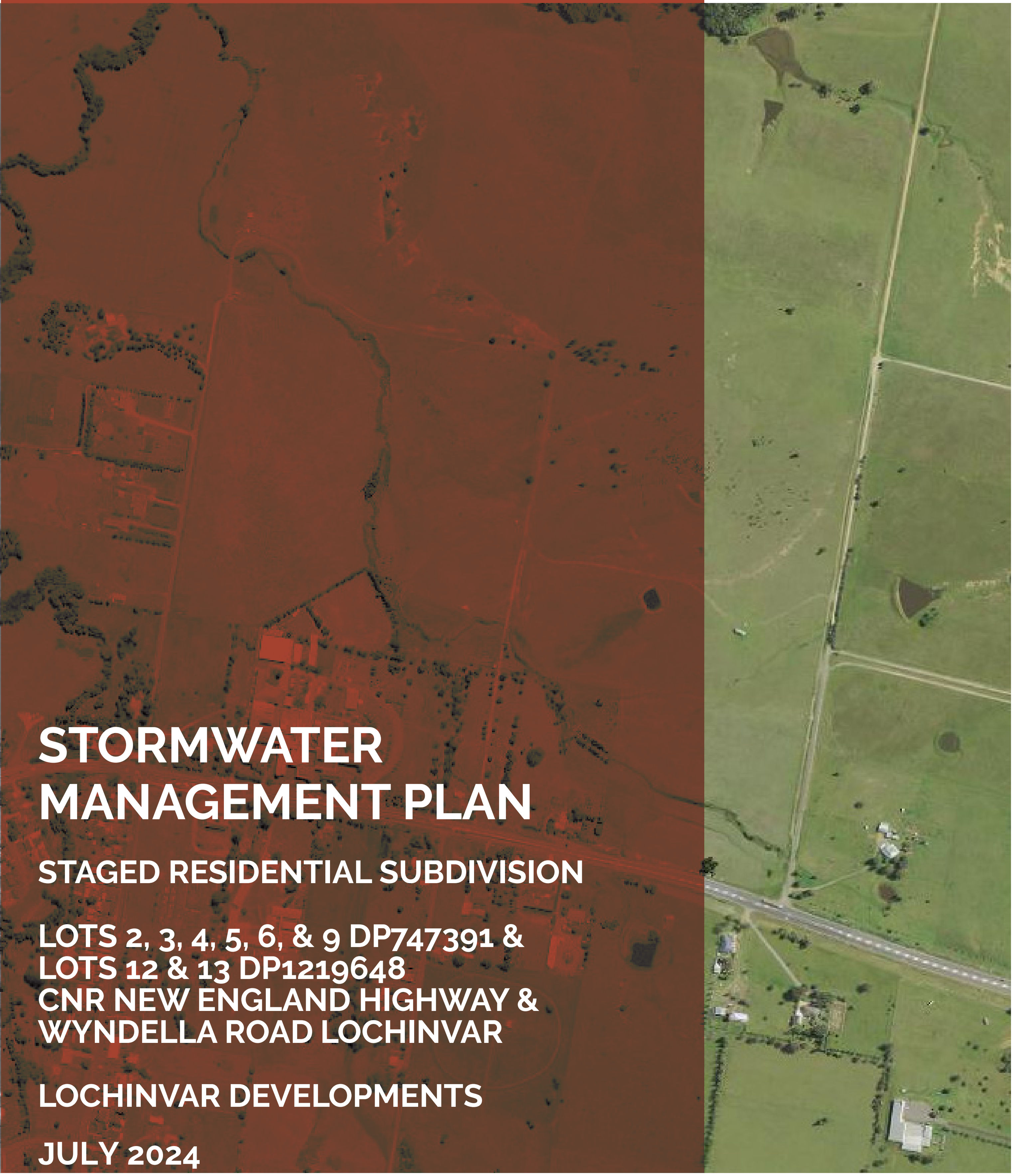

STORMWATER MANAGEMENT PLAN

STAGED RESIDENTIAL SUBDIVISION

LOTS 2, 3, 4, 5, 6, & 9 DP747391 & LOTS 12 & 13 DP1219648 CNR NEW ENGLAND HIGHWAY & WYNDELLA ROAD LOCHINVAR

LOCHINVAR DEVELOPMENTS

JULY 2024

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Document Control Sheet

Issue No.	Amendment	Date	Prepared By	Checked By
A	Preliminary Issue	21/03/2023	Mitchell Knox & Christian Langley	Lincoln Gibbs
B	Minor Amendments	21/04/2023	Mitchell Knox & Christian Langley	Mitchell Knox
C	Council Comments	28/06/2024	Mitchell Knox	Mitchell Knox
D	Minor Amendments	05/07/2024	Mitchell Knox	Mitchell Knox

Executive Summary

ADW Johnson has been engaged by Lochinvar Development Pty Ltd to prepare a Stormwater Management Plan addressing the stormwater management requirements for a proposed subdivision of Lots 2-6 and 9 DP 747391 and Lots 12-13 DP 1219648 at Lochinvar ('the site'). This report accompanies a development application for the residential subdivision which shall create 258 lots and supporting infrastructure.

This report has been updated to reflect the amended layout that has been prepared in response to Council's initial review of the development application.

Consistent with existing conditions, the proposed development drains to two legal points of discharge. A majority of the site reports to an existing tributary of Lochinvar Creek, whilst a smaller catchment in the site's north reports to Lot 2 1299958 in the location of a future road extension (by others).

Hydrologic modelling was undertaken to compare peak site discharges under existing and proposed conditions. Modelling confirmed that the detention basin proposed on the site's southern catchment is sufficiently sized to ensure that peak flows do not exceed predeveloped magnitudes for all design events up to the 1% AEP. There are no stormwater detention warrants on the site's northern catchment.

1-dimensional flood analysis has confirmed that all proposed lots are provided with adequate freeboard to the 1% AEP local design flood. Modelling confirmed no downstream impact on local flood extents up to the 1% AEP and minor improvements to upstream flood extents owing to proposed cross-drainage structure upgrades. Modelling confirmed that all proposed lots will facilitate dwellings which are outside of the Lochinvar Creek tributary's Probable Maximum Flood (PMF) envelope.

A stormwater quality treatment train has been developed comprising of rainwater tanks, Gross Pollutant Traps and bioretention basins. MUSIC modelling has confirmed that the proposed treatment train meets Council's objectives in relation to runoff quality improvement.

To ensure downstream waters and adjacent properties are protected, appropriate erosion and sediment controls are to be undertaken during construction. Controls are to be implemented and monitored in accordance with Landcom's 'Blue Book' and Council's engineering guidelines.

Site investigations by AEP as part of a Riparian Assessment Report have determined that the Lochinvar Creek Tributary near the site's southern boundary is a first order watercourse. Subsequently, the proposed stormwater management system is compliant with stormwater and Water Sensitive Urban Design controls imposed by the Lochinvar Urban Release Area Development Control Plan, and with the Natural Resource Access Regulator (NRAR's) requirements for controlled activities on waterfront land.

The details and information presented in this Stormwater Management Plan confirm that the proposed development can satisfy Council's requirements in relation to peak flow management, flooding runoff quality, and soil and water management.

Table of Contents

APPENDICES

LIST OF FIGURES

LIST OF TABLES

1.0 Introduction

ADW Johnson has been engaged by Lochinvar Developments Pty Ltd to prepare a Stormwater Management Plan addressing the stormwater management requirements for a proposed subdivision of Lots 2-6 and 9 DP 747391 and Lots 12-13 DP 1219648 at Lochinvar ('the site'). This report accompanies a development application for the residential subdivision which shall create 258 lots.

The site is bounded by Wyndella Road to the east and the New England Highway to the south. Unimproved pastoral land exists to the site's western and northern boundaries, with a school and sparse rural-residential properties situated to the south-west. Site locality is presented in ***Figure 1.***

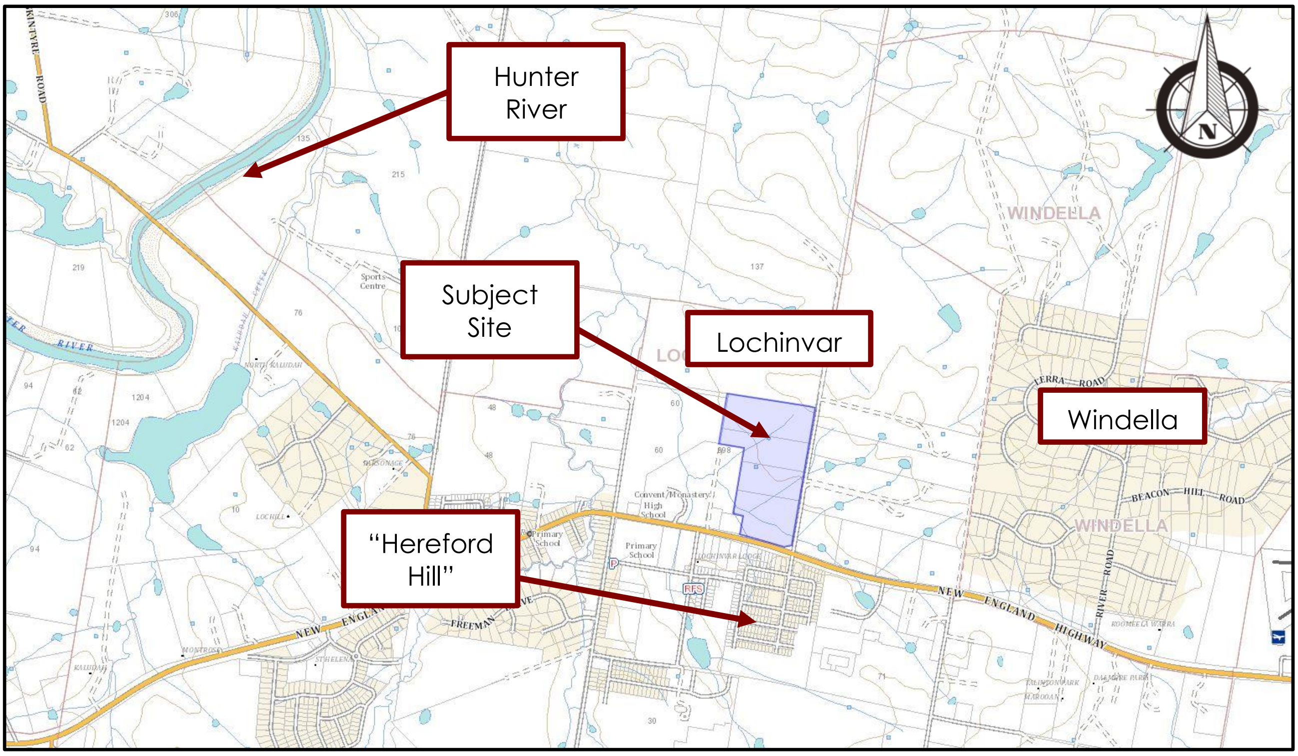

Figure 1 - Site Locality.
(Source: https://maps.six.nsw.gov.au/)

2.0 Site Description

2.1 EXISTING SITE

The site is located on Wyndella Road at Lochinvar within the Maitland LGA and comprises of approximately 22.5 ha of General Residential (R1) land.

The site is predominantly comprised of pastoral land and has been previously used for small-scale livestock grazing. Wooded vegetation is sparse, primarily existing in copses along the site's riparian corridor. Topography is generally undulating with slopes of up to ten percent directed towards a well-defined watercourse.

Existing access to the site is via Wyndella Road which is presently unsealed. Noting the exception of several farm dams and a barn, the site is devoid of improvements.

Adjoining land to the west consists of General Residential (R1) land. Adjoining land to the north consists of Primary Production (RU1) land. Adjoining land to the east consists of Rural Landscape (RU2) land. Adjoining land to the south primarily consists of the Hereford Hill residential development, being part of the Lochinvar Urban Release Area (URA).

Figure 2 presents an aerial photograph of the existing site.

Figure 2 – Existing Site.
(Source: https://maps.six.nsw.gov.au/)

The site is constrained by existing dual sewer rising mains (DN250 and DN375) running west to east across as seen in ***Figure 3***. Positive service location (potholing) indicates that depth to the proposed rising mains is variable, with minimum cover of approximately 0.8m. Importantly, the DN375 main's invert level is lower than the invert of the existing watercourse within the site's bounds. This requires piped drainage to cross over, rather than under, both mains.

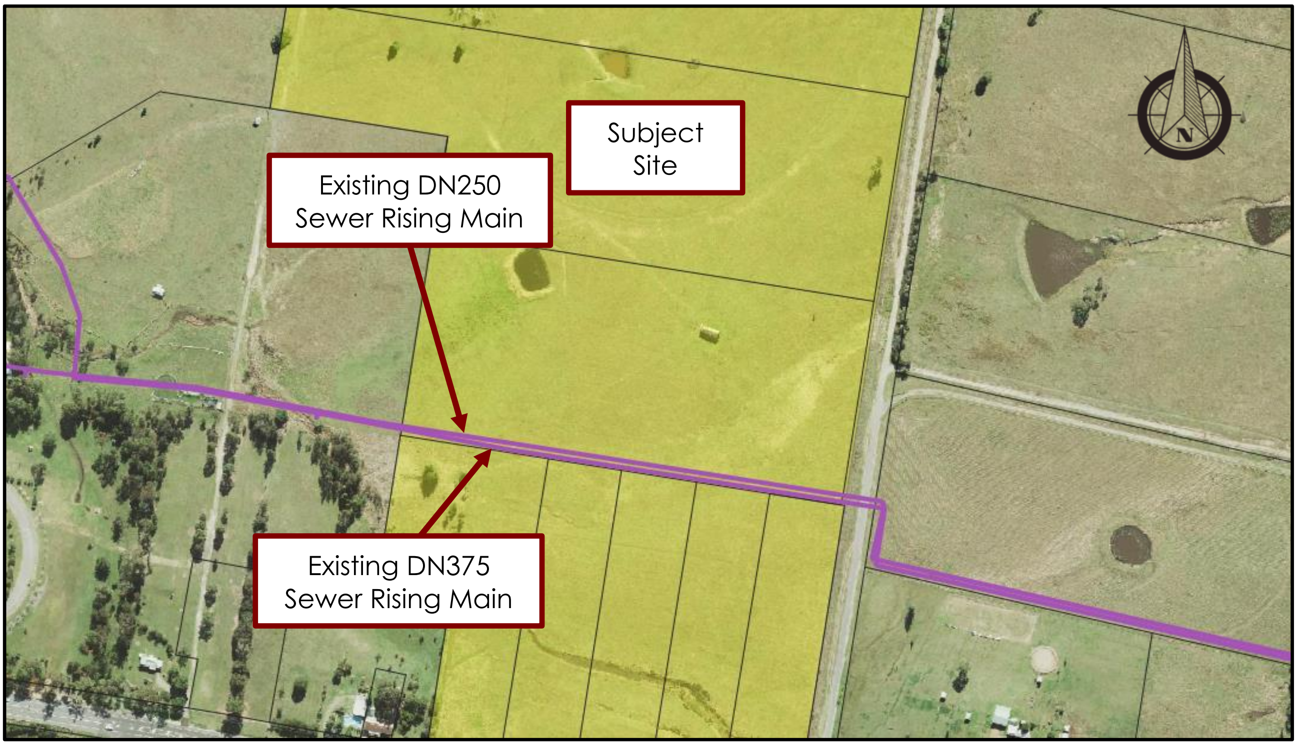

Figure 3 - Existing Sewer Rising Main Alignment.
(Source: Hunter Water Corporation)

2.2 EXISTING GEOLOGY

Desktop review using the NSW DPIE's *eSPADE* confirms that the site is situated within the North Eelah (nex) and Lovedale (lvv) landscapes, as seen in ***Figure 4***.

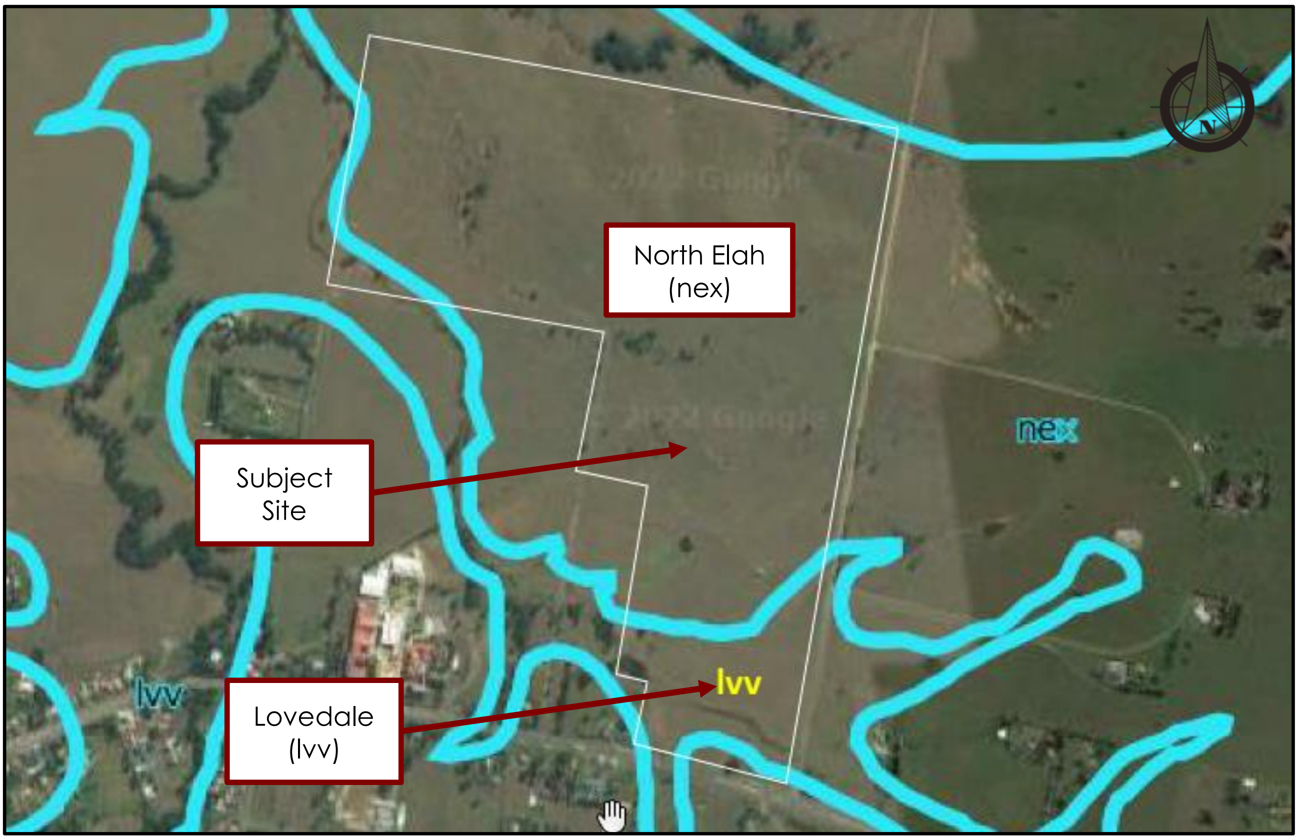

Figure 4 - Landscape Map Overlay.
(Source: NSW eSPADE)

From ***Figure 4*** it is seen that the northern area is mostly mapped as the North Elah Landscape, and is characterised by shallow soils, localised rock outcropping, and incised drainage lines.

The southern area is mapped as the Lovedale Landscape, and is characterised by alluvial fans, localised waterlogging and gently sloping drainage lines.

Qualtest attended site and from test pit investigation found that soil depths were variable but generally in the range of about 0.2m to 2.0m on the mid slopes, and generally greater than 2.0m on the lower / foot slopes. Rock outcrops were observed in the northern part of the site. The rock appeared to include Conglomerate and Pebbly Sandstone of estimated very high strength based upon limited surface observations.

Slow groundwater inflow was observed at TP09 (on the tributary watercourse) and TP50 (at the north-western corner of the site) at depths of 1.20m and 1.90m, respectively. No other groundwater inflows or water levels were encountered in the other test pits during testing.

2.3 EXISTING HYDROLOGY

As noted in ***Sections 2.1*** and ***2.2***, the site is typified by moderate slopes and well-defined watercourses. Subsequently, it is expected that the site's hydrologic regime is dominated by surface runoff into natural channels.

Initial desktop review by AEP using Department of planning, Industry and Environment (2020), Natural Resources Access regulator Waterfront Land e-Tool showed multiple tributaries of Lochinvar Creek converging within the subject site. Strahler ordering of DPE hydrolines is shown in ***Figure 5***.

