Overview:
The Bruce Highway is Queensland’s major north-south freight and commuter corridor, connecting coastal population centres from Brisbane to Cairns. There are more than 500 major waterway crossings along the highway with catchment areas greater than 2 km². Flooding in rivers and waterways along the highway causes parts of the Bruce Highway to close on a regular basis, resulting in significant economic impacts as well as social impacts for affected communities.

Conventional design flood estimation practice typically concentrates on providing a defined maximum probability of flooding (flood immunity) and times of closure at specific crossings, including bridges, culverts, and floodways. Whilst the maximum annual exceedance probability that can be passed without flooding a particular crossing may be relevant, the economic benefit for providing a particular level of flood immunity or performance will be more strongly related to the time of closure of regional links or sublinks between large population centres.

A Decision Support Tool (DST) was developed using GoldSim to calculate the flood immunity and times of closure for approximately 500 waterway crossings along the Bruce Highway. The tool combines hydraulic rating curves for each crossing with a timeseries of flow that was computed on an hourly time step for a 100-year period up to 2017. By using continuous simulation modelling, the DST assesses the coincidence of flooding and subsequent closures along linear sections of the highway, and enables the flood immunity of individual links, and the highway as a whole, to be assessed.

Hydrology:
The 100-year hourly flow timeseries was generated using historical stream flow records and continuous simulation hydrological modelling, which implemented the GR4H rainfall runoff model in the eWater’s Source modelling platform. To develop the continuous flow series, stream gauge records were used for gauges on major rivers with sufficiently long term stream records. These included, for example, the Burdekin, Fitzroy, Herbert and Pioneer Rivers.

Rainfall-runoff modelling was completed for all other crossings where long-term gauge records were not available. The hydrological models were calibrated to gauged flows at 58 streamflow gauging sites that had sufficiently long periods of flow record (typically at least 20 years). The calibrated rainfall runoff model parameters were regionalised along the Bruce Highway and applied to rainfall...
runoff models for ungauged catchments. Rainfall-runoff models were validated, where possible, using stream flow records, and flood frequency quantiles from the Australian Rainfall and Runoff Regional Flood Frequency Estimates (RFFE) method.

**Hydraulics:**  
The hydraulic assessment developed flow-height relationships (rating curves) and determined threshold heights (the height at which the flow submerges the road) for all major crossings. A variety of different hydraulic modelling approaches, including one and two-dimensional models, were used to extract rating curves and threshold heights. Where possible, previously developed and calibrated two-dimensional models were used to develop rating curves for this assessment. If no previous model existed, new hydraulic models were developed.

**Base Case Highway Assessment:**  
The Base Case highway assessment determined the average annual time of closure, average duration of closure, flood immunity and other key flooding statistics for individual crossings and groups of crossings within regional links and sublinks of the Bruce Highway. The base case results of the study were validated using anecdotal knowledge of flooding, flood hot spot data, road closure data from the Department of Transport and Main Roads and RACQ, and the results of previous hydraulic investigations.

**Planning:**  
A high level economic analysis was conducted to identify the Direct Transport Cost of delay caused by flooding closures on the Bruce Highway. The approach to the economic analysis is based on a conventional cost-benefit analysis. The approach considers three main road user responses to a flooding event (1) waiting for flood to subside, (2) diverting along an alternative route or (3) choosing not to travel e.g. cancel trip.

A series of flooding performance levels were assessed and a comparative high level economic assessment of the upgrade strategy to achieve these performance levels was undertaken. This informed the identification of a preferred flooding performance level for each link. An investment strategy was developed using a combination of the economic assessment and multi-criteria analysis, which captured broader social impacts, to prioritise links and projects.

This paper discusses the innovative approaches applied in the continuous simulation modelling to determine the times of closure for regional links and sublinks of the Bruce Highway, and prioritise future flood improvement projects for the Bruce Highway.