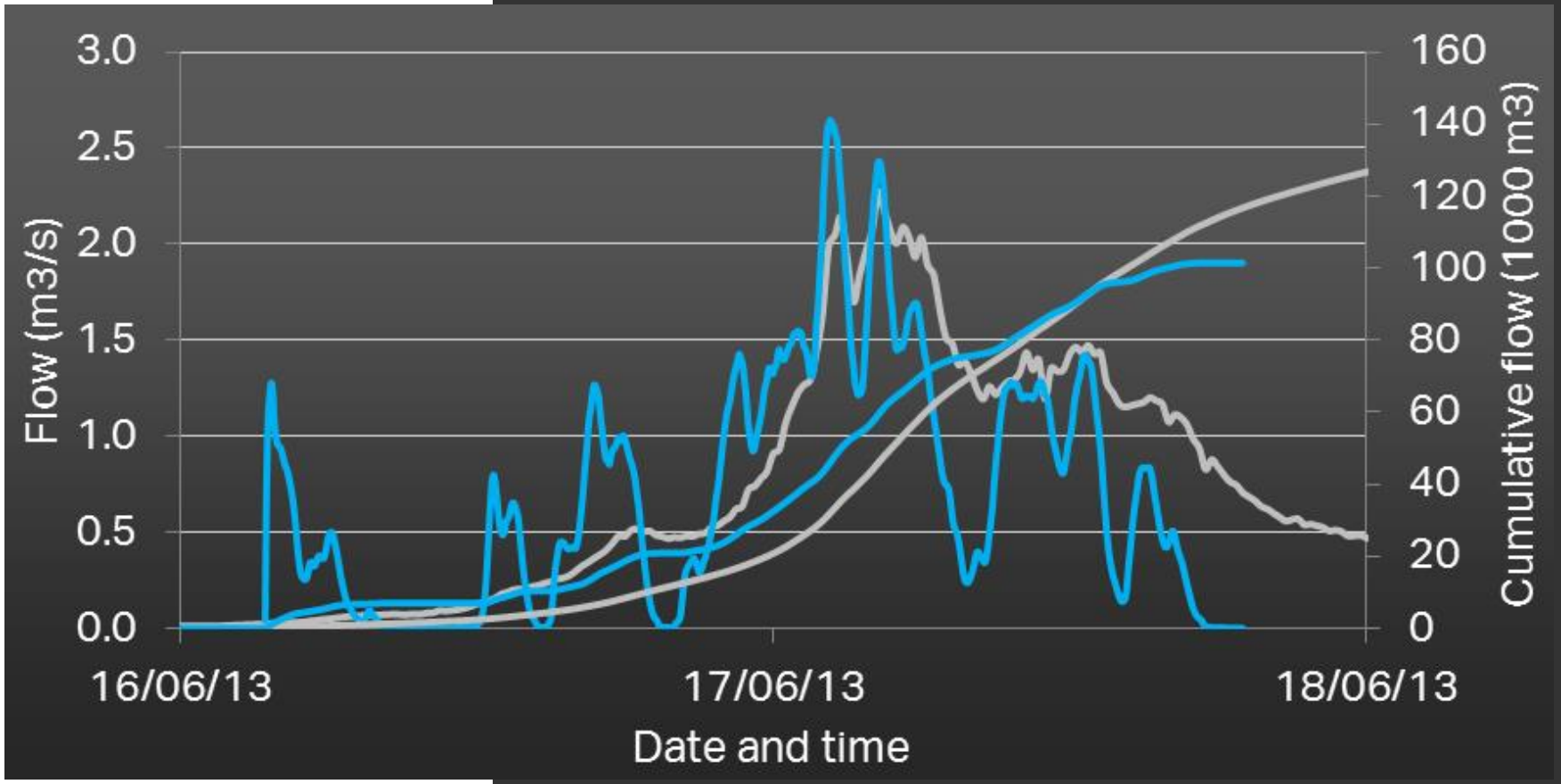


vexatious

ADJECTIVE

1. Causing or tending to cause annoyance, frustration, or worry.

