MEMO

To:	Chris Bacon
Cc:	Don Young
From:	Antoinette Tan
Project	44801419
Date:	28/05/2020
Subject:	Ashley Breakout Scenarios

The Waimakariri District Council (WDC) has commissioned DHI to complete a number of Ashley River breakout scenarios to assess the impact of potential breakouts on the surrounding areas. The study used the recently updated MIKE 21 district flood models of the North and South Ashley catchments to model the stopbank breakouts flowpaths and extents. The update to the district models is described in detail in the DHI report *Flood Hazard Models Update,* May 2020.

There were two phases to the methodology; for consistency with the email documentation received these will be called Phase 3a and Phase 3b. Phase 3a was completed as a screening test to assess the impact of four breakouts, from the Ashley River, on a dry catchment. Phase 3b assessed the same breakouts along with less frequent flood flows, these are described as the "wet" breakout scenarios. Methodology for the breakout scenarios was confirmed, by WDC, in discussions with Environment Canterbury (ECAN).

Breakout flows

The breakout flows have been defined by ECAN at 4 locations along the Ashley River, these are described in Table 1. Along with these hydrographs were provided as shown in Figure 1. The breakout flows and locations are all based on the 2016 breakout study done by ECAN. This study is documented in the report, *Ashley River Floodplain Investigation – 2016 Update (July 2016)*, Tony Oliver and Michelle Wild, ISBN 978-0-947511-55-5 (web).

Table 1: Ashley Breakout peak flow rates

Location	100yr ARI	200yr ARI	500yr ARI
A	400	580	850
B	400	580	580
C	400	400	400
E	400	400	400

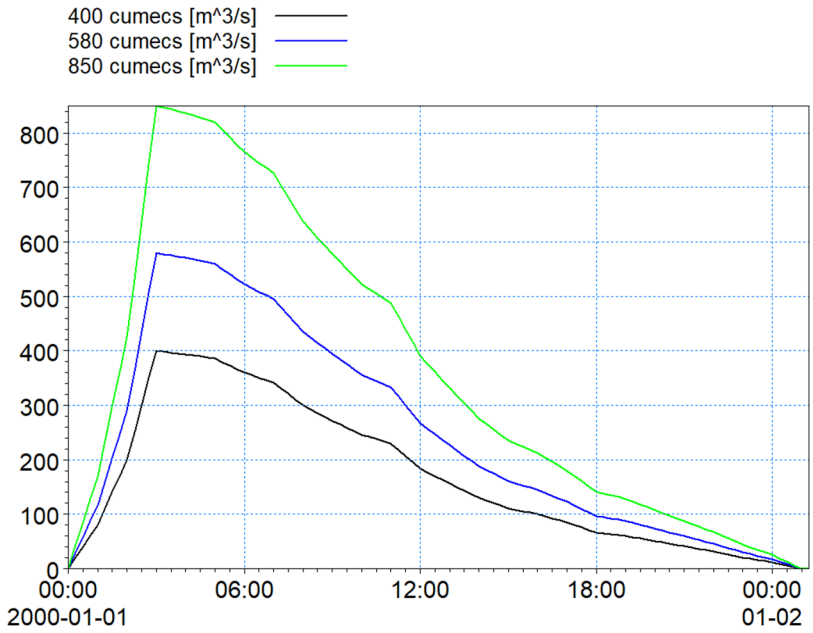

Figure 1: Ashley Breakout Hydrographs

Ashley River flow and sink point

The Ashley River is represented in both the North and South Ashley district models. The full width of the river has been included to the extent of the stopbanks. For the wet breakout scenarios (Phase 3b), the full river flow was represented by including a representation of the Ashley Gorge inflow and the runoff from the North Ashely catchment. At the location of the first breach point (Point A), a sink point was included that would remove the breakout flow from the Ashley to ensure that the downstream flow would not be overestimated.

The peak flows used for the Ashley Gorge were provided by ECAN, and the hydrograph shape was derived by assessing the Okuku stream hydrograph from the district flood models. Figure 2 shows the shape of the two hydrographs, because the Okuku hydrograph had a double peak this was removed with the general shape and timing if the peak flow maintained.

