PENRITH CITY COUNCIL

ST MARYS (BYRNES CREEK) CATCHMENT FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FEBRUARY 2020

VOLUME 1 – REPORT

FINAL REPORT

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FOREWORD

NSW Government's Flood Policy

The NSW Government's Flood Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities. The Policy provides for technical and financial support by the State through the following four sequential stages:

1.	Data Collection and Flood Study	Collects flood related data and undertakes an investigation to determine the nature and extent of flooding.
2.	Floodplain Risk Management Study	Evaluates management measures for the floodplain in respect of both existing and proposed development.
3.	Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
4.	Implementation of the Plan	Construction of flood mitigation works to protect existing development. Use of Local Environmental Plans to ensure new development is compatible with the flood hazard. Improvements to flood emergency management procedures.

Presentation of Study Results

The results of the flood study investigations commissioned by Penrith City Council have been presented in two separate reports:

- *St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study* dated November 2015.
- ***St Marys (Byrnes Creek) Floodplain Risk Management Study & Plan** (**this present report**)*

The studies have been prepared under the guidance of the Floodplain Risk Management Committee comprising representatives from Penrith City Council, the Office of Environment and Heritage and the NSW State Emergency Service.

ACKNOWLEDGEMENT

Penrith City Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

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ABBREVIATIONS

AEP	Annual Exceedance Probability (%)
AHD	Australian Height Datum
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff (1987 Edition)
BoM	Bureau of Meteorology
Council	Penrith City Council
DECC	Department of Environment and Climate Change
FDM	Floodplain Development Manual, 2005
FRMC	Floodplain Risk Management Committee
FPL	Flood Planning Level (1% AEP flood level + 500 mm freeboard)
FPA	Flood Planning Area
FRMS	Floodplain Risk Management Study
FRMP	Floodplain Risk Management Plan
FRMS&P	Floodplain Risk Management Study and Plan
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging (survey)
MFL	Minimum Floor Level
NSWG	New South Wales Government
NSW SES	New South Wales State Emergency Service
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
VP	Voluntary Purchase

SUMMARY

S1 Study Objectives

Penrith City Council (**Council**) commissioned the *Floodplain Risk Management Study and Plan* for the portion of St Marys which lies within the catchment of Byrnes Creek. The overall objectives of the *Floodplain Risk Management Study (**FRMS**)* were to assess the impacts of flooding, review existing Council policies as they relate to development of land in flood liable areas, consider measures for the management of flood affected land and to develop a *Floodplain Risk Management Plan (**FRMP**)* which:

i) Proposes modifications to existing Council policies to ensure that the development of flood affected land is undertaken so as to be compatible with the flood hazard and risk.

ii) Sets out the recommended program of works and measures aimed at reducing over time, the social, environmental and economic impacts of flooding.

iii) Provides a program for implementation of the proposed works and measures.

Byrnes Creek is a minor tributary of South Creek, the latter which is a major tributary of the Hawkesbury-Nepean River. **Figure 1.1** shows the location of the study area relative to the Byrnes Creek catchment, the larger South Creek catchment and the Hawkesbury-Nepean River.

The *FRMS* deals with the following three mechanisms of flooding which affect different parts of the study area:

- **Local Catchment Flooding** resulting from the surcharge of Byrnes Creek and the existing stormwater drainage system which controls runoff from the urbanised parts of the catchment. Several major overland flow paths develop in the urbanised parts of the study area due to this type of flooding. Flooding of this type is of a "flash flooding" nature, with water levels typically rising to their peak in less than two hours. Flows on the major overland flow paths would typically be less than 500 mm deep, travelling over the surface at velocities less than 1 m/s.
- **South Creek Flooding** resulting from flow that backs up from South Creek behind a large earthen levee which has been constructed on the floodplain (denoted herein as the "***St Marys Levee***"). **Figure 2.1** shows the alignment of the St Marys Levee relative to existing development in the study area. Flooding of this type is relatively slow rising in nature, with little to no velocity associated with the flow. During rare to extreme flood events, floodwater would also overtop the earthen section of the St Marys Levee, where it would impact existing development which lies outside the backwater zone.
- **Hawkesbury-Nepean River Flooding** resulting from flow that backs up South Creek from the Hawkesbury-Nepean River. Flooding of this type is slow rising in nature, with little to no velocity associated with the flow. Floodwater would commence to back up behind the St Marys Levee during a Hawkesbury-Nepean Flood with an Annual Exceedance Probability (**AEP**) of about 0.2 per cent.

S2 Study Activities

The activities undertaken in this *FRMS* included:

1. Undertaking a consultation program over the course of the study to ensure that the community was informed of its objectives, progress and outcomes (**Chapters 1** and **3**, as well as **Appendix A**).

2. Review of flooding patterns in the study area for flood events up to the Probable Maximum Flood (**PMF**), as determined in the *St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study* (Cardo, 2015) *(*herein, referred to as the ***Flood Study***), as well as additional flood modelling that was undertaken as part of the present study. (**Chapter 2** and **Appendix B**).
3. Review of the economic impacts of flooding, including the numbers of affected properties and estimation of flood damages as defined in the *Flood Study* (**Chapter 2**).
4. Review of current flood related planning controls and their compatibility with flooding conditions (**Chapter 2**).
5. Strategic review of potential floodplain management works and measures aimed at reducing flood damages, including an economic assessment of several measures (**Chapter 3**).
6. Ranking of works and measures using a multi-objective scoring system which took into account economic, financial, environmental and planning considerations (**Chapter 4**).
7. Preparation of the *FRMP* for the study area (**Chapter 5**).

S3 Summary of Flood Impacts

The study area is located in the suburb of St Marys which lies about 8 km to the east of Penrith (refer Figure 1.1) and is bounded by the Western Railway Line to the north, the St Marys Levee and the main arm of South Creek to the west, the M4 Motorway to the south and residential development to the east.

The present study found that there are a significant number of pipes which flow full during storms as frequent as 1EY (refer Figure 2.3 which comprises 2 sheets), indicating that overland flow would be experienced in a number of properties on a relatively frequent basis.

Figures 2.4 and 2.6 (2 sheets each) show the indicative extents and depths of inundation resulting from Local Catchment Flooding for a 1% AEP and PMF event, respectively, while Figures C1.2 to C1.9 (2 sheets each) in Appendix C show the indicative extents and depths of inundation for local catchment floods of between 1EY and 2% AEP, as well as the 0.5% and 0.2% AEP events.

While there are a number of residential properties that would be subject to relatively shallow and slow moving overland flow in a 1% AEP local catchment flood event, flooding due to surcharge of the main arm of Byrnes Creek is generally limited to development that is located downstream of Cook Park.

Surcharge of the enclosed reaches of Byrnes Creek downstream of Mamre Road has the potential to inundate roads which would need to be used to evacuate occupants of a large number of medium and high density residential type developments that are located behind the St Marys Levee during the rising limb of either a South Creek or Hawkesbury-Nepean River flood. These roads comprise Wilson Street, Saddington Street, Pages Street and Putland Street.

While the cascading detention basin arrangement in Monfarville Reserve is effective in mitigating the impacts of Local Catchment Flooding on development that is located behind the St Marys levee for floods up to about 0.2% AEP in magnitude, significant depths of inundation would be experienced in the protected area during very rare and extreme storm events, when the basins would be surcharged and the resulting catchment runoff would pond behind the St Marys Levee.

Figures 2.8 and **2.9** (2 sheets each) show the indicative depth and extent of inundation for the envelope of South Creek and Local Catchment Flooding for a 1% AEP and PMF event, respectively.

While backwater flooding from South Creek impacts only a small number of ground floor residential units for floods up to 1% AEP in magnitude, the present study identified that the freeboard to the crest of the earthen section of the St Marys Levee is less than 0.5 m at several locations. Based on an assumed design freeboard requirement of 1 m, the design standard of the earthen section of the St Marys Levee is equivalent to about a 5% AEP South Creek flood.

The *Updated South Creek Flood Study* (Worley Parsons, 2015) showed that a partial blockage of the Great Western Highway bridge crossing on South Creek would result in a maximum increase of 0.38 m in peak 1% AEP flood levels immediately upstream of the road corridor, reducing to 0.07 m at the southern (upstream) end of the St Marys Levee. This finding demonstrates that the freeboard to the crest level of the St Marys Levee could be effectively zero during a 1% AEP flood in South Creek.

As mentioned in **Section S1**, floodwater would commence to back up behind the St Marys Levee during a Hawkesbury-Nepean Flood with an AEP of about 0.2 per cent. During a PMF event on the Hawkesbury-Nepean River, backwater flooding would extend as far upstream as the Mamre Road culverts on Byrnes Creek and typically take over a day to reach its peak. **Figure 2.10** (2 sheets) shows the indicative extent and depth of inundation in the study area resulting from a PMF event on the Hawkesbury Nepean River.

At the 1% AEP level of flooding, the *Flood Study* identified that 285 residential properties would be flood affected (i.e. water inundates the allotment), 48 of which would experience above-floor inundation. Of the 48 dwellings that would experience above-floor inundation at the 1% AEP flood event, all but eight are located to the east of the main arm of Byrnes Creek and are affected by overland flow due to surcharge of the local stormwater drainage system. The *Flood Study* also identified that there are 48 commercial buildings that would be flood affected, 26 of which would be inundated above floor level at the 1% AEP level of flooding. The total cost of flood damages in the study area would be approximately $5.05 Million for a 1% AEP flood event.

The “present worth value” of damages in the study area resulting from all floods up to the 1% AEP event at a seven per cent discount rate and economic life of 50 years is $19.5 Million. This value represents the amount of capital spending that would be justified if a particular flood mitigation measure or a group of measures prevented flooding across the whole of the study area for all properties up to the 1% AEP event.

S4 Flood Risk and Development Controls

Figure 3.2 is an extract from the *Flood Planning Map* relating to the study area and its immediate environs. The extent of the Flood Planning Area (**FPA**) (the area subject to flood related development controls) is shown in a solid red colour on the *Flood Planning Map* and has been defined as the area which lies at or below the peak 1% AEP flood level plus 500 mm freeboard.

Properties that are intersected by the extent of the FPA would be subject to S10.7 flood affectation notification and planning controls graded according to flood hazard. A graded set of flood related planning controls would apply to future development depending on where it is located in the study area.

Tables 3.3 and **3.4** in Chapter 3 of the report set out the graded set of flood related planning controls which have been developed for the study area. **Table 3.3** deals with areas subject to Local Catchment Flooding due to surcharge of flow from the main arm of Byrnes Creek, as well as South Creek Flooding (denoted the "***St Marys (Byrnes Creek) Flood Related Development Control Area 1***"), while **Table 3.4** deals with areas subject to Local Catchment Flooding along the overland flow paths which drain in a westerly direction toward the main arm of Byrnes Creek (denoted the "***St Marys (Byrnes Creek) Flood Related Development Control Area 2***"). **Figure 3.3** is the *Development Controls Matrix Map* for the study area showing the areas over which the controls set out in **Tables 3.3** and **3.4** apply.

Minimum floor level requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The minimum floor levels for all land use types other than critical infrastructure and vulnerable development is the level of the 1% AEP flood event plus 500 mm freeboard.

S5 The Floodplain Risk Management Plan

The *FRMP* showing recommended flood management measures for the study area is presented in **Chapter 5**, with the recommended works and measures summarised in **Table S1** at the end of this Summary. The recommended works and measures have been given a provisional priority ranking, confirmed by the Floodplain Risk Management Committee, according to a range of economic, social, environmental and other criteria set out in **Table 4.1** of the report.

The draft *FRMP* includes four management measures which could be implemented by both Council and New South Wales State Emergency Service (**NSW SES**) using existing data and without requiring Government funding. The four measures are as follows:

- **Measure 1** - The application of a graded set of planning controls for future development that recognise the location of the development within the floodplain; to be applied through an improved set of flood related development controls. Application of these controls by Council will ensure that future development in flood liable areas in the study area is compatible with the flood risk.
- **Measure 2** – Minor amendment to the wording of clause 7.2 of the *Penrith Local Environmental Plan 2010* (***Penrith LEP 2010***) in order to support the implementation of improved set of planning controls, as well as the inclusion of a new floodplain risk management clause which would apply to land identified as Outer Floodplain (i.e. to land which lies between the FPA and the extent of the PMF).
- **Measures 3** - Improvements in the NSW SES's emergency planning, including use of the flood related information contained in this study to update the *Penrith City Local Flood Plan*.
- **Measure 4** – The development and implementation of a flood awareness and education program for residents and business owners located on the floodplain. This could include the preparation of a *Flood Information Brochure* to be prepared by Council with the assistance of NSW SES containing both generic and site specific data and distributed with the rate notices.

Measure 5 involves the installation of a telemetered stream gauge immediately upstream of the Great Western Highway bridge crossing of South Creek and the development of a *Flood Intelligence Card* by NSW SES which links water levels with consequences within the study area.

Measure 6 comprises a recommendation that the *South Creek Floodplain Risk Management Study and Plan* assess the upgrade requirement for the St Marys Levee. This would require an initial assessment to be undertaken of the freeboard which would be required to increase the design standard of the existing levee to 1% AEP.

The remaining eight measures comprise the investigation and design of a number of flood modification measures which are aimed at reducing the impacts of flooding in existing development, as well as reducing the risk that the roads that are relied upon for flood evacuation purposes are inundated by Local Catchment Flooding during the rising limb of either a South Creek or Hawkesbury-Nepean River flood. The eight measures are as follows:

- **Measures 7** – Investigation and concept design of a new stormwater drainage line extending from the sag that is located in Mamre Road between its intersection with Saddington Street and Ellis Street to the main arm of Byrnes Creek. Two alternative routes for the new drainage line are to be assessed, given the Ellis Street option would require the pipeline to be installed in a relatively deep trench, while the Saddington Street option could conflict with existing utilities and would result in major disruption to westbound traffic. The two alternative options are denoted herein as '**Stormwater Drainage Upgrade Schemes 5A and 5B'**.
- **Measures 8** – Detailed design and construction of either Stormwater Drainage Upgrade Scheme 5A or 5B.
- **Measures 9** – Investigation and concept design of a detention basin in the reserve which is located on the western side of Collins Street between its intersection with Lonsdale Street and Mitchell Street (denoted herein as '**Stormwater Drainage Upgrade Scheme 6**').
- **Measures 10** – Detailed design and construction of Stormwater Drainage Upgrade Scheme 6.
- **Measures 11** – Investigation and concept design of amplified temporary flood storage area in Cook Park immediately upstream of Saddington Street. .
- **Measures 12** – Detailed design and construction of works in Cook Park.
- **Measures 13** – Detailed design and construction of the upgrade to the earth embankment associated with Basin BA04 in Monfarville Reserve in order to incorporate a 0.5 m freeboard to the peak 1% AEP flood level. .
- **Measures 14** – Detailed design and installation of debris control structures at the following three locations:
    - adjacent to the inlet of four cell 1500 mm diameter pipes which control flow discharging from Basin BA04 in Monfarville Reserve,
    - adjacent to the inlet of the twin cell 1650 mm dimeter pipes extending downstream of Saddington Street in Cook Park; and
    - upstream of the box culvert under the Great Western Highway near the western end of Putland Street.

The implementation of these measures would require Government funding.

S6 Timing and Funding of FRMP Measures

The total estimated cost to implement the preferred floodplain management strategy is **$5.04 Million**, exclusive of Council and NSW SES Staff Costs. The timing of the measures will depend on Council's overall budgetary commitments and the availability of both Local and State Government funds.

Assistance for funding qualifying projects included in the *FRMP* may be available upon application under the Commonwealth and State funded floodplain management programs, currently administered by Office of Environment and Heritage.

S7 Council Action Plan

1. Council finalises the *FRMS* report and approves the *FRMP* according to the procedure recommended in **Section 5.15**.
2. Council and NSW SES commence work on the "non-structural" measures in the *FRMP (***Measures 1** to **4***)*.
3. Council applies for Government Funding for the installation of a telemetered stream gauge to be installed immediately upstream of the Great Western Highway bridge crossing of South Creek, following which NSW SES develop a *Flood Intelligence Card* which links water levels to consequences in the study area. **Measure 5** of the *FRMP*.
4. Council ensure that the *South Creek Floodplain Risk Management Study and Plan* assesses the upgrade requirements for the St Marys Levee. **Measure 6** of the *FRMP*.
5. Council apply for Government Funding to undertake the investigation and concept design of Stormwater Drainage Upgrade Scheme 5A or 5B, Stormwater Drainage Upgrade Scheme 6 and the temporary flood storage area works in Cook Park (**Measures 7**, **9** and **11** of the *FRMP*).
6. Council apply for Government Funding to undertake the detailed design and construction of the basin embankment upgrade works in Monfarville Reserve, as well as the detailed design and installation of the three debris controls structures on the main arm of Byrnes Creek (**Measures 13** and **14** of the *FRMP*).
7. Depending on the outcomes of the feasibility studies undertaken as part of Measures 7, 9 and 11, Council apply for Government Funding to undertake the detailed design and construction of the preferred set of measures.

TABLE S1
RECOMMENDED MEASURES FOR INCLUSION IN
ST MARYS (BYRNES CREEK) FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Benefit Cost Ratio	Priority
1. Implement recommended development controls based on recommended updates to *Penrith DCP 2014*.	(Council's staff costs)	▪ Graded set of flood controls based on the type of development and their location within the floodplain, defined as land inundated by the Probable Maximum Flood. ▪ Floodplain divided into six zones based on the assessed flood hazard. ▪ The Flood Planning Level for all development types is the 1% AEP plus a 500 mm allowance for freeboard. ▪ Controls for Essential Community Facilities, Critical Utilities and Flood Vulnerable development based on the Probable Maximum Flood.	-	**High Priority**: this measure is designed to mitigate the flood risk to future development and has a high priority for inclusion in the *FRMP*. It does not require Government funding.
2. Update of *Penrith LEP 2010*	Council's staff costs	➢ Minor amendment is required to the wording of clause 7.2 in *Penrith LEP 2010*. ➢ A new flood risk management clause should be incorporated in *Penrith LEP 2010* which applies to land that lies between the FPA and the Probable Maximum Flood (**PMF**). The new clause relates to development with particular evacuation or emergency response issues (e.g. group homes, residential aged care facilities, etc). It is also aimed at protecting the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.	-	**High Priority**: this measure is designed to mitigate the flood risk to future development and has a high priority for inclusion in the *FRMP*. It does not require Government funding.
3. Ensure flood data in this *FRMS* are available to the NSW SES for improvement of flood emergency planning.	NSW SES costs	➢ NSW SES should update the *Penrith City Local Flood Plan 2012* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in this report.	-	**High Priority**: this measure would improve emergency response procedures and has a high priority. It does not require Government funding.
4. Implement flood awareness and education program	Council staff costs	➢ Council to inform residents of the flood risk, based on the information presented in the *FRMS*. (e.g. displays of flood mapping at Council offices, preparation of *Flood Information Brochure* for distribution with rate notices, etc).	-	**High Priority**: this measure would improve the flood awareness of the community and has a high priority. It does not require Government funding.
5. Installation of telemetered stream gauge on South Creek immediately upstream of great Western Highway bridge crossing	$20,000[(1)]	➢ The installation of a telemetered stream gauge by WaterNSW would provide NSW SES and Council with real-time information on water levels in South Creek adjacent to the St Marys Levee. ➢ NSW SES to develop a *Flood Intelligence Card* which links water levels at the gauge site with the consequences of flooding in the study area.	-	**High Priority**: this measure would reduce flood damages by providing advance warning of rising water levels in South Creek.
6. South Creek Floodplain Risk Management Study to investigate upgrade requirements for St Marys Levee	$10,000	➢ Council to ensure that the South Creek Floodplain Risk Management Study and Plan investigates the upgrade requirements for the St Marys Levee, noting that this would require a preliminary assessment to be made of the freeboard and crest level requirements which are required to increase the design standard of the levee to 1% AEP.	-	**High Priority**: this measure would reduce the flood risk for development that is located behind the St Marys Levee.
7. Investigation and concept design of Stormwater Drainage Upgrade Scheme 5A or 5B[(2)]	$80,000	➢ Surveys of trunk drainage system to confirm key details, including potholing to confirm levels of critical services. ➢ Hydraulic modelling to confirm sizes of elements comprising either Stormwater Drainage Upgrade Scheme 5A or 5B. ➢ Refine concept designs and cost estimates prepared in this FRMS to the Preliminary Design Stage. ➢ Cost-benefit analysis to confirm the economic feasibility of the schemes and establish priorities for implementation. ➢ Prepare a submission for Council and Government funding for detailed design and construction.	0.57 (5A) 0.97 (5B)	**High Priority**: this measure would mitigate existing flooding problems. It would require Council and Government funding.
8. Detailed design and construction of Stormwater Drainage Upgrade Scheme 5A or 5B[(3,4)]	$2.0 Million	➢ Tasks involved are as follows: o Prepare detailed design and documentation for either Stormwater Drainage Upgrade Scheme 5A or 5B. o Prepare a submission for Council and Government funding. o Construct drainage improvements.		**Medium Priority**: this measure would mitigate existing flooding problems. It would require Council and Government funding. Note the required funding is an indicative present worth cost based on preliminary analyses undertaken in this *FRMS*.

Cont'd Over

TABLE S1 (Cont'd)
RECOMMENDED MEASURES FOR INCLUSION IN
ST MARYS (BYRNES CREEK) FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Benefit Cost Ratio	Priority
9. Investigation and concept design of Stormwater Drainage Upgrade Scheme 6[2]	$40,000	➢ Surveys of trunk drainage system to confirm key details, including potholing to confirm levels of critical services. ➢ Hydraulic modelling to confirm sizes of elements comprising Stormwater Drainage Upgrade Scheme 6. ➢ Refine concept designs and cost estimates prepared in this FRMS to the Preliminary Design Stage. ➢ Cost-benefit analysis to confirm the economic feasibility of the schemes and establish priorities for implementation. ➢ Prepare a submission for Council and Government funding for detailed design and construction.	0.85	**High Priority**: this measure would mitigate existing flooding problems. It would require Council and Government funding.
10. Detailed design and construction of Stormwater Drainage Upgrade Scheme 6[4]	$600,000	➢ Tasks involved are as follows: o Prepare detailed design and documentation for Stormwater Drainage Upgrade Scheme 6. o Prepare a submission for Council and Government funding. o Construct drainage improvements.		**Medium Priority**: this measure would mitigate existing flooding problems. It would require Council and Government funding. Note the required funding is an indicative present worth cost based on preliminary analyses undertaken in this *FRMS*.
11. Investigation and concept design of works associated with amplifying the temporary flood storage volume in Cook Park[2]	$40,000	➢ Hydraulic modelling to confirm scope of works within Cook Park. ➢ Refine concept designs and cost estimates prepared in this FRMS to the Preliminary Design Stage. ➢ Cost-benefit analysis to confirm the economic feasibility of the schemes and establish priorities for implementation. ➢ Prepare a submission for Council and Government funding for detailed design and construction.	-	**High Priority**: this measure would mitigate existing flooding problems. It would require Council and Government funding.
12. Detailed design and construction of works within Cook Park[4]	$1.3 Million	➢ Tasks involved are as follows: o Prepare detailed design and documentation for works within Cook Park. o Prepare a submission for Council and Government funding. o Construct drainage improvements.	-	**Medium Priority**: this measure would mitigate existing flooding problems. It would require Council and Government funding. Note the required funding is an indicative present worth cost based on preliminary analyses undertaken in this *FRMS*.
13. Detailed design and construction of the upgrade to the earth embankment associated with Basin BA04 in Monfarville Reserve[2,4]	$350,000[5]	➢ Survey of existing basin embankment, including potholing to confirm levels of critical services (if required). ➢ Geotechnical investigation to ➢ Hydraulic modelling to confirm basin upgrade requirements. ➢ Prepare detailed design and documentation for basin upgrade. ➢ Construct basin upgrade requirements.	-	**Medium Priority**: this measure would mitigate existing flooding problems. It would require Council and Government funding.
14. Detailed design and installation of the three debris controls structures on the main arm of Byrnes Creek[2,4]	$600,000	➢ Survey of existing culvert inlet and channel arrangement, including potholing to confirm levels of critical services (if required). ➢ Hydraulic modelling to confirm debris control structures will not exacerbate flooding behaviour when blocked. ➢ Prepare detailed design and documentation for debris control structures. ➢ Install three debris control structures along main arm of Byrnes Creek.	-	**Medium Priority**: this measure would mitigate existing flooding problems. It would require Council and Government funding.
Total Estimated Cost	**$5.04 Million**			

1. Excludes ongoing operation and maintenance and costs.
2. Does not include the cost of locating underground utilities.
3. The estimated capital cost of constructing the more expensive of the two schemes has been adopted in the *FRMP*.
4. Does not include the cost of relocating underground utilities.
5. Assumes existing embankment can be raised, rather than it needing be removed and rebuilt.

1 INTRODUCTION

1.1 Study Background

Penrith City Council (**Council**) commissioned the preparation of the *Floodplain Risk Management Study and Plan* (***FRMS&P***) for the lower portion of the Byrnes Creek catchment at St Marys in accordance with the New South Wales Government's *Flood Prone Land* policy. **Figure 1.1** shows the location and extent of the study area. This report sets out the findings of the *FRMS&P* investigation which utilises modified versions of the flood models that were developed as part of the *St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study* (Cardno, 2015) (herein referred to as the ***Flood Study***).

The *Floodplain Risk Management Study (**FRMS**)* reviewed baseline flooding conditions, including an assessment of economic impacts and the feasibility of potential measures aimed at reducing the impact of flooding on both existing and future development. This process allowed the formulation of the *Floodplain Risk Management Plan* (***FRMP***) for the study area.

1.2 Background Information

The following documents were used in the preparation of this report.

- *Floodplain Development Manual* (New South Wales Government (NSWG), 2005)
- *Penrith Local Environmental Plan, 2010* (*Penrith LEP 2010*)
- *Hawkesbury Floodplain Risk Management Study & Plan (Bewsher Consulting, 2012)*
- *Penrith Development Control Plan,* 2014 (*Penrith DCP 2014*)
- *St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study* (Cardno, 2015)
- *Updated South Creek Flood Study* (Worley Parsons, 2015)

1.3 Overview of FRMS Report

The results of the *FRMS* and the *FRMP* are set out in this report. Contents of each Chapter of the report are briefly outlined below:

- **Chapter 2**, **Baseline Flooding Conditions**. This Chapter includes a description of the drainage system and a review of existing flood behaviour in the study area as derived by modified versions of the hydrologic and hydraulic models that were developed as part of the *Flood Study*. The Chapter also summarises the economic impacts of flooding on existing urban development, reviews Council's flood planning controls and management measures and NSW State Emergency Service's (**NSW SES's**) flood emergency planning. The Chapter also assesses the impact of future urbanisation in the study area, as envisaged by the *Penrith LEP 2010.*
- **Chapter 3**, **Potential Floodplain Management Measures**. This Chapter reviews the feasibility of floodplain management options for their possible inclusion in the *FRMP.* The list of measures considered is based on input from the Community Consultation process, which sought the views of residents and business owners in the study area in regard to potential flood management measures which could be included in the *FRMP*. The measures are investigated at the strategic level of detail, including indicative cost estimates of the most promising measures and benefit/cost analysis.

