8. Preliminary Floodplain Management Measures

To mitigate and/or improve the flooding issues within the Blackbutt Creek catchment, the options described below were considered as part of this Floodplain Risk Management Plan. As described, these options fall within the groups of:

- Property Modification Measures
- Response Modification Measures
- Flood Modification Measures.

The initial set of flood modification measures were discussed with Council. Further consultation with the Community and Floodplain Management Committee in the following stages of the project will assist in refining and finalising the flood modification options as well as the property and response modification options.

Options were assessed based on their impacts to mitigate and/or reduce flood damage, a cost-benefit analysis, and contribution against social, economic and environmental considerations.

8.1 Overview of the Floodplain Management Options

Table 8-1 provides an overview of the preliminary property modification option which is focused on planning and development controls. Detailed description of the option is provided in Section 8.2.

Table 8-1 Preliminary Property Modification Options

Option ID	Type	Description
PM1	Planning and Development Controls	Amendments to LEP and DCP

Preliminary response modification options are summarised in Table 8-2. Detailed descriptions of each option are discussed in Section 8.3.

Table 8-2 Preliminary Response Modification Options

Option ID	Type	Description
RM1	Public Awareness	Ongoing Public Awareness Campaign
RM2	Flood Warning and Emergency Response	SES emergency flood management and response plan

Preliminary flood modification options are listed in Table 8-3. Detailed descriptions of each option are discussed in Section 8.4.

Table 8-3 Preliminary Flood Modification Options

Option ID	Description
FM1	Upgrading pit network in the vicinity of St Johns Avenue
FM2	Centre median to contain flood waters with the roadway along Vale Street
FM3	Water level management in the Killara Golf Course dam prior to flooding event
FM4	Raising footpath levels to contain flood water within the roadway along Norfolk St
FM5	Constructing a raised mound within the drainage easement along the property boundary with number 59 Bolwarra Avenue to confine flood waters within the drainage easement
FM6	Upgrading pit and pipe network in the vicinity of 21- 27 Moree St
FM7	Raising channel bank levels adjacent to property number 8 Calvert Avenue to confine flood waters within the channel
FM8	Raising the footpath level along Ryde Road to confine flood waters within the roadway to avoid overflowing on to access road area
FM9	Upgrading pit network along Browns Road

8.2 Identified Property Modification Options

As listed in Table 8-1, the property modification option identified as having potential in assisting the flood prone community is centred on planning and developed controls, specifically modifications to a number of clauses in the current LEP and DCP. Whilst there are properties located within high hazard areas, none of these is located within a main watercourse flow path and hence options such as house raising and house purchase have not been considered further at this time.

8.2.1 Option PM1: Planning and development controls

Recommended Changes to the Ku-ring-gai LEP (KLEP)

As discussed in Section 6.7, the KLEP 2015 does not include flood controls for flood liable land with flood related controls currently are only contained in Council's DCP. Hence, these are non-statutory controls and are not accompanied by an enabling clause within the LEP.

It is prudent for Council to consider inclusion of flood controls as per the Model Local Provisions for Flood Planning into the KLEP and link these controls to the KDCP provisions, eg Flood Study flood mapping and specific development controls. Note that advice from NSW Planning and Environment is that model local clauses are local clauses that have been settled by the Parliamentary Counsel's Office which address common topics raised by councils in their standard instrument LEP preparation.

The settled local provision for flood planning in the standard instrument Local Environmental Plans (for non-coastal Councils) is as follows:

S7.3 Flood planning

1. The objectives of this clause are as follows:
   a. to minimise the flood risk to life and property associated with the use of land
   b. to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change
   c. to avoid significant adverse impacts on flood behaviour and the environment.

2. This clause applies to:
   a. land that is shown as “Flood planning area” on the Flood Planning Map
   b. other land at or below the flood planning level.
3. Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:
   a. is compatible with the flood hazard of the land
   b. will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties
   c. incorporates appropriate measures to manage risk to life from flood
   d. will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses
   e. is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

4. A word or expression used in this clause has the same meaning as it has in the NSW Government’s Floodplain Development Manual published in 2005, unless it is otherwise defined in this clause.
5. In this clause:
   - flood planning area means the land shown as “Flood planning area” on the Flood Planning Map
   - flood planning level means the level of a 100 ARI (average recurrent interval) flood event plus [XX] metres freeboard
   - Flood Planning Map means the Local Environment Plan Flood Planning Map.

In applying the clause, Councils should provide a map of the flood planning area prepared in accordance with Floodplain Development Manual. Subclause (2) acknowledges that while Councils are able to go through the process and map areas as the "flood planning area", there are other areas where accurate mapping is not possible. Consequently, the wording of this subclause captures: (a) the land that can be accurately mapped; and (b) the land that cannot. Such unmapped land includes the “flood planning area” (as defined in the Floodplain Development Manual) up to the “flood planning level”.

Further details of requirements behind this clause should be provided in Councils’ DCPs.

Council is progressively producing Floodplain Risk Management Plans (and Flood Planning Maps) for each of the individual drainage catchments within the LGA. As this mapping process isn’t complete for the LGA, it is prudent for Council to adopt clause 2b) “land at or below the flood planning level” rather than referencing clause 2a) Flood Planning Maps only. This would be an interim approach which would be withdrawn once Council complete Floodplain Risk Management Plans for the entire LGA, Clause 2a) could then be adopted.

It is important that Council’s flood planning requirements are applied throughout the LGA to new development or redevelopments regardless of whether a Floodplain Risk Management Plan has been completed for the catchment or not.

Recommendation

It is recommended that Council consider inclusion of flood controls as per the Model Local Provisions for Flood Planning into the KLEP and link these controls to the KDCP provisions, eg Flood Study flood mapping and specific development controls.

Recommended changes to the Ku-ring-gai DCP (KDCP)

- Incorporate a definition for Flood Planning Area consistent with the LEP amendments (refer previous section) under Part 1B.1 of the DCP
- Update references elsewhere in the DCP to Part 24D.3 with the new terminology and references outlined above.

As discussed in Section 6.8, Part 24D of the KDCP provides Council with adequate measures to manage flood risk in the Blackbutt Creek catchment and Council LGA. It includes areas of the floodplains that are covered by a catchment wide flood study with a flood planning area map (and hence Flood Risk Precincts) and all other areas where Council deems a separate flood study is necessary.

For areas covered by Flood Planning Area mapping, the addition in the KDCP of specific land use planning measures applying to floodplains would strengthen and clarify Council's management of the flood risk. A flood planning matrix could be adopted that considers the Flood Risk Precincts (FRP), land use categories and a mix of appropriate planning controls. This matrix could be supplementary sub-section in Part 24 of the KDCP.

A Draft Flood Planning Matrix is shown in Appendix C. The matrix works around three sets of information:

- Flood Risk Precincts (FRPs) – it currently divides the floodplain up to the PMF into three precincts: High, Medium and Low based on the probability of flooding and the corresponding hydraulic hazard, with some consideration of evacuation constraints too
- Land use Categories – the matrix identifies land uses or land use types which are not appropriate within particular FRPs and others which are appropriate subject to suitable planning controls
- Planning Controls – these are a mix of prescriptive planning controls and objective based solutions which are to be applied to particular land uses within particular FRPs to manage specific planning considerations.

The amended KDCP can serve as an interim plan for managing floodplain within the Council LGA, which will be withdrawn once Council complete Floodplain Risk Management Plans for the entire LGA and then integrate outcomes from these plans into planning controls.

Recommendation

It is recommended that Council review the Draft Flood Planning Matrix and consider its inclusion in the KDCP Part 24D.

Recommended changes to the Council 149 Certificates

Section 149 Certificates

Schedule 4 of the Environmental Planning and Assessment Regulation 2000 (EPAR) identifies matters that must be shown on planning certificates issued under Section 149(2) of the EP&A Act. Clause 7A identifies the following requirements for flood related development controls information.

Clause 7A Flood related development controls information:

1) Whether or not development on that land or part of the land for the purposes of dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (not including development for the purposes of group homes or seniors housing) is subject to flood related development controls

2) Whether or not development on that land or part of the land for any other purpose is subject to flood related development controls

3) Words and expressions in this clause have the same meanings as in the Standard Instrument.

As the KLEP does not currently contain flood planning provisions prepared in accordance with the Floodplain Development Manual, it is considered that there are no flood related development controls applying in Ku-ring-gai. Any flood related controls contained in Council's DCP are non-statutory controls and are not accompanied by an enabling clause within the LEP. As such, Council's Section 149(2) certificates include the answer 'No" in respect to this matter.

One of the implications of not having flood planning provisions in place relates to the application of a number of State Environmental Planning Policies (SEPPs) and in particular the State Environmental Planning Policy (Exempt and Complying Development Codes) 2008 (Codes SEPP). Under the Codes SEPP, there are a number of additional considerations and restrictions that apply to "flood control lots" which are defined as follows:

> *"flood control lot means a lot to which flood related development controls apply in respect of development for the purposes of industrial buildings, commercial premises, dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (other than development for the purposes of group homes or seniors housing).*
>
> *Note. This information is a prescribed matter for the purpose of a certificate under Section 149 (2) of the Act."*

As there are currently no flood related development control provisions applying under the KLEP, there are considered to be no 'flood control lots" in Ku-ring-gai. Therefore, the additional considerations and restrictions under the Codes SEPP do not apply.

The inclusion of flood planning provisions into the KLEP as described above would enable an affirmative answer to the flood related development controls information on the Section 149(2) certificate.

In the case of properties which have been mapped as at or below the FPL, and that mapping is publicly available, these properties should be specifically identified on the Section 149 certificate. Additional properties could then be included as the mapping process for each catchment is finalised.

For all other properties a note could be included on Section 149(2) certificate, identifying the existence of the flood planning provisions.

Section 149(5) of the EP&A Act allows Councils to include in a planning certificate any advice on such other relevant matters affecting the land of which it may be aware. Council includes the following general statement on all 149(5) certificates:

> *39. IS FLOODING LIKELY TO RESTRICT DEVELOPMENT OF THE LAND?*
>
> *Some properties in the Ku-ring-gai Local Government area contain or adjoin natural drainage paths, pipelines, watercourses and depressions. During major rainfall or blockage of the drainage system surface water may affect the site or restrict future development.*
>
> *SPECIAL NOTE: The Department of Infrastructure, Planning & Natural Resources and the Department of Commerce have not indicated any private property which may be affected by flooding of major rivers or creeks in the Ku-ring-gai Local Government area.*

This statement, or similar, could continue to be used (subject to amendments to the Special Note) until such time the flood planning provisions are incorporated in the KLEP. At that time the wording of the statement should be reviewed, although as the Department of Infrastructure, Planning & Natural Resources and the Department of Commerce no longer exist, the reference could be changed to "*State agencies*" or similar.

