TATTERSALL LANDER PTY LTD

STORMWATER MANAGEMENT REPORT
for
CONCEPT PLAN APPLICATION

RIVERSIDE ESTATE
TEA GARDENS

Prepared by
TATTERSALL LANDER
PTY LTD
Development Consultants
October 2015

DEVELOPMENT CONSULTANTS IN ENGINEERING, SURVEYING, PLANNING & ENVIRONMENTAL
Tattersall Lander Pty Limited ABN 41 003 509 215
2 Bourke Street, RAYMOND TERRACE 2324 **All mail to**: PO Box 580
Telephone: (02) 4987 1500 **Fax**: (02) 4987 1733 **Email**: admin@tatland.com.au
www.tatland.com.au

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1.0 INTRODUCTION

1.1 REPORT REVISION

The previous version of this report (January 2013) was prepared for the Concept Plan Part 3A application to the Department of Planning and Infrastructure for the Riverside Estate at Tea Gardens. This report was peer reviewed by WBM BMT and ultimately adopted, with conditions, in the Instrument of Approval;

C9 Flooding and Climate Change

1) *In order to ensure the protection of life and property during a flood event, an updated flood assessment of the site must be submitted with the first stage development application.*

2) *The flood assessment in (1) must be consistent with the findings and recommendations within the Tattersall Landers Flood assessment included in Annexure C of the PPR dated January 2013. The flood assessment must be prepared in consultation with and to the satisfaction of the Director-General in consultation with OEH and include further information in relation to ground elevation data, model calibration and sensitivity analysis, refinement of the grid spacing, catchment boundary (Myall Rd), impact of the development on Myall River Flooding, impact of the development at northern boundary and Toonang Drive, the East West Deflector Embankment Levee, Blockage Modelling and Access and Evacuation routes.*

3) *All future applications for each stage of development are to incorporate any re-calibrations of the relevant Council flood model.*

4) *A preliminary development landform for the entire site is to be provided with the first development application for residential subdivision to allow comprehensive flood modelling to be carried out; but not in such a way as to preclude necessary modifications to land forms in subsequent stages of development.*

5) *All future applications for residential subdivision shall provide an updated Design Flood Level Map showing peak flood levels for local and regional flood events at 0.1 m contours and a detailed flood impact assessment for all flood liable land.*

Since the approval was granted there has been a layout revision to increase the size of the wildlife corridor though the north of the site, and a new regional flood study completed, both of which also necessitate an update to the flood modelling, from the previous Riverside report.

The layout modification has been required to further offset for wildlife corridors. The current layout is similar to the previous, but with some retraction to the south. In regard to the flooding assessment, this will increase the width of the East-West Branch, reducing the height of flows depths and thus hazard levels.

Boundary conditions for the previous Riverside report were derived in part from the Public Works Department's Lower Myall Flood Analysis (1980). Subsequent to the Project Approval, Great Lakes Council has released the Lower Myall River and Myall Lakes Flood Study (BMT WBM June 2015), which updated the previous PWD report by using more modern modelling methods and additional data sets.

This revised study has been prepared to support a Development Application for the subdivision of the site, by addressing the conditions of the consent as well as updating the modelling results to reflect the proposed layout modification and revised tailwater conditions determined in the BMT WBM report.

1.2 PROJECT DESCRIPTION

Riverside Estate has Concept Approval for a multi-staged Community Title subdivision on residentially zoned land at Tea Gardens, made up of 13 residential stages, and one stage containing a small tourist facility. Under the current modification application, the tourist facility is being removed and a re-numbering of the staging will result in a total of 16 stages. Ultimately the proposal will see land and services produced to cater for approximately 880 dwellings on the site.

Large portions of the site will remain undeveloped and set aside for various purposes, including environmental conservation, water management, public open space and recreation.

The site is bounded by Shearwater rural-residential estate to the north, Myall Street to the west, Myall Quays residential estate to the south, and the Myall River to the east.

Figure 1 - Locality Sketch

1.3 SITE DESCRIPTION

Previously part of a large pine plantation, the site is currently predominately clear and currently used for cattle grazing. The majority of the site has sandy soils and is extensively flat, with a slight fall to the south and to the east. Several existing drains assist in draining water east towards an existing SEPP14 wetland and beyond to the Myall River.

Due to their small size, and being near-level, these drains do not have a large capacity, and during extended wet periods or large rainfall events, surface water can pond on the site before draining away or infiltrating.

Photograph 1 – Existing Site Conditions

2.0 DRAINAGE DESIGN

The drainage regime approved for the Riverside Development has required minor modifications to reflect the modified layout. The proposed Drainage Concept Plan in Figure 6. The following summary describes the main drainage features in detail. Further specific technical details (modelled structure sizes, levels etc.) can also be seen in Appendix A.

2.1 Minimum Discharge Level

The design philosophy to date for drainage works in Tea Gardens has been to have drainage structure outlet levels at or above Mean High Water Mark, adopted at 0.5m AHD. Discussions with Great Lakes Council have determined that approach should continue, but this minimum should now be adjusted by 0.9m to 1.4m AHD to account for the worst case 2100 sea level rise due to climate change. As such, the minimum discharge level will be set at a 1.4m AHD. In most cases, this is the controlling feature for fill levels on the site.

2.2 Main Trunk Drainage Line – The West Branch Floodway

The remaining two (most westerly) Toonang Drive culverts are not able to be diverted around the site, and are instead directed to the top of the West Branch floodway. Running through the centre of the main portion of the development site, the West Branch has multiple functions which also includes acting to collect, detain, and infiltrate regular low flow discharges from the majority of the site, and convey high flow discharges to the downstream discharge structures, as well as providing areas of reforestation and public open space.

An illustration of the West Branch design cross section is shown in Figure 2.

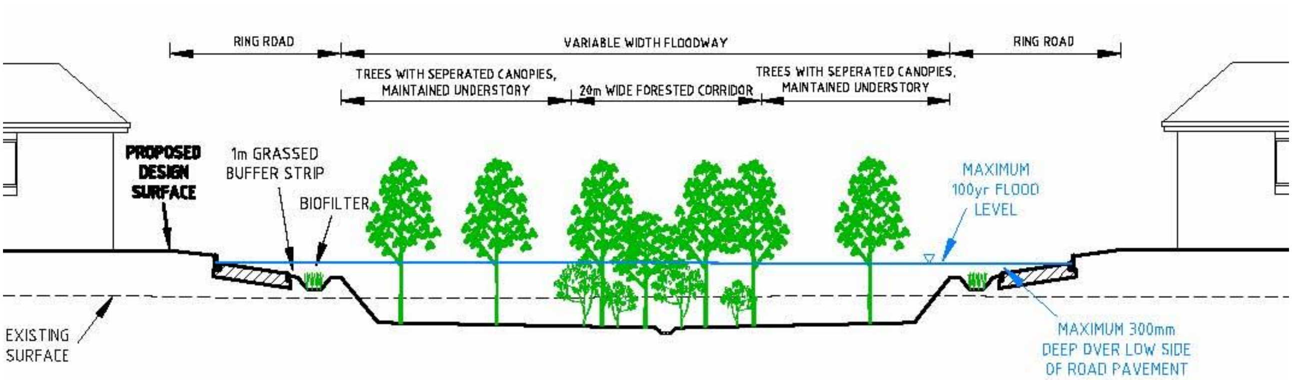


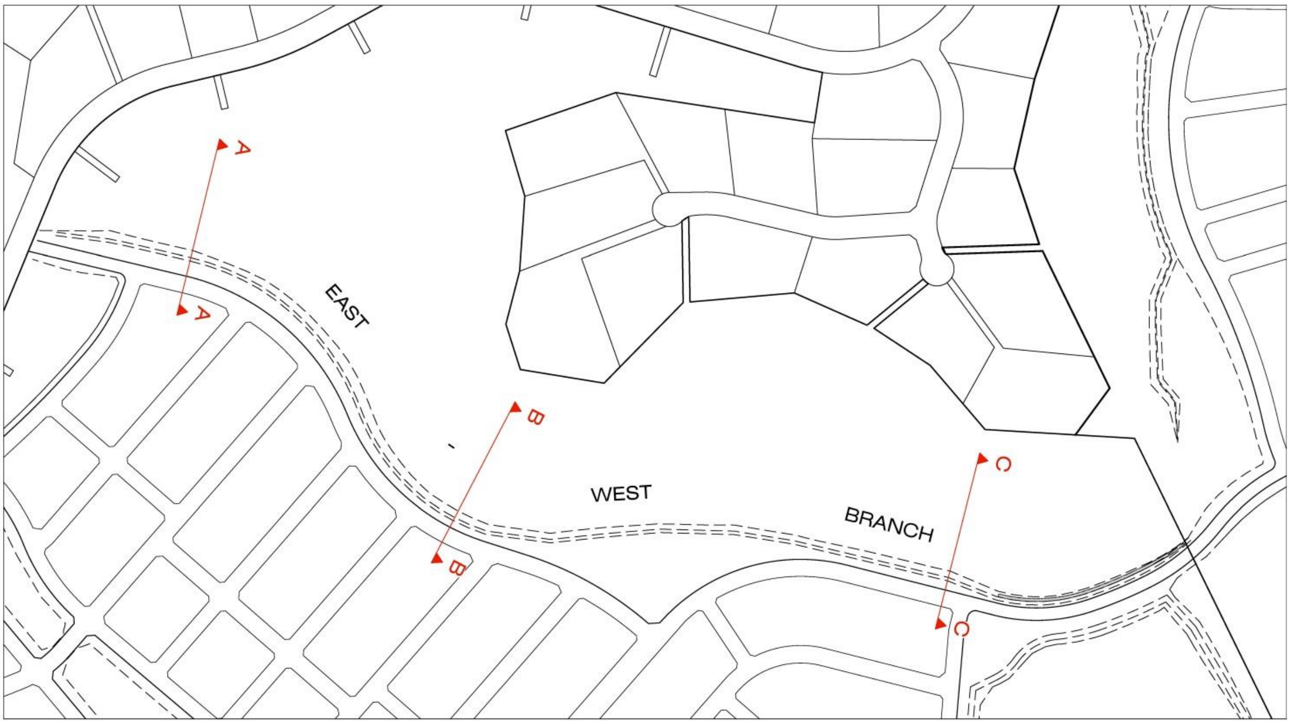
Figure 2 - West Branch / South Branch / Monkey Jacket Branch Floodway Typical Section

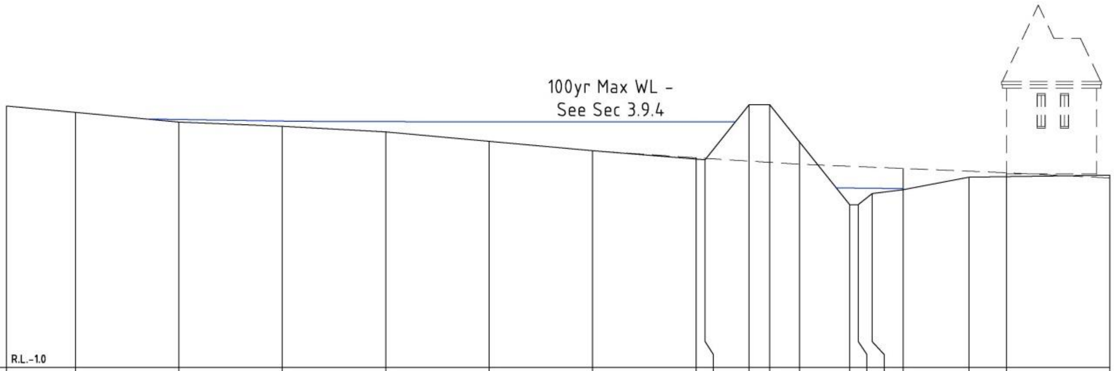
2.3 Interception of Upstream Flows – The East-West Branch Floodway

The majority of upstream flows from the existing Shearwater Estate enter the Riverside site via a series of seven culverts under Toonang Drive. To limit the impact of this water on the approved development, the East-West Branch will intercept flows from the five most easterly incoming culverts and divert these flows along the floodway and around the main development footprint.

Doubling as a wildlife corridor, minimal disturbance will be allowed in this floodway. Instead of invert excavation, the design will instead form the floodway over the existing surface by construction of the adjacent perimeter road, with the incorporation of a raised flood mound. The mound will have a 3m width at the top to accommodate a concrete cycleway, and will include 4(H):1(V) batter slopes, landscaped with native vegetation to avoid mowing maintenance. Base grades will be substantially flat, and will result in an effective floodway of between 50-100m wide within the wildlife corridor of between 120-200m overall width.

The review of the previous report incorrectly interpreted the magnitude of this flood mound and called for a Dam Safety Committee assessment of the structure. In an attempt to better clarify the extent of the proposed structure, the following figure provides additional detail. Floodway depths and 'dam break' scenario consequences are further discussed in Sections and 3.9.4 and 3.9.6.6.



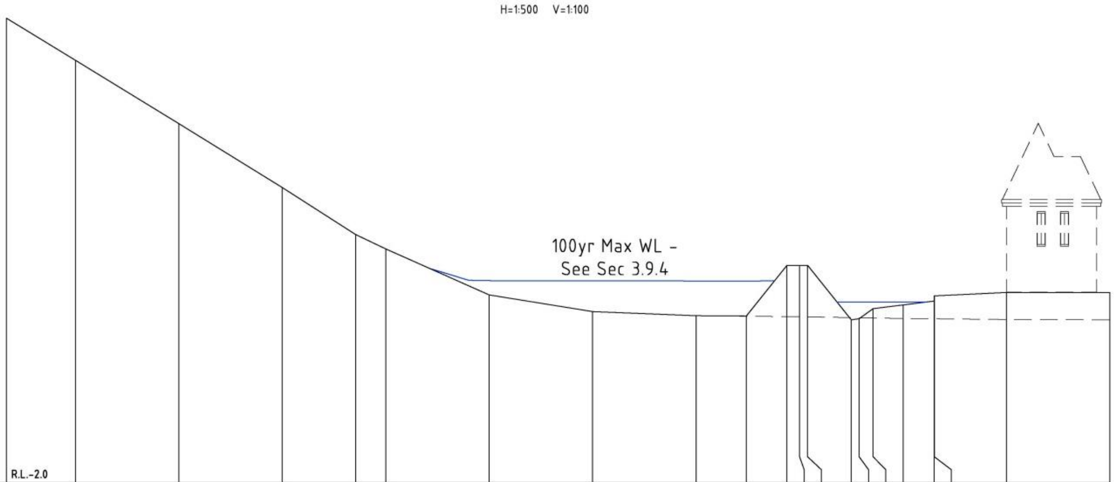


CHAINAGE	DESIGN LEVEL	EXISTING LEVEL
-130	6.581	6.581
-120	6.397	6.397
-105	6.116	6.116
-90	5.993	5.993
-75	5.831	5.831
-60	5.557	5.557
-45	5.285	5.283
-30	5.043	5.079
-28.7	5.022	
-22.321	6.617	
-19.321	6.617	
-15	5.537	4.893
-7.735	3.721	
-6.494	3.721	
-4.48	4.042	
0	4.154	4.77
9.579	4.517	
15	4.533	4.646
30	4.575	4.494

SECTION A-A
H=1:500 V=1:100

CHAINAGE	DESIGN LEVEL	EXISTING LEVEL
-130	4.575	4.575
-120	4.009	4.009
-105	3.434	3.434
-90	3.188	3.188
-75	3.086	3.086
-60	3.117	3.117
-45	3.067	3.067
-30	3.04	3.04
-21.479	3.023	
-15	4.643	3.01
-11.997	4.643	
-7.498	3.518	
-6.495	3.518	
-4.498	3.838	
0	3.951	2.979
4.503	4.063	
4.534	4.214	
15	4.322	2.949
30	4.322	2.93

SECTION B-B
H=1:500 V=1:100



CHAINAGE	DESIGN LEVEL	EXISTING LEVEL
-130	11.473	11.473
-120	10.252	10.252
-105	8.412	8.412
-90	6.557	6.557
-79.377	5.194	
-75	4.776	4.776
-60	3.44	3.44
-45	2.956	2.956
-30	2.836	2.833
-22.728	2.826	
-16.834	4.298	
-15	4.299	2.807
-13.832	4.299	
-7.498	2.716	
-6.364	2.749	
-4.334	3.041	
0	3.149	2.756
4.504	3.262	
4.534	3.412	
15	3.511	2.726
30	3.509	2.718

SECTION C-C
H=1:500 V=1:100

Figure 3 - East-West Branch Floodway Details

2.4 Distributing Site Discharges Along the Full Wetland Frontage

One of the main objectives for the design of the Riverside Estate is to minimise the impact on the adjacent downstream wetlands. Previous modifications to the proposal successively relocated the development footprint so that the main body of the development is now over 350m from the SEPP14 wetlands.

