MOLINO STEWART
ENVIRONMENT & NATURAL HAZARDS

18/04/2017

Roy Laria
Service Manager Strategic Planning
City of Parramatta PO Box 32,
Parramatta NSW 2124

Dear Roy,

Re: Parramatta CBD Flood Evacuation Assessment

This letter summarises the work that Molino Stewart and City of Parramatta Council have undertaken so far as part of the project titled "Parramatta CBD Flood Evacuation Assessment", which commenced on 31 March 2017. A draft of this study is due for completion on 24 May 2017, with the final report due for completion on 30 June 2017. Should you have any questions, please do not hesitate to contact me.

Background and Aim

The NSW Government and City of Parramatta Council have identified Parramatta CBD as a key growth centre for large scale commercial and residential development. Council has developed the Parramatta CBD Planning Strategy (the CBD Strategy), which was adopted in April 2015. Key features are:

- Expand the boundaries of the CBD
- Increase the floor space ratios in certain areas
- Alter solar access controls
- Alter building height restrictions
- Expand the commercial core of the CBD

An implementation strategy for the CBD Strategy has been developed, which includes the development of a planning proposal to modify Parramatta LEP 2011.

However, one of the most significant constraints for development within the Parramatta CBD is that the Parramatta River passes through the middle of the CBD, and most of the CBD is within the floodplain of the River or its tributaries. In addition, the relatively small catchment upstream of the CBD results in flash flooding with warning times of between 9 and 90 minutes. Even with the current population of the CBD, this lack of warning of an upcoming flood will create significant evacuation challenges, and the proposed population increase could exacerbate these.

Risk reduction can be achieved either by providing a means of horizontal evacuation to areas which are not flood affected or vertical evacuation in buildings to safe areas above the reach of floodwaters. While horizontal evacuation is traditionally achieved through people leaving by car or on foot at street level and travelling to a flood free location, this can also be achieved through the use of elevated walkways and/or internal connections between flood prone and flood free buildings.

While planning controls can in theory be used to create improved flood risk outcomes in Parramatta CBD, statutory requirements currently limit the controls which Council can impose. Specifically, Section 117 Direction 4.3 restricts the imposition of flood planning controls on residential development above the Flood Planning Level (which is generally defined as the 1% flood level plus 0.5m freeboard) except in exceptional circumstances.

Council contends that the flood situation in the Parramatta CBD is such that "exceptional circumstances" exist and it is about to begin the process of requesting permission to apply flood planning controls above the flood planning level.

However, to further support the case for exceptional circumstances, Council requires an evacuation analysis that considers many of the overlapping processes such as warning time, evacuation routes, road closures and population demographics to estimate the ability of people within the Parramatta CBD to evacuate either horizontally or vertically to safety during a flood event.

City of Parramatta Council has engaged Molino Stewart Pty Ltd to explore, at a high level, the various means of horizontal and vertical evacuation which might be feasible for Parramatta CBD now and into the future. The study is to evaluate their feasibility in light of the numbers of people, available warning times, and high-level urban design and cost-benefit considerations. The outputs of the study should be a risk analysis framework which is technically rigorous, transparent and defensible which will inform the review of planning controls and a forthcoming "exceptional circumstances" application, as well as recommendations for preferred evacuation approach(es) in the CBD.

Work Undertaken to Date

To date, the following activities were completed:

- Inception meeting with Council representatives;
- Review of background information;
- Site visit in Parramatta CBD to inspect locations of strategic importance, either for their exposure to flooding or for the likely role these will play in an evacuation scenario;
- Definition and collection of the required input data, including
    - Existing strategic planning instruments;
    - Available flood model results for the 20 year and 100 year ARI events and PMF;
    - GIS layers depicting the current and future CBD development landscape and road network;
    - Data on Parramatta CBD's current and future population and number of workers, divided by transport zone (obtained from the NSW Bureau of Transport Statistics);
    - Number of people commuting to Parramatta CBD by train and bus, obtained from Transport NSW;
    - Number of students enrolled in educational institutions within the CBD (data collection still ongoing);
    - Data on the current and future total number of car parking spaces, divided by block (obtained from Council).

