STORMWATER SYSTEM FLOOD AND RISK STUDY

FOR NORTHERN MIDLANDS COUNCIL

NORTHERN
MIDLANDS
COUNCIL

NORTH CAMPBELL TOWN

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Project: North Campbell Town Stormwater System Flood & Risk Study

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1. CONTEXT

The *Urban Drainage Act 2013* requires the Northern Midlands Council (NMC) to produce a System Management Plan (SSMP) which details its understanding of its urban stormwater systems, the identification of risks associated with them, and its plans for the provision and maintenance of such services.

This Stormwater System Flood and Risk Study (SSFRS) has been undertaken to identify potential risks associated with stormwater conveyance in the north Campbell Town urban area. It is a contributing document referenced by the first iteration of NMC's SSMP.

North Campbell Town is affected by riverine flooding from the Elizabeth River. A separate study is planned for 2020 to quantify the risks and effects of flooding from these waterways and to generate flood maps. These are very large rural catchments which impact on urban areas and are not directly related to the urban stormwater system per se. This SSFRS considers local rainfall, runoff and flooding rather than that from rivers for which NMC has no responsibility for management.

2. SERVICE LEVELS

NMC's existing stormwater system can be defined in terms of minor and major system components.

Minor Drainage Systems:

These make up the reticulated stormwater network and comprise of collection systems such as piped property connections, inlet pits, stormwater mains, channels, swales, soakage pits and their associated fixtures.

Major Drainage Systems:

These systems are designed to control overland flow. They consist of swales, channels, natural water courses, culverts, conduits, floodways, roadways, detention basins, retention basins and/or discharge structures, and their associated fixtures.

In accordance with NMC policy the performance of its minor drainage systems have been assessed in the context of their ability to minimise overland flow and to service flows from the 10% Annual Exceedance Probability (AEP). The performance of NMC's major drainage systems have been assessed in the context of their ability to protect people and property from damage or injury in storms up to the 1% AEP.

3. THE CATCHMENT

The local south Campbell Town catchment area is presented in Figure 1. The model boundary and modelled stormwater pipe and pit assets are highlighted in red.

Figure 1. North Campbell Town Catchment

The north Campbell Town township catchment is approximately 270 hectares in size and is located on the northern side of the Elizabeth River. The catchment descends from an elevation of approximately 232.5 mAHD in the vicinity of the Bond Street reservoir down to 183 mAHD at the river.

Stormwater from the township discharges through six outlets to the Elizabeth River. There are also several additional outlets which discharge to the rail corridor on the eastern side of the township.

Many properties in this catchment do not have a direct stormwater connection to the stormwater pipeline network but have kerb connections, which are modelled using dummy nodes and pipes to apply roof runoff direct to the roadways. Other properties appear to have no connection at all and probably just drain to the ground. These properties have been setup in the model to shed rainfall directly to the ground.

Figure 2 shows the Northern Midlands Interim Planning Scheme zoning for the catchment.

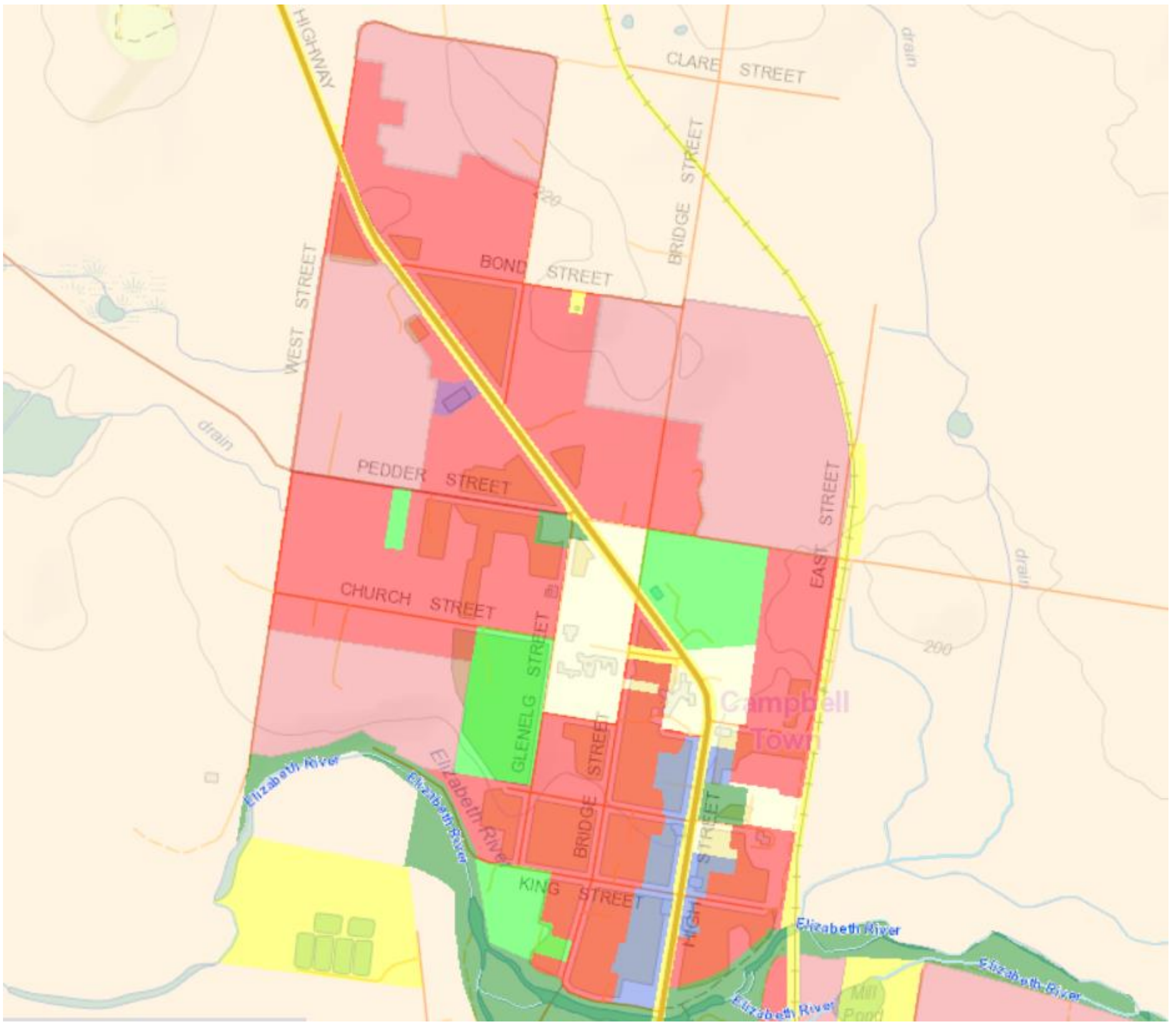


Figure 2. Northern Midlands Interim Planning Scheme 2013 Zoning. General residential (red), low density residential (puce), general business (blue), light industrial (magenta), general industrial (purple), utilities (yellow), and recreation (light green), open space (dark green) and rural resource (cream) – source: http://maps.thelist.tas.gov.au

A majority of the land either side of High Street is zoned general residential, with the land surrounding the township zoned rural resource.

The South rail line cuts through the catchment and the culverts beneath it are TasRail assets. Asset data for these culverts was not available during the model build and were therefore not included.

4. MODELLING INFORMATION

Modelling was undertaken using Infoworks ICM (Integrated Catchment Modelling) software in order to help understand the performance of stormwater assets within the catchment and to identify management problems and opportunities. Infoworks ICM allows full integration of 1D (pipes and pits) and 2D (overland flow) simulations.

Information about the model's hydrological and technical settings are provided in Appendix A.

4.1 ASSET DATA

Pipe and pit/manhole data recorded in NMC's GIS and asset spreadsheets was used to build the stormwater system model. The process of model validation identified the following common problems with some of the data:

- Missing manholes/pits (nodes) and pipes;
- Missing surface levels (SLs) and invert levels (ILs) for nodes;
- Missing ILs for pipes and culverts; and
- Upstream pipe/ and culvert invert levels (USILs) which were lower than downstream invert levels (DSILs).

Where necessary missing assets were added, usually based on observations in Google Street View. Erroneous data was improved either through new survey, or with assumed or inferred data. Pits and pipes which were not present within the raw data were given the label ''Temp'' in the model so they can be surveyed and added to NMC's GIS system when possible. Any adjustment to supplied data was flagged within the model for future reference.

The 2D triangular mesh used to represent terrain in the model was created from LIDAR obtained circa 2016. Kerbed road surface levels were usually dropped 150mm in order to ensure definition for kerbs within the 2D mesh.

Surface types for road, roof and impervious areas were derived from the 2016 aerial image obtained by NMC.

4.2 RAINFALL

Modelling was undertaken using the 2016 the Bureau of Meteorology (BOM) Intensity-Frequency-Duration (IFD) design rainfall estimates and temporal pattern ensembles. No Aerial Reduction Factors (ARF) were applied and prospective climate change was not modelled in this assessment.

4.3 DISPLAYED RESULTS

Modelling results presented in this document show the 2D (above ground) flooding and the 1D (pipe and node) surcharge levels during the critical duration 10% and 1% AEP storm bursts for each stormwater system network. In this study the 10% AEP is sometimes referred to as the 'minor event', and the 1% AEP as the 'major event'.

1D results are colour coded as follows:

- **Green** pipes have not surcharged. The water level is below the soffit level at both ends of the pipe;
- **Blue** pipes have surcharged. The water level at the upstream and/or downstream end of the pipe is above the soffit level. The flow is less than or equal to the pipe's full capacity;
- **Magenta** pipes have surcharged. The water level at the upstream and/or downstream end of the pipe is above the soffit level. The flow is greater than or equal to the pipe's full capacity;
- **Green** nodes have no surcharging;
- **Red** nodes have surcharging.

2D flood depth results are generally categorised as per Table 1:

< 0.02	>= 0.07844839	>= 0.1823402	>= 0.38895372
>= 0.02	>= 0.08522516	>= 0.19581741	>= 0.41575643
>= 0.02300717	>= 0.09243898	>= 0.21016386	>= 0.44428775
>= 0.02620829	>= 0.10011807	>= 0.22543553	>= 0.47465912
>= 0.02961587	>= 0.10829242	>= 0.24169219	>= 0.5069893
>= 0.03324321	>= 0.11699396	>= 0.25899726	>= 0.54140455
>= 0.0371045	>= 0.12625672	>= 0.27741843	>= 0.57803941
>= 0.04121482	>= 0.13611686	>= 0.29702765	>= 0.617037
>= 0.04559023	>= 0.14661291	>= 0.31790161	>= 0.65854985
>= 0.05024783	>= 0.15778594	>= 0.34012178	>= 0.70273989
>= 0.05520582	>= 0.16967952	>= 0.36377499	>= 0.74977994
>= 0.06048358			>= 0.7998538
>= 0.06610171			>= 0.85315734
>= 0.07208219			>= 0.90591019

Table 1. 2D (overland) flood depth results categories (metres)

4.4 RISK ASSESSMENT

To help prioritise actions for areas where flooding has been identified and/or the stormwater network is under capacity, a risk assessment was conducted using the following consequence and likelihood matrix:

		Level of consequence				
Likelihood of consequence	AEP (%)	Catastrophic	Major	Moderate	Minor	Insignificant
Moderate	10%	High	High	High	Medium	Low
Rare	1%	High	Medium	Medium	Low	Low

Table 2. Risk Assessment Table (*adapted from AS4360:2004 & NMC Interim Planning Scheme 2013 Table E5.1*)

Risks to people and property were assessed. The level of consequence definitions are presented in Table 3. The consequence definitions for property are derived from those presented in the *NMC Interim Planning Scheme* 2013 Section E5.7b. The consequence definitions for people are derived from the *NMC Interim Planning Scheme 2013* Section E5.7b as well as the Hazard Vulnerability Classes given in *Australian Rainfall and Runoff 2016* (*ARR2016*).

