

# CATHERINE FIELD (PART) PRECINCT PEER REVIEW WATER CYCLE MANAGEMENT & FLOODING



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### - CONTENTS -

<b>1</b>	<b>INTRODUCTION .....</b>	<b>4</b>
<b>2</b>	<b>PURPOSE AND SCOPE OF WORKS .....</b>	<b>4</b>
<b>3</b>	<b>PEER REVIEW .....</b>	<b>5</b>
3.1	EXHIBITED WATER CYCLE MANAGEMENT & FLOODING REPORT .....	5
3.2	APPLICABLE CONTROL DOCUMENTS .....	5
3.3	PREVIOUS RELEVANT STUDIES .....	5
3.3.1	<i>WMA Water (2012) – Upper South Creek Flood Study .....</i>	<i>5</i>
3.3.2	<i>GHD (2007) – Turner Road Precinct Planning – Water Sensitive Urban Design Strategy</i>	<i>6</i>
3.4	HYDRAULIC MODELLING .....	6
3.5	WATER QUANTITY MANAGEMENT .....	10
3.6	WATER QUALITY MANAGEMENT .....	13
3.7	STREAM EROSION INDEX .....	15
3.8	FLOOD EVACUATION STRATEGY .....	15
3.9	OTHER COMMENTS .....	16
3.10	SUMMARY .....	17
3.11	COMPLIANCE WITH CONTROL DOCUMENTS .....	19
3.11.1	<i>Camden Growth Centre Precincts Development Control Plan (2012) .....</i>	<i>19</i>
3.11.2	<i>Growth Centres Development Code (2006) .....</i>	<i>22</i>
3.11.3	<i>Camden Council Engineering Design Specification .....</i>	<i>24</i>
3.11.4	<i>Camden Council Flood Risk Management Policy .....</i>	<i>26</i>
<b>4</b>	<b>REVIEW AND COMMENTARY ON PUBLIC EXHIBITION SUBMISSIONS .....</b>	<b>28</b>
4.1	CAMDEN COUNCIL .....	28
4.2	DEPARTMENT OF PRIMARY INDUSTRIES .....	31
4.3	ANONYMOUS (18 DECEMBER 2012) .....	31
4.4	GREENFIELDS DEVELOPMENT COMPANY 2 .....	31
4.5	TERRY O'NEILL .....	32
4.6	PC LAW ON BEHALF OF MR & MRS SAMMUT .....	32
4.7	ANTHONY MARTIN .....	32
4.8	HIXSON .....	33
4.9	NSW OFFICE OF ENVIRONMENT AND HERITAGE .....	33
4.10	STATE EMERGENCY SERVICES .....	35
<b>5</b>	<b>CONCLUSION AND RECOMMENDATIONS .....</b>	<b>37</b>

### - List of Tables -

Table 3.1 – Detention Basin Summary .....	12
Table 3.2 - MUSIC Modelling Summary .....	14

## - List of Figures -

- Figure 1 Terrain Difference Map: Brown Terrain – WMA Water Terrain
- Figure 2 100 Yar ARI Flood Difference Map: Brown Existing – WMA Water Existing
- Figure 3 100 Year ARI Flood Difference Map: Brown Developed – WMA Water Existing
- Figure 4 100 Yar ARI Flood Difference Map: Brown Developed – Brown Existing

## 1 INTRODUCTION

The NSW Government established the North West and South West Growth Centres in 2005 to streamline the supply of greenfield land for urban development and coordinate the delivery of infrastructure through the Department of Planning and Infrastructure. Land designated for future urban development has been divided into Precincts, which are rezoned in a staged process.

Each precinct goes through a Precinct Planning process, where detailed investigations are undertaken to determine appropriate land use options, physical and environmental constraints and infrastructure requirements. A key investigation necessary to inform the Urban Planning of the Precinct is the Water Cycle Management and Flooding Strategy. The Water Cycle Management and Flooding study generally details how stormwater will be managed within the Precinct and includes:

- Water Quantity Management (peak flow management, stormwater detention measures, water sensitive urban design, stream erosion, climate change impacts, etc.).
- Water Quality Management (pollutant reduction, water sensitive urban design, stormwater treatment measures, etc.).
- Flooding (flood extents, flood planning levels, limits of permissible development, flood level impacts, flood evacuation, climate change impacts, etc.).

For the Catherine Field (Part) Precinct, the Water Cycle Management and Flooding investigation was undertaken by Brown Consulting. The Catherine Field (Part) Precinct planning package was placed on public exhibition from 21 November 2012 to 21 December 2012. Several agency and public submissions were made during the public exhibition phase. Due to the issues raised in the submissions, the Department of Planning and Infrastructure has requested a peer review of the Water Cycle Management and Flooding Strategy.

## 2 PURPOSE AND SCOPE OF WORKS

The Department of Planning and Infrastructure has engaged J. Wyndham Prince Pty Ltd to undertake a peer review of the study prepared by Brown Consulting. The peer review has considered only the technical aspects discussed within the study. The peer review did not include assessment of the structure or grammatical aspects of the report. The peer review has been divided into two phases:

- Peer review of the exhibited Water Cycle Management and Flood Study prepared by Brown Consulting.
- Peer review / comments on the submissions that were received during the exhibition phase that relate to water cycle management and flooding. It is noted that Brown Consulting also undertook additional work on behalf of landowners during the exhibition phase. This has been reviewed separately to their original report.

Copies of the hydrology, hydraulic and water quality models used in the investigation were also provided to J. Wyndham Prince. It is beyond the scope of this peer review to undertake a detailed assessment of the modelling, however a general overview of the hydrology and water quality models and the associated parameters was undertaken. The hydraulic model was not reviewed in detail as the software package used by Brown Consulting (SOBEK) is not one of the packages used by J. Wyndham Prince. The results of the hydraulic modelling were extracted (using WaterRide) and used for comparison purposes with Council's adopted hydraulic model for the Upper South Creek Catchment, which covers the Catherine Field (Part) Precinct.

### **3 PEER REVIEW**

#### **3.1 EXHIBITED WATER CYCLE MANAGEMENT & FLOODING REPORT**

The exhibited Water Cycle Management and Flooding Report was prepared by Brown Consulting on behalf of the Department of Planning and Infrastructure. The report reviewed is identified as Issue 'D' dated June 2012. The report summarises the results of the investigations undertaken in developing a Water Cycle Management and Flooding Strategy to integrate with and inform the planning process for the Precinct.

The investigation identifies stormwater and flooding issues to be taken into account in the development application, detailed design and development of the Catherine Field (Part) Precinct. The investigation identifies the locations and land areas required for the control of quantity and quality of stormwater leaving the site. The investigation included:

- Hydrologic (Water Quantity) Assessment, including mitigation measures
- Hydraulic (Flood) Assessment
- Water Quality Assessment
- Stream Erosion Index
- Flood Evacuation

#### **3.2 APPLICABLE CONTROL DOCUMENTS**

A number of control documents are applicable for the Catherine Field (Part) Precinct. The documents are listed below. The compliance of the Water Cycle Management and Flooding Study with these control documents is discussed in more detail in Section 3.11.

- Camden Growth Centre Precincts Development Control Plan
- Growth Centres Development Code (2006)
- Camden Council Engineering Design Specification
- Camden Council Flood Risk Management Policy

J. Wyndham Prince understands that the Camden Growth Centre Precincts Development Control Plan is still in draft format and may undergo further revisions before it is formally adopted. However, this DCP will be the document against which future development applications will be assessed and therefore needs to be considered in the preparation of technical studies.

#### **3.3 PREVIOUS RELEVANT STUDIES**

A number of previous studies have been undertaken which are relevant to the Catherine Field (Part) Precinct. These studies are summarised below.

##### **3.3.1 *WMA Water (2012) – Upper South Creek Flood Study***

This report was prepared on behalf of Camden Council as part of the State Government's Floodplain Risk Management Planning process. The study was undertaken to assist in planning

for the significant amount of development that is planned within the catchment over the coming years.

### 3.3.2 *GHD (2007) – Turner Road Precinct Planning – Water Sensitive Urban Design Strategy*

This report was prepared on behalf of the Growth Centres Commission as part of the Turner Road Precinct Planning process. The Turner Road Precinct is located to the east of Camden Valley Way, immediately upstream of (and within the catchment of) the Catherine Field (Part) Precinct. Of particular relevance to the Catherine Field (Part) Precinct, the Turner Road investigation included modelling of the water quantity control strategy, which includes several detention basins that restricted peak post development flows to existing levels.

## 3.4 HYDRAULIC MODELLING

The Brown Consulting report is generally lacking in detailed information about the parameters used and assumptions made in developing the hydraulic model, such as roughness factors for various land use types, existing and proposed hydraulic structures, allowance for blockages, extent of site regrading.

The project brief for the Precinct, as provided by the Department of Planning and Infrastructure, requires flood mapping of the 2, 20, 100, 200 and 500 year ARI as well as the PMF events. Only the 100 year ARI and PMF events have been mapped.

The Digital Elevation Model (DEM) used in the hydraulic modelling utilises a grid size of 5m x 5m. This appears to be reasonably coarse for the extent of modelling undertaken (approximately 320 hectares total study area). It is acknowledged that the WMA Water Upper South Creek Flood Study (WMA, 2012) utilised a model with grid size of 10m x 10m with DEM sampling at 5m centres. However, this Flood Study was for a much broader extent, covering the whole Upper South Creek catchment area, which is approximately 7,100 hectares, compared with approximately 310 hectares within the Catherine Field (Part) Precinct. Section 4.5.3 of the draft Australian Rainfall and Runoff document titled 'Two Dimensional Modelling in Urban and Rural Floodplains' suggests that 2D modelling runtimes of less than 24 hours are a viable modelling outcome. Based on an estimate that 50% of the Precinct is impacted by flood waters, a 2 metre cell size run would be completed in under 18 hours. This would result in a greater level of detail to confirm the flood impact for the Precinct and remove some uncertainties that modelling at a 5 metre grid size results in, particularly where flood extents are being trimmed for depths less than 150mm (refer separate discussion below). A finer grid of 2 metres may have been suitable for this assessment that achieved a reasonable balance between flood definition and computing times. If further modelling is undertaken for the Precinct it is recommended that this smaller grid size be considered.

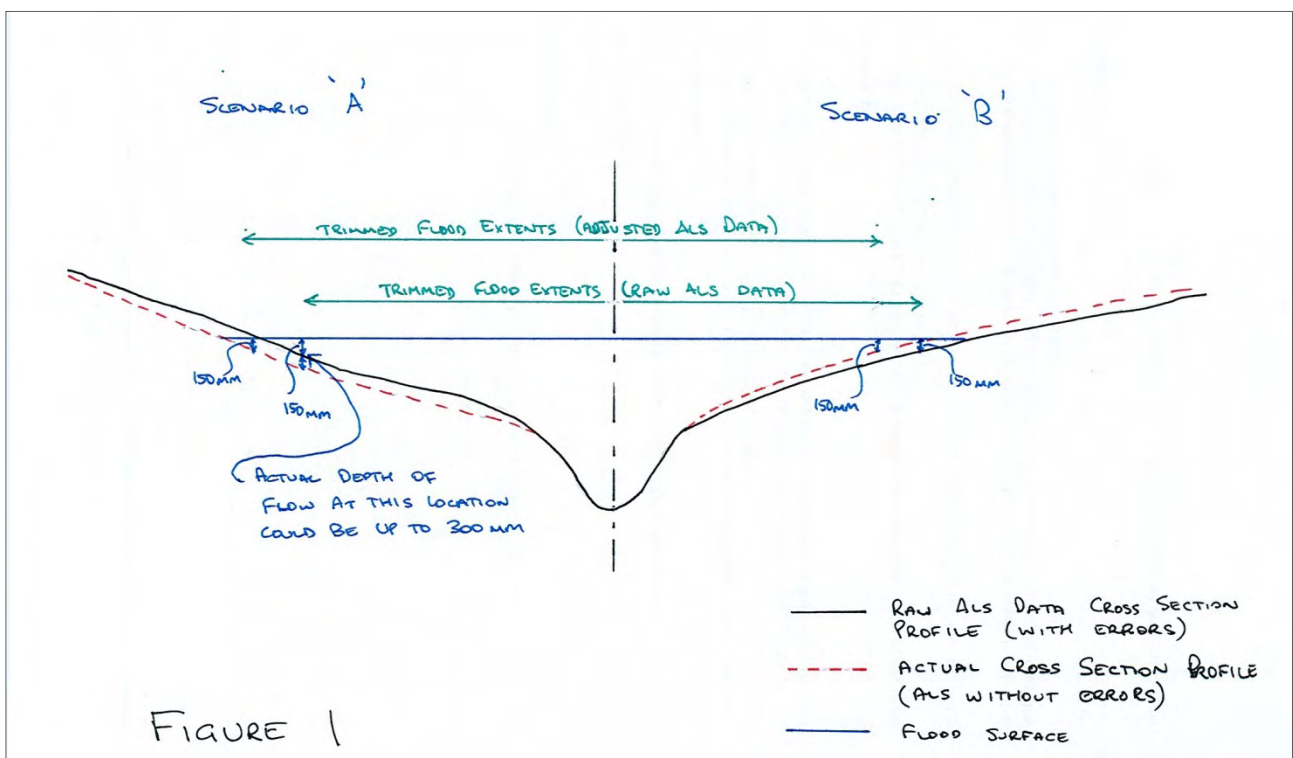
It is not clear whether the post development scenario models include an updated DEM to incorporate all proposed site regrading works. The report notes that the developed scenario assessed the flood fringe filling (Section 5.2.2), however there is no further details or plans showing the extents or depth of filling. There does not appear to be any compensatory storage provided to offset the filling works. It is also not clear whether some of the detention basin batters will extend into the floodplain and whether these have been included in the DEM.

