Flash Flood Intelligence in the Age of Instant Communication

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In a world in which there is an expectation of instant access to information, there is increasing pressure on agencies to quickly disseminate and communicate accurate information during storm events. This requires well informed decision making, collaboration between agencies, and efficient methods of communicating; both internally and with the public.

Urban flash flooding provides a greater challenge for emergency planners and responders: the emerging risk must be identified quickly to ensure there is sufficient time for warning and response. Flash flooding can cause extremely dangerous conditions, with rapidly rising levels and fast flowing water, capable of causing property damage and serious risk to life.

With recent developments in next-generation software, it's now possible to hydraulically model these flash flood events in real-time. However, flood maps alone are not sufficient to manage the flood risk; disaster managers need to understand where flooding might impact, what assets or communities are in that area, and when the inundation might occur. In response to this need, an intuitive online system (FloodIntel) was developed to collate, interpret and communicate a range of flooding information and geospatial data via a single online interface.

1. INTRODUCTION

1.1. Common Emergency Management Challenges

In the lead-up to and during a storm event, a large amount of data is created and interpreted by responders to understand the likely extent, hazards and consequences of flooding. Data changes minute by minute, requiring analysis of multiple datasets over different spatial and time scales. As a further complication, multiple agencies are often seeking to coordinate responses using different data sets.

BMT has experienced this challenge first-hand while supporting councils and emergency response agencies understand potential flood risk during rapidly evolving flood events. Our flood engineering staff were frequently sought out in the lead-up to and during flood events to answer questions such as:

- How does the predicted stream height compare to design flood heights?
- Will a particular road or community be impacted?
- What if the rain exceeds the forecasts? What's our worst-case scenario?

Our experience in this support role followed by extensive stakeholder consultation identified a number of relevant challenges:

- Information and data changes over time
- No two floods are alike, hence pre-developed mapping and planning is just a starting point. Flood intelligence must be updated during an event to reflect real-world conditions
- Key information comes from understanding spatial relationships, such as where the flooding occurs in relation to a town
- Flood study reports are generally designed with land use planning in mind, hence information in a disaster management format is not always readily accessible

- Multiple agencies and individuals are involved in response and it is critical that they are looking at the same information
- Floods can (and often do) occur at inconvenient times, when relevant personnel may be out of office
- During large floods, personnel may be seconded from other regions and have little familiarity with the location or flood information system

Flash floods (generally defined as floods which peak within 6 hours of the storm event commencing) exacerbate all of these issues.

1.2. Flash Flood Challenges

Flash flooding is generally caused by storm cells, rather than prolonged weather events, and can be difficult to forecast. This unpredictability, combined with high rainfall intensity and rapid onset can make flash floods extremely dangerous and challenging to respond to. With increasing urbanisation (including reduced urban permeability and higher population density) flash flooding risk is likely to increase in the future. Effective management of this risk, including real-time response will be increasingly important. Some of the key challenges associated with flash flooding response include:

- The rapid onset requires emergency managers to respond and issue flood warnings early in the event. There is limited time to wait and see if predictions pan out; warnings must be issued early when there is less confidence in the likely outcomes (see Figure 1).

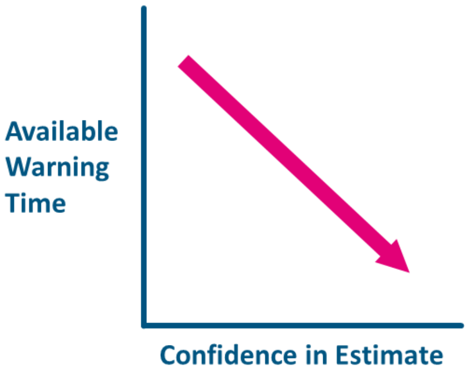

Figure 1 Trade-off Between Warning Time and Confidence

- Due to limited available warning time, the community may not be able to evacuate. Information about road closures is critical.
- High intensity rainfall quickly generates runoff, exceeding the capacity of the stormwater infrastructure.

2. THE SOLUTION

In response to these identified challenges, and in conjunction with a range of emergency managers, BMT developed FloodIntel. FloodIntel minimises the burden on agencies during storm events by integrating multiple data sets and delivering consistent and useful information, tailored to each user. This can be achieved through understanding relationships between rainfall, flooding and its impacts, and establishing those relationships in the customised FloodIntel system in advance of the event.