Post development, it is important to both maintain the flow regime during regular rainfall events, and ensure that large events are not concentrated to the point that they result in scouring, high velocity flows. An important feature of the Riverside development is a low level weir and level spreader along the full frontage between the development and the wetland buffer. Much of the low flow discharge from the existing site is via infiltration. In order to replicate this, post development low flows will be contained behind this weir and allowed to infiltrate.

Larger storm events will top over the weir along the full frontage of the wetland buffer and distribute low velocity flows into the wetland buffer and on towards the wetland, as would currently occur. In order for this arrangement to also provide peak flow attenuation, two low-flow outlets will be positioned where the existing surface drains currently deliver point source discharges into the wetland buffer area.

The design modelled for this spreader includes a 2.5m wide weir crest at RL2.0m AHD, with the two low-flow discharge culverts at RL.1.4m. It should be noted that the level spreader and low flow outlets are outside the wetland buffer area, and generally around 250m from the SEPP14 wetlands. An assessment of the effectiveness of this arrangement to replicate existing flows into the wetland buffer can be seen in Section 3.9.1.

2.5 South Branch Floodway

Primarily required to drain the future commercial area precinct and draining south under the existing ‘Bebo’ bridge into the existing saline, the South Branch is also connected to the West Branch via a high level overflow weir. Regular flows from the main Riverside site will not enter the South Branch, but in rarer events peak flow will top the weir and the South Branch will provide an additional floodway discharge path, replicating existing flow conditions.

Construction of this floodway area will include the removal of an existing temporary flood interception berm and haul road. It will also provide storage and infiltration capacity, and areas for reforestation and public open space.

2.6 Monkey Jacket Branch Floodway

In the eastern ‘Monkey Jacket Precinct’, upstream flows from Shearwater Estate will be intercepted by a collection drain above the development ring-road, and directed towards the Monkey Jacket Branch floodway that is central to this precinct. As with the West Branch, the Monkey Jacket Branch also has multiple functions which include acting to collect, detain, infiltrate and convey the development runoff.

Discharges from this branch will be initially into a downstream constructed wetland for water quality treatment before flowing into to the existing river inlet just as the existing drains do in this area of the site. This area will also provide areas for reforestation.

2.7 Bio-filtration Swales

Detailed discussions have been held with Council engineers to develop a preferred approach to incorporating bio-filtration swales into the streetscape. Bio-filtration swales are the favoured treatment device of Great Lakes Council as they provide ‘at source’ water quality treatment. They are, however, a relatively new addition to the urban stormwater landscape, and are yet to be widely implemented in the GLC area. Council’s Engineering Department had not yet developed standards for the implementation of bio-filtration swales until approached in regard to the Riverside development.

Significant efforts were made in conjunction with Council and local service authorities to adapt available bio-retention guidelines to the specific requirements of the Riverside site and Great Lakes Council. Required modifications from previous Council standards include a single road crossfall, modified kerb types, relocation of the footpath and rearrangement of service locations and road verge widths. Figures 4 and 5 detail the proposed arrangements.

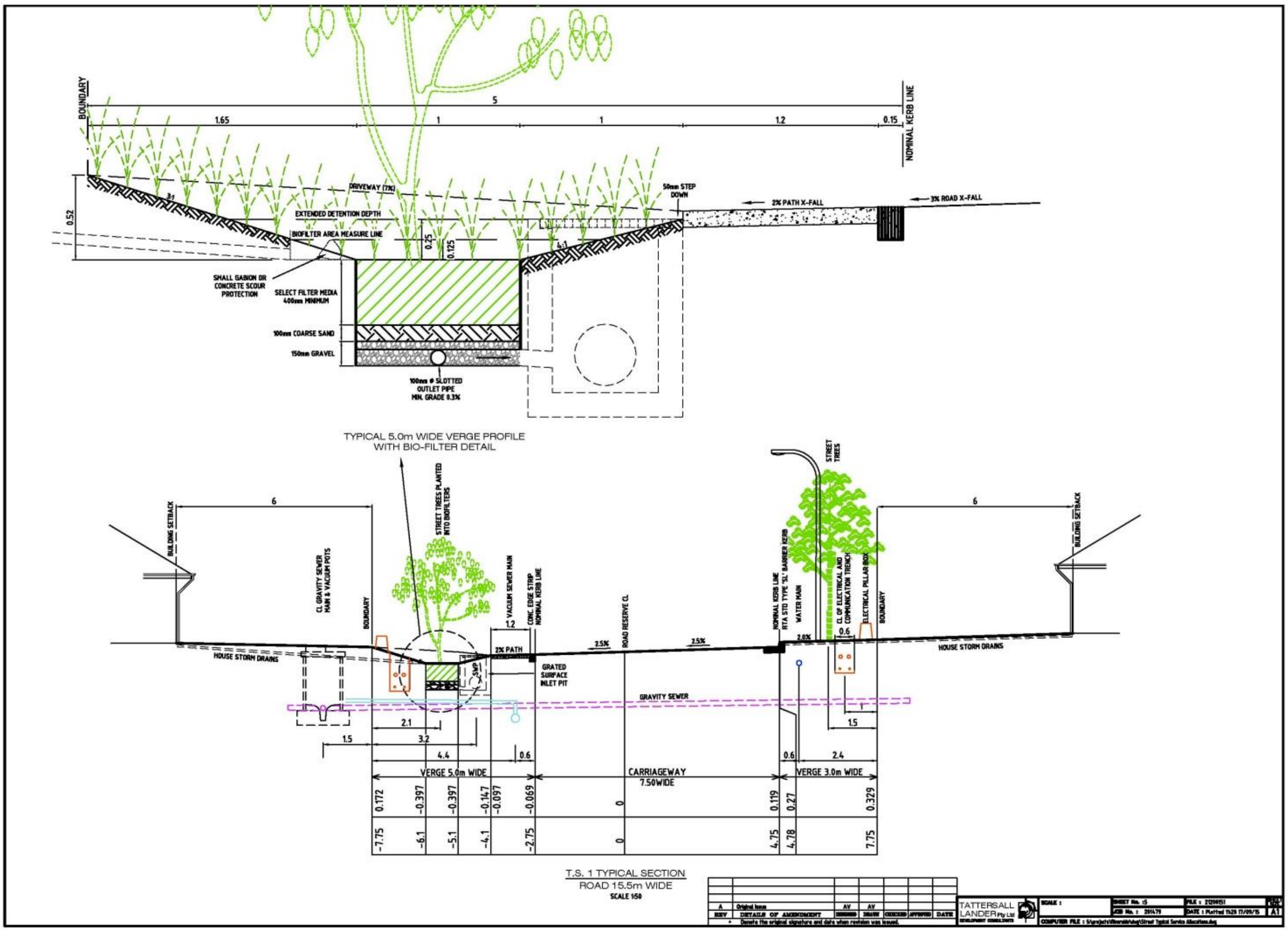


Figure 4 - Typical Street Profile including all Services and Bio-filtration Swales

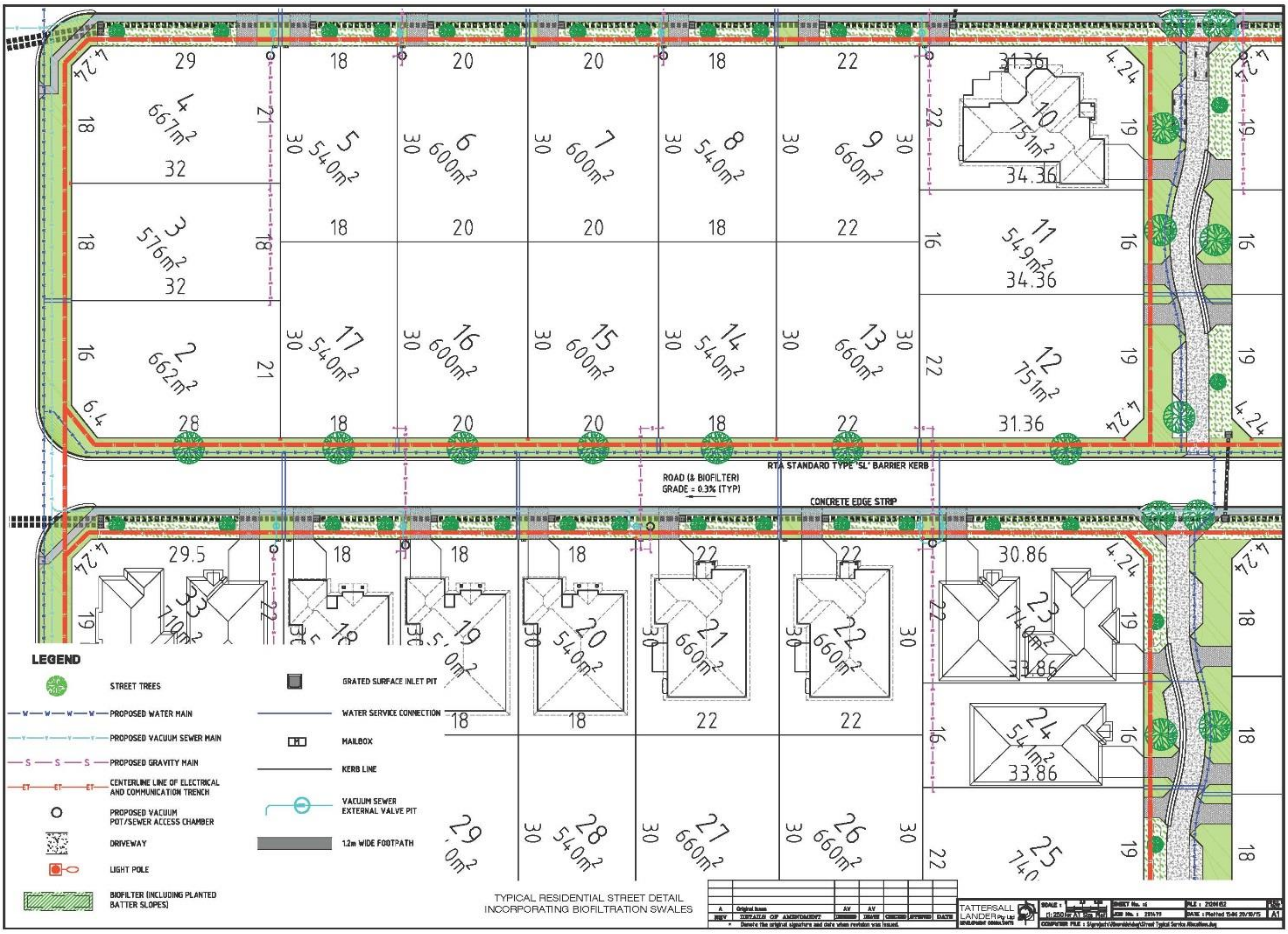


Figure 5 - Typical Street Detail including all Services and Bio-filtration Swales

2.8 Site Filling/Road and Street Drainage Design

In order to produce residential land suitable for future housing, the development footprint area of the site will be filled with imported material. Levels on all lots have been set to be free from the worst case 100yr flood levels. Minor roads adjoining floodways have been designed to be covered by a maximum of 0.3m of water by the worst case 100yr flood (see Figure 3).

Intersecting roads perpendicular to the floodway rise away at a minimum grade of 0.3%, the level controlled by the Great Lakes Council minimum stormwater pipe grade. The normal 0.5% minimum road grade is not relevant in this development as this is a kerb self-cleansing grade, and at Riverside the low side kerbs have now been replaced with bio-filtration swales.

Details regarding the extent of filling within the floodplain, and impact on flood behaviour are addressed in more detail in Section 3.8.