Oxford English Dictionary

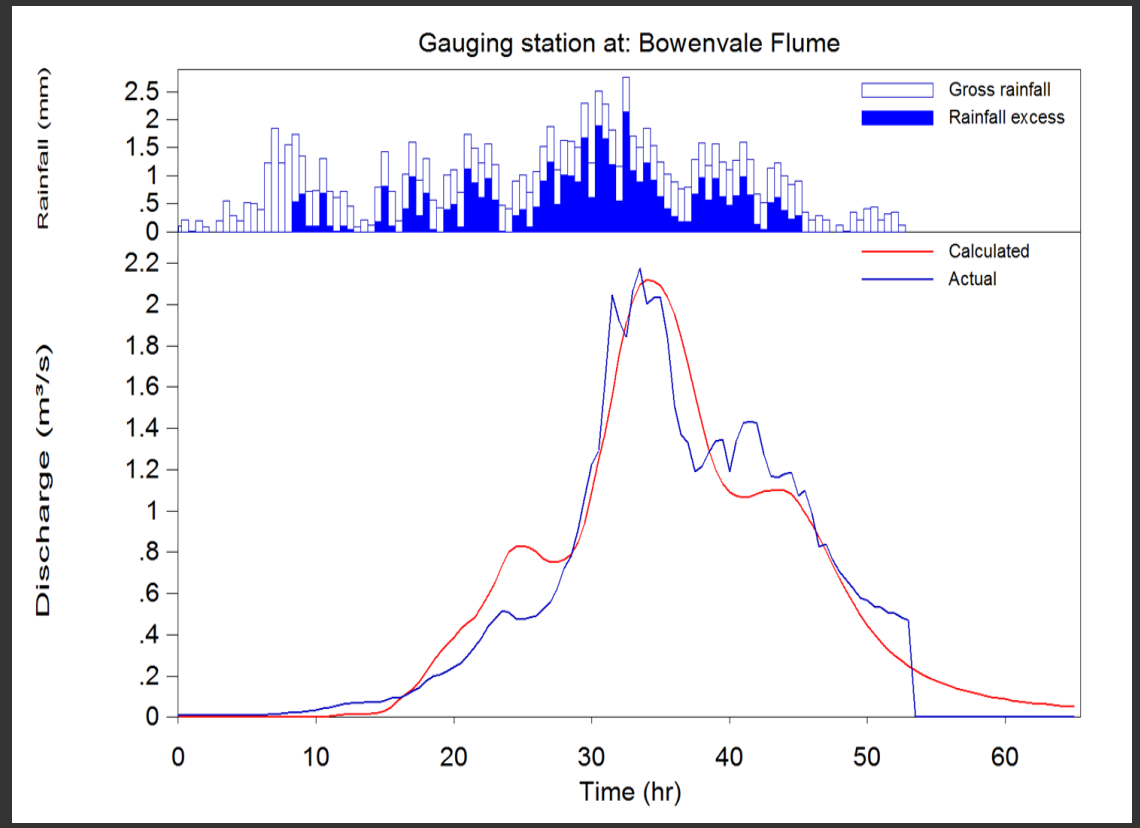


A surface hydrology problem?