    - Data on future growth of the CBD, based on the CBD Planning Proposal (data collection still ongoing)
- Identification and mapping of the best vehicular evacuation routes, in current conditions and under the assumption that there would be enough time to entirely evacuate the CBD before the roads start to flood. The best evacuation routes were obtained through the following steps:
    - Identification of evacuation routes out of the CBD that are unlikely to be cut in the PMF;
    - Mapping of evacuation paths from each building's driveway to one of the five out-of-the-CBD evacuation routes. This was done under the assumption that cars would need to respect one-way roads and move away from the river and creeks;
    - Identification of evacuation precincts within the CBD (an evacuation precinct was defined as a group of adjacent buildings sharing the same vehicular evacuation route);
    - Allocation of the total number of cars that would need to evacuate to each of the five selected out-of-the-CBD routes. This was done based on the designated evacuation precincts and CBD evacuation routes.
- Identification of the evacuation routes (within the CBD) that would be cut in case some streets are already flooded when the evacuation begins (these were determined using the 20 year ARI flood extent). We note that the 20 year ARI event was selected merely because it constitutes the best available event to indicate which streets and precincts would flood first;
- For those precincts that would not be able to evacuate by car in a 20 year ARI event, all possible pedestrian evacuation paths were identified and mapped. This exercise filtered out all the isolated precincts, for which evacuation by car or foot would not be possible in a 20 year ARI event;
- A progress meeting was organised to discuss the analysis done with Council, the Office of Environment and Heritage (OEH)and NSW SES . Unfortunately no NSW SES representatives were able to attend, due to the recent flood emergency in Northern NSW. The meeting was held anyway and Council and OEH representatives were updated on the project progress;
- The NSW SES Timeline Evacuation Model (Opper et al., 2010) was used to estimate the time required for vehicular evacuation.
- Analysis of the five identified evacuation routes to see whether flooding elsewhere would impact traffic flow on those routes or their distributary roads.

Preliminary Results

The analysis undertaken to date revealed that there would be five roads which could be used for vehicular evacuation out of the CBD. These are: Pennant Hills Road (North), Victoria road (East), Harris and Church Street (South), and the Great Western Highway (West). Figure 1 provides an overview of where the main roads external to the CBD are likely to be cut by floodwaters, while Figure 2 shows a map of the proposed CBD vehicular evacuation routes and precincts.

Assuming that vehicular evacuation could be completed before the CBD streets are flooded, each out-of-the-CBD evacuation route would need to cater for the following number of cars:

- Pennant Hills Road: 1,989cars
- Victoria Road: 201 cars
- Harris Street: 598 cars
- Church Street (South): 1,356cars
- Great Western Highway: 15,417cars

Evacuation time was then assessed for each route using the NSW SES Timeline Evacuation Model (Opper et al., 2010). The model was applied using the NSW SES recommended input parameters, namely:

- The time required by people to accept the order (Warning Acceptance Factor, WAF). NSW SES recommends using a minimum WAF of 1 hour;
- The time required for people to prepare to evacuate (Warning Lag Factor, WLF). NSW SES recommends using a minimum WLF of 1 hour;
- A Traffic Safety Factor (TSF), accounting for delays due to intense traffic, or 1 additional hour per 3 hours of vehicle movement time.

The model calculated the following evacuation times for each route:

- Pennant Hills Road: 4.7 hours (two lanes available) (Table 1)
- Victoria Road: 3.1 hours (three lanes available) (Table 2)
- Harris Street: 4.0 hours (one lane available) (Table 3)
- Church Street (South): 3.8 hours (three lanes available) (Table 4)
- Great Western Highway: 12.6 hours (three lanes available) (Table 5)

It should be stressed that the above listed evacuation times do not consider:

- the time required by NSW SES to mobilise and disseminate the evacuation order. This will depend on the warning system which is currently being designed by City of Parramatta Council, and
- background traffic at the time of evacuation (all roads are assumed to be clear in the modelling)

The next step of the analysis was to assess a scenario in which some of the CBD streets are already flooding when the evacuation commences. The analysis showed that if the evacuation began when the flood had already reached the 20 year ARI event extent, almost all buildings of the CBD located between the railways and Parramatta River would not be able to evacuate by car (Figure 3). At that point, of the people in these buildings, only a small part would be able to evacuate on foot, whereas the remainder would be isolated until the floodwaters have withdrawn (Figure 4).

