Memorandum

TO: Craig Naughton, Sophia Findlay
FROM: Michael Reeves
DATE: 6 October 2023
SUBJECT: DRAINS Modelling for Lane Cove Northern Catchments Flood Study
PROJECT NUMBER: 121054

1. INTRODUCTION

Ku-ring-gai Council (Council) provided WMAwater with data for undertaking the 'Lane Cove – Northern Catchments Flood Study'. This data included existing DRAINS hydrologic models. The purpose of this memorandum is to provide an overview of the DRAINS hydrologic modelling received and the updates that were undertaken to generate a model suitable for developing inflows for the Flood Study. Council requested that the existing DRAINS models be updated within the Lane Cove Northern Catchments study area. The primary purpose of these models is to generate inflow hydrographs for the TUFLOW hydraulic model, which will define flood behaviour within the study area. The models, however, will also be used as a supplementary tool for Council's stormwater team, for investigation of stormwater capacity and possible local drainage upgrades and localised design work, rather than requiring interrogation or running of the more accurate (but time consuming) TUFLOW model for such tasks. The DRAINS modelling will be simpler and less accurate than the detailed TUFLOW 2D hydraulic modelling, but can be useful for in-house Council design of minor drainage upgrades. This memorandum outlines the work undertaken to update the existing DRAINS models.

2. EXISTING DRAINS MODELS OVERVIEW

Council provided WMAwater with eight DRAINS models covering the Lane Cove Northern Catchments study area. These models are from the following studies:

- Lane Cove Northern Catchments Stormwater Planning Study (Cardno Willing 2005), covering the following catchments:
    - Lane Cove 1
    - Lane Cove 2
    - Lane Cove 3 (Congham Creek)
    - Avondale Creek
    - Fox Valley
    - Coups Creek

- Local Catchment Plan – Lane Cove River Southern Region Catchments (URS 2006), coving the following catchments:
    - Lane Cove 4 (Rudder Creek)
    - Loftberg Quarry Creek (Quarry Creek)

There are a total of 2,401 sub-catchments represented in these models. The stormwater network comprises 2,922 pits/nodes connected by 2,368 pipes. The primary concern for the use of the DRAINS model for flood study is the catchment representation (rather than the stormwater network, which will be simulated in the more accurate TUFLOW model). A summary of the sub-catchment parameters in each of the models is provided in Table 1.

Table 1: Sub-catchment representation in the existing DRAINS models

Model	Hydrology	Paved Storage (mm)	Supplementary Storage (mm)	Grass Storage (mm)	Soil Type	Catchment Data Type[1]	% Impervious (P/S/G)[2]	Time of Concentration or Additional Time (P/S/G, minutes)[3]
Avondale Creek	KU_RING_GAI ILSAX	1	5	5	3	Detailed	47/5/48	2/2/2
Coups Creek	KU_RING_GAI ILSAX	1	5	5	3	Abbreviated	47/5/48	5/5/5
Fox Valley Creek	KU_RING_GAI ILSAX	1	1	5	3	Detailed	47/5/48	5/5/5
Lane Cove 1	KU_RING_GAI ILSAX	1	5	5	3	Abbreviated	47/5/48	5/5/5
Lane Cove 2	KU_RING_GAI ILSAX	1	5	5	3	Abbreviated	47/5/48	5/5/5
Lane Cove 3	KU_RING_GAI ILSAX	1	5	5	3	Abbreviated	47/5/48	5/5/5
Lane Cove 4	KU_RING_GAI ILSAX	1	1	5	3	Detailed	47/5/48	2/2/2
Loftberg Quarry	Loftberg Quarry ILSAX	1	1	5	3	Detailed	47/5/48 some 100% paved, some 95% grassed	2/2/2

1 Abbreviated data simply uses a P(aved), S(upplementary) and G(rass) area within a subcatchment with a time of concentration specified
Detailed data uses a P(aved), S(upplementary) and G(rass) area within a subcatchment with a time, flowpath length, flowpath slope and additional time specified

2 Impervious percentage for P(aved), S(upplementary) and G(rass) areas within each subcatchment

3 Abbreviated data is time of concentration (mins) for P(aved), S(upplementary) and G(rass) areas
Detailed data is additional time (mins) for P(aved), S(upplementary) and G(rass) areas