	Level of consequence definitions		
Level of consequence	**For Property**	**For People**	**Hazard Vulnerability Classification**
Catastrophic	Not likely to be a recovery in the foreseeable future	Loss of life. Unsafe for vehicles and people	H6
Major	Complete structural failure, destruction of significant property and infrastructure, long-term recovery time	Extensive injuries. Unsafe for vehicles and people.	H5/H6
Moderate	Treatment required, significant building or infrastructure damage I.e., loss of minor outbuildings such as car ports, public park shelters and the like. Replacement of significant property components such as cladding, flooring, linings, hard paved surfaces. Short term recovery time	Unsafe for vehicles and some/all people	H3 & H4
Minor	Medium loss- seepage, replacement of floor/window coverings, some furniture, repair of building components. Easily remediated	Unsafe for small vehicles	H2
Insignificant	Low loss - cleaning but no replacement of habitable building components, some repair of garden beds, gravel driveways etc.	No injury. Generally safe for vehicles, people and buildings	H1

Table 3. Level of consequence definitions (adapted from NMC Interim Planning Scheme 2013 Section E5.7b and ARR2016)

The *ARR2016* hazard vulnerability classifications are a function of velocity and depth which can be measured in the modelled storm bursts, refer to Table 4:

Hazard Vulnerability Classification	Classification Limit (D and V in combination)	Limiting Still Water Depth (D)	Limiting Velocity (V)
H1	D*V ≤ 0.3	0.3	2.0
H2	D*V ≤ 0.6	0.5	2.0
H3	D*V ≤ 0.6	1.2	2.0
H4	D*V ≤ 1.0	2.0	2.0
H5	D*V ≤ 4.0	4.0	4.0
H6	D*V > 4.0	-	-

Table 4. Hazard Vulnerability Limits (from *ARR2016*)

5. ASSESSMENTS

5.1 WEST STREET (NORTH) STORMWATER SYSTEM

The West Street (north) stormwater system is located at the north-west of Campbell Town, refer to Figure 3. It has two headwalls which discharge to the open drain behind no. 13 West Street. The open drain then grades south along the eastern side of West Street to a culvert from which it heads west, to the north of Macquarie Road. The subcatchment consists predominately of pasture with a relatively small proportion of impervious roads and roofs.

Figures 4 and 5 show flooding during the 10% and 1% AEPs respectively based on critical duration flows from the DN450 outlet to the south of no.10 High Street. The flood risks within the system are located mainly at the interface between open drains and culvert inlets. The flood footprints upstream of these culverts can be seen in Figures 4 and 5 on the northern side of the intersection of West Street and the Midland Highway, on the eastern side of the High Street (opposite no. 8), and on the eastern side of West Street.

The piped network performs well during the minor event. It should be noted that since the aerial image used to create the model were obtained there has been additional development on the northern side of Bond Street which has not been modelled.

The 10% AEP flood areas seem to be constrained to the paddocks adjacent to the culvert inlets except for at the intersection of West Street on the northern side of the highway.

There is potential for roadway flooding in the area adjacent to no. 5a West Street during the 10% AEP. The model predicts the flooding in this location becomes more significant during the 1% AEP, refer to Figure 6, which potentially impacts the dwellings at no. 3 and 5. The flood depth against the dwellings is expected to be less than 100mm so the risk of internal flooding is low.

Figure 3. Hay Street stormwater system extent

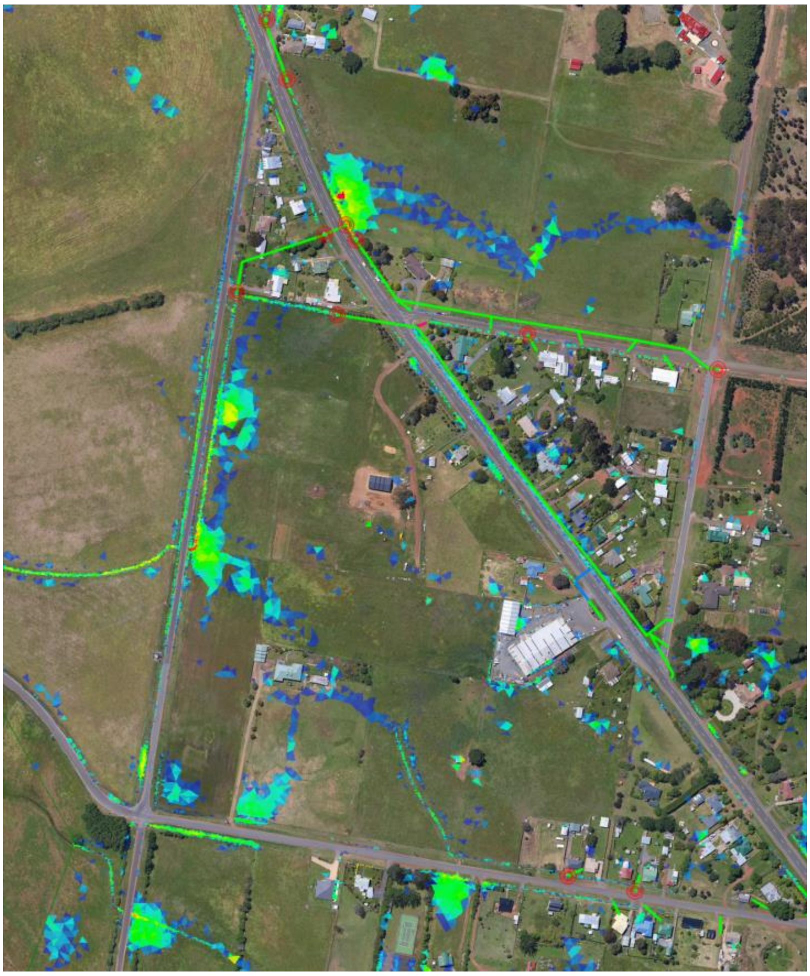


Figure 4. 10% AEP, 2-hour duration (storm burst no. 6) (flooding >20mm deep)

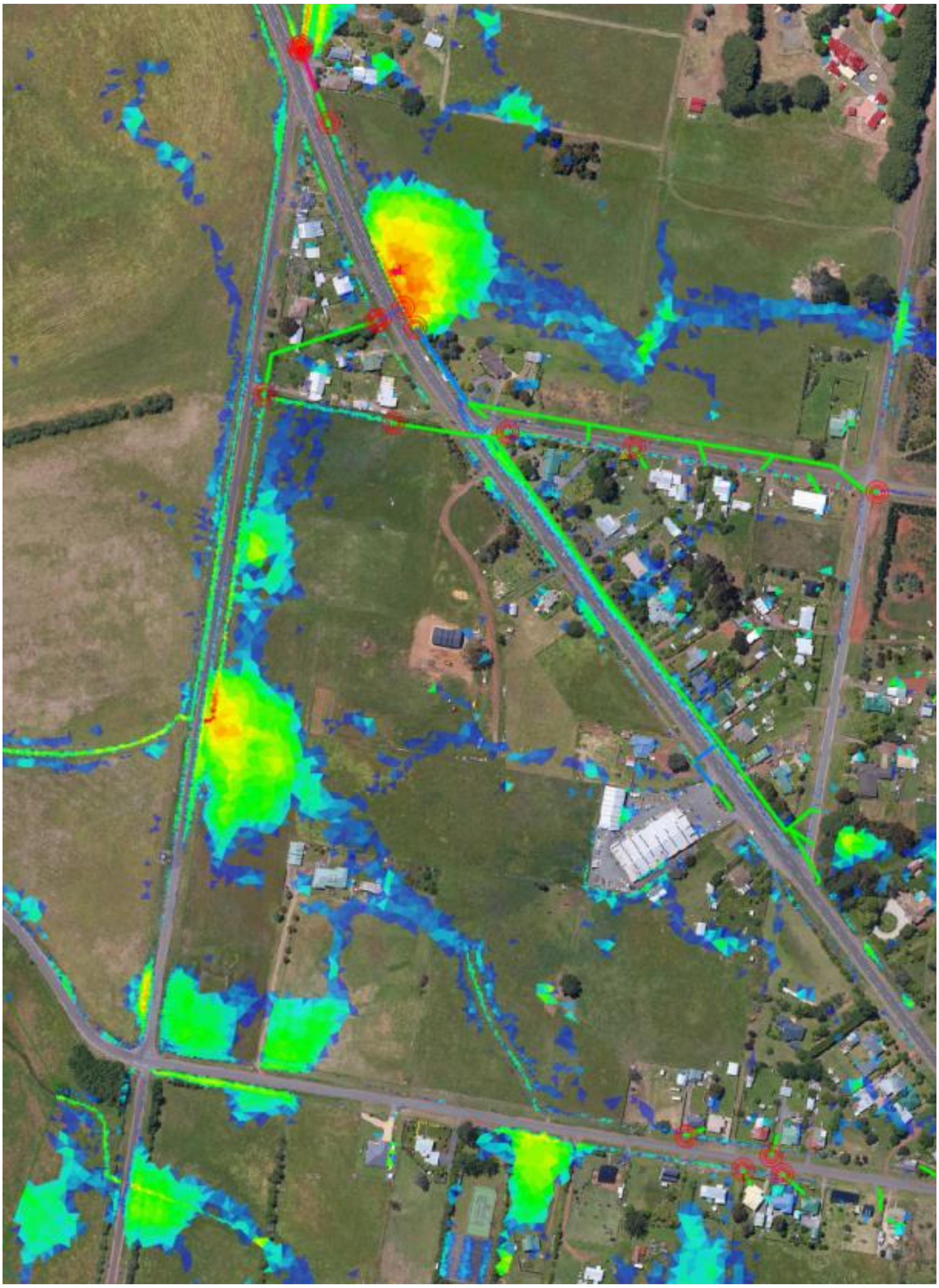


Figure 5. 1% AEP, 2-hour duration (storm burst no. 7) (flooding >20mm deep)

There is a gully running east to west through the middle of the catchment with flooding over Grant Street to no. 1a High Street during the 1% AEP. This is shown in Figure 7. The flooding over Grant Street is very shallow and it passes west through no. 21 Grant Street, nos. 1 to no. 7 Bond Street, then to no. 1a High Street where it is contained in the carriageway.

This flooding has the potential in particular to affect Bond Street properties and any dwellings constructed since the aerial photo was taken.

