A

Appendix A. DGRs

NSW GOVERNMENT | Planning

Contact: Amy Watson
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Our ref.: MP10_0155 and MP10_0180

Mr Scott Barwick
SJB Planning
Level 2, 490 Crown Street
Surry Hills NSW 2010

Dear Mr Barwick,

Subject: Director-General's Requirements for a Concept Plan and Stage 1 Project Application at 2-32 Smith Street, Summer Hill (MP10_0155 and MP10_0180)

The Department has received your application for the above project.

I have attached a copy of the Director-General's Requirements (DGRs) for the preparation of an Environmental Assessment for the project. These requirements have been prepared in consultation with relevant government authorities. I have also attached a copy of the government authorities' comments for your information.

The DGRs have been prepared based on the information you have provided to date. Please note that under section 75F(3) of the *Environmental Planning and Assessment Act 1979*, the Director-General may alter these requirements at any time. If you do not submit an Environmental Assessment for the project within 2 years, the DGRs will expire.

Prior to exhibiting the Environmental Assessment that you submit for the project, the Department will review the document to determine if it adequately addresses the DGRs. The Department may consult with other relevant government authorities in making this decision. Please provide 1 hard copy and 1 electronic copy/[1] of the Environmental Assessment to assist this review.

If the Director-General considers that the Environmental Assessment does not adequately address the DGRs, the Director-General may require you to revise the Environmental Assessment. Once the Director-General is satisfied that the DGRs have been adequately addressed, the Environmental Assessment will be made publicly available for at least 30 days.

Your contact officer for this proposal, Amy Watson, can be contacted on (02) 9228 6379 or via email at amy.watson@planning.nsw.gov.au. Please mark all correspondence regarding the proposal to the attention of the contact officer.

Yours sincerely,

16/12/2010

Michael Woodland
Director
Metropolitan Projects

[1] File parts must be no greater than 5Mb each. File parts should be logically named and divided.

NSW GOVERNMENT | Planning

Director-General's Requirements

Section 75F of the *Environmental Planning and Assessment Act 1979*

Application number	MP 10_0155 (Concept Plan) and MP10_0180 (Project Application)
Project	**Concept Plan** application for a mixed use residential, retail and commercial development with parking, public open space, new public streets and associated infrastructure works. **Stage 1 Project Application** for subdivision, partial demolition and construction of 2 to 6 storey residential and mixed use residential/retail/commercial buildings with basement car parking, together with infrastructure works including new public roads.
Location	2-32 Smith Street, Summer Hill
Proponent	SJB Planning on behalf of EG Funds Management Pty Ltd
Date issued	16 DECEMBER 2010
Expiry date	If the Environmental Assessment is not exhibited within 2 years after this date, the applicant must consult further with the Director-General in relation to the preparation of the Environmental Assessment.

Key issues	**CONCEPT PLAN**
	The Environmental Assessment (EA) must address the following key issues:
	1. Relevant EPI's Policies and Guidelines to be Addressed
	Planning provisions applying to the site, including permissibility and the provisions of all plans and policies are contained in **Appendix A.**
	2. Built Form/Urban Design
	• The EA shall address the height, bulk and scale of the proposed development within the context of:
	  ◦ the surrounding residential area including heritage conservation area/s;
	  ◦ the heritage buildings to be retained on site;
	  ◦ the adopted Marrickville Council McGill Street Precinct Masterplan; and
	  ◦ the Concept Plan application for 78-90 Old Canterbury Road, Lewisham (MP08_0195).
	• The EA shall provide the following:
	  ◦ Detailed envelope/height and contextual studies demonstrating how the proposal relates to the height of the existing, proposed and approved developments surrounding the subject site and in the locality to ensure the proposal integrates with the local environment and the public domain;
	  ◦ Options for siting and orientation of building envelopes, massing and articulation;
	  ◦ Visual and view analysis to and from the site from key vantage points;
	  ◦ Options for maximising access to and linkages across the proposed Sydney Inner West Light Rail corridor, the proposed Greenway, local path networks and transport facilities such as Lewisham and Summer Hill stations (Evidence of consultation with Railcorp in relation to any work adjacent to the rail corridor and the results of that consultation shall be provided in the EA); and
	  ◦ Consideration of any aircraft-related height restrictions (refer to Sydney Airports letter dated 3 December which outlines height restrictions for buildings and temporary structures).
	• The EA shall address the design quality with specific consideration of the façade, massing, setbacks, building articulation, landscape concepts, safety by design and public domain.

3. Land Use

- The EA shall address the relevant metropolitan, regional and local strategies in relation to the desired future mix of land uses, and provide a justification for the amount of residential and non-residential floorspace being proposed.
- The EA shall identify the proportion of housing to be allocated to "affordable housing" and the mechanisms to facilitate this housing including any planning agreement or other binding agreement.

4. Public Domain/Open Space

- The EA must explain the type, function and landscape character of the various private, communal and public areas on site. Pedestrian circulation and linkages between each space should be demonstrated in a schematic form.
- The EA must consider the connectivity to and pedestrian/cycle linkages between the site, the proposed Sydney Inner West light rail corridor and station adjacent to the site, the proposed Greenway, the local path network, Lewisham and Summer Hill Stations, the adopted Marrickville Council McGill Street Precinct Masterplan and the Concept Plan application for 78-90 Old Canterbury Road, Lewisham (MP08_0195). The landscape design treatment should be considered in connection with the Greenway/Light Rail crossing/station design to create a unique identity and high quality public place.
- The EA shall include details on the dedication proposed public areas, including public pedestrian and vehicular access on site and to the proposed light rail station, and consider on-going maintenance needs and costs and public liability cover.
- The EA is to demonstrate how the design of proposed structures and the treatment of public domain and open spaces will:
  - Maximise safety and security within the site and the public domain.
  - Maximise surveillance and activity within the site and the public domain.
  - Comply with Crime Prevention Through Environmental Design (CPTED) principles.
  - Ensure access for people with disabilities.
  - Minimise potential for vehicle and pedestrian conflicts.

5. Environmental and Amenity Impacts

- The EA must address solar access, overshadowing, acoustic privacy, visual privacy and view loss and achieve a high level of environmental and residential amenity.
- The EA must consider any cumulative impacts of the proposal taking into consideration the proposed Sydney Inner West light rail corridor and station adjacent to the site, the proposed Greenway, the adopted Marrickville Council McGill Street Precinct Masterplan and the Concept Plan application for 78-90 Old Canterbury Road, Lewisham (MP08_0195).
- The EA must demonstrate how the Concept Plan addresses the requirements of SEPP 65 and the associated Residential Flat Design Code (RFDC).

6. Transport and Accessibility (Construction and Operational)

- The EA shall provide a Traffic Management and Accessibility Plan (TMAP) prepared in accordance with the RTA's guidelines for TMAP's and to be prepared with reference to the *Metropolitan Transport Plan – Connecting the City of Cities, the NSW State Plan 2010, NSW Planning Guidelines for Walking and Cycling, the Integrating Land Use and Transport* policy package and the RTA's *Guide to Traffic Generating Developments*;
  - The TMAP shall consider traffic generation of the various land uses on site (including daily and peak traffic movements), any required road/intersection upgrades and analysis of intersection capacities to ensure adequate levels of services are maintained, access (including waste collection, deliveries and emergency vehicle access), loading dock(s) including vehicle type and delivery times, car parking arrangements, the impact of additional parking demand for on-street parking in surrounding / adjacent streets, measures to promote public transport usage and pedestrian and bicycle linkages;

- The TMAP shall model the relevant intersections and road network as detailed in the RTA's letter dated 3 December 2010 and Ashfield Council's letter dated 1 December 2010 (Point 6), provide an estimate of the total trips generated by the proposed development and analyse the impact on the road network.
- The TMAP shall consider any cumulative impacts of the proposal in the context of approved and proposed development within the vicinity of the site:
  - the proposed Sydney Inner West light rail corridor and station,
  - the proposed Greenway,
  - the local path network,
  - Lewisham and Summer Hill stations,
  - the adopted Marrickville Council McGill Street Precinct Masterplan and
  - the Concept Plan application for 78-90 Old Canterbury Road, Lewisham (MP08_0195);
- The TMAP should consider the appropriate provision of on site car parking for the proposal having regard to the site's very high accessibility to public transport, local planning controls and the RTA guidelines. (**Note**: the Department supports reduced car parking rates). Parking provision for shared cars and adaptive re-use of parking for storage or other uses should also been specifically addressed; and
- The TMAP should consider demand for on-street parking by potential future light rail users and the need and costs associated with the implementation of a resident parking scheme on the site.

- The EA shall provide a Transport Map detailing current and proposed public transport provision (bus, rail and light rail) and walking and cycling connections within the vicinity of the site and address the potential for improving accessibility to and from the site, to and from Lewisham and Summer Hill Stations, and connections to the wider region via sustainable transport modes.
- The EA shall identify measures to manage travel demand, increase the use of public and non-car transport modes, and assist in achieving the objectives and targets set out in the NSW State Plan 2010.
- The EA should demonstrate impacts of travel demand on bus operations and investigate the provision of bus priority measures at the intersection of Railway Terrace and Old Canterbury Road, and the potential signalised intersection of Edward Street and Old Canterbury Road.
- The EA should address the potential for implementing a location specific sustainable travel plan, such as a Workplace Travel Plan (WTP) for workers and/or a Travel Access Guide (TAG) for visitors of the site.

7. Economic Impact Assessment

- The EA shall address the economic impact of the proposal and include a detailed investigation into the impact of the proposed retail floor space upon surrounding centres. The EA shall address how the proposal would support the objectives/aims of relevant State and regional strategies for the locality.
- The EA must consider any cumulative impacts of the proposed retail floor space on the site and the proposed retail floor space within the McGill Street Precinct Masterplan and the Concept Plan application for 78-90 Old Canterbury Road, Lewisham (MP08_0195).

8. Noise and Vibration

- The EA should address the issue of noise and vibration impacts (including from road, heavy rail and aircraft) and provide details of how these will be managed and ameliorated though the design of the building, in compliance with relevant Australian Standards and the Department's *Interim Guidelines for Development near Rail Corridors and Busy Roads*.

9. Ecologically Sustainable Development (ESD)

- The EA shall detail how the development will incorporate ESD principles in the design, construction and ongoing operation phases of the development.

10. Heritage and Archaeological

- The EA shall provide a Heritage Assessment of the site, and a Statement of Heritage Impact for the proposal undertaken in accordance with the Burra Charter assessment procedures.
- The EA shall nominate heritage items to be retained on site and establish urban design principles for proposed buildings to relate and have a sympathetic scale and form to heritage items on the site and the adjacent heritage conservation area.
- The EA shall provide an Archaeological Assessment of Aboriginal and non-Indigenous archaeological resources, including an assessment of the significance and potential impact on the archaeological resources.

11. Drainage / Water Management / Flooding

- The EA shall address drainage/flooding issues associated with the development/site, including stormwater, overland flows, proximity to Hawthorne Canal, drainage infrastructure and incorporation of Water Sensitive Urban Design measures.
- The flood assessment and drainage design should consider the development of the site, in addition to any cumulative impacts of the proposed light rail station located in the floodplain and the development yield of the McGill Street Precinct Masterplan and the Concept Plan application for 78-90 Old Canterbury Road, Lewisham (MP08_0195).
- Evidence of consultation with the NSW Office of Water in relation to the potential impacts on Hawthorne Canal and possible rehabilitation/mitigation measures and the results of that consultation shall be provided in the EA.

12. Groundwater Management

- The EA is to identify groundwater issues and potential degradation to the groundwater source and shall address any impacts upon groundwater resources, and when impacts are identified, provide contingency measures to remediate, reduce or manage potential impacts.

13. Rail Impacts

- The EA shall address geotechnical issues and any impacts on the adjacent light rail corridor. A Geotechnical Report, Structural Report and Construction Methodology in accordance with RailCorp's "Standard Brief".

14. Contamination

- The EA is to demonstrate compliance that the site is suitable for the proposed use in accordance with SEPP 55 – Remediation of Land.

15. Flora & Fauna

- The EA shall address impacts on flora and fauna, including threatened species, populations and endangered ecological communities and their habitats and steps taken to mitigate any identified impacts to protect the environment, both marine and land in accordance with DECC "*Threatened Species Assessment Guidelines 2007*". In this regard, the EA shall include a detailed survey (using a variety of survey methods by a suitably qualified person) of the endangered long-nosed bandicoot population which occurs in this area, and determine whether and how they are using the site and adjoining areas, and assess any potential impact or threat to the population.
- The Commonwealth Department of Environment, Water, Heritage and the Arts should be consulted to ascertain whether the proposed development triggers the need for an assessment and approval under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

16. Contributions

- The EA shall address the provision of public benefit, services and infrastructure having regard to Council's Section 94 Contribution Plan, and provide details of any Planning Agreement or other legally binding instrument proposed to facilitate this development.

17. Consultation

- Undertake an appropriate and justified level of consultation in accordance with the Department's *Major Project Community Consultation Guidelines October 2007*, including discussion with relevant agencies.

18. Utilities

- In consultation with relevant agencies, the EA shall address the existing capacity and requirements of the development for the provision of utilities, including staging of infrastructure works. Utility capacity planning needs to be considered in the context of the development yields within the McGill Street Precinct Masterplan and the Concept Plan application for 78-90 Old Canterbury Road, Lewisham (MP08_0195).

19. Staging

- The EA must include details regarding the staging of the proposed development (if staged) including details of subsequent Project Applications and Construction Staging.

20. Statement of Commitments

- The EA must include separate draft Statement of Commitments for the Concept Plan and the Stage 1 Project Application detailing measures for environmental management, mitigation measures and ongoing monitoring for the project.

STAGE 1 PROJECT APPLICATION

In addition to addressing relevant items from the list above, the EA for the Project Application must give **detailed** consideration to the following additional project-specific matters:

21. Urban Form and Design

- The EA shall address all relevant requirements of SEPP 65 and the associated Residential Flat Design Code (RFDC).
- The EA shall include with specific consideration of the façade, massing, setbacks, building articulation, appropriate colours, materials, finishes, landscaping, safety by design and public domain, including an assessment against the CPTED Principles.
- The EA shall detail provision of appropriate private and public open space for Stage 1.

22. Heritage

- The EA shall identify all heritage impacts associated with Stage 1 works, and provide a detailed Statement of Heritage Impact for Stage 1 works detailing and evaluating any impacts that the development would have on the heritage significance of the site, including both built and landscape heritage (if applicable).

23. Drainage/Flooding

- The EA shall identify any water management structures proposed to service the Stage 1 Project Application, including any dams, swales or detention basins. Information regarding the size, location, capacity and purpose of any water management structures.

24. Staging and Infrastructure

- The EA shall address how the Stage 1 Project Application development will integrate with the overall Concept Plan proposal, including details of infrastructure work required to ensure that Stage 1 is fully serviced and provided with an appropriate level of infrastructure.

25. Construction Impacts

- The EA shall address noise and other impacts during the construction phase of the development and address how these will be managed and mitigated in accordance with the *"Interim Construction Noise Guideline" (DECCW, 2009).*
- The EA shall provide a Construction Traffic Management Plan (CTMP) to mitigate any potential impacts to accessibility, amenity and safety of public transport use, walking and cycling during construction, including access arrangements for emergency vehicles and workers and an estimation of the number of truck movements expected

	during the construction phase. **26. Rail impacts** • Given the possible likelihood of objects being dropped or thrown onto the rail corridor from balconies, windows and other external features (eg roof terraces and external fire escapes) that face the rail corridor, any part of the proposal within 20m of the rail corridor is required to include measures (eg awning windows, louvres, enclosed balconies etc) which prevent the throwing of objects onto the rail corridor. **27. Ecologically Sustainable Development (ESD)** • The EA must demonstrate that the development has been assessed against a suitably accredited rating scheme to meet industry best practice and relevant Council controls.
Deemed refusal period	60 days

APPENDIX A

Relevant EPI's policies and Guidelines to be Addressed

- Objects of the EP&A Act 1979
- NSW State Plan
- Sydney Metropolitan Strategy
- Draft Inner West Subregional Strategy and Draft South Subregional Strategy
- SEPP (Major Development) 2005
- SEPP (Building Sustainability Index: BASIX) 2004
- SEPP 65 - Design Quality of Residential Flat Development and the Residential Flat Design Code (RFDC)
- SEPP (Infrastructure) 2007
- SEPP 55 - Remediation of Land
- Draft SEPP (Competition)
- Ashfield Local Environmental Plan 1985 and relevant Ashfield Council documents including relevant Development Control Plans
- Marrickville Local Environment Plan 2001 and relevant Marrickville Council documents including relevant Development Control Plans
- Adopted Marrickville Council McGill Street Precinct Masterplan
- Metropolitan Transport Plan 2010
- NSW Bike Plan 2010
- Planning Guidelines for Walking and Cycling
- Integrating Land Use and Transport Policy Package 2001
- Healthy Urban Development Checklist 2010
- Development Near Rail Corridors and Busy Roads – Interim Guideline
- Airports Act 1996 and the Airports (Protection of Airspace) Regulations 1996
- Threatened Species Conservation Act 1995
- Environment Protection and Biodiversity Conservation Act 1999
- "GreenWay Group" Design Principles for Major Development fronting the GreenWay Corridor
- Nature and extent of any non-compliance with relevant environmental planning instruments, plans and guidelines and justification for any non-compliance.

