Appendix A - 2006 Master Plan Priority Works Map

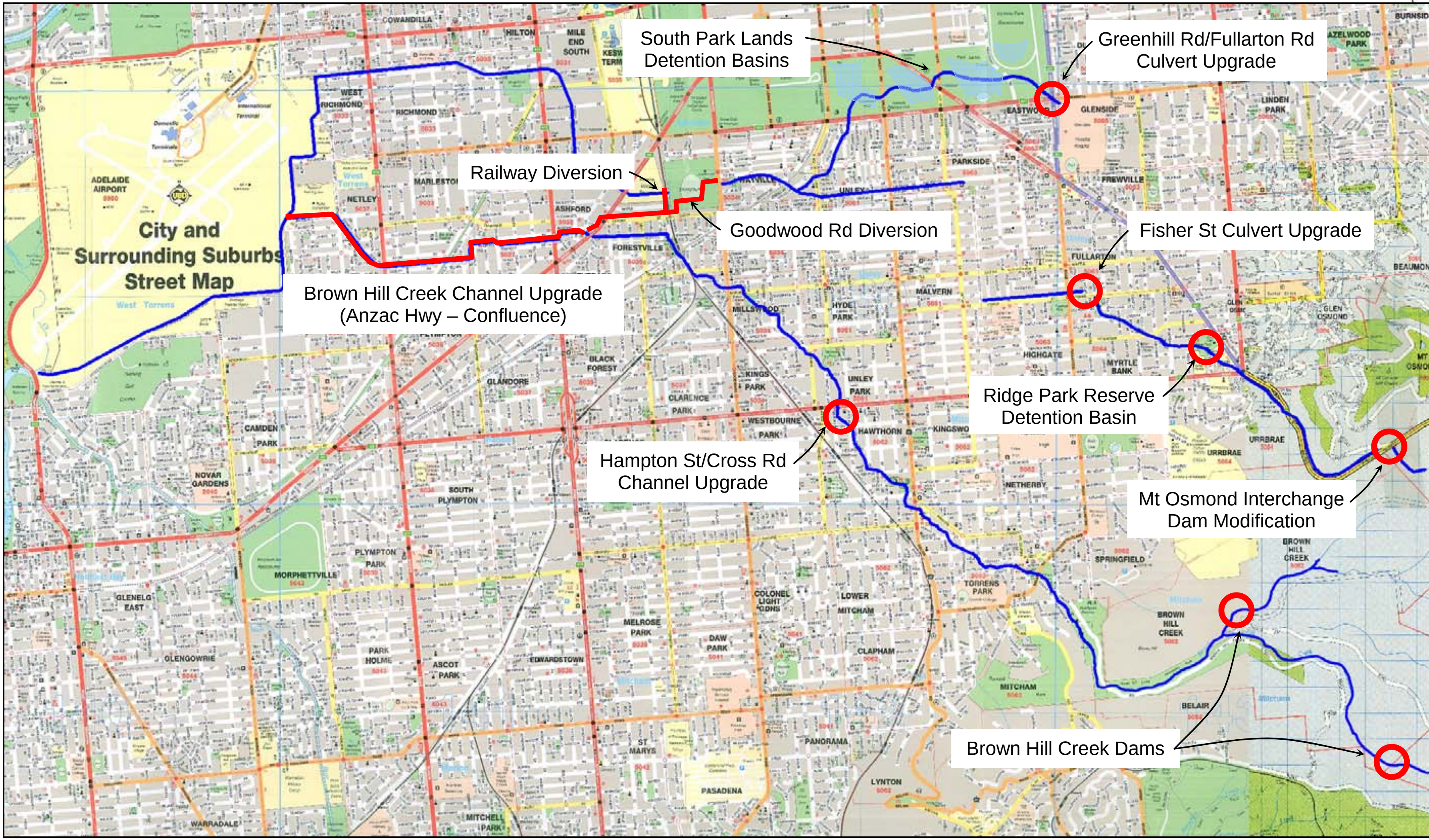

Figure 5-2 Map showing locations of priority works components.

Appendix B - City of Unley Submission to BHKCSP on 2011 Draft SMP

Submission to: Brownhill Keswick Creek Stormwater Project

Discussion Paper: Brownhill Keswick Creek Draft Stormwater Management Plan 2011

From: City of Unley

Date: May 2012

Introduction

Developing and agreeing to a strategic direction for the management of stormwater through the Brownhill and Keswick Creek catchment is a high priority for the City of Unley (Unley or the Council). Unley supports the planned whole of catchment approach by the participating councils and the intention of reducing the effects caused by flooding to property, people and infrastructure presented in the draft Stormwater Management Plan.

The submission on the Brownhill Keswick Creek Draft Stormwater Management Plan 2011 is outlined in the following topic areas, which provide suggestions, ideas, alternatives and questions to aspects of the draft Plan.

General Comments

1. Unley strongly supports the development of this plan and its objectives to reduce the effects of a 1:100 year ARI flood. The Council has identified in the draft Plan that 5 out of the 11 structural mitigation works are located within the Council area (with a construction value of $55.4m) these are:
    a. Develop an inline flood detention system in Ridge Park Reserve and rehabilitate stream ($0.7m)
    b. Bypass Culvert at Fisher Street ($4.3m)
    c. Keswick Creek to Brown Hill Creek Diversions at Le Hunte Street and Anzac Highway ($30.0m)
    d. High-Flow Bypass Culvert between Malcolm Street and the Glenelg Tramway ($11.3m)
    e. Brown Hill Creek Channel Upgrades between Leah Street and Anzac Highway ($10.1m)

2. The Council will require, if one of the new options proposed by the City of Mitcham becomes a viable alternative, a new round of public consultation for the residents of Unley be conducted to gauge public and stakeholder opinion and support.
3. The council will also want to independently review any new option to determine its direct and indirect economic, social and environmental impacts on the Unley community.

Technical – General

4. There are questions form council officers that roads identified for some of the diversion works may not have the ability to support the extra infrastructure. This is particularly the case for Fisher Street which already has sewer, water and fibre optic services and has also been identified to host the recycled water pipeline from the Ridge Park MAR. Planning should also consider the possible impacts of the proposed rail grade separation at Unley Park and Millswood.

5. It will be important to ensure that for all the works proposed for road within the Council area that any proposed kerbing, roadworks and footpath works scheduled for streets are timed to avoid conflict with the project and the cost of possible rework. It is therefore important for the Council to know the timings of the following projects within the plan: the bypass culvert for Glen Osmond Creek at Fisher Street Fullarton, Malcolm Street high flow bypass, Keswick Creek Diversion and the Upgrade of creek channel between Leah Street and Anzac Highway.

6. Bridge Upgrades: The City of Unley has an active asset management program in relation to its bridge structures. This program delivers regular inspections that correspond to a frequency dictated by the last reported condition of the bridge. This in turn provides information for the reporting, planning and replacement of bridge structures as required. In recent years, as a part of these replacement works, bridges have been designed with the intention of providing a flow capacity that is consistent with current 100 year ARI flow estimates. However, as described in the draft Plan (page 36), the provision of a greater flow capacity can create “the potential to transfer breakouts to downstream locations”. Where this has been known to be an issue, in recent years some bridges have been designed with either the ability to be duplicated in the future, or throttled with a demountable obstruction in order to not transfer flood risk.

   There is an opportunity for the Plan to:

- Identify all of the bridges requiring replacement in order to achieve a capacity that is consistent with that creek reach; and
- Identify any encumbrances (downstream works that must be completed) prior to that being upgraded to full design capacity

This will provide the Catchment Subsidiary with the necessary information to coordinate future delivery of various works packages in an integrated and orderly manner with Council bridge upgrade projects, and vice versa.

7. While the City of Unley would like to ensure base flows are maintained through private properties when the diversion drains are installed to preserve environmental, amenity and social interaction with the creek systems, ongoing maintenance of the privately owned channels remains crucial and an appropriate action plan should be developed.

Technical – Glen Osmond Creek

8. Flood Plain Mapping: An error in the flood plain mapping, in relation to a breakout of flows from Glen Osmond Creek at Wycliff Street has been noted. The report (page 20) states that:

   "a new 1500 mm diameter culvert was installed in 1996 that effectively bypasses the culvert at Wycliff Street. The culvert has not yet been incorporated into the hydraulic model of the creek system. This oversight dates back to the 2006 Master Plan and was only identified late in the course of the current investigation. It is estimated that the culvert has sufficient capacity to take a majority of the existing 100 year ARI flow along Glen Osmond Creek (and is expected to accommodate the entire flow if upstream detention works are carried out). As a result, in reality the extent of the flow breakout at this location is expected to be significantly reduced (and almost eliminated)"

9. The Council requests that the five catchment councils be provided with updated current, mid and post-upgrade works flood plain mapping to ensure that each development assessment process is using current information. The modelling also introduces some uncertainty in relation to the post-upgrade performance standard that will be achieved and whether the required scope of works has been appropriately defined.

10. Fisher Street Bypass Culvert (Fisher Street to Windsor Street): This culvert is described in the draft Plan (page 89) to:

"Reduce potential breakouts further downstream on Glen Osmond Creek between Fullarton Road and Windsor Street and to effectively reduce reliance on the creek within private properties where maintenance of the creek is problematic."