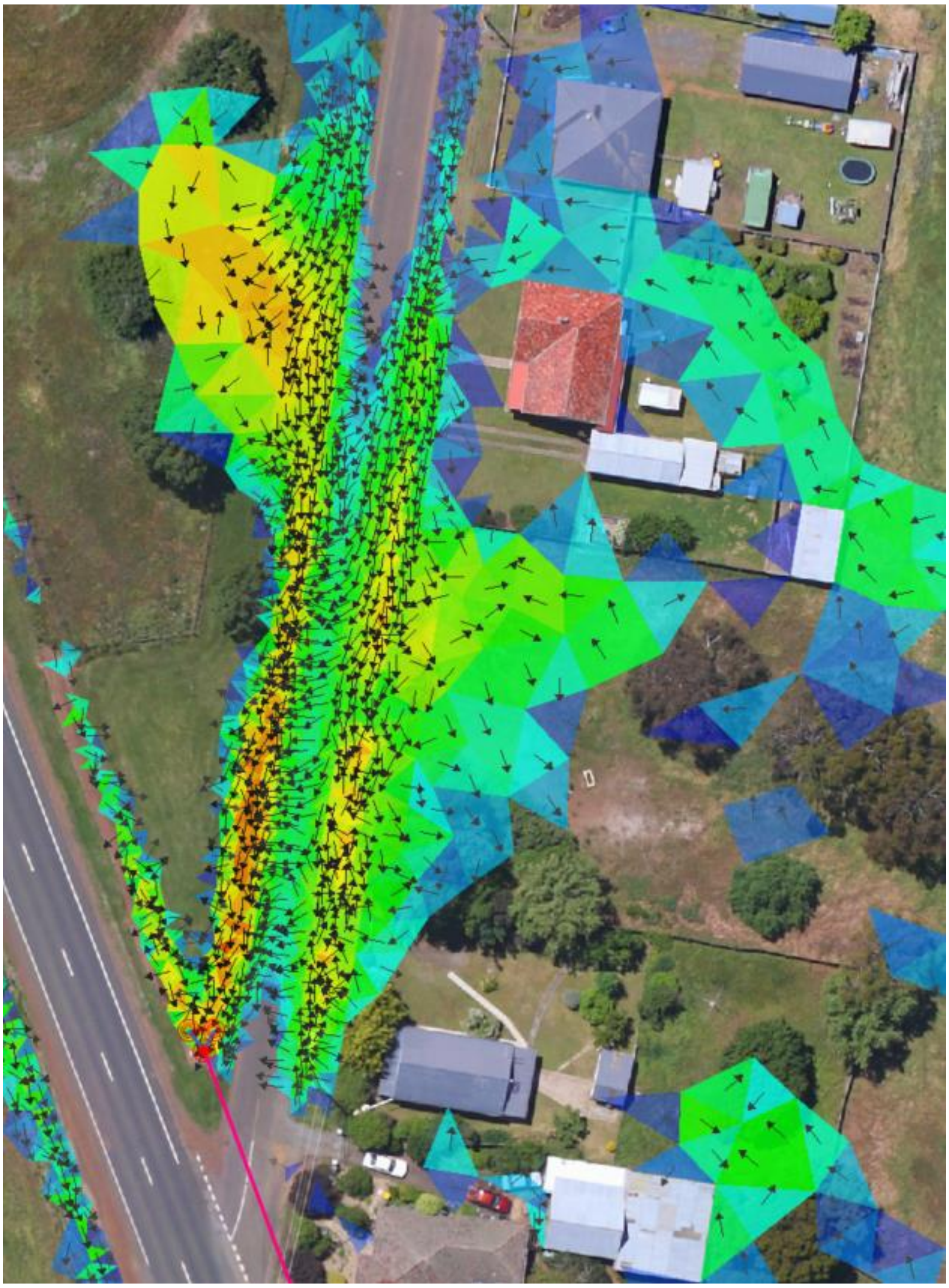


Figure 6. No. 5 West Street flooding, 1% AEP, 2-hour duration (storm burst no. 7) (flooding >20mm deep)

The flooding on the eastern side of High Street exceeds 700mm depth during the 10% AEP and 1m during the 1% AEP. There is currently no development within this area, however it had been flagged here so it will be considered if any new developments are proposed.

The rest of the flooding is relatively shallow, expect for in the vicinity of no. 3 Bond Street where it is up to 200mm deep during the 1% AEP.

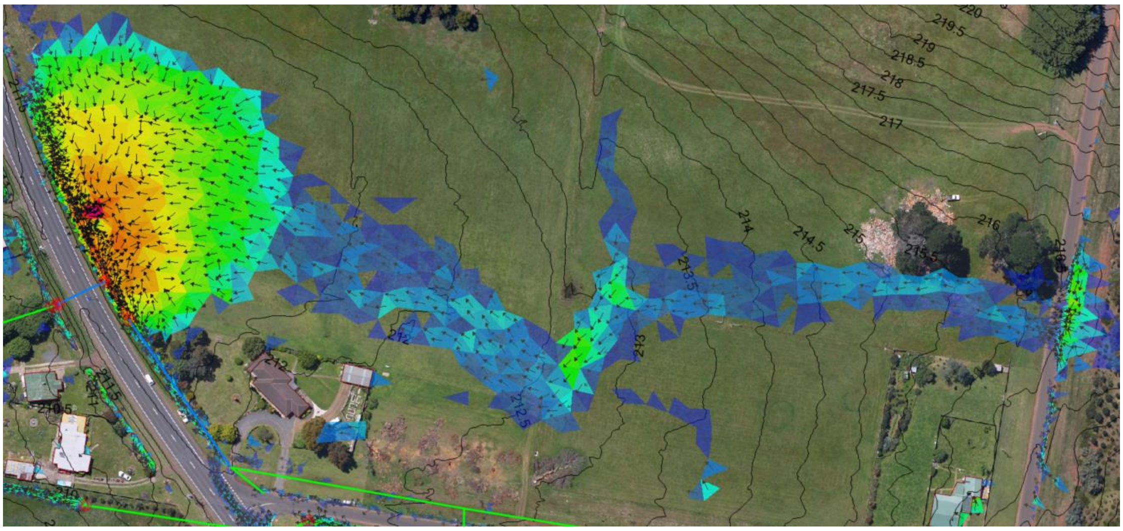


Figure 7. Grant Street to High Street flooding, 1% AEP, 2-hour duration (storm burst no. 7) (flooding >20mm deep)

At the southern end of the catchment ponding is expected against West Street, refer to Figure 8. Flooding in the open drain is approximately 700mm deep during the 10% AEP and 800mm during the 1% AEP. The existing culvert was not included in the asset data used to build the model so unless this culvert is blocked it is likely that the footprint would be reduced.

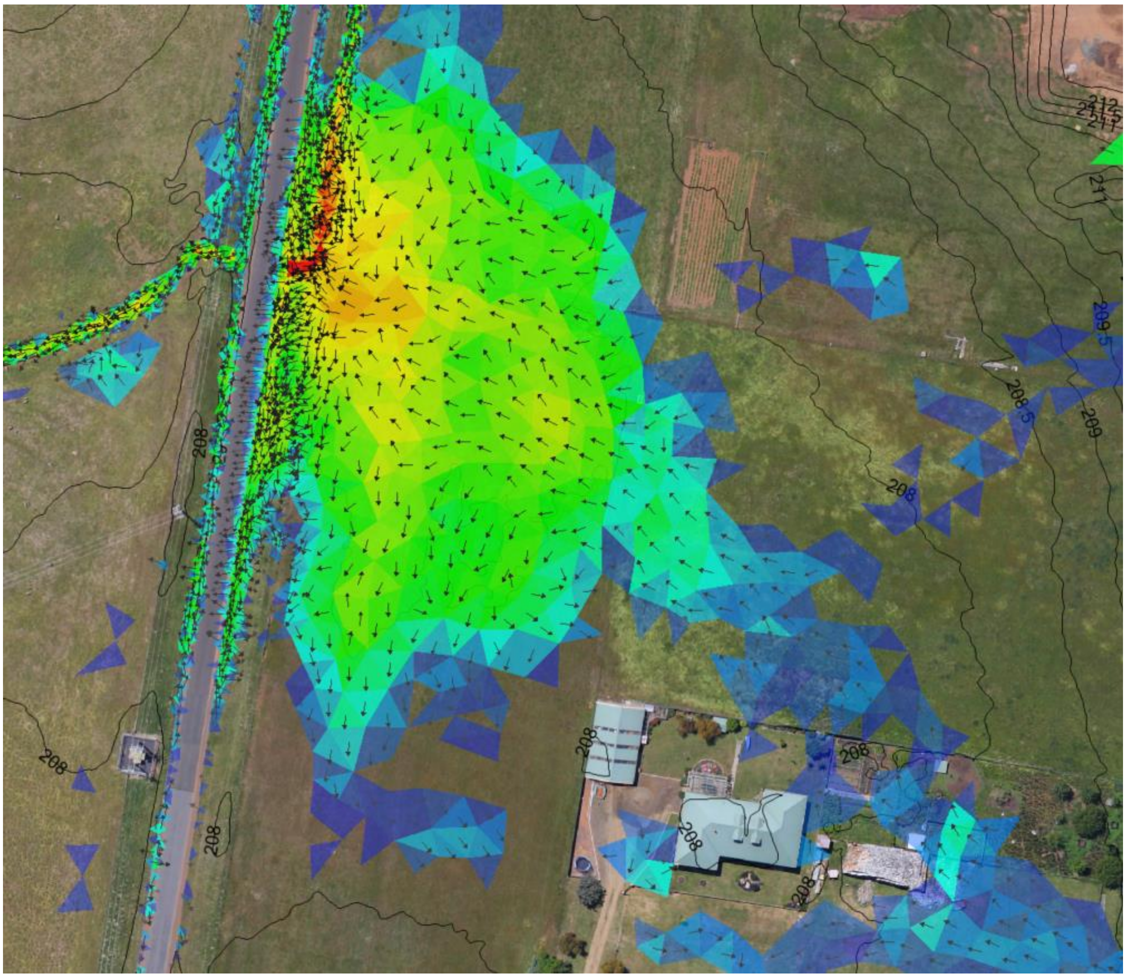


Figure 8. No. 28 West Street flooding, 1% AEP, 2-hour duration (storm burst no. 7) (flooding >20mm deep)

Finally, there is also some ponding shown on the southern side of Pedder Street and at the intersection of Pedder Street and Macquarie Street. This flooding is generally within paddocks however the absence of culvert asset data in the model likely overestimates flood footprints.

Risk	Likelihood	Consequence	Classification
Flooding of to nos. 3 and 5 West Street	Moderate/Rare	Insignificant	Low
Flooding of nos. 1 to 5 Bond Street	Moderate/Rare	Insignificant	Low
Flooding of paddock in no. 1a High Street adjacent to the roadway	Moderate/Rare	Moderate	High

Table 5. West Street (north) stormwater system risk assessment

Action	Priority
Update model to include new development in Bond Street. Conduct additional assessment on flood risks. Work to better define the open drain to the rear of these properties may be required	Low
Update the model to include missing culverts in Pedder Street and West Street	Low
Inspect and assess culvert inlets. Consider headwalls to prevent blockages and upgrades to network to reduce flood footprints. Ensure flood footprints are transferred to NMC Intramaps.	High

Table 6. West Street (north) stormwater system action plan

5.2 EAST STREET STORMWATER SYSTEM

The East Street stormwater system drains High Street from the Pedder Street intersection to the Church Street intersection. It also drains Church Street back to the Glenelg Street intersection.

Figure 9 shows the network and Figures 10 and 11 show peak flooding during the 10% and 1% AEP respectively, based on flows from the DN750 outlet south of the War Memorial football ground.

During the 1% AEP surcharging from the pipeline between Glenelg and Church Streets and from the adjacent roads has the potential to direct flooding towards the school, refer to Figure 12. This flooding may exceed 300mm against the building on the eastern side of the Glenelg Street and Church Street intersection.

Ponding in excess of 300mm deep is noted in the car parking area during both AEPs on the northern side of Church Street opposite the entrance to the Community Service. This may be unsafe for small vehicles as per Hazard Vulnerability Classification H2 during the major event.