ATTACHMENT 2
Plans and Documents to Accompany the Application

Plans and Documents to accompany the Application

General	The Environmental Assessment (EA) must include: 1. An executive summary; 2. A thorough site analysis including site plans, areal photographs and a description of the existing and surrounding environment; 3. A thorough description of the proposed development; 4. An assessment of the key issues specified above and a table outlining how these key issues have been addressed; 5. An assessment of the potential impacts of the project and a draft Statement of Commitments, outlining environmental management, mitigation and monitoring measures to be implemented to minimise any potential impacts of the project; 6. The plans and documents outlined below; 7. A signed statement from the author of the Environmental Assessment certifying that the information contained in the report is complete and neither false nor misleading; 8. A Quantity Surveyor's Certificate of Cost to verify the capital investment value of the project (in accordance with the definition contained in the Major Development SEPP and DoP Planning Circular PS10-008); and 9. A conclusion justifying the project, taking into consideration the environmental impacts of the proposal, the suitability of the site, and whether or not the project is in the public interest.
Plans and Documents	**CONCEPT PLAN APPLICATION** The following plans, architectural drawings, diagrams and relevant documentation shall be submitted; **1.** An **existing site survey plan** prepared by a registered surveyor drawn at an appropriate scale illustrating; • the location of the land, boundary measurements, area (sq.m) and north point; • the existing levels of the land in relation to buildings and roads; • location and height of existing structures on the site, including identification on whether there are any encroachments onto adjacent land; • the common boundary with any RailCorp landholding and any easements and right-of-ways; • location and height of adjacent buildings and private open space; and • all levels to be to Australian Height Datum. **2.** A **Site Analysis Plan** must be provided which identifies existing natural elements of the site (including all hazards and constraints), existing vegetation, footpath crossing levels and alignments, plans and elevations of the station, station concourse, platform and existing pedestrian access points, pedestrian flows, existing vehicular access points and other facilities, slope and topography, utility services, boundaries, orientation, view corridors and all structures on neighbouring properties where relevant to the application (including windows, driveways, private open space etc). **3.** A **locality/context plan** drawn at an appropriate scale should be submitted indicating: • significant local features such as parks, community facilities and open space and heritage items; • the location and uses of existing buildings, shopping and employment areas; and • traffic and road patterns, pedestrian routes and public transport nodes.

4. **Architectural drawings** at an appropriate scale illustrating:
   - the location of any existing and proposed building envelopes or structures on the land in relation to the boundaries of the land, setbacks to top of bank/riparian corridors and any development on adjoining land;
   - building envelopes and heights/ levels;
   - extent of basement car parking and deep soil zones;
   - envelope/ land use staging plans and diagrams;
   - the height (AHD) of the proposed development in relation to the land;
   - the level of the lowest floor, the level of any unbuilt area and the level of the ground;
   - any changes that will be made to the level of the land by excavation, filling or otherwise;
   - indicative section drawings showing overall site, building massing and storeys, topography of land, major landscaping, roads, major infrastructure, cur and fill, and the location of the rail corridor boundary and the location of the nearest light rail infrastructure, ie. stanchions and tracks.

5. **A Physical Massing Model** of the proposed development at an appropriate scale for the Concept Plan proposal and which clearly identifies those works associated with Stage 1.

6. **Other documents / plans**:
   - **Stormwater Concept Plan** - illustrating the concept for stormwater management.
   - **Flooding Report** - prepared by a recognised professional which assesses pre and post development flooding implications and mitigation measures in accordance with the NSW Floodplain Development Manual (2005), including the potential effects of climate change, sea level rise and an increase in rainfall intensity. The flood assessment shall consider pre-development flood impacts on the site, the extent of the 1 in 100 year floodplain, and implications for the proposed site layout, building location and habitable floor levels and the post-development implications of any works within the floodplain and measures to mitigate impacts.
   - **Geotechnical Report** - prepared by a recognised professional which assesses the risk of geotechnical failure on the site and identifies design solutions and works to be carried out to ensure the stability of the land and structures and safety of persons.
   - **View Analysis** - Visual aids such as photomontages must be used to demonstrate visual impacts of the proposed building envelopes in particular having regard to the siting, bulk and scale relationships from key areas and may include a 3 Dimensional Model of the proposed development (in CADD format, capable of being imported into Council's computer "Ashfield Simurban" model).
   - **Public Domain/Landscape Concept plan** - illustrating treatment of open space areas on the site, screen planting along common boundaries and tree protection measures both on and off the site.
   - **Shadow diagrams** - showing solar access to the site and adjacent properties at summer solstice (Dec 21), winter solstice (June 21) and the equinox (March 21 and September 21) at 9.00 am, 12.00 midday and 3.00 pm.
   - **Flora and Fauna Report** – to assess the potential flora and fauna impacts and measures to mitigate impacts.
   - **Arborist Report** – outlining retention of existing significant trees within public and communal open space wherever possible, providing justification for trees to be removed and detailing protective measures for the trees to be retained on or in the vicinity of the site.

- **Heritage impact statement** – prepared in accordance with the NSW Heritage Manual and illustrating the impact of the proposed re-use of the building on its heritage value.
- **Archaeological Assessment** – of Aboriginal and non-Indigenous archaeological resources, including an assessment of the significance and potential impact on the archaeological resources.

STAGE 1 PROJECT APPLICATION

In addition to the general assessment requirements specified above, the following additional detailed requirements relate to the preparation of the Stage 1 Project Application (MP10_0180):

1. **Detailed Architectural drawings** at an appropriate scale, illustrating:
   - the location of any existing buildings or structures on the land, in relation to the boundaries of the land and any development on adjoining land;
   - detailed floor plans, sections and elevations of the proposed buildings;
   - large scale elevation and section plans showing building fenestration, articulation, height, entries, windows, balconies and other features, other structures, road/footpath/cycleway pavements, cut and fill, basements, parking, landscaping, and labelled dimensions for space allocation.
   - elevation plans providing details of proposed external building materials and finishes and colour scheme(s);
   - section plans showing the location of the rail corridor boundary and the location of the nearest light rail infrastructure, ie. stanchions and tracks;
   - accessibility requirements of the Building Code of Australia and the Disability Discrimination Act; and
   - notation of the height(s) of the development (AHD) in relation to the land, the level of the lowest floor, the level of any unbuilt areas and the level of the ground, and identification of any changes that will be made to the level of the land by excavation, filling or otherwise.
2. **Detailed Landscape plans** detailing existing and proposed plantings, any trees to be removed, detention basins, fences, paving and the like, with specific details on the size and species of proposed plantings provided, along with an **Arborist Assessment** of any trees to be removed.
3. A **Schedule of Materials and Finishes** and a **Sample Board**, detailing all proposed materials and external finishes.
4. A **Stormwater and Drainage Plan** indicating the concept for stormwater management, designed in accordance with Council's guidelines.
5. A **Construction Management Plan** to mitigate impacts on neighbouring properties, including the adjacent rail corridor, and on nearby roads, including impacts on pedestrians and cyclists.
6. An **Access Report** to demonstrate compliance with the various Discrimination and Disability regulations for the building and open space areas, as well as access to the surrounding public spaces and integration with surrounding pathways and transport facilities.
7. An **Integrated Water Management Plan** and **Infrastructure Management Plan** should be prepared in accordance with Sydney Water's requirements.

Documents to be submitted	• 1 hard copy of the EA, plans and documentation, and 1 copy on CD-ROM for the **Test of Adequacy**; • **Once the EA has been determined adequate** and all outstanding issues adequately addressed, 8 hard copies of the EA for exhibition; • 8 sets of architectural and landscape plans to scale, including two (2) sets at A1 size (to scale); and • 10 copies of the Environmental Assessment and plans on CD-ROM (PDF format), each file not exceeding 5Mb in size. **NOTE:** Each file must be titled and saved in such a way that it is clearly recognisable without being opened. If multiple pdf's make up one document or report, these must be titled in sequential order.

ATTACHMENT 3

Government Authority Responses to Request for Key Issues

For Information Only

B

Appendix B. Flooding Report and Stormwater Concept Plan

APP

EG FUNDS MANAGEMENT

SUMMER HILL FLOUR MILL SITE
2-32 SMITH STREET

Flood Report &
Stormwater Drainage Concept Plan

Concept Plan Application Stage

Issue No. 2
MARCH 2011

EG FUNDS MANAGEMENT

Summer Hill Flour Mill Site
2-32 Smith Street

Flood Report &
Stormwater Drainage Concept Plan

Concept Plan Application Stage

Issue No. 2
MARCH 2011

Document Amendment and Approval Record

Issue	Description of Amendment	Prepared by [date]	Verified by [date]	Approved by [date]
1	Draft Report	Mike Shaw	Mike Shaw	Mike Shaw
2	Final Report	Mike Shaw	Mike Shaw	Mike Shaw

Note: This document is preliminary unless it is approved by a principal of Civil Certification.

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1 INTRODUCTION

The proposed development site is located on the corner of Smith Street and Edward Street, Summer Hill and is known as the Summer Hills Flour Mill site.

It is proposed to redevelop this former industrial site to create a mixed use residential, retail and commercial development incorporating parking, public open space, new public streets and associated infrastructure works.

The site has a total area of approximately 2.5 ha. The site is bounded by Smith Street, Edward Street, Longport Street, Old Canterbury Road and the former goods line rail corridor (*refer to **Figure 1***).

The site straddles the Local Government border between Marrickville Council and Ashfield Council.

Civil Certification has been engaged by APP on behalf of EG Funds Management to prepare a stormwater management report in support of the concept plan application for the site. In particular, to build upon the early stormwater management work undertaken by Meinhardt and to address the Director Generals Requirements (*MP10-0155 dated 16 December 2010*) related to drainage, flooding and water management.

The site is located in a low lying area immediately adjacent to Sydney Water controlled trunk drainage infrastructure, including Hawthorne Canal. As such careful consideration needs to be given to the possible stormwater management implications on the proposed development itself and adjoining sites.

This report addresses the following stormwater management elements:

- Mainstream flooding and overland flooding;
- Flood planning and assignment of appropriate minimum floor levels;
- Flood emergency response for extreme flood events;
- Stormwater detention;
- Stormwater quality and Water Sensitive Urban Design (*WSUD*); and
- Stormwater drainage concept design.

Assessment of the potential cumulative impacts resulting from the nearby McGill Street Precinct Masterplan, the Concept Plan Application for 78-90 Old Canterbury Roads Lewisham and the Sydney Light Rail Extension proposal have also been incorporated as part of this report along with consideration of possible climate change impacts.

1.1 QUALIFICATIONS OF AUTHOR

This report has been prepared by Michael Shaw, a Principal of Civil Certification. Michael has over 18 years experience in stormwater management and flood assessment. Details of Michael's qualifications and experienced are contained at **Appendix D**.

1.2 QUALIFIER

This report has been prepared for the benefit of APP and EG Funds Management with relation to the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of Civil Certification. In preparing this report, Civil Certification have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended.

2 BACKGROUND

2.1 SITE INSPECTION

A detailed site reconnaissance was carried out by Civil Certification at commencement of the project to identify stormwater management constraints and opportunities, flood controls and existing drainage infrastructure. Photographs from the site reconnaissance are contained at the rear of this report.

Notable observations from the site reconnaissance are provided below:

- The Longport Street culvert appears to be a major control for upstream flooding;
- A large proportion of the site sits well below the downstream weir level (*approx. RL13.2mAHD*)of the roundabout at the intersection of Smith Street and Longport Street;
- A secondary conduit for flow in larger events would be the railway culvert beneath Longport Street;
- The Goods railway line culvert appears to be another control for flooding and will determine the extent of overland flow traversing the railway corridor in larger events;
- Overland flows travelling down Smith Street are likely to enter the site near the existing substation and traverse the site until they enter Hawthorne Canal;
- There is a substantial drop from the lower parts of the site to the invert of Hawthorne Canal (*over 5m*);
- A network of pipes/pits currently serves the former industrial site;
- A section of the site to the east of the Canal (*Lot 1 DP900501-Marrickville*) is isolated from the main site by Hawthorne Canal;
- The existing areas of the opposite McGill Street Precinct rise up away from the Goods Railway corridor. Existing industrial development along the boundary with the Goods railway corridor provide an effective barrier to overland flows within the railway corridor; and
- Opportunities exists to provide WSUD measures in the lower parts of the site near Hawthorne Canal.

2.2 SURVEY

Survey detail for the site and immediate surrounds was supplied by Watson Buchan Pty Ltd (*Job Ref 07/0321*). Details of the existing survey are provided at **Appendix E**. Any additional topographic levels required outside of the detailed survey area were obtained from 1:2000 Orthophoto Maps of the area (*Leichhardt U0945-53*).

2.3 EXISTING SITE TOPOGRAPHY

The site topography levels are presented in **Figure 2**. The site ground levels generally rise away from the low point adjacent to where the Hawthorne Canal emerges on the site from the railway corridor.

The Edward Street frontage varies in level from RL 15m AHD at the southern end to generally RL 11m AHD at the northern end. Smith Street rises from approximately RL 9.7m AHD at its low point to RL 10.6m AHD at the intersection with Edward Street and continues to rise to the north as do other streets extending southwards from Edward Street.

The Longport Street crossing has levels generally between RL 14.5 and 15m AHD.

The heritage buildings on the site have the following approximate ground/base levels:-

- Mungo Building – RL 9.05m AHD;
- Storage Silos 6 – RL 11m AHD; and
- Storage Silos 4 – RL 11.5m AHD.

The railway corridor forms a crest between the subject site and the McGill Street Masterplan area. This crest level varies from around RL 12m AHD at the Old Canterbury Road overpass to approximately RL 9.6m AHD at the Longport Street overpass.

The site topography in the McGill Street Masterplan generally falls to the north western corner from Old Canterbury Road. The general ranges of levels are:-

- Old Canterbury Road - RL 12 to 15m AHD;
- Brown Street – RL 9.9 to 13m AHD;
- William Street – RL 10.5 to 13m AHD;
- Hudson Street – RL 11 to 13m AHD; and
- McGill Street – RL 12.5 to 15m AHD.

2.4 EXISTING DRAINAGE

Upstream of the subject site, Hawthorne Canal flows under Old Canterbury Road on the eastern side of the goods railway and extends to the goods railway line as an open channel. It then passes under the railway and existing buildings on the subject site as a covered channel/culvert. It is an open channel through the northern end of the subject site before passing under the Longport Street overpass as an approximate 3.8m diameter culvert.

The Smith Street drainage system enters from the west and joins the main Hawthorne Canal channel at the northern end of the site. The McGill Street Masterplan area is generally drained by a 1200mm diameter pipe extending under the railway line and joining with main Hawthorne Canal channel immediately downstream of the Longport Street crossing.

The approximate catchment area of Hawthorne Canal upstream of Longport Street is 297ha.

The canal is owned and maintained by Sydney Water and it is listed as a heritage item. The top of the concrete walls in the channel on the subject site generally vary from RL 5.7m AHD adjacent to the railway to RL 4m AHD at the Longport Street embankment. In the northern section of the site, steep banks rise from these walls to levels of RL 8.5 to 9m AHD on the western side and to levels around RL 10 -11m AHD on the eastern side.

The Smith Street Branch of the Hawthorne Canal system has limited pipe capacity (*around a 5 yr ARI*) with overland flow ponding in the low point in Smith Street opposite the site driveway and Energy Australia substation. It overflows the kerb and flows into the site down the existing tree corridor to the open section of the canal.