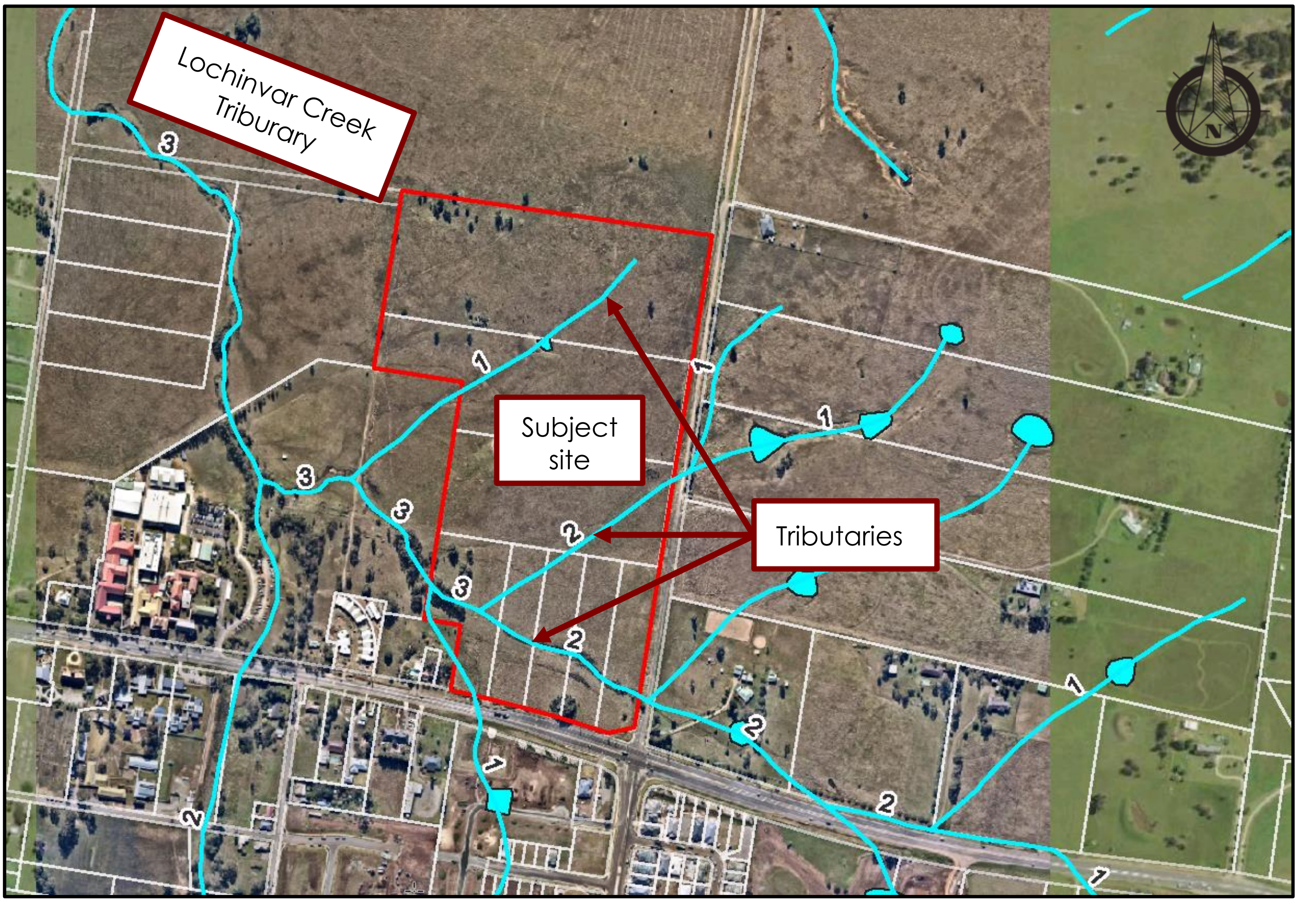

Figure 5 – Desktop Hierarchy of Watercourses
(Source: 2699 Lochinvar New England Riparian Assessment Rev 01 20220909 – AEP)

However, following a ground-truthing survey, Riparian Assessment Report prepared by AEP determined that several mapped hydrolines did not meet the definition of a watercourse. This led to an updated Strahler hierarchy of watercourses, as shown in ***Figure 6.***

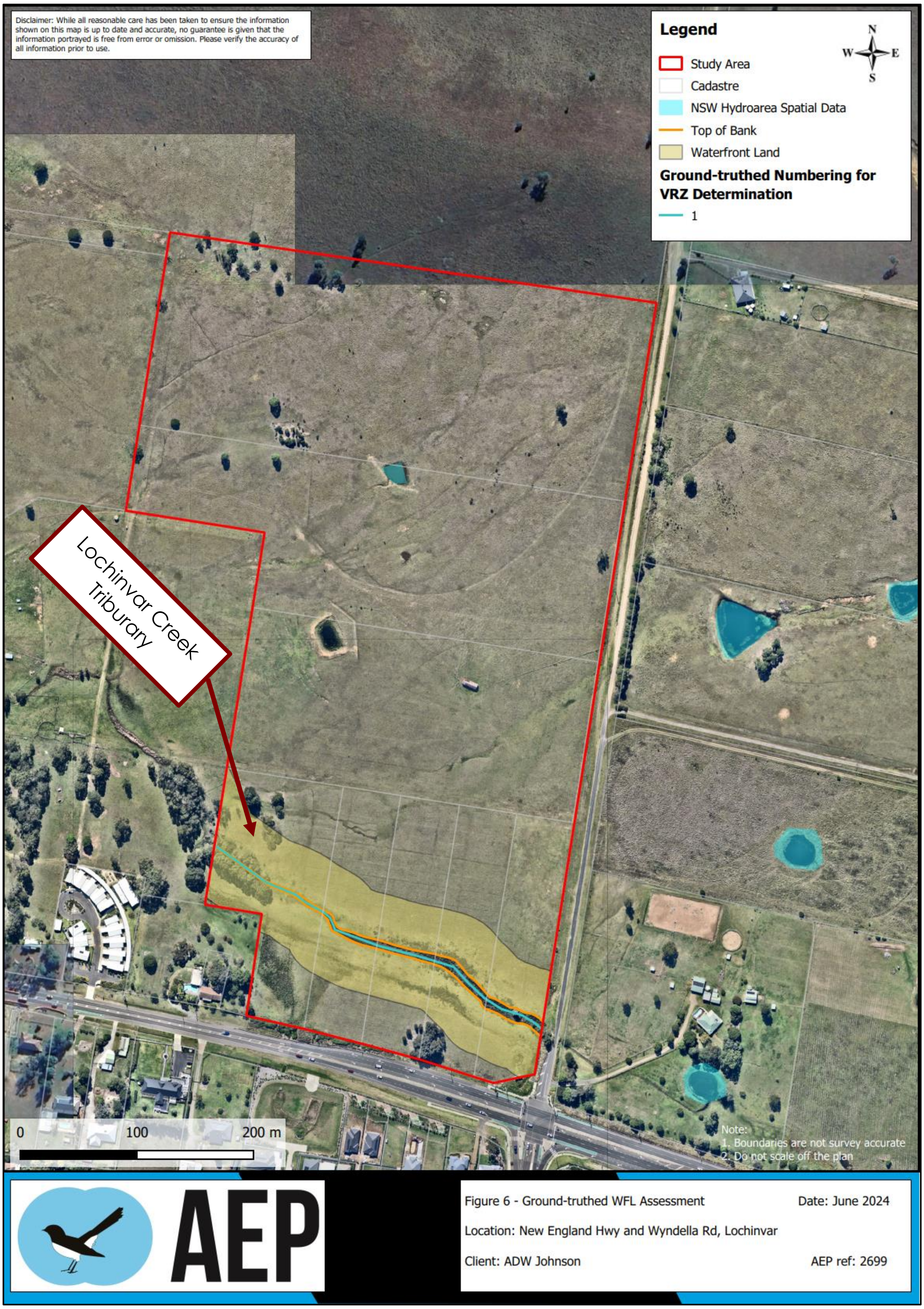

Figure 6 – Ground-truthed Hierarchy of Watercourses.
(Source: 2699 Lochinvar New England Riparian Assessment Rev 01 20220909 – AEP)

The site's existing drainage regime is presented in ***Figure 7*** and described below.

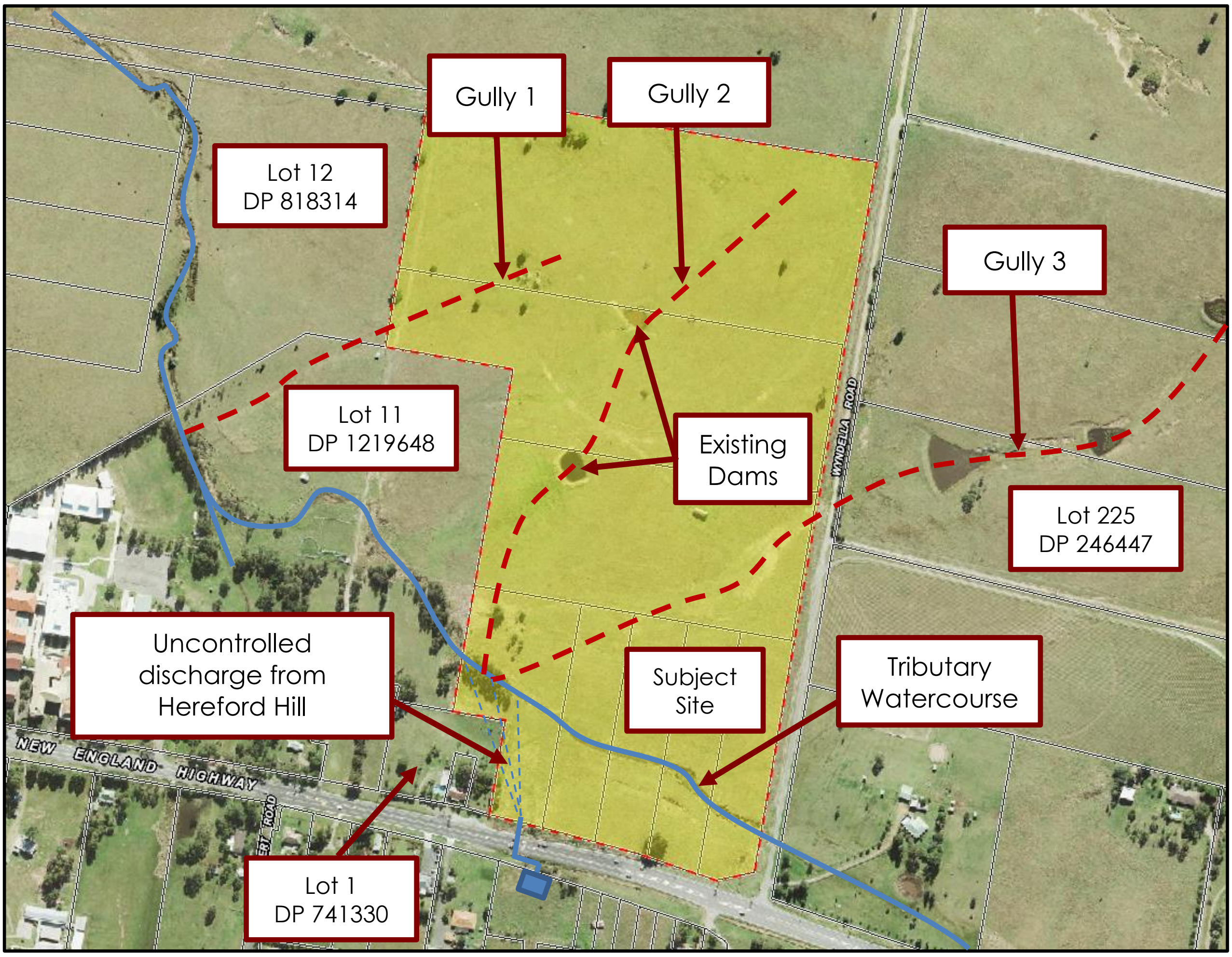

Figure 7 - Existing Hydrology.
(Source: https://maps.six.nsw.gov.au/)

A majority of the site's catchment drains southwest into the tributary watercourse within the site's south. The watercourse, which is a tributary of Lochinvar Creek, drains through Lot 11 DP 1219648 and ultimately reports to the Hunter River approximately 3 km north-east of the subject site.

Within this major catchment, runoff is concentrated in two existing gullies (Gullies 2 and 3 in ***Figure 7***) which ultimately report to the tributary watercourse. Two existing farm dams are located on Gully 2 and would be decommissioned by the proposed development.

A smaller catchment in the site's north drains to the site's westernmost corner via a defined gully (labelled as Gully 1 in ***Figure 7***). Gully 1 connects this catchment to the tributary watercourse downstream of the site.

An existing upstream catchment to the north-east discharges through the site via Gully 3. The gully receives a total upstream catchment of approximately 12.6 ha of pastoral land. Flows are conveyed beneath Wyndella Road via dual DN525 circular culverts depicted in ***Figure 8***.

Figure 8 - Circular culverts beneath Wyndella Road.
(Looking upstream)

The tributary watercourse draining through the site also receives an upstream catchment. The upstream catchment comprises of both rural and residential land to the southeast of the subject site, amounting to approximately 84 ha. Flows are conveyed beneath Wyndella Road via three (3) DN1050 circular culverts depicted in ***Figure 9***. Whilst the watercourse is known to be ephemeral, a baseflow was observed at time of inspection.

Figure 9 - Circular culverts beneath Wyndella Road.
(Looking downstream)

A separate upstream catchment enters the development from the south. This upstream catchment comprises of approximately 17.5Ha of residential land which is dominated by the adjoining Hereford Hill subdivision. Inflows report to a basin at the north of the Hereford Hill development before being discharging into the New England Highway Road reserve. As shown in ***Figure 10***, two circular culverts (DN450 and DN600) pass under the New England Highway and enter to subject site in an uncontrolled fashion.

Figure 10 - Circular culverts beneath the New England Highway.
(Looking upstream)

Ground-truthing from inspection of the subject site found the south-western corner of the subject site and the north-eastern corner of the adjoining property (Lot 1 DP 741330) were soft underfoot, suggesting this area is subject to overbank flows from the upstream catchment discharge in the site. This is consistent with AEP 2022 which identifies to affected land as an "overland dispersion area" which, if unresolved, is "highly likely to become a wetland in the future".

2.4 PROPOSED DEVELOPMENT

The site is intended for residential subdivision creating 258 lots in 13 stages. This development will form part of the Lochinvar Urban Release Area (URA) and comprise of typical urban residential elements such as residential lots, roads, footpaths and cycleways, parks, water and sewer reticulation and other services.

The stormwater drainage system will incorporate a piped drainage network, with the road network providing overland flowpaths. Runoff will be controlled by stormwater basins in relation to both runoff quality and peak flow attenuation.

Wyndella Road will require upgrade works to facilitate increased traffic demand from development. Whilst this report gives consideration to cross-drainage structures, the Wyndella Road/New England Highway intersection is beyond the scope of this assessment.

The proposed development is shown conceptually in ***Figure 11.***

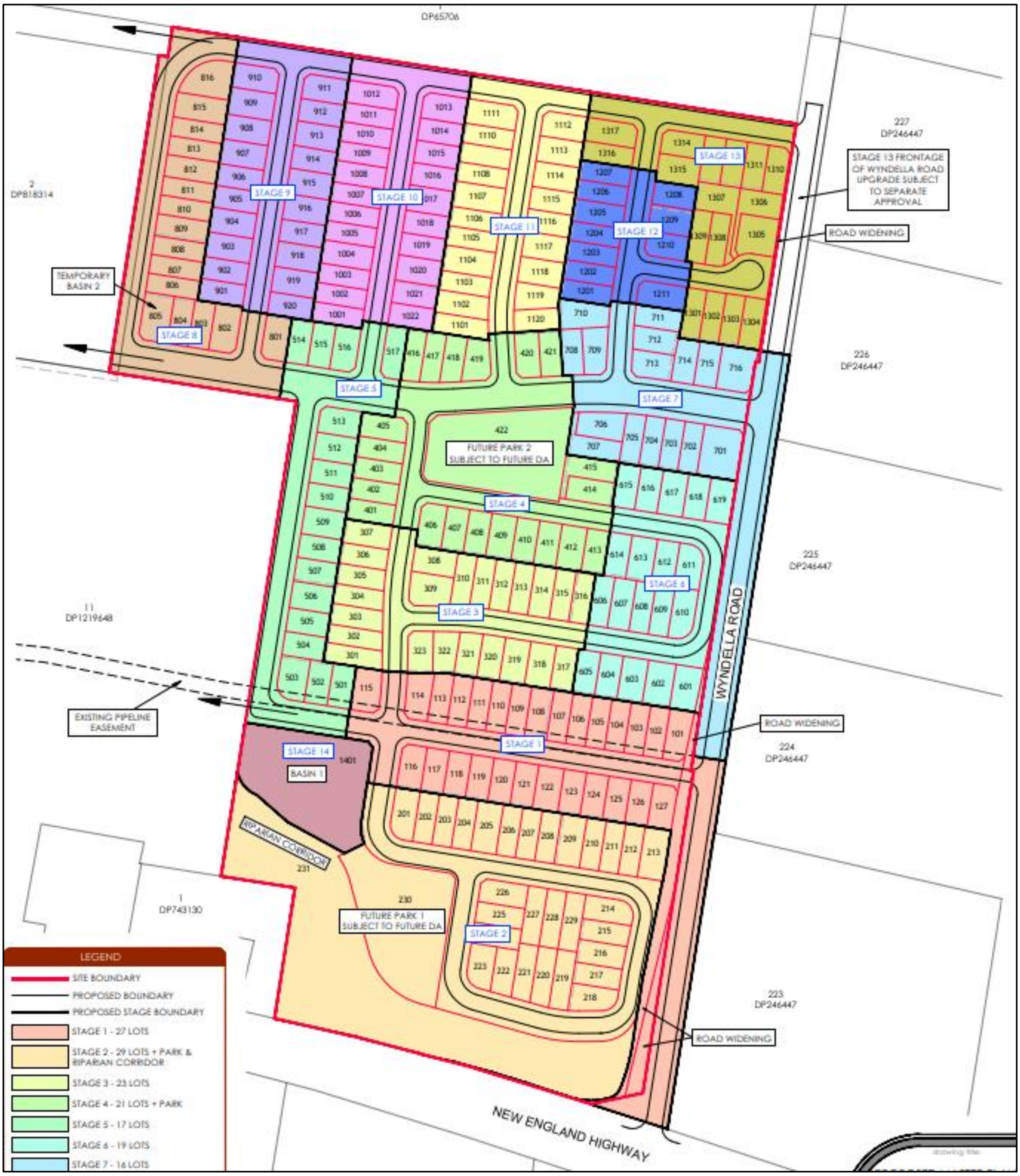

Figure 11 – Proposed Development.
(Source: ADW Johnson 2024)

3.0 Council Requirements

Maitland City Council outlines the engineering requirements for stormwater management within their Manual of Engineering Standards. Specifically, Section 6 of their standards outline the relevant requirements for stormwater drainage.

3.1 ONSITE DETENTION

Council requires that the proposed development will not exceed the predevelopment runoff for all storm durations for all return periods ranging from 63.2% AEP to 1% AEP.

Council's requirement to not exceed predeveloped flow magnitudes is to be demonstrated at each of the site's legal points of discharge. RAFTS modelling of peak flows under existing and developed conditions is presented in ***Section 5***.

Council has advised that the stormwater detention assessment must consider the site in isolation of upstream catchments which drain through the site.

3.2 FLOOD STUDY

Council's *Manual of Engineering Standards* requires demonstration that a proposed development achieves a total system which does not adversely affect existing systems or properties within the flowpath or catchment.

Open channels forming part of the trunk drainage system must cater for the 100-year ARI peak flow with 0.3m freeboard within the channel and 0.5m to habitable floors.

Cross-drainage structures must cater for the 100-year ARI peak flow with 0.3m freeboard (including afflux).

Portions of the site are identified as being flood liable by regional flood studies. It must therefore be demonstrated that development of the subject land can be made compatible with the NSW Floodplain Development Manual (2005). The Floodplain Development Manual requires consideration of the total flood risk, being up to and including the Probable Maximum Flood (PMF).

Flooding outcomes are addressed in ***Section 6***.

3.3 STORMWATER QUALITY

The proposed development is to include water quality treatment devices within the site to reduce pollutant loads prior to discharging downstream. Council's stormwater quality targets for urban areas are shown in ***Table 1.***

Table 1 - Water Quality Targets (Maitland City Council, 2014)

Pollutant	Targets
Total Suspended Solids (TSS)	80% of average annual load
Total Phosphorus (TP)	45% of average annual load
Total Nitrogen (TN)	45% of average annual load
Litter	Retention of all litter greater than ϕ50mm for flow up to the 3-month ARI peak flow
Oil and Grease	90% of average annual load

Runoff quality improvement is addressed in ***Section 7*** of this report.

3.4 SOIL AND WATER MANAGEMENT

Soil and Water Management (SWM) is to be undertaken according to Landcom's *Blue Book* (2004) and Council's Manual of Engineering Standards, specifically Appendix B. The intent of this requirement is to mitigate erosion and prevent sediment-laden run-off from leaving the site during site preparation and construction. SWM is addressed in ***Section 8*** of this report.

3.5 PROTECTION OF RIPARIAN CORRIDORS

The Lochinvar URA DCP establishes an intent to minimise vegetation clearing within riparian corridors and preserve their long-term character and amenity. The Natural Resource Access Regulator defines acceptable activities within riparian zones on the basis of a stream hierarchy (DPE 2022).

Management of riparian corridors is addressed in ***Section 9***.

3.6 LOCHINVAR URA DCP

In relation to stormwater and water quality management, the objectives of the Lochinvar URA DCP (Part 9) are as follows:

1. To provide for an integrated and sustainable approach to the design and provision of open space and urban water management;
2. To protect and enhance the water quality, water quantity and habitat value of downstream waterways and environment; and
3. To prevent erosion and run-off during site preparation, construction and the ongoing use of the land to minimise cumulative impact on receiving waterways.

The DCP imposes 21 controls towards the referenced objectives. A DCP compliance table is provided in ***Section 10***.

4.0 Stormwater Strategy

As discussed in ***Section 2.1***, the existing hydrology is characterised by moderate slopes and a single well-defined watercourse flowing through the southern portion of the site. A focal point of this strategy was to formalise site run-on whilst respecting the site's existing drainage regime.

The proposed development will drain to two legal points of discharge, being:

1. The Lochinvar Creek tributary which conveys through the site; and
2. The existing drainage gully in Lot 2 1299958.

The southern catchment will be serviced by a conventional pit-and-pipe system draining to a bioretention basin in the south-western corner of the site, ultimately discharging to the tributary watercourse. The level of the basin is governed by the invert of the watercourse and the levels of the existing sewer rising main running through the middle of the site. The southern catchment's treatment train consists of a Gross Pollutant Trap (GPT) and bioretention basin in addition to rainwater tanks expected on each lot.