Figure 9. East Street stormwater system extent

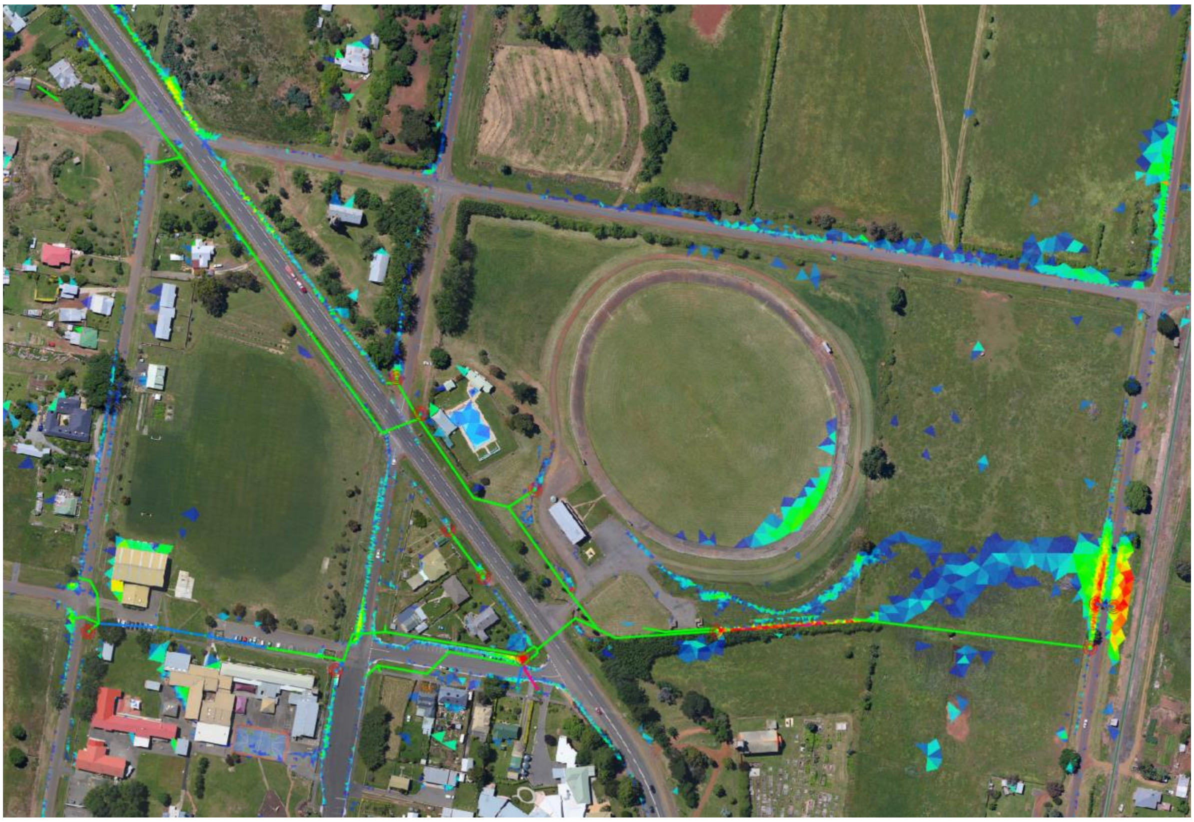


Figure 10. 10% AEP, 15-minute duration (storm burst no. 1) (flooding >20mm deep)

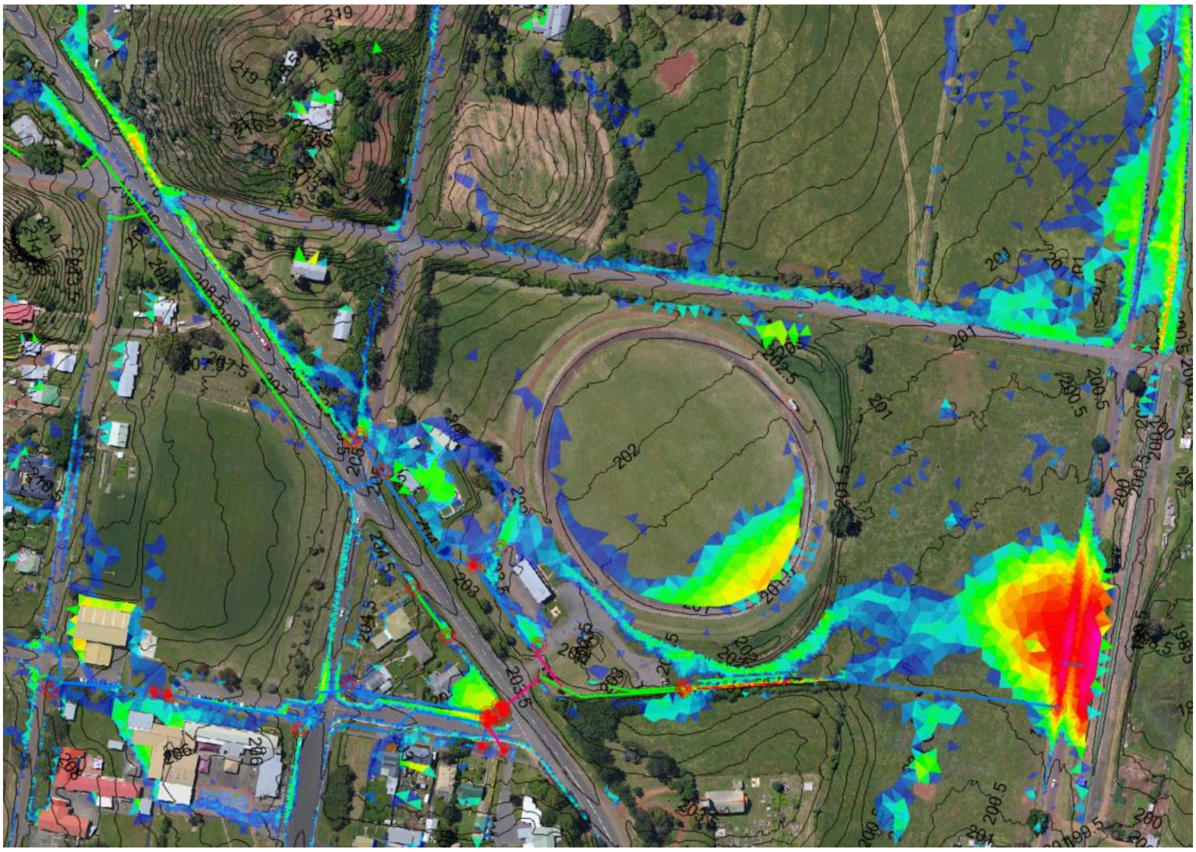


Figure 11. 1% AEP, 45-minute duration (storm burst no. 1) (flooding >20mm deep)

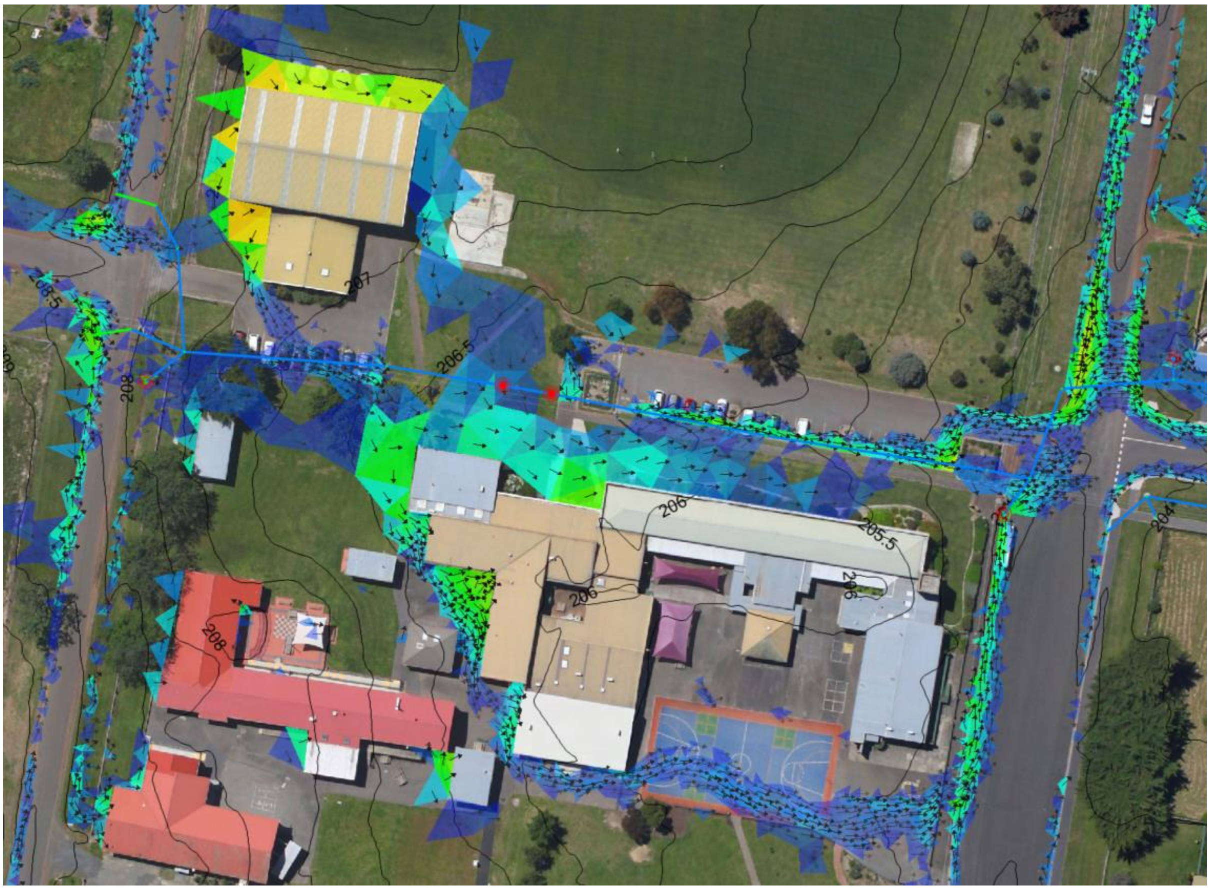


Figure 12. 1% AEP, 45-minute duration (storm burst no. 1) (flooding >20mm deep)

Modelling indicates there may also be a small amount of flooding in the south-east corner of no. 68 High Street originating from the open drain on High Street and from overtopping of the Church Street kerb. This flooding peaks at 200mm depth against the dwelling, refer to Figure 13.