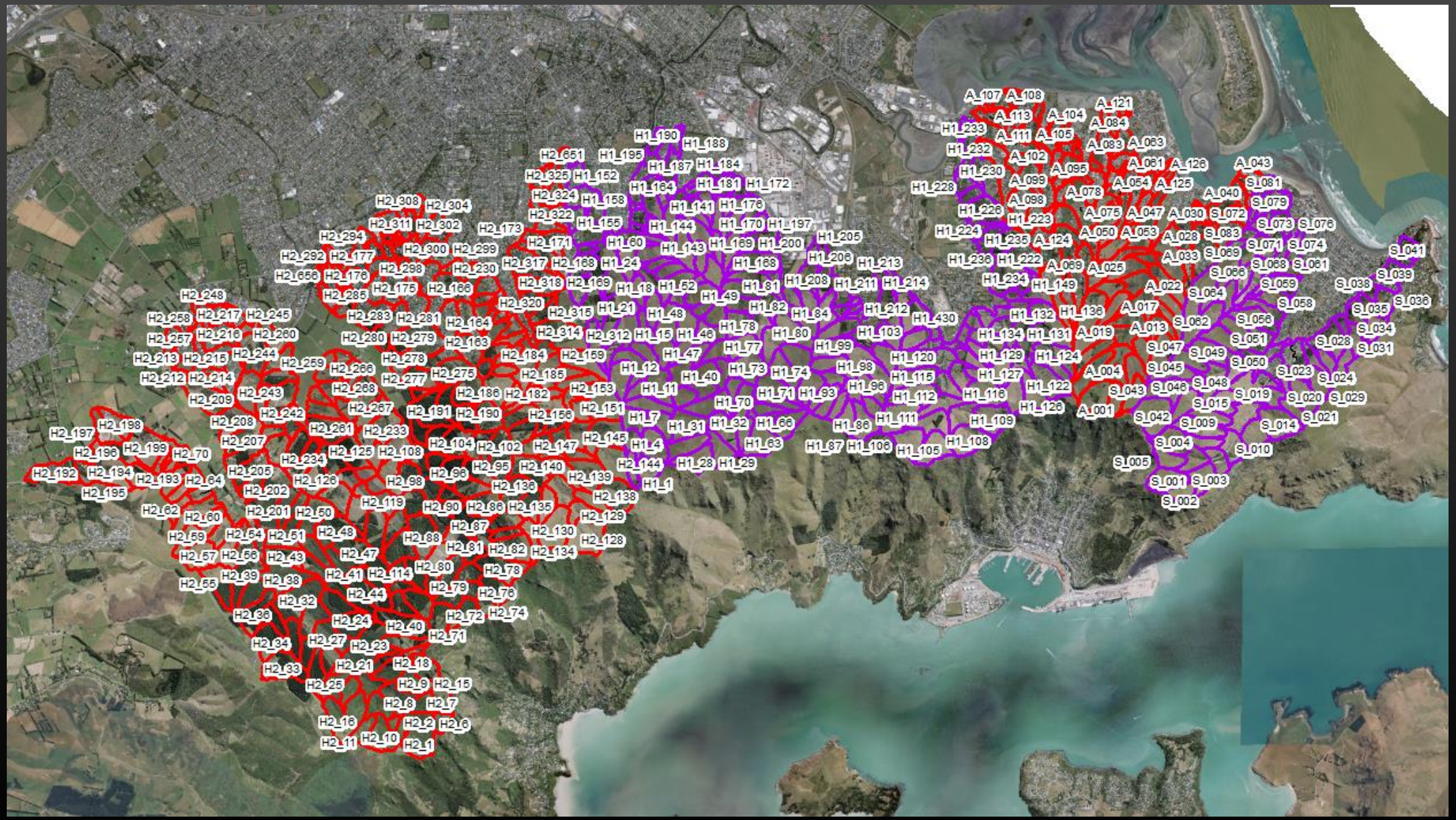
- If not a surface hydrology problem, a surface hydrology model would perform poorly
- XP-RAFTS and RORB non-linear routing models