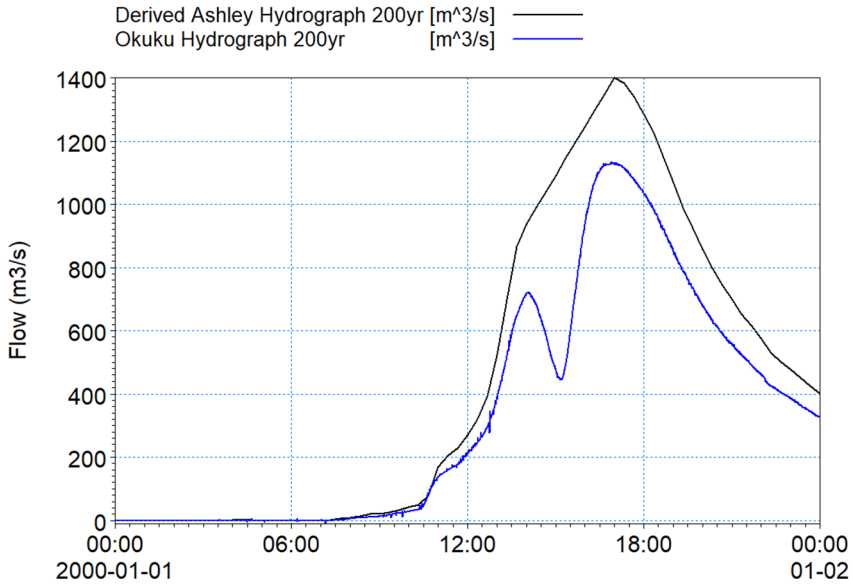

Figure 2: Ashley Gorge Hydrograph 200yr

Rainfall
WDC prepared rainfall for the 10 year, 20 year and 50 year return period events using the HIRDS v4 rainfall depths with the 80 year RCP 8.5 climate change emissions scenario. The 24 hour nested storm profile and general methodology was the same as was used in the district modelling.

Model extent
For the dry breakout scenarios, the MIKE 21 model domain was reduced in size to cover only the areas flooded by the breakout. This was done to reduce the results file size and simplify the simulation.

Model Scenarios

Phase 3a scenarios
The purpose of the Phase 3a was to do a quick assessment of the breakout flows in a dry catchment. These simulations were run for the North and South Ashley models using no rainfall and only the defined breakout flows as the four locations along the Ashley. Simulations completed are outlined in Table 2.

Table 2: Phase 3a breakout scenarios – modelled with a dry catchment

Model Run	WDC Flood Model	Breakout Events	Comments
1	North Ashley	Breakout E (400 m^3/s)	100, 200 and 500 year breakout scenarios for North Bank
2	South Ashley	Breakout A (400 m^3/s) + Breakout B (400 m^3/s) + Breakout C (400 m^3/s)	100 Year Breakout Scenario for South Bank
3	South Ashley	Breakout A (580 m^3/s) + Breakout B (580 m^3/s) + Breakout C (400 m^3/s)	200 Year Breakout Scenario for South Bank
4	South Ashley	Breakout A (850 m^3/s) + Breakout B (580 m^3/s) + Breakout C (400 m^3/s)	500 Year Breakout Scenario for South Bank

Phase 3b scenarios

The Phase 3b breakout scenarios represent the main breakout assessment and are the focus of this study. The six simulations use the parameters described in Table 3 and illustrated in Figure 3 and Figure 4.