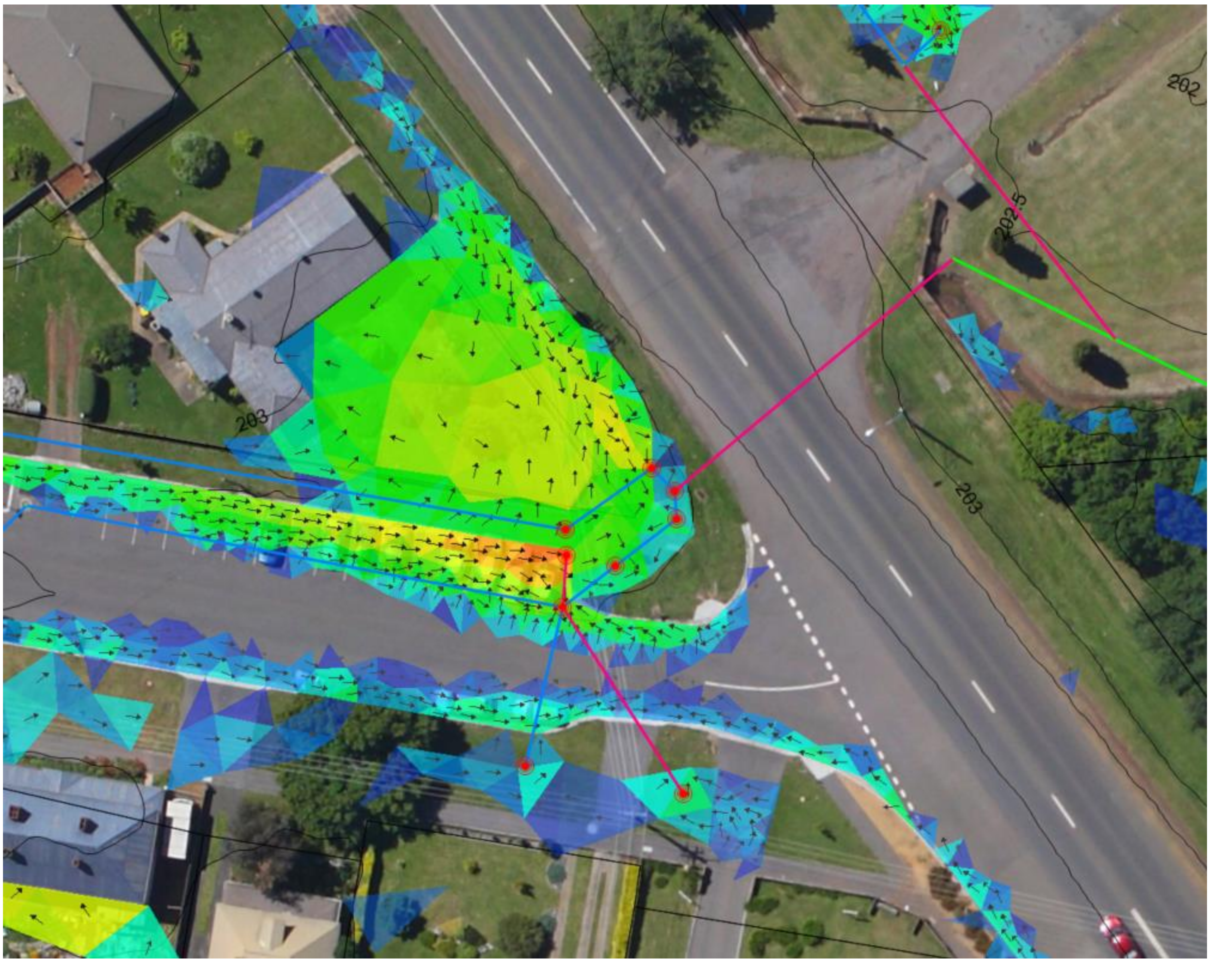


Figure 13. No. 68 High Street flooding, 1% AEP, 2-hour duration (storm burst no. 1) (flooding >20mm deep)

Figures 10 and 11 show a significant flood footprint over East Street. Flood depths peak at 800mm during the 1% AEP but are less than 300mm during the 10% AEP. Modelled flooding is exacerbated by the lack of a culvert under the rail line in the model.

Risk	Likelihood	Consequence	Classification
Flooding of Campbell Town District High School	Rare	Minor	Low
Flooding of eastern end of Church Street	Moderate/Rare	Minor	Medium
Flooding of no. 68 High Street from the adjacent open drain and kerb	Moderate/Rare	Insignificant	Low
Flooding of East Street	Moderate/Rare	Insignificant/Moderate	Medium

Table 7. East Street stormwater system risk assessment

Action	Priority
Consider the potential for flooding of the high school. Connections to the public network from school buildings may need to determined and the model updated	Low
Investigate the effectiveness of drainage pipes/pits and the eastern end of Church Street. Ensure the potential for road flooding is limited to <300mm flood depth	Medium
Consider the potential for flooding of no. 68 High Street and the adjacent carpark in Church Street. Verify whether flooding has occurred in the past and consider upgrading pipes, pits and/or open drain	Low
Update model to include the rail culvert in the vicinity of East Street to determine impacts on East Street	Medium

Table 8. East Street stormwater system action plan

5.3 WILLIAM STREET STORMWATER SYSTEM

The William Street subcatchment has a small stormwater system on the eastern side of High Street, as per Figure 14. No issues were identified in the 10% AEP. Figure 15 shows the flood footprint during the 1% AEP. It shows flooding from the open drain on the northern side of William Street which migrates across the road into no. 1 William Street. Google Streetview shows an apparent culvert in the open drain at the corner of William and East Streets for which asset data was not imported into the model. This will likely remove flooding of the private property.

There also appears to be some flooding from the open drain on the southern side of the road which overtops due to the absence of driveway culverts. There is a risk of some yard flooding impacting upon nos.1 and 3 East Street, due to the elevated level of East Street relative to the yards. The depth of the resulting flooding shown against the dwellings is less than 100mm. There may be an additional culvert crossing of unmade East Street which was also not included in the model. Addition of the culvert to the model would likely remove the flooding shown.

Figure 14. William Street stormwater system extent

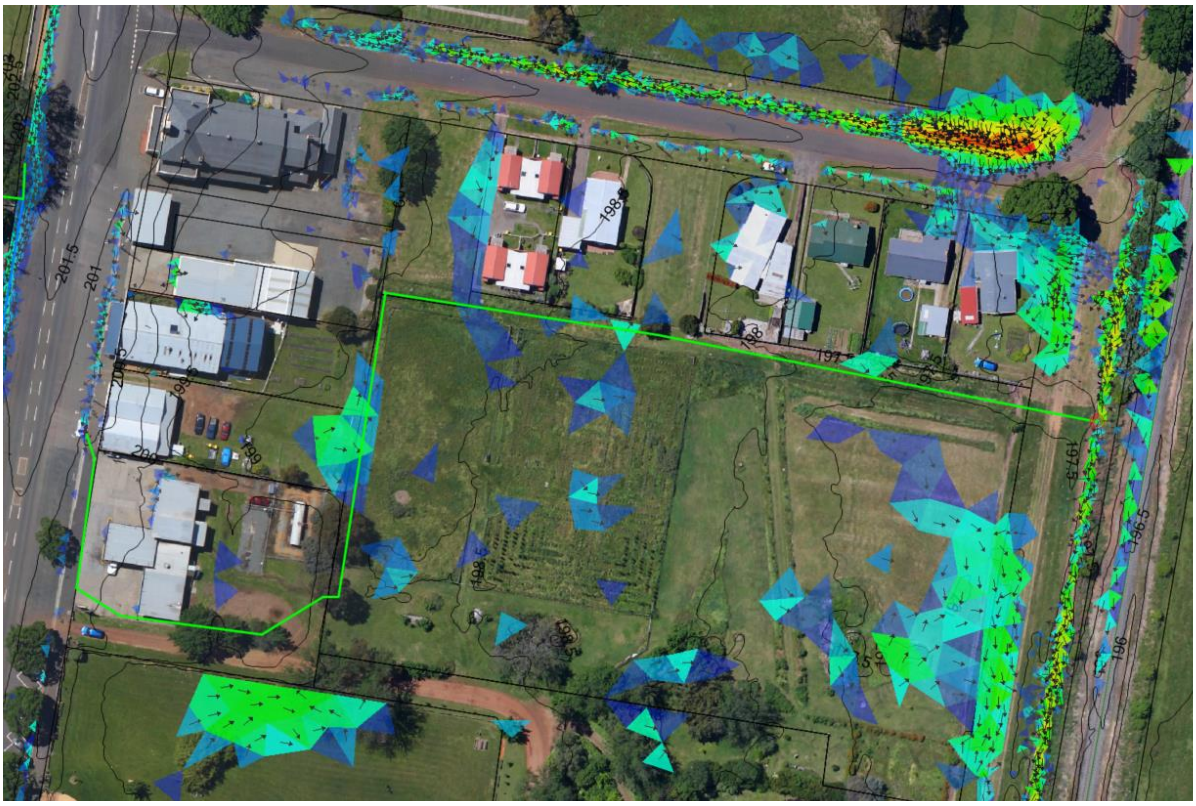


Figure 15. 1% AEP, 15-minure duration (storm burst no. 4) (flooding >20mm deep)

Risk	Likelihood	Consequence	Classification
Flooding of nos. 1 and 3 William Street due to flooding from open drains	Rare	Insignificant	Low

Table 9. East stormwater system risk assessment

Action	Priority
Update model to include William Street and East Street culverts to confirm the risks of flooding to no. 1 William Street	Low

Table 10. East Street stormwater system action plan

5.4 COMMONWEALTH LANE STORMWATER SYSTEM

The Commonwealth Lane stormwater system drains via two outfalls towards the rail line on the eastern side of Campbell Town, refer to Figure 16. The network performs well during the minor and major AEPs exempt for some road flooding which bypasses the last side-entry pit adjacent the Grange Meeting and Function Centre. Some flooding is shown to pass into the Function Centre Property during both AEPs. Figure 17 presents the peak duration burst result based on flows from the DN300 outfall adjacent the rail line in the 1% AEP. Flooding against the building is estimated to peak at 140mm during this event.

There remains capacity in the adjacent stormwater system during the 1% AEP, so flooding could be mitigated by ensuring road pits have sufficient capacity to capture road flows.

Figure 16. Commonwealth Lane subcatchment extent

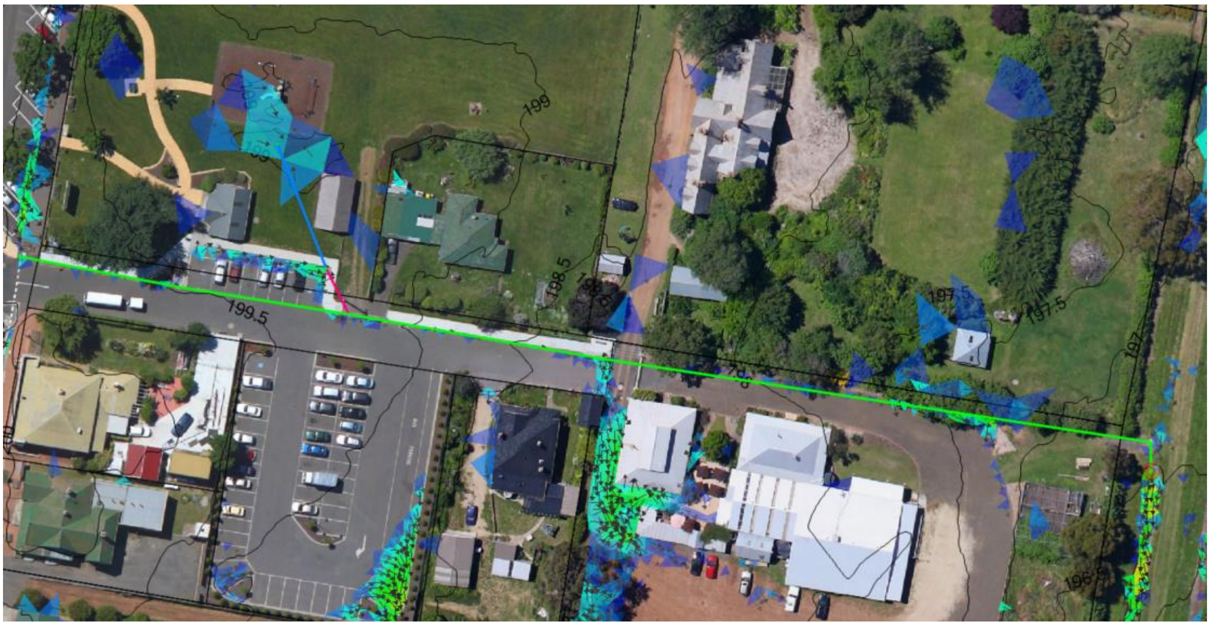


Figure 17. 1% AEP, 15-minure duration (storm burst no. 4) (flooding >20mm deep)

Risk	Likelihood	Consequence	Classification
Flooding of no. 4 Commonwealth Lane (Grange Meeting and Function Centre)	Moderate/Rare	Insignificant	Low

Table 11. Commonwealth Lane stormwater system risk assessment

Action	Priority
Consider upgrading existing SEP to LGAT standards and/or construct additional pits to prevent road flooding from passing to private property	Low

Table 12. Commonwealth Lane stormwater system action plan

5.5 KING STREET (EAST) STORMWATER SYSTEM

The King Street (east) stormwater system drains a small portion of High Street and the eastern end of King Street, refer to Figure 18. The network has limited capacity during the minor AEP, as shown in Figure 19. Some surcharge is expected from the pits at the intersection of King and High Street during both AEPs with shallow flooding contained within the road easement.