… a good outcome

- Complexity does not require modelling explicitly



RORB model development

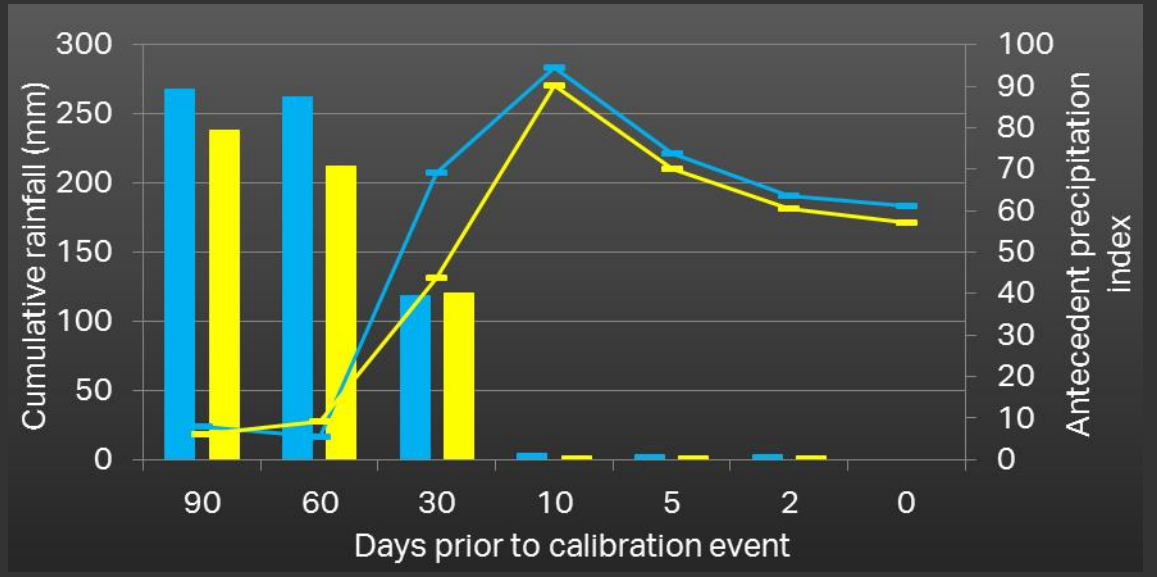


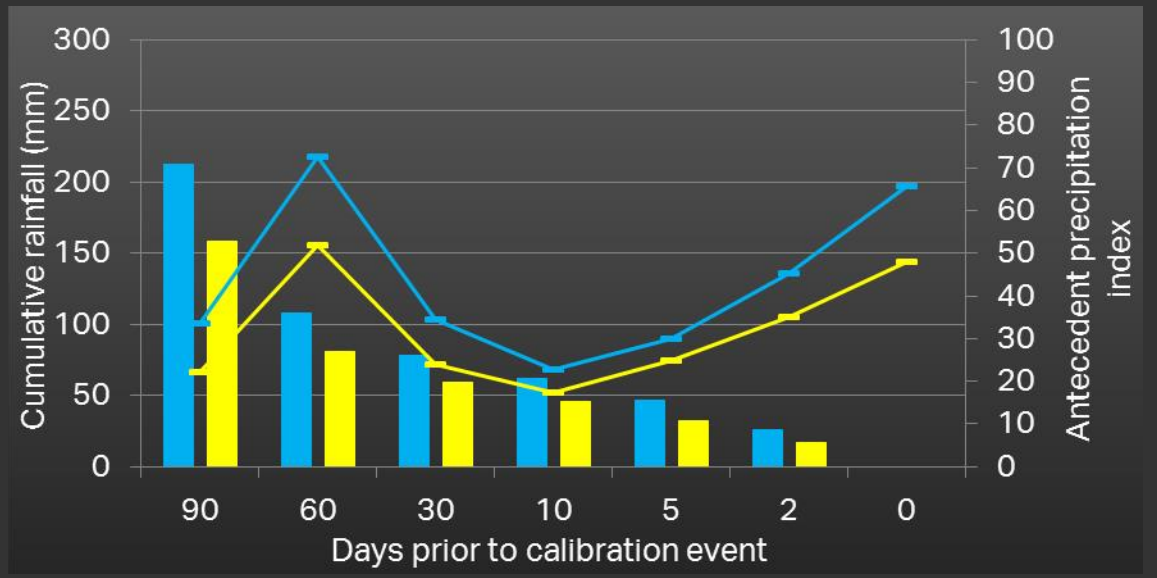
RORB model calibration

- Anecdotally:
  - 2013 = “wet antecedent conditions”
  - 2014 = “dry antecedent conditions”

- Reality:
  - 2013 = “a wet year but dry prior to flood”
  - 2014 = “a dry year but wet prior to flood”

