The current design flood levels for the Georges River are provided in Table 6.

Table 6: Design Flood Levels - Georges River

Event	Level (mAHD)
PMF	2.9
1% AEP	1.7
2% AEP	1.6 *
5% AEP	1.5

Note: * estimated for the purposes of this study.

7.3.2 Blockage Assessment

Given the combination of urban development and natural bushland within the catchment, the potential blockage of culverts and stream crossings by debris can increase the flood levels experienced along Oyster Creek. The role of blockages in exacerbating flood impacts during the August 1998 storm in North Wollongong highlights the importance of considering the implications for blockages in design flood assessment.

Based on numerous site inspections, and discussions with Council officers and local residents, the issue of potential culvert blockage is particularly relevant for Oyster Creek. Anecdotal evidence in Reference 4 indicates that two of the Bates Drive culverts were partially blocked in the 1974 event.

Evidence from the August 1998 North Wollongong storm indicates that there is the potential for culvert openings of less than 6 m width to be blocked during a runoff event. For Oyster Creek this observation would imply that all of the Bates Drive openings and the Box Road opening could be either partially or fully blocked.

To quantify the impacts of potential blockages on design flood behaviour, two blockage scenarios (Table 7) based on the 1% AEP event were simulated using the MIKE-11 model.

Table 7: Blockage Modelling Scenarios - 1% AEP Event

Scenario	Description
Base Case	No blockages
Scenario 1	Bates Drive culverts 50% blocked.
Scenario 2	Bates Drive culverts and Box Road opening 100% blocked (adopted for design).

Table 8 compares the resulting peak flood levels for the two different blockage scenarios.

Table 8: Comparison of Peak Flood Levels Due to Blockage [1] - 1% AEP

Location	No Blockage (m AHD)	Blockage Scenario	
		1: 50% Blockage	2: 100% Blockage
Bates Drive	3.02	+0.30	+0.61
100 m upstream of Bates Drive	3.12	+0.26	+0.55
200 m upstream of Bates Drive	3.18	+0.25	+0.52
300 m upstream of Bates Drive	3.49	+0.14	+0.36
400 m upstream of Bates Drive	3.94	+0.07	+0.20
Box Road	5.14	nil	+0.02
50 m upstream of Box Road	5.44	nil	nil

Note: (1) Result values represent the relative change in level (metres) compared to the ideal No Blockage case.

As expected, the results indicate that the inclusion of 100% blockage at the Bates Drive culverts has a significant impact on flood levels upstream. The impact of blockage at the Box Road opening is much less significant. The results from Scenario 2 (100% Blockage) were adopted for the establishment of design flood levels.

7.4 AEP of the Historical Floods

The traditional method to calibrate hydrologic/hydraulic models is to obtain rainfall data (pluviometer and daily read data), input these data to the hydrologic model and use the derived flows in the hydraulic model to obtain peak flood levels (refer Diagram 1). Through this process the models are calibrated to replicate the recorded flood levels. If flood data (rainfall and flood height) are available for other events these are used to verify the calibration.

As indicated previously a calibration is not possible as there are no pluviometers in the vicinity of Oyster Creek which operated during the time of the three floods. However it is important that the magnitude (AEP) of the historical events are estimated to allow a comparison with the design results produced by this study. Reference 4 indicates the AEP of the events as:

March 1974	approximately 50% AEP
March 1975	approximately 5% AEP (However Reference 4 also indicates that the 1975 event may be greater than a 1% AEP event as indicated by the results of the backwater analysis.)
March 1977	approximately <100% AEP

Reference 6 provides the most detailed assessment of the rainfall data. It indicates that Miranda received 435 mm of rain in the 48 hours to 9:00 am on 11th March 1975. The rain started at 8:00pm on 9th March 1975 with the peak burst occurring at around 6:00am on 10th March 1975. The peak rain ceased around 4:00pm on 10th March 1975. Table 9 indicates the average recurrence intervals for various durations.

Table 9: ARI Estimates of the March 1975 Rainfall (Reference 6)

Station	Duration				
	1 hour	2 hour	3 hour	6 hour	12 hour
Sydney - Observatory Hill	1 in 200	1 in 300	1 in 100	1 in 60	1 in 25
Mosman	1 in 75	1 in 600	1 in 400	1 in 125	1 in 25
Miranda	1 in 45	1 in 400	1 in 600	1 in 700	1 in 1000

Note: The above values are expressed as Average Recurrence Intervals rather than Annual Exceedance Probability for ease of understanding. Refer to Appendix A for definition of these terms.