Analysis of flooding outside of the Parramatta CBD indicated that four of the evacuation routes would probably be cut by flooding within a few kilometres of the CBD and not have distributary roads which could be used to bypass flooding (Figure 1). The exception is the Pennant Hills Road evacuation route which runs along a ridgeline for many kilometres.

Next Steps

- Meet with NSW SES to discuss the adopted methodology
- Estimate the number of vehicles to be evacuated in the future scenarios
- Estimate the number of people to be evacuated by foot in current and future scenarios
- Calculate vehicular and pedestrian evacuation times, with and without additional structural evacuation facilities (e.g. elevated walkways, connections between buildings, etc.)
- Draft design of infrastructure to facilitate evacuation in high-level horizontal evacuation option
- Progress meeting with Council to approve the design of the evacuation infrastructure
- Additional evacuation modelling including use of the evacuation infrastructure
- Progress meeting with Council to discuss the evacuation modelling results
- Cost-benefit analysis to determine the most suitable evacuation strategy
- Preparation of final report and maps

Yours faithfully

For Molino Stewart Pty Ltd

Steven Molino

Principal

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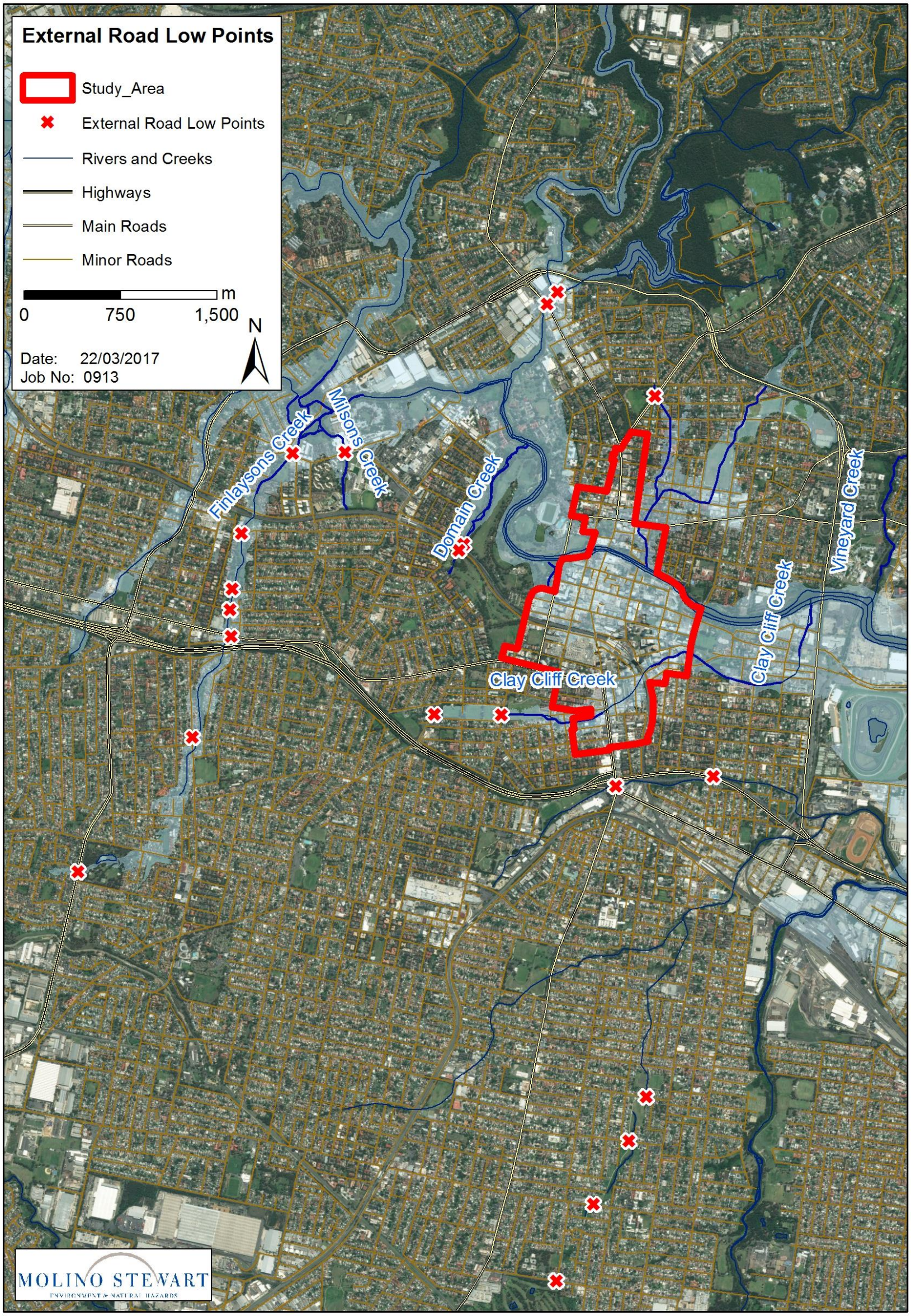