Investigations need to be undertaken to a sufficient level to confirm the following questions:

   a. That a capacity deficiency exists in this section – Hydraulic modelling contained in WBCM (1984) suggests that a flow of 10 m^3/s could pass through this section, with upgrades to the Cross Street and Torrens Avenue bridges.
   b. That existing development and lack of easements precludes the opportunity to upgrade this section in its existing alignment, if a capacity upgrade is required.
   c. That the long term cost in maintaining 2 drainage lines (the existing creek line will need to be maintained for drainage of adjoining houses and local street drainage) are favourable in comparison to the alternative scenario of maintaining a single channel.

11. Windsor Street (Fern Avenue to Henry Codd Reserve): The Windsor Street section was designed to a flow rate regime that progressively increased from 7.7m^3/s at Fern Avenue. This flow corresponds to the 50 year ARI flow reported in WBCM (1984). Further analysis need to be undertaken to confirm that the Windsor Street section has sufficient capacity to accept the proposed flow of 12 m^3/s (100 ARI) from the Fisher Street bypass culvert. Further, this raises the possibility that the plan might need to account for installation of further capacity on the Windsor Street section (through to the northern end of Henry Codd Reserve at which point the drain capacity increases to correspond with the current 100 year ARI flow estimate), to provide a consistent 100 year ARI standard.

12. Unley Road (Henry Codd Reserve to King William Road): The Council has progressively implemented works that have increased the capacity of Glen Osmond Creek between King William Road and Fern Avenue. While the last significant section was recently completed, a short section at Unley Road remains incomplete. This section has an approximate 5 year ARI capacity and will continue to cause overflow into Culvert Street and Unley Road during heavy storm events. Specifically, this element is comprised of:

   a. Replacement of an old twin cell culvert structure under Unley Road; and

b. Construction of a short section of 1200mm diameter drain in Culvert Street to augment the capacity of the existing culvert immediately upstream of Unley Road that is aligned under shop frontages and townhouse driveways.

The completion of these works at Unley Road is considered to be of merit and justifiable for inclusion within the draft Plan.

The integration of these works within the draft Plan will enable the Brown Hill Keswick Creek Stormwater Project to appropriately coordinate the works in a manner that ensures the orderly delivery of various elements (i.e. oversee the provision of appropriate works downstream prior to the removal of the ‘bottleneck’ at Unley Road).

13. King William Road: The Council believes further assessment of the capacity of the King William Road culverts and the immediate downstream creek (generally privately owned) is also required during the development of the Stormwater Management Plan ‘Part B’ considerations.

Technical – Keswick Creek

14. Le Hunte Street: Downstream of the junction through to Le Hunte Street, the draft Plan nominates (indicatively) that a 50 year ARI performance standard will be achieved (page 102). A reference is made to the influence of the tramway crossing (page 103) however options for achieving a 100 year ARI standard have not been presented.

15. Showgrounds Drainage Line: The section of Keswick Creek through the Adelaide Showgrounds is not covered by an easement to Council, and responsibility for this asset rests with the SA Government. This culvert section is old, and passes under a number of large buildings and historic structures. Given that the draft Plan is reliant on this section of creek to continue to provide its current capacity, responsibilities for ongoing monitoring, maintenance and planning/funding and ultimate replacement of this section should be clearly articulated in the Plan.

Technical – Parklands Creek

16. In addition to the 5 components listed in 1, the South Parklands Detention Basin component may include some bridge upgrade works on Parklands Creek (Young Street) within the City of Unley. It is anticipated that should these works be required, that this upgrade work will be accounted for

within the South Parklands Detention Basin project. The Council will also use its participation on the Steering Committee for this project to present this option.

Technical – Brownhill Creek

17. Cross Road to Malcolm Street: The 100 year ARI peak design flow for this section is understood to be 28m³/s. This exceeds the capacity of some road bridges in this section, as reported in HydroTasmania (2003) and WBCM (1984). The draft Plan notes (page 104) that “some residual over bank flooding is expected to occur upstream from Heywood Avenue, which may affect the rear of up to 5 properties.” It is likely that bridge upgrades at Heywood Avenue and Whistler Avenue would largely address this residual flooding.

Financial

18. There is concern that the current timeframe for the allocation of $14m over 7 years for the development of the infrastructure could be extended. The Council would support an increase to 10 years which allows for a more financially manageable timeframe.

19. The draft Plan offers some brief speculation (page 121) on the role of a Catchment Subsidiary in relation to asset maintenance responsibilities associated with the structural mitigation works components, beyond the implementation phase, with a maintenance budget of $0.1m/yr (page116), for an asset with an overall value of $133m. This would seem to be inadequate to maintain the proposed stormwater system and put a heavy burden on the local council to fund.

20. It is also noted that financial allocation for depreciation has not been identified.

21. The draft Plan notes that the respective Councils would be expected to fund maintenance of creek channels within their area, while the Regional Subsidiary would fund maintenance of the other elements. Would this include private ownership or is it only for public area?

Open Space

22. Currently the alignment of diversions, particularly from Cross Road through to Anzac Highway are predominantly aligned along road and rail corridors. The management objectives of the draft Plan identify with mitigating flooding but also identify opportunities for open space, recreation and

walking and cycling paths. The objective reflecting this states: *'Promote opportunities for multi-purpose benefits in structural stormwater management measures, including passive recreation, pedestrian and cycle paths, water quality improvements, biodiversity improvements and stormwater reuse'.*

a. The development of this flood mitigation infrastructure presents a unique opportunity to provide community benefits well beyond flood mitigation as already well documented through the stormwater works in Windsor Street and the Glen Osmond Creek redevelopment.
b. It is well documented that the City of Unley has the lowest ratio of open space per head of population in SA and in the recent review of Unley's Open Space Recreation Strategy it identifies the need for the Council to consider open space requirements now and into the future, particularly with the proposed increase in higher density housing identified for the city by the State Governments 30 Year Plan.
c. It is suggested that further investigation be undertaken and consideration given to exploring the possibility of the culvert and diversion systems currently proposed being moved to align with the Brownhill Creek. An example of where this would be possible is Wilberforce Walk in Forestville.
d. While this would have an increased financial cost, the benefits to social infrastructure and environmental enhancement of the City of Unley.
e. The potential possibility of creating a linear open space system that extents from the Mitcham Hills along Brownhill Creek through Unley and linking up with the Tramline Trail and the Parklands Trail would create a network open space system that provides recreation opportunities, amenity, social and environmental values.
f. In addition this could create an open space network for greater Adelaide that would provide off road linkages with Tea Tree Gully, Henley Beach, Glenelg, Adelaide and Mitcham as well as all the suburbs in between.
g. The next time this opportunity will present itself (if ever) the population density of Unley will be higher than we have now and new open space opportunities will be far more limited and expensive to create.

Planning and Policy

23. The City of Unley supports the Planning Policy and Development Assessment initiatives of the Plan as positive.

24. The Council's Assessment Guidelines for developments that are identified to be in areas prone to flooding were developed to streamline processing of Development Applications but the Development Plan currently lacks support in a policy context. This will be addressed when the draft Village Living and Desirable Neighbourhoods Development Plan Amendment - Stage 2 (Residential Character, Growth Areas and General Residential and Sustainability Policy Review) DPA 2, outlined in point 21.

25. The City of Unley draft Village Living and Desirable Neighbourhoods Development Plan Amendment - Stage 2 (Residential Character, Growth Areas and General Residential and Sustainability Policy Review) [DPA 2] has been endorsed by Council in November 2011 as a draft and submitted to the Minister for Planning for approval to release for public consultation, recognises these issues and seeks they be addressed by:
    a. incorporating flood hazard mapping into the Development Plan (including low, mid and high categories)
    b. consolidating and refining hazard (flooding) policy principles to tailor the approach for development design and assessment for low, mid and high categories
    c. consolidating and strengthening sustainability policy to reinforce WSUD (and energy efficiency) in all development (as far as practicable)

26. As flood mitigation works occur, and new modelling reveals changes to affected land, the mapping in the Development Plan will need to be changed. To change the mapping will require a full DPA process, meaning the development assessment criteria will be out of sync for a lag period while updating occurs. Strictly speaking the Development Plan maps and policy must apply, but a level of common sense and use of 'official' new modelling may be considered to temper an assessment.

Private Ownership

27. The private ownership of sections of creek along the Brownhill and Keswick Creeks have always provided a number of challenges when it comes to providing a clean creek system free of weeds, tree growing in the water course and modified banks in private ownership. The City of Unley has

been proactive in recent years in the maintenance of creek areas flowing through community land. This is reliant on all parts working together to achieve the identified objective, and therefore is only as strong as its weakest link. It is vital, for the success of the Brownhill Keswick Creek Draft Stormwater Management Plan, that the responsibility of maintaining a private section of creeks be effectively managed, monitored and enforced.

Community Consultation Report

28. The City of Unley has reviewed the Community Consultation Report produced by Urban and Regional Planning Solutions (URPS) for the five catchment councils.