Recommendation

It is recommended that Council review the proposed changes to the 149 Certificates following action on recommendations for the KLEP.

8.3 Identified Response Modification Options

As listed in Table 8-2, two preliminary response modification options were identified as having potential in flood management. This included raising public awareness and improvements to flood warning and emergency evacuation plans. These preliminary options are detailed in Sections 8.3.1 and 8.3.2.

8.3.1 Option RM1 Public Awareness

Raising public awareness of the flood risks in the catchment is expected to assist the community in understanding the necessary measures to be undertaken if required and be generally more flood prepared. This option would include actions as part of the floodplain management process as well as a number of small but easily implemented additional steps.

Due to recent flooding in the catchment, it is expected that some residents would already be aware of local flood risks. The process of Council undertaking floodplain risk management studies and plans is an example of Council's commitment to community flood-safe awareness.

Council's website already contains information regarding flood risk management in the Ku-ring-gai catchment and provides links to the latest flood studies for Blackbutt Creek and Lovers Jump Creek.

Potential Actions for Consideration

It is important that through community education the flood-affected communities are aware of the flood risk, are prepared for floods, know how to respond appropriately and are able to recover as quickly as possible. Flood education can significantly reduce damages and increase evacuation rates.

An ongoing public awareness and participation campaign is recommended to provide continual and up-to date flood information to the community. As part of the campaign, it is recommended

that Council consider the development of a **Flood Education Action Plan**, with key elements being:

- Regularly write to all flood-affected residents to reinforce that they live in a flood-prone area and encourage preparedness activities e.g. development of emergency plans
- Hold 'meet-the-street' events in high-risk areas to engage residents around the danger of flooding in their local area and encourage the development of street-based support networks
- Problem-solve flood scenarios with community groups
- Conduct emergency drills and exercises involving communities and emergency agencies
- Brief councillors about floodplain and emergency planning and provide them with information to speak to communities and answer enquiries
- Hold post-flood community de-brief meetings.

Council may also consider notations on their 149 Certificates as a measure to facilitate flood readiness and awareness.

8.3.2 Option RM2 Improve Flood Warning and Emergency Response

The State Emergency Services (SES) has responsibility in emergency management operations during flood events. Adequate flood warning time, especially for evacuation purposes, plays an important role in the safety of residents, which may not be achievable for this catchment. There is currently no flood emergency response plan directly applicable to the Ku-ring-gai area.

Potential Actions for Consideration

Flood warning and emergency response plans are vital to the community of Blackbutt Creek, although due to the 'flash flooding' nature on the catchment, the appropriateness of these measures may need consideration. As part of this floodplain risk management study, it is recommended that:

- SES emergency flood management and response plans be considered by SES and, if appropriate, be made available on Council's website. Information from the current floodplain management study could be incorporated into SES plans. In particular, SES could take into consideration the updated emergency response classification findings outlined earlier in this report
- SES emergency flood management and response plans, if produced, be made available on both the SES and Council websites
- If appropriate, SES to utilise the management considerations, ie. Flood Emergency Response Planning Classification of Communities in Section 2.9.5, for incorporation in a local flood plan specific to the area.

8.4 Identified Flood Modification Options

Table 8-3 lists flood modification options that have been identified at locations which have the potential to mitigate or reduce flood impacts within the floodplain. The flood modification options primarily include amendments to the stormwater drainage network and implementation of diversion walls or bunds. These options are detailed in Section 8.4.1 to 8.4.9.

Figure A - 13 shows the location of each of the flood modification options. A detailed description of each option is discussed in this section.

Hydraulic assessment of the preliminary flood modification options was conducted using TUFLOW modelling. This software was used to model the existing flood behaviour of the Blackbutt Creek catchment during the Flood Study stage. The same model was adopted as part of the Floodplain Risk Management Study, with refinements made to assess the preliminary flood modification options.

As presented in Table 8-3, preliminary flood modification options were initially identified based on a review of the community consultation responses and a review of the flood study findings. Focus was given to properties reported as being significantly flood-affected, such as by flooding above floor levels.

Consideration was also given to potential for improvement in flood parameters such as flood level, velocity and hazard.

For stormwater modification options, for the purposes of initially evaluating whether any improvement could be achieved, no blockage of the stormwater network was considered. The implications of this are discussed for each option, where relevant.

8.4.1 Option FM1 drainage/pits modification at St Johns Avenue

Description

An overland flow path is located within St Johns Avenue originating from a local upstream catchment. The main flow path traverses residential properties on Moree Street and St Johns Avenue, Gordon, with additional contribution from the local catchment located at the rear of the St Johns Avenue properties. The majority of runoff originates from paved and roof areas. A number of residential properties are affected by flooding in the 20% AEP event according to the flood study modelling results.

A resident of St. Johns Avenue commented during the community consultation feedback that they had been affected by flooding throughout the property during previous flooding events but details of flooding above floor level were not provided. Flood study modelling results support this, with overland flows traversing the property. Residents of a number of downstream properties along Bushlands Avenue and Ormiston Avenue also detailed flooding issues during community consultation feedback.

The existing stormwater system in this area contains a series of pits connecting to the underground stormwater pipe network that continues between residential properties numbers 46 and 48 St Johns Avenue. There is also a piped system at the rear of properties 44 and 46 to capture flows from the eastern catchment at the rear of the St Johns Avenue properties. The modelling indicated that the stormwater pipes had capacity to convey additional flows but that constraints on the capacity of the stormwater inlet pits were preventing effective use of the available capacity.

A potential mitigation option (FM1) was considered to modify pits in the location along St Johns Avenue. The aim was to eliminate and/or alleviate the overland flooding issues noted in this area and confirmed by flood study results. Alleviating /eliminating overland flows in this area

was expected also to provide improvement to affected properties on Bushlands Avenue and Ormiston Avenue further downstream.

Figure 8-1 Option FM1 Location

Hydraulic Modelling

A number of pit size increases were assessed until the pipe system was full or a particular inlet was controlling the system such that the system was found to be ‘at capacity’. This was undertaken by modelling a number of iterations of pit size increases until the system reached ‘capacity’ at a given point. Figure 8-1 shows the option location and the pits that were increased in size. The stormwater pit modifications on St Johns Avenue included increasing the pits to a 4.2 m opening size, larger than the current pits. This change would deliver increased capture of overland flows to the underground network, thus decreasing overland flows from propagating downstream to Ormiston Avenue and Bushland Avenue downstream. The increase in inlet size could be achieved by installation of additional stormwater inlet pits but would require extensive .modification of the existing pit and pipe network.

Results

The hydraulic analysis showed only minor reductions around the roadway with some reductions around the properties affected by flooding. The largest change in flood levels was estimated to occur in the 20% AEP event. Figure 8-2 shows the increase and decrease in flood levels for the 20% AEP event. Table 8-4 details the change in flood level at selected locations for both the 20% AEP event and the 1% AEP event.

Table 8-4 Option FM1 Results Summary

Location	20% AEP			1% AEP		
	Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Difference (m)	Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Difference (m)
A	98.19	98.07	-0.12	98.20	98.08	-0.12
B	98.37	98.21	-0.16	98.37	98.35	-0.02
C	96.48	96.71	-0.23	96.75	96.61	-0.14

The results identified that peak water elevations at each of the dwellings were reduced when compared with the existing scenario. At location C, in the 20% AEP event, the modelled reduction in flood level was 0.23 m, immediately around the building. Given the property has not been above floor flooded based on the community consultation, this reduction would benefit the resident by improving flooding impact occurring through the property but would not affect flooding to the dwelling itself.

Figure 8-2 displays the reduction in flood levels for the 20% AEP event. This event was chosen to illustrate the largest impact due to the lower overland flow depths.

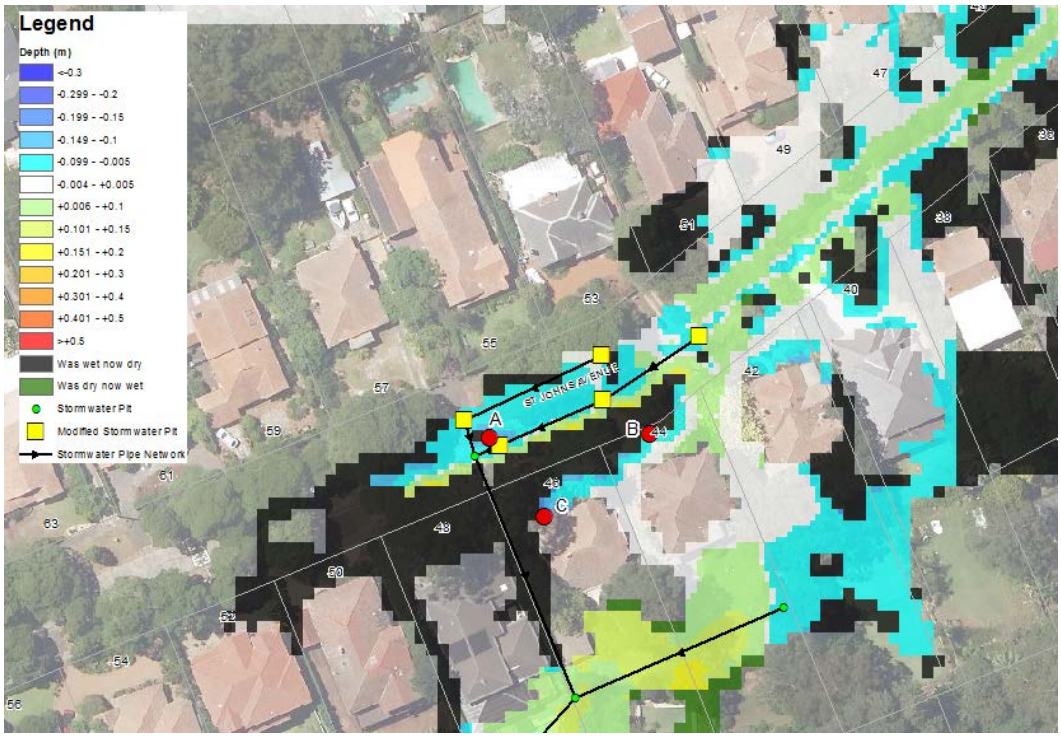

Figure 8-2 Option 1 20% AEP Change in Water Level

Analysis

Option FM1 shows that some reductions do occur with the increase in pit size. These reductions do not propagate any further downstream than the immediate area around numbers 46 and 48 St Johns Avenue. The benefit identified includes local reductions in flood level around flood-affected residences on St Johns Avenue.