The smaller northern catchment's total area is reduced by the proposed development. This is owing to site regrading which redirects the catchment southwards towards the tributary watercourse. This catchment will be serviced by piped drainage reporting to a bioretention basin in the north-western portion of the site. The southern catchment's treatment train consists of a Gross Pollutant Trap (GPT) and bioretention basin in addition to rainwater tanks expected on each lot.

The northern bioretention basin has been designed to satisfy council's requirements, but is intended to be temporary only. This is on the basis that that future development of the western (downstream) lot would be supported by additional WSUD infrastructure which could cater for this small catchment, and consolidating stormwater infrastructure to avoid multiple assets for Council to maintain. This temporary basin will be removed once a future basin within the Lochinvar URA is constructed, accommodating of the site's runoff. The temporary basin will remain in the ownership of the developer along with the maintenance burden until this occurs.

As noted in ***Section 2.2***, flows from an existing upstream catchment are conveyed under Wyndella Road via a culvert crossing and continue through the site via an existing gully. Council has advised that routing this catchment via piped drainage along Wyndella Road is not supportable. An updated drainage design has been developed which more closely mimics existing conditions as follows:

- The existing culvert crossing will be upgraded and connected to the development's internal drainage network; and
- The low point in Wyndella Road will be retained, creating an overland flow path into the internal road network.

By retaining the existing low point and directing runoff through the site it follows that the hydrologic regime south of the Wyndella Road culverts is not impacts.

Previous submissions of DA/2023/415 were constrained by the existing Lochinvar Creek Tributary which bisects the site. Council's RFI dated 13th November 2023 identified several undesirable outcomes created by the watercourse, including location of the public park, lot access, connectivity of the southern cul-de-sac road, provision of drainage for the Hereford Hill catchment and arrangement of an acoustic mound on the southern boundary. Consistent with its stream order (1st), this revised application proposes to realign the watercourse along the site's southern boundary. This realignment allows the upstream Hereford Hill catchment to report directly to the watercourse and consolidates lots and open space on the northern side. Additionally, the watercourse's repositioning closer to the New England Highway creates exceptional outcomes in relation to access for maintenance and visual amenity.

The proposed stream realignment has created opportunities to establish a Biodiversity Management Plan over the watercourse and land on its southern overbank. The realigned watercourse will incorporate riparian vegetation and a meandering low-flow channel with pools and riffles in accordance with Biodiversity Management Plan by AEP. The watercourse's geometry has been defined to meet Council's freeboard requirements to top-of-bank and created lots.

Also noted in ***Section 2.2***, flows from the existing upstream Hereford Hill catchment are conveyed through a culvert crossing beneath the New England Highway and discharge to the subject site in an uncontrolled manner. Following advice from AEP to preserve and mimic existing site conditions, it is proposed that the existing 'dispersion area' be retained. Overflows from the dispersion area will report directly to the realigned watercourse, whilst the high-flow bank has been repositioned along the site's southwestern boundary to divert runoff away from Lot 1 DP741330. Placing the bank on the site's southwestern boundary will provide public benefit by protecting downstream eastern properties from flood impacts up to the 1% AEP design event.

The existing culvert crossing conveying the tributary watercourse beneath Wyndella Road will be upgraded as part of the New England Highway/Wyndella Road Intersection.

Stormwater strategy outcomes in relation to peak flow management, runoff quality, flooding, erosion and sediment control and riparian corridor management are provided from ***Sections 5*** to **9**.

5.0 Peak Flow Management

The proposed development will increase the catchment's impervious area and therefore contribute to additional stormwater runoff. InfoWorks ICM was used to compare peak flow magnitudes under existing and developed conditions to establish detention warrants for the proposed development in the context of Council's requirements.

5.1 MODELLING PARAMETERS

5.1.1 Rainfall Intensity

The Rainfall Intensity Frequency Duration (IFD) data adopted was sourced from the Bureau of Meteorology website (IFD 2019 application). AR&R 2019 procedures were adopted following Council advice. It is noted that the Lochinvar URA DCP and upstream Hereford Hill stormwater management planning were based on AR&R 1987 procedures.

5.1.2 RAFTS Parameters

The InfoWorks ICM model was developed using the RAFTS routing model.

Key RAFTS parameters used within the model are summarised in ***Table 2*** below.

Table 2 - RAFTS Modelling Parameters

Parameter	Pervious Area	Imperious Area
Manning's 'n'	0.035	0.014
Initial Loss (IL)	10.0mm	1.2mm
Continuing Loss (CL)	2.5mm/hr	0mm/hr

The parameters outlined in ***Table 2*** are consistent with the approved Stormwater Management Plan for the upstream Hereford Hill catchment developed by ADW Johnson (November 2017).

5.2 CATCHMENTS

Catchments and subcatchments were delineated by analysis of the field survey undertaken as well as the topographical survey information (LiDAR) and concept engineering plans. Predeveloped and developed catchment plans are provided in ***Appendix A***. Detailed catchment parameters are provided in ***Appendix B***.

Council has advised that peak flow assessment is to consider the subject site in isolation with a view to avoid 'sneaking the peak'. A theoretical model was therefore developed which excludes the upstream catchments reporting through the tributary watercourse, including the Hereford Hill Development. The site's northern upstream catchments were retained in the model as these directly enter the proposed development via the piped drainage network.

5.2.1 Predeveloped Catchments

Predeveloped catchments containing unimproved pastoral land (including the subject site) were assumed to be wholly pervious. A modest provision for the existing Impervious fraction of Wyndella Road was adopted based on Aerial imagery. ***Table 3*** summarises the predeveloped catchment parameters.

Table 3- Predeveloped Catchment Parameters

Catchment	Sub-Catchment	Area (ha)	% Impervious
Southern Catchment	PRE 2	17.88	2%
	PRE 3	12.55	0%
	PRE 4	3.27	7%
	Subtotal	**33.70**	**2%**
Northern Catchment	PRE 1	6.23	0%
	Subtotal	**6.23**	**0%**
	TOTAL	**39.93**	**2%**

5.2.2 Developed Catchment

Developed catchments were delineated utilising the proposed site grading plan and concept stormwater layout. Maitland City Council's Manual of Engineering Standards includes standard impervious fractions for different land uses as shown in ***Table 4***.

These values have been incorporated into the hydrologic model.

Table 4 - Fraction Impervious Rates for Land Uses

Land Use	Fraction Impervious
Residential Lot Size < 1000 m^2	0.6
Road Reserve	0.7
Public Recreation Areas (mowed and with improvements)	0.5
Parkland, Natural Public Reserve	0.5

Source: MOES 2014

A summary of developed catchment parameters is provided in ***Table 5.***

Table 5 - Developed Catchment Parameters

System	Catchment	Area (ha)	% Impervious
Southern Catchment	DEV 2	18.38	64%
	DEV 2 EXT	12.55	0%
	DEV 4	2.38	51%
	DEV 5	1.44	16%
	Subtotal	**34.75**	**38%**
Northern Catchment	DEV 1	1.94	64%
	DEV 1 EXT	3.21	0%
	Subtotal	**5.15**	**23%**
	TOTAL	**39.90**	**36%**

From ***Table 5*** it is seen that the northern catchment's total area is reduced by the proposed development. This is owing to site regrading which redirects the catchment towards the tributary watercourse. Reciprocally, a modest increase in the tributary watercourse catchment is reported. A modest reduction in the overall catchment area is accounted for by small batters and to the northwest of the site associated with the future regrading of Wyndella Road allowed for by the concept engineering plans.

5.3 STORMWATER DETENTION

A stormwater detention basin is proposed on the site's southern catchment, being Basin 1. Assumed basin parameters are presented in ***Table 6.***

Table 6 – Basin 1 Parameters

Basin Parameter	Detail
Levels	30.30m AHD - Invert Level
	32.30m AHD - Berm Level
Outlet 1	1200mm x 1200mm RGSIP
	IL 30.60m AHD
	2x 525mm RCP
	IL 30.00m AHD
Outlet 2	2400mm x 2400mm RGSIP
	IL 31.00m AHD
	2x 900mm RCP
	IL 30.00m AHD
Outlet 3	Emergency Spillway - 10m Length, 1:5 Sides - IL 32.00m AHD
1% AEP Storage Volume	3,180 m^3

It is noted that the proposed outlet configuration is conceptual. Alternate configurations (such as cut-out pits) are acceptable provided an equivalent stage-discharge relationship is adhered to.

5.4 PEAK FLOW RESULTS

The predeveloped and developed peak flows were estimated using InfoWorks ICM all design events up to and including the 1% AEP.

Peak flows at Node 2 (northern catchment) are presented in ***Table 7***.

Table 7 - Node 2 Modelling Results

Design AEP	Peak Flowrate (m^3/s)	
	Predeveloped	Developed
63%	0.362	0.303
10%	0.984	0.816
5%	1.288	1.037
2%	1.745	1.379
1%	2.106	1.662

From ***Table 7*** it is seen that the peak developed flows from the catchment are smaller than the related predeveloped flows. This is an expected result due to the reduction in catchment size after development. It follows that detention is not required at this discharge point.

Peak flows at Node 1 (southern catchment) are presented in ***Table 8***.

Table 8 - Node 1 Modelling Results

Design Average Recurrence (years)	Peak Flowrate (m^3/s)	
	Predeveloped	Developed (Detained)
63%	1.678	1.570
10%	4.857	4.766
5%	6.002	5.783
2%	7.859	6.498
1%	9.427	7.942

From ***Table 8*** it is seen that the proposed detention basin is appropriately sized to attenuate peak discharges to their predeveloped magnitudes. Peak stages within Basin 1 are presented in ***Figure 12***.

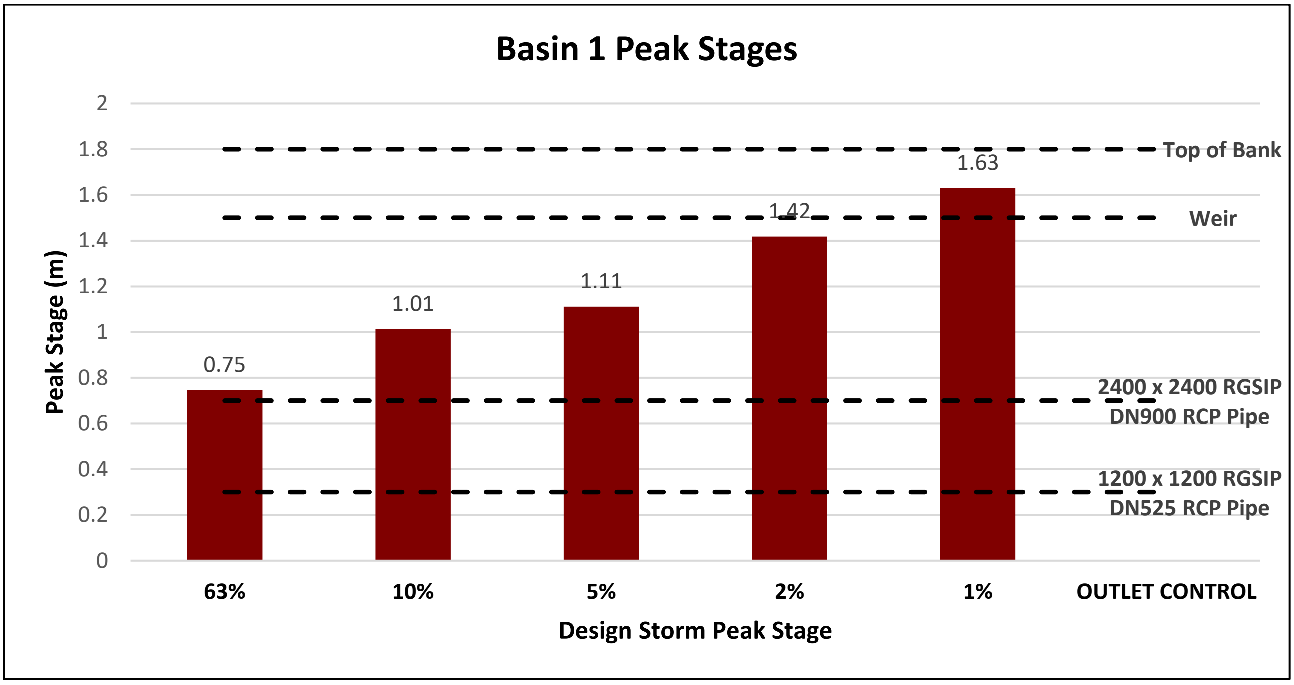

Figure 12 – Basin 1 Peak Stages.

From ***Figure 12*** it is seen that the proposed basin provides more than 150mm freeboard to the basin embankment during the critical 1% AEP design storm. Importantly, peak stage in the 5% AEP design event is less than 1.2m (MOES Stormwater Cl 8.1.5).

6.0 Flood Study

As noted in ***Section 2.2***, the site receives a significant upstream catchment via a tributary of Lochinvar Creek. A 1-dimensional flood study has been undertaken to verify that the proposed development is compatible with existing flood behaviour and the requirements of the NSW Floodplain Development Manual (2005).

The US. Army Corps of Engineers River Analysis System (HEC-RAS) software was used to compare flood extents under existing and developed conditions. Consideration was given to proposed cross-drainage structures and outcomes relating to extreme flood events. This section makes reference to existing flood studies within the Lochinvar Creek catchment.

6.1 PREVIOUS REPORTING

The Lochinvar Urban Release Area has been the subject of extensive flood reporting, as summarised below.

6.1.1 Lochinvar Flood Study (WMA Water, 2019)

The Lochinvar Flood Study (WMA Water, 2019) was adopted by Maitland City Council in 2019 and provides a comprehensive technical investigation of flood behaviour for the entire Lochinvar Creek Catchment. The report's scope addressed local flood behaviour for design events up to and including the Probable Maximum Flood (PMF). Consideration was given to hydraulic hazard categorisation and flood emergency response outcomes.

6.1.2 Lochinvar Urban Release Area Flood Study (ADW Johnson, 2015)

ADW Johnson was engaged by Maitland City Council to undertake a flood study in support of the Lochinvar URA Planning Proposal. The Lochinvar Urban Release Area Flood Study (ADWJ, 2015) was informed by 1-dimensional hydraulic modelling of the URA under existing and developed conditions. The report identified warrants for upgrades to an existing culvert in Wyndella Road.

6.1.3 Hunter River: Branxton to Green Rocks Flood Study (WMA Water, 2010)

Lochinvar Creek is a tributary of the Hunter River and is therefore modulated by regional flood behaviour. The Hunter River: Branxton to Green Rocks Flood Study (2010) provides a comprehensive analysis of Hunter River flooding for design events up to the Probable Maximum Flood. Lochinvar Creek was modelled as a backwater basin and its catchment was assigned to the Hunter River as an inflow hydrograph.

The Lochinvar Flood Study (WMA Water, 2017) adopted the 5% AEP Hunter River Flood Level as its downstream boundary condition, noting that significant local flooding can occur within the catchment in isolation of regional flooding.

6.2 MODELLING INPUTS

Watercourse networks were developed under existing and developed conditions in accordance with the existing hydrology (***Section 2.3***) and the proposed stormwater strategy. ***Appendix D*** presents network diagrams which clearly define the river and reach numbers of each modelled watercourse.

6.2.1 Inflows

Separate to the 'isolated' detention assessment presented in ***Section 5***, a standalone InfoWorks ICM scenario was developed which reintroduced upstream and downstream catchments. Peak 1% AEP and PMP design flows were obtained from the model at key locations.

Corresponding ICM subcatchments and HEC-RAS rivers are summarised in ***Tables 9*** and ***10***.

Table 9 - HEC-RAS Flow Inputs – Existing Conditions

HEC-RAS River/Reach	RAFTS Node	1% AEP Flow (m^3/s)
RIVER 1 CH 1566	PRE 5	16.18
RIVER 1 CH 1030	8.1 (Confluence of Hereford and Dev 4)	18.77
RIVER 1 CH 957	10.1 (Confluence of Pre 2 and Pre 4)	22.80
RIVER 1 CH 574	DS Break 1	49.05
RIVER 2 CH 638	PRE 3	4.10
RIVER 3 CH 357	DS 2	22.42

Note: Refer Appendix D for location of rivers and reaches.

Table 10 - HEC-RAS Flow Inputs – Developed Conditions

RAFTS Node	HEC-RAS River/Reach	1% AEP Flow (m^3/s)	PMP Flow (m^3/s)
RIVER 1 CH 574	DS BREAK 1	49.31	350.71
RIVER 2 CH 308	PRE 3	4.10	22.90
RIVER 3 CH 357	DS 2	22.16	159.90
RIVER 4 CH 996	PRE 5	16.18	112.31
RIVER 4 CH 437	8.1 (Confluence of Hereford and Dev 4)	17.52	131.66
RIVER 4 CH 284	10.1 (Confluence of Dev and Pre 4)	22.80	156.63

Note: Refer Appendix D for location of rivers and reaches.

6.2.2 Roughness

Modelled roughness values were adopted from WMA Water, 2017 and confirmed by way of field inspection. Modelling assumed the following Mannings 'n' values:

- 0.07 for lightly vegetated watercourses;
- 0.07 for the proposed realigned watercourse's main channel; and
- 0.04 for general overbank areas and unvegetated watercourses.

6.2.3 Boundary Conditions

Consideration was given to adopting the Hunter River regional flood level as a downstream boundary condition. However, with reference WMA Water, 2017, a lower value was adopted to not misconstrue local flood behaviour.

A fixed tailwater condition was applied to the Lochinvar Creek Tributary near the northern end of Cantwell Road. Known water surface levels were adopted from flood mapping appended the Lochinvar Creek Flood Study (WMA Water 2017) as follows:

- 100-year ARI – RL 24.0m AHD; and
- Probable Maximum Flood – RL 28.0m AHD.
-

6.3 EXISTING FLOOD BEHAVIOUR

Existing flood extents and levels are provided in ***Appendix C***. Extents are generally consistent with WMA Water, 2017.

Existing culvert structures in Wyndella Road were modelled without blockage. Modelling confirmed that Wyndella Road's northern culverts are undersized, with overtopping of Wyndella Road subject to the 1% AEP design flood. The existing DN525 culverts create a constriction which elevates upstream flood levels on Lot 225 DP 246447. This is an important result which identifies a need to address Wyndella Road's existing drainage regime.

Similarly, Wyndella Road's southern culverts were also found to overtop subject to a peak 1% AEP design flow. This is consistent with WMA Water, 2017 which observed that Wyndella Road South overtops in a 2% AEP event.

Runoff from the New England Highway's culverts was not modelled under existing conditions. As noted in ***Section 2.3***, the catchment's flowpath is poorly defined and not conducive to 1-dimensional flood assessment. Notwithstanding, modelling identified significant overbank flow into Lot 1 DP741330 which is consistent with anecdotal evidence and ground-truthing.

6.4 DEVELOPED FLOOD BEHAVIOUR

Developed flood extents and levels are provided in ***Appendix C***. From ***Appendix C*** the following outcomes are evident:

- The realigned tributary of Lochinvar Creek adequately contains the 1% AEP peak flood without overtopping of roads or embankments;
- All proposed lots have more than 500mm freeboard to the 1% AEP design flood. The realigned watercourse provides more than 300mm freeboard to the top of channel. ***Table 11*** presents design levels and freeboard for each waterfront lot.
- Upgraded culverts under Wyndella Road (south) serve to reduce upstream flood extents within Lot 223 DP 246447. This is an expected result given the existing culverts are undersized with respect to the design 1% AEP flowrate; and
- There is no observable impact to upstream or downstream flood extents or velocities up to the 1% AEP design flood.

Table 11 – Freeboard at Waterfront Lots

Lot	1% AEP Flood Level (m AHD)	Embankment Level (m AHD)	Embankment Freeboard (m AHD)	Lot Level[1] (m AHD)	Lot Freeboard (m AHD)
218	34.12	34.79	0.67	35.67	1.55
219	33.92	34.59	0.67	35.51	1.59
220	33.8	34.44	0.64	35.37	1.57
221	33.69	34.31	0.62	35.26	1.57
222	33.55	34.21	0.66	35.17	1.62
223	33.43	34.10	0.67	34.95	1.52
202	31.54	32.92	1.38	33.41	1.87
201	31.42	32.79	1.37	33.25	1.83

1. *Taken at the 5m front setback.*

These outcomes confirm that the proposed development is compatible with Maitland City Council's Manual of Engineering Standards and the NSW Floodplain Development Manual.

6.5 TRUNK DRAINAGE INFRASTRUCTURE

HEC-RAS flood modelling was used to size and analyse trunk drainage infrastructure. Consideration was also given to redirection of catchment from the existing northern Wyndella Road culverts vial proposed piped drainage infrastructure. These are detailed in ***Sections 6.5.1*** to ***6.5.2***.

6.5.1 Realigned Watercourse

HEC-RAS modelling was used to inform the typical section for the Wyndella Road Watercourse. Geometry for the watercourse is presented in ***Figure 13*** whilst key design parameters are presented in ***Table 12.***

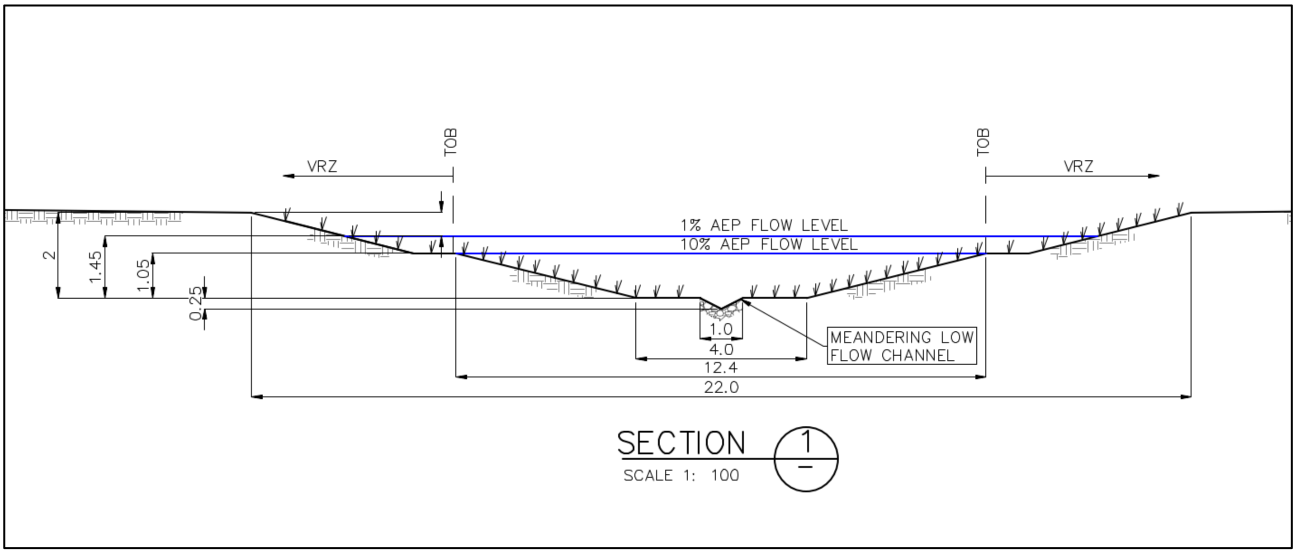

Figure 13 – Realigned Watercourse Typical Section.