Appendix C - Notification of 2012 SMP Strategy

Brown Hill Keswick Creek Stormwater Project

C/o City of Unley
PO Box 1
Unley SA 5061
Ph 8372 5111
Fax 8271 4886

30 April 2012

Mr Barry Grear AO
Presiding Member
Stormwater Management Authority
GPO Box 2834
Adelaide SA 5001

Dear Mr Grear

Stormwater Management Plan Strategy

I am writing to update the Authority on progress in finalizing a stormwater management plan (SMP) for the project. The Chief Executive Officers of the five catchment councils will be recommending to their respective councils in May the following strategy.

The Chief Executive Officers believe that the strategy presents a significant opportunity to deliver four key outcomes for all catchment communities:

1. Committing the councils to commence flood mitigation works (Part A Works)
2. Agreement on cost apportionment between the councils
3. Presenting a strong case and united front to the Commonwealth Government for funding support
4. Pursuit of a 'no dam' solution subject to its feasibility and community acceptance across all councils (Part B Works)

Proposed Strategy

1. It is proposed that:

   (a) The catchment councils recommend to the Stormwater Management Authority a stormwater management plan (the '2012 SMP') comprising the following points, as described in subsequent paragraphs:

   - Flood mitigation works for Part A of the catchment subject to effective flood mitigation performance and cost controls (paragraph 2)

- A process for determination of flood mitigation works for Part B of the catchment (paragraphs 5 - 12)
- Other flood mitigation measures (paragraph 13)
- Other information required to satisfy the Stormwater Management Authority Planning Guidelines (paragraph 14);

and

(b) The catchment councils, on approval of the 2012 SMP, undertake to agree the full scope of flood mitigation works for the catchment and incorporate them in the SMP (the 'Final SMP') in accordance with the process described in paragraphs 5 – 14.

Part A Works

2. The Part A Works comprise:

   (a) The following structural flood mitigation works of the *Draft Stormwater Management Plan* report of August 2011 by WorleyParsons (the '2011 Draft SMP'), as generally described in Section 11.1 and as varied by subsequent advances in design:

   - Detention basins in the South Park Lands / Glenside Campus (concept design completed)
   - Flood detention dam in Ridge Park Reserve (tender for full design to be let in April)
   - Bypass culvert in Fisher Street
   - Keswick Creek to Brownhill Creek diversions (Le Hunte / Leader Streets and Anzac Highway) (concept design completed)
   - Brownhill Creek channel upgrade between Leah Street and Anzac Highway (including the Highway culvert) to be designed to allow for the no-dam option in Brownhill Creek
   - Brownhill Creek channel upgrade from Anzac Highway to the confluence with Keswick Creek (concept design planned to be implemented in 2011/12);

   and

   (b) Channel upgrade and repairs relevant to Glen Osmond Creek, Parklands Creek and Keswick Creek as may be required as a result of the channels assessment investigation being carried out for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.

3. Planning details for the Part A Works are established and in some cases designs have been advanced to the concept stage or are entering detailed design.

4. The flood mitigation impact of the Part A Works (collectively or individually) has not been modelled. However, from extrapolation of other modelling scenarios

carried out for the 2011 Draft SMP, the effect for the 100 year ARI will be assessed.

Process – Part B Works

5. The Councils will determine the Part B Works (i.e. those works in upper Brownhill Creek generally above Forestville Reserve) by the process specified in the following paragraphs.

6. The councils, recognizing community opposition to a dam in the upper reaches of Brownhill Creek, commit to a preference to pursue a feasible and whole of catchment community supported 'no dam' solution with a target date for agreement of a feasible solution within 12 months of gazettal of the 2012 SMP.

7. Current investigations centre on structural mitigation works as outlined in the 2011 Draft SMP (Section 11.1), the *Bypass Culvert Feasibility Assessment* report by WorleyParsons of April 2012 and the channels assessment by the Adelaide and Mount Lofty Ranges NRM Board, being:

   - Channel improvement works to Brownhill Creek in Mitcham and parts of Unley
   - High flow by-pass culvert from Hampton Street to Malcolm Street (considering two routes – one via Grove Street and the other adjacent to the main railway line)
   - Upgraded high-flow bypass culvert between Malcolm Street and the Glenelg tramway (Forestville Reserve)

8. Determination of the Part B Works will include:

   - Description of the works to level of detail consistent with that of the Part A Works of the draft SMP, as a minimum standard
   - Estimated cost of design and construction to a level of detail consistent with that of the Part A Works of the draft SMP, as a minimum standard
   - Implementation program to be integrated with that of the Part A Works of the draft SMP
   - Any other information relevant to the Part B Works required for the draft SMP to satisfy the SMA Planning Guidelines (and to meet the objectives of the draft SMP)

9. In determining the Part B Works, the councils will:

   - Engage suitably qualified experts, including consultants if necessary, for technical or other investigations (including floodplain modelling) as appropriate

- Carry out community consultation in respect of the proposed Part B Works to satisfy, as minimum, the SMA Planning Guidelines and council policy requirements
- Provide the necessary funding in accordance with the currently agreed cost sharing arrangement, or as otherwise subsequently agreed, for development of the SMP and community consultation (the cost sharing arrangement assumes 50% contribution from the SMA)

10. In determining the Part B Works, the councils will use their best endeavours and negotiate in good faith to reach agreement on works which have a total estimated construction cost inclusive of Part A Works not exceeding a benchmark cost and any subsequent adjustments approved by the Councils.

11. Estimated costs to be based on December 2011 values (escalated by ABS reference data).

12. If the councils fail to agree on a Final SMP (paragraph 1) within the required timeframe (paragraph 6) they will inform the SMA accordingly.

Stormwater Management Plan

13. Other flood mitigation measures, to be included in the 2012 SMP and the Final SMP are the non-structural management actions identified in section 11.4 of the Draft 2011 SMP.

14. Other content of the 2012 SMP and the Final SMP will include, but may not necessarily be limited to:

    - Stormwater management objectives
    - Stormwater harvesting
    - Other multi-purpose benefits
    - Benefit-cost analysis (for each component separately and in conjunction with the other components)
    - SMP implementation including establishment of regional subsidiary
    - Implementation program
    - Estimated cost (construction and maintenance) and annual budgets

Funding Agreement

15. The proposed flood mitigation works represent a significant project for metropolitan Adelaide and South Australia. The proposed capital works would also potentially impose an unreasonable burden on local communities and local government. As such, commitment by the five catchment councils to the 2012 SMP and the Final SMP is on the understanding that councils will continue to

pursue shared funding for the whole of the detailed design and construction of the Part A and Part B flood mitigation works of the project between the three spheres of government in the following proportions:

- Commonwealth Government – 1/3
- State Government – 1/3
- Local Government – 1/3

16. Separate funding provisions are to remain in place to fund development of the SMP (including public consultation, investigation and preliminary scheme design) where the State (via the SMA) and local government agree to fund 50% each of the development costs.

17. Local government will continue to fund 100% of the project administration costs.

18. It is proposed that the five catchment councils cost sharing for the local government portion of the funding arrangements should be:
    - Project Administration – councils sharing costs at 20% each
    - SMP development – councils sharing costs at 20% each of 50% by local government (with 50% by the State via the SMA)
    - Design and construction – local government component apportioned:
      West Torrens – 49%
      Unley – 21%
      Burnside – 12%
      Mitcham – 10%
      Adelaide City – 8%

19. The 2012 SMP and the Final SMP will document the cost sharing arrangements as outlined above and the charter will include councils' agreed sharing arrangements, including procedures to deal with any likely cost increases.

Charter

In anticipation of being able to produce a SMP by the middle of this year and having it approved by the Authority, the Steering Group has formed a working group of council representatives to resume preparation of a charter (or equivalent agreement).

It is proposed that governance of the project, including responsibility for proper management of the SMP including construction, operation and maintenance of works and on-going management of other flood mitigation measures would be undertaken by the five catchment councils via a regional subsidiary. The charter would be the legal agreement between the five catchment councils which defines the creation and operation of the regional subsidiary.

In respect of responsibility for the SMP, the regional subsidiary could utilise legislative powers available to it under Schedule 1A of the Local Government Act to manage both the SMP and infrastructure.

Whilst every endeavour will be made by the councils to agree the terms of a charter as soon as possible, it is understood that the charter would not have to be settled before approval of the SMP.

Conclusion

The above position represents a significant opportunity to address a long standing community risk of flooding in the Brownhill and Keswick Creek catchments. The Chief Executive Officers of the five catchment councils will seek their council's endorsement of the strategy in May 2012.

Yours sincerely

Michael Salkeld
Project Director

Appendix D - Community Consultation Report Executive Summary

Brownhill Keswick Creek Draft Stormwater Management Plan

Community Consultation Report

Lead Consultant URPS

In association with Natalie Fuller & Associates Pty Ltd
Harlen Graphics

Prepared for Brownhill Keswick Creek Stormwater Project

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Executive Summary

A consultation process was undertaken between 31 October and 12 December 2011 regarding the Brownhill Keswick Creek Draft Stormwater Management Plan (the Draft Plan).

The consultation process was undertaken by an independent consultant team comprised of URPS, Natalie Fuller & Associates Pty Ltd, and Harlen Graphics, on behalf of the five catchment Councils: the Cities of Adelaide, Burnside, Mitcham, Unley and West Torrens.

