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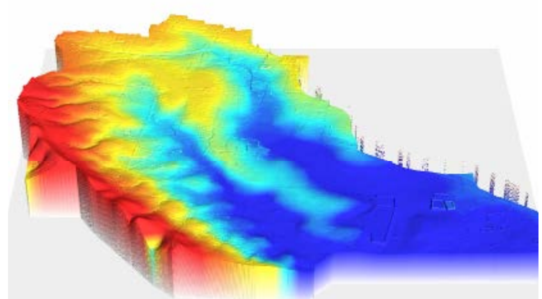
Bunya Creek Catchment
Flood Risk Reduction Study



Report

October 2006

Hervey Bay City Council

Bunya Creek Catchment Flood Risk Reduction Study

October 2006

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Appendices

1 Introduction

John Wilson & Partners (JWP) has been commissioned by Hervey Bay City Council (HBCC) to undertake a Flood Risk Reduction Study for the catchment referred to as the Bunya Creek catchment. The purpose of the analysis was to document existing flooding and drainage characteristics within the catchment along with assessing potential augmentation options for the purposes of reducing flood risk in the area and managing both existing and future development within the catchment.

This study includes a detailed hydrological and hydraulic analysis of the study area within the catchment.

The major components of works undertaken for this study have included: -

- Definition of overall catchment boundaries and the derivation of sub-catchments;
- A site inspection which allowed for the identification of existing drainage patterns including both piped systems and major overland flows;
- Data collection and review;
- Construction of an extensive XP-STORM model representing the major flow paths for the catchment;
- Hydrological and hydraulic model analysis to define flood levels, flow directions and flooding problems in the catchment for the 10, 20, 50 and 100 year ARI design flood events;
- Investigation of flooding risks for each drainage network investigated;
- Analysis of augmentation options for the purposes of flood risk reduction;
- Preliminary construction cost estimates for the augmentation options;
- Risk Management Assessment;
- Culvert upgrade assessment for critical culverts (larger than 300mm diameter) along Booral Road, Woods Road and Main Street; and
- Documentation of the study methodology and outcomes as part of a formal report on the investigation.

The following sections of this report fully document the analysis works undertaken as part of this investigation.

2 Study Area

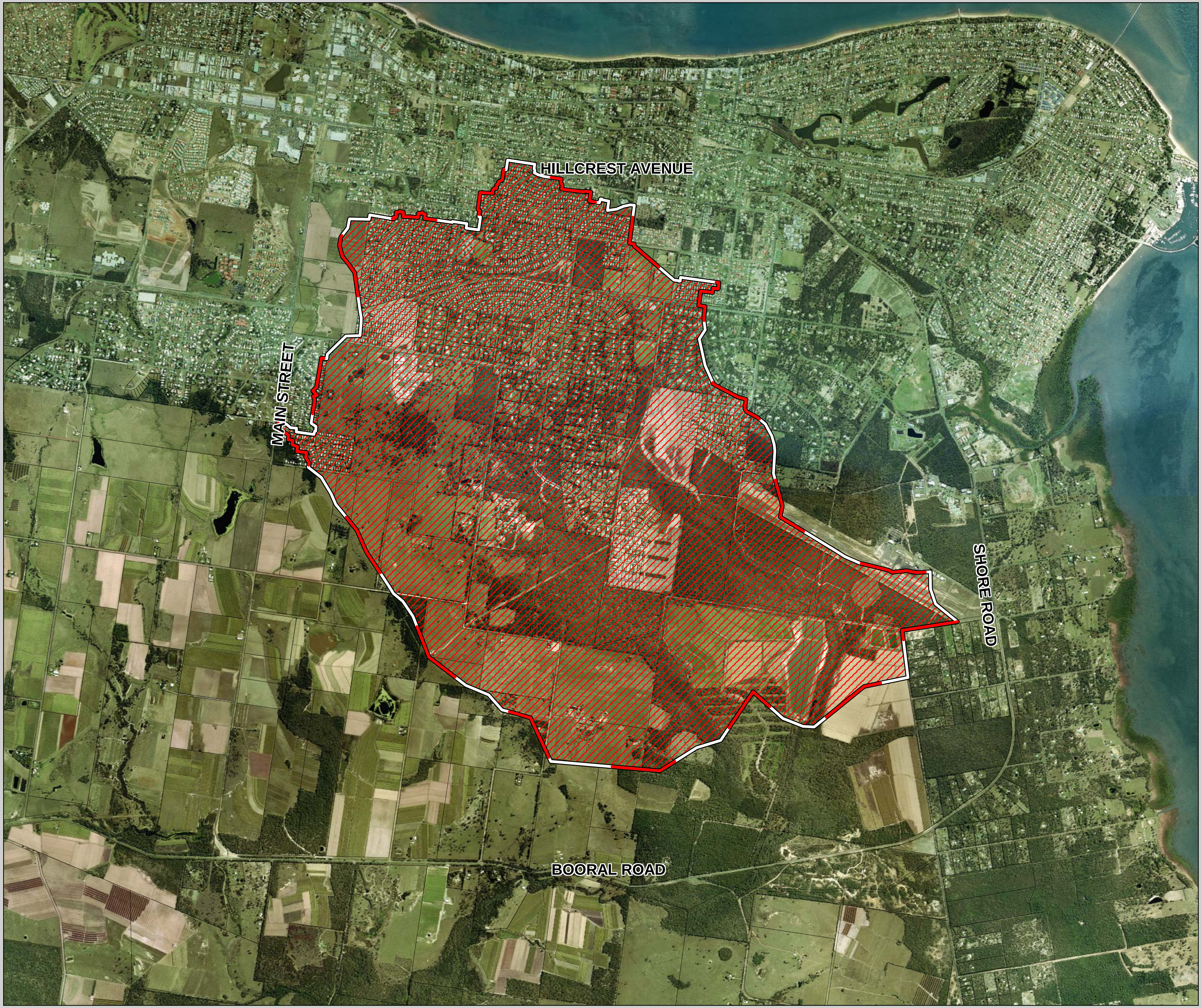
The study area is located in the city of Hervey Bay, in the suburbs of Kawungan and Wondunna, inland of Hervey Bay's north-eastern coastline. The extent of the study area was determined by the following road networks:

- Hillcrest Avenue to the north;
- Booral Road to the south;
- Main Street to the west; and
- Shore Road to the east

Within the Bunya Creek catchment, JWP have delineated two (2) discrete and separate drainage systems which were deemed suitable for inclusion in the XP-STORM models. These systems being:

- System 1 - represents the Kawungan/Wondunna catchment which comprises of approximately 702 hectares; and
- System 2 - represents the Doolong Flat catchment which comprises of approximately 795 hectares.

A locality plan of the study area is included as Figure 1.



N

Legend

Bunya Creek Study Area

Cadastre

300 0 300 600 900

Metres

Scale: 1:30,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 1

STUDY AREA LOCALITY PLAN

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Projection Trans. Merc. MGA56(GDA 94)

3 Data Collection and Review

The works undertaken as part of this study and particularly the establishment of two discrete XP-STORM models representing the two major flow paths, have been prepared based upon a compilation of data provided by Hervey Bay City Council, each of which are outlined and discussed separately below.

3.1 Topography Data

Topographical data for the catchment was provided in the form of contour information at various intervals ranging from 200mm to some 5 metres. To facilitate the use of the contour information, JWP have prepared a Digital Terrain Model (DTM) using all of the contour data supplied for the purposes of facilitating data extraction for the various modelling tasks undertaken as part of this study. This DTM was prepared using MapInfo Vertical Mapper software.

The contour data represents the only available topographical information provided for System 1 of the study; however a more detailed DTM was produced for the Doolong Flat Development Impact Assessment undertaken by JWP (2005) which covered a large portion of the System 2 area. As such, the best available data was adopted where possible for the study of System 2.

The DTM generated from contour information and the DTM used for the Doolong Flat study were combined to form the DTM used for this study. A copy of the DTM is included as Figure 2 which clearly illustrates the catchment location and topographical variations that exists throughout the catchment. The combined DTM was used as a basis on which the drainage patterns throughout the area have been defined and various overland flow path information digitally extracted and incorporated into the flood models.

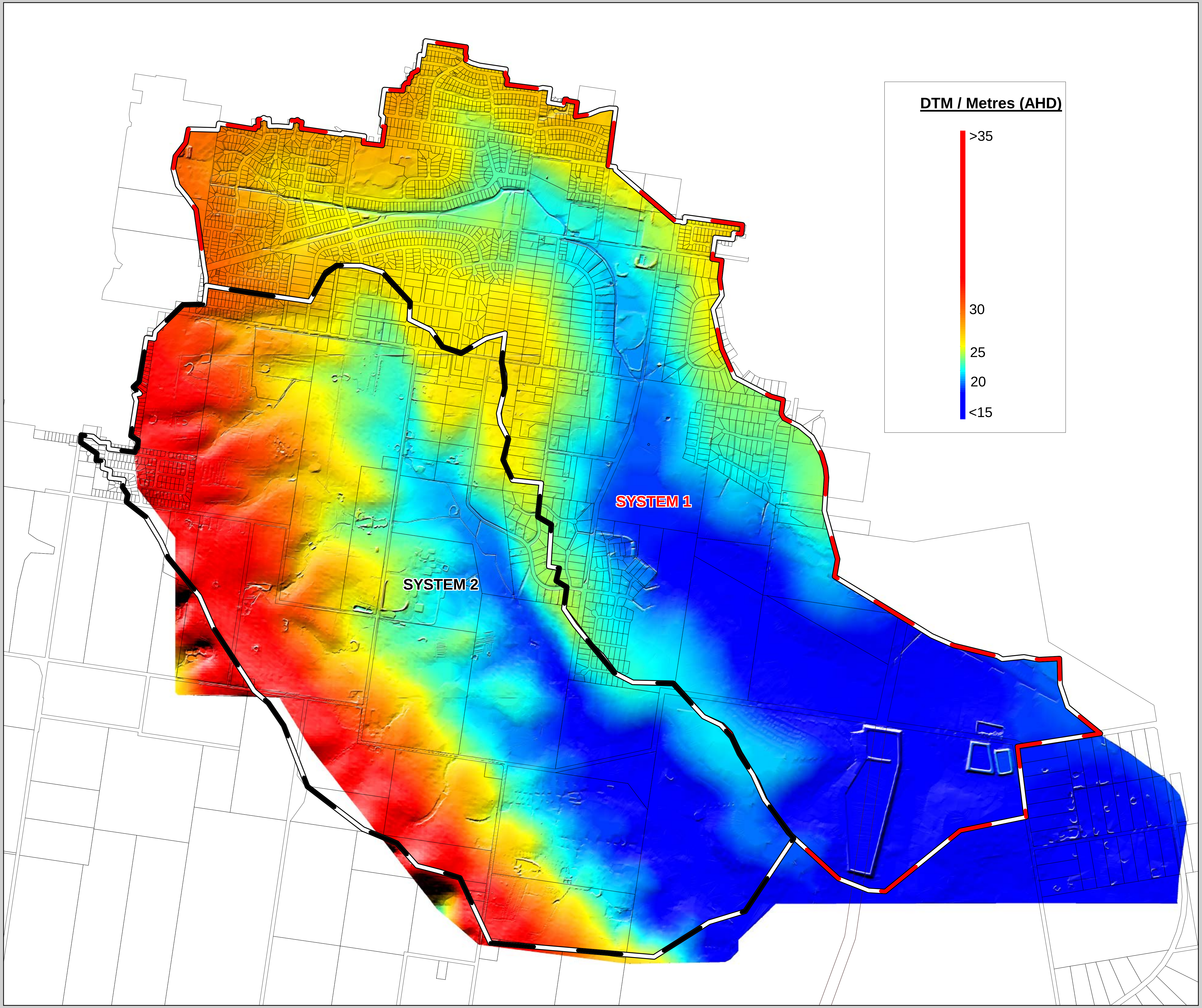
JWP note that the DTM prepared by JWP for the purposes of this study represents an interpolated topographic surface based upon contour information which itself represents an interpolated surface. As such, the DTM prepared for this study is unlikely to be sufficiently accurate to enable more detailed flood analysis works to be performed. The DTM is however suitable and appropriate for the purposes of a broad flood risk study as is the purpose of this study.

3.2 Survey Data

The collection of field survey data was undertaken as part of the culvert upgrade assessment along Booral Road, Woods Road and Main Street. The intent of the field survey collection was to obtain structure details along Booral Road, Woods Road and Main Street.

A GIS map highlighting the required areas of field survey was prepared by JWP and approval sought by Council. As part of the study, JWP were responsible for management of these works which included the preparation of a detailed survey brief, calling of survey tenders and managing the field collection data.

All detailed survey work for this project was undertaken by Surveyors@Work, a locally based and independent survey company in Hervey Bay. This information was collected using both traditional and GPS survey techniques and was provided in a digital AutoCAD format for the purposes of this project.



LEGEND

System1 Catchment Boundary

System2 Catchment Boundary

200 0 200 400 600

Metres

Scale: 1:20,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 2

DTM & CATCHMENT LOCATION

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Projection Trans. Merc. MGA56(GDA 94)

3.3 Pipe Data

Existing pipe and culvert crossing data throughout the catchment was provided through Council supplied GIS data. This data was supplemented using detailed survey information as previously discussed.

JWP note that some minor adjustments have been made to pipe data where significant discrepancies existed between invert levels supplied and those observed from the DTM and field inspection.

For example, GIS data indicated that the culvert under Grevillea Street has an invert 1 meter below the channel invert according to the DTM. The site inspection confirmed that the culvert invert should correspond to the channel invert. As such, JWP have made the assumption that the pipe invert is the culverts diameter (height) plus 300mm free-board below the road level.

3.4 Site Inspection

As part of the works for this study, JWP have undertaken a detailed and comprehensive site inspection of the catchment. The site inspection also included an extensive project inception meeting with HBCC.

The site inspection was documented by way of site notes and photographs. Outcomes from the inspection included:

- Assessment of physical catchment parameters including appropriate roughness parameters;
- Verification of crossings and existing hydraulic structures;
- A comprehensive investigation of the waterway; and
- Understanding of the flow dynamics of the catchment area and major waterway systems.

4 Catchment Modelling

The analysis of the catchment response and the determination of design flood discharge estimates have been prepared integrally within the XP-STORM model. These estimates were also verified independently through the use of the Rational Method at critical areas within the catchments. The RAFTS model functionality has been applied within the XP-STORM models for the determination of catchment discharge. The following sections of this report provide detail regarding the hydrological aspects associated with the preparation of the RAFTS models for the discrete sub catchment areas within the XP-STORM models.

As discussed with Council, only major flow paths were modelled for the two systems. This was due to overland (open channel) flow forming the basis of drainage for the catchment. We note that modelling was not undertaken for the Booral Road, Woods Road and Main Street culvert assessment component of this study due to the lack of DTM for the surrounding area and given the simplicity of the cross drainage systems. Rather, in these areas a rational method was used to estimate flows entering each discrete culvert crossing for each ARI event. These flows were then used as the basis for determining upgrade requirements in order to adequately reduce flood risk and satisfy Council's design standard.

4.1 XP-STORM (RAFTS) Approach

As indicated above, catchment hydrology for this study has essentially been prepared using the nonlinear runoff routing methodology of RAFTS as this methodology is integrated within the XP-STORM model. RAFTS utilises a network analysis with a series of sub-catchment and drainage links to model catchment performance. Hydrographs are produced for the design storm events by routing sub-catchment rainfall runoff through pre-defined drainage links within the catchment.

The RAFTS analysis involved: -

- the division of the selected modelling areas into a number of discrete sub-catchments;
- derivation of various physical properties for each of the sub-catchments, including:
    - impervious and pervious areas based upon ultimate land use development scenarios;
    - sub-catchment slopes; and
    - roughness value (Manning's 'n');
- the overall assembly of the sub-catchments and channels into a nodal network.

Storms with rainfall durations ranging from 15 minutes to 360 minutes were simulated as part of this study for the 1 in 10, 20, 50 and 100 year ARI design storm events. The assessment of numerous storm events for each design event allowed the determination of both critical durations and peak discharges at specific locations along each of the waterway systems.

4.2 Rainfall Intensities

The design rainfall Intensity-Frequency Duration (IFD) data for various storm events of the study catchment were derived based upon the procedures outlined in Book 2 of the Australian Rainfall and Runoff (AR&R 2001 edition). Various rainfall parameters were taken directly from AR&R based upon a location representing roughly the centroid of the Bunya Creek catchment. Using these parameters, design IFD data for the catchment has been prepared and this is summarised in Appendix A of this report.

Design rainfall IFD data was applied across the catchment based upon rainfall temporal patterns determined in accordance with the procedures detailed in Australian Rainfall and Runoff (AR&R 2001). The full range of temporal patters ranging from the 15 minute through to the 360 minute storms have been applied as part of this study.

It should be noted that no Areal Reduction Factors (ARF) have been applied to the rainfall intensities as part of this study. This approach is appropriate in this instance whereby catchment sizes are reasonably small and as such the magnitude of the reduction in rainfall intensities through the use of an ARF can be disregarded. This approach may result in a slightly conservative estimate of design flows from the catchment and this is appropriate especially in the context of a flood risk study.

4.3 Site and Catchment Characteristics

4.3.1 Catchment Definition

The overall catchment boundary for the analysis was delineated and supplied by Hervey Bay City Council. Using this overall catchment boundary and culvert and overland flow network details, JWP subdivided the catchment into a number of individual sub-catchments which were subsequently used to generate two individual XP-STORM models based on the separate drainage systems. Sub-catchment delineation was undertaken using the DTM prepared by JWP for the catchment.

Generally, the sub-catchment boundaries were prepared using water shed lines ascertained from the DTM in addition with due consideration of the existing drainage patterns at the site including urbanised blocks. These discrete sub-catchments were created to ensure that the hydrological calculations for each model were representative and appropriately determined based on the specific locations throughout the catchment.

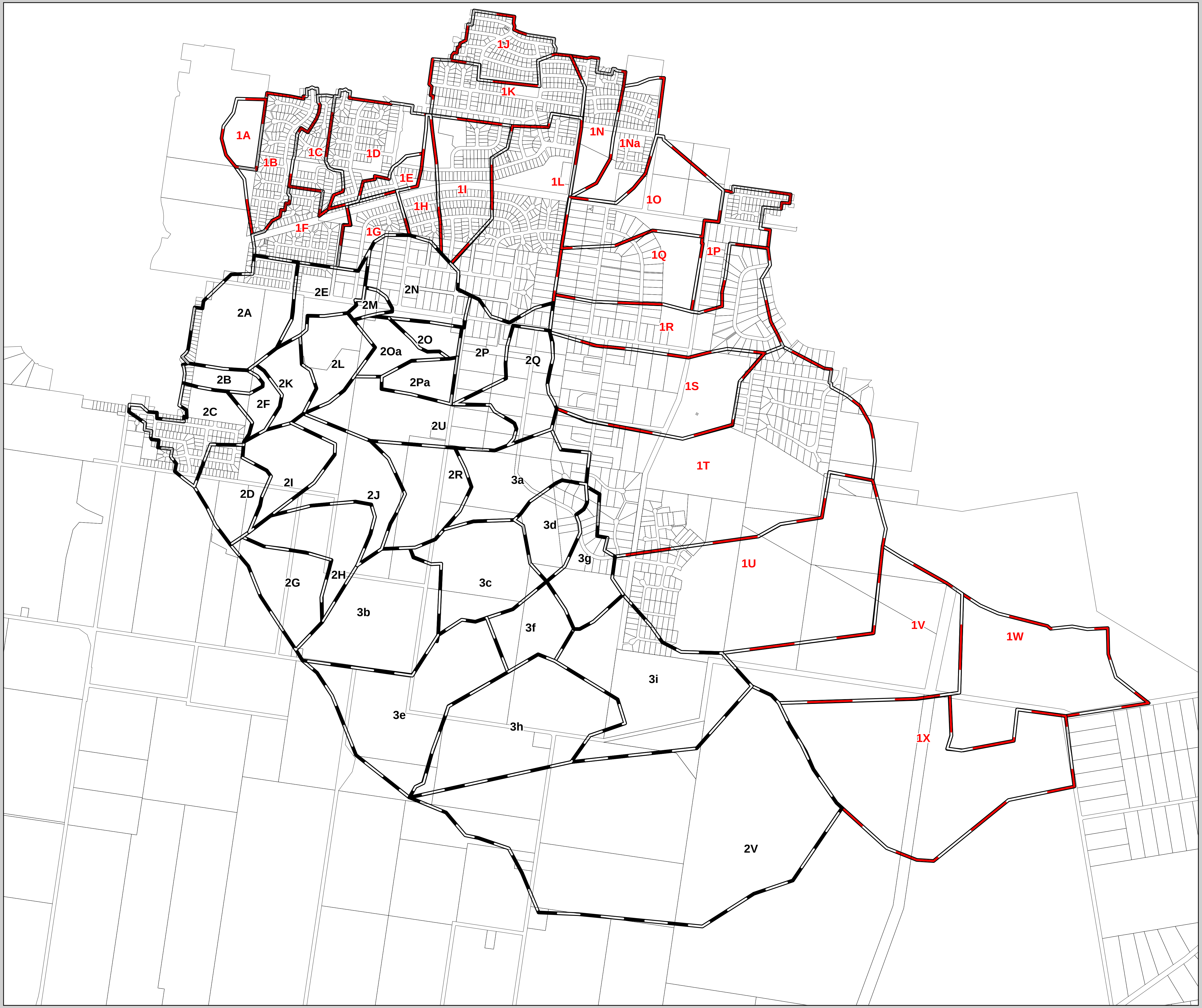
A plan illustrating the entire catchment and sub-catchment boundaries (delineated for the purposes of catchment hydrology) is provided in Figure 3. In all, a total of 55 separate and discrete sub-catchments have been delineated and applied in the various discrete XP-STORM models for this study. Rational method checks have been undertaken at 12 separate catchment locations.

The Hervey Bay City Planning Scheme 2006 land use within the Kawungan/Wondunna catchment (System 1) consists generally of low density residential and park residential land use with open space and special purpose making up the remaining land use for the catchment. The catchment is drained by a central drainage path which flattens out in the grounds of the City Council Sewerage Reserve before discharging into a gully which crosses Booral Road and into the upper reaches of Bunya Creek.

The Hervey Bay City Planning Scheme 2006 land use within the Doolong Flat catchment (System 2) varies from low density residential developments in the extreme north and west of the catchment, some park residential developments in the eastern boundary and emerging communities and special purpose making up the remaining land use for the catchment. The catchment is drained by Doolong Flat Creek which flows into the grounds of the City Council Sewerage reserve before discharging into a gully which crosses Booral Road and into the upper reaches of Bunya Creek.

Bunya Creek then discharges into the Mary River near its mouth with the Great Sandy Strait. The discharge from both catchments is beyond the reach of tidal influence.

The total catchment area comprises of some 1550 hectares. System 1 comprises of approximately 795 hectares whilst System 2 has an approximate area of 752 hectares.



N

LEGEND

System1 Sub Catchment Boundaries

System2 Sub Catchment Boundaries

200 0 200 400 600

Metres

Scale: 1:20,000

BUNYA CREEK FLOOD RISK REDUCTION STUDY

FIGURE 3

SUB CATCHMENT BREAKDOWN

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Projection Trans. Merc. MGA56(GDA 94)

4.3.2 Impervious Area and Roughness Values Determination

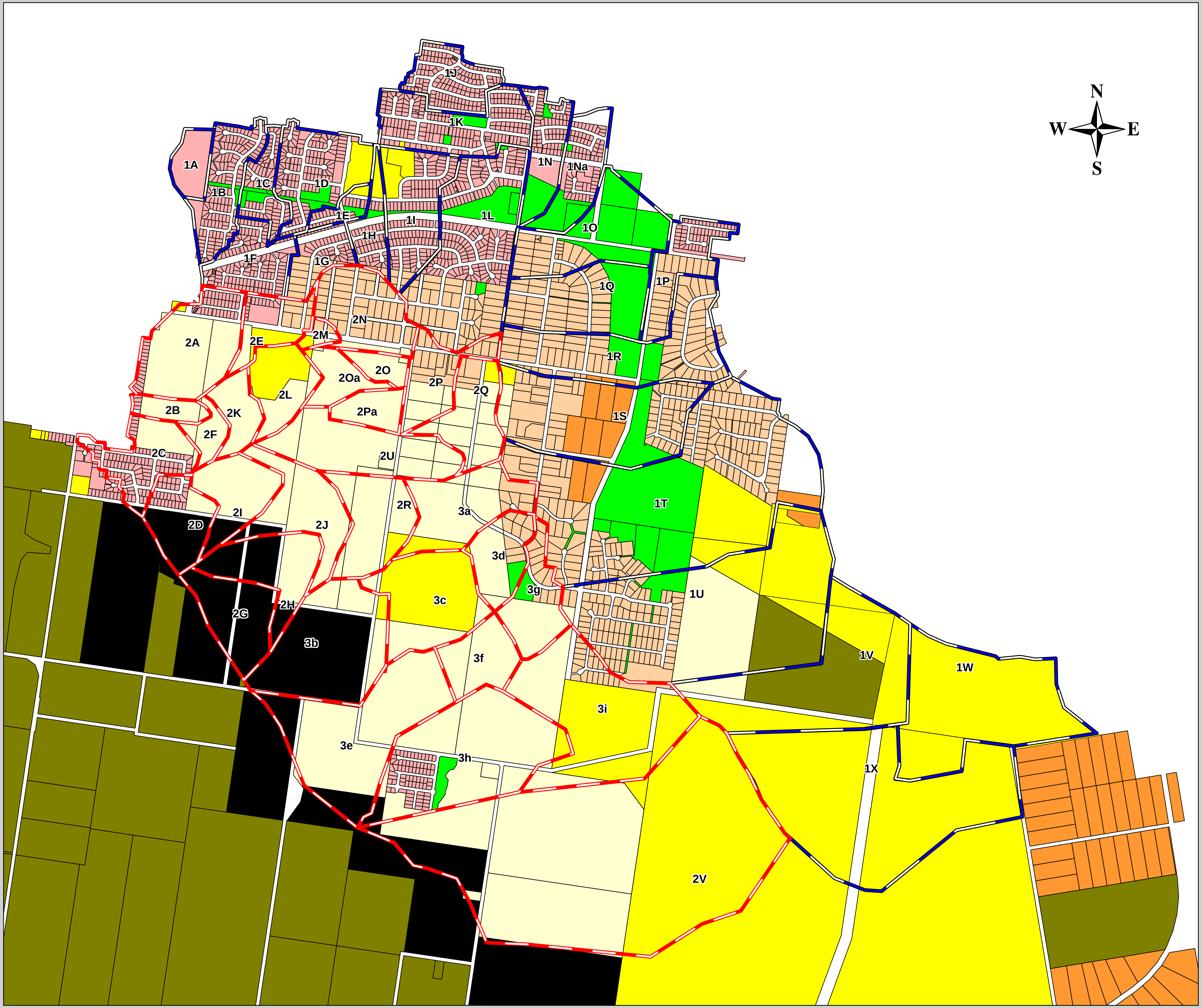
The quantity of pervious and impervious areas of each sub-catchment was determined based upon the land use data (Hervey Bay City Planning Scheme 2006) supplied by Hervey Bay City Council. As there was several different land uses represented in each particular sub-catchment, the amount of pervious and impervious areas were summed and averaged based on a land use balance. As such, determination of the area of impervious surfaces in each sub-catchment was based on, in order of preference, the runoff coefficients for the various land use types provided by Hervey Bay City Council, the Queensland Urban Drainage Manual (QUDM) (1992) and from previous experience with similar studies. The adopted runoff coefficients and appropriate roughness values applied for each land use type as detailed in Council's land use zone type are summarised in Table 4.1 below. Figure 4 illustrates the land use characteristics of the catchment as taken from Council's land use allocations attached to the cadastral database.

Table 4.1: Fraction Impervious and Roughness Coefficients

Land Use Type	Fraction Impervious	Pervious Area Roughness	Impervious Area Roughness
Low Density Urban Residential	45	0.025	0.015
Medium Density Urban Residential / Particular Development	60	0.025	0.015
Rural Land	2	0.07	0.015
Special Purposes	20	0.04	0.015
Rural Residential	20	0.04	0.015
Park Residential	20	0.04	0.015
Road Reserve (including footpath)	80	0.02	0.015
Open Space	10	0.04	0.015
Emerging Communities	45	0.025	0.015

GIS system information was used for the purposes of interrogating and compiling land use characteristics for the inclusion into the hydrologic models and rational method calculations. This included the analysis of the various land use areas within each of the 55 sub-catchments defined throughout the study area. A detailed summary of the land use areas for each of the sub-catchments delineated is attached in Appendix B of this report. This summary illustrates the various proportions of the total sub-catchment area based on land use derived from Council's zoning information.