- **Chapter 4**, **Selection of Floodplain Management Measures**. This Chapter assesses the feasibility of potential floodplain management strategies using a multi-objective scoring procedure which was developed in consultation with the Floodplain Risk Management Committee (**FRMC**) and outlines the preferred strategy.
- **Chapter 5, St Marys (Byrnes Creek) Floodplain Risk Management Plan** presents the *FRMP* which comprises a number of structural and non-structural measures which are aimed at increasing the flood awareness of the community and ensuring that future development is undertaken in accordance with the local flood risk.
- **Chapter 6** contains a glossary of terms used in the study.
- **Chapter 7** contains a list of References.

Five technical appendices provide further information on the study results:

Appendix A – Community Consultation summarises residents' and business owners' views on potential flood management measures which could be incorporated in the *FRMP*.

Appendix B – Plates Showing Historic Flooding - 6 June 2016 includes several photos showing the flooding that was experienced at the western end of Putland Street on 6 June 2016.

Appendix C – **Characteristics of Local Catchment Flooding Behaviour** contains a series of figures which show the results of running modified versions of the hydrologic and hydraulic models that were developed as part of the *Flood Study*. The results presented on the figures relate to inundation that arises in the study area as a result of rain falling directly over the Byrnes Creek catchment and does not include flooding from South Creek (referred to herein as "**Local Catchment Flooding**").

Appendix D – Design Flood Envelopes – South Creek and Local Catchment Flooding contains a series of figures showing the envelope of local catchment and main stream flooding, the latter which occurs due to elevated water levels on South Creek.

Appendix E – **Assessment of Potential Flood Modification Measures** contains a series of figures showing the flood mitigation benefits which could be achieved by implementing a number of measures which comprise the upgrade of the existing stormwater drainage system.

1.4 Community Consultation

Following the Inception Meeting of the FRMC, a *Community Information Sheet* was prepared by the Consultants and distributed to residents and business owners by Council. A *Community Questionnaire* was also distributed by Council seeking details from residents and business owners regarding their attitudes toward potential floodplain management measures. Community responses are summarised in **Chapter 3** of the report, with supporting information in **Appendix A**. The views of the community on potential flood management measures to be considered in the study were also taken into account in the assessment presented in **Chapter 3** of the report.

The FMRC reviewed the potential flood management measures developed in **Chapter 3** and assessed the measures using the proposed scoring system of **Chapter 4**. The *FRMS* and accompanying *FRMP* were also reviewed by the FRMC and amended prior to the preparation of the public exhibition report.

1.5 Flood Frequency and Terminology

In this report, the frequency of floods is referred to in terms of their Annual Exceedance Probability (**AEP**). The frequency of floods may also be referred to in terms of their Average Recurrence Interval (**ARI**). Floods more frequent than 50% AEP are expressed in terms of the number of exceedances per year (**EY**). The approximate correspondence between these two systems is:

Annual Exceedance Probability (AEP) – %	Average Recurrence Interval (ARI) – years
0.2	500
0.5	200
1	100
10	10
20	5
50	1.4
1EY	1
2EY	0.5

The AEP of a flood represents the percentage chance of its being equalled or exceeded in any one year. Thus a 1% AEP flood, which is equivalent to a 100 year ARI, has a 1% chance of being equalled or exceeded in any one year and would be experienced, on the average, once in 100 years; similarly, a 20 year ARI flood has a 5% chance of exceedance, and so on.

The 1% AEP flood (plus freeboard) is usually used to define the Flood Planning Level (**FPL**) and Flood Planning Area (**FPA**) for the application of flood related controls over residential and commercial/industrial development. While a 1% AEP flood is a major flood event, it does not define the upper limit of possible flooding. Over the course of a human lifetime of, say 70 years, there is a 50 per cent chance that a flood at least as big as a 1% AEP event will be experienced. Accordingly, a knowledge of flooding patterns in the event of larger flood events up to the Probable Maximum Flood (**PMF**), the largest flood that could reasonably be expected to occur, is required for land use and emergency management planning purposes. In the *Flood Study*, flooding patterns in the study area were assessed for design floods ranging between a 1EY event and the PMF.

2 BASELINE FLOODING CONDITIONS

2.1 Physical Setting

The study area is located in the suburb of St Marys which lies about 8 km to the east of Penrith (refer **Figure 1.1**). **T**he study area is bounded by the Western Railway Line to the north, an existing flood protection levee (denoted herein as the ***St Marys Levee***) and the main arm of South Creek to the west, the M4 Motorway to the south and residential development to the east. The Great Western Highway runs through the northern portion of the study area in an east-west direction, while Mamre Road runs to the south of the highway where it links up with the M4 Motorway via a series of on- and off-ramps.

While the study area is highly urbanised in nature, there are a number of public recreation areas, several of which border the main arm of Byrnes Creek. Development in the south-eastern portion of the study area comprises low density residential development, while the remainder comprises a mixture of medium and high density residential development, with commercial development generally located to the north of the Great Western Highway.

2.2 Drainage System

The study area comprises the lower portion of the Byrnes Creek catchment downstream of Monfarville Reserve, where a relatively large cascading basin arrangement has been built to mitigate local catchment flooding west of Mamre Road. **Figure 2.1** shows the extent of the 6.3 km^2 Byrnes Creek catchment relative to the 3.1 km^2 study area, as well as the layout of the existing stormwater drainage system.

Byrnes Creek is a minor tributary of the much larger South Creek, the extent of which is shown on **Figure 1.1**. South Creek is a major tributary of the Hawkesbury-Nepean River, with the confluence of the two watercourses located about 20 km to the north of the study area near Windsor.

The St Marys Levee is aimed at mitigating the impacts of flooding from South Creek on existing development that is located in the study area west of Mamre Road. **Figures 2.1** and **2.2** show the alignment of the St Marys Levee.

Runoff generated by the upper portion of the Byrnes Creek catchment discharges to the aforementioned cascading basin arrangement that is located in Monfarville Reserve. **Figure 2.2** shows that the cascading basin arrangement comprises four compartments, the most downstream of which is located adjacent to Mamre Road (refer Basins BA01, BA02, BA03 and BA04 on **Figure 2.2**). In addition to attenuating flows generated by the upper portion of the Byrnes Creek catchment, the piped outlet arrangement that is located beneath Mamre Road diverts flow toward the main arm of South Creek (i.e. away from the main arm of Byrnes Creek and the area which lies behind the St Marys Levee).

The reach of Byrnes Creek which runs between Monfarville Reserve and Saddington Street has been realigned at several locations and is generally in a semi-natural state. The main arm of the creek has been enclosed between Saddington Street and a location downstream of Neale Street. Between Saddington Street and Neale Street the enclosed system comprises twin cell 1.65 m diameter pipes, while the remainder of the enclosed system downstream of Neale Street comprises a single 3.8 m wide by 1.8 m high box culvert where it runs through a commercial development.

Flow conveyed in the aforementioned box culvert discharges to a short length of channel which runs in a northerly direction between the St Marys Levee and the aforementioned commercial development. Flow conveyed by the short reach of channel discharges to a single 3.5 m wide by 3.7 m high box culvert which is located beneath the Great Western Highway (denoted herein as the ***Great Western Highway culvert***). Flow conveyed by the Great Western Highway culvert combines with flow which discharges from an adjacent transverse drainage structure which is located on an overbank flood runner of South Creek and comprises a four cell 3.5 m wide by 3.7 m high box culvert arrangement.

Figure 2.2 shows that there are three principal trunk drainage lines that control runoff from the developed portion of the study area which lies to the east of Byrnes Creek. While flow that surcharges these three trunk drainage lines discharges to Byrnes Creek as overland flow, low flows are conveyed to the inlet of the aforementioned twin cell 1650 mm diameter pipes via a single 900 mm diameter pipe.

Two other principal trunk drainage lines control runoff that is generated by the northern portion of the study area, where they discharge to the main arm of South Creek immediately west of Charles Hackett Drive. The northern of these trunk drainage lines controls runoff from the central business district of St Marys and comprises three main branches. The southern branch is centred on King Street and includes a small detention basin which has been built in Bennett Park (refer Basin BA05 on **Figure 2.2**), while the central branch has recently been upgraded by Council where it runs between Queens Street and West Lane in Coachmans Park.[1]

2.3 Recent Flood Experience

Information on historic flooding in the study area is limited, as only a small number of respondents to the questionnaire that was distributed during the preparation of the *Flood Study* advised that they had experienced flooding, with only one advising that they had experienced above-floor inundation in their property. **Table 2.1** over the page lists the storm events which the respondents to the *Flood Study* questionnaire nominated as having caused flooding in their properties.

Two of these storms correspond with the years when major flooding was experienced in the broader South Creek catchment, as Worley Parsons, 2015 nominates 1986 and 1988 as years when elevated water levels were experienced at the Great Western Highway.

More recently, flooding was observed to have occurred on 6 June 2016 at the western end of Putland Street. **Plates 1**, **2** and **3** in **Appendix B** show the above-floor flooding that was experienced in one of the ground floor units at No. 66-68 Putland Street, while **Plates 4**, **5** and **6** show the elevation to which water levels reached in Putland Street at the time. The flooding that was experienced in this area is believed to be principally a function of backwater flooding from South Creek, rather than from stormwater runoff generated by the Byrnes Creek catchment.

[1] The location of Coachmans Park is not show on **Figure 2.2** due to its confined nature.

TABLE 2.1
YEARS WHEN FLOODING WAS OBSERVED
IN THE STUDY AREA(1)

Year of Storm Event	Number of Respondents who Identified Year of Storm Event
2008	4
2007/2006	5
1990	1
1989	1
1988	5
1987/1986	2
1976	1
1972	1

1. Source: Table 3.3 of the *Flood Study.*

2.4 Design Flood Behaviour

2.4.1 Background

The *Flood Study* defined the nature of local catchment flooding in the study area for storms ranging between 1EY and 0.5% AEP, as well as the PMF event. Flood behaviour was defined using a two-staged approach to flood modelling involving the running in series of:

1. The hydrologic model of the upper Byrnes Creek catchment which was based on the RAFTS rainfall-runoff software.
2. The hydrologic/hydraulic models of the lower reach of Byrnes Creek catchment and its drainage system which were based on the TUFLOW software.

The RAFTS model was used to compute discharge hydrographs which were then applied to the upstream boundary of the TUFLOW hydraulic model, while the direct-rainfall-on-grid approach was adopted for generating surface runoff within the study area. Design storms were derived using procedures set out in *Australian Rainfall and Runoff* (IEAust, 1987) and then applied to the RAFTS model to generate discharge hydrographs. These hydrographs constituted input to the TUFLOW hydraulic model.

The TUFLOW model used a two-dimensional (in plan), grid-based representation of the natural surface based on LiDAR survey data, as well as piped drainage data provided by Council. Field survey was used to derive cross sections (normal to the direction of flow) along the inbank area of Byrnes Creek, which was modelled as a one-dimensional element within TUFLOW. Field survey was also used to capture details of the existing stormwater drainage system.

A static water level approximating design flood levels in South Creek were adopted as the downstream boundary of the TUFLOW model. For 5% AEP and larger local catchment storms, the peak 5% AEP flood level at the Great Western Highway crossing of South Creek was adopted, while for the more frequent storm events, estimates were made of design peak flood levels in South Creek for the same AEP.

An "envelope" approach was adopted for defining design water surface elevations and flow patterns throughout the study area. The procedure involved running the model for a range of storm durations to define the upper limit (i.e. the envelope) of expected flooding for each design flood frequency.

2.4.2 Recent Updates to Flood Study TUFLOW Model

The TUFLOW hydraulic model was reviewed and updated as part of the present study to refine several aspects of its structure and to improve the accuracy of the flood mapping. For example, the model was expanded to include a portion of the South Creek floodplain in order to better understand the interaction of South Creek and local catchment flooding in the lower reaches of the Byrnes Creek drainage system. **Figure C1.1** in **Appendix C** shows the layout of the updated TUFLOW model.

The updated TUFLOW model was used to define flooding patterns in the study area for design storms of 1 EY up to 0.2% AEP, as well as the PMF event. The results of the TUFLOW modelling undertaken as part of the present study were combined with those derived as part of Worley Parsons, 2015 to develop a comprehensive picture of flooding behaviour in the study area.

2.4.3 Design Flooding Patterns

There are three principal sources of flooding that impact existing development in the study area:

- **Local Catchment Flooding** resulting from the surcharge of Byrnes Creek and the existing stormwater drainage system. Several major overland flow paths develop in the urbanised parts of the study area due to local catchment flooding. Flooding of this type is of a "flash flooding" nature, with water levels typically rising to their peak in less than two hours. Flows on the major overland flow paths would typically be less than 500 mm deep, travelling over the surface at velocities generally less than 1 m/s.
- **South Creek Flooding** resulting from flow that backs up the Great Western Highway culvert from South Creek during the rising limb of frequent to major flood events. Flooding of this type is relatively slow rising in nature, with little to no velocity associated with the flow. During rare to extreme flood events, floodwater would also overtop the St Marys Levee, where it would impact existing development which lies outside the backwater zone.
- **Hawkesbury-Nepean River Flooding** resulting from flow that backs up South Creek from the Hawkesbury Nepean River. Flooding of this type is slow rising in nature, with little to no velocity associated with the flow. Floodwater would commence to back up through the box culvert that is located under the Great Western Highway and commence to inundate the area which lies behind the St Marys Levee during a Hawkesbury Nepean Flood with an AEP of about 0.2 per cent.

Figure 2.3 (2 sheets) shows the AEP of the local catchment storm event which results in individual pipes first flowing full, or when inlet pits are first surcharged.

Figure 2.4 (2 sheets) shows the indicative depth and extent of inundation, while **Figure 2.5** (2 sheets) shows maximum flow velocities in the study area for a 1% AEP local catchment flood event. **Figure 2.4** also shows the extent of a 1% AEP South Creek flood event.

Figure 2.6 (2 sheets) shows the indicative depth and extent of inundation, while **Figure 2.7** (2 sheets) shows maximum flow velocities in the study area for a local catchment PMF event. **Figure 2.6** also shows the extent of a South Creek PMF event.

Figures C1.2 to **C1.9** (2 sheets each) in **Appendix C** show the indicative extent and depth of inundation for local catchment floods of between 1EY and 2% AEP, as well as the 0.5% and 0.2% AEP events.

Figures 2.8 and **2.9** (2 sheets each) show the indicative depth and extent of inundation for the envelope of South Creek and Local Catchment Flooding for 1% AEP and PMF events, respectively. **Figures D1.1** to **D1.4** in **Appendix D** show the same information for combined 5%, 2%, 0.5% and 0.2% AEP South Creek and Local Catchment Flooding.

Figure 2.10 (2 sheets) shows the indicative extent and depth of flooding in the study area resulting from a PMF event on the Hawkesbury-Nepean River.

Figure 2.11 shows the time of rise of floodwaters at several key locations along the main arm of Byrnes Creek, noting the data relates to Local Catchment Flooding only.

Figure 2.12 shows design water surface profiles along both sides of the St Marys Levee, noting the data relates to South Creek Flooding only.

Figure 2.13 shows design water surface profiles along the embankment of detention basin BA04 in Monfarville Reserve, noting the data relates to Local Catchment Flooding only.

Figure 2.14 (2 sheets) shows design water surface profiles along the main arm of Byrnes Creek for Hawkesbury Nepean River, South Creek and Local Catchment Flooding.

Storms up to 1% AEP in Intensity

There are a significant number of pipes which are shown to flow full during storms as frequent as 1EY (refer **Figure 2.3**), indicating that overland flow would be experienced in a number of properties on a relatively frequent basis.

The major overland flow paths that form due to the surcharge of the existing stormwater drainage system generally follow the alignment of the trunk drainage lines which control runoff from the urbanised areas that lie to the east of Byrnes Creek. Areas where existing residential development is subject to depths of major overland flow greater than 0.2 m in a 1% AEP local catchment flood event include:

- along the major overland flow path that forms between the Desborough Road/Macley Crescent intersection and the Monfarville Street/Carrington Street intersection (refer **Figure 2.4**, sheet 1);
- along the major overland flow path that forms between the Carpenter Street/Knox Street intersection and the main arm of Byrnes Creek (refer **Figure 2.4**, sheet 1); and
- along the major overland flow path that forms between the Knox Street/Morris Street intersection and the main arm of Byrnes Creek (refer **Figure 2.4**, sheet 2).

Existing commercial development that backs onto East Lane north of Chapel Street is also subject to depth of overland flow exceeding 0.2 m in a 1% AEP local catchment flood event, as is the northern carpark of The Village Centre (refer **Figure 2.4**, sheet 2).

While flow velocities along the major overland flow paths generally do not exceed 1 m/s, constrictions imposed by buildings and hydraulically steep roads result in flow velocities of up to 2 m/s occurring in several locations during a 1% AEP storm event.

While flows which surcharge the emergency spillway of Basin BA04 in Monfarville Reserve during storms more intense than about 2% AEP discharge directly to the main arm of Byrnes Creek, the section of embankment which backs onto existing residential development that is located along Chilaw Avenue is surcharged during storms that are more intense than about 1% AEP (refer **Figure 2.13**).

While flows are confined to the main arm of Byrnes Creek between Monfarville Reserve and Cook Park for local catchment storms up to 1% AEP, the triple cell 900 mm diameter pipes under Wilson Street will be surcharged during a 20% AEP storm event, while the twin cell 1650 mm diameter pipes under Saddington Street will be surcharged during a 5% AEP storm event. Major surcharge of the twin cell 1650 mm diameter pipes which run from Saddington Street to Neale Street occurs during a 2% AEP event, with residential development impacted by the resulting overland flow. While flow velocities along the main arm of Byrnes Creek are generally less than 1.5 m/s, they generally do not exceeds 0.5 m/s in areas subject to inundation due to surcharge of the enclosed reaches of the drainage system.

The channel which runs along the eastern side of the St Marys Levee north of Putland Street has sufficient capacity to convey flows generated by storms with intensities up to about 1% AEP, supporting the view that the flooding that was experienced in this area on 6 June 2016 was a result of backwater flooding from South Creek.

Backwater flooding from South Creek will extend south along the main arm of Byrnes Creek into Cooks Park and along the eastern side of the St Marys Levee during a 1% AEP South Creek flood event. **Table 2.2** gives the peak flood levels which result from backwater flooding from South Creek behind the St Marys Levee. Backwater flooding from South Creek does not generally extend into existing development during a 1% AEP flood event (principally due to the land having been raised above the peak 1% AEP flood level of RL 24.4 m AHD), with the exception of the following locations:

- in high density unit development that is located along the southern side of Putland Street east of George Street;
- in a single dwelling that is located on the southern side of Saddington Street immediately to the west of Cook Park;
- in single dwelling type development that is located at the western end of Saddington Street; and
- in single dwelling type development that is located principally on the western side of Schleicher Street.

TABLE 2.2
PEAK FLOOD LEVELS BEHIND ST MARYS LEVEE
SOUTH CREEK FLOODING

Design Flood Event (AEP) %	Peak Flood Level (m AHD)
5	24.0
2	24.2
1	24.4
0.5	24.6
PMF	27.5 - 28.0

1. Source: Worley Parsons, 2015

While depths of inundation in the abovementioned properties does not generally exceed 0.5 m during a 1% AEP South Creek flood, it will exceed 1 m in the single dwelling residential development that is located on the southern side of Saddington Street at its western end. The depth of inundation across the access driveway which leads off the western end of Saddington Street would also exceed 1 m during a 1% AEP South Creek flood event.

While Worley Parsons, 2015 states that flood levels on South Creek at the Great Western Highway would peak 26 hours following the onset of flood producing rain, this is for the 36 hour design storm that is critical for maximising peak flood levels on the floodplain. While shorter duration storms of the same AEP will generate lower peak flood levels adjacent to and behind the St Marys Levee, they would reach their peak over a shorter period, potentially resulting in the inundation of flood evacuation routes such as the low points in Putland Street and Neale Street over a period of less than a day.

The St Marys Levee would be overtopped at its northern end during South Creek floods larger than about 5% AEP (refer **Figure 2.12**). While the crest of the levee lies at or above the peak 0.5% AEP flood level on South Creek along the remainder of its length, the freeboard to the peak 1% AEP flood level is less than 0.5 m at several locations.[2]

Storm Intensities Greater than 1% AEP

While depths of inundation would not increase significantly for floods slightly larger than 1% AEP (refer **Figures C1.8** and **C1.9** in **Appendix B**), they would exceed 1.5 m in the majority of development that is located between the main arm of Byrnes Creek and the St Marys Levee during a local catchment PMF event. Significant depths of inundation would also be experienced in existing residential development that is located on the eastern overbank of Byrnes Creek north (downstream) of Monfarville Reserve. Flooding in this area is exacerbated by the blocking effects of the St Marys Levee and the Great Western Highway.

While depths of inundation along the major overland flow paths that are located to the east of Byrnes Creek would generally not exceed 1 m during a local catchment PMF event, greater depths of inundation would be experienced in residential development at the following locations:

[2] Worley Parsons, 2015 showed that a 30% blockage of the Great Western Highway bridge crossing would result in a maximum increase of 0.38 m in peak 1% AEP flood levels immediately upstream of the road corridor, reducing to 0.07 m at the southern (upstream) end of the St Marys Levee.

- in single dwelling residential type development that is located along Macleay Crescent, Moira Crescent, Monfarville Street and Ryan Street;
- in medium density residential townhouse type development that is located on the northern side of Lonsdale Street between Collins Street and Mamre Road; and
- in high density residential unit type development that is located on the southern side of Saddington Street west of Mamre Road.

Depths of inundation would also exceed 1.5 m in the rear of the commercial properties that back onto East Lane north of Chapel Street.

Overtopping of the St Marys Levee during a South Creek PMF event would result in depths of inundation generally exceeding 2 m in existing development that is located to the south of the Great Western Highway. Existing commercial development that is located along Gabriels Lane, Princess Mary Street and on the northern side of the Great Western Highway would also be inundated by up to 2 m due to floodwater surcharging the eastern bank of South Creek.

As mentioned, inundation of the study area due to Hawkesbury Nepean River Flooding would commence for floods with an AEP less than about 0.2 per cent. By reference to the peak flood levels set out in **Table 2.3**, the western end of Putland Street would be inundated by backwater flooding during a Hawkesbury-Nepean River Flood with an AEP less than 0.1 per cent (the minimum elevation of the road is about RL 22.5 m AHD), while the high density residential development that is located on its southern side would be inundated by up to 2.3 m in a PMF event (the minimum ground levels in this area generally vary between about RL 24.1 m AHD and RL 25.0 m AHD). Backwater flooding from the Hawkesbury-Nepean River would extend as far upstream as the Mamre Road culverts on Byrnes Creek during a PMF event and typically take over a day to reach its peak. **Figure 2.10** (2 sheets) shows the indicative extent and depth of inundation in the study area resulting from a PMF event on the Hawkesbury Nepean River.

TABLE 2.3
PEAK FLOOD LEVELS
HAWKESBURY NEPEAN RIVER FLOODING(1)

Design Flood Event (AEP) %	Peak Flood Level (m AHD)
20	11.1
10	12.3
5	13.7
2	15.7
1	17.3
0.5	18.7
0.2	20.2
0.1	21.9
PMF	26.4

1. Source: Bewsher Consulting, 2012

2.5 Impact of Flooding on Vulnerable Development and Critical Infrastructure

The figures contained in **Volume 2** of the report show the location of vulnerable development and critical infrastructure relative to the extent of inundation resulting from Local Catchment, South Creek and Hawkesbury Nepean River flooding, while **Table 2.4** over the page summarises the impact that flooding has on this type of development/infrastructure.[3]

St Marys Public School on Gabriels Lane (refer Location Identifier No. 1) is impacted by a 0.2% AEP flood on South Creek and a PMF event on the Hawkesbury Nepean River. It is also subject to shallow inundation during Local Catchment Flooding during storms as frequent as 50% AEP. While not impacted by either South Creek or Hawkesbury-Nepean River Flooding, Our Lady of the Rosary Primary School (refer Location Identifier No. 2) and St Marys South Public School (refer Location Identifier No. 3) are subject to Local Catchment Flooding during storms with AEP's of 50% and 10%, respectively.

The My First School Child Care Centre on Putland Street (refer Location Identifier No. 5) is impacted by a 0.2% AEP flood on South Creek and a PMF event on the Hawkesbury-Nepean River. The Summit Care St Marys aged care facility is impacted by a PMF event for Local Catchment, South Creek and Hawkesbury Nepean River flooding

It is noted that the NSW SES Penrith Local Unit is based on the western side of South Creek in Fowler Street, Claremont Meadows, while the evacuation centre nominated in the *Hawkesbury Nepean Flood Plan* (NSW SES, 2015) is located at Colyton High School which is located to the east of the study area. The St Marys Fire and Rescue NSW station is also located to the east of the study area at the intersection of the Great Western Highway and Marsden Street, St Marys.

2.6 Hydrologic Standard of Existing Road Network

Both major and minor roads in the study area are vulnerable to inundation during Local Catchment, South Creek and Hawkesbury-Nepean River dominant flood events. Identification of such roads is important to providing knowledge to NSW SES, identifying hazardous areas during floods, and evacuation planning.

The results of the hydraulic modelling show that several of the roads that would be used as evacuation routes for people living behind the St Marys Levee would be inundated by Local Catchment Flooding. These include the Wilson Street (<20% AEP), Saddington Street (<5% AEP), Pages Road (<2% AEP), Putland Street (<2% AEP) and Neale Street (<2% AEP) crossings of the main arm of Byrnes Creek.

The sag in Pages Road near its intersection with the Great Western Highway would also be inundated due to surcharge of the local stormwater drainage system during storms as frequent as 20% AEP.

Mamre Road would be inundated immediately south of its intersection with Saddington Street (refer Location Identifier No. 16) during storm events that occur once every year on the average and further south near its intersection with Wilson Street (refer Location Identifier Nos. 17 and 18) during storms more intense than about 2% AEP.

[3] Critical infrastructure has been split into two categories; community assets and emergency services.

