TOOWOOMBA OVERLAND FLOWPATH MAPPING

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Introduction

Toowoomba Regional Council has undertaken the Toowoomba Overland Flowpath Mapping Project. The primary objective was to develop hydraulic models to provide overland flowpath mapping utilising the direct rainfall approach for the Gowrie Creek catchment in Toowoomba. This paper details the study objectives, input data and methodology for undertaking the project.

Background

For Toowoomba, natural overland flowpaths have been altered through historical implementation of a gridded road network. Recent flood events have revealed a legacy of homes and business situated within overland flow paths. The city of Toowoomba and surrounding centres were affected by flash flooding on January 10, 2011. Numerous significant overland flow paths were active during the event. Furthermore, overland flow is estimated to represent about 70% of flooding and drainage complaints made to Council.

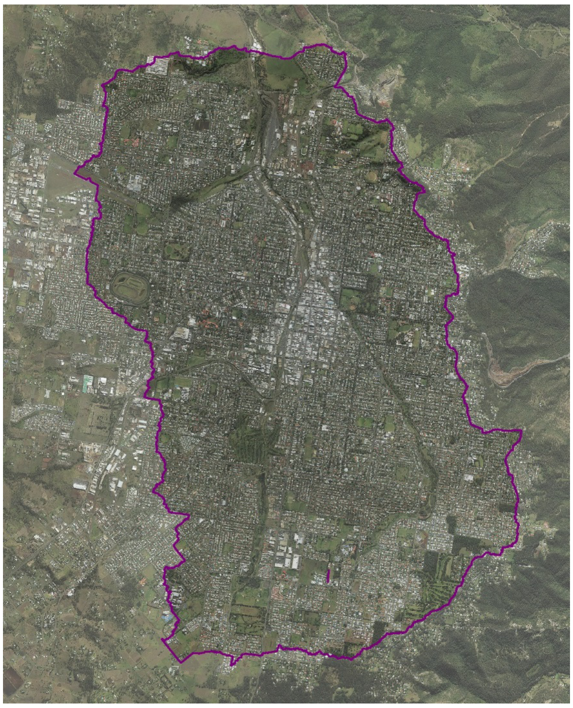

Figure 1 – Study Area

The Study Area: The project involved the mapping of overland flowpaths within the Gowrie Creek catchment. The catchment is characterised as relatively steep.

The primary objective of the project was to map overland flowpaths within the Gowrie Creek catchment. The benefits of the project were:

- Provision of maps of overland flowpaths for Toowoomba;
- Development of a consistent and well understood method of modelling overland flowpaths across the region;
- Enable targeting of future modelling efforts; and
- Development of a suite of two-dimensional models that, with localised upgrades, capable of simulating the likely impact of development within the vicinity of overland flow paths.

The primary components of the project were:

- Data collection;
- Catchment-wide modelling;
- Zoned modelling; and
- Mapping and analysis.

The project was linked to Council's Corporate Plan and meets several requirements of the Queensland Floods Commission of Inquiry. The project received funding via the Queensland Disaster Mitigation and Resilience Funding Scheme.

Available Data

The primary topographic data source was a DEM with a one metre grid spacing derived from LiDAR. Aerial photography had been captured for the full study area in 2013. Council's stormwater asset database was used as the basis of stormwater network modelling in this study. An analysis of missing attribute data was undertaken for pipe data. The results of the analysis revealed that of approximately 8,000 elements, 35 percent were missing invert levels and two percent were missing pipe diameters. Furthermore, the pit and pipe data was also missing an unknown number of stormwater elements. It can be noted that as a parallel project, Council is currently undertaking survey and condition assessment of all stormwater assets in the study area.