The land use summary, as presented in Appendix B, forms the basis on which sub-catchment land use was represented within the models. This included the determination of percentage pervious and impervious catchment data which was undertaken based upon a weighted average of catchment area and land use types. Each sub-catchment within the model has been represented based upon a pervious and impervious fraction in accordance with the RAFTS methodology.



LEGEND

System1 Sub Catchment Boundary

System2 Sub Catchment Boundary

Landuse Type

- Rural Residential
- Rural Land
- Special Purpose
- Park Residential
- Open Space
- Emerging Communities
- Multizone
- Low Density Residential
- Particular Development

200 0 200 400 600

Metres

Scale: 1:20,000

BUNYA CREEK FLOOD RISK REDUCTION STUDY

FIGURE 4

SUB CATCHMENT LAND USE SUMMARY

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Projection Trans. Merc. MGA56(GDA 94)

4.3.3 Rainfall Loss Parameters

Rainfall loss parameters adopted for this study included a 15 mm initial loss allowance along with a 2.5 mm/hour continuing loss in accordance with HBCC's specification. Initial and continuing losses were applied to pervious surfaces for all recurrence interval design storms. These loss rates are consistent with AR&R (2000) which recommends a continuing loss of 2.5 mm/hr and an initial loss of between 15-35 mm be applied in eastern Queensland.

Whilst Council have specified initial losses of 15mm for non-sand pervious surfaces and 35mm for sandy pervious surfaces, details of soil types throughout the catchment were not supplied and deemed to be highly variable, and thus an initial loss of 15mm was adopted. This approach is considered to be appropriate for the purposes of this study.

4.4 Hydrological Flow Verification (XP-Storm Models)

Calibration of the hydrological model to recorded data was not possible owing to stream gauging records not being available for the catchment. As such, rational method calculations were undertaken at various locations throughout the catchment for comparison and verification with the RAFTS results. The comparison of flows at key locations throughout the catchment are summarised in the tables below with reference to Figure 5.

Table 4.2: Comparison of Hydrologic Flow Results to Rational Method for System 1

Comparison Location	Q100 Rational Method (m^3/s)	Q100 XP-STORM Model (m^3/s)
Node N9 (Mackay Dr)	8.9	8.7
Node N49	26.2	26.1
Node N60 (Denmans Camp Rd)	37.1	36.5
Node N82 (Doolong Rd)	45.1	43.4
Node N193 (Outlet)	60.2	59.6

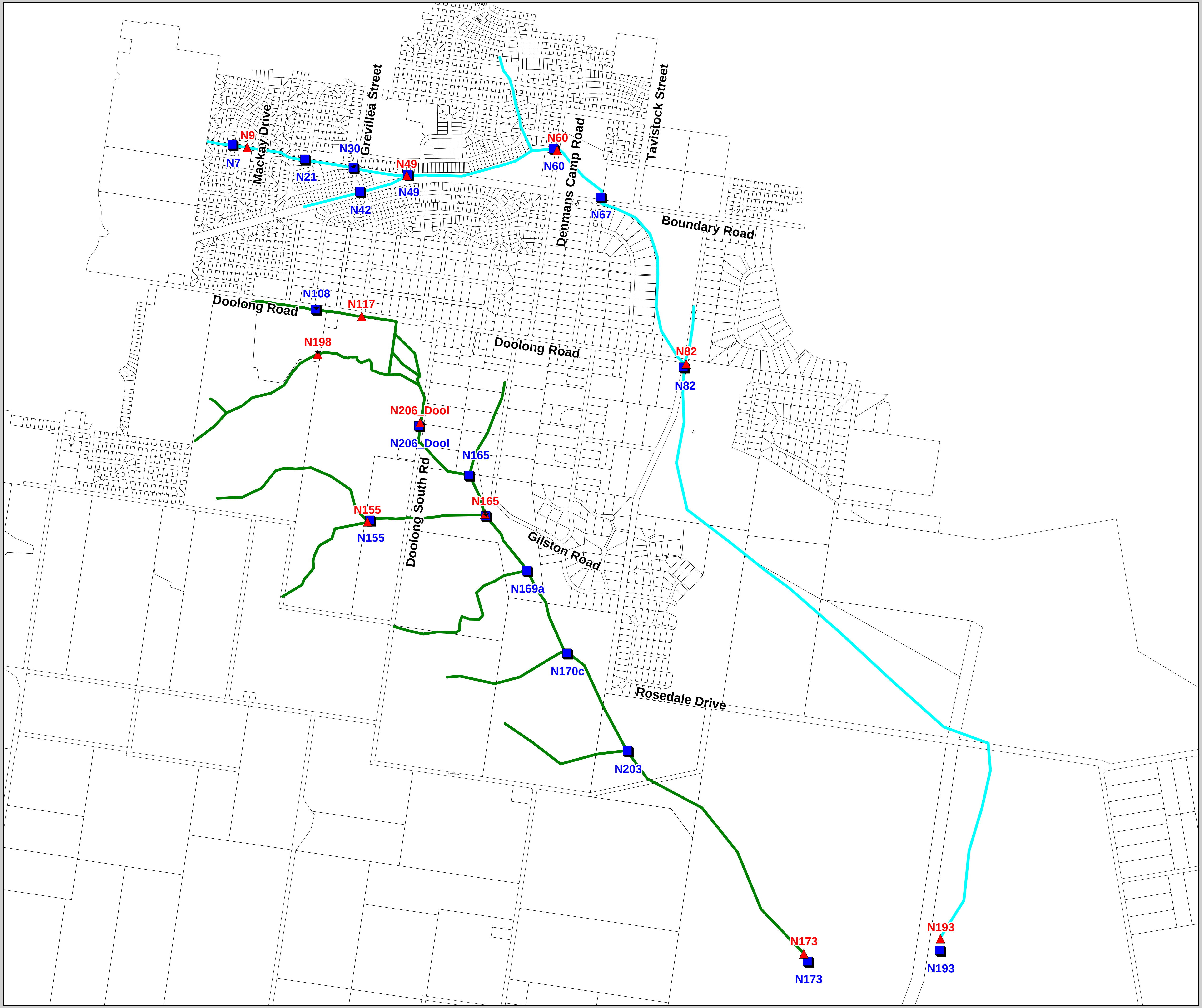
Table 4.3: Comparison of Hydrologic Flow Results to Rational Method for System 2

Comparison Location	Q100 Rational Method (m^3/s)	Q100 XP-STORM Model (m^3/s)
Node N117	12.8	12.5
Node N198	17.0	16.7
Node N206_Dool	35.2	34.5
Node N155	30.1	29.3
Node N165	58.9	54.6
Node N173 (Outlet)	80.2	75.1

On the basis of the comparison performed using the rational method, the flows estimated using the XP-STORM models as part of this study were found to generally correlate well. As such, the current XP-STORM models are considered to predict flows to an acceptable level of accuracy and have been adopted for the purposes of this assessment.

4.5 RAFTS Design Analysis Runs

The adopted XP-STORM models for the study have been analysed for the 10, 20, 50 and 100 year ARI storm events in the RAFTS hydrological mode in order to ascertain design flow estimates throughout the catchment. The analysis of each of the design events included model simulation for all rainfall events ranging from 15 to 360 minutes in order to ensure that critical design flows at each location throughout the catchment were fully identified. The results from the model are presented in further detail in the hydraulics section of this report. Table 5.2 provides a summary of the peak design flows at critical locations such as junctions, road crossings (upstream) and outlets whilst flow locations are shown in Figure 5.



N

Legend

- ▲ Flow Comparison Point
- System 1 Drainage Network
- System 2 Drainage Network
- Cadastre
- ■ XP-STORM Flow Point

180 0 180 360 540

Metres

Scale: 1:18,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 5

FLOW LOCATIONS

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Projection Trans. Merc. MGA56(GDA 94)

5 Hydraulic Modelling

5.1 Modelling Philosophy (XP-STORM)

Given the nature of the catchment including discrete areas of drainage network, flat topography and some ill-defined overland flow paths, it was necessary to construct a number of detailed quasi 2 dimensional (2D) hydraulic models of the catchment. The XP-STORM modelling package has been selected for this purpose. The XP-STORM model is particularly suited for urbanised drainage areas as both sub-surface pipes combined with multi-link overland flow paths can be incorporated into a single model and the model run in a fully dynamic mode. In addition, the in-built RAFTS hydrology mode is also of benefit as local inflows can be allocated to discrete piped and overland systems thereby allowing a more representative model of the catchment to be prepared.

The XP-STORM models created for the Bunya Creek catchment have included a significant number of overland flow paths to better define surface drainage flows and characteristics. Further details of the model setup and methodology is summarised in further detail below.

5.2 Model Preparation

5.2.1 Overland Flow Paths and Pipe System

The establishment of two discrete XP-STORM hydraulic models for each of System1 and System 2 was undertaken using the DTM for the entire catchment as discussed in Section 3. The DTM represents the ground surface and facilitates the identification of discrete flow paths and cross sectional information. As such, the DTM represents the base information on which the hydraulic models for the catchment and this study has been prepared.

JWP have utilised the supplied GIS information to prepare the XP-STORM models. This has included the definition of the model network including culverts, flow paths, nodes and cross section information. Models were constructed in a GIS environment and exported directly into XP-STORM resulting in a fully co-ordinated, correctly located and representative model of the selected modelling areas. Model data from the GIS has included: -

- Nodal information - where the ground level was taken directly from the DTM;
- Model cross sectional data - as digitally extracted using the DTM; and
- Flow paths including linkage lengths.

The above information was used to prepare the XP-STORM models for each of the systems. The above procedure was used to generate all the overland drainage systems for each model. In addition to this, the culvert drainage system was also prepared within the models using the pipe data supplied by Council. The overland model was integrally linked to the sub-surface pipe model in the XP-STORM models to facilitate the flow interaction to occur between overland and sub-surface systems. This was done through the inclusion of manholes to allow surcharge to occur as well as flow entering the pipe system as appropriate. Figure 6 illustrates the overall layout of the XP-STORM models prepared as part of this study.

5.2.2 DTM and Cross Sections

As mentioned, the DTM forms the basis on which the XP-STORM models have been prepared. As such, the nature and accuracy of the DTM is critical in the establishment of a representative model. Cross sections were used to form the conduit profile for overland links in the XP-STORM models as well as weirs representing road crests.

5.2.3 Catchment Hydrology

As discussed previously in Section 4 of this report, catchment hydrology was prepared within the XP-STORM models. Specifically, the XP-STORM models allow the analysis of both catchment hydrology and hydraulic computations within a single fully consolidated model. Individual sub-catchments were applied at specific model nodal locations based on the local catchment characteristics while also ensuring that flows were apportioned appropriately within the model.

5.2.4 Channel Roughness

Channel roughness was specified in terms of the Manning's 'n' parameter. Roughness values used in the hydraulic models were based on aerial photography in conjunction with a detailed site inspection undertaken as part of this study. In addition, channel roughness was also applied having regard to the project brief whereby various roughness parameters were pre-specified. Generally, roughness parameters for the catchment have been applied in accordance with those illustrated in Table 5.1 below.

Table 5.1: XP-STORM model Roughness Coefficients

Condition	Mannings "n"
Dirt or grass lined open channels	0.03-0.04
Roads	0.015
Overland flow (Medium density vegetation)	0.04–0.06
Overland flow (High density vegetation)	0.06-0.08
Concrete pipes and channels	0.015
Flow path though residential establishments	0.9
Water body	0.02

The above set of Manning 'n' roughness coefficients has been adopted as baseline data only. Values used within the XP-STORM models varied between the above values based upon the observations made during the site inspections.

5.2.5 Hydraulic Structures

Hydraulic structures within the model generally include discrete culvert crossings. The exclusion of the pipe systems have been discussed in Section 5.2.1.

5.2.6 Boundary Condition

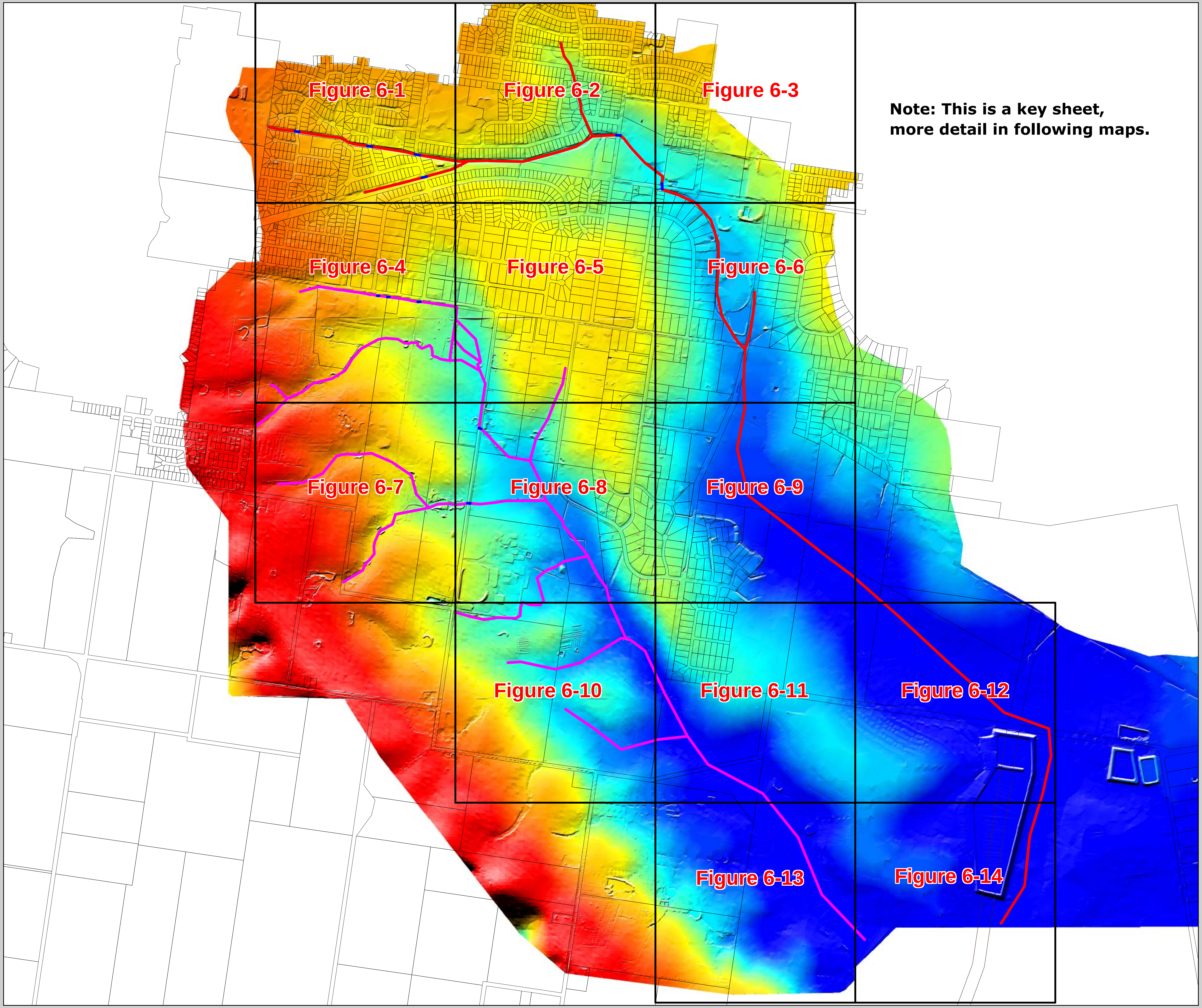
As previously stated, the discharge from the study area is beyond the reach of tidal influence and therefore a sensitivity analysis was not necessary for this study.

5.2.7 Model Design Runs

The XP-STORM hydraulic models were analysed for the 10, 20, 50 and 100 year ARI design flood events for the full range of critical durations ranging from the 15 to 360 minute events. Results from the hydrologic modelling of each design event have been used for hydraulic modelling and the determination of flooding levels. Table 5.2 provides a summary of the peak design flows at critical locations such as junctions, road crossings (upstream) and outlets whilst flow locations are shown in Figure 5.

Table 5.2: Summary of XP-STORM model Flows

	Location (XP-STORM Node ID)	Q100 (m^3/s)	Q50 (m^3/s)	Q20 (m^3/s)	Q10 (m^3/s)
System 1	N7	2.7	2.5	2.3	2.0
	N21	11.1	10.0	8.9	7.5
	N30	16.6	14.8	12.6	10.6
	N42	8.1	7.3	7.1	6.0
	N60	38.6	32.3	26.6	22.7
	N67	36.1	33.1	28.2	24.0
	N49	26.2	22.8	20.0	16.9
	N82	43.4	33.4	33.0	28.4
	N193	59.6	51.9	43.4	35.9
System 2	N108	11.7	10.7	9.6	8.5
	N206_Dool	34.4	30.1	25.9	21.8
	N155	29.3	25.8	22.0	18.8
	N168	37.8	32.9	27.9	22.9
	N169a	54.8	50.3	41.1	32.9
	N165	54.6	54.6	46.9	38.9
	N203	70.4	62.0	50.5	40.6
	N170c	63.5	54.7	44.5	36.0
	N173	77.2	66.7	53.2	42.2



N

Legend

Pipe Links (Culverts)

System 1 Overland Links

System 2 Overland Links

180 0 180 360 540

Metres

Scale: 1:18,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 6

**MODEL LAYOUT-
KEY SHEET**

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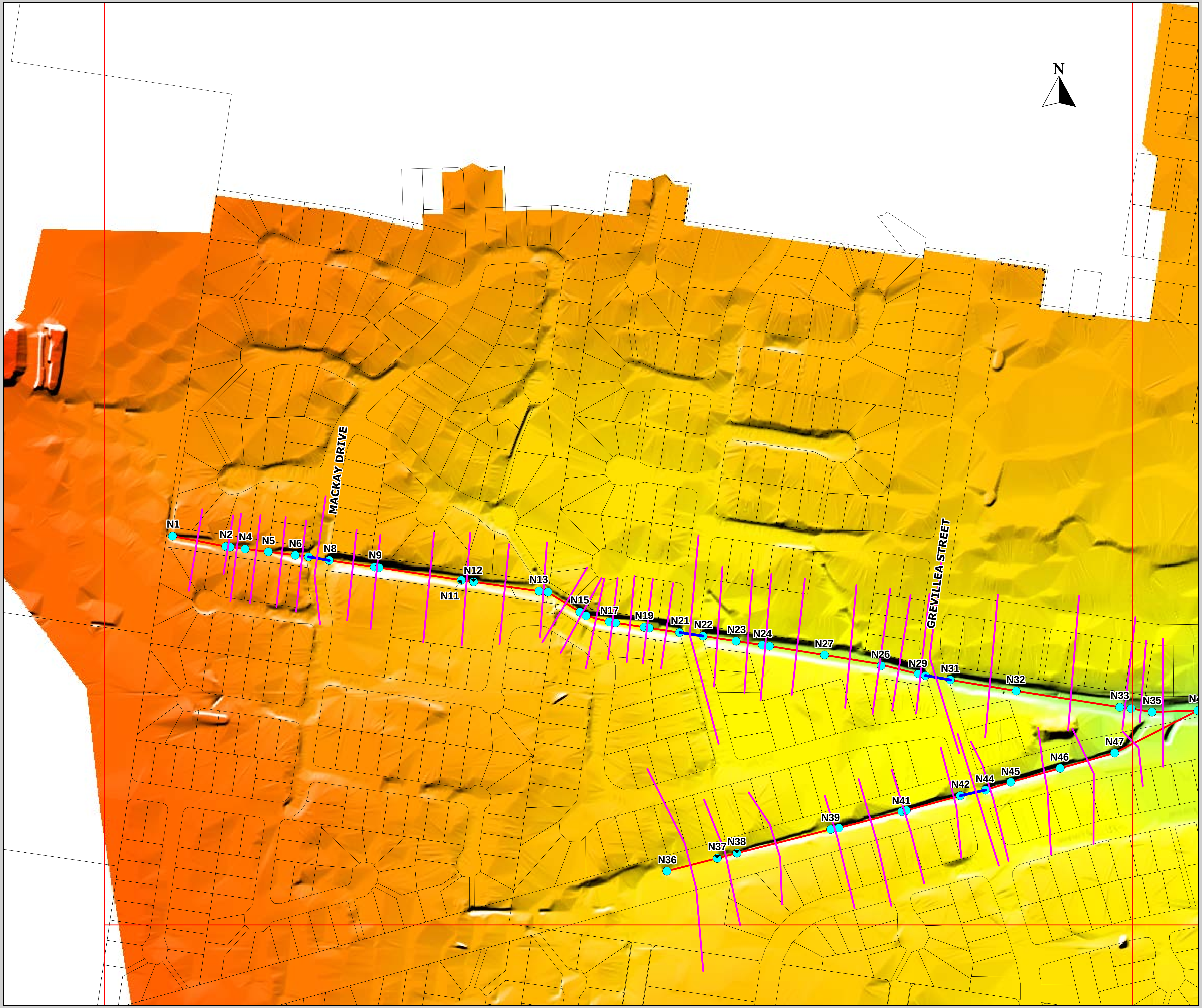
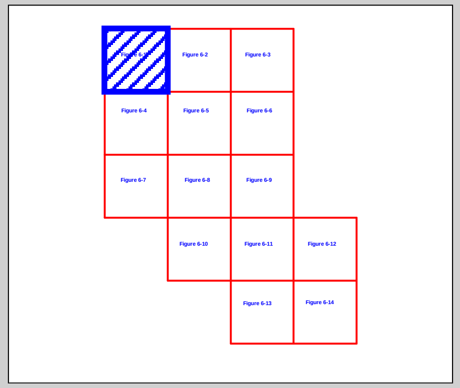
Projection Trans. Merc. MGA56(GDA 94)





BUNYA CREEK FLOOD RISK REDUCTION STUDY

FIGURE 6-1

MODEL LAYOUT

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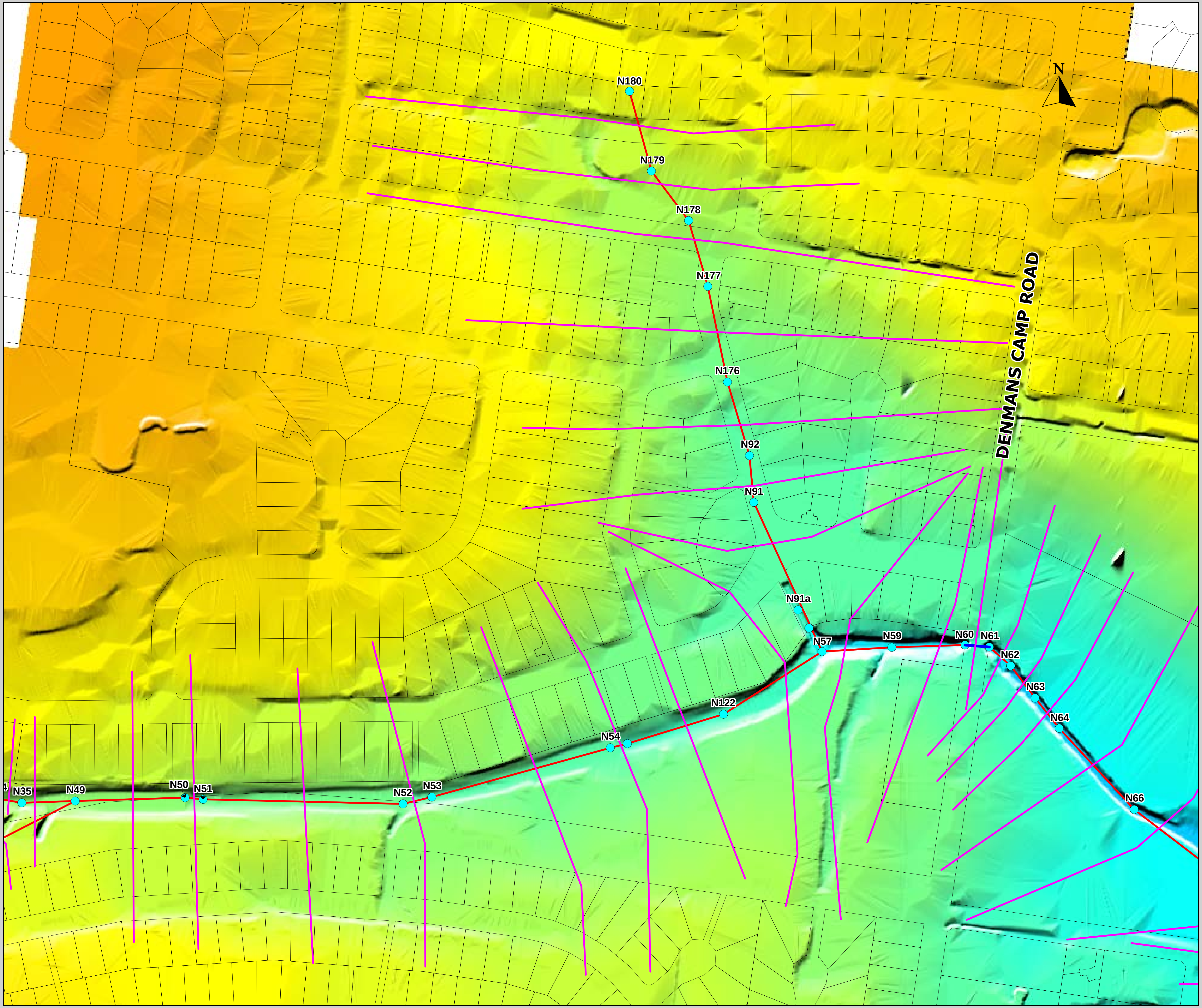
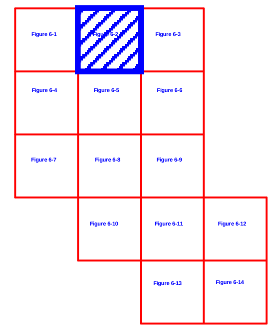
Projection Trans. Merc. MGA56(GDA 94)





Legend

- Pipe Links
- System 1 Overland Links
- Cross Sections
- System 1 Overland Nodes

30 0 30 60 90

Metres

Scale: 1:3,000

BUNYA CREEK FLOOD RISK REDUCTION STUDY

FIGURE 6-2

MODEL LAYOUT

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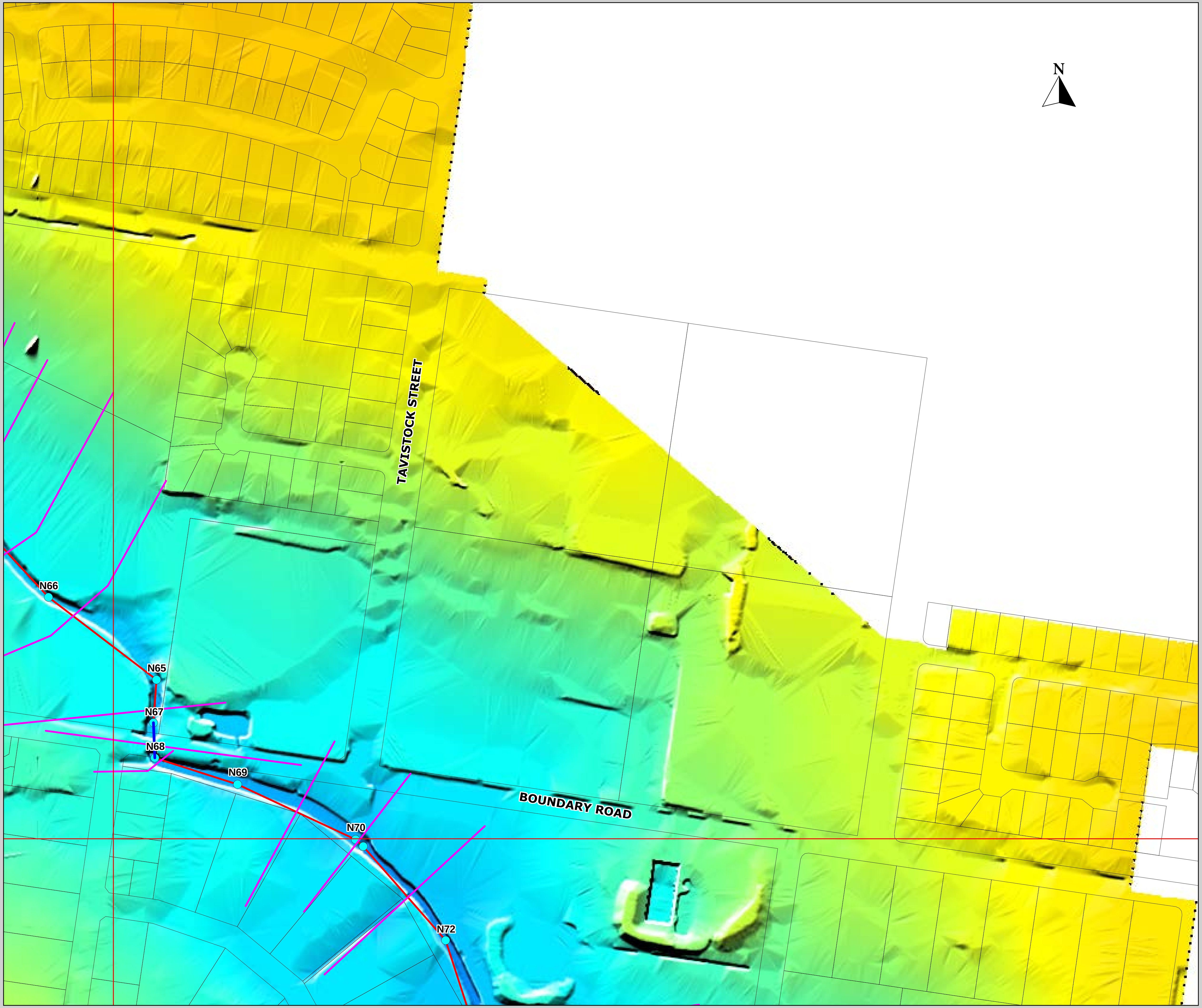
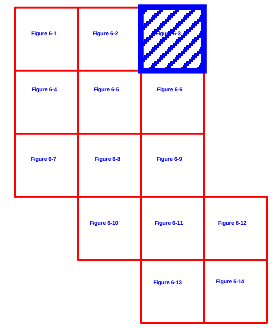
Projection Trans. Merc. MGA56(GDA 94)