Section 5.2.1 states that the extent of flood fringe filling is identified in Figure A8, however this figure does not appear to include this information. It is therefore unclear where the proposed flood fringe filling extents are.

The report does not include peak existing and post development flows extracted from the hydraulic model to indicate whether there is any impact downstream of the Precinct. Given that this is a model that takes into account floodplain storage, floodplain filling, etc. it would also be appropriate to report peak flows indicating whether or not the development has an impact.

The flood maps do not show any flood depth that is less than 150mm as it is considered that “*flood waters less than 150mm should not be indicative of whether an area is subject to flooding as it is within the limitation of the topographical data*”. It is noted that Brown Consulting have adopted this to be consistent with the assumptions made in the WMA Water Upper South Creek Flood Study. This assumption would appear valid only if the ALS data is lower than actual levels. If the modelled ground level is higher than actual levels (Scenario ‘A’ in Figure 1 below), then the depth of flow may be greater than 150mm once the adjustment is made. A flow depth result could be 150mm and excluded, where the adjusted depth is actually 300mm. The flood extents are also greater in this scenario. It is therefore queried whether this approach is valid. Scenario ‘B’ in Figure 1 below shows the alternate possibility (where the actual levels are higher than the ALS data), which is acknowledged as conservative.

Any proposal to trim the flood extents should first undertake an assessment to define the floodway, as was undertaken in the WMA Water study. Brown Consulting have adopted WMA Water’s floodway definition, however have used different software and a different modelling technique than WMA Water for their assessment. Therefore the WMA Water defined floodway may not be appropriate for Brown Consulting to adopt. Procedures such as those described in Thomas et al (2012) are considered to be a more appropriate method for defining floodway rather than adopting a single depth. It is recommended that a floodway definition assessment is necessary to inform the Precinct Planning.



In Section 5.2.4, a statement is made that “...*the proposed development does not aggravate flood velocities...*”. However, the flood velocity mapping shown on Figure A5 (existing 100 year ARI) and Figure A11 (developed 100 year ARI) show a significant portion of the flooded areas will experience higher velocities in the developed case. It is acknowledged that the velocities in the



developed case are still less than 1.6 m/s and are therefore not expected to cause erosion of the creek beds.

The report indicates that in the PMF event “...the site is predominantly flood free with no dwelling subject to inundation...”. However, the developed case PMF mapping (Figure A14) shows some areas where the flood extents appear to extend into the development layout. It is not clear from the report whether the post development modelling includes a DEM that accurately incorporates all proposed site regrading. We also understand that the PMF flood extents have been trimmed where the depth of flow is less than 150mm, meaning that more area than shown is potentially affected.

A sensitivity assessment of assumptions used in the modelling, such as material roughness and blockage of hydraulic structures, is not discussed in the report. It is therefore assumed that a sensitivity assessment has not been undertaken. It is noted that a sensitivity assessment was a specific requirement of the brief.

The report does not indicate whether or not proposed hydraulic structures have been included in the developed case modelling at road crossings and what parameters have been adopted (e.g. loss coefficients, culvert configurations, grades and blockage factors). If the proposed hydraulic structures have not been included in the modelling, the flood levels reported will almost certainly increase, particularly immediately upstream of the structures.

The results of the hydraulic models prepared by Brown Consulting and WMA Water provided to J. Wyndham Prince were analysed to determine differences between the two models for both terrain and flood levels. WaterRide and MapInfo were used to extract the model results and prepare the difference maps. The following difference maps have been prepared and are included in Appendix A.

1. Terrain Difference Map (Figure 1)
2. Brown Consulting Existing 100 Year Level – WMA Water Existing 100 Year Level (Figure 2)
3. Brown Consulting Developed 100 Year Level – WMA Water Existing 100 Year Level (Figure 3)
4. Brown Consulting Developed 100 Year Level – Brown Consulting Existing 100 Year Level (Figure 4)

It is acknowledged that the extraction of results from the two hydraulic models and conversion to alternate formats to enable the comparison may cause some minor discrepancies from the original data (typically  $\pm 20\text{mm}$ ).

The terrain difference mapping (Figure 1) shows that levels in the existing case surfaces do vary between the two models within the floodplain extents. There is a relatively even distribution of higher and lower terrain levels in the Brown surface. Levels also vary outside the floodplain extents, however will not impact on the flood modelling. It is understood that the surface used by Brown Consulting includes detail survey data, so should be to a greater level of accuracy. The surface levels between the two models (within the Brown Consulting 100 year ARI flood extents) vary by up to approximately  $\pm 400\text{mm}$ .

The existing case 100 year ARI flood difference mapping (Figure 2) shows that the majority of levels from the Brown modelling are the same or lower than the WMA Water levels, with some isolated areas where levels are higher. The Brown Consulting existing 100 year ARI flood levels are up to approximately 780mm lower in areas and up to approximately 240mm higher in other

areas. The difference mapping for this scenario also shows some increases in flood levels outside of the Precinct boundary.

A comparison of the Brown developed 100 year ARI case flood levels with the existing WMA Water levels (Figure 3) shows the majority of flood levels for the Brown modelling are the same or less than the WMA Water flood levels. There are some isolated areas where the Brown flood levels are higher. The Brown Consulting developed 100 year ARI flood levels are up to approximately 780mm lower in areas and up to approximately 230mm higher in other areas. The difference mapping for this scenario also shows some increases in flood levels outside of the Precinct boundary.

The difference mapping for the Brown developed 100 year ARI case versus the existing case (Figure 4) is generally consistent with the same map provided in the Brown report (Figure A13). There are some increases within the Precinct, mainly on South Creek. The difference mapping does not indicate any increases in flood levels outside the Precinct. The difference mapping indicates that developed case flood levels within the Precinct generally increase by no more than 150mm, with an isolated increase of approximately 670mm in the south-east corner of the Precinct where the tributary enters the site adjacent to Camden Valley Way.

The difference map produced by J. Wyndham Prince (Figure 4) also shows the areas that were flooded in the existing case that are now flood free in the developed case. There is a significant area within the main South Creek floodplain that was flood affected in the existing case but flood free in the developed case. It is acknowledged that the depth of flow in these areas are quite shallow (less than 150mm). However, it would still be expected that restricting the waterway area, along with increasing the Manning's 'n' roughness to account for revegetation of the riparian corridor, would result in some small increase in flood levels in this area. This is not reflected in the flood difference mapping. We therefore query the modelling parameters for the developed case.

The hydraulic model extends approximately 300m downstream of the Precinct boundary, which should be adequate to account for any tailwater impacts from hydraulic controls.

A climate change assessment has been undertaken by increasing rainfall intensities by 15%, in accordance with a recent study prepared for the Sydney Metropolitan Catchment Authority (J. Wyndham Prince, 2012). J. Wyndham Prince agrees with this approach.

The hydraulic assessment does not appear to include the significant extent of catchment on the western side of South Creek (see Figure 2). While this may not be an identified water course, there may be a need to provide a trunk drainage corridor to convey flows to South Creek. A post development catchment plan that correlates to the ILP has not been included, however the existing case catchment area to South Creek at this location exceeds 40 hectares.

### **Recommendations:**

- The report should be updated to include more details of the modelling process and the assumptions and parameters used in the modelling. This will allow the various stakeholders to determine whether the modelling meets their requirements and is fit for purpose.
- If required by the Department of Planning and Infrastructure, the additional flood surface profiles should be mapped in accordance with the project brief (2, 20, 200 and 500 year ARI events).
- If additional hydraulic modelling is undertaken, the use of a finer grid (say 2 metres) should be considered.

- Details of the digital elevation model used in the developed case scenario should be made clearer, for example, extent of fill, compensatory storage and site regrading. The digital elevation model should also include any proposed regrading work within the PMF extents (such as detention basins and perimeter roads) to ensure that this event is mapped correctly.
- A summary of peak existing and developed case peak flows from the hydraulic model should be included to confirm the proposed development does not have an adverse impact once the loss of floodplain storage is taken into consideration.
- Although Camden Council appears to have adopted the Flood Study undertaken by WMA Water, which includes trimming flood depths of less than 150mm, this position should be confirmed as it potentially results in a non-conservative outcome.
- A floodway definition assessment should be undertaken for the Brown Consulting hydraulic modelling if filling in the floodplain is proposed.
- A sensitivity assessment should be undertaken in accordance with the project brief to test the sensitivity of flood levels to the assumptions and parameters used in the modelling.
- The report should include a discussion on the future hydraulic structures (bridges, culverts, etc.) incorporated in the modelling, including the assumptions, parameters and blockage factors adopted. If the modelling does not currently include the future hydraulic structures, these should be incorporated as they will almost certainly impact flood levels.
- Clarification should be provided on how there is only very minor or no impact on existing flood levels in the Precinct when the floodplain is being constricted substantially in the developed case and an increased roughness factor should also have been applied to account for revegetation of the riparian corridor.
- The cumulative impact of filling in the floodplain be assessed on a catchment wide basis using Council's adopted model or other model covering the same area.
- The need to provide a trunk drainage corridor to the west of South Creeks needs to be clarified. It is not clear whether flows from this large area can be practically or safely conveyed in the pipe and street drainage network.

### 3.5 WATER QUANTITY MANAGEMENT

The hydrologic model is an updated version of the model used previously for South Creek (DWR 1990 and Bewsher Consulting 2004). It is noted that the areas upstream of the Catherine Field (Part) Precinct have been left as undeveloped on the assumption that future development will include detention measures to reduce peak flows to existing levels. While this may seem like a valid approach, it does not take into account the additional volume that is generated by the increase in impervious area and the change in timing of peak flows as a result of the development. These factors can affect peak flows downstream and peak flow detention basins cannot mitigate for these volumetric impacts. It is acknowledged that modification of the existing hydrology model upstream of the Catherine Field (Part) Precinct is likely to have been beyond the scope of Brown's engagement, particularly as this area is still being designed and constructed. However the potential implications of this modelling approach should be acknowledged.

It is also noted that there is a developed case XP-RAFTS model that was prepared as part of the Turner Road Precinct, which includes detention basins within the upstream catchment. Although these detention basins are likely to have been refined as part of the detailed design of these

catchments, incorporation of the developed upstream catchment and basins within the Catherine Field (Part) Precinct hydrology model would be considered more appropriate than adopting rural conditions.

Camden Council's Engineering Design Specification requires detention basins "...to attenuate flows where the peak flows due to the development are in excess of natural flows, or where required by Council. The basin shall be designed to perform in the full range of flood events up to 1% AEP...". The Brown Consulting study only includes a comparison of existing and developed case results for the 100 year ARI (1% AEP) event. The report also includes a statement that "...where practically possible, attenuate up to the 2 year ARI peak flow for discharges into Category 1 and 2 creeks...". No further information is provided indicating whether developed 2 year ARI peak flows have been attenuated to existing levels at any location.

It is also noted that the Camden Growth Centre DCP requires 5 year ARI peak developed case flows to be attenuated to existing levels.

The report indicates that approximately 360m<sup>3</sup>/ha of detention storage is provided across the Precinct. This volume is generally within the range that would be expected for attenuation of multiple ARI's up to the 100 year ARI to existing levels.

The report does not include detailed concept design plans (it is assumed that these were not required as part of the brief). It is therefore not clearly evident that the detention basin volumes required can be accommodated within the areas allocated on the Stormwater Masterplan (Figure A8). As a general rule of thumb, assuming an average storage depth of 1 metre, the total required basin area, including an allowance for berms, batters, curtiledge and access tracks, is approximately 1.3 times the basin volume (more for smaller basins and less for larger basins). The basin volumes are not included in the Brown Consulting report and were therefore extracted from the hydrologic model provided. The areas allocated for the basins were estimated from a digitised version of the Stormwater Masterplan. A summary of the results are shown in Table 3.1 below, which indicate that in some cases, it may not be possible to fit the detention basins within the area allocated. It is also noted that Council's engineering specification requires 500mm freeboard, which further impacts on the total basin footprint area. It is not clear whether this has been incorporated within the areas allocated. The adequacy of the detention basin allocations should be clarified with Brown Consulting.