This report summarises the feedback collected via the consultation process on the Draft Plan.

The consultation process aimed to:

- Provide information to stakeholders and the broader community regarding the Draft Plan;
- Receive feedback on the Draft Plan from stakeholders and the broader community;
- Collate and summarise feedback on the Draft Plan for use by the five Councils in finalising the Draft Plan.

The consultation process comprised three key aspects, namely:

- Preparation and distribution of information materials and feedback form;
- Conduct of briefings, meetings and open days;
- Receipt, collation and analysis of feedback.

Preparation and distribution of information materials

A suite of information materials was prepared including:

- A summary report which summarised key aspects of the Draft Plan;
- A summary brochure which provided an overview of the Draft Plan, the consultation process and how people could access more information;
- Fact sheets addressing key components of the Draft Plan.

A feedback form and reply paid envelope were also provided to assist members of the community to provide their feedback on the Draft Plan.

The information materials and the feedback form were made available via a direct mail out to:

- 26,539 property owners and occupiers across the catchment;

- A number of community, sporting and recreation groups, schools, libraries, community centres and Adelaide Park Lands user groups;
- Federal and State Members of Parliament, State government Ministers, government departments and Councils;

The information materials and the feedback form were also made available:

- At each Council's offices where consultation materials were displayed and made available to take home, and the Draft Plan was on display;
- On a dedicated web page linked to the home pages of the five catchment Councils which provided background information, details of the consultation process, and electronic copies of the information materials. The website also featured an online version of the feedback form.
- At the open days.

Conduct of briefings, meetings and open days

Members of the wider community could obtain further information about the Draft Plan by attending any or all of three open days which were held during the consultation period at the Unley Town Hall, the Mitcham Civic Centre and the West Torrens Civic Centre. The open days provided an opportunity to learn more about the Draft Plan and ask questions of members of the project team. In total, approximately 160 people attended the three open days.

It was recognised that there were a number of key stakeholders that had a special interest in the Draft Plan and therefore a number of key groups within the community were invited to meet with members of the consultation team as part of the consultation process. In total, six groups accepted this invitation to meet, with some groups meeting on more than one occasion.

Feedback on the Draft Plan from representatives of the Kaurna and Ramindjeri peoples was also pursued via telephone and direct mail but to date no response has been received.

Invitations to be briefed were provided to Federal and State Members of Parliament, State government Ministers, government departments and Councils. Briefings were held with the Department for Health, the State Emergency Service, and the Department for Water.

Feedback received

In total, 2,172 feedback forms were returned by members of the community, of which 2,149 were from respondents with an inertest in at least one of the five catchment councils.

Twenty nine written submissions were received from individuals, groups or organisations.

A petition stating that it contained 4,010 signatures was submitted to the City of Mitcham and forwarded onto the consultation process by the No Dam in Brownhill Creek Action Group. It is understood that since this time, the number of signatures to the petition has increased, but an updated version has not been received by the consultants undertaking the consultation process.

Five groups provided feedback via meetings with the consultant and/or project team. These groups comprised:

- Friends of Brown Hill Creek
- Residents living in close proximity to the proposed flood control dam at Brownhill Creek
- Residents for Effective Stormwater Solutions Inc. (RESS)
- South East City Residents Association
- Netley Residents' Association

The Department for Health, the State Emergency Service, and the Department for Water provided feedback at their briefing sessions, while written submissions were received from the Environment Protection Authority (EPA) and the Adelaide Airport.

Summary of feedback received

Several key trends have emerged from the consultation process, taking account of the various avenues for community feedback.

Overall there is general recognition of the importance of undertaking flood mitigation works to reduce the impacts of flooding across the catchment. This was particularly evident from analysis of the feedback forms, with the majority of respondents (74% unweighted data) considering it is important/very important to undertake flood mitigation works compared with only 12% (unweighted data) not considering it not important/not very important. Respondents with an interest in West Torrens were more likely to consider flood mitigation works are important/very important.

Qualitative comments indicated that many respondents are supportive of 'getting on and doing something'. As several respondents stated:

> *Well done! Please commence work as soon as possible.*
>
> *We need some action now ie before it is too late. It's been 6 years since the last flood in Millswood and I can't see any changes.*
>
> *Let's do it.*

This support for taking action is qualified however, by the need 'to get it right' and ensure that appropriate infrastructure measures are implemented that adequately reduce the impacts of flooding while at the same time delivering acceptable outcomes in terms of financial, environmental and social impacts. As one respondent stated:

> *I would support this action as long as the appropriate environmental impact reviews had been done and there was minimal to no impact (detrimental) to the environment and local fauna.*

In relation to the Draft Plan, while views varied in relation to specific components of the Plan, the majority of respondents indicated overall support for the Plan. Based on the analysis of feedback forms, 71% of all respondents (unweighted) indicated support (4 or 5 rating) while only 13% opposed (1 or 2 rating), with an overall mean score of 3.9 (unweighted). Levels of support varied across the five catchment councils, with respondents with an interest in West Torrens showing higher levels of support (mean score of 4.4) compared to those in Mitcham (mean score 3.2).

Analysis of the feedback forms also clearly indicates that support for the Draft Plan was higher amongst those respondents who attributed higher levels of importance to the need for flood mitigation as well as those currently at risk of flooding.

In relation to specific infrastructure components proposed in the Draft Plan, analysis of the feedback forms indicated high levels of support for all components across all five catchment councils with the exception of the proposed flood control dam at Brownhill Creek where there were both lower and more variable levels of support across the councils.

In relation to the components that were supported, feedback form responses indicated consistently high levels of support from all respondents (with weighted and unweighted data showing negligible differences), being supported by at least 70% of respondents from each council area for:

- Channel upgrades
- Minor channel and bridge works
- Improvements to planning and development processes
- Improvements to community awareness and emergency response
- Improvements to creek maintenance

Support for these infrastructure components is reflected by respondents own words:

> *Continual monitoring and improvements can only enhance the long term benefits of this stormwater management plan*

> Creek maintenance is *"always worthwhile"*

Anything that reduces the likelihood of my house flooding is good….

Channel upgrades will hopefully maintain environmental habitat and reduce erosion from flooding

Components with more variation in levels of support were the detention basins at Glenside and the South Park Lands and at Ridge Park Reserve Myrtle Bank, and bypass and diversion culverts. These variations were however within 14% between the highest and lowest proportions of respondents indicating support. It is noted that respondents with an interest in both the City of Adelaide and Burnside were more likely to oppose these three components. Concerns regarding the proposed South Park Lands proposal were also expressed in a meeting conducted with the South East Residents Association (SECRA) and re-iterated in their written submission.

Analysis of the feedback forms received showed that the flood control dam at Brownhill Creek Recreation Park was the least supported component of the Draft Plan overall and showed the most varying levels of support between the council areas. Using unweighted data, 60% of all respondents indicated support and 32% opposed. When subjected to weighting, support increased to 71% and opposition reduced to 19%.

This component of the Draft Plan was rated the lowest by respondents with an interest in each of the councils with the exception of West Torrens where it was rated the second lowest (after the detention basin at Ridge Park Reserve). Levels of support across councils ranged from 22% support and 74% opposition in Mitcham, to 82% support and 7% opposition in West Torrens.

A petition submitted to the City of Mitcham and copied to the consultation process contained 4,010 signatures supporting the statement *"We, the undersigned, hereby PETITION Council to protect the environment and heritage of Brownhill Creek by opposing the damming of the Creek"*. It is understood that since being submitted to the consultation process, the number of signatories to this petition has increased.

Based on the feedback forms as well as information received via meetings and written submissions (excluding the petition which is dealt with separately below), three key viewpoints emerged with respect to the flood control dam in Brown Hill Creek:

- Strong opposition to any dam on Brownhill Creek with a view that alternative infrastructure solutions that are available;
- Strong opposition to the proposed location of the dam in the Brownhill Creek Recreation Park based on concerns regarding visual amenity, heritage and the natural environment, but open to the possibility of another location along Brownhill Creek;
- Support for the dam together with concerns that the 'no dams' position may continue to delay implementation of mitigation works.

These differing viewpoints are reflected in qualitative comments recorded on feedback forms which included:

> *No dam. Explore other options.*
>
> *This is environmentally destructive and economically irresponsible. I suggest you look for alternative methods rather than putting a 15 metre cement wall through a beautiful national park, which I frequent on a constant basis, and grew up playing in and around*
>
> *Brownhill Creek is about keeping the flow, not major infrastructure to retain water. The creek needs to be returned to its natural course over time, with proper stormwater management along its course.*
>
> *Brownhill Creek Recreation Park is an historic natural place for the public (from all over Adelaide) to enjoy. Dams do not have a place in a public park. It is of heritage value and would be ruined.*
>
> *A dam in Brownhill Creek Recreation Park would be environmentally negligent and economically irresponsible.*
>
> *Dams have been used in England to prevent flooding, which have been successful, so I believe it will also work here*
>
> *We support the idea of a controlled dam at Brownhill Creek Recreation Park providing the area remains aesthetically unharmed.*
>
> *I strongly agree with the flood control dam. Strongly agree with other flood mitigation proposals. Strongly agree with this construction*
>
> *Build a dam for goodness sake!*
>
> *I consider that the dam is essential in providing flood mitigation for many flood prone properties*

In addition to this feedback received via feedback forms, other written submissions and meetings, the petition received specifically called for "Council to protect the environment and heritage of Brownhill Creek by opposing the damming of the Creek".

