STORMWATER MANAGEMENT STRATEGY:

65 Maffra-Sale Road, Maffra

June 2021

Document history

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Contents

Figures

Tables

Abbreviations

Alluvium	Alluvium Consulting Australia Pty Ltd
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BPEMG	Best Practice Environmental Management Guidelines (for Urban Stormwater)
DELWP	Department of Environment, Land, Water and Planning
EDD	Extended Detention Depth
IWM	Integrated Water Management
LSIO	Land Subject to Inundation Overlay
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
NWL	Normal Water Level
RB	Retarding Basin
SEPP	State Environmental Protection Policy
TED	Top of Extended Detention
WGCMA	West Gippsland Catchment Management Authority
WMS	Water Modelling Solutions

WL	Wetland

1 Introduction

Wellington Shire Council is planning for potential future residential expansion to the south east of the existing Maffra township. Alluvium Consulting Australia (Alluvium), along with flood modelling partners Water Modelling Solutions (WMS), have been engaged to:

- Develop a drainage strategy to accommodate future urban growth,
- Provide management strategies for stormwater quality, and stormwater quantity,
- Undertake a high-level flooding assessment.

This report summarises existing conditions and issues as they pertain to stormwater management in the project area, as well as issues and constraints that may impact upon the implementation of future water management strategies in a post-development scenario. The report covers the analysis undertaken to develop stormwater management treatment options, and existing and developed conditions flood modelling.

1.1 Location

The Maffra township is located approximately 20km north-west of Sale in Gippsland. The town centres on the Macalister River, which flows south into the Thomson River. The proposed development area is south east of the existing township and covers an area of approximately 23.8 ha. The area is expected to be zoned for residential development. This piece of work will inform to feasibility of any future zoning.

The existing features are described in more detailed in Section 2. A site context map is provided in Figure 1.

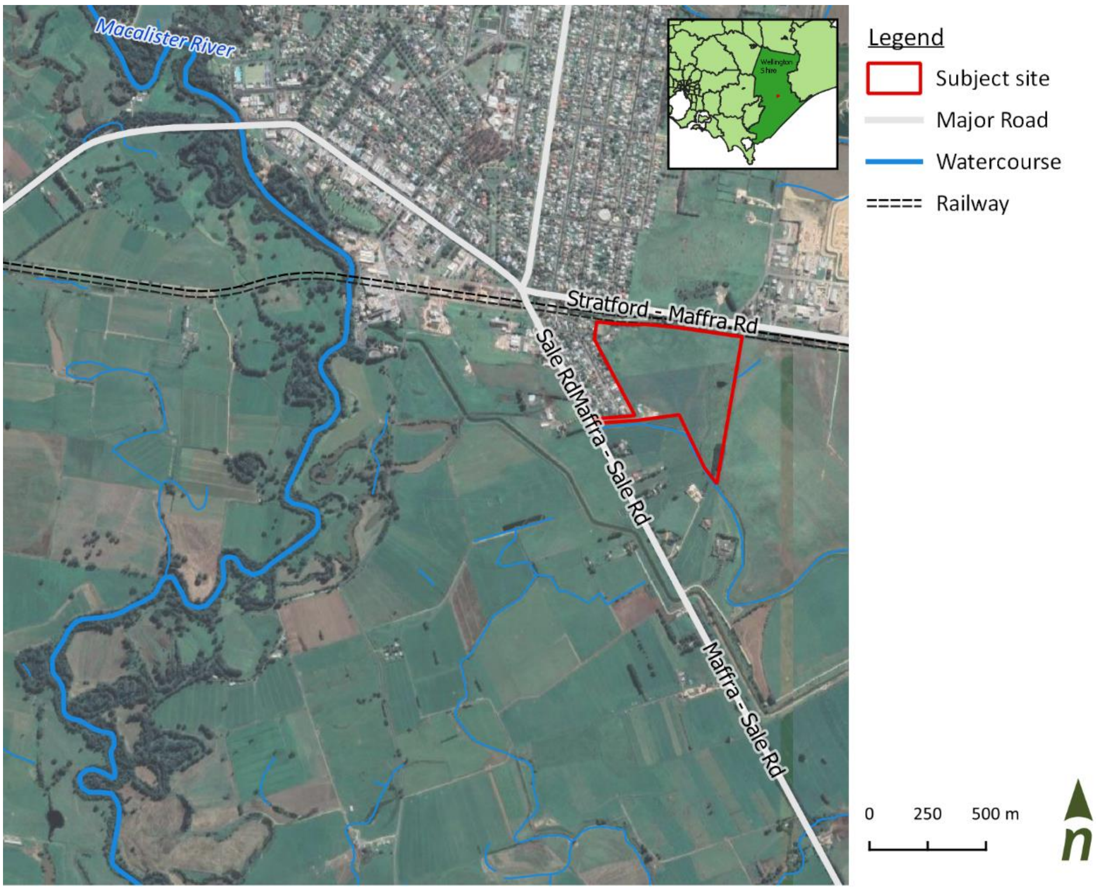


Figure 1. *Maffra township context map*

1.2 Project background

Maffra has a population of approximately 4,000 with this set to grow with future residential development, particularly from the proposed future development to the north of the Maffra Township.

A previous study, known as "Maffra Drainage and Integrated Water Management Strategy (Alluvium, 2020)" was completed for the proposed development north of the Maffra Township.

The proposed development area is provided in Figure 2. It includes the area to the south east of the existing township. At the time of this assessment there was no masterplan for this development. There is interest from the landholders to develop, and therefore a stormwater management strategy is required to inform the feasibility of any future development in respect to stormwater management.

Figure 2. *Proposed development area south east of Maffra*

1.3 Project objectives

The objective of this project is to develop a drainage strategy for the area north east of Maffra-Sale Road and south of Stratford-Maffra Road. The strategy aims to achieve the following objectives:

- Confirm the catchment context (external catchments coming through the site, topography, key overland flow paths, outfall locations)
- Confirm current flooding conditions in the site and the implications of reducing flood storage
- Identify likely stormwater treatment requirements to meet best practice treatment targets (noting the potential zoning and associated fraction impervious value will need to be confirmed with Council)
- Identify the required stormwater quantity requirements (detention requirements)
- Identify outfall constraints (i.e. downstream stormwater capacity constraints).

1.4 Background information

For this drainage strategy, the following sources of information have been drawn on:

- Maffra Drainage and Integrated Water Management Strategy, Alluvium 2020
- Existing drainage network and culvert information (Wellington Shire Council)
- Siphon information under Main Eastern Channel (Wellington Shire Council and Southern Rural Water)
- Proposed growth areas (Wellington Shire Council)
- Aerial imagery (nearmap)
- Elevation data:
    - LiDAR 2008 (provided by WGCMA)
- 1% AEP flood extent GIS layer

1.5 Stakeholders

There are numerous stakeholders to this site. No consultation has occurred as part of this preliminary assessment. The stakeholders include:

- Wellington Shire Council;
- West Gippsland Catchment Management Authority (WGCMA);
- Department of Environment, Land, Water and Planning (DELWP);
- Southern Rural Water;
- The development industry;
- Local residents and landowners.

2 Existing conditions

2.1 Current land use

The future Maffra development site is currently zoned 'Farming', reflecting agricultural uses. There is a small existing development along Maffra-Sale Road. The Maffra area generally outfalls into the Macalister River, and into the Thompson River.

The potential development site includes two property parcels.

2.2 Topography

Figure 3 shows the topography across the proposed development area and the region more broadly (using the 2008 LiDAR provided by WGCMA). Elevation ranges from 30.5 m AHD along the north eastern boundary of the site at Stratford-Maffra Road, to 25.0 m AHD at the south western boundary of the site at Maffra-Sale Road. The site generally falls in a south western direction. The site has grades varying from 0.5%-1.5%.

The proposed development site is a low point, receiving overland flows from the broader surrounding catchment. This is discussed further in Section 2.4 (catchments).

Following discussions with Council, we note that the LiDAR does not pick up raised elevations in the existing residential area bounding the west of the subject site, as this occurred after 2008. These areas were subsequently manually raised in the DEM for the flood modelling. Further detail is provided in the flood modelling report (Appendix C).

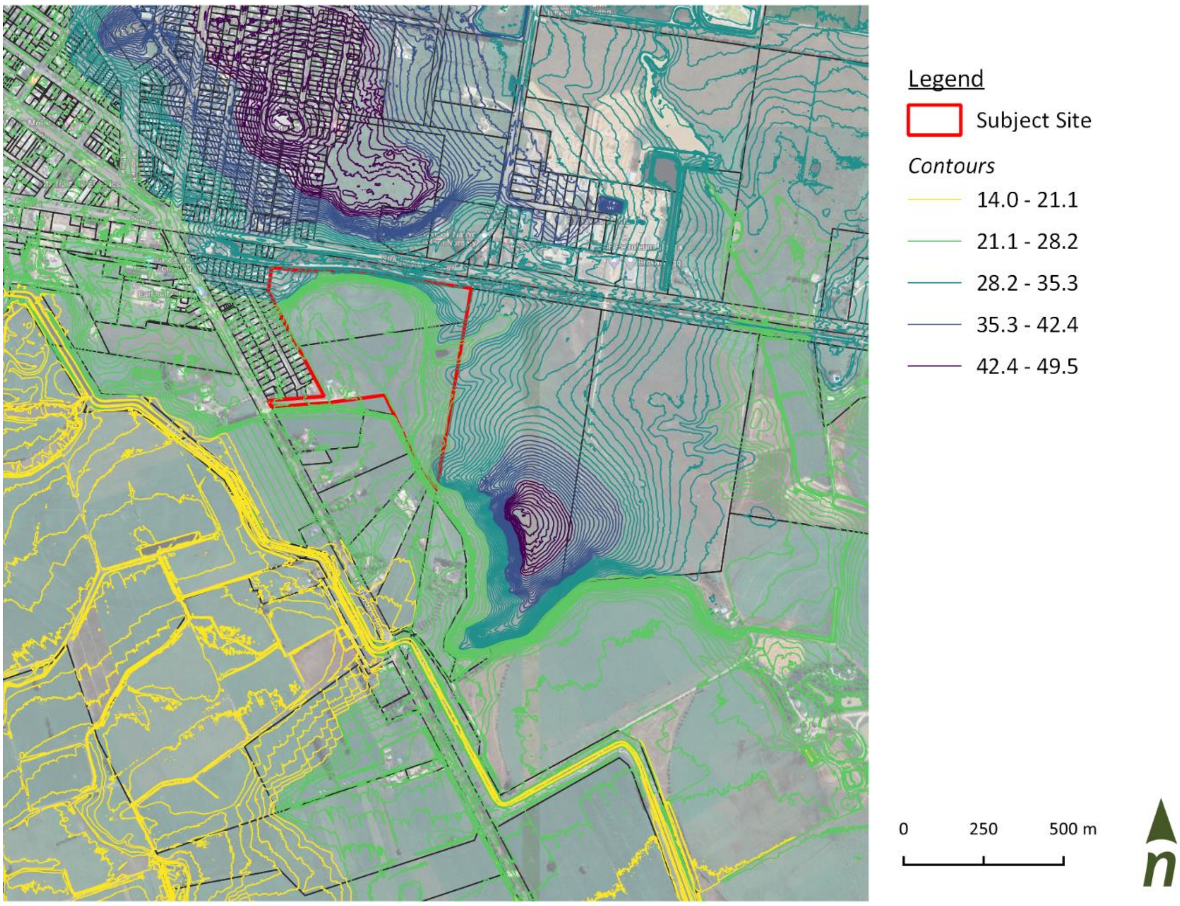


Figure 3. *Topography of Maffra and surrounds*

2.3 Existing services and infrastructure

Figure 4 shows the existing stormwater pipe network through the area. There are two stormwater network catchments to the north of the site which convey water under Stratford-Maffra Rd, and the flows then pass through the proposed development site via overland flow paths. There are two farm dams currently capturing the flows from the eastern catchment.

The major outfall from the subject site is the siphon pipeline under the Main Eastern Channel, which then daylights to an earth drain, and ultimately drains to the Macalister River (see Figure 5). The existing residential development between Stratford-Maffra Rd and Sale-Maffra Rd feeds into this siphon first via a 900mm pipe, and then a 1200mm x 450mm concrete box culvert just prior to the siphon. The siphon is a 24 inch (~600mm) diameter reinforced concrete pipe.

Future development will need to connect with the existing stormwater network and pass under the Main Eastern Channel. This would likely occur at the 600mm diameter stormwater pipe at the edge of the proposed development site, as indicated in the map below. An alternative would be another siphon under the channel, connected to a new stormwater pipe network for this development. This will depend on the current capacity of the network or siphon.

The subject site is also bounded to the south by an agricultural drain. This channel historically used to pass under Maffra-Sale Rd, but no longer does. Anecdotally we have been informed that this channel is largely dry.

Other existing services (sewer, water, gas etc.) are not shown on this map and will need to be considered in any future options development.

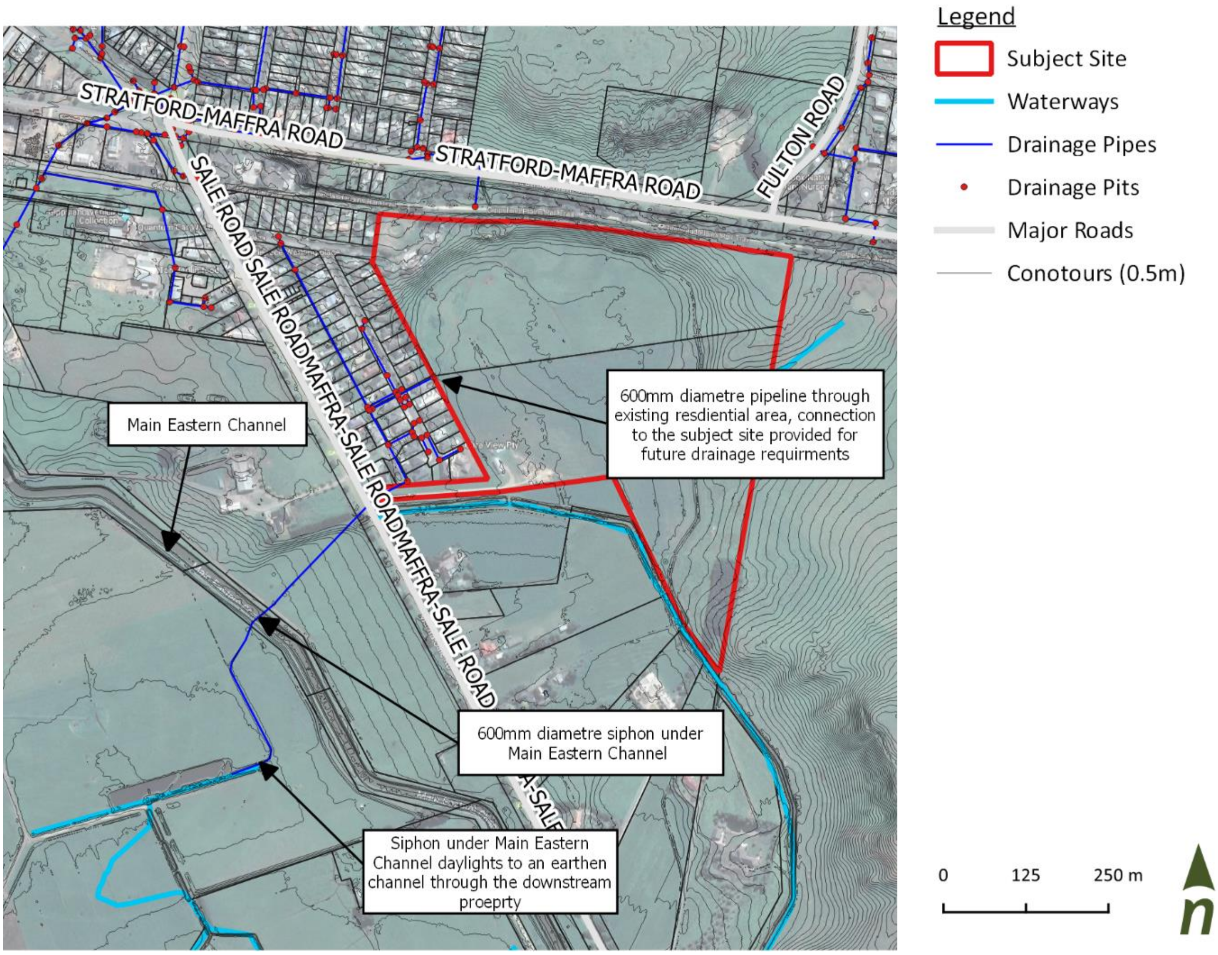


Figure 4. *Existing services and infrastructure through the Maffra development area and surrounds*

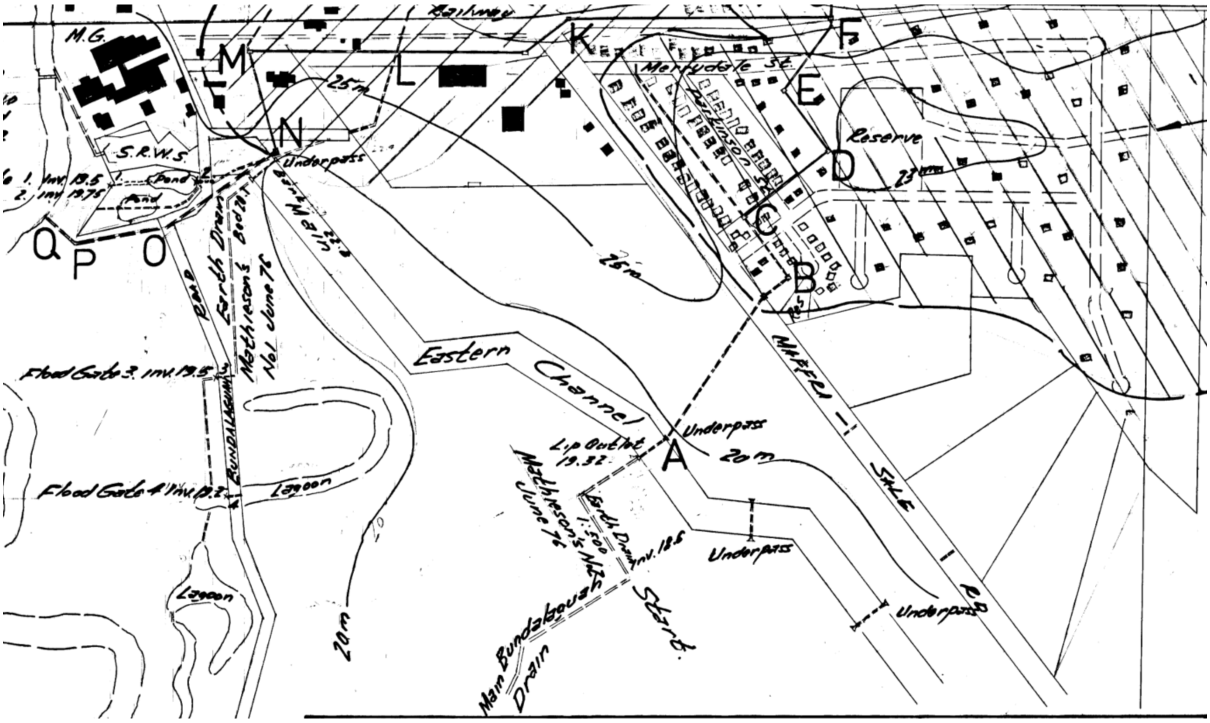


Figure 5. *Snapshot of South East Drainage original plans, 1979 (sourced from Wellington Shire Council)*

The adjacent residential development to the south west of the subject site was constructed in fill, and provides a minor drainage connection to the site, via a 600mm diameter pipeline. Although a minor drainage connection is provided, no allowance for overland flows has been provided through the downstream property.

The existing siphon under the Main Eastern Channel is the key outfall from the contributing catchment, connected to the existing residential area.

A capacity check of the existing siphon and existing upstream drainage infrastructure was undertaken to determine the outfall constraints of the site:

- Existing 600mm diameter siphon capacity – 0.57 m^3/s
- Existing 450mm x 1200mm box drain connection to siphon, capacity – 0.87 m^3/s
- Existing 900mm pipeline connecting to box drain, capacity – 1.43 m^3/s

As a result, runoff from the contributing catchment is limited to the 0.57 m^3/s flow rate at the existing siphon under the Main Eastern Channel. Any future connections to this network would need to ensure this capacity is not exceeded. We note that the existing residential area minor drainage network contributes ~1.3m^3/s already (20% AEP), and this must get stored in the box culverts until the siphon can drain it.

2.4 Catchments

The site is located within the Thomson River catchment, which flows in a south-easterly direction (Figure 6). The catchment is generally rural with some urbanised areas.

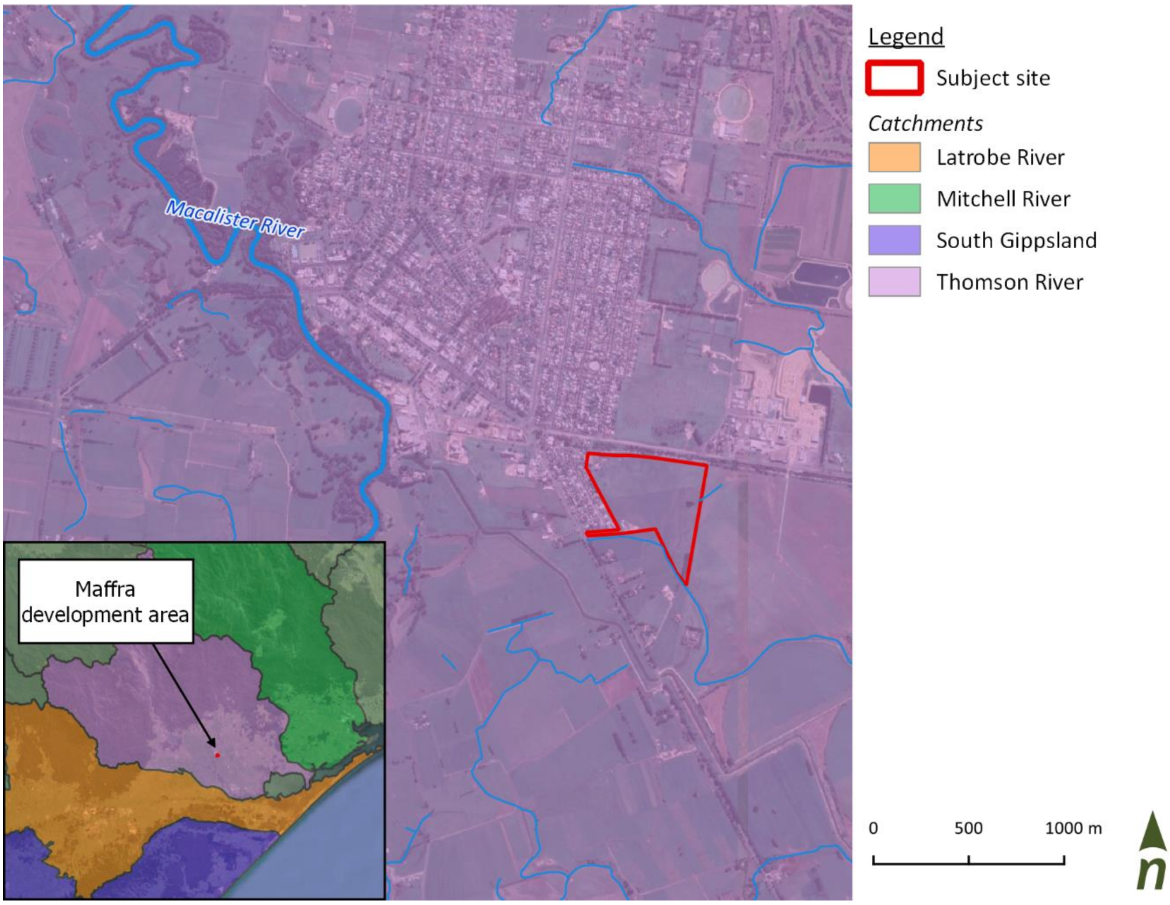


Figure 6. *Catchment context*

The proposed development area generally drains in a south-westerly direction. The catchment eventually outfalls into the Macalister River. The greater catchment of the proposed development site is shown in Figure 7.

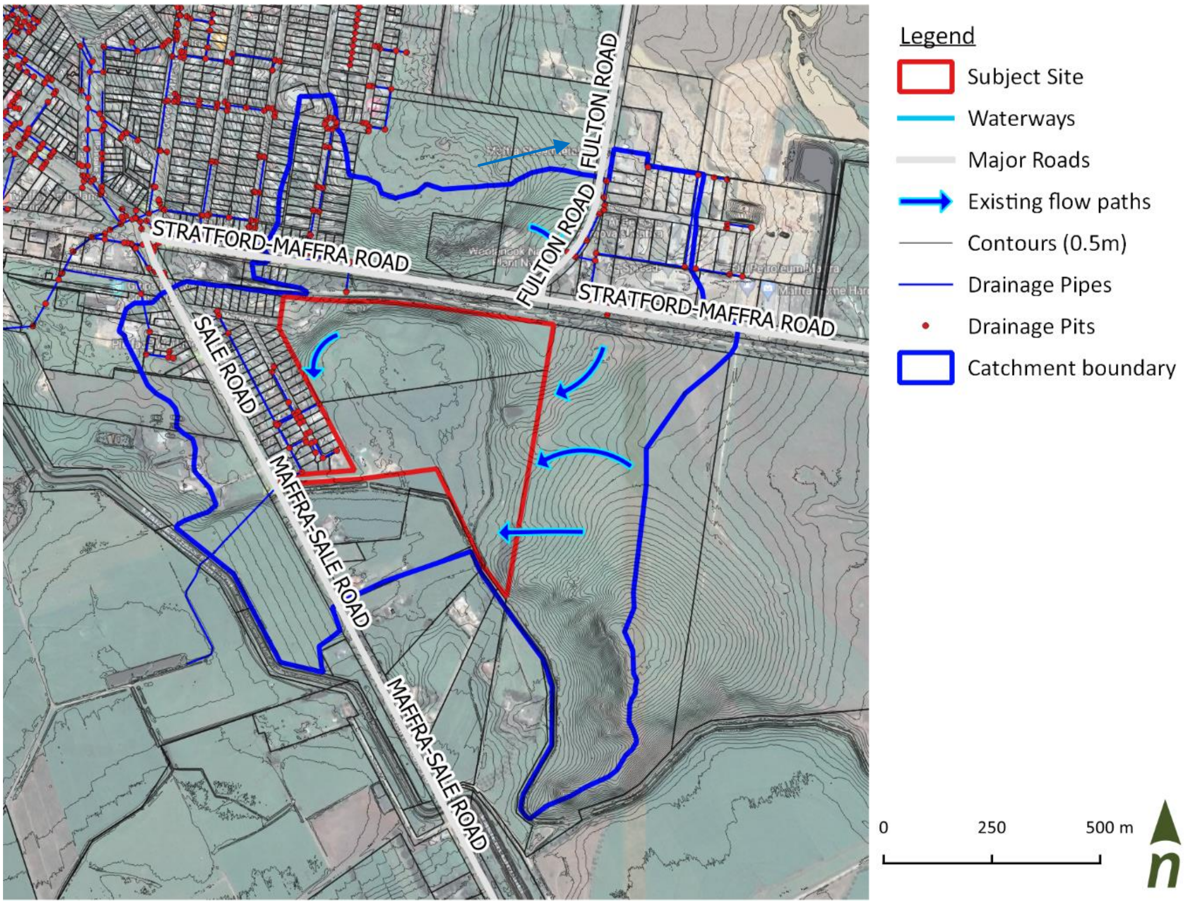


Figure 7. *Catchment of the proposed development area*

2.5 Broader flooding context

The best available information for Macalister River comes from the West Gippsland Floodplain Management Strategy 2018-2027. Figure 8 shows the 1% AEP flood extent along Macalister River. This does not interact with the proposed development site.

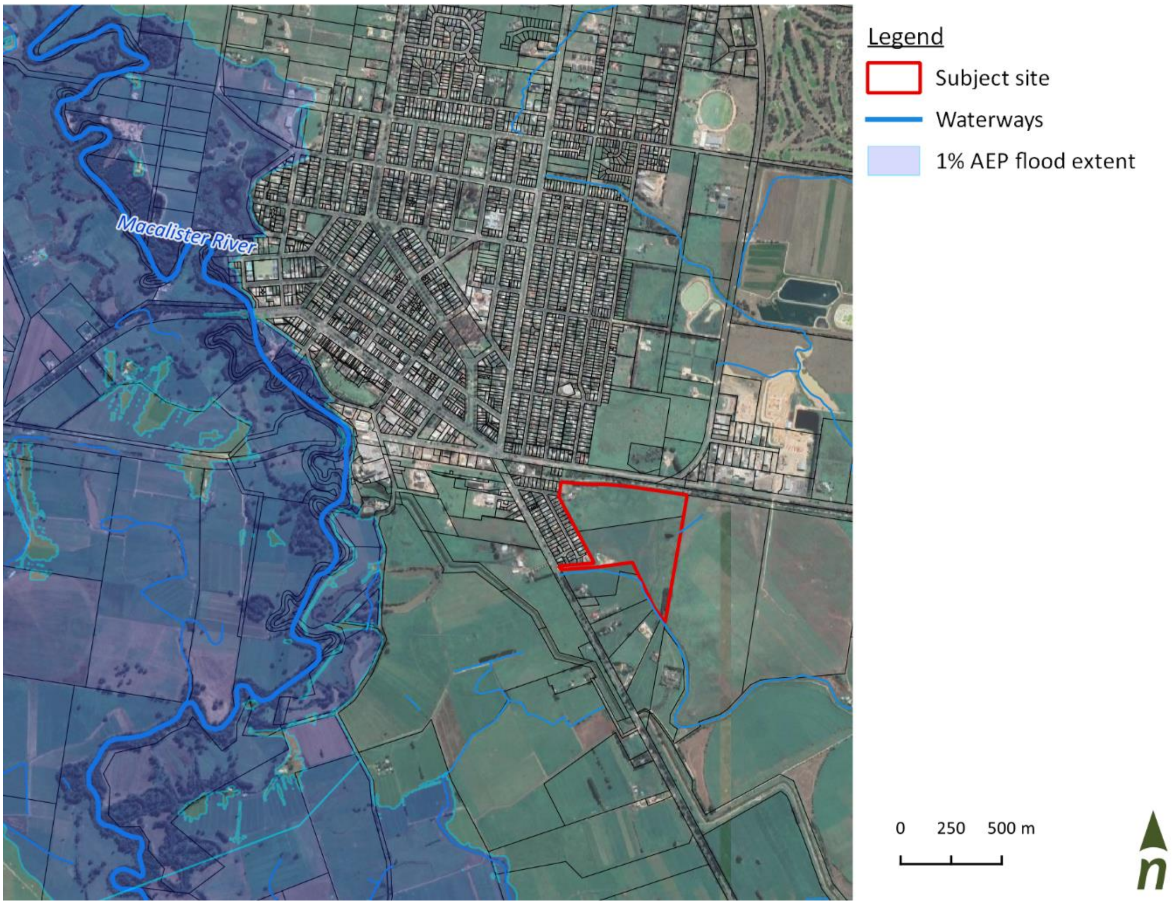


Figure 8. *1% AEP flood extent adjacent to the Maffra site*

2.6 Existing conditions flood modelling

Water Modelling Solutions (WMS) undertook high level flood modelling as part of this project. The flood modelling component of the project involves investigation and mapping of existing conditions for the 20% and 1% Annual Exceedance Probability (AEP) events as well as support for investigation of mitigation options for the existing flooding under 20% and 1% AEP events. The outcome of the modelling will be the development of sufficient flood information such that Council can undertake effective floodplain management and the information can be used by a variety of stakeholders for land use planning, flood management planning, treatment and mitigation.

The full flood modelling report is included in Appendix C, with all inputs, assumptions and results documented. This section summarises some key findings for the existing conditions.

Hydraulic modelling has been undertaken for the proposed development area utilising rainfall-excess hydrology supplied by Alluvium (RORB modelling). The modelling utilised the industry standard software, TUFLOW with a 1-dimensional drainage network connected to a 2-dimensional terrain. The temporal pattern associated with the peak critical flows was chosen to represent the ensemble modelling.

The figures below provide the 1% AEP and 20% AEP existing conditions mapping.

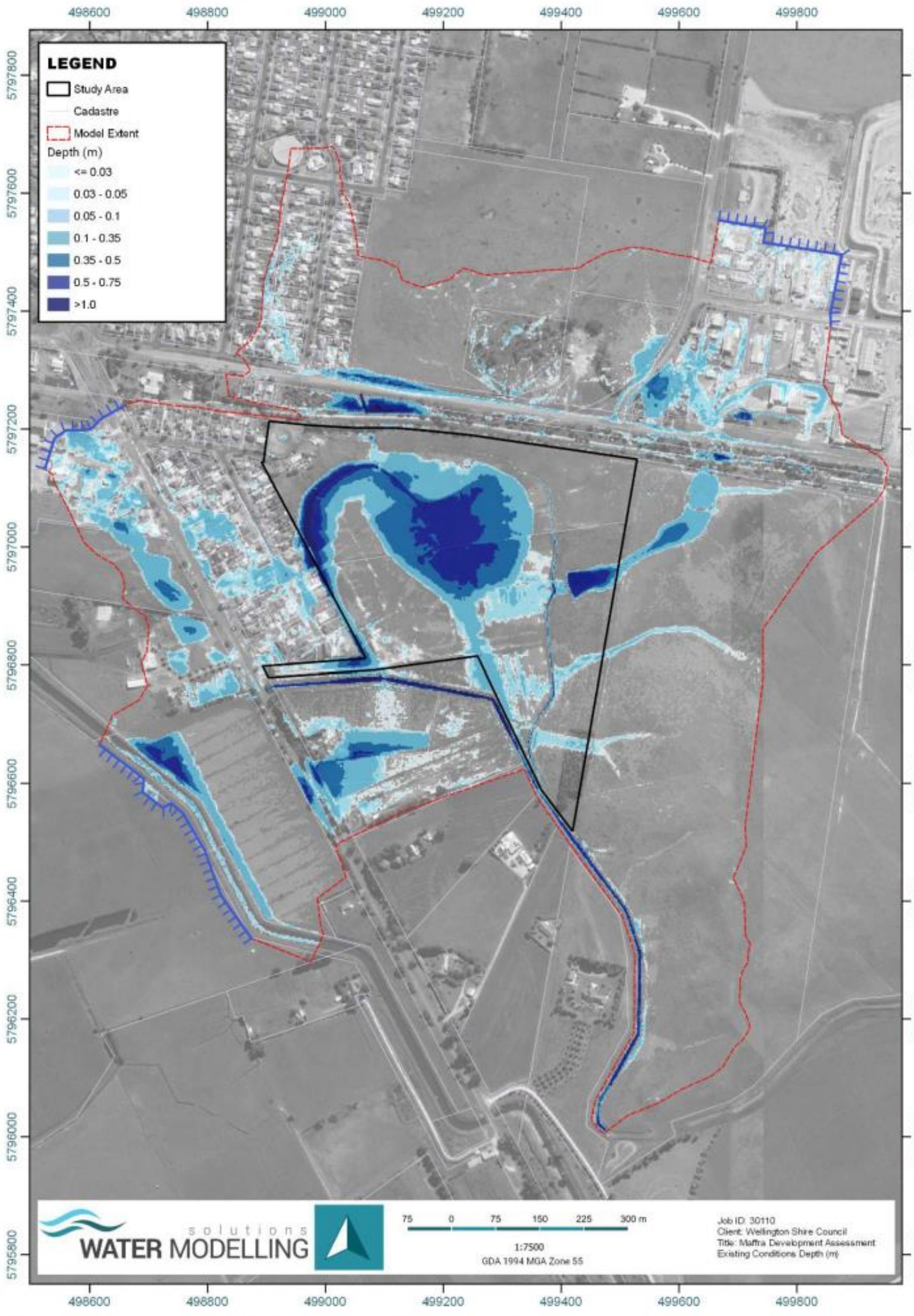


Figure 4-1 1% AEP Existing Conditions Flood Depths (extent) (m)

Figure 9. *Existing conditions flood modelling - 1% AEP*

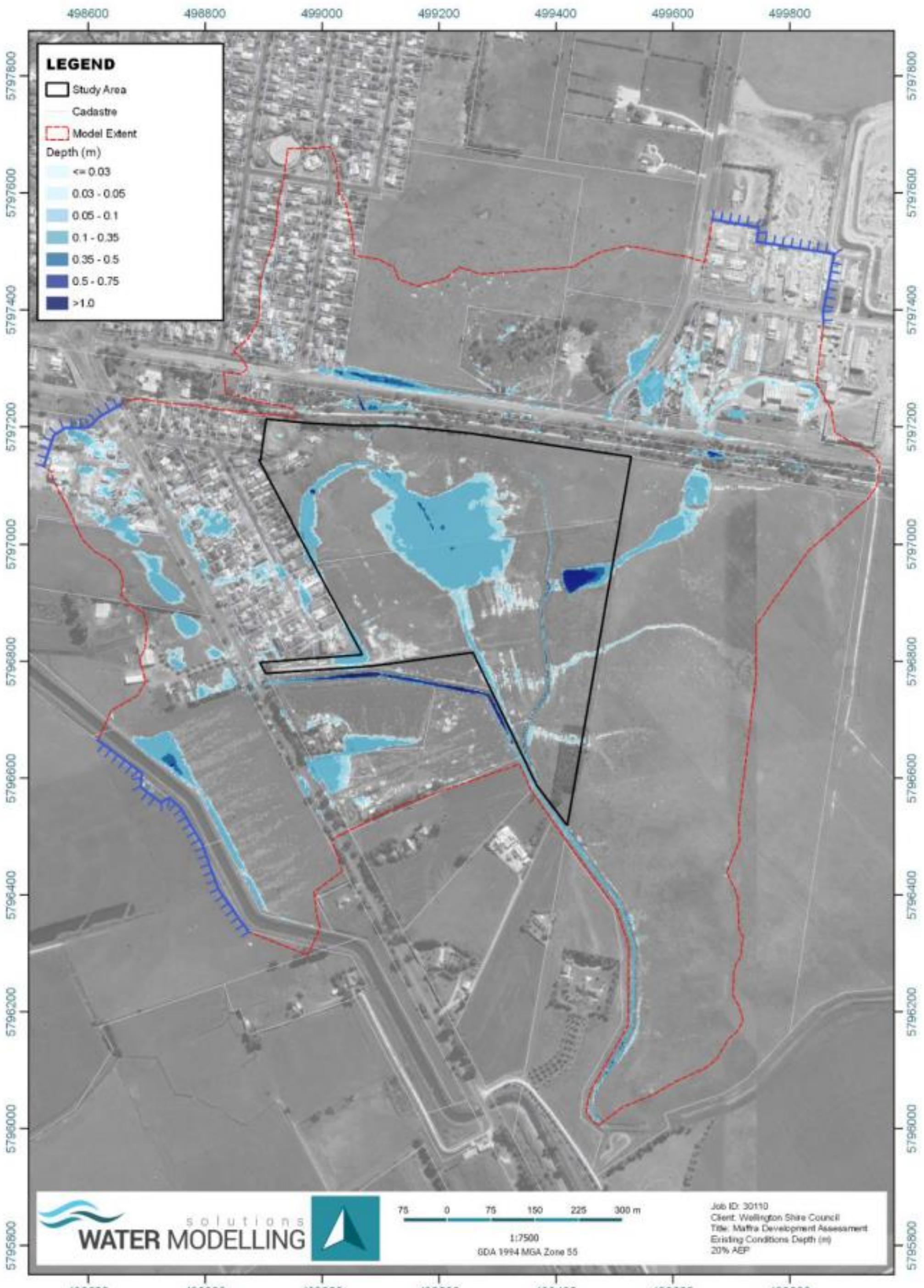


Figure 4-2 20% AEP Existing Conditions Flood Depths (extent) (m)

Figure 10. *Existing conditions flood modelling – 20% AEP*

Summary of results:

- The subject site is acting as a de facto basin, receiving flows from three predominant locations. One of these is from the industrial estate to the north east, the second one is from the north west residential estate, and the third is from the south east.

- In the 1% AEP event, basin flood depths are approximately 600-650 mm on average within the basin and 800-850 mm as flows leave the basin towards the north west, travelling towards the residential area to the west.
- Despite the existence of a levee wall at the rear of the property boundaries to the west, and raised elevations (fill pads), several properties (approximately 3-4) are still flooded as the water over tops the levee, with flood levels at approximately 23.97 m AHD.
- The flow regime in the 20% AEP is similar to that of the 1% AEP, however, there is noticeably less flow from the two northern residential and industrial catchments.

2.7 Site Values

Throughout the subject site, the Ecological Vegetation Class (EVC) of the site is classed as plains grassy woodland and plains grassy forest (Figure 11). To the west of the site, near the Macalister River exists floodplain riparian woodland, with billabong wetland aggregates along the Macalister River. The EVCs are likely to be heavily modified within the subject site.

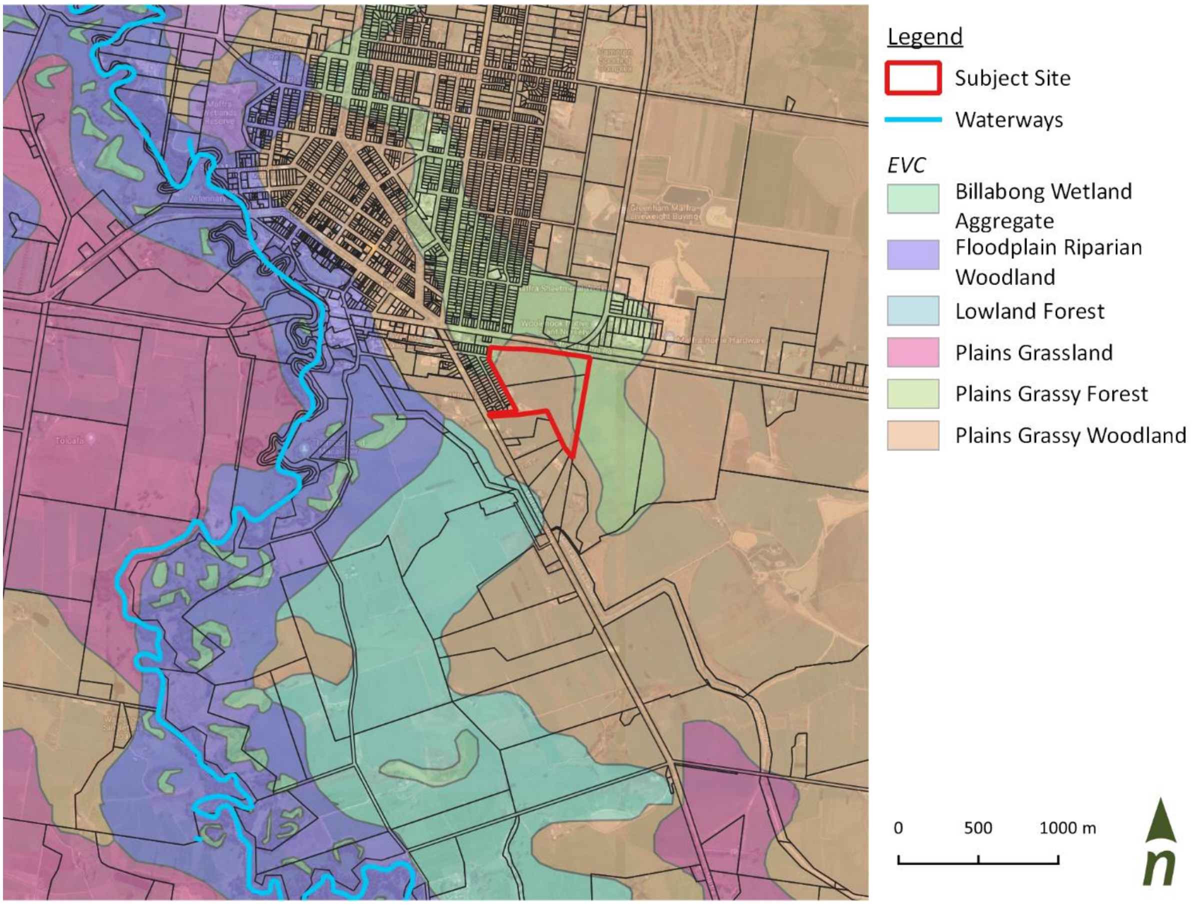


Figure 11. *EVCs within the Maffra area and surrounds*

3 Post development objectives and conditions

The following sets out the aim, objectives and approach of the drainage assessment for the post-development conditions.

3.1 Aim

For any drainage assessment the aim is to define the flood mitigation and stormwater quality management requirements for the post development conditions (the future land use of the site). In doing so, the work will define the stormwater quantity and stormwater quality assets required to control the impact of development on downstream receiving environments.

The design and layout of the proposed treatment assets are provided at a conceptual level.

3.2 Objectives and approach

There are four main objectives of any surface water management plan:

1. **Stormwater quantity management**

Fully developed 1% AEP stormwater runoff rates are to be retarded back to the equivalent 1% AEP pre-development peak flow rates before discharging downstream. This is typically achieved through the implementation of retention (or detention) systems within the catchment.

This assessment focuses on this aspect of drainage assessment requirements.

2. **Stormwater conveyance**

Stormwater conveyance is typically designed to a major and minor flow regime where:

- Minor flows i.e. up to and including the 20% AEP storm event (approximately the 1 in 5-year ARI event), are conveyed via the sub-surface stormwater network.
- Major flows i.e. between the 20% AEP and 1% AEP event are conveyed on the surface via roadways and waterways.

The entire pipe and road network has not been assessed as part of this this assessment due to the early stages of the planning process. However, the flood modelling establishes the flood extent, depth and safety risk throughout the site.

3. **Stormwater quality treatment**

Stormwater treatment concepts are required to meet the State Environmental Protection Policy (SEPP) best practice environmental management (BPEM) pollution reduction targets before being discharged into drainage networks and into receiving waters. These targets are defined as:

- 70% removal of the total Gross Pollutant load
- 80% removal of total Suspended Solids (TSS)
- 45% removal of total Nitrogen (TN)
- 45% removal of total Phosphorus (TP)

This assessment focuses on this aspect of drainage assessment requirements.

3.3 Future land use

To determine the stormwater quality and flow management requirements of the precinct, the post-development conditions of the site are modelled. Given at this early stage of planning there is no future layout plan, the assumption has been made that the future development will be residential. The surrounding residential areas have been assessed to form the basis of the future land use of this site. That is, that the fraction impervious value would likely be similar. It is acknowledged that land use concepts are subject to change over time, and that the assumptions have been made here for the purposes of being able to inform future zoning and layout arrangements.

The layout of the site and specifically the density of proposed development and the proportion of open space will impact the volume of stormwater runoff and therefore the treatment and flood mitigation systems required. In the first instance, adopting the assumption of a residential land use (in consultation with Council) is a reasonable approach in lieu of any development masterplans.

No surrounding parcels of land have been assumed to be developed, although it is noted that there is potential for the parcel to the east of the subject site to be considered for re-zoning. Should external sites that are part of the contributing catchment be rezoned, either they can manage their own stormwater in terms of quantity and quality before discharging off site, or consideration can be given to consolidating stormwater assets into a single, larger asset at the natural low point. This is further discussed later in the report.

4 Catchment analysis

With an understanding of existing site conditions, drainage infrastructure, existing flood issues, and the proposed development area, an analysis was undertaken to define treatment and detention opportunities, and their corresponding catchments and land uses. The site catchment was determined using the LiDAR data provided by WGCMA. It is important to map these catchments to understand the pollutant loads generated off them (discussed in section 6). The overall catchment was previously shown in section 2.5.

As stated previously, in lieu of a development masterplan the development itself has been assumed to be general residential. For the purposes of surface water modelling, each land use type assumes a fraction impervious. The fraction impervious assumes the proportion of land that is likely to be impervious or paved. This impacts the volume of stormwater runoff generated in a specific rainfall event for a specified land size.

The adopted fraction impervious values have been summarised in Table 1. The land uses include those outside of the development area.

Table 1. Adopted fraction impervious values for each proposed land use type

PSP proposed Land use	Adopted zone description	Adopted zone code	Fraction imperviousness
Medium Density Residential	General Residential Zone –Standard densities (Allotment size 300-600 m^2)	GRZ	0.60
Low Density Residential	Allotment size >1001 m^2	LDRZ	0.10 - 0.20
Road Zone	Major roads and freeways	RDZ1	0.70
Rural Zone	Agricultural / Farm land	RUZ	0.05
Local Park / Open Space	Public Park and Recreation Zone	PPRZ	0.05 - 0.10

4.1 Sub-catchments

Based on the existing topography, the subject site was divided into 20 sub-catchments (Figure 12). The area of each sub-catchment and the fraction imperviousness are summarised in Table 2. This catchment information was used for the treatment modelling inputs, in order to determine the target pollutant reduction load required for the proposed development. The existing residential area and the upstream rural area are not included in the treatment requirements. The sub-catchment information was also used as inputs for the hydrologic modelling (Section 5), which informed the flood modelling.

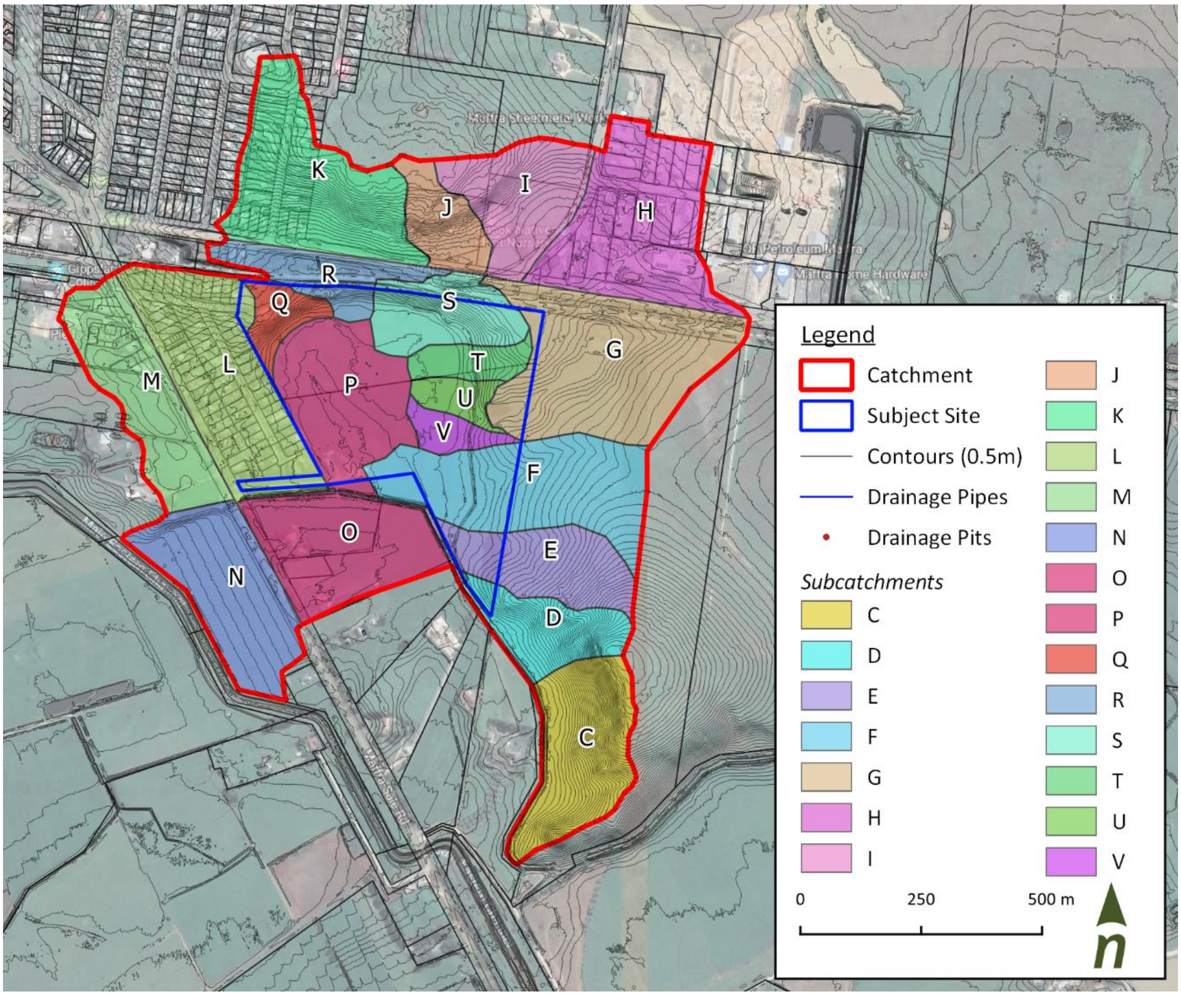


Figure 12. *Sub-catchment layout of the proposed development area*

Table 2. Developed conditions effective imperviousness area by sub-catchment

Sub-Catchment	Proposed land use (or existing)	Area (ha)	Fraction impervious	Effective impervious area (ha) (Area x Fraction impervious)
C	Open Space / Rural	6.99	0.05	
	Subtotal:	**6.99**	**0.05**	**0.35**
D	General Residential	0.30	0.60	
	Open Space / Rural	3.73	0.05	
	Subtotal:	**4.03**	**0.09**	**0.37**
E	General Residential	1.07	0.60	
	Open Space / Rural	4.08	0.05	
	Subtotal:	**5.15**	**0.16**	**0.84**
F	General Residential	3.57	0.60	
	Open Space / Rural	6.08	0.05	
	Subtotal:	**9.65**	**0.25**	**2.45**
G	General Residential	1.14	0.60	
	Roads	1.11	0.70	
	Open Space / Rural	9.82	0.05	
	Subtotal:	**12.07**	**0.16**	**1.95**

Sub-Catchment	Proposed land use (or existing)	Area (ha)	Fraction impervious	Effective impervious area (ha) (Area x Fraction impervious)
H	Industrial	7.69	0.90	
	Roads	2.29	0.70	
	Subtotal:	**9.98**	**0.85**	**8.52**
I	Roads	0.62	0.70	
	Open Space / Rural	5.02	0.05	
	Subtotal:	**5.65**	**0.12**	**0.69**
J	Roads	0.22	0.70	
	Open Space / Rural	2.64	0.05	
	Subtotal:	**2.85**	**0.10**	**0.28**
K	General Residential	3.64	0.60	
	Industrial	0.29	0.90	
	Roads	1.98	0.70	
	Open Space / Rural	3.56	0.05	
	Subtotal:	**9.48**	**0.42**	**4.02**
L	General Residential	7.69	0.60	
	Industrial	0.07	0.90	
	Roads	2.41	0.70	
	Subtotal:	**10.18**	**0.63**	**6.37**
M	Industrial	2.25	0.90	
	Roads	1.08	0.70	
	Open Space / Rural	3.60	0.05	
	Subtotal:	**6.93**	**0.43**	**2.96**
N	Roads	0.62	0.70	
	Open Space / Rural	6.87	0.05	
	Subtotal:	**7.50**	**0.10**	**0.78**
O	Roads	0.57	0.70	
	Open Space / Rural	6.95	0.05	
	Subtotal:	**7.52**	**0.10**	**0.75**
P	Residential	7.11	0.60	
	Open Space / Rural	0.24	0.05	
	Subtotal:	**7.35**	**0.58**	**4.28**
Q	Residential	1.64	0.60	
	Open Space / Rural	0.07	0.05	
	Subtotal:	**1.71**	**0.58**	**0.99**
R	General Residential	0.77	0.60	
	Roads	0.87	0.70	
	Open Space / Rural	1.74	0.05	
	Subtotal:	**3.38**	**0.34**	**1.16**
S	General Residential	3.24	0.60	
	Roads	0.20	0.70	
	Open Space / Rural	0.81	0.05	
	Subtotal:	**4.25**	**0.50**	**2.12**

Sub-Catchment	Proposed land use (or existing)	Area (ha)	Fraction impervious	Effective impervious area (ha) (Area x Fraction impervious)
T	General Residential	1.71	0.60	
	Subtotal:	**1.71**	**0.60**	**1.03**
U	General Residential	1.30	0.60	
	Subtotal:	**1.30**	**0.60**	**0.78**
V	General Residential	1.30	0.60	
	Subtotal:	**1.30**	**0.60**	**0.78**
	Total:	**118.98**	**0.40**	**47.71**

5 Stormwater quantity – hydrologic analysis

The hydrologic analysis of the proposed development site was undertaken to determine the pre and post-development peak runoff flow rates (m^3/s) for various flood events throughout the catchment. The hydrologic analysis is used to determine the storage capacities of proposed retarding basins required to retard the fully developed peak stormwater runoff rates back to pre-developed conditions (or to meet pipe capacity constraints), and to determine the flows entering the stormwater quality treatment assets proposed. The hydrology results are also used as inputs for the flood modelling.

5.1 Hydrologic modelling

The hydrologic analysis was undertaken using RORB (v6.31), which is a runoff-routing software designed to simulate attenuation and time of concentrations to produce flood estimates at specified catchment locations.

A RORB model was created for the subject site to determine:

- Existing peak flows
- The impact of development on peak flows
- The reduction in peak flows that is possible using retarding basin storage etc.

The RORB model was built by delineating the major catchments into sub-areas based on topography as previously discussed. The catchments, reach lengths and nodes used to build the RORB models are detailed in this section. These sections detail the peaks flows and storage requirements for the catchment. The fraction impervious values adopted for the developed conditions models were provided previously in Table 2. The same fraction impervious values were adopted for the stormwater treatment modelling (in MUSIC). Note no climate change modelling has been undertaken for this assessment.

5.2 Input parameters

Model inputs were obtained from the ARR2019 data hub and the Bureau of Meteorology's Intensity Frequency Duration (IFD) data. Full details on inputs and assumptions used for the hydrologic modelling can be found in Appendix A.

5.3 Storage design

The aim of the RORB modelling is to establish critical peak flows and the storage requirements within the proposed development site. This is to control ultimate developed conditions critical flow rates back to pre-developed conditions before ultimately discharging into the existing downstream drainage network.

The RORB model setup for the catchment is provided in Figure 13.

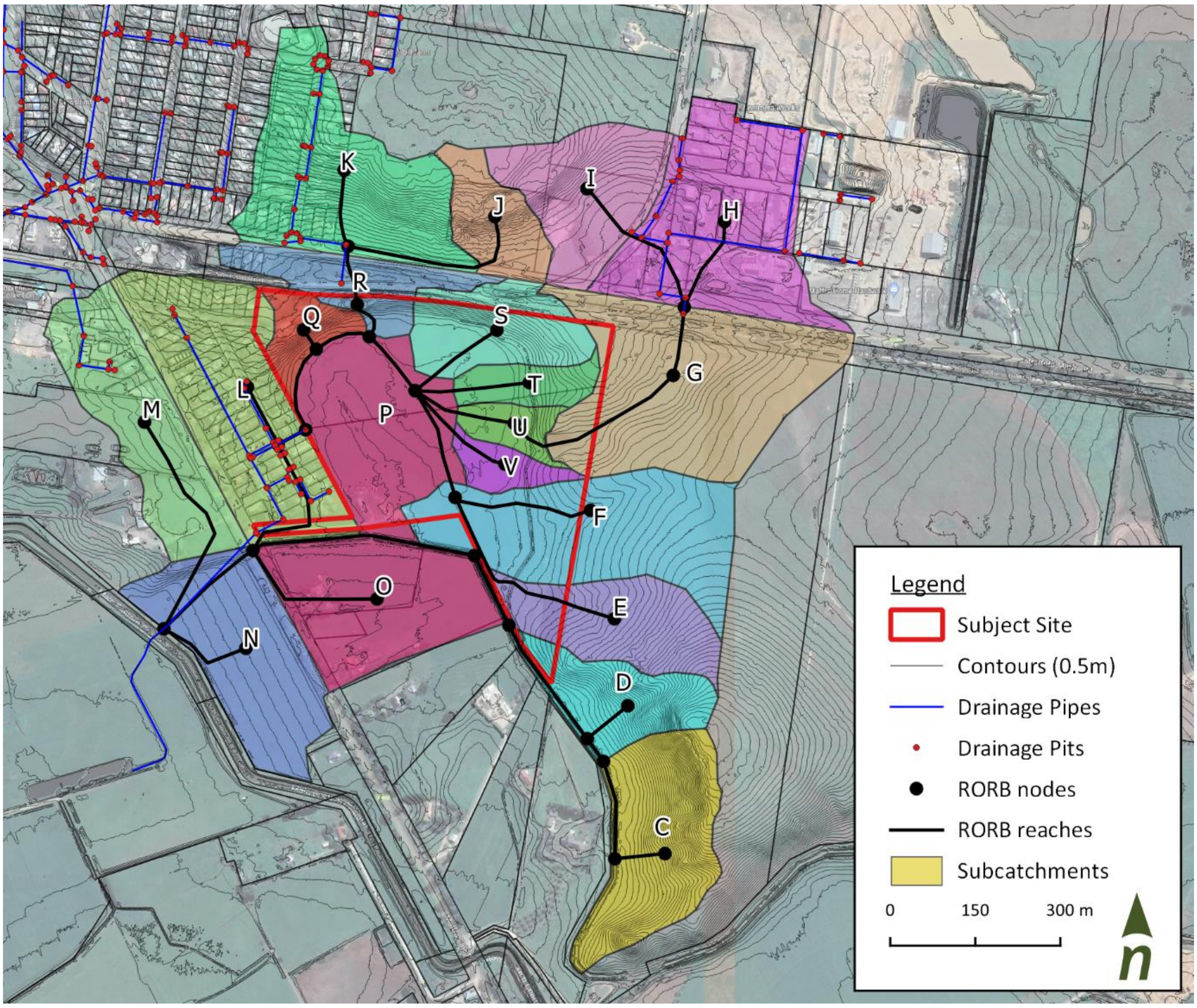


Figure 13. RORB model for the catchment of the proposed development

The RORB model was computed for the pre and post developed conditions under the 1% AEP flood event. The results are shown in Table 3. The results show the peak flows for the existing and developed conditions flowing into and out of the site. The results indicate any development would need to ensure no more than 7.9m^3/s is discharged from the site in a 1% AEP event. However, given the established capacity constraints in the existing network, the storage requirements for the RB will instead be driven by what can feasibly be discharged from the site.

Table 3. 1% AEP event RORB modelling results for the subject site

	Downstream of subject site (bottom of P)	**At location of siphon (bottom of N)**
Catchment area (ha)	76.1	119.2
Pre-developed critical flow rate (m^3/s)	7.9	11.2
Pre-developed conditions critical storm duration	1.5 hrs	1.5 hrs
Developed critical flow rate (m^3/s) (no mitigation measures)	15.34	15.98
Developed conditions critical storm duration	20 mins	45 mins

As the existing network is constrained by the siphon capacity (see section 2.6), a new pipe outlet is proposed from the RB, connecting to a new siphon under the channel. A 900mm diameter siphon has been proposed under the channel, with a 750mm pipe outfall from the WLRB, connecting to a 900mm pipe.

Preliminary calculations of the capacity of the proposed pipe and the siphon (based on proposed invert levels and pipe sizing) indicates that the siphon can take 1.45m^3/s. Therefore, the RB storage sizing has been influenced by this flow rate as opposed to holding back to pre-development peak 1% AEP flow rates. Increasing the siphon size will obviously increase the allowable flow rate and reduce storage requirements. This is a level of detail that would need to be refined in consultation with SRW.

Table 4 below shows the approximate capacity and details of the siphon.

Table 4. Siphon details

Parameter	Siphon
Length	42 m
Pipe diameter	900mm
Head loss	0.67 m
Capacity	1.45 m^3/s

Following the establishment of required peak flow rates, a retarding basin has then been modelled and sized to control the flow back to this rate. The total required area for the asset has been calculated assuming a 1(V):6(H) batter to existing surface, and an allowance of (preferably) 600mm of freeboard on top of the peak flood depth. The systems are designed so they are not in fill and therefore there is no loss of floodplain storage. In the base of the RB would be a treatment wetland (discussed further in Section 6).

Table 5 shows the required capacity of the retarding basin based on the RORB modelling undertaken.

Table 5. Retarding basin requirements

Parameter	Retarding Basin
Peak RB outflow (m^3/s)	1.29 m^3/s
Peak RB storage (m^3)	43,100 m^3
Peak RB flood depth (m)	22.88 m AHD
Freeboard above peak flood depth	600mm
Outlet configuration	1 x 750mm dia. pipe (IL:21.35m AHD)
Surface Area	3.50 ha

An overview of the RB location and footprint is provided in Figure 14. This map also shows the wetland that is required from a treatment perspective (discussed in Section 6 of this report).

A more detailed map of the asset design is provided in the Concept Designs section of this report – Section 7.

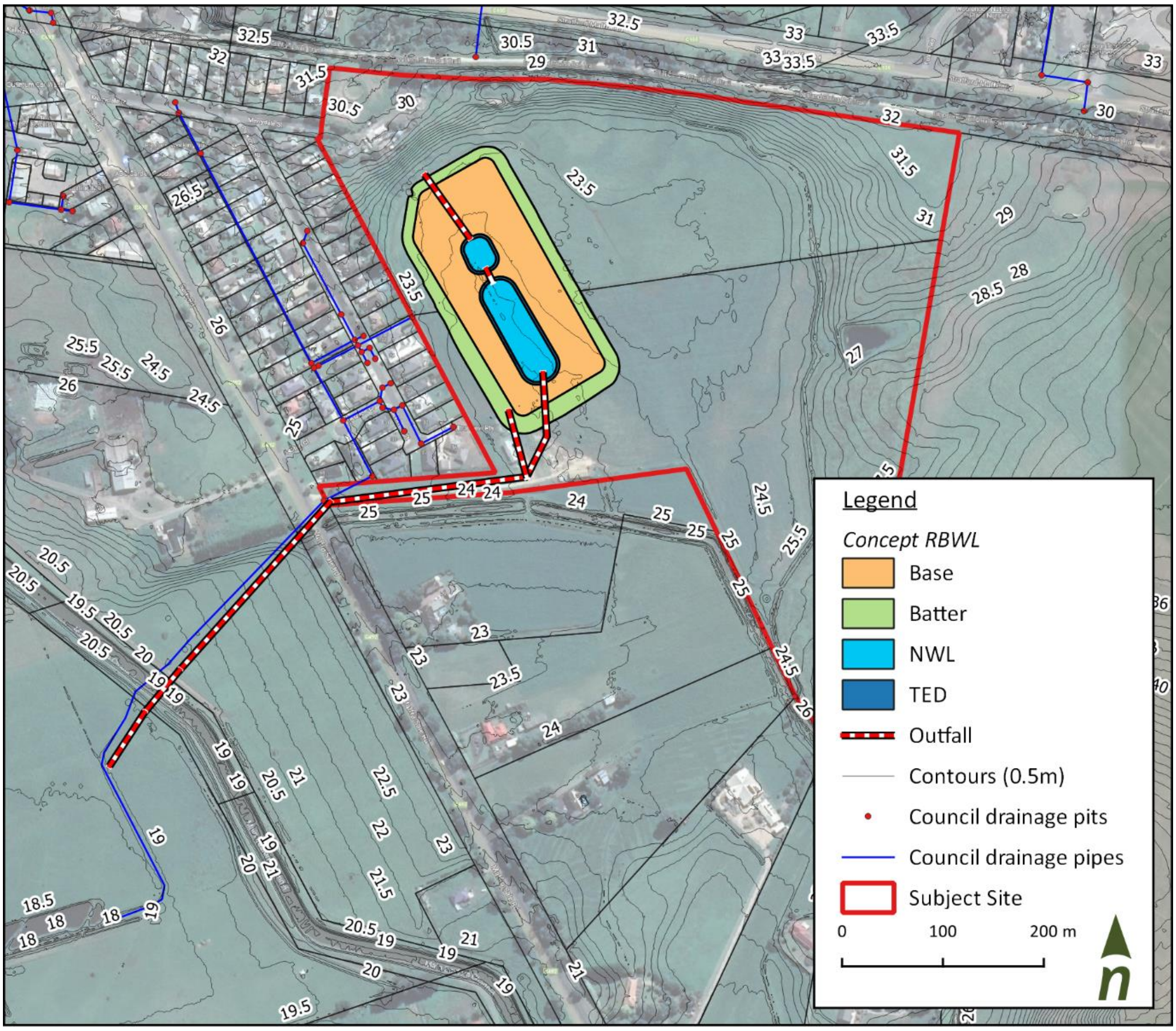


Figure 14. Retarding Basin / wetland locality plan

6 Stormwater quality treatment

A key principle for the development of the Maffra development is that all stormwater is to be treated to BPEMG (Best Practice Environmental Management Guidelines) before being discharged from the study area. As such, the Maffra development site will require treatment techniques in order to achieve the targeted reduction in pollutant load concentrations. The following BPEMG targets have been adopted:

- 70% removal of the total Gross Pollutant load
- 80% removal of total Suspended Solids (TSS)
- 45% removal of total Nitrogen (TN)
- 45% removal of total Phosphorus (TP).

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was developed to estimate the pollutant loads generated from the developed conditions scenario. This allowed us to understand the target pollutant load reduction, and therefore test the sizing and treatment capacity of assets required to meet the pollutant reduction targets. This modelling and asset sizing does not seek to treat existing residential areas or agricultural areas upstream, only future residential areas proposed within the site.

6.1 Modelling inputs

The key modelling inputs for the MUSIC model are rainfall and evapotranspiration. Generally, for MUSIC a ten year rainfall period is selected for a site which is a good representation of the average rainfall. The period adopted should consider a completeness of record, and representation of wet and dry periods. Council did not have a template rainfall dataset, so some analysis was done to ensure an appropriate dataset was used. This analysis was undertaken during the Maffra Drainage and IWM Assessment.

A historic rainfall dataset (1968- 2020) was obtained from the Bureau of Meteorology (BoM) for the Stratford rainfall gauge (085078). The average annual rainfall over this entire period was established and used to select a ten-year period from the historic dataset which produced a similar annual average rainfall. The average annual rainfall from BoM is 654.6 mm. The period from 1982 -1991 was adopted which has an annual average rainfall of 667.5mm.

The monthly average evaporation for Sale was also obtained from BoM and adopted for this modelling.

When modelling wetlands in MUSIC, an Extended Detention Depth of 0.35m is adopted and a detention time of 72 hours is aimed for. This allows sufficient contact time with the vegetation, and therefore treatment of the stormwater.

The sediment basin in the treatment modelling has been sized using the Fair and Geyer equation, where sediment basins are required to meet the following criteria:

- Capture 95% of coarse particles ≥ 125 µm diameter for the peak three-month ARI event.

The sediment basin sizing was used for the inlet pond in the wetland node. The sediment basin sizing is provided in Table 6.

Table 6. Sediment basin sizing for Maffra retarding basin WL

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	23.80
	Area of Basin (m^2)	750
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	0.50
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.12
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.54
	Capture Efficiency	95.1%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2.0
	Desired clean-out frequency, Fr	5
	Storage volume required, St	226
	Available sediment storage volume	512
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.5
	Area required for dewatering (m^2)	452

The catchment nodes used in the model have been calculated based on the areas, land uses and associated fraction impervious values used in the RORB modelling (provided in Table 2). The MUSIC model layout is shown in Figure 15. The assets have been sized to treat the loads being generated off the future developable area to best practice.

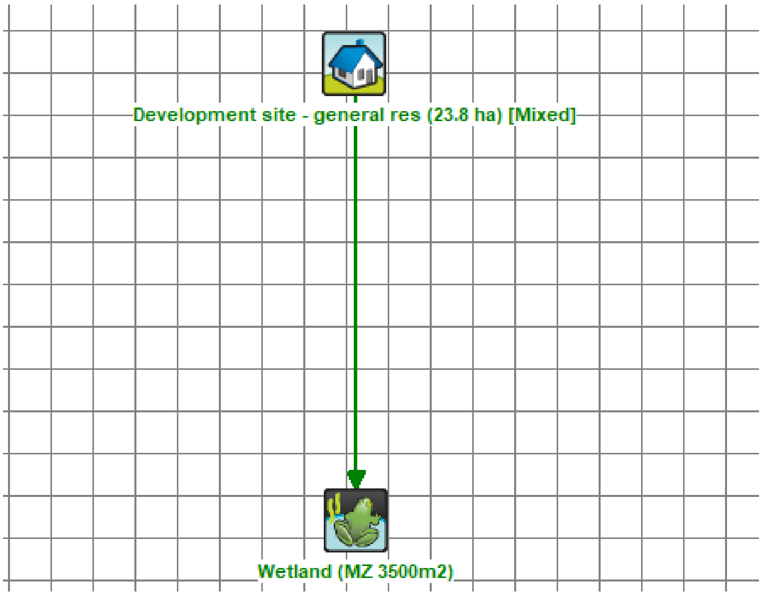


Figure 15. *MUSIC model for the site*

Asset Performance

The MUSIC modelling determined the sizing required for the wetland asset located at the catchment low point. The wetland has been designed to inform the retarding basin stage-storage relationship presented in Section 5.3. The details of the treatment systems are shown in Table 7.

Table 7. Treatment asset parameters

	Wetland
NWL area, m^2	3,500
Inlet pond area, m^2	750
Inlet pond volume m^3	750
Average depth wetland, m	0.40
Extended detention, m	0.35
Extended detention time, hr	70.7

The results of the MUSIC modelling analysis demonstrate that BPEMG targets are met with the performance of those assets, as shown in Table 8.

Table 8. MUSIC modelling results

	Source load	Residual load	% Reduction	Kg/yr removed
Total Suspended Solids (kg/yr)	15,700	1,720	89.0%	13,980
Total Phosphorus (kg/yr)	32.5	8.49	73.9%	24.0
Total Nitrogen (kg/yr)	245	135	45.1%	110
Gross Pollutants (kg/yr)	3,170	0	100%	3,170

7 Concept design

The concept designs for the options investigated are presented within this section. This includes:

- The macrophyte treatment area (NWL) as established in MUSIC
- The storage requirements as established in the hydrologic modelling
- A Normal Water Level (NWL) identified by looking at the topography of the site, as well as the inclusion of 0.35m EDD and any freeboard requirements
- An approximate overall footprint based on the selected NWL and battering up to existing surface at a 1 in 6 grade
- Indicative inlet pipe, transfer pipe (sediment basin to wetland), and outlet pipe locations
- A newly constructed siphon pipe under Main Eastern Channel

Other factors that influenced the configuration of the asset included:

- The ability to outfall (and existing stormwater network capacity constraints)
- The requirement to meet a length to width ratio of at least 4:1 [MZ4 in the constructed wetlands manual], and therefore the associated maximum width, and how this fit in with the surrounding terrain
- Minimising excavation requirements where possible
- A desire to not have the assets in fill (i.e. no reduction in flood storage)
- A minimum 4m offset from existing residential areas to allow for access.

The concept option is shown in Figure 16 below. The configuration of the asset can be refined in later design stages, but the concept design provides a conservative indication of land take and key infrastructure requirements which can assist with future planning of the site.

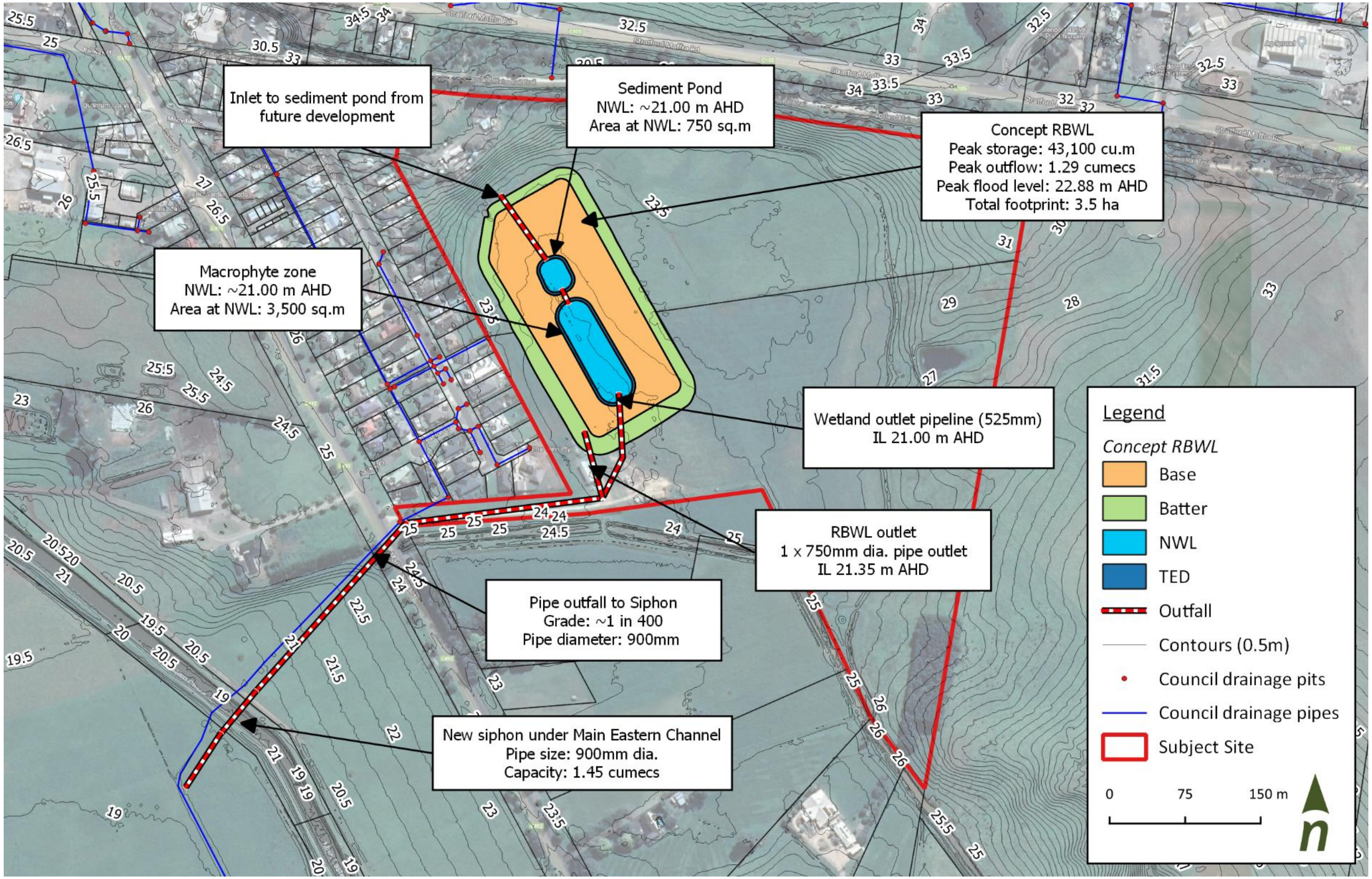


Figure 16. *Concept layout*

8 Developed conditions flood modelling

As discussed in Section 2.7, Water Modelling Solutions (WMS) undertook flood modelling as part of this study. WMS undertook developed conditions flood modelling using a design Digital Elevation Model (DEM) provided by Alluvium which incorporated the proposed treatment and storage options. This DEM did not include storage below the asset NWLs. Developed conditions hydrologic inputs were also provided to WMS for input into the modelling.

The full flood modelling report is included in Appendix C, with all inputs, assumptions and results documented. This section summarises some key findings for the developed conditions.

Key findings include:

- The implementation of the proposed assets and structures clearly shows a net benefit in controlling the flow of water downstream.
- The flooding on the properties adjacent to the basin are reduced, however, local catchment rain is prevented from leaving the rear of the properties as it is trapped by the levee.

Figure 17 shows the 1% AEP flood mapping under post-development conditions. The flood modelling still shows widespread inundation across the subject site. This could be reduced through careful filling and regarding towards the basin, which has not been modelled as part of this project. However, careful consideration would need to be given on the surrounding flood implications of doing this (e.g. upstream implications).

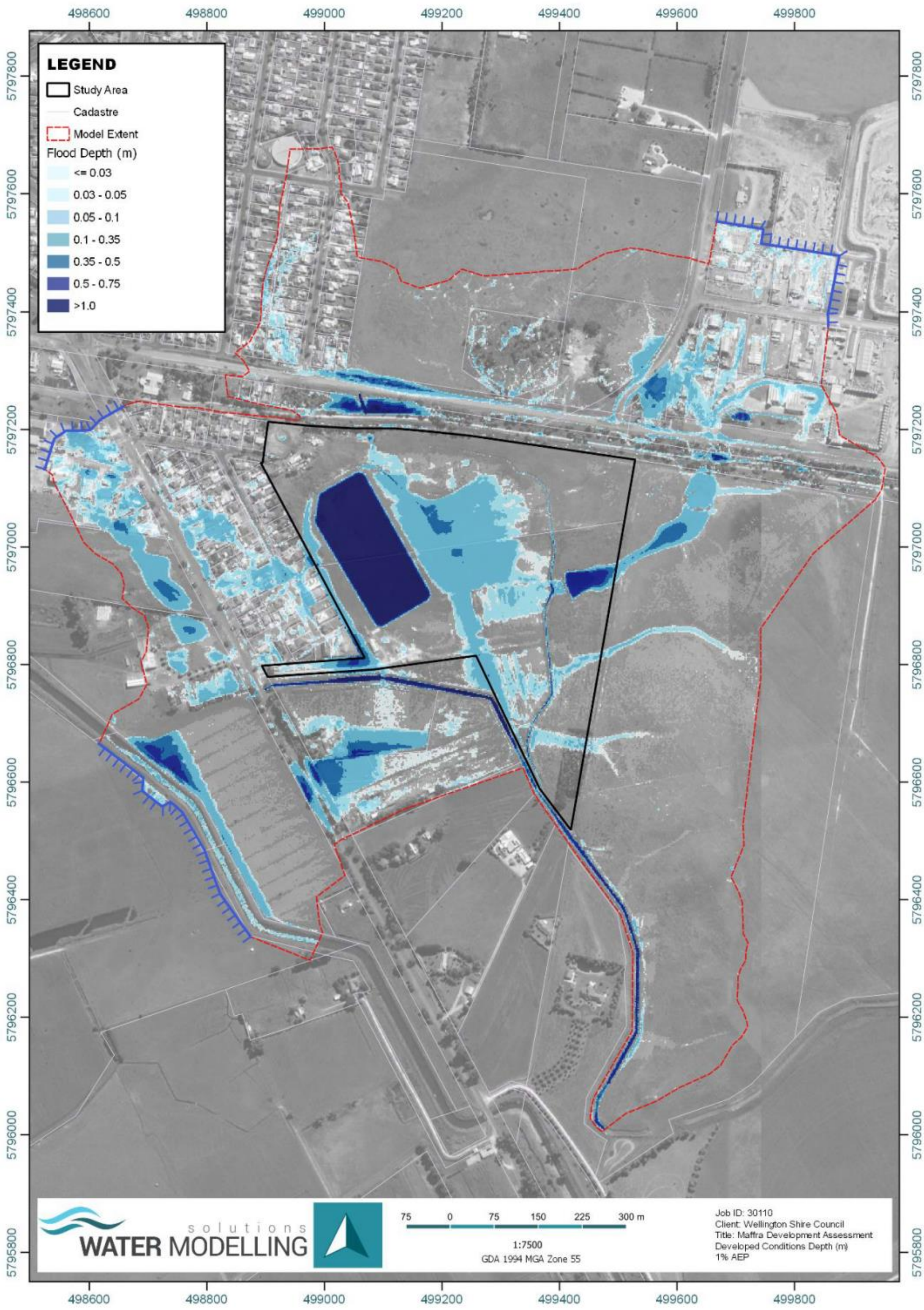


Figure 4-3 1% AEP Developed Conditions Flood Depths (extents) (m)

Figure 17. *1% AEP flood mapping – developed conditions with proposed assets*

9 Summary and recommendations

Wellington Shire Council is planning for potential future residential expansion to the south-east of the existing Maffra township. Alluvium and Water Modelling Solutions (WMS) were engaged to:

- develop a drainage strategy to identify stormwater quality and flow management asset requirements and help with future planning for the subject site;
- undertake a flooding assessment.

This assessment identifies problem flood areas through the flood modelling, identifies drainage requirements that will be driven by future development to manage both stormwater quantity and quality, and provides concept designs for necessary assets to meet those requirements.

Summary of assets

- A wetland (3500m^2) for meeting BPEM treatment requirements.
- A retarding basin to hold back flows to meet downstream pipe outfall capacity constraints, as opposed to holding back to peak 1% AEP pre-development flow rates. This results in a storage requirement of 43,100m^3, plus a freeboard requirement of 600mm.
- An overall asset footprint of 3.50 ha
- A new WLRB pipe outfall arrangement including:
    - A 750mm diameter RB outlet pipe
    - A 900mm diameter pipe (430 m long) from the RB 705mm pipe to a new siphon
    - A new 900mm diameter siphon under the Main Eastern Channel

The flood modelling indicates widespread flooding within the subject site under existing conditions due to the natural depression covering most of the site. This is significantly reduced in the post-development scenario due to the addition of the wetland/retarding basin, however there is still a substantial area impacted by inundation. Localised filling and regrading of the site towards the proposed basin would further alleviate flood depths and extent, however this would need to be carefully considered in terms of potential upstream flood impacts. It is recommended that additional flood modelling of any filling scenarios be undertaken.

The assessment did not include other potential parcels of land for rezoning - for example, the large parcel immediately to the east of the subject site that may be rezoned in the future. The inclusion of additional rezoned parcels (e.g. additional residential areas) that fall within the catchment may influence the stormwater management approach. For example, if the site immediately to the east of the subject site was rezoned as residential, either the parcel could manage stormwater entirely on-site before discharging, or could instead treat and manage flows in the natural low point, which is this subject site. The asset would need to be increased due to increased treatment and storage requirements. This is potentially preferable as it is the natural depression. This would have obvious implications on the available developable land within the subject site.

Next steps and recommendations for progressing the drainage assessment within Maffra include:

- Functional design of proposed flood mitigation and stormwater quality assets following any land rezoning.
- The staging of development will need to be confirmed to identify and further develop the assets required with the associated development.
- Consultation with SRW in regard to any additional infrastructure under the Main Eastern Channel.

10 References

CSIRO (1999), Urban stormwater best practice environmental management guidelines.

Geoscience Australia (2019). Australian Rainfall and Runoff: A guide to flood estimation.

Water Modelling Solutions (2021). Maffra Development Impact Assessment. Prepared for Alluvium and Wellington Shire Council.

Appendix A
Hydrologic modelling

Input parameters

Model inputs were obtained from the ARR2019 data hub and the Bureau of Meteorology's IFD data. An initial loss continuing loss model configuration was adopted.

For all models:

- Temporal Patterns - Southern Slopes (Vic/NSW)
- Catchment fraction imperviousness based on values in Table 2.
- *K_c=1.25 * dav (for Victorian catchments Pearse et al. 2002)*

The kc values adopted is shown in Table 19 as well as the initial loss (IL) and continuing loss (CL) values. The justification of the kc equation adopted for the models is provided in the calibration section below.

Table 9. RORB models and parameters used

RORB model	Total Area (km^2)	Kc	m	IL (mm)	CL (mm/hr)
Development site	1.192	1.36	0.80	16	2.7

Method

The RORB model was used to estimate key design flows throughout the catchment and size retarding basin storages. In accordance with best practice modelling procedures, at least 4 subareas exist upstream from the point of interest. The hydrologic modelling considered an ensemble simulation for the 1% Annual Exceedance Probability (AEP) event, for durations 10 minutes to 72 hours. From the ensemble simulation, ten temporal patterns were used to determine peak runoffs for each duration. The median flows (i.e. 6th highest peak flow) for each storm duration was determined, and the peak critical flow with respect to storage was calculated.

Following the release of the updated Australian Rainfall & Runoff (ARR) 2019 guidelines in April 2019, a new approach is to be undertaken when estimating peak runoff from a specified catchment. Key changes that influence the hydrologic modelling outputs include:

- Updated Intensity Frequency Duration (IFD) data based on updated rainfall data from a number of rainfall stations. This is sourced from the Bureau of Meteorology's (BoM) website.
- Running the model based upon an ensemble of temporal patterns sourced from the AR&R data hub and determining the median peak flow for a given storm event and duration, rather than using a single temporal pattern.
- Using Areal Reduction Factors from a modified version of the Bell's method, which is sourced from the ARR data hub, rather than using Areal Reduction Factors sourced from AR&R 87 (Siriwardena and Weinmann).
- Using an Initial Loss / Continuing Loss model, rather than a Runoff Coefficient model.
    - Where Initial Loss values are generally 10-25 mm (based on ARR Datahub),
    - and Continuing Loss values of 1-3 mm/h (based on ARR Datahub).

Given stormwater management infrastructure was previously designed and assessed following ARR 87 design guidelines, the updated ARR 2019 guidelines includes a more conservative approach to hydrologic modelling, and higher peak runoff volumes are generally estimated when compared to the ARR 87 guidelines.

Appendix B
Treatment modelling

Modelling inputs

The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model that was developed included the following input parameters:

- A historic rainfall dataset (1968- 2020) was obtained from BoM for the Stratford rainfall gauge (085078). The average annual rainfall over this entire period was obtained from the Bureau of Meteorology (BoM) and used to select a ten-year period from the historic dataset which produced a similar annual average rainfall. The average annual rainfall from BoM is 654.6 mm. The period from 1982 -1991 was adopted which has an annual average rainfall of 667.5mm.
- The monthly average evaporation for Sale was also obtained from BoM.
- MUSIC model run at a 6-minute timestep.
- Fraction impervious values and areas for sub catchments consistent with Table 2.
- Wetlands designed to not exceed 72.0 hours detention time, to prevent terrestrial and aquatic vegetation from 'drowning'.

Figure 18 outlines the iterative process of sizing the treatment infrastructure in MUSIC.

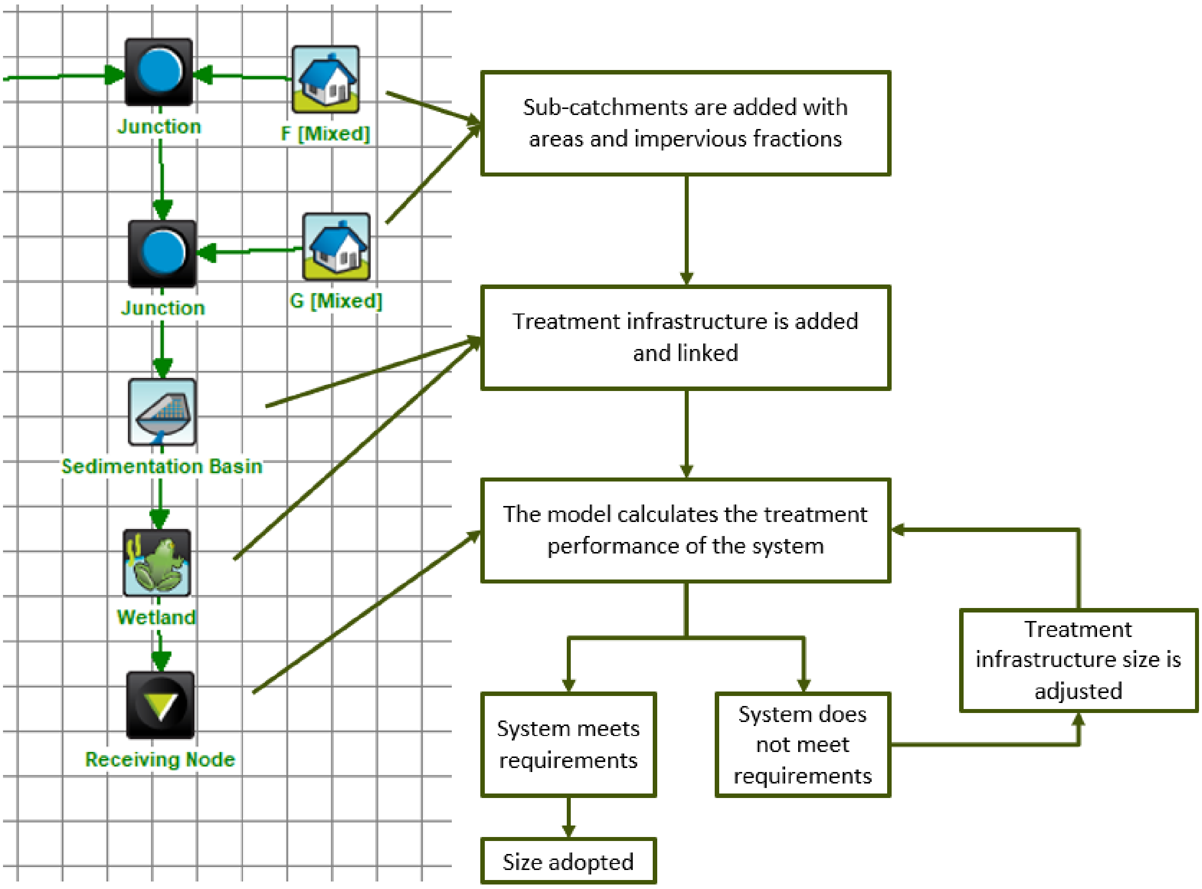


Figure 18. *Simplified MUSIC Method*

Appendix C
Flood modelling report

MAFFRA DEVELOPMENT IMPACT ASSESSMENT

MAY 2021

PREPARED FOR

Alluvium & Wellington Shire Council

Project Details	
Title	Maffra Development Impact Assessment
Prepared for	Alluvium & Wellington Shire Council
Document Name	30110-Alluvium-WSCDevelopmentAssessment-A

Document Control					
Revision	**Author**	**Reviewer**	**Approved for Issue**		
			Name	**Signature**	**Report Date**
A	KAS	KJ	K. Jusuf		28/05/2021

Revision Status	
Revision	**Description**
A	For client revision

EXECUTIVE SUMMARY

Wellington Shire Council engaged Alluvium Consulting in conjunction with Water Modelling Solutions to assess a proposed development site. Water Modelling Solutions was engaged to undertake the flood modelling component of the study, investigating the existing flooding conditions at the site and investigating the viability of a mitigation solution devised by Alluvium.

The subject site is located within a primarily rural area, adjacent to an irrigation channel. The site contains a naturally occurring depression that behaves like a retarding basin. There are a number of channels from three key catchments that flow into the depression, however, flows from the depression are uncontrolled and as such, there are flooding implications for a number of residential properties downstream of the depression.

Modelling demonstrates that under existing conditions in both the 1% AEP and the 20% AEP, flooding is severe across the subject site with depths up to 850 mm. In addition, 5-7 residential properties adjacent to the depression are flood affected, despite the presence of a levee wall. Modelling also demonstrates that by formalising the depression into a retarding basin and wetland, duplicating the underground network, and providing a second syphon under the irrigation channel, flooding across the site is significantly reduced and flooding on the adjacent properties is improved.

It is recommended that development at this location also improve the flooding situation for key residential properties adjacent to the subject site.

This report presents the modelling methodology, parameters and assumptions as well as the results and recommendations for development on the proposed subject site.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEP	Annual Exceedance Probability
WMS	Water Modelling Solutions
WSC	Wellington Shire Council

1 INTRODUCTION

1.1 BACKGROUND

A preliminary development application has been submitted to Wellington Shire Council (WSC) to develop a site located in the south east of Maffra. The site is approximately 23.8 Ha in size and is adjacent to the Stratford Maffra Road. Wellington Shire Council (WSC) would like to undertake high-level flood modelling to ascertain the impacts of the proposed development.

The site contains a naturally occurring basin and WSC have concerns that this basin has not been fully considered in the development proposal. In addition, most of the site is currently zoned FZ (farm zone), which means that developing this site may significantly increase the stormwater runoff. As such, a flood impact assessment in conjunction with the stormwater strategy that is being prepared by Alluvium will be undertaken by WMS.

An aerial image of the proposed site location is illustrated in Figure 1-1, below and the surrounding catchment developed by WSC is illustrated in Figure 1-2.

1.2 STUDY AREA

The study area, as highlighted in Figure 1-1 below, is predominantly a rural catchment with pockets of industrial and residential zonings. Within the central portion of the catchment there is a naturally occurring depression, which acts as a basin that receives runoff from several surrounding overland channels. The basin is not formalised and as will be demonstrated by the modelling, the spills from the basin are uncontrolled and may affect several properties adjacent to the depression.

The surrounding catchment, highlighted in Figure 1-2, is bisected by the Stratford Maffra Road and the Rail Trail and there is a new industrial estate in the north west corner that is still under construction as well as existing residential properties to the west and south west.

Figure 1-1 Study Area

Approximate catchment Boundary

Residential Area

Industrial Area

Figure 1-2 Surrounding catchment – Image provided by WSC

2 METHODOLOGY

The scope of the flood modelling component of the project is outlined as follows:

2.1 PROJECT INITIATION

A project initiation meeting was undertaken with WSC on Tuesday 27th April. Within this meeting the scope, methodology and timeframes for the project were confirmed as well as data requirements. The following details of specific concern to the flood modelling were discussed:

- Terrain crossfall and flow directions were confirmed, particularly for the new industrial estate in the northern region of the modelling boundary;
- No culvert details were initially available, although the dimensions of two culverts underneath the rail trail were subsequently provided by WSC;
- The irrigation channel is essentially dry;
- It was confirmed that the land use zoning remains as per the current zones and no changes are currently being considered; and
- It was confirmed that there exists a levee wall along the rear of the properties adjacent to the basin.

2.2 DATA COLLATION AND REVIEW

A high-level data review was undertaken as a gap analysis. The data was assumed fit-for-purpose for this study and as such was not analysed for data quality. The following data was received and reviewed:

- LiDAR, provided in GeoTIFF format at 1 m resolution, the LiDAR was dated 2008 and provided by WGCMA
- LiDAR contours at 0.5 m interval
- Plans:
  - Parkinson Street Residential Development, Stages 2 and 3;
  - Main SE Drain Longitudinal Section;
  - South East Drain Catchment and Drainage;
  - Markup of the location of the property levee;
  - Southern Rural Water Syphon Details
- Reports:
  - Wellington C74 Panel Report
- Shape file of the subject site;

The following data was obtained additionally for utilisation in the project:

- Vic Spatial Data Mart:
  - Planning Scheme Zones
  - Cadastre

The above two shape files were utilised to generate the Mannings 'n' roughness map.

- WSC underground drainage network shape files:
  - The shape files for the WSC underground drainage network were obtained from the previously undertaken Maffra Integrated Water Strategy project and clipped for utilisation in this project.

2.3 MODEL DEVELOPMENT AND DESIGN EVENT MODELLING

2.3.1 Hydrology

The hydrology for the Maffra Flood Impact Assessment was undertaken by Alluvium using the industry standard software RORB. WMS reviewed the hydrographs provided to ensure that they were fit for purpose for the hydraulic study and subsequently converted the files into an appropriate format for use in TUFLOW.

The events that were modelled for the Flood Impact Assessment are the 1% and 20% AEP. The critical duration for the 1% AEP event is 90 minutes (1.5 hour) and the critical duration for the 20% AEP event is 120-minutes (2 hour), while the median temporal pattern is TP06 for both durations in the existing conditions case and TP07 for both durations in the developed conditions case.

2.3.2 Hydraulics Approach

The hydraulic modelling for the Maffra Flood Impact Assessment was undertaken by developing a 1-dimensional / 2-dimensional combined hydraulic model in the industry standard software TUFLOW. TUFLOW is a numerical model used to simulate the hydrodynamic behaviour of rivers, floodplains and urban drainage environments (BMT Group Ltd, 2007 – 2018). The software is ideal for small- and large-scale complex terrain environments such as the Maffra site that incorporates a natural de facto retarding basin in conjunction with a network of underground drainage. The latest TUFLOW HPC (Heavily Parallelised Compute) module was used, which delivers a 10-100 times simulation speed increase compared to the standard CPU version (BMT Group Ltd, 2007 – 2018).

The modelling approach used for the hydraulic model was a rainfall excess methodology. A rainfall excess approach as illustrated in Figure 2-1, has some similarities to rain-on-grid, however, the hydrological modelling is initially undertaken in RORB, where there is greater control over the losses through the application of the fraction impervious map as well as initial and continuing losses. The resultant excess rainfall hyetographs are applied to the hydraulic model extents via source-area polygons and the routing is then undertaken in two dimensions within the hydraulic model. As discussed earlier, the RORB component of the modelling was undertaken prior by Alluvium.

For the purposes of efficiency for this study, the median temporal patterns, with the critical durations have been adopted for the 1% and 20% AEP design events for modelling.

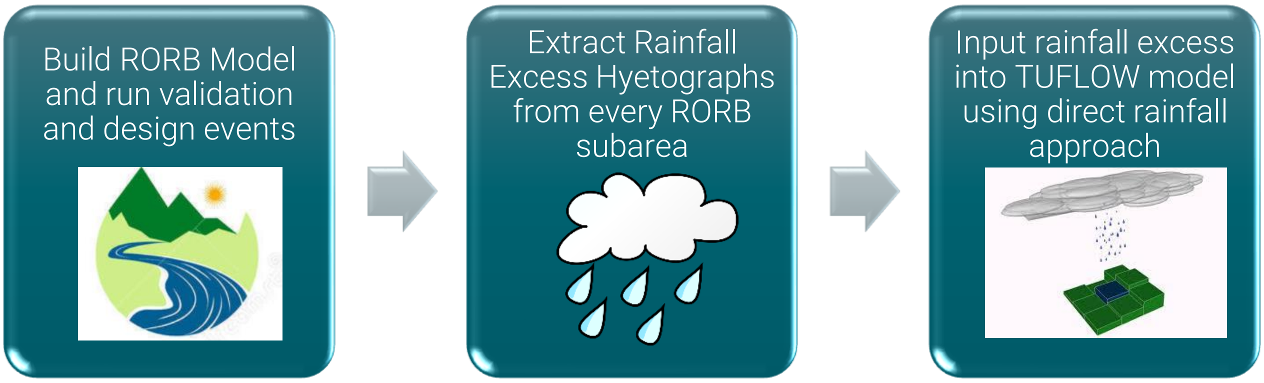


Figure 2-1 Rainfall excess approach

Discussion on the model development is provided below in Section 3 and the TUFLOW model parameters are outlined in Appendix A.

3 MODEL DEVELOPMENT

The hydraulic model construction was undertaken in a stepwise format to ensure that all aspects of the model build were robust and that checks were undertaken to ensure model health.

A high-level summary of the stages of the model build are provided in Sections 3.1 through 3.6 below.

3.1 TOPOGRAPHY

The model DEM (Digital Elevation Model) was developed using the 1 m LiDAR supplied by WGCMA. The DEM was supplied as a GeoTiff and all that was required for the DEM development was to convert the GeoTiff file into a floating-point binary file (flt) for use in TUFLOW. The floating-point file is typically a much smaller file size and provides modelling run time efficiencies. The DEM is illustrated in Figure 3-1.

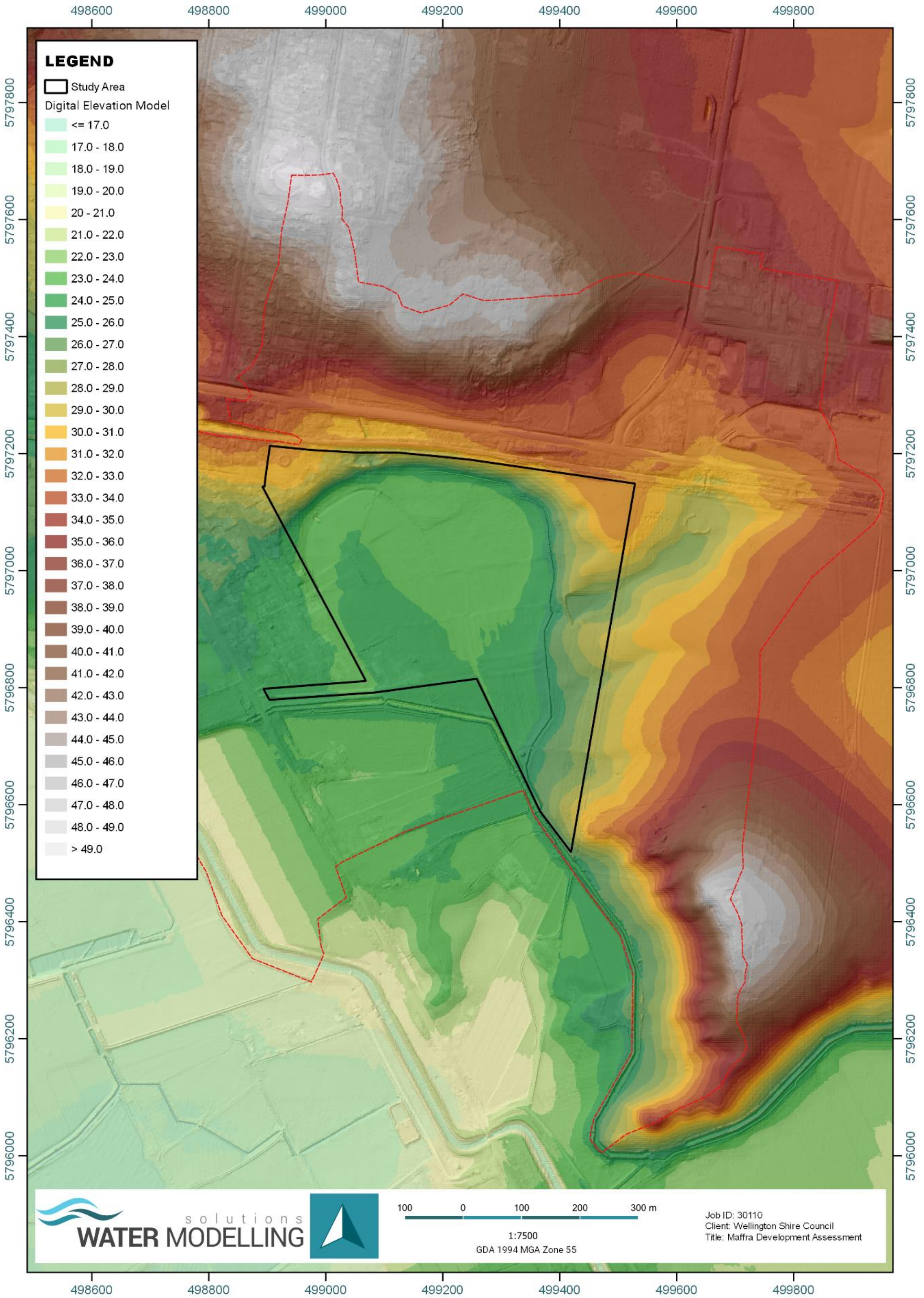


Figure 3-1 Maffra Study Area DEM

3.2 MODEL EXTENT AND BOUNDARY CONDITIONS

The extent of the modelling required was provided in the project brief and captures the proposed site boundary, the existing natural de facto basin, the upstream residential and industrial areas and the downstream irrigation channel and syphon.

The model inflows were applied as source-area polygons, which apply the rainfall excess across the whole terrain allowing the routing to be undertaking in TUFLOW. The source-area polygon shapes utilised the RORB sub-area boundaries to apply the whole sub-area inflow to the source-area polygon. This rainfall excess approach was discussed earlier in Section 2.3.2.

Several model outflow boundaries were applied. The main model outfall was slightly downstream of the Main Eastern Channel, however, some flows from the industrial area to the north were flowing north out of the model and some flows from the residential area to the west were flowing west, as such these zones utilised additional outfalls.

Terrain slope was used as the outflow boundary conditions and TUFLOW generates an automatic Head vs Flow (HQ) table within the software. The slope that has been applied at the main downstream boundary is 1 in 60. The model extents and inflow and outflow boundaries are illustrated in 3.2.

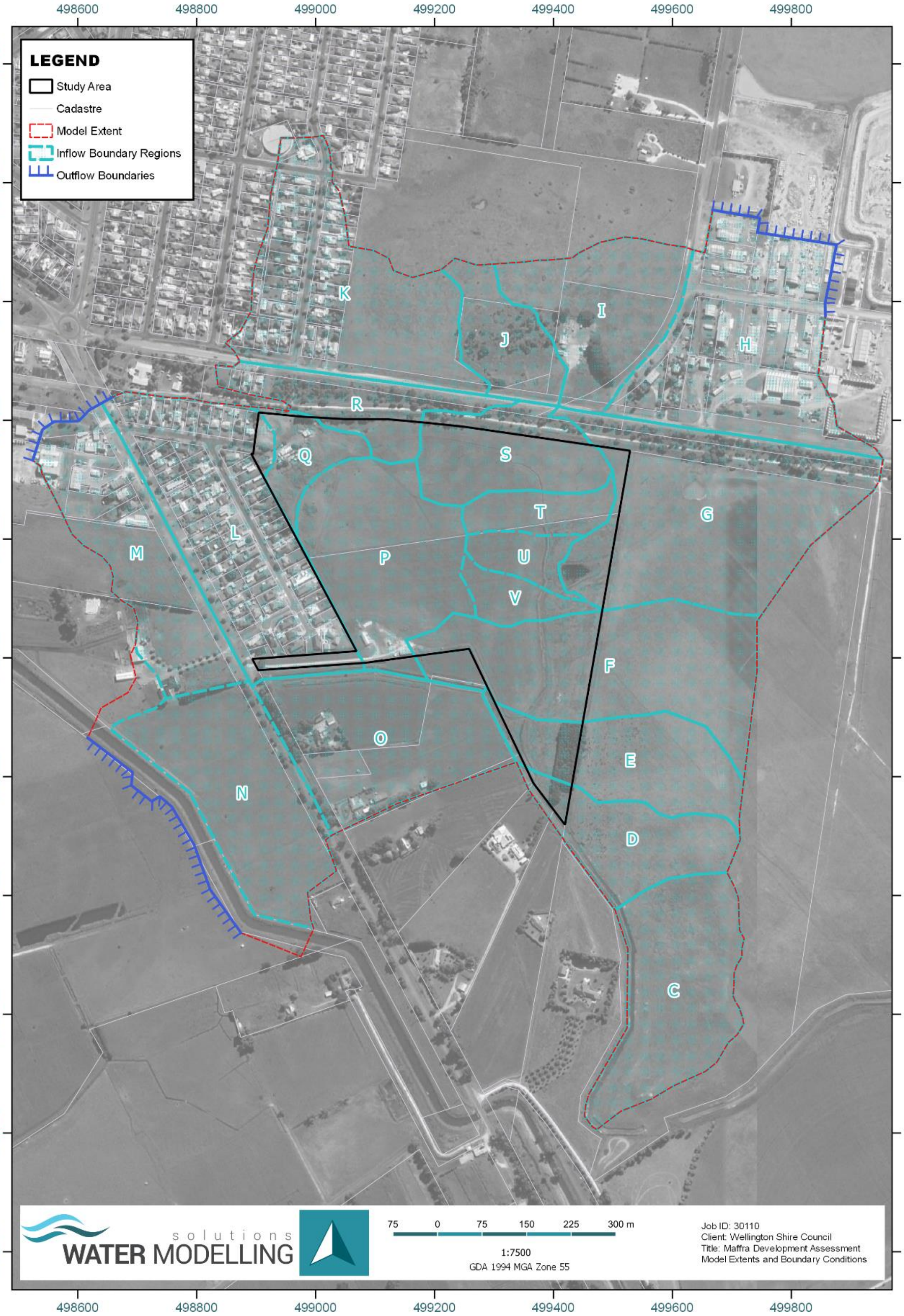


Figure 3-2 Model Extents and Boundary Conditions

3.3 MANNINGS ROUGHNESS

Similar Mannings Roughness Values as those utilised within the Maffra Flood Study were adopted for this flood impact assessment. The values adopted comply with ARR2019 and are outlined in Table 3-1.

Table 3-1 Roughness (Mannings 'n') Values

Description	'n' value
Farming	0.05
Dense Vegetation	0.08
Low Density Residential	0.2
Industrial / Commercial	0.3
Roads	0.02
Water Body	0.03
Public Parks and Recreation	0.3
Separate Building Footprints	3.0
Railway Reserve	0.06
Commercial	0.3

3.4 STRUCTURES

The pit and pipe network was provided by WSC for the Maffra IWM study as a shape file. The GIS shape file contained pits and pipes with the pipe layer containing information on length and diameter and the pit layer containing information on pit type. All pipes were assumed to be circular unless otherwise stated. Where diameter data was missing – the diameter was assumed from upstream and downstream pipes and in particular, the diameter was missing for most of the industrial area – the diameter was assumed to be 300mm based on the few available pipes.

Where invert data was missing the depth of cover values in Table 3-2 were assumed to calculate pipe invert levels, where IL (invert level) = terrain surface – cover – diameter. This data was converted into the appropriate format for use in TUFLOW.

No culvert information was initially provided, however there were two key places where modelling indicated that a culvert was required, and aerial imagery confirmed the locations. Both "assumed culverts" were located underneath the rail trail and the dimensions of these culverts were subsequently provided by WSC and updated into the model. The locations are marked in Figure 3-3.

An illustration of the structure schematisation is provided in Figure 3-3.

Table 3-2 Assumed Pipe Cover to determine pipe invert levels

Pipe Diameter (mm)	Assumed Depth of Cover (mm)
Less than or equal to 900 mm	600
Greater than 900 mm	750

In total, there are 75 stormwater pipes with 55 associated pits and 17 manholes and 2 culverts included within the study area.

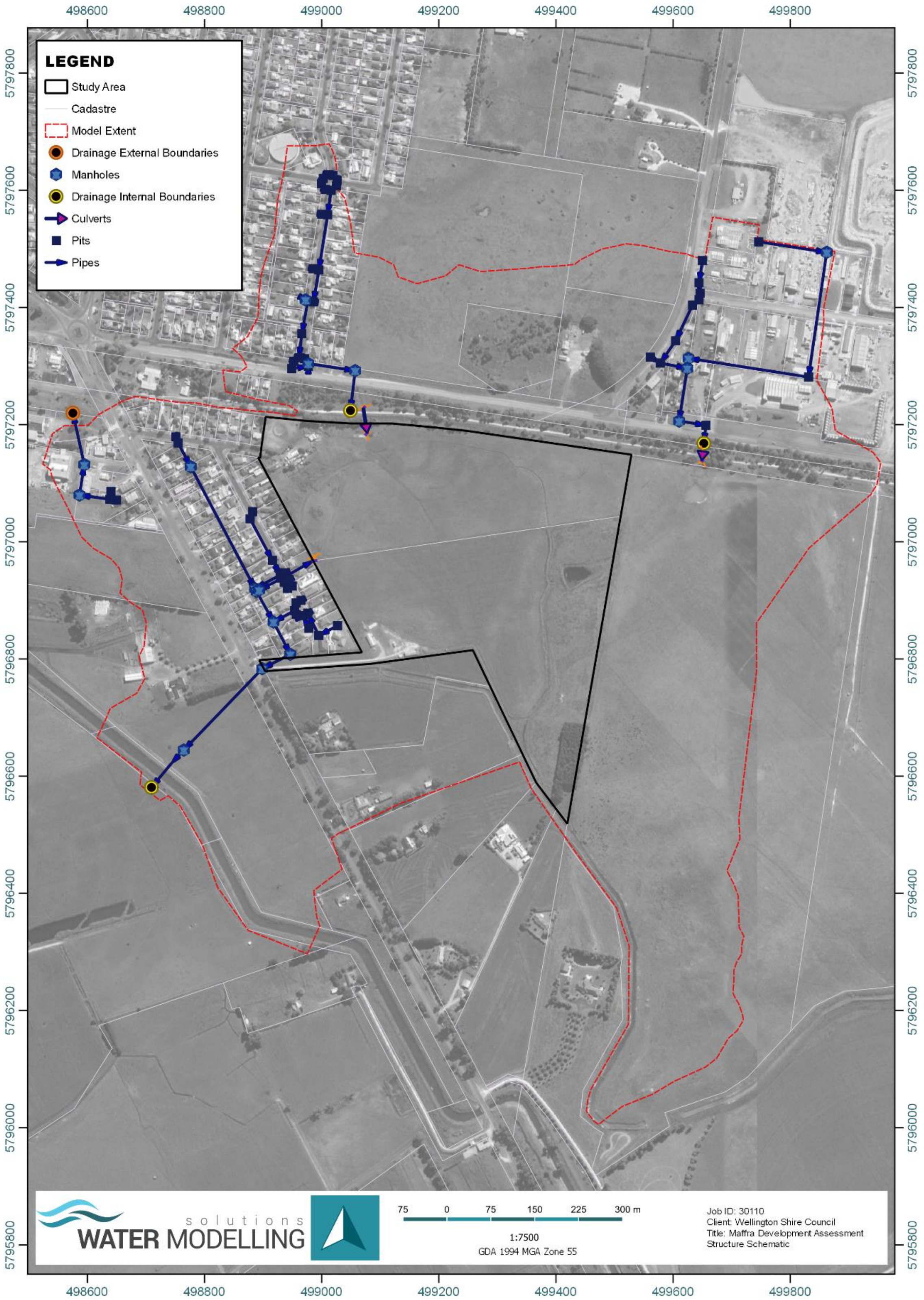


Figure 3-3 Structure Schematisation

3.5 TERRAIN MODIFICATION

Terrain modifiers were used in the Maffra model to reinforce the thalweg of the irrigation channel, to raise and reinforce the levee behind the properties adjacent to the natural basin and to create building pads at the residential development adjacent to the natural basin, where the filled terrain post-dated the LiDAR. The terrain modification is illustrated in Figure 3-4.

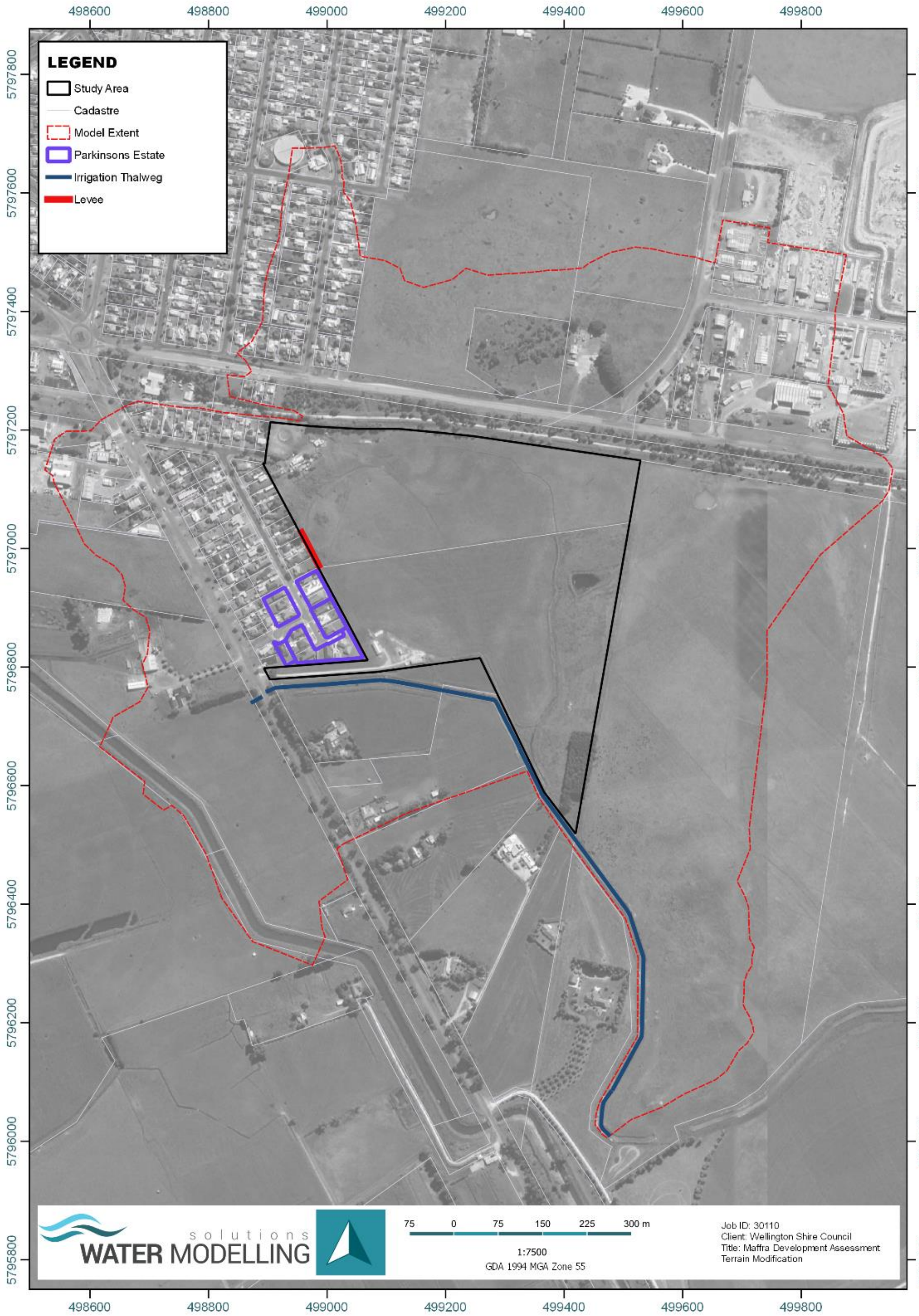


Figure 3-4 Terrain Modification

3.6 DEVELOPED CONDITIONS

The developed conditions changes to the modelling were provided by Alluvium, the following details were incorporated:

- A new retarding basin terrain surface;
- Outfall pipes from the retarding basin and wetland;
- A new 900 mm diameter pipe through to a new syphon under the irrigation channel;
- A new bubble up pit from the syphon outfall

The following assumptions were made to incorporate these changes into the modelling:

- A junction pit / lidded manhole would be required at the confluence of the two basin outfall pipes;
- A junction pit / lidded manhole at the connection between the new 900 mm diameter pipe and the new syphon

A schematic of the developed conditions structures is provided in Figure 3-5 with the proposed structures schematised in red.

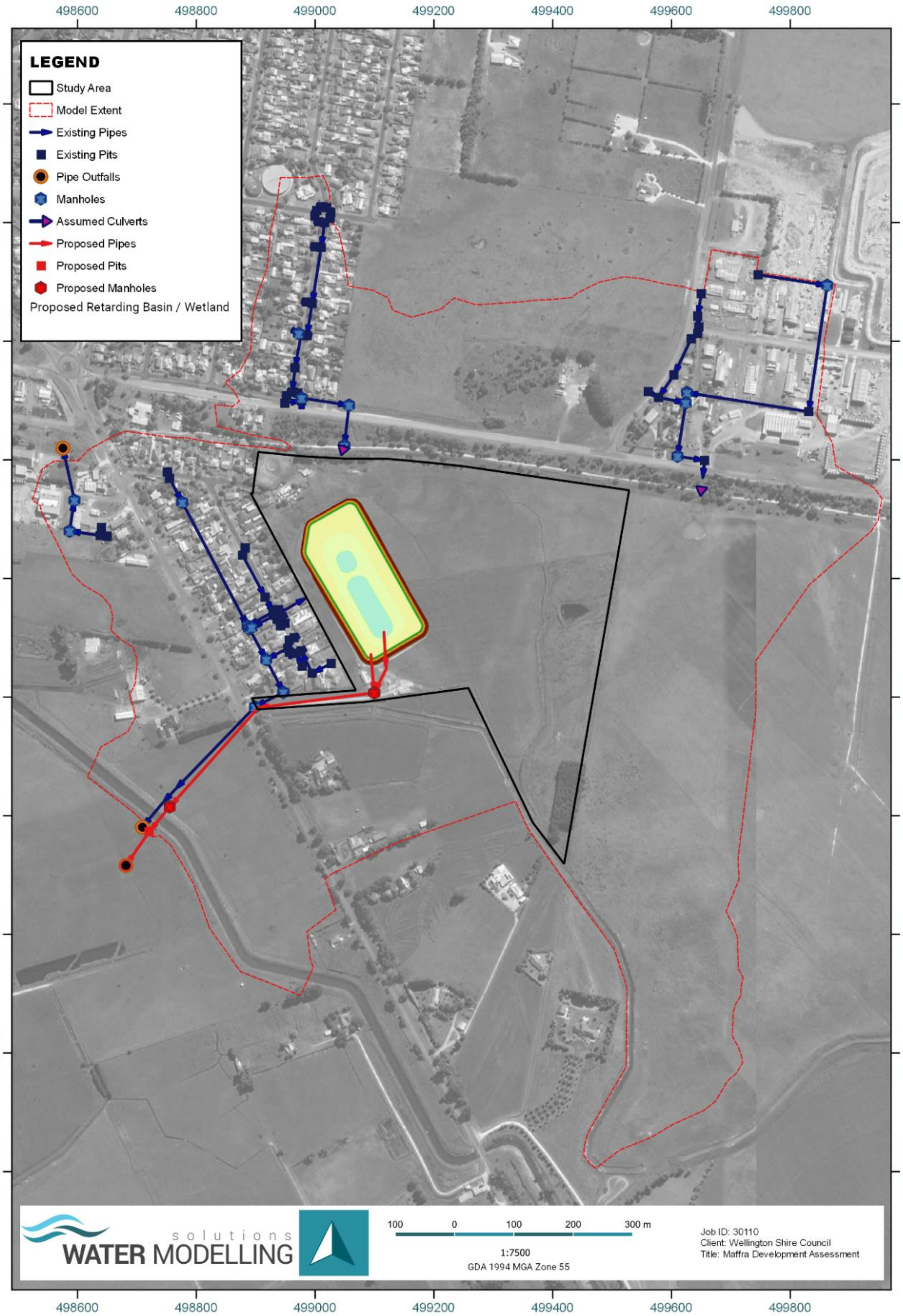


Figure 3-5 Developed Conditions Structures

4 RESULTS

4.1 EXISTING CONDITIONS FLOOD BEHAVIOUR

4.1.1 1% AEP

It can be seen from Figure 4-1 that the key area of interest for this study is the de facto basin in the centre of the subject site. Water is flowing into the basin from three predominant locations. The first is from the north east, where there is a flow path from the Industrial Estate. Floodwaters pond behind the rail trail to depths of approximately 0.5m and then travel downstream via the box culvert into a dam, which overtops and flows down into the basin. The second flow path is from the north west residential estate, water ponds significantly behind the rail trail (to depths great than 1m) and then travels downstream via the western culvert, into the basin and finally, there are two natural channels that flow from the south east, the channels combine at an offshoot of the irrigation channel and then flow north towards the basin.