Figure 20 shows 1% event flooding based on flows from the DN300 outlet.

Figure 18. King Street stormwater system extent

Figure 19. 10% AEP, 15-minute duration (storm burst no. 6) (flooding >20mm deep)

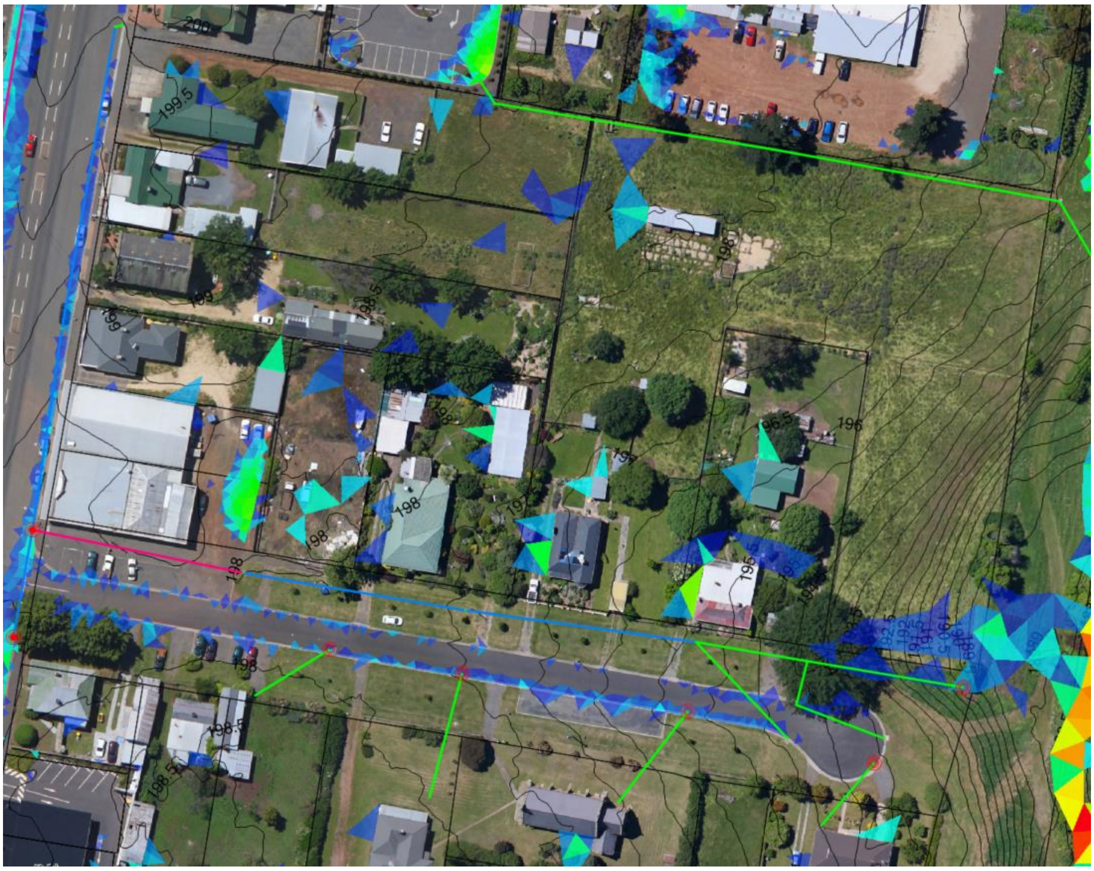


Figure 20. 1% AEP, 15-minute duration (storm burst no. 7) (flooding >20mm deep)

5.6 HIGH STREET (SOUTH) STORMWATER SYSTEM

The High Street (south) stormwater system is a narrow network which extends from Elizabeth Court to its DN375 outlet to the Elizabeth River near the Red Bridge. Figure 21 shows the extent of the network. The figure has been rotated so that west is at the top of the image and east at the bottom.

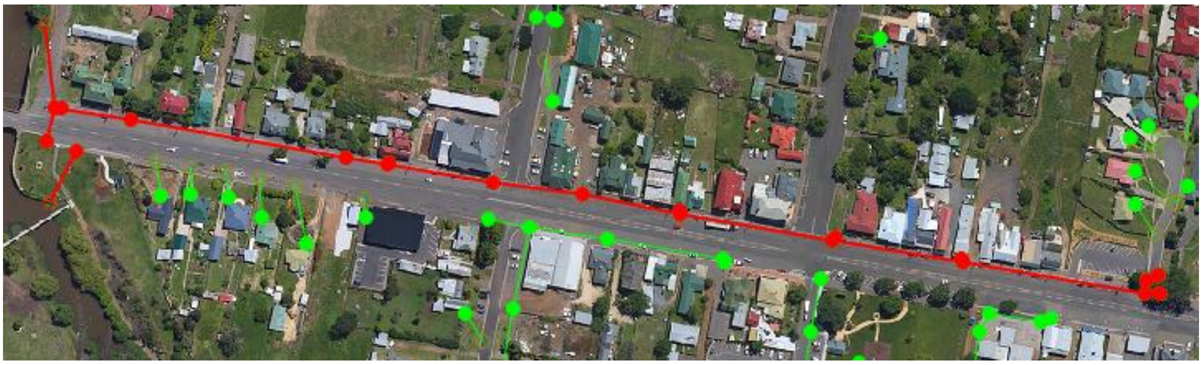


Figure 21. High Street (south) stormwater system extent (rotated 90 degrees)

There is some surcharge within the network during the 10% AEP however no flooding out of it is shown, refer to Figure 22:

Figure 22. 10% AEP, 15-minute duration (storm burst no. 8) (flooding >20mm deep) (rotated 90 degrees)

Some contained flooding is expected in the road easement, particularly on the western side of the road to the north of the Queen Street intersection. Road flooding is exacerbated during the major event with some pits contributing flows through surcharging, see Figure 23. Road flooding appears to be contained in the kerb and channel and has a low hazard vulnerability classification during the major AEP.

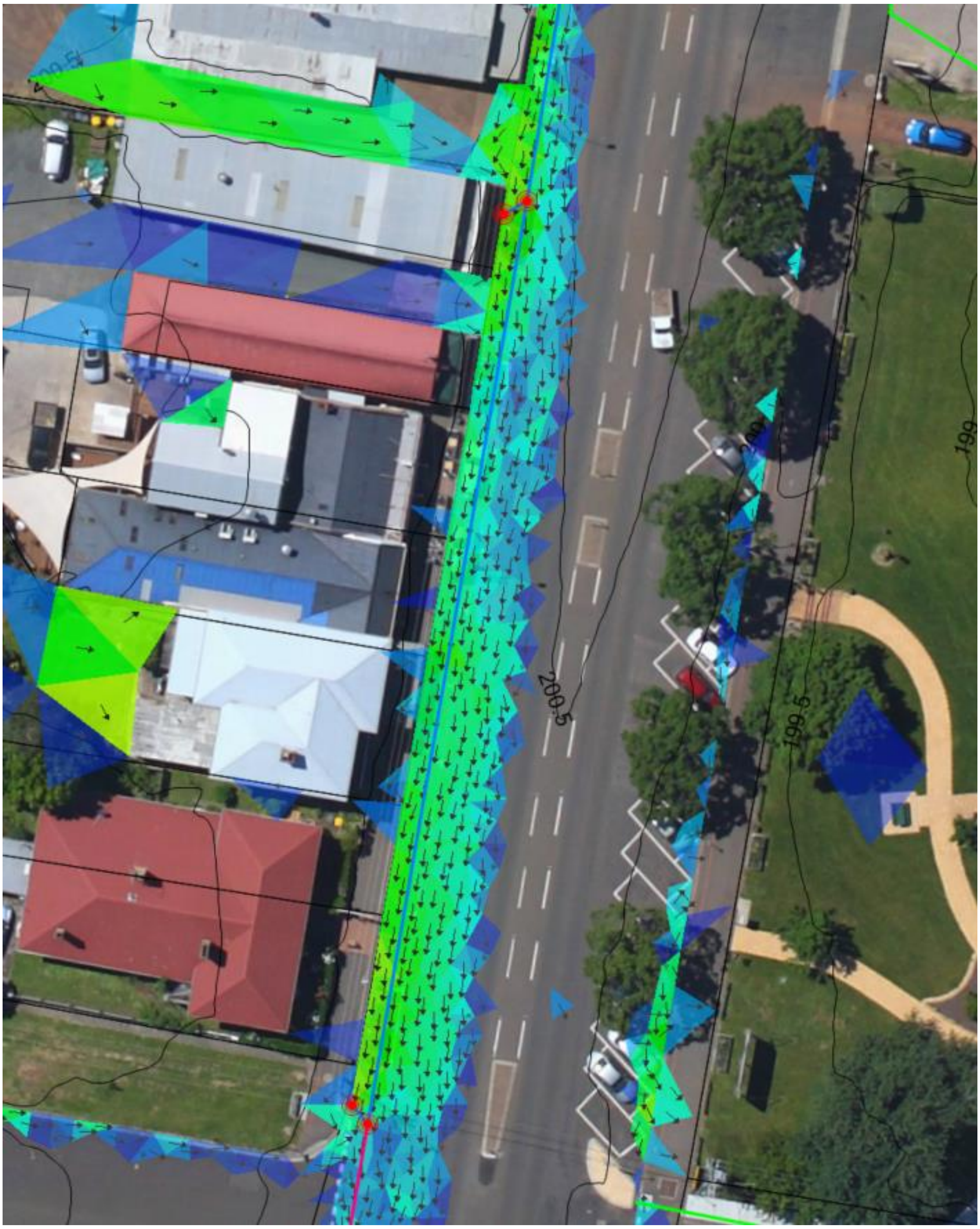


Figure 23. 1% AEP, 15-minute duration (storm burst no. 9) (flooding >20mm deep)

5.7 BRIDGE STREET STORMWATER SYSTEM

The Bridge Street stormwater system is shown in Figure 24. The figure has been rotated so that west is at the top of the image and east at the bottom. This is the largest stormwater network in Campbell Town. It extends from Hamilton Street to the Elizabeth River. It also collects Queen Street (Glenelg Street to Bridge Street) and part of King Street.

Figures 25 and 26 the minor 10% and major 1% storm burst results respectively.

Figure 24. Bridge Street stormwater system extent (rotated 90 degrees)

The network performs well during the 10% AEP with some minor surcharging contained within the network.

Some flooding across Queen Street is anticipated during the minor event, flooding which is also predicted to pass through no. 128 Bridge Street during the major event. This property lies within a natural gully that extends south from no. 128, with flooding also flowing through nos. 130 to 138 through to King Street. From King Street the stormwater passes through the paddock at no. 20-30 King Street, as shown in Figure 27. The predicted overland flows are shallow and are unlikely to cause internal flooding.

Full-width flooding is predicted on the eastern side of the King Street and Bridge Street intersections during the minor and major events. It is fully contained within the roadway and poses no safety risk to pedestrians or vehicles. The pipe retains capacity in the minor event so additional inlet pits may alleviate the flooding.