TABLE 2.4
IMPACT OF FLOODING ON VULNERABLE DEVELOPMENT AND CRITICAL INFRASTRUCTURE LOCATED IN THE STUDY AREA

Type	Development/Structure	Location Identifier[1]	Design Flood Event									
			1 EY	50% AEP	20% AEP	10% AEP	5%AEP	2% AEP	1% AEP	0.5%	0.2%	PMF
Vulnerable Development	Hospital	-	-	-	-	-	-	-	-	-	-	-
	Educational Facility (St Marys Public School)	1	O	LCF	LCF	LCF	LCF	LCF	LCF	LCF	LCF/SCF	LCF/SCF/HNRF
	Educational Facility (Our Lady of the Rosary Primary School)	2	O	LCF	LCF	LCF	LCF	LCF	LCF	LCF	LCF	LCF
	Educational Facility (St Marys South Public School)	3	O	O	O	LCF	LCF	LCF	LCF	LCF	LCF	LCF
	Child Care Facility (Busy Bees Long Day Child Care Centre)	4	O	O	O	O	O	O	O	O	O	O
	Child Care Facility (My First School Child Care Centre)	5	O	O	O	O	O	O	O	O	LCF/SCF	LCF/SCF/HNRF
	Child Care Facility (St Marys Children's Centre)	6	O	O	O	O	LCF	LCF	LCF	LCF	LCF	LCF
	Child Care Facility (Koala Corner Children's Centre)	7	O	O	O	O	O	O	O	O	O	O
	Child Care Facility (Mith Baai Family Day Care)	8	O	O	O	O	O	O	O	O	O	O
	Child Care Facility (Golden Kids Family Day Care)	9	O	O	O	O	O	O	O	O	O	O
	Child Care Facility (Mary's Tiny Tots Preschool)	10	O	O	O	O	O	O	O	O	O	O
	Caravan Park / Camping Ground	-	-	-	-	-	-	-	-	-	-	-
	Aged Care Facilities (Summit Care St Marys)	11	O	O	O	O	O	O	O	O	O	LCF/SCF/HNRF
Emergency Services	NSW SES Headquarters	-	-	-	-	-	-	-	-	-	-	-
	RFS Brigade	-	-	-	-	-	-	-	-	-	-	-
	St Marys Police Station	12	O	O	O	O	O	O	O	O	O	O
	Fire & Rescue NSW Station	-	-	-	-	-	-	-	-	-	-	-
	Ambulance	-	-	-	-	-	-	-	-	-	-	-
	Evacuation Centre	-	-	-	-	-	-	-	-	-	-	-
Community Assets	Electricity Substation	-	-	-	-	-	-	-	-	-	-	-
	Telephone Exchange	13	O	O	O	O	O	O	O	O	O	O
	Sewage Pump Station / Treatment Plant	-	-	-	-	-	-	-	-	-	-	-
	Water Supply Dam / Bore	-	-	-	-	-	-	-	-	-	-	-
	Major Road (Great Western Highway)	14	O	O	O	O	SCF	SCF	SCF	SCF	SCF	SCF
		15	O	O	O	O	O	SCF	LCF/SCF	LCF/SCF	LCF/SCF	LCF/SCF
	Major Road (Mamre Road)	16	LCF	LCF	LCF	LCF	LCF	LCF	LCF	LCF	LCF	LCF
		17	O	O	O	O	O	LCF	LCF	LCF	LCF	LCF
		18	O	O	O	O	O	LCF	LCF	LCF	LCF	LCF
		19	O	O	O	O	O	O	O	LCF	LCF	LCF

1. Refer figures in Volume 2 for location of vulnerable development and critical infrastructure.

"O" = Infrastructure not impacted by flooding.
"LCF" 'SCF' HNRF"= Infrastructure impacted by either Local Catchment Flooding (LCF), South Creek Flooding (SCF) or Hawkesbury-Nepean River Flooding (HNRF)
"-" = No such development/infrastructure in study area.

Backwater flooding from South Creek will inundate the western end of Putland Street, as well as the sag in Pages Road near its intersection with the Great Western Highway during a 1% AEP flood event, while a section of Charles Hackett Drive north of the highway will be inundated by floodwater which surcharges the eastern bank of South Creek during a 5% AEP flood. Floodwater originating from South Creek will inundate the Great Western Highway west of the St Marys Levee (refer Location Identifier No. 14) and opposite the Neale Street intersection (refer Location Identifier No. 15) during floods larger than about 5% AEP and 2% AEP, respectively.

As mentioned in **Section 2.4.3**, the western end of Putland Street would be inundated by backwater flooding from the Hawkesbury Nepean River during a flood with an AEP less than 0.1 per cent.

2.7 Existing Flood Mitigation Measures

The existing flood mitigation measures in the study area comprise detention basins in Monfarville Reserve (refer Basins BA01, BA02, BA03 and BA04 on **Figure 2.2**) and Bennett Park (refer Basins BA05 on **Figure 2.2**), as well as the St Marys Levee.

While Council has recently amplified the conveyance capacity of a short section of the existing stormwater drainage system where it runs through Coachmans Park west (downstream) of Queens Street, it currently provides limited flood mitigation benefit due to inlet and downstream pipe capacity constraints. While the St Marys Levee is effective at reducing the impact South Creek Flooding has on existing development, the available freeboard to its crest is less than 0.5 m for a 1% AEP flood event. Assuming a design freeboard requirement of 1 m, then the Imminent Failure Flood (**IFF**) is equivalent to about a 5% AEP event for its earthen portion, noting that the concrete section at its northern end is overtopped during a flood of this magnitude (refer **Figure 2.12**).

The above finding has implications in regards the setting of flood related planning controls for future development that is located behind the St Marys Levee, as until such time as the design freeboard is incorporated into the St Marys Levee, then controls should be linked to peak flood levels on the western (i.e. South Creek) side of the levee, rather than the peak 1% AEP backwater flood level of RL 24.4 m AHD which is current practice.

While the detention basins in Monfarville Reserve are effective at reducing the impacts of flooding along the main arm of Byrnes Creek due principally to the diversion of flows toward South Creek, the embankment of Basin BA04 is overtopped during a 1% AEP flood event adjacent to existing residential development that is located adjacent to Chilaw Avenue (refer **Figure 2.13**).

The detention basin in Bennett Park is effective at reducing the rate of flow in the existing stormwater drainage system which runs through the central business district of St Marys.

2.8 Economic Impacts of Flooding

The *Flood Study* assessed flood damages to residential and commercial/industrial property in areas affected by South Creek and Local Catchment Flooding, but not Hawkesbury-Nepean River Flooding. There are limited data available on historic flood damages in the study area. Accordingly, it was necessary to use data on damages experienced as a result of historic flooding in other urban centres. The residential flood damages were based on the publication *Floodplain Risk Management Guideline No. 4, 2007* (***Guideline No. 4***) published by the Department of Environment and Climate Change (**DECC**) (now OEH). Damages to commercial development were evaluated using data from previous floodplain management investigations in NSW.

It is to be noted that the principal objectives of the damages assessment were to gauge the severity of urban flooding likely to be experienced in the study area and also to provide data to allow the comparative economic benefits of various flood modification measures to be evaluated in **Chapter 3** of the report. It is not the intention to determine the damages accruing to *individual properties*, but rather to obtain a reasonable estimate of damages experienced over the extent of the urban area for the various design flood events. The estimation of damages using *Guideline No. 4* (in lieu of site specific data determined by a loss adjustor) also allows a uniform approach to be adopted by Government when assessing the relative merits of measures competing for financial assistance in flood prone centres in NSW.

Damages were estimated for the design flood levels determined from the hydraulic modelling undertaken as part of the *Flood Study*. The database comprised 969 properties, the floor levels of 832 of which were surveyed. The floor levels of the remaining 137 properties were assumed to be set 0.3 m above the adjacent surveyed ground level.

The number of properties predicted to experience "above-floor" inundation as a result of both South Creek and Local Catchment Flooding as derived by the *Flood Study*, together with estimated flood damages are set out in **Table 2.5**.

TABLE 2.5
FLOOD DAMAGES

Design Flood Event (% AEP)	Residential			Commercial			Total Damage ($ Million)
	Number of Properties		Damage ($Million)	Number of Properties		Damage ($Million)	
	Flood Affected	Flood Above Floor Level		Flood Affected	Flood Above Floor Level		
1 EY	91	10	0.73	0	0	0.00	0.73
50	115	14	1.00	0	0	0.00	1.00
20	244	25	1.75	16	0	0.00	1.75
10	249	32	2.07	40	21	1.31	3.38
5	264	36	2.44	43	24	1.55	3.99
2	272	41	2.80	44	25	1.70	4.50
1	285	48	3.19	48	26	1.86	5.05
0.5	315	52	3.44	52	27	2.08	5.52
PMF	639	216	14.99	95	76	8.38	23.37

At the 1% AEP level of flooding, 285 residential properties would be flood affected (i.e. water inundates the allotment), 48 of which would experience above-floor inundation. Similarly, 48 commercial buildings would be flood affected, 26 of which would be inundated above floor level. The total cost of flood damages in the study area would be approximately $5.05 Million for a 1% AEP event.

The "present worth value" of damages in the study area resulting from all floods up to the 1% AEP event at a seven per cent discount rate and economic life of 50 years is $19.5 Million. This value represents the amount of capital spending that would be justified if a particular flood mitigation measure or a group of measures prevented flooding across the whole of the study area for all properties up to the 1% AEP event.

It is noted that the largest South Creek flood assessed as part of the *Flood Study* had an AEP of 5 per cent. As a result, the flood damages assessed as part of the *Flood Study* do not include the impact of larger South Creek floods. This approach therefore underestimates the flood damages that would be incurred in the lower reaches of the Byrnes Creek drainage system for South Creek floods larger than 5% AEP.

2.9 Flood Hazard and Hydraulic Categorisation of the Floodplain

2.9.1 General

According to Appendix L of *NSWG, 2005*, in order to achieve effective and responsible floodplain risk management, it is necessary to divide the floodplain into areas that reflect:

1. The impact of flooding on existing and future development and people. To examine this impact it is necessary to divide the floodplain into *"flood hazard"* categories, which are provisionally assessed on the basis of the velocity and depth of flow. This task was undertaken in the *Flood Study* where the floodplain was divided into *Low Hazard* and *High Hazard* zones. In this present report, a *final determination* of hazard was undertaken which involved consideration of a number of additional factors which are site specific to the study area. **Section 2.9.2** below provides details of the procedure adopted.
2. The impact of future development activity on flood behaviour. Development in active flow paths (i.e. *"floodways"*) has the potential to adversely re-direct flows towards adjacent properties. Examination of this impact requires the division of flood prone land into various *"hydraulic categories"* to assess those parts which are effective for the conveyance of flow, where development may affect local flooding patterns. Hydraulic categorisation of the floodplain was also undertaken in the *Flood Study* and was reviewed and updated in this present study. **Section 2.9.3** below summarises the procedure adopted.

2.9.2 Flood Hazard Categorisation

As mentioned above, flood prone areas may be *provisionally* categorised into *Low Hazard* and *High Hazard* areas depending on the depth of inundation and flow velocity. A flood depth of 1 m in the absence of significant flow velocity represents the boundary between *Low Hazard* and *High Hazard* conditions. Similarly, a flow velocity of 2.0 m/s but with a small flood depth around 200 mm also represents the boundary between these two conditions. Interpolation may be used to assess the hazard for intermediate values of depth and velocity. Flood hazards categorised on the basis of depth and velocity only are *provisional*. They do not reflect the effects of other factors that influence hazard.

These other factors include:

1. Size of flood – major floods though rare can cause extensive damage and disruption.
2. Effective warning time – flood hazard and flood damage can be reduced by sandbagging entrances, raising contents above floor level and also by evacuation if adequate warning time is available.
3. Flood awareness of the population – flood awareness greatly influences the time taken by flood affected residents to respond effectively to flood warnings. The preparation

and promotion by Council of Flood Studies and Floodplain Risk Management Studies and Plans increases flood awareness, as does the formulation and implementation of response plans by NSW SES (Local Flood Plans) for the evacuation of people and possessions.

4. Rate of rise of floodwaters – situations where floodwaters rise rapidly are potentially more dangerous and cause more damage than situations in which flood levels increase slowly.
5. Duration of flooding – the duration of flooding (or length of time a community is cut off) can have a significant impact on costs associated with flooding. This duration is shorter in smaller, steeper catchments.
6. Evacuation problems and access routes – the availability of effective access routes from flood prone areas directly influences flood hazard and potential damage reduction measures.

Provisional hazard categories may be reduced or increased after consideration of the above factors in arriving at a final determination. A qualitative assessment of the influence of the above factors on the *provisional flood hazard* (i.e. the hazard based on velocity and depth considerations only) is presented in **Table 2.6** over the page.

Based on the scoring system set out in **Table 2.6**, areas affected by both South Creek and Local Catchment Flooding in the lower reaches of the Byrnes Creek drainage system that were provisionally classified as low hazard could be reclassified as high hazard. The major contributing factors to the reclassification of the floodplain are evacuation issues associated with coincident Local Catchment and South Creek Flooding, as well as the potential for dangerous flooding conditions to arise due to more extreme flood events. **Figure 2.15** shows the division of the floodplain into high and low hazard areas based on the 1% AEP for both Local Catchment and South Creek Flooding following consideration of the factors set out in **Table 2.6**.

2.9.3 Hydraulic Categorisation of the Floodplain

According to the *NSWG, 2005*, the floodplain may be subdivided into the following zones:

- ***Floodways*** are those areas where a significant volume of water flows during floods and are often aligned with obvious natural channels. They are areas that, even if partially blocked, would cause a significant increase in flood level and/or a significant re-distribution of flow, which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flow or areas where higher velocities occur.
- ***Flood Storage*** areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.
- ***Flood Fringe*** is the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

TABLE 2.6
INFLUENCE OF FLOOD RELATED PARAMETERS ON PROVISIONAL FLOOD HAZARD

Parameter	Flood Characteristics	Influence on Provisional Hazard		
		South Creek Flooding	Local Catchment Flooding	
			Upper Reaches	Lower Reaches
Size of flood	The effects of South Creek flooding in the study area are relatively minor in events less than a 1% AEP flood. Damages from more frequent events are mostly due to local catchment flooding, and any above-floor inundation that occurs would be relatively shallow. Impacts due to flooding become very significant for events that either overtop or cause a partial failure of the St Marys Levee. A local catchment flood event which causes major surcharge of the detention basins in Monfarville Reserve would also cause dangerous flooding conditions in the lower reaches of the Byrnes Creek drainage system.	+1	0	+1
Effective warning time	The potential for flooding from South Creek occurs several hours after the onset of heavy rain. The main arm of Byrnes Creek has a response time of less than two hours, while food levels along the major overland flow paths can peak in much shorter times. BoM maintains a flood warning service for the Hawkesbury-Nepean valley which would provide some warning time for South Creek flooding. BoM also maintains a storm warning service which would provide some warning for short-duration 'flash flooding'.	0	+1	+1
Flood awareness	Flood awareness appears to be quite low given the limited number of respondents who advised that they had experienced historic flooding in their property. Counter to this is the very low hydrologic standard of the existing stormwater drainage system that would indicate that properties located along the major overland flow paths experience frequent inundation, albeit of the shallow and short duration nature. Inundation due to backwater flooding from South Creek in recent years has also been limited to the 6 June 2016 event.	+1	0	+1
Rate of rise and velocity of floodwaters	Floodwaters rise very quickly after the onset of heavy rain, particularly along the main arm of Byrnes Creek and the major overland flow paths which form in the eastern portion of the study area. However, the depth and velocities associated with these flows are low hazard in nature. Floodwaters would rise more slowly due to backwater flooding from South Creek, with little to no velocity associated with the flow.	-1	+1	0
Duration of flooding	Flood levels due to backwater flooding will remain elevated for up to a day. In areas affected by local catchment flooding, the duration of inundation will be much shorter – typically less than an hour in the upper reaches and less than 2 hours in the lower reaches of the Byrnes Creek drainage system.	+1	-1	0

Refer over for legend

Cont'd Over

TABLE 2.4 (Cont'd)
INFLUENCE OF FLOOD RELATED PARAMETERS ON PROVISIONAL FLOOD HAZARD

Parameter	Flood Characteristics	Influence on Provisional Hazard		
		South Creek Flooding	Local Catchment Flooding	
			Upper Reaches	Lower Reaches
Evacuation problems	The evacuation of a large number of medium and high density residential type developments that are located between the main arm of Byrnes Creek and the St Marys Levee would be hampered by coincident South Creek and Local Catchment Flooding, as surcharge of the existing stormwater drainage system has the potential to prevent egress from this area during the rising limb of a South Creek flood. The evacuation of residential development located along the major overland flow paths is less of an issue given the short duration and low hazard nature of the flow.	+1	-1	0
	OVERALL SCORE	+3	0	+3

Legend 0 = neutral impact on provisional hazard
+ 1 = tendency to increase provisional hazard
– 1 = tendency to reduce provisional hazard

While the *Flood Study* incorporated a set of figures which showed the floodway, flood storage and flood fringe areas, these were reassessed for 1% AEP Local Catchment and South Creek floods based on the results of the updated TUFLOW modelling.

Floodplain Risk Management Guideline No. 2 Floodway Definition, offers guidance in relation to two alternative procedures for identifying floodways. They are:

- **Approach A**. Using a *qualitative approach* which is based on the judgement of an experienced hydraulic engineer. In assessing whether or not the area under consideration was a floodway, the qualitative approach would need to consider; whether obstruction would divert water to other existing flow paths; or would have a significant impact on upstream flood levels during major flood events; or would adversely re-direct flows towards existing development.
- **Approach B**. Using the hydraulic model, in this case TUFLOW, to define the floodway based on *quantitative experiments* where flows are restricted or the conveyance capacity of the flow path reduced, until there was a significant effect on upstream flood levels and/or a diversion of flows to existing or new flow paths.

One quantitative experimental procedure commonly used is to progressively encroach across either floodplain towards the channel until the designated flood level has increased by a significant amount (for example 0.1 m) above the existing (un-encroached) flood levels. This indicates the limits of the hydraulic floodway since any further encroachment will intrude into that part of the floodplain necessary for the free flow of flood waters – that is, into the floodway.

The *quantitative assessment* associated with **Approach B** is technically difficult to implement. Restricting the flow to achieve the 0.1 m increase in flood levels can result in contradictory results, especially in unsteady flow modelling, with the restriction actually causing reductions in computed levels in some areas due to changes in the distribution of flows along the main drainage line.

Accordingly the *qualitative approach* associated with **Approach A** was adopted, together with consideration of the findings of *Howells et al, 2004* who defined the floodway based on velocity of flow and depth. Howells et al suggested the following criteria for defining those areas which operate as a "floodway" in a 1% AEP event:

- Velocity x Depth greater than 0.25 m^2/s **and** Velocity greater than 0.25 m/s; or
- Velocity greater than 1 m/s.

Initial trials of the above criteria resulted in the floodway areas not being identified in the areas east of the main arm of Byrnes Creek that are affected by major overland flow. Through an iterative process it was found that a velocity x depth product of greater than 0.15 m^2/s in combination with the other abovementioned criteria provided the best approach to identifying floodway areas in the study area.

Flood storage areas were identified as those areas which do not operate as floodways in a 1% AEP event but where the depth of inundation exceeds 300 mm. The remainder of the flood affected area was classified as flood fringe.

Figure 2.15 shows the division of the floodplain into floodway, flood storage and flood fringe areas at the 1% AEP level of flooding.

High hazard floodway areas are generally confined to the inbank area of Byrnes Creek, while the floodway areas associated with major overland flow in the urban areas which lie to the east are generally of a low hazard nature. High hazard flood storage areas are present in the detention basins in Monfarville Reserve and Bennett Park, as well as the temporary flood storage area located in Cook Park, south (upstream) of Saddington Street. Backwater flooding from South Creek also results in a high hazard flood storage area forming at the western end of Putland and Saddington Streets. Low hazard flood storage areas are present throughout the study area and in a number of locations are a result of major overland flow ponding behind existing buildings and in sags in roads.

2.10 Potential Impacts of a Change in Hydraulic Roughness

An analysis was undertaken to assess the sensitivity of flooding behaviour to potential changes in hydraulic roughness. **Figures C1.10** and **C1.11** in **Appendix C** (2 sheets each) show the impact that a 20% increase and 20% decrease in the "best estimate" hydraulic roughness values would have on a 1% AEP Local Catchment Flood event, respectively.

The analysis showed that a 20% increase in the "best estimate" hydraulic roughness values would not increase peak 1% AEP flood levels by more than 50 mm, with the exception of the reach of Byrnes Creek which runs from the western end of Putland Street to the Great Western Highway culvert, where the increase would be in the range 50-100 mm.

While a 20% reduction in the "best estimate" hydraulic roughness values would resulting in a reduction in peak 1% AEP flood levels in the range 10-100 mm, this would not translate into a significant reduction in the extent of flooding.

Based on this finding, the adoption of a freeboard of between 300-500 mm for setting minimum floor levels in future development would cater for any potential increases in peak 1% AEP flood levels associated with changes in hydraulic roughness.

2.11 Potential Impacts of a Partial Blockage of Stormwater Drainage Structures

An analysis was undertaken to assess the impact a partial blockage of different parts of the stormwater drainage system would have on flooding behaviour. **Figures C1.12** and **C1.13** in **Appendix C** (2 sheets each) show the impact a 50% blockage of all the inlet pits and all the pipes within the study area would have on a 1% AEP Local Catchment Flood event, respectively. While a 50% blockage of the inlet pits would not result in more than a 50 mm increase in peak 1% AEP flood levels (indicating there is sufficient inlet capacity relatively to pipe capacity in the catchment at the 1% AEP level of flooding), a 50% blockage of the pipe network would result in increases in peak 1% AEP flood levels along the major overland flow paths east of the main arm of Byrnes Creek of up to 0.2 m and by more than 0.5 m along the main arm of Byrnes Creek. The large increase in peak flood levels along the main arm of Byrnes Creek is a result of an increase in the rate of flow surcharging the detention basin BA04 in Monfarville Reserve in combination with a reduction in the hydraulic capacity of the twin 1650 mm dimeter pipes which extend downstream of Saddington Street, as well as the Great Western Highway culvert. This is evidenced by the impact that the partial blockage of hydraulic structures located along the main arm of Byrnes Creek would have on flooding behaviour (refer **Figures C1.14** and **C1.15** (2 sheets each) in **Appendix C**).

Based on the above finding, the adoption of a 500 mm freeboard when setting the minimum floor level requirements for new development located in the lower reaches of the Byrnes Creek drainage system may not be sufficient to prevent above-floor inundation from occurring during a 1% AEP Local Catchment Flood event. In order to address this issue it is recommended that a series of debris control structures be installed along the main arm of Byrnes Creek to reduce the risk that a partial blockage of these structures will exacerbate flooding conditions in the lower reaches of the Byrnes Creek drainage system. Details on the location and form of these structures is contained in **Section 3.4.7** of the report.

2.12 Potential Impacts of a Potential Detention Basin Failure

As the severity of flooding in the lower reaches of the Byrnes Creek drainage system is significantly reduced by the operation of the four detention basins that are located in Monfarville Reserve, the impact a potential partial failure of their embankments on flooding behaviour was assessed. The following two basin embankment failure scenarios were assessed:

- **Scenario A**, which involved failing a 10 m wide section of the existing earth embankment in detention basin BA04 adjacent to the main arm of Byrnes Creek.
- **Scenario B**, which involved failing a 10 m wide section of the existing earth embankment in detention basins BA01, BA02, BA03 and BA04, the latter which was centred on the defined spillway which is located adjacent to the main arm of Byrnes Creek.

Figures C1.16 and **C1.17** in **Appendix C** (2 sheets each) show the impact that Scenarios A and B would have on flooding behaviour for a 1% AEP Local Catchment Flood, respectively. The analysis showed that flooding behaviour downstream of Monfarville Reserve is sensitive to a failure of detention basin BA04, given it would allow floodwater to discharge directly to the main arm of Byrnes Creek where the resulting flood wave would impact existing development. While peak 1% AEP flood levels would be increased by greater than 0.5 m immediately downstream of Monfarville Reserve, further downstream they would generally be increased by a maximum of between about 200-300 mm.

Further discussion on the potential upgrade requirements associated with the detention basins in Monfarville Reserve is contained in **Section 3.4.4** of the report.

2.13 Potential Impacts of Future Urbanisation

If not subject to appropriate controls, future urbanisation has the potential to increase the rate and volume of runoff conveyed along the major overland flow paths which are present in the study area, as well along the main arm of Byrnes Creek downstream of Monfarville Reserve. It also has the potential to increase the frequency of surcharge of the local stormwater drainage system.

While the study area is already highly urbanised, there is scope for further infill development to occur over time. Section 3.6 in Section C3 of the *Penrith Development Control Plan, 2014* entitled "Stormwater Management and Drainage" deals with the management of runoff generated by new development. One of the stated objectives set out in the document is the need to ensure that new development does not generate stormwater discharges that exceed the capacity of the existing drainage network. One of the stated means of achieving this objective is the provision of on-site detention. The primary control set out in the document in relation to the provision of on-site detention is that peak flows are not to be increased in the downstream drainage system for all storms up to 1% AEP in intensity.

Given the findings of the present study, namely the low hydraulic capacity of the existing stormwater drainage system in large parts of the study area, it is important that Council continue to inforce this requirement when approving new development.

2.14 Potential Impacts of Climate Change

OEH recommends that its guideline *Practical Consideration of Climate Change, 2007* be used as the basis for examining climate change in projects undertaken under the State Floodplain Management program and the *FDM, 2005*. The guideline recommends that until more work is completed in relation to the climate change impacts on rainfall intensities, sensitivity analyses should be undertaken based on increases in rainfall intensities ranging between 10 and 30 per cent.

On current projections the increase in rainfalls within the service life of developments or flood management measures is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit which may apply near the end of the century. Under present day climatic conditions, increasing the 1% AEP design rainfall intensities by 10 per cent would produce about a 0.5% AEP flood; and increasing those rainfalls by 30 per cent would produce about a 0.2% AEP event.

For the purpose of the present study, the impact 10% and 30% increases in design 1% AEP rainfall intensities would have on flooding behaviour was assessed by comparing the peak flood levels which were derived from the flood modelling for design events with AEP's of 1, 0.5 and 0.2 per cent.

Figure C1.18 (2 sheets) in **Appendix C** shows the afflux data (i.e. increase in peak flood levels compared with present day conditions) derived from the hydraulic modelling that was undertaken as part of the present study for the 1 and 0.5% AEP events. The potential impact of a 10% increase in rainfall intensity on flooding patterns in the study area may be summarised as follows:

- Depths of major overland flow would generally be increased in the range 10-50 mm, with increases in the range 50-100 mm shown to occur in several areas.

- Increased overtopping of detention basin BA04 in Monfarville Reserve, resulting in additional flooding being experienced in the rear of several residential properties that are located along Chilaw Avenue.
- Increases in peak 1% AEP flood levels along of the main arm of Byrnes Creek downstream of Wilson Oval generally in the range 50-100 m.

Figure C1.19 (2 sheets) in **Appendix C** shows the afflux data derived from the hydraulic modelling that was undertaken as part of the present study for the 1 and 0.2% AEP events under ideal flow conditions. The potential impact of a 30% increase in rainfall intensity on flooding patterns in the study area may be summarised as follows:

- Depths of major overland flow would generally be increased in the range 10-100 mm, with increases in the range 100-200 mm shown to occur in several areas.
- Increased overtopping of detention basin BA04 in Monfarville Reserve, resulting in additional flooding being experienced adjacent to several dwellings that are located along Chilaw Avenue.
- Increases in peak 1% AEP flood levels along of the main arm of Byrnes Creek downstream of Wilson Oval generally in the range 100-300 m.

2.15 Council's Existing Planning Instruments and Policies

2.15.1 General

The *Penrith Local Environmental Plan, 2010* (***Penrith LEP 2010***) is the principal statutory planning document used by Council for controlling development by defining zoning provisions, establishing permissibility of land use and regulating the extent of development in the Penrith local government area.

The *Penrith Development Control Plan 2014* (***Penrith DCP 2014***) supplements *Penrith LEP 2010* by providing general information and detailed guidelines and controls which relate to the decision making process.

2.15.2 Land Use Zoning – Penrith Local Environmental Plan 2010

Figure 2.16 shows the zonings that are incorporated in *Penrith LEP 2010* for the study area. The study area comprises a mixture of *Low (R2), Medium (R3)* and *High (R4) Density Residential* zoned areas, as well as *Mixed Use (B4)* and *Enterprise Corridor (B6)* zoned areas. A *Deferred Matter (DM)* is also located near the northern limits of the study area.

It is noted that the land located behind the St Marys Levee is zoned *Low (R2), Medium (R3)* and *High (R4) Density Residential* under *Penrith LEP 2010*, with the area largely developed to the maximum extent possible, with the exception of an area which is centred around Barker Street and zoned *Medium (R3)*.

2.15.3 Flood Provisions – Penrith LEP 2010

Clause 7.2 of *Penrith LEP 2010* entitled "Flood planning" outlines its objectives in regard to development of land that is at or below the FPL. It is similar to the standard Flood Planning Clause used in recently adopted LEP's in other NSW country centres and applies to land beneath the FPL.