The former industrial site contains a network of underground pipes and surface pits that convey locally generated flows to Hawthorne Canal.

2.5 DGRS

On the 16th December 2010, NSW Planning issued a number of requirements applicable to the Concept Plan Application Environmental Assessment for the subject site (*MP 10_0155*). These requirements are termed the Director Generals Requirements or DGR's.

The DGR's that relate specifically to stormwater management and flooding are summarised below:

Key issues - 11. Drainage / Water Management / Flooding

- "*The EA shall address drainage/flooding issues associated with the development site including stormwater, overland flows, proximity to Hawthorne Canal, drainage infrastructure and incorporation of Water Sensitive Urban Design Measures*";
- "*The flood assessment and drainage design should consider the development of the site, in addition to any cumulative impacts of the proposed light rail station located in the floodplain and the development yield of the McGill Street Precinct Masterplan and the Concept Plan Application for 78-90 Old Canterbury Road, Lewisham (MP08_0195)*";
- "*Evidence of consultation with the NSW Office of Water in relation to the potential impacts on Hawthorne Canal and possible rehabilitation/mitigation measures and the results of that consultation shall be provided in the EA*";

Attachment 2 - 6. Other Documents/Plans

- *"Stormwater Concept Plan – illustrating the concept for stormwater management"*
- *"Flooding report – prepared by a recognised professional which assesses pre and post development flooding implications and mitigation measures in accordance with the NSW Floodplain Development Manual (2005), including the potential effects of climate change, sea level rise and an increase in rainfall intensity. The flood assessment shall consider pre-development flood impacts on the site, the extent of the 1 in 100year floodplain, and implications for the proposed site layout, building location and*

habitable floor levels and the post development implications of any works within the floodplain and measures to mitigate impacts".

2.6 MEINHARDT REPORTS

Two reports were prepared for the site in mid 2010 by Meinhardt Infrastructure & Environment Pty Ltd (*Meinhardt*) as follows:

- "*Summer Hill Flour Mills, 2-32 Smith Street and 16-32 Edward Street, Summer Hill – Hawthorne Canal Flood Assessment*" 29 July 2010; and
- "*Summer Hill Flour Mills, 2-32 Smith Street and 16-32 Edward Street, Summer Hill – Stormwater Masterplan*" 11 August 2010.

A summary of the critical findings and recommendations with respect to the hydrological and hydraulic behaviour is provided below.

- A hydrological assessment was undertaken using DRAINS and estimated that the total 100yr ARI and 5yr ARI flows in the Hawthorne Canal just upstream of the Longport Street culvert were 86.6m^3/s and 42.1m^3/s respectively;
- A comparison of the DRAINS derived flows was made with Sydney Water's 1998 SWC62 Capacity Assessment and it was found that they correlated fairly well;
- A hydraulic assessment was undertaken using HEC RAS and estimated that the 100yr ARI water surface level at the centre of the site (*approx. CH 400*) was approximately RL 9.7mAHD. This flood level was found to reduce to approximately RL 9.4mAHD just upstream of the Long port Street culvert (*CH280*). The assessment also found that the 100yr ARI flood levels across the goods railway corridor range from RL11.7mAHD at CH480 to RL10.6mAHD at CH405;
- "*Based on the flow data calculated in the DRAINS analysis and the subsequent hydraulic assessment using HEC RAS, the upstream stormwater flows experienced during the peak 1 in 100yr ARI storm event cannot be contained within the Hawthorne Canal channel in its existing conditions*"p21;
- *"The dominant influence for the flood levels calculated within the SHFM* (Summer Hills Flour Mill) *site is the presence of the Longport Street Road Overpass and culvert found at the downstream end of the SHFM site"p21;*
- *"As the Longport Street culvert is not of adequate size to convey the calculated 1 in 100yr ARI flows, the overpass acts as a barrier and causes canal flows to rise up to an approximate RL of 9.59mAHD to drive the stormwater through the culvert (under pressure head). As with a small proportion of flow travelling under the Longport Street railway Tunnel…."p22;*
- *"……it is likely that tidal influences will have a negligible affect on calculated water levels"p22;*

- *"… given that the Longport Street culvert acts as the downstream control for floodwaters calculated within the SHFM site, it is unlikely that the expected future sea level rise will influence flood levels within the subject site"p22;*
- *"It is envisaged that stormwater runoff from the site will need to be treated to remove pollutants……As such it is envisaged that the site stormwater system will comprise Water Sensitive Urban Design (WSUD) principals and incorporate a treatment train approach with water retention and reuse in accordance with industry best practice"p23;*

2.7 MARRICKVILLE COUNCIL

Details of Marrickville Council's stormwater management requirements for the site are contained in the following policy document:

- "*Marrickville Council Stormwater and Onsite Detention Code*" Marrickville Council, 16 February, 1999.

2.8 ASHFIELD COUNCIL

Details of Ashfield Council's stormwater management requirements for the site are contained in the following policy document:

- "*Stormwater Management Code*" Ashfield Council, April 1995.

2.9 SYDNEY WATER

Liaison has previously occurred between Sydney Water and Meinhardt regarding those elements of the development proposal that directly effect Sydney Water and the assets under their direct management.

2.10 NSW OFFICE OF WATER

The DGRs require liaison with the NSW Office of Water (*NOW*).

It is understood that NOW was approached by EG Funds Management and their representatives, however they declined to meet for discussion on the project.

2.11 CLIMATE CHANGE

Guidance on potential climate change impacts were obtained from the following reports:

- "*Draft Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments*" DECCW NSW, October 2009;
- "*NSW Climate Impact Profile – The Impacts of Climate Change on the Biophysical Environment of NSW*" DECCW NSW, June 2010; and

- "*Floodplain Risk Management Guideline – Practical Consideration of Climate Change*" DECC NSW, 25 October 2007.

3 PROPOSED DEVELOPMENT

The proposed development of the former "*Summer Hills Flour Mill*" site will comprise a mix of retail, commercial and residential land uses, including townhouses, apartments and adaptive reuse of some of the existing buildings on the site including the former flour silos.

The development will include open space, community facilities and pedestrian linkages from the surrounding residential areas to the proposed light rail extension and greenway.

An illustration of the proposed development is presented in **Figure 2**. The proposed building numbers are shown in **Figure 3**.

Further details of the proposed development are provided under separate cover by Hassell.

The buildings to be retained onsite as part of the development and reused are summarised below:

- Mungo Building (*2A & 2B*) - Uses will include retail on the ground floor, commercial on the first and second floors and residential above. Ground floor will have a level of RL 9.05mAHD with a first floor level of 13.9, AHD;
- Storage Silos – 4 units (*3C*) - Uses will include residential. Ground floor level of RL 11.5m AHD; and
- Storage Silos – 6 units (*5A*) - Uses will include retail and residential. Ground floor levels will be RL 10.7 in AHD for retail and RL 11.5m AHD for residential.

The proposed new buildings are summarised below:

- Building (*1A*) - Minimum residential floor level RL 11.5m AHD, basement driveway entry crest level of RL 10.8m AHD, first floor level of RL 14m AHD and pedestrian bridge connection from first floor level of RL 14m AHD to Longport Street at RL 14.5m AHD;
- Building 1C – 1 Storey - One level retail with elevated floor at level of RL 9.05m AHD. Ready access to Building 2A for evacuation;
- Building 2A/2B - Heritage building to be retained and refurbished with existing floor levels. Ground floor level at RL 9.05m AHD with retail use and internal stair access to first floor at RL 13.9 AHD. Commercial uses in floors 1 & 2. Residential uses in floors above. Covered walkway connection between Buildings 2A and 3A at first floor level (*RL 13.9AHD*). Provides flood free access to basement of Building 3A;
- Building 2C – 1 Storey. Energy Australia electrical substation is a heritage building to be retained. Floor level at RL 9.7 AHD to be refurbished for retail use.

- Building 3 – Uses include 3A – residential – ground floor RL 11.5m AHD, 3B – retail – ground floor RL 11.5m AHD, 3C – Residential – Ground Floor RL 11.5m AHD, 3D – Residential – Ground Floor 12m AHD. Basement entry crest level – RL 13m AHD
- Building 4 – 5 Storeys. Uses - 4A – retail – floor level RL 10.4m AHD, 4A - residential – ground floor RL 11.5m AHD, 4B – residential – ground floor RL 11.5m AHD, 4C – residential – ground floor RL 11.5m – 12.7m AHD. Basement entry crest level RL 11.5m AHD.
- Building 5 – 5 Storeys. Uses - 5A – retail – ground floor RL 10.7 AHD, 5A – residential – ground floor RL 11.5m AHD, 5B – residential – ground floor RL 11.9m AHD, 5C – residential – ground floor RL 13.9m – 14.2m AHD, 5D – residential – ground floor RL 11.8 – 12.8m AHD, 5E – retail ground floor RL 13m AHD. Basement entry driveway crest level RL 13m AHD.

4 HYDROLOGY

As part of the Masterplan application for the subject site, a hydrological assessment was previously completed for the catchment of Hawthorne Canal upstream of the subject site. This assessment involved modelling using the software package called DRAINS and is described in the report titled "*Summer Hill Flour Mills, 2-32 Smith Street and 16-32 Edward Street, Summer Hill – Hawthorne Canal Flood Assessment*" Meinhardt Infrastructure and Environment Pty Ltd, 29 July 2010.

For this study we have undertaken the following hydrological assessment:

- Verification of the July 2010 Meinhardt Hydrology;
- Undertaking independent RAFTS modelling; and
- Modification of the July 2010 Meinhardt DRAINS model to test detention requirements.

All hydrological analyses have been undertaken in accordance with Australian Rainfall and Runoff (*AR&R*) 1987.

4.1 VERIFICATION OF MEINHARDT HYDROLOGY

As it is a critical design factor, it was considered appropriate to verify the hydrological results previously derived by Meinhardt in July 2010, by comparison with alternative techniques.

This verification process involved the following steps:

1. Detailed review of the existing Meinhardt DRAINS model;
2. Construction of a simplified hydrology focused DRAINS model based on the July 2010 Meinhardt DRAINS model;
3. Completion of Rational Method estimates of flow for the three main branches of the catchment upstream of the site;
4. Review of Sydney Waters estimates of hydrology for Hawthorne Canal; and
5. Comparison of the Meinhardt July 2010 results with the results of Steps 2, 3 and 4.

4.1.1 Meinhardt DRAINS Model and Results

A summary of the Meinhardt July 2010 DRAINS results at critical locations in the vicinity of the subject site are provided in **Table 1.**

These results have subsequently been used in all Meinhardt Flood modelling to ascertain flood profiles in the 100yr ARI and 20yr ARI events for the subject site.

Table 1 – Meinhardt DRAINS Results

HEC RAS Chainage	Location Description	Total 20yr ARI Peak Flow (m^3/s)	Total 100yr ARI Peak Flow (m^3/s)
25	Approx. 230m downstream of the Longport Street Culvert	69.8	103.0
230	Immediately downstream of the Longport Street Culvert	65.6	95.4
334.5	At the confluence of Hawthorne Canal and the Smith Street Branch	61.6	86.5
395	At the downstream end of the Goods Railway Line Culvert (*Hawthorne Canal*)	41.3	51.8
480	At the upstream end of the Goods Railway Line Culvert (*Hawthorne Canal*)*	41.0	50.9

Notes: * Approx. 23m^3/s of this total flow is conveyed in the culvert with the remainder flowing overland across the railway line.

4.1.2 Simplified DRAINS Model

A detailed review of the Meinhardt July 2010 DRAINS model revealed a number of minor issues (*ie flow continuity problems, undervalued 50yr ARI basic duration IFD data , excessive lagging*) and an unwarranted level of complexity.

Based on the model review it was considered appropriate to create a simplified version of the model, maintaining all catchment characteristics but removing all channel/pipe sections and simplifying lag (*ie a model focusing on hydrology only*).

It was anticipated that the results from this type of model would yield a conservative result but would be invaluable in confirming the effect of the identified minor issues and the adopted hydrological parameters.

The results of the simplified DRAINS model are summarised in **Table 2**. Details of the simplified DRAINS model are provided in **Appendix C**. The critical storm duration was 25minutes.

Table 2 – Simplified DRAINS Model Results

Location Description	Total 100yr ARI Peak Flow (m^3/s)	Total 20yr ARI Peak Flow (m^3/s)	Total 5yr ARI Peak Flow (m^3/s)
Smith Street Branch	30.4	22.8	16.5
Main Branch/Hawthorne Canal Upstream of Smith Street Branch	69.8	53.1	38.0
Petersham Branch	12.3	9.6	7.0
Outlet	116.0	86.2	61.6

4.1.3 Rational Method Estimates

The Rational Method was used to estimate the peak flows generated by the catchments of the three main branches of Hawthorne Canal that are converging near the subject site as well as the peak flow generated by the entire 295ha catchment upstream of the subject site. The results of these calculations are summarised in **Table 3**.

Table 3 – Rational Method Results

Parameter	Smith Street Branch	Main Branch	Petersham Branch	Total Catchment Upstream of site
Area (ha)	85.0	174.0	35.7	294.7
Tc (min)	42.9 (*say 40min*)	56.3 (*say 50min*)	30.8 (*say 30min*)	68.8 (*say 60min*)
% Imperv.	70	65	75	70
100yr ARI Intensity (mm/h)	116.6	104.6	133.5	95.5
20yr ARI Intensity (mm/h)	87.8	78.4	101.1	71.4
5yr ARI Intensity (mm/h)	66.0	58.7	76.4	53.2
C10	0.8	0.78	0.83	0.8
C100	0.96	0.94	1.0	0.96
C20	0.84	0.82	0.87	0.84
C5	0.76	0.74	0.79	0.76
100yr ARI Peak Flow (m^3/s)	26.5	47.6	13.3	75.1
20yr ARI Peak Flow (m^3/s)	17.4	31.1	8.7	49.1
5yr ARI Peak Flow (m^3/s)	11.9	21.0	6.0	33.1

4.1.4 Sydney Water Hawthorne Canal Hydrology

A report by Sydney Water titled "*Hawthorne Canal SWC62, Capacity Assessment*" May 1998 provides an estimate of 5yr ARI canal flows derived from the Rational Estimate. The estimated flows in the vicinity of the site are provided in **Table 4**.

Table 4 – SWC Capacity Assessment Flows

Location Description	Node Section	Total 5yr ARI Peak Flow (m^3/s)
Immediately Downstream of Longport Street Culvert	FE	46.1
Hawthorne Canal Just upstream of Smith Street Branch	JH	28.8

4.1.5 Comparison of Results

Overall, the comparison methods show that the July 2010 Meinhardt derived DRAINS flows are reasonable.

Comparison with the simplified DRAINS model shows that the Meinhardt derived flow estimates are slightly lower as expected but within an acceptable range.

Comparison with the Rational Method shows that the Meinhardt derived flow estimates are higher but within an acceptable range. Again, this would be expected due to the simple triple branch break up of the catchment *(ie minimal account for partial area effects*).

Comparison with the SWC Capacity Assessment results show that the Meinhardt derived flow estimates are still higher but closer than the Rational Method estimates described above. Again this is as expected, because even though the SWC Capacity Assessment also utilises the Rational Method, the catchment is broken into many smaller sub catchments than was the case for the Rational Method calculations undertaken in **Section 4.1.3**.

Based on the above and to maintain consistency it is considered appropriate to adopt the standard 20yr ARI and 100yr ARI flow estimates as derived by Meinhardt for this study.

4.2 INDEPENDENT RAFTS MODELLING

Once the results of the previous Meinhardt DRAIN's model had been verified as a fair representation of the hydrological conditions experienced at the site, a simplified RAFTS model was constructed to perform the following functions:

- Derive baseline 100yr ARI, 20yr ARI and 5yr ARI results;
- Estimate the PMF; and
- Test the impact of Possible Climate Change induced increases in rainfall intensity (*3 scenarios – 10%, 15% and 30% increase*) on peak flows when compared to the baseline case established in point 1 above.

RAFTS was chosen for the above task as it would provide further verification of the DRAINS derived flows, it ease of use and robust PMF modelling capability.

Details of all RAFTS model inputs and results are provided at **Appendix A**.

4.2.1 RAFTS

RAFTS is a non-linear rainfall/runoff program used to estimate peak flows for catchments, using actual storm events, or design rainfall data derived from *Australian Rainfall and Runoff (AR&R)* (*IEAust, 1987*).