Historical flood levels are available in Reference 4 for the March 1974, March 1975 and March 1977 events (refer Figure 8 and Table 3). Figure 8 also shows the house floor levels as this allows a comparison with the "inundated" floor level data provided in Table 3. There are some discrepancies between the floor level data provided in Reference 4 and the current floor level information, including:

- No. 33 Buderim Avenue has had its floor raised since 1975,
- No. 17 Buderim Avenue did not get inundated in 1975 according to the resident (lived there for the life of the building),
- several of the floor levels quoted in Reference 4 are similar to the current floor level data whilst others are not.

Figure 8 indicates the following AEP's for the three historical events assuming existing channel conditions and with no blockage of the Bates Drive culverts:

March 1974	approximately 5% AEP
March 1975	approximately 1% AEP
March 1977	approximately <10% AEP

It should be noted that the extent of dredging in the channel downstream of Bates Drive at the time of the event in 1975 is unknown. It is clear that the first 200m downstream of Bates Drive had been dredged by 1975. However, it would appear from Reference 4 that the parallel dredged channel, commencing at a point some 200m downstream of Bates Drive (from approximately chainage 1100 m downstream), was not excavated until after 1975. A hydraulic model run (refer Figure 8) was undertaken for the 1% AEP event assuming no such parallel dredged channel and this indicates a rise in the 1% AEP flood level of approximately 0.2m at Bates Drive. The maximum increase was 0.5m near Chainage 800. Thus if this was the case in 1975 the magnitude of the 1975 event may have been reduced to approximately a 2% AEP (the magnitude of the other floods would also have been reduced).

The assumption of a high tailwater downstream of Bates Drive being the cause of the high flood level experienced at Bates Drive in 1975, rather than as a result of a large peak flow, is supported by a relatively low recorded flood level and extent of damage at the Box Road footbridge (same bridge as today). As the waterway area at Box Road is significantly less than at Bates Drive it would be expected that a large peak flow would have produced a much higher flood level and caused more damage (e.g the footbridge was damaged).

7.5 Design Events

Peak height profiles for the 10%, 5%, 2%, 1%, 0.2% AEP events and the PMF assuming 100% blockage are provided on Figure 9. A listing of the design flood results (peak flood levels and flows) at each model cross-section location is provided in Appendix B.

Hydraulic and hazard categorisation for the 1% AEP event is provided on Figure 11. Design flood contours for the 1% AEP event are provided on Figure 12.

The adopted Manning's "n" values are provided in Table 10.

Table 10: Adopted Manning's "n" Values in Mike-11 Model

Chainage	Left Overbank	Channel	Right Overbank
0m to 1080m	0.10	0.04	0.10
1095m to 1290m	0.10	0.04	0.20
1315m to 1335m	0.06	0.04	0.20
1360m to 1560m	0.04	0.04	0.20
1575m to 1605m	0.06	0.05	0.20
1620m to 1767m	0.06	0.06	0.20
1783m to 1915m	0.10	0.10	0.10

7.6 Sensitivity Analyses

Given the lack of reliable historical flood level and streamflow data, only a limited calibration of the MIKE-11 model was possible. In view of this, sensitivity analyses were undertaken to determine the impacts of key model parameters on the simulated flood behaviour.

The following sensitivity analyses were carried out for the 1% AEP event (assuming no blockage):
- ±10% change in rainfall,
- ±10% change in WBNM storage parameter,
- change in tailwater level in Oyster Bay.

A summary of results at key locations for the above scenarios is provided in Table 11 and shown on Figure 10.

Table 11: Sensitivity Analyses - 1% AEP Event with No Blockage

Location	Rainfall		WBNM 'C' Value		Tailwater	
	+10%	-10%	+10%	-10%	0.5 m AHD	1.7 m AHD
550m downstream of Bates Drive	0.07	-0.07	-0.03	0.03	*	0.13
250 m downstream of Bates Drive	0.11	-0.11	-0.05	0.04	*	0.04
Bates Drive	0.13	-0.17	-0.07	0.07	*	0.03
100 m upstream of Bates Drive	0.13	-0.16	-0.06	0.07	*	0.03
200 m upstream of Bates Drive	0.13	-0.16	-0.06	0.07	*	0.03
300 m upstream of Bates Drive	0.13	-0.14	-0.07	0.07	*	*
400 m upstream of Bates Drive	0.15	-0.16	-0.08	0.09	*	*
Box Road	0.12	-0.13	-0.08	0.07	*	*
50m upstream of Box Road	0.13	-0.13	-0.08	0.07	*	*

Note: Results provided as a relative change in level (in metres) compared to the 1% AEP base case event with NO Blockage.
* changes in level less than ±0.01 m.