Legend
- Pipe Links
- System 1 Overland Links
- Cross Sections
- System 1 Overland Nodes

30 0 30 60 90
Metres
Scale: 1:3,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 6-3

MODEL LAYOUT

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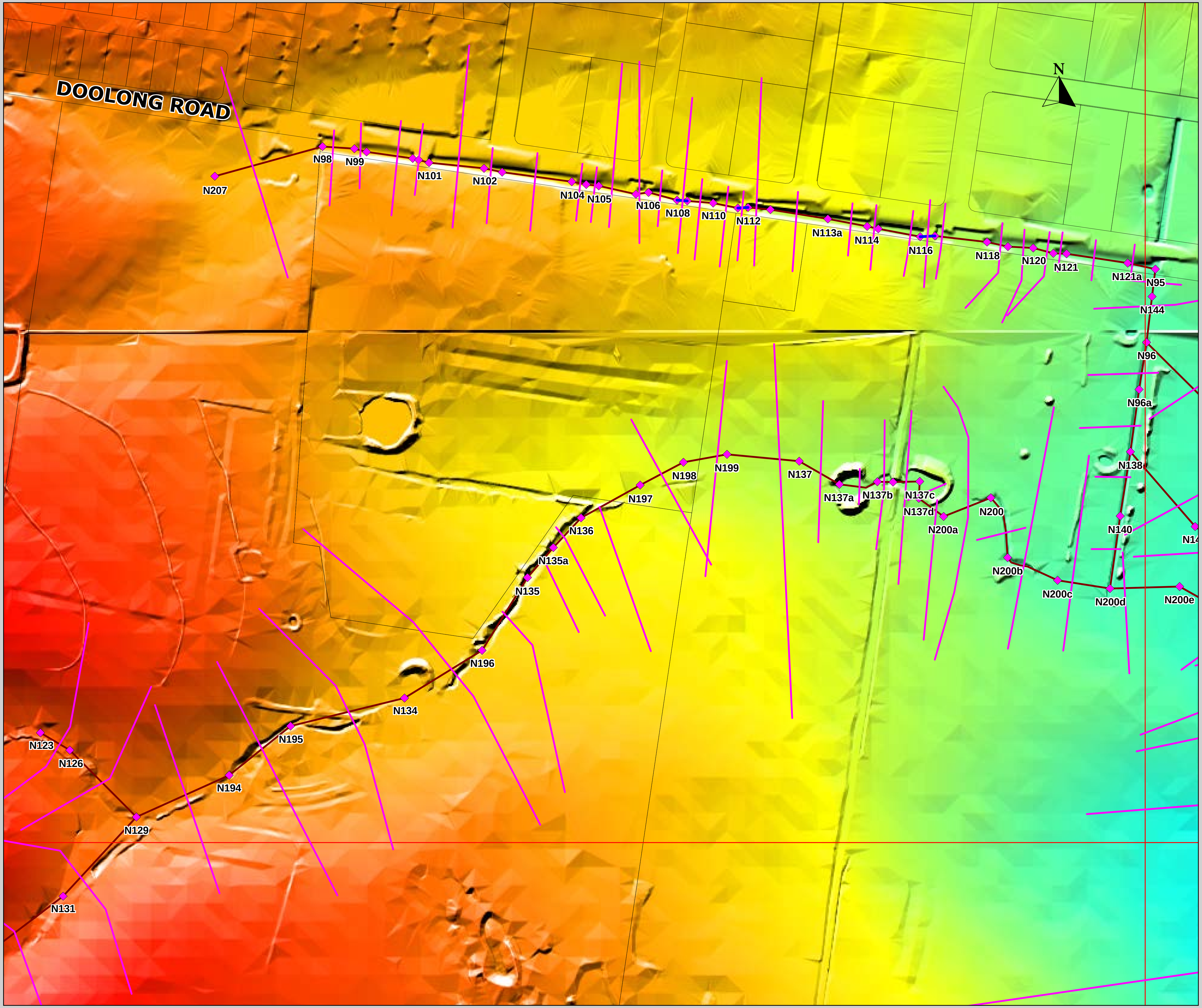
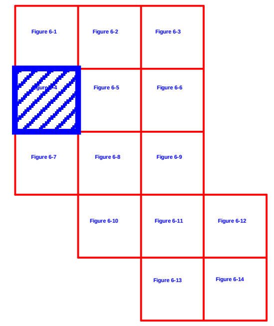
Projection Trans. Merc. MGA56(GDA 94)





Legend

- Pipe Links
- System 2 Overland Links
- Cross Section
- System 2 Overland Nodes

30 0 30 60 90

Metres

Scale: 1:3,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 6-4

MODEL LAYOUT

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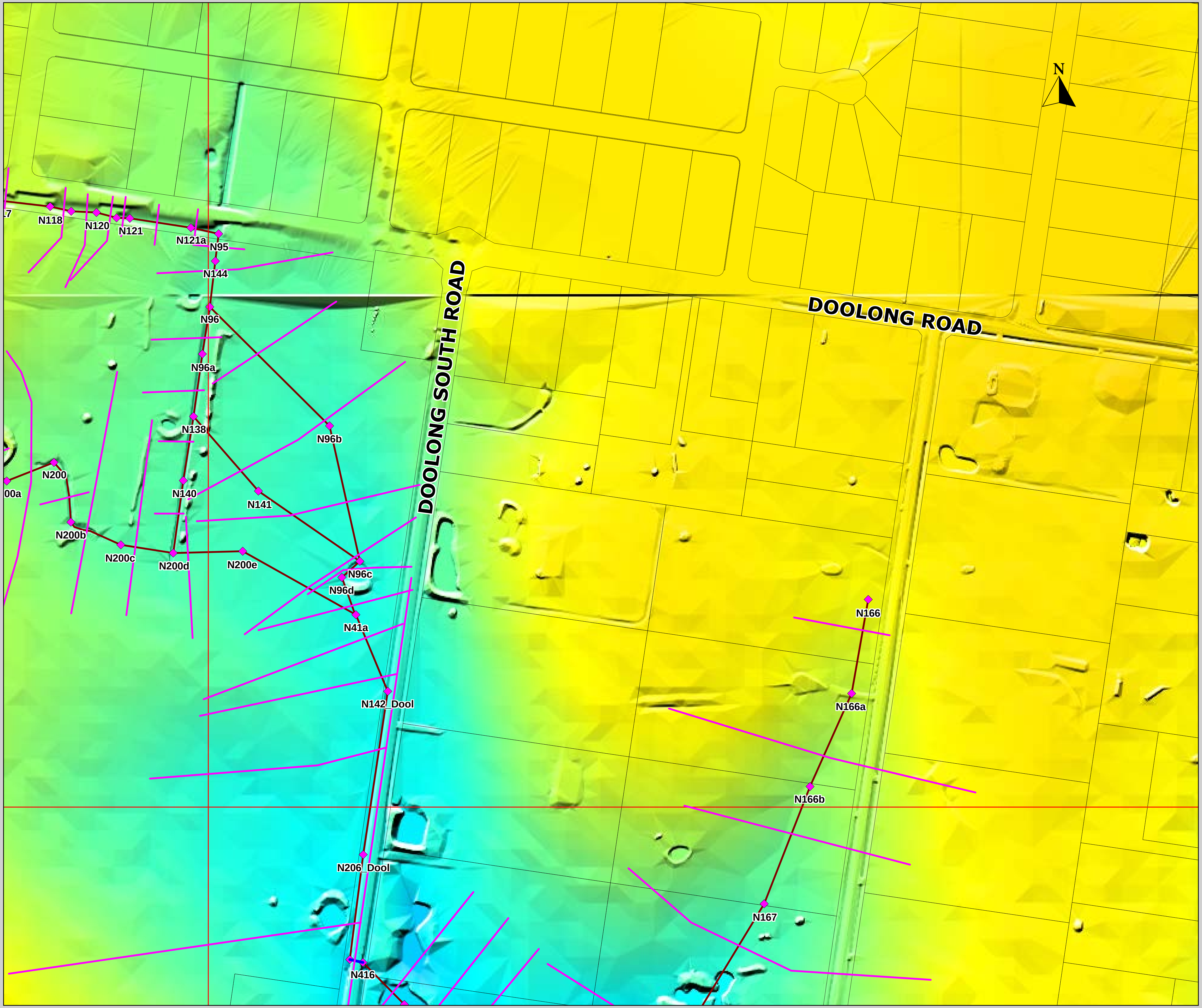
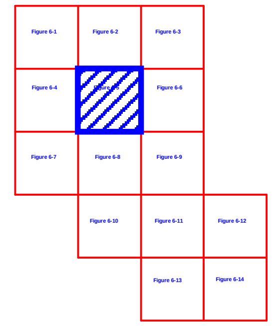
Projection Trans. Merc. MGA56(GDA 94)





Legend
- Pipe Links
- System 2 Overland Links
- Cross Sections
- System 2 Overland Nodes

30 0 30 60 90
Metres
Scale: 1:3,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 6-5

MODEL LAYOUT

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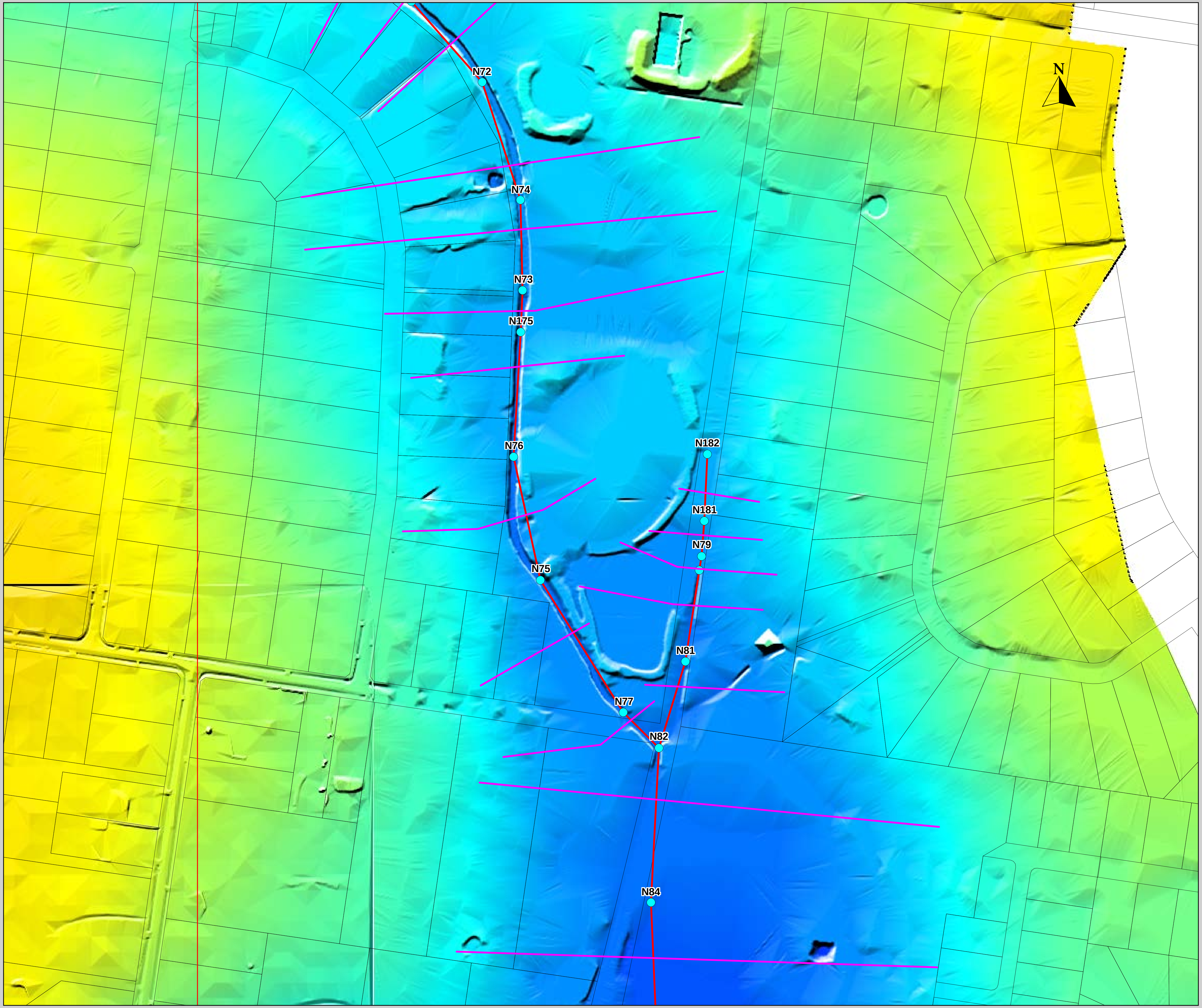
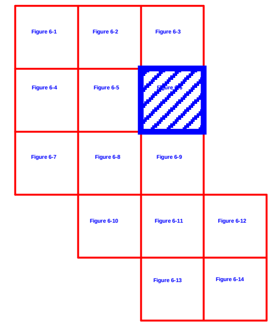
Projection Trans. Merc. MGA56(GDA 94)





Legend

Pipe Links

System 1 Overland Links

Cross Sections

System 1 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK FLOOD RISK REDUCTION STUDY

FIGURE 6-6

MODEL LAYOUT

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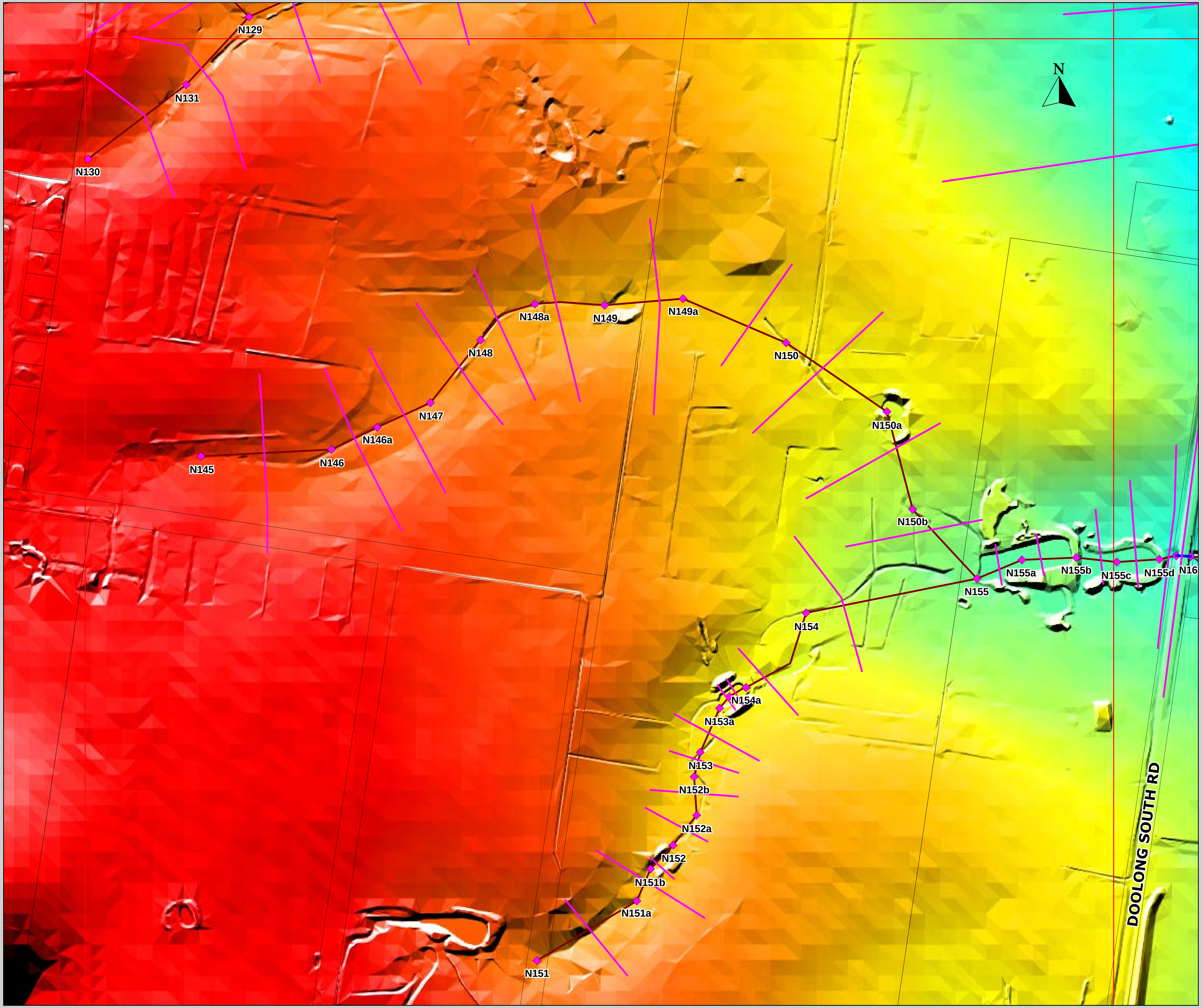
Projection Trans. Merc. MGA56(GDA 94)



BUNYA CREEK FLOOD RISK REDUCTION STUDY

FIGURE 6-7

MODEL LAYOUT

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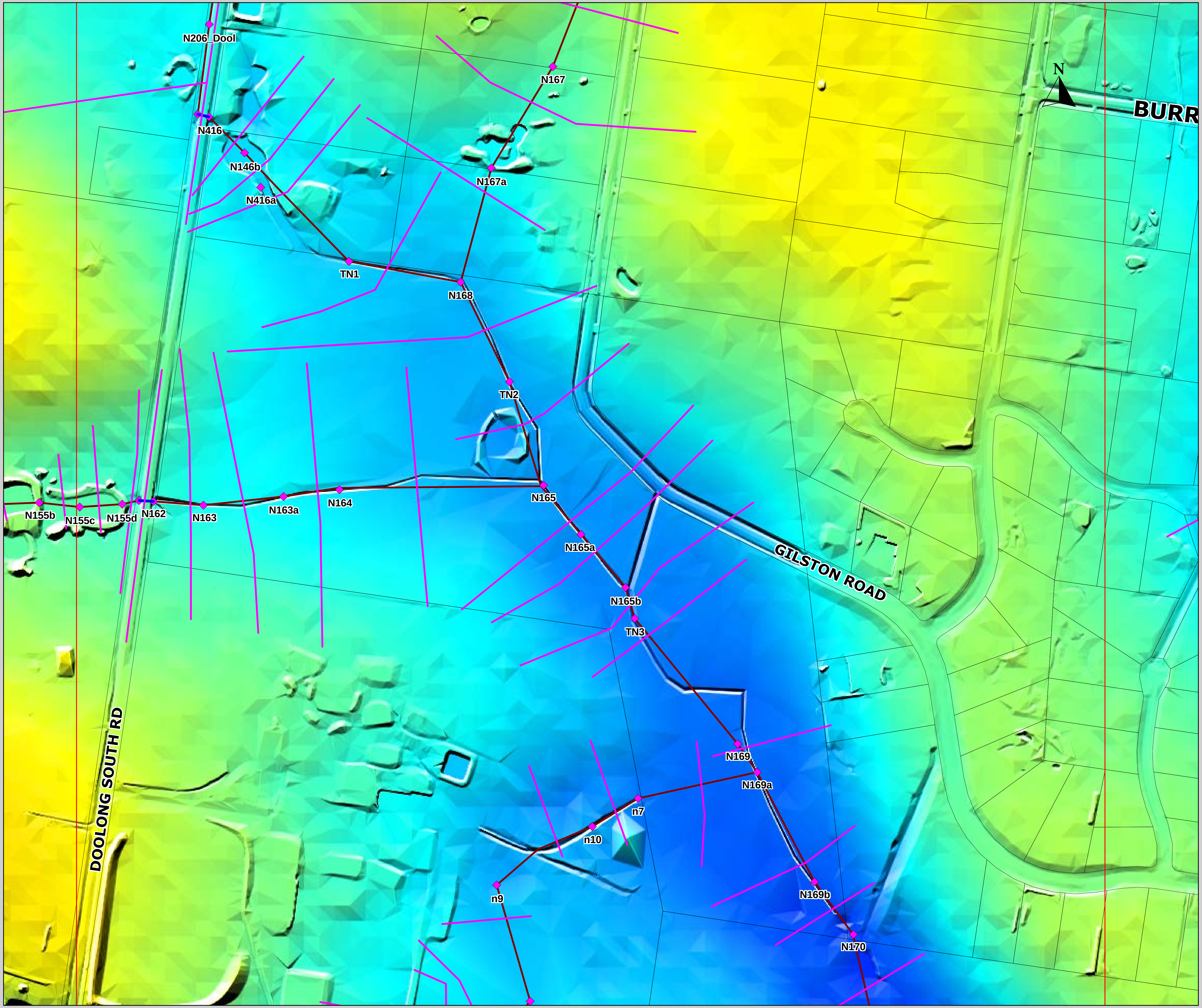
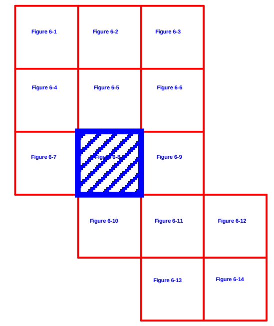
Projection Trans. Merc. MGA56(GDA 94)





Legend

- Pipe Links
- System 2 Overland Links
- Cross Sections
- System 2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 6-8

MODEL LAYOUT

HERVEY BAY CITY COUNCIL

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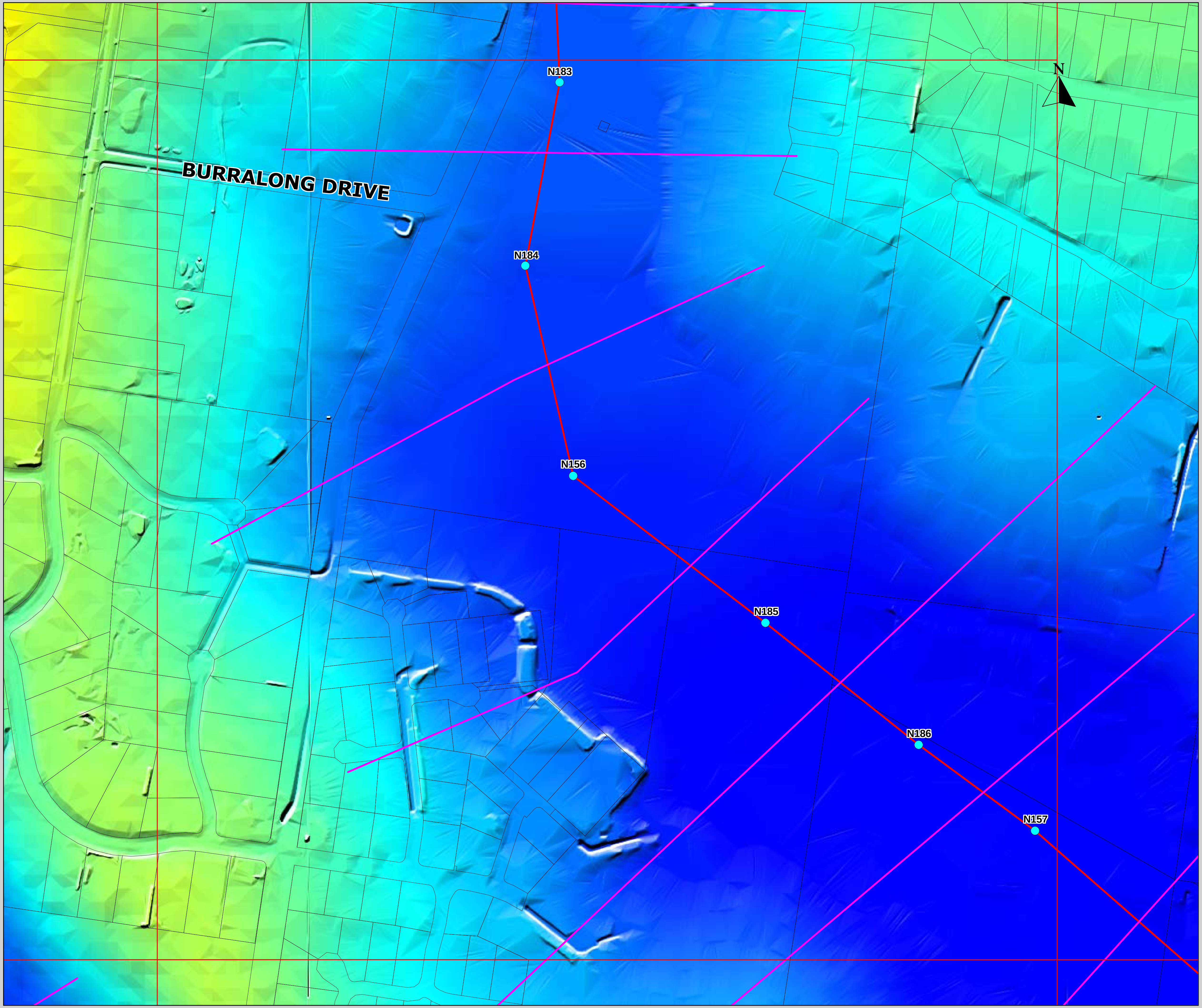
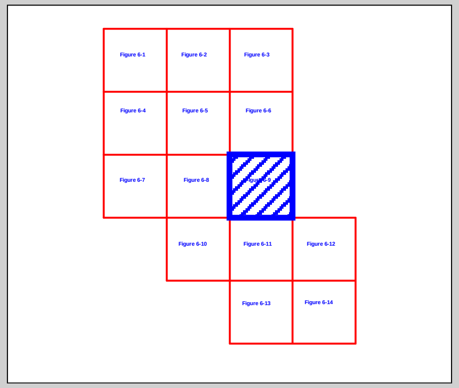
Projection Trans. Merc. MGA56(GDA 94)





Legend

- Pipe Links
- System 1 Overland Links
- Cross Sections
- System 1 Overland Nodes