RAFTS has been used extensively throughout Australia on both rural and urban catchments.

The RAFTS model can be used to separately route impervious and pervious sections of each sub-catchment (*i.e. a split sub catchment approach*). The model can also route flows through storages (*i.e. retarding basins, dams*) to assess the flood mitigation benefits downstream of the storage.

For the purposes of this study the PMF, 5yr, 20yr, 100yr Average Recurrence Intervals (*ARIs*) design storm events ranging in storm duration from 15 minutes to 12 hours were modelled, in addition to testing a range of climate change scenarios in the 100yr ARI event by increasing rainfall intensities by 10%, 15% and 30%.

4.2.2 RAFTS Network and Input Data

A simplified RAFTS network was constructed as illustrated in **Diagram 1** to represent the three main branches of Hawthorne Canal that converge near the subject site.

Lag times for each branch were simply calculated by dividing channel distance with an average velocity of 2m/s. This will result in a conservative estimate of timing effects for this long and elongated catchment.

Storage effects likely to be evident in this highly urbanised and unplanned catchment have been catered for by utilising the "*Old Urban*" option and modification of the global storage coefficient.

Moderate to high loss parameters have been adopted by using the IL/CL model however, the model has proved insensitive to this parameter due to the high impervious state of the catchment.

A split sub catchment approach was used to separately route pervious and impervious surfaces.

All other adopted catchment characteristics were identical to those utilised in the Meinhardt DRAINS model (*ie areas, impervious fraction, IFD*).

4.2.3 RAFTS Baseline Results (*100yr, 20yr and 100yr ARI*)

A summary of the RAFTS baseline results for the 100yr , 20yr and 5 yr ARI design storm events are provided in **Table 5**. The critical storm duration was 90 minutes.

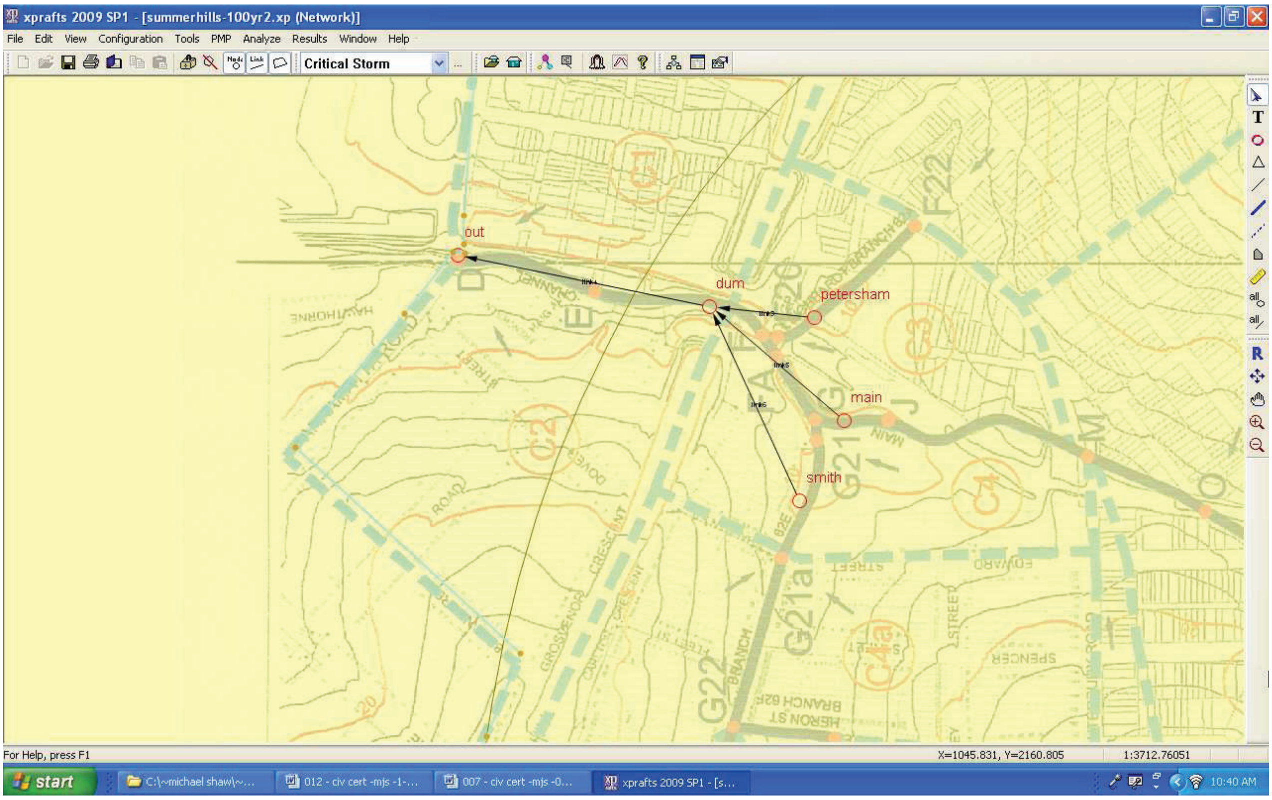
The resultant flows are marginally higher but compare well with the Meinhardt July 2010 DRAINS derived flows.

Table 5 – RAFTS Baseline Results (*Total Flow - m^3/s*)

	OUT	DUM	PETER	MAIN	SMITH
100yr ARI (90min)	111.2	108.3	14.6	92.0	38.9
20yr ARI (90 min)	88.3	86.3	11.8	74.5	31.3
5yr ARI (90min)	67.3	65.9	8.8	57.4	23.9

Model Name - Summerhills-100yr2.xp

Diagram 1 – RAFTS Network



4.2.4 RAFTS PMF

The baseline RAFTS model was modified to incorporate PMP values calculated using the BOM GSDM method (*June 2003*).

No spatial distribution was required as the catchment size (*295ha*) was approximately equal to the smallest ellipse.

Temporal distribution of the PMP was in accordance with Section 5 of the BOM GSDM publication.

A summary of the derived PMP values is contained in **Table 6** along with the resultant PMF flows.

Table 6 – PMF Results

Duration (min)	PMP (mm)	Peak Q (m^3/s) - OUT	Peak Q (m^3/s) - DUM	Peak Q (m^3/s) - PETER	Peak Q (m^3/s) - MAIN	Peak Q (m^3/s) - SMITH
15	160	438.0	434.4	53.6	351.9	145.7
30	240	438.6	414.6	44.1	273.0	114.4
45	300	391.6	369.6	37.8	240.6	100.9
60	340	343.4	321.0	32.4	210.5	87.6

Duration (min)	PMP (mm)	Peak Q (m^3/s) - OUT	Peak Q (m^3/s) - DUM	Peak Q (m^3/s) - PETER	Peak Q (m^3/s) - MAIN	Peak Q (m^3/s) - SMITH
90	390	268.5	250.0	25.9	164.2	69.4
120	440	232.6	217.6	22.4	144.6	62.0
150	470	203.9	189.0	19.2	127.5	54.5
180	490	181.5	167.3	16.7	112.8	48.0
240	540	154.6	143.9	13.9	94.4	40.0
300	580	136.5	126.9	12.2	81.4	34.6
360	610	121.0	112.2	11.0	71.6	30.4

Model Name - Summerhills-PMF2.xp

4.2.5 RAFTS Climate Change Modelling

To assess the impact of a potential increase in rainfall intensity as a result of climate change the baseline model described in **Section 4.2.3** was modified for three scenarios as follows:

- 10% increase in rainfall intensity;
- 15% increase in rainfall intensity; and
- 30% increase in rainfall intensity.

The resultant increase in flow was calculated as a percentage to apply to the adopted Meinhardt derived flows as a representation of climate change impact.

The results of the RAFTS climate change modelling for the three above scenarios are summarised in **Tables 7, 8 and 9**.

Table 7 – RAFTS 10% Climate Change Results (*Total Flow - m^3/s*)

	OUT	DUM	PETER	MAIN	SMITH
100yr ARI (90min)	123.3	120.1	16.1	102.0	43.0
20yr ARI (90 min)	97.9	95.6	13.0	82.5	34.7
5yr ARI (90min)	74.6	72.9	9.7	63.5	26.4
Increase compared with Base (100yr)%	10.88	10.90	10.27	10.87	10.54
Increase compared with Base (20yr)%	10.87	10.78	10.17	10.74	10.86
Increase compared with Base (5yr)%	10.85	10.62	10.23	10.63	10.46

Model Name - Summerhills-100yr3.xp

On average the RAFTS model shows that a 10% increase in rainfall intensity results in an increase in total flows of approximately 10.6% (*say 11%).*

Table 8 – RAFTS 15% Climate Change Results (*Total Flow - m³/s*)

	OUT	DUM	PETER	MAIN	SMITH
100yr ARI (90min)	129.2	125.8	16.9	106.9	45.1
20yr ARI (90 min)	102.7	100.3	13.6	86.5	36.4
5yr ARI (90min)	78.3	76.5	10.2	66.6	27.6
Increase compared with Base (100yr)%	16.19	16.16	15.75	16.20	15.94
Increase compared with Base (20yr)%	16.31	16.22	15.25	16.11	16.29
Increase compared with Base (5yr)%	16.34	16.08	15.91	16.03	15.48

Model Name - Summerhills-100yr4.xp

On average the RAFTS model shows that a 15% increase in rainfall intensity results in an increase in total flows of approximately 16.0% (*say 16.3%).*

Table 9 – RAFTS 30% Climate Change Results (*Total Flow - m³/s*)

	OUT	DUM	PETER	MAIN	SMITH
100yr ARI (90min)	147.3	143.3	19.2	121.8	51.3
20yr ARI (90 min)	117.3	114.5	15.4	98.8	41.4
5yr ARI (90min)	89.2	87.0	11.6	75.6	31.4
Increase compared with Base (100yr)%	32.46	32.32	31.51	32.39	31.88
Increase compared with Base (20yr)%	32.84	32.68	30.51	32.62	32.27
Increase compared with Base (5yr)%	32.54	32.02	31.82	31.71	31.38

Model Name - Summerhills-100yr5.xp

On average the RAFTS model shows that a 30% increase in rainfall intensity results in an increase in total flows of approximately 32.1% (*say 33%).*

4.3 ADOPTED HYDROLOGY

Based on the results of the verification process and the independent RAFTS modelling exercise it is considered that for consistency the July 2010 Mienhardt derived flows be adopted for the standard 20yr and 100yr ARI events, but modified to account for potential climate change impacts as a result of the RAFTs modelling as well as addition of the PMF estimates derived from RAFTS.

A summary of the final recommended hydrology for the hydraulic modelling exercise detailed in **Section 5** is contained in **Table 10**.

Table 10 – Adopted Hydrology (*Overland Flow Only- m^3/s*)

HEC RAS Chainage	Location Description	20yr ARI Peak Flow (m^3/s)	100yr ARI Peak Flow (m^3/s)	100yr ARI + 10% CC	100yr ARI + 15% CC	100yr ARI + 30% CC	PMF
25	Approx. 230m downstream of the Longport Street Culvert	69.8	103.0	114.3	120.3	137.5	438.0
230	Immediately downstream of the Longport Street Culvert	65.6	95.4	105.9	111.4	127.4	434.4
334.5	At the confluence of Hawthorne Canal and the Smith Street Branch	61.6	86.5	96.0	101.1	115.5	351.9
395	At the downstream end of the Goods Railway Line Culvert (*Hawthorne Canal*)	41.3	51.8	57.5	60.5	69.2	351.9
480	At the upstream end of the Goods Railway Line Culvert (*Hawthorne Canal*)*	18.0	27.9	31.0	32.6	37.2	326

Note * Overland flow only. Incorporates reduction in flow due to 23m3/s culvert capacity

4.4 DETENTION

4.4.1 Nil Detention Argument

A strong case exists for the exemption of onsite detention for the proposed development on the Summer Hills Flour Mill site.

A summary of the reasons why stormwater detention is not considered necessary is provided below.

- *Minimal change in impervious fraction* – The site is currently covered by a high proportion of impervious surfaces (*estimated to be approximately 65%).* Following development this is estimated to increase by approximately 10% to a total impervious fraction of 75%. Compared with predevelopment conditions this will lead to a minor increase in flows only. Futhermore, WSUD measures (*particularly reuse of roofwater*) will go a long way to mitigating this minor increase (*refer to* ***Section 6.6*** *for more details*);

- *Site location in lower part of catchment* – The proposed development site is located near the downstream end of a large catchment. In these circumstances (*due to lag and timing effects*) it is often beneficial to provide early release of site generated flows prior to arrival of the peak upstream hydrograph; and
- *Site will directly connect to SWC trunk drainage infrastructure(ie Hawthorne Canal) –* Marrickville Councils OSD Policy (Feb 1999) states that "*OSD will be required for all developments except for……….sites that discharge directly into a major Sydney Water Corporation controlled trunk drainage system*".

4.4.2 Nil Detention Case Modelling

To confirm the theory that detention would not be required for the subject site, the existing DRAINS model constructed by Meinhardt in July 2010 was modified to incorporate an increase of 10% impervious fraction due the proposed development and the impact of this increase was assessed.

Note for conservatism any beneficial detention effect provided by the proposed WSUD measures detailed in Section 6 was not included in the modified DRAINS modelling exercise.

The details of the modified (*detention case*) DRAINS model are included in **Appendix C**. The results are summarised in **Table 11**.

Table 11 – Nil Detention Case DRAINS Model Results (*Total Flow - m^3/s*)

	Smith St Branch Outlet	Model Outlet	Change Compared to Existing Case
100yr ARI	30.4	116.0	0% increase
20yr ARI	22.9	86.2	0.4% increase
5yr ARI	16.5	61.6	0% increase

The results confirm minimal increase in flow and hence provide justification for exemption of detention for the subject site.

4.5 CUMULATIVE EFFECTS

Consideration was given to the possible hydrological cumulative effects of the nearby Sydney Light Rail and McGill Precinct developments.

From a hydrological perspective, the greatest influence on increase in flows is generally related to an increase in impervious fraction.

Both the light rail proposal and McGill Street Masterplan development will not result in significantly different impervious fractions than currently exist.

Based on this it is not considered that their will be any significant hydrological cumulative impact.

5 FLOODING

The flood assessment undertaken as part of this study builds upon the earlier HEC RAS work by Meinhardt to include the following additional aspects:

- Prediction of extreme event flooding (*ie the PMF*);
- Incorporation of blockage at the critical Longport Street culvert;
- Incorporation of potential climate change impacts; and
- Consideration of cumulative effects due to the Sydney Light Rail extension and McGill Street Masterplan development.

Our assessment also included a detailed review of the existing HEC RAS model constructed by Meinhardt and incorporation of a number of minor improvements/changes to better reflect the existing & proposed conditions.

5.1 MAINSTREAM FLOODING

Mainstream flooding in Hawthorne canal has been assessed using the software package HEC RAS.

HEC-RAS is a water surface profile program capable of analysing steady, gradually varied channel flow. Subcritical, supercritical and mixed flow water surface profile computations are possible. It is based on the industry standard Corps of Engineers HEC-2 program.

The program can account for backwater effects created by bridges, culverts, weirs and other floodplain structures. The program can be used to evaluate floodway encroachments, identify flood hazard zones manage floodplains and design and evaluate channel improvements. Water surface profiles with different discharges or initial water surface elevations can be analysed at one time.

The program allows Manning's roughness coefficients to be varied in either horizontal or vertical directions.

5.1.1 Model Description

The HEC RAS model used for this study was assembled for the section of Hawthorne Canal from approximately 230m downstream of the Longport Street culvert (*Chainage 00*) to the upstream end of the Goods Railway line culvert (*Chainage 480*). Refer to **Figure 4** for details of the cross section locations.