However, this reduction in flooding at the pit locations along the roadway is not evident further downstream. Based on this point, the desired improvements to any residents currently experiencing flooding issues further downstream due to the proposed changes are not evident from the modelling. For this reason, this option was not investigated any further and would not be recommended going forward due to high construction costs, relative to the potential benefit to flooding predicted from the modelling results.

8.4.2 Option FM2 Flowpath Modification at Dumaresq & Vale Streets

Description

Two overland flow paths converge around Dumaresq and Vale Street. The overland flows originate upstream from:

- overland flows along Vale Street
- other flow paths passing through residential properties and traversing parts of McIntyre Street, Merriwa Street and Dumaresq Street, Gordon.

The majority of runoff originates from paved and roof areas. The flood model results showed that a number of residential properties are affected by flooding in the 20% AEP event. Residents of two properties on Vale Street responded during community consultation that they are affected by flooding above floor level. The above floor flooding was reported at 50cm through a garage/understorey area and around 15cm above the ground floor area at a second property. The properties are located below the Dumaresq Street and Vale Street road level.

Mitigation option FM2 included modifying the existing footpath levels along Dumaresq St. This option was investigated to alleviate overland flow to properties experiencing flooding issues along Vale St by raising footpath levels and hence and preventing flood waters from entering the properties. However, it was found that modifying levels along this footpath would have meant creating driveway grades too steep for acceptable vehicular access and with unacceptable geometry to transition from the road. To achieve acceptable driveway geometry would require extensive and substantial re-profiling of surrounding roads. The option was therefore not considered practical and was not investigated further.

A second modification option was investigated to incorporate a centre median strip along Dumaresq St to keep flows within the northern side of the roadway, thus preventing flow on the southern side of the road from continuing into Vale Street and affecting residences.

A number of centre median configurations were assessed. Figure 8-3 shows the location of the proposed centre median along Dumaresq Street to contain floodwaters within the roadway along Vale Street. For the hydraulic analysis a centre median, set to a height of 400mm spanning a length of approximately 150m along Dumaresq St, was incorporated. This inclusion sought to provide improvements by containing floodwaters downstream within the roadway along Vale Street, by decreasing overland flows affecting properties. A 400mm high median barrier would be high for an urban environment and difficult from a traffic management perspective. Further consideration of median type and safety aspects would be required to determine the feasibility of this option based flooding, public safety and traffic accessibility criteria. A lower median height was tested in the model however resulted in water overtopping the centre median and not effectively conveying water within the roadway for the 1% AEP event.

Hydraulic Modelling

A 400 mm high centre median was introduced into the flood model and a range of design storm events were simulated including the 20%, 5%, 2%, 1% and 0.5% AEP and PMF events.

Figure 8-3 Option FM2 Location

Results

The results of the hydraulic analysis were compared to the existing case flood levels to investigate the impact of the proposed change. The results of this are shown below in Table 8-5.

Table 8-5 Option FM2 Flood Levels around impacted properties

Area	Existing Floor Level (m AHD)	20% AEP		1% AEP	
		Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Existing Scenario (m AHD)	Proposed Scenario (m AHD)
Vale St property	70.70	70.64	70.62	70.91	70.89
Vale St property	70.20	68.86	68.86	69.10	69.08
Vale St property	67.87	68.66	68.65	68.99	68.99

Analysis

These results identified that peak water elevations at each of the dwellings were reduced by no more than 20mm when compared with the existing scenario. Hence, option FM2 provides no material flood mitigation benefit to the residents in this area.

A second overland flow path entering Dumaresq Street further upstream from the southern side still flows around towards the properties on Vale Street and cannot be diverted by implementation of the proposed median strip. With no material flood benefit being realised, combined with concerns about public safety and traffic accessibility, this option is not recommended for further investigation.

8.4.3 Option FM3 Killara Golf Course Dam Water Level Management

Description

The Killara Golf Course dam is located in the upper reaches of Honeysuckle Creek. Downstream of the dam, Honeysuckle Creek continues beneath Golf Course Links Road and through the residential areas downstream. During the community consultation, residents reported that during high rainfall events, overtopping of the dam occurs causing scouring issues within the backyards of residences whose properties are traversed by Honeysuckle Creek. No other flooding issues were identified in this area during the community consultation phase and the modelling undertaken during the flood study phase does not indicate any further issues within the catchment in this area.

Option FM3 involved testing, within the hydraulic model, the sensitivity of the flows in the downstream reaches of Honeysuckle Creek to the initial water level in the Killara Golf Course dam.

An assumption in the Flood Study was that the dam was nearly full at the commencement of a flood event. An option was investigated to determine if lowering the water level in the dam prior to a rainfall event could significantly influence downstream flooding.

Figure 8-4 shows the location of the dam and the downstream reaches affected by the overtopping.

Figure 8-4 Option FM3 Dam Location

Hydraulic Modelling

The initial water level in the TUFLOW model was varied by setting the water level to three (3) different levels in the dam at the start of the rainfall event. The base case scenario (scenario 1) used in the flood study set the initial water level (IWL) to 73 mAHD, which is equivalent to around 300mm below the spillway level. The dam is approximately 4m high.

Different initial water levels (IWL) in the dam were tested in 1m increments as follows:

- Scenario 2: Initial water level in dam = 72 mAHD (1.3m below spillway level)
- Scenario 3: Initial water level in dam = 71 mAHD (2.3 m below spillway level)
- Scenario 4: Initial water level in dam = 70 mAHD (3.3 m below spillway level).

The model was simulated for a range of events including the 20%, 5%, 2%, 1% AEP events and the peak flow rate through this downstream reach was compared to the existing scenario peak flow rate for the same event. The figure below shows the locations of the peak flow extraction.

Figure 8-5 Peak Flow Extraction Locations

Results

Table 8-6 shows the comparison of the peak flow rate for the existing scenario and the different initial water levels. The peak flow rates are presented for the 20% and 1% AEP events to provide an indication of the results during a more frequent and less frequent flooding event. Similar results were obtained for the other flood events.

Table 8-6 Option FM3 Peak Flow Rates for Initial Water Level (IWL) Sensitivity

Location	20% AEP Peak Flow (m^3/s)				1 % AEP Peak Flow (m^3/s)			
	Base Case IWL 1*	IWL 2*	IWL 3*	IWL 4*	Base Case IWL 1*	IWL 2*	IWL 3*	IWL 4*
1	0.4	0.4	0.4	0.4	7.8	3.1	0.8	0.8
2	7.1	3.5	3.2	3.2	17.2	11.3	7.6	6.1
3	9.2	5.7	5.7	5.7	20.5	10.9	10.9	10.9

* IWL 1, 2, 3 and 4 relate to an IWL of 73, 72, 71 and 70 m AHD, respectively.

Analysis

The results show a clear reduction in flow downstream with a draw down in starting water level of the dam. Table 8-6 shows that the further downstream of the dam, the greater the magnitude reduction in flow due to the drawing down of the dam. For example at location 3 the modelling indicates that with the initial water level in the dam set to 73m AHD, in the 20% AEP event the peak flow rate is around 9.2 m^3/s and 20.5 m^3/s in the 1% AEP event. Comparing this to an initial water level of 72m AHD, the peak flow rate is predicted to be 5.7 m^3/s and 10.9 m^3/s in the 20% and 1% AEP event, respectively.

The result of lower flows is a reduction in the scouring potential of the waterway. Lower flows will see lower velocities within the waterway. For example, in a 20% AEP and 1% AEP events, peak flood velocities at location 3 in the existing (base) case are approximately 2.4 m/s and 3.0 m/s, respectively. Such velocities could potentially cause scour as reported by residents depending where these velocities occur relative to the channel. A reduction in flood velocities (accompanying the reduction in flood flows) would be expected to reduce scour potential. If the option is further pursued, additional analysis is required to quantify the effect of the water level changes on parameters such as stream power and shear stresses, which are indicators of scour potential.

A constraint on implementing this option is the limited availability and accuracy of flood forecasting and flood warning information in order to effectively implement a dam water level management plan in advance of a flood event (refer also to section 2.9 and section 8.3). Rapid draining of the dam under existing outlet arrangements is also likely to be problematic. It is likely that permanent changes to the normal water level of the dam would be required.

In addition, the Killara Golf Club is reliant on this dam for on-course watering and for the pondage amenity. It is recommended that the Killara Golf Club be consulted in the next study phase to confirm:

- Current dam management regime
- Operational water use requirements for dam water.

The consultation will inform the feasibility of the option for further investigation.

8.4.4 Option FM4 Wall Fence/Bund at Norfolk Street

Description

An overland flow path runs along Essex Street, Killara, originating in the residential areas upstream. A second flow path traverses the residential areas of Maitland Street and Warwick Street. The two overland flow paths converge at the intersection of Norfolk St and Essex Street, crossing the road between 43A Norfolk St and 32 Essex St.

During the community consultation, a number of residents in this area reported being flood affected. Reports included flooding of one property through a garage/understorey area but not above habitable floor levels. The flood model results also indicated that a number of residential properties were affected by flooding in the 20% AEP event.

Initially, an option was investigated to provide a solid wall fence along the northern property boundary of 43A Norfolk St to guard against flooding of the property. Upon further investigation, it was observed within the modelling that the predominant flooding impacting this property originates from Norfolk Street, rather than from the tributary that runs through the backyard and into 32 Essex St. The fence was therefore not effective at excluding flood waters from the property.

A further mitigation option (FM4) was investigated to keep flows within the roadway through provision of an embankment next to the footpath along Norfolk St, which would provide an obstruction to flows overtopping the footpath and flowing into the properties. To achieve acceptable vehicular access transition from the road.to the resident driveway the embankment will be situated between the footpath and kerb and gutter of Norfolk Street thereby allowing vehicular access to properties.