3. SUITABILITY OF EXISTING DRAINS MODELS

The existing DRAINS models were not considered to be adequate in their representation of the catchment conditions. Primarily this relates to the catchment-wide adoption of a standard pervious/impervious fraction and time of concentration regardless of the sub-catchment size or land use. If the sub-catchment boundaries were available, these parameters could be updated with sub-catchment specific values. However, sub-catchment boundaries were not available. There are also areas where these models need to be extended into the bushland area downstream of the urban areas, for which the existing sub-catchment boundaries are also required. In consultation with Council, it was decided that the existing DRAINS models were to be updated for use in the Lane Cove Northern Catchments Flood Study.

4. UPDATED DRAINS MODELS

The updates made to the DRAINS models are contained in the following sections.

4.1. Sub-catchment Delineation

There are approximately 2,400 sub-catchments in the existing DRAINS models. It was not considered feasible to manually delineate each of these sub-catchments. Instead, a semi-automated approach was adopted using GIS techniques.

The latest available LiDAR information (2019/2020) was utilised in the TUFLOW model developed for the Flood Study. The TUFLOW model contained topographic modifications for hydraulic features. This included gutters, which are significant for the capture and directing of flows to individual pits. These gutters may not be adequately represented even in the 1 m LiDAR grid. The gutters were enforced as continuous flow paths in the TUFLOW model. A 2 m digital elevation model (DEM) grid was produced by TUFLOW with the terrain and hydraulic features. The terrain was 'hydrologically treated' to fill sinks and provide continuous flow paths through the study area. Hydrologic algorithms were then applied to calculate flow direction and flow accumulation grids. These grids were used to derive a dense stream network.

Pit inlet locations and nodes from the existing DRAINS models were exported into a GIS dataset. The dataset was filtered to leave only those nodes with sub-catchment inflows associated with them (i.e. removing 'junction' pits). This resulted in 2,394 nodes. The nodes were then georeferenced to the correct location, since the coordinates within the DRAINS model were not a standard coordinate system. The nodes were georeferenced to MGA zone 56 using GIS stormwater asset data obtained from Council. These nodes were then snapped to this stream network and the upstream catchment area was calculated to these points. The sub-catchments were reviewed and node locations adjusted in order to best represent the catchment draining to each point. These sub-catchments were further 'cleaned' and manually adjusted (where required) to obtain a detailed sub-catchment network. The GIS layer for these sub-catchments is provided and they are shown in Figure 1.

4.2. Sub-catchment Parameters

The 'detailed' catchment data approach was adopted for the updated DRAINS model. The adopted sub-catchment parameters are outlined below.

4.2.1. Sub-catchment Area

The area of each sub-catchment was calculated based on the GIS layer developed (see Section 4.1). These sub-catchment areas were used in the DRAINS model.

4.2.2. Land Use Type

DRAINS allows the land use in each sub-catchment to be modelled in terms of an impervious fraction (termed 'paved', representing directly connected impervious areas), a pervious fraction (termed 'grassed') and a supplementary fraction (representing indirectly connected impervious areas). This approach is described in Australian Rainfall and Runoff (ARR) 2019. The TUFLOW model surface roughness was used to define the impervious fractions within each sub-catchment. The adopted impervious percentages for each land use type are provided in Table 2 and can be seen in Figure 2.

Table 2: Land use types and impervious fractions

Land Use Type	Paved (%)	Supplementary (%)	Grassed (%)
Road corridors[1]	80	0	20
Residential	40	10	50
Bushland / Vegetated	0	0	100
Grassed (e.g. parks)	0	5	95
Commercial	50	20	30
Waterways[2]	100	0	0

1. Including verges
2. Open water assumed to be 100% impervious

4.2.3. Flow Path Length and Slope

Detailed sub-catchment data in DRAINS requires the user to specify the flow path length, flow path slope and retardance coefficient for use in the kinematic wave equation to calculate time of concentration. The alternative method (abbreviated data) requires the user to specify this time of concentration.

The longest flow path length for each sub-catchment was calculated using the 'Whitebox' tools (https://www.whiteboxgeo.com/) for the sub-catchment layer and the DEM. Where the longest flow path was calculated to be zero (21 sub-catchments), an estimate of the flow path length was made based on the relationship between catchment area and longest flow path for sub-catchments where the tool was successful.