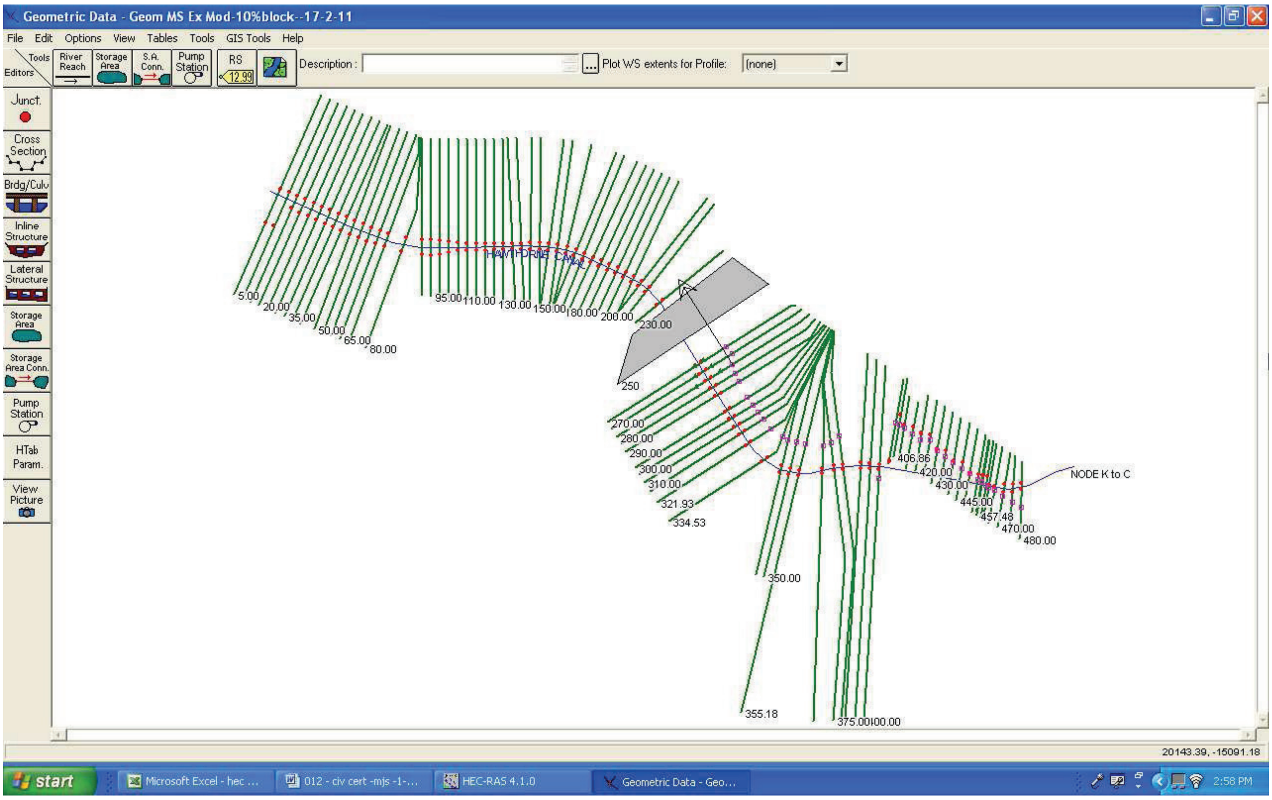
A number of scenarios were modelled as summarised below:

- Scenario A - Existing Conditions;

- Scenario B - Existing Conditions incorporating 10% blockage at the Longport Street Culvert;
- Scenario C - Proposed Conditions incorporating 10% blockage at the Longport Street Culvert;
- Scenario D - Proposed Conditions incorporating 10% blockage at the Longport Street Culvert and addition of the new Sydney Light Rail Extension Platforms; and
- Scenario E - Proposed Conditions incorporating 10% blockage at the Longport Street Culvert and amplification of the Goods Railway Line culvert (*extra 3 x 900mm dia pipes*).

An illustration of the model geometry is contained in **Diagram 2**.

Diagram 2 – HEC RAS Model Geometry (*Existing Conditions*)



5.1.2 Review of Existing Model

A detailed review of the Meinhardt HEC RAS model was undertaken as part of this study.

The review revealed that the model was generally satisfactory, although a number of minor issues were discovered.

These minor issues included missing levee detail, low Manning's n value for overbank areas and missing ineffective flow areas. These minor issues were rectified as part of the modified HEC RAS modelling undertaken by Civil Certification.

5.1.3 Model Parameters

Cross Sections
Cross section data from the Meinhardt model was generally adopted, although some sections were extended to allow modelling of the PMF

Steady State Flows
Steady state flows were adopted for the model as per **Section 4.3** of this report.

Boundary Conditions
Critical depth was set for the downstream boundary condition and normal depth at the upstream boundary.

Roughness Co-efficients
Roughness coeffecients were estimated based on visual inspection and the anticipated revegetation works.

Bridges/Weirs
The main bridge incorporated in the HEC RAS model is the Longport Street culvert/overpass. The Meinhardt adopted properties for this bridge were generally maintained by Civil Certification.

Blockage at the Longport Street culvert was modelled by reduction in the available cross sectional area of the culvert.

A new bridge was added in the proposed development scenario to assess the impact of raised roadway providing vehicular access to the north eastern portion of the site.

Floodway Encroachments
For existing conditions all areas of the site containing structures and buildings were blocked out.

Under proposed conditions the obstruction caused by proposed construction of new buildings was added to the models.

5.1.4 Model Results

Full details of all the HEC RAS modelling results are included at **Appendix F**.

The 100 year ARI flood extent for the proposed conditions 15% climate change & 10% blockage Scenario is illustrated in **Figure 6.**

A summary of results for the five development scenarios are presented in **Tables 12, 13, 14, 15 and 16**.

Table 12 – Scenario A (*Existing Condition*) HEC RAS Results

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
480	20yrARI	18	10.25	11.68	10.82	0.72	25.01	24.21	0.21
480	100yrARI	27.9	10.25	11.69	10.99	1.1	25.43	24.51	0.31
480	100yrARI10%CC	31	10.25	11.73	11.05	1.19	26.34	25.12	0.33
480	100yrARI15%CC	32.6	10.25	11.78	11.08	1.04	35.35	42.64	0.29
480	100yrARI30%CC	37.2	10.25	11.81	11.16	1.15	36.48	42.64	0.31
480	PMF	326	10.25	13.93	12.86	2.86	126.89	42.65	0.49
460	20yrARI	18	11	11.46	11.39	0.93	18.3	42.82	0.44
460	100yrARI	27.9	11	11.55	11.45	1.21	22.39	42.82	0.52
460	100yrARI10%CC	31	11	11.59	11.45	1.27	23.92	42.82	0.53
460	100yrARI15%CC	32.6	11	11.61	11.45	1.3	24.69	42.82	0.53
460	100yrARI30%CC	37.2	11	11.65	11.45	1.37	26.79	42.83	0.54
460	PMF	326	11	13.81	12.84	2.76	119.01	42.86	0.53
440	20yrARI	18	11.2	11.21	11.21	0.15	11.28	38.91	0.44
440	100yrARI	27.9	11.2	11.34	11.3	0.74	16.37	41.29	0.63
440	100yrARI10%CC	31	11.2	11.37	11.33	0.84	17.83	41.85	0.65
440	100yrARI15%CC	32.6	11.2	11.39	11.35	0.89	18.52	42.08	0.65
440	100yrARI30%CC	37.2	11.2	11.43	11.38	1.02	20.54	43.21	0.67
440	PMF	326	11.2	13.69	12.76	2.61	118.1	43.22	0.53
420	20yrARI	18	10.84	10.94	10.94	0.54	11.06	35.79	0.59
420	100yrARI	27.9	10.84	11.02	11.05	0.95	14.37	41.75	0.74
420	100yrARI10%CC	31	10.84	11.05	11.08	1.06	15.52	41.75	0.76
420	100yrARI15%CC	32.6	10.84	11.06	11.09	1.11	16.15	41.75	0.77
420	100yrARI30%CC	37.2	10.84	11.19	11.13	1.16	21.53	41.75	0.63
420	PMF	326	10.84	13.68	12.52	2.45	125.25	41.76	0.46
400	20yrARI	18	3.97	8.14	5.7	1.5	15.57	6.93	0.24
400	100yrARI	27.9	3.97	9.72	6.28	1.41	33.41	16.43	0.19
400	100yrARI10%CC	31	3.97	10.22	6.47	1.32	43.52	26.84	0.17
400	100yrARI15%CC	32.6	3.97	10.43	6.56	1.28	51.16	49.11	0.16
400	100yrARI30%CC	37.2	3.97	11.2	6.83	1	95.7	62.27	0.12
400	PMF	326	3.97	13.7	11.9	3.2	251.93	62.28	0.33
380	20yrARI	41.3	3.67	7.02	6.91	4.44	12.72	8.33	0.8
380	100yrARI	51.8	3.67	9.73	7.34	1.47	104.98	77.95	0.19
380	100yrARI10%CC	57.5	3.67	10.25	7.57	1.15	163.46	134.33	0.15
380	100yrARI15%CC	60.5	3.67	10.46	7.66	1.05	192.38	139.59	0.13
380	100yrARI30%CC	69.2	3.67	11.21	7.92	0.75	308.97	166.23	0.09
380	PMF	351.9	3.67	13.82	10.52	1.24	844.71	215.84	0.13

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
350	20yrARI	41.3	3.18	7.44	5.98	2.5	26.04	13.47	0.4
350	100yrARI	51.8	3.18	9.71	6.4	1.46	81.64	72.14	0.19
350	100yrARI10%CC	57.5	3.18	10.22	6.59	1.31	119.86	76.03	0.16
350	100yrARI15%CC	60.5	3.18	10.43	6.69	1.25	136.03	76.62	0.15
350	100yrARI30%CC	69.2	3.18	11.2	7.02	0.89	271.44	141.75	0.1
350	PMF	351.9	3.18	13.79	10.8	1.71	638.71	141.75	0.17
321.93	20yrARI	61.6	2.86	7.31	6.29	3.06	33.99	15.97	0.48
321.93	100yrARI	86.5	2.86	9.62	6.85	2.14	80.8	24.48	0.27
321.93	100yrARI10%CC	96	2.86	10.12	7.03	2.11	93.45	26.31	0.26
321.93	100yrARI15%CC	101.1	2.86	10.33	7.12	2.12	99.17	30.68	0.25
321.93	100yrARI30%CC	115.5	2.86	11.14	7.38	1.71	207.49	134.65	0.19
321.93	PMF	351.9	2.86	13.77	10.07	1.99	575.68	140.22	0.2
300	20yrARI	61.6	2.59	7.19	6.09	3.13	33.11	15.66	0.48
300	100yrARI	86.5	2.59	9.6	6.75	2.19	80.74	23.96	0.27
300	100yrARI10%CC	96	2.59	10.1	6.96	2.15	93.2	25.69	0.26
300	100yrARI15%CC	101.1	2.59	10.31	7.06	2.16	98.61	26.41	0.25
300	100yrARI30%CC	115.5	2.59	11.13	7.33	1.71	205.21	112.01	0.19
300	PMF	351.9	2.59	13.76	10.72	2.1	542.89	131.87	0.2
280	20yrARI	61.6	2.39	7.18	5.88	3	34.25	16.19	0.45
280	100yrARI	86.5	2.39	9.58	6.56	2.17	72.61	25.34	0.26
280	100yrARI10%CC	96	2.39	10.07	6.78	2.18	80.52	27.12	0.26
280	100yrARI15%CC	101.1	2.39	10.27	6.89	2.21	83.77	27.85	0.26
280	100yrARI30%CC	115.5	2.39	11.03	7.21	2.21	95.88	99.78	0.24
280	PMF	351.9	2.39	13.74	9.95	2.19	514.7	126.27	0.21
250		Culvert							
230	20yrARI	65.6	1.91	4.43	4.98	6.08	11.08	7.75	1.27
230	100yrARI	95.4	1.91	5.79	5.79	5.37	23.34	10	0.89
230	100yrARI10%CC	105.9	1.91	6	6	5.55	25.46	10.31	0.9
230	100yrARI15%CC	111.4	1.91	6.11	6.11	5.64	26.57	10.46	0.9
230	100yrARI30%CC	127.4	1.91	6.41	6.41	5.87	29.81	10.91	0.9
230	PMF	434.4	1.91	10.86	10.86	7.39	113.23	45.47	0.8

The 20yr ARI flood flow exceeds the capacity of the Hawthorne Canal culvert under the goods railway on the McGill Street Masterplan side causing overland flows along the rail corridor itself. These overland flows discharge from the goods railway corridor to the open channel canal on the subject site immediately downstream of the buildings located over the canal. The 20yr ARI flows on the subject side are contained fully within the Hawthorne Canal channel and banks.

The 100yr ARI flood behaviour upstream of the Hawthorne Canal open channel on the site is similar to the 20yr ARI flows. The 3.8m diameter culvert under the Longport Street overpass has a significant flow capacity *(80m³/s)* but is slightly below the estimated peak 100yr ARI flow rate of approximately 100m³/s. Flows therefore pond upstream of the overpass on the subject site until ponded levels reach the goods railway level at the Longport Street Overpass. This allows excess floodwaters to pass through this railway opening.

The PMF is controlled by the Longport Street overpass, with the openings of both the 3.8m dia. culvert and the railway bridge being inundated and water levels overtopping the low points of Longport Street either side of the railway line.

Under existing conditions (*no blockage*) the predicted 100yr ARI flood level (*15% climate change scenario*) at chainage 350 (*ie near the centre of the site*) is approximately RL 10.4mAHD.

Table 13 – Scenario B (*Existing Condition, 10% Blockage*) HEC RAS Results

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
480	20yrARI	18	10.25	11.68	10.82	0.72	25.01	24.21	0.21
480	100yrARI	27.9	10.25	11.69	10.99	1.1	25.43	24.51	0.31
480	100yrARI10%CC	31	10.25	11.73	11.05	1.19	26.34	25.12	0.33
480	100yrARI15%CC	32.6	10.25	11.78	11.08	1.04	35.35	42.64	0.29
480	100yrARI30%CC	37.2	10.25	11.81	11.16	1.15	36.48	42.64	0.31
480	PMF	326	10.25	13.96	12.86	2.83	128.14	42.65	0.48
460	20yrARI	18	11	11.46	11.39	0.93	18.3	42.82	0.44
460	100yrARI	27.9	11	11.55	11.45	1.21	22.39	42.82	0.52
460	100yrARI10%CC	31	11	11.59	11.45	1.27	23.92	42.82	0.53
460	100yrARI15%CC	32.6	11	11.61	11.45	1.3	24.69	42.82	0.53
460	100yrARI30%CC	37.2	11	11.65	11.45	1.37	26.79	42.83	0.54
460	PMF	326	11	13.84	12.84	2.73	120.54	42.86	0.52
440	20yrARI	18	11.2	11.21	11.21	0.15	11.28	38.91	0.44
440	100yrARI	27.9	11.2	11.34	11.3	0.74	16.37	41.29	0.63
440	100yrARI10%CC	31	11.2	11.37	11.33	0.84	17.83	41.85	0.65
440	100yrARI15%CC	32.6	11.2	11.39	11.35	0.89	18.52	42.08	0.65
440	100yrARI30%CC	37.2	11.2	11.43	11.38	1.02	20.54	43.21	0.67
440	PMF	326	11.2	13.74	12.76	2.57	119.97	43.22	0.52
420	20yrARI	18	10.84	10.94	10.94	0.54	11.06	35.79	0.59
420	100yrARI	27.9	10.84	11.02	11.05	0.95	14.37	41.75	0.74
420	100yrARI10%CC	31	10.84	11.05	11.08	1.06	15.52	41.75	0.76
420	100yrARI15%CC	32.6	10.84	11.06	11.09	1.11	16.15	41.75	0.77
420	100yrARI30%CC	37.2	10.84	11.17	11.13	1.18	20.55	41.75	0.67