Table 12 – Realigned Watercourse Typical Details

Parameter	Value
Base width (excluding low-flow)	4m
Batter slopes	1V:4H
Roughness	0.07 (between banks) 0.04 (overbank)
Channel slope	0.8%
1% AEP design flow	17.5 m^3/s

6.5.1 Wyndella Road Culverts (South)

Corroborated by this study, the Lochinvar Urban Release Area Flood Study (ADW Johnson, 2015) justifies upgrades to the existing circular culverts in Wyndella Road. HEC-RAS was used to size culverts to safely convey the 1% AEP peak flowrate as derived from RAFTS modelling (***Section 5***). The design blockage factor for each structure was deemed to be 0.25 in accordance with Australian Rainfall & Runoff's *Blockage of Hydraulic Structures* (2019). Blockages were directly applied uniformly from the culverts' invert within HEC-RAS.

Table 13 presents indicative sizing and hydraulic performance of the proposed Wyndella Road Culverts.

Table 13 – Wyndella Road Culvert Details

Property	Value
1% AEP peak flow	16.18 m^3/s
Design Levels	33.30m AHD (upstream invert)
	35.00m AHD (roadway)
Culvert configuration	7 x 1.5m (W) x 0.9m (H) RCBC
Tail Water Level	34.60 m AHD (proposed)
	34.92 m AHD (existing)
Freeboard (m AHD)	0.40m (to carriageway)

It noted that the culvert sizing reported herein is illustrative only. It is recommended that sizing is reviewed at detailed design, subject to confirmation of roadway levels and watercourse hydraulics. It is evident from ***Table 13*** that the culvert sizing is governed by freeboard to the Wyndella Road carriageway. There is clear justification for smaller culverts should there be scope to lift Wyndella Road (for instance through detailed design of the future AURA intersection upgrade).

Similarly, it is noted that a bridge structure or alternate culvert configuration should not be precluded subject to hydraulic capacity assessment.

6.5.3 Wyndella Road North Catchment

As noted in ***Section 4***, Wyndella road will be regraded southwards to render the existing northern culverts obsolete. The existing culverts receive a catchment of approximately 12.6 Ha corresponding to a 1% AEP peak flow of 4.10 m^3/s. This catchment is to be integrated with the development's internal drainage network.

The Wyndella Road drainage inlet was assessed using Henderson's *Open Channel Flow* stage-discharge relationships. Modelling assumed a 1.5 x 3.0m RGSIP positioned in the existing low point with a blockage factor of 50%. Hydrologic and hydraulic analysis confirmed that the proposed inlet can accept the 1% AEP peak flow with allowance for blockage.

The low point in Wyndella Road has been retained. An inverted verge is proposed at the sag to allow an overland flow path into the site, consistent with existing conditions. A parallel internal road (MC09) has been provided as an overland flow path to direct runoff through the site. Piped drainage will be sized such that bypass flows are safely conveyed within the road network.

To provide further contingency, a drainage channel is proposed on the eastern side of Wyndella Road consistent with Maitland Standard Drawing SD003. The intent of this channel is to protect the Wyndella Road pavement from a small rural upstream catchment.

6.6 RARE AND EXTREME FLOOD EVENTS

Probable Maximum Precipitation (PMP) is defined by the World Meteorological Organization (1986) as '*the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year*' (BOM 2003). The PMP does not represent a realistic event, with an estimated exceedance probability of one-in-ten million for a catchment of the subject's size (Lauenson and Kuczera 1999). However, it is of interest in the context of flood emergency and response planning, as well as risk assessment.

The PMP rainfall for the subject site was estimated using the Bureau of Meteorology's *Generalised Short-Method (GSDM)* for durations ranging from fifteen minutes to six hours. XPRAFTS was used to estimate peak PMP flows. The PMP catchment loss model was consistent with ***Section* 6.2** as statistically-dependent loss models are generally discouraged (AR&R 2019).

PMF extents were modelled in HEC-RAS by routing the estimated PMP flows through the developed terrain model. Predicted PMF extents are presented in ***Appendix C***. Key outcomes in relation to rare and extreme flooding are summarised in ***Section* 6.6.1** to **6.6.2**.

6.6.1 Flood Affectation

From ***Appendix C*** it can be seen that all lots are free of the PMF envelope with the exception of several batters within the 5m front setback. This is an important result which confirms that refuge-in-place is possible for all dwellings.

Modelling of PMF flows through the road and piped drainage network is beyond the scope of this assessment.

6.6.2 Flood Emergency Response

As noted in ***Section 6.6***, the PMF is conventionally used as a tool for emergency response planning. Flood Emergency response planning was examined by the Lochinvar Flood Study (2019). WMA Water Identified that, under existing conditions, Wyndella Road and sections of the New England Highway would be inundated by the PMF.

The Lochinvar Flood Study does not identify the New England Highway as being cut off to the east of Wyndella Road, providing an evacuation route to the east (***Figure 14***).

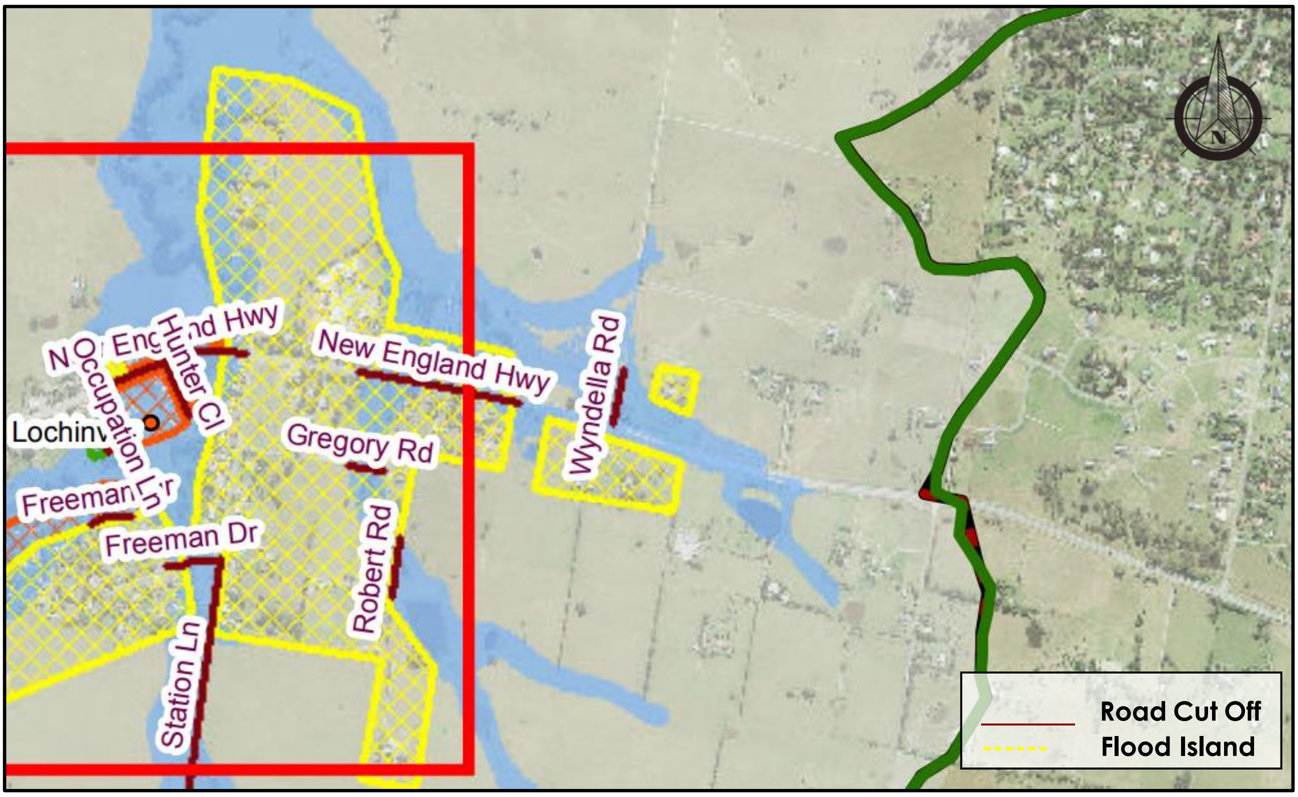

Figure 14 - Emergency Response Classification.
(Source: WMA Water, 2019)

Whilst no lots are liable to the PMF, each of the site's north-south roads may be utilised as a rising escape route. Wyndella Road is also considered to provide a rising escape route to the north.

7.0 Water Quality

The quality of the stormwater discharging from the development was determined using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). The MUSIC model was used to simulate pollutant source elements for the proposed development and the treatment of the pollutant loading using treatment devices.

7.1 MUSIC MODELLING PARAMETERS

7.1.1 Rainfall and Evapotranspiration

Rainfall data from Tocal, Paterson weather station was input into the MUSIC model. Paterson is situated 30km west of the subject site and suitably reflects local conditions. Six-minute rainfall information for the year of 1989 was analysed and deemed to be a reasonable representation of the average yearly rainfall and rainfall event distribution. A comparison of Paterson's 1989 rainfall with the long-term averages for Paterson is presented in ***Table 14*** below.

Table 14 – Comparison of Paterson Rainfall Data

Data suite	Paterson1989	Paterson Long-term Average
Annual rainfall (mm)	904.6	940.3
Annual days of rainfall	89	89.9

It can be seen from ***Table 14*** that the rainfall and number of rainfall days for Paterson in 1989 was comparable with the annual averages taken for the 50-year period from 1967 to 2018. The annual rainfall and evapotranspiration time series graph for Paterson in 1989 is shown in ***Figure 15.***

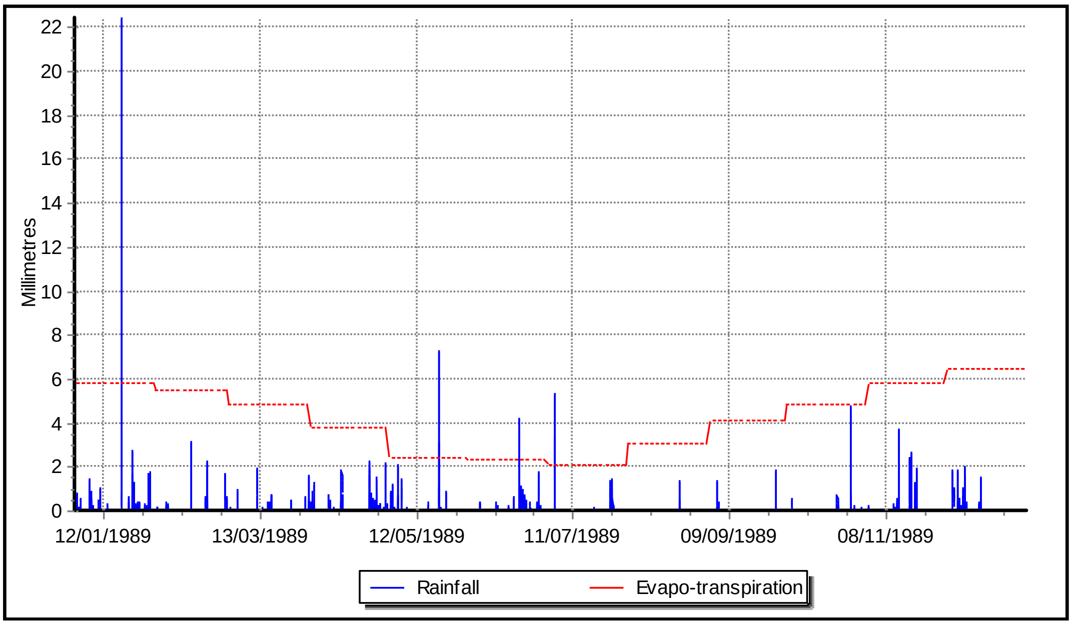

Figure 15 – Rainfall and Evapotranspiration Graph.

7.1.2 Catchments and Land Use

The developed catchment was delineated according to their treatment trains and points of discharge. Catchments were generally consistent with those used for peak flow estimation, noting there is no obligation to consider upstream catchments which bypass treatment.

Each catchment was broken down according to surface type as identified from the site masterplan. The MUSIC model incorporated the following surface types:

The MUSIC model defined the following land uses:

- Roof (Urban) – This land use defines the impervious roof area of each lot. Rooves are assumed to account for 50% of each lots area and are100% impervious;

- Lots (Urban) – This land use defines the lot area after the removal of the roof area. Lots were modelled in MUSIC using residential source nodes. Lots were assumed to be 20% impervious and account for the remaining 50% of overall lot area;

- Road (Urban) – This land use defines the road reserve area. Roads were assumed to be 70% impervious which is consistent with MOES 2014;

- Open Space (Urban) – This land use defines future parks and stormwater management facilities. Open space was represented in MUSIC using residential source nodes and were assumed to be 50% impervious; and

Summation of roof and lot areas equates to an impervious fraction of 60% for total lot areas. Impervious fractions for each land use are in accordance with MOES for residential lots of less than 1000m^2.

Table 15 summarises the area and composition of each MUSIC subcatchment. A MUSIC catchment plan is provided as ***Appendix E***.

Table 15 - MUSIC Catchment Areas

Catchment	Total Area (Ha)	Lot (Ha)	Roof (Ha)	Road (Ha)	Open Space (Ha)
DEV 1	1.69	0.52	0.52	0.65	0.00
DEV 2	16.36	5.36	5.36	5.21	0.44
DEV 3	1.45	0.25	0.25	0.44	0.50
TOTAL	**19.50**	**6.13**	**6.13**	**6.13**	**0.94**

It is noted that DEV 3 drains towards the south and discharges into the realigned watercourse. The treatment train for this catchment comprised of rainwater tanks located on each lot.

7.1.3 Rainfall-Runoff Parameters

Surface parameter inputs and pollutant concentrations were obtained from the *'NSW MUSIC Modelling Guidelines'* (BMT WBM, 2020) and checked for consistency against approved stormwater management plans in the Lochinvar URA.

Rainfall-runoff parameters are summarised in ***Table 16***.

Table 16 – Rainfall-Runoff Parameters

Parameter	Lot	Roof	Road	Open Space
Rainfall Threshold (mm/day)	1.0	0.3	0.5	1.0
Soil Storage Capacity (mm)	120			
Initial Storage (% of Capacity)	25			
Field Capacity (mm)	80			
Infiltration Capacity Coefficient - a	200			
Infiltration Capacity Exponent - b	1.0			
Initial Depth (mm)	10			
Daily Recharge Rate (%)	25			
Daily Baseflow Rate (%)	5			
Daily Deep Seepage Rate (%)	0			

7.2 TREATMENT DEVICES

A treatment train has been developed comprising of rainwater tanks, Gross Pollutant Traps (GPTs) and bioretention basins.

These treatment devices are described in detail in ***Sections 7.2.1*** to ***7.2.3***.

7.2.1 Rainwater Tanks

Rainwater tanks are at-source controls which harvest roof water and store it for on-site reuse. These controls are used on each lot as each dwelling is required to comply with BASIX requirements. A volume of 3000L for each tank has been conservatively adopted, the BASIX requirements is expected to yield in the range of 3000 – 4000L.

Table 17 outlines the rainwater tank parameters adopted for modelling purposes.

Table 17 - Rainwater Tank Parameters

Catchment	A
Volume Below Overflow Pipe (L)	3000
Depth Above Overflow pipe (m)	0.2
Surface Area (m^2)	3
Overflow Pipe Diameter (mm)	100
Daily Reuse (kL/day/dwelling)	0.324

The daily reuse was estimated from the NSW MUSIC Modelling Guidelines (BMT WBM, 2015). Allowance was made for an average household of three people utilising harvested rainwater for toilets, laundry and outdoor use.

7.2.2 Gross Pollutant Traps

GPTs are utilised as conveyance controls of litter and heavy settlement. Modelling was based on the Humes 'Humegard' which has been implemented successfully throughout developments of similar scale. Pollutant removal efficiencies were obtained from Humes' website and are presented in ***Table 18***.

Table 18 - GPT Pollutant Removal Efficiencies

Pollutant	% Removal Efficiency
Total Suspended Solids	49
Total Phosphorus	40
Total Nitrogen	26
Gross Pollutants	90
Total Hydrocarbons	90

Source: Humes 2023

Two catchments – DEV 1 and DEV 2 – report to GPTs situated in the site's low points. Estimates for the 3-month ARI peak flowrate – taken as 50% of the 1-year ARI flowrate obtained from RAFTS modelling – were compared against treatable flowrates to ensure GPTs were appropriately sized. Modelled GPT sizes are summarised in ***Table 19***, however would be reviewed subject to detailed design.

Table 19 - GPT Sizing

Catchment	Humegard Model	Treatable Flowrate (L/s)
DEV 1	HG15	130
DEV 2	HG35	1540

7.2.3 Bioretention Basins

Biorention basins are utilised as end-of-line controls consisting of a sandy loam media and selective planting. They provide essential pollutant reduction through the filtration and chemical uptake through biologically active media.

Both the larger site catchment (Dev 2) and the smaller north-western catchment (Dev 1) will report to bioretention basins downstream of their respective GPTs. Basins have been positioned to intercept a majority of runoff and are located offline of the site's existing watercourse. A 1.5m wide access track has been allowed for at each basin's perimeter for access and maintenance.

Table 20 summarises the modelled parameters for each basin.

Table 20 - Bioretention Basin Parameters

Bioretention Basin	South	North
Catchments Served	**DEV 2**	**DEV 1**
Surface Area (m^2)	1250	46
Extended Detention Depth (m)	0.3	0.3
Exfiltration Rate (mm/hr)	0	0
Filter Area (m^2)	200	20
Filter Depth (m)	0.5	0.5
Saturated Hydraulic Conductivity	180	180
Base Lined	Yes	Yes
Underdrain Present	Yes	Yes
Submerged Zone	No	No

7.3 WATER QUALITY RESULTS

A network diagram of the constructed MUSIC model, showing catchment links and treatment devices, is provided as an appendix to this report (***Appendix F***). Pollutant reductions for each individual catchment are provided as ***Appendix G***.

Monitoring nodes were used to represent pollutant loading from each of the road's discharge points, enabling pollutant reductions to be compared with the targets defined in ***Section 3***. The average annual pollutant loads for each point of discharge is shown in ***Tables 21*** and ***22***.

Table 21 - Treatment Train Effectiveness (Northern Discharge Point)

Pollutant	Developed Untreated Load (kg/yr)	Developed Treated Load (kg/yr)	Reduction (%)
TSS	1600	9.36	80.7
TP	3.21	308	64.4
TN	22	11.4	48.2
GP	335	0	100

Table 22 - Treatment Train Effectiveness (Southern Discharge Point)

Pollutant	Developed Untreated Load (kg/yr)	Developed Treated Load (kg/yr)	Reduction (%)
TSS	15400	2980	80.7
TP	32.9	11.6	64.8
TN	224	104	53.5
GP	3460	208	94

From ***Tables 21*** and ***22*** it can be seen that the proposed treatment train satisfies Council's runoff quality improvement targets at each of the site's legal points of discharge. ***Table 22*** represents of the overall treatment train effectiveness for the southern catchment, comprised of DEV 2 and DEV 3 combined. Noting that a minimum 94% of gross pollutants were removed for the full simulation period, it is considered that Council's requirement in relation to litter control is met.

8.0 Soil and Water Management

Council requires the use of erosion and sediment controls to manage and contain pollutant runoff during construction. All erosion and sediment controls and practices are to be in accordance with Council's Manual of Engineering Standards Appendix B and Landcom's *Managing Urban Stormwater: Soils and Construction* (2004) ('the Blue Book').

Treatment devices will be utilised to contain the generated pollutants from the site during construction. These include but are not limited to:

- Silt Fencing;
- Strawbale and Geotextile Fencing;
- Kerb Inlet Controls;
- Sandbag Kerb Inlet Sediment Traps;
- Shaker Ramps; and
- Diversion Drains.

Any clean water entering the site from upstream catchments is to be diverted around the construction site where possible hence remaining clean. Runoff generated from within the site is to be treated and managed using a combination of the above stated treatment devices.

It is noted that development of the site will incur significant earthworks. Construction is proposed in stages to minimise the area of disturbed soil at any given time. Consideration will be given to the construction of temporary sediment basins which would be sized and configured during detailed design.

A preliminary Soil and Water Management Plan is presented within the associated concept engineering plans (240332-CENG) by ADW Johnson. The Soil and Water Management Plan is indicative only as another Soil and Water Management Plan will be provided as part of the construction certificate drawings and a further plan will be provided by the contractor to evolve during construction.

9.0 Riparian Corridors

A riparian zone is land immediately alongside a watercourse and, when managed appropriately, often represents the most fertile and diverse portion of the surrounding landscape (NRAR 2018). Riparian lands contribute to streambank stability and ecological productivity, but may be vulnerable to deterioration induced by human activities.