Other comments and views that were expressed regarding the Draft Plan included:

- Concerns relating to the communication and consultation process both in relation to the current Draft Plan and on previous versions, while others acknowledged the extent of the direct mail out undertaken for the current consultation process and the number of open days conducted across the catchment.
- Queries relating to the timing for implementation of the Draft Plan (once approved) as well as how it will be funded. Others expressed frustration about the continued delay in implementing the Draft Plan.

- Specific design and ongoing management details regarding the detention basin proposed at the Glenside Campus.
- The need for risk mitigation and safety factors to be considered as part of the detailed design of the proposed works.
- The desire by the SES to share project flood modelling to inform their FloodSafe program and Emergency Response Plan to effectively target community engagement.
- Scepticism regarding the cost effectiveness of the Draft Plan.
- The assumptions the Draft Plan is based upon.
- The scope of the Draft Plan, including its lack of consideration of retention and reuse of stormwater, non-structural solutions like FloodSafe and revegetation, stormwater quality, water conservation, amenity, conservation, heritage, biodiversity, recreation and environmental flows.
- Concern over private property acquisition associated with channel upgrades.
- Concerns relating to the South Park Lands detention system including adverse impacts on the butterfly habitat, mosquitoes, dust, odour and pollution, contamination risk, impact on the BMX facility and impacts on trees. Also concerns that the Park Lands are being appropriated to protect private property.
- Alternative and/or additional flood mitigation options to those that are proposed in the Draft Plan.
- The need for all upstream mitigation actions to be undertaken in an environmentally and socially sustainable manner.

Appendix E - Hydrologic Modelling Summary

BROWNHILL KESWICK CREEK STORMWATER PROJECT - HYDROLOGY COMPONENT

INTRODUCTION

The hydrology of the catchment of Brownhill and Keswick Creeks upstream of Tapleys Hill Road has been extensively studied, firstly for providing hydrological data input (flow estimates at various location for various average recurrence intervals (ARIs)) for floodplain mapping and secondly to assess the hydrological effect of various flood mitigation strategies proposed.

All hydrologic modelling has been carried out using the RRR model. Two earlier separate creeks models have been combined and extended to cover the entire catchment and the complete model reviewed to ensure that information gained since the development of the two individual models is taken into account.

THE RRR MODEL

The RRR model has been developed as a result of the limitations that have been identified in runoff routing models normally used in Australia, such as RORB and RAFTS. One of the most important of these is that RORB and RAFTS can deal with only one runoff process.

The RRR model makes provision for separate channel storage and hillside (or process) storage. This represents a major change to existing runoff routing models that assume that only surface runoff is being modelled and that the total storage within the catchment can be represented by a series of storages along the watercourses.

The model is named RRR (or Rainfall Runoff Routing) model because like rainfall runoff models, it models hydrological processes and like runoff routing models these processes are represented by a series of concentrated storages.

The hillside storage must be able to be split to allow for the contributions from the different processes occurring. Since each process on the hillside is assumed to enter the channel by a separate flowpath, it is allowable to have non-linear storage in the hillside part of the model.

The channel storage is assumed to be linear (ie. the travel time does not vary with the amount of flow in the channel), as a result of evidence obtained from earlier investigations of channel travel times.

In its simplest form the model can be used with a single sub-area. The model structure for a single sub-area is as follows;

- The model has ten equal channel reaches of length d/10, where d is the longest flow path length in the catchment (km). It is assumed that the area contributing to each reach is also equal (ie. total catchment area/10).
- Channel storage for each channel reach is modelled as a linear storage of the form S = 3 600 k Q.
- Contributions from any number of separate hydrological processes can be added at the downstream end of each channel reach before routing through the channel storage.
- Each of these processes is modelled as per Laurenson's Runoff Routing Model, as used in the RAFTS model ie. with ten equal storages each with a storage $S = 3\,600\, k_p Q^m$, kp being a lag related to runoff process. The total area of each process model is the total catchment area/10, so that the area of each sub-catchment is the (total catchment area/100). The exponent m is taken to be 0.8.
- Each of the hydrological processes has an initial and continuing or proportional loss associated with it.

The use of ten storages for both the process and channel components follows the Laurenson Runoff Routing Model. The catchment is not however delineated with equal travel times, but with equal areas, as per the RAFTS model.

The RRR model is not a computer package as such, but a structure that can be set up and run using the industry standard XP-RAFTS graphical user interface.

Figure 1 shows diagrammatically the structure of a single sub-area of the model.

Although the model may initially look complicated with 100 sub-catchments it is in effect simple as all sub-catchments are the same size and storage parameters and losses need be input only once for each process modelled.

It has been found that for rural catchments three runoff processes are identifiable, and for ease of identification these are termed process 1 to 3. Process 1 is equivalent to the base flow found in most catchments and process 2 is the runoff normally modelled by Runoff Routing models such as RORB and RAFTS.

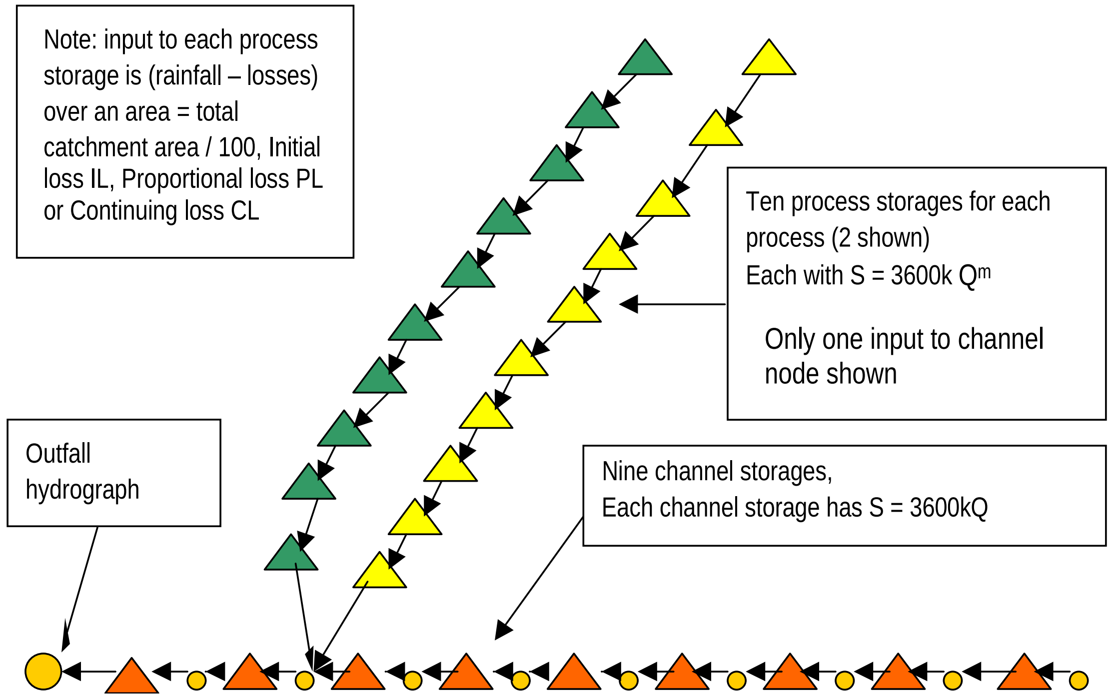


Figure 1. Structure of the single sub-area RRR model

Process 3 is most likely to be true surface runoff. Process storage in this case is zero, with the catchment lag for this process being the same as the channel lag.

The RRR model can also be used with multiple sub-areas, with channel reaches connecting sub-area outlets. With more than one sub-area generalised parameters have to be introduced for application to any catchment.

Two generalised parameters are required, being the *channel characteristic velocity,* v_c defined as:

$$v_c = \frac{d}{(36\,k)} \qquad (1)$$

Where v_c is the channel characteristic flood wave velocity (m/sec)
d is the longest flow path length in the catchment (km)
k is the channel storage parameter (hrs)

and the *catchment characteristic lag parameter, Cp*, where:

$$Cp = k_p A^{m-1} \qquad (2)$$

where *A* is the catchment or sub-area area (km^2)
m is the exponent in the storage equation
$S = 3600k_pQ^m$

There are normally two catchment characteristic lag parameters, designated Cp1 and Cp2.

In general the hydrograph from upstream sub-areas is translated according to the characteristic flood wave velocity to the next sub-area outlet.

In urban areas two processes contribute to the outflow, being the directly connected impervious and the unconnected area (composed of supplementary paved and pervious areas) contributions. In addition allowance is made for a separate but parallel overflow path to be modelled in conjunction with the normal flow path in each urban sub-area. Flows in excess of the pipe system capacity, at each channel storage, are passed to the parallel overflow path, where flows are routed through storages with a different storage delay time, representing the greater amount of storage available in the street system. Other features such as storage basins can also be incorporated in the model.