The FPL referred to is the 1:100 ARI (or 1% AEP) flood plus an allowance for freeboard of 500 mm. The area encompassed by the FPL (i.e. the FPA) denotes the area subject to flood related development controls, such as locating development outside high hazard areas and setting minimum floor levels for future residential development. It is now standard practice for the residential FPL to be based on the 1% AEP flood plus an appropriate freeboard unless exceptional circumstances apply.

Clause 7.2 also applies to land identified as "*Flood planning land*" on the "*Clause Application Map*" which is attached to *Penrith LEP 2010*.

For the *Clause Application Map* to be modified, a formal amendment would need to be made to *Penrith LEP 2010*, which would take considerable time. It is therefore recommended that the *Clause Application Map* not be attached to *Penrith LEP 2010*, as this way it can be updated without the need to update the LEP. Recommended amendments to the wording of clause 7.2 are set out in **Section 3.5.1.4** of the report.

It is also recommended that a new floodplain risk management clause be incorporated in *Penrith LEP 2010*. The objectives of the new clause are as follows:

- in relation to development with particular evacuation or emergency response issues (e.g. schools, group homes, residential care facilities, hospitals, etc.) to enable evacuation of land which lies above the FPL; and
- to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

The new clause would apply to land which lies between the FPL and the level of the PMF, but would not apply to land at or below the FPL. Suggested wording in relation to this new clause is given in **Section 3.5.1.4**.

2.15.4 Flooding and Stormwater Controls – Penrith DCP 2014

Chapter C3 of *Penrith DCP 2014* titled "Water Management" deals with flooding and stormwater related issues associated with development in the Penrith local government area. Section 3.5 in Chapter C3 titled "*Flood Planning*" deals with the management of flood risk. The stated objectives of the controls set out in Section 3.5 are:

> *"a) To ensure floodplain risk management minimises the potential impact of development and other activity upon the aesthetic, recreational and ecological value of the waterway corridors;*
>
> *b) To maintain the existing flood regime and flow conveyance capacity and avoid significant adverse impacts on flood behaviour;*
>
> *c) To avoid significant adverse effects on the floodplain environment that would cause erosion, siltation, destruction of riparian vegetation or a reduction in the stability of the river bank/watercourse;*
>
> *d) To reduce the impact of flooding and flood liability on individual owners and occupiers;*
>
> *e) To limit the potential risk of life and property resulting from flood events;*

f) To contain the potential for flood losses in all new developed areas by the application of effective planning and development controls;

g) To apply a "merit approach" to all development and building decisions, which takes account of social, economic and ecological factors as well as flooding considerations;

h) To prevent the introduction of unsuitable land uses on land subject to the flood planning provisions of the LEP; and

i) To deal equitably and consistently (where possible) with applications for the development of land affected by potential floods, in accordance with the principles contained in the Floodplain Development Manual, issued by the NSW Government."

In order to achieve these objectives a number of controls are set out in Section 3.5 of Chapter C3. In relation to residential type development, the key controls are:

i. no new development will be permitted in floodways or high hazard areas;[4]
ii. Council will not grant consent to filling of floodways or high hazard areas;
iii. the filling of other land will generally not be supported, but may be permitted provided a number of criteria are met;
iv. floor levels of habitable rooms shall be at least 0.5 m above the peak 1% AEP flood level;
v. flood safe access and emergency egress shall be provided to all new developments and for dwelling replacements where practicable; and[5]
vi. upper storey additions will not be considered as "New Development" provided; the first floor addition is above the FPL and the additions and alterations do not increase the building footprint at ground level beyond 35 m^2.

While the controls set out under point iii) and iv) above also apply to new commercial and industrial type development, Council may permit development to occur below the FPL provided the applicant can demonstrate that all practical measures will be taken to prevent or minimise the impact of flooding.

In relation to the management of overland flow, Council will not support development obstructing overland flow paths. *Penrith DCP 2014* also states that a merits based approach will be taken when assessing development applications that affect overland flow, noting that overland flow paths must be maintained for the 1% AEP storm event.

Section 3.6 in Chapter C3 titled "*Stormwater Management and Drainage*" deals with the management of rainfall excess generated runoff, principally in the urban drainage context. The stated objectives of the controls set out in Section 3.6 are:

[4] *Penrith DCP 2014* states that *"Flood hazard (high) or high flood hazard occurs when there is possible danger to life and limb; evacuation by trucks is difficult; there is the potential for structural damage; and social disruption and financial losses could be high."*

[5] *Penrith DCP 2014* states that *"Flood safe access means access that is generally considered satisfactory when the depth of flooding over vehicular driveways and roads is limited to approximately 0.25 m with low velocities."*

"a) To prevent damage by stormwater to the built and natural environment;

b) To ensure that new development does not generate stormwater discharges that exceed the capacity of the existing stormwater drainage network;

c) To ensure that an adequate and environmentally acceptable method of removing surface water and stormwater is implemented;

d) To minimise nuisance flows of stormwater from one property to adjoining properties;

e) To maximise reasonable on-site detention, to provide opportunities for rainwater re-use;

f) To minimise hardstand and impervious areas on developed land to minimise run off;

g) To provide a stormwater system which can be maintained economically;

h) To provide a stormwater system which utilises open space in a manner compatible with other uses;

i) To control flooding and enable access to allotment, stabilise the land form and control erosion; and

j) To minimise urban runoff pollutants to watercourses."

In order to achieve these objectives a number of controls are set out in Section 3.6 of Chapter C3. In relation to Local Catchment Flooding, the key controls are:

i. adequate stormwater systems shall be designed and constructed to ensure that, for all storm events up to 1% AEP in intensity, new developments and redevelopments do not increase stormwater peak flows in any downstream areas;

ii. any new piped drainage system shall be designed to control minor stormwater flows under normal operating conditions for a 20% AEP storm event; and

iii. any new drainage system shall be designed to control major stormwater flows under normal operating conditions for a 1% AEP storm event.

2.16 Flood Warning and Flood Preparedness

The NSW SES is nominated as the principal combat and response agency for flood emergencies in NSW. NSW SES is responsible for the issuing of relevant warnings (in collaboration with BoM), as well as ensuring that the community is aware of the flood threat and how to mitigate its impact.

The *Penrith City Local Flood Plan*, 2012 published by NSW SES covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for all levels of flooding on the Nepean River within the Penrith City area. The *Penrith City Local Flood Plan* is administered by the NSW SES Penrith City Local Controller who controls flood operations within the Penrith City area. The NSW SES Penrith City Local Unit has its headquarters based at 27 Fowler Street, Claremont Meadows, which is located on the western side of South Creek directly opposite the study area.

The *Penrith City Local Flood Plan* is a subordinate plan to the *Hawkesbury Nepean Flood Plan*, 2015 and the *Penrith Local Emergency Management Plan*, 2015, both of which are administered by the NSW SES.

The *Penrith City Local Flood Plan* follows the standard NSW SES template and is divided into the following sections:

- ***Introduction****;* this section of the *Penrith City Local Flood Plan* identifies the responsibilities of the NSW SES Local Controller and NSW SES members and supporting services such as the Police, BoM, Ambulance, Fire & Rescue, Penrith City Council, etc. The *Penrith City Local Flood Plan* identifies the importance for NSW SES and Council to coordinate the development and implementation of a public education program to advise the population of the flood risk.
- ***Preparedness****;* this section deals with activities required to ensure the *Penrith City Local Flood Plan* functions during the occurrence of the flood emergency. The Plan will devote considerable attention to flood alert and emergency response.
- ***Response.*** *Response operations will commence:*
  - on receipt of a BoM Flood Watch, Preliminary Flood Warning or Flood Warning for the Nepean River;
  - on receipt of a Flood Warning for the Hawkesbury River at Windsor which indicates backup flooding on Rickabys Creek, South Creek and Ropes Creek;
  - when other evidence leads to an expectation of flooding on the South Creek system; and
  - when other evidence leads to an expectation of flooding within the Penrith local government area.
- ***Recovery****,* involving measures to ensure the long term welfare for people who have been evacuated, recovery operations to restore services and clean up and de-briefing of emergency management personnel to review the effectiveness of the *Penrith City Local Flood Plan.*

The Penrith local area has been divided into a number of sectors which are used by NSW SES to plan and manage the evacuation of people from the Hawkesbury-Nepean floodplain during a flood event. The study area is located in the "*South Creek A Sector"*. The *Penrith City Local Flood Plan* states that flooding in the *South Creek A Sector* is mainly due to flooding on South Creek or from backup flooding from the Hawkesbury-Nepean River along Rickabys Creek and South Creek. It also states that the relevant flood gauge is the Windsor Bridge flood gauge on the Hawkesbury-Nepean River at Windsor.

The *Penrith City Local Flood Plan* defines the following two levels of flood operation in the Hawkesbury-Nepean Valley:

- **Level 1**, which is enacted when the water level in the Hawkesbury-Nepean River <u>is not</u> expected to exceed 15.0 metres on the Windsor Bridge gauge. For such a flood the operation is within the scope of normal arrangements detailed in the respective NSW SES Region and Local Flood Plans and the respective District and Local DISPLAN's.
- **Level 2**, which is enacted when the water level in the Hawkesbury-Nepean River is expected to exceed 15.0 metres on the Windsor Bridge gauge. In such a flood the operation will be beyond the scope of the respective NSW SES Region and Local Flood plans and the respective District and Local DISPLAN's. In this case the provisions of the *Hawkesbury Nepean Flood Emergency Plan* will apply.

Both the *Hawkesbury Nepean Flood Plan*, 2015 and the *Penrith City Local Flood Plan* deal principally with the flood risk associated with Hawkesbury-Nepean River Flooding. The only reference to non-Hawkesbury-Nepean Flooding in the study area is contained in Section 3.17 of the *Penrith City Local Flood Plan* which states that because of local flooding initially and back up flooding in South Creek and Ropes Creek for higher flood levels, up to 7,000 persons may have to be progressively evacuated from the St Marys and Werrington areas to evacuation centres during Level 2 flood evacuations.

2.17 Environmental Considerations

As mentioned, the main channel of Byrnes Creek has been highly modified downstream of Monfarville Reserve, while its tributary arms have been enclosed and now comprise a pit and pipe drainage system.

Council is currently assessing the merit of constructing a wetland in Cook Park which would be aimed at improving the quality of stormwater runoff discharging to South Creek. **Section 3.4.4** presents the findings of an investigation which was undertaken to assess the flood mitigation benefits that could be achieved by increasing the volume of temporary flood storage in Cook Park in combination with a wetland arrangement. The provision of additional temporary flood storage in Cook Park is aimed at reducing the frequency and depth of Local Catchment Flooding in Saddington Street, Pages Road and Putland Street, thereby reducing the likelihood that these roads would be inundated during the rising limb of either a South Creek or Hawkesbury-Nepean River flood.

3 POTENTIAL FLOODPLAIN MANAGEMENT MEASURES

3.1 Range of Available Measures

A variety of floodplain management measures can be implemented to reduce flood damages. They may be divided into three categories, as follows:

Flood modification measures change the behaviour of floods in regard to discharges and water surface levels to reduce flood risk. This can be done by the construction of levees, detention basins, channel improvements and upgrades of piped drainage systems in urban areas. Such measures are also known as "structural" measures as they involve the construction of engineering works. Vegetation management is also classified as a flood modification measure.

Property modification measures reduce risk to properties through appropriate land use zoning, specifying minimum floor levels for new developments, voluntary purchase of residential property in high hazard areas, or raising existing residences in the less hazardous areas. Such measures are largely planning (i.e. "non-structural") measures, as they are aimed at ensuring that the use of floodplains and the design of buildings are consistent with flood risk. Property modification measures could comprise a mix of structural and non-structural methods of damage minimisation to individual properties.

Response modification measures change the response of flood affected communities to the flood risk by increasing flood awareness, implementation of flood warning and broadcast systems and the development of emergency response plans for property evacuation. These measures are entirely non-structural.

3.2 Community Views

Comments on potential flood management measures were sought from the community by way of the *Community Questionnaire* which was distributed at the commencement of the study. The responses are summarised in **Appendix A** of this report. Question 8 in the *Community Questionnaire* outlined a range of potential flood management measures. The responses are shown on **Table 3.1** over the page together with initial comments on the feasibility of each measure. The measures are discussed in more detail in later sections of this Chapter.

The Community favoured the following measures:

- Improvements in the stormwater system.
- Management of vegetation along creek corridors.
- Flood related controls over future development in flood liable areas.
- Improved flood warning, evacuation and flood response procedures, including the preparation of Flood Action Plans for occupiers of the floodplain.
- Community education to promote flood awareness.
- Advice of flood affectation via Planning Certificates for properties located within the *Flood Planning Area*.

TABLE 3.1
COMMUNITY VIEWS ON POTENTIAL FLOOD MANAGEMENT MEASURES

	Flood Management Measure	Classification[(1)]	Respondent's Views			Comments
			Yes	No	Don't Know	
a)	Management of vegetation along creek corridors to provide flood mitigation, stability, aesthetic and habitat benefits	FM	106	2	7	While the community is strongly in favour of this measure, such works would be limited to the removal of macrophytes from the main arm of Byrnes Creek downstream of Monfarville Reserve.
b)	Widening and/or concrete lining of watercourses	FM	79	15	20	There is limited benefit in widening or concrete lining the main arm of Byrnes Creek between Mamre Road and Saddington Street given flooding is generally controlled by the capacity of the twin 1650 mm diameter pipes which extend downstream of Cook Park. Concrete lining the channel would also exacerbate flooding conditions in the lower reaches of the drainage system due to the more efficient nature of the drainage system.
c)	Construct detention basins	FM	62	10	31	While the cascading detention basin arrangement in Monfarville Reserve in combination with the downstream diversion works mitigate to a large degree the impact of Local Catchment Flooding on existing development that is located behind the St Marys Levee for storms up to 1% AEP in intensity, there is merit in raising a section of the existing basin embankment to prevent flooding of residential development that is located along Chilaw Avenue. There is also merit in increasing the size of the existing detention basin in Bennett Park, as this would reduce the severity of flooding experienced in several commercial properties that are located along Queen Street. The lowering of natural surface levels in Cook Park would also reduce the frequency and depth of Local Catchment Flooding in Saddington Street, Pages Road and Putland Street, thereby reducing the likelihood that these roads would be inundated by Local Catchment Flooding during the rising limb of a South Creek flood. The technical requirements associated with lowering natural surface levels in Cook Park and Bennett Park are discussed in **Section 3.4.4**.
d)	Improve stormwater drainage system	FM	110	1	3	This measure is strongly supported by the community and needs to be considered as part of the *FRMP*. The present study shows that the severity of Local Catchment Flooding could be significantly reduced in minor storm events if the existing stormwater drainage system is upgraded in several locations. This flood management measure and the technical requirements associated with an upgrade of the existing stormwater system are discussed in **Section 3.4.2**.
e)	Removal of floodplain obstructions	FM	78	2	28	While this measure is supported by the community, the main arm of Byrnes Creek downstream of Monfarville Reserve is generally free of any obstructions. While fencing can cause overland flow to temporarily pond in private property, there is no requirement set out in *Penrith DCP 2014* to provide openings in new fencing to relieve such flooding.
f)	Voluntary purchase of the most severely affected flood-liable properties	PM	37	21	49	The community is not in favour of this measure, which is often adopted to remove residential property in high hazard areas of the floodplain. While there are no existing dwellings located in the High Hazard Floodway area, this measure was reviewed in **Section 3.5.2**.
g)	Provide funding or subsidies to raise houses above major flood level in **low hazard** areas	PM	47	35	27	The community is not in favour of this measure. Nonetheless, this measure would have application for timber framed houses located in low hazard zones on the floodplain (of which there is none located in the study area) and is reviewed in **Section 3.5.3**.
h)	Flood proofing of individual properties by waterproofing walls, putting shutters across doors, etc.	PM	37	37	33	The community is not in favour of this measure, which should only be adopted as a means by which to mitigate the impact of flooding on existing development.
i)	Improve flood warning and evacuation procedures both before and during a flood.	RM	107	1	7	The study area is affected by three primary mechanisms of flooding; Hawkesbury-Nepean River Flooding, South Creek Flooding and Local Catchment Flooding, the latter which is of a "flash flooding" nature. Flash flooding results in a sudden rise in water levels after the onset of heavy rainfall. The sudden failure or overtopping of the St Marys Levee during a flood on South Creek would also result in the rapid rise of flood levels in the lower reaches of the Byrnes Creek drainage system. While BoM provides notice if flood producing rainfall is likely to occur in the area, as well as predictions relating to water levels on the Hawkesbury-Nepean River, no other formal warning system exists for the inundation of property due to South Creek and Local Catchment Flooding. NSW SES responds to flood occurrences in the study area in accordance with the *Penrith City Local Flood Plan*, which principally deals with back up flooding from the Hawkesbury-Nepean River. This document should be updated in response to the completion of the *FRMS&P*. Improvements to flood warning and flood emergency response planning (using information contained in this study) are strongly supported by the community and are considered in **Section 3.6.1** and **3.6.2**.
j)	Community education, participation and flood awareness programs.	RM	88	1	17	Ensuring the community is aware of the flood risk in the study area is favoured by the questionnaire respondents. This measure is reviewed in **Section 3.6.3**.
k)	Ensuring all owners have Flood Action Plans - these outline WHAT to do, WHERE to go and WHO to contact in a flood	RM	101	5	7	Ensuring the community knows what actions to take during a flood event is favoured by the questionnaire respondents. This measure is reviewed in **Section 3.6.3**.

Refer over for footnote to table

Cont'd Over

TABLE 3.1 (Cont'd)
COMMUNITY VIEWS ON POTENTIAL FLOOD MANAGEMENT MEASURES

Flood Management Measure		Classification[1]	Respondent's Views			Comments
			Yes	No	Don't Know	
l)	Specify controls on future development in flood-liable areas (e.g. controls on extent of filling, minimum floor levels, etc.)	PM	93	5	13	The community supports this measure, which is an essential part of the *FRMP*. The issue is reviewed in **Section 3.5.1**.
m)	Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected	PM	93	10	12	Provision of information on flood affection of properties is favoured by the community. This may be achieved by notation of flood affectation of allotments on Section 10.7 Planning Certificates. This measure is discussed in **Section 3.5.1.3**.
n)	Ensuring all information about the potential risks of flooding is available to all residents and business owners	PM	110	1	4	The community supports this measure, which is an essential part of the *FRMP*. The issue is reviewed in **Section 3.5.1**.

1. FM = Flood Modification Measure
PM = Property Modification Measure
RM = Response Modification Measure

3.3 Outline of Chapter

The measures set out in **Table 3.1** were examined at the strategic level of detail in **Chapter 3** and where appropriate, tested for feasibility on a range of assessment criteria in **Chapter 4**. Following consideration of the results by the FRMC, selected measures were included in the *FRMP* in **Chapter 5**.

Ten individual flood modification schemes were considered, all but two of which were aimed at reducing the impact of Local Catchment Flooding on existing residential and commercial development in parts of the study area.

In the economic analysis, the damages prevented by a flood modification scheme represent its benefits. The damages were computed for present day and post-scheme conditions for a range of Local Catchment Floods up to the PMF event. By integrating the area beneath the damage–frequency curve, the long term "average annual" value of benefits were calculated (by subtraction of post-scheme from present day damages). These average annual benefits were then converted to an equivalent present worth value for each of the three discount rates nominated by NSW Treasury Guidelines for the economic analysis of public works (i.e. 4, 7 and 11 per cent), over an economic life of 50 years. These present worth values of benefits were then divided by the estimated capital cost of the schemes to give benefit/cost ratios for the three discount rates.

The property modification measures considered as part of the present study include controls over future development, voluntary purchase of residential properties and house raising. Response modification measures such as improvements to the flood warning system, improvements to emergency planning and responses, and public awareness programs have also been considered.

3.4 Flood Modification Measures

3.4.1 Levees

Levees are an effective means of protecting flood affected properties up to the design flood level. In designing a levee, it is necessary to take account of three important factors: potential re-distribution of flood flows, the requirements for the collection and disposal of internal drainage from the protected area and the consequences of overtopping the levee in floods greater than the design event. A freeboard between the design flood level and the crest level of between 0.5 and 1 m would be required, based on an assessment of site specific flooding conditions.

Reinforced concrete and concrete block walls are often used in situations where there is insufficient land available for earth banks. Such walls are provided with reinforced concrete footings of sufficient width to withstand overturning during flood events. These footings may also need to be founded on sheet or reinforced concrete piles where bank stability is of concern.

As shown in **Figure 2.12**, the available freeboard between the crest level of the St Marys Levee and the peak 1% AEP flood level in South Creek is less than 0.5 m between about Chainage 1010 and 1120, Chainage 1250 and 1350, and Chainage 1460 and the Great Western Highway. Worley Parsons, 2015 also showed that a partial blockage of the Great Western Highway bridge on South Creek has the potential to further reduce the available freeboard to the crest level of the St Marys Levee.

While outside the scope of the present study, it is recommended that the *South Creek Floodplain Risk Management Study* assess the requirements for the upgrade of the St Marys Levee, as its sudden failure or overtopping would result in a rapid rise in water levels in the lower reaches of the Byrnes Creek drainage system where low, medium and high density residential development is present. A recommendation for the upgrade requirements for the St Marys Levee to be assessed as part of the *South Creek Floodplain Risk Management Study* has been included in the *FRMP.*

3.4.2 Stormwater Drainage Upgrades

Stormwater drainage systems are an effective means of preventing frequent flooding of urban areas by local catchment runoff. Stormwater drainage systems are usually designed to convey flows associated with more frequent rainfall events. Flows resulting from rarer events will usually exceed the capacity of the stormwater drainage system and travel along flow paths as local overland flow. While upgrading key elements of a stormwater drainage system may prevent nuisance flooding in low lying properties or inundation of low points in roads due to small storms that occur frequently, it is generally not a cost effective or practical way to mitigate damaging flooding that results from intense, rare storm events.

A number of options for upgrading the existing stormwater drainage system in parts of the study area were assessed. For the purpose of the following discussion, these have been denoted Stormwater Drainage Upgrade Schemes 1 to 8. **Figure 3.1** shows the location of Stormwater Drainage Upgrade Schemes 1 to 8, while **Figures E1** to **E10** in **Appendix E** show the layout of each individual scheme and the benefit that its implementation would provide for Local Catchment Floods with AEP's of 20, 5 and 1 per cent. **Table 3.2** over sets out the estimated capital cost of each Stormwater Drainage Upgrade Scheme and its benefit in terms of the flood damages that it would prevent. Also given is the computed benefit cost ratio for each scheme. Following is a brief description of each Stormwater Drainage Upgrade Scheme and its benefits in terms of its ability to reduce the extent and depth of Local Catchment Flooding, as well as the number of properties that would experience above-floor inundation. Note that an assessment has not be undertaken of the impact that the scheme would have on existing utilities, including any costs associated with their relocation.

Stormwater Drainage Upgrade Scheme 1

Stormwater Drainage Upgrade Scheme 1 involves the installation of a new 1500 mm diameter pipe downstream of Coachman Park to South Creek. The top left hand corner of **Figure E1.1** in **Appendix E** shows the route the new 1500 mm diameter pipe would take through Kokoda Park and the northern side of the car park in The Village Centre.

By inspection of **Figure E1.1**, Stormwater Drainage Upgrade Scheme 1 would reduce the depth of flooding in Coachman Park and in the northern car park of The Village Centre. It would also reduce the depth of ponding in East Lane and prevent above-floor inundation being experienced in up to two commercial properties during storms of varying AEP.

Given the limited benefits of the scheme in terms of preventing flood damages in combination with the large cost of installing the long length of 1500 mm diameter pipe, its benefit cost ratio for a 7% discount rate is only 0.1. As the scheme is not economically feasible it has not been considered further.

TABLE 3.2
ECONOMIC ANALYSIS
POTENTIAL STORMWATER DRAINAGE UPGRADE SCHEMES

Stormwater Drainage Upgrade Scheme	Present Worth Value of Benefits (Damages Prevented) $ Million			Estimated Cost of Scheme $ Million	Benefit/Cost Ratio		
	Discount Rate %				Discount Rate %		
	4	7	10		4	7	10
SDUS 1	0.34	0.22	0.14	2.1	0.16	0.10	0.07
SDUS 2	0.68	0.43	0.28	3.1	0.22	0.14	0.09
SDUS 3	0.72	0.46	0.30	3.3	0.22	0.14	0.09
SDUS 4A	0.04	0.02	0.02	0.6	0.06	0.04	0.03
SDUS 4B	0.05	0.03	0.02	1.8	0.03	0.02	0.01
SDUS 5A	1.77	1.14	0.74	2.0	0.89	0.57	0.37
SDUS 5B	1.81	1.16	0.76	1.2	1.51	0.97	0.63
SDUS 6	0.79	0.51	0.33	0.6	1.32	0.85	0.55
SDUS 7	2.23	1.43	0.93	4.2	0.53	0.34	0.22
SDUS 8	0.01	0.00	0.00	1.7	0.00	0.00	0.00

Stormwater Drainage Upgrade Scheme 2

Stormwater Drainage Upgrade Scheme 2 involves the construction of a small detention basin in the reserve which is located on the northern side of Chapel Street east of Gidley Street in combination with the works associated with Stormwater Drainage Upgrade Scheme 1. Stormwater Drainage Upgrade Scheme 2 also includes the adoption of 2 off 1350 mm diameter pipes extending from Kokoda Park to South Creek instead of the single 1500 mm diameter pipe which forms part of Stormwater Drainage Upgrade Scheme 1. The top left hand corner of **Figure E1.2** in **Appendix E** shows the pipe and basin arrangement.

The inclusion of the basin in the scheme has a limited benefit in terms of reducing the depth of ponding in East Lane and hence the number of commercial properties that experience above-floor inundation.

As the benefit cost ratio of the scheme is only marginally improved by the inclusion of the additional works it also has not been considered further.

Stormwater Drainage Upgrade Scheme 3

Stormwater Drainage Upgrade Scheme 3 is the same as Stormwater Drainage Upgrade Scheme 2 but for the construction of a new 600 mm diameter stormwater drainage pipe from the aforementioned basin to Coachman Park via Gidley Street. The top left hand corner of **Figure E1.3** in **Appendix E** shows the new pipe and basin arrangement.

The inclusion of the new pipe in Gidley Street again has a limited benefit in terms of reducing the depth of ponding in East Lane and hence the number of commercial properties that experience above-floor inundation.

As the benefit cost ratio of the scheme is similarly only marginally improved by the inclusion of the additional works it also has not been considered further.

Stormwater Drainage Upgrade Scheme 4A

Stormwater Drainage Upgrade Scheme 4A involves the lowering of natural surface levels in the south-east corner of Bennett Park. The top left hand corner of **Figure E1.4** in **Appendix E** shows the extent of the assessed earthworks.

While the lowering of natural surface levels in the south-east corner of Bennett Park would reduce the depth and extent of flooding in several residential properties that are located on the eastern side of Stapleton Parade, it would result in adverse flooding conditions being experienced in the St Marys Veterinary Clinic which is located at the intersection of King Street and Gidley Street, as well as in a new residential unit development that is located at the intersection of King Street and East Lane (refer **Figure E1.4**).[6]

The scheme cannot be justified on economic grounds given its relatively low benefit cost ratio of 0.04. As a result it has not been considered further.