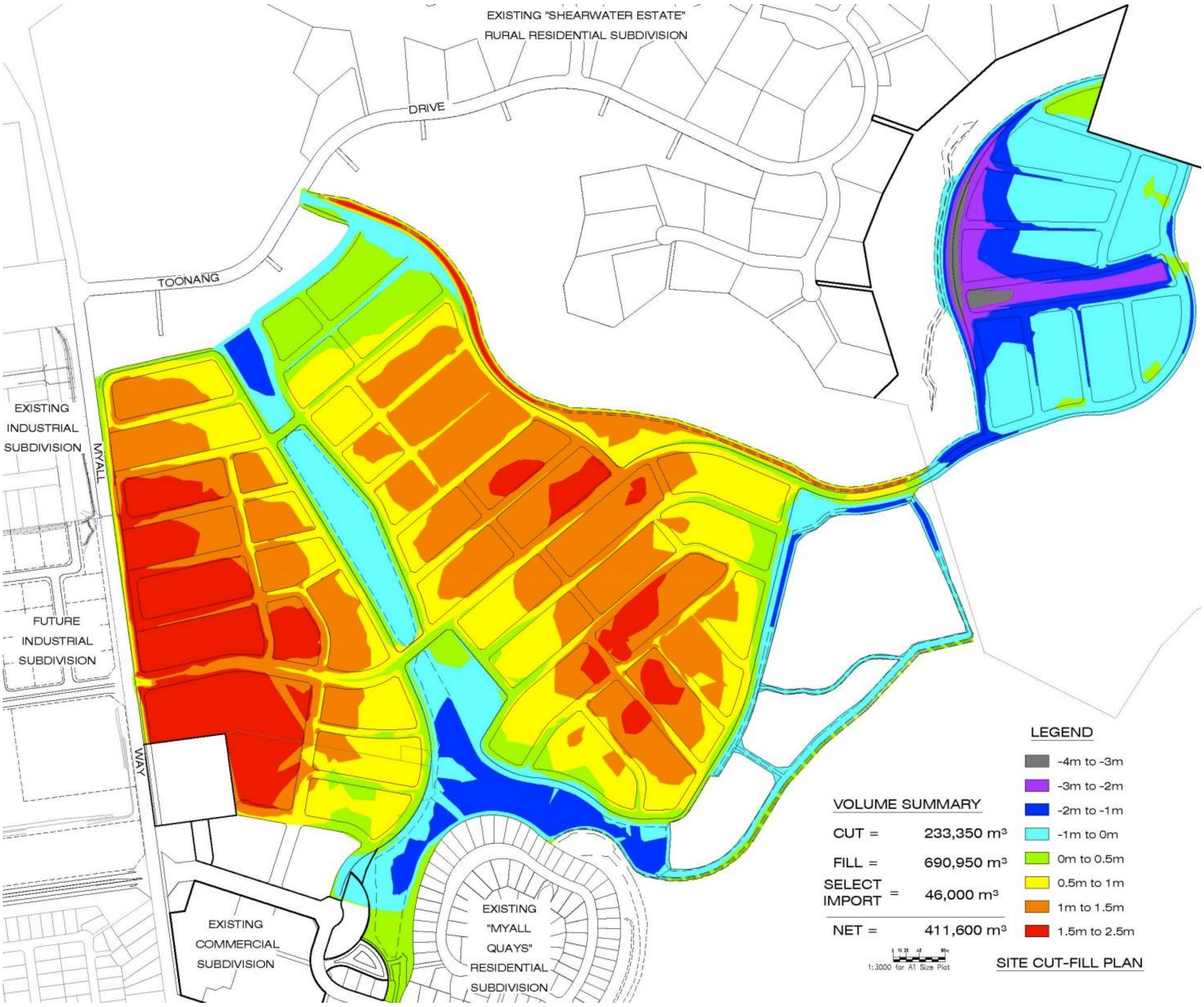


Figure 6 - Site Cut-Fill Plan Illustrating Proposed Earthworks

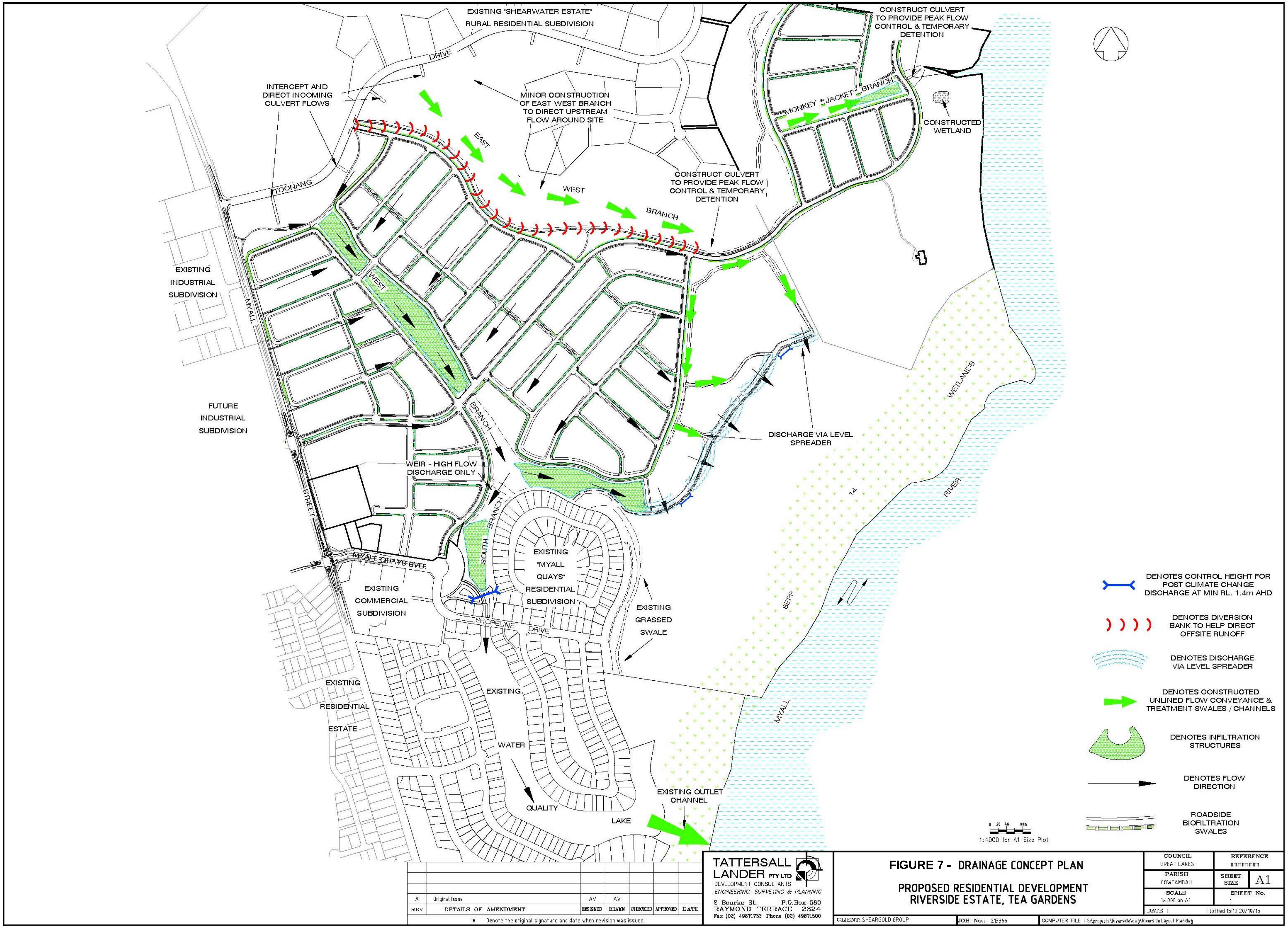


Figure 7 - Drainage Concept Plan

3.0 FLOODING AND DRAINAGE ASSESSMENT

3.1 BACKGROUND

The aims of this flood study include;

- To update previous Riverside flood study results to consider the modified layout and development footprint,
- To update previous Riverside flood study results to consider the results of the new Lower Myall River and Myall Lakes Flood Study,
- To refine the design of approved concept floodways, drainage structures and required fill levels within the development,
- To address all drainage related conditions on the Concept Plan Approval (Section C9 Flooding and Climate Change), including further details about "*ground elevation data, model calibration and sensitivity analysis, refinement of the grid spacing, catchment boundary (Myall Rd), impact of the development on Myall River Flooding, impact of the development at northern boundary and Toonang Drive, the East West Deflector Embankment Levee, Blockage Modelling and Access and Evacuation routes.*"

A hydrological model of the Riverside development and surrounding areas has been prepared utilising the XP-Storm 2D computer modelling software. Both existing and developed DTM scenarios were modelled with numerous storm events covering the full range of exceedance probabilities. Only durations previously determined critical were re-run for the purposes of this report.

3.2 PREVIOUS STUDIES

The most recent study on the site was prepared by Tattersall Lander in January 2013, which was peer reviewed by BMT WBM and approved with conditions as part of the Riverside Concept Approval. It included a number of additional assessment criteria identified as shortcomings in the previous reports prepared by Cardno to support previous iterations of the Riverside proposal. These included Hydraulic Category mapping, Flood Hazard mapping, Probable Maximum Flood assessment, Flood Planning Level assessment, analysis of public safety and evacuation requirements and the inclusion of the Monkey Jacket precinct within the flood study.

Following further modification to the proposed development footprint and drainage strategy, this study is intended to provide similar analysis to the previous study, incorporating the updated development proposal, data from more recent adjacent studies, and addressing the areas of the previous report highlighted in the consent as requiring further detail.

3.3 CATCHMENTS

Prior to the last Tattersall Lander flood study for the Concept Approval, previous studies on the site had utilised a 1D xprafts ‘node and links’ flood model, which required the catchment to be broken up smaller sub-catchments and allocated indicative areas, widths, slopes, routing parameters etc. to attempt to replicate flow conditions. With the advent of 2D modelling, this approach is now unnecessary. In the models prepared for the previous report and this update, rainfall was applied directly to the grid, which then flows across the model as directed by the underlying DTM.

The extent of the model stretches from the top of the watershed along Viney Creek Road above Shearwater Estate to the north, west to Myall Street, east across the SEPP14 wetlands to the Myall River, and south to Coupland Avenue. The extent of the 2D model is shown below in Figure 8. In total, the 2D model extents cover around 350Ha. It can be seen the modelled catchment includes all upstream lands to the top of the catchment, the Riverside site and all adjoining downstream land potentially affected by flows from the site.

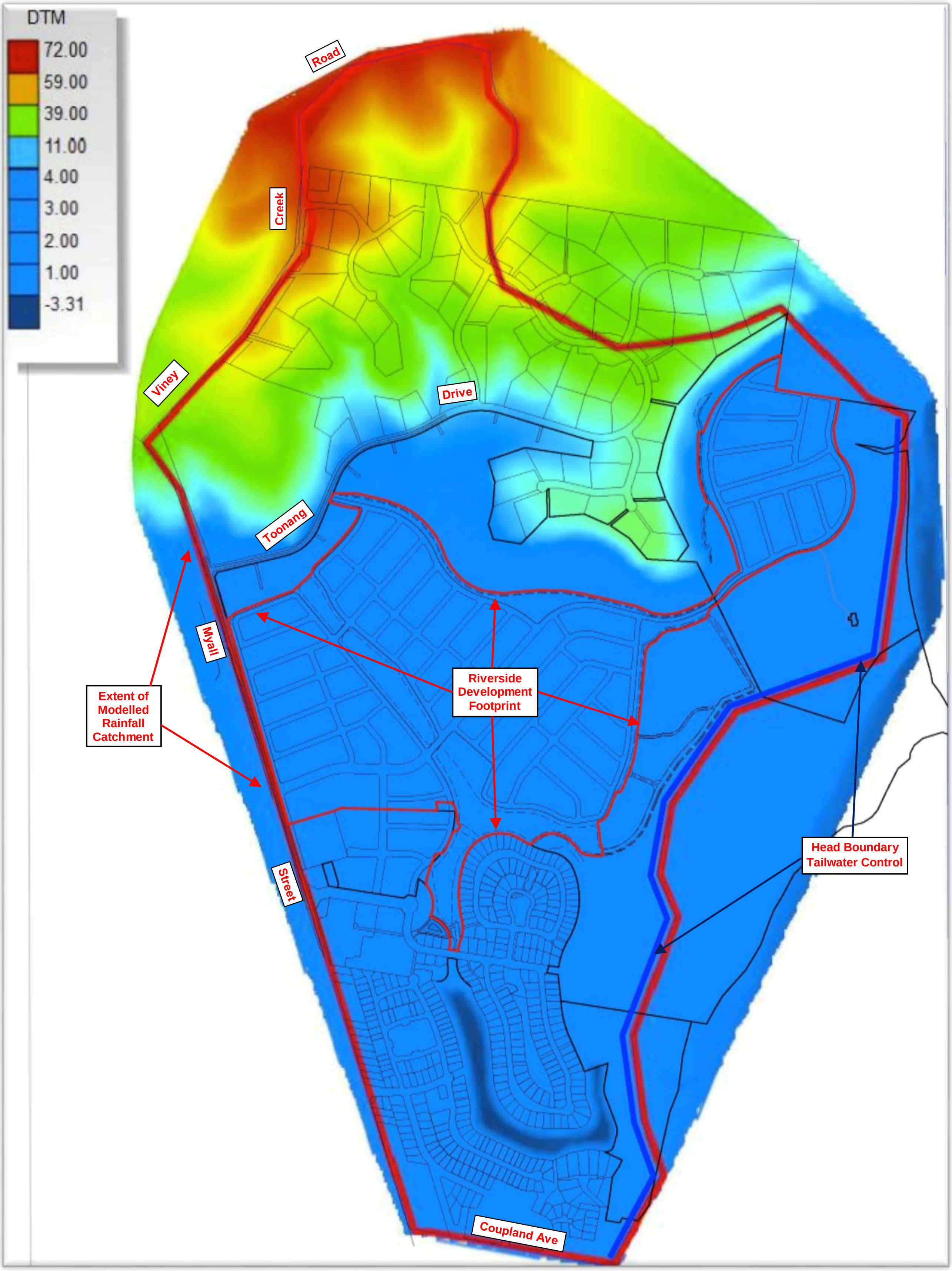


Figure 8 - DTM and Modelled Catchment Extent

Given that 2D modelling (utilising 'rainfall on grid') is still a relatively new modelling procedure, it is often suggested results be compared with, or even 'calibrated' back to results achieved with older modelling techniques. It is not necessarily easy to make direct comparisons with previous models – the previous 1D model of Riverside prepared by Cardno simplified the entire model into 38 nodes populated with 'average' conditions for a certain area of the model. Flow between nodes is via simplified 1D links with average channel properties between the nodes. By comparison the 2D model breaks the 350Ha model area into over 550,000 2.5m x 2.5m cells, and calculates automatically flow slopes and directions. It is considered this approach provides a much more thorough catchment breakdown and better results if implemented properly.

As a check, however, modelled flows were compared where possible to the previous XP RAFTS modelling prepared by Cardno. Total incoming flows from the upstream catchment onto the site from both the Cardno and current flood study are shown below for a 9hr 100yr storm.

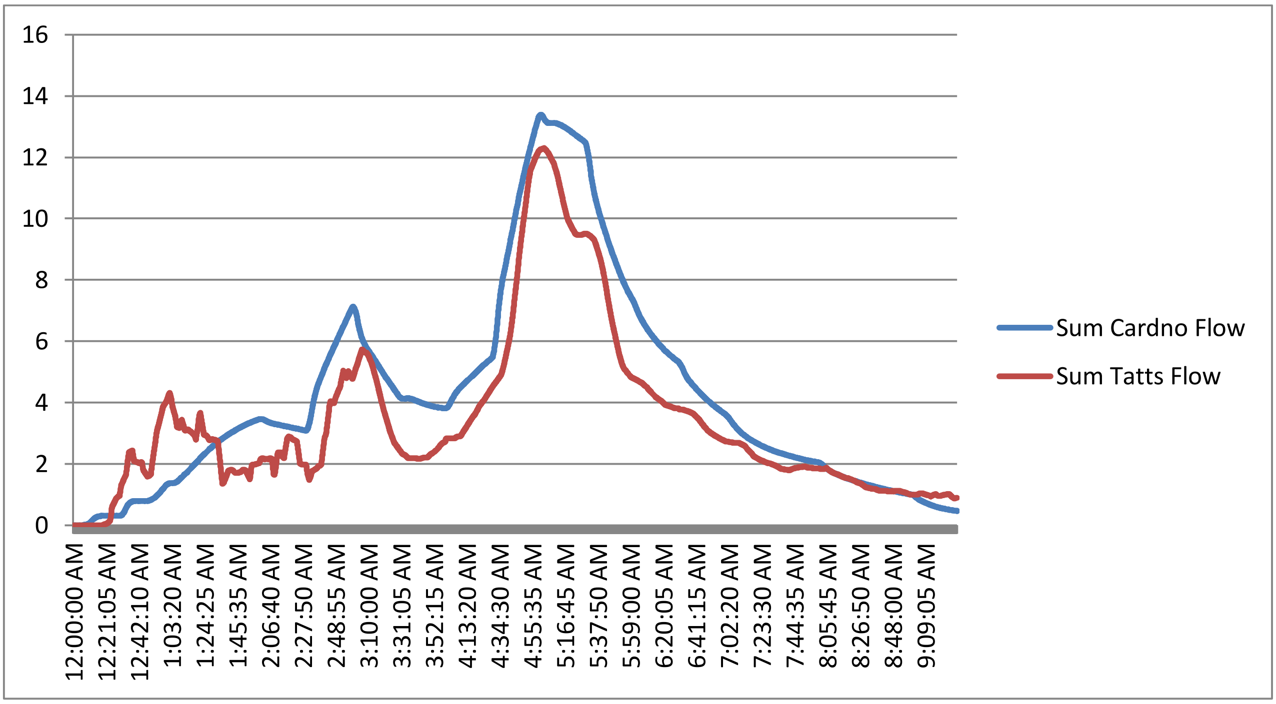


Figure 9 - Runoff Flow comparison entering Riverside Site across Toonang Drive

It can be seen the flows generated by the two models are in reasonable agreement, considering the significantly different modelling techniques utilised. The previous model had approximated this area (total area 76Ha) with only two idealised discrete catchments. While slightly lower, it is considered the current approach gives a more accurate representation than the previous work.

3.3.1 Myall Street Culverts

There are two existing culverts that flow under Myall Street, each directing a small table drain catchment from east to west. The location of these two culverts is shown in Figure 12. There is no catchment west of Myall St that drains east under Myall Street onto the Riverside site.

It was previously proposed to disuse and remove the more northern of these culverts (near the southern end of the existing industrial estate) during the Riverside development. This would have been undertaken during an upgrade to Myall Street as part of the Riverside development. In recent discussions with Council, they have indicated that they **do not** want Myall Street to be reconstructed, and instead supplemented only as required to construct new access intersections. Without reconstructing Myall Street it will not be possible to drain the road back into the Riverside drainage network as previously proposed. The northern most culvert will now remain in place and continue to drain Myall Street as it currently does. The Riverside development site will, however, be filled to drain internally and away from Myall Street, and will not direct any additional waters through this culvert.

The more southern culvert (75m south of Settlers Way) will also remain, and the small catchment draining west through this culvert was excluded from the 2D grid extents as it is a distinct separate catchment with no connection to the Riverside project or adjoining east draining areas.

Photograph 2 – Small existing culvert will be retained to drain the existing table drain

3.4 RAINFALL INTENSITIES

IFD data for the standard range of storms (1yr-100yr Average Recurrence Interval) generated via the methods outlined in Australian Rainfall and Runoff was obtained from Great Lakes Council's engineering department, and can be seen in Appendix B. The quarterly ARI intensity values were assumed to be half of the equivalent 1yr intensity.

Given the small size of the catchment (3.5km^2), rainfall was assumed to be uniformly distributed across the model and no areal reduction factor applied. Temporal patterns were applied as defined in AR&R.