40 0 40 80 120

Metres

Scale: 1:4,000

BUNYA CREEK FLOOD RISK REDUCTION STUDY

FIGURE 6-9

MODEL LAYOUT

HERVEY BAY CITY COUNCIL

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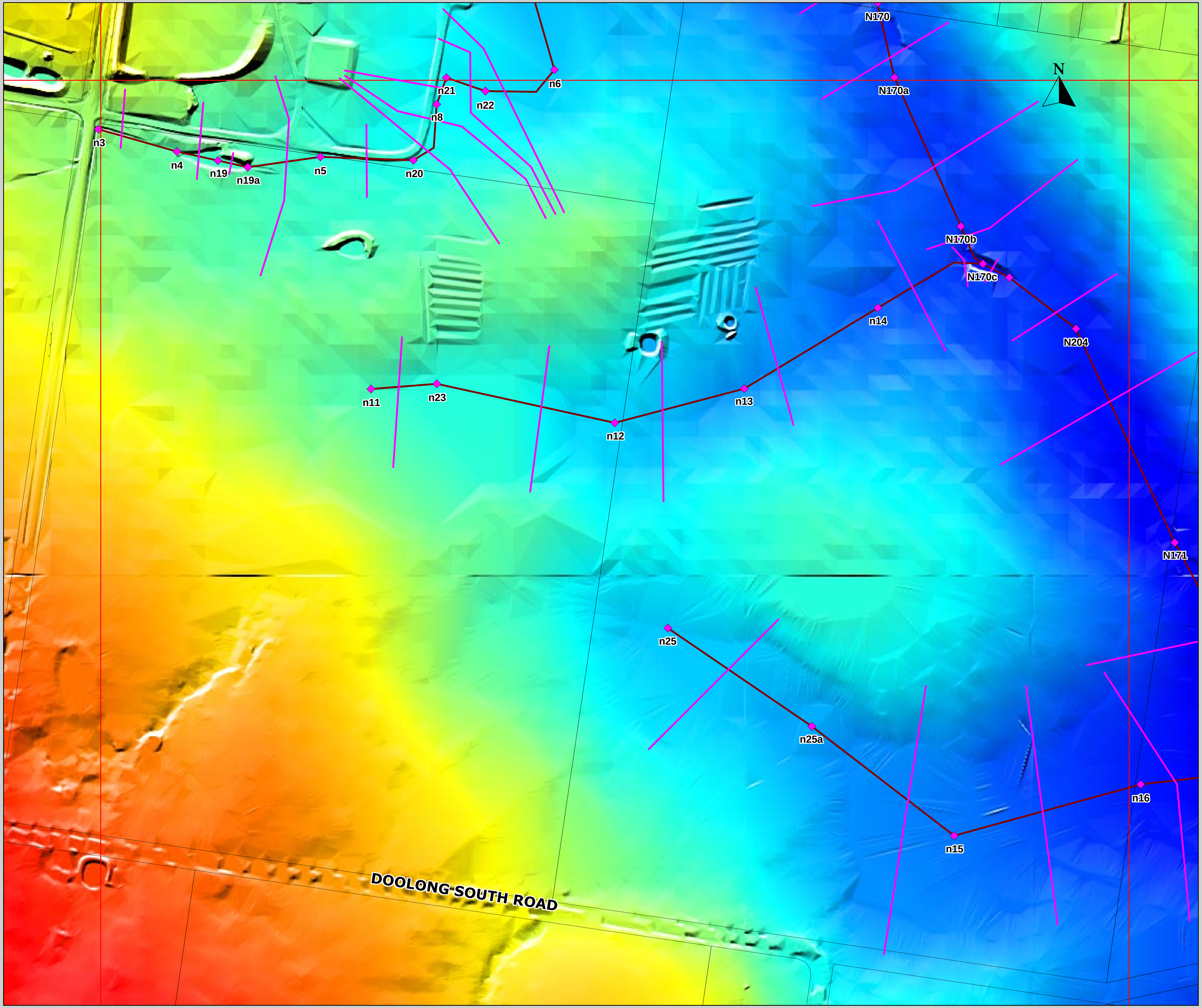
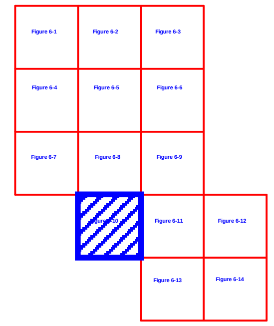
Projection Trans. Merc. MGA56(GDA 94)





Legend

- Pipe Links
- System 2 Overland Links
- Cross Sections
- System 2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 6-10

MODEL LAYOUT

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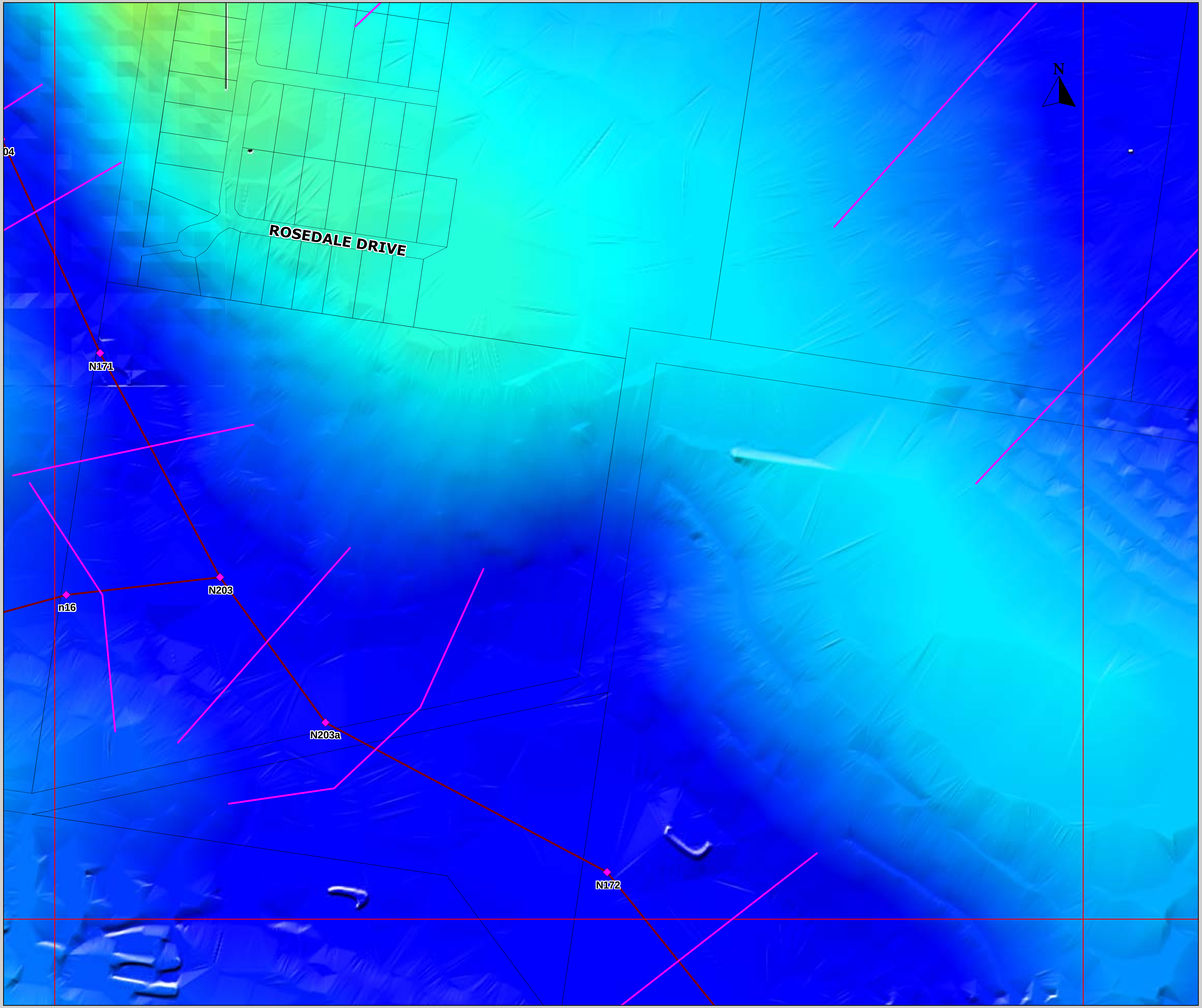
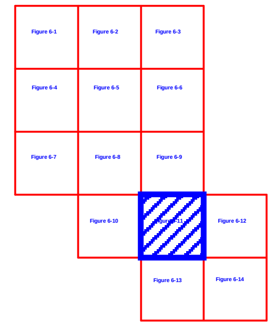
Projection Trans. Merc. MGA56(GDA 94)





Legend

- Pipe Links
- System 2 Overland Links
- Cross Sections
- System 2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK FLOOD RISK REDUCTION STUDY

FIGURE 6-11

MODEL LAYOUT

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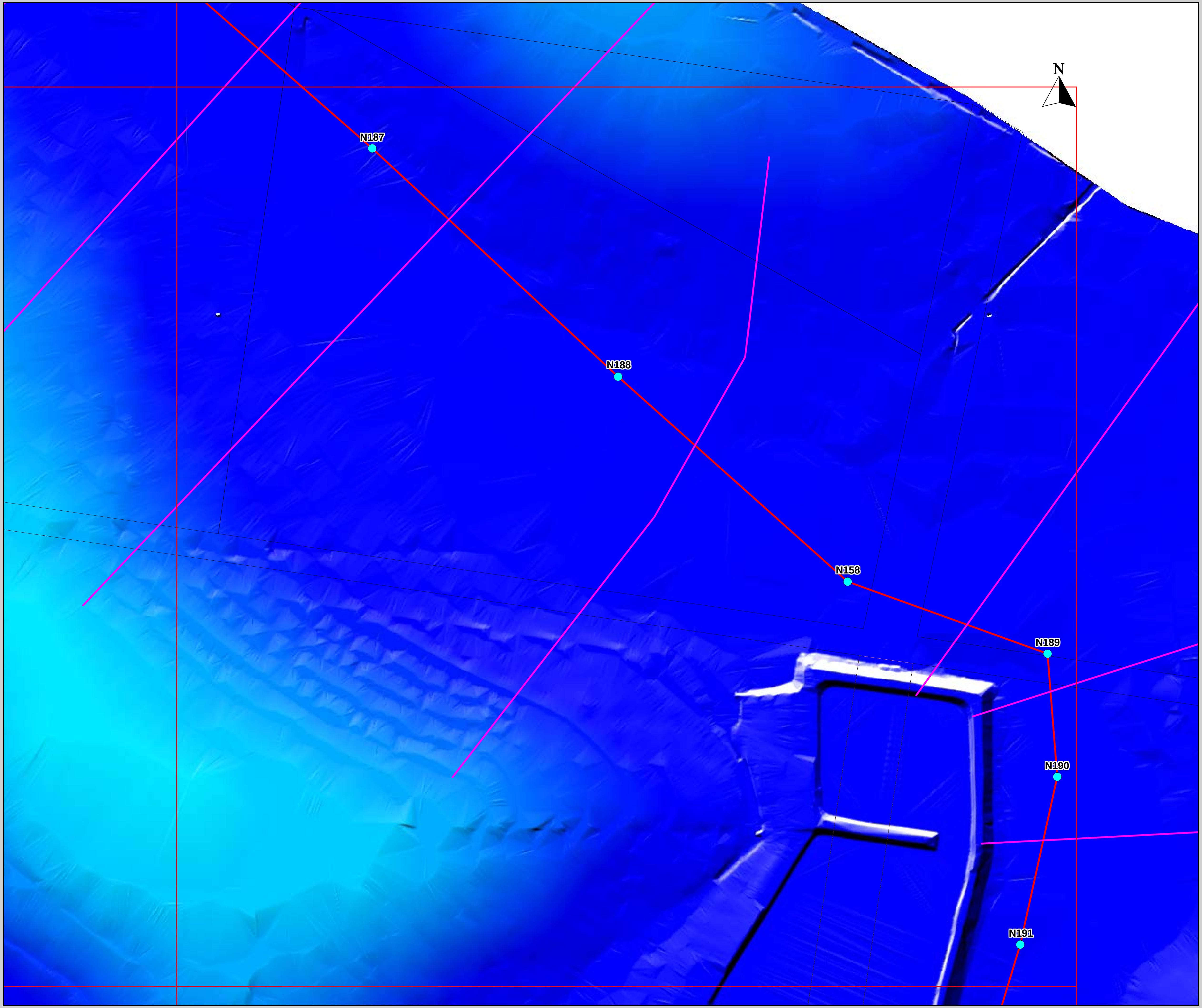
Projection Trans. Merc. MGA56(GDA 94)



Legend

- Pipe Links
- System 1 Overland Links
- Cross Sections
- System 1 Overland Nodes

40 0 40 80 120
Metres
Scale: 1:4,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 6-12

MODEL LAYOUT

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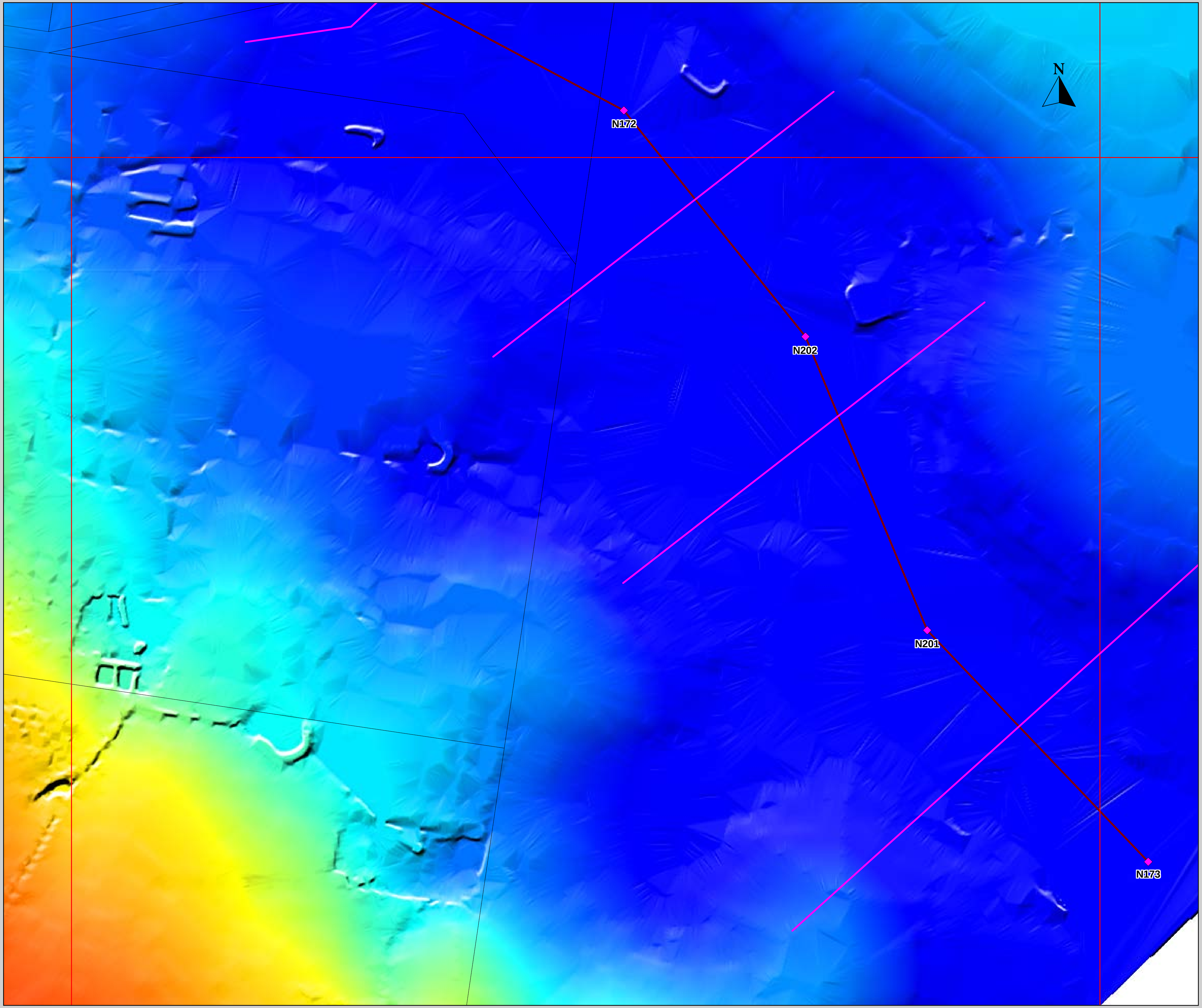
Projection Trans. Merc. MGA56(GDA 94)



Legend
- Pipe Links
- System 2 Overland Links
- Cross Sections
- System 2 Overland Nodes

35 0 35 70 105
Metres
Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 6-13

MODEL LAYOUT

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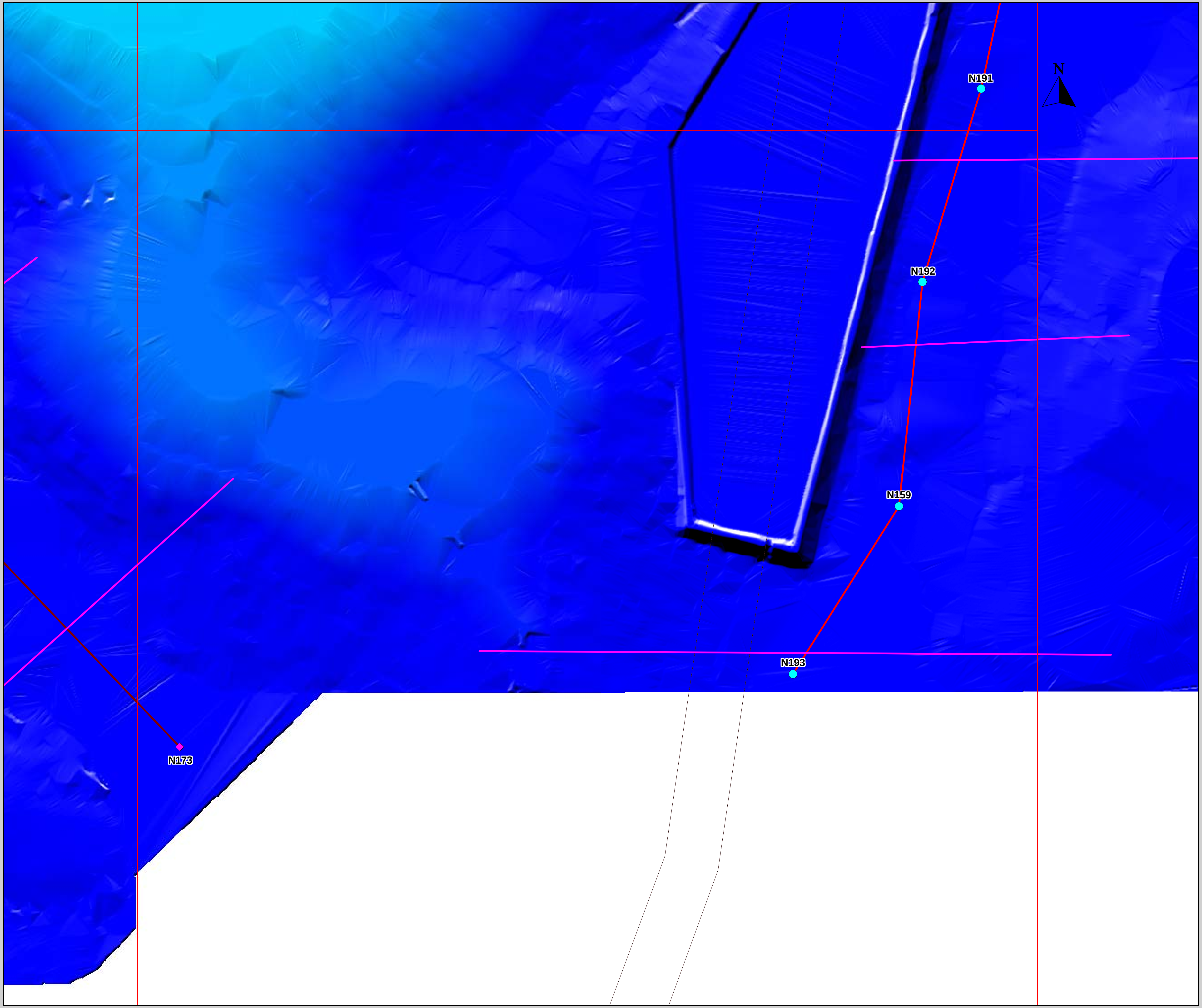
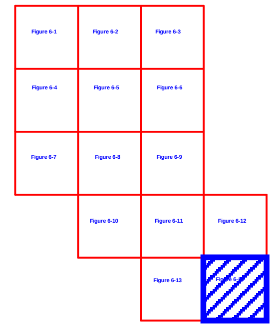
Projection Trans. Merc. MGA56(GDA 94)





Legend

- Pipe Links
- System 1 Overland Links
- System 2 Overland Links
- Cross Sections
- System 1 Overland Nodes
- System 2 Overland Nodes

40 0 40 80 120

Metres

Scale: 1:4,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 6-14

MODEL LAYOUT

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Projection Trans. Merc. MGA56(GDA 94)

6 Existing Case Analysis Results

6.1 Results

All flood level results from the existing XP-STORM models are presented in Appendix C of this report. The results are presented based on flood level reporting locations which are summarised in detail in a spreadsheet format contained in Appendix C of this report. The flood extent plans for the existing case model conditions also contained in Appendix C of this report contain the model reporting locations and names to facilitate the determination of flood characteristics at specific locations throughout the catchment.

6.2 Flood Extent Mapping

Flood extent plans have been prepared as part of this study. The plans are presented to illustrate the anticipated extent of flooding for the 10, 20, 50 and 100 year ARI events over the study area for the existing case, and the required design event for the mitigated case. The flood extent plans have been prepared based upon the DTM and using the outcomes from the hydraulic model. A 3-dimensional (3D) flood surface has been created using the model results within the GIS and this surface has been draped over the DTM in order to prepare a 3D flood depth surface. The 3D depth surface has been contoured such that only depths greater than or equal to zero are displayed which by default defines the extent of flood inundation for the event under question.

The flood extent plans prepared as part of this study include extent of mapping limits as have been identified on the plans. These limits have been included to illustrate the point of which mapping has been prepared and this is based on both the extent of the model prepared along with the extent of the DTM data for the catchment. Limit of mapping lines have also been included in other isolated areas whereby the extent of flooding was either undiscernible or inaccurately defined based upon the information available. In all cases, water will discharge from the catchment in these areas.

The flood inundation mapping prepared as part of this study is subject to the following notations: -

1. The flood extent and associated flood data prepared as part of this study is based on available survey data as supplied by Hervey Bay City Council. This includes aerial photogrammetric survey, limited field validation survey and stormwater pipe and pit information. The flood extents and flood results will therefore be subject to the accuracy and detail of the background study information. Drainage conditions may also have changed since the collection of the survey information;

2. Flood extents shown in urbanised areas have generally been shown (where applicable) with the extent of flooding limited to the width of the road carriageway. This methodology was adopted where the depth of flooding within the road reserve was found to be less than 200mm (contained within the carriageway);

3. Local flooding within some property allotments was unable to be accurately defined as part of this study and is misleading if shown owing to the level of detail contained within the DTM and the interpolated procedures in estimating intermediate property ground level information. Properties in these areas may or may not be subject to inundation and a detailed floor and ground level survey would be necessary in these areas to accurately determine property inundation. These areas are clearly shown where applicable on the inundation maps;

4. All flood extents prepared as part of this study have been prepared based upon the DTM formed for the study area. Where critical information such as open channels have not been adequately represented in the DTM as a result of the original photogrammetric data captured, flood extents shown could be different to those which may occur on the ground. The accuracy of the flood extents prepared from this study is subject to the accuracy of the topographical representation contained within the DTM.

7 Existing Scenario Risk Identification & Prioritisation

7.1.1 Risk Identification Methodology

The method of evaluating flood risk prepared as part of this study is summarised in the following tables.

Likelihood parameters

Almost certain	A 99.5% chance of a hazard being exceeded in a 50 year period – a 1 in 10 year event.
Likely	Probability of exceedance is greater than 50% in a 50 year period, but less than 99.5% - a 1 in 50 year event.
Possible	Probability of exceedance is greater than 20% in a 50 year period, but less than 50% - a 1 in 100 - 200year event.
Unlikely	Probability of exceedance is greater than 5% in a 50 year period. but less than 20% - a 1 in 500 year event
Rare	Probability of exceedance is less than 5% in a 50 year period - a 1 in 500 year event.

Consequence parameters (based on 2000 AU$)

Insignificant	Natural hazards are experienced and cause some stress on community lifelines. Community agencies cope with some effort and total community financial loss is less than $1.0m.
Minor	No disaster is officially declared and effects lead to temporary failure of lifelines other than energy supply for up to 24 hours. Total community financial loss is less than $10m.
Moderate	Disruption lasts for more than 5 days including energy disruption. Recovery takes 14 – 21 days. Vulnerable elements are severely affected and all major agencies are involved. Hospitalisation of victims occurs and total community financial loss is less than $50m. State of emergency is declared during the event.
Major	All lifelines affected. Energy is disrupted for up to 14 days. Recovery takes 4 – 6 weeks. At least one death is suffered and temporary evacuation of area is required. State of Disaster is declared and total community loss is up to $200m.
Catastrophic	Effects are severe and all lifelines are affected. No energy for up to 8 weeks and recovery takes 6 – 24 months. At least 10 deaths suffered and significant evacuation required. Total community financial loss in hundreds of millions.

Risk Ranking

Return period	**Consequence** **Likelihood**	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
10	Almost certain	H	H	E	E	E
50	Likely	M	H	H	E	E
100/200	Possible	L	M	H	E	E
500	Unlikely	L	L	M	H	E
1000	Rare	L	L	M	H	H

Where: E = extreme risk H = high risk M = moderate risk L = low risk

In addition to infrastructure lifelines, risk parameters for people, buildings, economic loss and loss of the natural environment are proposed as follows:

Risk element	Extreme (unacceptable) risk
People	Vulnerability to natural hazards is generally measured by the risk to life and property from known hazards. An area may be prone to a known hazard, but if there is no possible risk to life or property, the vulnerability is low. Where life and property are at risk, the magnitude and likelihood of the hazard combine to create a measure of vulnerability. **Unacceptable risks are death, serious injury and major health hazard.**
Buildings	The built environment is at risk from a number of known hazards in Hervey Bay. Various regulations have been developed locally (e.g. Local Laws) and at a wider scale (e.g. the Building Code of Australia) to minimise the risk of damage to the built environment. All of these regulations are based on an acceptable level of risk which has been determined either by Council or a wider community of interest (e.g., 1:100 flood immunity). Inevitably there will be extreme events which go beyond the acceptable level of immunity and the only possible way to immunise against these events is avoidance. **Unacceptable risks are collapse or damage to buildings requiring demolition.**
Economic loss	In all disaster events there is bound to be some form of economic loss. The Federal Government under the Natural Disaster Relief Arrangements provides funding to victims of disaster events. This funding is generally short term and designed to minimise immediate suffering and loss. Businesses need to make their own assessment of potential economic loss through a natural disaster event and make plans accordingly. These would range from building construction, to choice of location to insurance. **Unacceptable risks are loss of livelihood for more than 10% of the working community.**
Natural environment	The natural environment is at risk from a number of known hazards in Hervey Bay. **Unacceptable risks are loss of ecological systems, major habitats or conservation areas. Significant disruption to natural drainage systems.**
Risk escalation Risk escalation is likely to happen when initial risk minimisation programs or event response mechanisms do not achieve their intended purpose. The risks outlined in this document may have follow-on or secondary effects (e.g. an earthquake may lead to a dam break, which may lead to flooding, which may lead to injury or isolation). **Unacceptable risks arise from the failure of initial risk minimisation and response mechanisms.**	
Risk frequency Risks to physical infrastructure are usually incorporated in design parameters (e.g. bridges are designed to withstand certain loads; drains are designed to accommodate mathematically derived flood levels). These are generally based on industry standards of acceptable levels of risk. These standards have until recently had very little legislative basis. The recent adoption of *State Planning 1/03 - Mitigating the adverse impacts of Flood, Bushfire and Landslide* introduces risk frequency levels (e.g. 1:100 years) which are required to be accommodated in planning and design documents (e.g. planning schemes and infrastructure codes). **Unacceptable risks are events which occur within the design capacity of infrastructure or industry accepted measures.**	

Legal and social justice implications Risk management is applied by Council across all parts of its jurisdiction in an equal manner and includes all persons. Council is required to make decisions on an annual basis about prioritising its expenditure on various competing items. Expenditure on risk minimisation is incorporated in most capital works projects by way of an in-built design standard. **Unacceptable risks are deliberate inequality of expenditure against any one group, or any one part of the city.**
Political implications Council's decisions are subject to scrutiny and influence from various elements and sectors of the community. It is Council's role to make informed and un-biased decisions. **Unacceptable risks are decisions made which reflect unlawful political bias.**

For each model prepared as part of the Bunya Creek Catchment Flood Risk Identification Study, specific flood risks were identified through use of the above risk matrix and examination of modelling results as discussed in Section 6. The risk matrix was used in conjunction with a detailed assessment that was undertaken for each of the roads contained in the models to determine less obvious flooding risks such as minor overtopping and property inundation and to determine any risk (velocity x depth) issues. A risk ranking for each specific flooding risk was then determined. This risk ranking, used to prioritise mitigation options within the total catchment, is discussed in more detail in Chapter 8. A description of flooding and risk ranking for each model is provided in the following text.