The Natural Resources Access Regulator prescribes minimum Vegetated Riparian Zones (VRZs) on either side of a recognised watercourse. Works within VRZs are restricted to certain activities which cause limited disturbance to the riparian corridor in accordance with the *Water Management Act 2000 (NSW)*. VRZ widths are a function of streamflow category as follows in ***Table 23***.

Table 23 - Recommended Riparian Corridor Widths

Stream category	VRZ width (from top of bank)
1st order	10 m
2nd order	20 m
3rd order	30 m
4th order	40 m

Where development encroaches onto a riparian corridor, the 'averaging rule' allows for development in the outer 50% of a VRZ provided offsets are created in the opposite corridor as shown in ***Figure 16*** below.

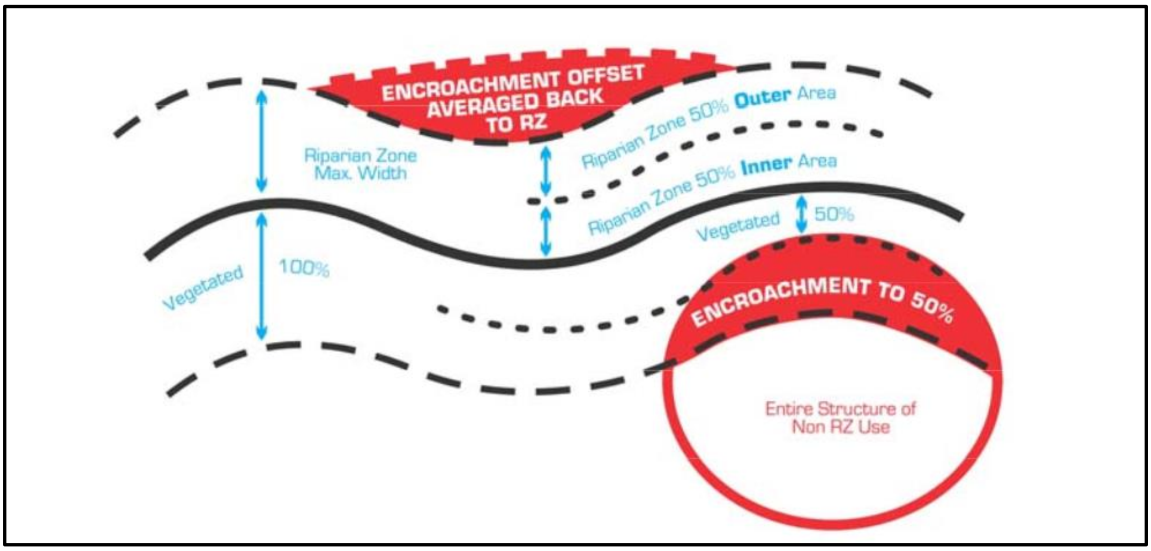

Figure 16 - Offset of Riparian Encroachment.
(Source: NRAR 2018)

The present tributary watercourse has been categorised in ***Section 2*** of this report and confirm that the site is subject to the controls of 1st order streams. Stream realignment is identified as an acceptable activity in the NRAR's *Riparian Corridor Matrix*. The watercourse's new alignment has been selected to maximise opportunities for establishing a riparian corridor.

Where necessary, the averaging rule will be applied to ensure that an adequate riparian corridor is retained. A plan of riparian corridor encroachments and offsets is provided as ***Appendix H*** and demonstrates that the requirements for controlled activities on waterfront land are met.

10.0 Development Control Plans

Section DC.3 of the Maitland Development Control Plan (Part C) relates to drainage, water quality and soil erosion controls. ***Table 24*** details each DCP requirement with commentary relating to the subject development.

Table 24 - Maitland DCP Controls

No.	Control	Response
DC.3.1	Existing topography and natural drainage lines should be incorporated into drainage designs for larger proposals, and enhanced through provision of additional landscaping, detention areas, artificial wetlands and the like.	The stormwater strategy respects the site's existing points of discharge and drainage regime. An existing watercourse, being a tributary of Lochinvar Creek, is to be retained as a key component of the site's stormwater management system. The watercourse will incorporate a Vegetated Riparian Corridor (VRZ) which will be improved by way of a Vegetation Management Plan. No artificial wetlands are proposed, however the proposed bioretention basins will incorporate landscaping and planting.
DC.3.2	Drainage from proposed lots should be consistent with the pre-development stormwater patterns. An analysis of the downstream drainage system, to the receiving area or waters, may be required.	Hydrologic modelling has been undertaken to compare peak site discharges under existing and developed conditions. Modelling has confirmed that the development will not intensify peak flows at either point of discharge, and that peak flows are well correlated to predeveloped magnitudes.
DC.3.3	Best management practices should be implemented to control runoff and soil erosion and to trap sediment on the subject land to ensure there is no net impact on downstream water quality. The quality of runoff water from the subject land should be the same or better than the quality of water prior to the subdivision taking place.	A stormwater quality treatment train has been developed comprising of rainwater tanks, Gross Pollutant Traps and bioretention basins. MUSIC modelling has confirmed that the proposed treatment train meets Council's load-based objectives in relation to runoff quality improvement.
DC.3.4	Where possible, design multiple use drainage and treatment systems incorporating gross pollutant traps, constructed wetlands and detention basins.	A stormwater quality treatment train has been developed comprising of rainwater tanks, GPTs, bioretention basins and buffer strips. No constructed wetlands are proposed.
DC.3.5	The subdivision should be designed so as to minimise disturbance of the subject land especially in circumstances where there are topographical constraints.	The proposed earthworks strategy has been optimised to existing site constraints including the existing watercourse, flood extents, presence of rock, existing services and the sightline from the New England Highway to the hillcrest. Topographically, existing high and low points have been respected.
DC.3.6	Adequate provision should be made for implementation of measures during subdivision construction to ensure that the landform is stabilised and erosion controlled.	Conceptual Soil and Water Management Plans are provided within the concept engineering plans. To ensure downstream waters and adjacent properties are protected, appropriate erosion and sediment controls are to be undertaken during construction. Controls are to be implemented and monitored in accordance with Landcom's 'Blue Book' and Council's engineering guidelines.

No.	Control	Response
DC.3.7	All trunk drainage is to be located in publicly owned land, (reserves), in open space land or in an appropriate easement.	Trunk drainage being the existing watercourse and the southwestern channel are to be dedicated as public drainage reserve.
DC.3.8	Where the drainage impacts of the subdivision proposal cannot be limited to pre-development stormwater levels by retention or other approved methods, drainage easements will be required over all necessary properties and watercourses. In such circumstances, the easement must be the subject of a signed agreement prior to issue of development consent. Such easements shall be created with, or prior to issue of the Subdivision Certificate.	Through the provision of stormwater detention facilities, modelling has confirmed that the development will not intensity peak flows at either point of discharge, and that peak flows are well correlated to predeveloped magnitudes. Hydraulic modelling has confirmed no affectation of upstream and downstream floods up to the 1% AEP.
DC.3.9	Where site topography in new residential subdivisions prevents discharge of storm water directly to the street gutter or a Council controlled pipe system, inter allotment drainage should be provided to accept run off from all existing or future parcels of land. The design and construction of the inter allotment drainage system should be in accordance with the requirements of Council's Manual of Engineering Standards.	The concept engineering plans show interallotment drainage and appropriate easements on all rear-draining lots.
DC.3.10	Where inter-allotment drainage is required, easements having a general minimum width of 1.5m are to be identified on plans submitted.	The concept engineering plans show interallotment drainage and appropriate easements on all rear-draining lots.
DC.3.11	A soil and water management plan (SWMP) should be prepared by a properly qualified practitioner with the aim of minimising erosion and maximising the quality of any water leaving the site. Applicants should refer to Council's Manual of Engineering Standards.	Conceptual Soil and Water Management Plans are provided within the concept engineering plans. To ensure downstream waters and adjacent properties are protected, appropriate erosion and sediment controls are to be undertaken during construction. Controls are to be implemented and monitored in accordance with Landcom's 'Blue Book' and Council's engineering guidelines.

From ***Table 24*** it is seen that Council's DCP requirements are met.

Due to its location within the Lochinvar URA, the development site is subject to requirements of the Lochinvar URA Development Control Plan. Section 1.5 of the Lochinvar URA DCP (Part 9) pertains to stormwater and WSUD controls. ***Table 25*** presents each DCP control with commentary relating to the subject development.

Table 25 - Lochinvar URA DCP Controls

No.	Control	Response
1.5.1	The stormwater and water quality management controls shall be consistent with the principles of Water Sensitive Urban Design (WSUD) Targets.	A WSUD treatment train has been developed which meets Council's pollutant reduction targets. Efforts have been made to 'disconnect' impervious surfaces, for instance by way of rainwater tanks.
1.5.2	The number and location of WSUD elements should be determined by modelling to develop the WSUD strategy for the site, and be integrated with the overall design and wider catchment.	MUSIC modelling has been undertaken to affirm the suitability of the proposed WSUD strategy.
1.5.3	Long-term maintenance costs are to be identified in the design of the WSUD elements and are to be submitted to Council for consideration prior to acceptance of the WSUD strategy.	The proposed treatment train is typical of Council's existing assets, the number of basins and GPTs has been minimised to reduce long-term maintenance costs.
1.5.4	Development Applications need to ensure that post-development stormwater flows do not exceed pre-development stormwater flows.	RAFTs modelling has confirmed that post-developed flows do not exceed predeveloped magnitudes at each point of discharge.
1.5.5	Development applications are to identify stormwater detention areas in accordance with the nominated locations identified in Figure 64, and supported by the flood Study prepared by ADW Johnson dated September 2015. It should be noted that the locations of the stormwater detention basins form part of the wider trunk drainage network, to which developers will be required to make contributions under the Lochinvar Section 94 Contributions Plan.	ADW Johnson 2015 does not propose any regional detention basins within the subject site. Upgrades to the Wyndella Road culverts (south) are identified under the Lochinvar Section 94 Contributions Plan and have been indicatively sized.
1.5.6	Stormwater calculations shall be based upon the ultimate development state of the catchment. The time of concentration is the time from the most remote part of the catchment to the catchment outlet. (i.e., from the top of Greedy Creek and Lochinvar Creek to the New England Highway).	Flood assessment modelling assumes full development of the subject site. The neighbouring Hereford Hill has been modelled under fully developed conditions. Consistent with Council advice, stormwater detention calculations have regarded the site in isolation.
1.5.7	No development can occur in the Greedy Creek or Lochinvar Creek catchments unless sufficient regional basin(s) are constructed to mitigate any impacts on Hunter Close catchment.	The proposed development is not upstream of the Hunter Close catchment.
1.5.8	Minimum road widths may need to be increased on account of WSUD features such as swales.	No swales are proposed to service the development's internal road network.
1.5.9	Swales may be accepted where it can be demonstrated that they will meet Council's performance and maintenance objectives and facilitate safe and effective movement of pedestrians and vehicles.	No swales are proposed to service the development's internal road network.
1.5.10	Swales may be considered on the outside of perimeter roads where no	No swales are proposed to service the development's internal road network.

No.	Control	Response
	residential access is provided. Swales shall not exceed 4% gradient.	
1.5.11	Flow control measures shall be used where grades in swales exceed 4%.	No swales are proposed to service the development's internal road network.
1.5.12	Where practical, WSUD elements may be incorporated in a centre depressed median of dual carriage roads.	No dual carriage roads are proposed by the subject development.
1.5.13	Wherever possible, existing natural drainage gullies should form part of a stormwater and runoff drainage management system. Detention basins and / or wetlands to alleviate stormwater peaks and retain pollutants can be considered on-line only for 1 stand 2nd order streams.	No online basins are proposed. The existing watercourse, whilst being realigned, remains an essential part of the stormwater management system.
1.5.14	Wetlands should be well-designed creating an attractive and safe amenity, and be highly visible for both the adjoining residents and passers-by.	No wetlands are proposed by the subject development. However, bioretention basins have been located prominently and are subject to landscape design. 1V: 5H internal batters are proposed for the southern basin for ease of egress.
1.5.15	Walking paths should have frequent contact adjacent to the wetland edge.	No wetlands are proposed by the subject development. However, a footpath is proposed around the perimeter of the site's main (southern) basin.
1.5.16	Vegetation should be designed such that generous unobstructed view of the wetland is available.	Refer landscape plans for detail.
1.5.17	Emergent macrophytes should be minimal and manageable.	Permanent waterbodies will be discouraged to minimise macrophyte growth.
1.5.18	Slopes surrounding wetlands should be gentle and offer convenient tractor mowing access.	No wetlands are proposed by the subject development. However, all batters are not steeper than 1V:4H and therefore considered mowable by a tractor.
1.5.19	Flat grassed areas that potentially may be water-logged should be avoided.	All open space areas are no flatter than 1% to promote surface runoff.
1.5.20	Gullies intended to be left in their natural state should be assessed, and if necessary enhanced to offset the need for maintenance.	The Lochinvar Creek tributary will be subject to a revegetation processes.
1.5.21	In general, grassed areas must be kept to a minimum for maintenance purposes, and wetland and gullies should offer a sense of ownership to the public.	Grassed areas have been kept to a minimum. No wetlands are proposed. Footpaths and a future park will front the Lochinvar Creek tributary to create a sense of public ownership.

From ***Table 25*** it is seen that Council's DCP requirements are met.

11.0 Conclusion

ADW Johnson has been engaged by Lochinvar Developments Pty Ltd to prepare a Stormwater Management Plan addressing the stormwater management requirements for a proposed subdivision of Lots 2-6 and 9 DP 747391 and Lots 12-13 DP 1219648 at Lochinvar ('the site'). This report accompanies a development application for the residential subdivision which shall create 258 lots and supporting infrastructure.

The site is characterised by moderate slopes falling towards a tributary of Lochinvar Creek which drains westward through the site. The tributary, being a first order watercourse, will be realigned by the proposed development with an appropriate VRZ. Whilst a majority of the site's catchment reports to this watercourse, a smaller catchment in the site's north reports to Lot 2 1299958 in the location of a future road extension (by others).

Hyrdologic modelling has been undertaken to compare peak runoff under existing and proposed conditions under existing and proposed conditions. RAFTS modelling confirmed that, owing to a redistribution of catchment under developed conditions, peak flows are not intensified at the site's (smaller) northern catchment. A detention basin has been sized to attenuate peak flows from the site's southern catchment to below their predeveloped magnitudes.

1-dimensional flood modelling was undertaken to compare 1% AEP flood extents under existing and developed conditions. Modelling confirmed that the proposed development does not adversely impact downstream flood affectation up to the 1% AEP design event. Upstream flood extents will be improved by the proposed development owing to the provision of upgraded culverts under Wyndella Road. All lots and proposed trunk drainage systems were confirmed to meet Council's minimum freeboard requirements.

HEC-RAS modelling of the Probable Maximum Flood (PMF) was undertaken to determine the site's full flood liability. Modelling found that all lots will accommodate dwellings above the PMF envelope. Robust emergency response outcomes exist by way of rising escape routes to the north.

A Water Sensitive Urban Design (WSUD) treatment train was developed comprising rainwater tanks, Gross Pollutant Traps and bioretention basins. MUSIC modelling confirmed that the proposed treatment train meets Council's runoff quality objectives at each of the site's legal points of discharge.

To ensure downstream waters and adjacent properties are protected, appropriate erosion and sediment controls are to be undertaken during construction. Controls are to be implemented and monitored in accordance with Landcom's 'Blue Book' and Council's Manual of Engineering Standards.

VRZ's have been identified along the Lochinvar Creek Tributary. Mapping of encroachments and offsets confirm that all requirements in relation to controlled activities on waterfront land are met. Realignment of the Lochinvar Creek Tributary is acceptable on the basis of its identification as a first order watercourse (AEP 2024).

The proposed stormwater management system and WSUD elements meet the specific controls imposed by the Lochinvar Urban Release Area Development Control Plan.

The details and information presented in this Stormwater Management Plan confirm that the proposed development is fit for purpose and satisfies Council's requirements in relation to peak flow management, flooding, runoff quality and erosion and sediment control.

12.0 References

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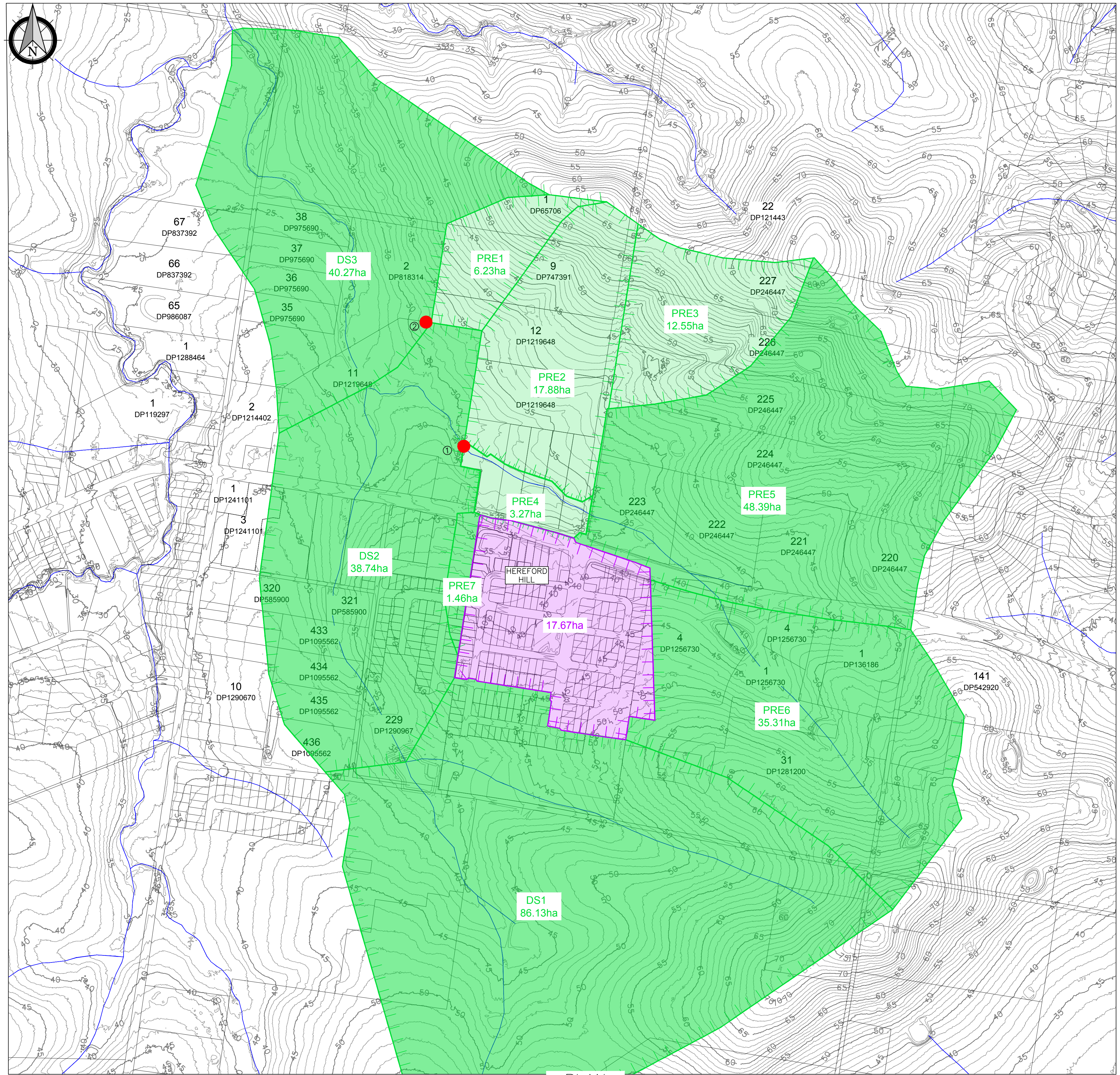
Appendix A

CATCHMENT PLANS

240332-ESK-004(B)



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PLAN

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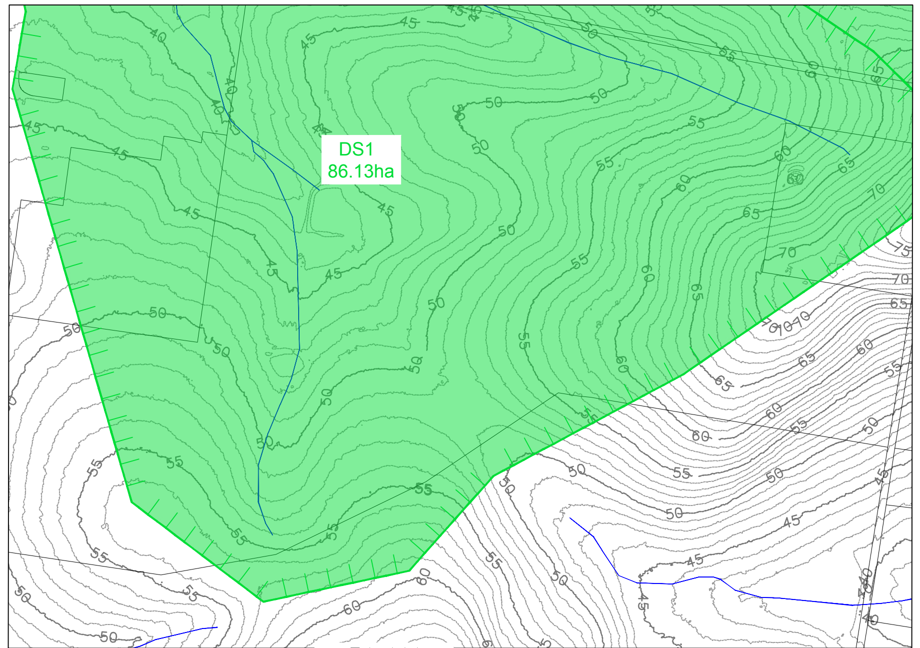
LEGEND