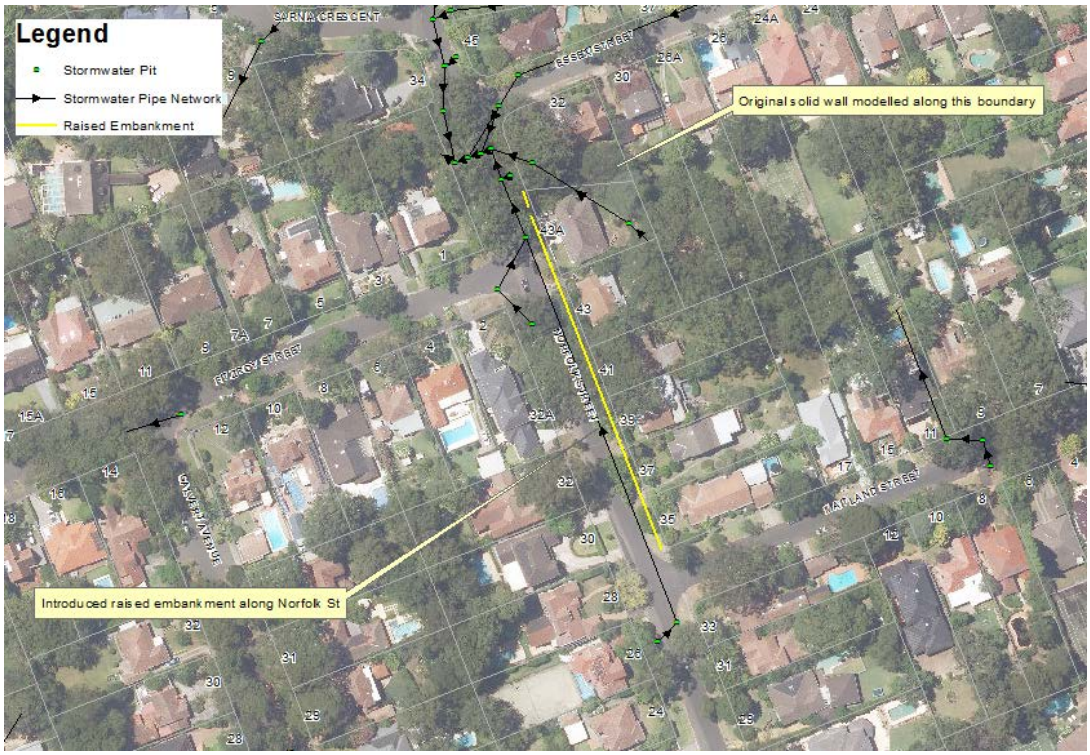

Figure 8-6 Option FM4 Location

Hydraulic Modelling

Initially, a solid wall along the boundary was included into the model, however did not provide any flood improvement.

The option of modifying levels adjacent to Norfolk Street to represent construction of an embankment was then assessed.

The proposed works at this location include construction of an embankment up to 0.3m high and approximately 125m long, between the footpath and kerb and gutter of Norfolk Street. The purpose of this flood modification measure is to contain flooding to within the roadway and to control/decrease overland flow from Norfolk Street overflowing into the properties. Details of the proposed works at this location are shown above in Figure 8-6. A range of design storm events was simulated. These included the 20%, 5%, 2% and 1% AEP events.

Results

The results of the preliminary hydraulic analysis were compared to the existing case flood levels to establish the impact of the proposed changes. The results show that peak water elevations at 43A Norfolk Street were reduced by approximately 100 mm to 150 mm when compared with the existing scenario results from the flood study (Table 8-7). Figure 8-7 and Figure 8-8 show the 20% and 1% AEP event results for change in water level.

Table 8-7 Option FM4 Flood Levels at 43 A Norfolk Street

Area	Existing Floor Level (m AHD)	20% AEP		1% AEP	
		Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Existing Scenario (m AHD)	Proposed Scenario (m AHD)
43A Norfolk St	82.59	80.53	80.36	80.58	80.45

Figure 8-7 Option FM4 20% AEP Change in Water Level

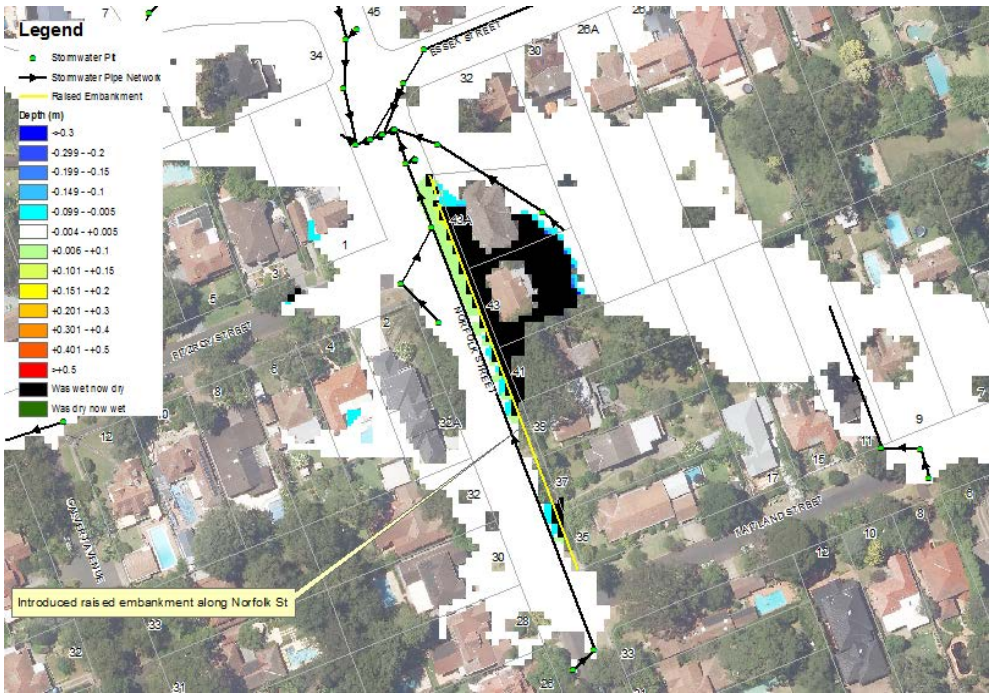

Figure 8-8 Option FM4 1% AEP Change in Water Level

Analysis

The above figures show that the increased footpath level will have an impact in protecting 43 and 43A Norfolk St from flood waters that travel down the roadway and encroach within these properties. With the proposed mitigation measure in place, the modelling shows no flooding of the affected residences in a 20% or 1% AEP event (as indicated by the “was wet now dry” area on the figures). The flows would largely be confined to the roadway with the mitigation measure in place. The modelled reduction in flood level was around 170mm in the 20% AEP event and around 130mm in the 1% AEP event.

Given the mitigation option shows benefits to 2 residents on Norfolk Street in this area it is recommended for further investigation. However, it should be noted that only a single resident responded to community consultation with details of flood damage during actual rainfall events in this area.

Provision of an embankment along Norfolk Street would be constrained by several factors, including:

- Potential environmental constraints associated with tree removal to facilitate the construction of the bund
- Financial costs associated with the implementation of the embankment with respect to expected benefit.

8.4.5 Option FM5 Drainage works at Bolwarra Avenue

Description

An overland flow path is located around Bolwarra Avenue, and flows through residential properties on Duneba Avenue, Dunoon Avenue and Bolwarra Avenue, West Pymble. Runoff contributing to this flow path is generated from the area to the west of Bolwarra Avenue. A number of properties are affected by flooding from these flow paths. The majority of runoff originates from paved and roof areas. The flood study results showed that a number of residential properties are affected by flooding in the 20% AEP event. A resident of Bolwarra Avenue indicated in their consultation response that they are affected by above floor flooding. Flooding above floor level was reported to be up to 30cm during previous flood events. This is supported by the results provided from the flood study modelling. A drainage easement runs beside 59 Bolwarra Avenue and stormwater flowing through the easement reportedly overflows into the property, according to consultation feedback.

The proposed mitigation option (FM5) included investigation of the impact of increasing the stormwater pit and pipe sizes near the road and drainage easement adjacent to 59 Bolwarra Avenue. A second mitigation option was also investigated at this location and consisted of construction of a small earthen mound along the drainage easement and its boundary with 59 Bolwarra Avenue.

Hydraulic Modelling

Initially, a stormwater pit on Bolwarra Avenue and the pipe running underground through the drainage easement were increased in size within the TUFLOW model. The impact of this change was compared against the existing flooding scenario from the flood study results. This change resulted in localised improvements (reductions) in flood level and these reductions were confined to the roadway, with no improvements to flooding at the nearby residences. The bund option was investigated and the model was simulated for a range of flood events including the 20%, 5%, 2% and 1% AEP events.

This proposed modification option was modelled by including a solid mound up to 0.3m high and approximately 50m long, along the drainage easement that runs beside the property. The purpose of this flood modification measure is to confine flooding to within the drainage easement and minimise or eliminate overland flow from running into nearby properties. Details of the proposed works at this location are shown in Figure 8-9.

Figure 8-9 Option FM5 Location

Results

The results of the hydraulic analysis were compared to the existing case flood levels to establish the impact of the proposed changes and are provided in Table 8-8.

Table 8-8 Option FM5 - Flood Levels around impacted property

Area	Existing Floor Level (m AHD)	20% AEP			1% AEP		
		Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Change in Flood Level (m)	Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Change in Flood Level (m)
59 Bolwarra Avenue	52.93	53.58	53.50	-0.08	53.76	53.64	-0.12

Figure 8-10 and Figure 8-11 show change in water level for the 20% and 1% AEP events.

Analysis

Figure 8-10 and Figure 8-11 shows that this option has some benefit around two residences on Bolwarra Avenue. Reductions of up to 120mm were noted in the 1% AEP and 80mm in the 20% AEP storm event. However, some increases in flood level were also predicted at nearby properties. Any adverse impacts on surrounding residences would not be acceptable for an implemented mitigation measure. Benefits to one residence only are unlikely to result in a cost effective solution, particularly as above-floor flooding is not eliminated through implementation of the option.