Based on the derived risk ranking and the flooding characteristics of each location the upgrade and immunity requirements are presented in Tables 7.1 – 7.3. These tables summarise the risk analysis for each specific model, namely System 1 and System 2, which represent the various discrete drainage networks within the Bunya Creek catchment.

7.1.2 Risk Identification

Modelling of the catchments identified the following results. Based on this preliminary assessment, it was determined whether further analysis of the areas was warranted.

7.1.3 System 1 Model

Six (6) road crossings were assessed in System 1 as shown in Table 7.1. JWP notes that due to discrepancies in Council's GIS pipe data and the DTM, flooding was determined based on the model and the assumptions made in creating the model, as discussed in Section 3.3. Inundation or overtopping of road crossings is outlined below and shown in the flood inundation extents (Appendix C).

Table 7.1: Flooding of Road Crossings

Road Crossing	HBCC Road Hierarchy	Existing Drainage System (Dimensions in mm)	Flooding Depth (mm)			
			Q10	Q20	Q50	Q100
Mackay Dr	Minor Road	3 No. 825 RCP	0	0	0	0
Areca Dr	Minor Road	2 No. 1200 x 1100 RCBC	0	138	231	290
Grevillea St #1	Major Road	1 No. 1500 x 1200 RCBC	312	344	374	399
Grevillea St #2	Major Road	3 No. 825 RCP	73	116	133	150
Denmans Camp Rd	Major Road	2 No. 1800mm x 1850 RCBC	0	137	231	286
Boundary Rd	Major Road	5 No. 1200 x 1200 RCBC	95	168	277	365
Doolong South Rd	Major Road	4 No. 900 RCP	240	285	325	350

Where: #1 – Northern Grevillea St crossing
#2 – Southern Grevillea St crossing

According to section 5.09 of QUDM, it is recommended that the maximum depth of flow on any road be limited to 300mm and the product of depth (d) and average velocity (V_{ave}) in the kerb and channel should not exceed 0.4 m^2/s to limit hazard for pedestrians within the roadway. This standard has been adopted for this analysis due to the fact that the roads may be used by both pedestrians and vehicles.

According to the HBCC Road Hierarchy, all roads except Mackay Drive and Areca Drive are considered to be Major Roads and are therefore required to be trafficable for the 50 year ARI event. Minor roads, such as Mackay Drive and Areca Drive are required to be trafficable for the 10 year ARI event. HBCC also requires flood immunity of properties for the 100 year ARI storm event.

Mackay Drive and Areca Drive have flood immunity for the required 10 year ARI event and the $d \times V_{ave}$ products are acceptable. It is noted that properties upstream of the Mackay Drive crossing experience inundation due to flow overtopping the channel for all design events analysed. The same applies upstream of Areca Drive. The overtopping of the channel upstream of both crossings warrants further investigation.

The maximum depth of flow along the roadways of Grevillea Street#2, Denmans Camp Road and Boundary Road are limited to 300mm for the 50 year ARI event. The $d \times V_{ave}$ product for Grevillea Street#2 and Denmans Camp Road is acceptable (less than 0.4 m^2/s) and is therefore trafficable and safe for both pedestrians and vehicles. However, the $d \times V_{ave}$ product for Boundary Road is greater than 0.4 m^2/s and therefore an upgrade of the culverts under Boundary Road is required for the 50 year ARI storm event. It should be noted that the property (RP158846) located on the corner of Tavistock Street and Boundary Road experiences flooding during all events and therefore further assessment of this area is warranted.

The Grevillea St#1 crossing experiences flooding with depths of flow greater than 300mm for all design events. The $d \times V_{ave}$ product is also greater than 0.4 m^2/s and therefore does not satisfy Council requirements.

Also, due to the inadequate capacity of the culverts on Grevillea St#1, Grevillea St#2 and Denmans Camp Rd, several surrounding properties are inundated and therefore an upgrade of all culverts is required to provide properties with immunity for the 100 year ARI storm event (as required by HBCC).

Flood extents for System 1 indicate that properties along Lindemans Court, Bauhinia Drive and Kathleen Cres experience inundation as a result of flow overtopping the channel, however floor levels of properties are unknown to JWP and as such further investigation is required to determine whether these houses experience inundation. The same applies for properties surrounding the channel upstream of Denmans Camp Road. This overtopping warrants further investigation.

Another area of concern is the flow path from Oleander Avenue along Poinciana Court to the main drainage channel, which has been identified as a potential drainage problem area and may require further investigation by Council. JWP notes that this flow path has been modelled based on the DTM as discussed with Council. The sub surface drainage network and the flow along the roadway has been neglected due to the DTM inadequately representing the roadway and surrounding properties.

7.1.4 System 2 Model

The open channel alongside Doolong Road has been identified as a potential drainage issue as it does not have sufficient capacity to contain flow for even the 10 year ARI storm event. The channel is relatively dense with long grass and weeds, has an approximate width of 10m and an average depth of 500mm. It has been determined that properties located at 104 and 108 Doolong Road, 1 Snapper Street and the vacant property (SP165539) located on Doolong Road experience flooding with depths of up to 500mm for the 100 year ARI event.

Flow from the channel is believed to overtop approximately 300m of the Doolong Road carriageway with depths of up to 700mm over the road for the 50 year ARI event. The Doolong Road carriageway does not have storage capacity due to the absence of a kerb and channel structure. As such, flow overtopping the drainage channel travels over the road and into adjoining properties. Doolong Road is deemed a Major Road according to HBCC's Road Hierarchy and therefore it is required that the $d \times V_{ave}$ product value is less than 0.4 m^2/s and the maximum depth of flow over the road is 300mm.

Both the $d \times V_{ave}$ product value and required maximum depth of flow (300mm) over the road is exceeded and therefore mitigation is required to ensure that Doolong Road is trafficable during the 50 year ARI storm event. Due to the inundated properties along Doolong Road, it is necessary to upgrade the channel to accommodate flow for the 100 year ARI storm event in accordance with Council requirements. In combination with the channel upgrade, several culverts under driveways would also require upgrade.

An additional area of concern includes the housing estate on Doolong Road (lot 1 SP168813). Flood extents for all events indicate that numerous properties surrounding the overland drainage channel experience inundation due to the proximity to the channel which passes the south-eastern boundary of the estate. House floor levels were not provided to JWP, however, due to the date the DTM was created JWP is of the understanding that the DTM does not include the land filling that may have taken place as a result of the development of the estate. JWP advises Council to further investigate this issue to determine whether these properties would experience inundation and if so what drainage/channel work is required.

The overtopping of approximately 430m of Doolong South Road causes concern, with a maximum depth of 325mm overtopping the road sag during the 50 year ARI event. The road is deemed a Major Road according to HBCC's Road Hierarchy. The existing drainage system of 4 No. 900mm diameter RCP's have been incorporated into the model to convey flow under the road. Whilst the $d \times V_{ave}$ product value is acceptable due to low velocity, the road is not considered trafficable due to the depth of flow over the road. Property inundation also occurs as a result and as such mitigation is required to ensure Doolong South Road is trafficable during the 50 year ARI event.

Table 8.2: Flood Risk Analysis for System 1 and System 2 models.

Location	Risk Element	Acceptable standard	Currently meets desired risk standard	Likelihood	Consequence	Risk Ranking	Upgrade recommended
System 1 Model							
Mackay Drive Crossing	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	**Low**	×
	People - ease of egress	DV Product <0.4	✓	Unlikely	Insignificant	**Low**	×
	Buildings	Q100 immunity	✓	Unlikely	Insignificant	**Low**	×
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	**Low**	×
	Natural environment	N/A	✓	Unlikely	Insignificant	**Low**	×
Areca Drive Crossing	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	**Low**	×
	People - ease of egress	DV Product <0.4	✓	Possible	Insignificant	**Low**	×
	Buildings	Q100 immunity	✓	Unlikely	Insignificant	**Low**	×
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	**Low**	×
	Natural environment	N/A	✓	Unlikely	Insignificant	**Low**	×
Grevillea St[#1] Crossing	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	**Low**	×
	People - ease of egress	DV Product <0.4	×	Almost Certain	Insignificant	**High**	✓
	Buildings	Q100 immunity	×	Almost Certain	Insignificant	**High**	✓
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	**Low**	×
	Natural environment	N/A	✓	Unlikely	Insignificant	**Low**	×

Location	Risk Element	Acceptable standard	Currently meets desired risk standard	Likelihood	Consequence	Risk Ranking	Upgrade recommended
Grevillea St[#2] Crossing	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	Low	×
	People - ease of egress	DV Product <0.4	✓	Unlikely	Insignificant	Low	×
	Buildings	Q100 immunity	×	Almost Certain	Insignificant	High	✓
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	Low	×
	Natural environment	N/A	✓	Unlikely	Insignificant	Low	×
Denmans Camp Road Crossing	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	Low	×
	People - ease of egress	DV Product <0.4	✓	Unlikely	Insignificant	Low	×
	Buildings	Q100 immunity	×	Almost Certain	Insignificant	High	✓
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	Low	×
	Natural environment	N/A	✓	Unlikely	Insignificant	Low	×
Boundary Road Crossing	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	Low	×
	People - ease of egress	DV Product <0.4	×	Likely	Insignificant	Moderate	✓
	Buildings	Q100 immunity	✓	Unlikely	Insignificant	Low	×
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	Low	×
	Natural environment	N/A	✓	Unlikely	Insignificant	Low	×
System 2 Model							
Doolong Road	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	Low	×
	People - ease of egress	DV Product <0.4	✓	Unlikely	Insignificant	Low	×

Location	Risk Element	Acceptable standard	Currently meets desired risk standard	Likelihood	Consequence	Risk Ranking	Upgrade recommended
	Buildings	Q100 immunity	×	Almost Certain	Insignificant	**High**	✓
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	**Low**	×
	Natural environment	N/A	✓	Unlikely	Insignificant	**Low**	×
Doolong South Road Crossing	People - drowning	No resultant deaths, injuries or major health hazards	✓	Unlikely	Insignificant	**Low**	×
	People - ease of egress	DV Product <0.4	✓	Possible	Insignificant	**Low**	×
	Buildings	Q100 immunity	✓	Unlikely	Insignificant	**Low**	×
	Economic loss	Loss of livelihood for less than 10% of working community	✓	Unlikely	Insignificant	**Low**	×
	Natural environment	N/A	✓	Unlikely	Insignificant	**Low**	×

8 Culvert Upgrade Assessment for Booral Road, Main Street and Woods Road

A hydraulic analysis has been conducted for the various culverts identified in the project brief and through discussion with Council. Culverts with a diameter/height greater than 300mm have been assessed along Booral Road, Main Street and Woods Road. Assessment of the existing capacity of the culverts and the required capacity of the culverts has allowed for the required upgrade to be determined. It is noted that the upgrade would provide complete flooding immunity of the road.

As a result of Booral Road, Main Street and Woods Road being investigated using a rational method and Q=VxA approach, inundation extents for the areas investigated using this method are not available.

8.1 Hydrological Methodology

As previously stated, the DTM does not extend to Booral Road and as such, Rational Method calculations were used to determine flows entering each culvert system. Contour information has formed the basis on which the sub-catchments were defined. Discrete sub-catchments representing the watershed flowing to each culvert crossing were defined, and appropriate details such as slope, path length and roughness recorded.

8.2 Hydraulic Methodology

Maximum discharge was determined by Q=VA, where a maximum velocity through the culverts of 1.5 m/s was assumed. The pipe on grade (Manning's equation) analysis was deemed to be incorrect methodology due to many large culvert systems being on a flat grade, therefore accommodating minimal or no flow according to Manning's Equation. This approach also failed to take into consideration the effects of head build-up behind the road bund. As such, a maximum velocity approach was adopted. Overall assumptions included:

- Road crest levels on Booral Rd, Woods Rd and Main St were taken from survey supplied by Surveyors @ Work;
- Minimum cover of 600mm was required above culverts for road pavements as per Section 5.15.1 of QUDM;
- All upgrades supplement existing structures, therefore retaining existing culvert structures;
- Where excessive multiple large culverts were required, a bridge option was explored;
- For larger catchment flows, RCBC's were adopted where the largest RCP diameter able to fit under the road was less than 1500mm due to minimal cover. This was dependant on the amount of flow passing through the specific culvert system;
- For smaller flows, multiple RCP's were adopted;
- Due to the absence of a DTM, where specific flow paths were unable to be identified using the available contour information and where multiple culvert systems servicing these flows were spaced apart (say 100m), these systems were treated as one investigation. Culvert ID 4 and 5 are an example of this approach (See Table 8.3).
- Main Street and Booral Road culverts were upgraded to achieve the standard of service of a major road for the 50 year ARI storm event.
- Woods Street culverts were upgraded to achieve the standard of service of a minor road for the 10 year ARI storm event.

8.2.1 Culvert Upgrade Assessment – Booral Road, Woods Road and Main Street

As discussed earlier, culverts with a diameter/height greater than 300mm have been assessed along Booral Road, Main Street and Woods Road. Assessment of the existing capacity of the culverts and the required capacity of the culverts has allowed for the required upgrade to be determined.

Many of the culvert crossings investigated were undersized for either the 10 or 50 year ARI design event, depending on the desired standard of service. As such, the required upgrade has been determined based on assumptions specified in Section 6. Table 8.3 provides a summary of the assessment. For culvert locations refer to Figure 7.

Table 8.3: Design Capacity Analysis for Culvert Assessment

Culvert ID (Map Reference)	Existing Culverts	Existing Capacity (m^3/s)	Required Capacity (m^3/s)	Upgrade Required	Proposed Additional Drainage Requirements
1	4 * 375 (RCP)	0.66	3.99	YES	4 * (1200 * 600) (RCBC)
2	4 * 375 (RCP)	0.66	9.44	YES	2 * (2100 * 1500) (RCBC) **or** 3 * 1650 (RCP)
3	4 * 375 (RCP)	0.66	3.93	YES	4 * 1200 (RCBC)
4-5	8 * 375 (RCP)	1.31	1.56	NO	-
	4 * 375 (RCP)	0.66			
6	1 * 600 (RCP)	0.42	1.35	YES	1 * (900 * 750) (RCBC) **or** 1 * 900 (RCP)
8	2 * 1200 (RCP)	3.39	3.3	NO	
9	4 * 450 (RCP)	0.95	56.22	YES	14 * (3000 * 900) (RCBC) **or** Bridge
11	1 * 600 (RCP)	0.42	14.88	YES	4 * (3600 * 900) (RCBC)
14	1 * 2100 (RCP)	3.78	3.51	NO	-
15	2 * 450 (RCP)	0.48	1.7	YES	1 * (1200 * 750) (RCBC)
17	2 * 450 (RCP)	0.48	1.14	YES	1 * (1200 * 450) (RCBC)
18	2 * 675 (RCP)	1.07	9.19	YES	2 * (2100 * 1500) (RCBC)
19 (a)	6 * 375 (RCP)	0.99	4.41	YES	1 * (2400 * 750) (RCBC)
19 (b)	4 * 450 (RCP)	0.95			
20	4 * 800 (RCP)	3.02	7.9	YES	3 * (1500 * 750) (RCBC)
21-23 (a)	2100 * 750 (RCBC)	4.73	49.47	YES	15 * (2700 * 750) (RCBC) **or** Bridge
21-23 (b)	3 * 450 (RCP)	0.72			
22	5 * 450 (RCP)	1.19	14.95	YES	17 * (1200 * 450) (RCBC) **or** Bridge
26-28 (a)	1 * 900 (RCP)	0.95	11.07	YES	9 * (1200 * 375) (RCBC)
26 -28 (b)	1 * 1200 (RCP)	1.7			
26- 28 (c)	2 * 1200 (RCP)	3.39			
29	1 * 900 (RCP)	0.95	4.41	YES	2 * (1500 * 900) (RCBC)
31	1 * 600 (RCP)	0.42	6.17	YES	2 * (1800 * 1200) (RCBC)
34	4 * 525 (RCP)	1.3	4.35	YES	1 * (1200 * 800) (RCBC)
35	4 * 2100 (RCP)	18.9	184	YES	21 * (3600 * 1500) (RCBC) **or** Bridge
39	5 * 1050 (RCP)	6.49	14.6	YES	
40	3 * 450 (RCP)	0.72	0.84	YES	1 * (450 * 225) (RCBC)
43	3 * 800 (RCP)	2.26	3.35	YES	1 * (1200 * 450) (RCBC)
44	3 * 1200 (RCP)	3.24	14.86	YES	4 * (2400 * 900) (RCBC) **or** 13 * 900 (RCP)
45	3 * 1200 (RCP)	2.43	1.81	NO	-
46-47 (a)	4 * 2400 (RCP)	34.56	161.69	YES	8 * (3000 * 3000) (RCBC) **or** 10 * 3000 (RCP) **or** Bridge
46- 47 (b)	3 * 3300 (RCP)	22.28			
49	4 * 600 (RCP)	1.7	1.81	YES	1 * (450 * 225) (RCBC) **or** 1 * 375 (RCP)
50	6 * 375 (RCP)	0.99	7.57	YES	2 * (2100 * 1200) (RCBC) **or** 4 * 1200 (RCP)
51	2 * 600 (RCP)	0.85	1.35	YES	1 * (750 * 600) (RCBC) **or** 1 * 675 (RCP)

N

Legend
- Culvert Location
- Cadastre

300 0 300 600 900
Metres
Scale: 1:30,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

FIGURE 7

CULVERT ASSESSMENT LOCALITY PLAN

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

John Wilson and Partners Pty. Ltd.
ABN 85 011 022 503
PO Box 585, Fortitude Valley QLD 4006
Ph. 32449600 Fax. 32449699

File Path : Z:\42-Wways\050302-001_Bunya_Creek_Flood_Risk\GIS\Workspaces

Projection Trans. Merc. MGA56(GDA 94)

9 Risk Treatment & Flood Mitigation

Treatment of flooding risks in each model as identified in Chapter 8 of this report has been investigated and is summarised below. Flood mitigation has been based on failure to meet risk standards as well as Council's design standards.

Specifically, flooding areas that were identified as high risk were mitigated by means of drainage augmentation or other forms of mitigation works with the aim of an overall reduction of the flooding risk. Where flow depths were identified as failing to meet Council design guidelines, mitigation options have been suggested to alleviate flooding depths and ensure compliance with Council design requirements. Proposed upgrade sketch plans are illustrated in Appendix E.

9.1 System 1 Model

The risk rankings for System 1 was generally low, however risk standards were not met for all System 1 locations. Therefore, it is recommended that mitigation works be undertaken at the following culvert crossing locations with the estimated augmentation costs outlined below:

- Grevillea St [#1] – Acceptable standards not met for DV Product < 0.4 and Q100 immunity, whilst the depth of flow over the road exceeded Council's design standard. Preliminary cost analysis estimate the total cost of upgrade to be $205,000.

- Grevillea St [#2] – Acceptable standard not met for Q100 immunity. Preliminary cost analysis estimate the total cost of upgrade to be $175,000.

- Denmans Camp Rd – Acceptable standard not met for Q100 immunity. Preliminary cost analysis estimate the total cost of upgrade to be $210,000.

- Boundary Rd – Acceptable standards not met for DV Product < 0.4 and the depth of flow over the road exceeded Council's design standard. Preliminary cost analysis estimate the total cost of upgrade to be $130,000.

Preliminary cost analysis undertaken for these upgrades includes 20% for provisional contingencies. Refer to Appendix F for cost breakdowns. Proposed upgrade sketch plans are illustrated in Appendix E.

9.2 System 2 Model

Risk rankings for System 2 was generally low, however high risk was identified at several properties along Doolong Road due to the Q100 immunity risk standard not being met. As discussed in Section 8.1.3, it was found that properties on Doolong Road would experience inundation as a result of flow for all design events overtopping the drainage channel. The depth of flow over the road also failed to meet Council's design requirements for trafficability.

It is therefore recommended that channel augmentation works be undertaken to ensure that surrounding properties are immune from flooding for the 100 year ARI event and that Doolong Road is trafficable for the 50 year ARI event. Preliminary cost analysis undertaken for this upgrade estimate the total cost of this upgrade to be $460,000, including 20% for provisional contingencies.

Whilst it was determined that the risk ranking for Doolong South Road was low, the depth of flow over the road during the 50 year ARI event exceeds Council's design requirement and therefore it is recommended that mitigation works be undertaken to ensure that the design standard is achieved. Due to the extent of flooding on Doolong South Road, JWP believes that raising approximately 430 meters of the road by up to 300mm would alleviate flooding of the road. Preliminary cost analysis undertaken for this upgrade estimate the total cost of this upgrade to be $690,000, including 20% for provisional contingencies. It is also recommended that Council provide adequate local drainage to reduce flood impacts upstream of the road. Refer to Appendix F for cost breakdowns. Proposed upgrade sketch plans are illustrated in Appendix E.

9.3 Risk Treatment Summary

Whilst the Bunya Creek catchment has definitive areas of flood risk, a vast majority of the flooding/inundation experienced throughout the catchment is largely nuisance flooding in various locations. As such, many of the augmentation upgrades are aimed at eliminating this localised flooding for the purposes of achieving Council design guideline requirements and minimising flood risk.

Table 9.1: Flood Risk Treatment Summary (Does not include upgrades suggested in order to meet HBCC design requirements)

Location	Risk	Acceptable standard	Current Risk Ranking	Mitigation works proposed	Mitigated Risk Ranking	Estimated cost
Model 3						
Grevillea St[#1] Crossing	Buildings	Q100 immunity	**High**	Drainage augmentation works. Upgrade culverts under Grevillea Street. (Appendix E-1)	**Low**	$205,000
	People – ease of egress	DV Product<0.4				
Grevillea St[#2] Crossing	Buildings	Q100 immunity	**High**	Drainage augmentation works. Upgrade culverts under Grevillea Street. (Appendix E-1)	**Low**	$175,000
	People – ease of egress	DV Product<0.4				
Denmans Camp Rd Crossing	Buildings	Q100 immunity	**High**	Drainage augmentation works. Upgrade culverts under Denmans Camp Road. (Appendix E-2)	**Low**	$210,000
Boundary Rd Crossing	People – ease of egress	DV Product<0.4	**Moderate**	Drainage augmentation works. Upgrade culverts under Boundary Road. (Appendix E-3)	**Low**	$130,000
Doolong Rd	Buildings	Q100 immunity	**High**	Upgrade drainage channel. (Appendix E-4)	**Low**	$460,000

10 Conclusions

This study has been successful in identifying and quantifying flooding risk and providing drainage augmentation options for the Bunya Creek catchment for the primary purposes of reducing existing flood risks. Specifically, the works completed have included: -

- The identification and assessment of existing drainage capacities, flow paths and flood information for the 10, 20, 50 and 100 year ARI design flood events;
- Preparation of detailed flood data outputs to fully document the outcomes from the analysis works including flood summary data, catchment flows and flood extent plans;
- Assessment of flood risk and the preparation of flood risk summaries;
- Identification of potential mitigation options for the catchment;
- Formal hydrological and hydraulic assessment of the agreed drainage augmentation options for the catchment including the preparation of detailed outputs to fully document the outcomes from the mitigation works;
- Identification of a preferred augmentation options for the catchment which has be shown to provide a beneficial outcome for the study in terms of lowering flood levels, reducing flood inundation and consequently flood risk;
- Preparation of preliminary establishment cost estimates for the preferred work options;
- Culvert upgrade assessment for culverts larger than 300mm diameter along Booral Road, Woods Road and Main Street;
- Preparation of summary tables, models, flood extents, GIS mapping and reporting outputs to formally document the outcomes of the study; and
- Preparation of a report congruous with Hervey Bay City Council Disaster Mitigation Plan.

JWP recommends that Council utilises the outcomes from this Flood Risk Assessment Study for the Bunya Creek catchment in the management of existing and future stakeholders within the catchment in terms of reducing flood risk to an acceptable and manageable standard. In addition, it is also recommended that further works be instigated to proceed with the detailed design of the preferred mitigation works such that flood risks throughout the catchments can be significantly reduced. This would also include programming these works and securing future allocations under Council's Capital Works Program or alternatively through other funding arrangements.

11 References

1. The Queensland Urban Drainage Manual (QUDM);
2. Australian Rainfall and Runoff (AR&R - 2001 edition);
3. James Cook University – Storm Surge Water Level Return Period website

12 Qualification

1. In preparing the report and estimate of costs JWP has exercised the degree of skill and care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering design principles.

2. JWP has used all reasonable endeavours to inform itself of the parameters and requirements of the project and has taken all reasonable steps to ensure that the report and costs estimate is as accurate and comprehensive as possible given the information upon which it is based.

3. It is not intended that this report and costs estimate represent a final assessment of the feasibility of the project.

4. JWP reserves the right to review and amend all calculations, cost estimates and/or opinions included or referred to in the report if:

   (a) additional sources of information not presently available (for whatever reason) are provided or become known to JWP; or

   (b) JWP considers it prudent to revise the estimate in light of any information which becomes known to it after the date of submission.

5. JWP does not give any warranty nor accept any liability in relation to the completeness or accuracy of the report and cost estimate.

6. If any warranty would be implied whether by law, custom or otherwise, that warranty is to the full extent permitted by law excluded.

7. All limitations of liability shall apply for the benefit of the employees, agents and representatives of JWP to the same extent that they apply for the benefit of JWP.

8. This report and cost estimate is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this report and cost estimate.

9. If any claim or demand is made by any person against JWP on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the report and cost estimate or information therein, JWP will rely upon this provision as a defence to any such claim or demand.