Figure 25. 10% AEP, 20-minute duration (storm burst no. 9) (flooding >10mm deep) (rotated 90 degrees)

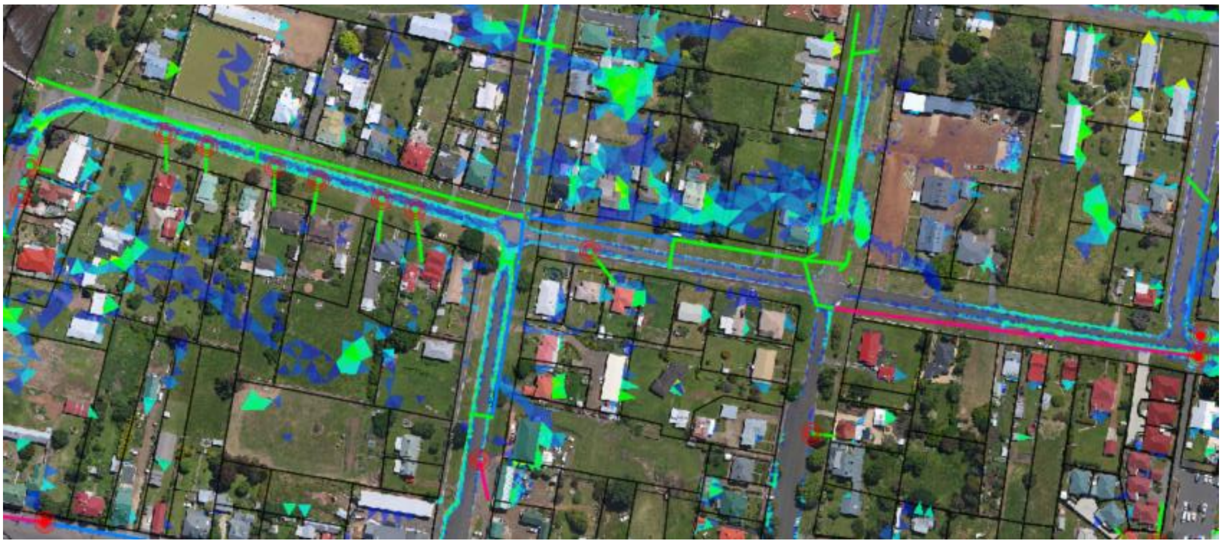


Figure 26. 1% AEP, 15-minute duration (storm burst no. 2 (flooding >10mm deep) (rotated 90 degrees)

Risk	**Likelihood**	**Consequence**	**Classification**
Road flooding of Queen Street	Moderate/Rare	Insignificant	Low
Flooding of no. 128 to 138 Bridge Street though to no. 20-30 King Street	Rare	Insignificant	Low
Flooding of eastern side of King and Bridge Street intersection	Moderate/Rare	Insignificant	Low

Table 13. Bridge Street stormwater system risk assessment

Action	**Priority**
Consider installing an additional road pits on the northern side of the road at the sag in Queen Street. Remodel the effects to ensure overflows are not passed to Bridge Street private properties	Low
Consider raising driveways of nos. 18 and 20-30 King Street and 140 Bridge Street and installing additional pits in the sag in King Street	Low
Provide additional pits or upgrade existing SEPs on the eastern side of the King and Bridge Street intersections	Low

Table 14. Bridge Street stormwater system action plan

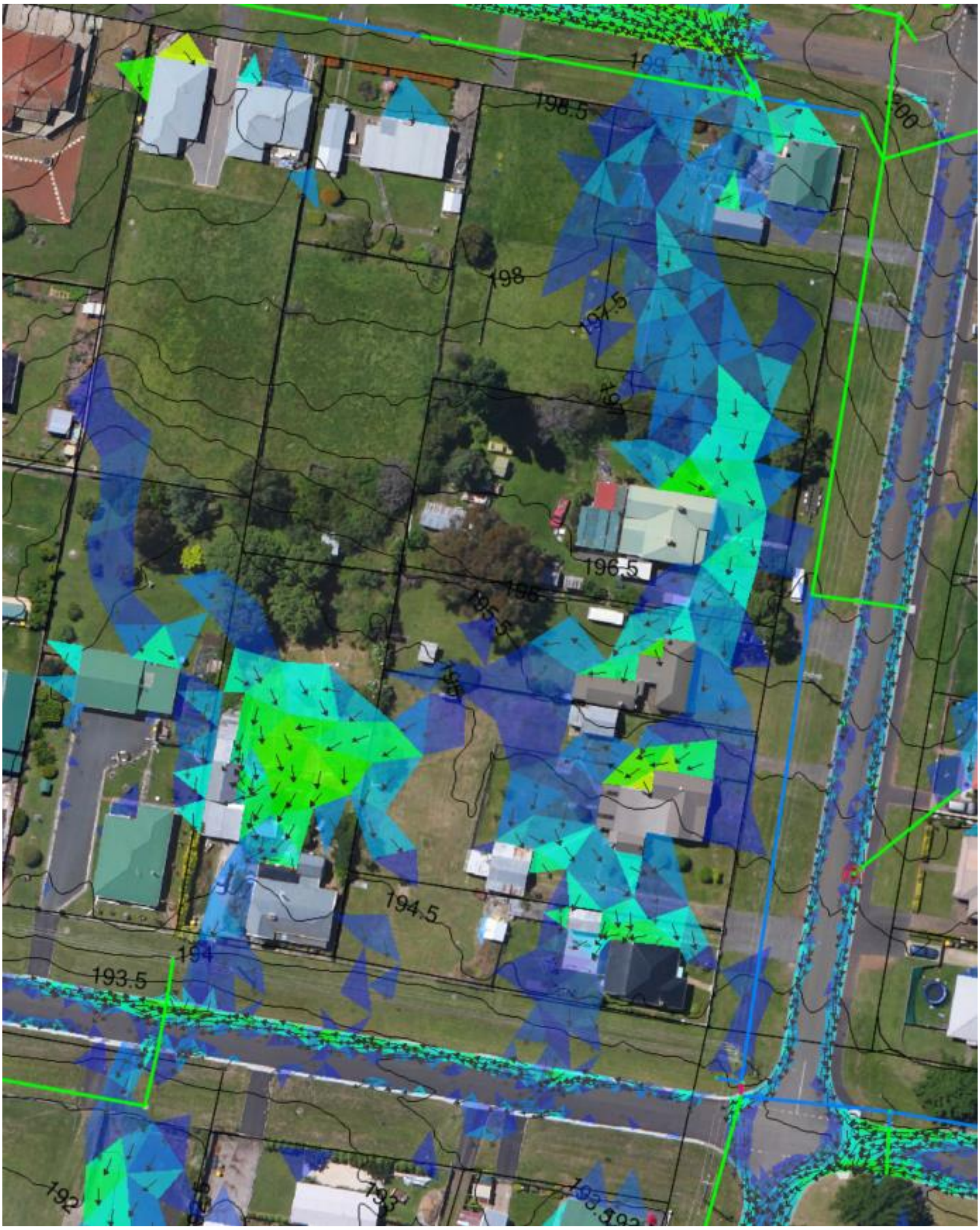


Figure 27. Bridge Street flooding: 1% AEP, 30-minute duration (flooding >10mm deep)

5.8 KING STREET (WEST) STORMWATER SYSTEM

The small King Street (west) stormwater system is located on the western side of Campbell Town adjacent to the Elizabeth River. The piped network collects the western end of King Street as well as Glenelg Street (from Queen to King Streets), refer to Figure 28. Figures 29 and 30 show peak flooding during the 10% and 1% AEP respectively based on flows from the DN450 outlet on the Elizabeth River.

No risks were identified in either the minor or major event.

Figure 28. King Street (west) stormwater system extent

Figure 29. 10% AEP, 10-minute duration (storm burst no.10) (flooding >20mm deep)

Figure 30. 1% AEP, 30-minute duration (storm burst no.9) (flooding >20mm deep)

APPENDIX A – MODEL SETTINGS (Ref. Infoworks ICM Help File, DRAINS User Manual, ARR2016)

A.1 HYDROLOGY

Modelling was undertaken using Infoworks ICM. ICM allows a variety of runoff volume and routing models, as well as the ability for the user to define the manner in which losses are applied. Parameters within these models can be adjusted to better replicate the response of real-world catchments to rainfall.

There is difficulty in applying the Australian Rainfall and Runoff (ARR2016) initial loss (IL) and continuing loss (CL) in Infoworks ICM. The IL/CL regime can easily be applied to Infoworks 1D subcatchments however there is no facility to use this when applying rainfall directly to the 2D mesh. The other issue is that the rainfall patterns provided in the ARR Data Hub are bursts. It is necessary to subtract pre-burst rainfall from the initial loss of the storm (IL_S) to determine the initial loss of the burst (IL_B), refer to Figure A1.1. Pre-burst rainfall depths are only available from the ARR Data Hub for storms with durations of 1 hour and greater, where for small urban catchments the critical storm durations are usually less than 1 hour.

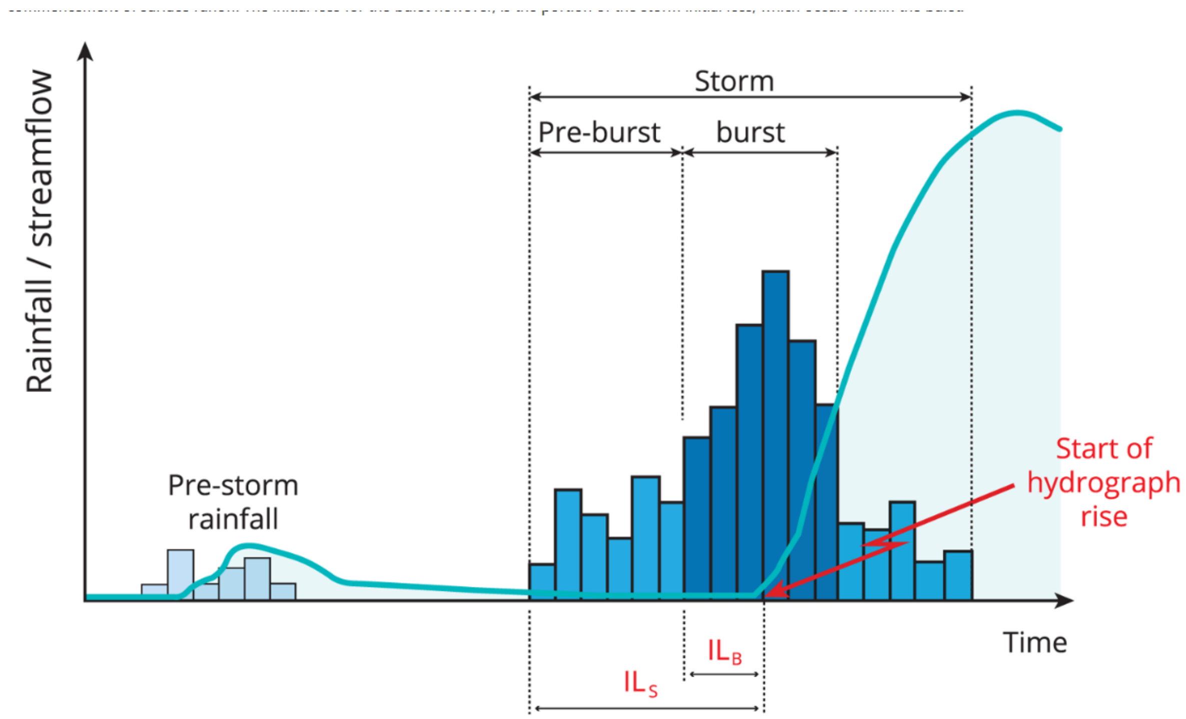


Figure A1.1. Distinction between storm and burst initial loss

In the absence of actual rainfall and flow response data with which to calibrate the model it was deemed appropriate to adopt the "Fixed" and "Horton" runoff models to represent the runoff from impermeable and permeable surfaces respectively for the purposes of this assessment.