PMF rainfall depths were estimated using the Bureau of Meteorology's "The Estimation of Probable Maximum Precipitation: Generalised Short-Duration Method". The GSDM calculation sheet can be seen in Appendix C. Due to the steepness of the upstream catchment, the effect the high tailwater levels have on site storages and flow conveyance, and the small size of the local catchment, the GSDM was seen as the most appropriate analysis method (the GSDM upper catchment limit is 1000km^2). The GSDM method allows analysis of storms from 1 to 6hrs duration. A review of results in Section 3.9.6.5 and in Appendix D shows the 1 and 2hr duration events to be the critical PMF event on the Riverside site.

Note - if durations longer than 6hrs were critical, or for catchments greater than 1000km^2, the site falls in the "Coastal Transition Zone', and would potentially need to be assessed under both the Generalised Southeast Australia Method and the Generalised Tropical Storm Method. The small catchment (and resulting short critical duration) means the GSDM is the most appropriate PMF assessment method.

3.5 LANDUSE CATEGORIES, RAINFALL LOSSES & IMPERVIOUSNESS

Rainfall losses were modelled in xpstorm using the initial loss/continuing loss method, which can be set separately for each defined landuse zone. A USDA Soil Type also needs to be allocated to each landuse type, which the program uses to define attributes for parameters such as soil porosity and hydraulic conductivity.

Soil profile mapping across the site shows there is a fair range of soil types ranging from straight Sand through to Sandy Clay. In recognition that each landuse zone does not necessarily correspond with existing soil types, and the fact that much of the development footprint will need to be filled with unknown material from an external source (previous adjacent site filling has been done with clean sand from a nearby quarry), an 'average' Sandy Loam USDA soil type and 10mm/5mm/hr Initial Loss/Continuing Loss values were applied to pervious areas. These values also match those adopted by Cardno in previous studies. 1mm/0mm/hr Initial Loss/Continuing Loss values were applied to impervious areas.

Impervious percentage also varies with landuse, and is summarised in Table 1.

Surface roughness values were applied using the survey data, high quality aerial photography, and the proposed development layout. Applied pre and post development model roughness values and areas are summarised in the following table and figures.

Table 1: Landuse Category Properties

Surface Type	Mannings Roughness	% Impervious
Open Water	0.02	100
Roads	0.025	100
Wetland / Wetland Buffer	0.1	0
Maintained Grass/Pasture	0.05	0
Commercial	0.025	90
Reserves	0.06	10
Rural Residential	0.04	10
Residential	0.03	50

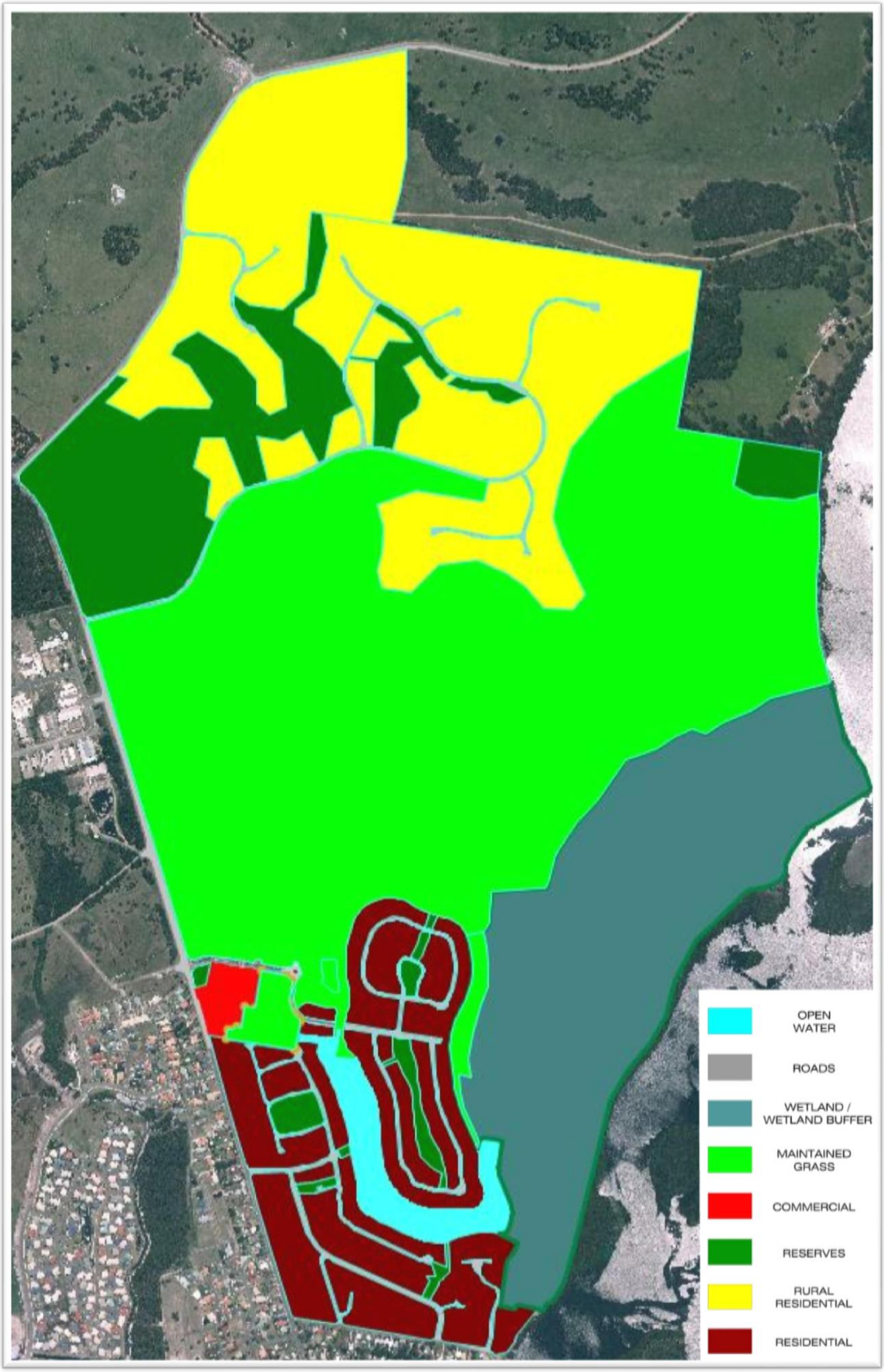


Figure 10 - Existing State Model Roughness Values

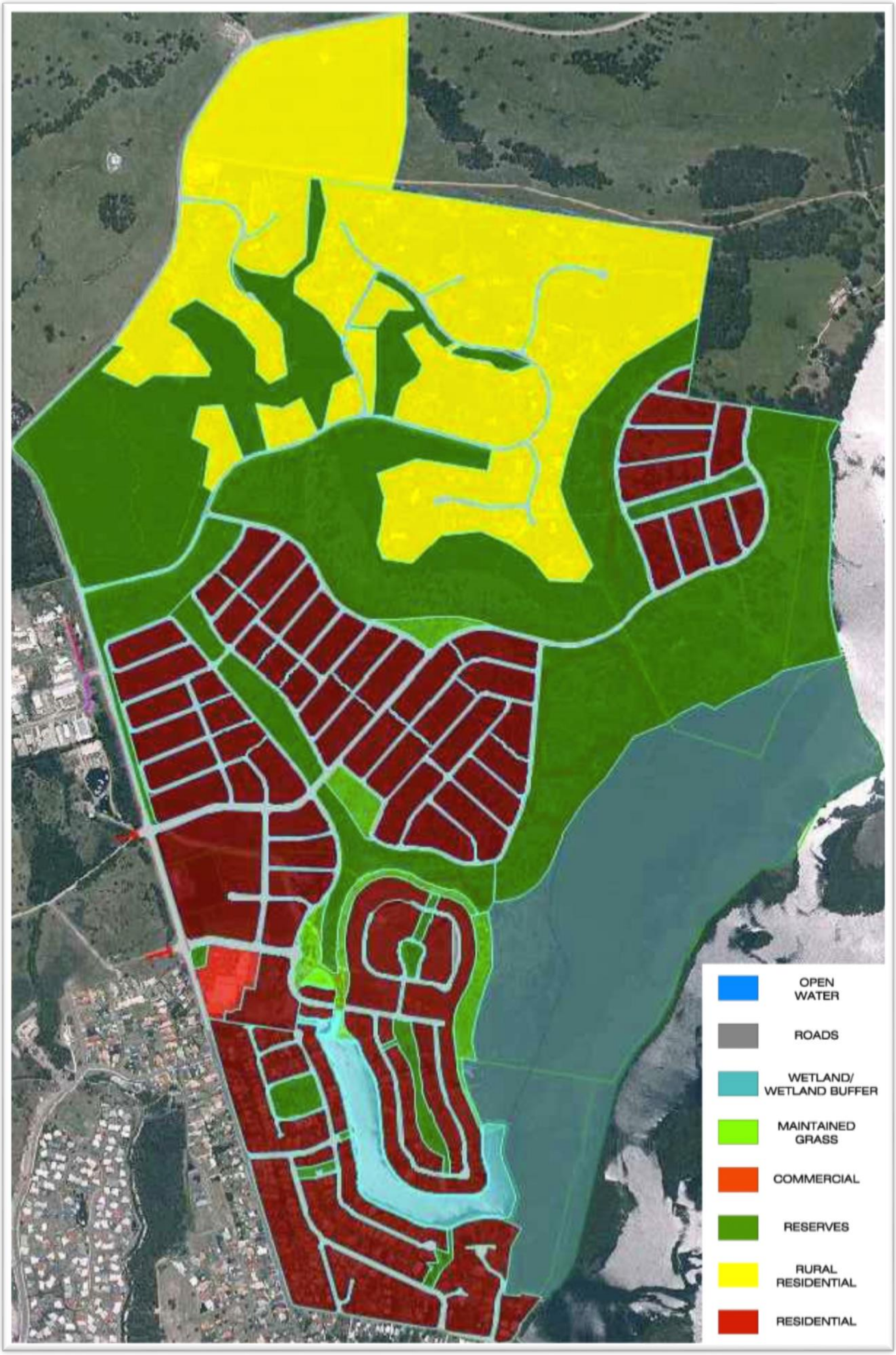


Figure 11 - Design State Model Roughness Values

3.6 TAILWATER CONDITIONS

A constant Head Boundary plane was set up along the full frontage of the Myall River to serve as the downstream boundary control. Various levels were used for different modelling purposes, and following discussions with Great Lakes Council's Engineering Department were generally sourced from the recent Lower Myall River and Myall Lakes Flood Study[1].

This new BMT WBM report supersedes and significantly updates the previous Department of Public Works Lower Myall Flood Analysis previously relied on for tailwater conditions. It provides a comprehensive flood analysis from Myall Lake down to Port Stephens, including 2D flood mapping past the Riverside development site for a full range of storm events.

A short summary is shown below in Table 2.

Table 2: Tailwater Conditions

Tailwater Condition	Adopted Level (m AHD)	Level (Previous Riverside Report) (m AHD)	Change
Existing Mean High Water	0.5	0.5	-
2100 Mean High Water	1.4	1.4	-
2100 5yr River Level	2.15	2.0	+0.15
2100 100yr River Level	2.3	2.8	-0.5
2100 'Extreme' River Level	2.5	3.3	-0.8

It should be noted that in all cases the tailwater conditions have been set at a constant steady state peak level. This is a conservative assumption as the primary factor influencing peak river levels is a tidal influence from Port Stephens. In short duration events this would have little impact on the modelled results, whereas in longer duration events the effects would be more pronounced as varying river levels during the tidal cycle may result in higher capacity for discharge and thus lower peak flood levels.

[1] BMT WBM (2015), Lower Myall River and Myall Lakes Flood Study

3.7 1D/2D MODELLING AND DTM CREATION

The model was set up as a combined 1D/2D model utilising the xpstorm flood modelling software. xpstorm is an integrated 1D/2D application that utilises a version of the EPA SWMM engine for 1D calculation and the TUFLOW engine for 2D calculations. The application of a 2D analysis should provide more accurate modelling of stormwater behaviour through the proposed Riverside development site.

The 2D domain with 2.5m grid spacing and accompanying DTM were utilised across the entire 3.5km^2 catchment. Several features were also modelled as 1D structures within the 2D domain with nodes linked directly to the grid, including both existing and proposed drainage culverts.

In order to compare results from different modelling conditions, standard ‘head/velocity’ points and ‘flow line’ sections were defined within the model. This included breaking the frontage along the wetland buffer into six 300m sections to ensure that pre and post development flows distributions are maintained.

The locations and a brief description of these points and sections are shown below.

Table 3: Head/Velocity Sample Points

Location	Description
A - E	East-West Branch Floodway
F - J	West Branch Floodway
K	Existing Basin
L - M	Existing Lake
N	Existing Discharge Swales
O - P	‘Monkey Jacket’ Branch Floodway

Table 4: ‘Flow Line’ Sections

Location	Description
CREEK	Discharge direct to the Myall River via existing creek inlet
RIVER	Discharge direct to the Myall River
WETLAND 1-6	Segmented discharge into the wetland buffer
LAKE	Discharge into existing basin flowing towards existing lake

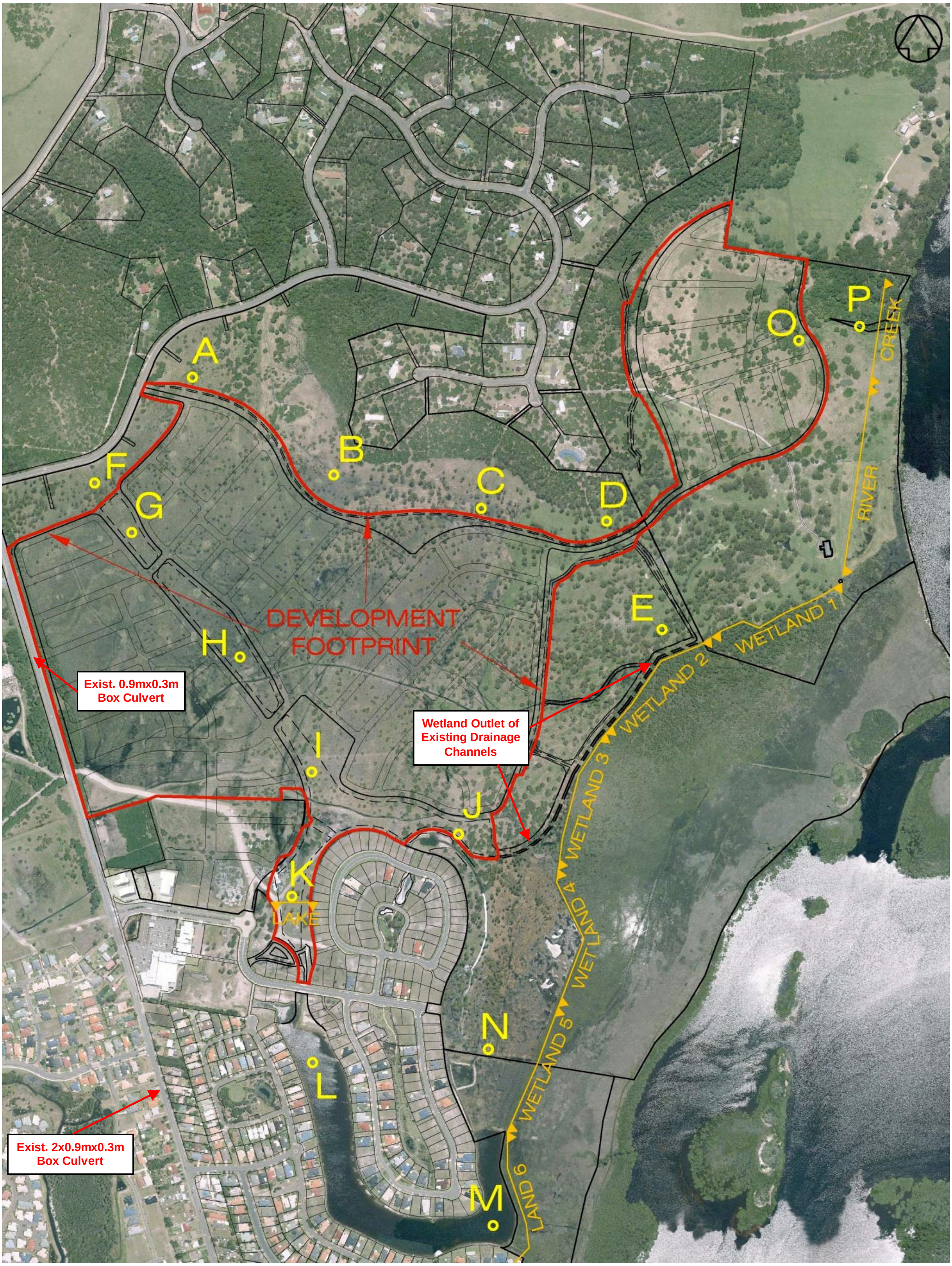


Figure 12 - Head/Velocity Sample Points and Flow Lines

Note: Under this revised proposal, the West Branch has been truncated adjacent with the northern extent of the development footprint, rather than extending all the way to Toonang Drive. This means Point F is no longer within a defined flow path and as such results are not relevant and have not been included in this version of the report.