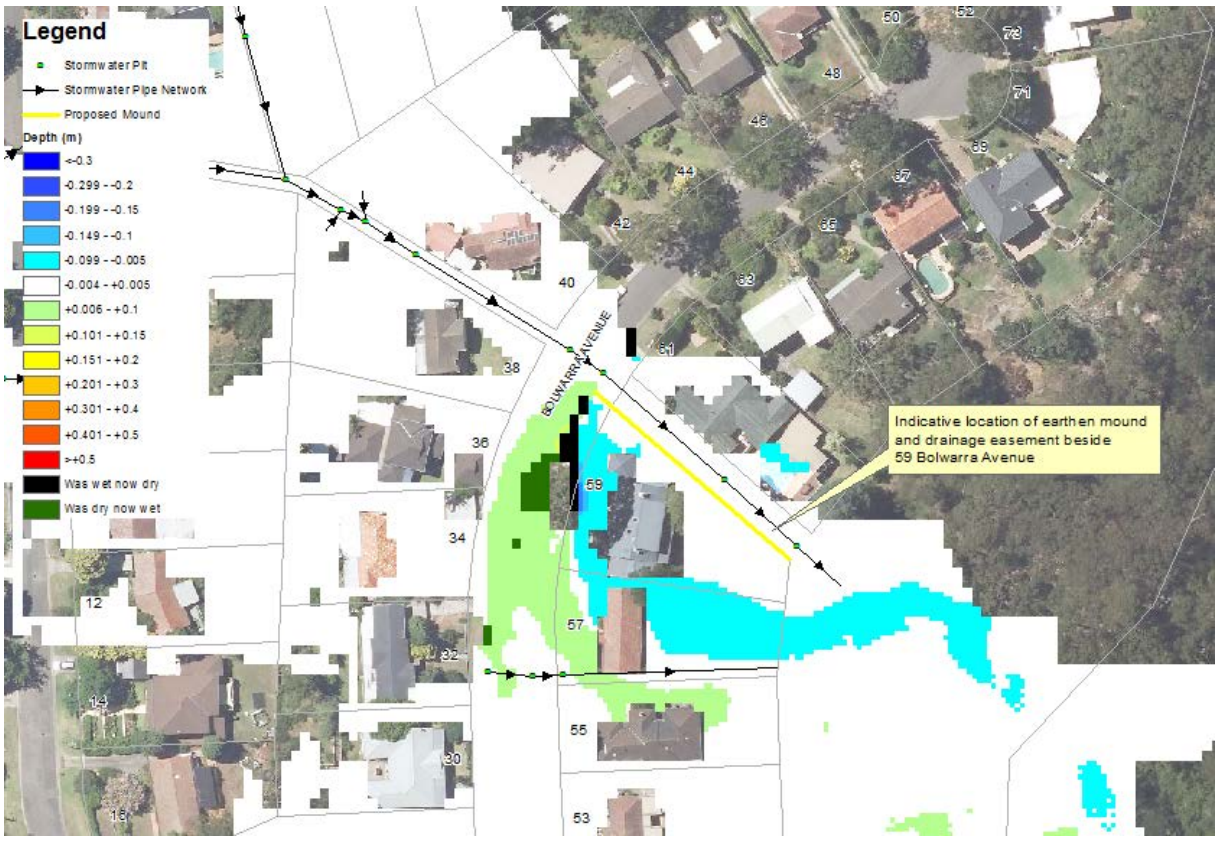

Figure 8-10 Option FM5 20% AEP Change in Water Level

Figure 8-11 Option FM5 1% AEP Change in Water Level

8.4.6 Option FM6 Drainage works at Moree Street

Description

Several overland flow paths converge around Moree Street and Dumaresq Street, immediately originating upstream from these roads. These overland flow paths flow through various residential properties on Moree Street and Dumaresq Street, Gordon. A number of properties are affected by flooding from these flow paths according to the flood study results, including in events as frequent as the 20% AEP event. The residents in Moree Street have responded in community consultation feedback that they are affected by flooding through their properties though there was no indication of flooding above floor level.

The existing stormwater system features in this area include a series of pits connecting to the underground stormwater pipe network. It was observed during a site visit that a proposed development has been approved at 29/29A Moree St, where a stormwater pipe is currently located. The modelling indicated that the stormwater pipe had no capacity to convey additional flows through the underground network. Similarly, constraints on the capacity of the stormwater inlet pits were preventing any additional flow from entering the system. Therefore, based on this observation the proposed mitigation option (FM6) considered modifying pits in the location along Moree Street and increasing the size of the current stormwater pipe that flows through 29/29A Moree St. Details of the proposed works at this location are presented in Figure 8-12.

Figure 8-12 Option FM6 Location

Hydraulic Modelling

The stormwater pit modifications included investigating increases in pit openings to stormwater pits along Moree Street to an inlet opening length of 4.2m. The intention was to provide increased capture of gutter and roadway flows to the underground network and to decrease overland flows from flowing downstream to residents of 21-27 Moree Street. To address the pipe capacity constraints, the stormwater pipe through property number 29 and 29A was increased in size. This may be possible to implement at the same time as any development works proposed in the area. The proposed pipe size change included increasing the current

600mm diameter stormwater pipe to a 1.2m diameter stormwater pipe, to convey additional flows.

Results

The results of the hydraulic analysis were compared to the existing case flood levels to establish the impact of the proposed changes. The results of these are shown below in Table 8-9.

Table 8-9 Option FM6 - Flood Levels around impacted property

Area	20% AEP		1% AEP	
	Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Existing Scenario (m AHD)	Proposed Scenario (m AHD)
21-27 Moree Street	98.34	98.32	98.36	98.33

Figure 8-13 and Figure 8-14 show results for the 20% and 1% AEP events for change in water level.

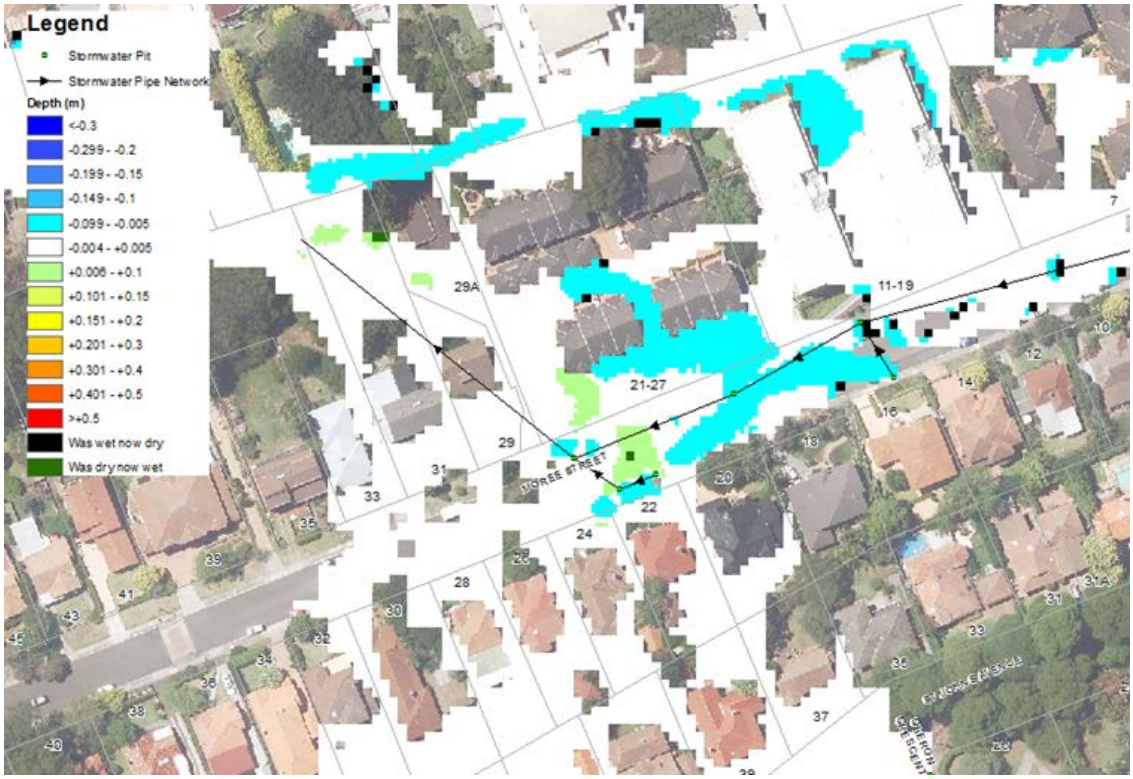

Figure 8-13 Option FM6 20% AEP Change in Water Level

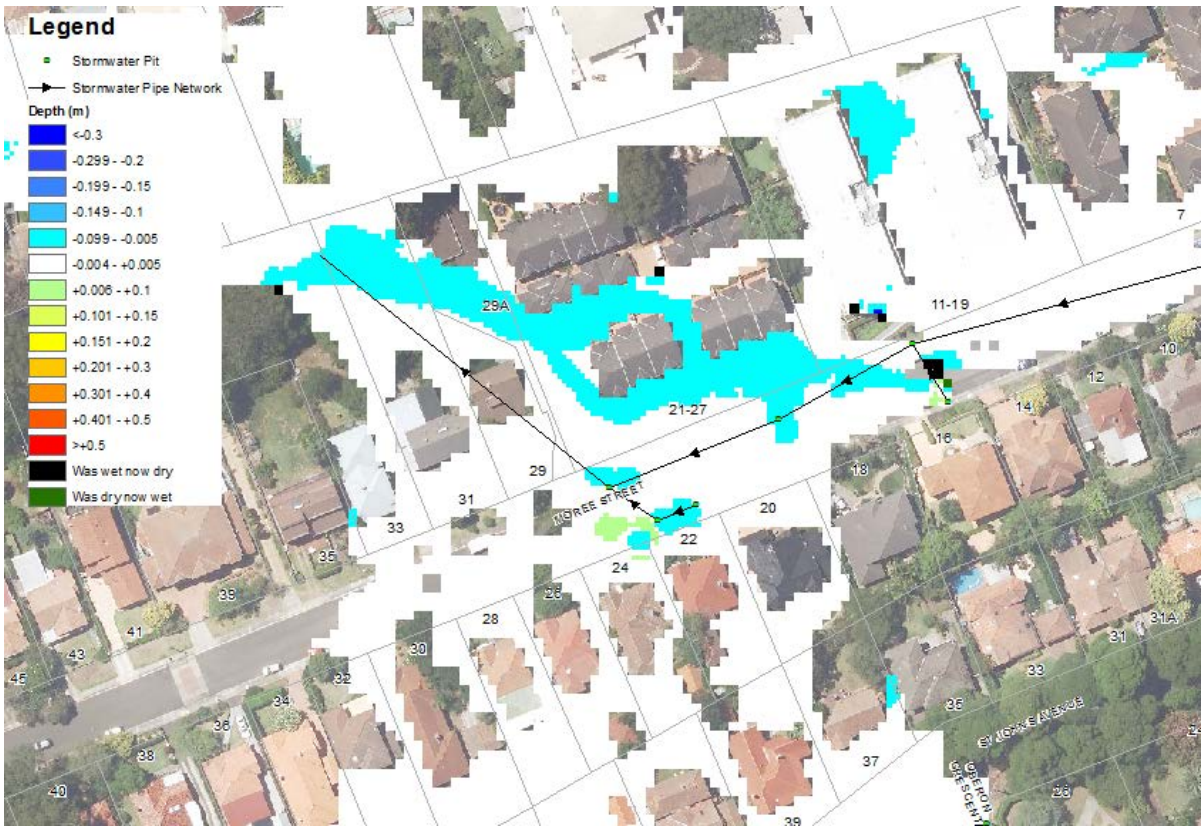

Figure 8-14 Option FM6 1% AEP Change in Water Level

Analysis

Figure 8-13 and Figure 8-14 show that this flood modification option will have some positive benefit around the unit complex at 21-27 Moree Street. Results indicated that reductions in flood level of up to 30mm were evident in the 1% AEP event immediately around the unit complex and 20mm in the 20% AEP storm event. This is attributed to the increase in pit sizes along Moree Street as well as the increase in pipe size. Whilst any reduction in flood level would be beneficial to residents, the modelled improvements in flood level are very minor compared to the likely cost of both pit improvements and pipe size upgrades.