Stormwater Drainage Upgrade Scheme 4B

Stormwater Drainage Upgrade Scheme 4B involves the lowering of natural surface levels in the south-east corner of Bennett Park in combination with the enlargement of the detention basin that is located at its western end. The top left hand corner of **Figure E1.5** in **Appendix E** shows the extent of the assessed earthworks.

By inspection of **Figure E1.5**, increasing the volume in the existing basin would mitigate the impact the lowering of natural surface levels in the south-west corner of Bennett Park in addition to removing flooding from the two aforementioned properties for all storms up to 1% AEP in intensity (refer **Figure E1.5**).

The cost of the scheme is increased significantly when compared to Stormwater Drainage Upgrade Scheme 4A as it has been assumed that the excavated material would need to be sent to a waste management centre for disposal. As the scheme only has a benefit cost ratio of 0.02, it cannot be justified on economic grounds. As a result it has not been considered further.

Stormwater Drainage Upgrade Scheme 5A

Stormwater Drainage Upgrade Scheme 5A involves the provision of additional inlet capacity at the location of the sag in Mamre Road south of its intersection with Saddington Street, as well as the installation of 2 off 1050 mm diameter pipes extending south along Mamre Road and west along Edgar Street. The top left hand corner of **Figure E1.6** in **Appendix E** shows the layout of the new pit and pipe system.

The new pit and pipe system would reduce the frequency and depth of flooding in Our Lady of the Rosary Primary School which is presently impacted during storms as frequent as 50% AEP. It would also remove above-floor inundation in two of the school buildings, as well as up to three dwellings that are located along Edgar Street.

[6] Details of the new residential unit development were not available at the time of writing, it appears that the ground floor level of the new building lies above the peak 1% AEP flood level. That said, it is unclear whether there are any opening along the eastern side of the building which would permit the ingress of overland flow to the basement car parking.

While the benefit cost ratio of this scheme is only 0.57, the scheme would provide a significant social benefit by removing frequent flooding both in the primary school and the sag in Mamre Road. One issue associated with Stormwater Drainage Upgrade Scheme 5A is that the trench associated with the 2 off 1050 mm diameter pipes would need to be about 4 m deep at the intersection of Mamre Road and Edgar Street, resulting in the need to use mechanical shoring when installing the pipes along a section of Mamre Road and Edgar Street.

Given its significant social benefits, the investigation and design of this scheme (including a more detailed assessment of its alternative below) was included in the *FRMP*.

Stormwater Drainage Upgrade Scheme 5B

Stormwater Drainage Upgrade Scheme 5B seeks to address the issue of the deep trench by rerouting the 2 off 1050 mm diameter pipes along Saddington Street. The top left hand corner of **Figure E1.7** in **Appendix E** shows the layout of the alternative scheme.

While the shallower depth of excavation results in the benefit cost ratio for Stormwater Drainage Upgrade Scheme 5B increasing to about 1 (mainly due to the need not to use mechanical shoring), it would involve trenching along Saddington Street which is more heavily trafficked than Edgar Street. There is also greater risk of existing utilities being impacted by the works and therefore needing relocating which would increase the cost of the works.

Given its significant social benefits in combination with the reduced depth of trenching, the investigation and design of this scheme (including a more detailed assessment of its alternative above) was included in the *FRMP*.

Stormwater Drainage Upgrade Scheme 6

Stormwater Drainage Upgrade Scheme 6 would involve the construction of a detention basin in an existing reserve that is located on the western side of Collins Street between its intersection with Lonsdale Street and Mitchell Street. The top left hand corner of **Figure E1.8** in **Appendix E** shows the layout of the basin arrangement.

As the scheme has a benefit cost ratio of 0.85, Council would likely be successful in securing funding for its design and construction under from the NSW Government's Floodplain Management Program. As a result, the investigation and design of the scheme has been included in the *FRMP*.

Stormwater Drainage Upgrade Scheme 7

Stormwater Drainage Upgrade Scheme 7 would involve the construction of a detention basin in an existing reserve that is located on the northern side of Maranie Avenue adjacent to its intersection with Arnold Avenue in combination with a new trunk drainage line which would extend west along Desborough Road and south through St Marys South Public School. The top left hand corner of **Figure E1.9** in **Appendix E** shows the key features of the drainage upgrade scheme.

While the scheme would reduce the frequency and depth of inundation in a large number of residential properties that are located to the south of Desborough Road, its large cost results in its having a benefit cost ratio of only 0.34. As the scheme is not economically feasible, it has not been considered further.

Stormwater Drainage Upgrade Scheme 8

Stormwater Drainage Upgrade Scheme 8is aimed at reducing the frequency and depth of ponding that presently occurs in Pages Road adjacent to Victoria Park, thereby reducing the likelihood that the road would be inundated during the rising limb of either a South Creek or Hawkesbury Nepean River flood. The top left hand corner of **Figure E1.10** in **Appendix E** shows the key feature of the scheme.

While the scheme would assist in maintaining traffic movements onto the Great Western Highway from the area which lies behind the St Marys Levee during a local catchment storm event, its large cost and the availability of alternative evacuation routes out of the area mean that it has not been considered further.

3.4.3 Major Hydraulic Structure Upgrades

Upgrading major hydraulic structures by increasing their waterway area has the potential to reduce the impact of flooding on existing development. However, care must be taken when assessing the merits of such upgrades as changes in flooding patterns and the removal of temporary flood storage can under certain circumstances increase downstream flood peaks. The risk of a blockage of hydraulic structures by debris also needs to be taken into consideration when determining appropriate dimensions for an upgraded structure.

While flood damages arising from surcharge of the main arm of Byrnes Creek is generally limited to development that is located to the north (downstream) of Saddington Street, by inspection the upgrade the trunk drainage system in this area would not be economically feasible.

While from a flood evacuation point of view upgrading the trunk drainage system in this area would improve the level of flood immunity of Putland Street, Pages Road and Saddington Street in relation to Local Catchment Flooding, it would be more cost effective and less disruptive to increase the temporary flood storage area in Cook Park. The scope of such a measure and the benefits that it would provide are set in **Section 3.4.4** of the report.

3.4.4 Detention Basins

Detention basins provide a temporary storage of floodwaters additional to that contained in the floodplain, with the objective of reducing the flood peak in downstream reaches of the drainage system. “Offline” basins, remote from the stream, with intake and outlet channels to and from the stream, are preferred over embankments constructed across the channel in order to maintain the continuity of the creek. The basin should also be located in the middle or lower reaches of the catchment, sufficiently close to the area intended to be protected, that its attenuating effects over flood peaks is not negated by downstream tributary inflows. Typically the basin should command in excess of 60 to 70 per cent of the total catchment at the urban centre to be protected.

Another requirement is that the basin be of sufficient size to store a significant percentage of runoff from the design storm. Basins attenuate the flood peak (i.e. reduce the downstream peak rate of runoff) by temporarily storing the incoming discharge hydrograph and releasing it at a controlled rate. To be effective, basins storing a minimum of 50 per cent of the volume of runoff of the incoming flood event are required.

For optimum performance in reducing downstream flows, the design flood should be conveyed through the basin via a low level outlet without the spillway operating. To achieve this objective often requires a large storage. Small basins are quickly overwhelmed by the incoming flood

waters, with the result that the level of stored water quickly rises to the level of the emergency spillway. Because the spillway is able to pass a large rate of flow, with little rise in level, the rate of outflow rapidly rises to the rate of inflow, negating the main purpose of the basin.

Upgrade of Basin BA04 in Monfarville Reserve

While the existing cascading basin arrangement in Monfarville Reserve and its diversion outlet works reduce the impact of Local Catchment Flooding on existing development located downstream of the Mamre Road culverts, the present study identified that there is insufficient freeboard between the crest level of the basin embankment where it runs adjacent to several residential properties that are located along Chilaw Avenue and the peak 1% AEP flood level. The present study also showed that flooding behaviour in the lower reaches of the Byrnes Creek drainage system would be exacerbated should the earth embankment associated with detention basin BA04 partially fail during a storm event.

A recommendation for Council to investigate the geotechnical stability of the existing earth embankment and to also raise it in order to provide a minimum 0.5 m freeboard between the crest level and the peak 1% AEP flood level in the basin has been included in the *FRMP*. The cost of these works are estimated to be about $0.35 Million.[7]

Increase in the Volume of Temporary Flood Storage in Cook Park

While it is not considered a classic detention basin arrangement, there is merit in lowering natural surface levels in Cook Park upstream of the inlet to the existing twin cell 1650 mm diameter pipes which extend downstream of Saddington Street to increase the temporary flood storage in this area. An assessment was carried out whereby natural surface levels in Cook Park were lowered in combination with a possible wetland arrangement. **Figure E1.11** in **Appendix E** shows the extent of the assessed bulk earth works, while **Figure E1.12** shows the impact that increasing the temporary flood storage in Cook Park would have on Local Catchment Flooding behaviour.

The lowering of natural surface levels has the potential to increase the volume of temporary flood storage in Cook Park by about 12,000 m^3. By inspection of **Figure E1.12**, the works would prevent flooding of the sag in Saddington Street for storms up to 5% AEP in intensity and reduce the depth of inundation in the Saddington Street, Pages Road and Putland Street sags for storms of between 5 and 1% AEP in intensity. The cost of undertaking the bulk earthworks and re-establishing grass cover in Cook Park over the extent of the works is estimated to cost about $2.5 Million.[8]

While the works could not be justified on economic grounds, they would assist in reducing the frequency and depth of Local Catchment Flooding along the roads which are critical for evacuating occupiers of the adjacent medium and high density residential development during the rising limb of either a South Creek or Hawkesbury-Nepean River flood. It is recommended that Council investigate options for incorporating water quality benefits into the scheme, as this would assist in justifying its large cost. Council may also have sites where the excavated material could be deposited at a cheaper rate, thereby significantly reducing the capital cost of the scheme.

[7] Assumes existing embankment can be raised, rather than it needing be removed and rebuilt.

[8] It has been assumed that the excavated material would need to be sent to a waste management centre for disposal, which adds significantly to the cost of the works.

Upgrade of Basin BA05 in Bennett Park

It is noted that the upgrade of the existing detention basin in Bennett Park was assessed as part of Stormwater Drainage Upgrade Scheme 4B and discarded on economic grounds.

3.4.5 Channel Widening

The hydraulic capacity of a stream may be increased by widening, deepening or straightening the channel and clearing the banks of obstructions. The scope of such improvements can vary from: schemes which do not increase the waterway area but ensure the creek is maintained in a condition which maximises hydraulic capacity; to major channel excavations. Careful attention to design is required to ensure stability of the channel is maintained and scour or sediment build-up is minimised. The potential for large scale improvements to increase downstream flood peaks also needs to be considered. In general, channel improvements need to be carried out over a substantial stream length to have any significant effect on flood levels. Proposals also need to conform with Government Policies in regard to retention of native vegetation, maintenance of fish habitat and other environmental considerations.

While the cascading basin arrangement in Monfarville Reserve and its outlet diversion works reduce the impact of flooding along the main arm of Byrnes Creek downstream for Mamre Road for rare storm events, the narrow nature of the channel which runs along the back of the St Marys Levee from the western end of Putland Road to the inlet of the Great Western Highway culvert acts as a major constriction on flow discharging to South Creek during very rare and extreme Local Catchment Flood events. This leads to hazardous flooding conditions arising in the densely populated area which lies behind the St Marys Levee.

A potential flood modification scheme involving the realignment of the northern section of the St Marys Levee so that it ties into the Great Western Highway on the western side of the adjacent 3 cell 3.5 m wide by 3.7 m wide box culverts was assessed. However, it was found that peak flood levels upstream of the Great Western Highway culverts would only be reduced by about 0.5 m during a PMF event, thereby not removing hazardous flooding behind the St Marys Levee. Based on this finding, a scheme involving the realignment of the St Marys Levee at its northern end was not considered further.

3.4.6 Vegetation Management

Management programs in creeks typically involve maintenance of batters, the removal of sediment, removal of dense vegetation and the clearance of flood debris after significant flow events. Clearance of debris within the stream corridor reduces the potential for future capture by the flow and blockage of culverts.

Apart from the accumulation of sediment and the growth of macrophytes along the main arm of Byrnes Creek downstream of the Mamre Road culverts, there is limited merit in Council developing and implementing a *Vegetation Management Plan* for the study area. That said, there is merit in Council maintaining the hydraulic capacity of Byrnes Creek where it runs between the Mamre Road and Saddington Street culverts as part of its general works program.

3.4.7 Debris Control Structures

As discussed in **Section 2.11**, the partial blockage of major hydraulic structures located along the main arm of Byrnes Creek has the potential to exacerbate flooding conditions in the lower reaches of the drainage system behind the St Marys Levee. Based on the findings of the

blockage assessment it is considered that the installation of debris control structures at the following three locations would assist in reducing the likelihood of flooding conditions being exacerbated by a partial blockage:

- adjacent to the inlet of four cell 1500 mm diameter pipes which control flow discharging from detention basin BA04,
- adjacent to the inlet of the twin cell 1650 mm dimeter pipes extending downstream of Saddington Street in Cook Park; and
- upstream of the box culvert under the Great Western Highway near the western end of Putland Street.

While it would be necessary to confirm that the installation of the three structures would not exacerbate flood behaviour should they become blocked by debris, given the benefits that they would provide in terms of reducing potential increases in flood damages, their design and installation has been included in the *FRMP*.

3.5 Property Modification Measures

3.5.1 Controls over Future Development

3.5.1.1 Considerations for Setting Flood Planning Level

Selection of the FPL for an area is an important and fundamental decision as the standard is the reference point for the preparation of floodplain management plans. It is based on adoption of the peak level reached by a particular flood plus an appropriate allowance for freeboard. It involves balancing social, economic and ecological considerations against the consequences of flooding, with a view to minimising the potential for property damage and the risk to life and limb. If the adopted FPL is too low, new development in areas outside the FPA (particularly where the difference in level is not great) may be inundated relatively frequently and damage to associated public services will be greater. Alternatively, adoption of an excessively high FPL will subject land that is rarely flooded to unwarranted controls.

Councils are responsible for determining the appropriate FPL's within their local government area. *Penrith LEP 2010* nominates the "*1:100 ARI (average recurrence interval) flood event plus 0.5 m freeboard*" as the FPL. This requirement is supported by *Penrith DCP 2014* which requires the floor levels of all new habitable rooms to be set a minimum of 0.5 m above the peak 1% AEP flood level.

3.5.1.2 Current Government Policy

The circular issued by the Department of Planning on 31 January 2007 contained a package of changes clarifying flood related development controls to be applied on land in low flood risk areas (land above the 1% AEP flood). The package included an amendment to the *Environmental Planning and Assessment Regulation 2000* in relation to the questions about flooding to be answered in Section 10.7 planning certificates, a revised ministerial direction (Direction 4.3 issued on 1 July 2009) regarding flood prone land (issued under Section 9.1 of the EP&A Act, 1979) and a new Guideline concerning flood-related development controls in low flood risk areas. The Circular advised that councils will need to follow both NSWG, 2005, as well as the Guideline to gain the legal protection given by Section 733 of the Local Government Act.

The Department of Planning Guideline confirmed that unless exceptional circumstances applied, councils should adopt the 1% AEP flood with appropriate freeboard as the FPL for residential development. In proposing a case for exceptional circumstances, a council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood. Unless there were exceptional circumstances, Council should not impose flood-related development controls on residential development on land with a low probability of flooding, that is land above the residential FPL.

Nevertheless, the safety of people and associated emergency response management needs to be considered in low flood risk areas, which may result in:

- Restrictions on types of development which are particularly vulnerable to emergency response, for example, developments for aged care and schools.
- Restrictions on critical emergency response and recovery facilities and infrastructure. These aim to ensure that these facilities and the infrastructure can fulfil their emergency response and recovery functions during and after a flood event.

3.5.1.3 Proposed Planning Controls

While several councils are moving toward the adoption of a variable freeboard approach, whereby a value of less than 0.5 m is applied to new development that is affected by major overland flow, Council through the Technical Working Group advised that the currently adopted value of 0.5 m is to apply to all new development in the local government area that is subject to flooding. **Figure 3.2** is an extract of the *Flood Planning Map* which has been updated based on the findings of the present study and the adoption of a 0.5 m freeboard for setting the FPL in areas affected by Local Catchment and South Creek flooding.[9]

It is proposed that properties intersected by the extent of the FPA would be subject to S10.7 flood affectation notification and planning controls graded according to flood. The Floodplain Development Manual (NSWG, 2005) suggests wording on S10.7 (2) Planning Certificates along the following lines:

> *"Council considers the land in question to be within the Flood Planning Area and therefore subject to flood related development controls. Information relating to this flood risk may be obtained from Council. Restrictions on development in relation to flooding apply to this land as set out in Council's Flood Policy which is available for inspection at Council offices or website."*

Tables 3.3 and **3.4** over the page set out the graded set of flood related planning controls which have been developed for the study area. **Table 3.3** deals with areas subject to Local Catchment Flooding due to surcharge of flow from the main arm of Byrnes Creek, as well as South Creek Flooding (denoted the "***St Marys (Byrnes Creek) Flood Related Development Control Area 1***"), while **Table 3.4** deals with areas subject to Local Catchment Flooding along the overland flow paths which drain in a westerly direction toward the main arm of Byrnes Creek (denoted the "***St Marys (Byrnes Creek) Flood Related Development Control Area 2***").

Figure 3.3 is the *Development Controls Matrix Map* for the study area showing the areas over which the controls set out in **Tables 3.3** and **3.4** apply.

[9] Note that Hawkesbury-Nepean River Flooding does not affected the study area at the 1% AEP level of flooding.

TABLE 3.3
DEVELOPMENT CONTROLS MATRIX – ST MARYS (BYRNES CREEK) FLOOD RELATED DEVELOPMENT CONTROL AREA 1

	Outer Floodplain								Intermediate Floodplain								Inner Floodplain (Hazard Category 2)								Inner Floodplain (Hazard Category 1)							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level												1	1		1	1				1	1		1	1								
Building Components												1	1		1	1				1	1		1	1								
Structural Soundness												1	1		1	1				1	1		1	1								
Flood Affectation																				1	1	1	1	1						1		
Below Ground Car Parking												1	1		1	1				1	1		1	1								
Evacuation / Access																				1	1	1	1	1								
Management and Design													3		1	5				6	3,6	2,6	1,6	5						2,6		

Not Relevant | Unsuitable Land Use

See Notes over page:

TABLE 3.3 (CONT'D)
DEVELOPMENT CONTROLS MATRIX - ST MARYS (BYRNES CREEK) FLOOD RELATED DEVELOPMENT CONTROL AREA 1

Floor Level

1. Floor levels to be equal to or greater than the 1% AEP flood level plus 500 mm freeboard.

Building Components

1. All structures to have flood compatible building components below the 1% AEP flood level plus 500 mm freeboard.

Structural Soundness

1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to the 1% AEP flood level plus 500 mm freeboard.

Flood Affection in Adjacent Areas

1. A Flood Risk Report may be required to demonstrate that the development will not increase flood hazard (see Item 7 Management and Design below).
   Note: When assessing Flood Affectation the following must be considered:
   i. Loss of conveyance capacity in the floodway or areas where there is significant flow velocity.
   ii. Changes in flood levels and flow velocities caused by the alteration of conveyance of floodwaters.

Below Ground Car Parking

1. Must have all access, ventilation and any other potential water entry point above the 1% AEP flood level plus 500 mm freeboard and a clearly signposted flood free pedestrian evacuation route from the basement area separate to the vehicular access ramps.

Evacuation/ Access

1. Reliable access for pedestrians or vehicles required in the event of 1% AEP flood.

Management and Design

1. Applicant to demonstrate that potential developments as a consequence of a subdivision proposal can be undertaken in accordance with this Policy and the Plan.
2. No external storage of materials which may cause pollution or be potentially hazardous during PMF.
3. Where it is not practicable to provide floor levels to the 1% AEP flood level plus 500 mm freeboard, applicant is to provide an area to store goods at that level.
4. Applicant is to provide an area to store valuable equipment above the 1% AEP flood level plus 500 mm freeboard (level to be advised by Council).
5. Where it is not practicable to provide floor levels to the 1% AEP flood level plus 500 mm freeboard, Council may allow a reduction for minor additions to habitable**.**
6. Flood Risk Report may be required prior to development of this area**.**

TABLE 3.4
DEVELOPMENT CONTROLS MATRIX – ST MARYS (BYRNES CREEK) FLOOD RELATED DEVELOPMENT CONTROL AREA 2

Outer Floodplain

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level								
Building Components								
Structural Soundness								
Flood Affectation								
Below Ground Car Parking								
Evacuation / Access								
Management and Design								

Intermediate Floodplain

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level	2	2	2	2	2		2	2
Building Components	2	2	1	1	1		1	1
Structural Soundness	2	2	1	1	1		1	1
Flood Affectation								
Below Ground Car Parking	1	1	1	1	1		1	1
Evacuation / Access	1	1	1					
Management and Design	2,3	2,3	5		4		1	6

Low Hazard Floodway / Flood Storage

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level				1	1		1	1
Building Components				1	1		1	1
Structural Soundness				1	1		1	1
Flood Affectation				1	1		1	1
Below Ground Car Parking				1	1		1	1
Evacuation / Access								
Management and Design				7	4,7		1,7	6

High Hazard Floodway

	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level								1
Building Components								1
Structural Soundness								1
Flood Affectation						1		1
Below Ground Car Parking								1
Evacuation / Access								
Management and Design						3,7		6,7

Not Relevant   Unsuitable Land Use

See Notes over page:

ANNEXURE 2.2 (CONT'D)
DEVELOPMENT CONTROLS MATRIX - ST MARYS (BYRNES CREEK) FLOOD RELATED DEVELOPMENT CONTROL AREA 2

Floor Level

1. Floor levels to be equal to or greater than the 1% AEP flood level plus 500 mm freeboard.

Building Components

1. All structures to have flood compatible building components below 1% AEP flood level plus 500 mm freeboard.
2. All structures to have flood compatible building components below PMF flood level (where PMF level is higher than the 1% AEP flood level plus 500 mm freeboard).

Structural Soundness

1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to 1% AEP flood level plus 500 mm freeboard.
2. Structure to be designed to withstand forces of floodwater, debris and buoyancy up to PMF flood (where PMF level is higher than the 1% AEP flood level plus 500 mm freeboard).

Flood Affection in Adjacent Areas

1. Residential development may be "deemed to comply" provided it conforms with the requirements set out in the Penrith Development Control Plan. A Flood Risk Report may be required to demonstrate that the development will not increase flood hazard (see Item 7 Management and Design below).

   Note: When assessing Flood Affectation the following must be considered:

   i) Loss of conveyance capacity in the floodway or areas where there is significant flow velocity.
   ii) Changes in flood levels and flow velocities caused by the alteration of conveyance of floodwaters.

Below Ground Car Parking

1. Must have all access, ventilation and any other potential water entry point above the 1% AEP flood level plus 500 mm freeboard and a clearly signposted flood free pedestrian evacuation route from the basement area separate to the vehicular access ramps.

Evacuation/ Access

1. Reliable access for pedestrians or vehicles required in the event of 1% AEP flood.

Management and Design

1. Applicant to demonstrate that potential developments as a consequence of a subdivision proposal can be undertaken in accordance with this Policy and the Plan.
2. Applicant to demonstrate that facility is able to continue to function in event of PMF.
3. No external storage of materials which may cause pollution or be potentially hazardous during PMF.
4. Where it is not practicable to provide floor levels to 1% AEP flood level plus 300 mm freeboard, applicant is to provide an area to store goods at that level.
5. Applicant is to provide an area to store valuable equipment above 1% AEP flood level plus 500 mm freeboard (level to be advised by Council).
6. Where it is not practicable to provide floor levels to 1% AEP flood level plus 500 mm freeboard, Council may allow a reduction for minor additions to habitable areas.
7. Flood Risk Report may be required prior to development of this nature in this area.

Minimum floor level requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. **Figure 3.4** is the *Flood Hazard Map* for the study area which shows the subdivision of the floodplain into a number of categories which have been used as the basis for developing the graded set of planning controls.

The floodplain has been divided into the following four categories in *St Marys (Byrnes Creek) Flood Related Development Control Area 1*:

- The **Inner Floodplain (Hazard Category 1)** zone (shown as a solid red colour) comprises areas where factors such as the depth and velocity of flow, time of rise, isolation on Low Flood Islands and evacuation problems mean that the land is unsuitable for most types of development. It principally comprises High and Low Hazard Floodway areas. Erection of buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.
- The **Inner Floodplain (Hazard Category 2)** zone (shown as a solid yellow colour) comprises Low Hazard Floodway areas, where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow toward adjacent properties. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
- The **Intermediate Floodplain** zone (shown as a solid blue colour) is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA. Within this zone, there would only be the requirement for minimum floor levels to be set at the 1% AEP flood levels plus 500 mm. While land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan, Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development are not permitted in this zone.
- The **Outer Floodplain** zone is the area outside the Intermediate Floodplain where the depth of inundation will exceed 150 mm in the PMF (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply.

The floodplain has also been divided into the following two additional categories in *St Marys (Byrnes Creek) Flood Related Development Control Area 2*:

- **High Hazard Floodway**, which is shown in solid orange colour. Future development in this area is not permitted under the *Flood Policy*.
- **Low Hazard Floodway / Flood Fringe**, which is shown in solid green colour. Residential, commercial and industrial type development can occur in this zone subject to compliance with a prescribed set of flood related development controls.

The **Intermediate Floodplain** zone in areas subject to overland flow is the remaining land lying outside the extent of the Floodway and Flood Fringe areas, but within the FPA, while the **Outer Floodplain** zone represents the area outside the aforementioned zones where the depth of

inundation will exceed 150 mm during the PMF.[10] Flood related planning controls in these two areas are similar to those that apply to development in areas subject to Local Catchment Flooding along the main arm of Byrnes Creek and South Creek Flooding, with the following exception:

- the potential for Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential type development to take place in both the **Intermediate Floodplain** and **Outer Floodplain** zones subject to compliance with the flood related development controls set out in **Table 3.4**.

It needs to be noted that the flood mapping shown on **Figures 3.2**, **3.3** and **3.4** has been derived assuming that the St Marys Levee has a design standard of 1% AEP, which based on the findings of the present study is not the case. Prior to the adoption of the approach set out in this report it will be necessary for Council to raise the crest height of the St Marys Levee so that it incorporates the necessary freeboard to protect against a 1% AEP South Creek flood.

3.5.1.4 Revision of Penrith LEP 2010 by Council

In order to provide Council with more flexibility in addressing floodplain risk management issues in different parts of the local government area over time, clause 7.2 of *Penrith LEP 2010* would require minor amendments, namely in regards the wording of sub clause (2) and (5). It is recommended that the following clause replaces the existing clause 7.2 of *Penrith LEP 2010*:

"7.2 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 land at or below the flood planning level.

(3) Development consent must not be granted for 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, and

(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

[10] The extent of the Intermediate Floodplain zone has been trimmed to the extent of the Outer Floodplain zone where the PMF level is less than 500 mm above the corresponding peak 1% AEP flood level.

(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, and

(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 Floodplain Development Manual, unless it is otherwise defined in this Plan."

In order to support the proposed changes to clause 7.2 of *Penrith LEP 2010*, it will be necessary to include the following definitions in the Dictionary:

- ***Flood planning level*** means the level of a 1% AEP (annual exceedance probability) flood event plus 0.5 metre freeboard, or other freeboard as determined by any floodplain risk management plan adopted by the Council in accordance with the Floodplain Development Manual.
- ***Floodplain Development Manual*** means Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005.