The capabilities of next generation flood modelling software (TUFLOW HPC) has also recently expanded to include full capability for modelling stormwater drainage infrastructure, allowing these urban models to be run very quickly. For the first time, 2D stormwater and overland flow models can be run in a real-time context, identifying locations of overland flow where piped drainage has exceeded capacity. When coupled with next generation, fast hydraulic models such as TUFLOW HPC, FloodIntel offers an end-to-end solution which uses real-time and / or forecast rainfall, displays maps of the current flood situation, analyses rainfall and mapping against critical thresholds to understand the impact of the event, and generates automated or semi-automated reports, alerts, text messages etc. The system is accessible to many users at once, through any standard browser on a variety of devices, and is fast and highly intuitive, allowing a new user to open the system without any training and quickly find the information they need.

FloodIntel and TUFLOW HPC combined with proven, industry-standard components can be configured to produce a genuine end-to-end flash flood forecasting system which converts a rainfall forecast into flood mapping and identification of at-risk areas.

3. EXAMPLE WORKFLOW

The FloodIntel system can be fully automated to ingest telemetry and other data, run hydraulic models, display mapping from those models in the user interface, intersect mapping with asset data, and issue alerts if thresholds are triggered. A typical workflow during a storm is described below.

A registered user (e.g. an emergency manager) receives a text message that a low-level threshold has been triggered, for instance a certain gauge has recorded a high rainfall intensity. The message includes a hyperlink to FloodIntel which takes the user to a dashboard with summary information including text-based warnings from the Bureau of Meteorology and overviews of real-time data feeds (Figure 3).

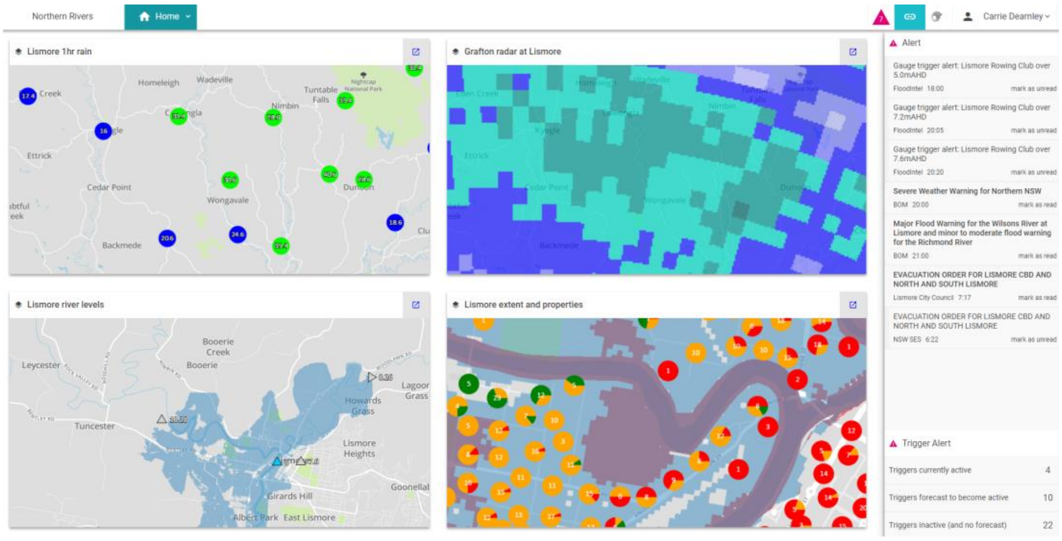

Figure 2 Example FloodIntel Dashboard

The user selects one of the preview maps to explore the current situation. They might check rainfall radar (real-time, looped data), and look at a map of catchment average rainfall to see which catchments are likely to receive most of the rain (Figure 3).

Now that the user has a better understanding of the rainfall patterns, they zoom in to urban areas to see how rivers have responded to flooding. They can examine gauged river levels including current height, gauge classification (e.g. minor, moderate, major), water level trends (rising, falling, steady), and click on the gauge icon to display water level time-series information.