Table 3: Ashley Breakout Scenarios Phase 3b

Model Run	Breakout Events	Ashley Gorge Flow	Ashley River Tributary Flows	River Sink	Localised Rainfall Event
1 – North Ashley 100 Year	Breakout E (400 m^3/s)	100 Year Inflow Hydrograph	100 Year Inflow Hydrographs from 100 Year North Ashley District Model and 100 Year South Ashley District Model	Sink in Riverbed at Breakout A (400 m^3/s)	10 Year Rain on Grid (restricted to eastern part of catchment not covered by river flow inputs)
2 – North Ashley 200 Year	Breakout E (400 m^3/s)	200 Year Inflow Hydrograph	200 Year Inflow Hydrographs from 200 Year North Ashley District Model and 200 Year South Ashley District Model	Sink in Riverbed at Breakout A (580 m^3/s)	20 Year Rain on Grid (restricted to eastern part of catchment not covered by river flow inputs)
3 – North Ashley 500 Year	Breakout E (400 m^3/s)	500 Year Inflow Hydrograph	500 Year Inflow Hydrographs from 500 Year North Ashley District Model and 500 Year South Ashley District Model	Sink in Riverbed at Breakout A (850 m^3/s)	50 Year Rain on Grid (restricted to eastern part of catchment not covered by river flow inputs)
4 – South Ashley 100 Year	Breakout A (400 m^3/s) + Breakout B (400 m^3/s) + Breakout C (400 m^3/s)	100 Year Inflow Hydrograph	100 Year Inflow Hydrographs from 100 Year North Ashley District Model	Sink in Riverbed at Breakout A (400 m^3/s)	10 Year Rain on Grid (full catchment)
5 – South Ashley 200 Year	Breakout A (580 m^3/s) + Breakout B (580 m^3/s) + Breakout C (400 m^3/s)	200 Year Inflow Hydrograph	200 Year Inflow Hydrographs from 200 Year North Ashley District Model	Sink in Riverbed at Breakout A (580 m^3/s)	20 Year Rain on Grid (full catchment)
6 – South Ashley 500 Year	Breakout A (850 m^3/s) + Breakout B (580 m^3/s) + Breakout C (400 m^3/s)	500 Year Inflow Hydrograph	100 Year Inflow Hydrographs from 500 Year North Ashley District Model	Sink in Riverbed at Breakout A (850 m^3/s)	50 Year Rain on Grid (full catchment)

