

# IDENTIFYING FLOOD CONTROL LOTS IN THE HORNSBY LGA

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## Introduction

The Hornsby Shire Council Local Government Area (LGA) covers a number of Sydney's northern suburbs, extending from Carlingford in the south through to Wisemans Ferry in the North. The total area of the LGA is approximately 510km<sup>2</sup>, making it the second largest LGA in the Sydney region (Hornsby, 2009). About 10% of the Shire is zoned and used for urban development, 14.6% for rural purposes, 4.8% for open space, and the remainder is National Park or Nature Reserve (Hornsby, 2009).

Mainstream flooding occurs through a number of creeks and tributaries within the LGA, as well as along the Hawkesbury River. However, the majority of these are contained within the National Parks and Reserves, with a relatively small number of properties affected by these systems.

Overland flow generally affects the upper catchment areas. It may result from obstruction of overland flow paths due to development, the conversion of natural creeks systems into piped systems, and other similar effects.

## ***2010 Overland Flow Study***

In 2010 Hornsby Shire Council completed a broadscale Overland Flow Study of the entire LGA to identify properties affected potentially by overland flooding associated with major drainage (Cardno, 2010).

## *Hydrology*

Hydrological modelling has been undertaken using two methods:

- Direct Rainfall – for all urban areas within the Hornsby LGA
- Traditional Hydrological Modelling using **xprafits** – for areas outside of the Hornsby LGA

The Direct Rainfall method applies rainfall directly to the 2D domain, rather than utilising a separate hydrological model. This approach has significant advantages for overland flow studies, where the overland flow behaviour in the upper catchment is required.

For the Beecroft model only, an **xprafits** rainfall/runoff model was used to generate inflow hydrographs from a number of external catchments (ie. upper sections of some catchments not located within Hornsby LGA) as an alternative to the Direct Rainfall approach. This avoided the need to extend the 2D model beyond the boundaries of the Hornsby LGA, which would have resulted in larger models and longer computational run times.

Design rainfall depths and temporal patterns for the 100 year event were developed using standard techniques provided in AR&R (1999).

All models except the Beecroft model were run for a 60 minute storm burst duration. Consideration of the short flow paths indicates that the critical duration in these catchments would be 60 minutes or less. The Devlins Creek catchment in the Beecroft model has an estimated Time of Concentration (Bransby-Williams formula) of approximately 2 hours. Therefore, that model was run for storms of 1 hour and 2 hour duration and the envelope of the maximum water levels for the two runs was adopted.

Rainfall loss rates were adjusted in accordance with land use zones identified in the study areas and were incorporated in the model to produce zone-dependent excess rainfall hyetographs.

### *Hydraulics*

Two dimensional (2D) hydraulic modelling was carried out using TUFLOW to estimate the overland flow behaviour for the urban areas only within the LGA. This was then used to define properties inundated by overland flow to a depth greater than 150 mm during a 100 year ARI design storm event.

Aerial survey data was supplied by Council and was used to create the topographic grids for the two-dimensional hydraulic model. A 5 m x 5 m grid was deemed appropriate to adequately define urban features and street flow paths. To improve on the computational run times, the overall LGA was divided into 8 separate models covering the urban areas of the LGA. These models were divided based on catchment boundaries. . Approximately 3.4 million grid cells were required to model the entire 104 square kilometres of the urban areas of the LGA.

In the case of the Brooklyn and Glenorie models, the model boundaries were extended to cover the upstream catchments which are predominantly rural or National Park.

The downstream boundaries of the models were extended 100 m or more beyond the urban areas to ensure that boundary conditions did not affect the modelling results.

The major culverts were incorporated in the models as 1D elements.

It was assumed that all stormwater pits and pipes were effectively blocked during the 100 year ARI event, and were therefore not included in the models.

### *Verification*

Historical flood data was available from Council and was provided in a GIS format. The data was derived from information that Hornsby Shire Council gathered following two large flood events in April 1988 and February 1990. It included information on whether a property experienced overfloor flooding in either habitable or non-habitable areas, or experienced yard flooding only.

The models were run using recorded historical rainfall to predict overland flows in the April 1988 event because this event was generally larger the February 1990 event for the entire LGA.

**Table 1 Summary of Verification Results**

	<b>No. of Properties</b>
Total number of properties that reported problems	1150
Total number of properties mapped based on modelling of the 1988 event	4660
Total number of properties that were identified both by modelling & observation	630
Total number of properties that were identified both by modelling and pipe location & observation	730

A comparison was then made between the resulting flood extents from the model and the pipe criteria mapping with the observations (refer Table 1).

It is noted that there are a total of 1,150 properties where historical flooding data was noted for the 1988 and 1990 flood events. Using the mapping procedure adopted in this study, the total number of properties with observations that were selected was approximately 730 ie. there were 420 properties that reported flooding problems that would not have been identified by the mapping process adopted in the study.