APPENDIX A

Rainfall IFD Table

HERVEY BAY IFD

	LOCATION - Hervey Bay, QLD							
	Duration	1 Year ARI	2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI
Duration	(mins)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)
(mins, hrs)	Minutes	1	2	5	10	20	50	100
5 min	5	115	148	186	209	239	280	311
5.5 min	5.5	112	143	180	202	232	270	300
6 min	6	108	139	175	196	224	262	291
6.5 min	6.5	105	135	170	190	218	254	282
7 min	7	102	131	165	185	212	247	275
7.5 min	7.5	100	128	161	180	206	241	267
8 min	8	97	125	157	176	201	235	261
8.5 min	8.5	95	122	153	171	196	229	254
9 min	9	93	119	150	168	192	224	248
9.5 min	9.5	91	116	146	164	188	219	243
10 min	10	89	114	143	160	184	214	238
11 min	11	85	109	138	154	176	206	228
12 min	12	82	105	132	148	170	198	220
13 min	13	80	102	128	143	164	191	212
14 min	14	77	98	124	138	158	185	205
15 min	15	75	95	120	134	153	179	198
16 min	16	72	93	116	130	149	174	193
17 min	17	70	90	113	126	145	169	187
18 min	18	69	88	110	123	141	164	182
19 min	19	67	85	107	120	137	160	177
20 min	20	65	83	105	117	134	156	173
21 min	21	64	81	102	114	131	152	169
22 min	22	62	80	100	112	128	149	165
23 min	23	61	78	98	109	125	145	161
24 min	24	60	76	95	107	122	142	158
25 min	25	58	75	94	105	120	139	154
26 min	26	57	73	92	102	117	136	151
27 min	27	56	72	90	100	115	134	148
28 min	28	55	70	88	99	113	131	145
29 min	29	54	69	87	97	111	129	143
30 min	30	53	68	85	95	109	127	140
32 min	32	51	66	82	92	105	122	135
34 min	34	49.8	64	80	89	102	118	131
36 min	36	48.3	62	77	86	99	115	127
38 min	38	46.9	60	75	84	96	111	123
40 min	40	45.6	58	73	81	93	108	120
45 min	45	42.8	55	68	76	87	101	112
50 min	50	40.4	52	64	72	82	96	106
55 min	55	38.3	48.9	61	68	78	90	100
1 hrs	60	36.5	46.5	58	65	74	86	95
1.25 hrs	75	31.7	40.5	51	57	65	75	83
1.5 hrs	90	28.2	36	45.2	51	58	67	75
1.75 hrs	105	25.5	32.6	41	45.9	53	61	68
2 hrs	120	23.4	29.9	37.7	42.2	48.3	56	63
2.25 hrs	135	21.6	27.7	34.9	39.1	44.9	52	58
2.5 hrs	150	20.2	25.9	32.7	36.6	42	49	54
2.75 hrs	165	19	24.3	30.7	34.5	39.5	46.2	51
3 hrs	180	17.9	23	29	32.6	37.4	43.8	48.6
3.25 hrs	195	17	21.8	27.6	31	35.6	41.6	46.3
3.5 hrs	210	16.2	20.8	26.3	29.5	33.9	39.7	44.2

APPENDIX B

Catchment Land Use Summary

System 1 Model

Client: HBCC
Job: Bunya Creek
User: MP
Printed On: 2006/10/10

Sub Catchment ID	Area (ha)	Emerging Communities	Low Density Residential	Open Space	Park Residential	Rural Land	Rural Residential	Special Purpose	Roads
1A	7.1		100.0%						
1B	17.5		76.3%	3.5%					20.2%
1C	9.7		69.5%	13.6%					16.9%
1D	22.0		56.1%	8.8%				15.4%	19.7%
1E	4.4		51.0%	13.0%				14.3%	21.8%
1F	15.4		69.6%		0.2%				30.3%
1G	9.9		36.2%		39.2%				24.6%
1H	8.5		43.4%	5.5%	5.1%			17.6%	28.4%
1I	22.9		53.7%	1.7%	5.0%			17.9%	21.7%
1J	14.6		68.2%						31.8%
1K	24.3		67.3%	6.3%				0.7%	25.7%
1L	49.5		36.5%	11.5%	30.0%				22.0%
1N	13.6		54.3%	28.9%					16.8%
1Na	15.6		44.6%	29.8%					25.5%
1O	28.3			57.1%	27.4%				15.5%
1P	15.7		26.1%	4.0%	49.8%				20.1%
1Q	27.3			31.6%	60.8%				7.6%
1R	38.4			14.5%	68.8%		2.3%		14.4%
1S	46.5	4.2%		12.6%	47.4%		25.3%	2.0%	8.5%
1T	113.6	0.5%		25.1%	40.9%		5.0%	14.8%	13.7%
1U	92.2	25.9%		3.4%	25.0%	13.5%	1.5%	25.4%	5.3%
1V	57.9	6.6%				36.7%		50.8%	5.9%
1W	52.7							100.0%	
1X	88.7							93.2%	6.8%

System 2 Model

Client: HBCC
Job: Bunya Creek
User: MP
Printed On: 2006/10/10

Sub Catchment ID	Area (ha)	Emerging Communities	Low Density Residential	Multizone	Open Space	Park Residential	Special Purpose	Roads
2A	27.1	74.5%	16.9%				0.8%	7.9%
2B	5.1	88.7%	8.9%					2.4%
2C	17.3	30.9%	46.0%	1.7%				21.4%
2D	14.7	12.2%	19.2%	58.3%				10.3%
2E	11.6	15.8%	24.4%			22.5%	20.9%	16.4%
2F	5.2	100.0%						
2G	17.8			93.7%				6.3%
2H	19.6	37.6%		55.5%				6.9%
2I	15.5	81.3%		16.1%				2.7%
2J	20.8	89.3%		7.7%				3.1%
2K	8.9	99.7%						0.3%
2L	14.0	45.0%					55.0%	
2M	2.5	19.0%				28.3%	23.5%	29.2%
2N	21.1	8.7%				69.4%		21.8%
2O	4.9	100.0%						
2Oa	8.3	97.0%					3.0%	
2P	14.5	37.7%				48.5%		13.8%
2Pa	7.4	100.0%						
2Q	17.2	73.1%				13.5%	5.7%	7.8%
2R	20.4	87.6%					7.2%	5.2%
2U	27.3	98.2%						1.8%
2V	168.2	49.2%		5.8%			44.1%	0.9%
3a	23.1	69.9%				14.6%	10.9%	4.6%
3b	38.0	22.7%		67.6%			2.4%	7.3%
3c	28.1	27.2%					71.9%	0.9%
3d	13.6	57.5%			9.3%	25.7%	1.2%	6.3%
3e	46.9	79.7%		15.7%				4.6%
3f	13.6	99.9%						
3g	15.3	56.6%			8.5%	29.6%		5.3%
3h	50.0	72.4%	11.0%	2.4%	3.7%		2.6%	7.9%
3i	52.8	25.8%				9.2%	57.2%	7.8%

APPENDIX C

Existing Scenario Model Results

Model: System 1 - Existing Scenario
Client: HBCC
User: MP
Date: 2007/01/25

		10 yr ARI Storm Event		20 yr ARI Storm Event		50 yr ARI Storm Event		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)
N1	28.47	28.88	0.406	28.909	0.435	28.934	0.460	28.973	0.499
N2	28.46	28.731	0.275	28.758	0.302	28.796	0.340	28.867	0.411
N3	27.99	28.519	0.525	28.543	0.549	28.558	0.564	28.575	0.581
N4	27.96	28.299	0.337	28.318	0.356	28.332	0.370	28.345	0.383
N5	28.00	28.205	0.203	28.22	0.218	28.231	0.229	28.241	0.239
N6	26.47	26.614	0.142	26.625	0.153	26.633	0.161	26.641	0.169
N7	25.59	26.109	0.519	26.184	0.594	26.245	0.655	26.308	0.718
N8	25.45	25.975	0.522	26.027	0.574	26.065	0.612	26.104	0.651
N9	25.49	25.811	0.324	25.857	0.370	25.891	0.404	25.924	0.437
N10	25.00	25.781	0.782	25.832	0.834	25.87	0.872	25.906	0.907
N11	24.99	25.511	0.523	25.544	0.556	25.569	0.581	25.591	0.603
N12	24.47	25.227	0.759	25.256	0.788	25.28	0.812	25.298	0.830
N13	24.50	24.807	0.311	24.843	0.347	24.873	0.377	24.901	0.405
N14	23.95	24.721	0.772	24.772	0.823	24.812	0.863	24.853	0.904
N15	23.95	24.446	0.492	24.484	0.530	24.517	0.563	24.549	0.595
N16	23.46	24.08	0.624	24.131	0.675	24.179	0.723	24.216	0.760
N17	23.50	23.93	0.428	23.995	0.493	24.044	0.542	24.076	0.574
N18	23.00	23.668	0.668	23.81	0.810	23.922	0.922	24.005	1.006
N19	22.97	23.611	0.639	23.775	0.803	23.89	0.918	23.958	0.986
N20	22.55	23.654	1.101	23.804	1.251	23.909	1.356	23.976	1.423
N21	22.49	23.64	1.148	23.788	1.296	23.881	1.389	23.941	1.449
N22	22.00	23.153	1.158	23.223	1.228	23.283	1.288	23.337	1.342
N23	22.00	23.119	1.116	23.185	1.182	23.24	1.237	23.29	1.287
N24	22.00	23.093	1.094	23.153	1.154	23.204	1.205	23.248	1.249
N25	21.94	23.09	1.152	23.148	1.210	23.198	1.260	23.241	1.303
N26	21.63	23.039	1.409	23.08	1.450	23.12	1.490	23.156	1.526
N27	21.96	23.064	1.104	23.115	1.155	23.16	1.200	23.198	1.238
N29	21.45	23.026	1.573	23.062	1.609	23.097	1.644	23.125	1.672
N30	21.49	23.017	1.524	23.049	1.556	23.079	1.586	23.105	1.612
N31	21.50	22.455	0.951	22.538	1.034	22.641	1.137	22.723	1.219
N32	21.45	22.346	0.891	22.421	0.966	22.512	1.057	22.579	1.124
N33	21.45	21.989	0.538	22.071	0.620	22.198	0.747	22.253	0.802
N34	21.02	22.002	0.982	22.1	1.080	22.237	1.217	22.289	1.269
N35	21.00	21.948	0.952	22.05	1.054	22.195	1.199	22.244	1.248
N36	24.00	24.474	0.476	24.505	0.507	24.531	0.533	24.56	0.562
N37	23.99	24.347	0.357	24.38	0.390	24.411	0.421	24.446	0.456
N38	23.07	23.909	0.836	23.942	0.869	23.971	0.898	24.001	0.928
N39	22.97	23.429	0.454	23.458	0.483	23.481	0.506	23.502	0.527
N40	22.49	23.302	0.816	23.354	0.868	23.345	0.859	23.372	0.886
N41	22.44	23.172	0.733	23.22	0.781	23.198	0.759	23.202	0.764
N42	21.96	23.073	1.116	23.116	1.159	23.133	1.176	23.152	1.195
N43	21.98	23.137	1.153	23.191	1.207	23.205	1.221	23.229	1.245
N44	21.49	22.511	1.025	22.627	1.141	22.671	1.185	22.722	1.236
N45	21.45	22.478	1.025	22.587	1.134	22.622	1.169	22.668	1.215
N46	21.45	22.328	0.875	22.394	0.941	22.445	0.992	22.489	1.036
N47	21.43	22.108	0.674	22.209	0.775	22.296	0.862	22.355	0.921
N49	20.94	21.835	0.891	21.912	0.968	22.059	1.115	22.102	1.158
N50	20.92	21.603	0.685	21.672	0.754	21.729	0.811	21.789	0.871
N51	20.44	21.578	1.143	21.65	1.215	21.706	1.271	21.768	1.333
N52	20.41	21.121	0.714	21.181	0.774	21.22	0.813	21.264	0.857
N53	19.93	20.961	1.028	21.036	1.103	21.08	1.147	21.127	1.194
N54	19.92	20.638	0.717	20.689	0.768	20.735	0.814	20.861	0.940
N55	19.47	20.597	1.132	20.646	1.181	20.693	1.228	20.805	1.340
N57	18.54	20.166	1.628	20.279	1.741	20.35	1.812	20.393	1.855
N59	18.03	20.151	2.122	20.284	2.255	20.376	2.347	20.429	2.400
N60	18.01	20.084	2.076	20.237	2.229	20.331	2.323	20.387	2.379

		10 yr ARI Storm Event		20 yr ARI Storm Event		50 yr ARI Storm Event		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)
N61	17.99	19.293	1.305	19.365	1.377	19.406	1.418	19.449	1.461
N62	17.89	19.23	1.342	19.271	1.383	19.3	1.412	19.342	1.454
N63	17.47	19.221	1.749	19.282	1.810	19.362	1.890	19.425	1.953
N64	17.47	19.177	1.702	19.237	1.762	19.315	1.840	19.378	1.903
N65	17.30	18.986	1.688	19.055	1.757	19.152	1.854	19.236	1.938
N66	17.46	19.061	1.597	19.122	1.658	19.207	1.743	19.28	1.816
N67	17.26	18.795	1.538	18.873	1.616	18.977	1.720	19.065	1.808
N68	17.01	18.284	1.275	18.374	1.365	18.477	1.468	18.589	1.580
N69	16.98	18.154	1.175	18.21	1.231	18.271	1.292	18.314	1.335
N71	16.50	18.083	1.584	18.14	1.641	18.199	1.700	18.239	1.740
N72	16.48	17.929	1.449	17.98	1.500	18.045	1.565	18.091	1.611
N73	16.44	17.803	1.360	17.858	1.415	17.923	1.480	17.965	1.522
N74	16.48	17.845	1.367	17.898	1.420	17.961	1.483	18.006	1.528
N75	15.97	17.364	1.392	17.425	1.453	17.497	1.525	17.543	1.571
N76	15.97	17.583	1.611	17.64	1.668	17.708	1.736	17.751	1.779
N77	15.96	16.866	0.905	16.906	0.945	16.954	0.993	16.984	1.023
N79	16.49	16.704	0.212	16.723	0.231	16.74	0.248	16.759	0.267
N80	16.02	16.697	0.676	16.716	0.695	16.735	0.714	16.754	0.733
N81	15.98	16.55	0.570	16.582	0.602	16.628	0.648	16.655	0.675
N82	15.94	16.528	0.590	16.561	0.623	16.607	0.669	16.638	0.700
N84	15.86	16.312	0.455	16.346	0.489	16.395	0.538	16.43	0.573
N91	19.98	20.23	0.254	20.307	0.331	20.373	0.397	20.411	0.435
N92	20.00	20.279	0.279	20.321	0.321	20.383	0.383	20.424	0.424
N122	19.44	20.213	0.776	20.32	0.883	20.391	0.954	20.57	1.133
N156	14.50	14.977	0.478	15.014	0.515	15.056	0.557	15.089	0.590
N157	13.00	13.65	0.650	13.698	0.698	13.757	0.757	13.802	0.802
N158	10.53	11.462	0.930	11.513	0.981	11.57	1.038	11.62	1.088
N159	9.00	10.447	1.450	10.594	1.597	10.758	1.761	10.886	1.889
N175	15.96	17.762	1.805	17.822	1.865	17.891	1.934	17.935	1.978
N176	20.49	20.821	0.331	20.844	0.354	20.867	0.377	20.888	0.398
N177	21.00	21.235	0.236	21.253	0.254	21.266	0.267	21.278	0.279
N178	21.40	21.559	0.163	21.569	0.173	21.577	0.181	21.585	0.189
N179	21.81	22.065	0.255	22.081	0.270	22.094	0.284	22.107	0.296
N180	22.85	22.937	0.085	22.942	0.090	22.946	0.094	22.95	0.098
N181	16.95	17.195	0.243	17.211	0.259	17.221	0.269	17.234	0.282
N182	17.00	17.349	0.349	17.373	0.373	17.393	0.393	17.414	0.414
N183	15.49	16.02	0.535	16.049	0.564	16.084	0.599	16.11	0.625
N184	15.05	15.348	0.302	15.374	0.328	15.406	0.360	15.431	0.385
N185	14.00	14.631	0.628	14.669	0.666	14.711	0.708	14.744	0.741
N186	13.50	14.132	0.632	14.172	0.672	14.219	0.719	14.256	0.756
N187	12.50	13.147	0.646	13.194	0.693	13.248	0.747	13.289	0.788
N188	11.50	12.055	0.556	12.103	0.604	12.161	0.662	12.206	0.707
N189	10.14	10.931	0.792	11.009	0.870	11.101	0.962	11.189	1.050
N190	10.00	10.705	0.705	10.815	0.815	10.946	0.946	11.056	1.056
N191	9.67	10.597	0.924	10.73	1.057	10.88	1.207	11	1.327
N192	9.09	10.504	1.413	10.648	1.557	10.809	1.718	10.935	1.844
N193	9.01	10.437	1.428	10.584	1.575	10.749	1.740	10.876	1.867
N91a	19.44	20.23	0.790	20.307	0.867	20.373	0.933	20.41	0.970

Model: **System 2 - Existing Scenario**
Client: HBCC
User: MP
Date: 2007/01/25

		10 yr ARI Storm Event		20 yr ARI Storm Event		50 yr ARI Storm Event		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)
N95	19.98	20.711	0.69	20.737	0.75	20.766	0.78	20.786	0.80
N96	19.99	20.668	0.64	20.694	0.70	20.722	0.73	20.742	0.75
N98	25.96	26.406	0.36	26.453	0.50	26.51	0.55	26.563	0.61
N99	25.94	26.35	0.27	26.431	0.49	26.489	0.55	26.547	0.60
N100	25.44	26.334	0.74	26.425	0.98	26.485	1.04	26.544	1.10
N101	25.10	25.6	0.40	25.64	0.54	25.745	0.65	25.761	0.66
N102	24.96	25.514	0.49	25.546	0.59	25.57	0.61	25.607	0.65
N103	24.46	25.421	0.92	25.448	0.99	25.472	1.01	25.502	1.04
N104	24.44	25.003	0.56	25.046	0.60	25.092	0.65	25.145	0.70
N105	23.95	24.645	0.70	24.675	0.73	24.689	0.74	24.744	0.80
N106	23.45	24.457	1.01	24.538	1.09	24.572	1.12	24.6	1.15
N107	23.97	24.516	0.55	24.585	0.62	24.599	0.63	24.698	0.73
N108	23.48	24.303	0.82	24.41	0.93	24.433	0.95	24.445	0.97
N109	23.35	23.735	0.38	23.778	0.43	23.814	0.46	23.845	0.49
N110	22.97	23.531	0.56	23.578	0.61	23.608	0.64	23.633	0.66
N111	22.98	23.587	0.61	23.635	0.66	23.67	0.69	23.699	0.72
N112	22.73	23.038	0.31	23.076	0.34	23.111	0.38	23.145	0.41
N113	22.00	22.884	0.89	22.921	0.92	22.957	0.96	22.991	0.99
N114	21.97	22.195	0.22	22.251	0.28	22.283	0.31	22.312	0.34
N115	21.49	22.172	0.68	22.239	0.75	22.27	0.78	22.297	0.81
N116	21.47	22.188	0.72	22.226	0.76	22.255	0.79	22.28	0.81
N117	21.78	21.702	-0.08	21.729	-0.05	21.738	-0.04	21.744	-0.04
N118	21.03	21.367	0.34	21.473	0.45	21.488	0.46	21.5	0.47
N119	20.96	21.137	0.18	21.155	0.20	21.173	0.22	21.188	0.23
N120	20.95	21.122	0.17	21.143	0.19	21.162	0.21	21.178	0.22
N121	20.46	20.93	0.47	20.944	0.48	20.959	0.50	20.973	0.51
N123	31.78	31.985	0.20	32.003	0.22	32.01	0.23	32.018	0.24
N126	31.09	31.379	0.29	31.4	0.31	31.415	0.33	31.426	0.34
N129	29.43	29.782	0.35	29.803	0.38	29.82	0.39	29.837	0.41
N130	34.72	35.113	0.39	35.134	0.41	35.15	0.43	35.168	0.45
N131	31.46	31.739	0.28	31.756	0.30	31.769	0.31	31.783	0.33
N134	26.10	26.952	0.85	26.979	0.88	27.001	0.90	27.02	0.92
N135	23.68	24.532	0.85	24.581	0.90	24.692	1.01	24.815	1.14
N136	23.07	23.425	0.35	23.452	0.38	23.472	0.40	23.493	0.42
N137	21.69	21.997	0.31	22.029	0.34	22.049	0.36	22.067	0.38
N138	19.68	20.218	0.54	20.231	0.55	20.248	0.57	20.26	0.58
N140	19.64	20.118	0.48	20.147	0.51	20.192	0.55	20.232	0.59
N142_Do	18.61	19.334	0.72	19.375	0.77	19.411	0.80	19.445	0.84
N144	19.97	20.673	0.70	20.699	0.73	20.728	0.76	20.748	0.78
N145	34.33	34.682	0.35	34.696	0.36	34.706	0.38	34.717	0.39
N146	31.35	31.839	0.49	31.859	0.51	31.874	0.53	31.89	0.54
N147	29.11	29.386	0.27	29.408	0.30	29.425	0.31	29.441	0.33
N148	28.08	28.661	0.58	28.688	0.61	28.712	0.63	28.733	0.65
N149	26.04	26.354	0.31	26.38	0.34	26.403	0.36	26.423	0.38
N150	24.06	24.403	0.34	24.426	0.36	24.446	0.38	24.459	0.40
N151	29.02	29.495	0.47	29.523	0.50	29.545	0.52	29.569	0.55

		10 yr ARI Storm Event		20 yr ARI Storm Event		50 yr ARI Storm Event		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)
N152	25.79	26.208	0.42	26.224	0.44	26.239	0.45	26.253	0.47
N153	24.49	24.835	0.34	24.849	0.36	24.86	0.37	24.871	0.38
N154	22.29	22.75	0.46	22.771	0.48	22.79	0.50	22.809	0.52
N155	20.59	21.256	0.67	21.273	0.69	21.292	0.70	21.309	0.72
N162	18.62	19.668	1.05	19.698	1.08	19.73	1.11	19.757	1.14
N163	18.29	19.002	0.71	19.032	0.74	19.063	0.77	19.089	0.80
N164	17.35	17.932	0.59	17.957	0.61	17.986	0.64	18.01	0.66
N165	15.45	17.16	1.71	17.228	1.78	17.299	1.85	17.363	1.91
N166	22.89	23.163	0.27	23.182	0.29	23.195	0.31	23.209	0.32
N167	19.99	20.201	0.21	20.218	0.23	20.233	0.25	20.247	0.26
N168	17.02	17.799	0.78	17.835	0.82	17.872	0.86	17.911	0.90
N169	15.95	16.657	0.70	16.759	0.81	16.867	0.91	16.966	1.01
N170	15.27	16.421	1.15	16.51	1.24	16.6	1.33	16.67	1.40
N171	13.81	14.902	1.09	15.012	1.20	15.124	1.31	15.209	1.40
N172	12.49	13.115	0.62	13.189	0.70	13.272	0.78	13.33	0.84
N173	11.01	11.973	0.97	12.08	1.07	12.202	1.20	12.281	1.28
N416	18.01	18.386	0.37	18.433	0.42	18.477	0.46	18.516	0.50
N194	28.39	29.213	0.83	29.242	0.85	29.266	0.88	29.288	0.90
N195	27.15	27.788	0.64	27.813	0.67	27.834	0.69	27.852	0.71
N196	24.98	26.188	1.21	26.224	1.24	26.261	1.28	26.301	1.32
N197	22.57	22.908	0.34	22.936	0.37	22.956	0.39	22.976	0.41
N198	22.17	22.562	0.39	22.594	0.42	22.616	0.44	22.639	0.47
N199	22.01	22.368	0.36	22.4	0.39	22.421	0.41	22.444	0.44
N200	20.22	20.969	0.75	21.005	0.79	21.038	0.82	21.066	0.85
N201	11.30	12.264	0.96	12.372	1.07	12.493	1.19	12.573	1.27
N202	11.67	12.506	0.84	12.609	0.94	12.724	1.06	12.804	1.14
N203	13.50	14.413	0.91	14.502	1.00	14.592	1.09	14.658	1.16
N204	14.49	15.434	0.94	15.535	1.04	15.641	1.15	15.729	1.24
N206_Do	18.42	19.117	0.70	19.156	0.74	19.191	0.77	19.224	0.81
N207	26.85	27.215	0.36	27.243	0.39	27.265	0.41	27.288	0.43
N174	18.02	18.966	0.95	18.989	0.97	19.01	0.99	19.03	1.01
n3	20.41	21.034	0.63	21.057	0.65	21.076	0.67	21.095	0.69
n4	19.84	20.548	0.71	20.561	0.72	20.577	0.74	20.605	0.77
n5	18.96	19.623	0.66	19.656	0.70	19.702	0.74	19.769	0.81
n6	17.51	17.975	0.46	18.008	0.49	18.035	0.52	18.054	0.54
n7	15.92	16.638	0.72	16.739	0.82	16.846	0.93	16.946	1.03
TN1	17.18	18.056	0.88	18.094	0.91	18.13	0.95	18.164	0.98
TN2	16.16	17.289	1.13	17.359	1.20	17.423	1.26	17.484	1.33
TN3	15.45	16.832	1.38	16.917	1.46	17.008	1.55	17.095	1.64
N104a	23.99	24.833	0.84	24.872	0.88	24.901	0.91	24.946	0.96
N113a	21.97	22.447	0.48	22.479	0.51	22.508	0.54	22.534	0.56
n8	18.26	18.788	0.53	18.821	0.56	18.842	0.58	18.859	0.60
n9	17.01	17.558	0.54	17.582	0.57	17.603	0.59	17.617	0.60
n10	16.27	16.928	0.66	16.966	0.70	17.003	0.73	17.038	0.77
n11	19.53	20.053	0.53	20.088	0.56	20.108	0.58	20.133	0.61
n12	17.68	18.057	0.37	18.079	0.40	18.101	0.42	18.121	0.44
n13	16.64	17.057	0.41	17.088	0.44	17.118	0.47	17.144	0.50
n14	15.55	15.914	0.37	15.939	0.39	15.962	0.42	16.022	0.48
n15	16.11	16.411	0.30	16.433	0.32	16.453	0.34	16.471	0.36
n16	14.51	14.817	0.31	14.841	0.33	14.862	0.36	14.883	0.38
n19	19.47	20.262	0.79	20.315	0.85	20.349	0.88	20.385	0.92
n20	18.76	19.13	0.37	19.152	0.39	19.167	0.40	19.179	0.42

		10 yr ARI Storm Event		20 yr ARI Storm Event		50 yr ARI Storm Event		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)
n21	18.22	18.632	0.41	18.654	0.43	18.669	0.45	18.681	0.46
n22	17.99	18.378	0.38	18.399	0.41	18.416	0.42	18.429	0.44
n23	18.99	19.368	0.37	19.393	0.40	19.415	0.42	19.439	0.45
n25	17.51	17.929	0.42	17.963	0.46	17.991	0.48	18.016	0.51
N137a	21.03	21.515	0.49	21.568	0.54	21.603	0.57	21.635	0.61
N137b	21.07	21.371	0.30	21.431	0.36	21.46	0.39	21.484	0.41
N137rd	20.81	21.396	0.59	21.435	0.62	21.466	0.66	21.493	0.68
N137c	20.81	21.383	0.57	21.421	0.61	21.451	0.64	21.477	0.67
N137d	20.95	21.371	0.42	21.408	0.46	21.436	0.49	21.462	0.51
N135a	23.55	24.12	0.57	24.148	0.60	24.166	0.62	24.185	0.64
N200a	20.76	21.032	0.27	21.063	0.30	21.092	0.33	21.118	0.35
N200b	19.92	20.498	0.57	20.521	0.60	20.542	0.62	20.56	0.64
N100a	25.49	26.319	0.83	26.424	0.94	26.486	1.00	26.547	1.06
N101rd	26.42	26.42	0.00	26.424	0.00	26.486	0.07	26.547	0.13
N120a	20.90	21.122	0.23	21.143	0.25	21.162	0.27	21.178	0.28
N121a	20.45	20.8	0.35	20.826	0.37	20.852	0.40	20.872	0.42
N96a	19.69	20.343	0.65	20.36	0.67	20.378	0.68	20.391	0.70
N200c	19.97	20.267	0.30	20.291	0.32	20.317	0.35	20.343	0.37
N200d	19.61	20.051	0.45	20.1	0.49	20.165	0.56	20.219	0.61
N41a	18.79	19.409	0.62	19.453	0.66	19.493	0.70	19.529	0.74
N166a	22.13	22.32	0.19	22.334	0.20	22.341	0.21	22.35	0.22
N166b	21.12	21.326	0.21	21.338	0.22	21.349	0.23	21.36	0.24
N167a	18.66	18.758	0.10	18.765	0.10	18.771	0.11	18.777	0.12
N416a	17.67	18.327	0.66	18.372	0.70	18.417	0.75	18.456	0.79
N146a	30.41	30.76	0.35	30.783	0.37	30.801	0.39	30.819	0.41
N148a	27.22	27.495	0.28	27.516	0.30	27.528	0.31	27.544	0.32
N149a	25.65	25.864	0.22	25.883	0.24	25.9	0.25	25.915	0.27
N150a	22.33	22.571	0.24	22.587	0.26	22.6	0.27	22.614	0.28
N150b	21.11	21.353	0.25	21.377	0.27	21.401	0.29	21.426	0.32
N151a	26.51	27.047	0.53	27.074	0.56	27.096	0.58	27.118	0.60
N152a	25.44	25.82	0.38	25.835	0.40	25.848	0.41	25.86	0.42
N152b	24.90	25.327	0.43	25.34	0.44	25.35	0.45	25.361	0.46
N151b	26.09	26.403	0.31	26.431	0.34	26.454	0.36	26.475	0.38
N153a	23.51	24.124	0.61	24.151	0.64	24.174	0.66	24.194	0.68
N154a	23.72	24.132	0.41	24.161	0.44	24.183	0.46	24.204	0.48
N155b	20.99	21.266	0.28	21.285	0.30	21.304	0.32	21.321	0.33
N155d	20.28	20.586	0.31	20.61	0.33	20.636	0.36	20.654	0.38
N162a	18.88	20.102	1.22	20.115	1.23	20.129	1.25	20.143	1.26
N155a	20.09	21.28	1.19	21.302	1.21	21.326	1.23	21.348	1.26
N153b	23.27	24.134	0.87	24.163	0.90	24.185	0.92	24.207	0.94
N155c	19.84	20.601	0.76	20.628	0.78	20.657	0.81	20.678	0.83
N163a	17.66	18.495	0.83	18.519	0.85	18.545	0.88	18.567	0.90
N165a	15.79	17.098	1.31	17.162	1.37	17.231	1.44	17.294	1.51
n19a	19.62	19.928	0.30	19.954	0.33	19.972	0.35	19.987	0.36
N169a	15.12	16.638	1.52	16.739	1.62	16.846	1.73	16.945	1.83
N169b	14.89	16.518	1.63	16.616	1.73	16.722	1.84	16.823	1.94
N170a	15.30	16.259	0.96	16.34	1.04	16.428	1.13	16.497	1.20
n25a	17.00	17.316	0.32	17.338	0.34	17.357	0.36	17.375	0.38
N203a	13.30	14.037	0.74	14.101	0.80	14.166	0.87	14.213	0.91
N170c	14.44	15.711	1.27	15.807	1.36	15.914	1.47	16.001	1.56
N204a	14.60	15.635	1.03	15.738	1.13	15.851	1.25	15.94	1.34
N170b	14.96	15.786	0.82	15.882	0.92	15.99	1.03	16.075	1.11