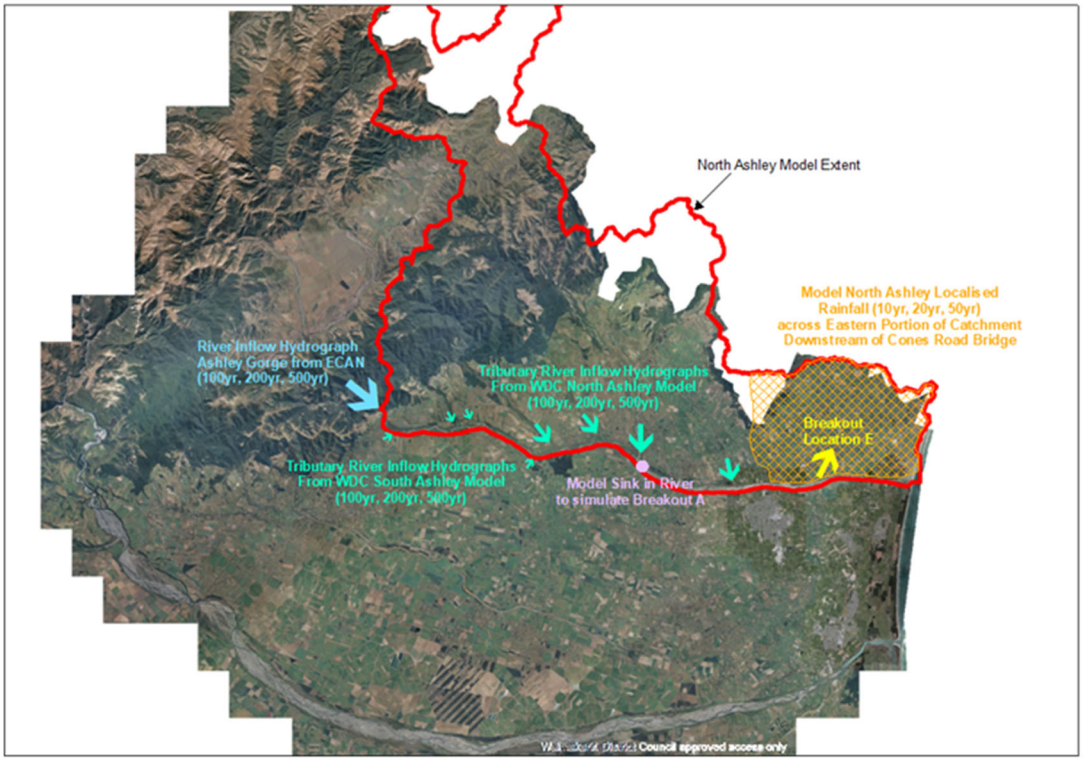

Figure 3: North Ashley Phase 3b setup

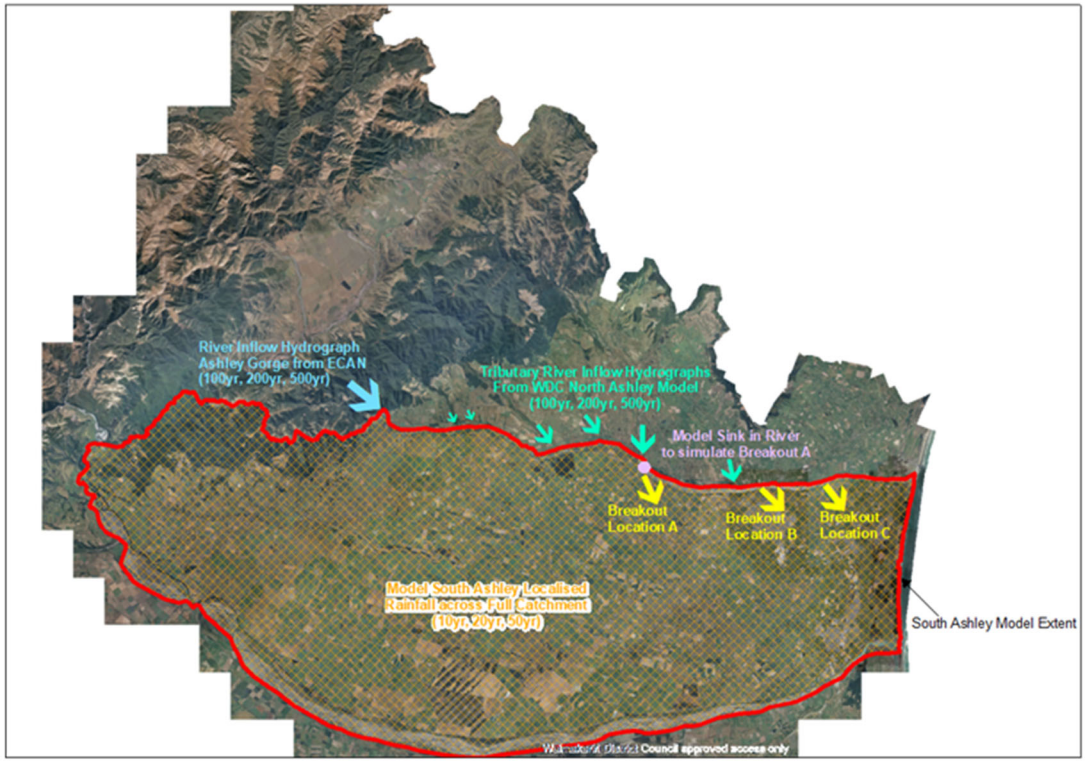

Figure 4: South Ashley Phase 3b setup

Study assumptions and limitations

The following assumptions and limitations have been identified as part of this study:

- Ashley Gorge inflows are not explicitly modelled and the flow hydrograph has been assumed.
- Roughness values used in the Ashley river differ from those used in the ECAN 2016 study and may result in higher flood levels in this model.
- It is assumed that the breaches at points A, B and C will not interact with each other. These have been all modelled in the same simulation but should be considered as independent events.
- Due to the inclusion of the sink point in the Ashley river it is acknowledged that the flows in the Ashley downstream of this point will not be realistic.
- Breakout flows were applied as a hydrograph, and thus represent a fixed breakout flow, adding new water to the domain, instead of a dynamic breakout where flow is taken from the Ashley.

Results discussion

In the South Ashley model, breach location A creates the most widespread flooding. Breakout A has different breakout flows for each of the 3 rainfall scenarios, and is located in a position where the flow spreads out significantly on the floodplain, this can be seen by looking at the dry scenario flood extent in Figure 5. Breakout point B is contained within the secondary stopbank designed to protect Rangiora and as such the breakout tends to feed back into the Ashley River, with only a small overflow. There is some interaction between breakouts A and B, however given that the impact of B is very minor this is unlikely to be an issue when interpreting the results. Breakout C appears isolated and flows directly east. As the volume of breakout C is the same in each scenario the results differ very little between the events.