It was noted from discussions with Council that a number of the observations were due to localised flooding on properties, which was not necessarily covered by the study. Furthermore, a review of a number of the observations showed that some of the properties are located near ridgelines or close to local catchment boundaries. It is expected that there may be a number of anomalies in the data set, which makes a direct comparison and verification difficult.

#### *Number of Properties*

The overland flow modelling identified 4,879 properties as being inundated by overland flow to a depth greater than 150 mm during a 100 year ARI design storm event

#### *Public Exhibition*

When Council exhibited the broadscale Overland Flow Study in early 2011 it received more than 600 submissions many of which questioned the approach adopted to flood mapping and the resulting classification of properties.

During the Public Exhibition the Department of Planning also issued further planning provisions on 25 February 2011 regarding flood control lots and complying development provisions under the Exempt and Complying Development SEPP. A new process was introduced for flood control lots. Lots identified as “high hazard/risk flood planning areas” on LEP maps do not benefit from the complying development provisions. “Low hazard/risk flood planning areas” may benefit from the complying development provisions.

Based on the community feedback received during the Public Exhibition of the Hornsby Overland Flow Study and in the light of the changes to the planning provisions for flood control lots, Council decided in 2011 to commission an assessment of alternative methods for identifying high flood risk properties within the Hornsby Shire.

## 2011 Study

The objectives of the 2011 study included the:

- Identification of “high risk” overland flow affected properties, in line with the amended DoP guidelines; and
- Sensitivity analysis of some of the key assumptions of the overland flow modelling.

### *Approach*

While the 2010 study did undertake a sensitivity analysis on the key parameters, such as rainfall and roughness, it did not consider the effects of including local drainage systems and/or the blockage of buildings on the estimated flood extents and the ramifications for the number of flood affected properties. Some residents also queried the accuracy of the adopted 5 m x 5 m grid size in the 2010 study.

To identify the significance or otherwise of these factors, sensitivity analyses were undertaken on a small pilot area identified by Council. The sensitivity testing comprised:

- (i) Modelling a smaller grid size, such as a 2 m x 2m grid, across the pilot model area to determine the impact that grid size has on the results;
- (ii) Assessing the 5 yr ARI flood extents as a possible surrogate for flooding in a 100 yr ARI event with a fully functional drainage system with around a 5 yr ARI capacity;
- (iii) Incorporation of pits and pipes into the pilot model to determine the impact that the stormwater infrastructure has on the 100 yr ARI overland flow extents; and
- (iv) Incorporation of buildings into the pilot model as raised elements (or completely blocked to flow) to determine the impact that this has on the 100 yr ARI overland flow extents.

It was also proposed to assess the likely change in the number of properties identified across the LGA by assessing the changes in one of the original model zones (based on a 5 m x 5 m grid) by:

- (v) Assessing the 5 yr ARI flood extents as a possible surrogate for flooding in a 100 yr ARI event with a fully functional drainage system with around a 5 yr ARI capacity;
- (vi) Also mapping of properties with depths greater than 300mm or affected by high hazard for depths greater than 150mm, for both the 100 yr ARI and the 5 yr ARI cases.

### *Results*

Council nominated a local area in Pennant Hills for the pilot model study. Various pilot models were assembled at a 2 m x 2 m grid for the following scenarios:

- |            |  |
|------------|--|
| Scenario 1 | 100 yr ARI without drainage pipes or buildings   |
| Scenario 2 | 5 yr ARI without drainage pipes or buildings (as a possible surrogate for flooding in a 100 yr ARI event with a fully functional drainage system with around a 5 yr ARI capacity); |
| Scenario 3 | 100 yr ARI with drainage pipes but without buildings   |
| Scenario 4 | 100 yr ARI with drainage pipes and with buildings  |

Various plots were prepared as follows. It should be noted that that there was no attempt to edit out any “islands” nor was the extent of areas with High Hazard for depths > 150 mm plotted separately from the areas of depth 300 mm in a 100 yr ARI event.

Figure 1 compares the flood extents under Scenario 1 with 150 mm and 300 mm depth filters only applied.

Figure 2 compares the flood extents under Scenario 2 with 150 mm and 300 mm depth filters only applied.

Figure 3 compares the flood extents under Scenario 1 and Scenario 2 with a 150 mm depth filter only applied. The flood extents under Scenario 1 and Scenario 2 with a 300 mm depth filter only applied are plotted in Figure 4. These two plots are indicators as to how well a 5 yr ARI flood extent without a drainage system represents a 100 yr ARI flood event with a fully functional drainage system.

Figure 5 compares the flood extents under Scenario 2 and Scenario 4 with a 150 mm depth filter only applied while Figure 6 compares the flood extents under Scenario 2 and Scenario 4 with a 300 mm depth filter only applied.

The numbers of properties which would be identified as flood affected for each scenario and for each depth filter are summarised in Table 2 for both the 2 m x 2 m grid pilot model and as determined for the pilot area from the results of the 2010 model with a 5 m x 5 m grid.