It is also recommended that a new floodplain risk management clause be added to *Penrith L*EP *2010* as follows:

"Floodplain risk management

(1) The objectives of this clause are as follows:

(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events exceeding the flood planning level,

(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

(2) This clause applies to land which lies between the flood planning level and the level of the probable maximum flood, but does not apply to land at or below the flood planning level.

(3) Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land:

(a) amusement centre

(b) camping ground

(c) caravan park

(d) child care centre

(e) commercial premises (including business premises and retail premises)

(f) community facility

(g) correctional centre

(h) eco-tourist facility

(i) educational establishment (including schools and tertiary institutions)

(j) emergency services facility

(k) entertainment facility

(l) extractive industry

(m) function centre

(n) health services facility

(o) industry

(p) mining

(q) place of public worship

(r) residential accommodation (including seniors housing)

(s) respite day care centre

(t) tourist and visitor accommodation

(u) waste or resource management facility

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual, unless it is otherwise defined in this Plan."

In order to support the inclusion of the new clause in *Penrith L*EP *2010*, it will be necessary to include the following definitions in the Dictionary:

- ***probable maximum flood*** means the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation.

The steps involved in Council's amending *Penrith L*EP *2010* following the finalisation and adoption of the *FRMS&P* are:

1. Council Planning Staff consider the conclusions of the *FRMS&P* and suggested amendments to *Penrith LEP 2010*.
2. Council resolves to amend *Penrith LEP 2010* in accordance with the *FRMS&P*.
3. Council prepares a Planning Proposal in accordance with NSW Planning and Environment Guidelines. Planning Proposal submitted to NSW Planning and Environment in accordance with section 3.33 of the EP&A Act, 1979.
4. Planning Proposal considered by NSW Planning and Environment and determination made in accordance with section 3.34 of the EP&A Act, 1979 as follows:

   (a) whether the matter should proceed (with or without variation),

(b) whether the matter should be resubmitted for any reason (including for further studies or other information, or for the revision of the planning proposal),

(c) community consultation required before consideration is given to the making of the proposed instrument (the community consultation requirements),

(d) any consultation required with State or Commonwealth public authorities that will or may be adversely affected by the proposed instrument,

(e) whether a public hearing is to be held into the matter by the Planning Assessment Commission or other specified person or body,

(f) the times within which the various stages of the procedure for the making of the proposed instrument are to be completed.

5. Planning Proposal exhibited for public comment.
6. Planning Proposal reviewed following public submissions and submissions from relevant State and Commonwealth authorities.
7. Final Local Environmental Plan with proposed amendments drafted.
8. Amending Local Environmental Plan made by the Minister and gazetted.

3.5.2 Voluntary Purchase of Residential Properties

Removal of housing from high hazard floodway areas in the floodplain is generally accepted as a cost-effective means of correcting previous decisions to build in such areas. The Voluntary Purchase (**VP**) of residential property in hazardous areas has been part of subsidised floodplain management programs in NSW for over 20 years. After purchase, land is subsequently cleared and the site re-developed and re-zoned for public open space or some other flood compatible use. A further criterion applied by State Government agencies in assessing eligibility for funding is that the property must be in a high hazard floodway area, that is, in the path of flowing floodwaters where the depth and velocity at the peak of the flood are such that life could be threatened, damage of property is likely and evacuation difficult.

Under a VP scheme the owner is notified that the body controlling the scheme, Council in the present case, is prepared to purchase the property when the owner is ready to sell. There is no compulsion whatsoever to sell at any time. The price is determined by independent valuers and the Valuer General, and by negotiation between Council and the owners. Valuations are not reduced due to the flood affected nature of the site.

By inspection of **Figure 2.15** there are no existing dwellings that are located in high hazard floodway areas. As a result, none of the 48 dwellings that the *Flood Study* identified would experience above-floor inundation in a 1% AEP flood would quality for inclusion in a VP scheme.

3.5.3 Raising Floor Levels of Residential Properties

The term “house raising” refers to procedures undertaken, usually on a property by property basis, to protect structures from damage by floodwaters. The most common process is to raise the affected house by a convenient amount so that the floor level is at or above the minimum floor level. For weatherboard and similar buildings this can be achieved by jacking up the house, constructing new supports, stairways and balconies and reconnecting services. Alternatively, where the house contains high ceilings, floor levels can be raised within rooms without actually

raising the house. It is usually not practical to raise brick or masonry houses. Most of the costs associated with this measure relate to the disconnection and reconnection of services. Accordingly, houses may be raised a considerable elevation without incurring large incremental costs.

State and Federal Governments have agreed that flood mitigation funds will be available for house raising, subject to the same economic evaluation and subsidy arrangements that apply to other structural and non-structural flood mitigation measures. In accepting schemes for eligibility, the Government has laid down the following conditions:

- House raising should be part of the adopted *FRMP*.
- The scheme should be administered by the local authority.

The Government also requires that councils carry out ongoing monitoring in areas where subsidised voluntary house raising has occurred to ensure that redevelopment does not occur to re-establish habitable areas below the design floor level. In addition, it is expected that councils will provide documentation during the conveyancing process so that subsequent owners are made aware of restrictions on development below the design floor level.

Council's principal role in subsidised voluntary house raising would be to:

- Define a habitable floor level, which it will have already done in exercising controls over new house building in the area.
- Guarantee a payment to the builder after satisfactory completion of the agreed work.
- Monitor the area of voluntary house raising to ensure that redevelopment does not occur to re-establish habitable areas below the design floor level.

The current cost to raise a medium sized (150 m^2) house is about $100,000 based on recent experience in other centres.

Of the 48 dwellings that would experience above-floor inundation at the 1% AEP flood event, all but eight are affected by overland flow. Given the relatively shallow, slow moving and short duration nature of the above-floor flooding that arises as a result of overland flow, adoption of a house raising scheme for the 40 affected properties cannot be justified on both social and economic grounds. While the remaining eight properties are located on the western side of Byrnes Creek and appear to be subject to longer duration flooding, they are all of brick veneer type construction and therefore could not be raised. Based on this finding, a voluntary house raising scheme is not recommended for the study area.

3.6 Response Modification Measures

3.6.1 Improvements to Flood Warning System

Improvements to the flood warning and response procedures were strongly favoured by the community during the consultation process. An effective flood warning system has three key components, i.e. a flood forecasting system, a flood warning broadcast system and a response/evacuation plan. All systems need to be underpinned by an appropriate public flood awareness program.

As mentioned in **Section 2.16**, BoM currently operates a well-established and proven flood warning system which provides advance warning of potential flood producing storms in the Hawkesbury Nepean Valley. BoM's flood warning system also provides information on predicted flood levels on the Hawkesbury Nepean River. While this service provides both a means of forecasting and flood warning to NSW SES and other management authorities, as well as residents, it is important that 'flood watches' issued by BoM are relayed to residents via radio, TV, social media and other mediums.

As also mentioned in **Section 2.16**, BoM's flood warning system and NSW SES's planning documents are principally aimed at managing the flood risk associated with Hawkesbury Nepean River Flooding and therefore do not provide specific advice on dealing with the flood risk associated with South Creek and Local Catchment Flooding in the study area. To improve flood response in in the study area it is therefore recommended that:

a) The *Penrith City Local Flood Plan* be updated (see **Section 3.6.2**) to provide the most up to date information on the nature of flooding in in the study area.

b) A telemetered stream gauge be installed on the upstream side of Great Western Highway Bridge and trigger levels set which are linked to a loud speaker system which warns residents and business owners located behind the St Marys Levee of rising water levels in South Creek.

c) A *Flood Intelligence Card* be prepared by NSW SES which is linked to the telemetered stream gauge. The information contained on the *Flood Intelligence Card* could be derived from the findings of the present study, as well as Worley Parsons, 2015.

d) Ongoing consultation with residents and business owners that are located behind the St Marys Levee to ensure they are aware of the existing flood risk and the need to respond to announcements made by the loudspeaker system. Consideration should also be given to linking the trigger levels to the dissemination of flood warnings via SMS on the newly installed stream gauge to mobile phones.

3.6.2 Improved Emergency Planning and Response

As mentioned in **Section 2.16**, the *Penrith City Local Flood Plan* provides detailed information regarding preparedness measures, conduct of response operations and coordination of immediate recovery measures for all levels of flooding.

NSW SES should ensure information contained in this report on the impacts of flooding on urban development, as well as recommendations regarding flood warning and community education are used to update the *Penrith City Local Flood Plan*. A separate annexure should be incorporated in the *Penrith City Local Flood Plan* which includes the following sections:

1 – The Flood Threat includes the following sub-sections:

1.1 Land Forms and River Systems – ref. **Sections 2.1** and **2.2** of the report for information on these topics.

1.4 Characteristics of Flooding – Indicative extents of inundation for the 1% AEP event and the typical times of rise of floodwaters at key locations along the main arm of Byrnes Creek for Local Catchment Flooding were assessed (**Figures 2.4**, **2.8** and **2.10**). **Table 2.4** summarises the impact flooding has on vulnerable development and critical infrastructure in the study area. The location of critical infrastructure relative to the flood extents is shown on the report figures.

1.5 Flood History – Recent flood experience in the study area is discussed in **Section 2.3**, while several plates showing the flooding that was experienced at the western end of Putland Street in June 2016 as a result of backwater flooding from South Creek are contained in **Appendix B** of the report.

1.6 Flood Mitigation Systems – Details of the St Marys Levee, as well as the basin arrangements in Monfarville Reserve and Bennett Park are contained in **Section 2.7** of the report.

1.7 Extreme Flood Events – The nature of flooding arising from a PMF was assessed and the indicative extent and depth of inundation associated with Local Catchment, South Creek and Hawkesbury-Nepean River flooding is presented on **Figures 2.6**, **2.9** and **2.10**.

2 – Effects on the Community

Figure 2.11 shows stage hydrographs at locations along the main arm of Byrnes Creek. The figure contains information such as the assessed minimum road level, times to peak flood levels, times to overtopping of the road crossing, and maximum depth of inundation resulting from Local Catchment Flooding.

The report figures shows the location of vulnerable development and critical infrastructure relative to the depth and extent of inundation resulting from Local Catchment, South Creek and Hawkesbury Nepean River flooding. Refer **Section 2.5** and **Table 2.4** for details of affected development and infrastructure.

Figures 3.5 and **3.6** show the flood emergency response planning classifications for the 1% AEP and PMF events, respectively, based on the definitions set out in the *Floodplain Risk Management Guideline – Flood Emergency Response Classification of Communities* (DECC, 2007).

3.6.3 Public Awareness Programs

Community awareness and appreciation of the existing flood hazards in the floodplain would promote proper land use and development in flood affected areas. A well informed community would be more receptive to requirements for flood proofing of buildings and general building and development controls imposed by Council. Council should also take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplains of the flood risk.

One aspect of a community's preparedness for flooding is the "flood awareness" of individuals. This includes awareness of the flood threat in their area and how to protect themselves against it. The overall level of flood awareness within the community tends to reduce with time, as memories fade and as residents move into and out of the floodplain. The improvements to flood warning arrangements described above, as well as the process of disseminating this information to the community, would represent a major opportunity for increasing flood awareness in St Marys, especially for those people that are located behind the St Marys Levee.

Means by which community awareness of flood risks can be maintained or may be increased include:

- displays at Council offices using the information contained in the present study and photographs of historic flooding in the area; and

- talks by NSW SES officers with participation by Council and longstanding residents with first-hand experience of flooding in the area.
- preparation of a *Flood Information Brochure* which could be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with rate notices.

The community should also be made aware that a flood greater than historic levels or the planning level can, and will, occur at some time in the future.

4 SELECTION OF FLOODPLAIN MANAGEMENT MEASURES

4.1 Background

NSWG, 2005 requires a Council to develop a *FRMP* based on balancing the merits of social, environmental and economic considerations which are relevant to the community. This chapter sets out a range of factors which need to be taken into consideration when selecting the mix of works and measures that should be included in the *FRMP*.

The community will have different priorities and, therefore, each needs to establish its own set of considerations used to assess the merits of different measures. The considerations adopted by a community must, however, recognise the State Government's requirements for floodplain management as set out in NSWG, 2005 and other relevant policies. A further consideration is that some elements of the *FRMP* may be eligible for subsidy from State and Federal Government sources and the requirements for such funding must, therefore, be taken into account.

Typically, State and Federal Government funding is given on the basis of merit, as judged by a range of criteria:

- The magnitude of damage to property caused by flooding and the effectiveness of the measure in mitigating damage and reducing the flood risk to the community.
- Community involvement in the preparation of the *FRMP* and acceptance of the measure.
- The technical feasibility of the measure (relevant to structural works).
- Conformance of the measure with Council's planning objectives.
- Impacts of the measure on the environment.
- The economic justification, as measured by the benefit/cost ratio of the measure.
- The financial feasibility as gauged by Council's ability to meet its commitment to fund its part of the cost.
- The performance of the measure in the event of a flood greater than the design event.
- Conformance of the measure with Government Policies (e.g. NSWG, 2005 and Catchment Management objectives).

4.2 Ranking of Measures

A suggested approach to assessing the merits of various measures is to use a subjective scoring system. The chief merits of such a system are that it allows comparisons to be made between alternatives using a common "currency". In addition, it makes the assessment of alternatives "transparent" (i.e. all important factors are included in the analysis). The system does not, however, provide an absolute "right" answer as to what should be included in the *FRMP* and what should be left out. Rather, it provides a method by which Council can re-examine the measures and if necessary, debate the relative scoring given to aspects of the *FRMP*.

Each measure is given a score according to how well the measure meets the considerations discussed above. In order to keep the scoring simple, the following system is proposed:

+2 Measure rates very highly

+1 Measure rates well

0 Measure is neutral

- 1 Measure rates poorly

- 2 Measure rates very poorly

The scores are added to get a total for each measure.

Based on considerations outlined in this chapter, **Table 4.1** presents a suggested scoring matrix for the measures reviewed in **Chapter 3**. This scoring has been used as the basis for prioritising the components of the *FRMP*.

4.3 Summary

Table 4.1 indicates that there are good reasons to consider including the following elements into the draft *FRMP*:

- Improved planning controls through the update of *Penrith DCP 2014*
- An update of the *Penrith LEP 2010* to allow better management of the floodplain
- Incorporation of the catchment specific information on flooding impacts contained in this Study in NSW SES Response Planning and Flood Awareness documentation for the study area.
- Improvements to the Flood Warning System for the St Marys area, including the installation of a telemetered stream gauge on the upstream side of the Great Western Highway bridge crossing of South Creek.
- Improved public awareness of flood risk in the community.
- Investigate the upgrade requirements for the St Marys Levee as part of the South Creek FRMS&P
- Upgrade of existing stormwater drainage system in Mamre Road between Ellis Street and Saddington Street (Stormwater Drainage Upgrade Scheme 5A and 5B)
- Construct a new detention basin on western side of Collins Street (Stormwater Drainage Upgrade Scheme 6)
- Increase temporary flood storage area in Cook Park
- Raise the embankment of Basin BA04 in Monfarville Reserve
- Construct three debris control structures on the inlet of major hydraulic structures along the main arm of Byrnes Creek

TABLE 4.1
ASSESSMENT OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR INCLUSION IN THE ST MARYS (BYRNES CREEK) FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Impact on Flooding/ Reduction in Flood Risk	Community Acceptance	Technical Feasibility	Planning Objectives	Environ. Impacts	Economic Justification	Financial Feasibility	Extreme Flood	Government Policies and TCM Objectives	Score
Flood Modification										
Investigate the upgrade requirements for the St Marys Levee as part of the *South Creek FRMS&P*	+2	+2	+2	+2	0	+2	0	+1	+1	+12
Stormwater Drainage Upgrade Scheme 1	+1	+2	+1	0	+1	-2	-2	0	0	+1
Stormwater Drainage Upgrade Scheme 2	+1	+2	+1	0	+1	-2	-2	0	0	+1
Stormwater Drainage Upgrade Scheme 3	+1	+2	+1	0	+1	-2	-2	0	0	+1
Stormwater Drainage Upgrade Scheme 4A	-2	+2	+2	-2	0	-2	0	0	-2	-4
Stormwater Drainage Upgrade Scheme 4B	+2	+2	+2	+2	+1	-2	-2	0	0	+5
Stormwater Drainage Upgrade Scheme 5A	+2	+2	+1	+1	+1	-1	-1	0	+1	+6
Stormwater Drainage Upgrade Scheme 5B	+2	+2	+2	+1	+1	-1	-1	0	+1	+7
Stormwater Drainage Upgrade Scheme 6	+2	+2	+2	+1	+1	0	-1	0	+1	+7
Stormwater Drainage Upgrade Scheme 7	+2	+2	+1	+2	+1	-2	-2	0	+1	+5
Stormwater Drainage Upgrade Scheme 8	+2	+2	+1	0	0	-2	-2	0	0	+1
Increase temporary flood storage area in Cook Park	+2	+2	+2	+1	+1	-1	-1	0	+2	+8
Upgrade of Basin BA04 embankment in Monfarville Reserve	+2	+1	+2	+1	0	+1	-1	0	+1	+7
Construction of three debris control structures on the inlet of major hydraulic structures along the main arm of Byrnes Creek	+1	+1	+2	0	0	+1	0	0	+1	+6

Cont'd Over

TABLE 4.1 (Cont'd)
ASSESSMENT OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR INCLUSION IN THE ST MARYS (BYRNES CREEK) FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Impact on Flooding/ Reduction in Flood Risk	Community Acceptance	Technical Feasibility	Planning Objectives	Environ. Impacts	Economic Justification	Financial Feasibility	Extreme Flood	Government Policies and TCM Objectives	Score
Property Modification										
Controls over Future Development (via update of *Penrith LEP 2010* and *Penrith DCP 2014*)	+2	+2	+2	+2	0	0	0	+1	+2	+11
Response Modification										
Improvements to Flood Warning System	+2	+2	+2	+1	0	0	0	+2	+2	+11
Improved Emergency Planning and Response	+2	+2	+2	+1	0	0	0	+2	+2	+11
Public Awareness Programs	+1	+2	+2	+1	0	0	0	+1	+2	+9

5 ST MARYS (BYRNES CREEK) FLOODPLAIN RISK MANAGEMENT PLAN

5.1 The Floodplain Risk Management Process

The *Floodplain Risk Management Study (**FRMS**)* and draft *Floodplain Risk Management Plan* (***FRMP***) have been prepared for the lower portion of the Byrnes Creek catchment at St Marys (**study area**) as part of a Government program to mitigate the impacts of major floods and reduce the hazards in the floodplain. The *FRMP* which is set out in this Chapter has been prepared as part of the Floodplain Risk Management Process in accordance with NSW Government's Flood Prone Land Policy.

The first steps in the process of preparing the *FRMP* were the collection of flood data and the review of the *St Marys (Byrnes Creek) Catchment Detailed Overland Flow Flood Study* (***Flood Study***). The *Flood Study* was the formal starting process of defining management measures for flood liable land and represented a detailed technical investigation of flood behaviour for the study area.

5.2 Purpose of the Plan

The overall objectives of the *FRMS* were to assess the impacts of flooding, review policies and measures for management of flood affected land and to develop a *FRMP* which:

- Sets out the recommended program of works and measures aimed at reducing over time, the social, environmental and economic impacts of flooding and establishes a program and funding mechanism for the *FRMP*.
- Proposes amendments to Penrith City Council's (**Council's**) existing policies to ensure that the future development of flood affected land in the study area is undertaken so as to be compatible with the flood hazard and risk.
- Ensures the *FRMP* is consistent with NSW SES's local emergency response planning procedures.
- Ensures that the *FRMP* has the support of the community.

5.3 The Study Area

The study area for this *FRMP* comprises the lower portion of the Byrnes Creek catchment and is bounded by the Western Railway Line to the north, an existing flood protection levee (denoted herein as the ***St Marys Levee***) and the main arm of South Creek to the west, the M4 Motorway to the south and residential development to the east. The *FRMP* applies in areas affected by the three flood producing mechanisms that occur in parts of the study area: ***Hawkesbury-Nepean River Flooding*** which occurs when floodwater backs up South Creek from near Windsor, ***South Creek Flooding*** which occurs when flows exceed the capacity of the main channel and either back up behind the St Marys Levee or surcharge its crest, and ***Local Catchment Flooding*** which occurs when heavy rain falling over the Byrnes Creek catchment causes the surcharge of the local stormwater drainage system.

5.4 Community Consultation

The Community Consultation process provided valuable direction over the course of the investigations, bringing together views from key Council staff, other departments and agencies, and importantly, the views of the community gained through:

- the delivery of a *Community Information Sheet* and *Questionnaire* to property occupiers in the study area which allowed the wider community to gain an understanding of the issues being addressed as part of the study; and
- meetings of the Floodplain Risk Management Committee to discuss results as they became available.

5.5 Existing Flooding Behaviour

Parts of the study area are impacted by the following three mechanisms of flooding:

- **Local Catchment Flooding** resulting from the surcharge of Byrnes Creek and the existing stormwater drainage system. Several major overland flow paths develop in the urbanised parts of the study area due to local catchment flooding. Flooding of this type is of a "flash flooding" nature, with water levels typically rising to their peak in less than two hours. Flows on the major overland flow paths would typically be less than 500 mm deep, travelling over the surface at velocities generally less than 1 m/s.
- **South Creek Flooding** resulting from flow that backs up the Great Western Highway culvert from South Creek during the rising limb of frequent to major flood events. Flooding of this type is relatively slow rising in nature, with little to no velocity associated with the flow. During rare to extreme flood events, floodwater would also overtop the St Marys Levee, where it would impact existing development which lies outside the backwater zone.
- **Hawkesbury-Nepean River Flooding** resulting from flow that backs up South Creek from the Hawkesbury Nepean River. Flooding of this type is slow rising in nature, with little to no velocity associated with the flow. Floodwater would commence to back up through the box culvert that is located under the Great Western Highway and commence to inundate the area which lies behind the St Marys Levee during a Hawkesbury Nepean Flood with an AEP of about 0.2 per cent.

The present study found that a number of stormwater drainage pipes in the study area have a capacity of less than 1 EY which results in several properties being inundated by major overland flow on a relatively frequent basis.

Figures 2.4 to **2.10** show the depth and extent of Local Catchment, South Creek and Hawkesbury-Nepean River flooding in the study area for the 1% AEP and PMF events. While floodwater from South Creek backs up behind the St Marys Levee along the main arm of Byrnes Creek during relatively frequent flood events, the inundation of existing development is limited to several older-style unit developments that are located at the western end of Putland Street, as well as several dwellings that are located directly behind the earth embankment. The plates contained in **Appendix B** of the *FRMS* report show the backwater flooding that was experienced at the western end of Putland Street on 6 June 2016.

The 1% AEP design flood which has been adopted as the "planning flood" for the purposes of specifying flood related controls over future development. The extent of flooding is indicative only, being based on modified versions of the hydrologic and hydraulic models that were originally developed both as part of the *Flood Study*.

5.6 Existing Flood Mitigation Measures

Existing flood mitigation measures in the study area comprise the St Marys Levee which is aimed at protecting existing development from South Creek Flooding, a series of four detention basins in Monfarville Reserve which are aimed at protecting existing development that is located by the St Marys Levee from Local Catchment Flooding and a detention basin in Bennett Park which is aimed at protecting several commercial properties that are located to the north of the Great Western Highway from Local Catchment Flooding.

The present study identified that the available freeboard to the crest of the St Marys Levee is less than 0.5 m in a 1% AEP flood event (refer Figure 2.12), and that its design standard is likely to be about 5% AEP. This finding has implications in regards the setting of flood related planning controls for future development that is located behind the St Marys Levee, as until such time as the required freeboard is incorporated into the St Marys Levee, then controls should be linked to peak flood levels on the western (i.e. South Creek) side of the levee, rather than the peak 1% AEP backwater flood level of RL 24.4 m AHD which is current practice.

5.7 Economic Impacts of Flooding

Table 5.1 shows the number of properties that would be flooded to above-floor level and the damages experienced in residential and commercial development in the study area. Of the 48 dwellings that would experience above-floor inundation during a 1% AEP flood event, all but eight are located to the east of Byrnes Creek and are impacted by relatively shallow and slow moving major overland flow.

TABLE 5.1
ECONOMIC IMPACTS OF FLOODING IN STUDY AREA

Design Flood Event (% AEP)	Properties Flooded Above-Floor Level				Total Flood Damages
	Residential		Commercial/Industrial		
	No.	$ Million	No.	$ Million	$ Million
1 EY	10	0.73	0	0.00	0.73
50	14	1.00	0	0.00	1.00
20	25	1.75	0	0.00	1.75
10	32	2.07	21	1.31	3.38
5	36	2.44	24	1.55	3.99
2	41	2.80	25	1.70	4.50
1	48	3.19	26	1.86	5.05
0.5	52	3.44	27	2.08	5.52
PMF	216	14.99	76	8.38	23.37

5.8 Structure of St Marys Floodplain Risk Management Plan

A summary of the *FRMP* proposed for the study area along with broad funding requirements for the recommended measures are shown in **Table S1** at the commencement of the *FRMS* report. These measures comprise preparation of planning documentation by Council, improvements to the flood warning system and community education on flooding by Council and NSW SES to improve flood awareness and response, as well as the investigation and design of a number of flood modification measures. The measures will over time achieve the objectives of reducing the flood risk to existing and future development for the full range of floods.

The *FRMP* is based on the following mix of measures which have been given a provisional priority ranking according to a range of economic, social, environmental and other criteria set out in **Table 4.1** of the report:

- **Measure 1** – Improvements to planning and development controls for future development in flood prone areas
- **Measure 2** – Update wording in *Penrith LEP 2010*
- **Measure 3** – Improvements to emergency response planning
- **Measure 4** – Increase public awareness of the risks of flooding in the community
- **Measure 5** – Installation of an automated water level alert system
- **Measure 6** – Investigation upgrade requirements for the St Marys Levee as part of the *South Creek FRMS&P*
- **Measure 7** – Undertake feasibility study and prepare concept design of stormwater drainage system upgrade in Mamre Road between Ellis Street and Saddington Street (either Stormwater Drainage Upgrade Scheme 5A or 5B)
- **Measure 8** – Design and construct stormwater drainage system upgrade in Mamre Road between Ellis Street and Saddington Street (either Stormwater Drainage Upgrade Scheme 5A or 5B)
- **Measure 9** – Undertake feasibility study and prepare concept design of new detention basin in reserve located on western side of Collins Street (Stormwater Drainage Upgrade Scheme 6)
- **Measure 10** – Design and construct new detention basin in reserve located on western side of Collins Street (Stormwater Drainage Upgrade Scheme 6)
- **Measure 11** – Undertake feasibility study and prepare concept design of flood mitigation works in Cook Park
- **Measure 12** – Design and construct flood mitigation works along main arm of Byrnes Creek in Cook Park
- **Measure 13** – Design and construct Basin BA04 embankment upgrade in Monfarville Reserve
- **Measure 14** – Design and construct three debris control structures on the inlet of major hydraulic structures located along the main arm of Byrnes Creek

5.9 Planning and Development Controls

The results of the *FRMS* indicate that an important measure (**Measure 1**) for Council to adopt in the floodplain would be strong floodplain management planning applied consistently by all branches of Council.

5.10 Flood Policy

The approach to managing future development in the study area uses the concepts of *flood hazard* and *hydraulic categorisation* outlined in **Section 2.9** of the report based on the envelope of the three mechanisms of flooding that are described in **Section 5.5**.