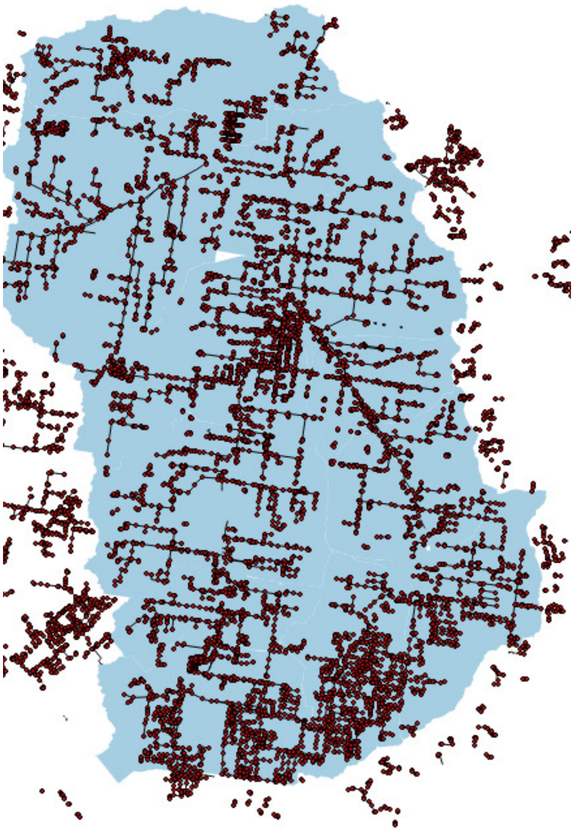

Figure 2 – Pit & Pipe GIS Data within the Study Area

Land use data was available in GIS format with classifications for Residential, Industrial, Roads, Commercial and Open Areas. In addition, a building footprints layer was also available. This included dwellings, commercial buildings and industrial buildings. Minor buildings such as sheds and garages were not included in the footprint layer. In addition, there were known deficiencies in the extent of the data.

GIS layers of kerb alignments were produced as part of the vehicle-based LiDAR capture project. The GIS layers consisted of polylines aligned to the top of street kerb. This dataset was incorporated into the model topography to more accurately represent street-level drainage features.

Catchment-wide Modelling

A catchment-wide model was developed using the TUFLOW GPU software. This model utilised a 2D only scheme and adopted the direct rainfall approach to hydrologic inputs. The purpose of the catchment-wide model was to determine approximate overland flowpath extents. With an appropriate buffer, these extents were used to inform the community engagement mail-out and to focus the effort expended on manual updates to the building footprints and hydraulic roughness delineation. The results were also used to inform delineation of the catchment into sub-catchments.

A model grid size of two metres was selected for the catchment-wide model. Delineation of land use zones was based on the Council's land use planning data without manual revision. Where embankments existed in the base DEM, the topography was manually adjusted to allow flow through the embankment. Given the purpose of the catchment-wide modelling, this approach was considered to give an adequate outcome. The width of the opening adopted was based on the width of the channel in each particular location and the structure width was based on aerial photography.

Community Engagement

Identification and engagement of key stakeholders was considered critical to the success of the project. As such, a stakeholder engagement strategy was developed in order to ensure that stakeholders were informed of the project's purpose and objectives and were provided an opportunity to provide input to the project where appropriate.

A mail-out was sent to properties that were identified as being affected by overland flow using the catchment-wide (TUFLOW GPU) model results. Community engagement material contained within the mail-out included:

- An open letter from the Mayor to residents and business owners outlining the purpose of the study and instructions for providing a response to Council;
- An information sheet with frequently asked questions; and
- A study questionnaire.

In addition to the mail-out, an online forum and online questionnaire were hosted using specialist community engagement software run via Council's external facing website.

Approximately 1,000 responses were received and the information gathered was used to inform the modelling process.

Modelling

Hydrologic Inputs

The temporal patters were sourced from AR&R (1997). Design IFD data was sourced from the online Bureau of Meteorology (BoM) IFD generation tool. The IFD data was generated for a single point within the Gowrie Creek catchment. Loss parameters adopted for the 2013 AECOM study were utilised for this study.

Hydraulic Model Development

Topography for all of the models developed was based on the DEM with one metre grid spacing derived from LiDAR.

Based on the model simulation time analysis and the results of the catchment-wide modelling, the study area was divided into 13 zones. Limiting the model simulation time was partly aimed at easing the burden on future uses of the model suite. A grid resolution of two metres was adopted for all detailed zone models except for zones three and four, which were combined into a single model due to significant hydraulic interconnectivity. A three metre grid resolution was selected for this combined zone.