A small localised increase in flood level is predicted within 21-27 Moree St in the 20% AEP storm event, which is thought to be within the model tolerance rather than being indicative of an actual increase caused by the stormwater network modifications.

8.4.7 Option FM7 Construct berm/embankment at Calvert Avenue

Description

An overland flow path is located along Calvert Avenue and another originates immediately upstream from Spencer Road and Norfolk Street. Flow paths exist through residential properties on Spencer Road, Norfolk Street and Calvert Avenue, Killara. A number of properties are affected by flooding from these flow paths in the 1% AEP event according to the flood study modelling results. A resident of Calvert Avenue reported flooding throughout the property including flows of 5 to 6cm through their garage/understorey area.

The proposed mitigation option (FM7) included management of flooding at the upstream reach of Links Creek adjacent to 6 and 8 Calvert Avenue. At this location, Links Creek discharges from the underground system to an overland channel where the property boundary of 6 Calvert Avenue begins and the roadway stops. The Creek then traverses along the property boundary between these two residences in a channel and continues to the back of the properties and onto the Killara Golf Course. In higher flows the channel does not have capacity to contain the flow

and spills out on to adjacent areas. Details of the proposed works at this location are presented in Figure 8-15.

The mitigation options consists of a small berm or embankment along the boundary of 6 and 8 Calvert Avenue to avoid the overtopping of the channel and flooding of the surrounding properties.

Figure 8-15 Option FM7 Location

Hydraulic Modelling

To assess the impact of this change, modifications were made to the TUFLOW model to include a proposed berm to prevent the channel from overtopping and spilling into the understorey of the residence at 8 Calvert Avenue. The proposed works at this location include construction of a solid wall up to 75cm high and approximately 25m long. This modification was incorporated into the model and simulated for the 1% AEP flood event. Additional flood events were not assessed given the desired outcome was not achieved for the 1% AEP event. It is expected a similar result to the 1% AEP event impact would be found across different flooding events given the flooding mechanisms in this area are similar across all events.

Results

The results of the preliminary hydraulic analysis were compared to the existing case flood levels to establish the impact of the proposed changes. The results identified that peak water levels nearby the key affected location had a significant adverse effect on flood behaviour resulting in detrimental increases when compared with the existing scenario results from the flood study. The results are summarised below in Table 8-10.

Table 8-10 Option FM7 - Flood Levels around impacted property

Area	Existing Floor Level (m AHD)	1% AEP	
		Existing Scenario (m AHD)	Proposed Scenario (m AHD)
8 Calvert Avenue	64.70	64.79	65.87

Figure 8-16 shows the 1% AEP event change in flood level with option FM7 in place.

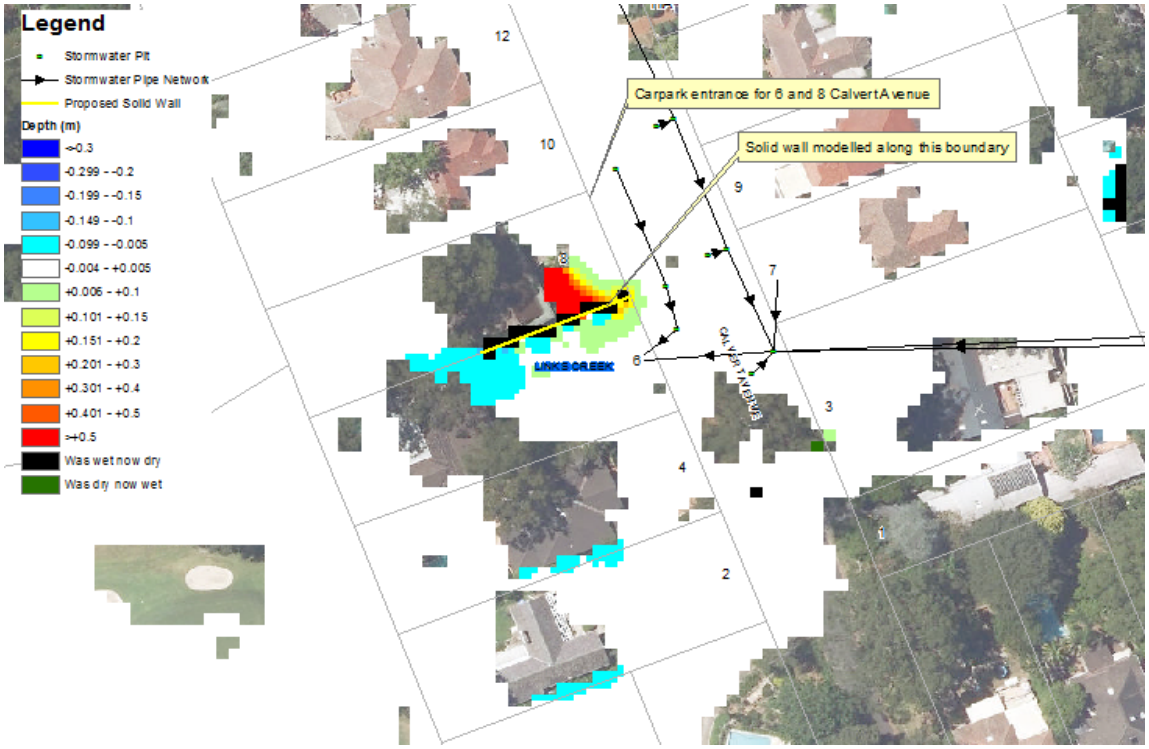

Figure 8-16 Option FM7 1% AEP Change in Water Level

Analysis

Figure 8-16 shows that the implementation of the solid wall on the property boundary did not have the impact that was originally expected. The flood levels on the property indicated significant adverse impact on flood behaviour. The impact was attributed to flow originating from Calvert Avenue from the north to the south, which is conveyed onto the property. This flow is conveyed down the driveway and front yard area of the property (see Figure 8-16) and without the proposed mitigation wall in place, would discharge to the main Links Creek. With the mitigation option in place, this wall acts as a barrier to this flow path and stops the flow from joining the main Links Creek. This results in increased ponding behind the wall and on the property of over 0.5m.

An alternative solution of bunding on the road reserve was considered but topographic constraints and the need to maintain driveway access for the properties meant that this option was considered infeasible without extensive driveway re-profiling works.

8.4.8 Option FM8 Ryde Road

Description

An overland flow path is located along Ryde Road and combines with the main Blackbutt Creek waterway near where the Creek crosses under Ryde Road. The overland flow path and main channel converge and subsequently continue downstream through a drainage reserve. During the community consultation phase, feedback was provided from a resident near this location along Ryde Road who experienced flooding of their property during a recent rainfall event. No mention was made in the feedback of above floor flooding. Flooding occurred through the garage and understorey area of the property with depths estimated between 100-200 mm.

The proposed mitigation option (FM8) included investigation of amplifying the pits in the street to allow larger flow capture into the underground stormwater system. A second option was also investigated to raise the existing berm above the inlet to culverts under Ryde Road. The aim of the berm raising would be to confine flow to the main Blackbutt Creek channel and prevent overflows from entering the access road area low point where the residences are affected.

Further modelling analysis indicated that flood waters generally affecting this property were influenced by water flowing down Ryde Road, as opposed to flooding from the Creek. The alternative mitigation option of a solid wall along Ryde Road was considered in an effort to divert spilling into the access road area. Details of the proposed mitigation works at this location are presented in Figure 8-17.

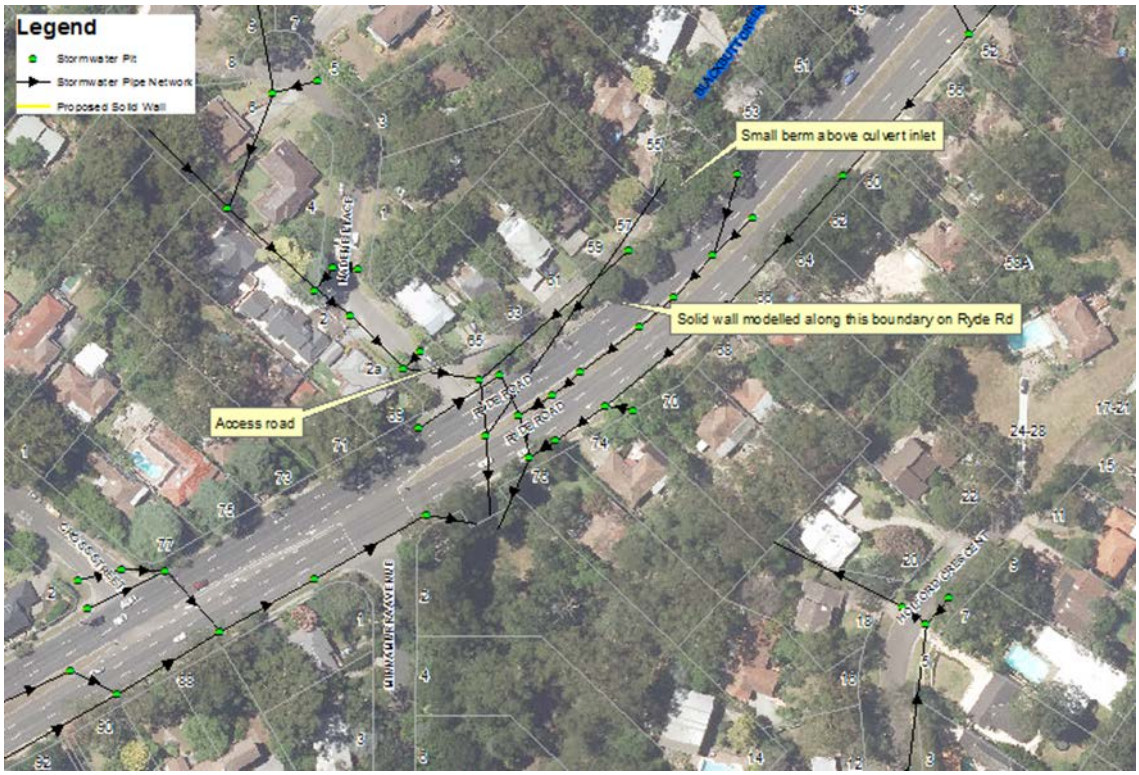

Figure 8-17 Option FM8 Location

Hydraulic Modelling

Originally, raising the berm above the inlet to culverts under Ryde Road was included in the TUFLOW model. This mitigation option had a negligible and, in some areas, negative impact (increases in flood level) on flood behaviour. Further investigation of the flooding regime in this area indicated the main source of flooding, for events higher than the 20% AEP event, was flood water spilling from Ryde Road and entering the access road and properties, and also

draining back to Blackbutt Creek. Due to this flood behaviour, increasing the berm height resulted in the obstruction of floodwater draining to the Creek and hence causing increases in flood levels along the access road.