**Table 3.1 – Detention Basin Summary**

Basin	Volume <sup>1</sup>	Area <sup>2</sup>	Ratio
B1	8200	9000	1.10
B2	2750	3800	1.38
B3	25900	27000	1.04
B4	6200	7700	1.24
B5+6	13400	16000	1.19
B7	4100	7100	1.73
B8	1400	3050	2.18
B9	7400	8100	1.09
B10	3700	3800	1.03
B12	3400	4550	1.34
B13	3200	4400	1.38

1. As extracted from the XP-RAFTS hydrologic model
2. As scaled from the Stormwater Masterplan (Figure A8)

The Brown Consulting report does not include information on peak PMF flows or how they have been determined. It is noted that the hydrology models provided do not include rainfall data for the PMF events.

Other parameters adopted in the XP-RAFTS hydrologic model generally appear to be in accordance with Camden Council’s requirements (e.g. rainfall intensities, initial / continuing losses, etc.). A gross check of the total catchment area within the existing and post development models confirmed that the areas are consistent. Sub-catchment areas, catchment slopes, detention basin details were not reviewed in detail. It is noted that a thorough assessment of the hydrologic model is beyond the extent of this peer review.

The detention basin names shown on Brown Consulting’s Stormwater Masterplan (Figure A8) do not correspond to the names given in the XP-RAFTS hydrologic model provided. The catchment plan (Figure A1) does not include catchment names or areas. It is therefore difficult to correlate between the plans and the modelling.

The Brown Consulting report does not provide a comparison of peak flows from their model with those from the WMA Water model (or the GHD Turner Road model). We understand that the WMA Water is Council’s adopted model and therefore a comparison of peak flows with this model is suggested.

**Recommendations:**

- Seek clarification from Brown Consulting on which hydrologic model they were instructed to use in the assessment and whether it was agreed not to incorporate the previously modelled detention basins within the Turner Road Precinct. If further hydrologic modelling is undertaken, it is recommended that the upstream basins be incorporated if possible.
- Brown Consulting to confirm whether the basins have been designed to attenuate 2 and 5 year ARI flows in accordance with the brief and the Camden Growth Centre DCP.
- Include a comparison of peak flows between the various hydrologic models to confirm consistency.

- Brown Consulting to confirm that the areas allocated for the detention basins are adequate, including provision for berms, batters, curtilage and access tracks (as required).
- The catchment plan should include catchment areas and catchment names that correlate to the hydrologic model for clarity in future reviews or use of the model. Detention basins names in the report and model should also correlate.

### 3.6 WATER QUALITY MANAGEMENT

The Brown Consulting report does not include a schematic for the MUSIC water quality model, however the electronic model was provided and interrogated. The report notes that MUSIC modelling was undertaken in Version 4.10, however the model provided does not appear to be a valid Version 4 file. The assessment described below has therefore been undertaken in Version 5. Some of the variations in results discussed below may be partially as a result of the different software versions.

A single “urban” node has been used to represent each of the developed case sub-catchments. Water quality modelling guidelines, such as the “Draft NSW MUSIC Modelling Guidelines (2010)”, recommend breaking the subcatchments into the various land uses (e.g. roofs, roads, other impervious and pervious areas). This allows different pollutant concentrations to be applied to each land use type. For example, the pollutant concentrations from an urban road will be different to the pollutant concentrations from a roof. Breaking the catchment up this way also allows a more realistic assessment, for example, of how rainwater tanks can be included to only capture flows from roofs. It is acknowledged that Brown Consulting’s simplified MUSIC model is likely to be conservative than a detailed model.

As noted above, the MUSIC model is a simplified model that does not break the catchment up into the various land use types and, therefore, does not include rainwater tanks, even though the report indicates that rainwater tanks will be provided to capture and reuse stormwater runoff.

The modelling includes gross pollutant traps, which have been configured to remove 90% of gross pollutants and zero nutrients. This is considered to be a reasonable assumption.

The report indicates that soil properties and pollutant concentrations adopted for each source node are the MUSIC defaults. Interrogation of the model confirmed this is the case. The former Department of Environment and Conservation issued a Technical Note for development within the Growth Centre Precincts with more appropriate parameters for use in Western Sydney areas. The modelling should be amended to incorporate these parameters.

The report does not indicate which meteorological data (rainfall data (location, duration or timestep) and evapotranspiration data) has been used in the water quality modelling. The size of water quality devices required to achieve the reduction targets are sensitive to meteorological data. It is therefore important that the rainfall data used in the simulation is representative of the long term statistical data for the site and extends for a duration that will cover extended wet and dry periods, as well as a number of various intensity storm events.

Interrogation of the MUSIC model shows that approximately 14 years of daily data from the Brownlow Hill rainfall station was adopted for the assessment. Generally, 6 minute data (rather than daily data) is considered to be more appropriate for this type of assessment as it provides more accurate results and is recommended in the MUSIC manual for modelling of bioretention systems. Daily data will not account for short duration intense storms and the peak runoff values, as these get distributed over the entire day. Subsequently, daily data will not result in as much overflow from the treatment systems as 6 minute data will. Daily rainfall data therefore results in less conservative results than 6 minute data. A quick assessment of the model with daily versus 6

minute data shows that the daily data assessment results are up to approximately 7% higher than the 6 minute assessment results (or 14% of the total 6 minute reductions). The use of daily rainfall data is therefore results in a non-conservative assessment and is not recommended.

Richmond evapotranspiration data has been adopted in the model which would be expected to be representative of the Precinct.

As expected from the above discussion, the results of the Browns’s MUSIC assessment (Table 8.3) indicate very high pollutant removal, much higher than what is required. This would initially indicate that the water quality devices are either much larger than they need to be (to achieve the target reductions). When the same model is run with 10 years of 6 minute rainfall data (Liverpool station), the results for TSS and TP are reduced (refer Table 3.2). When the soil properties and pollutant concentrations are amended to be consistent with the specified DEC values (as discussed above), the results are further reduced (also shown in Table 3.2). The results show that TP no longer complies with the minimum reduction of 65%. It is expected, given the size of the bioretention systems in relation to the subcatchment sizes, that if the model were modified to include the various land use types and rainwater tanks, the results for TP is likely to meet the targets, however this needs to be confirmed by additional modelling.

**Table 3.2 - MUSIC Modelling Summary**

Pollutant	Target Reduction	% Reductions		
		Brown Model With Daily Data (Brownlow Hill Data) <sup>1</sup>	Brown Model Modified With 6 Minute Data (Liverpool Data) <sup>2</sup>	Brown Model Modified With 6 Minute Data (Liverpool) and DEC Parameters <sup>2</sup>
TSS	85%	97.1	88.1	87.2
TP	65%	84.1	68.6	60.1
TN	45%	53.9	57.5	53.0

1. Table 8.3 of Brown Consulting Report
2. As modelled in MUSIC Version 5

The report provides a specification for the bioretention transition layer but not for the main media filter layer. The specifications for these layers can be developed and refined at the development application and detailed design phases.

It is also noted that the MUSIC model provided includes provision of a 1.47 hectare wetland, which is not shown on the Stormwater Masterplan (Figure A8). It is therefore assumed that the model provided is for the work that was undertaken during the exhibition phase.

**Recommendations:**

- The MUSIC modelling be refined to include a breakup of the various land uses within each subcatchment (roads, roofs and other urban areas).
- Rainwater tanks be incorporated in the model (if they are proposed) to capture a percentage of runoff from the roofs.
- The model should use 6 minute rainfall data instead of daily data.

- The soil properties and pollutant concentrations for each source node should be modified to be consistent with the Technical Note for development within the Growth Centre Precincts, issued by the Department of Environment and Conservation.
- The model should be reanalysed with the above amendments to ensure the proposed water quality devices are adequate to achieve the required pollutant target reductions.
- The model should reflect the adopted ILP stormwater management arrangement.

### 3.7 STREAM EROSION INDEX

The Stream Erosion Index provides a means of determining how frequently flows greater than the 'stream forming flow' will occur in the developed scenario compared to the natural case. This in turn provides an indicator of the increased potential erosion risk. The 'stream forming flow' is defined by the former Department of Environment and Conservation as 50% of the 2 year ARI flow rate for the catchment under natural conditions (Managing Urban Stormwater: Stormwater Planning, 2007).

The former Department of Environment and Conservation and Camden Council engineering guidelines (2009) require a Stream Erosion Index of no greater than 3.5 – 5.0.

The Brown Consulting report makes the assumption that attenuating the 2 year ARI flow is expected to result in a Stream Erosion Index of between 1 and 2. No modelling has been presented to confirm this is the case. In this regard we provide the following comments:

- The Brown report indicates (in Section 7.1) that attenuation of 2 year ARI flows would occur where practically possible for discharges into Category 1 and 2 creeks. It is therefore not clear where or how attenuation of 2 year ARI flows will occur.
- Stream forming flows are defined as 50% of the 2 year ARI flow rate (under natural catchment conditions), which equates approximately to a 4 – 6 month flow. It would be expected that a 4 – 6 month flow rate would pass through a 2 year ARI outlet with only minor attenuation. That is, a 2 year ARI detention system would offer little assistance in reducing the stream erosion index.
- Guidelines on determining the Stream Erosion Index are included in the Draft NSW MUSIC Modelling Guidelines (BMT WBM, SMCMA, 2010). This method uses the MUSIC software to determine the index. As the study already includes a MUSIC model for the water quality assessment, it could be easily extended to complete the SEI assessment.
- In JWP's experience on other developments with similar treatment train networks, the SEI is generally maintained around 3.5 – 4.5, so still within the required range.

#### Recommendations:

- A stream erosion index assessment be completed using the amended MUSIC model (see Section 3.6) in accordance with the Draft NSW MUSIC Modelling Guidelines (BMT WBM, SMCMA, 2010).

### 3.8 FLOOD EVACUATION STRATEGY

There are a number of contradictory statements within the Brown Consulting report regarding flood evacuation. Section 5.2.9 states "*...the modelling has shown that during the extreme events*



*including the PMF, the site is predominantly flood free with no dwelling subject to inundation...". If this were the case then no flood evacuation would be required. However, the same chapter also states "...the primary flood evacuation for the site would be vertical evacuation therefore occupants remain inside the dwellings...". Additionally, Paragraph 1 of Chapter 9 (Flood Evacuation Strategy) states that "...a flood evacuation plan will be required as part of the future development application process...".*

The developed scenario PMF flood mapping included in the Brown Consulting report shows some inundation within the proposed development, albeit minor. Although hydraulic modelling of flood fringe filling is discussed in the report, it is not clear whether the DEM used in the developed case PMF scenario was updated to include all proposed site regrading. It is recommended that this be made clearer in future revisions of the report.

Given the PMF flood mapping shows some areas of inundation within the proposed development footprint, it is considered necessary to prepare a flood evacuation plan as part of the Precinct Planning process to ensure that the necessary design requirements and controls are identified and managed prior to the DA phase. The identified controls should be incorporated within the Development Control Plan.

It is likely that the evacuation strategy would be relatively simple as PMF depths within the development are expected to be minor, given the mapped PMF extents (developed case PMF flood depth map not provided in Brown report). The flood evacuation strategy should be confirmed in any future revision of the study.

#### **Recommendations:**

- The flood evacuation strategy should be clarified. The strategy also needs to be developed in consultation with Council and the SES to ensure compliance with their requirements.

### **3.9 OTHER COMMENTS**

The report prepared by Brown Consulting does not clearly define the control documents and guidelines that are applicable to the Precinct and how their strategy complies with the specific requirements.

The report prepared by Brown Consulting does not cross reference relevant key issues from other technical studies for the Precinct. The two main reports that may impact on the Water Cycle Management Strategy are:

- Land Capability, Salinity and Contamination Assessment
- Riparian Assessment

It is acknowledged that the timing of the completion of these other technical studies may have prevented them being referenced.

The report does not identify the key constraints and opportunities for the Precinct (site topography and filling, riparian corridors, non-certified land, conveyance of flows from upstream catchments, stormwater reuse, etc.) and how this has influenced the outcomes and recommendations of the Water Cycle Management Strategy.

### 3.10 SUMMARY

The Brown Consulting report provides a general overview of the stormwater management and flooding issues for the Catherine Field (Part) Precinct. However, the level of detail provided in some sections of the report is not adequate to determine whether the modelling has been undertaken in accordance with best practice methodology and therefore whether the results are satisfactory and valid. Our recommendations are provided within each of the sections above.

Copies of the models used in the assessment were provided during the peer review process and have been interrogated in order to allow for comment on some of the modelling assumptions and parameters. Notwithstanding, the main issues with the report include:

#### **General**

- The report is generally lacking technical details about the modelling undertaken. Without significant interrogation of the various models used in the assessment, it is not possible to determine whether some sections of the strategy are valid. Details of the assumptions and parameters used to develop some of the modelling have not been included in the Brown Consulting report.