For the calibration of the RRR model in the Brown Hill and Keswick Creek catchment flows in excess of the urban channel capacity are transferred to a separate overflow path having a series of storages to represent the greater delay of flows outside the channel system. The RRR model used for the production of floodplain mapping do not have these overflow paths as overflows are dealt with by the hydraulic model. In this mode the RRR model is used only to provide inflows to the hydraulic model. For this purpose inflow hydrographs were provided at the upstream boundaries of the hydraulic model and at a number of locations along the main channel system.

The RRR model has been subject to verification on gauged urban catchments at Glenelg and the Paddocks in South Australia and at Jamison Park in New South Wales, with good results. It has also been verified on six gauged rural catchments, four in the Mount Lofty Ranges in South Australia, one in New South Wales and one in the Northern Territory.

On independent peer review, prior to undertaking this current study, the flood flow estimates being produced by the RRR model were considered to be "suitable for design purposes".

THE ADVANTAGES OF THE RRR MODEL

There are several features of the RRR model as described above that make it ideal for application on the Brown Hill and Keswick Creeks catchment.

Firstly the model can deal with a hydrological system that behaves differently for small and large events. Flows in excess of the pipe network capacity in urban areas will travel through the street network. These will travel much more slowly than the pipe network and thus must be modelled differently. The RRR model as developed deals with this by having essentially two layers, with different storage relationships for each layer.

Secondly the model can be calibrated to any number of individual locations, without affecting the predicted flows at other parts of the model, which would not be expected to change as a result of the calibration. This is part of model self-consistency, which does not exist in models such as RORB and RAFTS. In addition there is no single catchment wide storage parameter in RRR as there is in RORB. Different storage parameters and losses can be applied to different parts of the model that have different land use characteristics. For instance hydrological differences between rural and urban areas can be readily accommodated.

In addition because the RRR model treats the in-channel and process storages separately (or in-channel and pipe system storage routing) the RRR model will intrinsically give a better indication of flood peak travel times than RORB.

MODEL CALIBRATION

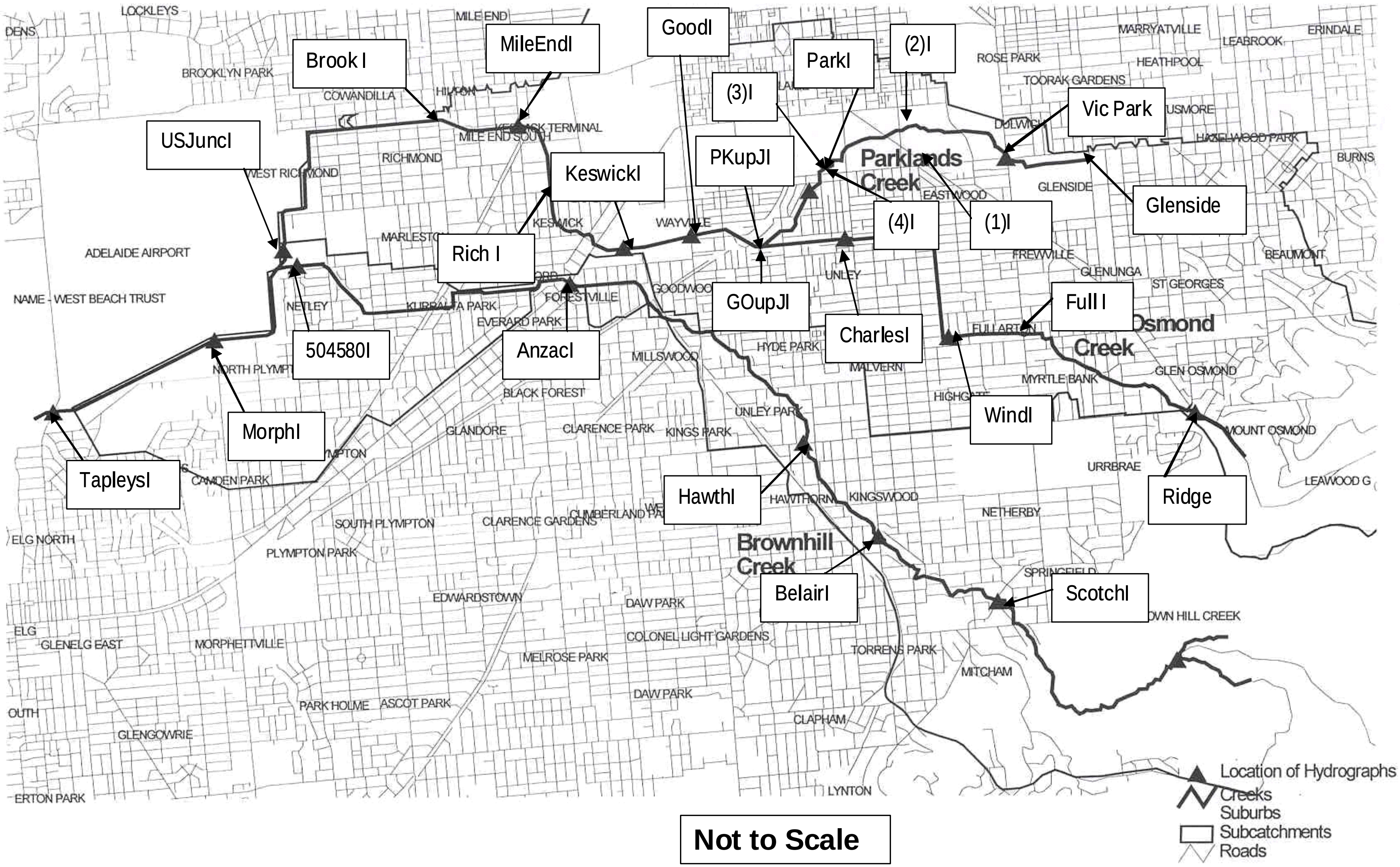
The model was developed based on estimated contributing percentages of directly connected impervious areas and sub-area response time in urban sub-areas. The storage and loss parameters for the rural catchment to Scotch College were based on calibrated parameters for other rural catchments in the Mount Lofty Ranges. All these parameters were verified and adjusted where necessary by the application of the model on a number of flood events in the catchment.

SUMMARY

The RRR model has been developed to overcome a number of limitations in runoff routing models such as RORB and RAFTS, and as such it is an appropriate model for the catchment. On independent peer review, prior to undertaking this current study, the flood flow estimates being produced by the RRR model were considered to be “suitable for design purposes”.

The model parameters have been adjusted based on the application of the model to a range of monitored flood events, and it can thus be used as a basis for the prediction of flood hydrographs.

Brownhill and Keswick Creeks
Location of Calculated Hydrographs



Not to Scale

Appendix F - MIKE Flood Model Technical Summary

Background on Brown Hill and Keswick Creek Floodplain Modelling Process

Comparison of One and Two-dimensional Modelling Approaches

In general, one-dimensional models are applicable when flow paths are well defined and the length of the flow path in one direction is much greater than the width. This is typically the case for long lengths of channels and rivers with well defined floodplains or river systems with steep longitudinal grades.

Two-dimensional models are applicable when flow paths are poorly defined (typically in areas with flat terrain), the floodplain width and stream length are of similar magnitude or the hydraulic details of the direction of flood flows across a floodplain are of interest.

Another other main distinction between one and a two-dimensional modeling is the definition of hydraulic structures such as weirs and culverts. These are more commonly implemented in a one-dimensional context, however these can generally be nested within either a one or two-dimensional model and hence should not greatly affect the selection of which approach is most appropriate for a given application.

For higher accuracy and greater spatial extents, a fully two dimensional model will be appropriate. However this will in turn increase run times, data processing time and data storage requirements. Conversely if less accuracy is needed and faster run times are appropriate, a one-dimensional approach will be better. The table that follows provides a summary of 2D vs 1D model characteristics

Hydraulic Model Characteristics

Model Type	**Features**	**Requirements/Characteristics**
One-dimensional model	• Series of linked channels with discrete cross-sections at regular intervals (eg 100 - 1000m) • Output at each cross-section can include average water level, depth and velocity.	• Cross-sections input to model, based on field survey or DTM • Time consuming to build - quick to modify • Quick to run (minutes – hours) • Result files are relatively small (MBs) • Requires more interpolation and interpretation of results
Two-dimensional model	• Regular grid-based topography with cell sizes typically ranging from 10 – 100 m • Output at each grid cell can include water level, depth and velocity	• Requires detailed grid to be interpolated from aerial and/or field survey based DTM • Time consuming to build, not a easy to modify as in 1-d • Relatively slow to run (hours to days) • Result files are relatively large (100's MB per simulation) • Less interpolation of results required and more easily linked to GIS

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MIKE Flood

MIKE-Flood has been used for the floodplain modelling in Brown Hill and Keswick Creeks.

MIKE-Flood is an integrated 1-dimensional/2-dimensional software package developed by DHI Software in Denmark. This package enables control structures such as bridges and culverts to be included in the 2-dimensional model, which facilitates more accurate modelling, particularly for smaller flows.

DHI's MIKE suite of models are well recognised "industry standard" models. They are used worldwide and by many companies in Australia.

MIKE-Flood couples together two other DHI Software products – MIKE-11 and MIKE-21.