3.7.1 Existing State Model

The majority of the existing state DTM was created from an extensive compilation of detail survey information, including the entire development site as well as all downstream areas down to the modelled receiving waters. In total there are almost 22,000 surveyed points included in the DTM. The expected accuracy of these points would be < 10mm in both position and elevation. It is considered that this is the best quality data available.

Sections of the upper third of the DTM have been prepared using a digitization of existing topographic maps. Comparison with isolated ground survey works undertaken in this area by Tattersall Lander show these levels are generally accurate to within 0.5m in height. This area forms part of the upstream catchment to the development site and is included in the modelling primarily to simulate incoming flows to the site. As this area is significantly steep in nature and has well-defined flow paths, the accuracy of the DTM in this area is considered sufficient for the purposes of the model. Care was taken to ensure no anomalies existed in the transition area between detail survey points and the lesser accuracy topographic contours sections.

Figure 13 below illustrated the breakdown of DTM sources.

A Head Boundary line was set up along the complete frontage to the Myall River as the downstream control, and initial water levels were set in the existing basins to each respective boundary condition.

A series of five separate culverts under Toonang Drive and the existing lake discharge channel were modelled as 1D structures. Additionally, there are several small existing surface drains on the site, which generally drain west to east towards the wetland. It is expected these drains will have little effect on major storm flows, but will have an impact on smaller rainfall events. The more significant of these drains have also been included as 1D structures within the model.

Note: The peer review of the previous report suggested limiting the use of the 1D structures due to the inherent loss of momentum in the way the model calculates across a 1D-2D interface, and that a smaller grid size would allow adequate representation of the existing channels. This is not the case, as the channels represented are in the order of 2m across and so would need an impractically small grid size to model properly. They were, however, made inactive in the larger flood events where high tailwater levels inundate the drains and make them less relevant to the overall results.

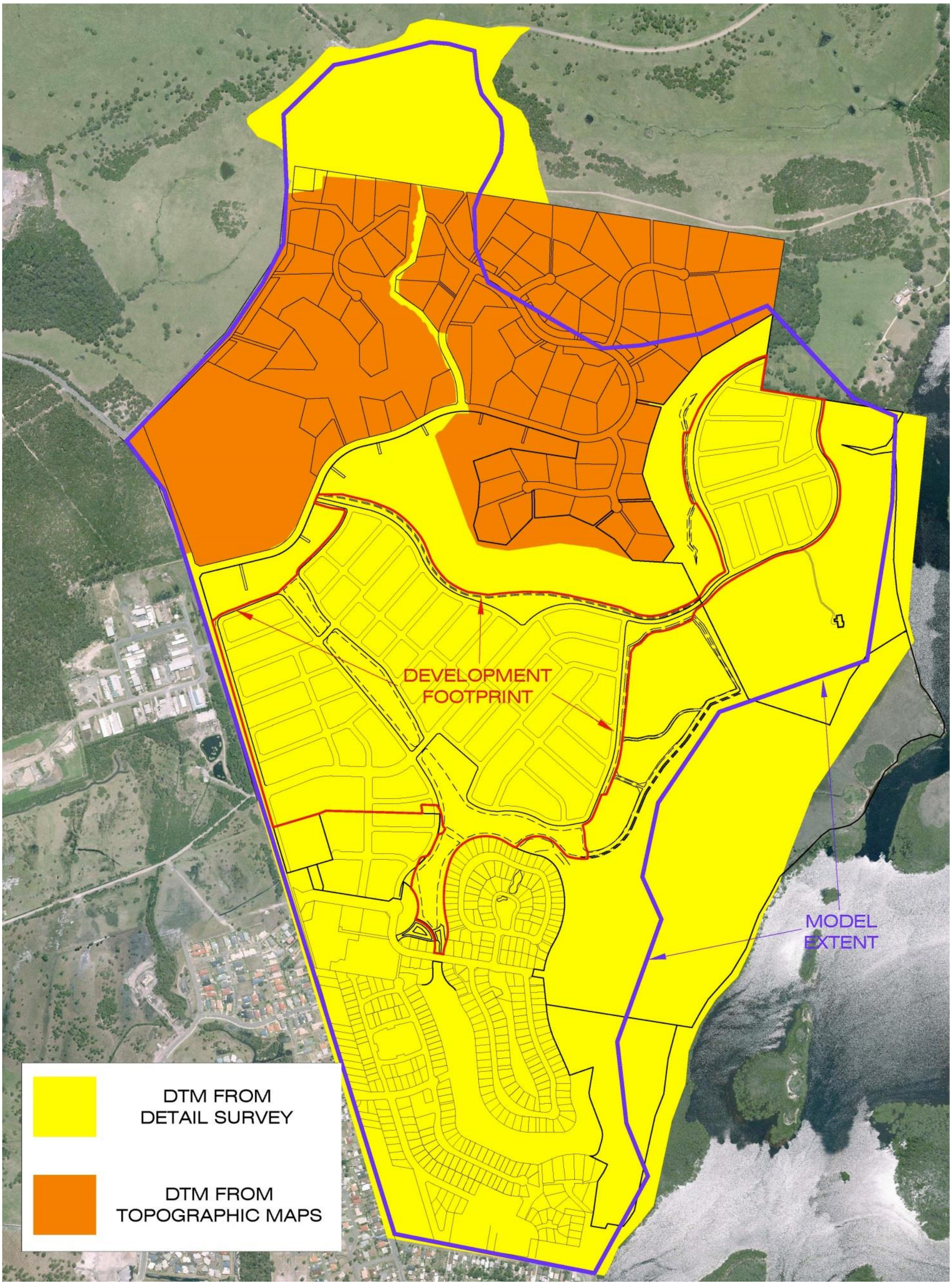


Figure 13 - DTM data sources

Screenshots from a few critical areas are shown below to illustrate the level of detail and results being achieved.

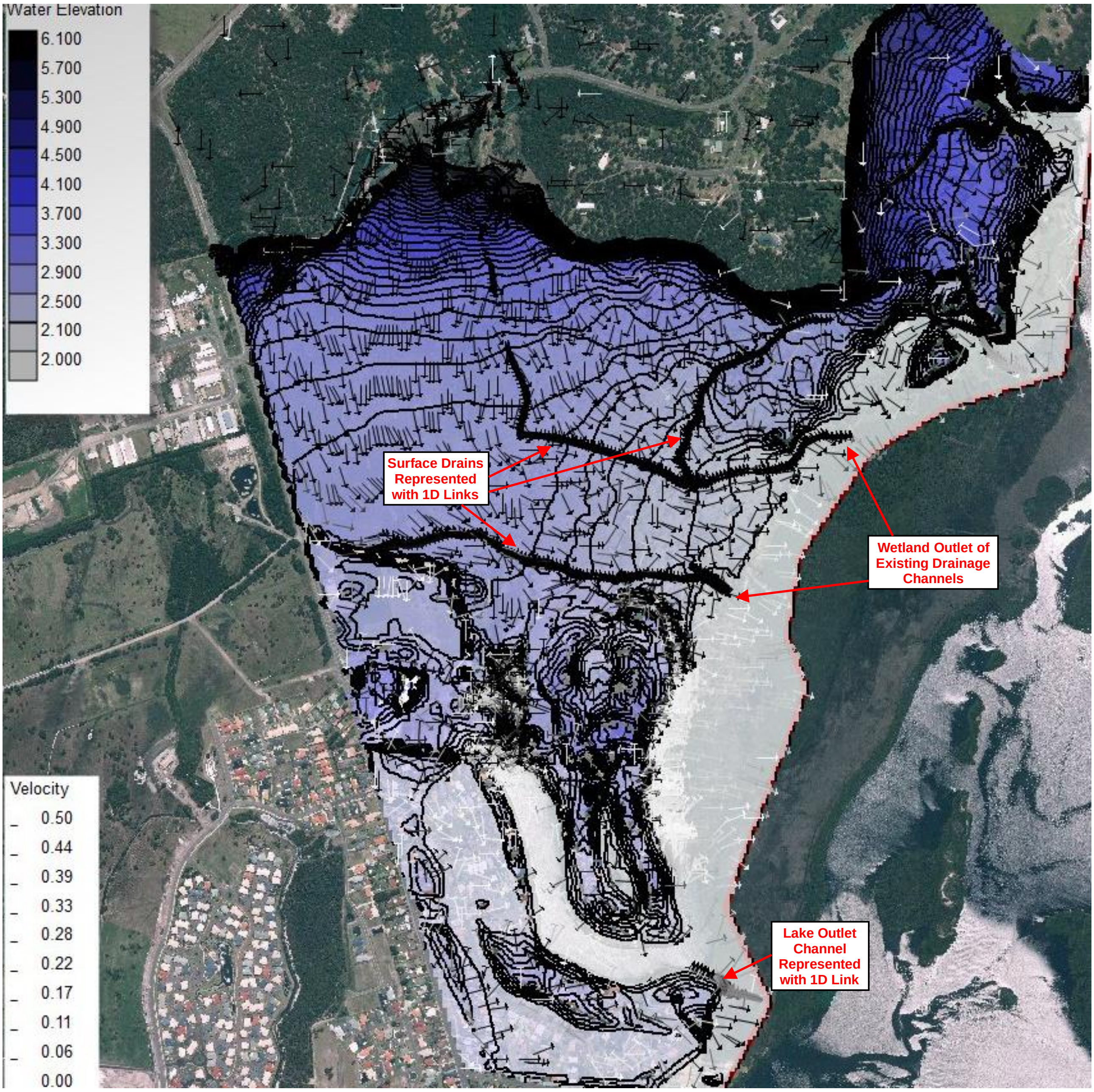


Figure 14 - Flood Contours Across the Existing Riverside Site

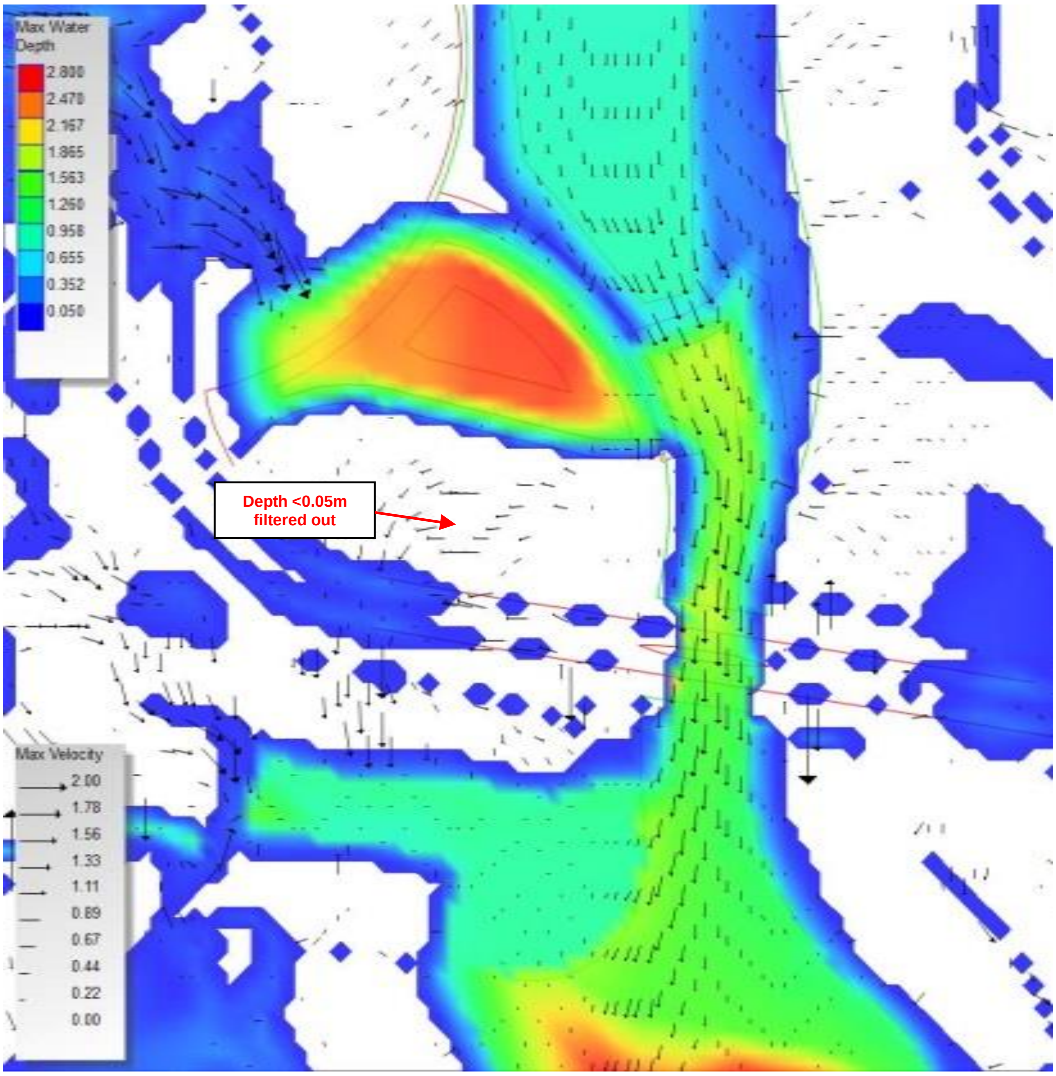


Figure 15 - Flood Depths at the Existing 'Bebo' Bridge and Adjacent Basin/Spillway

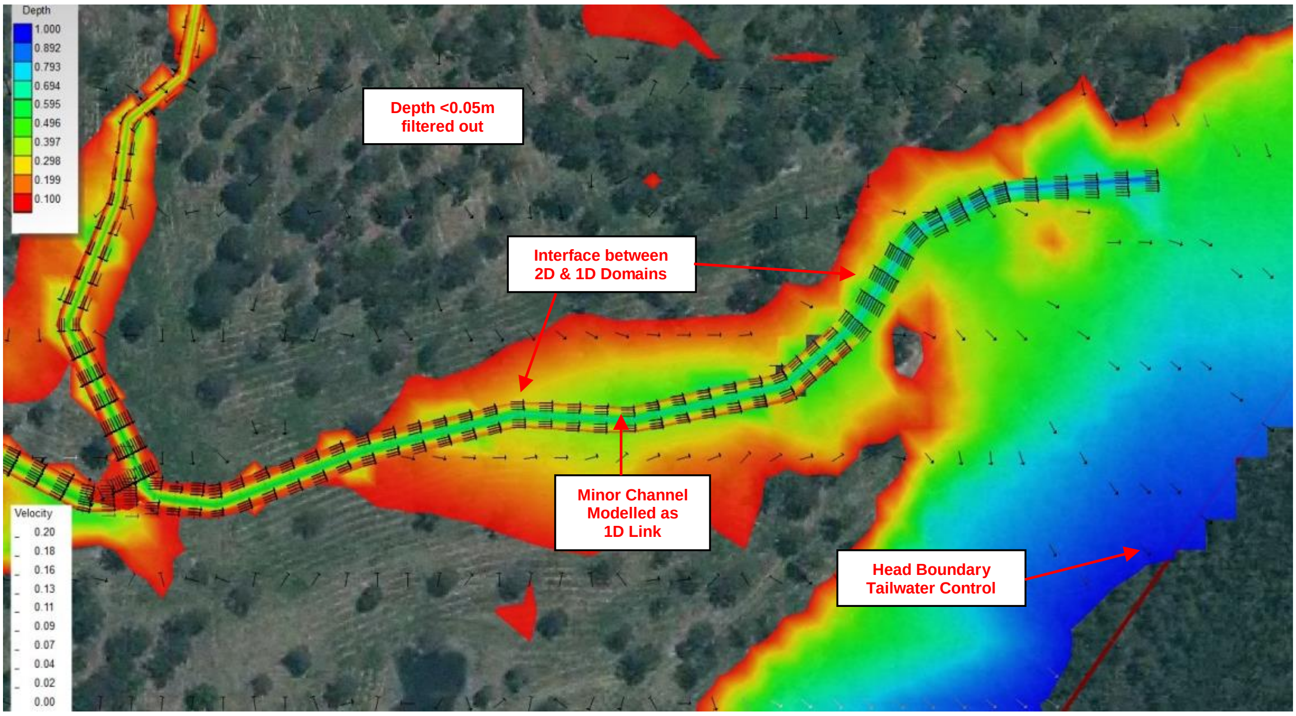


Figure 16 - Flood Depths at an Existing Drainage Channel

(channel modelled in 1D, linked to 2D)