The interesting conclusions from the summary given in Table 2 include:

- The number of properties identified by Scenario 2 (5 yr ARI without a drainage system) is comparable to the number of properties identified under Scenario 3 (100 yr ARI with drainage system) irrespective of the depth filter adopted ie. the 5 yr ARI event without a drainage system is a surprisingly good representation of a 100 yr ARI flood event with a fully functional drainage system;
- The number of properties identified by Scenario 2 and a 150 mm depth filter is comparable to the number of properties identified under Scenario 1 with a 300 mm depth filter and/or high hazard for depths greater than 150 mm;
- Adopting a 2 m grid instead of a 5 m grid increases the number of properties that are identified contrary to the views expressed in a number of submissions to Council;
- While the inclusion of buildings (Scenario 4) increases the number of properties that would be tagged this appears due to the local trapping of overland flow behind a number of buildings which appear distant from mapped flood extents ie. these numbers may be misleading.

**Table 2 Summary of Number of Properties impacted by Flood Extents in the Pilot Study Area**

Results based on local flood models

Criteria for Tagging a Property	2 m Grid Model			
	100yr ARI without Pipes	5yr ARI without Pipes	100yr ARI with Pipes	100yr ARI with Pipes & Bldgs
Depth>150mm	49	36	38	56
Depth>300mm or Depth >150mm and High Hazard	33	29	31	39

Reduction in Number of Properties

Criteria for Tagging a Property	100yr ARI without Pipes	5yr ARI without Pipes	100yr ARI with Pipes	100yr ARI with Pipes & Bldgs
Depth>150mm		13	11	-7
Depth>300mm or Depth >150mm and High Hazard	16	20	18	10

Reduction in Number of Properties

Criteria for Tagging a Property	100yr ARI without Pipes	5yr ARI without Pipes	100yr ARI with Pipes	100yr ARI with Pipes & Bldgs
Depth>150mm		26.5%	22.4%	-14.3%
Depth>300mm or Depth >150mm and High Hazard	32.7%	40.8%	36.7%	20.4%

Change from 2 m Grid Model

Results based on local flood models

Criteria for Tagging a Property	5 m Grid Model		5 m Grid Model	
	100yr ARI without Pipes	5yr ARI without Pipes	100yr ARI without Pipes	5yr ARI without Pipes
Depth>150mm	49	29	0	-7
Depth>300mm or Depth >150mm and High Hazard	30	24	-3	-5

Reduction in Number of Properties

Criteria for Tagging a Property	100yr ARI without Pipes	5yr ARI without Pipes
Depth>150mm		20
Depth>300mm or Depth >150mm and High Hazard	19	25

Reduction in Number of Properties

Criteria for Tagging a Property	100yr ARI without Pipes	5yr ARI without Pipes
Depth>150mm		40.8%
Depth>300mm or Depth >150mm and High Hazard	38.8%	51.0%

The numbers of properties which would be identified as flood affected under Scenarios 1 and 2 within the Pennant Hills model zone for each depth filter are summarised in Table 3 for the 2010 model with a 5 m x 5 m grid.

**Table 3 Summary of Number of Properties impacted by Flood Extents in the Pennant Hills Model Zone**

Criteria for Tagging a Property	100yr ARI	5yr ARI
Depth>150mm	2410	1648
Depth>300mm or Depth >150mm and High Hazard	1643	844

Reduction in Number of Properties

Criteria for Tagging a Property	100yr ARI	5yr ARI
Depth>150mm		-762
Depth>300mm or Depth >150mm and High Hazard	-767	-1566

Criteria for Tagging a Property	100yr ARI	5yr ARI
Depth>150mm		-31.6%
Depth>300mm or Depth >150mm and High Hazard	-31.8%	-65.0%

As was concluded in the pilot study area it was also concluded from the results given in Table 3 that the number of properties identified by Scenario 2 and a 150 mm depth filter is comparable to the number of properties identified under Scenario 3 with a 300 mm depth filter and/or high hazard for depths greater than 150 mm.

## CONCLUSIONS

Based on the above assessments it was concluded that Council could consider adopting

- Flood extents based on a 5 yr ARI event without drainage and a 150 mm depth filter; or
- Flood extents based on a 100 yr ARI event without drainage and a 300 mm depth filter and/or high hazard for depths greater than 150 mm

as the criteria for tagging high hazard properties.

The advantage of the 150 mm depth filter is that this appears to give contiguous zones and reduces the number of islands that appear with a 300 mm depth filter.

## ACKNOWLEDGEMENT

The permission of the Hornsby Shire Council to outline the assessment of alternative methods for identifying high flood risk properties within the Hornsby Shire is gratefully acknowledged.