The flow path slope for each sub-catchment was calculated using the 'Whitebox' tools (https://www.whiteboxgeo.com/) for the sub-catchment layer and the DEM. Where the flow path slope was calculated to be more than 30% (59 sub-catchments), this was set to 30% (maximum allowable slope in DRAINS). Where the flow path slope was not computed (for those sub-catchments with zero flow path length), an average slope was assigned, which was 7% for the study area.

An additional time of 2 minutes was assigned for paved areas (representing concentration time from pervious areas such as roofs) and 1 minute for supplementary and grassed areas. The retardance coefficient (n*) of 0.015 was assigned for paved areas (representing concrete) and 0.1 for supplementary and grassed areas. These values were adopted based on consideration of guidance in the DRAINS manual. It should be noted that the retardance coefficient (n*) is similar to, but not the same as the traditional Manning's 'n' parameter.

4.3. DRAINS Model Development

The updated DRAINS model was developed in version 2022.012 (64 bit). The Horton/ILSAX hydrologic model was adopted, with the relevant parameters outlined in Table 3. These parameters are broadly consistent with the 'KU_RING_GAI ILSAX' parameters in the existing models.

Table 3: ILSAX Parameters Adopted

Parameter	Value
Paved area (impervious) depression storage (mm)	1
Supplementary area depression storage (mm)	1
Grassed (pervious) area depression storage (mm)	5
Soil Type	3
Overland Flow Approach	Kinematic Wave Equation

Two different models were produced:

1. A model for the flood study, which covers the entire study area but has the sub-catchments only
2. Models for Council's stormwater team, which consists of separate models for each of the existing model areas (as outlined in Table 1). For these models, the stormwater network (pits, pipes, channels and overflow routes) were retained from the existing models. A new model background was also generated for these models, consisting of the cadastre, street names and contours.

The updated DRAINS models are designed to run in version 2022.012 (64 bit), and as such, there were updates made to the 'pit blocking theory' and 'overland flow routes' that DRAINS recommends. The updated models are also correctly georeferenced using MGA zone 56.

4.4. ARR 2019 Updates

The updated DRAINS models were also updated to incorporate ARR 2019. The following data was used:

- IFD data obtained from the Bureau of Meteorology (http://www.bom.gov.au/water/designRainfalls/revised-ifd/), for the study area centroid (nearest grid cell 33.7375°S 151.1125°E).
- Temporal patterns were obtained from the ARR Datahub (https://data.arr-software.org/), for the study area centroid (33.743°S 151.116°E). These are for the South East Coast region.

The full range of available AEPs (12 EY to 1 in 2000) and durations (5 minutes to 7 days) were imported into DRAINS and available for simulation, with each AEP and duration combination having 10 temporal patterns.

5. VALIDATION

Checks were undertaken at each stage of the model development for quality assurance. One of the key inputs to the model is the catchment delineation. The catchment areas were checked against the existing model areas to validate the new catchments generated. It was found that the average difference in sub-catchment area was 0.07 ha. The total area covered by the models increases from 1,410 ha to 1,580 ha – an increase of 170 ha, or 12%. The minimum difference was 12 ha (i.e. a reduction in sub-catchment area) and the maximum difference was 115 ha (i.e. an increase in sub-catchment area). The largest differences were investigated and validated, and described in Table 4.

Table 4: Sub-catchments with large differences in area compared to existing models

Sub-catchment	Model	Difference in area [updated – existing] (ha)	Comment
ACC01A10	Coups Creek	+115	This is the large sub-catchment located at the north-west extent of the study area (Figure 1). This is actually the headwaters of the Lane Cove River to the Comenarra Parkway where it joins Coups Creek. This area was deemed to be correct.
ACCA090	Coups Creek	+33	This sub-catchment is located on Coups Creek, at the confluence with a tributary. It appears as though the existing model did not include this tributary.
AFVA110	Fox Valley	+13	These nodes are located on the creek line upstream of the Comenarra Parkway, and it appears that the area has been re-distributed between these two nodes. The total catchment area to the Comenarra Parkway is considered to be correct, however, it is distributed differently between the two nodes which are located approximately 100 m apart.
AFVA120	Fox Valley	-12	
ACC13D10	Coups Creek	+12	This sub-catchment is located at the northern extent of the study area (Figure 1). It is bounded by the Pacific Highway and Pennant Hills Road. This area was deemed to be correct.
AFVA010	Fox Valley	+8	This is the most downstream catchment in the Fox Valley model, at the confluence of two tributaries. The area was deemed to be correct.