#### **Hydraulic (Flood) Modelling**

- There is a lack of information on the assumptions and parameters adopted in the hydraulic model that was used to determine flood levels.
- The grid size of 5 x 5 metres appears coarse for the extent of modelling.
- The assumption that flood depths less than 150mm be excluded from the mapping (despite this being consistent with Council's adopted model) appears to potentially be a non-conservative position and not a method that is described in the relevant guidelines, such as the Floodplain Development Manual.
- No floodway definition assessment has been undertaken for the Brown's hydraulic model to support filling in the floodplain.
- The extent of proposed filling, the provision of compensatory storage and the inclusion of these in the developed case terrain model is not reported nor accounted for within the provided models.
- A comparison of peak existing and developed flows from the hydraulic model (that account for the loss of floodplain storage) are not included to indicate whether there is any impact downstream of the Precinct.
- Cumulative impacts of flood fringe filling on a catchment wide scale has not been addressed.
- Not all of the storm events specified in the project brief for the Precinct have been mapped.
- It is not clear whether all proposed hydraulic structures have been included in the post development model to accurately determine the impact on flood levels. Whether included or not, it is also not clear whether the required freeboard allowances to any bridge or culvert has been allowed for and the impact this may have on the site fill requirements.

### **Hydrology (Water Quantity)**

- The hydrology assessment does not indicate whether peak post development 2 and 5 year ARI flows have been attenuated to existing levels as required by the brief and Camden Growth Centre DCP. The report specifies that 360m<sup>3</sup>/ha of detention is provided, which would generally be adequate.
- It is not clear whether the detention basins incorporate 500mm freeboard in accordance with Council's engineering specification. This may impact on the total area required for the basins as well as the extent of filling within the floodplain and the development.
- The summary provided in Table 3.1 above suggests that it may be difficult to fit the proposed detention basins within the areas allocated.

### **Water Quality**

- The MUSIC water quality model is a simplistic model which initially appears to be conservative and shows very high pollutant reductions.
- The simplistic modelling cannot account for the different loading rates for different land use areas (e.g. roads, roofs, other urban). The benefits of rainwater tanks also cannot be accounted for in the simplistic model.
- The soil properties and pollutant concentrations are not in accordance with the former Department of Environment and Conservation parameters specified for Growth Centre Precincts.
- The modelling adopts a daily rainfall timestep, which is far less conservative than a 6 minute timestep and is inappropriate for assessment of bioretention systems.
- Preliminary assessment of a revised simplistic model with the correct parameters and 6 minute rainfall data indicates that the model does not achieve the target reductions required. However, given the size of the water quality treatment devices in relation to the subcatchment areas, it is expected that a more detailed model that accounts for the various land use types and all water quality elements (including rainwater tanks) would achieve the target reductions.

### **Stream Erosion Index**

- No modelling has been undertaken in accordance with the relevant guidelines to confirm the assumptions that the target will be achieved.

### **Flood Evacuation Strategy**

- The strategy is unclear as there are contradictory statements.
- Council and the SES have both raised concerns regarding the proposed 'shelter-in-place' evacuation strategy.

### 3.11 COMPLIANCE WITH CONTROL DOCUMENTS

#### 3.11.1 Camden Growth Centre Precincts Development Control Plan (2012)

The Camden Growth Centre Precincts Development Control Plan is currently in draft format, however will be adopted in the future and will be the control document for the Catherine Field (Part) Precinct for which Council assesses development applications. The Plan identifies the following controls for consideration with regard to Flooding and Water Cycle Management for Precinct Planning (Chapter 2).

CONTROL	JWP COMMENT
<b>Flooding</b>	
<p>The subdivision layout is to ensure that the ability to develop land, including adjoining properties, is not adversely impacted, with regard to the 1% Annual Exceedance Probability (AEP) flood extent shown on the <b>Flood Prone Land</b> figure in the relevant Precinct's Schedule and Council's Floodplain Risk Management Policy.</p>	<p>The flood modelling undertaken by Brown Consulting shows that the proposed development layout and associated flood fringe filling will result in some increases in flood levels within the Precinct which are generally less than 150mm. There are no increases shown outside the Precinct boundary.</p>
<p>Filling and/or other development within the 1% Annual Exceedance Probability (AEP) flood extent shown on the <b>Flood Prone Land</b> figure in the relevant Precinct's Schedule may be permitted where site specific flood investigations demonstrate compliance with Council's Floodplain Risk Management Policy and Council's Engineering Specification.</p>	<p>The proposal includes flood fringe filling. The flood investigation indicates that there are no adverse impacts on 100 year ARI flood levels outside the Precinct boundary. Other storm events have not been assessed.</p> <p>The strategy makes the assumption that there will be no cumulative impacts as a result of flood fringe filling as there are no adverse impacts immediately upstream or downstream of the site. This assumption has not been confirmed with regional flood modelling that simulates flood fringe filling on upstream and downstream sites.</p>
<p>Pedestrian and vehicle access to basement car parking is to be located above the 1% AEP level plus 500mm freeboard.</p>	<p>This is an issue for future building development applications.</p>
<p>The design of the road network is to ensure that evacuation routes from the proposed development and any existing development and adjoining properties are maintained, or suitable alternative evacuation routes are provided for in accordance with Council's Floodplain Risk Management Policy and the Precinct Water Cycle Management Strategy (available from Council).</p>	<p>As noted within the peer review, the flood evacuation strategy requires clarification as there are contradictory statements. It appears that flooding in the PMF event has a minor impact on the development and that most, if not all, future residents will be able to shelter in place or with close neighbours.</p>
<b>Water Cycle Management</b>	
<p>Management of 'minor' flows and 'major'</p>	<p>The strategy generally appears to comply</p>

<p>flows within subdivisions and development sites is to be in accordance with Council's Engineering Specification. (Control 1 – see below)</p>	<p>with this control.</p> <p>However, it is noted that there are some larger catchments (up to approximately 40 hectares) toward the western side of the Precinct that do not have a drainage reserve connecting them to the main creek system. It may be difficult to safely convey flows from these catchments in the road/pipe network without the use of significant or multiple culverts. This may result in necessary trunk drainage costs being excluded from the Section 94 plan.</p>
<p>Stormwater within new subdivisions is to be managed primarily through a gravity network of pipes and overland flows generally following streets where flow volumes exceed the capacity of pipes in accordance with Council's Engineering Specification.</p>	<p>The strategy complies with this control.</p>
<p>All new development is to be connected, via the network described in Control 1 above, to the Council's trunk drainage system shown on the <b>Key elements of the water cycle management and ecology strategy</b> figure, in the relevant Precinct Schedule.</p>	<p>The strategy generally appears to comply with this control, however note the comments in Control 1 above.</p>
<p>The acquisition of drainage easements over downstream properties, or inclusion of drainage easements on subdivision plans, will be required where direct access to Council's drainage system or discharge of stormwater to a creek via the street network is not possible (i.e. street kerb and gutter, piped system or open channels and watercourses). However, the design of subdivisions is to generally comply with controls 1 and 2 above and management of stormwater through easements will only be permitted by Council in exceptional circumstances where no other practical solution is available.</p>	<p>The strategy does not appear to require the management of stormwater through easements. However, also note the comments in Control 1 above.</p>
<p>Roads on primary drainage lines shown on the <b>Key elements of the water cycle management and ecology strategy</b> figure, in the relevant Precinct Schedule, are to be constructed in the locations shown (subject to detailed survey and subdivision design), and are to be designed in accordance with Council's Engineering Specifications.</p>	<p>The strategy complies with this control.</p>
<p>The developed 1%, 20% and 50% AEP peak flows are to be maintained at pre-</p>	<p>The Brown strategy maintains 1% AEP peak post development flows to pre development</p>

<p>development flows through the incorporation of stormwater detention and management devices. Where subdivision works occur prior to the completion of required trunk drainage works, temporary on site facilities need to be provided in order to limit drainage volume and velocity to that experienced prior to development.</p>	<p>levels. The strategy discusses maintaining 50% AEP peak flows to existing levels where possible, however does not indicate if and where this has been achieved. The strategy does not assess 20% AEP peak flows. However, the detention volume stated (360m<sup>3</sup>/ha) would appear to be adequate to satisfy this requirement.</p>
<p>Where development includes the construction of water quality treatment infrastructure, the infrastructure is to be constructed in accordance with the Precinct Water Cycle Management Strategy (available from Council) and Council's Engineering Specification. The applicant must demonstrate that the proposed infrastructure will achieve the water quality targets in <b>Table 2-1</b>.</p>	<p>The proposed water quality strategy claims to achieve the targets listed in Table 2.1 of the DCP. However, as noted within the peer review, the modelling is simplistic, utilises daily rainfall data and does not use all of the correct parameters. Preliminary assessment shows that the modelling may not achieve the required targets when 6 minute rainfall data and the correct parameters are used. However, a more rigorous model that includes all proposed water quality devices would be expected to achieve the targets but would need to be confirmed. A detailed description of the water quality modelling assumptions and inputs is not included in the report. It is recommended that any updated report includes this information so the model does not have to be interrogated to extract the information.</p> <p>The strategy claims to achieve the Environmental Flow requirement, however no modelling was undertaken to confirm this.</p>
<p>Trunk drainage channels are to be designed and constructed as naturalised channels.</p>	<p>The majority of the drainage channels within the Precinct are existing natural creeks, which will be retained in their naturalised state. An “engineered meandering creekline” is proposed for the tributary that enters the site through the southern boundary (Harrington Creek). No further details are provided, however it is assumed that it will be designed and constructed as a naturalised channel in accordance with the requirements of the Riparian Assessment prepared by Eco Logical Australia. It is not clear whether the hydraulic modelling has included appropriate Manning’s ‘n’ values to account for the full riparian revegetation.</p>
<p>Council may consider amendments to the Precinct water cycle management strategy if a revised strategy is submitted that can demonstrate to Council’s satisfaction:</p> <ul style="list-style-type: none"> <li>• compliance with the targets in <b>Table 2-1</b>;</li> </ul>	<p>Not applicable.</p>

<ul style="list-style-type: none"> <li>• any costs associated with construction (including the cost of land) will be met by the applicant; and</li> <li>• a maintenance framework addressing maintenance strategies and life-cycle maintenance costs</li> </ul>	
<p>Where development is located on land that drains towards the Sydney Catchment Authority Upper Canal, specific water quality measures may be required to ensure that development does not adversely impact on the quality of water in the Upper Canal. Specific controls are contained in relevant Precinct Schedules.</p>	<p>Not applicable.</p>
<p>Where development includes land within a Riparian Protection Area (refer to the Riparian Protection Areas Map that is part of the Growth Centres SEPP) applicants are to refer to the <i>Guidelines for riparian corridors on waterfront land</i> prepared by the NSW Office of Water. The guidelines contain the outcomes and requirements for development on land containing a riparian protection area within the Growth Centres.</p>	<p>The strategy appears to be consistent with the Riparian Corridor Guidelines, and also consistent with the Riparian Assessment completed by Eco Logical Australia.</p>

**3.11.2 Growth Centres Development Code (2006)**

The Growth Centres Development Code was developed by the Growth Centres Commission to guide development within the North West and South West Growth Centres. The Code identifies the following objectives for consideration with regard to Water Sensitive Urban Design and stormwater management.

