Avon River Modelling Bears Fruit

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ABSTRACT

INTRODUCTION

Christchurch City Council ('council') has been improving its stormwater models across the city to inform development of the Land Drainage Recovery Programme (LDRP) and the Long Term Plan (LTP), assess impacts of the Canterbury Earthquake Sequence ('the earthquakes') and a wide range of other activities including, informing floor level setting across the city.

The Citywide Modelling project began in 2015 with the aim of delivering updated river catchment models for 'flat land' Christchurch with much greater detail and a single combined hydraulic model of the City's pipe networks (greater than 300 mm), waterways and the estuary and to an open sea level as the model boundary condition (Preston, Parsons, 2016).

Modelling of the Avon River catchment has been progressed in advance of the other large river catchments. The model now provides detailed results across the catchment in ways that previous models could not, along with the new capability to predict flood inundation for a wide range of design storm event durations and magnitude.

The surface model includes an area of 12,000 ha and contains 1.8 million computational elements, the smallest of which is 12 m^2. The one-dimensional models include 160 km of waterways, 360 km of piped networks, 11,000 manholes and representation of all 14,000 sump inlets.

A rain on grid hydrological approach has been adopted across the catchment with multiple design storms that enable an assessment of critical duration for small catchments and an evaluation of the risk down to the street level. This level of detail is useful as the aim of the modelling is to be able to inform council of flood risk across a broad spectrum of event magnitudes; from 10% AEP up to 0.5% AEP and for a range of durations from 0.5 hour up to 36 hour.

MULTIPURPOSE MODEL STABILITY

The model has been run for over 50 widely different design events. The frequent events (10% AEP) are required to inform the application of Council flood intervention policy (where earthquake affected property owners at high risk are offered assistance, being, house raising, on-property works or voluntary property purchase). The infrequent events are used to inform Council activities such as floor level setting for new development and identification of flood ponding areas. The wide range of durations allow these assessments to be applied high up into the river catchments.

At the start of the project it was recognised that creating a single model capable of running stably across a widely diverse set of operating conditions was a significant challenge and one that was not commonly attempted in the NZ industry. The build team was confident that with intelligent schematisation, robust build and effective stabilisation processes that it should be possible but could present challenges. The presentation will explain the approach taken for stability, including development of tools to better measure stability outcomes and development of standards for reporting against and ultimately how this notable achievement was delivered.

DETAILED RESULTS

A high level of detail is included in the upstream areas of the model, with all road gutters distinguished from road centrelines, representation of every stormwater sump, and stormwater pipes down to diameters of 300 mm. This was required given the very flat Christchurch topography.

The presentation will show and describe typical map result locations with integrated M21/M11 flood depth, mesh outlines, MU/M11 networks and curb inlet couplings overlaid and a M21 flood depth animation.

CALIBRATION

In the short period since the earthquakes some notable flooding events have struck the city. The largest flood event was the March 2014 event where 148 mm of rain fell over 24 hours in the central city resulting in widespread flooding across the city with many homes inundated. Records from this event were used to calibrate the hydrological and hydraulic components of the model. The model was also verified to a June 2013 event and later partially calibrated to better account for the much wetter antecedent conditions.

The presentation will compare 2014 calibration model results with recorded observations for;

- flood extents in Flockton basin and Cross stream near Elmwood Park
- level recorders around the across the Ihutai / Avon-Heathcote Estuary and how the wind conditions were taken into account
- level and pump station records near Horseshoe Lake pump station (the Cities largest pump station) were factors such as anecdotal records of stopbank overtopping had to be accounted for in conjunction with the screw pump station which was sometimes operating with either high discharge levels (or low suction levels) reducing its capacity, all in an area of the river where levels are highly dominated by tidal variation.
- flood extents near Jefferies Road (upstream of Elmwood Park) which showed flooding that was not observed and will discuss some likely causes of this.
- the key Gloucester St gauge location in the CBD (2014 and 2013)

The model was initially verified against the June 2013 event. This showed that model runoff was lower than observed runoff which was attributed to the unusually wet antecedent conditions in June. The response was to test model sensitivity to adjustments in infiltration losses. This became essentially a partial calibration exercise which produced a good fit to the recorded data at the key recording site (Gloucester Street) and to observed flooding around Cranford and Flockton Basins. This work also built confidence that, with due consideration to antecedent conditions, the model could replicate recorded flows and flooding from both events.

NEW FLOOD RISK AREAS

Model results from the various design storm events confirmed many areas of known flooding but also found some new areas. One such area was around Kyle Street, Riccarton. The presentation will show how and why the improved model resolution was required to represent a subtle phenomenon which results in substantially more predicted flooding in this location than the previous models. Upon close inspection of the new model results (and actual topography) it can be seen that higher flood water can contribute to the Kyle Street area from catchment areas that typically drain to other tributaries in lower flood conditions. Previous modelling with relatively large lumped catchments precluded this possibility due to the simpler modelling approach.

The shorter modelled durations also highlighted unrecognised potential flood risk in areas in the west of the city, typically with limited reticulation, ephemeral waterways and high potential infiltration and built soakage to ground. The presentation will show how the model has drawn attention to this area, how confidence has been established in this new result and what further work in planned to improve that confidence.

CRITICAL DURATION UNDERSTANDING

Another useful output from the modelling to date has been the ability to map critical storm duration (the storm producing the greatest depth of flooding). Some findings were surprising with much longer than expected durations (12-24 hrs) shown in western parts of the city as far west as the airport. A typical example will be explored in the presentation.

INPUT DATA CHALLENGES

Underpasses and bridge handrails were two areas of the modelling where input data has proven more challenging than was considered at the project scoping stage.

Underpasses are openings generally under major roads or railway lines typically for pedestrians and cycleways. They can also function as significant flood flow paths. The presentation will describe data sources explored and the difficulty in establishing confidence in the complete existence and location of underpasses. The Council GIS and initial model build duly showed the modest box culvert which serves the watercourse in small flood events, but existence of the much larger pedestrian underpass was not recognised in the early modelling. In larger flood events the box culvert is inadequate and the underpass forms a key stormwater function conveying most of the peak flows and making a large difference in flood levels upstream of the railway.

The highlight location from this exercise at Bellvue Ave will also be presented. Here a watercourse and pedestrian underpass share the same crossing location under a sizable railway embankment. The presentation will explain why early modelling only included the modest box culvert and what happened when the much larger pedestrian underpass was also included.

Handrails on bridges (and culverts) have been difficult to address in the modelling. The presentation will explain how this was addressed in previous modelling, why change was motivated, what (limited) data was available and explore the approach adopted for the various categories of bridges and the investigations undertaken to gain confidence in the model results.

FUTURE AND CONCLUSION

The next steps for the model will be to produce a 2018 model, calibrate this model against the recently much expanded collection of temporary flow monitoring sites, develop a 2068 or maximum probable development model and re-running of the flood hazard modelling.

We have only begun to use and explore results from the new Avon River model. The step change increase in detail has already provided significant learnings about the stormwater system performance and areas of high sensitivity and risk. It has also highlighted areas of where improvements in system data would present opportunities for enhancing future model fidelity. There will doubtless be many more such learnings and opportunities recognised as this model is put to work in evaluation of numerous projects over coming years and the model continues to evolve and be further improved. We are excited now that these projects will be supported by such a high quality planning and assessment tool and to realise the benefits that this will deliver in improving Council investment decision making.

KEYWORDS

Stormwater modelling, Mike Flood, M21, M11, MU, flexible mesh, flood hazard assessment, earthquake, coupling, risk