		10 yr ARI Storm Event		20 yr ARI Storm Event		50 yr ARI Storm Event		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)
N165b	15.59	16.927	1.34	17	1.41	17.078	1.49	17.152	1.56
N146b	17.79	18.376	0.59	18.422	0.63	18.465	0.67	18.502	0.71
N141	19.49	19.807	0.32	19.824	0.33	19.844	0.35	19.866	0.37
N200e	19.52	19.865	0.34	19.891	0.37	19.916	0.40	19.936	0.42
N96b	19.35	19.691	0.34	19.725	0.37	19.757	0.41	20.782	1.43
N96d	18.99	19.454	0.47	19.497	0.51	19.535	0.55	19.571	0.58
N96c	19.02	19.482	0.46	19.521	0.50	19.558	0.54	19.592	0.57

N

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

200 0 200 400 600

Metres

Scale: 1:20,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C

EXISTING MODEL INUNDATION EXTENT- KEY SHEET

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

John Wilson and Partners Pty. Ltd.
ABN 85 011 022 503
PO Box 585, Fortitude Valley QLD 4006
Ph. 32449600 Fax. 32449699

File Path: Z:\142-Wways\050302-001 Bunya Creek Flood Risk\GIS\MapInfo\Figures

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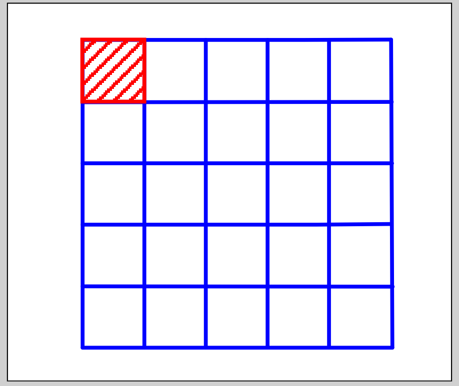

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK FLOOD RISK REDUCTION STUDY

APPENDIX C-1

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

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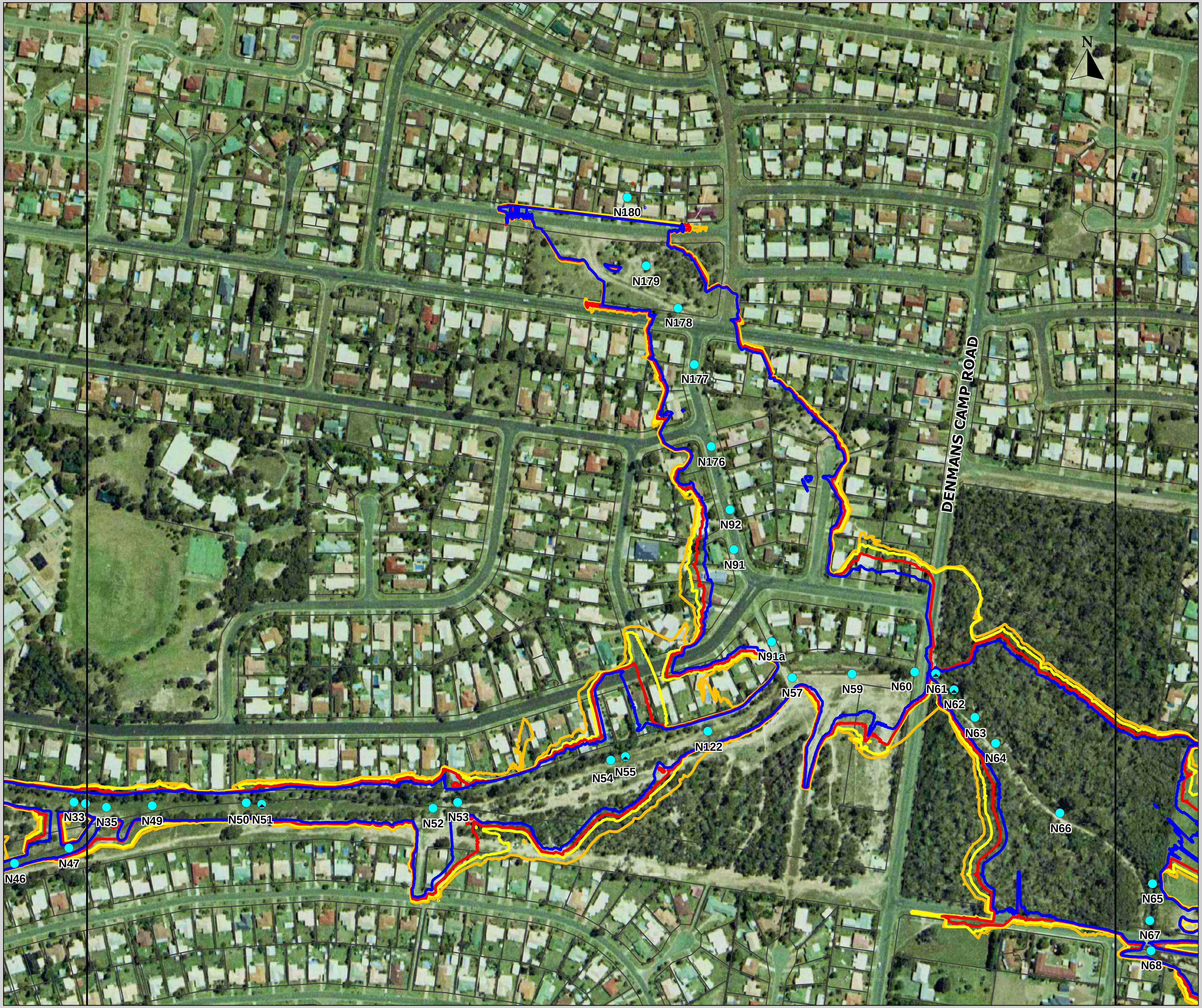

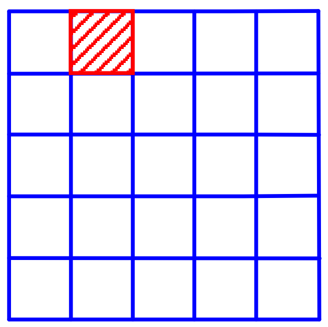

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-2

EXISTING MODEL INUNDATION EXTENT

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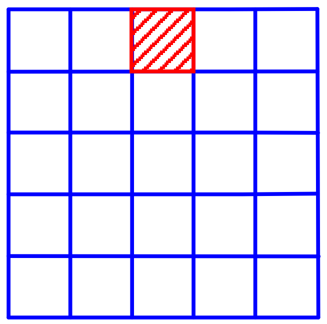

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK FLOOD RISK REDUCTION STUDY

APPENDIX C-3

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

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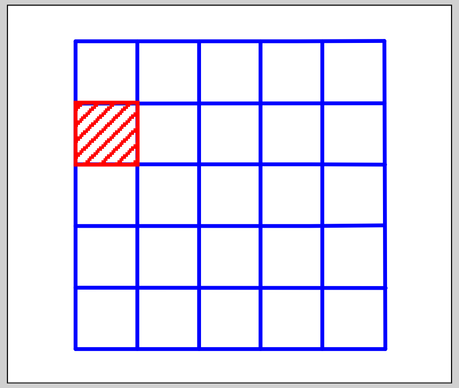

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-4

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

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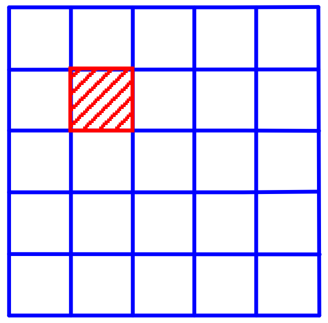

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-5

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

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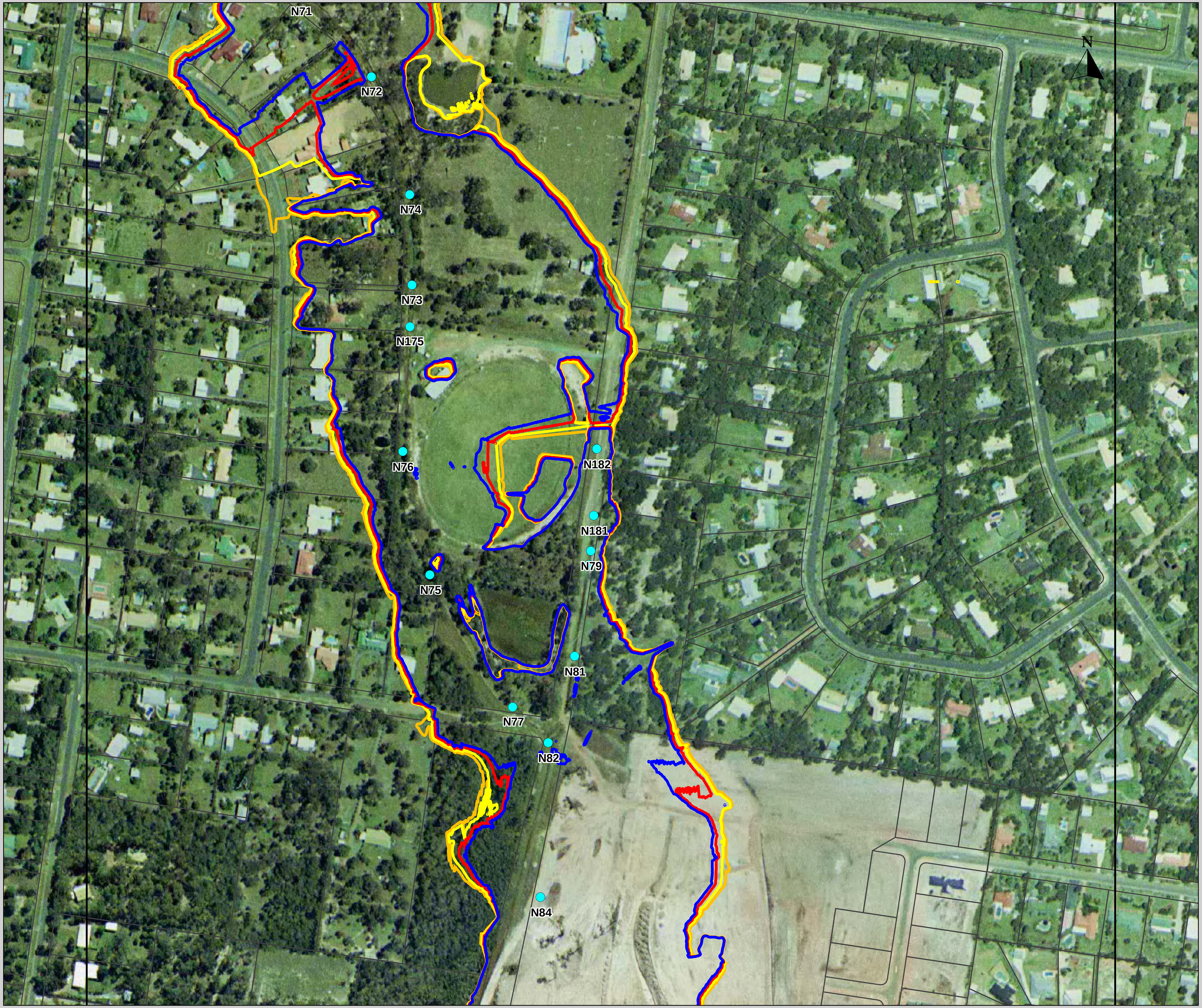

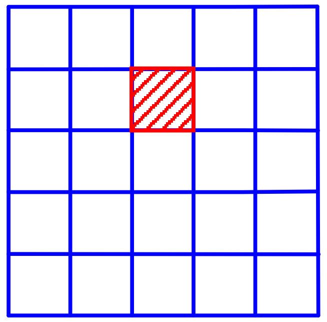

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-6

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

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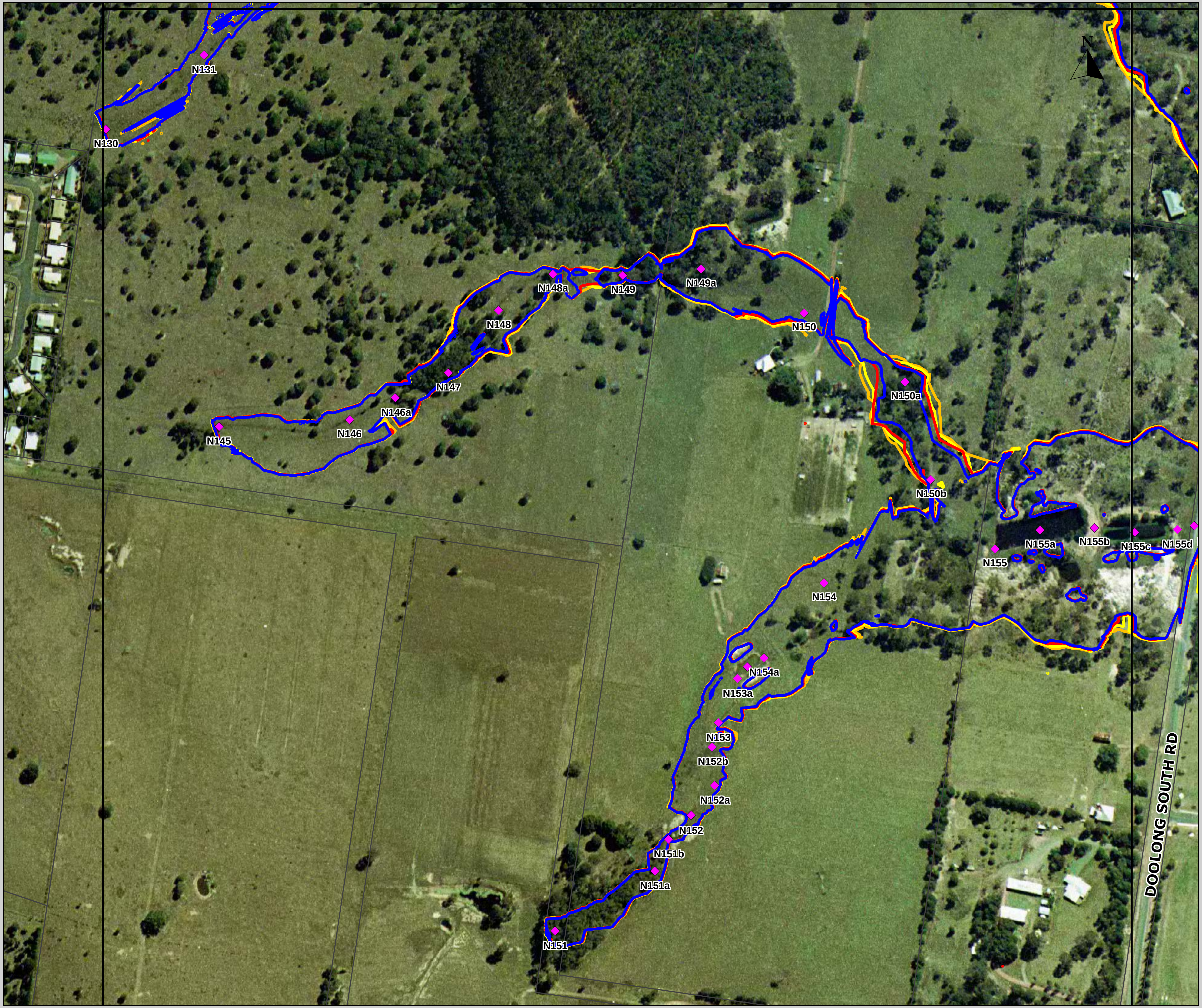

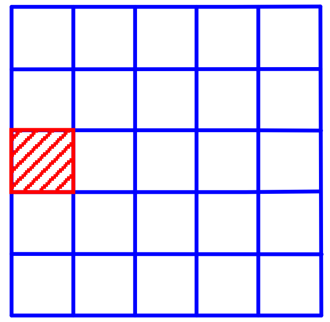

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-7

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

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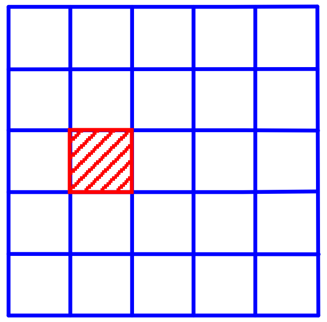

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK FLOOD RISK REDUCTION STUDY

APPENDIX C-8

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

John Wilson and Partners Pty. Ltd.
ABN 85 011 022 503
PO Box 585, Fortitude Valley QLD 4006
Ph. 32449600 Fax. 32449699

File Path : Z:\142-Wways\050302-001 Bunya Creek Flood Risk\GIS\MapInfo\Figures

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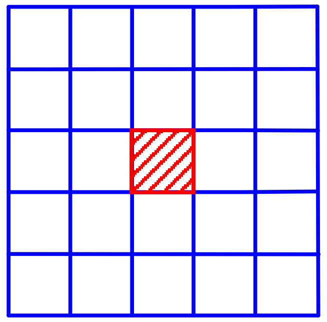

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-9

EXISTING MODEL INUNDATION EXTENT

"Success through Partnership"

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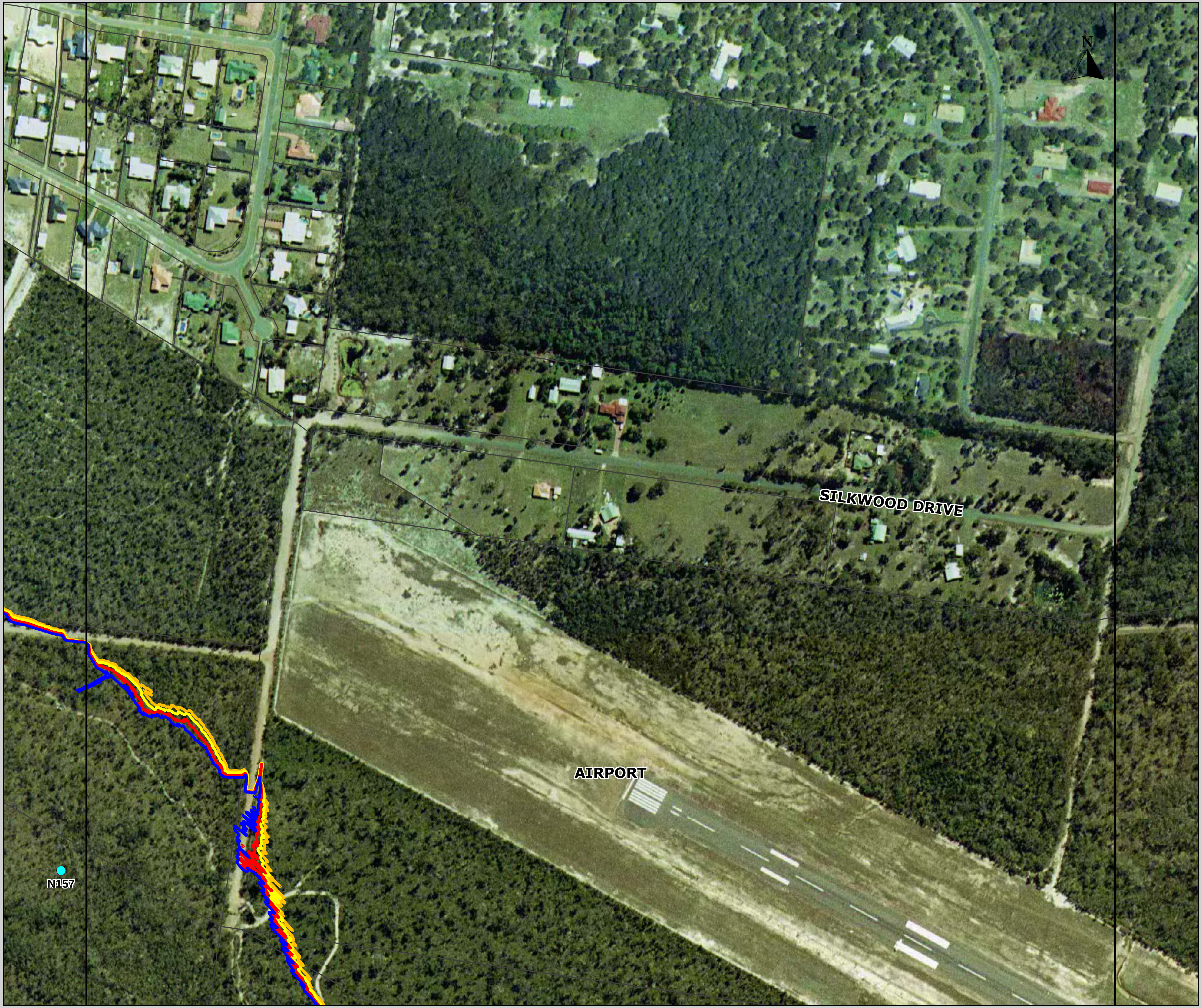

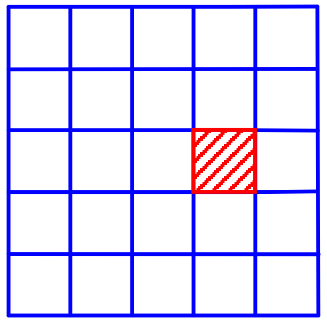

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-10

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

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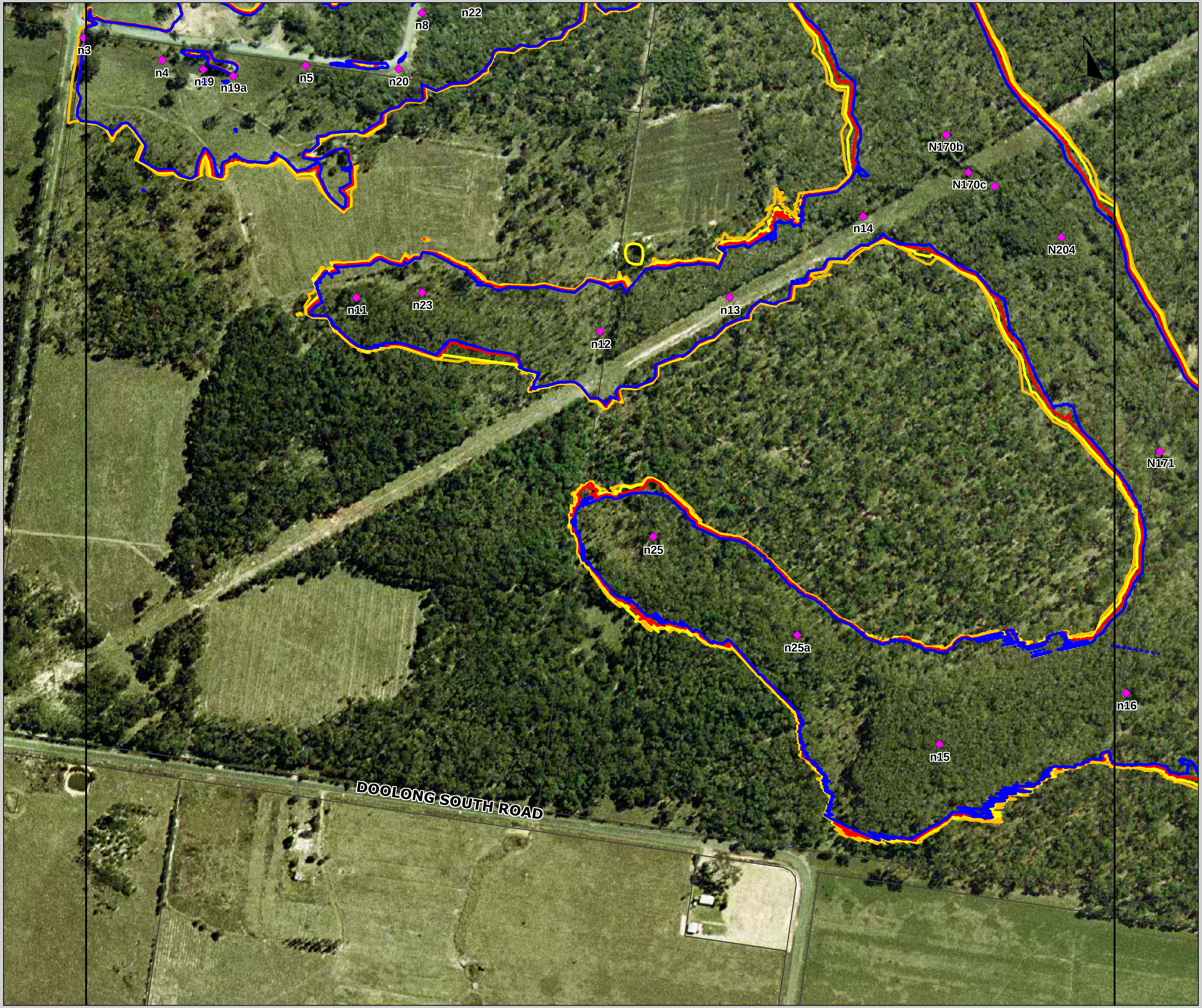
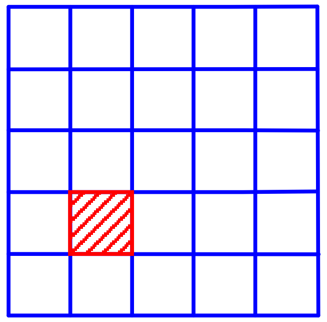
Projection Trans. Merc. MGA56(GDA 94)





LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-11

EXISTING MODEL INUNDATION EXTENT

"Success through Partnership"

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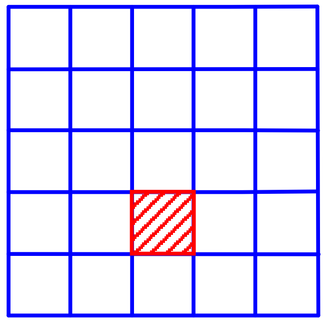
Projection: Trans. Merc. MGA56 (GDA 94)



LEGEND

Q10 Flood Extent
Q20 Flood Extent
Q50 Flood Extent
Q100 Flood Extent
System1 Overland Nodes
System2 Overland Nodes

