

## **Spatial-Temporal dynamics of surface water flooding and consequences for emergency services accessibility**

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Urban areas are increasingly susceptible to surface water flooding, with more intense precipitation and intensification of land development. Flooding has both direct impacts i.e. locations inundated with water, and indirect impacts i.e. transport networks, utility e.g. electricity/water services etc. The direct areas flooded evolve in space through the event, and are predicted by standard inundation models. However, the wider indirect impacts and the spatial-temporal patterns are less constrained and it is these that are needed to manage the impacts in real-time.

This paper focusses on the Category One responders of the Fire and Rescue and Ambulance Services in the City of Leicester, East Midlands, UK. Leicester is ranked 16th out of 4215 settlements at risk of surface water flooding in the UK based upon the population at risk (15,200 people) (DEFRA, 2009). The analysis undertaken involved overlaying the flood extent with the Integrated Transport Network (ITN) data within a GIS framework. Then a simple transport routing algorithm was used to predict the travel time from specific nodes representing ambulance or fire stations to different parts of the city. Flood magnitudes with 1:20, 1:100 and 1:1000 return periods have been investigated.

Under a scenario of no flooding, 100% of the city is accessible by the six fire stations in the city. However, in the 1 in 20 year surface water flood event the peak inundation results in 66.5% being accessible in the 10 minute permitted time and 6% is totally inaccessible. This falls to 40% and 13% respectively for the 1 in 100 year event. Maps show the area of the city that are accessible by two or more stations within the permitted response time, which shows these areas are the most resilient to surface water flooding. However, it isn't just the peak water depths at every location which impacts accessibility within the city but the spatial-temporal patterns of the inundation. The areas within the 10 minute response time expand and contract through the event as the inundated area makes roads in different parts of the city inaccessible through the event. These maps also allow key access roads to be identified. Key stakeholders, within the City of Leicester, have highlighted the potential benefit of such dynamic accessibility maps for their multi-agency planning and response for surface water flooding.