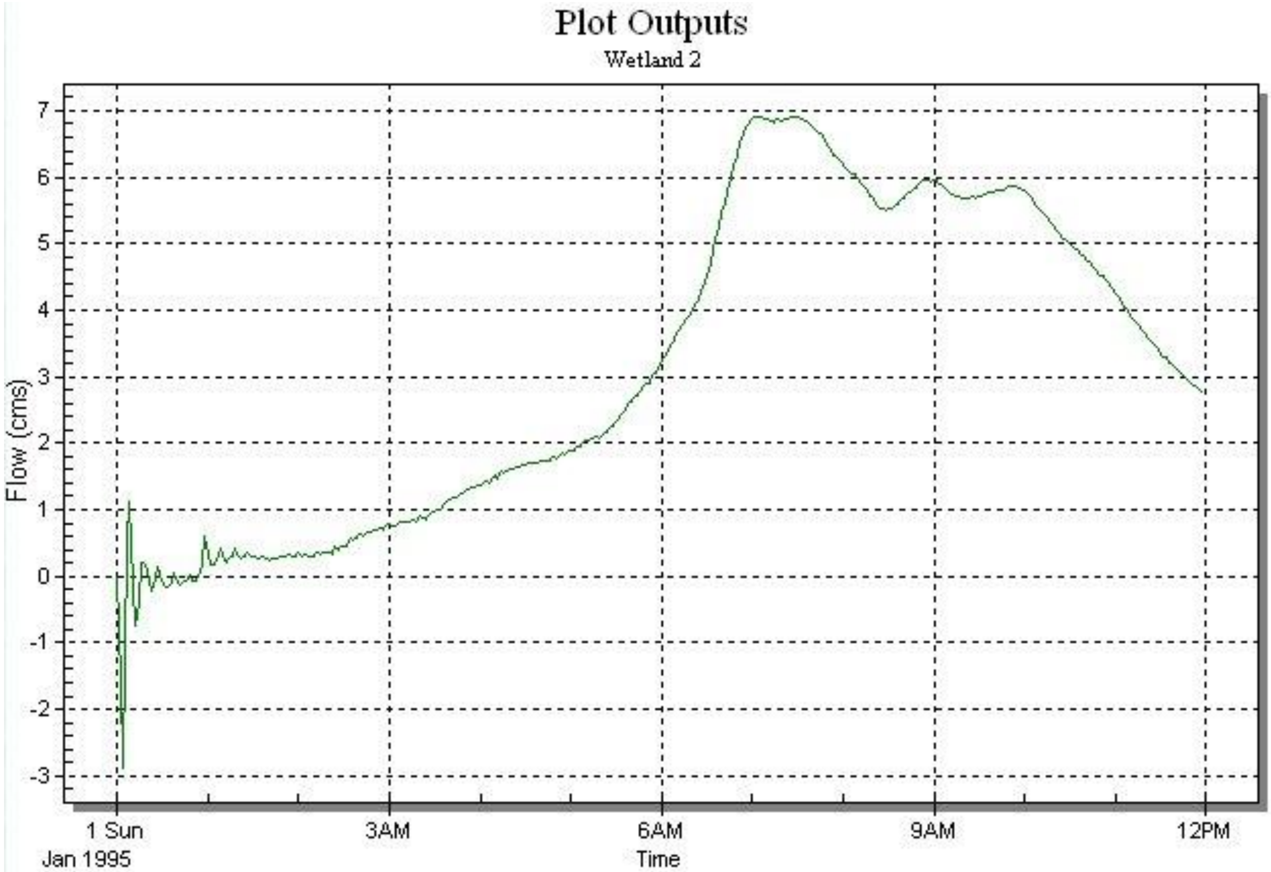


Figure 17 - Typical Flow Line Discharge Hydrograph – 'Wetland 2' 100yr 12hr Storm

3.7.2 Design State Model

The preliminary design DTM surface used in the design state flood models was created using engineering design software to model the proposed ultimate site conditions. In this DTM the drainage features described in Section 2 of this report have all been designed in detail to ensure designs are practical and the flood modelling is as accurate as possible. This included a preliminary design of every street within the development.

As with the existing state model, the design model includes the Toonang Drive culverts and lake outlet as 1D structures. In addition to this, several other proposed culverts were also modelled as 1D structures (including correcting the 'Culvert A' instability issues identified in the previous report peer review).

The model area was covered with a 2.5m grid, with 1D structures or the 'Elevation Shapes' feature used where required to ensure critical structures were identified by the model.

Only major drainage structures were included in both the Existing and Design models. There are extensive street and inter-allotment drainage networks installed in the existing residential and commercial areas adjacent to Riverside. Similar drainage structures will also be features of the final developed site. It was considered beyond the scope of this report to attempt to model the entire (existing and future) drainage network across the entire catchment area.

While significant effort and detail have been applied to the creation of the design state DTM used for this modelling to make it as close as possible to the ultimate landform, it is important to realise that this is a *preliminary* design surface only. It is still likely that there may be refining of fill levels, road grades etc. during detailed design, along with inclusion of the street and inter-allotment drainage network during the detail design process required at Construction Certificate stage. As such, results in this report are not presented as a 'fait accompli', but rather intended to demonstrate that managing stormwater as proposed in the Riverside development can meet all requirements in regard to both maintaining environmental flows to the wetland and safely dealing with minor and major flooding.

Screenshots from a few critical areas are shown below to illustrate the level of detail and results being achieved in the design state flood modelling. Detailed results relating to specific criteria are reported in Section 3.9.

Note: The existing drainage basin West of Leeward Circuit was previously included in the modelling as it is an existing structure. It caused some concern as the legality of the structure was in question. It is now understood the basin is to be removed, and as such has not been included in this revised modelling. As previously explained, the basin had no function in relation to the Riverside development and its removal has had negligible impact on model results.

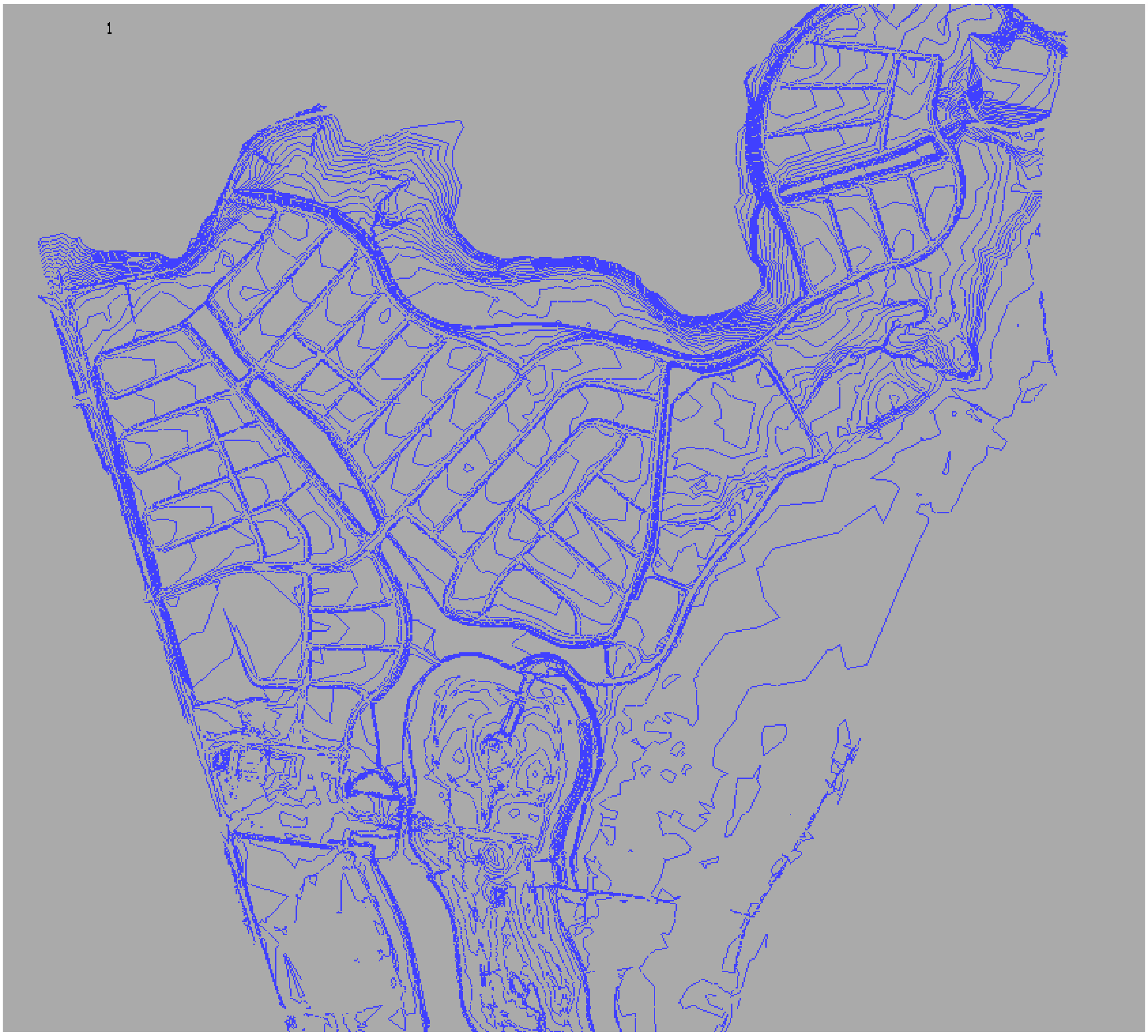


Figure 18 - Preliminary Design DTM Illustration

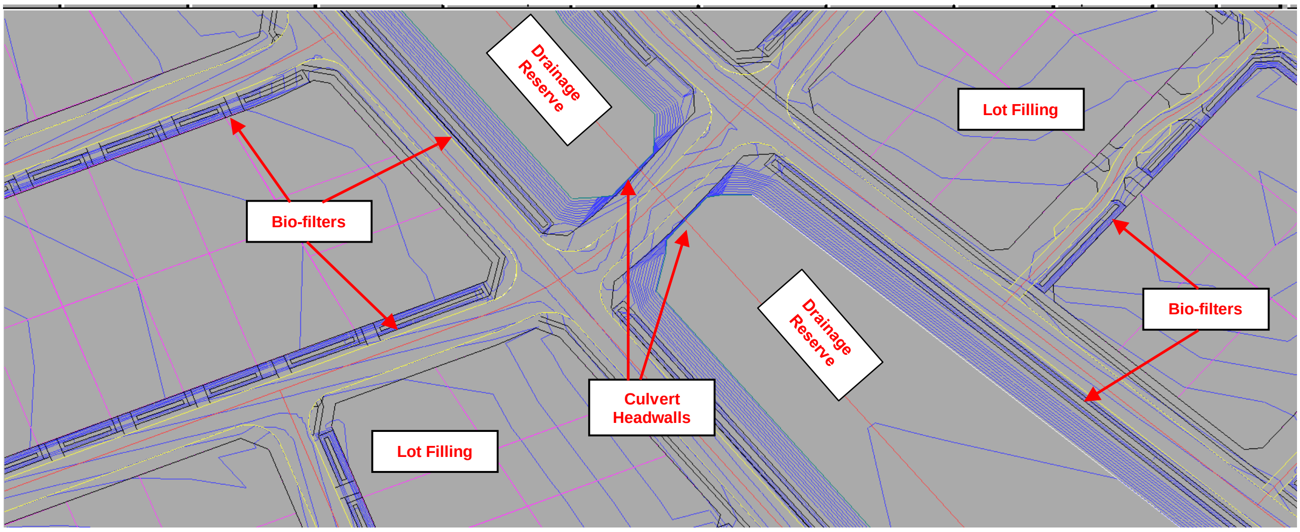


Figure 19 - Sample Detailed Preliminary Design DTM Illustration

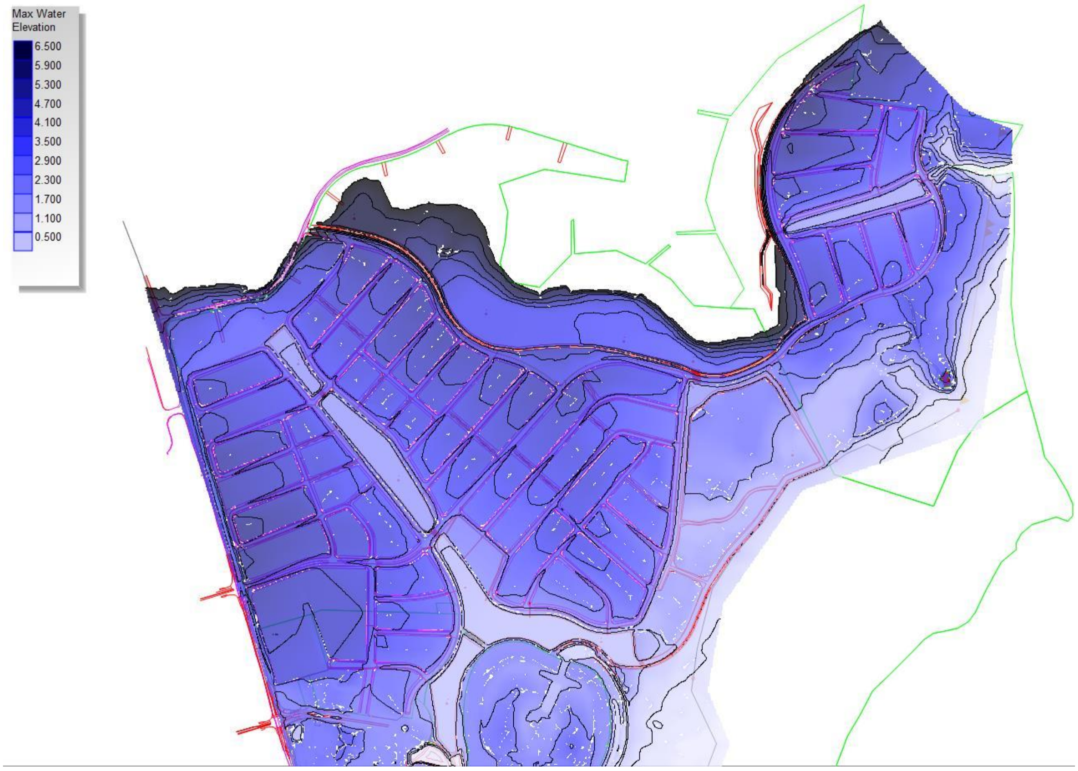


Figure 20 - Flood Levels Across Preliminary Design Riverside Site – 1yr 2hr Storm, 0.5m Tailwater