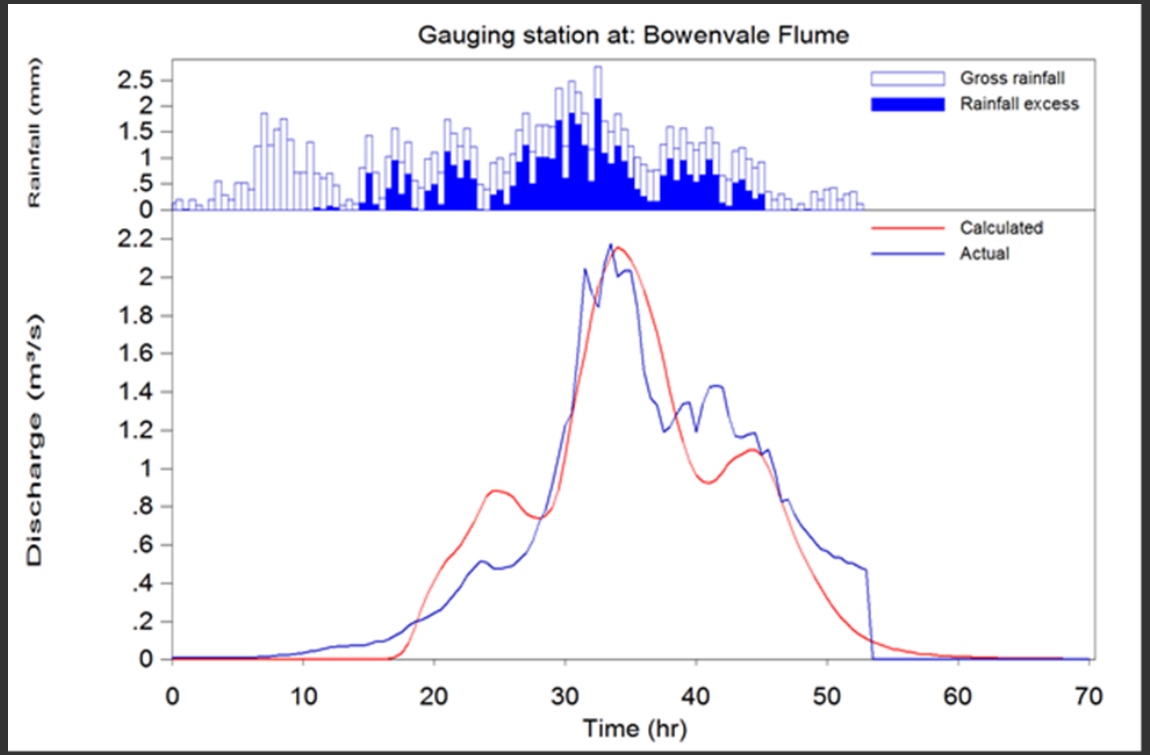
- API similar for both events!





Parameter fitting

- Loss parameters
  - IL 17.5 mm and CL 1.25 mm/hr give best match of hydrograph volume
- Routing parameters
  - k_c = 2.0
  - m = 0.8