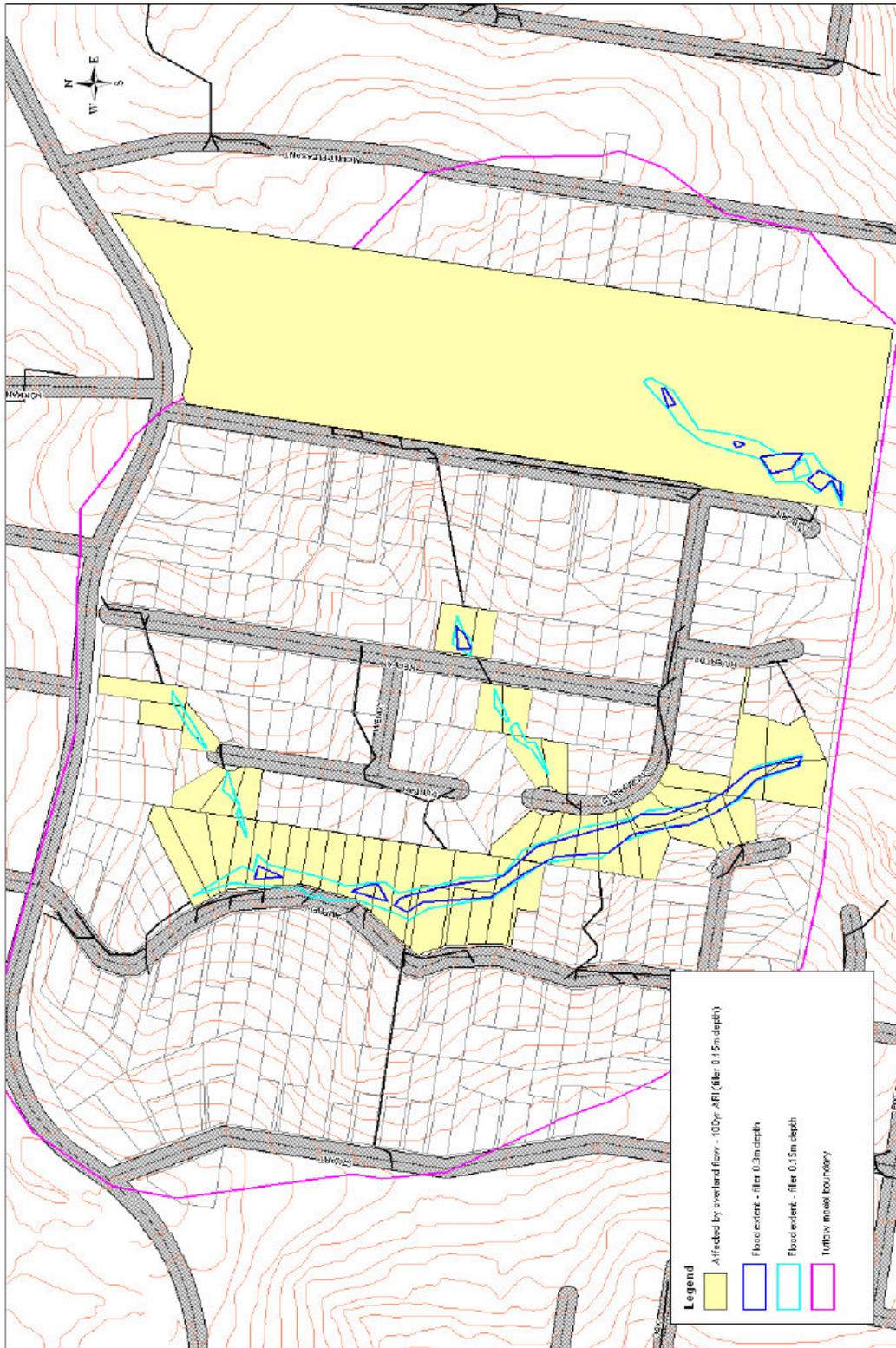
## REFERENCES

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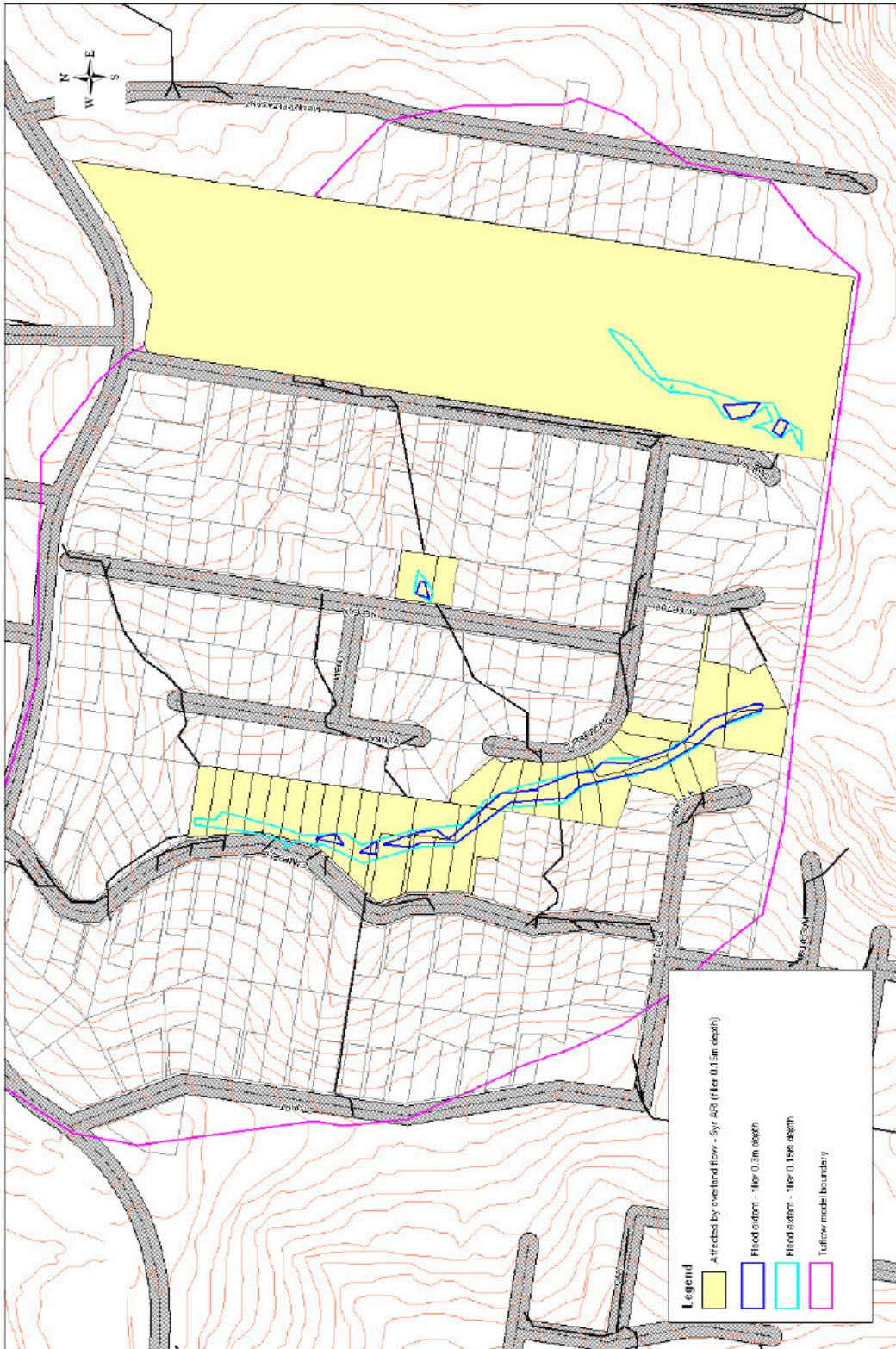