An alternative mitigation option of providing a solid wall along the footpath of Ryde Road to prevent spilling onto the access road, was investigated. This modification option was modelled by including a 2m high and 115m long solid wall along Ryde Road. Again, the purpose of this flood modification measure is to contain flooding to within Ryde Road and to control/decrease overland flow into the access road and properties. The model was simulated for a range of flood events including the 20%, 5%, 2% and 1% AEP events. Details of the proposed works at this location are displayed in Figure 8-17.

Results

The results of the hydraulic analysis of the original mitigation measure of introducing an increase to the berm height above the culverts under Ryde Road were compared to the existing flood levels to establish the impact of the proposed changes. The results are summarised in Table 8-11.

Table 8-11 Option FM8 - Flood Levels on Ryde Rd access road (original mitigation approach)

Area	Existing Floor Level (m AHD)	5% AEP			1% AEP		
		Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Change in Flood Level (m)	Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Change in Flood Level (m)
59 Ryde Road	63.18	62.91	63.03	0.12	63.25	63.25	0.0

The results of the hydraulic analysis of the wall along Ryde Road were compared to the existing case flood levels to establish the impact of the proposed changes. The results are summarised in Table 8-12.

Table 8-12 Option FM8 - Flood Levels on Ryde Rd access road (alternative mitigation approach)

Area	Existing Floor Level (m AHD)	5% AEP			1% AEP		
		Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Change in Flood Level (m)	Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Change in Flood Level (m)
59 Ryde Road	63.18	62.91	62.88	-0.03	63.25	63.24	-0.01

Figure 8-18 and Figure 8-19 show the 5% and 1% AEP event results for change in water level.

Analysis

Figure 8-18 and Figure 8-19 illustrate a small positive impact from this option in reducing flood waters around the properties along Ryde Road access road. Results indicate that reductions in flood level of up to 10mm were evident in the 1% AEP event and 30mm in the 5% AEP storm event.

However, the model results for the 20% AEP indicated that peak flood waters actually increase in the area around the access road. This is likely due to the obstruction of flows in this smaller

event (and most likely during higher frequency events) draining to the Creek inlet at Ryde Road by the existing small berm. Increases in flood levels along properties towards the Nadene Place end of the access road are also evident.

This option was considered positive in terms of flood impact but would be expensive to implement. The justification being that any potential economic benefit to the local community is isolated to a single resident according to the community consultation feedback, whereas the cost implementing the option would be substantial.

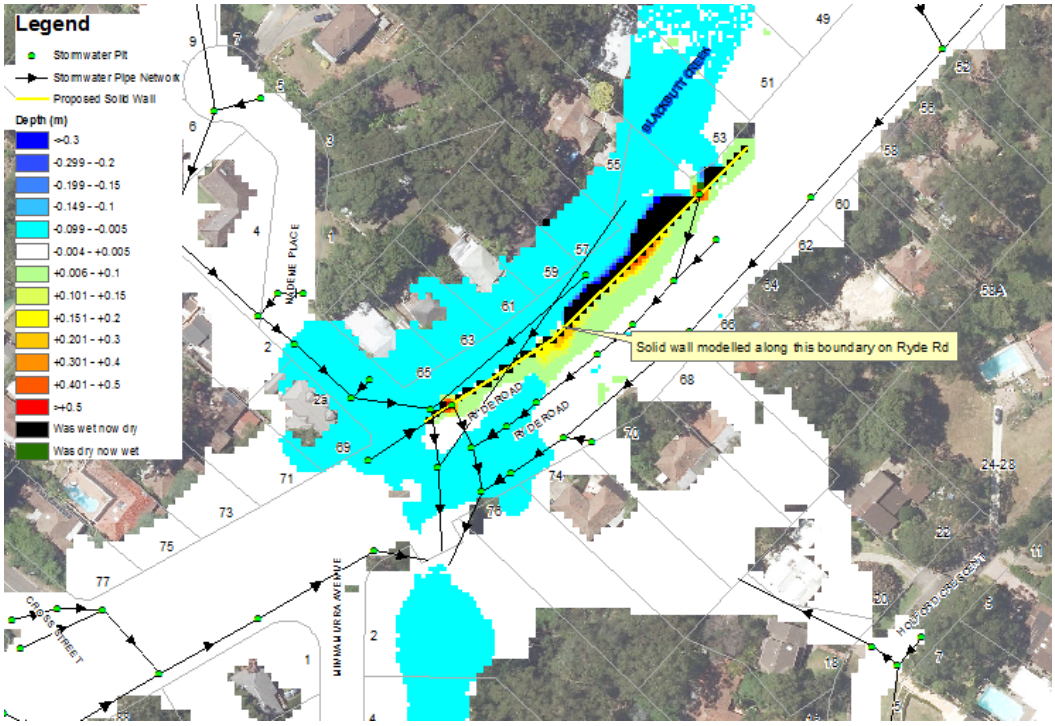

Figure 8-18 Option FM8 5% AEP Change in Water Level

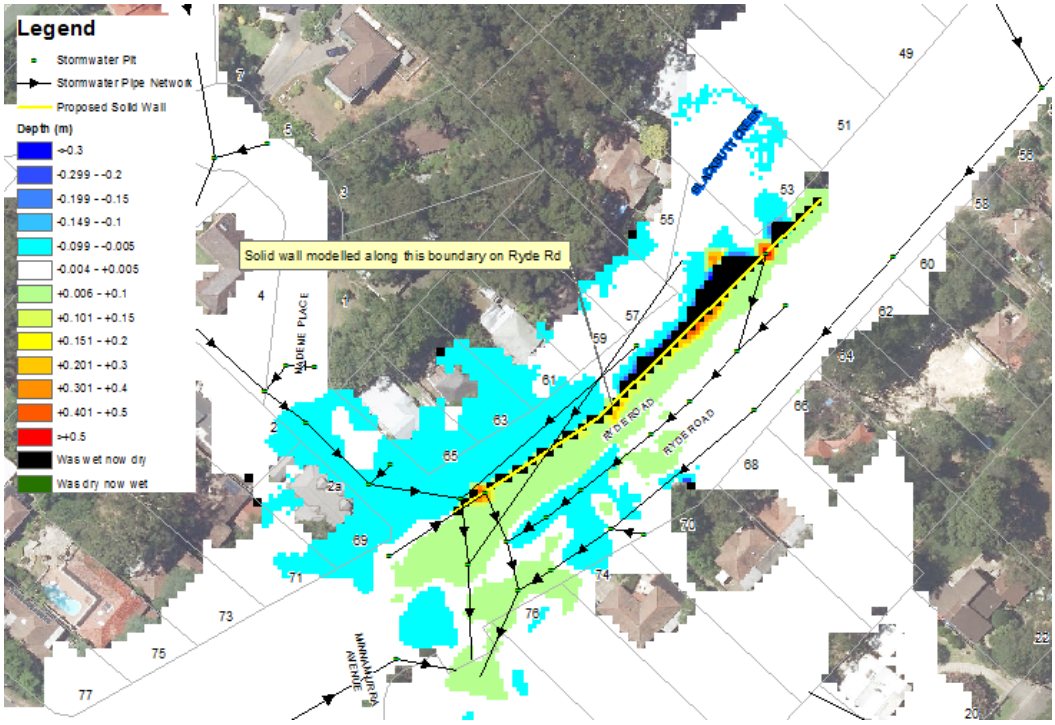

Figure 8-19 Option FM8 1% AEP Change in Water Level

8.4.9 Option FM9 Pit Modification at Browns Road

Description

An overland flow path is located across Browns Road originating immediately upstream from Pennant Avenue. The flow path passes through residential and recreational properties on Pennant Avenue, Yarabah Avenue and Browns Road, Gordon. A number of properties are impacted by flooding within these flow paths. In particular, a number of residential properties are inundated by the 1% AEP event based on the flood study modelling results. A resident of Browns Road responded during the community consultation feedback that they are affected by flooding throughout the property but did not indicate any above floor level flooding issues from previous flood events. The resident indicated that they experienced property flooding depths of 75mm through their front yard area.

The proposed mitigation option (FM9) included pit modifications along Browns Road. This area encompasses a small number of pits connecting to the underground stormwater pipe network that continues beneath properties downstream of the Road. The purpose of this option was to increase flow conveyance into the underground stormwater system to reduce localised overland flow, which impacts properties on Browns Rd, Bushmans Avenue and further downstream. Details of the proposed mitigation works at this location are presented in Figure 8-20.