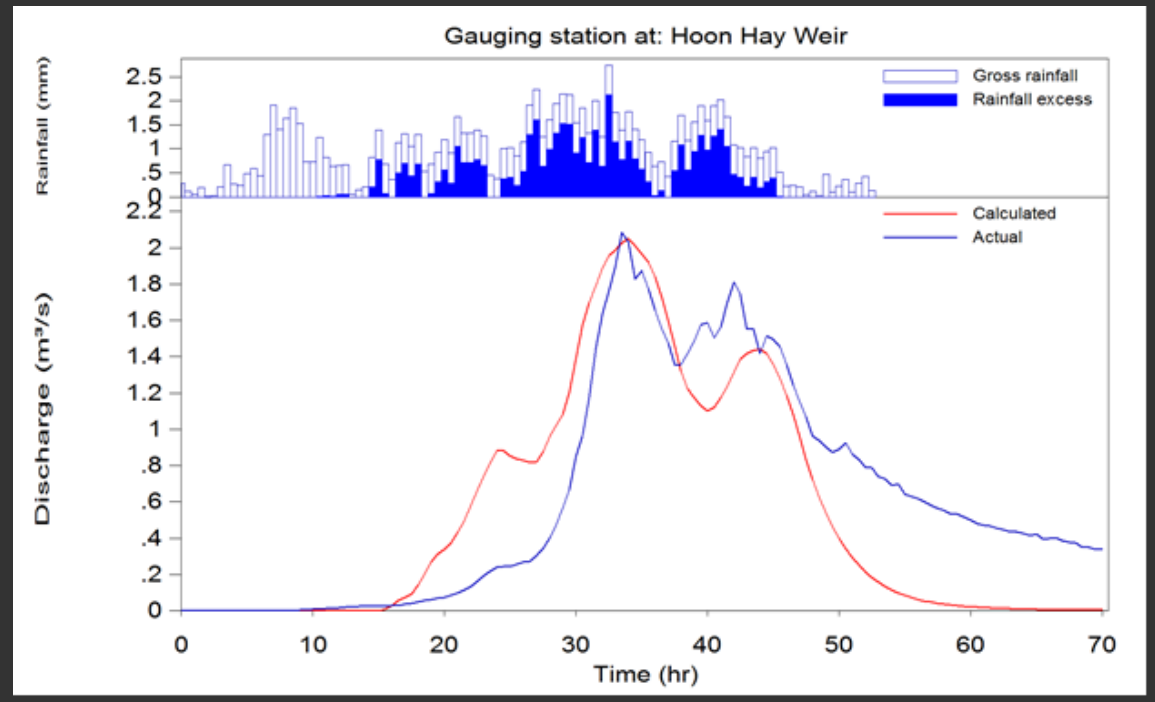


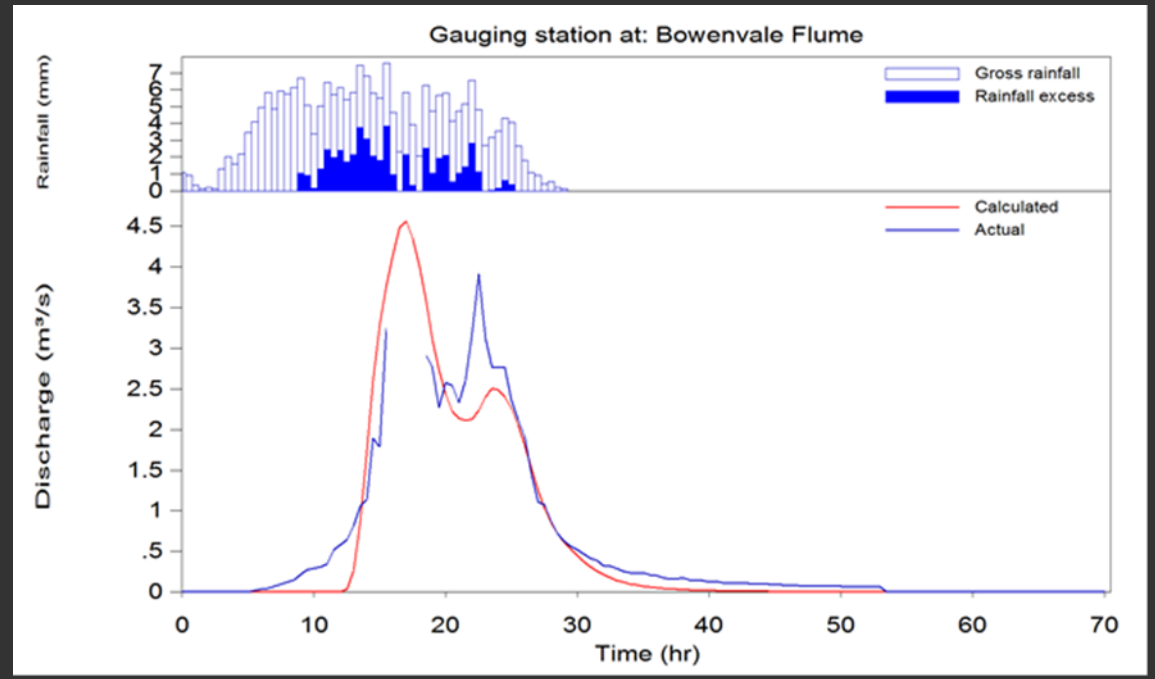
Parameter	Calculated	Actual	Error (%)
Peak discharge (m^3/s)	2.2	2.2	-0.8
Time to peak (hrs)	34.0	33.5	1.5
Volume (m^3)	0.12 x 10^6	0.13 x 10^6	-2.8
Time to centroid (hrs)	35.4	36.2	-2.3
Lag (mass)	4.6	5.5	-15.3
Lag to peak (hours)	3.2	2.7	18.3

Model validation

- Test 1: Parameters applicable to other hillside catchments?