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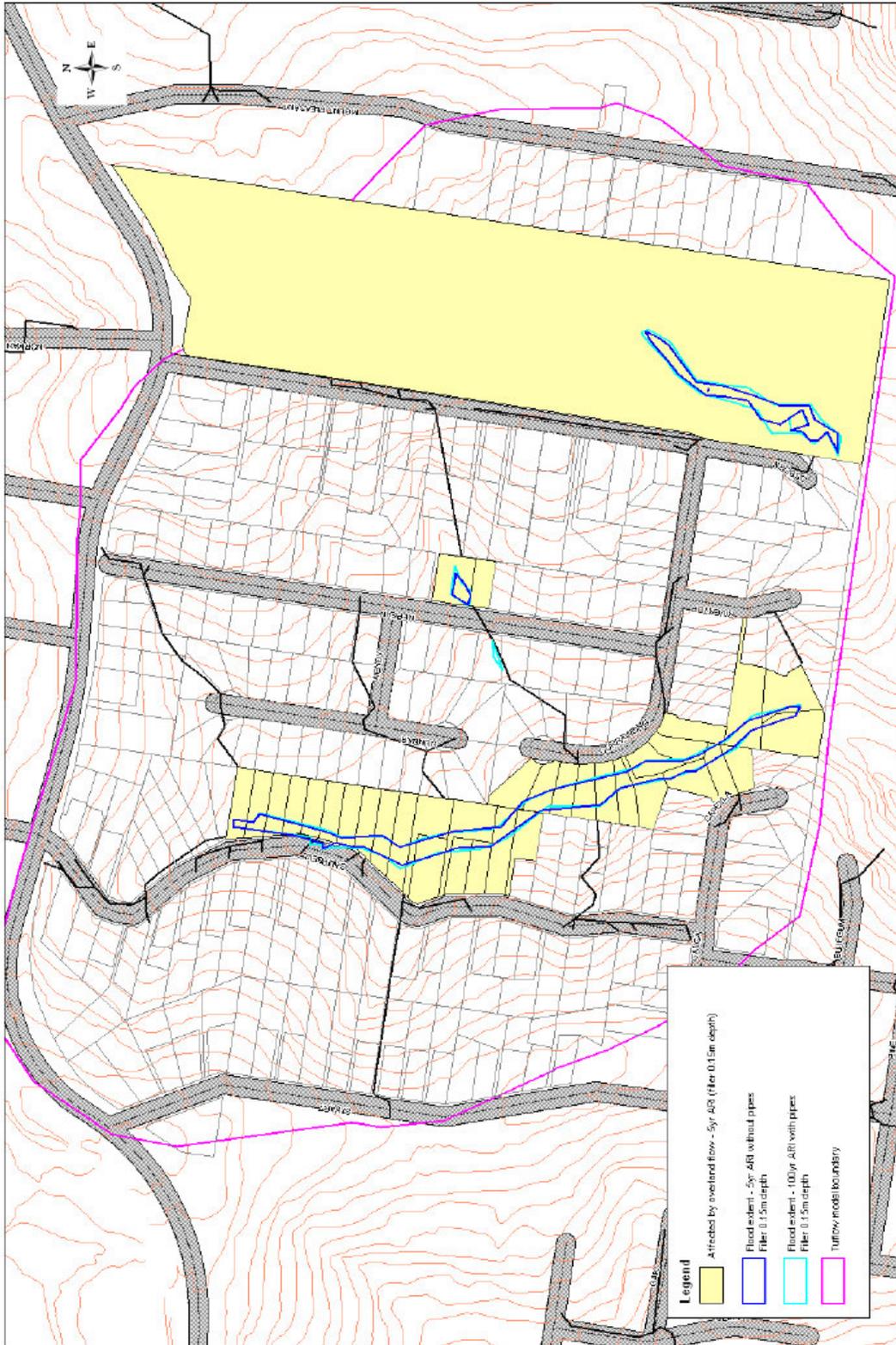
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