35 0 35 70 105
Metres
Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-12

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

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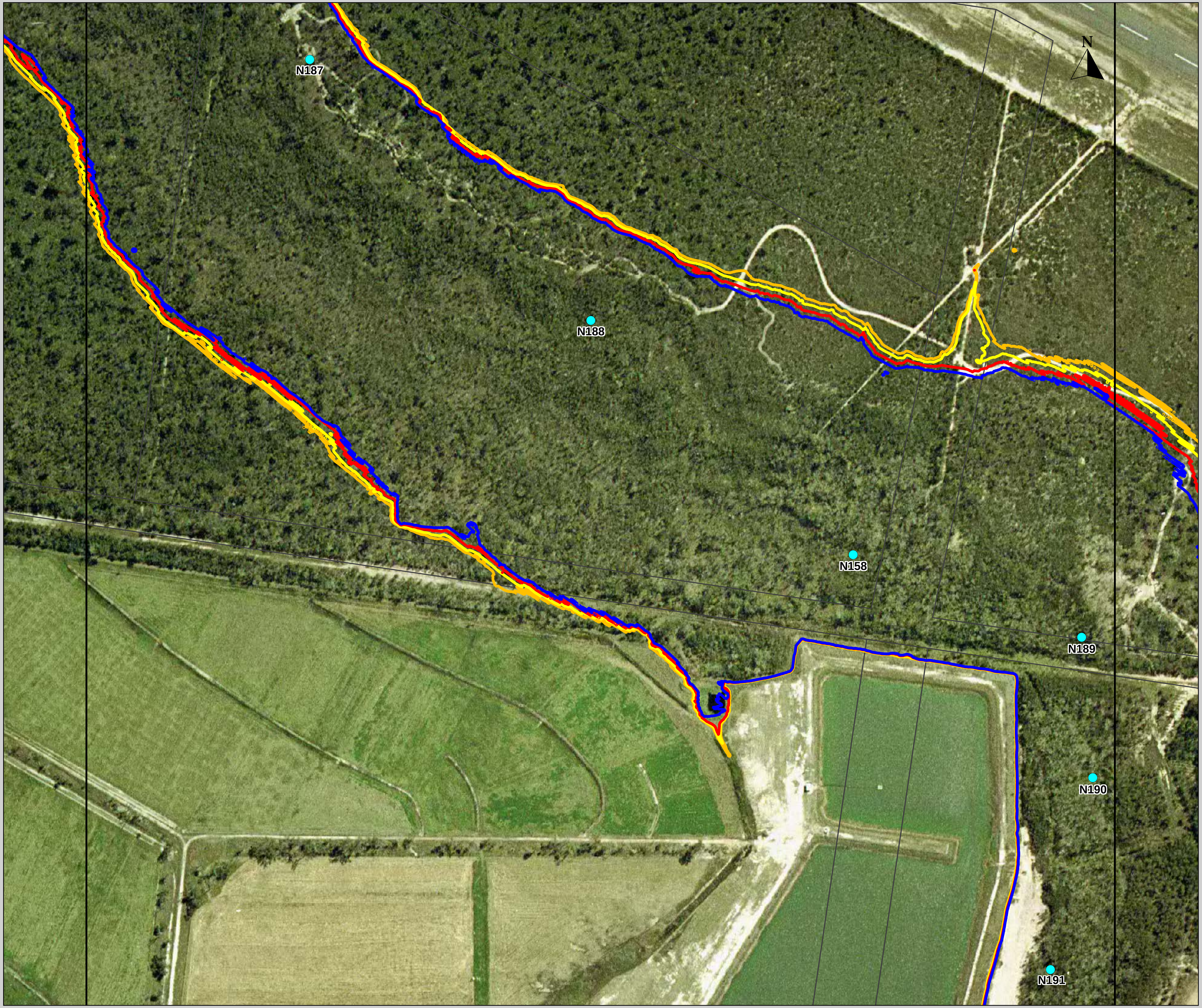
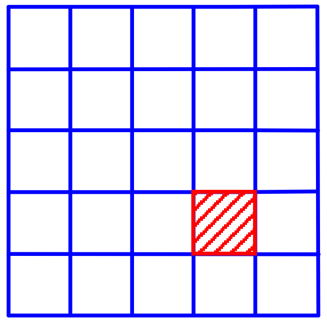
Projection Trans. Merc. MGA56(GDA 94)





LEGEND

Q10 Flood Extent
Q20 Flood Extent
Q50 Flood Extent
Q100 Flood Extent
System1 Overland Nodes
System2 Overland Nodes

35 0 35 70 105
Metres
Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-13

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

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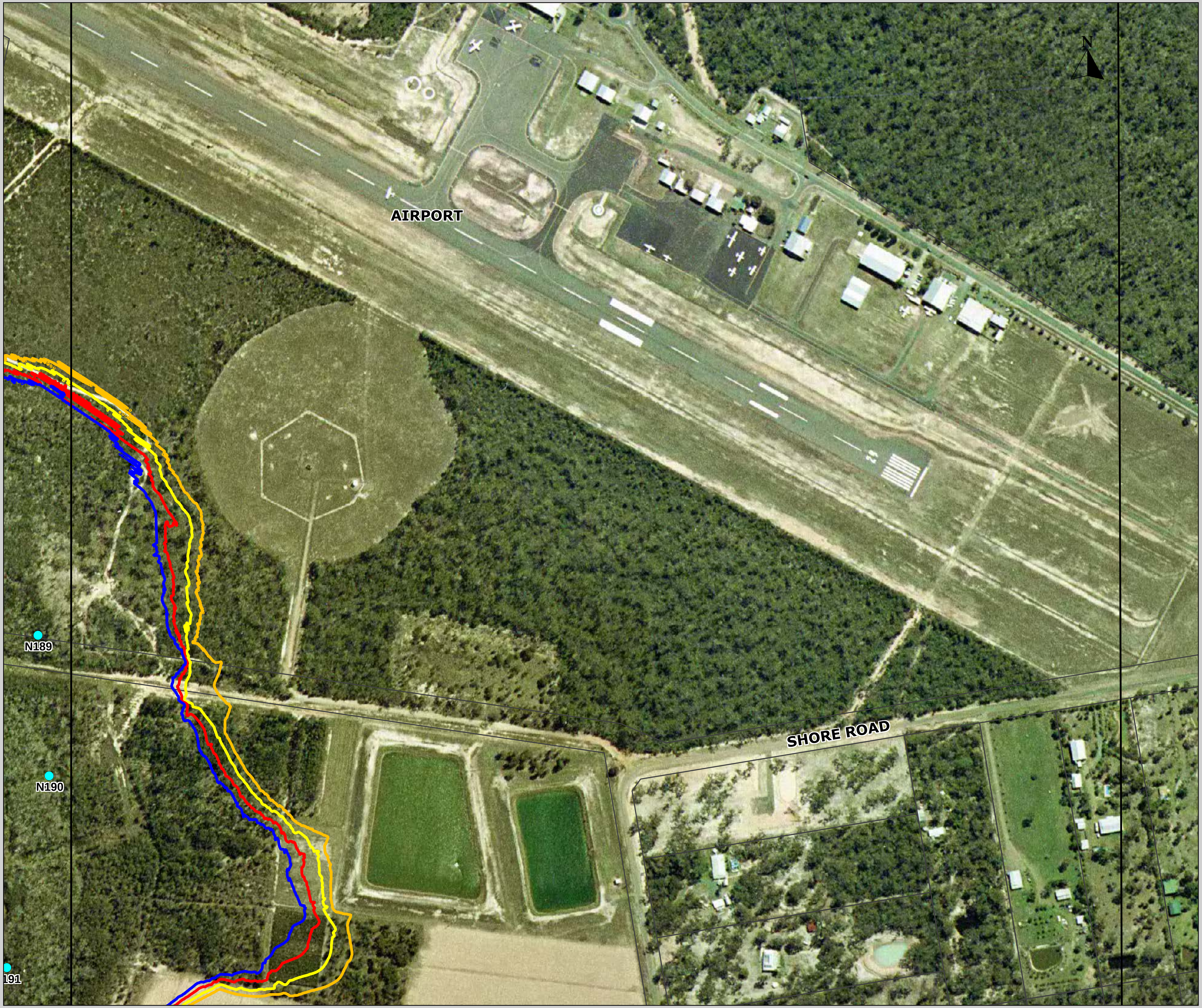

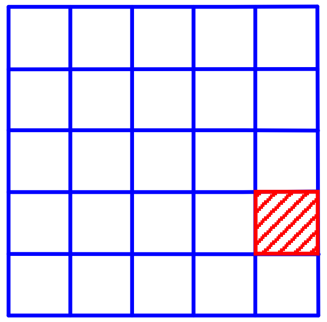

LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-14

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

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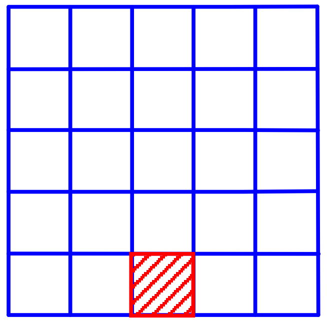
Projection Trans. Merc. MGA56(GDA 94)



LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-15

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

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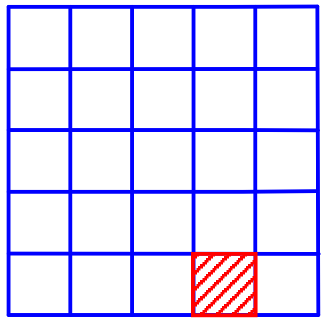
Projection Trans. Merc. MGA56(GDA 94)



LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX C-16

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

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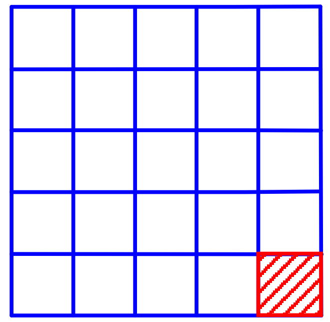
Projection Trans. Merc. MGA56(GDA 94)



LEGEND

- Q10 Flood Extent
- Q20 Flood Extent
- Q50 Flood Extent
- Q100 Flood Extent
- System1 Overland Nodes
- System2 Overland Nodes

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK FLOOD RISK REDUCTION STUDY

APPENDIX C-17

EXISTING MODEL INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

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Projection Trans. Merc. MGA56(GDA 94)

APPENDIX D

Mitigated Scenario Model Results

Model: **System 1 - Mitigated Scenario**
Client: HBCC
User: MP
Date: 30/10/2006

		50 yr ARI Storm Event		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)
N1	28.47	28.906	0.432	28.973	0.499
N2	28.46	28.755	0.299	28.867	0.411
N3	27.99	28.542	0.548	28.575	0.581
N4	27.96	28.317	0.355	28.345	0.383
N5	28.00	28.219	0.217	28.241	0.239
N6	26.47	26.624	0.152	26.641	0.169
N7	25.59	26.177	0.587	26.308	0.718
N8	25.45	26.022	0.569	26.102	0.649
N9	25.49	25.853	0.366	25.924	0.437
N10	25.00	25.828	0.829	25.906	0.907
N11	24.99	25.541	0.553	25.591	0.603
N12	24.47	25.253	0.785	25.298	0.830
N13	24.50	24.843	0.347	24.901	0.405
N14	23.95	24.783	0.834	24.852	0.903
N15	23.95	24.494	0.540	24.548	0.593
N16	23.46	24.153	0.697	24.216	0.760
N17	23.50	24.02	0.518	24.076	0.574
N18	23.00	23.875	0.875	23.967	0.967
N19	22.97	23.842	0.870	23.931	0.959
N20	22.55	23.866	1.313	23.951	1.398
N21	22.49	23.845	1.353	23.913	1.421
N22	22.00	23.265	1.270	23.166	1.171
N23	22.00	23.224	1.221	23.088	1.085
N24	22.00	23.189	1.190	23.02	1.021
N25	21.94	23.183	1.245	23.013	1.075
N26	21.63	23.105	1.475	22.904	1.274
N27	21.96	23.144	1.184	22.954	0.994
N29	21.45	23.084	1.631	22.859	1.406
N30	21.49	23.067	1.574	22.837	1.344
N31	21.50	22.603	1.099	22.72	1.216
N32	21.45	22.481	1.026	22.579	1.124
N33	21.45	22.177	0.726	22.255	0.804
N34	21.02	22.214	1.194	22.291	1.271
N35	21.00	22.174	1.178	22.246	1.250
N36	24.00	24.498	0.500	24.56	0.562
N37	23.99	24.374	0.384	24.446	0.456
N38	23.07	23.94	0.867	24.001	0.928
N39	22.97	23.456	0.481	23.503	0.528
N40	22.49	23.319	0.833	23.357	0.871
N41	22.44	23.161	0.723	22.925	0.486
N42	21.96	23.124	1.167	22.785	0.828
N43	21.98	23.193	1.209	22.958	0.974
N44	21.49	22.654	1.168	22.727	1.241
N45	21.45	22.61	1.157	22.675	1.222
N46	21.45	22.429	0.976	22.496	1.043
N47	21.43	22.272	0.838	22.361	0.927
N49	20.94	22.043	1.099	22.106	1.162
N50	20.92	21.706	0.788	21.796	0.878
N51	20.44	21.683	1.248	21.776	1.341
N52	20.41	21.206	0.799	21.27	0.863
N53	19.93	21.069	1.136	21.13	1.197
N54	19.92	20.726	0.805	20.81	0.889
N55	19.47	20.686	1.221	20.711	1.246
N57	18.54	20.35	1.812	20.196	1.658
N59	18.03	20.376	2.347	20.112	2.083
N60	18.01	20.331	2.323	19.856	1.848

		50 yr ARI Storm Event		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)	WSL (m,AHD)	Depth (m)
N61	17.99	19.403	1.415	19.479	1.491
N62	17.89	19.295	1.407	19.359	1.471
N63	17.47	19.351	1.879	19.487	2.015
N64	17.47	19.3	1.825	19.443	1.968
N65	17.30	19.112	1.814	19.315	2.017
N66	17.46	19.179	1.715	19.355	1.891
N67	17.26	18.914	1.657	19.164	1.907
N68	17.01	18.486	1.477	18.677	1.668
N69	16.98	18.274	1.295	18.368	1.389
N71	16.50	18.201	1.702	18.288	1.789
N72	16.48	18.047	1.567	18.142	1.662
N73	16.44	17.925	1.482	18.011	1.568
N74	16.48	17.963	1.485	18.058	1.580
N75	15.97	17.5	1.528	17.586	1.614
N76	15.97	17.71	1.738	17.789	1.817
N77	15.96	16.956	0.995	17.01	1.049
N79	16.49	16.738	0.246	16.759	0.267
N80	16.02	16.732	0.711	16.754	0.733
N81	15.98	16.629	0.649	16.663	0.683
N82	15.94	16.609	0.671	16.657	0.719
N84	15.86	16.397	0.540	16.448	0.591
N91	19.98	20.373	0.397	20.306	0.330
N92	20.00	20.383	0.383	20.355	0.355
N122	19.44	20.391	0.954	20.304	0.867
N156	14.50	15.049	0.550	15.086	0.587
N157	13.00	13.735	0.735	13.778	0.778
N158	10.53	11.537	1.005	11.573	1.041
N159	9.00	10.517	1.520	10.573	1.576
N175	15.96	17.894	1.937	17.98	2.023
N176	20.49	20.856	0.366	20.888	0.398
N177	21.00	21.257	0.258	21.278	0.279
N178	21.40	21.568	0.172	21.585	0.189
N179	21.81	22.08	0.269	22.107	0.296
N180	22.85	22.941	0.089	22.95	0.098
N181	16.95	17.205	0.253	17.233	0.281
N182	17.00	17.37	0.370	17.414	0.414
N183	15.49	16.085	0.600	16.121	0.636
N184	15.05	15.404	0.358	15.435	0.389
N185	14.00	14.7	0.697	14.736	0.733
N186	13.50	14.203	0.703	14.24	0.740
N187	12.50	13.226	0.725	13.265	0.764
N188	11.50	12.132	0.633	12.168	0.669
N189	10.14	11.014	0.875	11.057	0.918
N190	10.00	10.778	0.778	10.824	0.824
N191	9.67	10.669	0.996	10.721	1.048
N192	9.09	10.573	1.482	10.628	1.537
N193	9.01	10.508	1.499	10.564	1.555
N91a	19.44	20.373	0.933	20.306	0.866

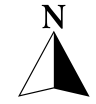
Model: **System 2 - Mitigated Scenario**
Client: HBCC
User: MP
Date: 2007/01/25

		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)
n108	23.48	23.651	0.173
N111	22.98	23.291	0.312
N95	19.98	20.828	0.844
N96	19.99	20.784	0.790
N98	25.96	26.361	0.406
N99	25.94	26.193	0.249
N100	25.44	26.126	0.683
N101	25.10	25.492	0.393
N102	24.96	25.196	0.241
N103	24.46	25.137	0.676
N104	24.44	24.901	0.457
N105	23.95	24.418	0.469
N106	23.45	24.061	0.610
N107	23.97	24.156	0.189
N109	23.35	23.572	0.220
N110	22.97	23.389	0.420
N112	22.73	23.283	0.551
N113	22.00	23.117	1.118
N114	21.97	22.4	0.429
N115	21.49	22.374	0.887
N116	21.47	22.359	0.890
N117	21.10	21.781	0.681
N118	21.03	21.58	0.553
N119	20.96	21.229	0.273
N120	20.95	21.217	0.262
N121	20.46	21.021	0.560
N123	31.78	32.017	0.236
N126	31.09	31.426	0.338
N129	29.43	29.838	0.411
N130	34.72	35.167	0.447
N131	31.46	31.783	0.326
N134	26.10	27.021	0.922
N135	23.68	24.815	1.137
N136	23.07	23.494	0.424
N137	21.69	22.067	0.376
N138	19.68	20.267	0.585
N140	19.64	20.233	0.592
N141	19.49	19.869	0.378
N142_Dool	18.61	19.45	0.840
N144	19.97	20.79	0.820
N145	34.33	34.716	0.385
N146	31.35	31.89	0.544
N147	29.11	29.442	0.330
N148	28.08	28.734	0.654
N149	26.04	26.424	0.381
N150	24.06	24.46	0.397
N151	29.02	29.569	0.549
N152	25.79	26.254	0.469
N153	24.49	24.871	0.380
N154	22.29	22.809	0.518
N155	20.59	21.309	0.721
N162	18.62	19.757	1.141
N163	18.29	19.089	0.799
N164	17.35	18.01	0.664
N165	15.45	17.314	1.864
N166	22.89	23.21	0.321

		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)
N167	19.99	20.248	0.262
N168	17.02	17.899	0.883
N169	15.95	16.858	0.905
N170	15.27	16.587	1.315
N171	13.81	15.068	1.257
N172	12.49	13.201	0.707
N173	11.01	12.08	1.074
N416	18.01	18.511	0.497
N194	28.39	29.29	0.902
N195	27.15	27.854	0.707
N196	24.98	26.302	1.320
N197	22.57	22.977	0.407
N198	22.17	22.639	0.467
N199	22.01	22.444	0.437
N200	20.22	21.066	0.847
N201	11.30	12.373	1.073
N202	11.67	12.611	0.944
N203	13.50	14.537	1.038
N204	14.49	15.598	1.106
N206_Dool	18.42	19.225	0.807
N207	26.85	27.203	0.349
N174	18.02	19.03	1.010
n3	20.41	21.094	0.688
n4	19.84	20.604	0.765
n5	18.96	19.771	0.812
n6	17.51	18.054	0.540
n7	15.92	16.836	0.918
TN1	17.18	18.158	0.978
TN2	16.16	17.448	1.289
TN3	15.45	17.012	1.559
N104a	23.99	24.919	0.930
N113a	21.97	22.629	0.658
n8	18.26	18.859	0.601
n9	17.01	17.617	0.604
n10	16.27	17.037	0.768
n11	19.53	20.131	0.606
n12	17.68	18.121	0.438
n13	16.64	17.143	0.499
n14	15.55	15.983	0.437
n15	16.11	16.471	0.361
n16	14.51	14.88	0.374
n19	19.47	20.385	0.918
n20	18.76	19.179	0.416
n21	18.22	18.681	0.460
n22	17.99	18.429	0.435
n23	18.99	19.432	0.439
n25	17.51	18.017	0.509
N137a	21.03	21.635	0.606
N137b	21.07	21.484	0.415
N137rd	20.81	21.493	0.683
N137c	20.81	21.477	0.667
N137d	20.95	21.462	0.514
N135a	23.55	24.185	0.636
N200a	20.76	21.118	0.354
N200b	19.92	20.561	0.637
N100a	25.49	25.658	0.169
N101rd	26.42	26.42	0.000
N120a	20.90	21.216	0.320
N121a	20.45	20.936	0.483
N96a	19.69	20.416	0.722
N200c	19.97	20.345	0.377
N200e	19.52	19.938	0.418

		100 yr ARI Storm Event	
Node ID	Node Level (m, AHD)	WSL (m,AHD)	Depth (m)
N200d	19.61	20.222	0.616
N41a	18.79	19.535	0.745
N166a	22.13	22.344	0.214
N166b	21.12	21.353	0.236
N167a	18.66	18.777	0.117
N416a	17.67	18.45	0.780
N146a	30.41	30.819	0.408
N148a	27.22	27.545	0.326
N149a	25.65	25.915	0.270
N150a	22.33	22.614	0.282
N150b	21.11	21.426	0.318
N151a	26.51	27.118	0.604
N152a	25.44	25.86	0.425
N152b	24.90	25.361	0.459
N151b	26.09	26.475	0.384
N153a	23.51	24.195	0.681
N154a	23.72	24.205	0.481
N155b	20.99	21.321	0.334
N155d	20.28	20.654	0.377
N162a	18.88	20.144	1.260
N155a	20.09	21.348	1.256
N153b	23.27	24.209	0.941
N155c	19.84	20.678	0.834
N163a	17.66	18.567	0.903
N165a	15.79	17.244	1.455
n19a	19.62	19.988	0.363
N169a	15.12	16.836	1.717
N169b	14.89	16.705	1.818
N170a	15.30	16.412	1.116
n25a	17.00	17.375	0.375
N203a	13.30	14.123	0.824
N170c	14.44	15.874	1.432
N204a	14.60	15.808	1.203
N170b	14.96	15.955	0.992
N165b	15.59	17.086	1.498
N146b	17.79	18.497	0.706
N96b	19.35	19.79	0.439
N96c	19.02	19.595	0.577
N96d	18.99	19.575	0.588

N



Legend

Q100 Mitigated Flood Extent

Cadastre

15 0 15 30 45

Metres

Scale: 1:1,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX D-1

MITIGATED MODEL GREVILLEA ST INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

John Wilson and Partners Pty. Ltd.
ABN 85 011 022 503
PO Box 585, Fortitude Valley QLD 4006
Ph. 32449600 Fax. 32449699

File Path : Z:\42-Wways\050302-001_Bunya_Creek_Flood_Risk\GIS\MapInfo\Figures

Projection Trans. Merc. MGA56(GDA 94)

N

Legend

Q100 Mitigated Flood Extent

Cadastre

20 0 20 40 60

Metres

Scale: 1:2,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX D-2

**MITIGATED MODEL
DENMANS CAMP RD
INUNDATION
EXTENT**

HERVEY BAY CITY COUNCIL

"Success through Partnership"

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Projection Trans. Merc. MGA56(GDA 94)

N

Legend

Q50 Mitigated Flood Extent

Cadastre

15 0 15 30 45

Metres

Scale: 1:1,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX D-3

**MITIGATED MODEL
BOUNDARY ROAD
INUNDATION
EXTENT**

HERVEY BAY CITY COUNCIL

"Success through Partnership"

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Projection Trans. Merc. MGA56(GDA 94)

N

Legend

Q100 Mitigated Flood Extent

Cadastre

15 0 15 30 45

Metres

Scale: 1:1,500

BUNYA CREEK FLOOD RISK REDUCTION STUDY

APPENDIX D-4

MITIGATED MODEL DOOLONG ROAD INUNDATION EXTENT

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HERVEY BAY CITY COUNCIL

JWP

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Projection Trans. Merc. MGA56(GDA 94)

N

Legend

- Q50 Mitigated Flood Extent
- Cadastre

30 0 30 60 90

Metres

Scale: 1:3,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX D-5

MITIGATED MODEL DOOLONG STH RD INUNDATION EXTENT

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

John Wilson and Partners Pty. Ltd.
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Ph. 32449600 Fax. 32449699

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Projection Trans. Merc. MGA56(GDA 94)

APPENDIX E

Proposed Upgrade Sketch Plans

N

Legend

Proposed Culvert Upgrade

Cadastre

10 0 10 20 30

Metres

Scale: 1:1,000

BUNYA CREEK FLOOD RISK REDUCTION STUDY

APPENDIX E-1

GREVILLEA STREET Q100 DRAINAGE UPGRADE

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

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Projection Trans. Merc. MGA56 (GDA 94)

N

Legend

Proposed Culvert Upgrade

Cadastre

10 0 10 20 30

Metres

Scale: 1:1,000

BUNYA CREEK FLOOD RISK REDUCTION STUDY

APPENDIX E-2

DENMANS CAMP RD Q100 DRAINAGE UPGRADE

HERVEY BAY CITY COUNCIL

"Success through Partnership"

JWP

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Ph. 32449600 Fax. 32449699

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Projection Trans. Merc. MGA56(GDA 94)

N

Legend

Proposed Culvert Upgrade

Cadastre

10 0 10 20 30

Metres

Scale: 1:1,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX E-3

BOUNDARY ROAD Q50 DRAINAGE UPGRADE

"Success through Partnership"

John Wilson and Partners Pty. Ltd.
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Projection Trans. Merc. MGA56(GDA 94)

N

Legend

- Proposed Spanning Slab Driveway
- Proposed Concrete Channel
- Cadastre

30 0 30 60 90

Metres

Scale: 1:3,000

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX E-4

DOOLONG ROAD Q100 DRAINAGE UPGRADE

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Projection Trans. Merc. MGA56(GDA 94)

N

Legend

Proposed raising of Doolong South Road

35 0 35 70 105

Metres

Scale: 1:3,500

BUNYA CREEK
FLOOD RISK
REDUCTION STUDY

APPENDIX E-5

DOOLONG STH ROAD
Q50 DRAINAGE
UPGRADE

"Success through Partnership"

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ABN 85 011 022 503
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Projection Trans. Merc. MGA56(GDA 94)

APPENDIX F

Preliminary Cost Estimates

Cost Estimate:
Culvert Upgrades for Grevillea Street, Denmans Camp Road and Boundary Road

Road Crossing	HBCC Road Hierarchy	Proposed Drainage Upgrade (Dimensions in mm)
Grevillea St [#1]	Major Road	3 No. 3100 x 1200 RCBC
Grevillea St [#2]	Major Road	3 No. 2500 x 900 RCBC
Denmans Camp Rd	Major Road	3 No. 3000mm x 2100 RCBC
Boundary Rd	Major Road	5 No. 1500 x 1200 RCBC

Supply Cost of Culvert Materials

	Crown	Base	**Total**
Grevillea St #1	$87,120.00	$56,760.00	$143,880.00
Grevillea St #2	$63,540.00	$43,500.00	$107,040.00
Denman Camp Rd	$97,560.00	$51,480.00	$149,040.00
Boundary Rd	$59,900.00	$27,900.00	$87,800.00

Excavate Lay and Backfill (on precast base)	
Grevillea St #1	$25,080.00
Grevillea St #2	$37,380.00
Denman Camp Rd	$25,200.00
Boundary Rd	$18,800.00

Headwalls	
Grevillea St #1	$1,500.00
Grevillea St #2	$1,500.00
Denman Camp Rd	$1,500.00
Boundary Rd	$1,500.00

Total Estimated Culvert Cost (incl. 20% contingency)	
Grevillea St #1	**$205,000**
Grevillea St #2	**$175,000**
Denmans Camp Rd	**$210,000**
Boundary Rd	**$130,000**

Date Printed : 2007/01/25

ESTIMATE OF COST FOR PROJECT: BUNYA CREEK STUDY

Doolong Road - Channel Upgrade
PRELIMINARY DRAINAGE ESTIMATE

Description	Comment	Unit		Unit Cost	Number	Amount
GENERAL						
Site Establishment		ITEM		$ 1.00	10000	$ 10,000.00
Box out & remove existing driveways		ITEM		$ 300.00	3	$ 900.00
DRAINAGE						
Excavation of open drain		m3	Scale	$ 19.50	700	$ 13,650.00
CONCRETE						
Concrete open drain		m3		$ 620.00	550	$ 341,000.00
Subtotal						$ 365,550.00
Contingencies						
Contingencies (Provisional)		ITEM		20%		$ 73,110.00
DESIGN CHARGES						
Predesign Survey		ITEM		$ 1.00	5484	$ 5,484.00
Project Design		ITEM		$ 1.00	10967	$ 10,967.00
Construction Survey		ITEM		$ 1.00	3656	$ 3,656.00
Total						$ 458,767.00
Proposed Upgrade: Widen and concrete line existing channel						

Date Printed 2007/01/25

ESTIMATE OF COST FOR PROJECT: BUNYA CREEK

Doolong South Road - Road Upgrade
PRELIMINARY DRAINAGE ESTIMATE

Description	Comment	Unit	Unit Cost	Number	Amount
GENERAL					
Site Establishment	Min. $10,000	ITEM	$ 1.00	10000	$ 10,000.00
Remove existing K & C structures		ITEM	$ 10.00	500	$ 5,000.00
ROADWORKS					
Gravel base course (solid)		m3	$ 15.00	1920	$ 28,800.00
BITUMEN SURFACING					
Prime Coat		m2	$ 10.00	3840	$ 38,400.00
Asphaltic Concrete type 2 (10mm) S & L	(light traffic) 25-40mm Thick	Tonne	$ 94.28	2880	$ 271,527.00
MATERIALS					
Supply & Deliver Class 2.1 Roadbase		Tonne	$ 16.00	4608	$ 73,728.00
PROVISIONAL					
Construction safety fee	$ 805,000.00	ITEM	$ 1.00	$ -	$ 1,000.00
Supervision	$ 805,000.00	ITEM	$ 1.00		$ 28,980.00
Subtotal					$ 457,435.00
Contingencies					
Contingencies (Provisional)		ITEM	20%		$ 91,487.00
DESIGN CHARGES					
Project Design & Survey		ITEM	$ 1.00	45744	$ 45,744.00
Total					$ 595,000.00

Proposed Upgrade: Raise rd (sag) by up to 300mm