OBJECTIVE	JWP COMMENT
<p>Stormwater management strategies should be based on the objectives and principles of Water Sensitive Urban Design. They should promote water reuse and maximise potable water conservation</p>	<p>The strategy seeks to incorporate WSUD principles such as treatment of urban stormwater runoff, reducing potable water demand through the use of rainwater tanks and the use of detention to prevent rapid conveyance of stormwater. The report does not include opportunities for stormwater harvesting. There are opportunities to provide stormwater harvesting schemes to irrigate public domain areas, in particular the two sportsfields.</p>
<p>Existing waterways and riparian zones should be conserved and enhanced where possible</p>	<p>Although not cross referenced in the Brown report, a separate Riparian Assessment report has been prepared that addresses</p>

	this.
Stormwater management strategies should be developed and implemented in a manner which considers and addresses potential salinity hazards	The Brown report does not incorporate a discussion on salinity. The report prepared by WSP Environment and Energy listed the provisional recommendations for limiting the impacts of salinity as: maintaining a natural water balance; maintaining good drainage; avoiding disturbance of sensitive soils; implementing building controls where required and retaining or maintaining native vegetation. While not all of these issues can be addressed in the Water Cycle Management Strategy, it should include a discussion on what is proposed to address the applicable recommendations.
Stormwater management strategies should be adopted by the ILP to maximise efficient use of land and facilitate adequate allocation of land for stormwater management purposes	Notwithstanding the comments in the peer review, it appears that the ILP adequately incorporates the stormwater management strategy as presented on the Brown Stormwater Masterplan (Figure A8).
A treatment train approach should be used, incorporating structural stormwater treatment measures at the primary, secondary and tertiary levels as necessary to comply with the stormwater management targets	The strategy incorporates a treatment train approach to comply with the stormwater management targets.
The design of stormwater management systems should be integrated with the planning of road layout and design, given the potential benefits of incorporating suitable WSUD elements into road corridors	The Brown’s stormwater management strategy does not appear to incorporate WSUD elements within the road corridors. It is acknowledged that it is difficult to incorporate WSUD into urban streets without sacrificing significant amounts of otherwise developable land and causing significant ongoing maintenance and safety issues. Collector roads with central medians are one exception where these elements could be reasonably easily incorporated. The strategy should not preclude the use of measures in the streets if so desired by developers.
Stormwater reuse, retention and detention strategies should be used to minimise changes to the hydrological (or flow) regime of receiving waterways	Stormwater detention has been incorporated within the strategy as has reuse through the provision of rainwater tanks (although not included in the water quality modelling). Stormwater harvesting schemes for irrigation of public domain areas, in particular the sportsfields, should also be discussed.
Urban stormwater should not be discharged to areas of native bushland unless such discharge cannot be avoided. High levels of stormwater treatment and flow retention or	Stormwater treatment and detention has been provided for in the strategy to limit the impact to the receiving environment.



detention should be implemented where such a discharge occurs to limit soil erosion and weed growth within areas of native vegetation	
Management of stormwater should be considered on a subcatchment basis to employ source control techniques in preference to highly centralised 'end-of-pipe' treatment measures wherever practicable	Management of stormwater on a subcatchment basis has been incorporated as much as is considered practicable.
Trunk drainage routes and dual carriageways should be aligned where possible, to allow use of centre medians for WSUD drainage systems	No dual carriageways with central medians are proposed for the Precinct.
WSUD drainage systems may be incorporated into other roads and streets, where practicable and compatible with other design issues, including safety requirements of the relevant Road Authority	The report by Browns does not discuss this, however WSUD within urban streets is generally impractical and creates maintenance and safety issues for little benefit, as these systems usually only service very small catchment areas.
Any development within the 1:100 ARI flood level and the PMF should be designed to provide for emergency access	As noted in the peer review, there is contradictory information regarding flood evacuation for the Precinct. This should be made clearer.
Critical infrastructure, such as major roads and rail, are to be located above the 1:100 flood level wherever possible	The strategy complies.
Evacuation routes that continually rise from residential properties to higher land should be provided	As noted above, the evacuation strategy requires clarification.

### 3.11.3 Camden Council Engineering Design Specification

Camden Council's Engineering Design Specification contains a comprehensive list of requirements, much of which is more applicable at the Development Application and Detail Design phases. The key issues that were considered appropriate to the Precinct Planning phase and may affect the ILP are listed below.

CRITERIA	JWP COMMENT
<b>Natural Watercourses/Open Channels</b>	
Natural watercourses and open channels must be designed using an increased Manning's n coefficient, to represent snagging and partial obstruction of the channel by debris.	It is not clear from the Brown report what Manning's n values have been adopted in the flood modelling and whether it accounts for partial obstruction from debris.

<p>A minimum 500 mm freeboard above the top water level of 1% AEP event is to be incorporated within the open channel.</p>	<p>The report does not confirm whether the channels incorporate 500 mm freeboard.</p>
<p>The product of velocity x depth shall not exceed 0.4m<sup>2</sup>/s for channels, watercourses and floodplain areas without safety fences.</p>	<p>The flood modelling indicates that the velocity x depth product does not exceed 0.4m<sup>2</sup>/s in the majority of cases. It is considered unrealistic that all values will be below 0.4m<sup>2</sup>/s in a major watercourse and also impractical that virtually the whole length of South Creek through the Precinct be fenced. The mapping included in the report indicates there is virtually no difference in the velocity x depth product between the existing and developed conditions.</p>
<p>Provision of access for maintenance machinery shall be incorporated in the design of all channels.</p>	<p>This is only relevant where the channel interfaces directly with lots, which is not the case with the current ILP.</p>
<p>The channel upstream shall contain the estimated afflux and required freeboard through any culvert or bridge. Appropriate scour protection shall be included at the culvert or bridge outlet.</p>	<p>It is not clear whether the flood modelling has included bridges and culverts at the road crossings. There may be an impact on flood levels and extents if they haven't yet been included. Site fill levels may be impacted to comply with freeboard requirements.</p>
<p><b>Bridges</b></p>	
<p>Bridges are to be designed for the 1% AEP flow with a freeboard of 500 mm. The effects of a Probable Maximum Flood shall also be assessed. Afflux and hydraulic grade lines are to be assessed in all cases.</p> <p>The minimum clearance to be provided to the soffit of the bridge structure above the expected flood level is to be generally in accordance with Table 3.2 (500mm, 1000mm or 1250mm depending on the bridge/culvert and the velocities).</p> <p>It is critical that freeboard and other design requirements are achieved during the designated flood on evacuation routes.</p>	<p>It is not clear from the report whether the flood modelling undertaken by Brown Consulting included bridges (with appropriate blockage factors) at the locations where they are proposed. It is not clear whether 500mm freeboard has been provided and what impact this may have on site fill levels if it has not been included.</p> <p>It is not clear whether the minimum clearances to the bridge soffit structures have been allowed for (in accordance with Table 3.2 of Council's engineering specification).</p> <p>It is essential to consider the general configuration and levels of the proposed bridge / culvert structures prior to development applications for the surrounding lots otherwise the design constraints may be impossible to achieve.</p>
<p><b>Retention/Detention Basins</b></p>	
<p>Detention or retention basins are required to</p>	<p>The detention basins have been designed to</p>

attenuate flows where the peak flows due to the development are in excess of natural flows, or where required by Council. The basin shall be designed to perform in the full range of flood events up to 1% AEP. New retention/detention basins and other water quality control structures should be created as off-line to natural watercourses and open channels, unless otherwise approved by Council.	attenuate peak post development flows to existing levels for the 1% AEP event. The report indicates that where possible the basins will attenuate flows in the 50% AEP event. The assessment of other design events are not discussed in the report.
A freeboard of 500 mm for the 1% AEP event to be incorporated into the basin embankment, unless otherwise specified.	As no basin concept designs have been provided, it is not clear whether the 500mm freeboard requirement has been incorporated into the basin and what impact this will have on the total area required to be allocated for the basin if it hasn't been included.
Grassed internal batters shall not be steeper than 1(V):4(H).  Grassed external batters shall not be steeper than 1(V):4(H).	Concept designs for the basins are not included in the report so it is not clear what maximum batter slopes have been assumed in determining the drainage reserve extents.
The minimum slope of the basin floor shall be 1%, unless otherwise specified.	Concept designs for the basins are not included in the report so it is not clear what basin floor slope has been assumed.
Access to the retention/detention basin should be designed to allow machinery to remove sediment and litter. Truck access should be as close as possible to the basin to minimise spillage of material.	It is not clear whether the areas allocated for basins incorporates an allowance for access. Table 3.1 above suggests that there may not be adequate area allocated to accommodate some of the proposed detention basins. This should be clarified with Brown Consulting.

**3.11.4 Camden Council Flood Risk Management Policy**

Camden Council's Flood Risk Management Policy is applicable to the Catherine Field (Part) Precinct. The specific relevant requirements and comments on compliance are summarised below.

CRITERIA	JWP COMMENT
Flood Planning Level  The Flood Planning Level (FPL) used for general planning control purposes is derived from a combination of the 1% Annual Exceedance Probability (AEP) flood event plus a freeboard of 600mm.	From the information available it appears the Brown strategy generally complies with this requirement. Compliance will also need to be confirmed during the Development Application and Detailed Design phases.
Local Overland Flooding	

<p>Properties affected by local overland flow or major drainage currently not identified on Council’s Flood Maps and Flood Studies are subject to the same Flood Risk Management development controls and guidelines detailed in the Camden Council Flood Risk Management Policy.</p>	<p>There appear to be areas within the ILP, particularly to the west, where large catchment extents (40 hectares) have not been provided with a drainage reserve to convey flows to the main creek system. Generally, flows from catchments greater than 15 hectares cannot be conveyed in the pipe/street minor/major drainage network without the provision of very large and/or multiple culverts. There is no information provided in the Brown report on peak flows or flow directions so we are unable to confirm whether there will be issues. The assessment of local overland flow and major drainage will be an ongoing process throughout the Development Application and Detailed Design phases.</p>
<p><b>Reliable Safe Flood Access</b></p> <p>For the purpose of Council’s Flood Risk Management Policy, reliable safe flood access is considered satisfactory when the depth of floodwater over vehicular access routes (roads and legal right of ways) allows the safe and stable movement of vehicles and the safe and stable movement of people in floods up to and including the PMF event.</p>	<p>As noted in the peer review, there is contradictory information in the Brown report regarding flood evacuation. It would appear that the Precinct is relatively unaffected by flooding from the PMF and most, if not all, future residents would be able to shelter in place during an extreme storm event. This however needs to be clarified.</p>
<p><b>Mine Subsidence</b></p> <p>Levels of anticipated subsidence can be obtained from the Mine Subsidence Board and must be included in the determination of the Flood Planning Level.</p>	<p>The Mine Subsidence Board mapping indicates that the Catherine Field (Part) Precinct is not located within a mine subsidence area.</p>
<p><b>Land Forming and Fill Operations</b></p> <p>Fill operations will not be permitted below the 1% AEP flood level in floodways and flood storage areas.</p> <p>All applications on land below the 1% AEP flood level in flood fringe areas that propose to undertake land forming operations must be accompanied by a detailed submission, including a hydraulic report, prepared by a qualified engineer with suitable specialist experience in hydraulic engineering and flood risk management. The report must certify that no adverse impacts to mainstream or local drainage will occur as a result of the proposed land forming operations. The report must examine hydraulic characteristics, such as peak flow, flows and depth of flows for all</p>	<p>The strategy proposed by Brown Consulting proposes filling within the flood fringe of the 1% AEP event. The extent of filling is not clearly shown on the plans, however is assumed to coincide with the riparian or environmental conservation boundary (whichever is the greater).</p> <p>The study has included an assessment of the potential impacts only for the 1% AEP event, not other events as required by the Policy.</p> <p>The 1% AEP flood difference mapping shows that the increase in flood levels as a result of the filling are generally less than 150mm. The flood difference map indicates that there are no increases in 1% AEP flood levels</p>

<p>flood and storm events, and potential impacts on any other land. The report must also address the cumulative effect from the land forming operation if similar land forming operations are undertaken on other properties in the vicinity.</p>	<p>outside the Precinct boundary.</p> <p>The report makes the assumption that because flood levels and flows outside the Precinct boundary do not increase, then there will be no cumulative impacts for similar filling regimes on adjacent sites. This assumption has not been confirmed with modelling.</p> <p>A floodway definition assessment for the Brown Consulting hydraulic modelling should be undertaken if filling in the floodplain is proposed.</p>
<p><b>On-Site Detention</b></p> <p>For all development sites, the total flow rate and concentration of stormwater runoff in the post-developed state is to be no more than that which exists in the pre-developed state. For subdivision developments, one or more single detention basins may be used to achieve this condition.</p>	<p>On-site detention, through the provision of subcatchment scale detention basins, has been proposed for the Precinct.</p>

**4 REVIEW AND COMMENTARY ON PUBLIC EXHIBITION SUBMISSIONS**

The Catherine Field (Part) Precinct Plan was placed on public exhibition from 21 November 2012 to 21 December 2012. All technical reports, including the Water Cycle Management and Flooding Report, were available to the public for review and comment during this time. The Department of Planning and Infrastructure received many submissions during the exhibition phase. The submissions that relate to Water Cycle Management and Flooding and the review comments are summarised below.

**4.1 CAMDEN COUNCIL**

Camden Council have provided a detailed (draft) submission which highlights several issues with the Water Cycle Management Strategy. These are summarised and discussed below.