Figure 1. Overview of low points on external roads

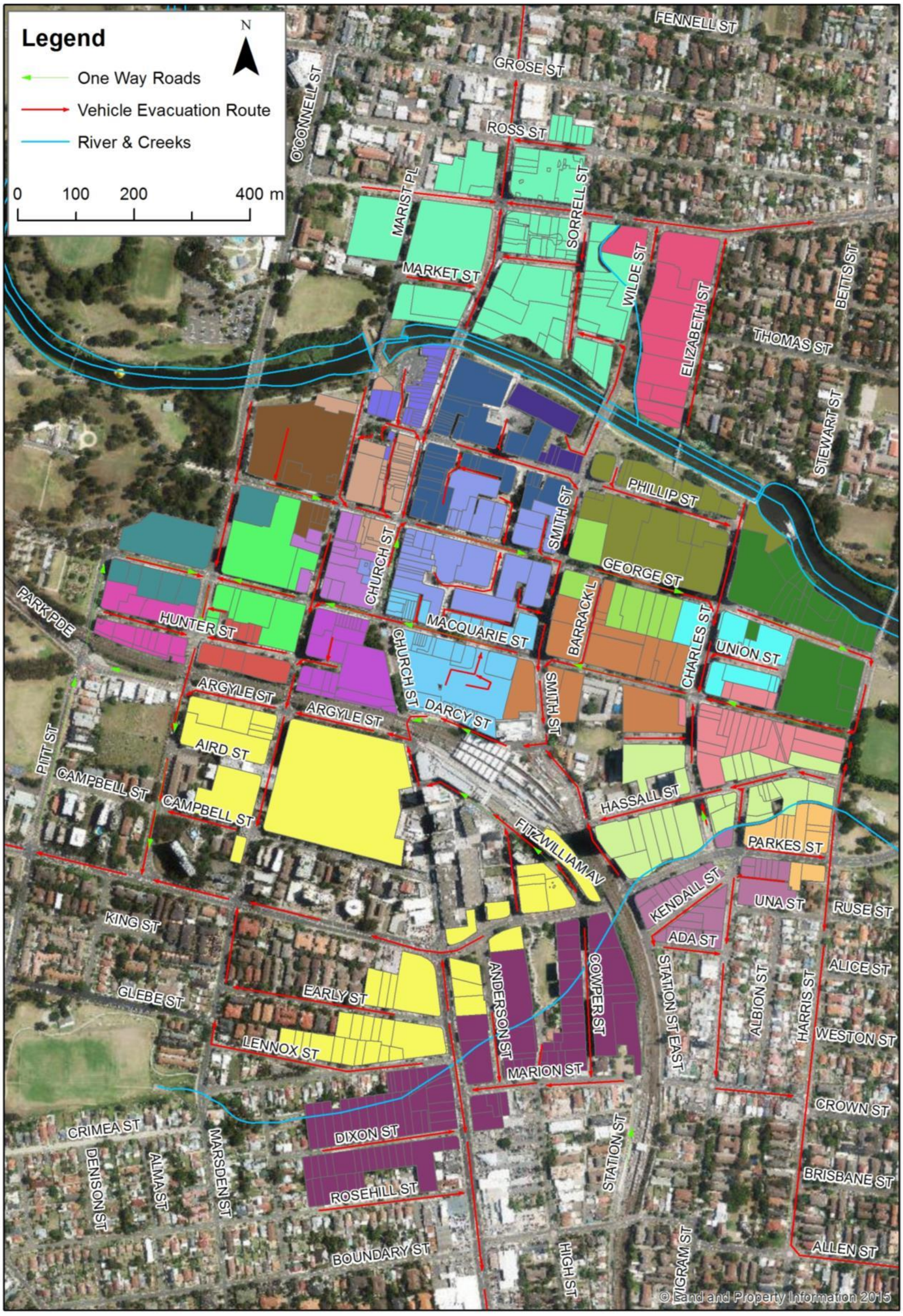

Figure 2. Vehicular evacuation routes and