- MIKE-11 is a quasi-1-dimensional unsteady flow modelling tool that has been used in the Brown Hill Keswick Creek catchment to model the flow in the channel sections and in the closed conduits deemed to affect the hydraulics of the floodplain. The channels and conduits are linked to MIKE-21 by the MIKE-Flood Software.

- MIKE-21 is a 2-dimensional modelling system for free surface flows where stratification can be neglected. It was initially developed for the simulation of hydraulic and related phenomena in lakes, estuaries, bays, coastal areas and seas. It has been developed and improved through the experience gained from applications both overseas and in Australia. The software simulates the variation in water level and flow on a rectangular grid covering the area of interest when provided with topographic data, ground surface resistance coefficients and hydrographic boundary conditions.

Evolution of the current MIKE Flood model

Entura (formerly Hydro Tasmania Consulting) has been involved in hydraulic modelling of the Brownhill and Keswick Creeks and their floodplains since the year 2000. The original modelling was carried out using a beta version of DHI's MIKE Flood software. The original models were essentially MIKE 21 (two-dimensional) hydraulic models with nine key culverts included. The creek channels within the model were modelled in MIKE 21 and no cross sections were included.

A 1984 study by WBCM provided cross section information and culvert/bridge details for each of Brownhill, Keswick, Parklands and Glen Osmond Creeks. During the 2003 study, significant work went into the representation of the channel system and culverts within the MIKE 21 model. This included filed verification of the cross sections and culvert/bridge details. From these cross sections, a HEC-RAS model was built that was used to assess channel capacities. The MIKE-Flood model channels were checked against the HEC-RAS model to ensure that that the capacity of the creek channels represented in the MIKE 21 was reasonable.

At the time, the method adopted was the best available method for defining the flood inundation extents for Brownhill and Keswick Creeks. This approach is often still used today.

Entura was again engaged to carry out hydraulic modelling of the floodplain for the 2006 study. In the years since the original study, the MIKE-Flood software had evolved into a truly integrated 1D/2D hydraulic modelling package. MIKE-11 cross sections are embedded in the MIKE-21 grid and the links between the two models are controlled by the MIKE-Flood software.

For the 2006 study, the HEC-RAS cross sections that were developed for the 2003 study were again verified then transferred into a MIKE-11 model of the four creeks. The extent of the cross sections stops at the top of bank, where the cross section is linked to the MIKE-21 grid. Some 120 culverts and bridges were also incorporated into the MIKE-11 model.

Current Model Setup

The current MIKE-Flood model is based on the 2006 model and incorporates the full dynamic linkages between MIKE 11 and MIKE 21.

There are some 120 culverts included in the model and 350 channel cross sections (in addition to the culverts sections) represented in the MIKE 11 component of the model.

The floodplain is represented by 5 m grid. The selection of the grid size involves a trade off in model run time and accuracy. The smaller the grid the more accurate but the longer the run times. The final model was completed in two adjoining and overlapping parts - the Upper Brown Hill model consisting of 330,000 cells and the much larger Brown Hill - Keswick model that was made up of 2.2 million cells.

Dynamics of the MIKE 11 and MIKE 21 interface

There are different types of links within MIKE Flood that can be used to couple the MIKE 11 and MIKE 21 hydrodynamic models.

The Brownhill Keswick MIKE FLOOD model utilizes lateral links to facilitate flow between the MIKE 11 channels and MIKE 21 floodplain. A string of MIKE 21 grid cells are laterally linked to a section of a branch or an entire branch in MIKE 11. The lateral link allows transfer of flow between MIKE 11 h points (where water levels are calculated in the MIKE 11 model) and MIKE 21 grid cells. Refer to Figures 1 and 2 for a schematic of this process.

Flow through the lateral link between MIKE 11 and MIKE 21 is through a model boundary which is typically defined using a weir formula with a crest level determined by MIKE 21 grid cell levels, MIKE 11 cross-section markers (or a combination of highest levels from both) or from an external file. The boundary can also be defined a level/depth table in external file or as a headloss based on velocity head.

The model boundary weir formula approach has been used for all links in the Brown Hill Keswick Creek model. The parameters required to define a weir link include:

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- Weir Type: Defines the type of weir formula used.
- Source: Determine the definition of the weir crest as described above.
- Depth tolerance: This parameter is used to smooth out the transition when the flow over the lateral link changes direction and model instability may occur if suppression is not applied to the model.
- Weir C: Discharge coefficient adopted for the weir.
- Manning's n: Roughness value adopted for the weir.

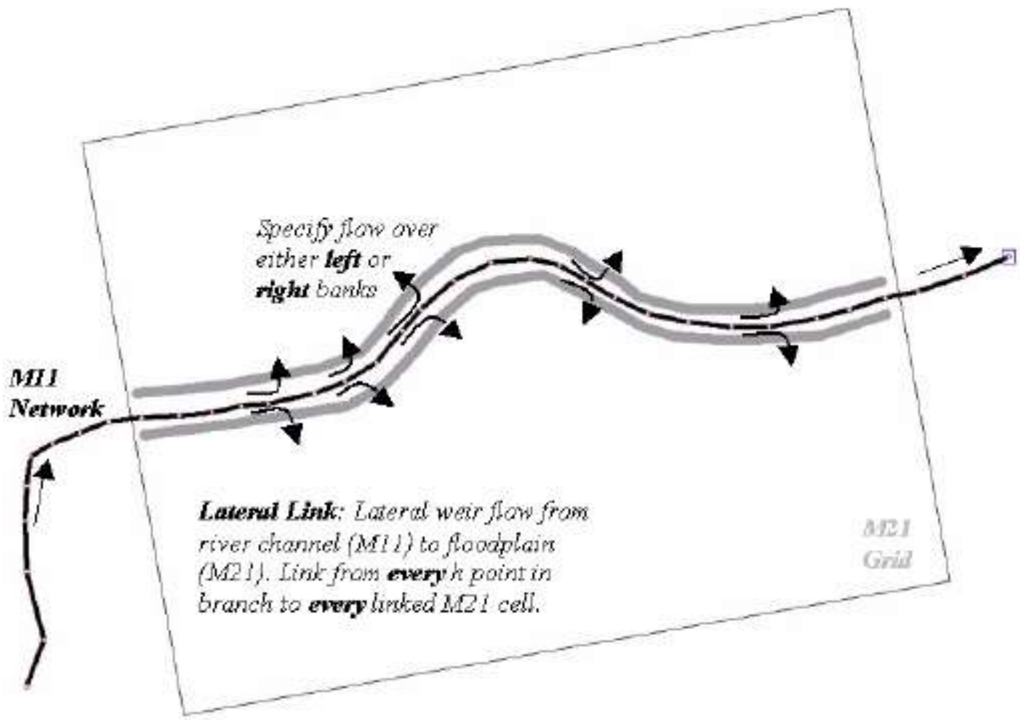

Figure 1: MIKE FLOOD 1D-2D Modelling Schematic (Source Fig 2.2 user Manual, DHI 2009).

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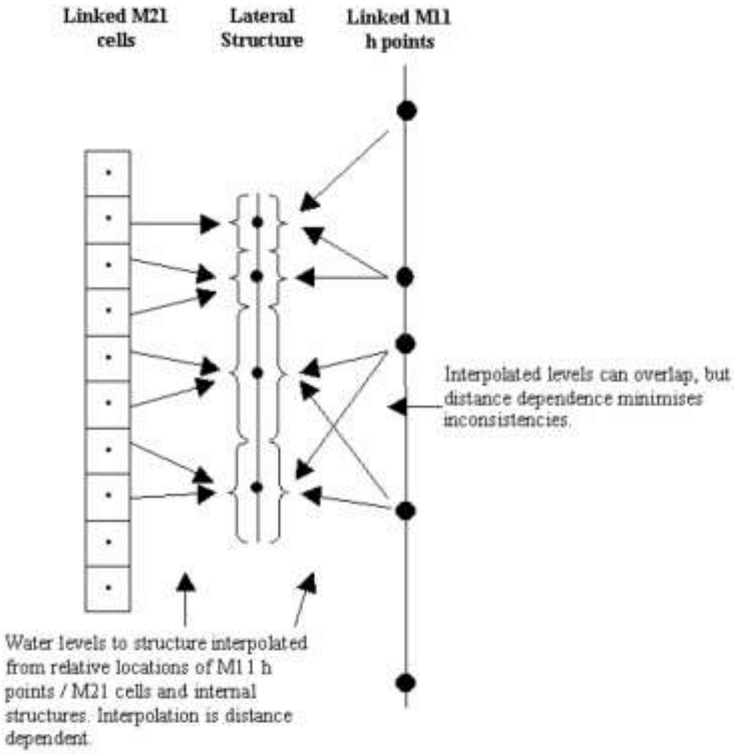

Figure 2: MIKE FLOOD 1D-2D Lateral Links Schematic (Source Fig 8.2 Modelling user Manual, DHI 2009).

The parameters adopted for the Brownhill Keswick model are provided in Table 1 below.