"Fixed" is commonly used for such purposes and the "Horton" model is able to be better aligned to the ARR2016 guidelines. It was decided to make use of the "SWMM" non-linear routing model for the routing of volume, which allows the use of a Manning's roughness coefficient. The setup of the roof surfaces for subcatchments, which drain directly to pits and conduits, or to the road via kerb connections, is provided in Table A1 below:

Runoff surface ID	Description	Runoff routing type	Runoff routing value	Surface type	Ground slope (m/m)	Routing model	Fixed runoff coefficient
20	ROOF	Absolute	0.01	Impervious	0.05	SWMM	1

Table A1.1. Subcatchment surfaces

Roofs were given a fixed runoff coefficient of 1. ARR2016 indicates a storm initial loss of 1-2mm is appropriate for effective impervious areas and no continuing losses. Pre-burst rainfall would reduce this initial storm loss, so for simplicity no initial loss has been applied. Given that only 1D roofs are directly connected to the 1D pipe and pit network any neglected burst initial losses effectively act to marginally increase flows to the adjacent pipes and pits. These small additional inflows could be considered to be drainage from hardstand within these properties which is directly plumbed to the network.

Kerb connections have been rationalised where required and drain to the adjacent road mesh via a 2D outfall.

The setup of the infiltration surfaces for rainfall which was applied to direct to 2D mesh elements is as follows:

ID	Infiltration type	Horton initial (mm/hr)	Horton limiting (mm/hr)	Horton decay (1/hr)	Fixed runoff coefficient
Horton	Horton	33.7	3.9	2	
Road	Fixed				1
Roof	Fixed				1

Table A1.2. Runoff surfaces

The Horton infiltration model was used to provide a typical conservative hydrology for all pervious and remaining areas. The Horton infiltration model is as follows:

$$f = f_c + (f_0 - f_c)\, e^{-kt} \quad (1)$$

where:

f_0 is the initial infiltration rate (mm/hr)

f_c is the final (limiting) infiltration rate (mm/hr)

k is the coefficient of the exponential term (1/hr)

Within this infiltration model US Soil Conservation Services type C soils are defined as follows:

Soils in this group have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure

(https://engineering.purdue.edu/mapserve/LTHIA7/documentation/hsg.html)

A 'rather wet' antecedent moisture condition (AMC) was assumed, to take into account pre-storm and pre-burst rainfall:

Number	Description	Total rainfall in 5 days preceding the storm (mm)
1	Completely dry	0
2	Rather dry	0 to 12.5
3	Rather wet	12.5 to 25
4	Saturated	Over 25

Table A1.3. Antecedent moisture conditions

Factor	Soil Type			
	A (or 1)	B (or 2)	C (or 3)	D (or 4)
Initial Rate, f_0 (mm/h)	250	200	125	75
Final Rate, f_c (mm/h)	25	13	6	3
Shape Factor, k (h^{-1})	2	2	2	2
Antecedent Rainfall Depths (mm) for AMCs:				
1	0	0	0	0
2	50	38	25	18
3	100	75	50	38
4	150	100	75	50
Initial Infiltration Rates (mm/h) for AMCs:				
1	250	200	125	75
2	162.3	130.1	78.0	40.9
3	83.6	66.3	33.7	7.4
4	33.1	30.7	6.6	3.0

Table A1.4. Horton infiltration model parameters

Therefore, for soil type C and an AMC of 3 the initial infiltration rate, f_0, was set to 33.7 mm/hr as per Table A1.4.

The Australian Rainfall and Runoff data hub (http://data.arr-software.org/) recommends a continuing loss (CL) of 3.9 mm/hr for rural catchments at Campbell Town. Therefore, the final (limiting) infiltration rate, f_c, was set to 3.9 mm/hr. The Horton coefficient, k, was set to 2.

A.2 2D ROUGHNESS COEFFICIENTS

Table A2.1 shows the Manning's 'n' roughness coefficients that were generally applied to the 2D land use types:

Landuse Type	Mannings 'n' roughness coefficient
Building (roof)	0.016
Roads (asphalt/concrete)	0.018
Railway	0.05
Open drain/channel	0.02
Grass/general green areas (set as default)	0.04
Ponds/Dams	0.02
Thick vegetation/trees	0.12

Table A2.1. Manning's roughness representation

A.3 2D ROADWAYS

Roadways with kerb and channel were usually artificially dropped 150mm to provide defined roadways for road flows.

A.4 PIPE ROUGHNESS

In the absence of specific data or CCTV pipe roughness was set to the following Colebrook-White values for different materials:

PP BlackMax/Stormpro:	0.02
PVC:	0.02
Concrete/VC:	0.6
Unknown:	0.6

A.5 MANHOLE/ENERGY LOSS DUE TO TURBULENCE

Infoworks ICM calculates headloss at the top of each conduit, to represent the energy lost due to turbulence at the transition between a manhole and a conduit. It is also calculated at the bottom of each conduit to represent the loss at transition from conduit to manhole. There is greater turbulence, and therefore headloss, at the top of a conduit.

The headloss equation is presented below:

$\Delta h = ku * ks * kv * (v^2/2g)$ (1)

where:

Δh = headloss

ku = user defined headloss factor

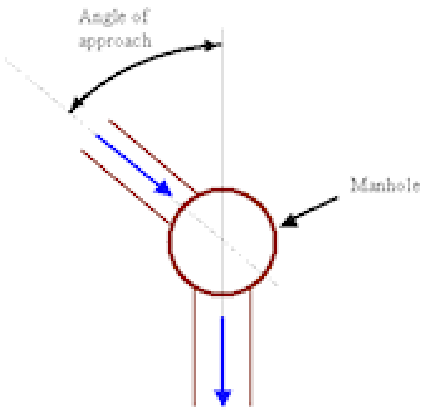
ks = surcharge ratio coefficient

kv = velocity coefficient

v = flow velocity (m/s)

g = acceleration due to gravity (m/s^2)

The headloss factor (Ku) was defined as follows by the angle of approach to the manhole:



Angle of Approach	Ku
30	3.3
60	6.0
90	6.6
>90	8.0

Figure A5.1. Manhole headloss factors (Ku)

For the normal and high headloss types the surcharge ratio coefficient (ks) and the velocity coefficient are hard coded into Infoworks ICM, as shown in the following figure:

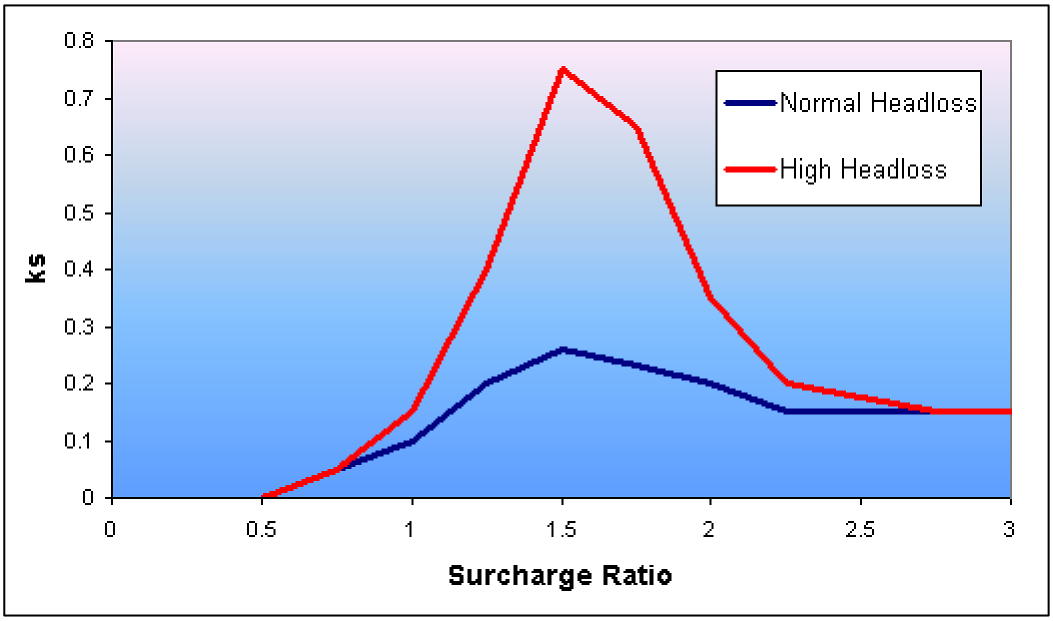


Figure A5.2. Surcharge ratio coefficients (Ks)

The internal condition of individual manholes and pits within the stormwater system is unknown. It has been assumed that all manholes are well-constructed and as such 'normal' headloss type has been assumed. 'High' headloss is appropriate for badly constructed manholes that are benched only to half pipe height. When actual condition of manholes is determined then these headloss types may be individually changed in future.

A.6 GULLY PIT INLET PARAMETERS

For simplicity it has been assumed that all pits have a hydraulic capacity as per a 1220mm side entry pit in sag conditions. Refer to LGAT Standard Drawing TSD-RF03-v1:

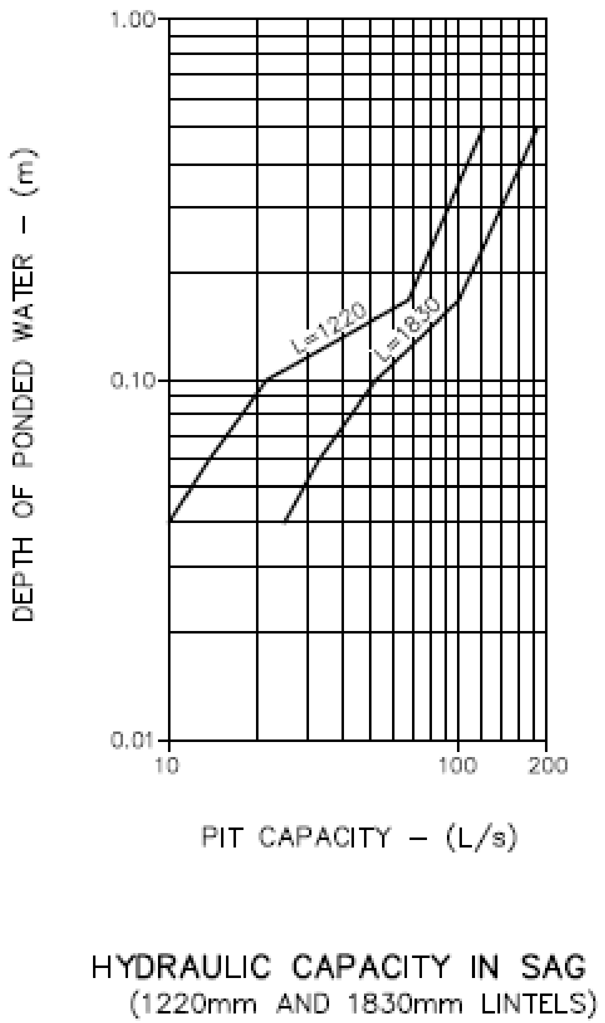


Figure A5.3. Pit hydraulic capacity

Where larger pits were evident additional pit capacity was added. No blockages were assumed.