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
420	PMF	326	10.84	13.72	12.52	2.41	127.08	41.76	0.45
400	20yrARI	18	3.97	8.2	5.7	1.48	15.98	7.04	0.23
400	100yrARI	27.9	3.97	10.15	6.28	1.22	41.63	24.62	0.16
400	100yrARI10%CC	31	3.97	10.58	6.47	1.14	58.78	54.13	0.14
400	100yrARI15%CC	32.6	3.97	10.81	6.56	1.07	71.92	58.43	0.13
400	100yrARI30%CC	37.2	3.97	11.1	6.83	1.05	89.54	62.27	0.13
400	PMF	326	3.97	13.75	11.9	3.16	254.76	62.28	0.32
380	20yrARI	41.3	3.67	7.64	6.91	3.44	18.52	10.63	0.57
380	100yrARI	51.8	3.67	10.17	7.34	1.09	153.05	132.27	0.14
380	100yrARI10%CC	57.5	3.67	10.6	7.57	0.91	212.12	143.15	0.11
380	100yrARI15%CC	60.5	3.67	10.83	7.66	0.82	247.23	157.78	0.1
380	100yrARI30%CC	69.2	3.67	11.11	7.92	0.79	293	163.18	0.09
380	PMF	351.9	3.67	13.86	10.52	1.22	853.8	215.84	0.12
350	20yrARI	41.3	3.18	7.84	5.98	2.16	31.75	15.11	0.33
350	100yrARI	51.8	3.18	10.14	6.4	1.22	114.29	75.83	0.15
350	100yrARI10%CC	57.5	3.18	10.58	6.59	1.03	184.17	136.64	0.12
350	100yrARI15%CC	60.5	3.18	10.82	6.69	0.95	216.92	141.75	0.11
350	100yrARI30%CC	69.2	3.18	11.1	7.02	0.93	257.51	141.75	0.11
350	PMF	351.9	3.18	13.83	10.8	1.69	644.77	141.75	0.17
321.93	20yrARI	61.6	2.86	7.75	6.29	2.62	41.48	17.61	0.39
321.93	100yrARI	86.5	2.86	10.06	6.85	1.93	92.01	26.1	0.23
321.93	100yrARI10%CC	96	2.86	10.49	7.03	1.94	104.55	36.29	0.23
321.93	100yrARI15%CC	101.1	2.86	10.72	7.12	1.94	113.85	44.34	0.22
321.93	100yrARI30%CC	115.5	2.86	11.04	7.38	1.79	193.56	129.26	0.2
321.93	PMF	351.9	2.86	13.81	10.07	1.97	581.77	140.22	0.19
300	20yrARI	61.6	2.59	7.69	6.09	2.64	41.31	17.38	0.38
300	100yrARI	86.5	2.59	10.05	6.75	1.96	91.87	25.51	0.23
300	100yrARI10%CC	96	2.59	10.47	6.96	1.97	103.27	31.12	0.23
300	100yrARI15%CC	101.1	2.59	10.73	7.06	1.75	162.38	98.55	0.2
300	100yrARI30%CC	115.5	2.59	11.03	7.33	1.78	193.54	108.51	0.2
300	PMF	351.9	2.59	13.8	10.72	2.08	548.67	131.87	0.2
280	20yrARI	61.6	2.39	7.68	5.88	2.54	42.29	18.39	0.36
280	100yrARI	86.5	2.39	10.03	6.56	1.98	79.78	26.95	0.23
280	100yrARI10%CC	96	2.39	10.44	6.78	2.03	86.44	28.46	0.23
280	100yrARI15%CC	101.1	2.39	10.66	6.89	2.06	89.86	87.39	0.23
280	100yrARI30%CC	115.5	2.39	10.93	7.21	2.24	94.2	96.33	0.25
280	PMF	351.9	2.39	13.79	9.95	2.16	520.28	126.27	0.21

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
250		Culvert							
230	20yrARI	65.6	1.91	4.67	4.98	5.44	13.01	8.38	1.08
230	100yrARI	95.4	1.91	5.79	5.79	5.37	23.34	10	0.89
230	100yrARI10%CC	105.9	1.91	6	6	5.55	25.46	10.31	0.9
230	100yrARI15%CC	111.4	1.91	6.11	6.11	5.64	26.57	10.46	0.9
230	100yrARI30%CC	127.4	1.91	6.41	6.41	5.87	29.81	10.91	0.9
230	PMF	434.4	1.91	10.86	10.86	7.39	113.23	45.47	0.8

Under existing conditions (*incorporating 10% blockage*) the predicted 100yr ARI flood level (*15% climate change scenario*) at chainage 350 is approximately RL 10.8mAHD. This is an increase of approximately 400mm compared with the no blockage scenario.

Table 14 – Scenario C (*Proposed Condition, 10% Blockage*) HEC RAS Results

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
480	20yrARI	18	10.25	11.68	10.82	0.72	25.01	24.21	0.21
480	100yrARI	27.9	10.25	11.69	10.99	1.1	25.43	24.51	0.31
480	100yrARI10%CC	31	10.25	11.73	11.05	1.19	26.34	25.12	0.33
480	100yrARI15%CC	32.6	10.25	11.78	11.08	1.04	35.35	42.64	0.29
480	100yrARI30%CC	37.2	10.25	11.81	11.16	1.15	36.48	42.64	0.31
480	PMF	326	10.25	13.96	12.86	2.82	128.47	42.65	0.48
460	20yrARI	18	11	11.46	11.39	0.93	18.3	42.82	0.44
460	100yrARI	27.9	11	11.55	11.45	1.21	22.39	42.82	0.52
460	100yrARI10%CC	31	11	11.59	11.45	1.27	23.92	42.82	0.53
460	100yrARI15%CC	32.6	11	11.61	11.45	1.3	24.69	42.82	0.53
460	100yrARI30%CC	37.2	11	11.65	11.45	1.37	26.79	42.83	0.54
460	PMF	326	11	13.85	12.84	2.72	120.93	42.86	0.51
440	20yrARI	18	11.2	11.21	11.21	0.15	11.28	38.91	0.44
440	100yrARI	27.9	11.2	11.34	11.3	0.74	16.37	41.29	0.63
440	100yrARI10%CC	31	11.2	11.37	11.33	0.84	17.83	41.85	0.65
440	100yrARI15%CC	32.6	11.2	11.39	11.35	0.89	18.52	42.08	0.65
440	100yrARI30%CC	37.2	11.2	11.43	11.38	1.02	20.54	43.21	0.67
440	PMF	326	11.2	13.75	12.76	2.56	120.44	43.22	0.51
420	20yrARI	18	10.84	10.94	10.94	0.54	11.06	35.79	0.59
420	100yrARI	27.9	10.84	11.02	11.05	0.95	14.37	41.75	0.74
420	100yrARI10%CC	31	10.84	11.05	11.08	1.06	15.52	41.75	0.76

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
420	100yrARI15%CC	32.6	10.84	11.06	11.09	1.11	16.15	41.75	0.77
420	100yrARI30%CC	37.2	10.84	11.17	11.13	1.18	20.55	41.75	0.67
420	PMF	326	10.84	13.73	12.52	2.4	127.55	41.76	0.45
400	20yrARI	18	3.97	8.2	5.7	1.48	15.98	7.04	0.23
400	100yrARI	27.9	3.97	10.15	6.28	1.22	41.61	24.6	0.16
400	100yrARI10%CC	31	3.97	10.58	6.47	1.14	59.01	54.21	0.14
400	100yrARI15%CC	32.6	3.97	10.82	6.56	1.07	72.38	58.65	0.13
400	100yrARI30%CC	37.2	3.97	11.11	6.83	1.05	90.34	62.27	0.13
400	PMF	326	3.97	13.76	11.9	3.15	255.47	62.28	0.32
380	20yrARI	41.3	3.67	7.63	6.91	3.45	18.49	10.62	0.57
380	100yrARI	51.8	3.67	10.17	7.34	1.09	152.95	132.24	0.14
380	100yrARI10%CC	57.5	3.67	10.6	7.57	0.91	212.7	143.24	0.11
380	100yrARI15%CC	60.5	3.67	10.83	7.66	0.82	248.45	157.95	0.1
380	100yrARI30%CC	69.2	3.67	11.12	7.92	0.79	295.04	163.41	0.09
380	PMF	351.9	3.67	13.87	10.52	1.22	856.09	215.84	0.12
350	20yrARI	41.3	3.18	7.83	5.98	2.18	30.68	12.73	0.33
350	100yrARI	51.8	3.18	10.13	6.4	1.31	99.55	67	0.16
350	100yrARI10%CC	57.5	3.18	10.57	6.59	1.12	158.48	108.34	0.13
350	100yrARI15%CC	60.5	3.18	10.81	6.69	1.05	184.87	113.75	0.12
350	100yrARI30%CC	69.2	3.18	11.1	7.02	1.04	217.51	113.75	0.12
350	PMF	351.9	3.18	13.82	10.91	2.02	527.05	113.75	0.2
321.93	20yrARI	61.6	2.86	7.75	6.29	2.62	41.13	16.44	0.39
321.93	100yrARI	86.5	2.86	10.05	6.85	2.02	83.08	20.11	0.24
321.93	100yrARI10%CC	96	2.86	10.46	7.03	2.05	92.64	28.73	0.24
321.93	100yrARI15%CC	101.1	2.86	10.69	7.12	2.06	100.12	36.28	0.24
321.93	100yrARI30%CC	115.5	2.86	11.01	7.37	1.95	162.13	100.14	0.22
321.93	PMF	351.9	2.86	13.78	10.05	2.36	471.46	112.22	0.23
300	20yrARI	61.6	2.59	7.69	6.09	2.64	41.16	16.6	0.38
300	100yrARI	86.5	2.59	10.03	6.75	2.05	84.38	20.39	0.24
300	100yrARI10%CC	96	2.59	10.44	6.96	2.1	93.21	24.37	0.24
300	100yrARI15%CC	101.1	2.59	10.7	7.06	1.92	138.47	74.67	0.22
300	100yrARI30%CC	115.5	2.59	11	7.35	1.99	162.06	84.47	0.22
300	PMF	351.9	2.59	13.76	10.77	2.55	451.2	108.87	0.25
280	20yrARI	61.6	2.39	7.68	5.88	2.56	41.62	16.73	0.37
280	100yrARI	86.5	2.39	10	6.56	2.11	76.47	20.61	0.25
280	100yrARI10%CC	96	2.39	10.41	6.78	2.18	82.65	21.27	0.25
280	100yrARI15%CC	101.1	2.39	10.62	6.92	2.21	85.82	68.33	0.25

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
280	100yrARI30%CC	115.5	2.39	10.89	7.2	2.43	89.76	76.98	0.27
280	PMF	351.9	2.39	13.74	10	2.6	436.19	108.27	0.25
250		Culvert							
230	20yrARI	65.6	1.91	4.67	4.98	5.44	13.01	8.38	1.08
230	100yrARI	95.4	1.91	5.79	5.79	5.37	23.34	10	0.89
230	100yrARI10%CC	105.9	1.91	6	6	5.55	25.46	10.31	0.9
230	100yrARI15%CC	111.4	1.91	6.11	6.11	5.64	26.57	10.46	0.9
230	100yrARI30%CC	127.4	1.91	6.41	6.41	5.87	29.81	10.91	0.9
230	PMF	434.4	1.91	10.86	10.86	7.39	113.23	45.47	0.8

Under proposed conditions (*incorporating 10% blockage*) the predicted 100yr ARI flood level (*15% climate change scenario*) at chainage 350 is approximately RL 10.8mAHD. This represents no change from existing conditions (*10% blockage scenario*). In fact, 100yr ARI flood levels at all chainages remain unchanged compared with existing conditions (*10% blockage scenario*).

Table 15 – Scenario D (*Proposed Condition, 10% Blockage, Incorp. Light Rail Platforms*) HEC RAS Results

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
480	20yrARI	18	10.25	11.68	10.82	0.72	25.01	24.21	0.21
480	100yrARI	27.9	10.25	11.69	10.99	1.1	25.43	24.51	0.31
480	100yrARI10%CC	31	10.25	11.73	11.05	1.19	26.36	25.14	0.33
480	100yrARI15%CC	32.6	10.25	11.78	11.08	1.04	35.38	42.64	0.29
480	100yrARI30%CC	37.2	10.25	11.81	11.16	1.15	36.52	42.64	0.31
480	PMF	326	10.25	13.97	12.86	2.81	128.86	42.65	0.48
460	20yrARI	18	11	11.46	11.39	0.93	18.3	42.82	0.44
460	100yrARI	27.9	11	11.56	11.45	1.2	22.55	42.82	0.52
460	100yrARI10%CC	31	11	11.59	11.45	1.26	24.06	42.82	0.52
460	100yrARI15%CC	32.6	11	11.61	11.45	1.29	24.81	42.82	0.53
460	100yrARI30%CC	37.2	11	11.66	11.45	1.36	26.92	42.83	0.54
460	PMF	326	11	13.86	12.84	2.71	121.39	42.86	0.51
440	20yrARI	18	11.2	11.21	11.21	0.18	11.15	39	0.47
440	100yrARI	27.9	11.2	11.31	11.31	0.73	15.21	40.94	0.68
440	100yrARI10%CC	31	11.2	11.35	11.34	0.85	16.82	41.56	0.69
440	100yrARI15%CC	32.6	11.2	11.37	11.35	0.91	17.57	41.84	0.7
440	100yrARI30%CC	37.2	11.2	11.41	11.39	1.04	19.06	43.21	0.73

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
440	PMF	326	11.2	13.76	12.77	2.57	120.68	43.22	0.51
420	20yrARI	18	10.84	10.98	10.98	0.67	11.2	36.75	0.59
420	100yrARI	27.9	10.84	11.17	11.11	1	18.63	41.75	0.56
420	100yrARI10%CC	31	10.84	11.22	11.14	1.06	20.61	41.75	0.56
420	100yrARI15%CC	32.6	10.84	11.25	11.15	1.09	21.61	41.75	0.55
420	100yrARI30%CC	37.2	10.84	11.3	11.19	1.17	24.01	41.75	0.56
420	PMF	326	10.84	13.73	12.57	2.5	125.4	41.76	0.47
400	20yrARI	18	3.97	8.2	5.7	1.48	15.98	7.04	0.23
400	100yrARI	27.9	3.97	10.15	6.28	1.22	41.63	24.62	0.16
400	100yrARI10%CC	31	3.97	10.58	6.47	1.14	58.78	54.13	0.14
400	100yrARI15%CC	32.6	3.97	10.81	6.56	1.07	71.92	58.43	0.13
400	100yrARI30%CC	37.2	3.97	11.1	6.83	1.05	89.54	62.27	0.13
400	PMF	326	3.97	13.75	11.9	3.16	254.76	62.28	0.32
380	20yrARI	41.3	3.67	7.64	6.91	3.44	18.52	10.63	0.57
380	100yrARI	51.8	3.67	10.17	7.34	1.09	153.05	132.27	0.14
380	100yrARI10%CC	57.5	3.67	10.6	7.57	0.91	212.12	143.15	0.11
380	100yrARI15%CC	60.5	3.67	10.83	7.66	0.82	247.23	157.78	0.1
380	100yrARI30%CC	69.2	3.67	11.11	7.92	0.79	293	163.18	0.09
380	PMF	351.9	3.67	13.86	10.52	1.22	853.8	215.84	0.12
350	20yrARI	41.3	3.18	7.84	5.98	2.16	31.75	15.11	0.33
350	100yrARI	51.8	3.18	10.14	6.4	1.22	114.29	75.83	0.15
350	100yrARI10%CC	57.5	3.18	10.58	6.59	1.03	184.17	136.64	0.12
350	100yrARI15%CC	60.5	3.18	10.82	6.69	0.95	216.92	141.75	0.11
350	100yrARI30%CC	69.2	3.18	11.1	7.02	0.93	257.51	141.75	0.11
350	PMF	351.9	3.18	13.83	10.8	1.69	644.77	141.75	0.17
321.93	20yrARI	61.6	2.86	7.75	6.29	2.62	41.48	17.61	0.39
321.93	100yrARI	86.5	2.86	10.06	6.85	1.93	92.01	26.1	0.23
321.93	100yrARI10%CC	96	2.86	10.49	7.03	1.94	104.55	36.29	0.23
321.93	100yrARI15%CC	101.1	2.86	10.72	7.12	1.94	113.85	44.34	0.22
321.93	100yrARI30%CC	115.5	2.86	11.04	7.38	1.79	193.56	129.26	0.2
321.93	PMF	351.9	2.86	13.81	10.07	1.97	581.77	140.22	0.19
300	20yrARI	61.6	2.59	7.69	6.09	2.64	41.31	17.38	0.38
300	100yrARI	86.5	2.59	10.05	6.75	1.96	91.87	25.51	0.23
300	100yrARI10%CC	96	2.59	10.47	6.96	1.97	103.27	31.12	0.23
300	100yrARI15%CC	101.1	2.59	10.73	7.06	1.75	162.38	98.55	0.2
300	100yrARI30%CC	115.5	2.59	11.03	7.33	1.78	193.54	108.51	0.2
300	PMF	351.9	2.59	13.8	10.72	2.08	548.67	131.87	0.2

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
280	20yrARI	61.6	2.39	7.68	5.88	2.54	42.29	18.39	0.36
280	100yrARI	86.5	2.39	10.03	6.56	1.98	79.78	26.95	0.23
280	100yrARI10%CC	96	2.39	10.44	6.78	2.03	86.44	28.46	0.23
280	100yrARI15%CC	101.1	2.39	10.66	6.89	2.06	89.86	87.39	0.23
280	100yrARI30%CC	115.5	2.39	10.93	7.21	2.24	94.2	96.33	0.25
280	PMF	351.9	2.39	13.79	9.95	2.16	520.28	126.27	0.21
250		Culvert							
230	20yrARI	65.6	1.91	4.67	4.98	5.44	13.01	8.38	1.08
230	100yrARI	95.4	1.91	5.79	5.79	5.37	23.34	10	0.89
230	100yrARI10%CC	105.9	1.91	6	6	5.55	25.46	10.31	0.9
230	100yrARI15%CC	111.4	1.91	6.11	6.11	5.64	26.57	10.46	0.9
230	100yrARI30%CC	127.4	1.91	6.41	6.41	5.87	29.81	10.91	0.9
230	PMF	434.4	1.91	10.86	10.86	7.39	113.23	45.47	0.8

Under Scenario D (*incorporating the Light Rail Platforms*) the predicted 100yr ARI flood level (*15% climate change scenario*) at chainage 350 is maintained at approximately RL 10.8mAHD. However, there is a local increase in flood level of approximately 200mm between chainages 405 and 430 as a direct result of the reduction in flow area due to the new platforms.