Table 1: Brown Hill Keswick Creek Model 1D-2D Lateral Weir Interface Description

Parameter	Value	Comment
Type	Weir 1	$Q = W \cdot C \cdot (H_{us} - H_w)^k \cdot \left[1 - \left(\frac{H_{ds} - H_w}{H_{us} - H_w}\right)^k\right]^{0,385}$ Refer to MIKE 11 reference manual for details.
Source	HGH	HGH adopted for model stability (highest of MIKE 21 grid cell and MIKE 11 overbank levels).
Depth Tolerance	0.1m	For model stability.
Weir C	1.838	Default discharge coefficient.
Manning's n	0.05	Adopted value.

The calculation process for flow transfer through a lateral link is summarised below:

- Water levels at MIKE 11 h points and MIKE 21 grid cells are calculated.
- Where required water levels are interpolated between MIKE 11 h points and MIKE 21 grid cells to provide water levels either side of the lateral link at the locations of the link structures. Refer to Figure 2 for a schematic diagram for this process.

- The width of link structure engaged for flow transfer based on the interpolated water levels is calculated.
- Flow over the link structure is calculated based on the length of link structure engaged, upstream and downstream water levels and the hydraulic equation for the lateral weir interface.
- Flow over the structure is then distributed to the relevant MIKE 11 h points and MIKE 21 cells.

Flow Over the Floodplain

MIKE 21 calculates water depth over a model (floodplain) based on the shear stress (resistance to flow). While the values may be specified as either a Manning's M number, (where M = 1/n and n = Manning's 'n' value) or a Chezy number, Manning's M numbers have been adopted for Brown Hill and Keswick Creeks because more resistance data is available and the model developers were more familiar with its use.

In MIKE-Flood, resistance can be specified as a constant value for the whole model or as a value for each grid cell. Normally for such a large model (over 2 million cells) it would be time consuming and costly to define the various land usages and prepare the data given the nature of the floodplain (residential, parkland, road, river, etc). However, as cadastral information was available it was possible to prepare a two-dimensional data file of resistance parameters (Manning M) for the various land uses.

The modelling process assumes that buildings are permeable but that flows are retarded or diverted by structures (buildings) on the floodplain. This is simulated in the model by increasing the roughness parameter.

The resistance parameters given in Table 2 were adopted for the various land uses. They were chosen from literature and Hydro Tasmania's previous modelling experience. No sensitivity analysis was undertaken as the adopted parameters were considered to be the best estimate.

Table 2: Adopted Resistance Parameters

Land Use	Manning's n	Manning's M
Recreational, parkland	0.055	20
Road pavement	0.018	55.6
Residential, commercial	0.17	6

Boundary Conditions

In MIKE Flood, model boundaries can be either open or closed. For open boundaries, it is possible to specify water level or flow with each being either constant or varying with time. In floodplain situations where flow extends overland beyond a boundary, it is customary to class define an open boundary. The boundary can be conceptualised as a wide "excavated trench" and a constant water level set below that of the adjacent topography. This allows the overland flow to discharge into the trench before it is lost to the system. The results on the floodplain are therefore not affected in the vicinity of the trench (boundary condition).

For the Upper Brown Hill model, open boundaries were identified at two locations along the four model boundaries. All boundaries, except for those locations specified below, were considered closed due to topographical features. The open boundaries were located on the northern and western boundaries in the northwest corner of the model. The northern boundary was defined as a constant water level of 43.5 m AHD, while the western boundary was defined as a constant water level of 47.0 m AHD. These constant water levels are set below the adjacent ground levels.

In the main Brown Hill – Keswick model, only one open boundary was defined. It was located on the western boundary of the model where the Brown Hill Creek channel drains into the Patawalonga Lake. A constant water level boundary was adopted and set at a level of 0.5 m AHD for all flood scenarios.

Model Calibration and Verification

The model calibration process can involve the adjustment of:

- Hydraulic roughness – in river channels and floodplain areas
- Configuration of structures - critical levels and operation or head-loss characteristics.
- Model topography/structure – in terms of any identified inconsistencies between the survey and observed behaviour.

Roughness parameters are usually derived in the first instance based on field observations, past experience and interpretation of aerial photographs and satellite imagery as available.

As there is limited history of floodplain inundation in the Brown Hill Keswick Creek catchments it was not possible to calibrate the floodplain model in 2003. More recently the flood event in November 2005 was used to verify model performance for the 2006 upgrade of the model.

Experience with detailed hydraulic models of this type has shown that once the model structure is correct, often only small adjustments are required in calibration, with major inconsistencies usually associated with errors in structures.

Key Assumptions of Computer Model

A range of assumptions are normally required to construct and use a complex floodplain model. These assumptions are all simplifying assumptions necessary to represent complex natural processes in way that can be effectively represented in a numerical model. Key assumptions made in the Brown Hill and Keswick Creek model are as follows:

- All channels are clean with nothing in or around them that could possibly be washed into the channel causing blockages of the channel or of the culverts or bridges through which water flows.

- Floodplain roughness values were based solely on cadastral information. House footprints were not taken into account so water can flow “through” houses. Also, due to the high roughness value assigned to residential and commercial areas, water may be restricted in flowing through open areas where it may be expected to flow.

- The ground and channel geometry is assumed to be stable. Neither the MIKE 11 nor MIKE 21 models provide for dynamic changes to the landscape during the simulation process due to water cutting new channels and altering the distribution of flow.

Appendix G - Original Flood Damages Multipliers

Consequence Assessment Multipliers

Land Use	Depth Class	Flood Level	Multiplier
Residential	0 - 0.1	Above Floor	0.045
		Below Floor	0.021
	0.1 - 0.25	Above Floor	0.276
		Below Floor	0.032
	0.25 - 0.5	Above Floor	0.336
		Below Floor	0.042
	0.5 - 1.0	Above Floor	0.414
		Below Floor	0.084
	1.0 - 1.5	Above Floor	0.555
		Below Floor	0.138
	1.5 - 2.5	Above Floor	0.924
		Below Floor	0.297
	2.5 - 5.0	Above Floor	2.013
		Below Floor	0.567
Commercial	0 - 0.1	Above Floor	0.330
Office		Below Floor	0.051
	0.1 - 0.25	Above Floor	0.414
		Below Floor	0.078
	0.25 - 0.5	Above Floor	0.504
		Below Floor	0.138
	0.5 - 1.0	Above Floor	0.621
		Below Floor	0.273
	1.0 - 1.5	Above Floor	0.828
		Below Floor	0.357
	1.5 - 2.5	Above Floor	1.386
		Below Floor	0.438
	2.5 - 5.0	Above Floor	2.403
		Below Floor	0.681
Commercial	0 - 0.1	Above Floor	0.438
Retail		Below Floor	0.096
	0.1 - 0.25	Above Floor	0.552
		Below Floor	0.144
	0.25 - 0.5	Above Floor	1.872
		Below Floor	0.417
	0.5 - 1.0	Above Floor	3.047
		Below Floor	0.903
	1.0 - 1.5	Above Floor	5.296
		Below Floor	2.097
	1.5 - 2.5	Above Floor	8.770
		Below Floor	3.129
	2.5 - 5.0	Above Floor	12.091
		Below Floor	4.519
Industrial	0 - 0.1	Above Floor	0.364
		Below Floor	0.098
	0.1 - 0.25	Above Floor	0.489
		Below Floor	0.118
	0.25 - 0.5	Above Floor	1.046
		Below Floor	0.234
	0.5 - 1.0	Above Floor	1.476
		Below Floor	0.343
	1.0 - 1.5	Above Floor	2.185
		Below Floor	0.533
	1.5 - 2.5	Above Floor	3.419
		Below Floor	0.875
	2.5 - 5.0	Above Floor	4.889
		Below Floor	0.547

Land Use	Depth Class	Flood Level	Multiplier
Institution	0 - 0.1	Above Floor	0.110
		Below Floor	0.042
	0.1 - 0.25	Above Floor	0.149
		Below Floor	0.067
	0.25 - 0.5	Above Floor	0.236
		Below Floor	0.098
	0.5 - 1.0	Above Floor	0.384
		Below Floor	0.189
	1.0 - 1.5	Above Floor	0.551
		Below Floor	0.222
	1.5 - 2.5	Above Floor	0.833
		Below Floor	0.289
	2.5 - 5.0	Above Floor	1.554
		Below Floor	0.391
Public	0 - 0.1	Above Floor	0.110
Utility		Below Floor	0.042
	0.1 - 0.25	Above Floor	0.149
		Below Floor	0.067
	0.25 - 0.5	Above Floor	0.236
		Below Floor	0.098
	0.5 - 1.0	Above Floor	0.384
		Below Floor	0.189
	1.0 - 1.5	Above Floor	0.551
		Below Floor	0.222
	1.5 - 2.5	Above Floor	0.833
		Below Floor	0.289
	2.5 - 5.0	Above Floor	1.554
		Below Floor	0.391
Recreation	0 - 0.1	Above Floor	0.057
		Below Floor	0.018
	0.1 - 0.25	Above Floor	0.285
		Below Floor	0.024
	0.25 - 0.5	Above Floor	0.333
		Below Floor	0.043
	0.5 - 1.0	Above Floor	0.501
		Below Floor	0.088
	1.0 - 1.5	Above Floor	0.689
		Below Floor	0.147
	1.5 - 2.5	Above Floor	0.994
		Below Floor	0.238
	2.5 - 5.0	Above Floor	1.998
		Below Floor	0.571