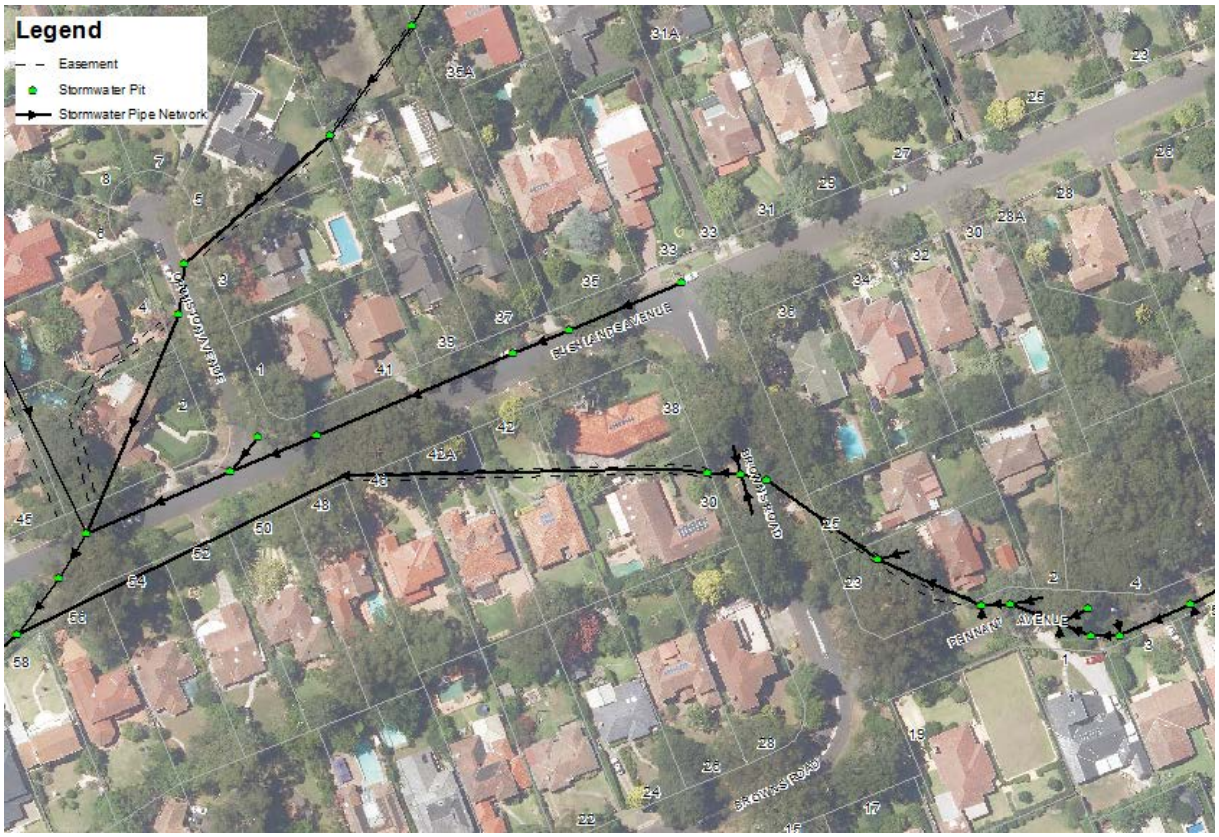

Figure 8-20 Option FM9 Location

Hydraulic Modelling

The stormwater pit modifications investigated involved increasing the stormwater lintel pit along Browns Road to an inlet opening length of 4.2m, which would provide increased capture of gutter and roadway flows to the underground network. The increase in inlet size could be achieved by installation of additional stormwater inlet pits but would require extensive .modification of the existing pit and pipe network.

Results

The results of the hydraulic analysis were compared to the existing case flood levels to establish the impact of the proposed changes. The results at a location where the largest impact was found to occur are summarised below in Table 8-13.

Table 8-13 Option FM9 - Flood Levels around impacted property

Area	1% AEP		
	Existing Scenario (m AHD)	Proposed Scenario (m AHD)	Difference (m)
30 Browns Road	88.55	88.54	-0.01

Details of the change in flood level at this location are shown in Figure 8-21.

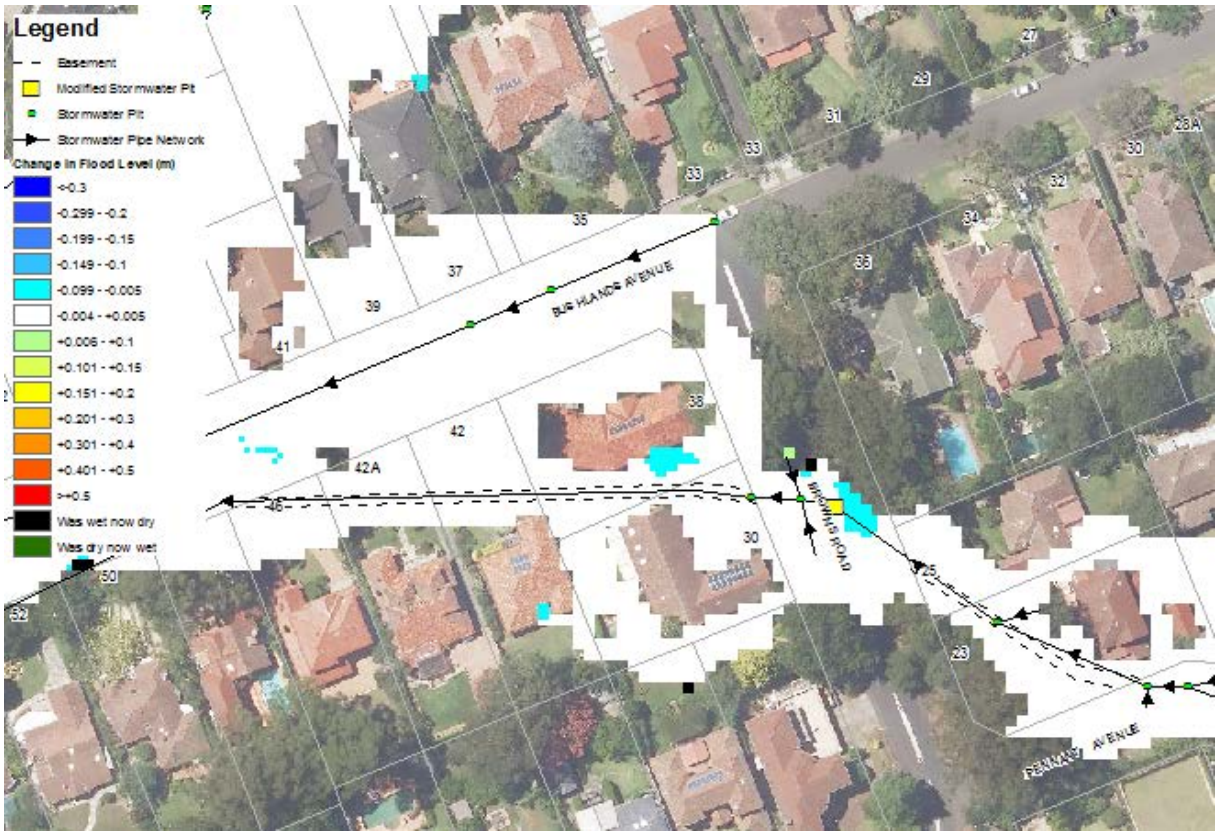

Figure 8-21 Option FM9 1% AEP Change in Water Level

Analysis

Figure 8-21 shows that this flood modification option would have very little impact on flood levels (up to 10mm in the 1% AEP event).

Any reduction in flood level is predicted to be highly localised and would not continue downstream. Hence, this option provides limited improvement to flooding. Also, increasing the pipe size downstream to further alleviate overland flooding was not investigated due to the alignment of the existing stormwater pipe, which runs underneath downstream residences.

This option is considered to have positive a flooding impact but the economic merit of implementing this option would not by justifiable. The justification being that any potential economic benefit to the local community is isolated to a single resident according to the community consultation feedback, whereas the cost implementing the option would be substantial.

8.5 Options assessment

8.5.1 Overview

The identified options were assessed based on consideration of the following:

- Impact on flooding
- Difficulty of implementation from a practical or technical standpoint
- Likely potential for adverse or positive environmental outcomes
- Likely potential for adverse or positive social outcomes
- Financial cost with respect to expected benefit.

Social assessment focused on factors such as disruption to residents but did not include consideration of impact from flooding, which was separately considered under the flood impact criterion.

Benefit Cost considerations for the structural options were qualitatively assessed due to the relatively low benefits, ie beneficiaries being generally individual properties. The assessment considered the degree of flood improvement compared to the complexity and cost of the flood mitigation option.

The options were identified as being either positive, negative or neutral with respect to the above considerations.

The qualitative matrix assessment of floodplain risk management options is summarised in Table 8-14.

Table 8-14 Qualitative matrix assessment of floodplain risk management options*

No.	Description	Impact on flooding	Practicality / technical difficulty	Environment	Social	Economic merit	Priority for action **	Timing (Years)	Comments
	Non-structural options								
PM1	Amendments to LEP and DCP	+	+	+	+	+	1	0-1	Implementation at next review / update of documents
RM1	Ongoing public awareness campaign	+	+	+	+	+	1	0-1	
RM2	SES emergency flood management and evacuation plan	+	+	+	+	+	1	1-2	
	Structural options								
FM1	Upgrading pit network in the vicinity of St Johns Avenue	+ / -	0	0	0	-	3	>3	Both increases and decreases in flood level predicted
FM2	Centre median to contain flood waters with the roadway along Vale Street	0	0	0	0	-	3	>3	No material improvement in flooding
FM3	Water level management in the Killara Golf Course dam prior to flooding event	+	-	+	-	-	2	>2	Potential to improve riparian condition through scour reduction. Likely adverse impact to golf course operations
FM4	Raising footpath levels to contain flood water within the roadway along Norfolk St	+	0	-	0	-	2	>2	Potential to maintain active flow in streetscape
FM5	Constructing a raised mound within the drainage easement along the property boundary with number 59 Bolwarra Avenue to confine flood waters within the drainage easement	+ / -	0	-	0	-	3	>3	Possible vegetation impacts towards the downstream of the proposed mitigation measures would need to be confirmed through site specific assessment
FM6	Upgrading pit and pipe network in the vicinity of 21- 27 Moree St	+	0	0	0	-	3	>3	Very minor reductions in flood level only
FM7	Raising channel bank levels adjacent to property number 8 Calvert Avenue to confine flood waters within the channel	-	0	0	0	-	3	>3	

No.	Description	Impact on flooding	Practicality / technical difficulty	Environment	Social	Economic merit	Priority for action **	Timing (Years)	Comments
FM8	Raising the footpath level along Ryde Road to confine flood waters within the roadway to avoid overflowing on to access road area	+ / -	0	0	0	-	3	>3	Both increases and decreases in flood level predicted
FM9	Upgrading pit network along Browns Road	+	0	0	0	-	3	>3	Very minor reductions in flood level only

* ***Ratings are qualitative where:***

+ Favourable

0 Neutral

- Unfavourable

***** 1 is highest priority and 3 is lowest priority***

8.5.2 Discussion

The property and response modification options would not have an impact on the current flooding situation but would mitigate potential future flooding impacts through improved planning controls or responses to flooding.

They are considered to be implementable as part of general Council activities or activities of other agencies. For example, modifications to the LEP or DCP could be implemented during scheduled DCP and LEP reviews and updates. Likewise, through the continued activities of the local SES, the local flood response planning could be updated with information contained in this plan over time.

For these reasons, the property and response modification options were rated highly to be taken forward for further consideration in the floodplain risk management plan.

The floodplain modification options varied in scale of influence on flood behaviour but outcomes were generally localised with potential improvements for only one or two properties. The expected costs of major stormwater works, such as replacing stormwater pipes with additional capacity, would generally be unlikely to be offset by an improvement in flood damages, especially given that none of the options was effective in reducing above floor flooding, where it occurred, to below the floor levels.

Option FM4 was assigned a higher priority for further consideration due to reductions in flood level of greater than 100 mm, although these were also localised and of benefit to only a small number of properties.

It is anticipated that there will be practical limitations to the management of water levels at the Killara Golf Course dam (option FM3) that would limit its feasibility for implementation. Given the potential for improvements to scour, it is worth further investigation of this option through consultation with Killara Golf Course, and has therefore been assigned a medium priority (2) for further implementation.

The remainder of the options identified are considered to be of low priority for further consideration.