Table 16 – Scenario E (*Proposed Condition, 10% Blockage, Incorp. Upgrade to Goods Rail Line Culvert*) HEC RAS Results

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
480	20yrARI	12	10.25	11.56	10.69	0.53	22.24	22.14	0.16
480	100yrARI	21.9	10.25	11.72	10.89	0.85	25.97	24.9	0.24
480	100yrARI10%CC	25	10.25	11.81	10.95	0.77	36.64	42.64	0.21
480	100yrARI15%CC	26.6	10.25	11.68	10.97	1.06	25.19	24.34	0.3
480	100yrARI30%CC	31.2	10.25	11.76	11.05	1.01	34.51	42.64	0.28
480	PMF	320	10.25	13.95	12.83	2.79	127.8	42.65	0.47
460	20yrARI	12	11	11.47	11.29	0.61	18.73	42.82	0.29
460	100yrARI	21.9	11	11.48	11.45	1.08	19.31	42.82	0.5
460	100yrARI10%CC	25	11	11.52	11.45	1.16	20.88	42.82	0.51
460	100yrARI15%CC	26.6	11	11.54	11.45	1.19	21.73	42.82	0.52
460	100yrARI30%CC	31.2	11	11.59	11.45	1.27	24.02	42.82	0.53
460	PMF	320	11	13.84	12.81	2.68	120.41	42.86	0.51
440	20yrARI	12	11.2	11.21	11.21	0.1	11.28	38.91	0.3

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
440	100yrARI	21.9	11.2	11.26	11.25	0.45	13.31	40.2	0.58
440	100yrARI10%CC	25	11.2	11.3	11.28	0.62	14.97	40.75	0.61
440	100yrARI15%CC	26.6	11.2	11.32	11.29	0.69	15.76	41.06	0.62
440	100yrARI30%CC	31.2	11.2	11.37	11.33	0.85	17.93	41.88	0.65
440	PMF	320	11.2	13.74	12.74	2.52	120.13	43.22	0.51
420	20yrARI	12	10.84	10.88	10.88	0.21	9.02	33.52	0.41
420	100yrARI	21.9	10.84	10.99	10.99	0.74	13.25	41.75	0.62
420	100yrARI10%CC	25	10.84	11.03	11.03	0.85	14.56	41.75	0.65
420	100yrARI15%CC	26.6	10.84	11.04	11.04	0.91	15.17	41.75	0.67
420	100yrARI30%CC	31.2	10.84	11.1	11.08	1.04	17.75	41.75	0.67
420	PMF	320	10.84	13.72	12.5	2.37	127.27	41.76	0.45
400	20yrARI	12	3.97	8.26	5.3	0.96	16.43	7.16	0.15
400	100yrARI	21.9	3.97	10.16	5.93	0.95	42.01	25.08	0.12
400	100yrARI10%CC	25	3.97	10.59	6.11	0.92	59.38	54.33	0.11
400	100yrARI15%CC	26.6	3.97	10.82	6.21	0.87	72.42	58.67	0.11
400	100yrARI30%CC	31.2	3.97	11.1	6.48	0.88	89.96	62.27	0.11
400	PMF	320	3.97	13.75	11.88	3.1	255.05	62.28	0.32
380	20yrARI	41.3	3.67	7.64	6.91	3.44	18.52	10.63	0.57
380	100yrARI	51.8	3.67	10.17	7.34	1.09	153.05	132.27	0.14
380	100yrARI10%CC	57.5	3.67	10.6	7.57	0.91	212.12	143.15	0.11
380	100yrARI15%CC	60.5	3.67	10.83	7.66	0.82	247.23	157.78	0.1
380	100yrARI30%CC	69.2	3.67	11.11	7.92	0.79	293	163.18	0.09
380	PMF	351.9	3.67	13.86	10.52	1.22	853.8	215.84	0.12
350	20yrARI	41.3	3.18	7.84	5.98	2.16	31.75	15.11	0.33
350	100yrARI	51.8	3.18	10.14	6.4	1.22	114.29	75.83	0.15
350	100yrARI10%CC	57.5	3.18	10.58	6.59	1.03	184.17	136.64	0.12
350	100yrARI15%CC	60.5	3.18	10.82	6.69	0.95	216.92	141.75	0.11
350	100yrARI30%CC	69.2	3.18	11.1	7.02	0.93	257.51	141.75	0.11
350	PMF	351.9	3.18	13.83	10.8	1.69	644.77	141.75	0.17
321.93	20yrARI	61.6	2.86	7.75	6.29	2.62	41.48	17.61	0.39
321.93	100yrARI	86.5	2.86	10.06	6.85	1.93	92.01	26.1	0.23
321.93	100yrARI10%CC	96	2.86	10.49	7.03	1.94	104.55	36.29	0.23
321.93	100yrARI15%CC	101.1	2.86	10.72	7.12	1.94	113.85	44.34	0.22
321.93	100yrARI30%CC	115.5	2.86	11.04	7.38	1.79	193.56	129.26	0.2
321.93	PMF	351.9	2.86	13.81	10.07	1.97	581.77	140.22	0.19
300	20yrARI	61.6	2.59	7.69	6.09	2.64	41.31	17.38	0.38
300	100yrARI	86.5	2.59	10.05	6.75	1.96	91.87	25.51	0.23

River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
300	100yrARI10%CC	96	2.59	10.47	6.96	1.97	103.27	31.12	0.23
300	100yrARI15%CC	101.1	2.59	10.73	7.06	1.75	162.38	98.55	0.2
300	100yrARI30%CC	115.5	2.59	11.03	7.33	1.78	193.54	108.51	0.2
300	PMF	351.9	2.59	13.8	10.72	2.08	548.67	131.87	0.2
280	20yrARI	61.6	2.39	7.68	5.88	2.54	42.29	18.39	0.36
280	100yrARI	86.5	2.39	10.03	6.56	1.98	79.78	26.95	0.23
280	100yrARI10%CC	96	2.39	10.44	6.78	2.03	86.44	28.46	0.23
280	100yrARI15%CC	101.1	2.39	10.66	6.89	2.06	89.86	87.39	0.23
280	100yrARI30%CC	115.5	2.39	10.93	7.21	2.24	94.2	96.33	0.25
280	PMF	351.9	2.39	13.79	9.95	2.16	520.28	126.27	0.21
250		Culvert							
230	20yrARI	65.6	1.91	4.67	4.98	5.44	13.01	8.38	1.08
230	100yrARI	95.4	1.91	5.79	5.79	5.37	23.34	10	0.89
230	100yrARI10%CC	105.9	1.91	6	6	5.55	25.46	10.31	0.9
230	100yrARI15%CC	111.4	1.91	6.11	6.11	5.64	26.57	10.46	0.9
230	100yrARI30%CC	127.4	1.91	6.41	6.41	5.87	29.81	10.91	0.9
230	PMF	434.4	1.91	10.86	10.86	7.39	113.23	45.47	0.8

The scenario E model shows that the overland flows travelling across the Goods Railway line between chainage 400 and 480 can be reduced to a depth x velocity product of less than 0.4 by installation of an additional 3 x 900mm dia. pipes in addition to the existing Sydney Water culvert (*refer to Section 5.2.2 for more details*).

5.2 OVERLAND FLOW FLOODING

Overland flows on the site need to provide for safe pedestrian access. The main overland flow routes include:-

- Flows from railway corridor into Hawthorne Canal open channel on the subject site;
- Flows from Smith Street to the open channel; and
- Flows from the southern end of the site to the open channel.

The target is to achieve a maximum velocity depth product of 0.4m²/s prior to ponding on the site in the overland flows path. As ponding occurs, people will relocate to the buildings or to higher areas in the surrounding streets.

In the 100yr ARI flood, waters will begin to pond behind the Longport Street overpass and will gradually slow down the flow velocities for overland flow entering the site from Smith Street and the railway corridor. In the 20yr ARI flood, the flows will be fully contained within the open channel on the site resulting in higher flow velocities in the overland flow onto the site.

The overland flows from the southern end of the site will be relatively small and given the new drainage system will have a 20yr ARI capacity, the overland flows will be the difference between the 100 yr and 20yr ARI flows. If necessary, the overland flow would be reduced to a safe level by increasing the capacity of the stormwater pipe system on the site.

5.2.1 Smith Street Overland Flow

The Smith Street branch of SWC62 services the catchment to the west along Smith Street.

Smith Street rises to the west from a trapped low point along the frontage to the subject site. The existing piped system has limited capacity and a significant portion of the flows arrive at the site as overland flow on the road.

The pipe system for this branch is aligned along the southern side of Smith Street at the subject site and joins with the main Hawthorne Canal in the subject site.

Overland flows pond in Smith Street adjacent the site until they overtop the boundary and flow along the alignment of the established tree corridor on the site to the open channel of Hawthorne Canal.

In the 100yr ARI flood, the flood waters ponding on the site would extend onto Smith Street and as such flows down Smith Street would discharge into this pond of floodwaters on the site.

The proposed development would not change this flood behaviour and would maintain the existing peak flood flow rates so that there would be no change in flood levels compared with existing conditions.

In the 100yr ARI event overland flows from Smith Street may present a hazard for pedestrians in the proposed development site. Based on this it is recommended that consideration be given to construction of a new pipe and associated inlet structure at the low point adjacent to the site in Smith Street.

The inlet structure would be constructed along the street frontage of the subject site at the kerb level and at the site boundary in order to maximise the flow captured in a pipe and to minimise the overland flow on the site from this source. A separate pipe (1350mm diameter) would carry this flow from the new inlets to the open channel of the canal and discharge at a high level so that it is less impacted by existing flows in the canal. It would not interfere with the existing SWC Smith Street drainage infrastructure.

The overland flows from Smith Street in a 100yr ARI flood with this new system would reduce the peak flow rate to $16.35m^3/s$. Ignoring the ponding which would occur on the site and slow down overland flows, the flood hazard in this worst case scenario would be safe for pedestrians with an estimated velocity depth product of $0.33m^2/s$ (*i.e. less than* $0.4m^2/s$).

The landform and landscaping proposed between Smith Street and the canal and between the rail corridor and the canal will be sculptured to ensure the remaining overland flows spread over a wide area.

5.2.2 Good Railway Line Overland Flow

The Hawthorne Canal passes beneath the rail corridor between chainage 400 to 480 via a culvert that has a capacity less than the 20yr ARI flow.

Because of this flood flows in excess of the 10-20yr ARI pond above the open channel in the McGill Street Masterplan are and gradually overtop and flow north down the rail corridor towards the proposed development site.

The predicted flood levels in this area are at the crest of the rail corridor and are applicable to the McGill Street Masterplan area.

Floodwaters would flow in a shallow depth over the rail crest and along the western side of the rail corridor.

The mainstream HEC RAS model detailed in **Section 5.1** incorporates this overland flow path and the flood levels reported in **Tables 12 to 16** between chainages 400 and 480 represent the flood levels of this overland flow path.

The Scenario E HEC RAS model was developed to test the works required to ensure a safe depth x velocity product for this overland flow path.

The model shows that an increase in capacity of the existing culvert by $6m^3/s$ will ensure that this overland flow path is safe for pedestrians in the 100yr ARI (*15% climate change, 10% blockage scenario*).

Alternatively the overland flow from the rail corridor could be partially captured in a new inlet system along the site boundary with the corridor and the provision of three 900mm diameter drainage pipes directly to the canal. Again, ignoring the ponding which could occur on site and slow down overland flows in the 100yr ARI flood, the flood hazard in this worst case scenario would be safe for pedestrians with an estimated velocity depth product of $0.4m^2/s$.

5.3 NSW FLOOPLAIN DEVELOPMENT MANUAL

The NSW Floodplain Development Manual (*2005*) presents a merit based assessment process which has the objectives of appropriate management of the risk of flood drainages and flood related risk to personal safety while not adversely impacting on flood levels for adjacent development. This flood report has been prepared in accordance with the Manual as well as undertaking sensitively testing for the potential impacts of climate change and reduction in flow capacity of the Hawthorne Canal culvert under the Longport Street overpass. Also, as required by the DGRs, the cumulative impact of the Sydney Light Rail, McGill Street Masterplan and Major Project 08-0195 developments on the flood behaviour on the subject site has also been considered.

5.4 COUNCIL FLOOD POLICIES

The local government boundary between Ashfield and Marrickville Councils runs along the Hawthorne Canal. As such, the proposed building in the north eastern corner of the site (*Building 1A*) is located in Marrickville Council while the remainder of the development is located in Ashfield Council.

The Council flood policies conform to the NSW Floodplain Development Manual in that they are merit based policies with objectives which conform to the Manual. Ashfield Council recommend a freeboard of 0.3m for residential floors while Marrickville Council recommends 0.5m freeboard.

5.5 FLOOD PLANNING LEVELS

The impact of the predicted 100yr ARI on the proposed buildings is summarised in **Table 17**.

Table 17 – Impact of 100yr ARI on Proposed Floor Levels

Building		Freeboard (m)	
	Predicted 100yr ARI Flood Level m AHD	Ground Floor	Basement Entry Crest
1A	Floor 9.23 – 9.73 Basement 9.6	1.77 – 2.27	1.2
1C retail	9.73	-0.68	No basement
2A – 2B	9.73	-0.68	No basement
2C retail	9.73	0	No basement
3A, 3B, 3C	9.73	1.77	3.27
3D	9.73	2.27	3.27
4A, 4B, 4C residential	9.73	1.77	1.77
4A retail	9.73	0.67	1.77
4C	9.73	1.77	1.77
5A retail	9.73	0.97	3.27
5A residential	9.73	1.77	3.27
5B	9.73	2.17	3.27
5C	9.73	4.17	3.27
5D	9.73	2.07	3.27
5E retail	9.73	1.57	3.27

All the residential buildings have appropriate freeboards to habitable floor levels and to basement driveway entry crest levels to provide acceptable levels of risk for flood damage and personal safety. Personal safety issues are dealt with in more detail in **Section 5.8.**

The significant heritage buildings to be retained on site are buildings 2A/2B/2C, 3C, 5A and 5E. Buildings 3C and 5A are the storage silos and the lowest residential floors have been set at RL 11.5m AHD which provides adequate freeboard to the 100yr ARI flood level. These buildings will have access to a basement car park which will serve the entire footprint of Buildings 3 and 5 and provide flood free access to a level of RL 13m AHD at the driveway entry.

The proposed retail areas are very important to the success of this transport orientated development to service residents in the development but more importantly to attract people to the light rail station and provide amenity for the community and light rail users. These retail areas need to be accessible to the main pedestrian pathways to the station and present well to adjacent open space to maximise the amenities for users. These retail areas will include specialty activities such as cafés, newsagencies, corner shops etc.

The Mungo Scott Building (*2A/2B*) has a ground floor level of approximately RL 9.05m AHD and first floor level of approximately RL 13.9m AHD. The ground floor would be flood proofed to minimise flood damages and internal stairs would be provided for evacuation to the first floor level which would have a commercial use. A gantry bridge connection would be made from this first floor level to Building 3A which would provide flood free access to the basement of Building 3 in case of an emergency. In this way, the use of Building 2A/2B is considered appropriate in terms of the flood risks.