- EXISTING LOT BOUNDARY
- PROPOSED LOT BOUNDARY
- FINISHED SURFACE CONTOURS
- EXISTING HEREFORD HILL DEVELOPMENT
- ISOLATED CATCHMENT (DETENTION ASSESSMENT)
- OVERALL CATCHMENT (FLOOD ASSESSMENT)
- EXISTING WATERCOURSE
- MONITORING NODE



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ADJOINS LEFT

GDA2020

drawing title:

EXISTING CATCHMENT PLAN

location: NEW ENGLAND HIGHWAY, LOCHINVAR

council: MAITLAND CITY COUNCIL

dwg ref: 240332-ESK-004(B)

client: CPG ESTATES

ver.	date	comment	drawn	pm	co-ordinate information	level information	scale (A1 original size)	notes
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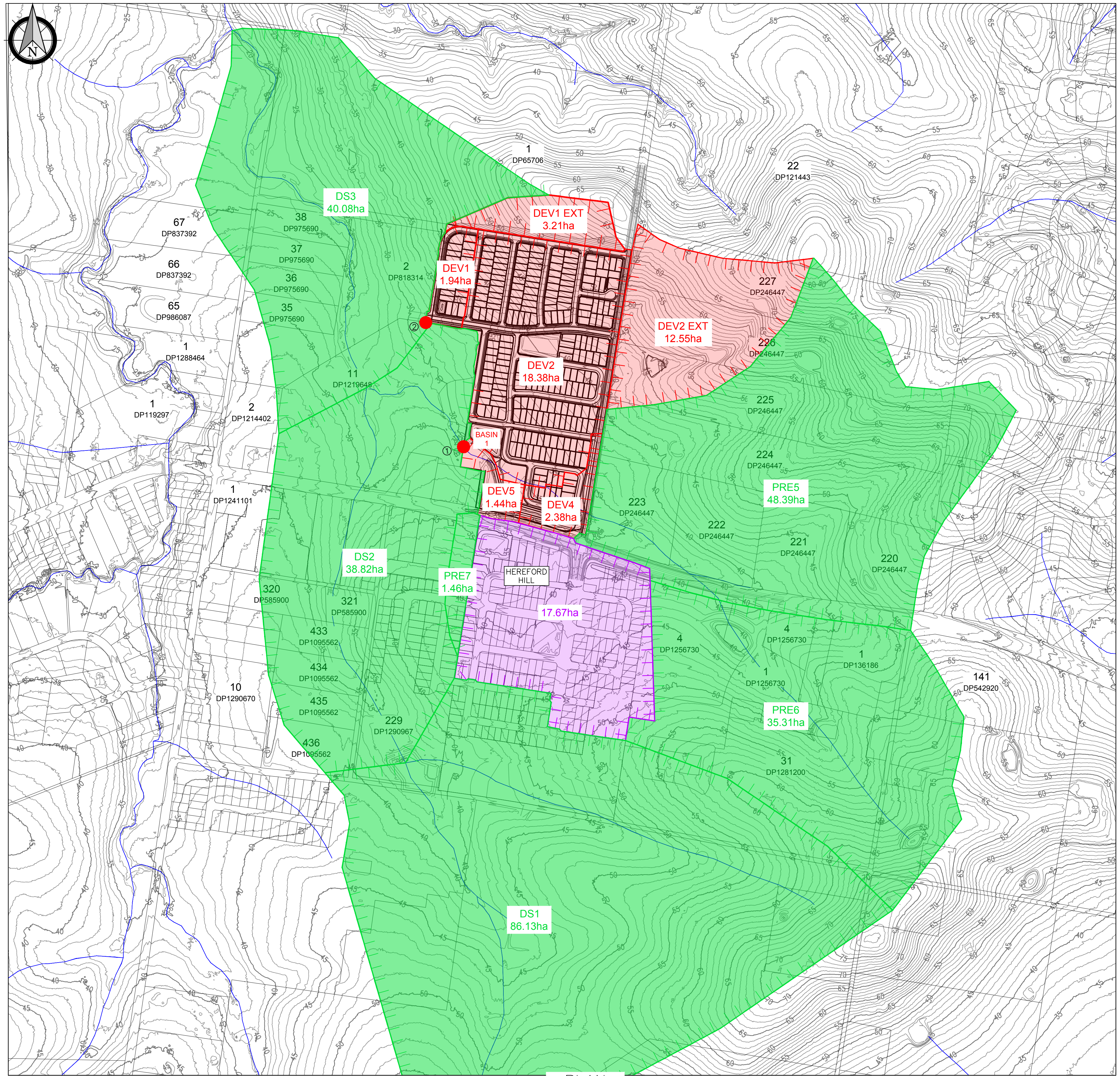

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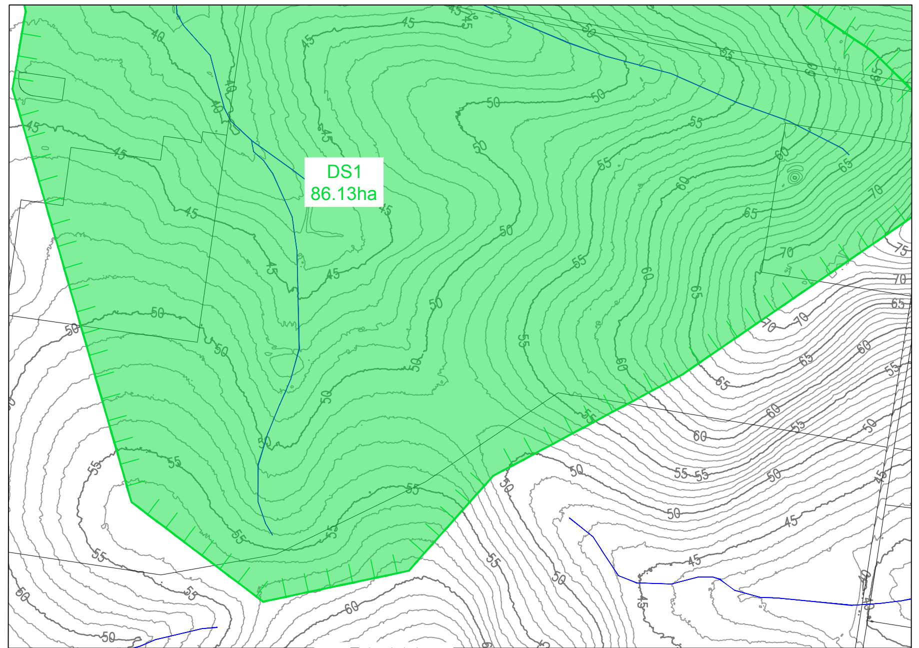

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ADJOINS LEFT

LEGEND

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- PROPOSED LOT BOUNDARY
- FINISHED SURFACE CONTOUR
- ISOLATED CATCHMENT (DETENTION ASSESSMENT)
- EXISTING HEREFORD HILL DEVELOPMENT
- OVERALL CATCHMENT (FLOOD ASSESSMENT)
- EXISTING WATERCOURSE
- MONITORING NODE

GDA2020

drawing title:

DEVELOPED CATCHMENT PLAN

location: NEW ENGLAND HIGHWAY, LOCHINVAR

council: MAITLAND CITY COUNCIL

dwg ref: 240332-ESK-005(C)

client: CPG ESTATES

ver.	date	comment	drawn	pm	co-ordinate information	level information	scale (A1 original size)	notes
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Appendix B

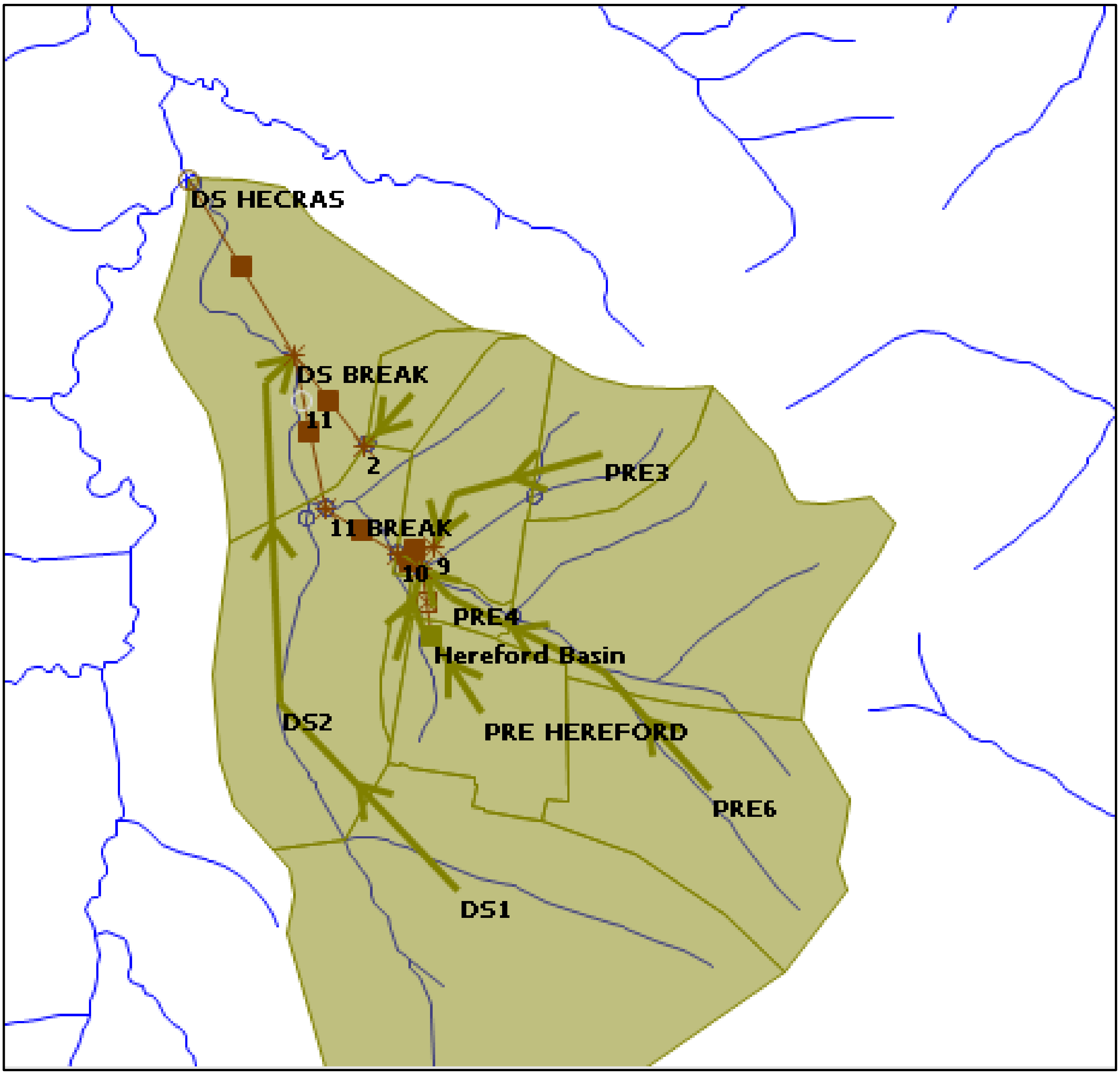
INFOWORKS ICM MODEL INPUTS

Predeveloped Model Inputs

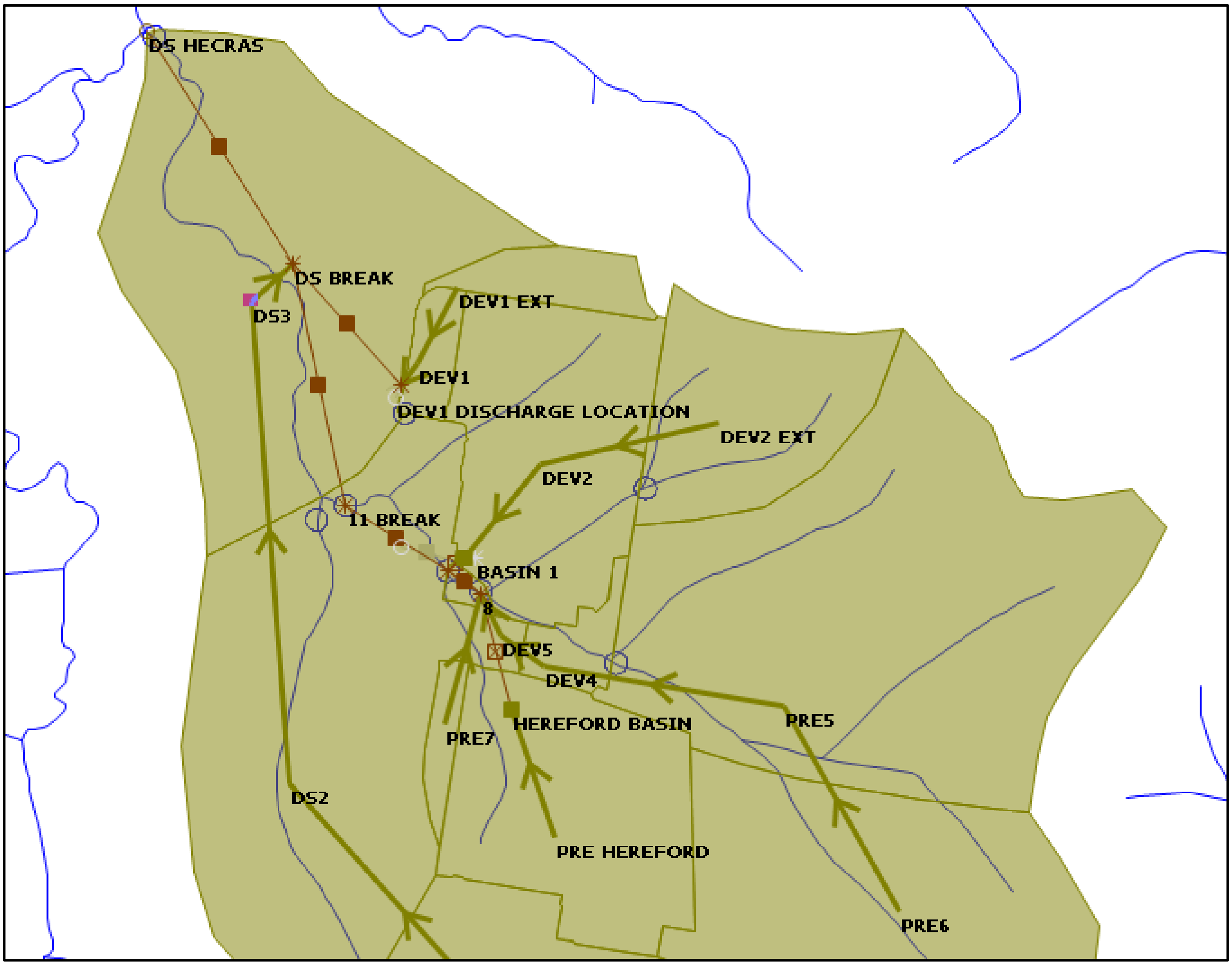
Catchment	Subcatchment Number	Total Area [ha]	Percentage Impervious [%]	Catchment Slope [%]	Catchment Mannings 'n'
PRE1	1	6.226	0	7	0.035
PRE2	1	17.510	0	6	0.035
	2	0.373	100	6	0.014
PRE3	1	12.554	0	8	0.035
PRE4	1	3.040	0	4	0.035
	2	0.233	100	4	0.014
PRE5	1	45.970	0	4	0.035
	2	2.419	100	4	0.014
PRE6	1	31.779	0	4	0.035
	2	3.531	100	4	0.014
PRE7	1	1.165	0	3	0.035
	2	0.291	100	3	0.014
HEREFORD HILL	1	7.775	0	3	0.035
	2	9.895	100	3	0.014
DS1	1	81.825	0	5	0.035
	2	4.307	100	5	0.014
DS2	1	34.870	0	5	0.035
	2	3.874	100	5	0.014
DS3	1	40.266	0	5	0.035
Total		307.903	**8%**		

Developed Model Inputs

Catchment	Subcatchment Number	Total Area [ha]	Percentage Impervious [%]	Catchment Slope [%]	Catchment Mannings 'n'
DEV1	1	0.706	0	5	0.035
	2	1.231	100	5	0.014
DEV1 EXT	1	3.207	0	7	0.035
DEV2	1	6.609	0	5	0.035
	2	11.774	100	5	0.014
DEV2 EXT	1	12.55	0	8	0.035
DEV4	1	1.175	0	4	0.035
	2	1.202	100	4	0.014
DEV5	1	1.21	0	4	0.035
	2	0.228	100	4	0.014
PRE5	1	45.97	0	4	0.035
	2	2.19	100	4	0.014
PRE6	1	31.779	0	4	0.035
	2	3.531	100	4	0.014
PRE7	1	1.165	0	3	0.035
	2	0.291	100	3	0.014
HEREFORD HILL	1	7.775	0	3	0.035
	2	9.895	100	3	0.014
DS1	1	81.825	0	5	0.035
	2	4.307	100	5	0.014
DS2	1	34.939	0	5	0.035
	2	3.882	100	5	0.014
DS3	1	40.084	0	5	0.035
Total		**307.525**	**13%**		



Predeveloped ICM Network Diagram

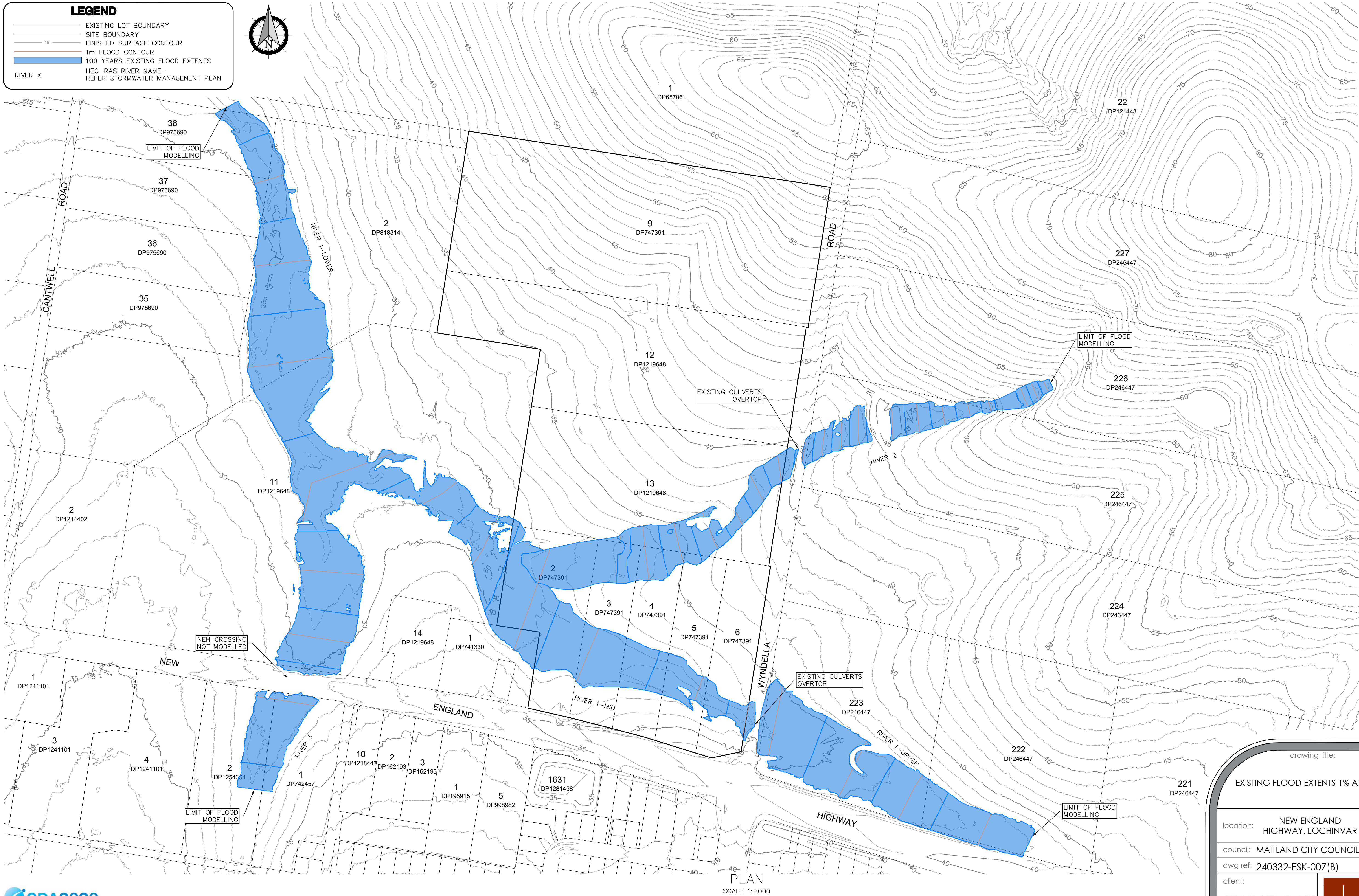


Developed ICM Network Diagram

Appendix C

FLOOD MAPS

240332-ESK-007(B)