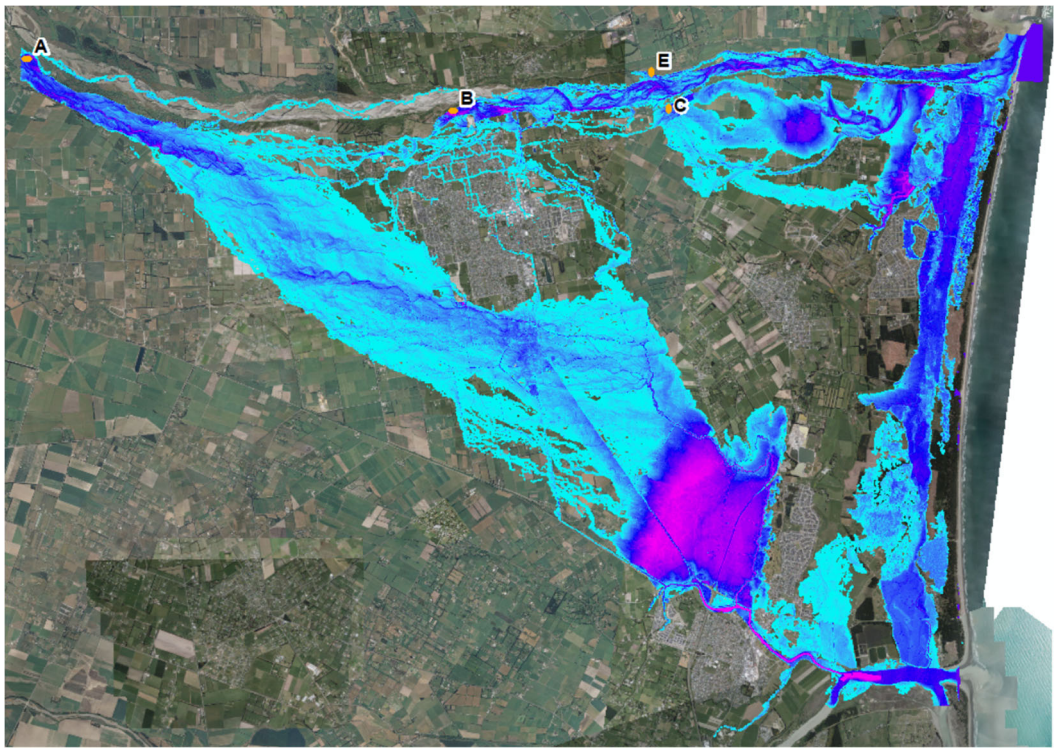

Figure 5: 500yr Dry Breakout scenario indicating breakout locations (South Ashley)

The most significant differences in the South Ashley model between the 3 scenarios is in the large ponding area upstream of Kaiapoi. Where the water level is 1m higher in the 500year scenario than the 100year.

For the North Ashley model, the results in the area of the breakout for the three scenarios are very similar. This indicates that all differences in the model results are due to the impact of the rainfall differences. No additional overtopping of the Ashley stopbanks is observed in the North or South Ashley models.

Comparing the flood levels with the base district models, which use the higher rainfall, i.e. 100year, 200year and 500year, compared to 10year, 20year and 50year, the corresponding breakout scenarios all exceed the base model water levels in the areas directly downstream of the breakouts. In breakout A the impact of the breakout extends to directly upstream of the ponding area north of Kaiapoi. For breakout B, because the impact is minor the impact extends to around 3km downstream of the breakout location with some impact on the houses in Rangiora closest to the breakout location. For breakout C the impact extends to the area directly east of the breakout as well as to the entire strip of dunes between the Ashley and Waimakariri rivers (directly adjacent to the coastline). For breakout C the impacts extend along the 8km between the breakout location and State Highway 1.

All results have been processed in raster format for flood depth, water level, hazard and velocity. In addition, various difference rasters have been calculated which show comparisons between events.

Conclusion

The breakout scenarios show that the risk from a 1 in 100 year breakout scenario can be larger than the risk from the 1 in 100 year rainfall event when looking at the floodplain directly downstream of the breach locations. This conclusion also holds for the 200 year and 500 year events. The rasters provided with this memo illustrate the model outputs, and can be used to interrogate the areas most at risk from a breakout of the Ashley River. The modelling methodology has been provided by WDC and confirmed in discussion with ECAN to maintain consistency with previous Ashley Breakout modelling. This combined with use of the recently updated district MIKE 21 models should provide confidence in the model predictions.