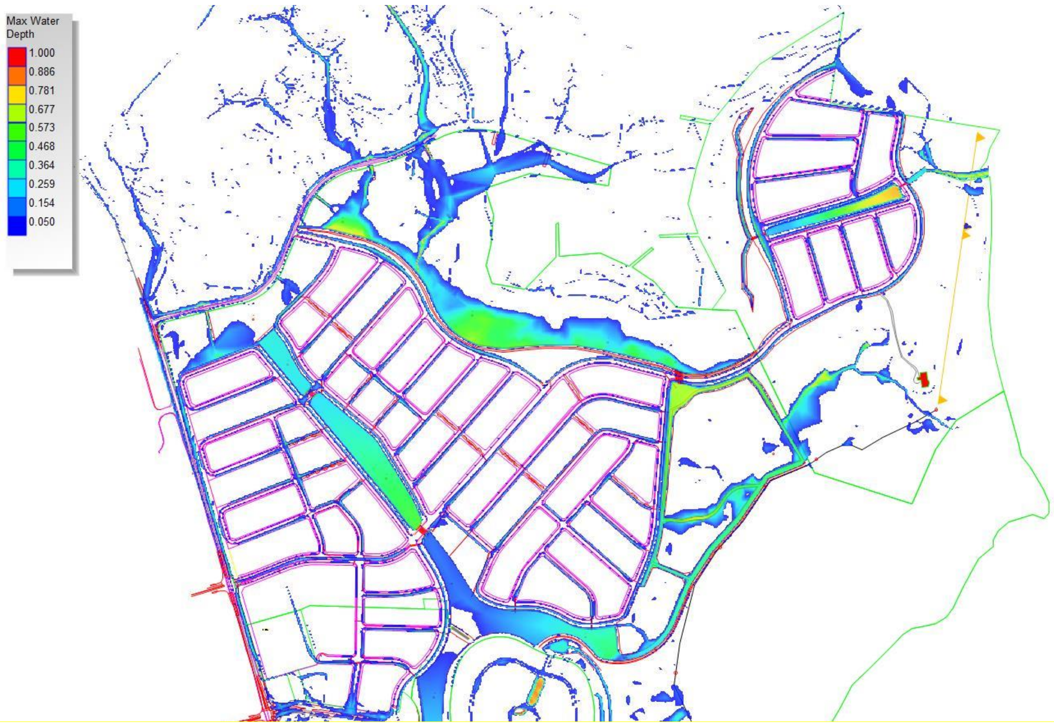


Figure 21 - Flow Depths Across Preliminary Design Riverside Site – 1yr 2hr Storm, 0.5m Tailwater

It is important to note that because "rainfall on grid" has been used to generate runoff, flood level plots (such as Figure 17 above) will appear to show flood water covering the entire site. In fact much of this area is covered only by minor surface flows. Unfortunately this is not able to be filtered out in xpstorm. By comparison, Figure 18 shows the same flood event, displaying depths rather than absolute levels. In this instance minor surface water (<0.05m) can be filtered out, showing flood waters are actually confined to designated flowpaths.

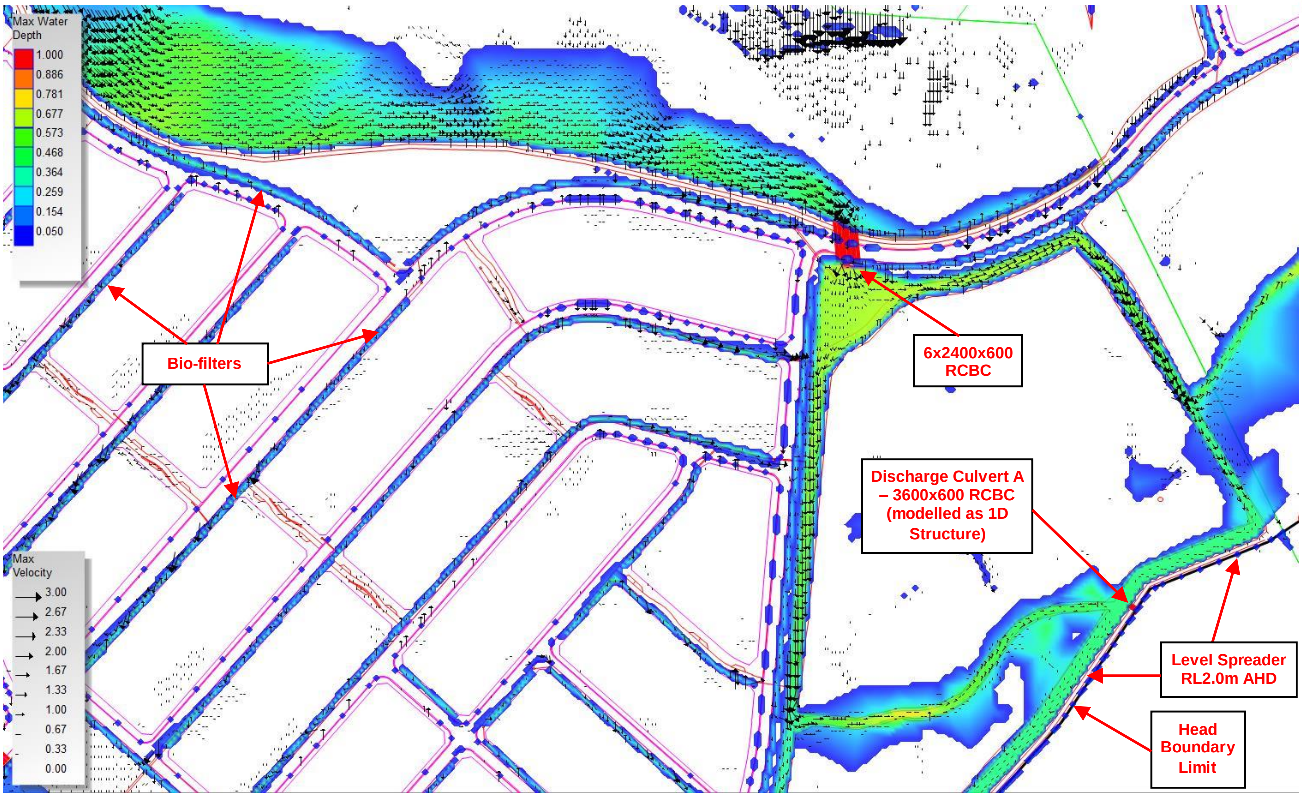


Figure 22 - Flow Depths at Discharge Culvert A – 1yr 2hr Storm, 0.5m Tailwater

Note – Level spreader is not topped

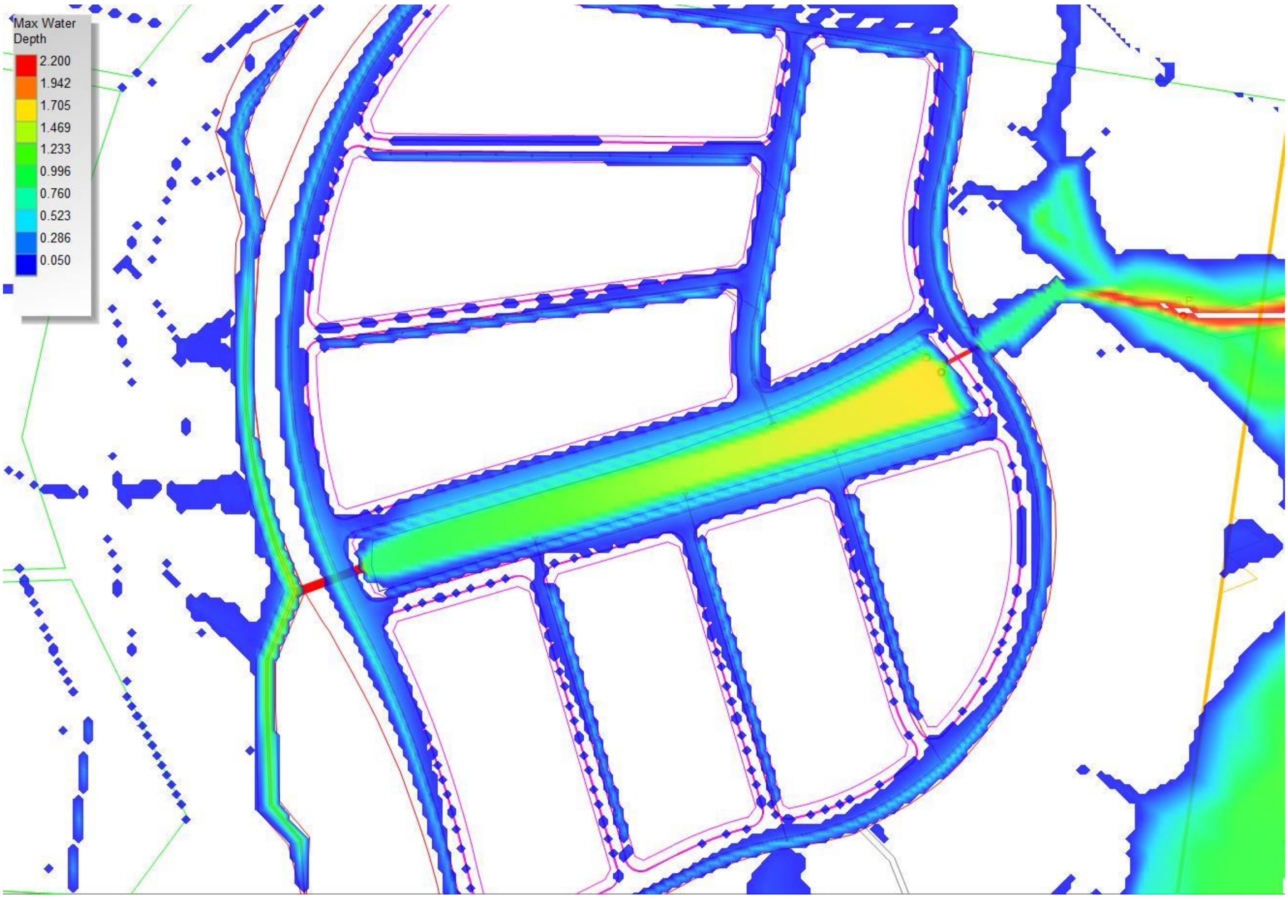


Figure 23 - Flow Depths at the Monkey Jacket Precinct – 100yr 2hr Storm, 2.15m Tailwater

3.8 HYDRAULIC CATEGORY MAPPING

The three hydraulic categories as defined by the NSW Government Floodplain Development Manual are;

- **Floodways** are areas conveying a significant proportion of the flood flow and where partial blocking will adversely affect flood behaviour to a significant and unacceptable extent.
- **Flood Storage** areas are those areas outside the floodway which, if completely filled with solid material, would cause peak flood levels to increase anywhere by more than 0.1m and/or would cause peak discharge anywhere downstream to increase by more than 10%.
- **Flood Fringe** is the remaining area of land affected by flooding, after Floodway and Flood Storage areas have been defined.

It was acknowledged in the previous Riverside report that truly accurate Hydraulic Category Mapping at the Riverside site was only possible from a larger scale catchment model. It was also known that the then underway Lower Myall River and Myall Lakes Flood Study was to include such mapping, but as the results of that report were not available at the time of the Major Projects assessment of Riverside, some ‘preliminary’ or ‘interim’ mapping was prepared with the best available information at the time.

This interim mapping can now be replaced with the BMT WBM mapping. It is important to note that the BMT WBM report utilised a 20m grid spacing in the vicinity of the Riverside development (as opposed to the 2.5m grid in this report), so the resolution of mapping extents is not as well defined as the other figures in this report.

The following figures are derived from Figure:HydCat_1% from the Lower Myall River and Myall Lakes Flood Study.

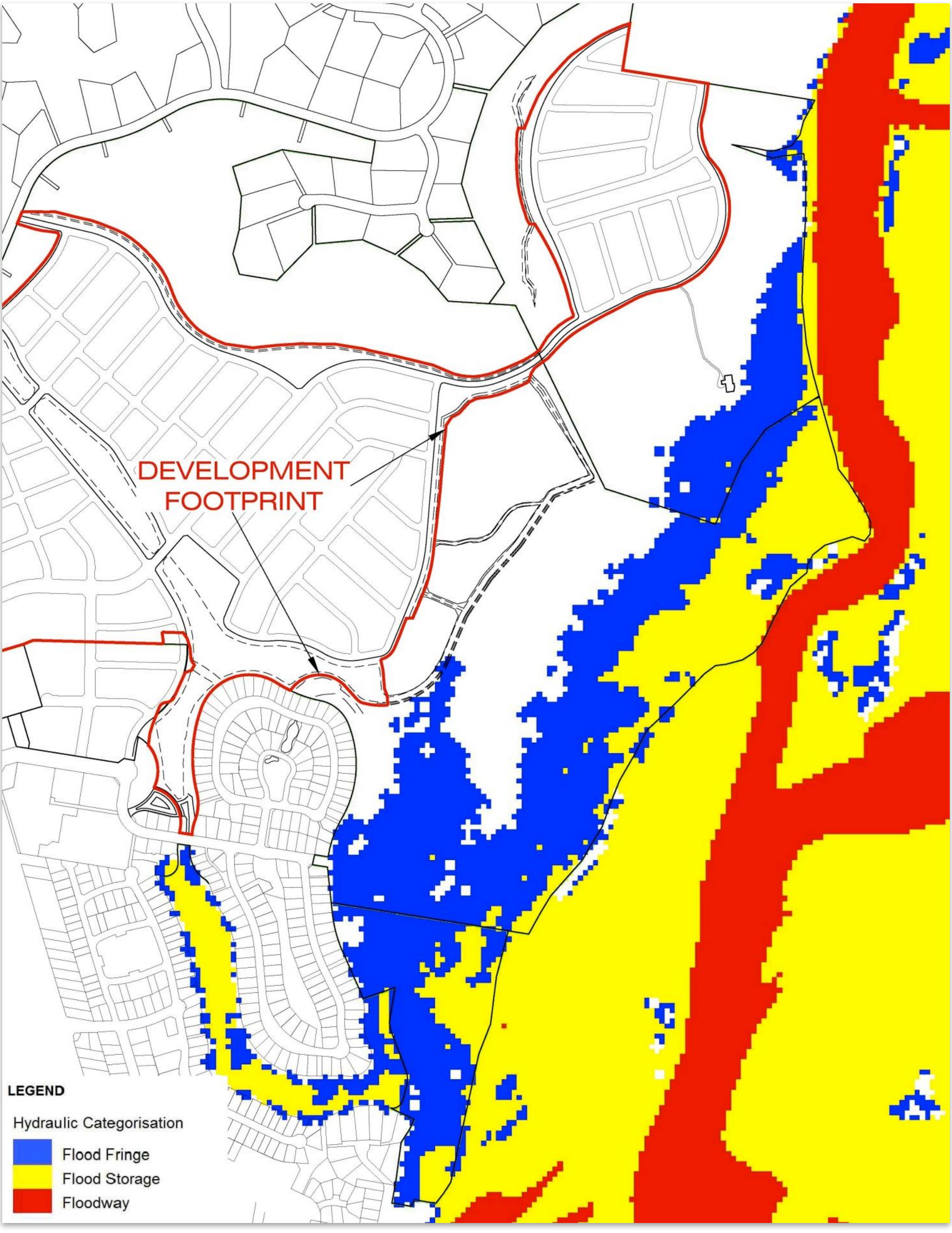


Figure 24 - BMT WBM Lower Myall Flood Study – Hydraulic Categories: 1% AEP Event

It can be seen that the Riverside site is entirely outside all Hydraulic Categories, other than a minor encroachment into the flood fringe by the south eastern corner of the level spreader.

Furthermore, the BMT WBM report identifies the 100yr 2100 regional flood level past the Riverside site to be 2.29m at Tea Gardens (near the bridge) and 2.25m at Monkey Jacket. By interpolation the 100yr flood level adjacent to the Riverside site would be around 2.27m AHD. (For simplicity, Council have adopted a uniform 2.3m for all development at Tea Gardens).

The following figure shows the total extent of encroachment within the 2100 100yr flood extents. Flood depths within this area are a in the range of 0-0.4m, and in total represents approximately 13,800cu.m removed from the floodplain by filling for the development.