<b>Camden Council Comment</b>	<b>JWP Comment</b>
<p>The report fails to provide adequate information for Council to ensure the modelling undertaken is best practice and that adequate measures are in place to mitigate impacts for downstream residents.</p>	<p>As noted throughout the peer review, the report in some instances does not include detailed information on the modelling assumptions and inputs. JWP therefore agree with Council’s comment.</p>
<p>The 150mm baseline discrepancy previously conveyed by Council to both the Department and Brown Consulting has not been adequately addressed or incorporated into the report.</p>	<p>It is noted that Brown Consulting appear to be consistent with the WMA Water assumption that flood depths of less than 150mm be removed from the flood maps as it is considered that flood waters less than 150mm deep should not necessarily be</p>

	<p>indicative of whether an area is subject to flooding or not. We understand that the WMA Water model has been adopted by Council, which would contradict Council's comment on the Brown modelling. Therefore this issue requires further clarification from Council on what has been agreed to and adopted.</p>
<p>Filling is proposed in the floodplain. However the extent of filling in the floodplain is unclear.</p>	<p>As noted in the peer review, it is unclear what surface information has been incorporated in the post development modelling and the extent and depth of filling within the floodplain. JWP therefore agrees with Council's comment.</p>
<p>The report has failed to address the logical consequence of filling in the floodplain, i.e. the loss of floodplain storage and hence, according to basic hydrological theory, the exacerbation of downstream peak flow, reduced time to achieve peak flow downstream and also the exacerbation of flood levels in downstream areas.</p>	<p>As noted above, it is not clear what surface has been used in the modelling and the extent and depth of filling in the floodplain. No details on the loss of volume through filling have been provided and whether peak flows extracted from the hydraulic model (which is the model being used to account for loss of floodplain storage) for the developed case match existing levels downstream. JWP therefore agrees with Council's comment.</p>
<p>The report should address the issue of cumulative impact of filling.</p>	<p>The modelling only considers filling within the Catherine Field (Part) Precinct. There does not appear to be compensatory storage provided. While the report indicates that there is no impact within the Precinct or immediately downstream, similar filling on adjacent developments may result in an overall impact in the catchment. The modelling does not include an assessment for the cumulative impact, hence JWP agrees with Council's comment. Council have indicated that the WMA Water flood model is available to undertake this assessment.</p>
<p>Brown's report describes the use of detention basins in order to mitigate post-development flows. Of concern to Council is that it appears that the intent is to capture all flow in the 2Y ARI event and less. Council is concerned regarding the impact this may have on the downstream environment as it is likely to markedly change creek ecosystems given that they will presumably be drier for more of the time than previously.</p>	<p>As noted in the peer review, it is unclear whether detention will be provided for the 2 year ARI event in some or all of the detention basins. Regardless, the downstream environment is unlikely to be drier for more of the time. The increase in impervious area will result in a significant increase in volumetric runoff in the post development case. It is only the peak flow rates that are potentially reduced. Additionally, regular flows (e.g. 3 month ARI) are not going to be reduced significantly by an outlet that is designed to attenuate 2 year</p>

	<p>ARI flows and peak flows for these regular events may increase in the post development case. J. Wyndham Prince therefore disagrees with Council's comment.</p>
<p>Further clarification of the basins is required, i.e. do they capture flow, without release, in some scenarios. Further analysis of the impact of a flood event that exceeds the 100Y ARI design event should form part of any post exhibition work.</p>	<p>The Brown report indicates that the basins attenuate peak flows, not hold stormwater without release.</p> <p>The assessment includes analysis of the PMF event. Though, as noted previously, it is not clear whether the terrain model used includes all site works (filling, detention basins, etc). No difference map for the existing and developed case PMF is provided, however there is no requirement to match existing PMF levels. If the PMF difference mapping was undertaken, it should be for information purposes only. J. Wyndham Prince therefore disagrees with Council's comment unless the analysis is required for information purposes only.</p>
<p>Council finds that the current work provided by Brown (May, 2012) in regard to flood egress is inadequate as it fails to detail which roads will be overtopped in the event of flooding and hence which parts of the proposed development may be cut-off from road egress and for how long.</p>	<p>As noted in the peer review, the flood evacuation strategy contains contradictory statements. JWP therefore agree with Council's comments and recommend that the flood evacuation strategy be made clearer.</p>
<p>The response plan outlined in Brown (May, 2012) is limited to evacuation in place. What this does not account for however is that during a flooding event people may need to leave (hospital emergencies etc.) and if safe vehicular egress is not available then evacuation can become highly complicated and place those evacuating and those facilitating such evacuation in danger.</p>	<p>The SES submission has also raised concerns regarding the 'shelter-in-place' evacuation strategy (see Section 4.10) and the significant associated risks. In light of Council's and the SES's concerns, it may be necessary to revisit the evacuation strategy. It appears that very few residents would be affected and continuously rising grades out of the floodwater look to be available.</p>
<p>Section 8.7 of the Brown Report provides a statement that the Stream Erosion Index is expected to be satisfactory. Such a statement without providing any calculations or evidence that this is the case is unacceptable. The SEI for the watercycle masterplan should be calculated and the masterplan modified as needed to ensure that the SEI complies with Growth Centre specifications.</p>	<p>JWP agrees with Council's comment. The SEI can quite easily be determined by utilising the MUSIC model that has already been developed for the water quality assessment.</p>

## 4.2 DEPARTMENT OF PRIMARY INDUSTRIES

The Department of Primary Industries (DPI) submission dated 13 December 2012 notes that the waterway crossings will need to be designed in accordance with Fisheries NSW: 'Policy and Guidelines for Fish Friendly Water Crossings' and 'Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings'.

### ***JWP Comment***

As noted in the peer review, it is not clear from the Brown report whether or not road crossings (culverts or bridges) of the watercourses have been included in the modelling. Nevertheless, the configuration of culverts and bridges to comply with the DPI requirements would be undertaken at development application and detailed design stages. It is essential that the basic bridge and culvert configurations be resolved very early in the DA process to avoid ending up with impossible constraints (e.g. freeboard to lots).

## 4.3 ANONYMOUS (18 DECEMBER 2012)

The anonymous submission dated 18 December 2012 requested that the run off from the culvert under Oran Park Drive that currently discharges to their property be diverted to run along Oran Park Drive and drain to the proposed drainage channel under the Electrical Easement.

### ***JWP Comment***

As the submission is anonymous, it is not clear which property is referred to, how far it is from the drainage reserve, what the size of the culvert is and the magnitude of the upstream catchment / flow. It is unlikely that flows from the upstream catchment will be allowed to discharge into future residential land uncontrolled. However, it is not possible to provide an informed response for this submission without knowing the above details.

## 4.4 GREENFIELDS DEVELOPMENT COMPANY 2

The Greenfields Development Company 2 submission provides an amended ILP based on further technical studies, including additional work undertaken by Brown Consulting for the Water Cycle Management and Flooding Strategy.

### ***JWP Comment***

The alternate ILP included in the submission shows reduced drainage areas within the Greenfield Development Company's (GDC) site. The alternate ILP is based on additional work undertaken by Brown Consulting during the exhibition period. No information is provided within the submission on the additional water cycle management and flooding work undertaken other than two plans summarising the alternate basin sizes and locations. Therefore, only a gross check can be made on the new basin sizes in relation to the catchment areas.

The gross check shows the detention volumes for the alternate ILP are approximately 350m<sup>3</sup>/ha (assuming an average detention depth of 1.0 m). This is within the range of what would be expected for detention basins within residential areas. It is not clear whether the areas nominated on the plans include provision for all necessary berms and batters and, if not, whether there is additional land to accommodate them within the ILP. If all necessary berms and batters are included in the detention basin surface areas shown on the plans, the



areas would appear to be very much toward the smaller end of the range that would be expected (refer Table 3.1 of the peer review and associated discussion).

It is recommended that Brown Consulting clarify that the areas allocated for detention basins are adequate, including provision for berms, batters, curtiledge and access tracks.

#### **4.5 TERRY O'NEILL**

The submission objects to the proposed riparian corridor requiring acquisition of approximately 50% of the lot.

##### ***JWP Comment***

The flood assessments undertaken by both WMA Water and Brown Consulting show that the property in question lies within a gully and is flood affected, albeit only minor depths of inundation. The location of the proposed riparian corridor is also consistent with the negotiated outcomes with NSW Office of Water.

The designated zoning of drainage / riparian corridor within the subject property is considered to be valid.

#### **4.6 PC LAW ON BEHALF OF MR & MRS SAMMUT**

The submission requests that the land zoned for drainage on Lot 291 DP 708154 instead be zoned as residential because “...*they and their neighbours no longer experience any water flow through those sections of their land following re-development of the precinct on the eastern side of Camden Valley Way...*”.

##### ***JWP Comment***

The development to the east of Camden Valley Way does not involve redirecting catchments away from the subject property. Additionally, the majority of this external catchment that drains to the property is yet to be developed. The lack of flows through the creek (at the time the submission was made) would presumably be due to no recent significant rainfall at that time.

The flood modelling undertaken by both WMA Water and Brown Consulting show that the area designated for drainage is flood affected. Additionally, a proposed Category 2 riparian corridor is proposed over the majority of area designated as drainage, as negotiated with the NSW Office of Water.

The designated zoning of drainage within the subject property is considered to be valid.

#### **4.7 ANTHONY MARTIN**

The submission queries the need for the riparian corridor over the property located at 743 Camden Valley Way due to the understanding that there will be no means for flows to enter the creek once all the roads around the area are constructed and Camden Valley Way has been upgraded.

**JWP Comment**

The proposed works within the adjacent upstream development east of Camden Valley Way as well as the Camden Valley Way upgrade works will not redirect flows. Any new roads that cross a watercourse will need to be provided with culverts or bridges to convey flows. The Camden Valley Way upgrade works will also include bridges and culverts at the low points to ensure that flows can be conveyed under the road and through the Catherine Field (Part) Precinct, as currently occurs.

The flood modelling undertaken by both WMA Water and Brown Consulting show that the area designated as riparian corridor is flood affected. Additionally, a proposed Category 2 riparian corridor is proposed over the majority of area designated as drainage, as negotiated with the NSW Office of Water.

The designated riparian corridor within the subject property is considered to be valid.

**4.8 HIXSON**

Brown Consulting prepared a revised Water Cycle Management and Flooding investigation on behalf of Hixson during the public exhibition phase. The main changes included in the revised strategy were:

- Update the flood modelling to incorporate more detailed survey data.
- Revise the water quantity and quality control strategy based on a revised ILP.
- Incorporate detention and the playing fields where possible for less frequent storms (i.e. events greater than the 20 year ARI event).

**JWP Comment**

The letter report provided by Brown Consulting (included as Appendix 1 in the Hixson submission) provides only a brief summary of the work undertaken and no details on the additional modelling. We therefore suggest that the comments and recommendations provided on the report that was exhibited also apply to the work that was undertaken during the public exhibition phase. The comments and recommendations are provided in Chapter 3 of this document.

The incorporation of detention within the playing fields for less frequent events is supported by J. Wyndham Prince.

**4.9 NSW OFFICE OF ENVIRONMENT AND HERITAGE**

The NSW Office of Environment and Heritage (OEH) submission made several comments with regards to flooding. These summarised and discussed below.

<b>OEH Comment</b>	<b>JWP Comment</b>
<p>Cumulative Impact</p> <p>OEH noted that the flood assessment should consider cumulative impacts for all</p>	<p>As noted previously in the peer review, the report makes the assumption that because</p>

<p>development planned for the Upper South Creek Catchment. The flood model prepared by WMA Water and adopted by Council could be used for this purpose.</p>	<p>flood levels and flows outside the Precinct boundary do not increase, then there will be no cumulative impacts for similar filling regimes on adjacent sites. This assumption has not been confirmed with modelling.</p>
<p><b>Impact from Upstream Catchments</b></p> <p>The Brown Consulting modelling assumes that upstream post developed flows entering the Catherine Field (Part) Precinct do not exceed existing peak flows, based on the mitigation works that will likely occur within the upstream developments.</p>	<p>It is understood that stormwater detention will be provided within the upstream catchments to reduce peak post development flows to existing levels. Therefore the assumption made by Brown Consulting is valid and a similar approach has been adopted in other studies. However, the report does not acknowledge that the timing of peak flows may change and the volume of runoff will almost certainly increase as a result of development and mitigation works. This may potentially impact peak flows within the site and further downstream, particularly when creeks and tributaries merge. It is also noted that GHD prepared a hydrology model as part of the Turner Road Precinct Planning (the upstream catchment). The post development model incorporated detention basins. Although the configuration of the detention basins may have been modified slightly as part of the detailed design, the inclusion of the urban catchment with these basins in Brown's model is considered more appropriate than a rural catchment with no basins.</p>
<p><b>Stormwater Quantity Mitigation Measures</b></p> <p>OEH advises that the detention basin systems should be assessed by the NSW Dam Safety Committee (DSC).</p> <p>Consideration should be given to basins overtopping during all floods larger than the design and to the outflow capacity of the basins. The impact on downstream development and infrastructure should be assessed utilising effective management measures.</p> <p>Subdivision and land use planning should be carefully designed in the precinct particularly with utilisation of a detention basin strategy.</p>	<p>Referral to the DSC is considered to be more appropriate at the development application and detailed design stages. The Brown report could make this comment.</p> <p>Consideration of storms larger than the design event for the basin designs is considered to be more appropriate at the development application and detailed design stages. The flood modelling will indicate the impact on downstream development and infrastructure as long as the terrain represents the developed scenario.</p> <p>It is believed that the proposed detention basin strategy is generally in accordance with the guideline, which recommends locating</p>

<p>It is recommended to refer to the <i>Hawkesbury-Nepean Subdivision Guideline – Designing Safer Subdivision in Flood Prone Areas</i>.</p>	<p>regional basins within the upper reaches of the catchment.</p>
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**4.10 STATE EMERGENCY SERVICES**

The State Emergency Services (SES) submission raises a number of issues with regards to flooding. These are summarised and discussed below.