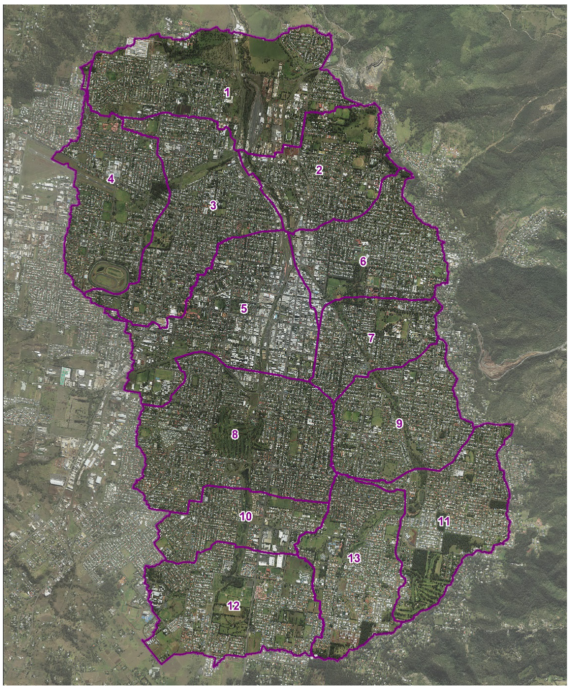

Figure 3 – Study Area Divided Into Model Zones

The roughness layer adopted for the catchment-wide model was further refined for the detailed modelling. This involved manual inspection of the previous layer with changes being made where the assigned land use did not match actual land use based on the aerial photography.

Individual buildings were represented as areas of depth-varying roughness. At very shallow depths, a smooth Manning's n value was adopted to allow runoff of direct rainfall inputs. At greater depths, a very rough value was applied to block overland flow and divert these flows around the buildings.

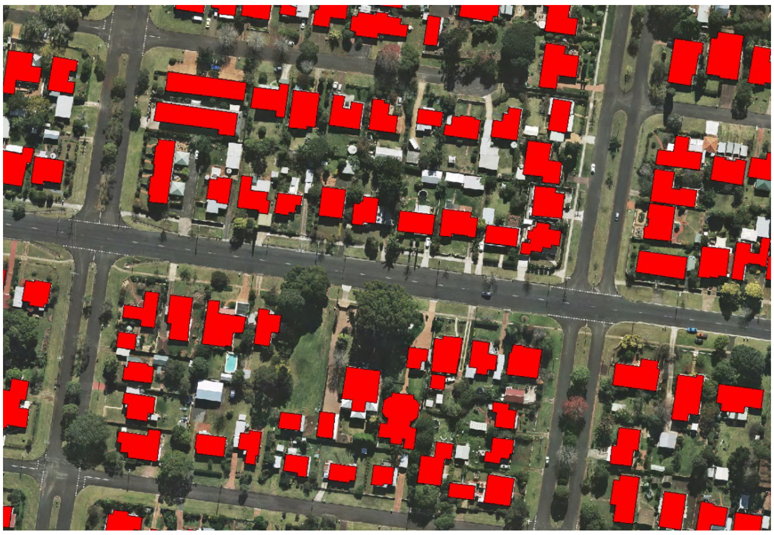

Figure 4 – Building Footprint Polygons (before manual edits)

Culverts were represented using embedded hydrodynamic 1D elements and curb alignment polylines were incorporated into the hydraulic model using 'thin break lines'. Curb alignments were lowered by 150 mm to allow for a flow path along gutters.

The underground 1D pipe network was dynamically connected to the 2D overland surface via pits. Pipe invert and dimensional data was sourced from the GIS-based asset database. Where missing data existed, this was filled based on GIS techniques. Pipes with a diameter of less than 300 mm were excluded from the model.

The 10% and 1% AEP events were simulated for storm durations from ten minutes through to six hours.

Sensitivity simulations were carried out for representation of buildings as raised topography rather than depth-varying roughness. Simulations were also run for testing the sensitivity of the downstream boundary conditions.