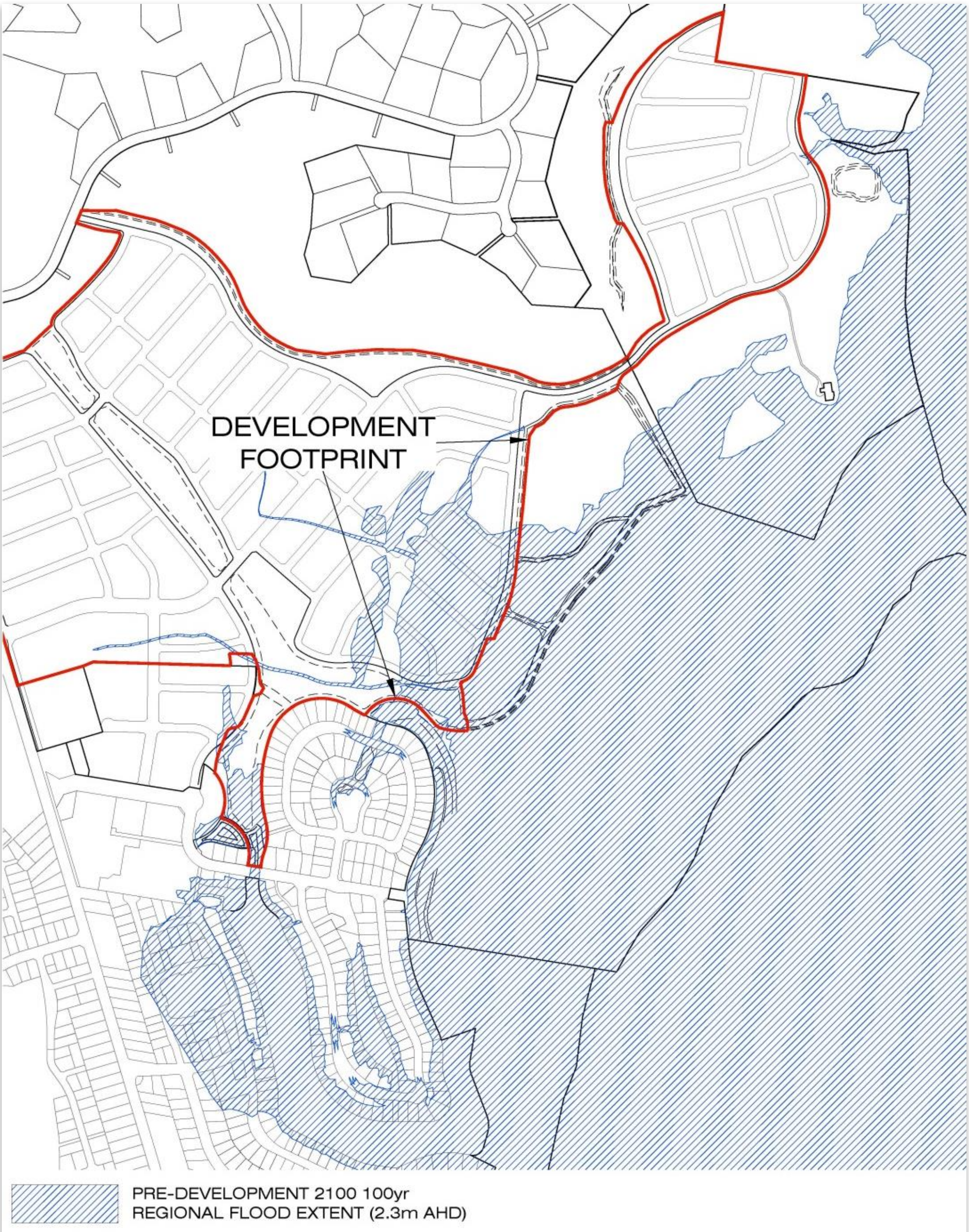


Figure 25 - 2100 100yr Regional Flood Extents – Pre-development

More than compensating for this figure is the excavations required to construct the West Branch and Monkey Jacket Branch, which adds approximately 59,600cu.m of storage volume below 2.27m AHD. Both these volumes are considered negligible in relation to the total floodplain capacity, and thus the Riverside development will have a negligible if not positive impact on the 2100 regional flood levels.

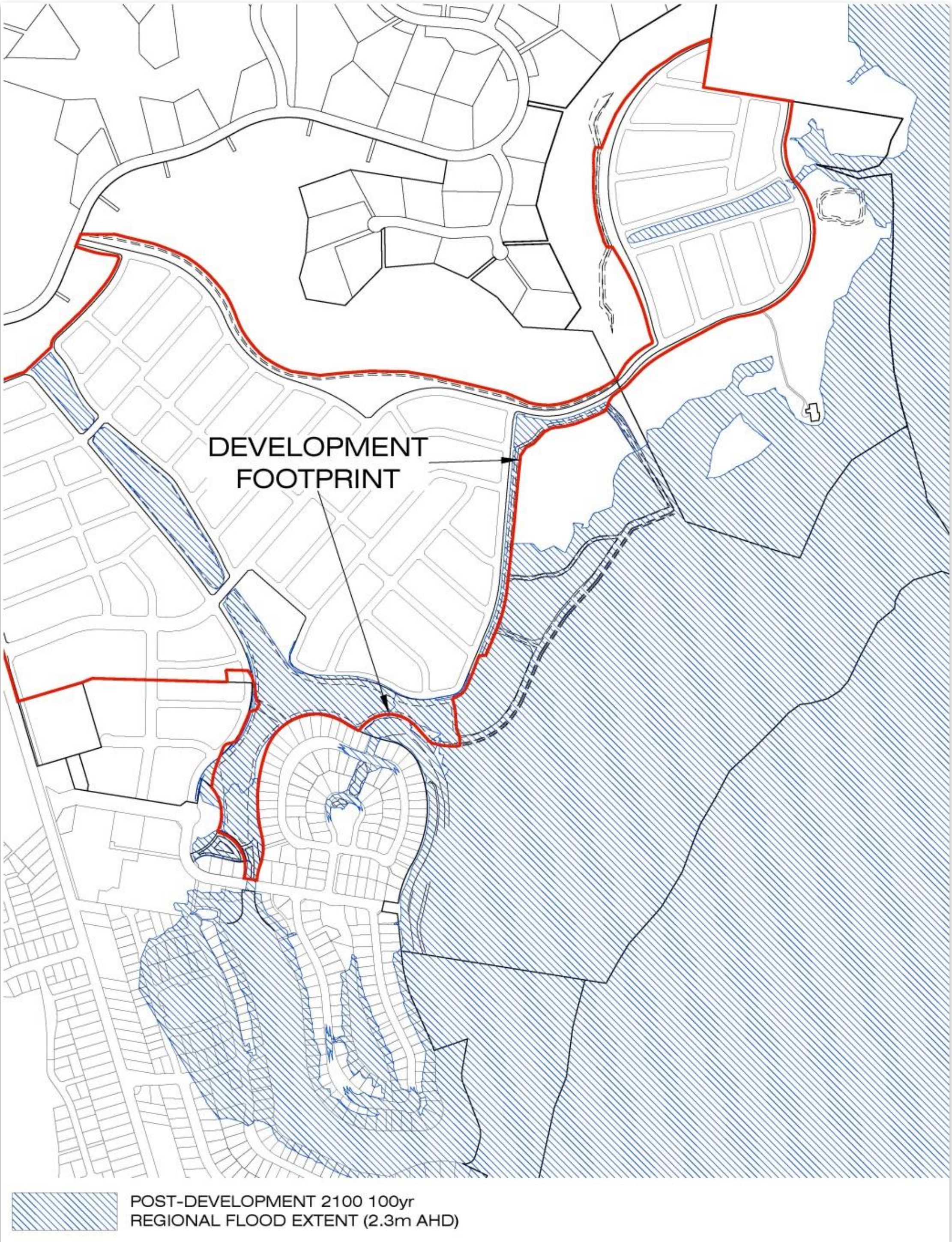


Figure 26 - 2100 100yr Regional Flood Extents – Post - development

3.9 DESIGN STORM/TAILWATER CONDITIONS

A full range of storms have been simulated across both the pre and post development models. Both the existing and proposed design catchments are complex, made up of various sub-catchments with varying critical durations. One of the benefits of a 2D analysis is that it allows more accurate modelling of these local features, rather than making broad simplifications required for 1D modelling.

In the previous Riverside report, a full range of durations was run for every recurrence interval in order to determine the critical durations for each event. For the purposes of this updated repot, only the durations previously found critical have been re-run.

The different events have been modelled for different purposes. A short summary is shown below;

- Maintain existing regular 'environmental' flows into the wetland buffer and existing lake – 0.25yr and 1yr rainfall events, existing tailwater conditions,
- Ensure no increase in potentially scouring peak flow velocities within the wetland during major storm events – 100yr storm, existing tailwater conditions
- Maintain existing flood levels in surrounding areas post development – 5yr and 20yr storms with 2100 MHW tailwater levels,
- Determine the relevant "Flood Planning Level" for the proposed development – both 100yr storm/5yr 2100 tailwater and 5yr storm/100yr 2100 tailwater combinations,
- Assess the impact of possible Climate Change induced rainfall intensity increases on the Flood Planning Level assessment
- Emergency response assessment for a 'worst case' extreme flood – both PMF storm event/100yr 2100 tailwater and 100yr storm/'extreme' event tailwater combinations.

3.9.1 Environmental Flows – Replicating Minor/Regular Rainfall Events

The adjacent wetland ecosystem is a complicated mix of peak and base groundwater and surface flows. Ensuring regular existing discharge rates into the adjoining wetland are replicated post-development will be important in order to maintain wetland health.

It is acknowledged that wetland ecology is more likely to be impacted on by overall long term water base flows than from peak runoff from an individual rainfall event, but this sort of assessment is outside the capabilities of a flood model such as the one prepared here. None-the-less, modelling peak flows from regular storm events was requested by the Department of Planning and Infrastructure, and so the following presents those findings. Realistically, the results of the Water Balance Assessment prepared by Martens and Associates are of more relevance to assessing impact on wetland health.

Both Pre and Post development models were set up to simulate both quarterly and annual rainfall events with existing MHW (0.5m AHD) as the downstream tailwater condition.

It is proposed to control the regular release of stormwater into the downstream wetland via a constructed level spreader, which incorporates two concentrated low-flow outlets (box culverts). These culverts are positioned at the same location that existing site drains flow into the wetland (identified on Figures 12 and 14). The dimensions of the discharge culverts and level spreader crest have been sized with the aid of model results to approximate existing conditions.

The results of both pre and post development quarterly and annual rainfall events are presented below. Critical flow peaks are highlighted in yellow. It can be seen that the pre and post development flows are well matched for the most frequent quarterly events, and a little less on annual events.

Table 5: Pre and Post Development Quarterly Peak Flows

	2hr		3hr		6hr		9hr		12hr		18hr	
Location	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Peak Flow (m^3/s)												
Wetland 1	0	0.02	0.01	0.02	0.02	0.03	0.06	0.08	0.07	0.09	0.05	0.02
Wetland 2	0.01	0.02	0.15	0.20	0.26	0.28	0.40	0.39	0.48	0.45	0.43	0.46
Wetland 3	0.01	0.02	0.01	0.02	0.01	0.03	0.03	0.04	0.03	0.04	0.02	0.01
Wetland 4	0	0.01	0	0.01	0	0.01	0	0.02	0	0.02	0	0.01
Wetland 5	0	0.01	0	0.01	0	0.01	0.01	0.02	0.01	0.02	0.01	0.01
Wetland 6	0	0.01	0	0.01	0	0.01	0.01	0.02	0.01	0.02	0.01	0.01
Overall Discharge	0.02	0.13	0.17	0.15	0.30	0.43	0.46	0.66	0.65	0.86	0.55	0.68

Table 6: Pre and Post Development Annual Peak Flows

	2hr		3hr		6hr		9hr		12hr		18hr	
Location	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Flow (m^3/s)												
Wetland 1	0.14	0.36	0.18	0.37	0.21	0.36	0.31	0.47	0.26	0.39	0.20	0.32
Wetland 2	0.78	1.39	1.06	1.80	1.25	2.02	1.74	2.80	1.68	2.22	1.46	1.61
Wetland 3	0.35	0.10	0.45	0.18	0.48	0.58	0.50	0.98	0.53	0.98	0.50	0.78
Wetland 4	0.02	0.11	0.02	0.12	0.05	0.18	0.07	0.28	0.13	0.44	0.10	0.35
Wetland 5	0.03	0.06	0.04	0.08	0.04	0.09	0.08	0.15	0.09	0.17	0.10	0.14
Wetland 6	0.04	0.07	0.04	0.07	0.05	0.18	0.18	0.30	0.22	0.51	0.21	0.50
Overall Discharge	1.30	2.35	1.71	3.18	2.27	3.55	2.99	5.20	3.30	4.85	2.82	4.05

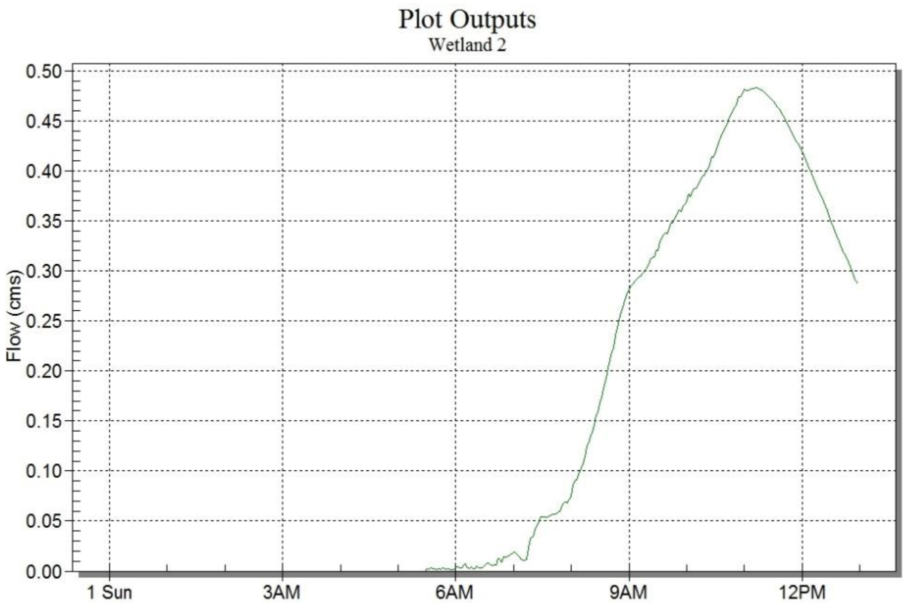


Figure 27 - Example Existing Discharge Hydrograph – 'Wetland 2' Flow Line 0.25yr 12hr Storm

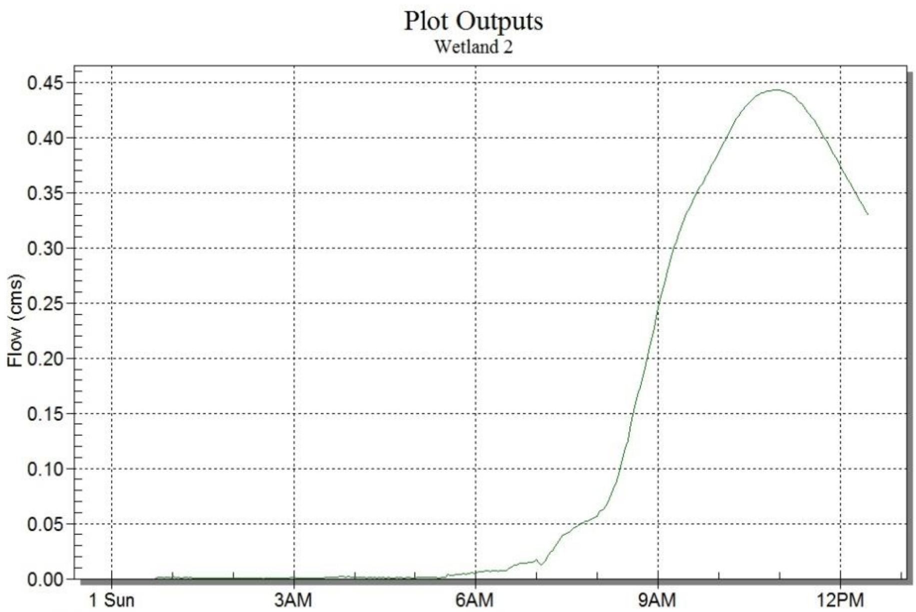


Figure 28 - Example Design Discharge Hydrograph – 'Wetland 2' Flow Line 0.25yr 12hr Storm