<p><b>SES Comment</b></p>	<p><b>JWP Comment</b></p>
<p>Flash Flooding</p> <p>Consideration should be given to the potential risk from flash flooding in the area.</p>	<p>The flood modelling for the PMF shows only a very small portion of the proposed development is affected from flooding in the creek and drainage reserve network. The development is therefore not considered to be at a great risk from flash flooding other than what may occur from local overland flows.</p>
<p>Cumulative Impacts</p> <p>The cumulative impact of filling in the floodplain should be assessed.</p>	<p>As noted previously in the peer review, the report makes the assumption that because flood levels and flows outside the Precinct boundary do not increase, then there will be no cumulative impacts for similar filling regimes on adjacent sites. This assumption has not been confirmed with modelling.</p>
<p>Flood Evacuation</p> <p>Steadily rising local roads linking to arterial or regional routes should be provided to enable timely evacuation during floods. It is also recommended that a section on flood evacuation route design considerations is included. The SES submission also identifies a number of significant associated risks with a 'shelter-in-place' strategy.</p>	<p>As discussed within the peer review, the flood evacuation strategy for the Precinct is not clear as there are contradictory statements within the report.</p> <p>Given the PMF flood mapping shows some areas of inundation within the proposed development footprint, it is considered necessary to prepare a flood evacuation plan as part of the Precinct Planning process to ensure that the necessary design requirements and controls are identified and managed prior to the DA phase. The identified controls should be incorporated within the Development Control Plan.</p> <p>It is likely that the evacuation strategy will be very simple as flood depths within the development are expected to be minor</p>

	<p>(developed case PMF flood depth map not provided in Brown report). In this case affected residents should be able to evacuate to higher ground via continuously rising local roads and shelter in place with neighbours or other centres external to the Precinct. The flood evacuation strategy should be confirmed in any future revision of the study.</p>
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## **5 CONCLUSION AND RECOMMENDATIONS**

The peer review has identified several issues with the Brown Consulting Water Cycle Management and Flooding Strategy that require clarification and possibly additional modelling. The recommendations from the peer review are included in each section within Chapter 3 and also repeated below.

### **Hydraulic Modelling**

- The report should be updated to include more details of the modelling process and the assumptions and parameters used in the modelling. This will allow the various stakeholders to determine whether the modelling meets their requirements and is fit for purpose.
- If required by the Department of Planning and Infrastructure, the additional flood surface profiles should be mapped in accordance with the project brief (2, 20, 200 and 500 year ARI events).
- If additional hydraulic modelling is undertaken, the use of a finer grid (say 2 metres) should be considered.
- Details of the digital elevation model used in the developed case scenario should be made clearer, for example, extent of fill, compensatory storage and site regrading. The digital elevation model should also include any proposed regrading work within the PMF extents (such as detention basins and perimeter roads) to ensure that this event is mapped correctly.
- A summary of peak existing and developed case peak flows from the hydraulic model should be included to confirm the proposed development does not have an adverse impact once the loss of floodplain storage is taken into consideration.
- Although Camden Council appears to have adopted the Flood Study undertaken by WMA Water, which includes trimming flood depths of less than 150mm, this position should be confirmed as it potentially results in a non-conservative outcome.
- A floodway definition assessment should be undertaken for the Brown Consulting hydraulic modelling if filling in the floodplain is proposed.
- A sensitivity assessment should be undertaken in accordance with the project brief to test the sensitivity of flood levels to the assumptions and parameters used in the modelling.
- The report should include a discussion on the future hydraulic structures (bridges, culverts, etc.) incorporated in the modelling, including the assumptions, parameters and blockage factors adopted. If the modelling does not currently include the future hydraulic structures, these should be incorporated as they will almost certainly impact flood levels.
- Clarification should be provided on how there is only very minor or no impact on existing flood levels in the Precinct when the floodplain is being substantially constricted in the developed case and an increased roughness factor should also have been applied to account for revegetation of the riparian corridor.
- The cumulative impact of filling in the floodplain be assessed on a catchment wide basis using Council's adopted model or other model covering the same area.

- The need to provide a trunk drainage corridor to the west of South Creeks needs to be clarified. It is not clear whether flows from this large area can be practically or safely conveyed in the pipe and street drainage network.

### **Water Quantity (Hydrologic) Assessment**

- Seek clarification from Brown Consulting on which hydrologic model they were instructed to use in the assessment and whether it was agreed not to incorporate the previously modelled detention basins within the Turner Road Precinct. If further hydrologic modelling is undertaken, it is recommended that the upstream basins be incorporated if possible.
- Brown Consulting to confirm whether the basins have been designed to attenuate 2 and 5 year ARI flows in accordance with the brief and the Camden Growth Centre DCP.
- Include a comparison of peak flows between the various hydrologic models to confirm consistency.
- Brown Consulting to confirm that the areas allocated for the detention basins are adequate, including provision for berms, batters, curtiledge and access tracks (as required).
- The catchment plan should include catchment areas and catchment names that correlate to the hydrologic model for clarity in future reviews or use of the model. Detention basins names in the report and model should also correlate.

### **Water Quality Assessment**

- The MUSIC modelling be refined to include a breakup of the various land uses within each subcatchment (roads, roofs and other urban areas).
- Rainwater tanks be incorporated in the model (if they are proposed) to capture a percentage of runoff from the roofs.
- The model should use 6 minute rainfall data instead of daily data.
- The soil properties and pollutant concentrations for each source node should be modified to be consistent with the Technical Note for development within the Growth Centre Precincts, issued by the Department of Environment and Conservation.
- The model should be reanalysed with the above amendments to ensure the proposed water quality devices are adequate to achieve the required pollutant target reductions.
- The model should reflect the adopted ILP stormwater management arrangement.

### **Stream Erosion Index**

- A stream erosion index assessment be completed using the amended MUSIC model (see Section 3.6) in accordance with the Draft NSW MUSIC Modelling Guidelines (BMT WBM, SMCMA, 2010).

### **Flood Evacuation Strategy**

- The flood evacuation strategy should be clarified. The strategy also needs to be developed in consultation with Council and the SES to ensure compliance with their requirements.

The submissions received during the public exhibition phase that relate to water cycle management and flooding have been reviewed. The comments and recommendations, which are provided in Chapter 4, are extensive in some cases and have therefore not been repeated here.



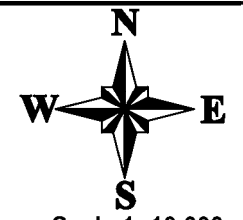
## APPENDIX A – FIGURES

**J. WYNDHAM PRINCE**

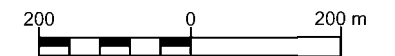
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS & PROJECT MANAGERS  
 PO Box 4366 PENRITH WESTFIELD NSW 2750  
 P 02 4720 3300 W www.jwprince.com.au  
 F 02 4721 7638 E jwp@jwprince.com.au

**LEGEND**

- INCREASE IN TERRAIN LEVELS (m)**
- 0.4+
  - 0.36
  - 0.32
  - 0.28
  - 0.24
  - 0.20
  - 0.16
  - 0.12
  - 0.08
  - 0.04
  - 0
  - 0.04
  - 0.08
  - 0.12
  - 0.16
  - 0.20
  - 0.24
  - 0.28
  - 0.32
  - 0.36
  - 0.4+
- PRECINCT BOUNDARY
- EXISTING 100 YEAR ARI FLOOD EXTENTS (BROWNS)



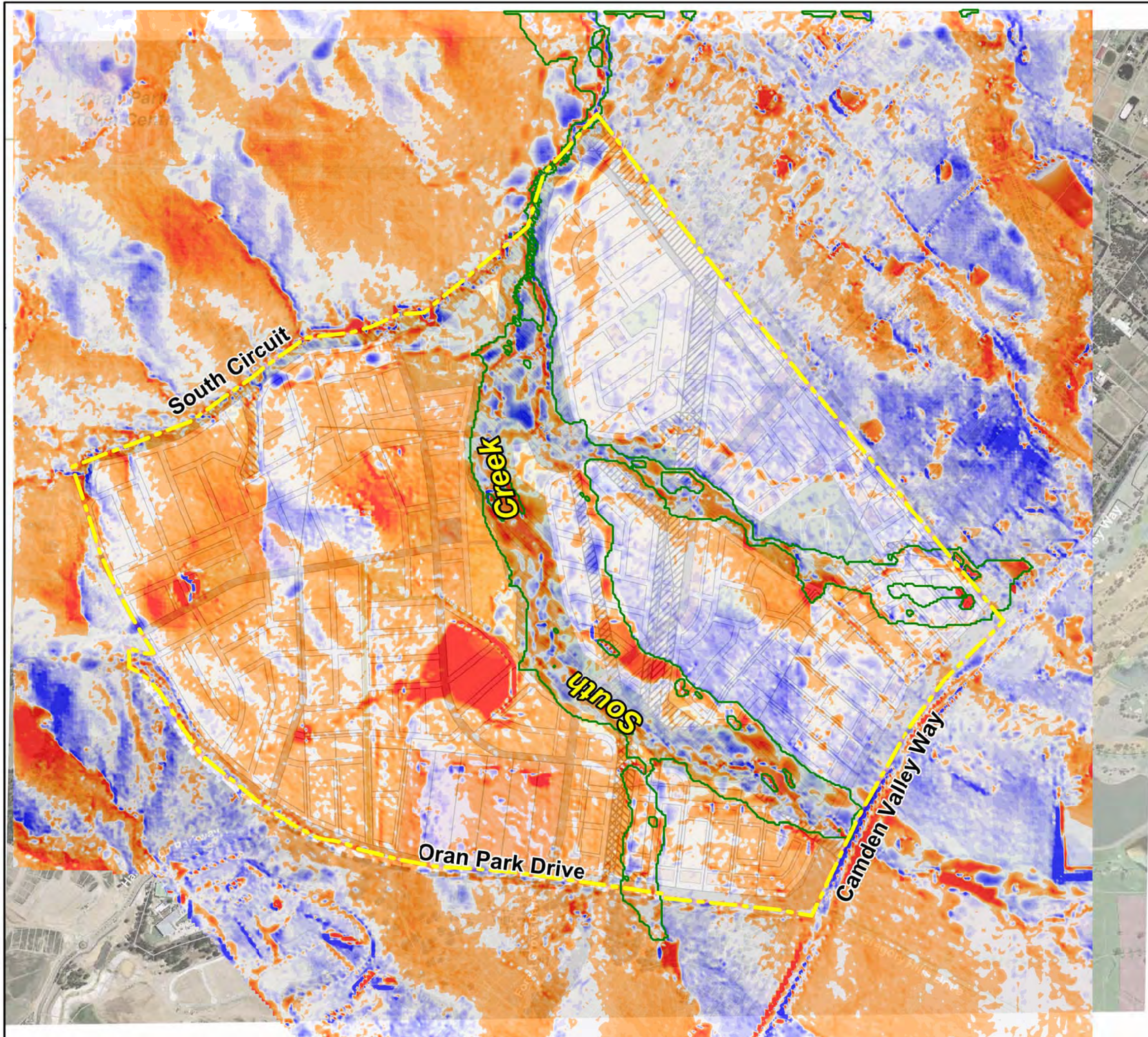
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**Figure 1**

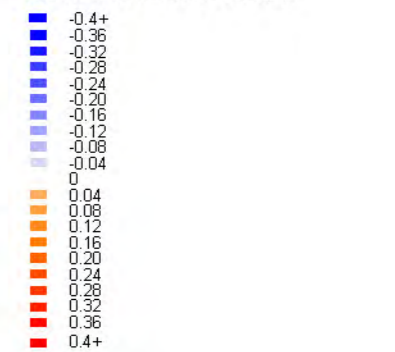
**Catherine Field (Part) Precinct**

**Terrain Difference Map  
 Brown Terrain - WMA Water  
 Terrain**



**LEGEND**

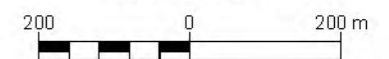
INCREASE IN FLOOD LEVELS (m)



--- PRECINCT BOUNDARY  
 WMA WATER 100 YEAR FLOOD EXTENTS (TRIMMED FOR DEPTHS LESS THAN 150mm)



