Background: In 2011, major floods in the Brisbane River catchment led to 3.5 to 4.5 billion Australian dollars in damages and 35 fatalities. The two main reservoirs in the catchment, Wivenhoe and Somerset, reached critical levels and could therefore not prevent major flooding downstream in the cities of Brisbane and Ipswich. The government of Queensland, Australia, recognized the need for an improved flood management plan, and issued a call for a catchment-wide flood study to support it.

Assignment:
Deltares was part of a consortium that carried out a comprehensive hydrological study, the goal of which was to determine the probabilities that extreme river flows (throughout the catchment) are exceeded – critical input for flood risk management.

Client:
State of Queensland, Australia

Period:
2013 - 2015

The Brisbane River has a total length of 309 km and is the longest river in south east Queensland. The catchment is a mixture of rural and urban areas and is a complex and heterogeneous system. Commonly applied methods to estimate flood probabilities in river catchments use simplified representations of the physical characteristics and ignore the heterogeneity of rainfall patterns. Deltares addressed these issues by implementing a Monte-Carlo-based framework for estimating flood probabilities. In this approach, a large number of realistic and representative synthetic rainfall events are generated and simulated with a combined hydrological- and reservoir simulation model. The method has the advantage over more traditional approaches in that it explicitly considers the natural variability of all relevant physical processes that contribute to flood events. As a consequence, it provides a better understanding of flooding mechanisms and interactions.
The computation scheme of Figure 2 provides a broad outline of the framework, which consists of the following three components:

1. Pre-processing: a combination of advanced statistical techniques to generate a large set of realistic and representative synthetic flood events. These events are characterised by rainfall, antecedent moisture conditions, initial reservoir volumes and ocean water levels.

2. Processing: simulation of the synthetic events with a combination of a hydrological model and a reservoir simulation model to obtain peak discharges and flow volumes at each river location of interest.

3. Post-processing: statistical techniques to combine the results of the previous steps to derive annual exceedance probabilities for a range of peak flows and flow volumes at each river location of interest.

The framework uses an efficient sampling scheme to keep simulation times manageable and to increase the accuracy of the results. The main output of the framework consists of annual exceedance probabilities of peak flows and flow volumes. Furthermore, the framework produces a large set of synthetic events - characterised by discharge hydrographs, ocean water level hydrographs and spatio-temporal rainfall intensities - as such offering a wealth of realistic flood scenarios to be considered in flood management studies. For the Brisbane River catchment, a flood management study will be conducted as the follow-up of the flood study, with the objective to implement a management plan for the entire catchment.

The Monte Carlo framework is implemented in Delft-FEWS (Werner et al., 2013). Delft-FEWS is a sophisticated collection of modules designed for building an operational water management system. Delft-FEWS is mainly used for flow forecasting, for example by the Environment Agency (UK), the National Weather Service (US) and the Bureau of Meteorology (Australia), but it is also used for the purpose of operational reservoir management, for example by Seqwater (Australia). The component-based generic set-up of Delft-FEWS makes the Monte Carlo framework relatively easy to transfer to other catchments in Australia and the rest of the world. The system has a user-friendly interface, enabling clients to carry out complex Monte Carlo simulations at the push of a button.

Further reading: