Rapid Flood Risk Assessment - North Central CMA Region

Newlyn North

Version 2

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Contents

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Newlyn North

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Copyright and Limitation

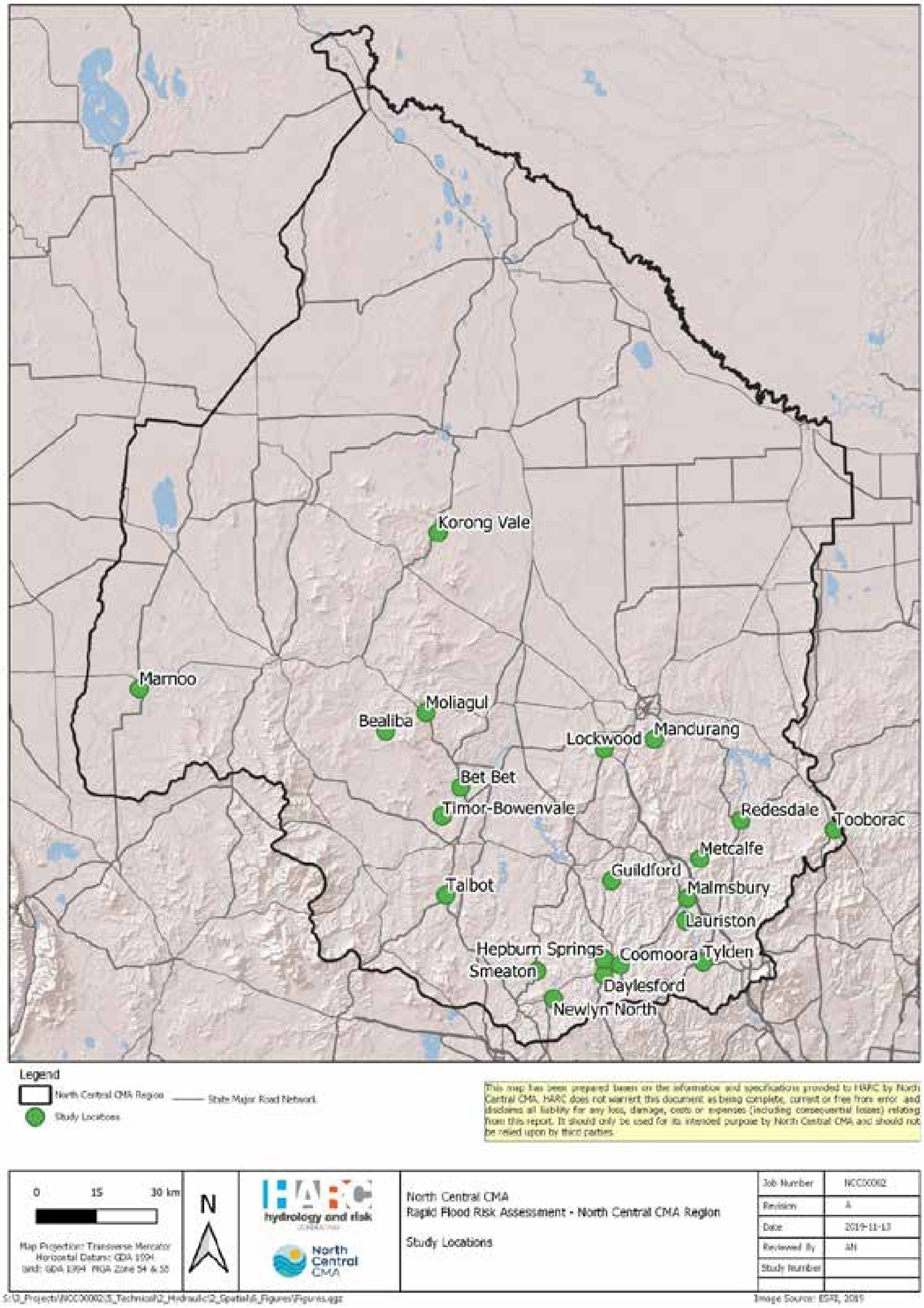
The Rapid Flood Risk Assessments project is a joint initiative funded through the Victorian and Australian governments.

Acknowledgment of Country

We acknowledge Aboriginal Traditional Owners within the region, their rich culture and spiritual connection to Country. We also recognise and acknowledge the contribution and interest of Aboriginal people and organisations in land and natural resource management.

1. Introduction

The North Central Catchment Management Authority (CMA) commissioned HARC to undertake a rapid flood risk assessment for 21 townships in the North Central CMA region. The Rapid Flood Risk Assessments project is a joint initiative funded through the Victorian and Australian governments. The study focused on providing mapped flood extents for a range of AEPs using a range of existing and new hydrologic and hydraulic models. The rapid nature of the assessment precluded detailed, site specific studies, extensive model calibration or community engagement. The outcomes of the study were used to provide preliminary estimates of flood risk at the 21 locations, and to help identify and prioritise areas where more detailed, site specific flood studies were recommended. The study locations are shown in Figure 1-1 and the list of townships is shown in Table 1-1.



- **Figure 1-1 Rapid Flood Risk Assessment Project Study Locations**

Table 1-1 List of Study Locations (Study Location in bold denotes the township covered in this report)

No.	Name	No.	Name
1	Lockwood	12	Daylesford
2	Mandurang	13	Hepburn Springs
3	Redesdale	14	Korong Vale
4	Moliagul	15	Malmsbury
5	Bet Bet	16	Lauriston
6	Talbot	17	Tylden
7	Bealiba	18	Tooborac
8	Timor-Bowenvale	19	Guildford
9	Coomoora	20	Metcalfe
10	**Newlyn North**	21	Marnoo
11	Smeaton		

This report documents the investigation undertaken for the study location of Newlyn North.

Newlyn North has a population of approximately 128 and is located approximately 27 km north-east of Ballarat. Birch Creek runs through the centre of the town, which has an upstream catchment area of 78 km². The creek channel is relatively well defined with two small tributaries joining within the study area. Newlyn North is located immediately downstream of Newlyn Reservoir. Within the study area there are also two large farm dams, one located south of Forest Hill Road and one located north. A map of the study area is shown in Figure 1-2.

■ **Figure 1-2 Newlyn North study area**

2. Available Data

This section describes the key information used in the hydrological and hydraulic investigation.

2.1 Information Used in Hydrological Analysis

2.1.1 Previous Hydrological models

There was a RORB model set up as part of the Review of Flood Hydrology for Newlyn Dam (SKM, 2005) which included Newlyn North. Table 2-1 summarises the key RORB parameters from the previous study.

- **Table 2-1 Previous RORB model summary of key parameters**

No.	Study Area	Previous Study	k_c	d_{av}	$C_{0.8}$ (k_c/d_{av})	IL (mm)	CL (mm/h)	Shire
10	Newlyn North	Newlyn Dam Hydrology	19	15.5	1.2	35	3	Hepburn

2.2 Information Used in Hydraulic Analysis

2.2.1 Hydraulic Structures

There are several hydraulic structures located within the study area. The main structures are listed in Table 2-2 and the location of these structures is shown in Figure 7-2. There may be other minor crossings within the study area but they have been assessed as likely to have little/no impact on the flood extents. The North Central CMA approached three organisations to provide information on their bridges and culverts. The three organisations were:

- VicRoads;
- VicTrack; and
- Council

- **Table 2-2 Summary of hydraulic structures for consideration**

No.	Township Name	Source	Structure Type	Description
10	Newlyn North	VicRoads	Bridge	Midland Hwy (SN1557)
		Council	Bridge	Midland Hwy Newlyn
		Estimated*	Culvert	Forest Hill Rd

* For structures without details dimension were generally estimated based on the aerial image and street view from Google Maps in conjunction with the existing information of the structures within the area.

2.2.2 Topographic Data

To undertake detailed hydraulic modelling requires high quality ground surface information. For this study, aerial captured ground survey, LIDAR, was supplied by North Central CMA. The LIDAR was used to generate a Digital Elevation Model (DEM) of the study area. This LIDAR covered the whole model extent. Further information on the LiDAR dataset used for this study is provided in Section 7.1.

2.3 Previous Flood Studies

The North Central CMA provided a number of reports to provide background information for this project. The main reports relevant to this study area are listed in Table 2-3.

Table 2-3 Summary of flood studies

No.	Township Name	Previous Studies
10	Newlyn North	Carisbrook Flood and Drainage Management Plan (2013), Water Technology

3. Hydrologic model development

A rainfall runoff model (RORB) was established for the catchment, terminating at the study area downstream boundary (refer to Figure 1-2). RORB (Laurenson, Mein and Nathan, 2010) is a general runoff and streamflow routing program that is used to calculate flood hydrographs from rainfall and other channel inputs. It subtracts losses from rainfall to determine rainfall excess and routes this through catchment storages to produce streamflow hydrographs at points of interest. The model is spatially distributed, non-linear, and applicable to both rural and urban catchments. It makes provision for both temporal and areal spatial distribution of rainfall as well as losses, and can model flows at any number of points throughout a catchment (including upstream and downstream of reservoirs). RORB also has the capacity to use a Monte-Carlo approach to produce design flood estimates that incorporate the joint probability of several factors that influence flood characteristics.

In general terms, development of a RORB model entails sub-dividing the catchment into a series of subareas to suit the catchment topography and other features such as the location of gauging stations and storage locations.

Four different types of reaches can be defined in RORB, each having different properties and different relative delay times. The reach types are identified as natural, excavated but unlined, lined channel or pipe and drowned reaches. Drowned reaches were used within reservoir water bodies; natural reaches were used for all other reaches. Excavated and lined channel reaches are normally only applied in urbanised areas and hence were not used in this study.

Impervious fractions are required for each sub-area. For rural areas the impervious fraction was assumed to be zero. For any areas within a dam or reservoir water body, an impervious fraction was calculated based on the percentage of the sub-area that would be inundated. The RORB model also includes some urban areas. The total impervious area (TIA) was estimated for the urban areas using aerial photography and land use information. The Victorian Land Use Information System (VLUIS) dataset was used to define the land use. Because not all impervious areas are well connected to the drainage network (i.e. they flow onto pervious parts of the catchment), the effective impervious area (EIA) is less than the TIA. ARR2019 (Book 5, Chapter 5, Hill and Thomson, 2015) and Phillips et al. (2014) have consolidated the recommended industry practice for estimating EIA and loss parameters for the pervious portion of urban catchments. Phillips et al. (2014) analysed eight catchments and concluded that EIA is typically 55 to 65% of the TIA. ARR2019 recommends an EIA/TIA ratio of 60%. For the RORB model the TIA fraction was multiplied by 0.6 to estimate EIA. The EIA assigned to each land use is shown in Table 3-1.

Table 3-1 EIA assigned for each land use

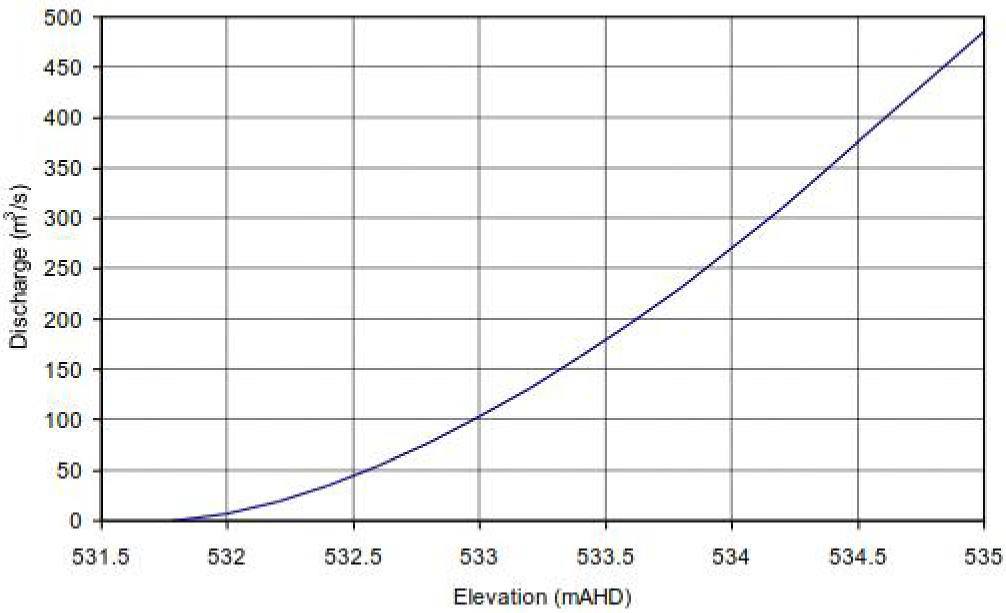
Land Use Type	EIA
Residential areas – high density	0.45
Residential areas – low density	0.12
Industrial/commercial – low density	0.54

Land Use Type	EIA
Open space or waterway – minimal vegetation	0.0
Open space or waterway – moderate vegetation	0.0
Open space or waterway – heavy vegetation	0.0
Paved roads/car park/driveways	0.6
Railway line	0.6
Grass reserves/floodway (regularly mowed)	0.0
Rural floodplains in clear paddocks	0.0
Forested (heavy stand of timber)	0.0
Dam/Reservoir body of water	1.0

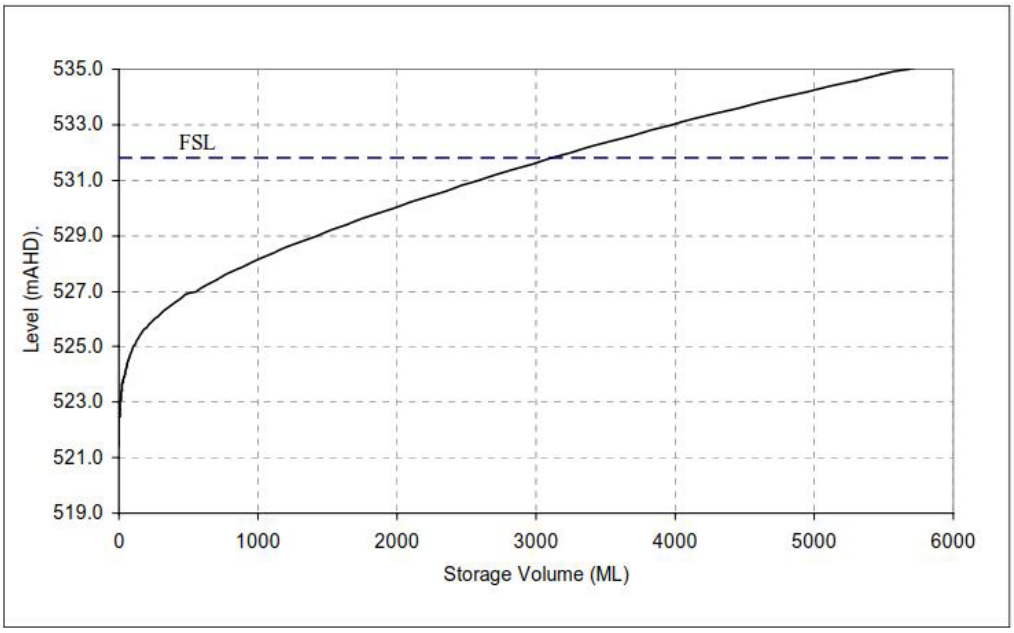
3.1 Newlyn North RORB model

The Newlyn North RORB model was based on the RORB model established by SKM for the hydrology investigation undertaken as a part of the Review of Flood Hydrology for Newlyn Dam (SKM, 2005). The subarea layout and reach types were adopted from this study. Some minor adjustments were made to the subarea at the boundary of the study area to terminate at the boundary of the study area. The RORB model layout is shown in Figure 3-3.

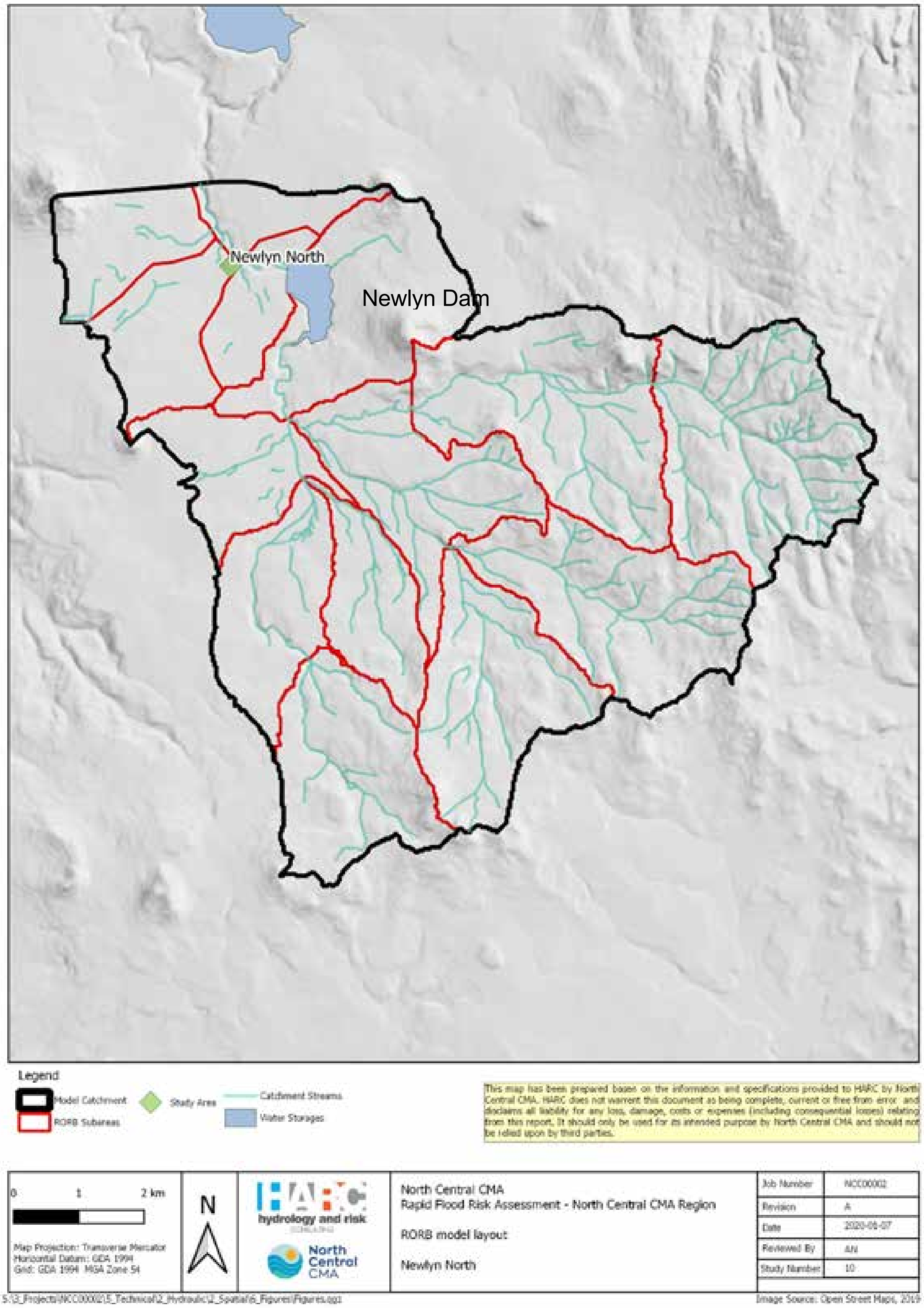
Newlyn Reservoir was modelled as a storage in RORB, with the elevation discharge and elevation storage relationships taken from SKM (2005). These relationships are shown in Figure 3-1 and Figure 3-2.



- **Figure 3-1 Elevation Discharge relationship for Newlyn Dam (Source: SKM (2005))**



- **Figure 3-2 Elevation Storage relationship for Newlyn Dam (Source: SKM (2005))**



■ **Figure 3-3 RORB model layout**

4. Design hydrology approach and inputs

4.1 Overview of adopted design flood approach

The estimation of design floods has traditionally been based on the ‘design event‘ approach, in which all parameters other than rainfall are input as fixed, single values. This concept is illustrated in Figure 4-1 for the case where a distribution of design rainfalls is combined with fixed values of losses, rainfall temporal patterns and spatial patterns. Considerable effort is made to ensure that the single values of the adopted parameters are ’AEP-neutral‘, that is, they are selected with the objective of ensuring that the resulting flood has the same annual exceedance probability as its causative rainfall.

This approach suffers from the limitations that:

- the AEP-neutrality of some inputs can only be tested on frequent events for which independent estimates are available;
- for more extreme events, the adopted values of AEP-neutral inputs must be conditioned by physical and theoretical reasoning; and
- the treatment of more complex interactions (such as the variability in rainfall spatial and temporal pattern) becomes rapidly more complex and less easy to defend.

Joint probability techniques offer an improvement to the traditional design event method. These techniques recognise that any design flood characteristics (e.g. peak flow) could result from a variety of combinations of flood producing factors, rather than from a single combination. For example, the same peak flood could result from a moderate storm on a saturated catchment, or a large storm on a dry catchment. In probabilistic terms, a 1 in 100 AEP flood could be the result of a 1 in 50 AEP rainfall on a very wet catchment, or a 1 in 200 AEP rainfall on a dry catchment. Joint probability approaches attempt to mimic ‘mother nature’ in that the influence of the key probability distributed inputs are explicitly considered, thereby providing a more realistic representation of the flood generation processes.

The application of joint probability approaches to flood estimation is widely acknowledged to be a more thorough and defensible approach to design flood estimation than the design event approach in Australian practice, and has been incorporated in the 2019 version of Australian Rainfall and Runoff (Ball et al., 2019).

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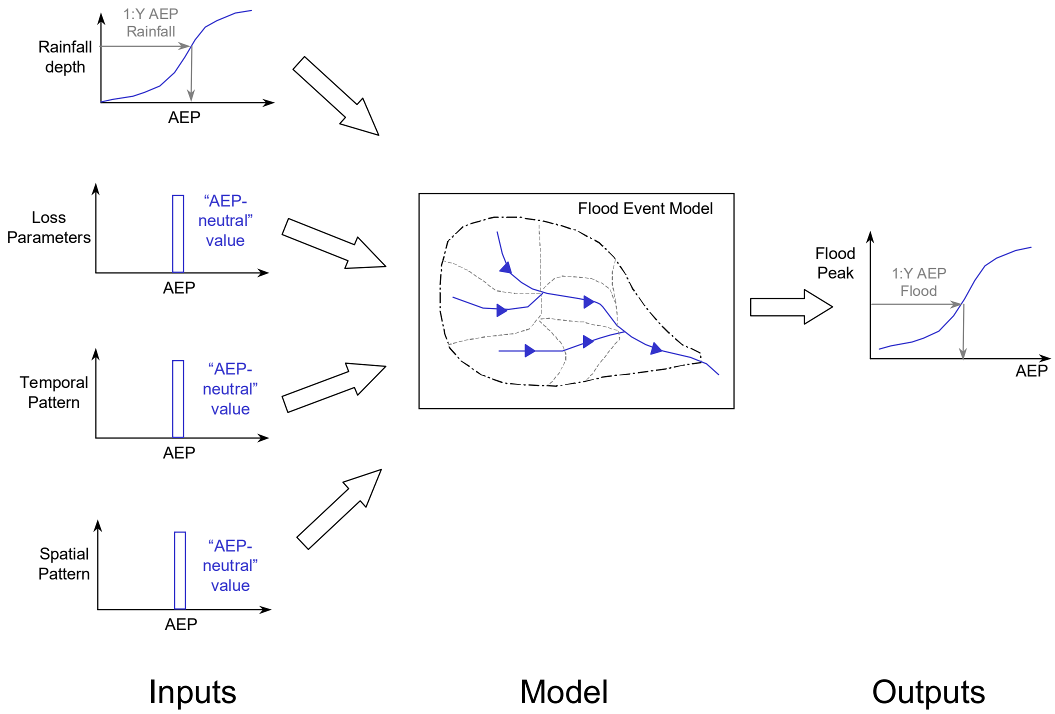
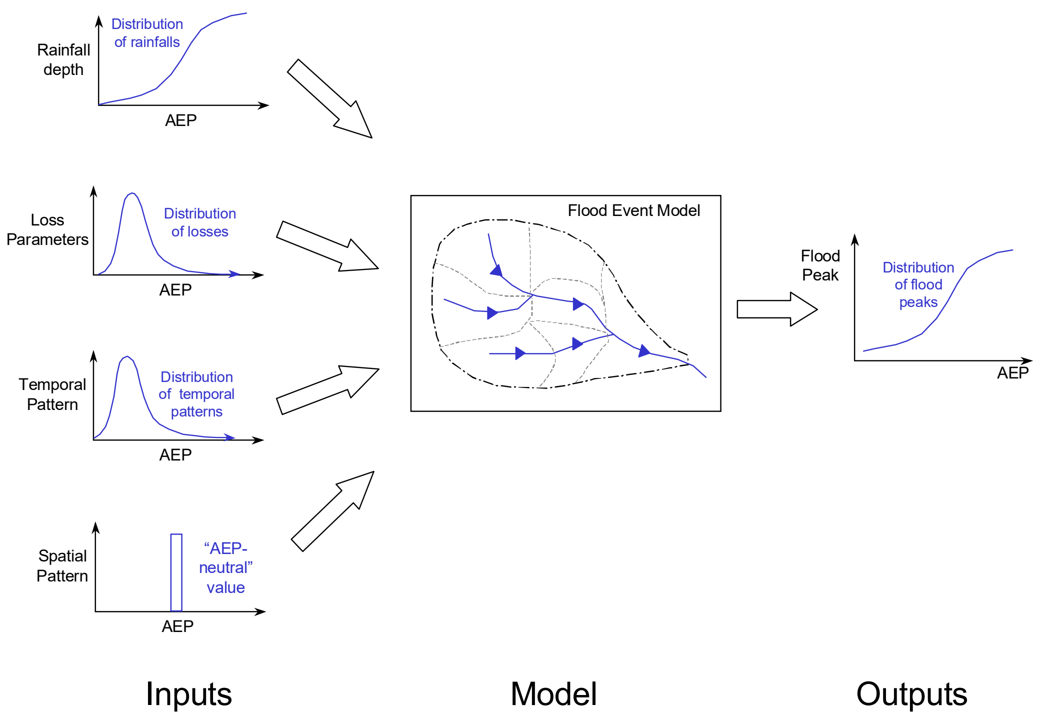
- **Table 8-5 Summary of road Inundation**

AEP (1 in Y)	Roads impacted by flooding	Maximum depth over road (m)	Duration of inundation (hours)
5	Midland Highway	0.0	0
10	Midland Highway	0.0	0



▪ **Figure 4-1 Schematic illustration of the design event approach**



▪ **Figure 4-2 Schematic illustration of the joint probability approach**

The joint probability framework adopted for the study was developed by Nathan et al (2002, 2003) and is summarised in Figure 4-3. In essence the approach involves undertaking numerous model simulations, where the model inputs are sampled from non-parametric distributions that are based either on readily available design information or on the results of recent research. For those study areas where reservoir starting water level is applicable, the level in the storage is also sampled.

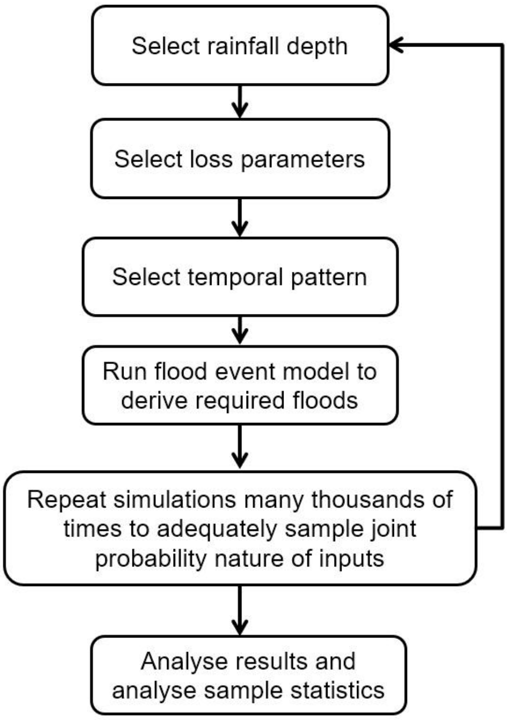


Figure 4-3 Overview of adopted joint probability framework

In developing the joint probability framework particular attention was given to ensuring that the model inputs and the manner in which they were incorporated was consistent with ARR (Ball et al., 2019). The following briefly describes the main inputs, and how they will relate to establishing design information.

Select rainfall depth. Rainfall depths were stochastically sampled from the cumulative distribution of rainfall depths.

Select storm losses. Storm initial losses were stochastically sampled from a nonparametric distribution that was determined from the analysis of a large number of catchments across Australia (Hill et al., 2014). The limited number of investigations that have explored the correlation between initial and continuing loss values have concluded that there is little systematic dependence between the two. There is little information regarding the correlation between initial and continuing loss rates, and since antecedent conditions have most influence on initial loss rates, in this study the continuing loss rates will be held constant. Current practice is for initial losses to be sampled from a distribution, while the continuing loss is held constant; this approach was used for the design flood modelling.

Select temporal pattern. Temporal patterns were randomly selected from a sample of temporal patterns relevant to the catchment area and duration of the storm. The temporal patterns in the data hub were derived from large historic storms that have been observed in the region.

Monte-Carlo simulation. Simulations were undertaken using a stratified sampling approach in which the sampling procedure focuses selectively on the probabilistic range of interest. Thus, rather than undertake many millions of simulations in order to estimate an event with, say, a 1 in 100 probability of exceedance, a reduced number of simulations were undertaken over a specified number of probability intervals. In this study, the rainfall frequency curve was divided into 100 intervals uniformly spaced over the standardised normal probability domain, and 250 simulations were taken within each division. Thus, a total of 25,000 simulations were undertaken to derive the frequency curve corresponding to each storm duration considered. This approach accounts for the natural variability inherent in floods. Monte Carlo techniques are grounded in, and consistent with, the principle that “no two floods are ever the same”.

The key advantage of the Monte Carlo approach is that it reduces uncertainty by accounting for variability. The results of a Monte Carlo analysis are presented as median peak flow estimates rather than single hydrographs, however it must be remembered that the natural variability of the key inputs is built into these median estimates. The median peak flows are not biased one way or the other by selection of a single arbitrary rainfall temporal or spatial pattern. Using the technique described above hydrographs were produced for the 20%, 10%, 5%, 2%, 1% and 0.5% AEP events.

In the context of a rapid flood risk assessment the estimation of the magnitude of the PMF was based on the regional prediction equation described in Nathan et al. (1994).

4.2 Overview of design flood hydrology inputs

Design inputs were produced in accordance with ARR2019. Inputs include:

- Rainfall depths (IFD - BOM),
- Areal reduction factors (Data hub),
- Spatial patterns (Rainfall depths over the catchment – based on IFD)
- Temporal patterns (Rainfall depths over time – Data hub)
- Losses (ARR guidance)
- Pre-burst (Data hub)
- Baseflow (ARR guidance)

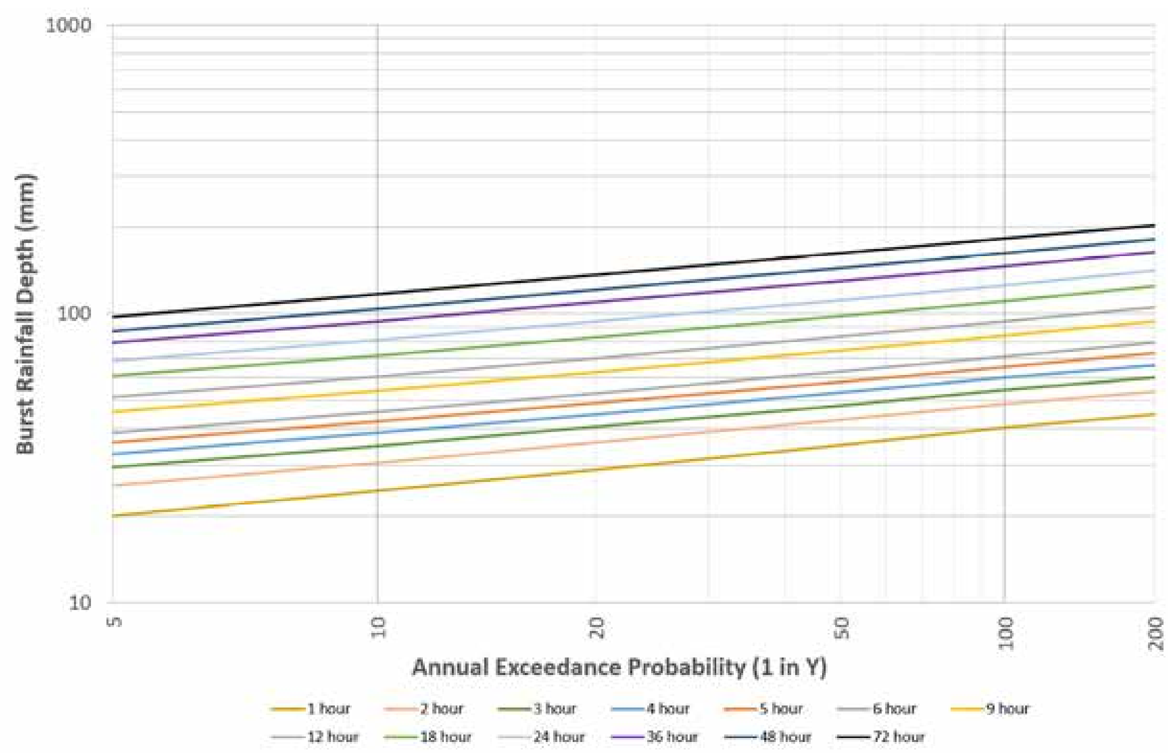
4.2.1 Rainfall depths

Catchment average point design rainfall depths for burst durations between 1 and 72 hours, and AEPs from 1 in 5 to 1 in 200, were taken from the Bureau of Meteorology (2016) (http://www.bom.gov.au/water/designRainfalls/revised-ifd/).

4.2.2 Areal reduction factors

The point rainfall estimates were converted to areal values using the ARR2019 areal reduction factors (Jordan et al, 2016) extracted from the ARR Data Hub. Conceptually, these factors account for the fact that larger catchments are less likely to experience high intensity storms over the whole catchment.

A summary of the complete, catchment average areally reduced design rainfall depths adopted are shown in Figure 4-4 and Table 4-1.



- **Figure 4-4 Adopted design rainfall depths**
- **Table 4-1 Adopted design rainfall depths**

AEP (1 in Y)	1	2	3	4	5	6	9	12	18	24	36	48	72
5	20	25	29	33	36	39	46	52	61	69	80	87	98
10	24	31	35	39	42	46	54	61	72	81	94	104	117

AEP (1 in Y)	1	2	3	4	5	6	9	12	18	24	36	48	72
20	29	36	41	45	49	53	63	70	83	94	110	121	136
50	35	43	48	53	58	63	75	83	98	111	130	144	162
100	40	49	54	60	66	71	84	94	111	126	146	162	183
200	45	54	60	67	73	80	94	105	124	141	164	181	204

4.2.3 Spatial patterns

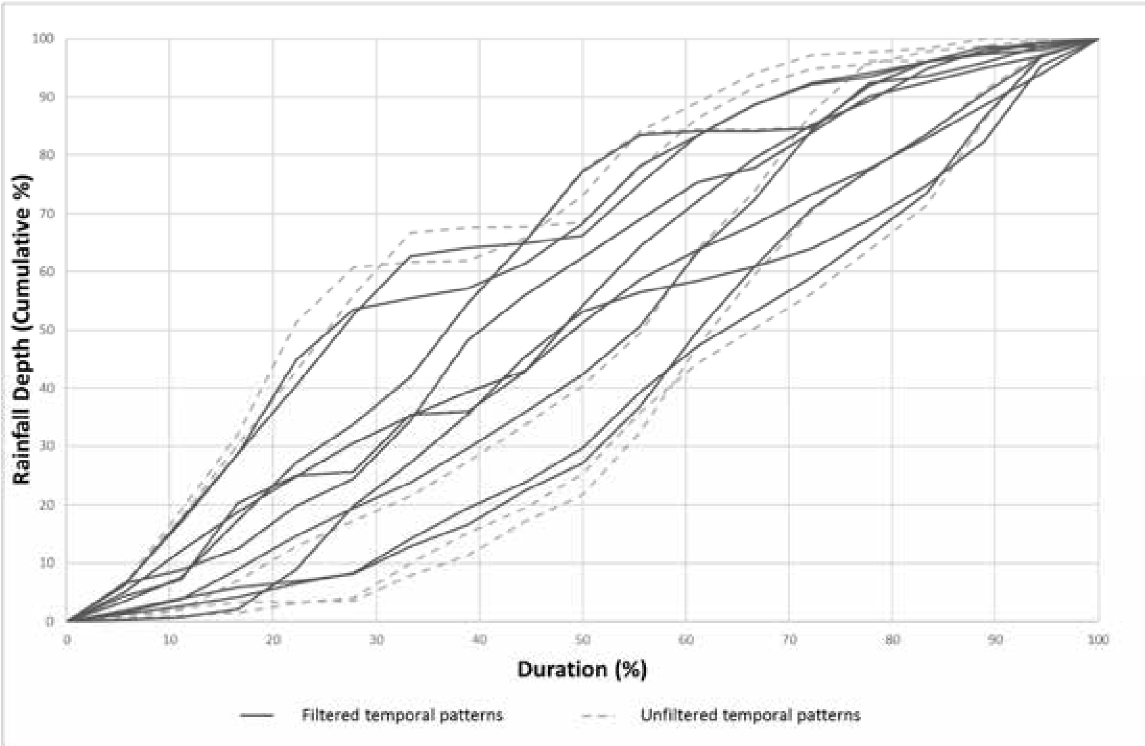
The spatial pattern for the catchment has been based on the rainfall depths from the Bureau of Meteorology, i.e. the IFD, which is recommended in ARR2019.

4.2.4 Temporal patterns

For catchment areas greater than 75km^2 ARR recommends the use of the sample of areal temporal patterns available from the ARR data hub (Geoscience Australia, 2019) for long durations (greater than 24 hours). The derivation of these patterns is discussed in ARR 2019 (Ball et al., 2019). For the shorter duration storms, the sample of temporal patterns derived by Jordan et al (2005) was used. For catchment areas less than 75km^2 ARR recommends the use of ARR data hub (Geoscience Australia, 2019) point patterns.

Before the temporal patterns were used, they required some filtering to remove embedded bursts. An embedded burst is a sub-period of rainfall within a given temporal pattern that has a rarer AEP than the actual burst itself. The method described by Scorah et al. (2016) was used to smooth out the embedded bursts. As an example, Figure 4-5 shows the 24 hour design temporal patterns, before and after embedded bursts are removed.

All temporal patterns in the sets used for sampling were given equal probability of selection in the Monte Carlo simulation.



- **Figure 4-5 24-hour design temporal patterns before filtering and after filtering to remove embedded bursts**

4.2.5 Losses

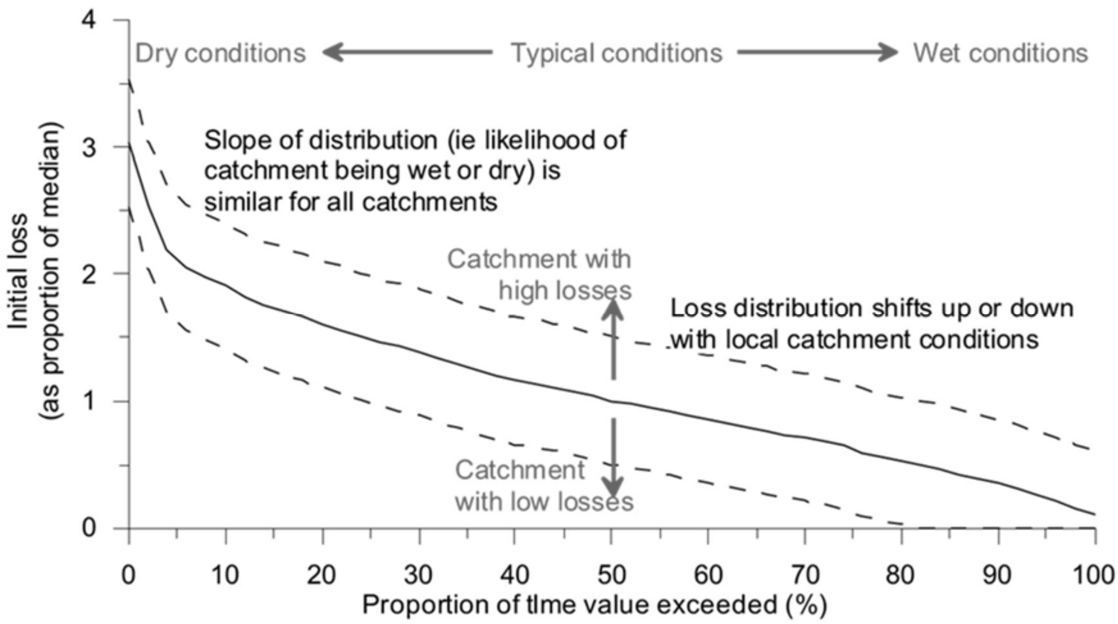
There are two key types of loss models that are typically adopted when modelling design floods:

- Initial loss/continuing loss
- Initial loss/proportional loss

Investigations by Hill et al. (2014) as part of the ARR 2019 revision were inconclusive as to which loss model works best. Even for catchments where one of the loss models performed better for a majority of events, there were still some events for which the other approach was better. Similarly, there was no obvious relationship between the relative performance of the loss models and hydro-climatic or catchment characteristics.

The advice in ARR is that the initial loss/continuing loss model is most suitable for design flood modelling, because it can be used to estimate flood peaks and volumes for all AEPs. In contrast, it is often difficult to derive unbiased estimates of flood quantiles using the initial loss/proportional loss model over the same range of AEPs. The initial loss/proportional loss model underestimates peak flows for extreme floods if the proportional loss is not varied appropriately with AEP; and to date there is little evidence about how proportional loss varies with AEP. Therefore, for this study an initial loss/continuing loss model was adopted.

The shape of the initial loss distribution used in the design flood modelling was derived by Hill et al. (2014) from flood modelling results for a large number of catchments across Australia. Hill et al. (2014) developed a non-dimensional distribution of initial loss values for each catchment, by representing initial losses as a proportion of the median loss. This allowed the distributions of initial losses across different catchments to be directly compared. The standardised distributions exhibited a high degree of consistency, and suggested that while the magnitude of initial losses may vary between different catchments, the shape of the distribution does not. That is, while it may be expected that typical loss rates vary from one catchment to another, the likelihood of a catchment being in a relatively dry or wet state is similar for all catchments. The adopted distribution of initial loss is shown in Figure 4-6.



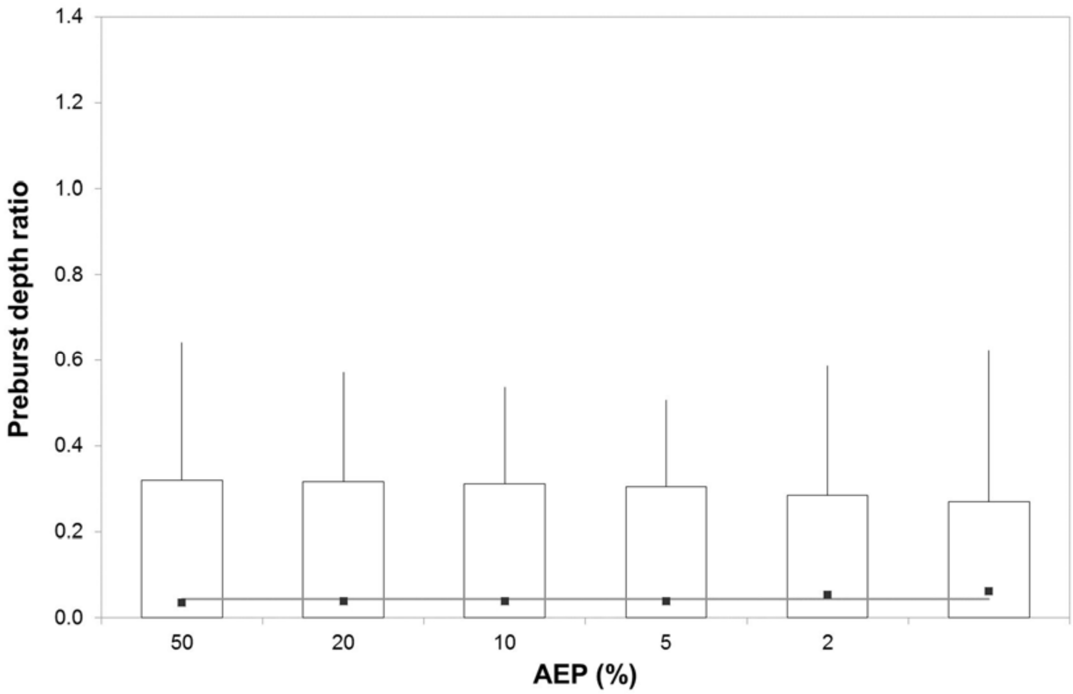
- **Figure 4-6 Cumulative probability distribution of initial loss**

The correlation between initial losses and continuing losses is not well understood. Current practice is for initial losses to be sampled from a distribution, while the continuing loss is held constant; this approach was used for this study.

4.2.6 Pre-burst rainfall depths and temporal patterns

Estimates of the percentage of burst depth of rainfall antecedent to the main burst were taken from the ARR data hub (Geoscience Australia, 2019). The data hub provides a distribution of pre-burst depths by duration and AEP. The median pre-burst depths for each duration was compared across AEPs, and for the purpose of design flood modelling, it was decided that adopting an average of the median for each duration was appropriate (Figure 4-7).

Although the ARR data hub provides pre-burst depths, it does not contain information regarding the temporal patterns. Therefore, temporal patterns of rainfall antecedent to the main burst were taken from Minty and Meighen (1999) and applied to burst durations of 12 hours and longer (Minty and Meighen, 1999). For the shorter durations, the pre-burst patterns from Jordan et al (2005) were applied.



- **Figure 4-7 Pre-burst rainfall depths – 6 hour burst – shown as a ratio of burst depth, using a box plot of the 10th, 25th, 50th, 75th and 90th percentiles. The grey line shows the adopted value for the design flood modelling; this is the average of the median values across the available AEPs.**

4.2.7 Baseflow

As RORB only estimates the surface runoff, baseflow needs to be added. For baseflow, regional estimates were used. From the ARR data hub the peak factor was extracted. The baseflow peak factor is applied to the estimated surface runoff peak flow to give the value of peak baseflow for a 10% AEP event. ARR 2019 provides a scaling factor to be applied to the 10% AEP baseflow peak factor to determine the baseflow peak factor for events of various AEPs.

A frequency distribution of baseflow with AEP was estimated by using the Regional Flood Frequency Estimation (RFFE - refer to Section 5) distribution. This provided the frequency distribution for baseflow under the peak of the annual maxima flood events.

4.2.8 Drawdown

Due to the strong influence which Newlyn Dam has on flows downstream it is important to consider the impact that drawdown (i.e. reservoir starting water level) has on the design flows for the study area. For this investigation the drawdown curve was taken from SKM (2005). The drawdown distribution used in the RORB model is shown in Figure 4-8.

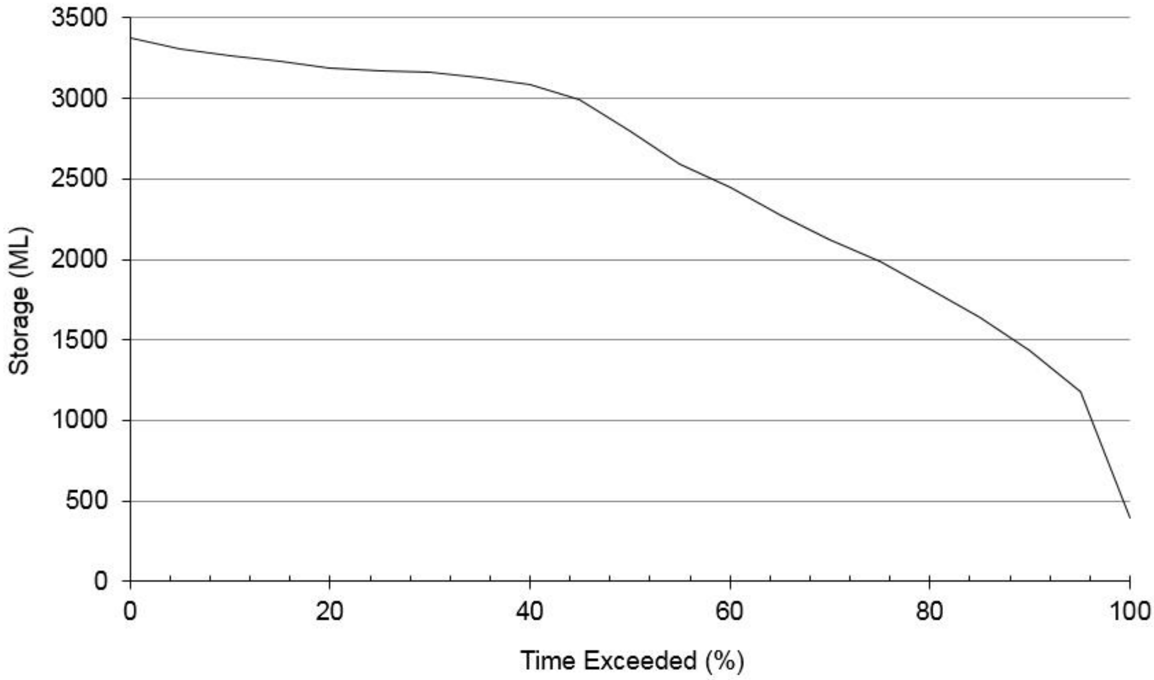


Figure 4-8 Drawdown distribution for Newlyn Dam (SKM 2005)

5. Hydrologic model verification

5.1 Adopted parameters

For the RORB model the routing parameters (m and k_c) were taken from the Review of Flood Hydrology for Newlyn Dam (SKM, 2005). For the routing parameter, k_c, the ratio of k_c/d_{av} was used to ensure that the same routing was applied to the RORB model established for the study area as per the previous model. McMahon and Muller (1983) showed that k_c is directly proportional to d_{av}, where d_{av} is the weighted average flow distance to the catchment outlet (this is calculated automatically in the RORB model). Therefore, a way to measure the similarity of two different RORB models is to compare k_c/d_{av}.

“Calibration of the model parameters was not carried out for the Newlyn Dam RORB model and therefore suitable values of model parameters and loss parameters are determined through the process of reconciliation. Reconciliation is the comparison of estimated peak flows for a given AEP from the RORB model with the frequency analysis of recorded peak flows” (SKM, 2005). The frequency analysis in SKM, 2005 was undertaken on the Birch Creek at Smeaton (407227) gauge.

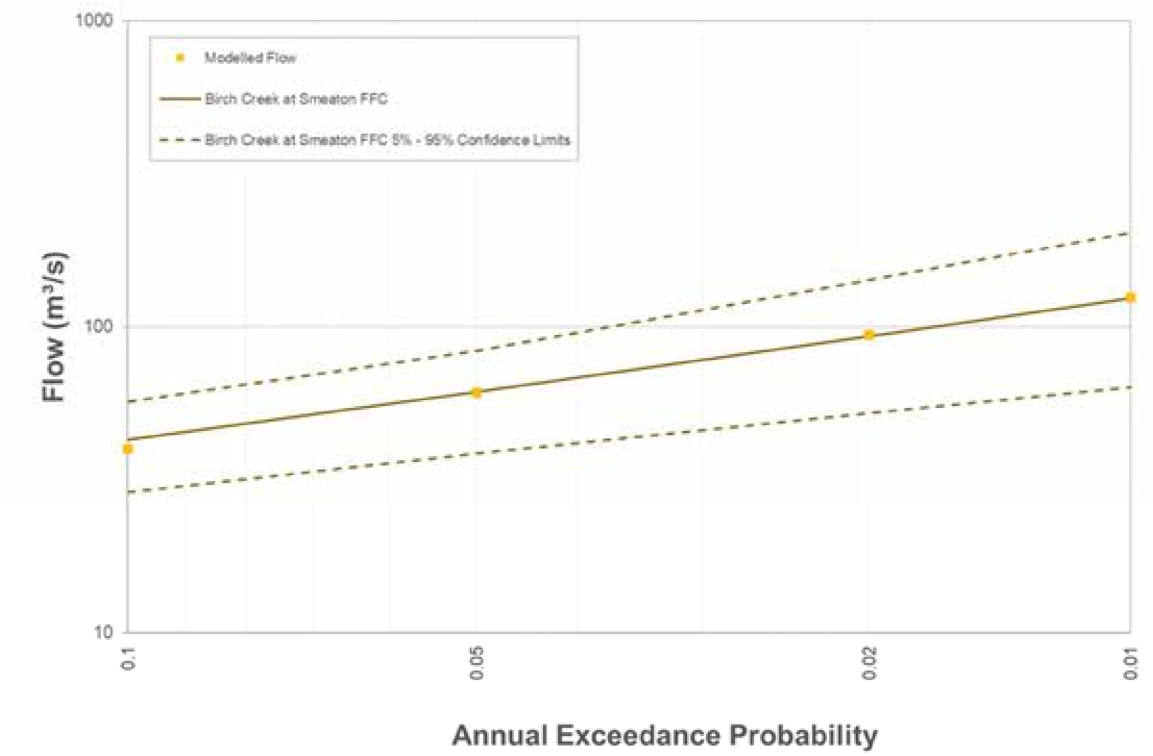
For this investigation the verification process was undertaken in conjunction with Smeaton (HARC, 2020). The Smeaton model was verified to the flood frequency gauge at Birch Creek at Smeaton (407227) and the same losses were applied to the Newlyn North catchment. Table 5-1 summarises the RORB parameters adopted for Newlyn North.

■ **Table 5-1 Summary of key hydrologic parameters adapted from the Smeaton**

Parameter	Value
k_c	12.8
d_{av}	10.2
$C_{0.8}$ (k_c/d_{av})	1.25
m	0.8
IL (mm)	20.0
CL (mm/hr)	2.0

5.2 Verification

The parameters adopted for Newlyn North were based on the verification at Birch Creek at Smeaton (407227). Figure 5-1 shows the flood frequency curve and verification results at the Birch Creek @ Smeaton. Additional details on the verification can be found in the Smeaton report (HARC, 2020).



▪ Figure 5-1 Verification results

5.3 Comparison to regional parameters

As mentioned in Section 5.1 the choice of k_c for the Newlyn North catchment was based on the calibration result from the Review of Flood Hydrology for Newlyn Dam (SKM, 2005) however, the results from the calibration were compared to a number of regional estimates.

For Victorian regions with a mean annual rainfall of less than 800 mm k_c is estimated using equation 1 from ARR 2016 (Hansen et al, 1986).

$$k_c = 0.49\,A^{0.65} \qquad (1)$$

Where A is the area in km^2.

The k_c value from calibration was also compared to another regional estimate by Pearse et. al. (2002). Pearse et. al. (2002) analysed a large database of routing parameters collated by the CRC for Catchment Hydrology and derived a prediction equation applicable to Victoria. The d_{av} for the catchment was used to predict the k_c value where k_c is directly proportional to d_{av} giving equation 2

$$k_c = C\,d_{av} \qquad (2)$$

Where C is a characteristic of the catchment independent of the scale or size of the catchment and d_{av} is the weighted average flow distance to the catchment outlet (this is calculated automatically in the RORB model).

Pearse et al. (2002) also gave an expected value and one standard deviation (High and Low).

Table 5-2 provides a summary of the regional estimates along with the adopted value. Table 5-2 shows the k_c based on the calibration event undertaken in the Review of Flood Hydrology for Newlyn Dam (SKM, 2005) is in line with the regional estimates.

- **Table 5-2 k_c values – regional estimates**

Location	Area (km^2)	k_c (equation 1)	k_c (equation 2)			k_c (adopted)
			Expected	High	Low	
Newlyn North	65	8.3	12.8	21.2	7.7	12.8

The ARR2019 data hub provides some regional estimates of losses. The regional losses are to only be used as a guide as ARR2019 clearly states it is always desirable to reconcile design values with independent flood frequency estimates where possible. Table 5-3 shows the regional estimates along with the adopted values. Table 5-3 shows that the adopted CL value is lower than the regional estimate, highlighting the important of verifying the losses where possible.

- **Table 5-3 Loss values – regional estimates**

Location	Regional		Adopted	
	IL (mm)	CL (mm/h)	IL (mm)	CL (mm/h)
Newlyn North	25.0	4.4	20.0	2.0

6. Design flood hydrology

6.1 Design flows for the 20% to 0.5% AEP events

The RORB model was run in the joint probability framework, with the design inputs and the adopted routing parameters, initial and continuing losses to generate design flood frequency curves and inflow hydrographs.

In order to generate hydrographs the RORB model was run in the joint probability framework described in Section 4.1, with the design inputs summarised in Section 4.2 and the adopted parameters summarised in Section 5.

The joint probability framework provides a peak flow, whereas the hydraulic model requires a set of hydrographs. The results of the Monte Carlo analysis are presented as median peak flow estimates rather than single hydrographs, with the natural variability of the key inputs built into the median estimates. The median peak flows are not biased one way or the other by selection of a single arbitrary rainfall temporal or spatial pattern. Hydrographs were chosen from the set of Monte Carlo results that best matched the median peak flows and were an unbiased transformation from input rainfall AEP to flood AEP.

For the hydraulic model hydrographs were extracted at key locations within the study area. Table 6-1 shows the peak flows at downstream end of the study area from the event centred over the entire catchment.

Table 6-1 Summary of modelled peak flow estimates for Newlyn North

AEP (1 in Y)	Peak Flow (m^3/s)	Critical Duration (hours)
5	21.2	18.0
10	40.0	18.0
20	57.9	18.0
50	88.7	18.0
100	107.0	18.0
200	131.4	18.0

6.2 PMF estimate

As mentioned earlier in the context of a rapid flood risk assessment the estimation of the magnitude of the PMF was based on the regional prediction equation described in Nathan et al. (1994). Nathan et al. (1994) looked at 56 sites across South-Eastern Australia and developed a series of equations to estimate the peak, volume and time to peak of a PMF.

Nathan et al. (1994) estimates of the PMF magnitude are based on the catchment area using the following equations.

$$Q_p = 129.1 * A^{0.616} \qquad (1)$$

$$V = 497.7 * A^{0.984} \qquad (2)$$

$$T_p = 1.066 * 10^{-4} * A^{-1.057} * V^{1.446} \qquad (3)$$

And from a mass balance taking Equations (1) and (2).

$$T_r = \frac{V}{1.8 * Q_p} \qquad (4)$$

Where: Q_p is peak flow (m^3/s);

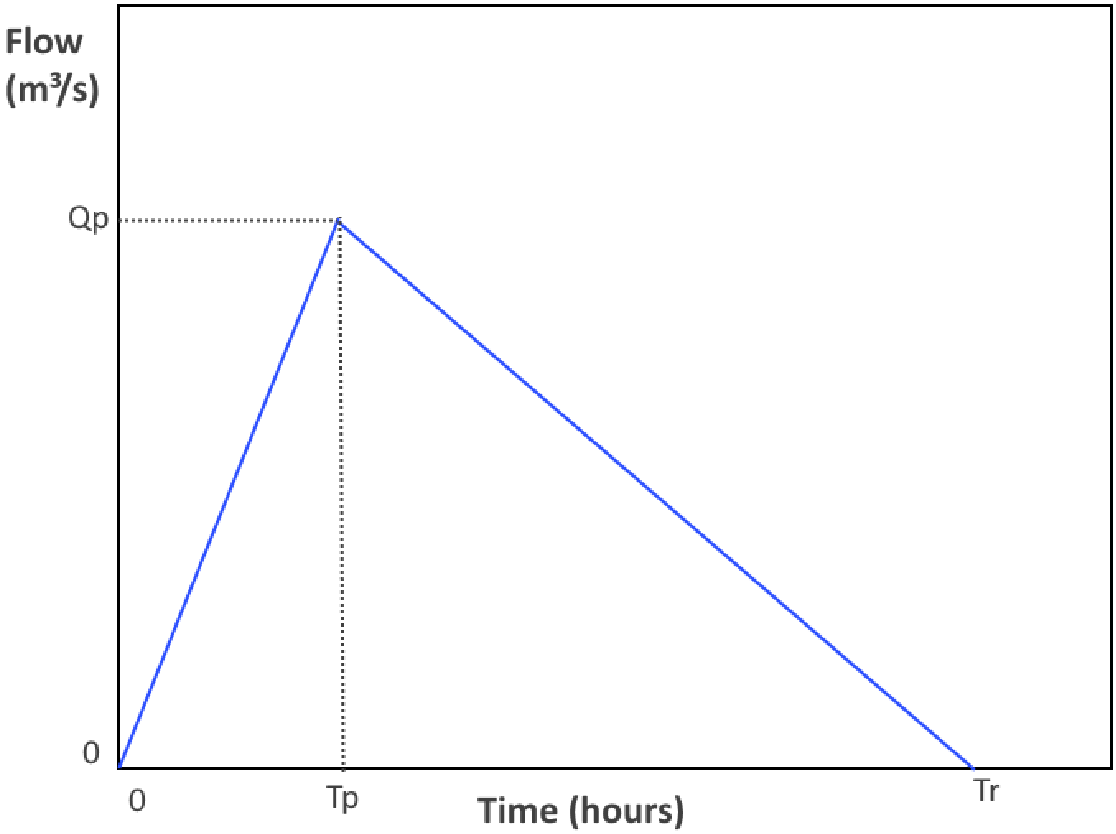
A is catchment area (km^2)

V is the Volume of the hydrograph (ML)

T_p is the time to peak flow (hours)

T_r is the total time of the hydrograph (hours)

Each of these characteristics has been used to determine a 'triangular' PMF hydrograph. Figure 6-1 illustrates the characteristics of the 'triangular' PMF hydrograph.



- **Figure 6-1 - Characteristics of 'triangular' PMF - source: Nathan et al. (1994)**

The peak PMF flow was estimated to be 1692 m^3/s.

6.3 Climate change and sensitivity analysis

An important aspect of any hydrological modelling is the undertaking of appropriate sensitivity testing. Sensitivity testing helps to understand the influence of key parameters and the model schematisation on the result. The Monte Carlo framework accounts for the key inputs which influence flows (i.e. temporal patterns and losses) and incorporates these into flow estimates. In this way the Monte Carlo analysis already takes into account the impact of the natural variability of the key parameters. However, an important aspect to consider is the impact of climate change on the design flow estimates.

Concentration Pathways (RCPs) for greenhouse gas and aerosol concentrations that were used to drive the GCMs. The RCPs are designated as 2.6, 4.5, 6.0 and 8.5, and are named according to radiative forcing values (W m-2) in the year 2100 relative to pre-industrial values" (ARR, 2019). ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated in the Data Hub to the values that can be found on the climate change in Australia website.

ARR2019 considers a six step process to incorporate climate change risks into decisions involving the estimation of design flood characteristics. The six steps are:

Step 1 – set the effective service life or planning horizon

Step 2 – set the flood design standard

Step 3 – consider the purpose and nature of the asset or activity and consequence of its failure

Step 4 – carry out a climate change risk screening analysis

Step 5- consider climate change projections and their consequences

Step 6 – consider statutory requirements.

For this study the service life was considered to be long term (step 1). The design standard is notionally 1 in 100 AEP for this investigation (step 2). The consequence of failure is considered to be high, as from ARR2019 "this category generally relates to high value assets, or assets of significant economic or welfare importance" (step 3). For step 4 it has been assumed that climate change is a "significant issue for the facility of interest" (ARR2019) therefore this is rated as medium/high. From ARR2019 "in reaching Step 5, the minimum basis for design should be the low greenhouse gas and aerosol concentration pathway RCP4.5 and the maximum GCM consensus case indicated by the Climate Futures web tool for the NRM cluster of interest". "Where the additional expense can be justified on socioeconomic and environmental grounds, the maximum consensus case for the high concentration pathway RCP8.5 should also be considered". Step 6 from ARR2019 states that "if statutory requirements relating to climate change are in place, adopt the changed design. Otherwise, carry out an economic analysis (e.g. cost-benefit or cost effectiveness analysis, or multi-attribute utility theory) of potential changes in flood-related design requirements and make an informed decision on how to proceed". An economic analysis is beyond the scope of this study therefore, the results of the impacts of climate change on rainfall intensities for an RCP of 4.5 are recommended for adoption for this study. However, the results from RCP 8.5 have also been provided for completeness.

The ARR2019 approach to climate change has a number of limitations, including the fact that it does not provide a means to account for potential increases in rainfall losses under a drying climate. Therefore, it is suggested that full consideration of climate change impacts be held over until detailed flood studies are undertaken.

For this investigation a somewhat simplified approach was undertaken where the increase in rainfall is directly related to an increase in flow. As such, modified design rainfall IFD tables were not produced and run through the hydrologic model, as previous experience suggests that the increase in rainfall intensity is likely to be the upper bound of the increase in peak flow rates. Additional discussion on climate change is found in Section 8.3.

7. Hydraulic Model

To determine the various mapping outputs required for the study, specifically flood extent, flood depth, flood height, velocity, hazard and other hydraulic properties, a two-dimensional (2D) hydraulic model (TUFLOW) was developed. The extents of the models (i.e. TUFLOW 2D code boundary) was based on the study area shown in Figure 1-2.

The key inputs to the hydraulic models are:

- Topographical information
- Cell size
- Roughness values
- Hydraulic structures
- Inflows
- Downstream boundary

7.1 Topography

The topographical information was based on the LIDAR data supplied by the North Central CMA. Given the rapid nature of the project, the LIDAR data was not verified against survey data or Permanent Survey Marks.

Any farm dams that are within the study locations have been modelled as they appear in the LIDAR data, which effectively assumes a starting water level based on the water level at the time the LIDAR was flown.

As mentioned in Section 1 there are two large farm dams located within the study area, one located south of Forest Hill Road and one located north. For modelling purposes the dams were assumed to be at the level they were when the LIDAR data was flown.

7.2 Cell size

One of the key considerations in hydraulic modelling is the selection of an appropriate grid element size. Grid element size affects the resolution, or degree of accuracy, of the representation of the physical properties of the study area as well as the size of the computer model and its resulting run times. Selecting a smaller grid size will result in both higher resolution and longer model run times.

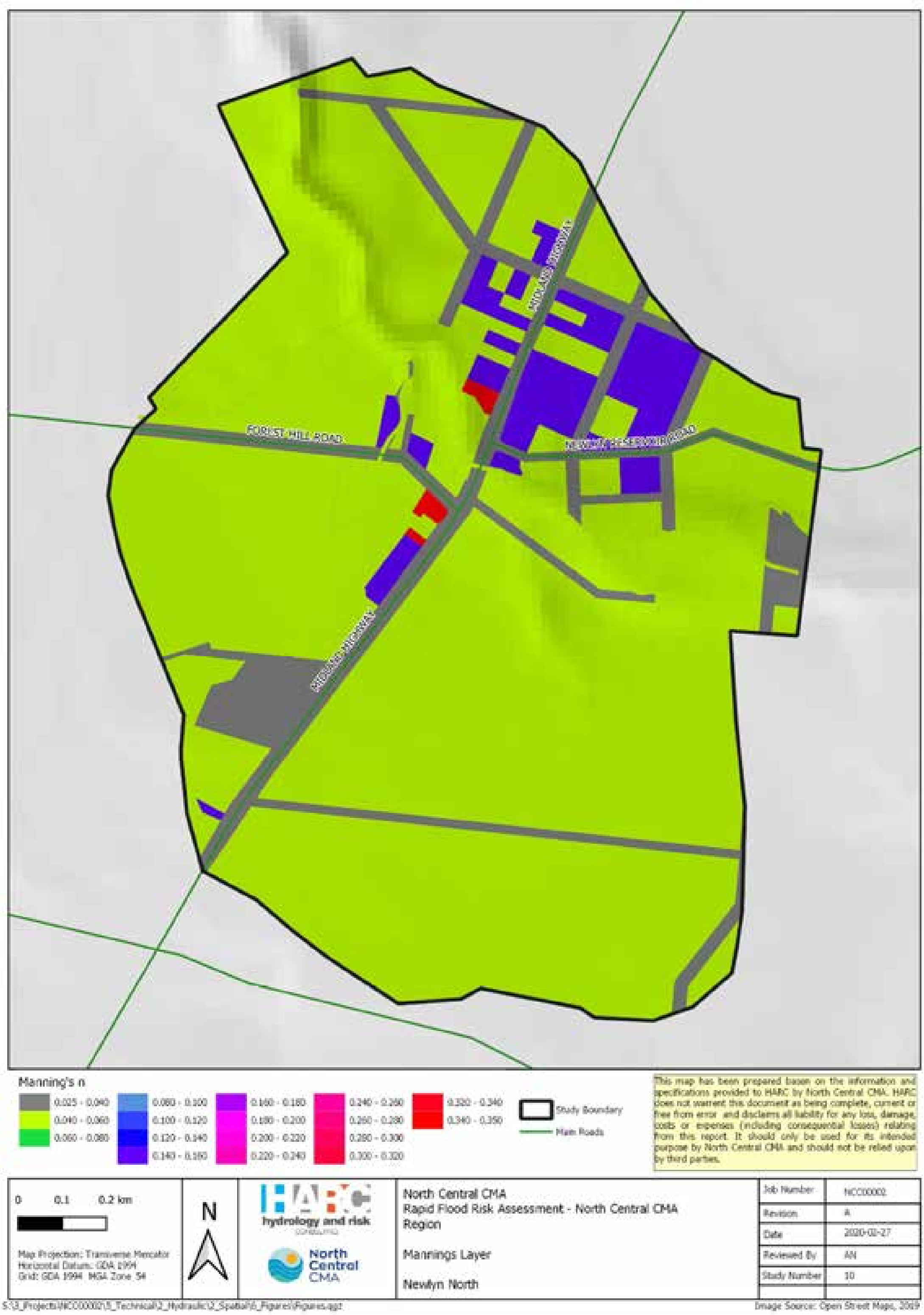
To ensure accurate representation of flooding within the catchment a grid size of 2 metres was adopted for the model. In adopting this grid size, the above issues were considered in conjunction with the final objectives of the study.

7.3 Roughness values

The Manning's roughness assignment utilised the Victorian Land Use Information System (VLUIS) dataset. This provided a consistent and efficient means of assigning Manning's n. A basic check was undertaken by comparing the VLUIS to aerial imagery to check for consistency. The basic check was only intended to pick up any large errors in assigned land use rather than lot scale errors. Using Manning's n values listed in Table 7-1 each VLUIS layer was assigned a Manning's n value and the surface roughness layer is shown in Figure 7-1. The number adopted for Manning's n categories were selected to be in line with the values provided by ARR2019. No calibration of the hydraulic models was undertaken for this project.

Table 7-1 Manning's n values for different land use types

Land Use Type	Manning's n adopted
Residential areas – urban high density (building and parcel combined)	0.35
Residential areas – rural high density (building and parcel combined)	0.15
Industrial/commercial or large buildings	0.30
Residential areas – rural low density (parcel only or large blocks with house)	0.05
Open space or waterway – minimal vegetation	0.04
Open space or waterway – moderate vegetation	0.06
Open space or waterway – heavy vegetation	0.095
Paved roads/car park/driveways	0.025
Railway line	0.05
Grass reserves/floodway (regularly mowed)	0.035
Rural floodplains in clear paddocks	0.05
Forested (heavy stand of timber)	0.12
Dam/Reservoir body of water	0.035



▪ **Figure 7-1 Surface roughness distribution**

7.4 Hydraulic structures

Table 2-2 lists the culverts/bridges that were entered into the model. Bridges were represented using a layered flow constriction and culverts in 1D.

Bridge structures were modelled with the appropriate losses derived from Waterway Design: A Guide to the Hydraulic Design of Bridges, Culverts and Floodways (Austroads, 1994). The layered flow constrictions used to model these bridges allows for typical bridge characteristics such as deck height and thickness, pier shape and width and blockages associated with guard or hand rails to be directly incorporated into the 2D domain. The details of these were extracted from supplied plans. Where plans were not available the losses and dimensions were estimated based on typical bridge configurations and loss parameters.

The 1D elements were dynamically linked to the 2D domain. Details of the culverts were extracted from supplied plans, details provided by Council or the North Central CMA.

7.5 Inflows

The inflows to the hydraulic model were taken from the RORB model, as discussed in Section 6 and modelled in TUFLOW as two-dimensional source area polygons distributing the inflow over the polygon. The polygons were located along the waterways within the study area.

The results of the Monte Carlo analysis are presented as peak flow estimates rather than single hydrographs, with the natural variability of the key inputs built into the estimates. The peak flows are not biased one way or the other by selection of a single arbitrary rainfall temporal or spatial pattern. The hydrographs entered into the hydraulic model were chosen from the suite of runs from the Monte Carlo analysis such that the single hydrographs matched the peak flows.

7.6 Downstream boundary

The downstream boundary condition was entered as a normal depth relationship with a slope of 1% based on the LIDAR data.

A schematisation of the hydraulic model is found in Figure 7-2.

All the hydraulic models were run for the 1 in 5, 10, 20, 50, 100 and 200 AEP and PMF events, for the critical durations identified in Table 6-1.

Figure 7-2 Hydraulic model schematisation

8. Flood Risk Assessment

8.1 Flood Mapping

Flood maps showing flood level, depth, velocity and hazard (depth x velocity) have been produced for the 1 in 5, 10, 20, 50, 100 and 200 AEP event along with the PMF. The flood maps are shown in Appendix A.

Table 8-1 shows the flood map reference numbers that correspond to the maps in Appendix A.

Table 8-1 Flood maps reference table

Map Number	Map Name	Map Number	Map Name
10-5-1	1 in 5 year Depth Map	10-5-4	1 in 5 year Hazard Map
10-10-1	1 in 10 year Depth Map	10-10-4	1 in 10 year Hazard Map
10-20-1	1 in 20 year Depth Map	10-20-4	1 in 20 year Hazard Map
10-50-1	1 in 50 year Depth Map	10-50-4	1 in 50 year Hazard Map
10-100-1	1 in 100 year Depth Map	10-100-4	1 in 100 year Hazard Map
10-200-1	1 in 200 year Depth Map	10-200-4	1 in 200 year Hazard Map
10-PMF-1	PMF Depth Map	10-PMF-4	PMF Hazard Map
10-5-2	1 in 5 year Depth x Velocity Map	10-5-5	1 in 5 year Velocity Map
10-10-2	1 in 10 year Depth x Velocity Map	10-10-5	1 in 10 year Velocity Map
10-20-2	1 in 20 year Depth x Velocity Map	10-20-5	1 in 20 year Velocity Map
10-50-2	1 in 50 year Depth x Velocity Map	10-50-5	1 in 50 year Velocity Map
10-100-2	1 in 100 year Depth x Velocity Map	10-100-5	1 in 100 year Velocity Map
10-200-2	1 in 200 year Depth x Velocity Map	10-200-5	1 in 200 year Velocity Map
10-PMF-2	PMF Depth x Velocity Map	10-PMF-5	PMF Velocity Map
10-5-3	1 in 5 year Elevation Map		
10-10-3	1 in 10 year Elevation Map		
10-20-3	1 in 20 year Elevation Map		
10-50-3	1 in 50 year Elevation Map		
10-100-3	1 in 100 year Elevation Map		
10-200-3	1 in 200 year Elevation Map		
10-PMF-3	PMF Elevation Map		

8.2 Flood behaviour and impact of flooding

The following section summarises the impact of flooding. Table 8-2 provides a summary of the water level at the location shown in Figure 8-1 along with the main impacts for each AEP. Table 8-3 is a summary of the number of properties that are inundated for each AEP event. Table 8-4 is a summary of the number of properties that are inundated above floor for each AEP event. Table 8-5 is a summary of the main roads that are overtopped.

- **Table 8-2 Summary of impacts of flooding**

AEP (1 in Y)	Water level upstream of Midland Highway (mAHD)	Impact
5	517.5	One Industrial property is inundated near Newlyn Recreation Reserve
10	518.1	One Industrial property is inundated as above
20	518.8	One Industrial property is inundated as above
50	520.2	Midland Highway overtopped. One Industrial property is inundated as above
100	520.4	Midland Highway overtopped. One Industrial property is inundated as above
200	520.5	Additional property is inundated near the inundated industrial property

Table 8-3 Summary of property inundation

AEP (1 in Y)	Residential	Industrial	Agriculture	Public	Commercial	Fire	Aged Care	Education	Hospital	Police	Caravan / Camp Ground
5	0	1	0	0	0	0	0	0	0	0	0
10	0	1	0	0	0	0	0	0	0	0	0
20	0	1	0	0	0	0	0	0	0	0	0
50	0	1	0	0	0	0	0	0	0	0	0
100	0	1	0	0	0	0	0	0	0	0	0
200	1	1	0	0	0	0	0	0	0	0	0

Table 8-4 Summary of over floor flooding*

AEP (1 in Y)	Residential	Industrial	Agriculture	Public	Commercial	Fire	Aged Care	Education	Hospital	Police	Caravan / Camp Ground
5	0	0	0	0	0	0	0	0	0	0	0
10	0	1	0	0	0	0	0	0	0	0	0
20	0	1	0	0	0	0	0	0	0	0	0
50	0	1	0	0	0	0	0	0	0	0	0
100	0	1	0	0	0	0	0	0	0	0	0
200	0	1	0	0	0	0	0	0	0	0	0

* Note the floor levels have assumed to be 300 mm above the natural surface level for those buildings without surveyed floor levels

Runoff (Ball et al., 2019).

Table 8-5 Summary of road Inundation

AEP (1 in Y)	Roads impacted by flooding	Maximum depth over road (m)	Duration of inundation (hours)
5	Midland Highway	0.0	0
10	Midland Highway	0.0	0
20	Midland Highway	0.0	0
50	Midland Highway	0.1	3
100	Midland Highway	0.3	5
200	Midland Highway	0.4	7

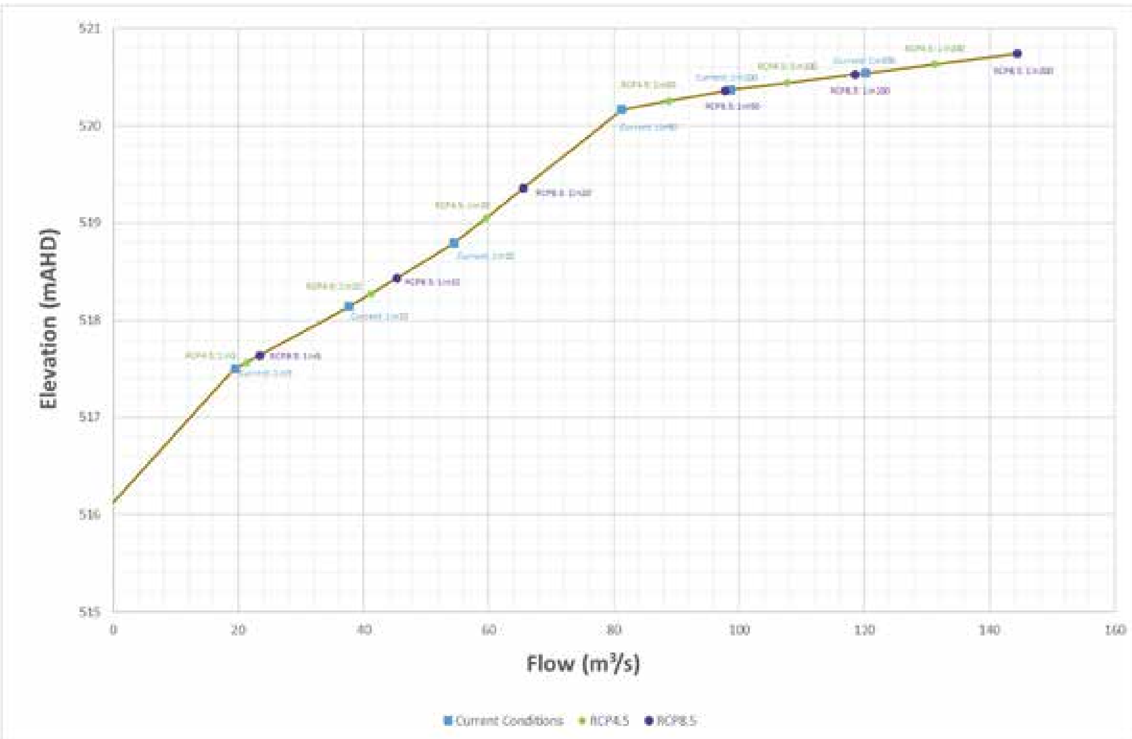
Figure 8-1 Reporting location

8.3 Climate change

The increase in flows due to climate change was discussed in Section 6.3. To present the sensitivity of flood levels to changes resulting from climate change a rating curve of flow and water level at a key location within the study area is shown in Figure 8-2. Figure 8-1 shows the location of the rating curve and Table 8-6 the flows. The flow for the current conditions shown in Table 8-6 was taken from the TUFLOW model. The climate change flows were derived by multiplying the current climate peak flows by the percentages as discussed in Section 6.3 . The rating curve shows the water level that corresponds to a peak flow under existing climate conditions as well as the corresponding water level under climate change conditions (RCP 4.5 and 8.5).

▪ **Table 8-6 Climate change flow**

AEP (1 in Y)	Current Climate – Peak Flow (m³/s)	Climate Change – Peak Flow (m³/s)	
		RCP 4.5	RCP 8.5
5	19.5	21.3	23.4
10	37.7	41.2	45.3
20	54.5	59.5	65.5
50	81.3	88.7	97.7
100	98.6	107.7	118.6
200	120.2	131.2	144.4



▪ **Figure 8-2 Estimated changes in peak water level associated with climate change**

Table 8-7 shows which AEP map to consider adopting under various climate change scenarios. Note that the results have been based on the flows shown in Table 8-6 and rounded to the nearest AEP.

- **Table 8-7 Map to consider adopting under various climate change scenarios**

Current AEP	Event Map to consider adopting under various climate change scenarios	
	RCP4.5	RCP8.5
1 in 5	1 in 5	1 in 5
1 in 10	1 in 10	1 in 10
1 in 20	1 in 20	1 in 20
1 in 50	1 in 50	1 in 100
1 in 100	1 in 100	1 in 200

8.4 Flood Intelligence Information

From the modelling results and other project deliverables the relevant MFEPs have been updated.

Results from this investigation have been used to update the MFEPs with key information. This has included:

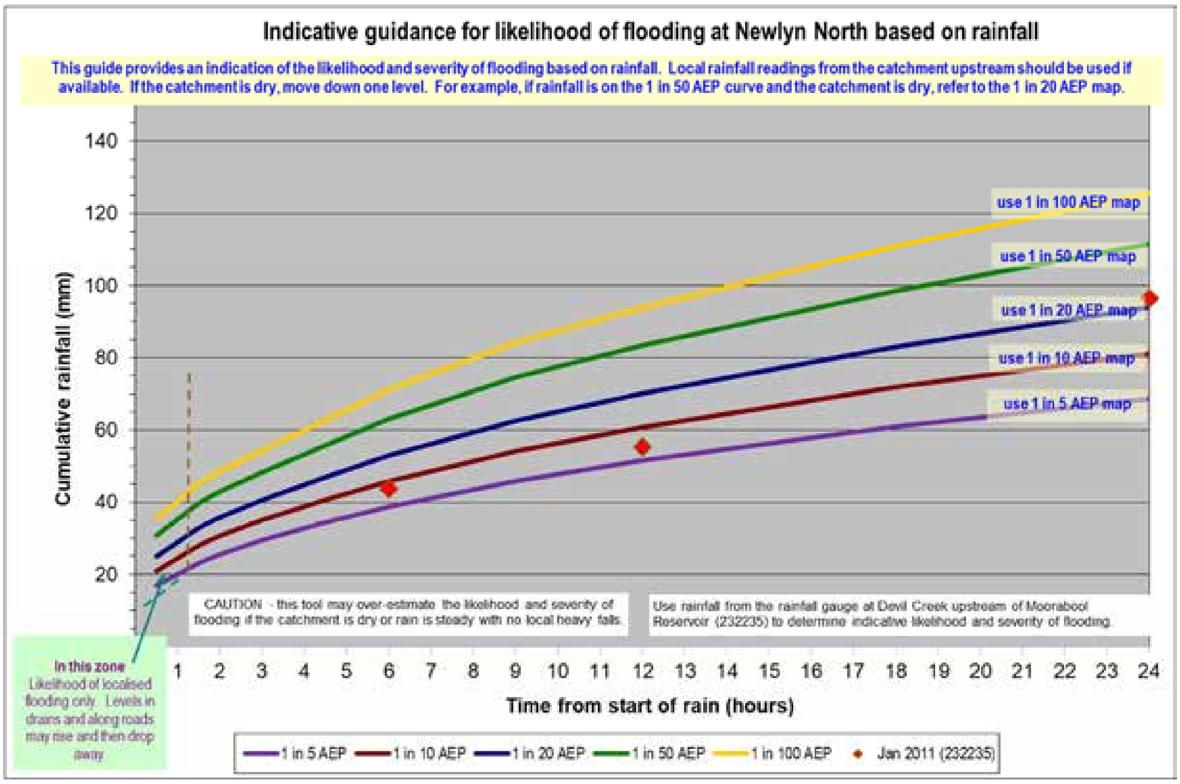
- Interpreting relevant flood related intelligence and consequence information from the mapping and modelling including typical flood travel times, rates of rise, etc;
- Identifying properties, roads and other community assets (e.g. essential infrastructure and services, high risk facilities, emergency service properties, low points in roads, etc.) affected by flooding;
- Identifying likely isolations and shrinking islands;
- Identifying areas of probable high flood risk / high hazard;
- Building flood intelligence tables; and
- Extracting catchment descriptions and flooding chronology from project deliverables.

8.5 Developing Indicative Quick Look Flood / No-Flood Tools

Using the results of the hydrologic and hydraulic modelling work, an indicative quick look flood / no-flood assessment tool has been developed for the study area.

The tool is aimed at providing a rapid indication of whether flooding is likely with some lead time. It is intended to be indicative only and will not provide a forecast of expected flood depth. The tool is designed to be linked to the mapping and intelligence produced by this project and in that way provides an indication of likely consequences.

The tool is driven by rainfall recorded at Devil Creek upstream of Moorabool Reservoir (232235). IFD data from this location has been compared to the study area specific IFD data. Adjusted rainfall depths were then plotted against time to produce the tool as shown in Figure 8-3.



- Figure 8-3 Quick look tool

8.5.1 Guidance on the use of the Quick Look Flood / No flood Tool

8.5.1.1 In the lead up to a flood

The quick look indicative flood / no-flood tool provided in Figure 8-3 gives guidance on the likelihood and severity of expected flooding at Newlyn North.

Rainfall recorded at Devil Creek upstream of Moorabool Reservoir (232235) was used to develop the quick look tool. As the data being used comes from a rain gauge that is outside the Newlyn North catchment, the tool may not perform to expectations in severe thunderstorm situations and / or when there is locally heavy rainfall embedded in more general rain. In such situations, rainfalls recorded more locally are likely to drive a more accurate indication of flooding and likely severity.

Unless there are unusual circumstances, actions as per the Flood Intelligence Card in the MFEP should be initiated as soon as the tool suggests flooding is likely. Response can be escalated if the tool indicates an increase in the expected severity of flooding.

8.5.1.2 During a flood - using the quick look tool

Plot cumulative rainfall depth against elapsed time on a copy of the tool. Do not start using the tool until rainfall exceeds approximately 2 mm an hour (i.e. ignore early drizzle or very light rain).

At each time step, after plotting the cumulative rainfall, assess the likelihood and expected severity of flooding from the curves. Some degree of judgement is required to determine if the quick look tool is providing an answer that is in line with expected outcomes. When plotted rainfall data crosses a curve on Figure 8-3 this indicates that flooding of around that severity is possible.

If the catchment is dry, it would generally be appropriate to step down one level. For example, if the rainfall plot is on the 1 in 50 AEP curve and the catchment is dry, refer to the 1 in 20 AEP map and associated consequences listed in the flood intelligence card available in the MFEP. The exception to this would be if there was very heavy rain on a dry catchment. In that circumstance, adopt a cautious approach and do not step down a level.

If the catchment is dry and / or rain extends over more than 12 hours, the quick look tool will tend to over-estimate the likelihood of flooding.

The tool is based on the reservoir upstream being at FSL or very close to it (i.e. spilling during the event). If the storage is below FSL and unlikely to spill during the event, it would be appropriate to step down a level.

8.5.1.3 After a flood – updating the tool

After a flood event, plot the event rainfall depth (with date) on the quick look tool. At the same time, include an overview of the event, along with commentary on antecedent conditions and other relevant information, in the relevant Appendix of the MFEP.

8.5.1.4 Example use of the quick look tool

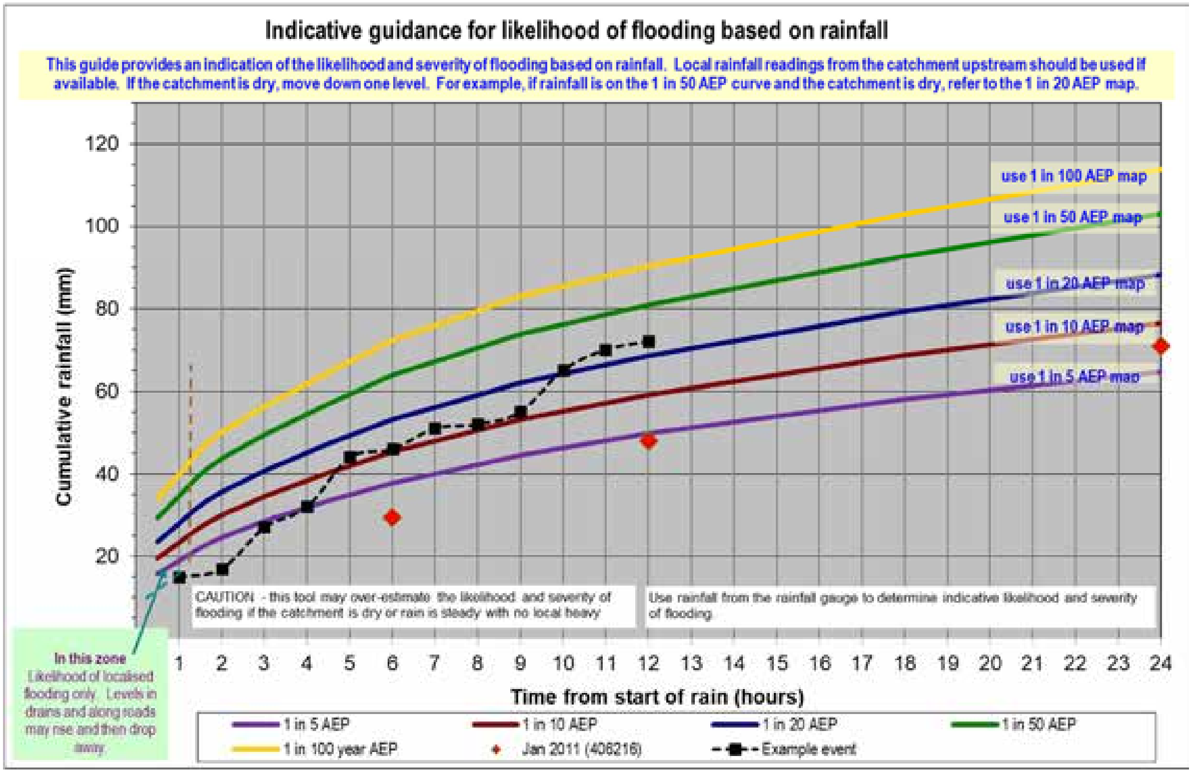
The section below is a fictitious example of how to use the quick look tool. Table 8-7 shows the rainfall depths recorded at the rain gauge and the action to take on the basis of the recorded rainfall. Figure 8-4 shows the fictitious example plotted up on the quick look tool.

Note that in cases where the tool has not been used from the start of rain (i.e. from early in the event), data should be either picked up from the start of the event or the first data plotted should include an estimate of how much rain has fallen and the time over which it has fallen. If this is not done, the tool will likely under-estimate likely flood severity.

- **Table 8-8 Rainfall depths for example use of tool**

Time (hours)	Rainfall Depth (mm)	Action
0	1	Ignore
1	2	Ignore
3	2	Ignore
4	1	Ignore
5	15	Plot as 15 mm at 1 hour
6	2	Plot as 17 mm at 2 hours
7	10	Plot as 27 mm at 3 hours

Time (hours)	Rainfall Depth (mm)	Action
8	5	Plot as 32 mm at 4 hours Indicates it may be a 5-year (20% AEP) event
9	12	Plot as 44 mm at 5 hours Indicates it may be a 10-year (10% AEP) event Start planning for a 10% AEP event
10	2	Plot as 46 mm at 6 hours More confident that a 10% AEP event is likely
11	5	Plot as 51 mm at 7 hours
12	1	Plot as 52 mm at 8 hours
13	3	Plot as 55 mm at 9 hours
14	10	Plot as 65 mm at 10 hours Indicates it may be a 20-year (5% AEP) event.
15	5	Plot as 70 mm at 11 hours More confident that a 5% AEP event is likely
16	2	Plot as 72 mm at 12 hours



■ **Figure 8-4 Quick look tool example**

8.6 Flood classification – Bureau of Meteorology

Electronic maps have been produced for the minor[1], moderate[2] and major[3] flood (as defined by the BoM). The minor, moderate and major flood has been based on the flood impacts. For Newlyn North the 1 in 5, 10 and 20 AEP has been adopted for the minor, moderate and major flood respectively.

[1] Minor Flooding - Causes inconvenience. Low-lying areas next to water courses are inundated. Minor roads may be closed and low-level bridges submerged. In urban areas inundation may affect some backyards and buildings below the floor level as well as bicycle and pedestrian paths. In rural areas removal of stock and equipment may be required.

[2] Moderate Flooding - In addition to minor flooding, the area of inundation is more substantial. Main traffic routes may be affected. Some buildings may be affected above the floor level. Evacuation of flood affected areas may be required. In rural areas removal of stock is required

[3] Major Flooding – In addition to moderate flooding, extensive rural areas and/or urban areas are inundated. Many buildings may be affected above the floor level. Properties and towns are likely to be isolated and major rail and traffic routes closed. Evacuation of flood affected areas may be required. Utility services may be impacted

9. Summary of rating of key areas

The following section provides a summary rating of each of the key areas of the project. The rating is subjective but has been rated against current standards and industry best practice for undertaking detailed flood studies.

The intention is that this will enable the North Central CMA to easily identify the areas where additional caution may need to be applied when using the information from this investigation for making decisions on flooding issues. In addition it will identify the areas of additional investigation, should a more detailed study be undertaken in the future.

Table 9-1 shows a summary of the rating for Newlyn North where green is considered to be good, orange is OK and red is poor. Below is a summary of the main considerations given to each aspect of the study:

- *RORB model set up*. Adequacy of sub-area division, reach types, impervious fractions
- *RORB model parameters*. Has the RORB model been calibrated and/or verified to streamflow gauge information
- *Currency of hydrology*. Rated based on whether the hydrology used in the study is consistent with current practice and data sets.
- *Topographic data*. Typically will be rated orange or red if LiDAR data is not available and if the state wide DEM is required for use.
- *Manning's n*. Has land use been represented with appropriate values
- *Modelling of key structures*. Reflects whether the model was attempted to incorporate key hydraulic structures within the inundation zone and to what degree.
- *TUFLOW model set up.* Considers such aspects as does the cell size capture key features and the boundary conditions.
- *TUFLOW parameters*. Has the TUFLOW model been calibrated and/or verified to recorded flood levels.

Table 9-1 Summary of review –Newlyn

Category	Comment	Rating
RORB model set up	Adequate sub-area division for larger catchment. However, additional local catchment sub-division recommended if more detailed local flows are required.	
RORB model parameters	Based on a verified model. Calibration to recorded data would improve the confidence in the routing parameter.	
Currency of hydrology	All inputs are based on ARR2019	
Topographic data	LIDAR available for entire study area	
Manning's n	Generally OK but was based on VLUIS	
Modelling of key structures	One bridge and two culverts explicitly modelled. Reasonable data was available for one bridge and culvert with one minor culvert estimated from available data.	
TUFLOW model set up	Cell size adequately represents waterway and boundary conditions modelled appropriately.	
TUFLOW parameters	TUFLOW parameters have not been calibrated or verified to recorded flood levels.	

10. Limitations

Any information provided by the Bureau of Meteorology, Geoscience Australia as well as published methodologies (e.g. Australian Rainfall and Runoff) cannot be guaranteed to be free of errors.

The hydrological parameters rely on the previous calibration and verification undertaken for each of the RORB models. Therefore, the accuracy of this will vary depending on the information available to calibrate the models. However, any calibration and verification of the models to streamflow information will most likely be better than just relying on regional parameter estimates.

The proposed methodology for the PMF estimate is preliminary in nature. Other, more detailed techniques are available in which to estimate the PMF. However, for this investigation a preliminary assessment has been considered to be appropriate.

The analysis has relied heavily on the supplied LIDAR terrain data. For this investigation no survey will be undertaken to independently check the terrain data.

For the hydraulic model the intention is that the waterways are represented by 4-5 cells. Where a waterway is less eight metres wide it will be represented by less than the 4-5 cells which could mean that the waterway is not fully represented.

The Manning's roughness adopted for the study areas utilising the VLUIS dataset. As the VLUIS is a state wide dataset there may be some areas that have either been developed since the VLUIS was established or not captured accuracy. Whilst, basic checks have been undertaken to pick up any large errors in assigned land use there may still be some lot scale differences in land use which may not be picked up.

As the hydraulic model was not calibrated to surveyed flood levels the Manning's n values listed in Table 7-1 may not necessarily represent the roughness values accurately.

As mentioned in Section 6.3 the ARR2019 approach to climate change has a number of limitations, including the fact that it does not provide a means to account for potential increases in rainfall losses under a drying climate.

The quick look flood / no flood tools may be replaced where more detailed investigations are undertaken in the future.

11. Conclusion

This project forms part of the Rapid Flood Risk Assessment for the North Central CMA region. Outputs from the assessment will assist the North Central CMA to meet a range of business requirements. Outputs can be used to assist in flood related controls, develop flood intelligence products, inform emergency response planning and assist in the preparation of community flood awareness and education products.

12. References

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Appendix A Maps

the key parameters. However, an important aspect to consider is the impact of climate change on the design flow estimates.

for an RCP of 4.5 are recommended for adoption for this study. However, the results from RCP 8.5 have also been provided for completeness.

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_DmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

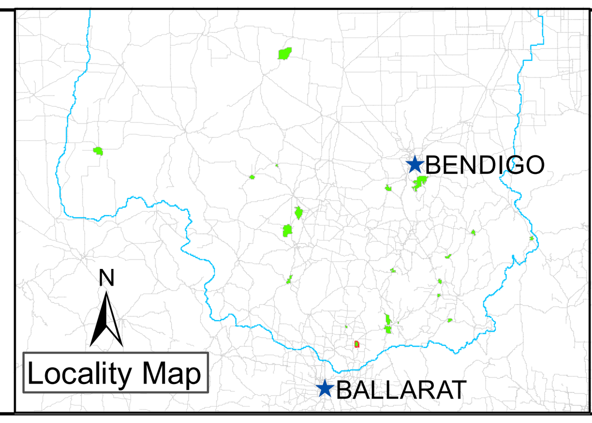
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Depth (m)

- < 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM DEPTH (m)

Newlyn North - 20% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 5 - 1

HARC hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
No two floods behave in exactly the same manner, even though they may rise to the same maximum height at a given location. The information given shall be regarded as only representing typical conditions.
The North Central CMA and Hydrology and Risk Consulting do not warrant that this document is definitive nor free of error, and does not accept responsibility for any loss caused or arising from reliance upon the information provided herein.

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VxDmaxMGA54.m

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max V x D (m²/s)

- < 0.4
- 0.4 - 0.8
- 0.8 - 1.2
- > 1.2

Locality Map: BENDIGO, BALLARAT, N

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM V x D (m²/s)

Newlyn North - 20% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale: 1:5,000 when printed @ A1

Date: 25/02/2020

Map No.: 10 - 5 - 2

HARC hydrology and risk CONSULTING

VICTORIA State Government

North Central CMA

Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

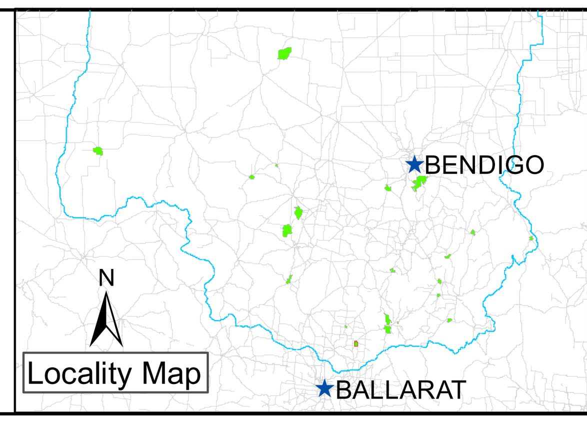
Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent
- Contour (1m)
- Contour (0.5m)

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max WSE (mAHD) Newlyn North
Value
High : 526
Low : 511



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM WATER LEVEL (mAHD)

Newlyn North - 20% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 5 - 3

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VICTORIA State Government
North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HazardsMGA54.m
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Locality Map (BENDIGO, BALLARAT)

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM HAZARD

Newlyn North - 20% AEP Flood Event

0 200 400 Meters

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale: 1:5,000 when printed @ A1
Date: 25/02/2020
Map No.: 10 - 5 - 4

HARC hydrology and risk consulting
VICTORIA State Government
North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

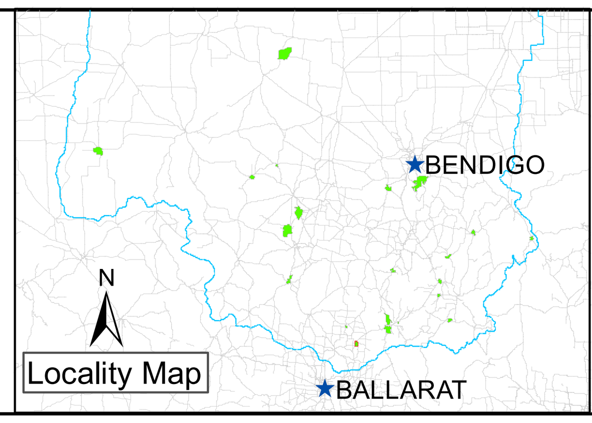
Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Velocity (m/s)
- < 1
- 1 - 2
- 2 - 3
- > 3



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM VELOCITY (m/s)

Newlyn North - 20% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 5 - 5

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VICTORIA State Government
North Central CMA
Australian Government

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Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
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- Industrial
- Public

Building Inundation
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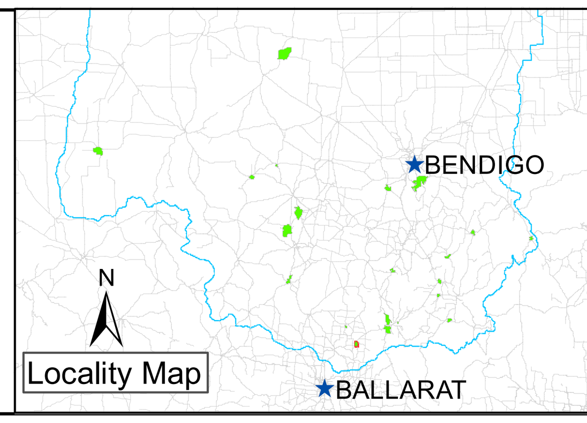
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Depth (m)
- < 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.2
- > 1.2



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM DEPTH (m)

Newlyn North - 10% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale: 1:5,000 when printed @ A1
Date: 25/02/2020
Map No.: 10 - 10 - 1

HARC hydrology and risk CONSULTING
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North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VxDmaxMGA54.m
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

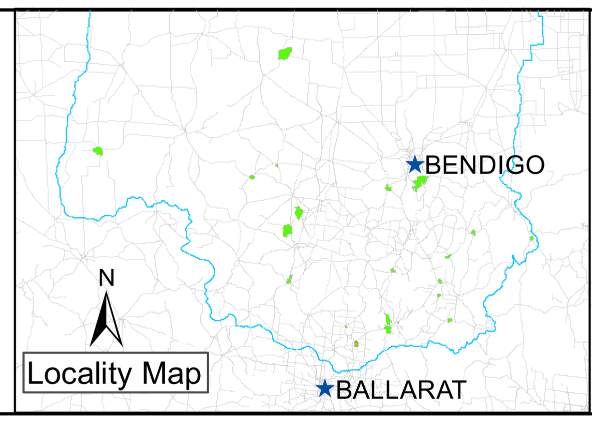
Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max V x D (m²/s)
- < 0.4
- 0.4 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM V x D (m²/s)

Newlyn North - 10% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 10 - 2

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
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- Tertiary Road
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- Contour (1m)
- Contour (0.5m)

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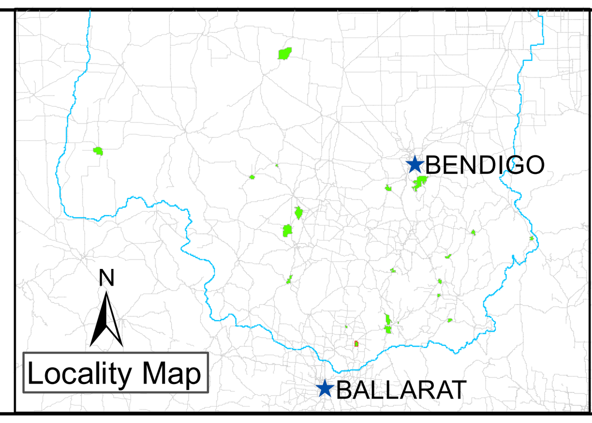
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max WSE (mAHD) Newlyn North
Value
High : 526
Low : 511



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM WATER LEVEL (mAHD)

Newlyn North - 10% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 10 - 3

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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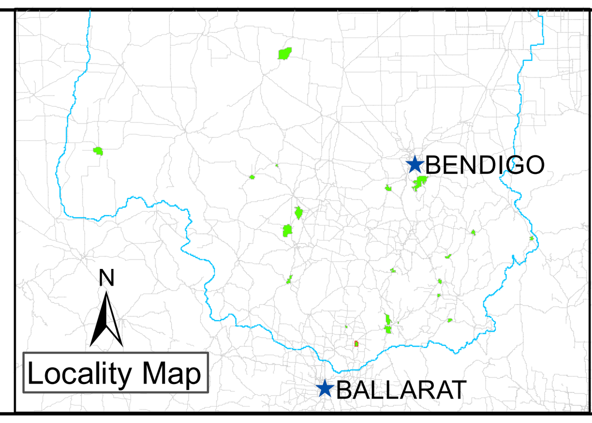
Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HazardsMGA54.m
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM HAZARD

Newlyn North - 10% AEP Flood Event

0 200 400
Meters

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale: 1:5,000 when printed @ A1
Date: 25/02/2020
Map No.: 10 - 10 - 4

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

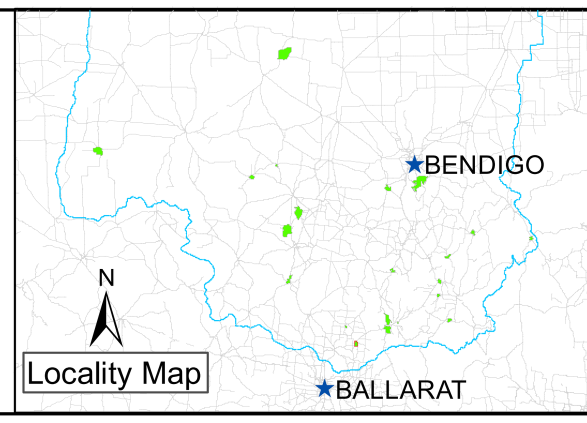
CFA/MFB Fire Station
Police Station
Hospital
School/College
Nursing Home/Aged Care
Carvaran Park

Main Road
Tertiary Road
Railway Line
Flood Model Extent

Building Classification
Residential
Commercial
Industrial
Public

Building Inundation
not inundated
inundated (without floor level survey)
below floor level (with floor level survey)
above floor level (with floor level survey)

Max Velocity (m/s)
< 1
1 - 2
2 - 3
> 3



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM VELOCITY (m/s)

Newlyn North - 10% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 10 - 5

HARC hydrology and risk
VICTORIA State Government
North Central CMA
Australian Government

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Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

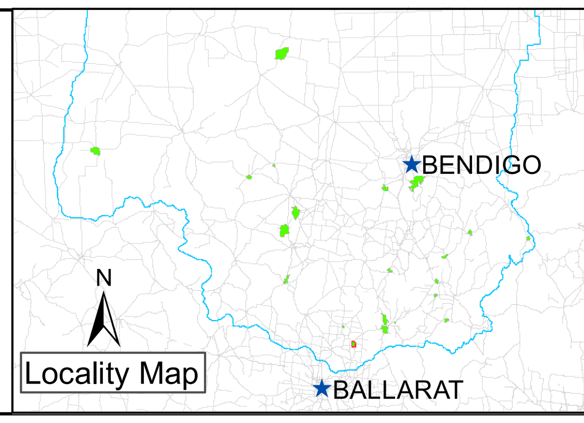
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Depth (m)

- < 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM DEPTH (m)

Newlyn North - 5% AEP Flood Event

0 200 400
Meters

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 20 - 1

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VxDmaxMGA54.m
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

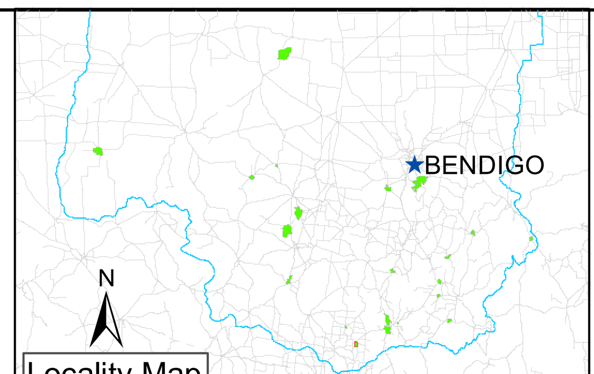
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max V x D (m²/s)

- < 0.4
- 0.4 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM V x D (m²/s)

Newlyn North - 5% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 20 - 2

HARC hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent
- Contour (1m)
- Contour (0.5m)

Building Classification

- Residential
- Commercial
- Industrial
- Public

Building Inundation

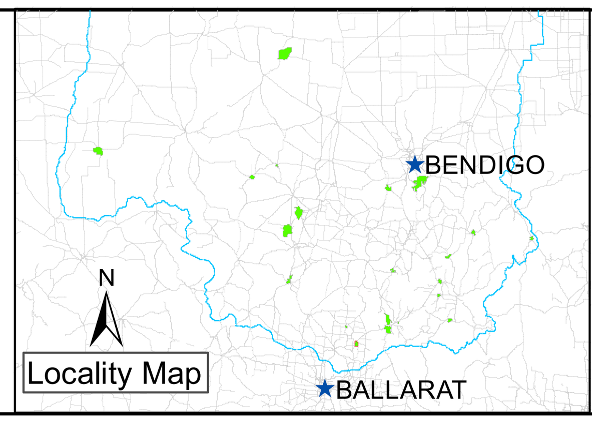
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max WSE (mAHD) Newlyn North

Value

High : 526

Low : 511



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM WATER LEVEL (mAHD)

Newlyn North - 5% AEP Flood Event

0 200 400
Meters

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 20 - 3

HARC hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HazardsMGA54.m

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

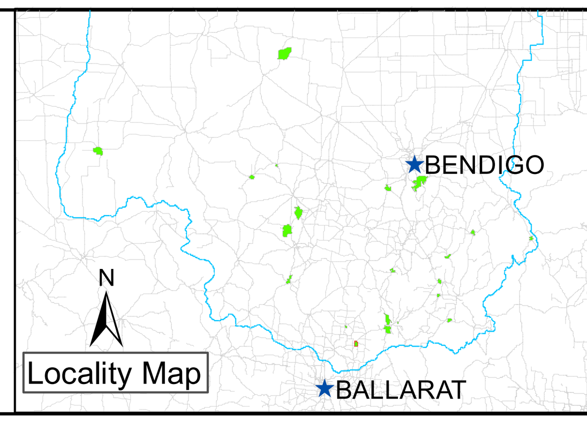
- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM HAZARD

Newlyn North - 5% AEP Flood Event

0 200 400
Meters

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 20 - 4

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

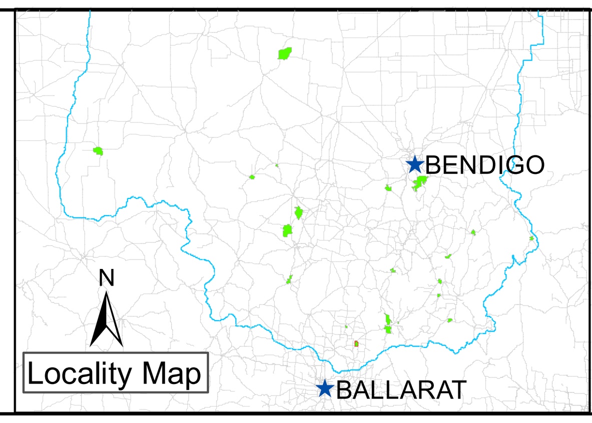
Legend

- F CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Velocity (m/s)
- < 1
- 1 - 2
- 2 - 3
- > 3



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM VELOCITY (m/s)

Newlyn North - 5% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 20 - 5

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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_DmaxMGA54.mxd

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

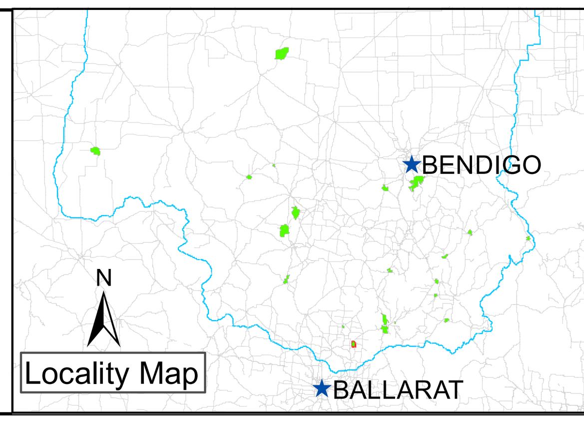
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Depth (m)

- < 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.2
- > 1.2



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM DEPTH (m)

Newlyn North - 2% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 50 - 1

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North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VxDmaxMGA54.m

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

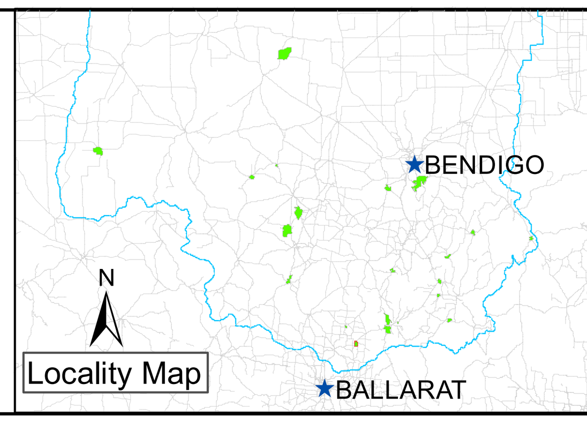
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max V x D (m²/s)

- < 0.4
- 0.4 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM V x D (m²/s)

Newlyn North - 2% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 50 - 2

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent
- Contour (1m)
- Contour (0.5m)

Building Classification
- Residential
- Commercial
- Industrial
- Public

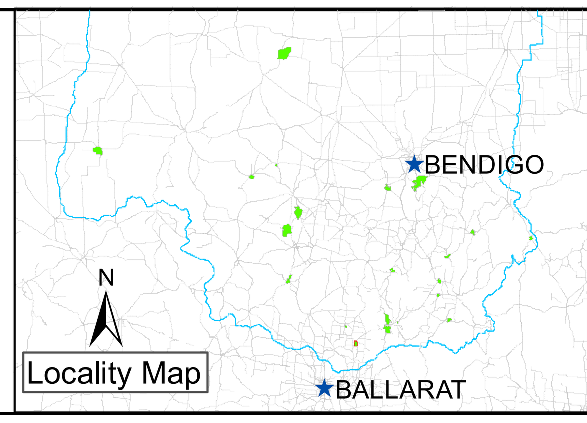
Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max WSE (mAHD) Newlyn North

Value

High : 526

Low : 511



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM WATER LEVEL (mAHD)

Newlyn North - 2% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 50 - 3

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HazardsMGA54.m

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

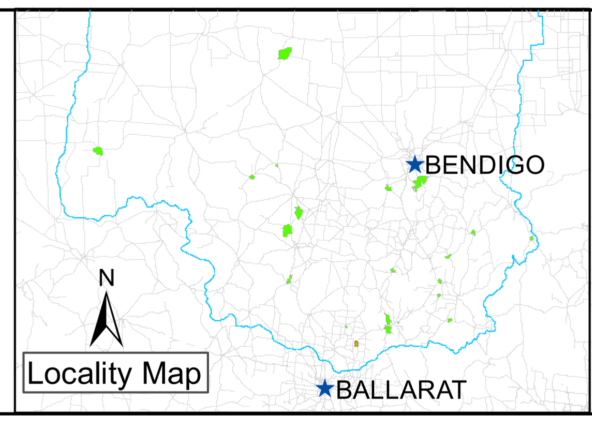
- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM HAZARD

Newlyn North - 2% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 50 - 4

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VICTORIA State Government

North Central CMA

Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VmaxMGA54.mxd

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- F CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- N Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

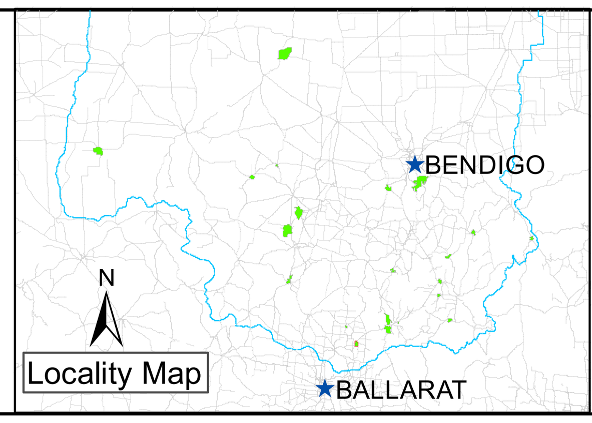
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Velocity (m/s)

- < 1
- 1 - 2
- 2 - 3
- > 3



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM VELOCITY (m/s)

Newlyn North - 2% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 50 - 5

HARC hydrology and risk
VICTORIA State Government
North Central CMA
Australian Government

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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_DmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

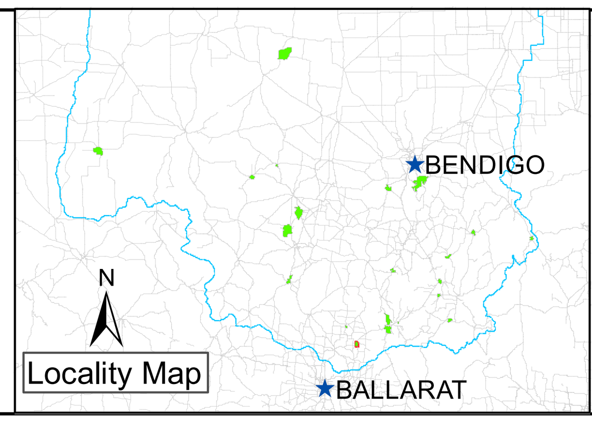
Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Depth (m)
- < 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM DEPTH (m)

Newlyn North - 1% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 100 - 1

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VxDmaxMGA54.m

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- F CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- N Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

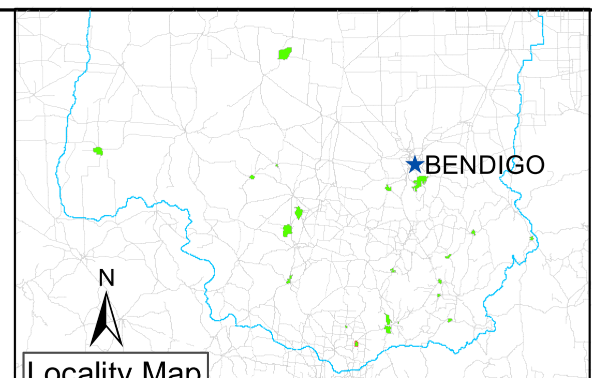
- ● Residential
- ⬟ Commercial
- ▲ Industrial
- ★ Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max V x D (m²/s)

- < 0.4
- 0.4 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM V x D (m²/s)

Newlyn North - 1% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 100 - 2

HARC hydrology and risk CONSULTING

VICTORIA State Government

North Central CMA

Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent
- Contour (1m)
- Contour (0.5m)

Building Classification
- Residential
- Commercial
- Industrial
- Public

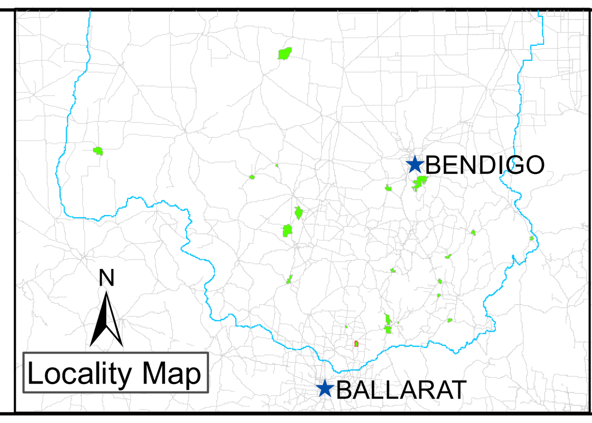
Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max WSE (mAHD) Newlyn North

Value

High : 526

Low : 511



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM WATER LEVEL (mAHD)

Newlyn North - 1% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 100 - 3

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HazardsMGA54.m
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

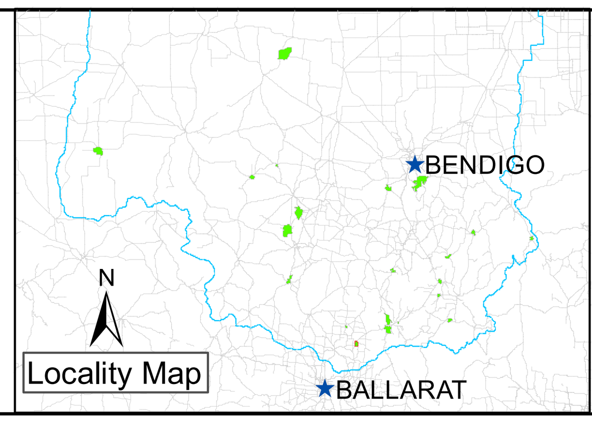
- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM HAZARD

Newlyn North - 1% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 100 - 4

HARC hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

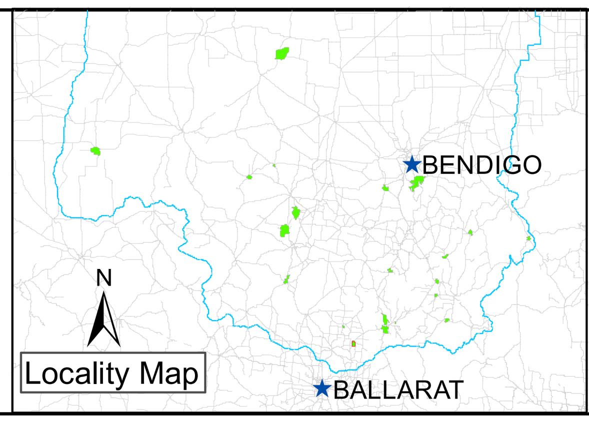
Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Velocity (m/s)
- < 1
- 1 - 2
- 2 - 3
- > 3



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM VELOCITY (m/s)

Newlyn North - 1% AEP Flood Event

0 200 400
Meters

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 100 - 5

HARC hydrology and risk
VICTORIA State Government
North Central CMA
Australian Government

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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_DmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

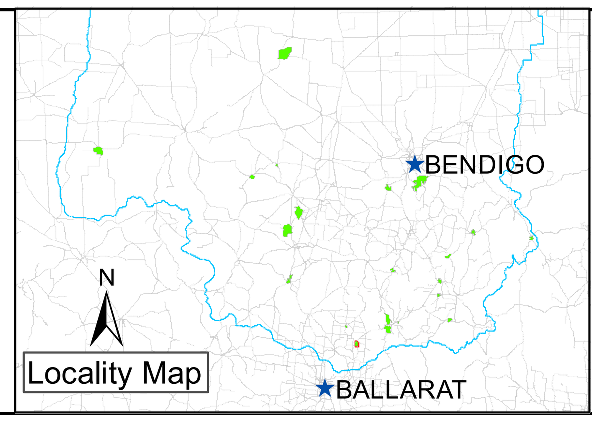
Legend

- F CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Depth (m)
- < 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM DEPTH (m)

Newlyn North - 0.5% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 200 - 1

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VxDmaxMGA54.m

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

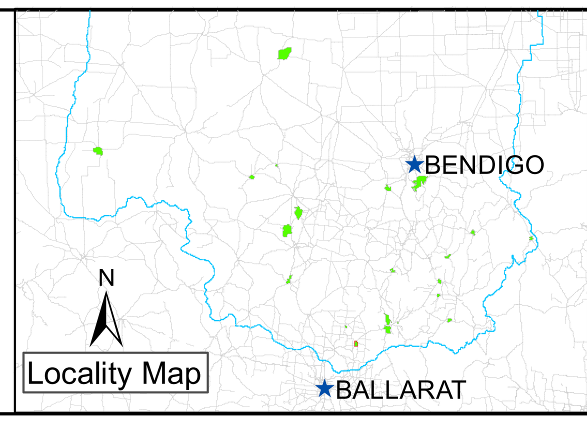
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max V x D (m²/s)

- < 0.4
- 0.4 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM V x D (m²/s)

Newlyn North - 0.5% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 200 - 2

HARC hydrology and risk CONSULTING

VICTORIA State Government

North Central CMA

Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

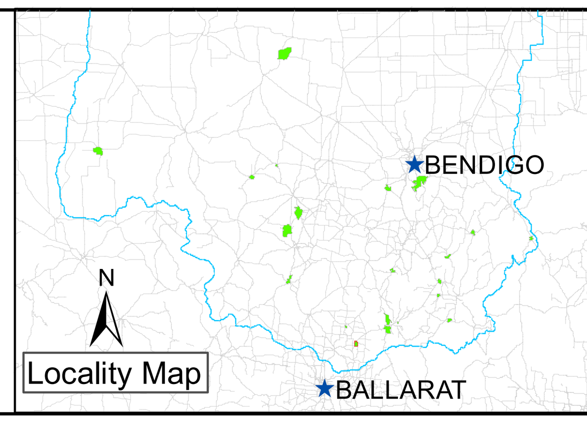
- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent
- Contour (1m)
- Contour (0.5m)

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max WSE (mAHD) Newlyn North

Value
High : 526
Low : 511



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM WATER LEVEL (mAHD)

Newlyn North - 0.5% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 200 - 3

hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

Combined Flood Hazard Curves (ARR, 2016)

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HazardsMGA54.m

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

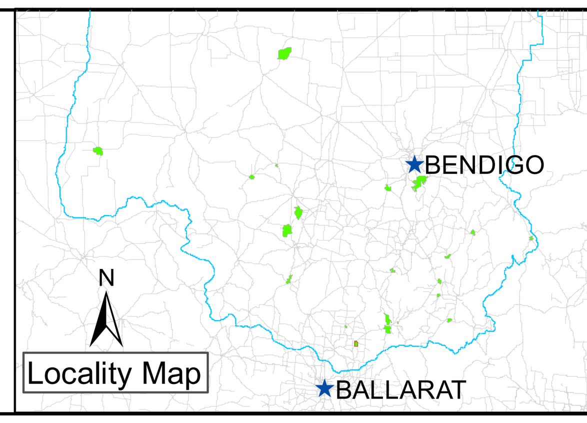
- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM HAZARD

Newlyn North - 0.5% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 200 - 4

HARC hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

This map shows the area that could be inundated following the flood event shown in the title block. Interpretation of these maps should be made by a competent person with reference to the accompanying flood study report.
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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VmaxMGA54.mxd

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- F CFA/MFB Fire Station
- Police Station
- Hospital
- S School/College
- N Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

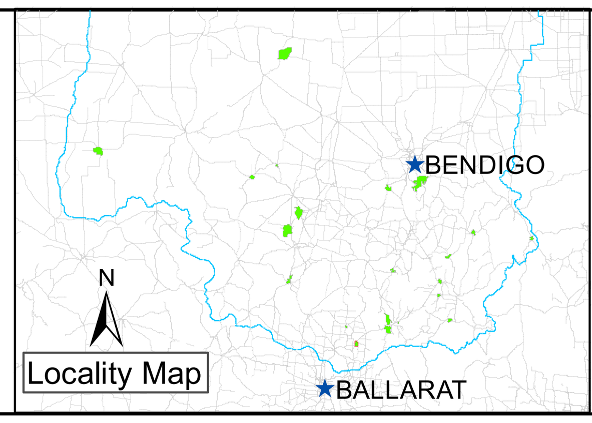
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Velocity (m/s)

- < 1
- 1 - 2
- 2 - 3
- > 3



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM VELOCITY (m/s)

Newlyn North - 0.5% AEP Flood Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - 200 - 5

HARC hydrology and risk
VICTORIA State Government
North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_DmaxMGA54.mxd

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

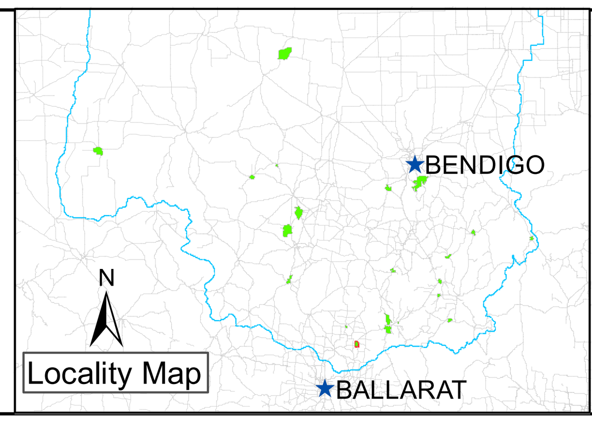
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Depth (m)

- < 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.2
- > 1.2



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM DEPTH (m)

Newlyn North - PMF Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - PMF - 1

HARC hydrology and risk CONSULTING
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North Central CMA
Australian Government

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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VxDmaxMGA54.m
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

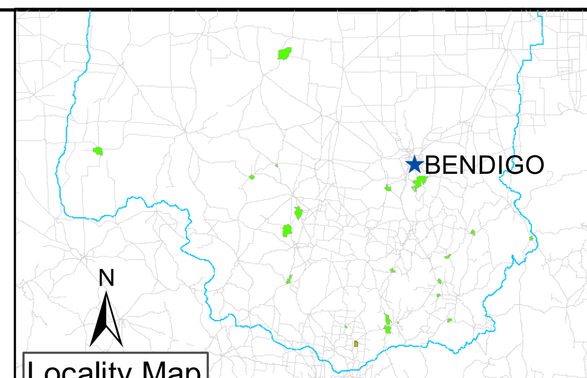
Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max V x D (m²/s)
- < 0.4
- 0.4 - 0.8
- 0.8 - 1.2
- > 1.2



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM V x D (m²/s)

Newlyn North - PMF Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - PMF - 2

HARC hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

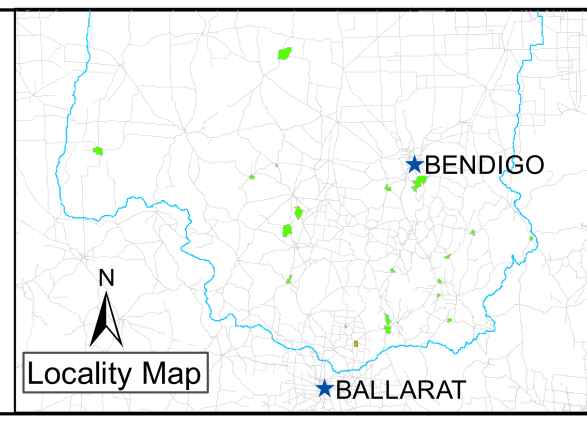
Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent
- Contour (1m)
- Contour (0.5m)

Building Classification
- Residential
- Commercial
- Industrial
- Public

Building Inundation
- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max WSE (mAHD) Newlyn North
Value
High : 526
Low : 511



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM WATER LEVEL (mAHD)

Newlyn North - PMF Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale: 1:5,000 when printed @ A1
Date: 25/02/2020
Map No.: 10 - PMF - 3

HARC hydrology and risk CONSULTING
VICTORIA State Government
North Central CMA
Australian Government

Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_HazardsMGA54.m

Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

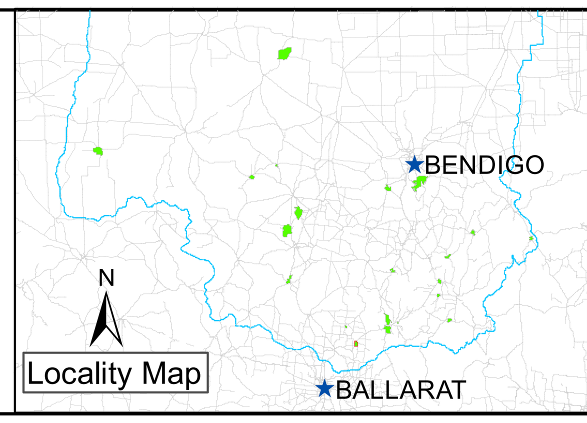
- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)



Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager: N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM HAZARD

Newlyn North - PMF Event

0 200 400 Meters

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - PMF - 4

HARC hydrology and risk CONSULTING · North Central CMA · VICTORIA State Government · Australian Government

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Data Location: S:\3_Projects\NCC00002\5_Technical\3_Mapping\NCC00002_InundationMapping_Datadrivenpages_VmaxMGA54.mxd
Roads Layer: Vicmap; Imagery: ESRI ; Geoscape Polygons: Navigate, PSMA Australia,

Legend

- CFA/MFB Fire Station
- Police Station
- Hospital
- School/College
- Nursing Home/Aged Care
- Carvaran Park
- Main Road
- Tertiary Road
- Railway Line
- Flood Model Extent

Building Classification

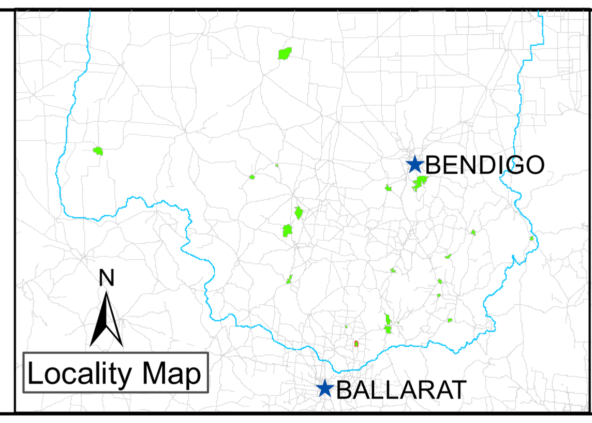
- Residential
- Commercial
- Industrial
- Public

Building Inundation

- not inundated
- inundated (without floor level survey)
- below floor level (with floor level survey)
- above floor level (with floor level survey)

Max Velocity (m/s)

- < 1
- 1 - 2
- 2 - 3
- > 3



Locality Map

Drawn: A. SHEN	Project Director: D. STEPHENS
Checked: T. CRAIG	
Project Manager: A. NORTHFIELD	
Project No.: NCC00002	
North Central CMA Project Manager : N. TRELOAR	

NORTH CENTRAL CMA RAPID FLOOD RISK ASSESSMENT
MAXIMUM VELOCITY (m/s)

Newlyn North - PMF Event

0 200 400
Meters

N

Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

Scale:	Date:	Map No.:
1:5,000 when printed @ A1	25/02/2020	10 - PMF - 5

hydrology and risk
North Central CMA
VICTORIA State Government
Australian Government