Basin depths are approximately 600-650 mm, on average, within the basin and 800 -850 mm as flows leave the basin towards the north west, travelling towards the residential area to the west. Despite the existence of a levee wall at the rear of the property boundaries to the west, several properties (approximately 3-4) are still flooded as the water over tops the levee, with flood levels at 23.97 mAHD and the levee grading from 23.7 mAHD at the north down to 23.6 mAHD at the south.

There is a trapped low point behind the levee that has depths of over 850mm in the rear of at least one property and two properties within the Parkinson Street Residential Estate experience local flood depths of up to 200mm.

The following changes are observed since the previous iteration of the modelling:

- The flood depths in the basin are slightly greater due to implementing the correct rail trail culverts within the model, this has generated more flow into the basin from the upstream industrial and residential estates;
- Raising the terrain at the location of the new lots within the Parkinson Street Development has redirected the majority of flows around the estate;
- Due to greater flood depths within the basin, the water is still overtopping the levee, however, the number of properties is reduced, as the terrain is raised appropriately.

The 1% AEP flood depth map is shown in Figure 4-1

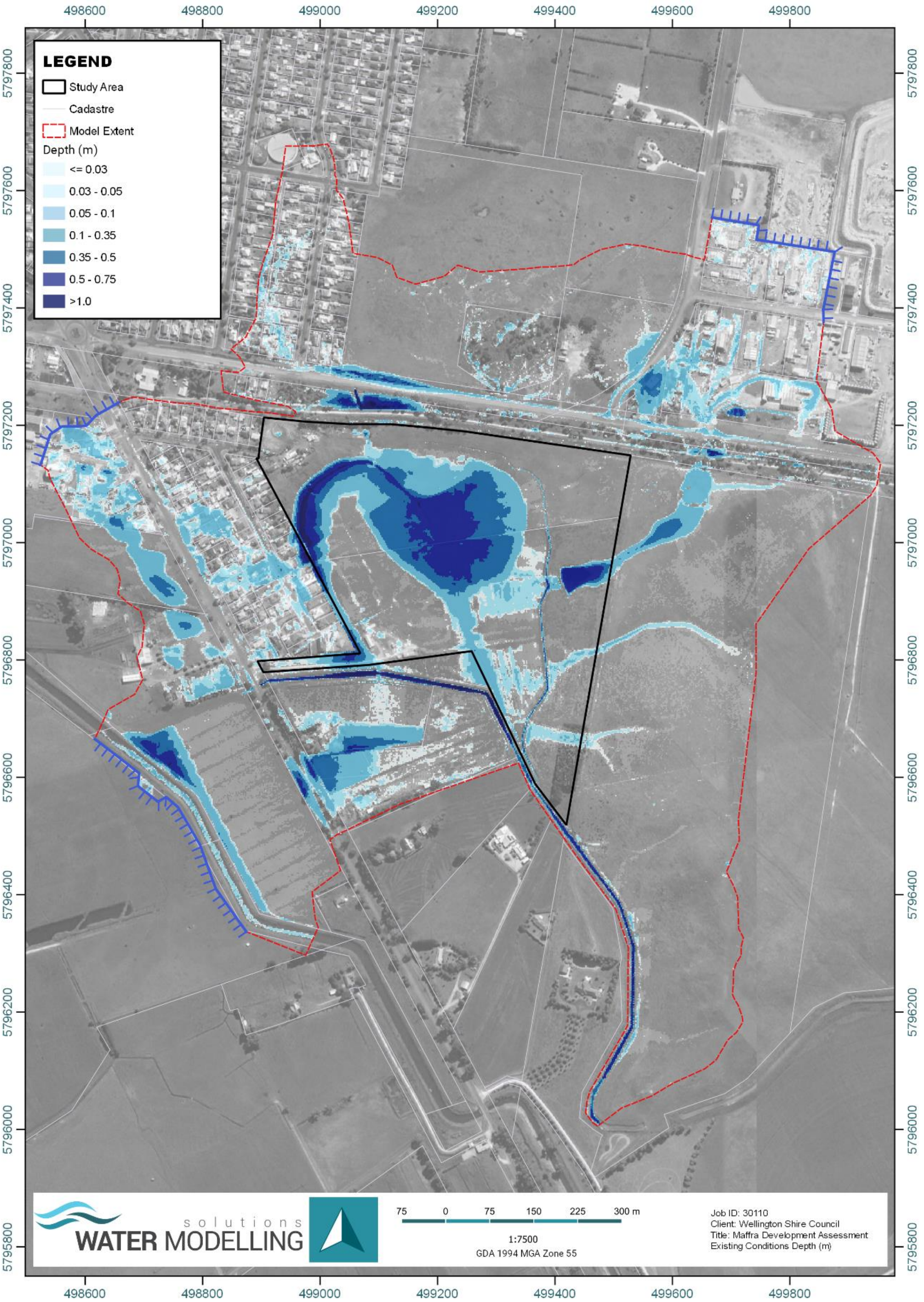


Figure 4-1 1% AEP Existing Conditions Flood Depths (extent) (m)

4.1.2 20% AEP

The flow regime in the 20% AEP is similar to that of the 1% AEP, however, there is noticeably less flow from the two northern residential and industrial catchments. As such, the depths in the basin average 300 – 350 mm (c.f. 650 mm in the 1% AEP). Depths in the outflow channel towards the residential area average 150 mm to 220 mm and typically do not overtop the levee except at the very northern end.. However, there is still a trapped low point behind the levee within one particular property that has flood depths of approximately 260 – 300 mm. There is local catchment flooding within the estate.

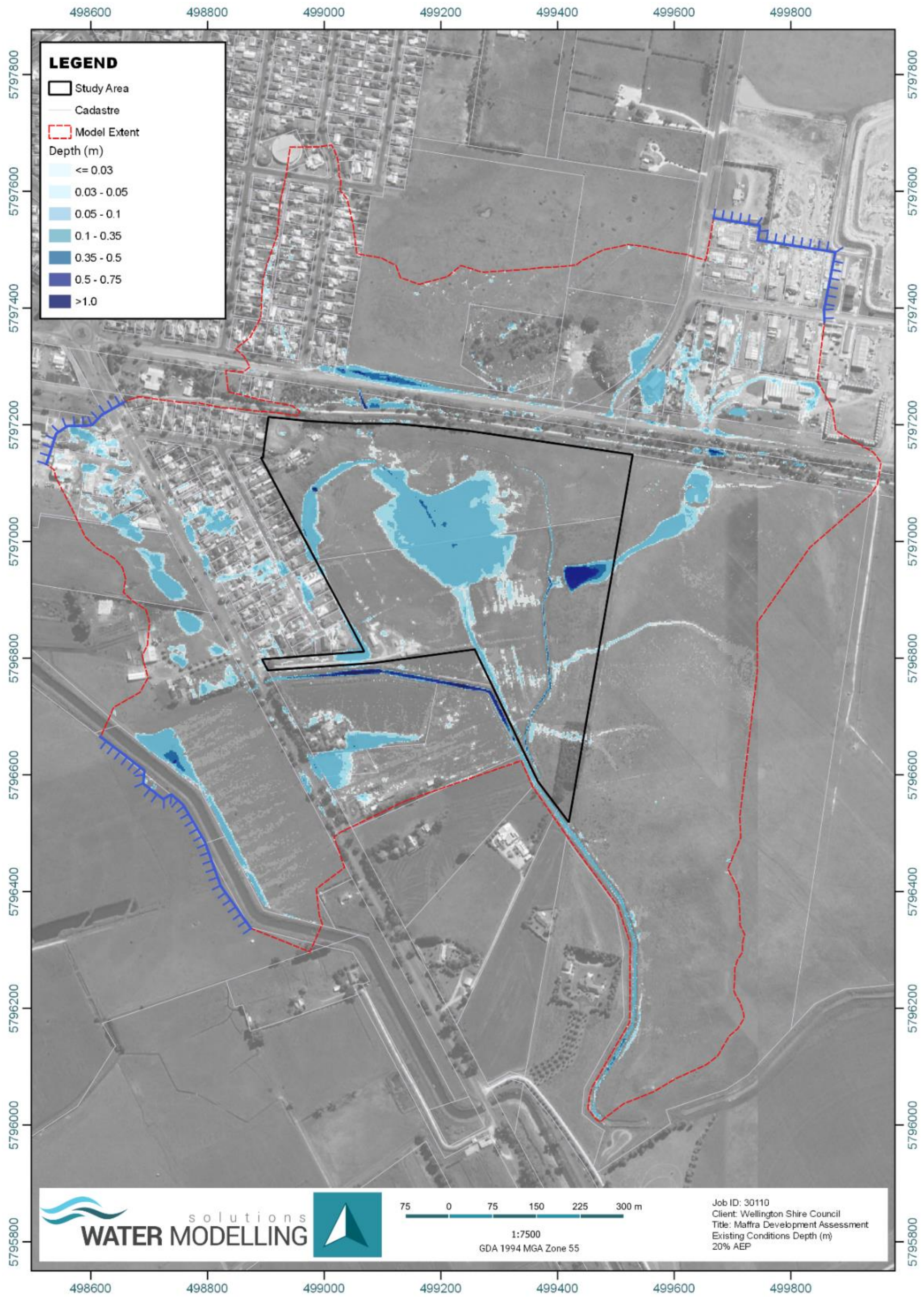


Figure 4-2 20% AEP Existing Conditions Flood Depths (extent) (m)

4.2 DEVELOPED CONDITIONS FLOOD BEHAVIOUR

4.2.1 1% AEP

In the developed conditions for the Maffra site, a formalised retarding basin and wetland has been added in place of the natural basin and an additional parallel 900 mm diameter drain to a second syphon underneath the irrigation channel. The implementation of these structures clearly shows a net benefit in controlling the flow of water downstream. The flow regime into the basin remains unchanged, however the depth of water within the basin is now 1.22 m

The flooding on the properties adjacent to the basin is reduced with depths up to 250mm from the basin, local catchment rain is prevented from leaving the rear of the properties as it is trapped by the levee, but depths are reduced to 450mm compared to 850mm in the existing conditions.

Since the previous iteration of the report the following changes are noted:

- The depth in the basin is slightly greater due to implementation of the correct culverts into the model;
- Flood waters may still be slightly overtopping the levee due to deeper flooding in the basin; and
- The corner property of the Parkinson Street Estate is no longer flooded, due to raising the terrain to the new estate levels.

The 1% AEP developed conditions flood depth is highlighted in Figure 4-3.

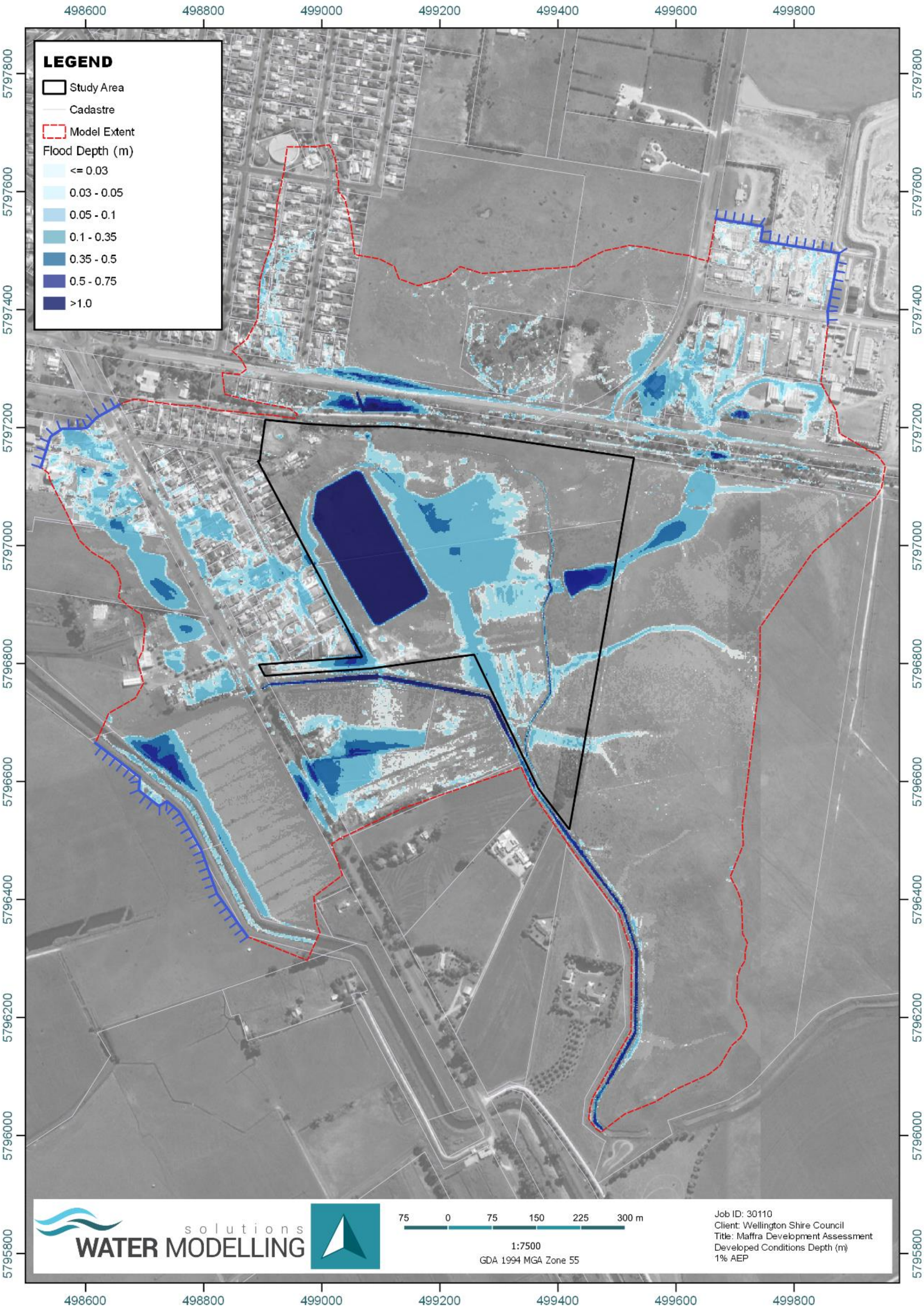


Figure 4-3 1% AEP Developed Conditions Flood Depths (extents) (m)

4.2.2 20% AEP

In the 20% AEP developed conditions the flow regime into the basin remains unchanged from the existing conditions and the 1% AEP. However, there is significantly less flow from the upstream catchments than in the 1% AEP.

The depths in the formalised basin are 0.53 m, which reduces (but does not eliminate) surrounding flood waters. The water is not overtopping the levee, but the trapped low point behind the levee remains with a depth of approximately 130 mm. It is expected that this trapped low point is primarily due to local catchment runoff being unable to get away due to the levee.

The noticeable changes within this iteration of the report since the previous version are as follows:

- The depth within the basin has increase by approximately 0.3 – 0.4m. This is due to additional flow into the basin via the two rail trail culverts being implemented correctly within this version; and
- The property on the corner of the Parkinson Street Residential Estate is no longer flooded. This is due to raising the terrain within the model to the finished surface levels.

Figure 4-4 illustrates the 20% AEP flood depths.

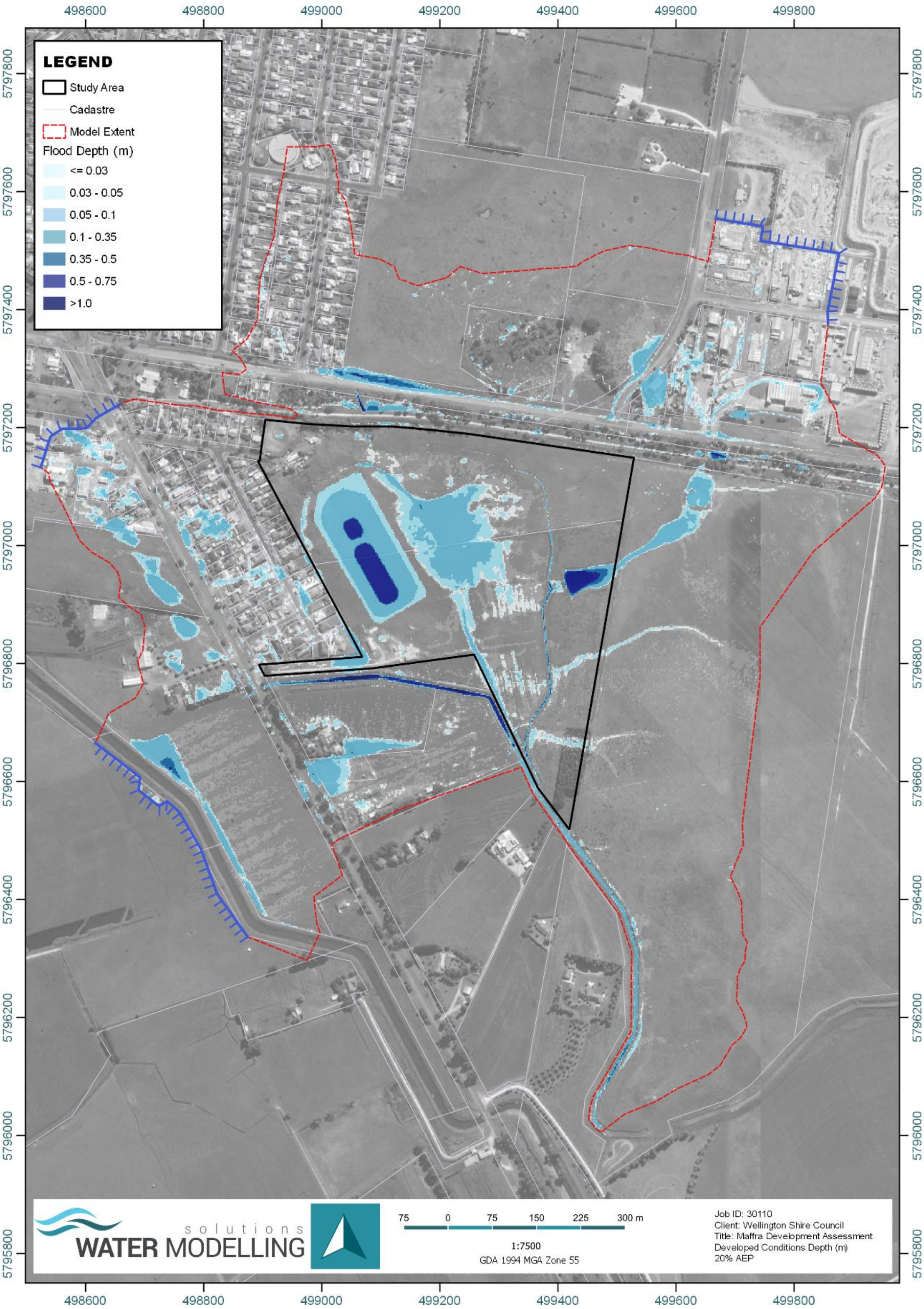


Figure 4-4 20% AEP Developed Conditions Flood Depths (extents) (m)

4.3 IMPACT

An impact map is the difference between the water surface elevation of the developed conditions and the water surface elevation of the existing conditions. The impact map clearly highlights the areas where flood waters are increased or decreased due to development or changes in topography.

4.3.1 1% AEP

In the 1% AEP event, there are some minor patchy increases in flooding (approximately 10-15 mm) broadly across the model extent and there is also a very minor (~10-15 mm) increase in flooding within the irrigation channel, this could simply be due to the change in temporal pattern used in the hydrology.

Most significantly, the water levels in the vicinity of the natural basin have decreased, ranging from 15 mm at the very outer ring, to approximately 300mm across the broad depression and over 2 m within the base of the new basin itself.

There is an increase in ponding behind the rail trail downstream of the residential area of 15-20 mm. This is likely due to the proposed development causing an increase in flooding upstream.

On the residential properties adjacent to the levee there is an average 350 - 400 mm decrease in flooding as the rear of the property approaches the basin and 300 – 350mm reduction in flooding along the remainder of the rear property boundaries adjacent to the basin.