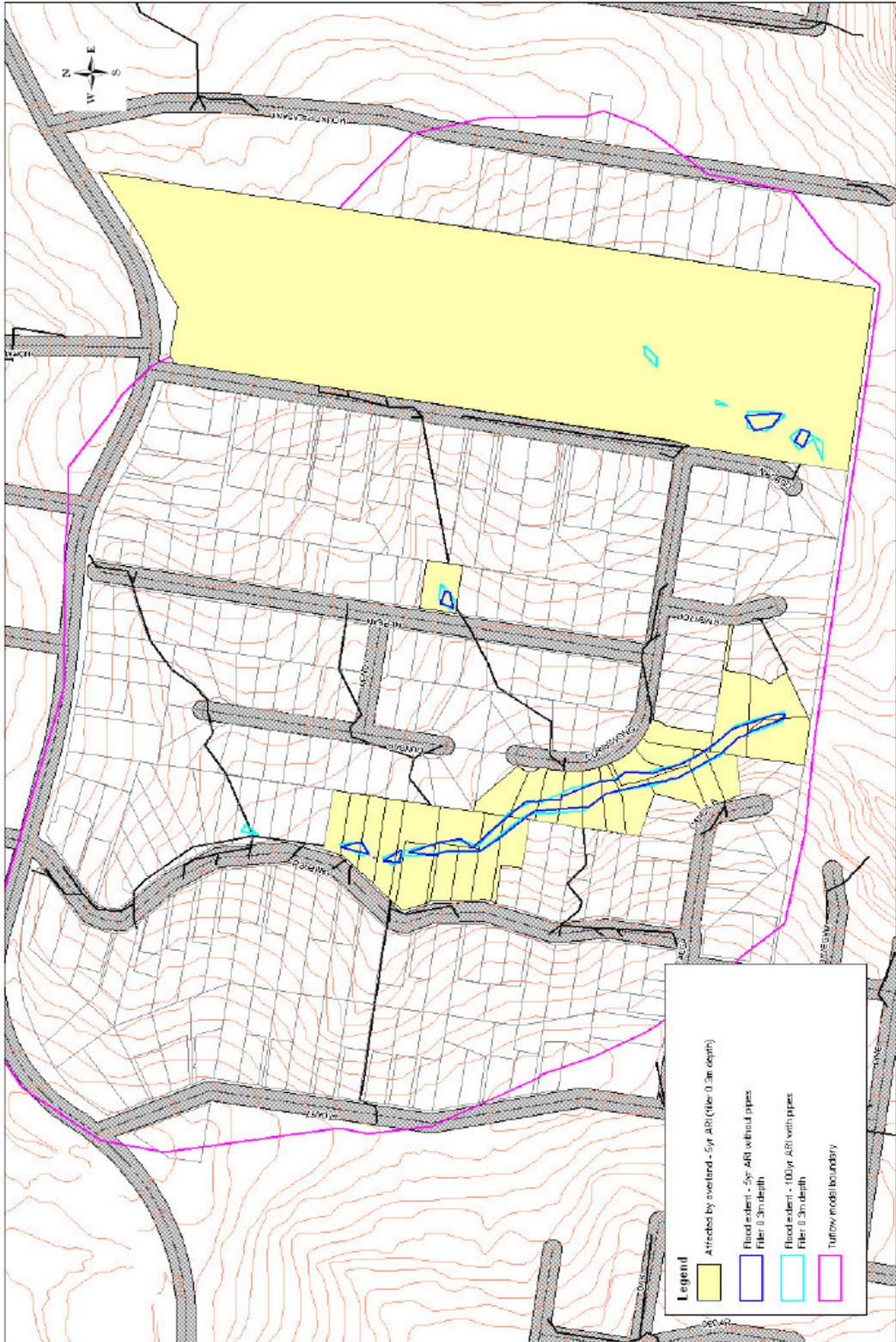
**Figure 1 100 yr ARI Flood Extents without Pipes  
Depth Filter = 150 mm and 300 mm**