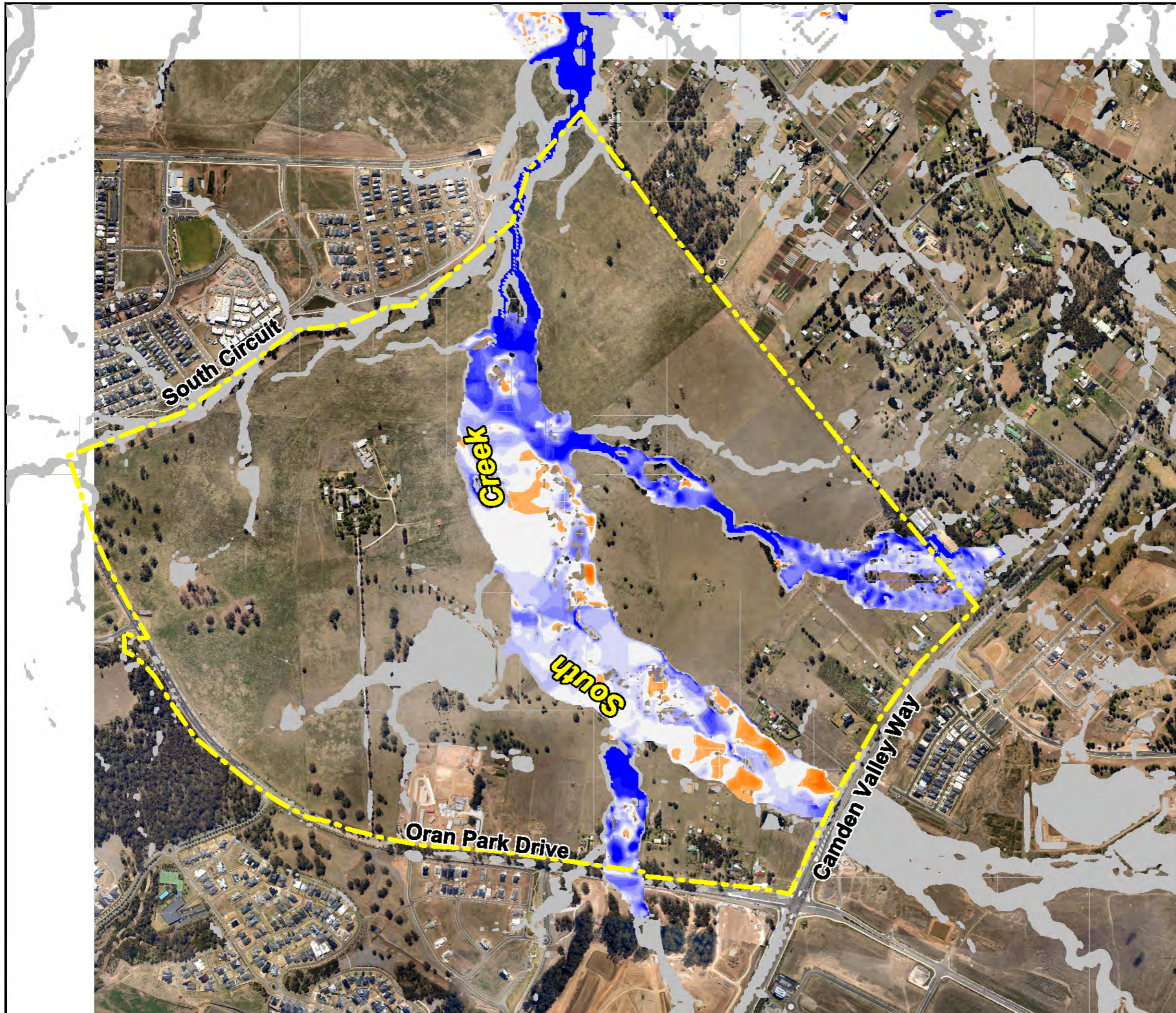
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**Figure 2**

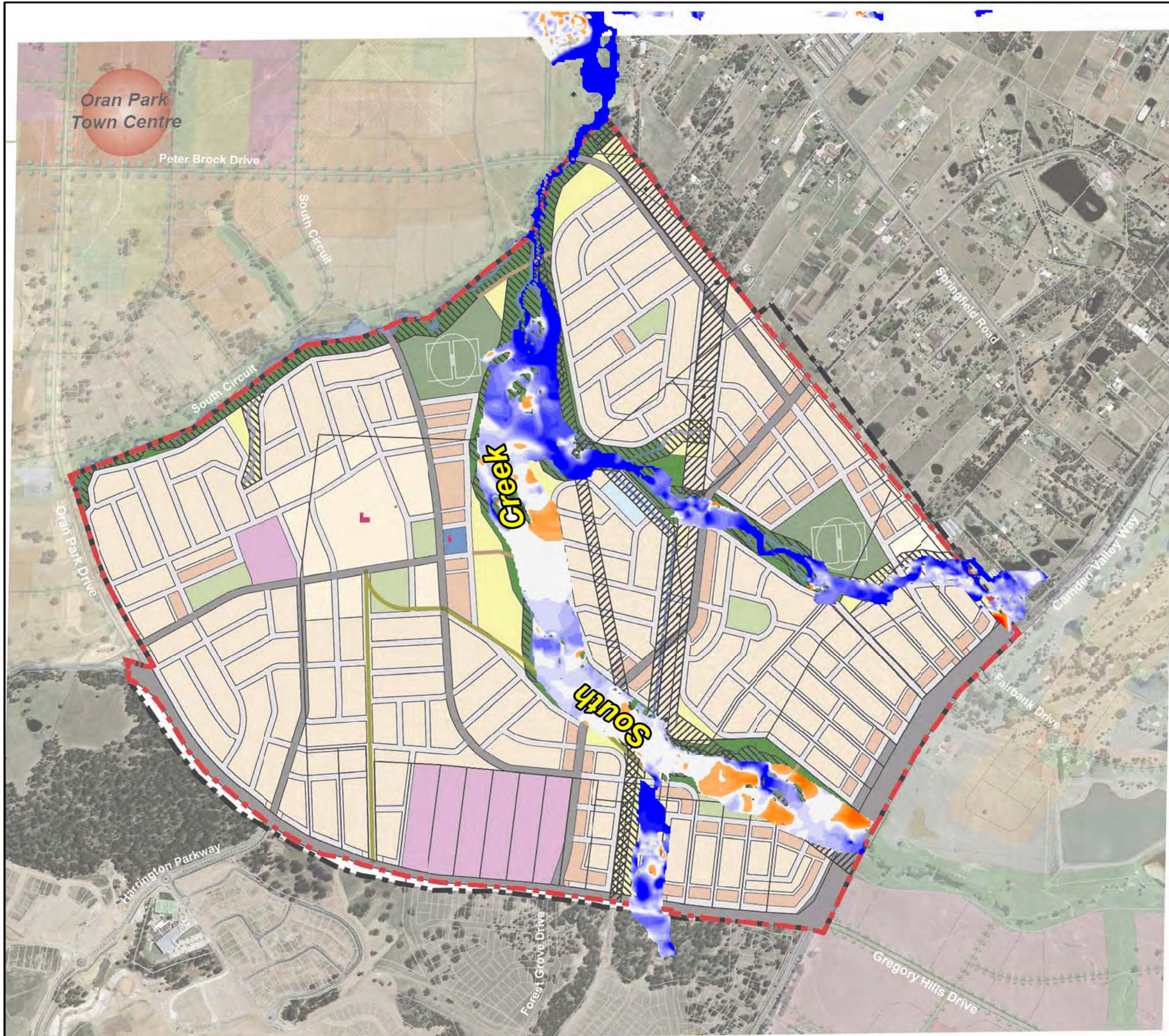
**Catherine Field (Part) Precinct**

100 Year ARI Difference Map  
 Brown Existing - WMA Water Existing



**J. WYNDHAM PRINCE**

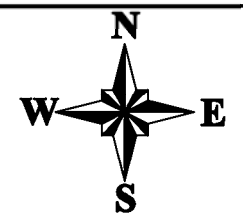
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS  
& PROJECT MANAGERS  
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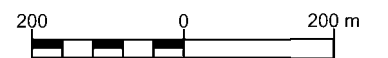
**LEGEND**

INCREASE IN FLOOD LEVELS (m)

- -0.4+
- -0.36
- -0.32
- -0.28
- -0.24
- -0.20
- -0.16
- -0.12
- -0.08
- -0.04
- 0
- 0.04
- 0.08
- 0.12
- 0.16
- 0.20
- 0.24
- 0.28
- 0.32
- 0.36
- 0.4+



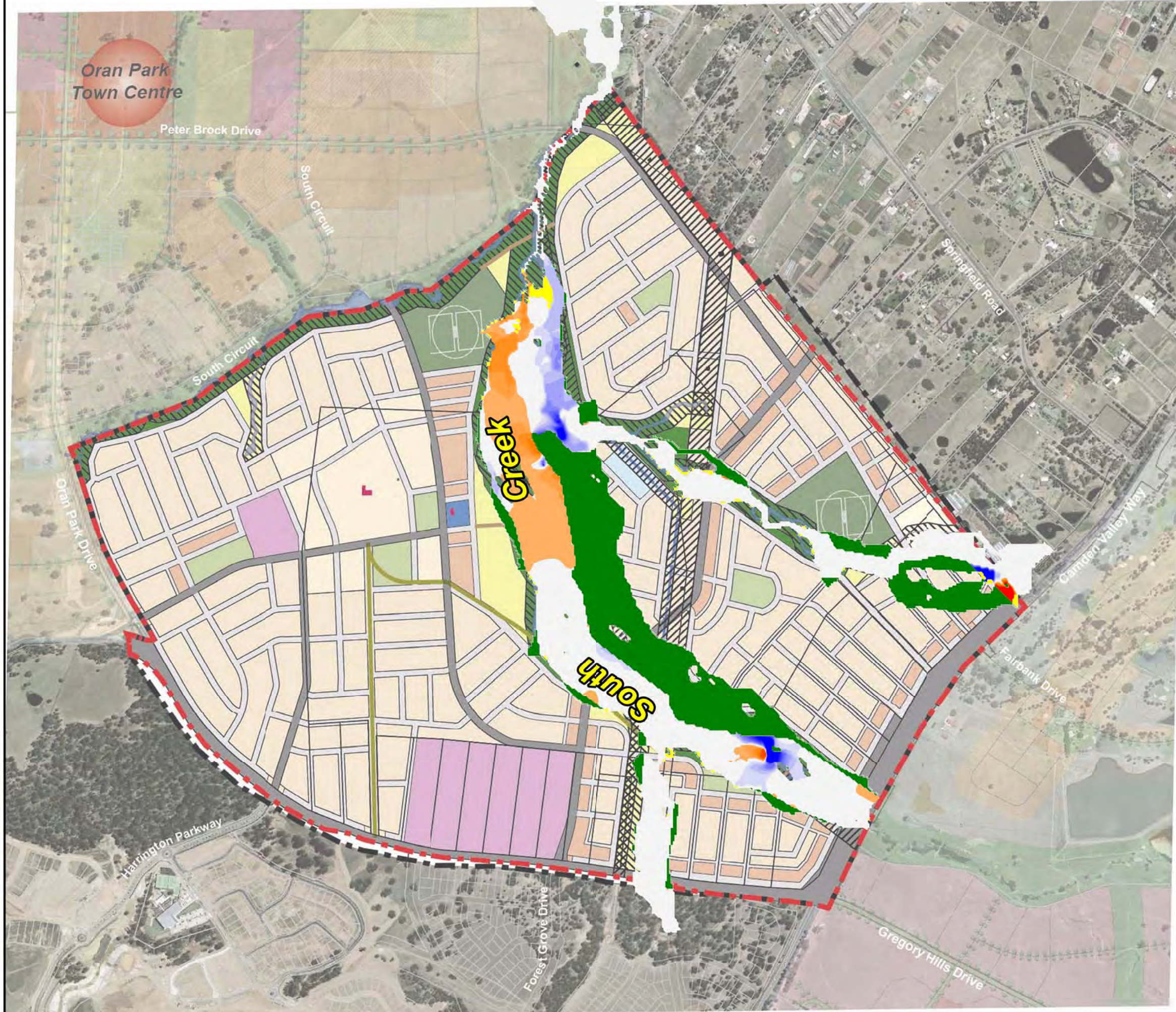
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**Figure 3**

**Catherine Field (Part)  
Precinct**

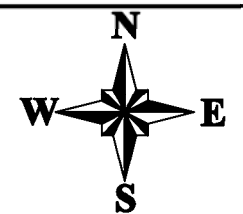
**100 Year ARI Difference Map  
Brown Developed - WMA Water  
Existing**



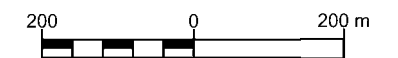
**LEGEND**

INCREASE IN FLOOD LEVELS (m)

- -0.4+
  - -0.36
  - -0.32
  - -0.28
  - -0.24
  - -0.20
  - -0.16
  - -0.12
  - -0.08
  - -0.04
  - 0
  - 0.04
  - 0.08
  - 0.12
  - 0.16
  - 0.20
  - 0.24
  - 0.28
  - 0.32
  - 0.36
  - 0.4+
- AREAS NOW FLOOD FREE  
 ■ AREAS NOW FLOOD AFFECTED



Scale 1: 10,000 @ A3



**Figure 4**

**Catherine Field (Part) Precinct**

**100 Year ARI Difference Map  
 Brown Developed - Brown Existing**