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drawing title: EXISTING FLOOD EXTENTS 1% AEP

location: NEW ENGLAND HIGHWAY, LOCHINVAR

council: MAITLAND CITY COUNCIL

dwg ref: 240332-ESK-007(B)

client: CPG ESTATES

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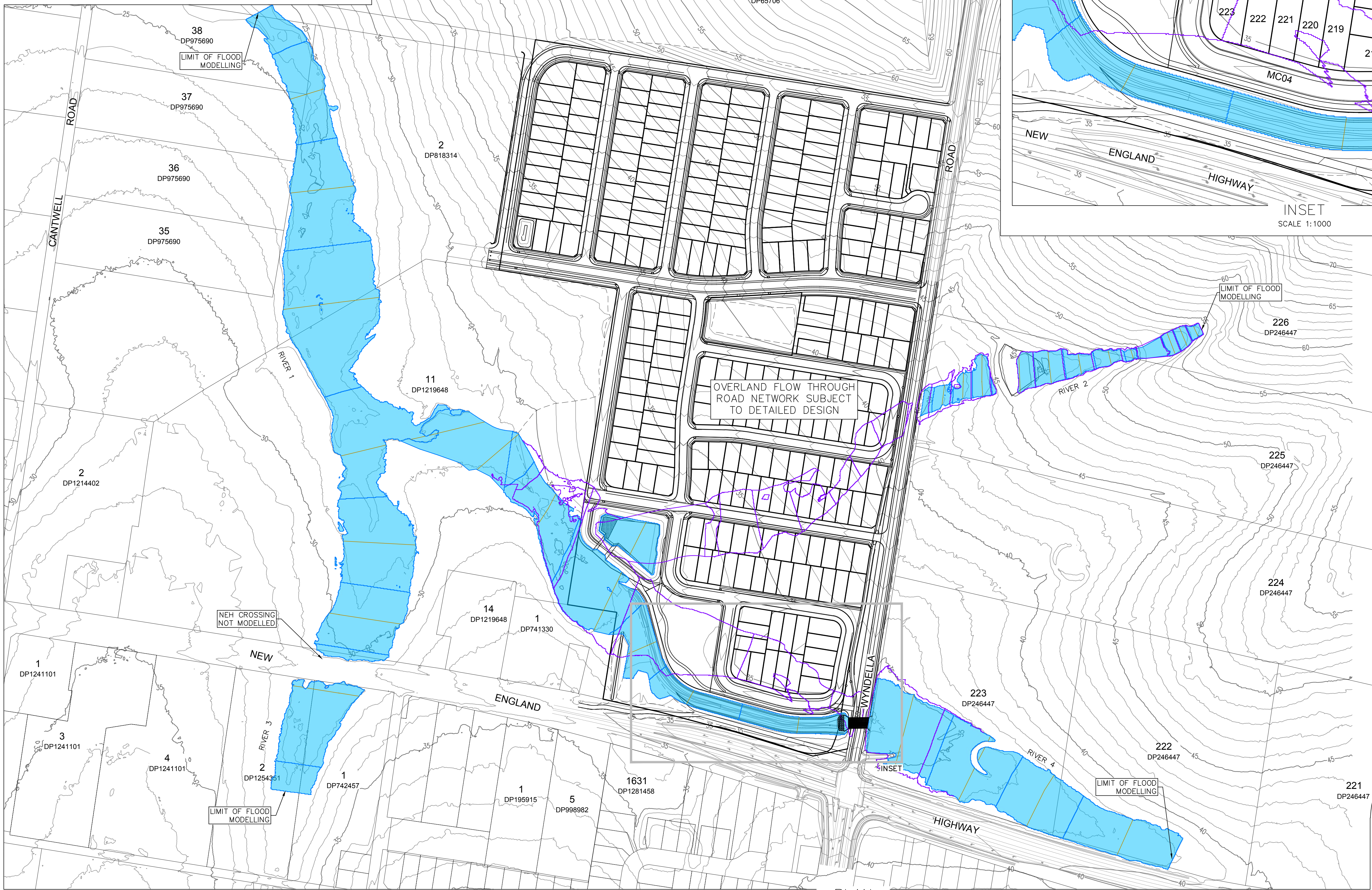
240332-ESK-008(C)

LEGEND

- EXISTING LOT BOUNDARY
- PROPOSED LOT BOUNDARY
- FINISHED SURFACE CONTOUR
- 1m FLOOD CONTOUR
- EXISTING 1% AEP FLOOD ENVELOPE REFER SHEET 007
- 100 YEAR DEVELOPED FLOOD EXTENTS
- RIVER X — HEC-RAS RIVER NAME- REFER STORMWATER MANAGENENT PLAN



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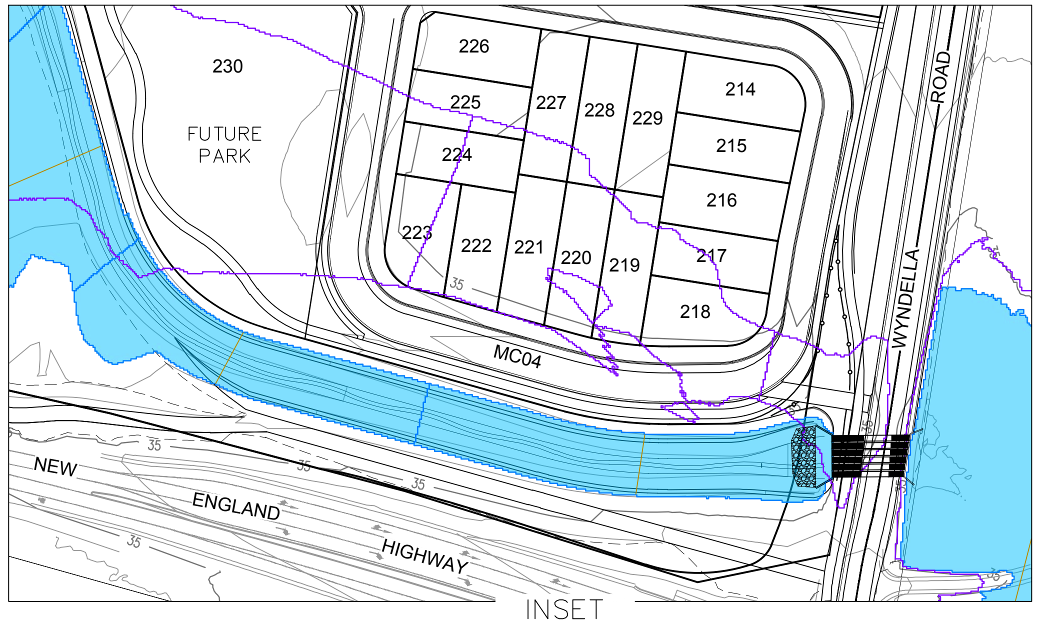

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drawing title: DEVELOPED FLOOD EXTENTS 1% AEP

location: NEW ENGLAND HIGHWAY, LOCHINVAR

council: MAITLAND CITY COUNCIL

dwg ref: 240332-ESK-008(C)

client: CPG ESTATES

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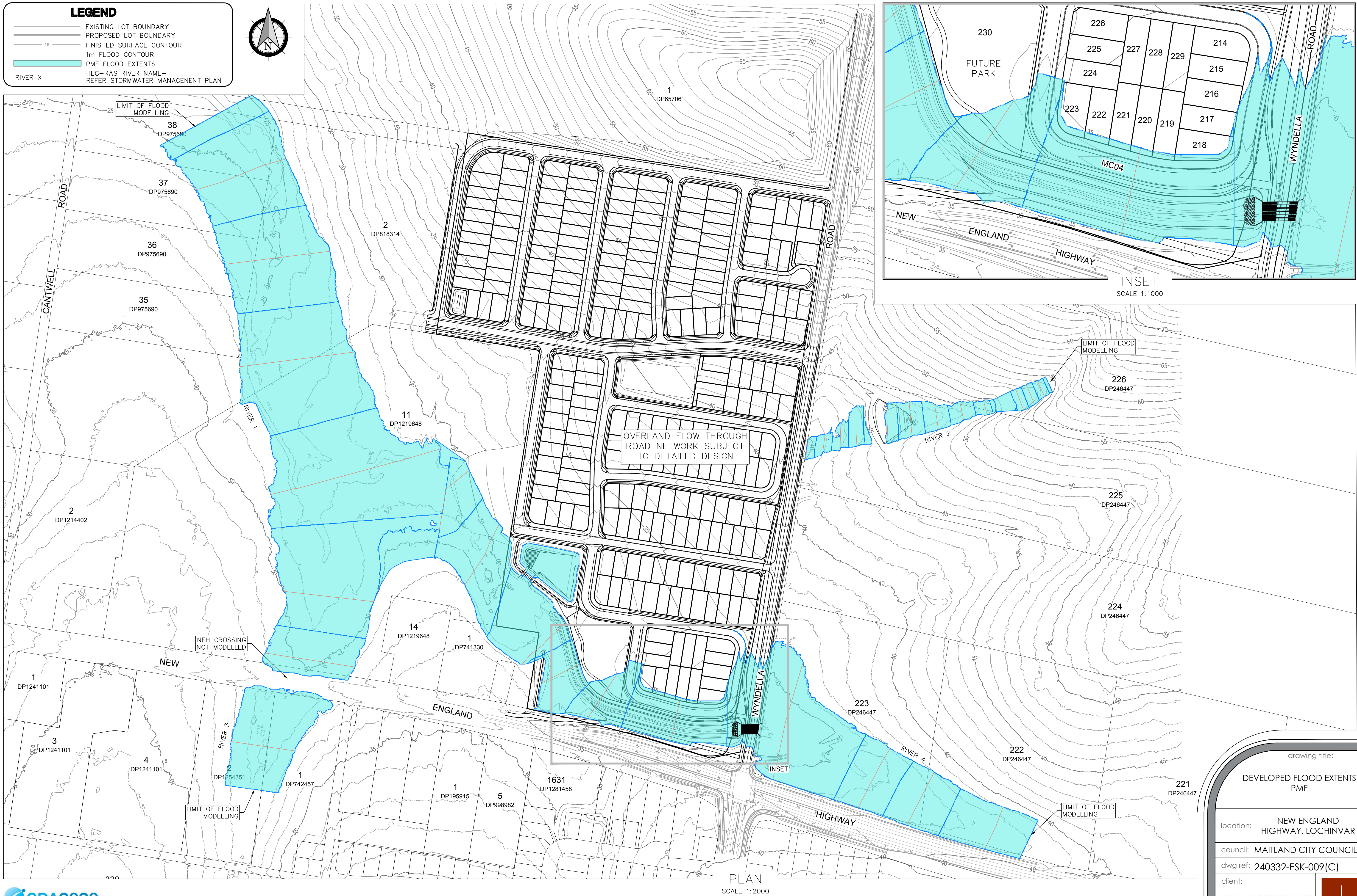

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location: NEW ENGLAND HIGHWAY, LOCHINVAR

council: MAITLAND CITY COUNCIL

dwg ref: 240332-ESK-009(C)

client: CPG ESTATES

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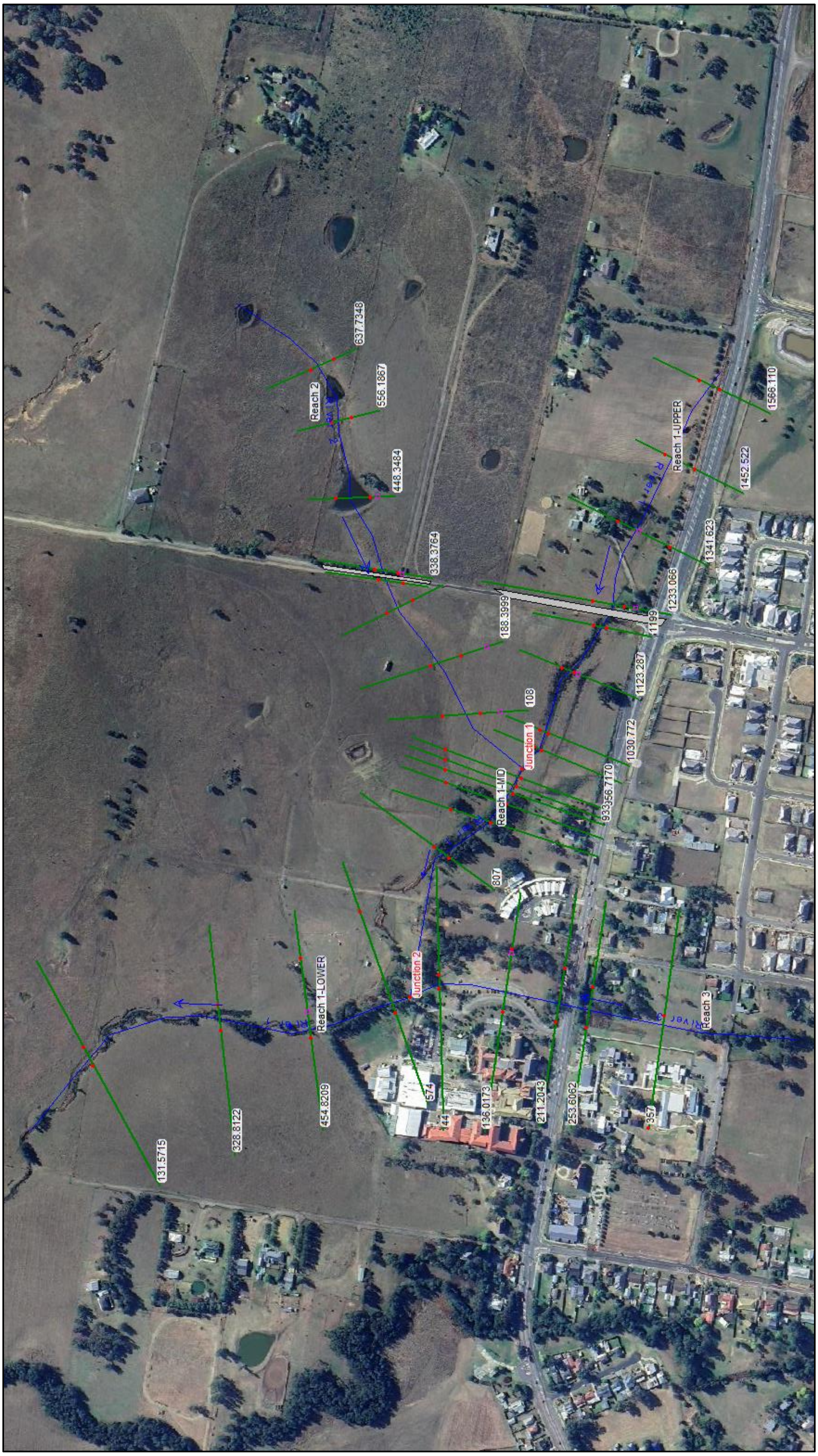
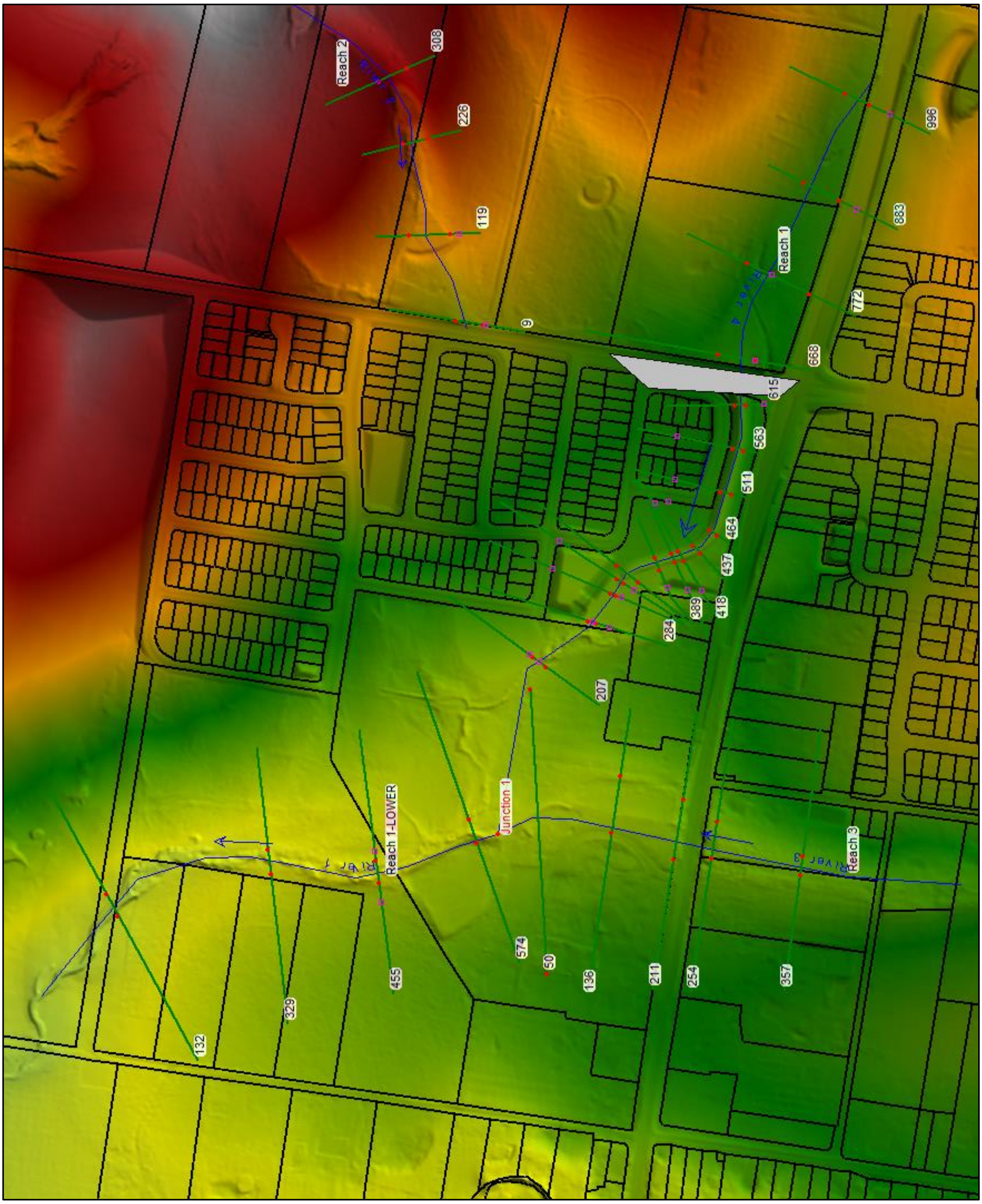
Appendix D

HEC-RAS PARAMETERS



Existing HEC-RAS Model



Developed HEC-RAS Model

1% AEP – Existing Conditions – Results Summary

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
River 3	Reach 3	357	PF 1	22.42	31.09	31.69		31.8	0.014574	1.53	14.67	40.67	0.81
River 3	Reach 3	253.6062	PF 1	22.42	30.42	31.03		31.07	0.004036	0.9	25.58	66.64	0.44
River 3	Reach 3	211.2043	PF 1	22.42	30.06	30.59	30.59	30.71	0.026373	1.51	14.9	69.58	1.01
River 3	Reach 3	136.0173	PF 1	22.42	28.74	29.42	29.26	29.48	0.00619	1.06	21.21	53.82	0.54
River 3	Reach 3	44	PF 1	22.42	27.59	28.42	28.42	28.59	0.016317	1.97	13.07	39.97	0.9
River 2	Reach 2	637.7348	PF 1	4.1	54.11	54.47	54.47	54.59	0.026699	1.48	2.76	12.6	1.01
River 2	Reach 2	556.1867	PF 1	4.1	48.29	48.64	48.64	48.75	0.025785	1.49	2.76	12.18	1
River 2	Reach 2	448.3484	PF 1	4.1	44.87	45.03	45.03	45.08	0.034691	1.02	4	38.78	1.02
River 2	Reach 2	338.3764	PF 1	4.1	39.44	40.17	39.78	40.18	0.000648	0.28	12.89	37.36	0.17
River 2	Reach 2	330		Culvert									
River 2	Reach 2	324	PF 1	4.1	39.26	39.51	39.51	39.59	0.027243	1.29	3.25	19.95	0.99
River 2	Reach 2	282.9475	PF 1	4.1	38.17	38.37	38.36	38.42	0.0249	1.02	4.04	30.89	0.9
River 2	Reach 2	188.3999	PF 1	4.1	35.47	35.67	35.67	35.72	0.03303	1.01	4.03	38.04	1
River 2	Reach 2	108	PF 1	4.1	33.26	33.68	33.49	33.68	0.000875	0.3	14.27	61.58	0.19
River 1	Reach 1-UPPER	1566.11	PF 1	16.18	37.85	38.47	38.36	38.55	0.022617	1.22	13.37	34.96	0.6
River 1	Reach 1-UPPER	1452.522	PF 1	16.18	36.77	37.46		37.49	0.004978	0.67	24.44	49.29	0.29
River 1	Reach 1-UPPER	1341.623	PF 1	16.18	35.47	35.95	35.95	36.08	0.073447	1.63	9.94	36.45	0.99
River 1	Reach 1-UPPER	1233.066	PF 1	16.18	33.72	34.92	34.33	34.92	0.000518	0.29	54.26	87.77	0.1
River 1	Reach 1-UPPER	1215		Culvert									
River 1	Reach 1-UPPER	1199	PF 1	16.18	32.53	33.7		33.77	0.008919	1.15	14.33	23.86	0.41
River 1	Reach 1-UPPER	1123.287	PF 1	16.18	31.81	32.77	32.55	32.87	0.016683	1.39	11.94	23.96	0.55
River 1	Reach 1-UPPER	1030.772	PF 1	18.77	31.07	32.17		32.2	0.004122	0.68	25.38	65.54	0.27
River 1	Reach 1-UPPER	1006	PF 1	18.77	31.16	32.01		32.06	0.008423	0.77	20.54	67.58	0.36
River 1	Reach 1-MID	956.717	PF 1	22.8	30.99	31.6		31.67	0.013262	0.59	21.44	83.45	0.41
River 1	Reach 1-MID	944	PF 1	22.8	30.7	31.43		31.49	0.013486	0.59	21.43	84.31	0.41
River 1	Reach 1-MID	933	PF 1	22.8	30.86	31.31		31.36	0.009847	0.54	24.43	89.08	0.36
River 1	Reach 1-MID	916	PF 1	22.8	30.25	30.95	30.94	31.05	0.038627	1.12	16.39	79.95	0.71
River 1	Reach 1-MID	883.0047	PF 1	22.8	29.79	30.65	30.46	30.67	0.005107	0.46	34.63	118.85	0.27
River 1	Reach 1-MID	807	PF 1	22.8	28.93	29.62	29.62	29.77	0.050537	1.73	13.15	43.21	0.88
River 1	Reach 1-LOWER	574	PF 1	49.05	26.33	27.67		27.73	0.003283	1.12	43.88	63.44	0.43