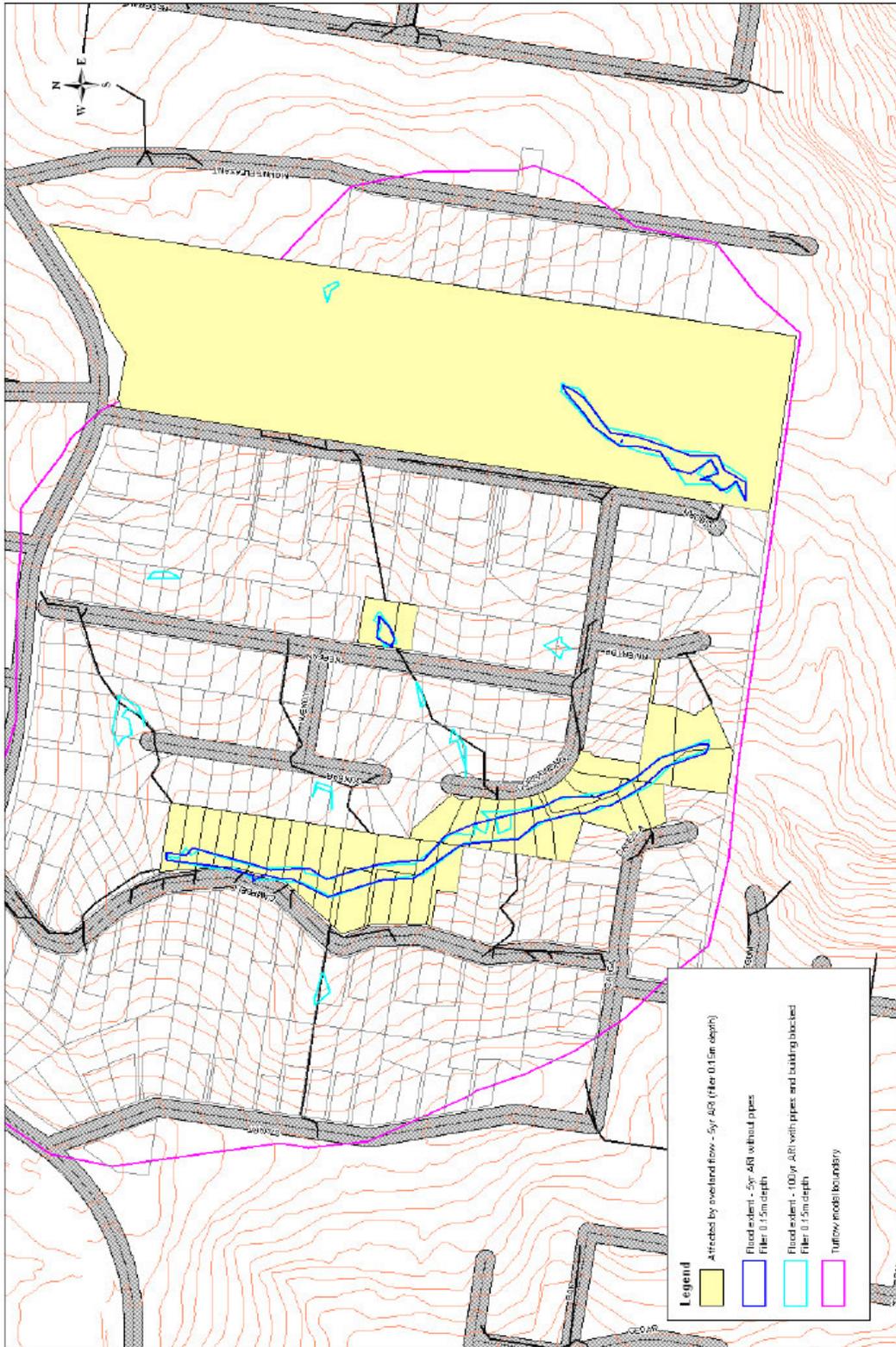
**Figure 2 5 yr ARI Flood Extents without Pipes  
Depth Filter = 150 mm and 300 mm**