Finally, there is an increase of flooding of 20-100mm at the location of the new syphon and bubble-up pit.

The noticeable changes between this iteration and previous iteration of the report are as follows:

- An increase in ponding behind the rail trail due to the change in culvert assumptions

The 1% AEP impact map is show in Figure 4-5.

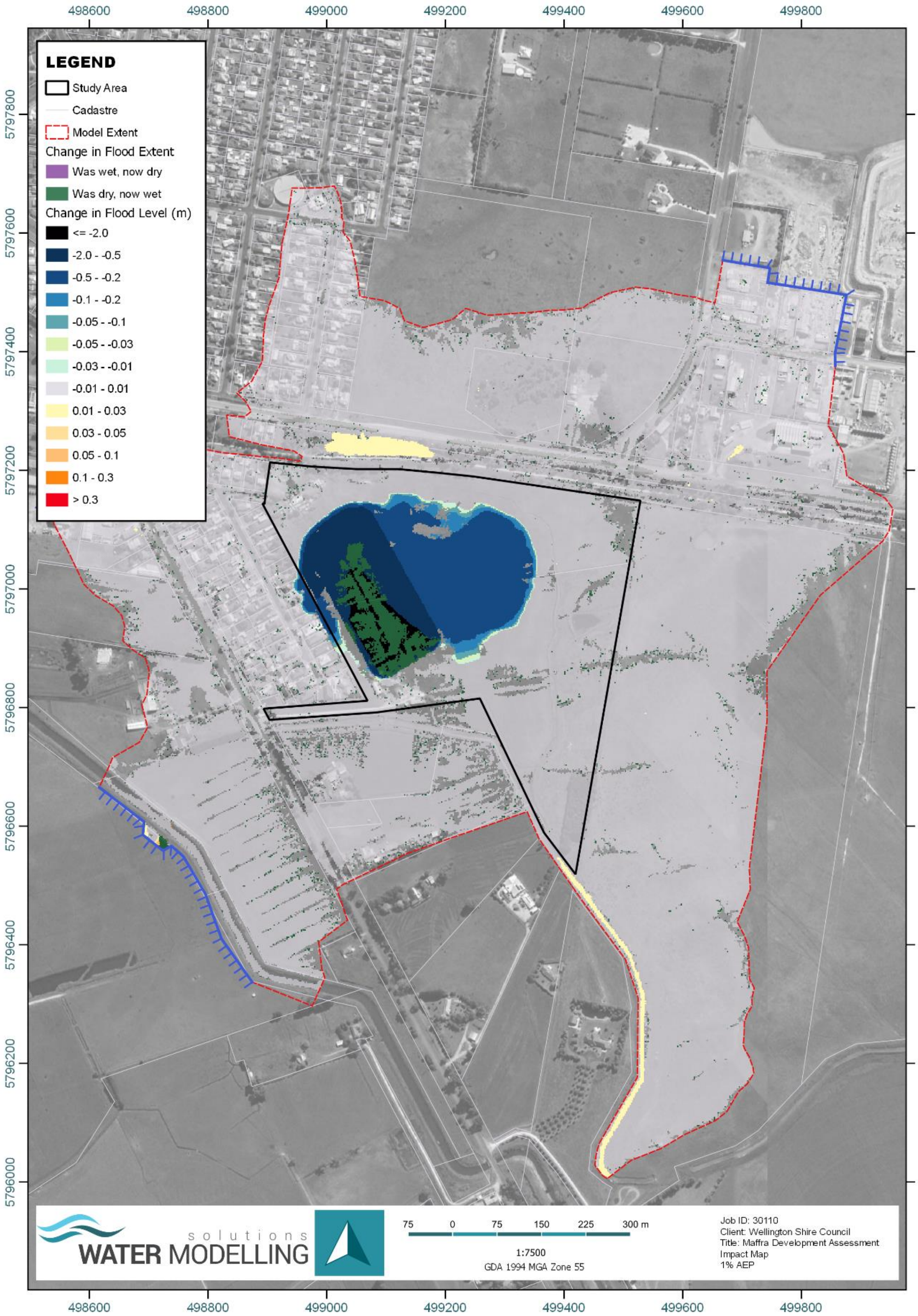


Figure 4-5 1% AEP Impact Map

4.3.2 20% AEP

The 20% AEP impact map shows a patchy 10 – 20mm increase in flooding more broadly across the study area and upstream. In this case, the impact cannot be explained by a change in Temporal Pattern but is more likely to be due to the proposed development.

Implementation of the basin reduces the surrounding flood levels by up to 75mm across the broader depression area and up to 250mm in the basin outflow.

Adjacent to the levee there is a decrease in flooding of 150 mm and a decrease in flooding at the trapped low point of 150-300mm.

At the location of the new proposed syphon and bubble up pit, there is an increase in flooding of approximately 35mm.

The 20% AEP impact map is shown in Figure 4-6.

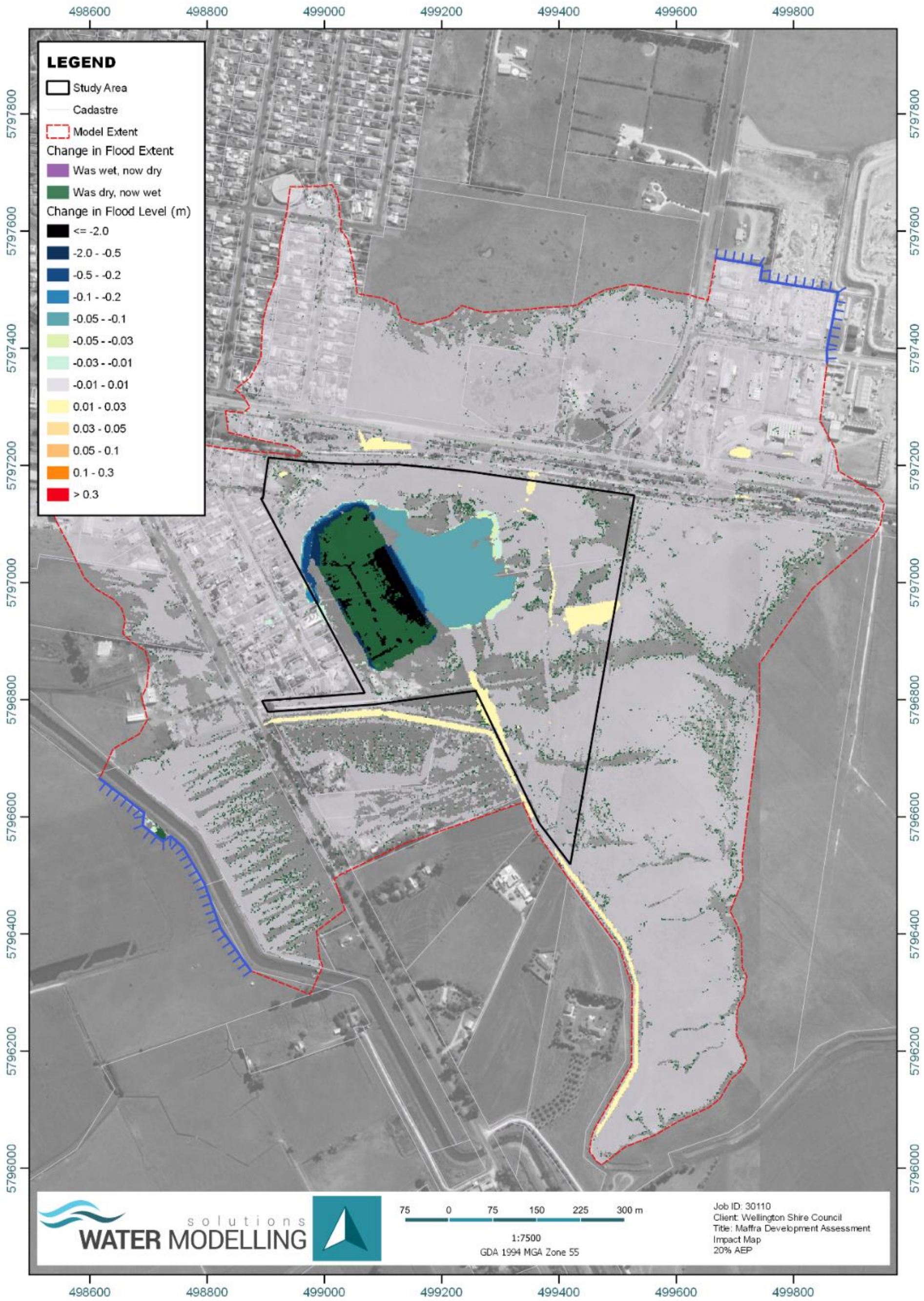


Figure 4-6 20% AEP Impact Map

5 ASSUMPTIONS

The following limitations are applicable to the data used as input to the investigation and the hydraulic modelling results and mapping deliverables. Some assumptions made have been discussed in this report, all assumptions are summarised together here.

The modelling results should therefore be viewed in light of these limitations.

1. The underground pit and pipe network in the industrial estate at the north east corner of the model was missing most pipe attributes. The pipe diameters have been assumed to be 300 mm as per the available pipe diameters in the estate. The pipe lengths have been assumed to be that of the length of the provided GIS shape file.
2. The invert data was assumed as per the discussion in Section 3.4.
3. A small number of pipe grade issues were repaired using an assumption of a 1 in 100 grade.
4. All downstream boundary conditions were assumed to be free outfall based on terrain slope.
5. The irrigation channel had several raised "bunds", which may be filled levees or farm crossings. It was assumed that these would likely have culverts and since the culvert details were not available it was assumed the channel would flow freely.
6. Two culverts were added under the rail trail, as discussed in Section 3.4.
7. The 1D pipe external boundary conditions were taken to be the pipe obvert levels.

6 SUMMARY AND CONCLUSIONS

This report outlines the modelling methodology, parameters used, and assumptions made to undertake a flood study of the existing (base case) conditions and developed (proposed) conditions at the site of a proposed development south of Maffra Township within Wellington Shire Council.

The modelling shows that the implementation of a retarding basin / wetland and associated drainage, with an additional parallel 900 mm drain and second syphon has a net benefit on the flood regime within the subject site, but that the site nevertheless is very flooded and due consideration will need to be given to developing the are within and surrounding the naturally occurring depression.

There are some problematic flooding issues around the adjacent residential area that would ideally be addressed as part of the works, these areas are:

- The trapped low point behind the levee bank; and
- The levee itself may need to be raised and/or extended slightly north.

7 REFERENCES

BMT Group Ltd (2007 – 2018), TUFLOW, [Online] June 23rd, 2020, at < https://www.tuflow.com/>

APPENDIX A

TUFLOW MODEL PARAMETERS

A.1 TUFLOW MODEL PARAMETERS

Table A-1 TUFLOW Model Parameters

Model Parameter	Value	Comments
TUFLOW Version	2020-10-AA-TUFLOW_iSP-w64	Utilising Sub Grid Sampling to Capture details in the channels
Guidelines	ARR2019	
LiDAR	1m Resolution	2008, Supplied by CMA
Cell Size	2m	
2D Time Step	1s	Adaptive time stepping used
1D Time Step	0.5s	Adaptive time stepping used
Projection	GDA94Z55	
Inflows	RORB excess inflows, input as 2d_SA ALL	Hydrology provided by Alluvium
Downstream Boundary Conditions	Based on terrain slope: 1 in 60 at the main outfall	
1d / 2d Connections	SX / CN Lines, 1d Nodes and 1d SX Pits	
Mannings Roughness Values	Outlined in Section 3.3	
Events	1% and 20% AEP	Critical Duration and Median Temporal Pattern for each event – as calculated by Alluvium.

APPENDIX B

FLOOD MAPS

WATER MODELLING solutions

Maffra Flood Impact Assessment

Legend

Study Area
Model Extents

Water Surface Elevation (mAHD)

- <= 20
- 20.0 - 25.0
- 25.0 - 30.0
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 55.0
- > 55.0

1% AEP WSEL Existing Conditions

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

50 0 50 100 150 200 m


WATER MODELLING solutions
Maffra Flood Impact Assessment
Legend
Study Area
Model Extents
Water Surface Elevation (mAHD)
<= 20
20.0 - 25.0
25.0 - 30.0
30.0 - 35.0
35.0 - 40.0
40.0 - 45.0
45.0 - 50.0
50.0 - 55.0
> 55.0
20% AEP WSEL Existing Conditions
A3 Scale: 1:6500
GDA 1994 / MGA Zone 55
Job ID: 30110
04/06/2021
50 0 50 100 150 200 m

WATER MODELLING solutions

Maffra Flood Impact Assessment

1% AEP WSEL Developed Conditions

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

solutions
WATER MODELLING

Maffra Flood Impact Assessment

Legend

Study Area
Model Extents

Water Surface Elevation (mAHD)

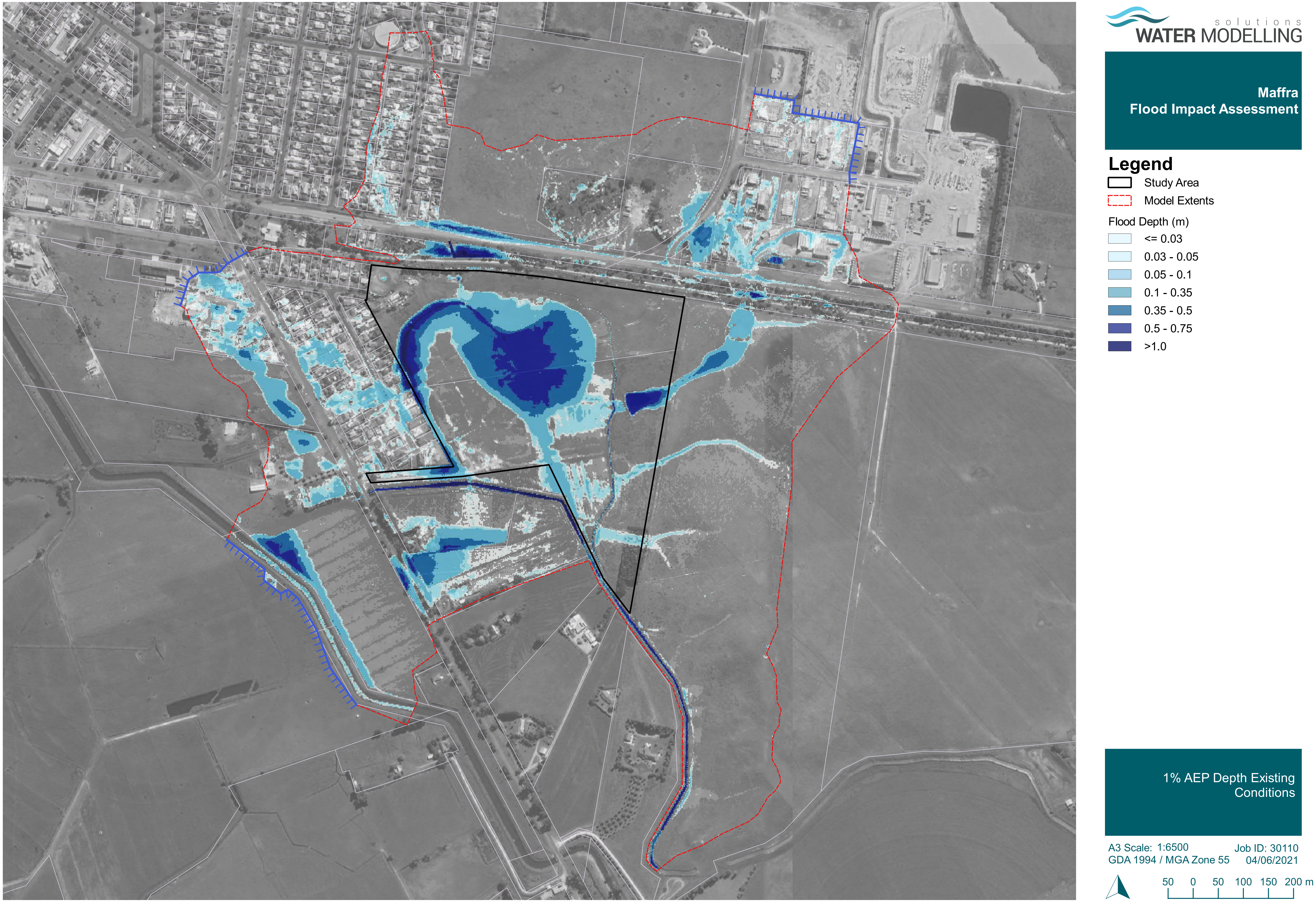
<= 20
20.0 - 25.0
25.0 - 30.0
30.0 - 35.0
35.0 - 40.0
40.0 - 45.0
45.0 - 50.0
50.0 - 55.0
> 55.0

20% AEP WSEL Developed Conditions

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

50 0 50 100 150 200 m



solutions
WATER MODELLING
Maffra
Flood Impact Assessment
Legend
Study Area
Model Extents
Flood Depth (m)
<= 0.03
0.03 - 0.05
0.05 - 0.1
0.1 - 0.35
0.35 - 0.5
0.5 - 0.75
>1.0
1% AEP Depth Existing Conditions
A3 Scale: 1:6500
GDA 1994 / MGA Zone 55
Job ID: 30110
04/06/2021
50 0 50 100 150 200 m


solutions
WATER MODELLING
Maffra
Flood Impact Assessment
Legend
Study Area
Model Extents
Flood Depth (m)
<= 0.03
0.03 - 0.05
0.05 - 0.1
0.1 - 0.35
0.35 - 0.5
0.5 - 0.75
>1.0
20% AEP Depth Existing Conditions
A3 Scale: 1:6500
GDA 1994 / MGA Zone 55
Job ID: 30110
04/06/2021
50 0 50 100 150 200 m

solutions
WATER MODELLING

Maffra
Flood Impact Assessment

Legend

Study Area
Model Extents

Flood Depth (m)

- <= 0.03
- 0.03 - 0.05
- 0.05 - 0.1
- 0.1 - 0.35
- 0.35 - 0.5
- 0.5 - 0.75
- >1.0

1% AEP Depth Developed Conditions

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

50 0 50 100 150 200 m

solutions
WATER MODELLING

Maffra
Flood Impact Assessment

Legend

- Study Area
- Model Extents

Flood Depth (m)

- <= 0.03
- 0.03 - 0.05
- 0.05 - 0.1
- 0.1 - 0.35
- 0.35 - 0.5
- 0.5 - 0.75
- >1.0

20% AEP Depth Developed Conditions

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

50 0 50 100 150 200 m

solutions
WATER MODELLING

Maffra
Flood Impact Assessment

Legend

Study Area
Model Extents

Flood Velocity (m/s)

<= 0.05
0.05 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.75 - 1.0
1.0 - 1.25
0.75 - 1.0
> 1.0

1% AEP Velocity Existing Conditions

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

50 0 50 100 150 200 m

WATER MODELLING solutions

Maffra
Flood Impact Assessment

Legend

- Study Area
- Model Extents

Flood Velocity (m/s)

- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.75 - 1.0
- 1.0 - 1.25
- 0.75 - 1.0
- > 1.0

20% AEP Velocity Existing Conditions

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

50 0 50 100 150 200 m

WATER MODELLING solutions

Maffra
Flood Impact Assessment

Legend

- Study Area
- Model Extents

Flood Velocity (m/s)

- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.75 - 1.0
- 1.0 - 1.25
- 0.75 - 1.0
- > 1.0

1% AEP Velocity Developed Conditions

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

50 0 50 100 150 200 m

solutions WATER MODELLING

Maffra
Flood Impact Assessment

Legend

- Study Area
- Model Extents

Flood Velocity (m/s)

- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.75 - 1.0
- 1.0 - 1.25
- 0.75 - 1.0
- > 1.0

20% AEP Velocity Developed Conditions

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

50 0 50 100 150 200 m

solutions
WATER MODELLING

Maffra
Flood Impact Assessment

Legend

Study Area
Model Extents

Change in Flood Extent
- Was wet, now dry
- Was dry, now wet

Change in Flood Level (m)
- <= -2.0
- -2.0 - -0.5
- -0.5 - -0.2
- -0.1 - -0.2
- -0.05 - -0.1
- -0.05 - -0.03
- -0.03 - -0.01
- -0.01 - 0.01
- 0.01 - 0.03
- 0.03 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- > 0.3

1% AEP Afflux

A3 Scale: 1:6500
GDA 1994 / MGA Zone 55

Job ID: 30110
04/06/2021

50 0 50 100 150 200 m

solutions
WATER MODELLING
Maffra
Flood Impact Assessment
Legend
Study Area
Model Extents
Change in Flood Extent
Was wet, now dry
Was dry, now wet
Change in Flood Level (m)
<= -2.0
-2.0 - -0.5
-0.5 - -0.2
-0.1 - -0.2
-0.05 - -0.1
-0.05 - -0.03
-0.03 - -0.01
-0.01 - 0.01
0.01 - 0.03
0.03 - 0.05
0.05 - 0.1
0.1 - 0.3
> 0.3
20% AEP Afflux
A3 Scale: 1:6500
Job ID: 30110
GDA 1994 / MGA Zone 55
04/06/2021
50 0 50 100 150 200 m