The peak flood levels predicted by the hydraulic model were found to be relatively insensitive to variations (±10%) in the WBNM lag parameter with the change generally being within ±0.1 m compared to the corresponding base case levels.

Changes to the design rainfall produced changes in the predicted flood peaks of up to ±0.16m throughout the model.

The results in Table 10 demonstrate that for a significant flood event, the impacts of assumed tailwater conditions are confined to the very lower reaches of Oyster Creek. Model results indicate that even with a relatively high tailwater (1.7 mAHD), the backwater effects are less than 0.05 m at 250 m downstream of Bates Drive. For low tailwater conditions the backwater effects are negligible at 550 m downstream of Bates Drive. Thus the tailwater levels have no significant impact upon the 1% AEP flood levels at Bates Drive.

8. ACKNOWLEDGMENTS

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- Department of Infrastructure, Planning and Natural Resources,
- Residents of the Oyster Creek catchment.

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10. DHI Water and Environment
Mike-11 Reference Manual V2003

FIGURE 1

OYSTER CREEK CATCHMENT

FIGURE 2

LEP ZONINGS

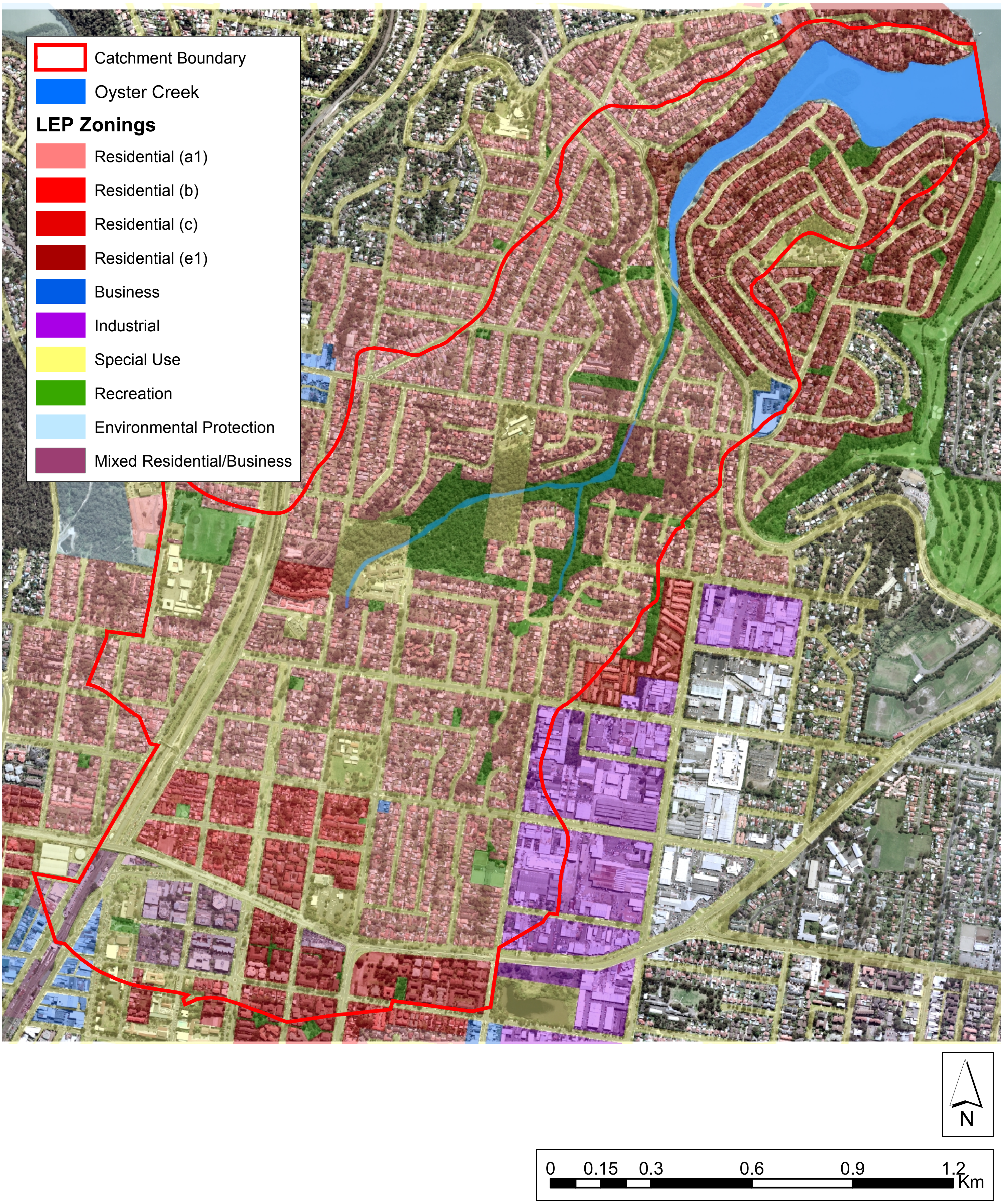
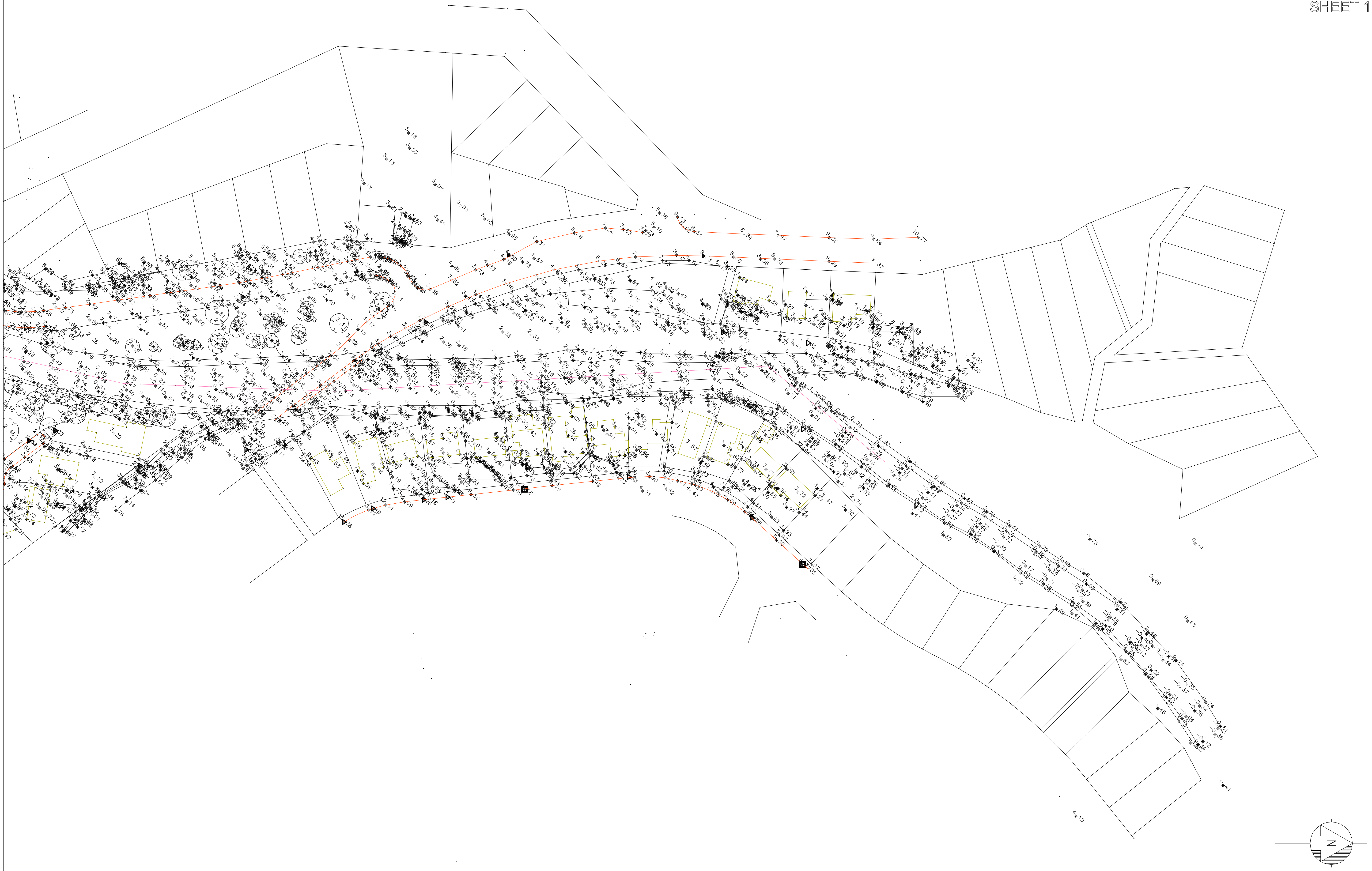