To implement the recommended approach set out in the *FRMS&P*, clause 7.2 of *Penrith LEP 2010* would require minor amendment. A new clause aimed at addressing potential flood evacuation issues in parts of the study area would also need to be inserted into *Penrith LEP 2010* (ref. **Section 5.11** below).

Figure 3.2 is an extract from the *Flood Planning Map* relating to the study area. The extent of the Flood Planning Area (**FPA**) (the area subject to flood related development controls) is shown in a solid red colour on the *Flood Planning Map* and has been defined as land which lies below the 1% AEP plus 500 mm freeboard.

Properties that are intersected by the extent of the FPA would be subject to S10.7 flood affectation notification and planning controls graded according to flood hazard. A graded set of flood related planning controls would apply to future development depending on where it is located in the study area (identified as ***St Marys (Byrnes Creek) Flood Related Development Control Area 1*** and ***St Marys (Byrnes Creek) Flood Related Development Control Area 2*** on **Figure 3.3**).

Minimum floor level requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The minimum floor levels for all land use types is the level of the 1% AEP flood event plus 500 mm freeboard.

As shown on **Figure 3.4**, the floodplain has been divided into the following four categories in *St Marys (Byrnes Creek) Flood Related Development Control Area 1*:

- The **Inner Floodplain (Hazard Category 1)** zone (shown as a solid red colour) comprises areas where factors such as the depth and velocity of flow, time of rise, isolation on Low Flood Islands and evacuation problems mean that the land is unsuitable for most types of development. It principally comprises High and Low Hazard Floodway areas. Erection of buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.
- The **Inner Floodplain (Hazard Category 2)** zone (shown as a solid yellow colour) comprises Low Hazard Floodway areas, where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow toward adjacent properties. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.

- The **Intermediate Floodplain** zone (shown as a solid blue colour) is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA. Within this zone, there would only be the requirement for minimum floor levels to be set at the 1% AEP flood levels plus 500 mm. While land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan, Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development are not permitted in this zone.
- The **Outer Floodplain** zone is the area outside the Intermediate Floodplain where the depth of inundation will exceed 150 mm in the PMF (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply.

The floodplain has also been divided into the following two additional categories in *St Marys (Byrnes Creek) Flood Related Development Control Area 2*:

- **High Hazard Floodway**, which is shown in solid orange colour. Future development in this area is not permitted under the *Flood Policy*.
- **Low Hazard Floodway / Flood Fringe**, which is shown in solid green colour. Residential, commercial and industrial type development can occur in this zone subject to compliance with a prescribed set of flood related development controls.

The **Intermediate Floodplain** zone in areas subject to overland flow is the remaining land lying outside the extent of the Floodway and Flood Fringe areas, but within the FPA, while the **Outer Floodplain** zone represents the area outside the aforementioned zones where the depth of inundation will exceed 150 mm during the PMF.[11] Flood related planning controls in these two areas are similar to those that apply to development in areas subject to Local Catchment Flooding along the main arm of Byrnes Creek and South Creek Flooding, with the following exception:

- the potential for Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential type development to take place in both the **Intermediate Floodplain** and **Outer Floodplain** zones subject to compliance with a specified set of flood related development controls.

It needs to be noted that the flood mapping shown on **Figures 3.2**, **3.3** and **3.4** has been derived assuming that the St Marys Levee has a design standard of 1% AEP, which based on the findings of the present study is not the case. Prior to the adoption of the approach set out in this report it will be necessary for Council to raise the crest height of the St Marys Levee so that it incorporates the necessary freeboard to protect against a 1% AEP South Creek flood.

5.11 Revision to Penrith LEP 2010

Measure 2 recommends that the wording in the *Penrith LEP 2010* concerning flood planning be updated. Clause 7.2 of *Penrith LEP 2010* entitled “Flood planning” outlines its objectives in regard to development of flood prone land. It is similar to the standard Flood Planning Clause used in recently adopted LEPs in other NSW country centres and applies to land beneath the Flood Planning Level (**FPL**). The FPL referred to is the 1% AEP flood plus an allowance for

[11] The extent of the Intermediate Floodplain zone has been trimmed to the extent of the Outer Floodplain zone where the PMF level is less than 500 mm above the corresponding peak 1% AEP flood level.

freeboard of 500 mm. The area encompassed by the FPL is known as the FPA and denotes the area subject to flood related development controls, such as locating development outside high hazard areas and setting minimum floor levels for future residential development.

To improve the approach to floodplain risk management in the Penrith LGA, clause 7.2 of *Penrith LEP 2010* would require minor amendment. Suggested amendments are given in **Section 3.5.1.4**. It is also recommended that a new floodplain risk management clause be included in *Penrith LEP 2010*. The objectives of the new clause are as follows:

- in relation to development with particular evacuation or emergency response issues (e.g. group homes, residential care facilities, etc.) to enable evacuation of land subject to flooding in events exceeding the flood planning level; and
- to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

The new clause would apply to land identified as Outer Floodplain (i.e. land which lies between the FPA and the extent of the PMF). Suggested wording in relation to this new clause is given in **Section 3.5.1.4**.

5.12 Improvements to Flood Warning, Emergency Response Planning and Community Awareness

Three measures are proposed in the *FRMP* to improve flood warning, emergency response planning and community awareness to the threat posed by flooding.

Measure 3 involves the update by NSW SES of the *Penrith City Local Flood Plan* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in this report. Figures have been prepared showing indicative extents of flooding, high hazard areas, expected rates of rise of floodwaters in key areas and locations where flooding problems would be expected. **Section 3.6.2** references the locations of key data within this report.

Council should also take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplains of the flood risk (included as **Measure 4** of the *FRMP*). This information could be included in a *Flood Information Brochure* to be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with the rate notices. The community should also be made aware that a flood greater than historic levels or the planning level can, and will, occur at some time in the future. The *FRMP* should be publicised and exhibited at community gathering places to make residents aware of the measures being proposed.

Measure 5 involves improvements to the existing Flood Warning System for South Creek through the installation of a telemetered stream gauge on the upstream side of the Great Western Highway bridge crossing. A *Flood Intelligence Card* should also be prepared by NSW SES which is linked to the telemetered stream gauge. The information contained on the *Flood Intelligence Card* could be derived from the findings of the present study, as well as Worley Parsons, 2015.

5.13 Flood Modification Works

The present study identified that the earthen section of the St Marys Levee has a freeboard of less than 0.5 m to the peak 1% AEP flood on South Creek. Worley Parsons, 2015 also showed that a partial blockage of the Great Western Highway bridge crossing of South Creek has the potential to increase peak flood levels along the levee by a maximum of about 0.38 m. It is recommended that the *South Creek Floodplain Risk Management Study and Plan* investigate the upgrade requirements for the St Marys Levee in order that its design standard be increased to a 1% AEP flood on South Creek (included as **Measure 6** in the *FRMP*).

Measure 7 comprises an investigation to assess the feasibility of constructing a new stormwater drainage line from the sag that is located in Mamre Road between its intersection with Saddington Street and Ellis Street to the main arm of Byrnes Creek (denoted Stormwater Drainage Upgrade Scheme 5A and 5B). Two alternative routes for the new drainage line are to be assessed given the Ellis Street option would require the pipeline to be installed in a relatively deep trench, while the Saddington Street option is at greater risk of conflicting with existing utilities and would result in major disruption to westbound traffic. This measure also includes the preparation of a concept design of the preferred alignment. **Measure 8** comprises the detailed design and construction of either Stormwater Drainage Upgrade Scheme 5A or 5B.

Measure 9 comprises an investigation to assess the feasibility of constructing a detention basin in the reserve which is located on the western side of Collins Street between its intersection with Lonsdale Street and Mitchell Street (denoted Stormwater Drainage Upgrade Scheme 6), as well as the preparation of a concept design for the basin works. **Measure 10** comprises the detailed design and construction of Stormwater Drainage Upgrade Scheme 6.

Measure 11 comprises an investigation to assess the feasibility of enlarging the temporary flood storage area in Cook Park immediately upstream of Saddington Street. This measure also includes the preparation of a concept design of the storage enlargement works. **Measure 12** comprises the detailed design and construction of the works in Cook Park.

Measure 13 comprises the detailed design and construction of the upgrade to the earth embankment associated with Basin BA04 in Monfarville Reserve which is required to provide a 0.5 m freeboard to the peak 1% AEP flood level.

Measure 14 comprises the design and installation of debris control structures at the following three locations:

- adjacent to the inlet of four cell 1500 mm diameter pipes which control flow discharging from detention basin BA04,
- adjacent to the inlet of the twin cell 1650 mm dimeter pipes extending downstream of Saddington Street in Cook Park; and
- upstream of the box culvert under the Great Western Highway near the western end of Putland Street.

5.14 Mitigating Effects of Future Development

As future infill development within the study area has the potential to increase peak flows in the existing drainage system and thereby exacerbate flooding in existing development, it is important that Council continue to inforce the requirements set out in *Penrith DCP 2014* in relation to the control of stormwater runoff from new developments.

5.15 Implementation Program

The steps in progressing the floodplain management process from this point onwards are:

1. Floodplain Risk Management Committee to consider and adopt recommendations of this study. In particular, the Committee should review the basis for ranking floodplain management measures (as set out in **Table 4.1** of the *FRMS* and the proposed works and measures to be included in the *FRMP* as set out in **Table S1**); exhibit the *draft FRMS* and *FRMP* and seek community comment.
2. Consider public comment, modify the document if and as required, and submit to Council.
3. Council adopts the *FRMP* and submits an application for funding assistance. Assistance for funding qualifying projects included in the *FRMP* may be available upon application under the Commonwealth and State funded floodplain management programs currently administered by the NSW Office of Environment and Heritage.
4. Assistance for funding qualifying projects included in the *FRMP* may be available upon application under the Commonwealth and State funded floodplain management programs, currently administered by NSW Office of Environment and Heritage.
5. As funds become available from Government agencies and/or Council's own resources, implement the measures in accordance with the established priorities.

The *FRMP* should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding, reviews of Council's planning strategies and importantly, the outcome of some of the studies proposed in this report as part of the *FRMP*. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the *FRMP*.

6 GLOSSARY OF TERMS

Note: For expanded list of definitions, refer to Glossary contained within the NSW Government Floodplain Development Manual, 2005.

TERM	DEFINITION
Average Exceedance probability (AEP)	The average exceedance probability of a flood represents the percentage chance of its being equalled or exceeded in any one year. Thus a 1% AEP flood has a 1% chance of being equalled or exceeded in any one year and would be experienced, on the average, once in 100 years.
Australian Height Datum (AHD)	A common national surface level datum corresponding approximately to mean sea level.
Flood Affected Properties	Properties that are either encompassed or intersected by the Flood Planning Area.
Floodplain	Area of land which is subject to inundation by floods up to and including the Probable Maximum Flood (**PMF**) event, that is, flood prone land.
Flood Planning Area	The area of land that is shown to be in the Flood Planning Area on the *Flood Planning Map*. The Flood Planning Area is the area of land which lies below the Flood Planning Level.
Flood Planning Map	The *Flood Planning Map* referred to in the *Penrith Local Environmental Plan 2010*, an extract of which is shown on **Figure 3.2**.
Flood Planning Level (FPL)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans. For the St Marys (Byrnes Creek) study area, the FPL is the 1% AEP flood level plus a 500 mm allowance for freeboard.
Flood Prone/Flood Liable Land	Land susceptible to flooding by the PMF. Flood Prone land is synonymous with Flood Liable land.
Floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding a particular flood chosen as the basis for the FPL and setting minimum floor level requirements is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the derivation of the FPL and the setting of minimum floor level requirements.
Habitable Room	In a residential situation: a living or working area, such as a lounge room, dining room, kitchen, bedroom or workroom. In an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.

TERM	DEFINITION
Hawkesbury Nepean River Flooding	Resulting from flow that backs up South Creek from the Hawkesbury Nepean River. Flooding of this type is slow rising in nature, with little to no velocity associated with the flow. Floodwater would commence to back up through the box culvert that is located under the Great Western Highway and commence to inundate the area which lies behind the St Marys Levee during a Hawkesbury Nepean Flood with an AEP of about 0.2 per cent.
Inner Floodplain (Hazard Category 1)	Comprises areas where factors such as the depth and velocity of flow, time of rise, isolation and evacuation difficulties mean that the land is unsuitable for future development. It includes areas of High and Low Hazard Floodway, Flood Storage, Flood Fringe, Intermediate Floodplain and Outer Floodplain areas. It also includes land which may become isolated during a flood event. Future development is not permitted in this zone.
Inner Floodplain (Hazard Category 2)	Comprises areas of Low Hazard Floodway and Flood Storage areas where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow towards adjacent properties. It also includes land which may become isolated during a flood event. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
Intermediate Floodplain	It is the area of land which lies at or below the 1% AEP flood level plus 500 mm freeboard and is not classified as Inner Floodplain (Hazard Category 1), Inner Floodplain (Hazard Category 2) or Low Hazard Floodway / Flood Storage.
Local Catchment Flooding	Results from the surcharge of Byrnes Creek and the existing stormwater drainage system. Several major overland flow paths develop in the urbanised parts of the study area due to local catchment flooding. Flooding of this type is of a “flash flooding” nature, with water levels typically rising to their peak in less than two hours. Flows on the major overland flow paths would typically be less than 500 mm deep, travelling over the surface at velocities less than 1 m/s.
Local Drainage	Land on an overland flow path where the depth of inundation during the 1% AEP storm event is less than 150 mm.
Major Overland Flow	Where the depth of overland flow during the 1% AEP storm event is greater than 150 mm.
Minimum Floor Level	The combinations of flood levels and freeboards selected for setting the minimum floor levels of future development located in properties subject to flood related planning controls.
Outer Floodplain	This is defined as the land between the FPA and the extent of the PMF event.

TERM	DEFINITION
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. For the study area, the extent of the PMF has been trimmed to include depths greater than 100 mm.
South Creek Flooding	Resulting from flow that backs up the Great Western Highway culvert from South Creek during the rising limb of frequent to major flood events. Flooding of this type is relatively slow rising in nature, with little to no velocity associated with the flow. During rare to extreme flood events, floodwater would also overtop the St Marys Levee, where it would impact existing development which lies outside the backwater zone.

7 REFERENCES

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APPENDIX A

COMMUNITY CONSULTATION

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ATTACHMENTS

ATTACHMENT 1 Community Information Flyer and Questionnaire

ATTACHMENT 2 Responses to Community Questionnaire

A1. INTRODUCTION

At the commencement of the *FRMS,* the Consultants prepared a *Community Information Sheet* and a *Community Questionnaire*, both of which were distributed by Council to residents in the Byrnes Creek Catchment (refer to **Attachment 1**). The *Community Information Sheet* and *Community Questionnaire* were also published on Council's website and were made available for download.

The purpose of the *Community Information Sheet* was to introduce the objectives of the study and set the scene on flooding conditions so that the community would be better able to respond to the *Community Questionnair*e and contribute to the study process.

The *Information Flyer* contained the following information:

- A plan showing the extent of the study area, as well as the extent of both the 1% AEP and PMF events as defined in the *Flood Study*.
- A statement of the objectives of the *FRMS&DP*; namely the development of a strategy for reducing the flood risk and minimising the long-term impact of flooding on the community.

The *Community Questionnaire* was structured with the objectives of:

- Determining residents' and business owners' attitudes to controls over future development in flood liable areas.
- Inviting community views on possible flood management options which could be considered for further investigation in the *FRMS* and possible inclusion in the resulting *FRMP*.
- Obtaining feedback on any other flood related issues and concerns which the residents and business owners cared to raise.

This **Appendix** to the *FRMS&P* report discusses the responses to the eight questions that were included in the *Community Questionnaire* and comments made by respondents.

Chapter A2 deals with the residents' and business owners' views on the relative importance of classes of development over which flood-related controls should be imposed by Council and the level of flood-related control that should be implemented. This chapter also considers the type of notification that should be given to potentially flood affected properties.

Chapter A3 discusses the best methods by which the community could provide feedback to the consultants over the course of the study.

Chapter A4 identifies residents' and business owners' views on the suitability of the various measures which could be considered in more detail in the *FRMS&P.*

Chapter A5 summarises the findings of the community consultation process.

A2 RESPONDENT PROFILE AND VIEWS TOWARDS FLOOD RELATED CONTROLS

A2.1 General

While residents were requested to complete the *Community Questionnaire* and return it to Council or the Consultants by 14 February 2017, all responses received after this date were considered as part of the community consultation process. The Consultants received 126 responses in total out of the approximately 3500 letters that had been distributed.

The Consultants have collated the responses, which are shown in graphical format in **Attachment 2**.

A2.2 Respondent Profile

The first three questions of the *Community Questionnaire* canvassed resident information including the type of occupant, length of time at the property and the type of property (e.g. house, unit/flat). Of those who replied, 43 respondents identified as residents while 91 said they owned the property. A further nine responses were property renters, while two were business owners (**Question 1**). Five respondents had lived at the property for less than a year, 17 between 1 to 5 years, 45 for 5 to 20 years and 56 for more than 20 years (**Question 2**). The majority of the respondents occupied a house (75), while some residents lived in townhouses (14) or apartments (26). Six responses were from shops and one response was received from each of the remaining property types, i.e. vacant land, industrial unit, warehouse and community building (**Question 3**).

A2.3 Controls over Development in Flood Prone Areas

The respondents were asked to rank from 1 to 6 the classes of development which they consider should receive protection from flooding (**Question 4**). Rank 1 was the most important and Rank 6 the least.

The classes in decreasing order of importance to respondents, ranged from residential, critical utilities, essential community facilities (e.g. schools, evacuation centres), commercial property, new residential subdivisions and lastly, minor developments or additions.

These results gave a guide to the Consultants as to the appropriate location of future development of the various classes within the floodplain. For example, on the basis of community views, residential development would receive the highest level of protection, followed by critical utilities and essential community facilities.

The respondents were also asked to choose what level of control should be placed by Council on new developments to reduce flood related risk (**Question 5**). The choices included prohibitive measures, restrictive measures and advisory measures. Apart from Council providing no advice at all, respondents were fairly evenly split over the level of control the Council should specify.

Prohibiting all new development on land with any potential to flood received 33 responses while prohibiting development in extremely hazardous locations received 27. Restricting development to reduce the potential flood damage by implementing measures such as minimum floor levels received 34 responses. Advising individuals of the flood risks but allowing development to proceed provided steps were taken to reduce risk received 35 responses whereas providing no advice regarding potential flood risk received 1 response.

Question 6 asked respondents to choose what notifications Council should give to potential flood affected properties. Advising every resident and property owner on a regular basis of known potential flood threat received the highest number of responses (90). Advising only those who enquire to Council about potential flood threat received 26 responses, while advising prospective purchasers of the known potential flood threat received 55 responses. Only one respondent felt that Council should provide no notifications.

A3 INPUT TO THE STUDY AND FEEDBACK FROM THE COMMUNITY

At **Question 7** residents were asked for their view on the best methods of their providing input to the Study and feedback to the Consultants over the course of the investigation. Articles in the local newspaper (72) and communication via Council's website (66) were the two most popular methods. Other options that were popular included communication through the Council's Floodplain Risk Management Committee (34), public meetings (28) and open days/ drop-in days (19). Mail drops (12) and community workshops (10) received the fewest responses from respondents.

A4 POTENTIAL FLOOD MANAGEMENT MEASURES

The respondents were also asked for their opinion on potential flood management measures which could be evaluated in the *FRMS&P* (and if found to be feasible included in the *FRMP*), by ticking a "yes" or "no" to the fourteen potential options identified in **Question 8**.

The options comprised a range of *structural flood management measures* (e.g. management of vegetation along creek corridor; widening and/or concrete lining watercourses; constructing detention basins; improving the stormwater system; and removal of floodplain obstructions), as well as various *non-structural management measures* (e.g. voluntary purchase of residential properties in high hazard areas; raising floor levels of houses in low hazard areas; flood proofing of individual houses; improvements to flood warning and evacuation procedures; community education on flooding; ensuring all residents and business owners have a Flood Action Plan; flood related controls over new developments; provide Planning Certificates to purchasers; and ensuring all flood related information is available to the community). The options were not mutually exclusive, as the *FRMP* adopted could, in theory, include all of the options set out in the Questionnaire, or indeed, other measures to be nominated by the respondents or the FMC.

The most popular *structural measures* were improving the stormwater system to capture and convey overland flows travelling to the creek system more efficiently than at present and management of vegetation along creek corridors to provide flood mitigation, stability, and aesthetic and habitat benefits. The number of responses that disapproved of these measures were only one and two respectively.

Widening of watercourses, detention basin construction and removal of floodplain obstacles were mostly popular but had a larger number of 'Don't Know' responses compared to the most popular options. This suggests further community consultation and/or a better public education and engagement may be required before these options are considered further.

The least popular *non-structural measures* were voluntary purchase of hazardous properties, subsidies for floor raising of flood prone properties and flood proofing of individual properties. These options were similar in that they all received equal levels of approval and disapproval from respondents. Compared to other options, the number of respondents that disapproved of these three options was much higher. Furthermore, these three options all had significant proportions of 'Don't Know' responses.

All *non-structural measures* other than those mentioned above were popular and all had greater than 80% approval. It should also be noted that the number of 'Don't Know' responses was larger than the number of 'No' responses for these *non-structural measures*. This shows that disapproval for these measures was low.

The most popular *non-structural measures* included ensuring all information on potential flood risk is made available to the community, improvement of flood warning and evacuation procedures, and ensuring all owners have a Flood Action Plan. In both cases, only one respondent disapproved of the option.

A5 SUMMARY

One-hundred and twenty six (126) responses were received to the *Community Questionnaire* which was distributed by Council to residents and business owners in the Study Area. The responses amounted to about four per cent of the total distributed.

A5.1 Issues

The issues identified by respondents in their responses to the *Community Questionnaire* support the objectives of the study, as nominated in the attached *Community Information Flyer,* and the activities nominated in the Study Brief. No new issues were identified in regard to main stream and major overland flooding.

A5.2 Attitudes to Flood Related Controls

Question 4 showed that residential areas and critical utilities are the most important areas to protect from floods, while new subdivisions and minor developments are the least important.

Respondents were evenly split over the level of control that should be placed over new development, with the exception that Council giving no advice on potential flood risks was not a favoured outcome.

A clear majority of respondents supported the idea of Council advising every property owner regularly of the known potential flood threat while some would prefer Council to advise only those that enquire or advise prospective purchasers of property of the known potential flood threat. There was almost no support for Council giving no notifications on flood risk.

A5.3 Flood Management Measures

Of the *structural measures* which could be incorporated in the *FRMP*, the most popular were improving the capacity of the stormwater system, and the management of vegetation along the creek corridors. Other *structural measures* were also popular but more respondents were uncertain about these measures.

Improvements to flood warning and evacuation procedures; community education programs; ensuring owners have Flood Action Plans; planning controls over new development in flood liable areas; provision of a planning certificate to purchasers in flood prone areas; and ensuring all information about potential flood risks is available to the community were all popular *non-structural measures* with very few disapproving responses.

Voluntary purchase of flood liable properties; providing funding for raising houses above major flood level; and flood proofing individual properties were the most unpopular of all options. The response to these measures were characterised by comparatively high numbers of disapproving responses, as well as high numbers of ‘Don’t Know’ responses.

ATTACHMENT 1

COMMUNITY INFORMATION FLYER AND QUESTIONNAIRE

ST MARYS (BYRNES CREEK) CATCHMENT FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

INFORMATION SHEET

INTRODUCTION

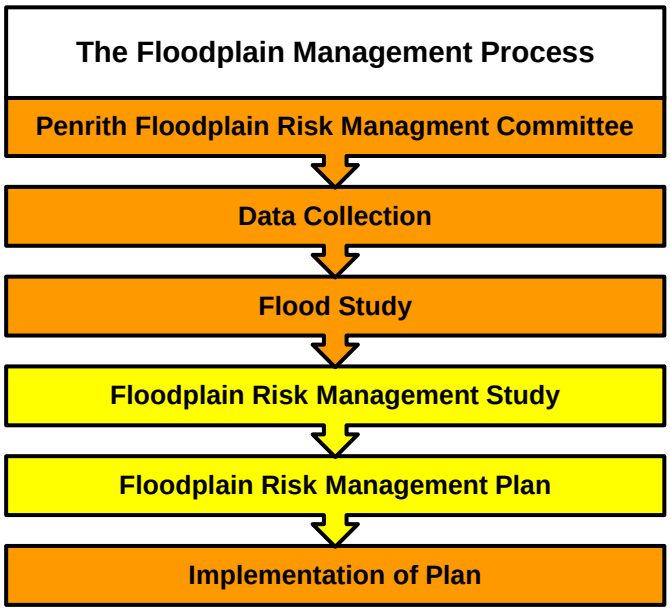
Penrith City Council is preparing a Floodplain Risk Management Study and Plan for the St Marys (Byrnes Creek) catchment, and we would like your help. The study will tell us what flood management measures are needed and help us plan for and manage known flood risks. Sound flood management is important to reduce flood damage, enhance resilience and improve social and economic opportunities.

Council has appointed engineering consultants Lyall and Associates to prepare the study and plan on our behalf. The study will be overseen by the Penrith Floodplain Risk Management Committee, and receive financial support from the State Government under its Floodplain Management Program.

WHY DO WE NEED A FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN?

Council is required to address flooding issues under the NSW Government Flood Prone Land Policy. Penrith is dominated by rivers, creeks and waterways, along with wide floodplains, so the risk of flood is real and serious for our region.

The policy sets out a staged process we must follow, which includes data collection, a flood study, a floodplain risk management study and plan, and implementation of the plan. The St Marys (Byrnes Creek) is now starting the management phase, highlighted in yellow below.