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
River 1	Reach 1-LOWER	454.8209	PF 1	49.05	25.9	27.04	27.04	27.12	0.008987	1.27	38.66	99.98	0.65
River 1	Reach 1-LOWER	328.8122	PF 1	49.05	24.69	25.99		26.11	0.005239	1.56	35.08	64.31	0.56
River 1	Reach 1-LOWER	131.5715	PF 1	49.05	22.33	24.01	24.01	24.35	0.0177	2.58	19.15	30.82	0.99

1% AEP – Developed Conditions – Results Summary

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
River 4	Reach 1	996	PF 1	16.18	37.85	38.47	38.36	38.55	0.022617	1.22	13.37	34.96	0.6
River 4	Reach 1	883	PF 1	16.18	36.77	37.46	37.15	37.49	0.004978	0.67	24.44	49.29	0.29
River 4	Reach 1	772	PF 1	16.18	35.47	35.95	35.95	36.08	0.073447	1.63	9.94	36.45	0.99
River 4	Reach 1	668	PF 1	16.18	33.89	34.7	34.4	34.71	0.003399	0.52	29.8	74.32	0.24
River 4	Reach 1	640		Culvert									
River 4	Reach 1	615	PF 1	16.18	32.92	34.23	33.75	34.3	0.007144	1.2	13.85	17.76	0.38
River 4	Reach 1	563	PF 1	16.18	32.49	33.82	33.37	33.9	0.008309	1.27	13.05	16.65	0.41
River 4	Reach 1	511	PF 1	16.18	32.05	33.38	32.94	33.46	0.008725	1.29	12.86	16.58	0.42
River 4	Reach 1	464	PF 1	16.18	31.66	32.92	32.54	33.01	0.010224	1.37	12.1	16.05	0.45
River 4	Reach 1	437	PF 1	17.52	31.43	32.59	32.36	32.69	0.01296	1.44	13	25.58	0.5
River 4	Reach 1	418	PF 1	17.52	31.27	32.25	32.25	32.38	0.022511	1.66	12.22	43.3	0.64
River 4	Reach 1	408	PF 1	17.52	31.19	32.07	31.97	32.15	0.013703	1.25	13.85	34.86	0.49
River 4	Reach 1	389	PF 1	17.52	31.02	31.81	31.65	31.89	0.012075	1.08	14.02	29.52	0.45
River 4	Reach 1	353	PF 1	17.52	30.72	31.37		31.43	0.013391	0.72	17.56	69.59	0.43
River 4	Reach 1	341	PF 1	17.52	30.69	31.19	31.16	31.24	0.016143	0.71	17.33	91.32	0.45
River 4	Reach 1	324	PF 1	17.52	30.4	30.92	30.88	31	0.011961	0.6	14.54	55.05	0.39
River 4	Reach 1	284	PF 1	22.8	29.82	30.7	30.52	30.73	0.004379	0.63	28.22	72.57	0.27
River 4	Reach 1	207	PF 1	22.8	29.09	29.76	29.76	29.94	0.045191	1.91	12.1	33.23	0.86
River 3	Reach 3	357	PF 1	22.16	31.2	31.68	31.63	31.8	0.014392	1.42	14.58	40.59	0.79
River 3	Reach 3	254	PF 1	22.16	30.42	31.03		31.07	0.004048	0.93	25.57	66.63	0.44
River 3	Reach 3	211	PF 1	22.16	30.06	30.59	30.59	30.7	0.026426	1.5	14.78	69.37	1.01
River 3	Reach 3	136	PF 1	22.16	28.74	29.44	29.27	29.48	0.005561	0.94	23.78	68.69	0.5
River 3	Reach 3	50	PF 1	22.16	27.57	28.46	28.46	28.61	0.023514	1.7	13.07	44.37	1
River 2	Reach 2	308	PF 1	4.1	54.11	54.43	54.47	54.6	0.050052	1.85	2.22	11.68	1.35
River 2	Reach 2	226	PF 1	4.1	48.29	48.54	48.64	48.85	0.10624	2.48	1.66	9.86	1.93
River 2	Reach 2	119	PF 1	4.1	44.87	45.03	45.03	45.08	0.034691	1.02	4	38.78	1.02
River 2	Reach 2	9	PF 1	4.1	39.44	40	39.78	40.02	0.002474	0.5	7.5	26.04	0.32
River 1	Reach 1-LOWER	574	PF 1	49.31	26.33	27.65	27.29	27.72	0.003388	1.32	42.64	62.75	0.45
River 1	Reach 1-LOWER	455	PF 1	49.31	25.9	27.04	27.04	27.14	0.007547	1.66	38.66	99.98	0.65
River 1	Reach 1-LOWER	329	PF 1	49.31	24.69	26	25.82	26.11	0.005285	1.64	35.46	64.48	0.56

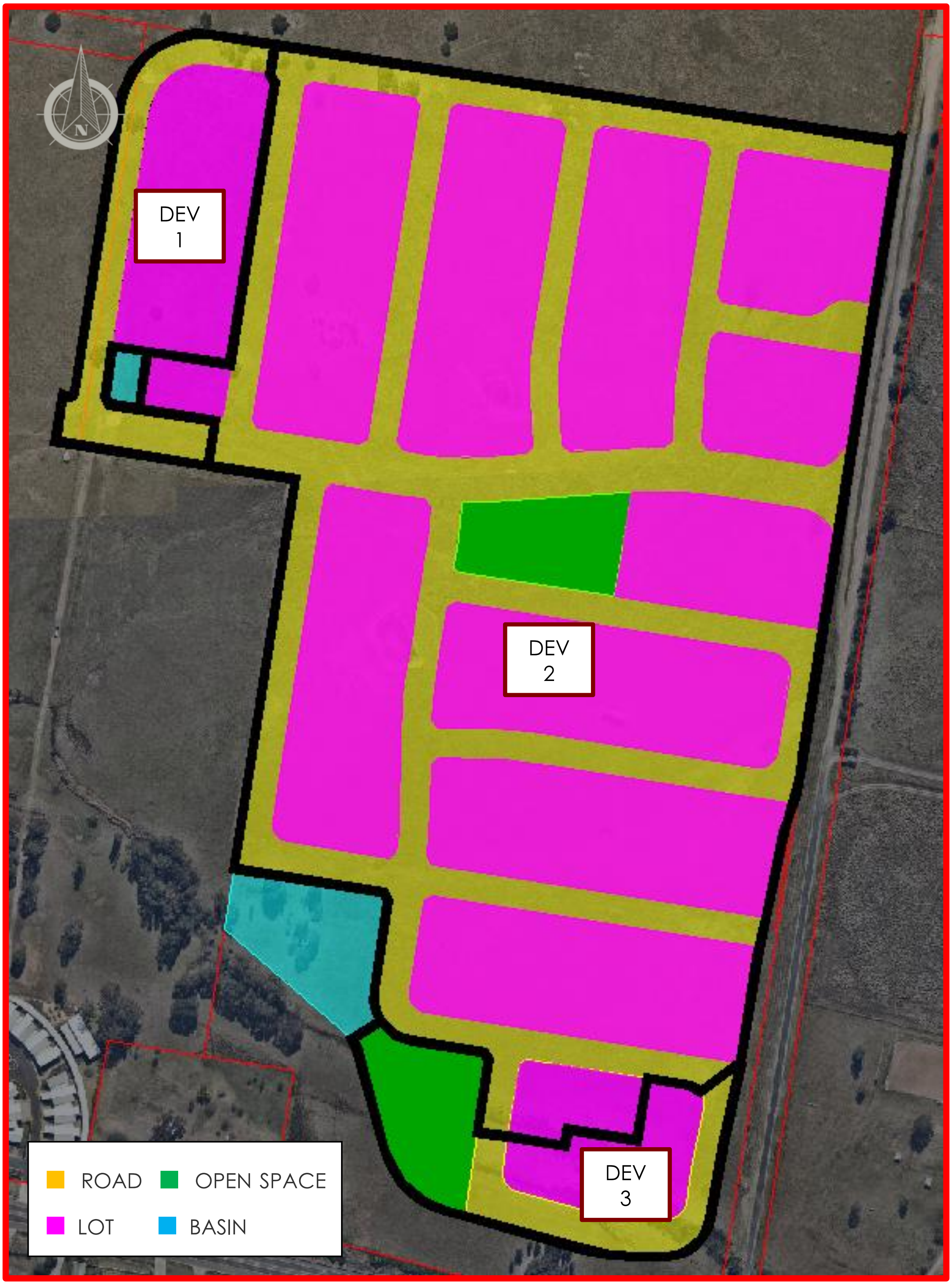
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
River 1	Reach 1-LOWER	132	PF 1	49.31	22.33	24.01	24.01	24.35	0.017687	2.57	19.28	31.23	0.99

PMF – Developed Conditions – Results Summary

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
River 4	Reach 1	996	PF 1	112.31	37.85	39.38	39.09	39.62	0.014944	2.08	52.32	49.39	0.58
River 4	Reach 1	883	PF 1	112.31	36.77	38.35	37.79	38.46	0.006957	1.51	75.25	65.89	0.4
River 4	Reach 1	772	PF 1	112.31	35.47	36.48	36.48	36.76	0.054924	2.35	47.84	84.75	0.98
River 4	Reach 1	668	PF 1	112.31	33.89	35.91	34.92	35.93	0.001052	0.66	163.53	150.48	0.16
River 4	Reach 1	640		Culvert									
River 4	Reach 1	615	PF 1	112.31	32.92	35.46	35.12	35.64	0.007129	2.04	59.5	53.78	0.44
River 4	Reach 1	563	PF 1	112.31	32.49	35.04	34.76	35.25	0.008124	2.15	56.43	51.63	0.46
River 4	Reach 1	511	PF 1	112.31	32.05	34.68	34.34	34.86	0.006742	2	60.29	53.08	0.42
River 4	Reach 1	464	PF 1	112.31	31.66	33.99	33.98	34.36	0.016656	2.9	45	62.35	0.65
River 4	Reach 1	437	PF 1	131.66	31.43	33.39	33.39	33.81	0.022831	2.98	46.51	55.14	0.74
River 4	Reach 1	418	PF 1	131.66	31.27	33.2	32.94	33.46	0.009838	1.94	59.44	55.45	0.49
River 4	Reach 1	408	PF 1	131.66	31.19	32.81	32.81	33.31	0.020377	2.49	43.5	44.06	0.68
River 4	Reach 1	389	PF 1	131.66	31.02	32.66	32.66	32.83	0.006675	1.44	74.47	76.52	0.39
River 4	Reach 1	353	PF 1	131.66	30.72	31.69	31.87	32.27	0.04872	2.19	41.74	80.22	0.92
River 4	Reach 1	341	PF 1	131.66	30.69	31.77	31.59	31.91	0.008033	1.02	79.36	119.84	0.38
River 4	Reach 1	324	PF 1	131.66	30.4	31.75	31.32	31.82	0.002656	0.76	113.14	126.52	0.24
River 4	Reach 1	284	PF 1	156.63	29.82	31.52	31.11	31.67	0.004588	1.18	94.06	87.23	0.32
River 4	Reach 1	207	PF 1	156.63	29.09	30.59	30.59	30.96	0.024772	2.72	58.02	77.95	0.75
River 3	Reach 3	357	PF 1	159.9	31.2	32.27	32.44	32.92	0.030013	3.67	45.1	62.92	1.33
River 3	Reach 3	254	PF 1	159.9	30.42	31.72	31.51	31.94	0.006791	2.24	81.76	97.88	0.67
River 3	Reach 3	211	PF 1	159.9	30.06	31.18	31.18	31.51	0.015367	2.64	64.88	99.74	0.95
River 3	Reach 3	136	PF 1	159.9	28.74	30.07	29.92	30.3	0.00806	2.22	77.7	97.44	0.71
River 3	Reach 3	50	PF 1	159.9	27.57	29.57		29.67	0.006053	1.38	115.61	192.32	0.57
River 2	Reach 2	308	PF 1	22.9	54.11	54.78	54.92	55.25	0.050059	3.03	7.57	18.93	1.53
River 2	Reach 2	226	PF 1	22.9	48.29	48.85	49.09	49.66	0.098125	3.99	5.74	15.72	2.11
River 2	Reach 2	119	PF 1	22.9	44.87	45.25	45.25	45.4	0.023434	1.7	13.46	45.34	1
River 2	Reach 2	9	PF 1	22.9	39.44	39.97	40.16	40.59	0.105627	3.12	6.64	24.34	2.04
River 1	Reach 1-LOWER	574	PF 1	350.71	26.33	28.75	28.51	29.07	0.006381	3.08	151.33	140.03	0.71
River 1	Reach 1-LOWER	455	PF 1	350.71	25.9	28.06	27.76	28.33	0.005826	2.7	159.6	135.08	0.66

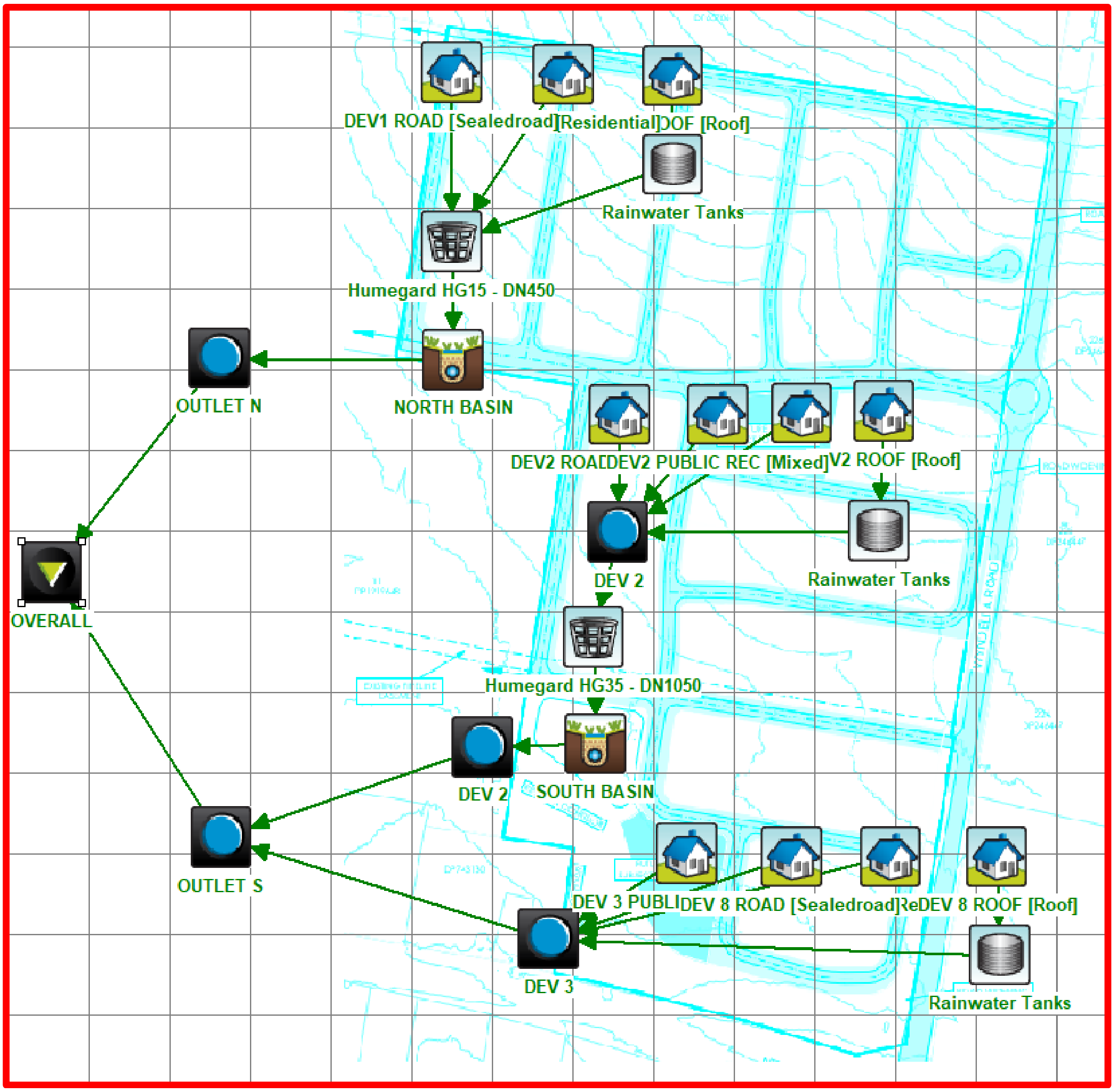
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
River 1	Reach 1-LOWER	329	PF 1	350.71	24.69	27.07	26.95	27.48	0.007604	3.37	135.81	122.08	0.78
River 1	Reach 1-LOWER	132	PF 1	350.71	22.33	25.26	25.26	25.78	0.009745	3.78	124.93	121.22	0.87

MUSIC CATCHMENT PLAN



Appendix F

MUSIC NETWORK DIAGRAM



Appendix G

MUSIC RESULTS BY CATCHMENT

DEV 1 Treatment Train Effectiveness

Pollutant	Developed Untreated Load (kg/yr)	Developed Treated Load (kg/yr)	Reduction (%)
TSS	1600	9.36	80.7
TP	3.21	308	64.4
TN	22	11.4	48.2
GP	335	0	100

DEV 2 Treatment Train Effectiveness

Pollutant	Developed Untreated Load (kg/yr)	Developed Treated Load (kg/yr)	Reduction (%)
TSS	13900	1480	89.3
TP	30	8.75	70.9
TN	206	86.5	57.9
GP	3190	0	100

DEV 3 Treatment Train Effectiveness

Pollutant	Developed Untreated Load (kg/yr)	Developed Treated Load (kg/yr)	Reduction (%)
TSS	1520	1500	1.4
TP	2.87	2.82	1.5
TN	18.3	17.6	3.6
GP	278	208	25.2

Appendix H

RIPARIAN SETBACK PLAN

LEGEND

- EXISTING LOT BOUNDARY
- PROPOSED LOT BOUNDARY
- FINISHED SURFACE CONTOUR
- EXISTING WATERCOURSE
- RIPARIAN CORRIDOR INNER 5m
- RIPARIAN CORRIDOR OUTER 10m
- RIPARIAN CORRIDOR AREA OFFSET
- RIPARIAN CORRIDOR OUTER 5m ENCROACHMENT

	TOTAL
RIPARIAN ENCROACHMENT AREA (m^2)	1550
ENCROACHMENT OFFSET AREA (m^2)	3250
SURPLUS OFFSET (m^2)	1700

NOTES:
STREAM ORDER DESIGNATION IS BASED ON "RIPARIAN ASSESSMENT REPORT" REFERENCE 2699 BY AEP DATED JUNE 2024.

PLAN
SCALE 1:800

GDA2020

ver.	date	comment	drawn	pm
C	27/06/2024	MINOR ADJUSTMENTS	DN	ML

co-ordinate information: CO-ORDINATE SYSTEM: MGA56

level information: DATUM: N/A; CONTOUR INTERVAL: 0.5m

scale (A1 original size): SCALE: 1:800 (FULL)

notes

drawing title: RIPARIAN CORRIDOR PLAN

location: NEW ENGLAND HIGHWAY, LOCHINVAR

council: MAITLAND CITY COUNCIL

dwg ref: 240332-ESK-006(C)

client: CPG ESTATES

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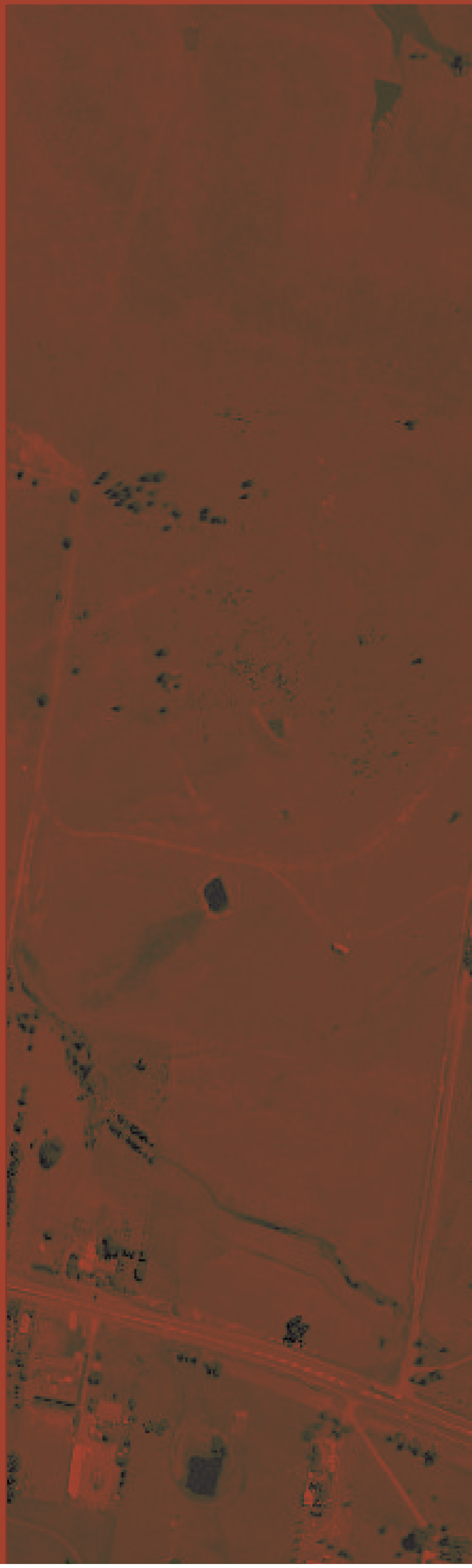

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