FIGURE 3a

SURVEY DATA
SHEET 1



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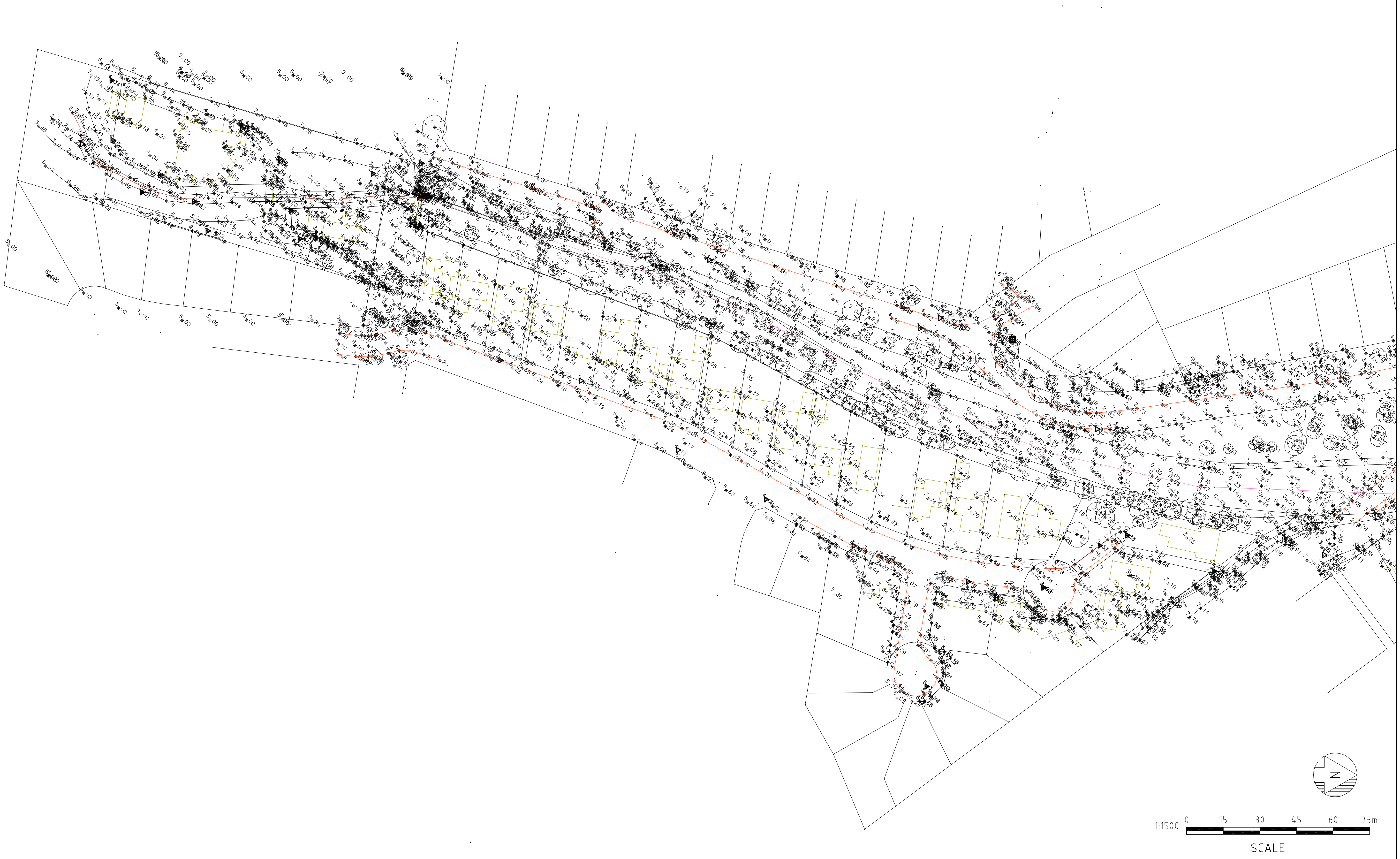
SCALE