evacuation precincts

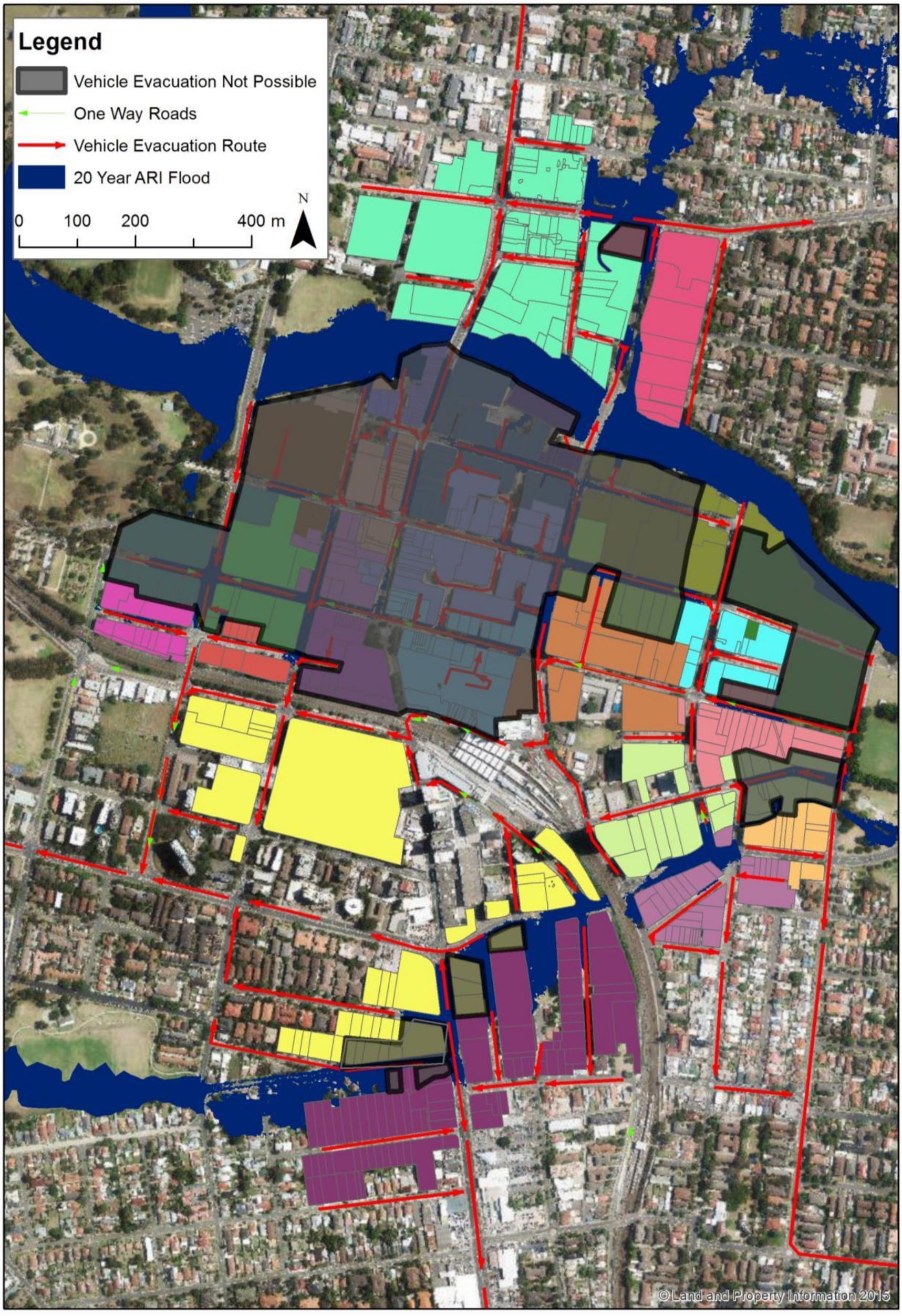

Figure 3. Vehicular evacuation routes cut in the 20 year ARI event.