The user toggles on flood mapping layers to examine the current flood extents and depths (Figure 4). For a fully end-to-end system (which includes hydraulic modelling with TUFLOW HPC), these maps are produced by real-time two-dimensional hydraulic modelling based on telemetry input. This means that both in-stream and floodplain behaviour will be well-represented.

If particular assets are of interest (e.g. schools), the user can toggle on layers to see these key locations in relation to the flood mapping and inspect assets to view relevant information (e.g. contact phone numbers, building type, number of residents etc.). If stormwater infrastructure is included in the hydraulic model, the user might toggle on a drainage layer to observe where infrastructure has exceeded capacity.

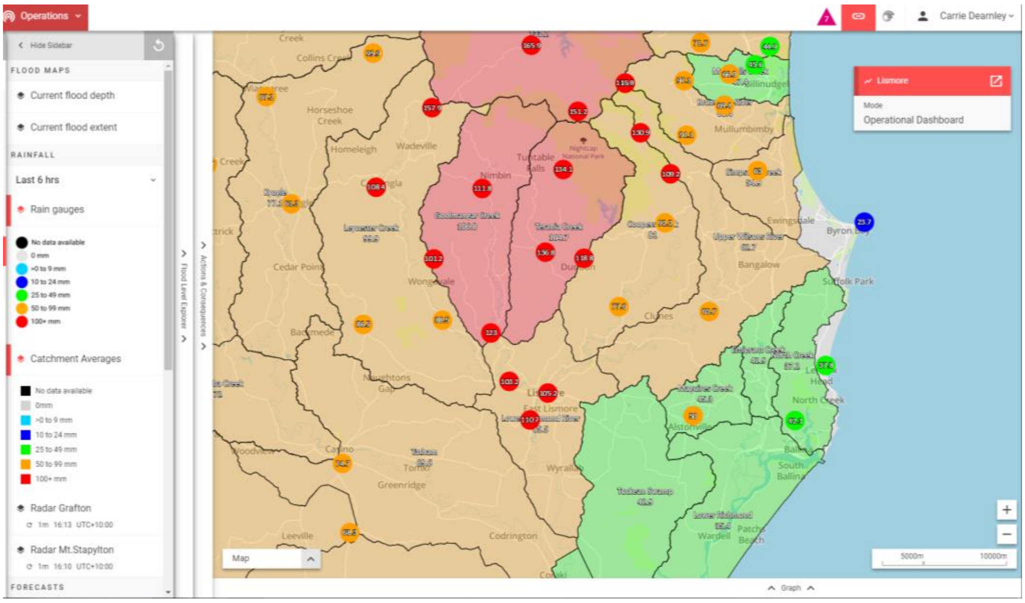

Figure 3 Example View of Catchment Rainfall Averages

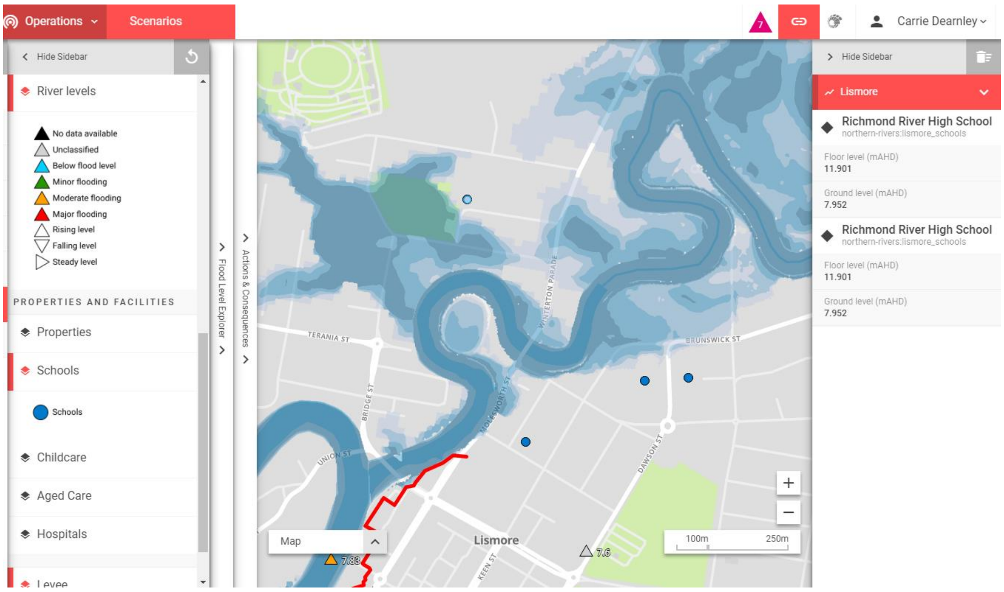

Figure 4 Example View of Flood Inundation Mapping

Now that the user is across the current flood situation, they want to know how the flood might progress. If forecast rainfall is available for the location, they might inspect forecast flood mapping and impacts in the same way they have for the current situation.

If forecast rainfall is not available, the user would navigate to the scenario explorer (Figure 5). This function allows the user to compare existing flood extents with potentially larger flood extents. FloodIntel pins this comparison to a river gauge and draws upon a pre-developed library of flood maps for the scenario mapping. This library could include historic or design flood mapping. As for the current flood mapping, assets can be compared to the mapping or can be configured to dynamically interact with the flood mapping and automatically change styles (Figure 5 shows an example of property points which automatically change colour to represent whether there is flooding at the property).