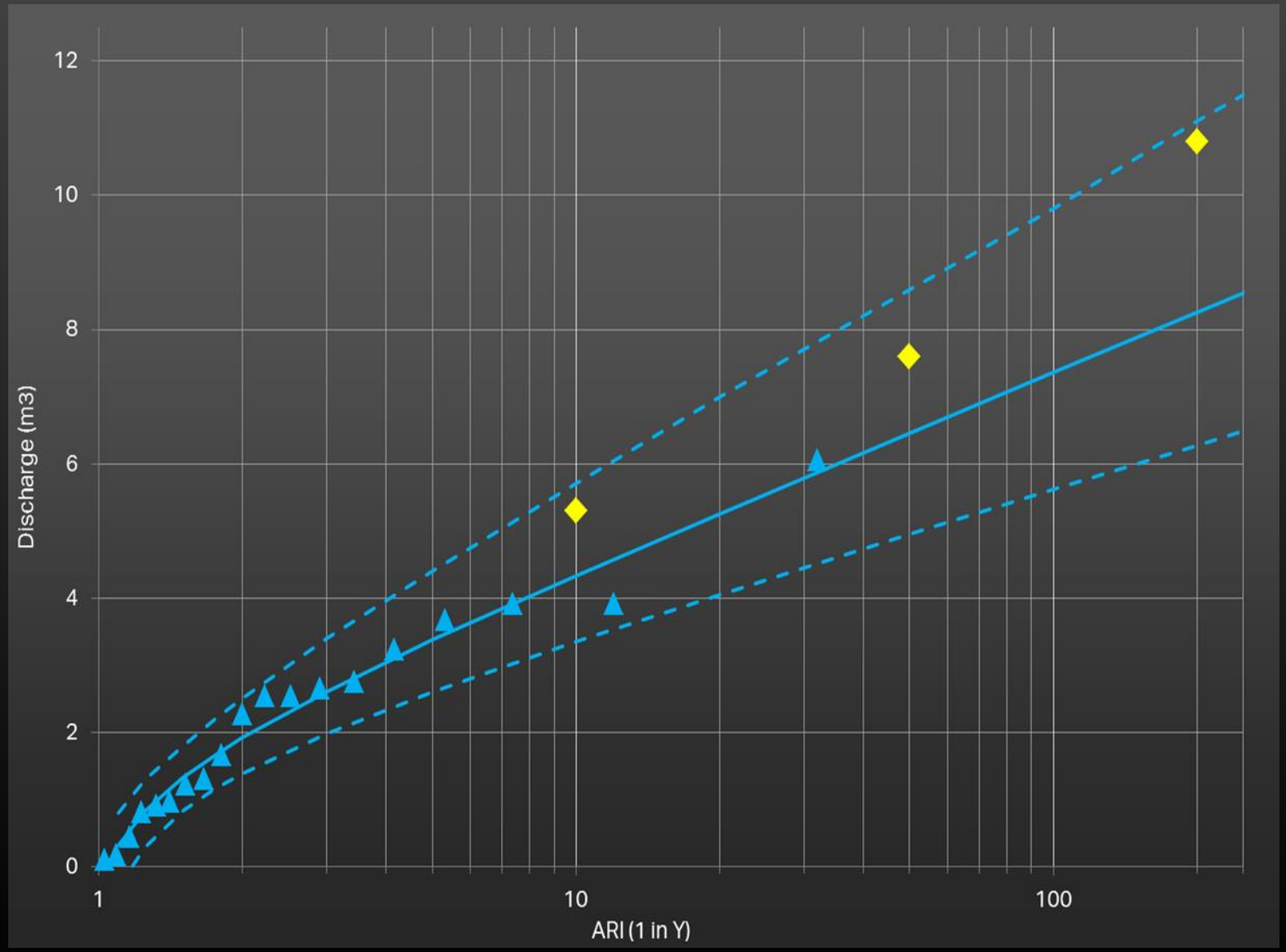
- Test 2 : Parameters applicable to other event?





Flood frequency analysis

- 20 years of gauge data
- Possible rating curve error
- Gumbel distribution best fit



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