The remaining differences in area are less than 8 ha. With the sub-catchments in Table 4 assigned the area from the previous model, the average difference in area was 0.00 ha, with a total difference of just 0.05 ha between the updated and existing models.

FIGURES

FIGURE 1
LANE COVE NORTHERN CATCHMENTS
DRAINS MODEL SUBCATCHMENTS

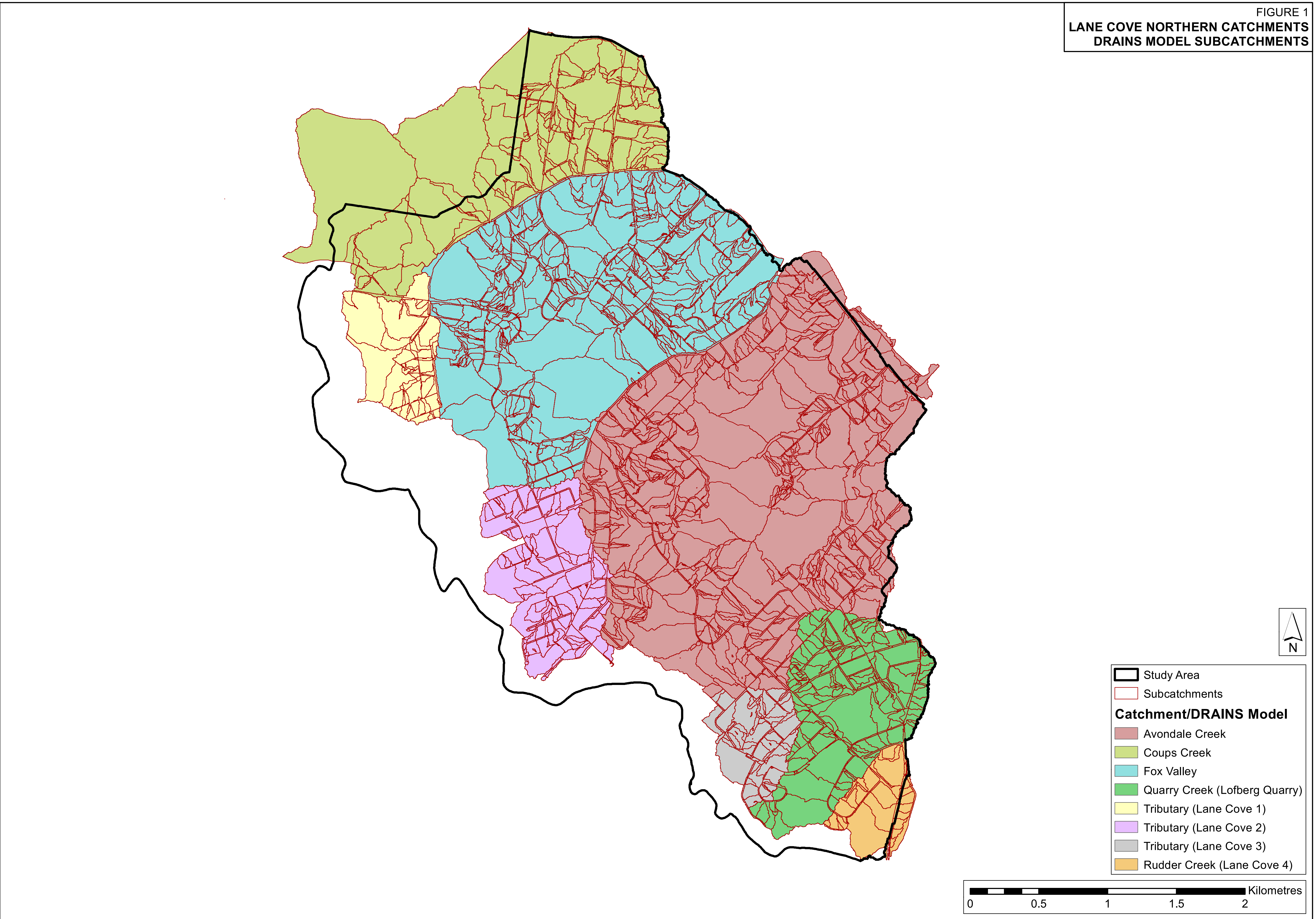

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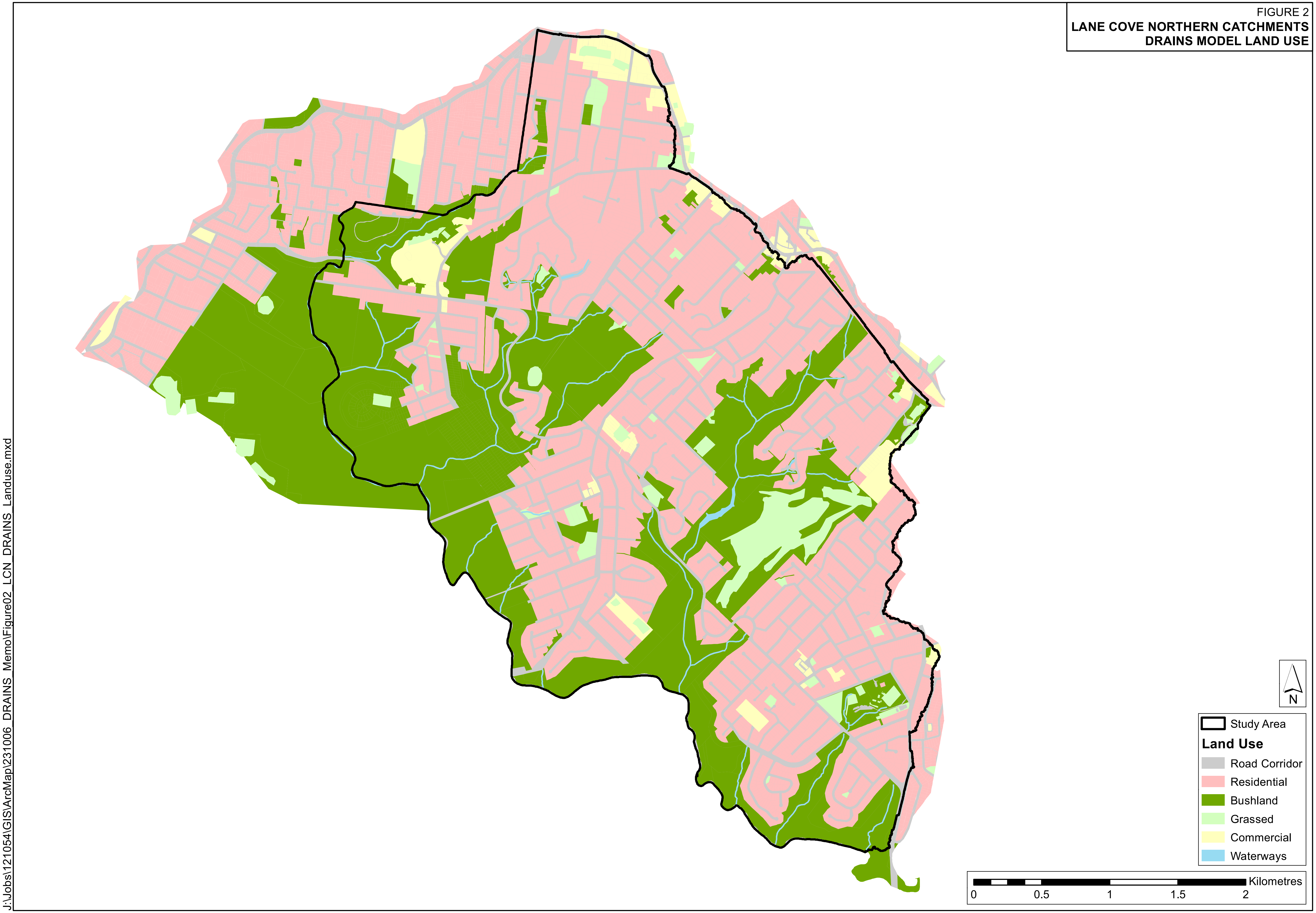
FIGURE 2
LANE COVE NORTHERN CATCHMENTS
DRAINS MODEL LAND USE



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