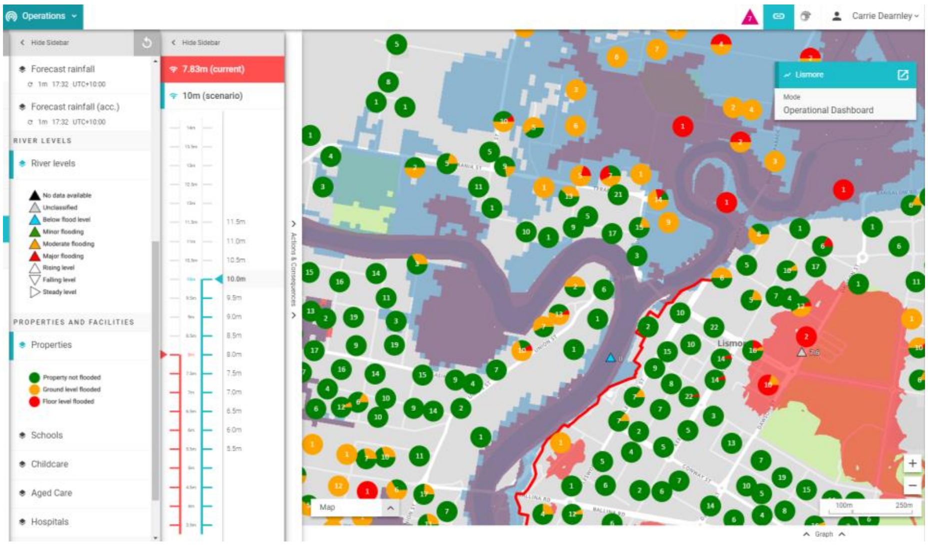

Figure 5 Example View of Scenario Explorer

This entire workflow might take less than five minutes using the FloodIntel system but would take much longer to manually examine this information (if it's available at all). During a flash flood event, this time saved is crucial and results in a faster response from emergency managers, earlier warnings being issued to the public and ultimately improved management of flood risk.

4. CONCLUSION

The end-to-end FloodIntel flash flood forecasting system significantly advances the ability of emergency managers to access and understand relevant information in a time-critical situation. The system is fast and highly intuitive, allowing a new user to open the system without any training and quickly find the information they need.

BMT has designed FloodIntel to be extremely robust and flexible for different user needs. The system components can ingest nearly any data format and configured to meet the needs of different councils or emergency response authorities. This flexibility allows for the addition of numerous other functions including (but not limited to): integration of CCTV feeds to examine on the ground flooding, display of real-time external data feeds such as Google Maps traffic feeds, and integration with external messaging applications (such as Telstra Whispir) to send flood warnings directly from FloodIntel.

With increasing flash flood risk in urban areas, the ability to understand risk as it evolves is critical to protect lives and properties from the damaging impacts of flooding.