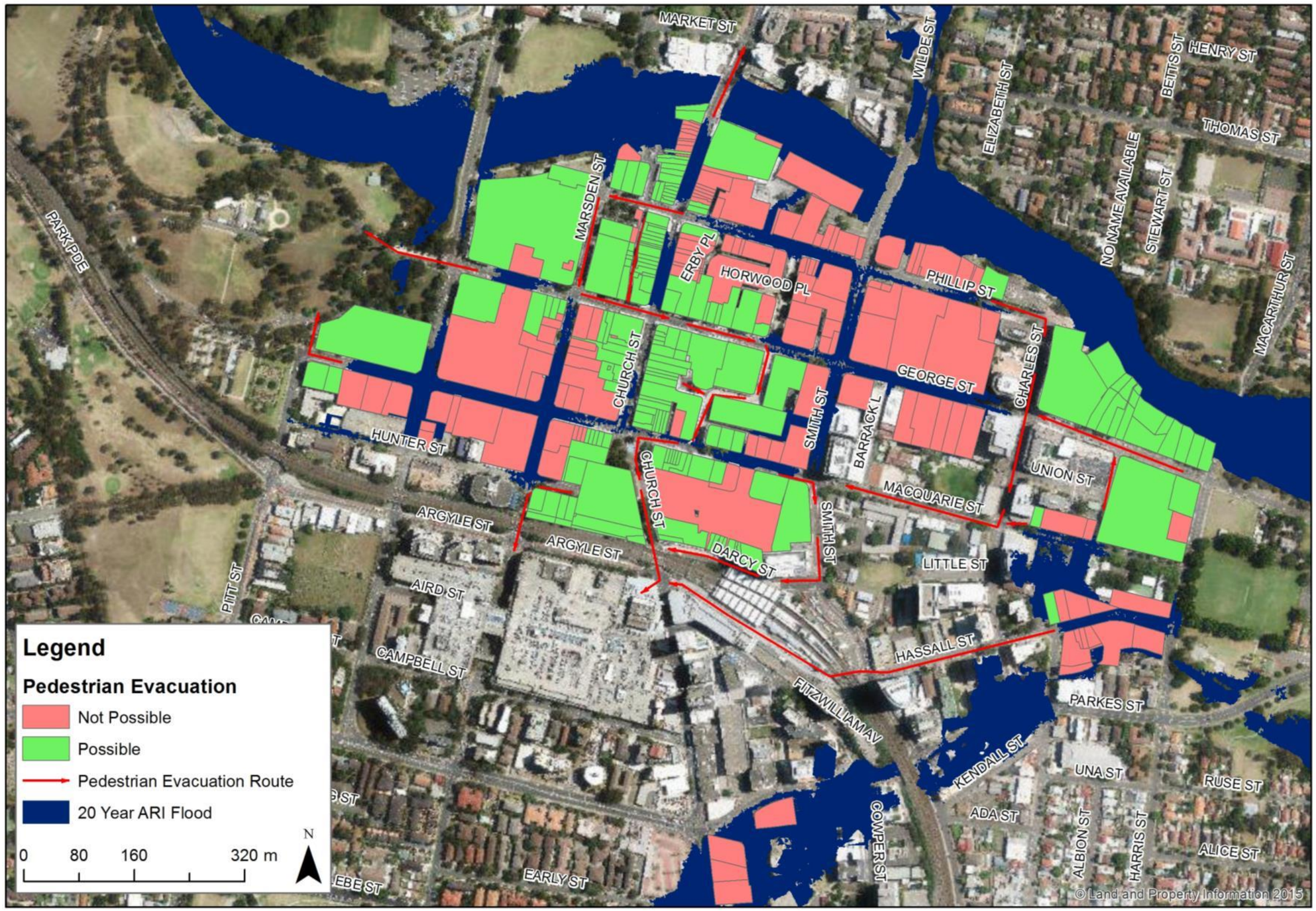

Figure 4. Buildings for which pedestrian evacuation would be possible and not possible in the 20 year ARI event