Mapping and Analysis

The primary output of the project was mapping of overland flowpaths and stormwater system capacity. As a large suite of storm durations were simulated, max-max rasters were developed. As the direct rainfall approach was adopted, further clean-up of the raw model results was required. GIS processing was undertaken to remove depths less than 0.07 m and velocity-depth product of less than 0.01. In addition, further processing was undertaken to remove 'puddles' and 'islands' with an area of less than 250 m^2 (Yazdani et al, 2012).

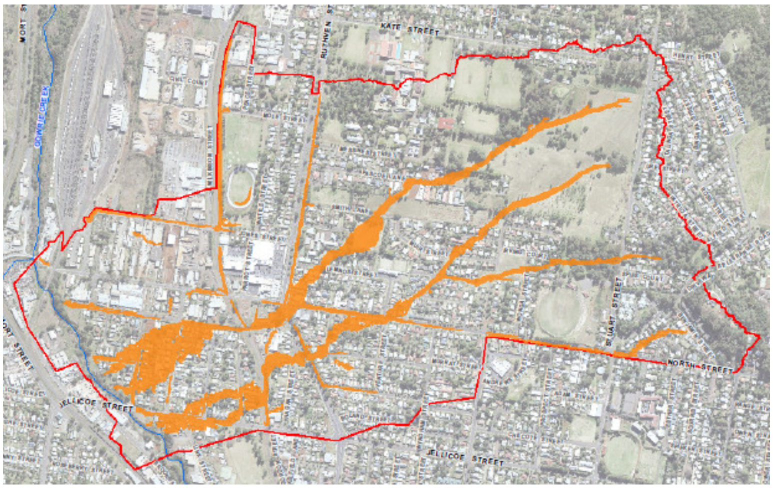

Figure 5 – Example of Processed Overland Flowpath Map

In addition to the maps of extent, for the 10% AEP event, maps of stormwater pipe capacity were produced.

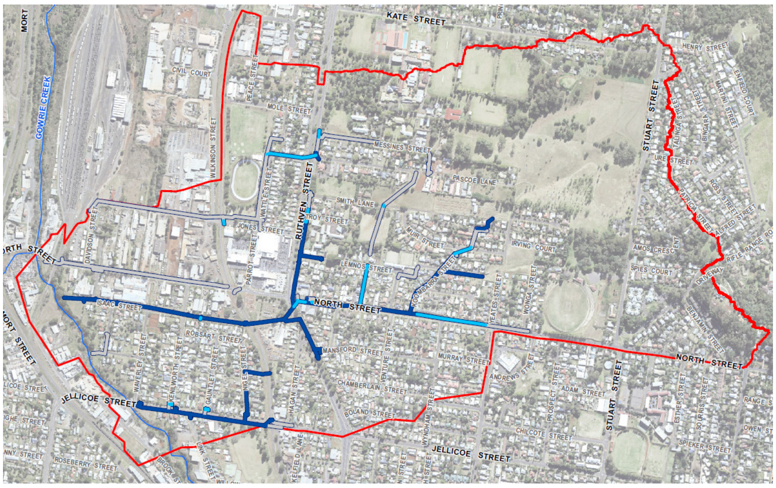

Figure 6 – Example of Stormwater System Capacity Map

Based on detailed analysis of flow characteristics, a number of locations identified that had significant impacts to existing properties because of overland flooding. These areas are considered to warrant further, detailed investigation.

Summary

Toowoomba Regional Council has undertaken hydraulic modelling using the direct rainfall approach of Toowoomba city. Contemporary GPU modelling techniques have been used to define the likely flood extents and to inform the zoned model development. The study area was divided into thirteen zones to enable high detail hydraulic modelling with reasonable simulation times. The modelling was used to develop maps of overland flowpaths and stormwater capacity. The mapping will also be used to enable targeted investment of future modelling effort and to inform planning and development decisions.

References

AECOM (2013), *Gowrie Creek Flood Risk Management Study*, Brisbane 2013.

BMT WBM (2010), *TUFLOW User Manual, BMT WBM*, Brisbane 2010.

Engineers Australia (2013), *Australian Rainfall and Runoff Revision Project 15 Two Dimensional Modelling in Urban and Rural Floodplains Stage 1&2 Report*, Canberra 2012.

Yazdani S. and Roso S. (2012), *Preparation of Overland Flowpath Mapping for Moreton Bay Regional Council*.