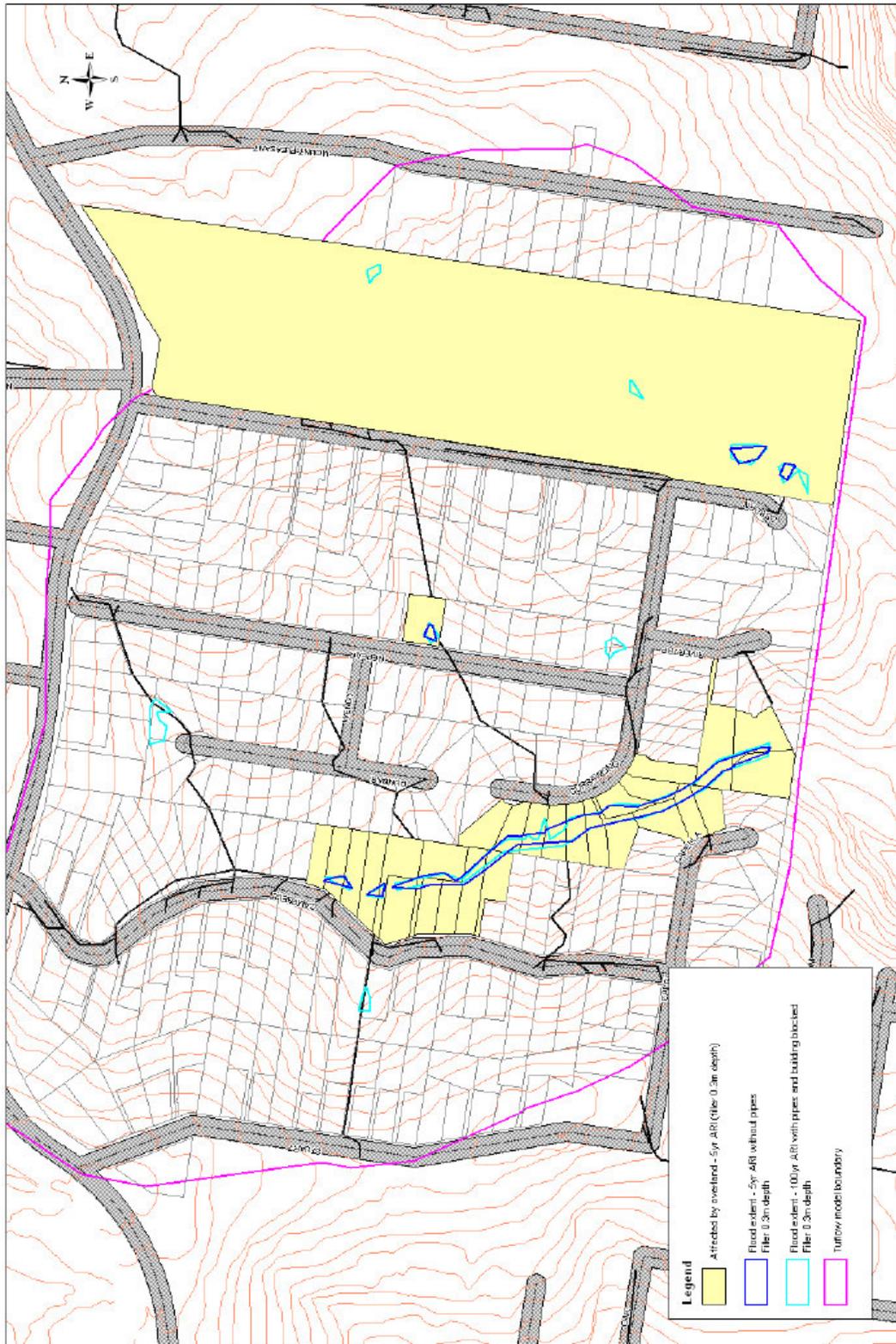
**Figure 3 Comparison of 5 yr ARI Flood Extents without Pipes and 100 yr ARI Flood Extents with Pipes  
Depth Filter = 150 mm**



**Figure 4 Comparison of 5 yr ARI Flood Extents without Pipes and 100 yr ARI Flood Extents with Pipes  
Depth Filter = 300 mm**



**Figure 5 Comparison of 5 yr ARI Flood Extents without Pipes and 100 yr ARI Flood Extents with Pipes and Buildings Blocked Out  
Depth Filter = 150 mm**



**Figure 6 Comparison of 5 yr ARI Flood Extents without Pipes and 100 yr ARI Flood Extents with Pipes and Buildings Blocked Out  
Depth Filter = 300 mm**