SES Timeline Evacuation Model. Report Generated From Standard Tool Version 4.0 (26/05/2013)		
Date:	12/04/2017	
Development A:	Buildings evacuating onto Pennant Hills Road	
Calculation ID:	Evac_Precincts_A3_v2.3	
Calculations By:	Molino Stewart	
Notes:	Current condition, CBD not flooded	

Input Data	Development A	Data Source
Number of Residential Vehicles	1989	E.g. Indicative Layout Plan (ILP) Version 3 Revision 2
Number of Commercial Vehicles	0	E.g. ILP Version 3 Revision 2
Evacuation Route Capacity (lanes):	2	E.g. Google Earth, critical location is Flood Street
BOM Forecast Time	0	E.g. State Flood Plan
Additional Time	0	E.g. Allowance for rising road access or remote gauge
Flood Emergency Response Categorisation	0	E.g. Floodplain Risk Management Study

Variables	Value	Justification
Lane Capacity (Vehicles per Lane)	600	SES Default
Warning Acceptance Factor (hours)	1	SES Default
Warning Lag Factor (hours)	1	SES Default
Queue Length per car (m)	6	SES Default
Speed (km/hr)	2	SES Default

Evacuation Results	Development A
Travel Time (hours)	1.7
Traffic Safety Factor (hours)	1.0
Evacuation Time Required (hours)	4.7
Evacuation Time Available (hours)	N/A
Surplus Time (hours)	-4.7
Total Number of Vehicles	1989
Vehicles Not Evacuated	5589

Table 1 SES Timeline Evacuation Model Results for Pennant Hills Road

SES Timeline Evacuation Model. Report Generated From Standard Tool Version 4.0 (26/05/2013)		
Date:	12/04/2017	
Development A:	Buildings evacuating onto Victoria Road (east)	
Calculation ID:	Evac_Precincts_A3_v2.3	
Calculations By:	Molino Stewart	
Notes:	Current condition, CBD not flooded	

Input Data	Development A	Data Source
Number of Residential Vehicles	201	E.g. Indicative Layout Plan (ILP) Version 3 Revision 2
Number of Commercial Vehicles	0	E.g. ILP Version 3 Revision 2
Evacuation Route Capacity (lanes):	3	E.g. Google Earth, critical location is Flood Street
BOM Forecast Time	0	E.g. State Flood Plan
Additional Time	0	E.g. Allowance for rising road access or remote gauge
Flood Emergency Response Categorisation	0	E.g. Floodplain Risk Management Study

Variables	Value	Justification
Lane Capacity (Vehicles per Lane)	600	SES Default
Warning Acceptance Factor (hours)	1	SES Default
Warning Lag Factor (hours)	1	SES Default
Queue Length per car (m)	6	SES Default
Speed (km/hr)	2	SES Default

Evacuation Results	Development A
Travel Time (hours)	0.1
Traffic Safety Factor (hours)	1.0
Evacuation Time Required (hours)	3.1
Evacuation Time Available (hours)	N/A
Surplus Time (hours)	-3.1
Total Number of Vehicles	201
Vehicles Not Evacuated	5601

Table 2 SES Timeline Evacuation Model Results for Victoria Road (east)

SES Timeline Evacuation Model. Report Generated From Standard Tool Version 4.0 (26/05/2013)		
Date:	12/04/2017	
Development A:	Buildings evacuating onto Harris Street (south)	
Calculation ID:	Evac_Precincts_A3_v2.3	
Calculations By:	Molino Stewart	
Notes:	Current condition, CBD not flooded	