FIGURE 3b

SURVEY DATA
SHEET 2



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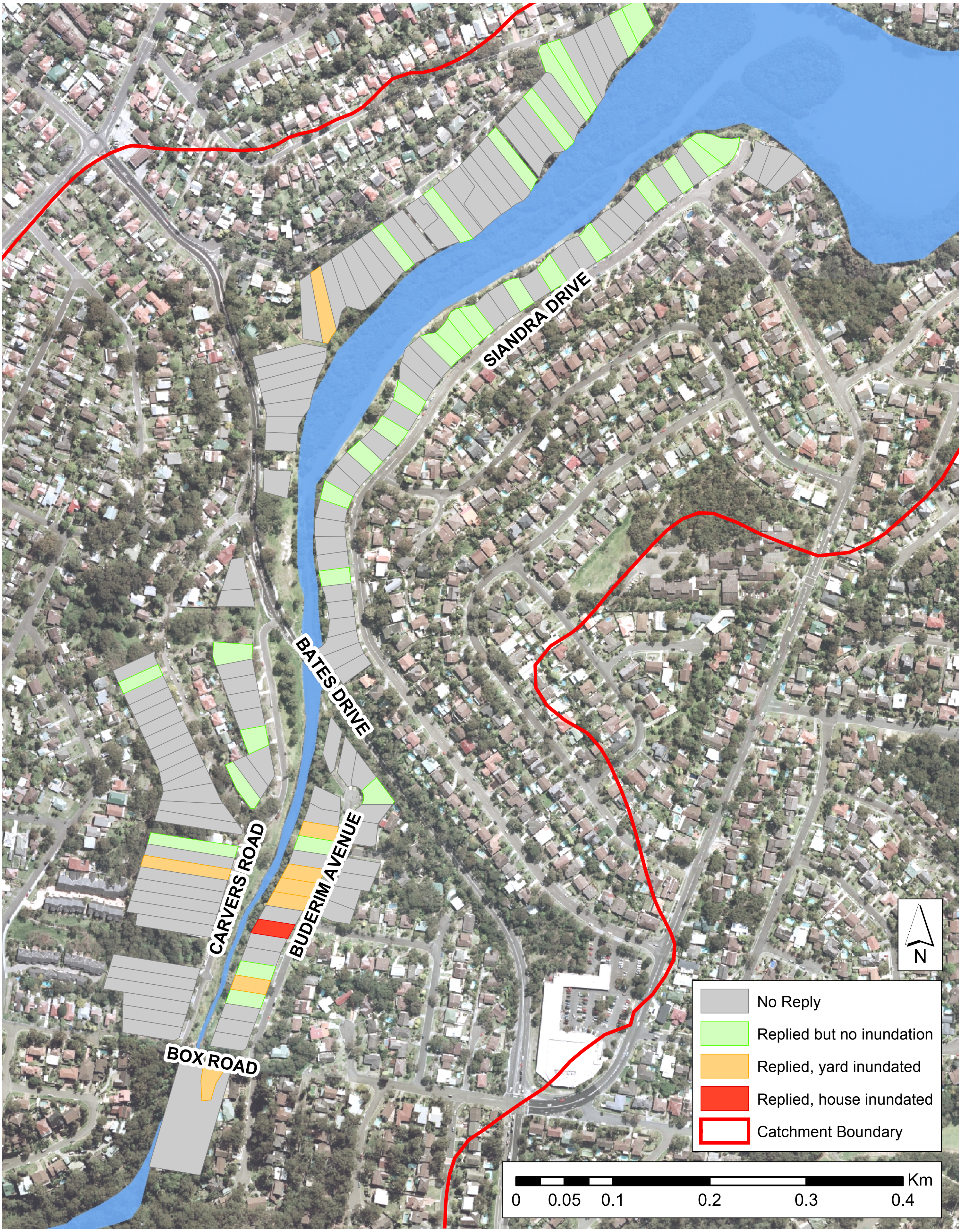
Date > 14/04/04

FIGURE 4
QUESTIONNAIRE SURVEY



ANALYSIS OF QUESTIONNAIRE RESULTS