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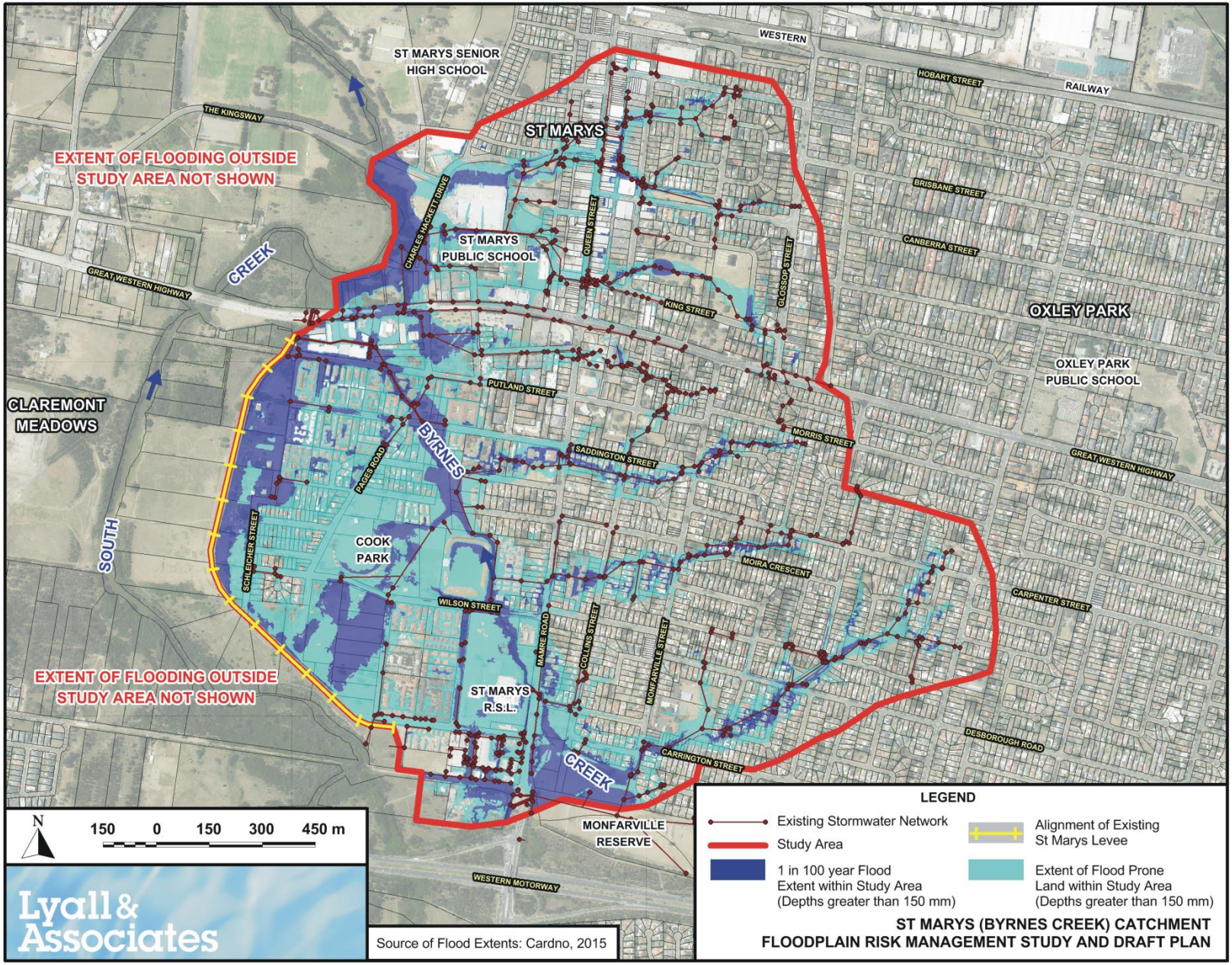

The Floodplain Risk Management Study will identify which measures could be implemented to reduce the risk and cost of flooding to the community, assist with emergency management and guide future development. A select set of these measures will be incorporated in the Floodplain Risk Management Plan. The process will also consider measures by which we can make the community more resilient and prepared, including education and preparation.

WHAT'S INVOLVED IN PREPARING A FLOODPLAIN RISK MANAGEMENT STUDY?

A considerable amount of work is involved in preparing a Floodplain Risk Management Study, including:

- identifying areas at risk of flooding, through use of the computer modelling completed for the Flood Study and from the community questionnaire
- developing a range of options for managing flood risk. These can include modifying the creek channel, constructing levees, enforcing planning controls for new development, planning for evacuation, education and awareness
- analysing the options, considering environmental, social and economic benefits, as well as their potential to reduce flood risk
- preparing a Floodplain Risk Management Report which summarises the outcome of all stages of the investigation and makes recommendations to be carried forward to the Floodplain Risk Management Plan

HOW CAN I BE INVOLVED?

We know that the local knowledge and personal experience of people in the community is valuable in helping identify flood 'trouble spots' and develop floodplain risk management measures that are comprehensive and effective.

The study team will consult with the community at two stages:

1. **questionnaire** – we encourage you to complete the questionnaire included with this information sheet, and share your experiences and opinions
2. **community workshop** – once the draft Floodplain Risk Management Study report is prepared, a community workshop will be held to give you an opportunity to review the report and ask questions about the flood management options investigated. Any comments from the workshop will be reviewed and addressed as part of the final report

STAY UP TO DATE

Our website will be updated throughout the study and plan process to provide the latest available information including details of the above community consultations.

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MORE INFORMATION

If you have any questions or would like to submit any information you think may be helpful to the study, please contact:

Myl Senthilvasan - Penrith City Council
PO Box 60, Penrith NSW 2751
Phone: 4732 7947
Email: myl.senthilvasan@penrith.city

ATTACHMENT 2

RESPONSES TO COMMUNITY QUESTIONNAIRE

ST MARYS (BYRNES CREEK) CATCHMENT FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

COMMUNITY QUESTIONNAIRE

COMPLETING THE QUESTIONNAIRE

You can share your experiences by completing the below questionnaire.

Please answer as many questions as you can and give as much detail as possible (attach additional pages if necessary).

If you have any questions or require further information, contact Council's Engineering Coordinator – Policy and Projects, Myl Senthilvasan on 4732 7947.

No information provided in this questionnaire will be supplied to insurance agencies.

CONTACT DETAILS

You do not have to provide your contact details. However, it is useful so we can contact you if we need more information. If you choose to provide contact details, this information will remain confidential at all times and will not be published.

Name: _____

Address: _____

_____

Phone number: _____

Email: _____

Please indicate if and how you would like us to contact you for more information or to provide you with study updates:

☐ Yes – telephone/email/mail (circle your preferred method of contact)

☐ No

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ABOUT YOUR PROPERTY

1. Please tick as appropriate:

- [ ] I am a resident
- [ ] I am a business owner
- [ ] I own the property
- [ ] I rent the property
- [ ] Other (please specify)

_____

2. How long have you been at this address?

- [ ] Less than a year
- [ ] 1 year to 5 years
- [ ] 5 years to 20 years
- [ ] More than 20 years (____ years)

3. What is your property?

- [ ] House
- [ ] Villa/Townhouse
- [ ] Unit/Flat/Apartment
- [ ] Vacant land
- [ ] Industrial unit in larger complex
- [ ] Standalone warehouse or factory
- [ ] Shop/Retail
- [ ] Community building
- [ ] Other

COUNCIL'S DEVELOPMENT CONTROLS

4. Please rank the following development types according to which you think are the most important to protect from floods

(1=highest priority to 6= least priority)

- [ ] Commercial
- [ ] Residential
- [ ] Essential community facilities
- [ ] Critical Utilities
- [ ] Minor developments and additions
- [ ] New residential subdivisions

5. What level of control do you consider Council should place on new development to minimise flood-related risks?

(Tick only one box)

(In addition to being favoured by the Community, these options would also need to comply with legislation)

- [ ] Prohibit all new development on land with any potential to flood
- [ ] Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties
- [ ] Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or the use of flood compatible building materials)
- [ ] Advise of the flood risks, but allow the individual a choice as to whether they develop or not, provided steps are taken to minimise potential flood risks
- [ ] Provide no advice regarding the potential flood risks or measures that could minimise those risks
- [ ] Don't know

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6. What notifications do you consider Council should give about the potential flood affectation of individual properties?

(Tick one or more boxes)

- ☐ Advise every resident and property owner on a regular basis of the known potential flood threat
- ☐ Advise only those who enquire to Council about the known potential flood threat
- ☐ Advise prospective purchasers of property of the known potential flood threat.
- ☐ Provide no notifications
- ☐ Other (_____)

OTHER INFORMATION

7. What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study?

(Tick one or more boxes)

- ☐ Council's website
- ☐ Articles in local newspaper
- ☐ Open days or drop-in days
- ☐ Community workshops
- ☐ Public Meetings
- ☐ Council's Floodplain Management Committee
- ☐ Other (please specify)

_____

FLOODPLAIN RISK MANAGEMENT MEASURES AND CONTROLS

8. Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the Study Area (see plan on attached Fact Sheet).

This list is not in any order of importance and there may be other options that you think should be considered. For each of the options listed, please indicate "yes", or "no" to indicate if you favour the option or "don't know" if undecided. (In addition to being favoured by the Community, management options would also need to comply with legislation and be capable of being funded).

Option	Yes	No	Don't Know
Management of vegetation along creek corridors to provide flood mitigation, stability, aesthetic and habitat benefits			
Widening and/or concrete lining of watercourses			
Construct detention basins			
Improve stormwater drainage system			
Removal of floodplain obstructions			
Voluntary purchase of the most severely affected flood-liable properties			
Provide funding or subsidies to raise houses above major flood level in low hazard areas.			
Flood proofing of individual properties by waterproofing walls, putting shutters across doors, etc.			
Improve flood warning and evacuation procedures both before and during a flood.			
Community education, participation and flood awareness programs.			
Ensuring all residents and business owners have Flood Action Plans - these outline WHAT people should do, WHERE they should go and WHO they should contact in a flood			
Specify controls on future development in flood-liable areas (e.g. controls on extent of filling, minimum floor levels, etc.)			
Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected.			
Ensuring all information about the potential risks of flooding is available to all residents and business owners			

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Thank you for taking the time to complete this questionnaire.

It can be returned without a postage stamp or scanned and emailed to: lacewater@bigpond.com.au by **Friday 23 December 2016**. Flood photos and videos can also be sent to this email address or posted to:

Lyall and Associates
Level 1, 26 Ridge Street,
North Sydney NSW 2060

Fold Here First

Delivery Address:
PO Box 60
PENRITH NSW 2751

No stamp required
if posted in Australia

Penrith City Council
Engineering Services – St Marys (Byrnes Creek) FRMS&P
Reply Paid 60
PENRITH NSW 2751

Fold Here Second

How to send back this questionnaire...

Please fold this questionnaire using 'Fold Here' lines as a guide to form a business sized envelope with the address on the front and this text box on the back. Seal the folded pages with tape on all sides to help maintain privacy (please do not use staples) and then post it.

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APPENDIX B

PLATES SHOWING HISTORIC FLOODING
6 JUNE 2016

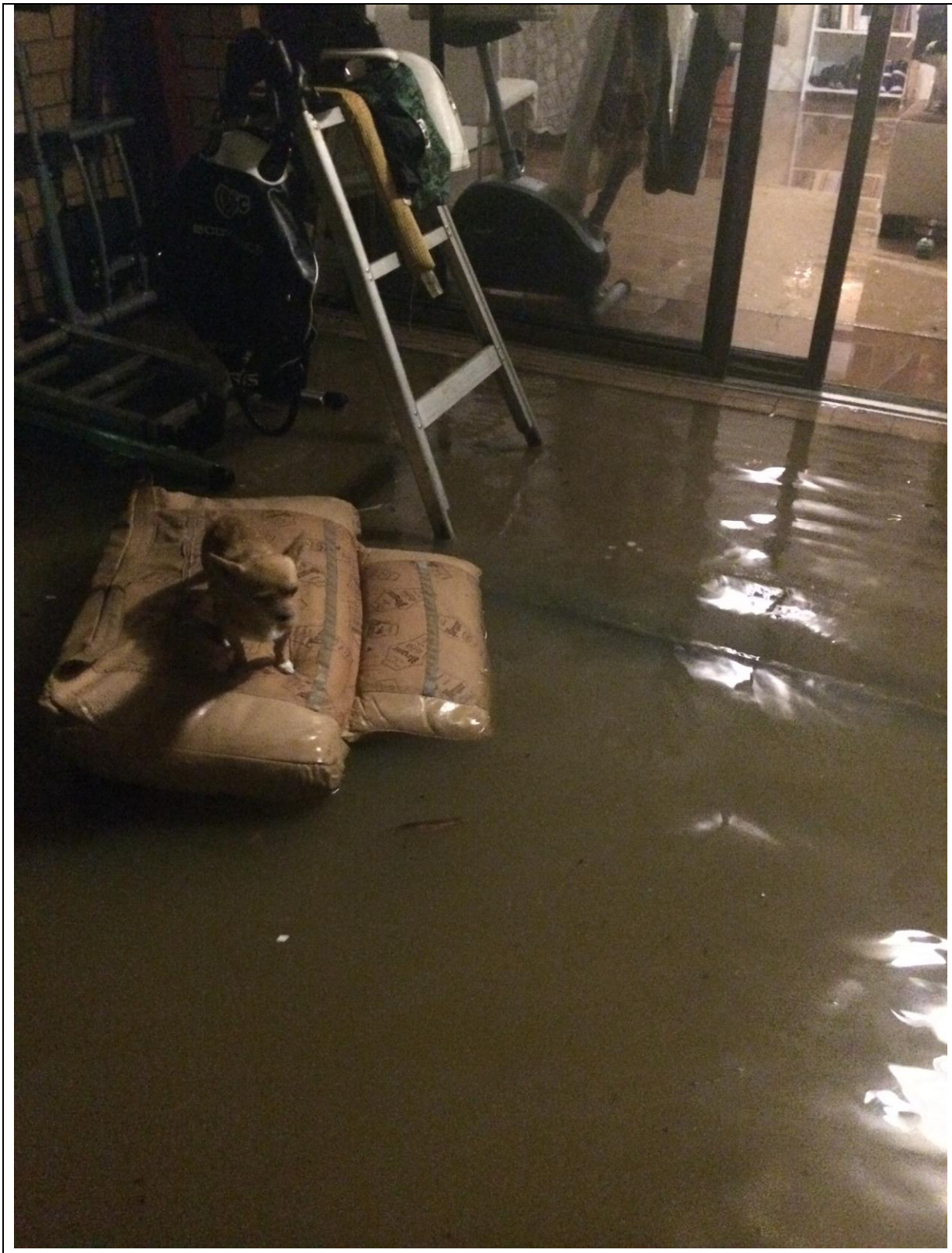

Plate 1 – Above-floor flooding in ground floor unit at No. 66-68 Putland Street, St Marys

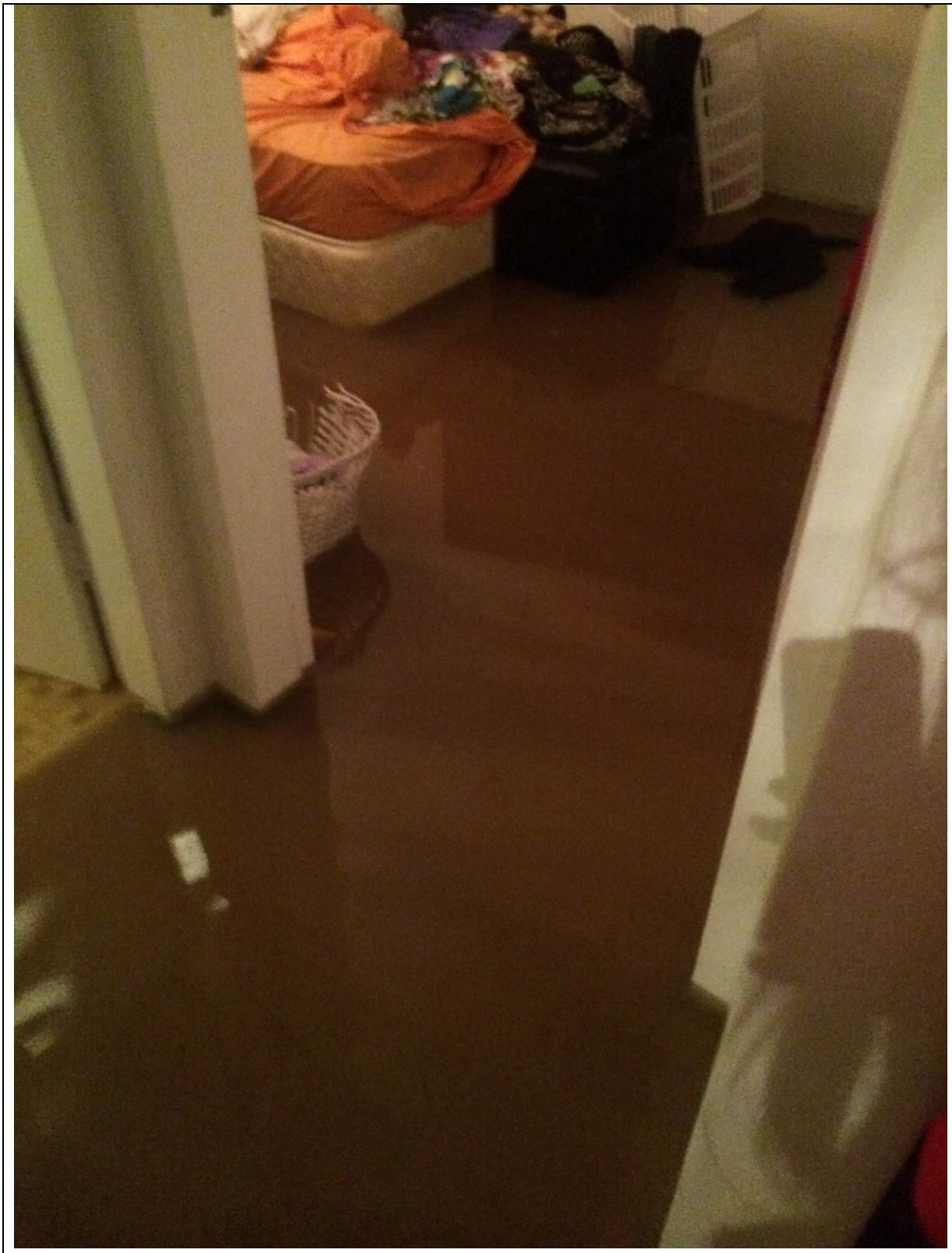

Plate 2 – Above-floor flooding in ground floor unit at No. 66-68 Putland Street, St Marys

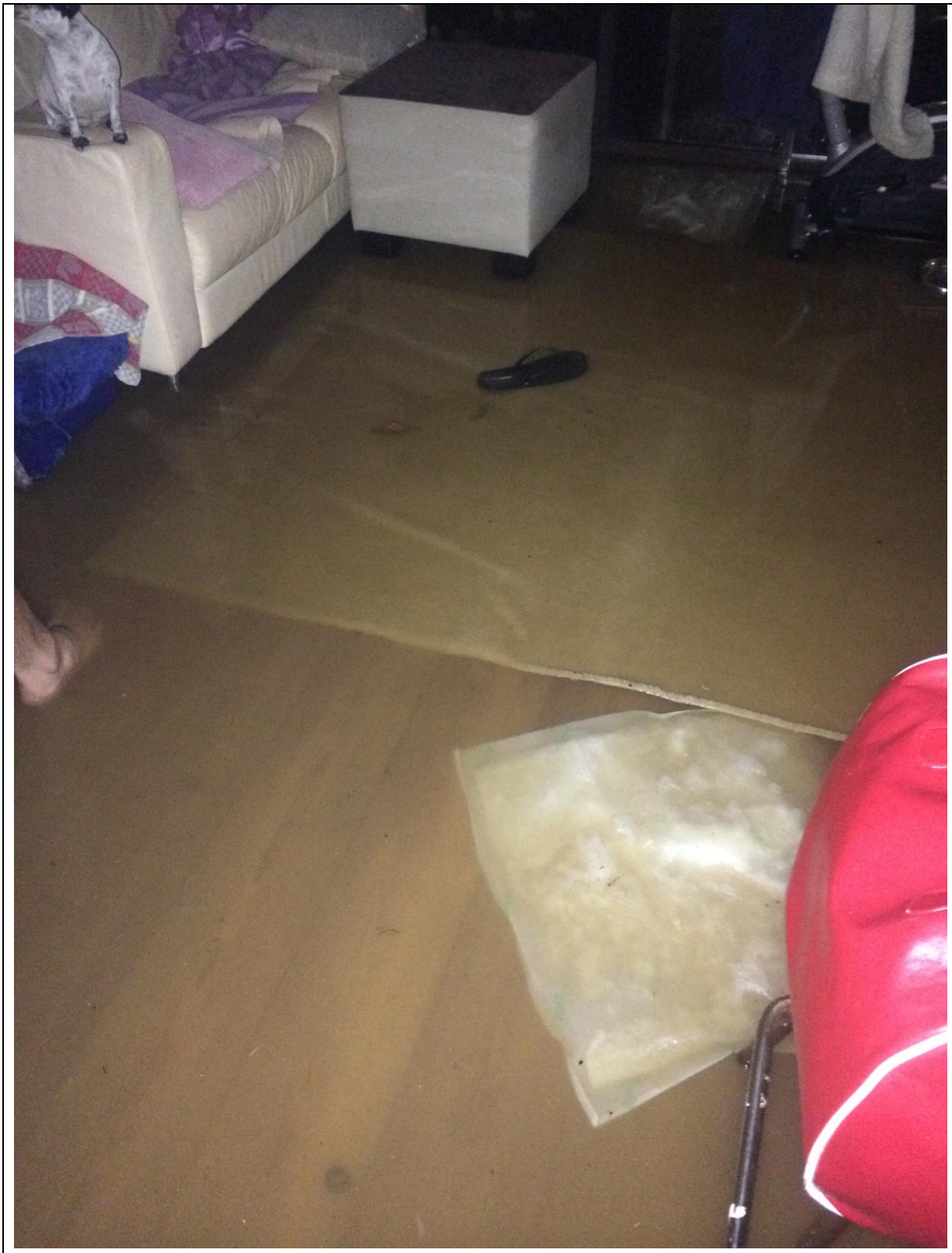

Plate 3 – Above-floor flooding in ground floor unit at No. 66-68 Putland Street, St Marys

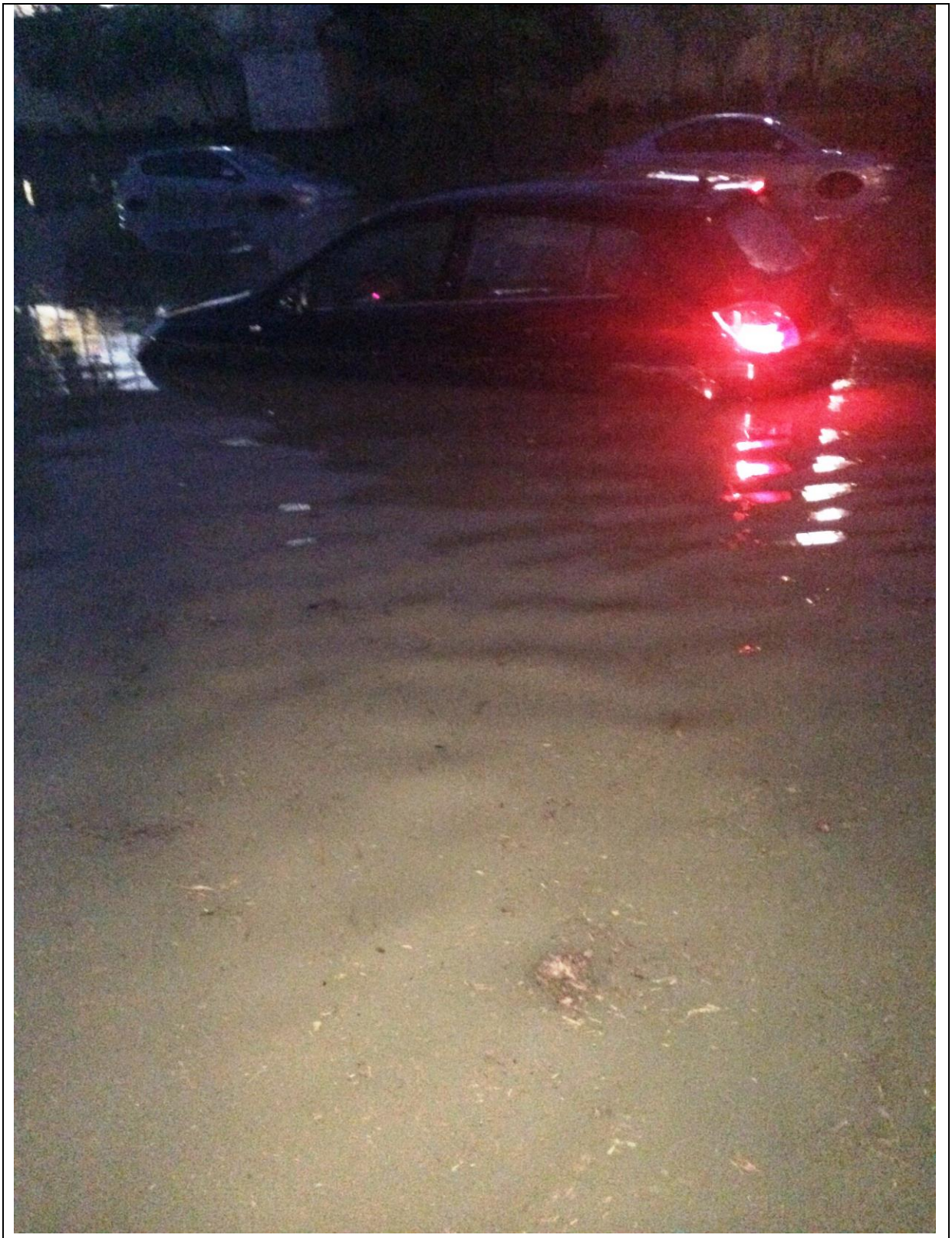

Plate 4 – Flooding observed at western end of Putland Street

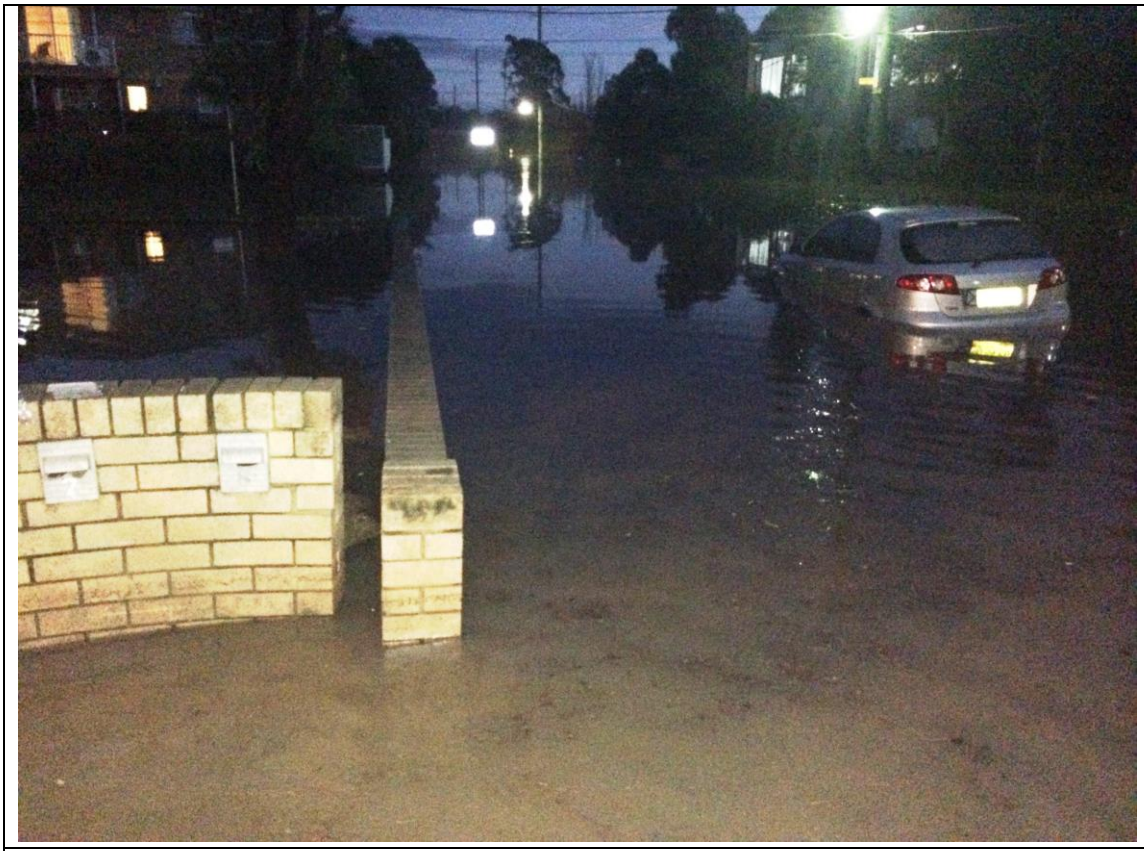

Plate 5 – Flooding observed at western end of Putland Street

Plate 6 – Flooding observed at western end of Putland Street