Input Data	Development A	Data Source
Number of Residential Vehicles	598	E.g. Indicative Layout Plan (ILP) Version 3 Revision 2
Number of Commercial Vehicles	0	E.g. ILP Version 3 Revision 2
Evacuation Route Capacity (lanes):	1	E.g. Google Earth, critical location is Flood Street
BOM Forecast Time	0	E.g. State Flood Plan
Additional Time	0	E.g. Allowance for rising road access or remote gauge
Flood Emergency Response Categorisation	0	E.g. Floodplain Risk Management Study

Variables	Value	Justification
Lane Capacity (Vehicles per Lane)	600	SES Default
Warning Acceptance Factor (hours)	1	SES Default
Warning Lag Factor (hours)	1	SES Default
Queue Length per car (m)	6	SES Default
Speed (km/hr)	2	SES Default

Evacuation Results	Development A
Travel Time (hours)	1.0
Traffic Safety Factor (hours)	1.0
Evacuation Time Required (hours)	4.0
Evacuation Time Available (hours)	N/A
Surplus Time (hours)	-4.0
Total Number of Vehicles	598
Vehicles Not Evacuated	2398

Table 3 SES Timeline Evacuation Model Results for Harris Street (south)

SES Timeline Evacuation Model. Report Generated From Standard Tool Version 4.0 (26/05/2013)		
Date:	12/04/2017	
Development A:	Buildings evacuating onto Church Street (south)	
Calculation ID:	Evac_Precincts_A3_v2.3	
Calculations By:	Molino Stewart	
Notes:	Current condition, CBD not flooded	

Input Data	Development A	Data Source
Number of Residential Vehicles	1356	E.g. Indicative Layout Plan (ILP) Version 3 Revision 2
Number of Commercial Vehicles	0	E.g. ILP Version 3 Revision 2
Evacuation Route Capacity (lanes):	3	E.g. Google Earth, critical location is Flood Street
BOM Forecast Time	0	E.g. State Flood Plan
Additional Time	0	E.g. Allowance for rising road access or remote gauge
Flood Emergency Response Categorisation	0	E.g. Floodplain Risk Management Study

Variables	Value	Justification
Lane Capacity (Vehicles per Lane)	600	SES Default
Warning Acceptance Factor (hours)	1	SES Default
Warning Lag Factor (hours)	1	SES Default
Queue Length per car (m)	6	SES Default
Speed (km/hr)	2	SES Default

Evacuation Results	Development A
Travel Time (hours)	0.8
Traffic Safety Factor (hours)	1.0
Evacuation Time Required (hours)	3.8
Evacuation Time Available (hours)	N/A
Surplus Time (hours)	-3.8
Total Number of Vehicles	1356
Vehicles Not Evacuated	6756

Table 4 SES Timeline Evacuation Model Results for Church Street (south)

SES Timeline Evacuation Model. Report Generated From Standard Tool Version 4.0 (26/05/2013)		
Date:	12/04/2017	
Development A:	Buildings evacuating onto Great Western Highway	
Calculation ID:	Evac_Precincts_A3_v2.3	
Calculations By:	Molino Stewart	
Notes:	Current condition, CBD not flooded	

Input Data	Development A	Data Source
Number of Residential Vehicles	15417	E.g. Indicative Layout Plan (ILP) Version 3 Revision 2
Number of Commercial Vehicles	0	E.g. ILP Version 3 Revision 2
Evacuation Route Capacity (lanes):	3	E.g. Google Earth, critical location is Flood Street
BOM Forecast Time	0	E.g. State Flood Plan
Additional Time	0	E.g. Allowance for rising road access or remote gauge
Flood Emergency Response Categorisation	0	E.g. Floodplain Risk Management Study

Variables	Value	Justification
Lane Capacity (Vehicles per Lane)	600	SES Default
Warning Acceptance Factor (hours)	1	SES Default
Warning Lag Factor (hours)	1	SES Default
Queue Length per car (m)	6	SES Default
Speed (km/hr)	2	SES Default

Evacuation Results	Development A
Travel Time (hours)	8.6
Traffic Safety Factor (hours)	2.0
Evacuation Time Required (hours)	12.6
Evacuation Time Available (hours)	N/A
Surplus Time (hours)	-12.6
Total Number of Vehicles	15417
Vehicles Not Evacuated	22617

Table 5 SES Timeline Evacuation Model Results for Great Western Highway