Building 1C would be a light framed building with a floor elevated (*at RL 9.05m AHD*) above existing ground levels with speciality retail uses. This building will serve as the main convenience retail service to the community and light rail users. It would be flood proofed to minimise flood damages and would have ready access to Building 2A/2B for access to higher levels or to the basement of Building 3 in case of an emergency. In this way, the use of Building 1C is considered appropriate in terms of the flood risk especially given its important role in the success of this area as a transport orientated node and the broader benefit to the community from this type of development.

Building 2C is the electrical substation building which would be retained. Its existing floor level is at the footpath level. This building would have a retail use to attract pedestrians to the light rail station and other specialty retail. The building would be flood proofed and users would have ready access to higher levels in Building 4 and to the basement in this building in case of an emergency. In this way, the retail use of Building 2C is considered appropriate in terms of the flood risks.

Building 5E is the former amenities building which would be retained and refurbished for retail and community uses. The retail use on the ground floor would have an approximate level of RL 11.3m AHD. This provides readily appropriate levels of freeboard and users would have ready access to higher refuge levels on the first floor (*RL 14.3m AHD*) or in Building 5D.

5.6 SENSITIVITY TESTING – CLIMATE CHANGE AND BLOCKAGE

5.6.1 Climate Change

Rainfall Intensities

Climate change has the potential to change rainfall patterns in Sydney with possible increases in rainfall intensity. There is limited data available to provide accurate predictions of likely extents of any changes however the latest advice is up to a 15% increase in rainfall intensity due to climate change effects. The DoP has recommended that sensitivity testing be undertaken up to a 30% increase to understand the possible impacts of lower or higher increases in rainfall intensity.

Sensitivity testing has been undertaken for this study with increases in rainfall intensity of 10%, 15% and 30%. The predicted 100yr ARI flood levels for these increases in rainfall intensity are compared with the flood levels for existing conditions in **Table 18**.

Table 18 – Climate Change Sensitivity Testing – 100yr ARI Flood Levels (RL mAHD)

Existing	10% increase in Intensity	15% increase in Intensity	30% increase in Intensity
9.73	10.25	10.46	11.21

It is considered appropriate, given the information available, to adopt a 15% increase in rainfall intensity for estimation of likely future 100yr ARI flood levels on the subject site. This increases the predicted flood level on the site by 0.73m from RL 9.73 AHD to RL 10.46m AHD for the 100yr ARI flood level.

The impact of this level of RL 10.46m AHD on the proposal development is:-

- Residential floor levels;
  - A minimum floor level of RL 11.5m AHD still provides over a metre freeboard which is readily acceptable;
  - Even with a 30% increase in rainfall intensity , the predicted flood level would be below the residential floor levels (*300mm freeboard*);
- Basement entry crests;
  - The flood level at the Building 1A basement entry would be RL 10.31m AHD for 15% increase in rainfall which would provide an acceptable freeboard of 0.5m to the crest;
  - All other basement entry crests are significantly higher than for Building 1A and hence acceptable.

Sea Level Rise

It is predicted that sea level will rise by up to 0.91m by 2100. This will increase the mean sea level to approximately RL 0.9m AHD with a mean high tide level around RL 1.5 AHD. The invert of the Hawthorne Canal at the Longport Street overpass culvert is approximately RL 2m AHD which is above the more common high tide levels in the harbour.

Also, the peak flood level on the site for the 100yr ARI flood is controlled by the level of the rail tunnel through the Longport Street overpass which has no connection to the tidal levels in the canal. The combination of these two factors means that the predicted sea level sea level rise by 2100 would not have a significant impact on flood levels on the subject site.

5.6.2 Blockage

The Hawthorne Canal culvert through the Longport Street overpass is a 3.8m diameter tunnel which has an invert level of approximately RL 2.3m AHD at its upstream end on the subject site.

The potential for blockage of this culvert is very low due to a number of factors:-

- Its large diameter readily exceeds the size of most materials likely to cause blockages;
- Characteristics of the upstream catchment; and
- During a severe flood there will be over 7m of head driving water through this large culvert.

The size of the culvert would accommodate large items of potential debris and the slopes and narrow channel flows would tend to align any debris along the channel further reducing the potential for blockage.

The potential source of debris from upstream sections of the channel would be severely hindered by the covering of the channel by the rail corridor. The culvert under the rail corridor is significantly smaller than the Longport Street overpass culvert allowing debris to be trapped upstream of the rail corridor. Also, further debris would be trapped by the railway corridor crest as flood waters pond behind the crest and only a shallow depth of flow passes over the railway crest.

The other potential source of debris for blockage is the Smith Street branch however this is a heavily developed urban catchment which minimises the potential for debris. Also, the majority of flows would be along the roadways with a ponding location opposite the site in Smith Street. This ponding would trap the majority of large debris.

The head of water above the culvert is considerable and will drive flow through the culvert minimising the potential for debris to block the culvert.

Given the above, a blockage factor of 10% was adopted for sensitively testing of the potential flood levels on the site. This blockage factor was combined with a 15% climate change induced increase in rainfall intensity to test the sensitivity to the proposed development. The predicted 100yr ARI flood with 10% blockage and 15% increase in rainfall intensity would be:-

- Chainage 270 – RL 10.57m AHD
- Chainage 300 – RL 10.73m AHD

- Chainage 380 – RL 10.83m AHD
- Chainage 400 – RL 10.81m AHD

At these levels, the minimum residential floor levels at RL 11.5m AHD would still have a freeboard of 0.67m which is more than appropriate.

The lowest basement entry crest level is for Building 1A at RL 10.8m AHD. The applicable predicted flood level at this location would be RL 10.73m AHD. As such, this driveway entry crest would not be overtopped even with the climate change and blockage factors included for the 100yr ARI flood.

The other basement entry crests at RL 11.5m and 13m AHD would have freeboards of 0.67m and 2.17m respectively which are considered readily adequate for the 100yr ARI event with a 15% climate change induced increase in rainfall intensity and 10% blockage.

5.7 ACCESS TO BUILDING 1A

The access road to the Building 1A basement will be an elevated structure to allow overland flows to pass under the road.

This structure has been designed to sit wholly above the 100yr ARI flood and cause minimal impedance to flows below.

This will allow flood free vehicular access to the areas at the north east corner of the site.

Details of the proposed structure will be provided at Construction Certificate stage. Approval will need to be sought from Sydney Water to ensure no part of the new structure interferes with the existing heritage canal.

5.8 FLOOD EMERGENCY RESPONSE

A flood emergency response plan has been formulated for the site to cater for the flood risk for floods between the 100yr ARI and PMF floods. While the 100yr ARI flood is the adopted flood standard for establishing floor levels, an emergency flood response plan is required to appropriately manage the risk to personal safety during more severe floods up to the PMF event.

The proposed emergency flood response plan for the development consists of:-

- Vertical evacuation to higher floor levels above the flood levels to make the plan self-sufficient;
- An alarm sounds when floodwaters on the site reach RL 10.8m AHD requiring residents and workers to move to higher floors above the PMF level;
- Requirement for each body corporate to be responsible for the plan including nomination of people to be wardens in the building, training of all residents/workers and instigating annual drills to practice the plan requirements;

- Provision of signs and lighting to inform people of the evacuation route; and
- Access for emergency services if required during a flood.

The predicted PMF levels on the subject site for existing conditions and the sensitivity testing scenarios do not vary greatly because of the physical features providing overland flow escape for relatively high levels of ponding. The levels vary between approximately RL 13.7 and RL 13.8m AHD.

All residential buildings have floor levels above the PMF level so vertical evacuation provides flood free refuge for all floods. Residents of Buildings 2,3,4 and 5 would also have access to flood free land by walking west along Wellesley Street.

Similarly residents of Building 1A would have access to refuge above the PMF level within the building or via pedestrian access from the first floor level at RL 14m AHD to the Longport Street overpass.

The small retail buildings 1C and 2C have ready access to adjacent tall buildings providing refuge above PMF levels.

The retail ground floor of Buildings 2A and 2B would have access to the first levels at RL 13.9m AHD which is above the PMF level. Higher floors in Building 2A provide further refuge as there would be a connection between Buildings 2A and 2B at the first floor level. In case of emergency requiring say medical attention, access would be provided by covered gantry from Building 2A to 3A and then to the combined basement under Buildings 3 and 5. Emergency vehicles could obtain access to the basement up to flood levels of RL 13m AHD.

The ground floor retail in the one storey Building 3B has a floor level of RL 12m AHD and has ready access to flood refuge floors in Building 3A.

The ground floor retail at the northern end of Building 4A has a floor level of RL 10.4m AHD with ready access to flood refuge floors in the same building.

The retail and community uses in the two storey Building 5E has internal access to the first floor level at RL 14.3m AHD above the PMF level or ready access to higher levels in the adjacent Building 5D.

The ground floor retail in the 11 storey Building 5A, has a floor level of RL 10.7mAHD and ready access to floors above the PMF level in the same building.

5.9 CUMULATIVE EFFECTS

5.9.1 Sydney Light Rail Extension

The rail corridor forms a crest between the subject site and the McGill Street Precinct Masterplan area and hence has a major influence on severe flood levels in the McGill Street Precinct Masterplan area. Also, flood flows re-enter the open channel of Hawthorne Canal around the proposed location of the Lewisham West station. As such, the design of the Light Rail Extension has to ensure the existing levels of the rail corridor are maintained. Also, any station structures need to be at grade or be elevated and light weight structures so as not to impede or concentrate flood flows onto the subject site.

5.9.2 McGill Street Precinct Masterplan

The development proposed in the McGill Street Precinct Masterplan drains via the existing pipe drainage system which joins the Hawthorne Canal downstream of the Longport Street overpass. This pipe flow has been incorporated into the flood model in the estimation of flood levels on the subject site.

The estimation of flood flows for the Hawthorne Canal and the subject site incorporated the McGill Street Precinct Masterplan development and as such, predicted flood levels on the subject site allow for this development.

5.9.3 MP 08_0195

This project is over a part of the McGill Street Precinct Masterplan area and while the yield is above that envisaged by the Masterplan it would not significantly change the runoff generated from this area. Therefore, the allowances made for the McGill Street Precinct Masterplan in the flood assessment on the subject site include appropriate allowances also for MP 08_195.

6 STORMWATER QUALITY

6.1 CONSTRUCTION PHASE

During demolition, bulk earthworks and construction of internal roads and associated infrastructure for the proposed development, sediment and erosion control facilities would be designed and constructed/installed in accordance with the DECC publication "*Managing Urban Stormwater – Soils and Construction*" January 2008 *(i.e. the Blue Book) and* all relevant Council codes/standards.

A sediment and erosion control plan would be prepared for each developed stage prior to construction (*i.e. prior to issue of Construction Certificate*), outlining the strategies proposed to prevent excessive pollutant loads being exported from the site in runoff and due to wind during and immediately following construction.

A summary of the principle elements of a preferred sediment and erosion control plan for each developed stage is summarised below:

- Minimising the extent of disturbed surfaces at any one time (*i.e. staging of earthworks etc*);
- Stabilising disturbed surfaces immediately upon completion of works (*i.e. hydromulch or vegetation*);
- Diverting clean runoff around disturbed work areas (*i.e. using earth bunds/diversion mounds/channels*);
- Protecting stockpiles (*i.e. using silt fence, diversion bunds, temporary vegetative cover etc*);
- Implementation of dust control/suppression measures during works(*i.e. perimeter fencing, wind velocity monitoring, cessation of earthworks activities during high wind conditions, watering down disturbed areas, setup of recycled water irrigation sprays etc*);
- Use of sediment basins;
- Use of silt fencing downslope of disturbed surfaces;
- Use of silt socks or equivalent around existing drainage structures;
- Use of rock/haybale/mulch check dams along designated overland flow paths;
- Use of floating silt curtains /floating booms at the entry points to existing trunk drainage channels;
- Protection of exposed slopes;
- Restriction of vehicle entry/exit points to construction zones;
- Setup of stabilised site access points; and
- Setup of vehicle washdown/wheel wash baths at exit points of disturbed areas.

6.2 POST DEVELOPMENT PHASE

The preferred water quality management system for the ultimate developed conditions would ideally consist of the following elements:

- use of rainwater storage tanks for reuse in toilet flushing, irrigation and other non potable uses;
- use of bio-retention systems, infiltrations systems, permeable paving or similar;
- installation of Gross Pollutant Traps (*GPTs*) and/or litter baskets; and
- use of vegetated buffers.

The software package developed by the CRC for Catchment Hydrology termed "MUSIC" (*Model for Urban Stormwater Improvement Conceptualisation*) was used to assess the effectiveness of the preferred "*treatment train*".

Only the post development with treatment measures scenario was assessed.

Details of the MUSIC modelling exercise (*including results*) are included at **Appendix B** and summarised in the following sections.

Water quality control would ideally be implemented using a treatment train approach, the first step of which would be the use of rainwater tanks on an allotment group scale. The rainwater tanks will act to intercept and re-use rainwater for toilet flushing, irrigation and other non potable uses. The reduction in stormwater runoff volume achieved through re-use will indirectly result in a reduction in pollutant load exported to the catchment as well as minimising potable water demand for the development.

In addition to rainwater tanks, gross pollutant traps, bio-retention systems (or equivalent), permeable paving and vegetated buffer strips would ideally be utilised in order to reduce pollutant loads discharging from the site.

6.3 WATER QUALITY OBJECTIVES

6.3.1 Department of Environment, Climate Change and Water (DECCW) Water Quality Guidelines

The water quality guidelines recommended by DECCW's are presented below in **Table 19**.

Table 19 – Water Quality Targets (*DECCW*)

	WATER QUALITY % reduction in pollutant load			
	Gross Pollutants GP (> 5mm)	Total suspended solids (TSS)	Total Phosphorus (TP)	Total Nitrogen (TN)
Stormwater Management Objective	90	85	65	45

6.3.2 Adopted Water Management Objectives

Based on review of the above documentation the following objectives have been adopted for the preparation of a site stormwater quality strategy for the Summer Hills Flour Mill site. Stormwater quality treatment measures will be implemented for the development to target sediments, nutrients and litter. The following water management objective will be achieved as a minimum:

- 85% reduction in annual post development Total Suspended Solid (TSS) load;
- 65% reduction in annual post development Total Phosphorous (TP) load;
- 45% reduction in annual post development for Total Nitrogen (TN) load; and
- 90% reduction in annual post development for Gross Pollutant/litter load (>5mm).

6.4 ASSESSMENT METHODOLOGY (*MUSIC*)

To ensure the objectives outlined in **Section 6.3** can be achieved, a preliminary MUSIC model has been established for the proposed development site.

MUSIC is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology (*CRCCH*). MUSIC can be used to estimate the long-term annual average stormwater volume generated by a catchment as well as the expected pollutant loads. It is able to conceptually simulate the performance of a group of stormwater treatment measures (*treatment train*) to assess whether a proposed water quality strategy is able to meet specified water quality objectives.

MUSIC was chosen for this investigation because it has the following attributes:

- it can account for the temporal variation in storm rainfall throughout the year;
- modelling steps can be as low as 6 minutes to allow accurate modelling of treatment devices;
- it can model a range of treatment devices;
- it can be used to estimate pollutant loads at any location within the catchment; and
- it is based on logical and accepted algorithms.

6.4.1 Rainfall

Rainfall data adopted in the preliminary MUSIC modelling (*all scenarios*) was sourced from the Bureau of Meteorology (*BOM*). A rainfall range over a number of years (*1996 to 1999 inclusive*) was selected to exceed the annual average for the region. In addition, a mix of dry, average and wet years was included in the selected range.

6.4.2 Evaporation

Monthly areal Potential Evapotranspiration values were obtained for the site from the 'Climate Atlas of Australia, Evapotranspiration' (*Bureau of Meteorology, 2001*) and are shown in **Table 20**.

Table 20 – Adopted Monthly Areal Potential Evapotranspiration

Month	Areal Potential Evapotranspiration (mm)
January	170
February	145
March	130
April	80
May	61
June	45
July	45
August	60
September	90
October	130
November	151
December	165

6.4.3 Sub Catchment Areas

The site was broken into a number of sub catchments in accordance with the proposed development layout and proposed treatment measure locations. Details of the sub catchment area characteristics are provided in **Table 21**.

Table 21 – Sub catchment Characteristics

Sub catchment Name	Area (m^2)	% Impervious
Roof-4	2,000	100
Non Roof-4	1,300	75
Road-4	520	100
Main Rd	500	90

Sub catchment Name	Area (m^2)	% Impervious
BRS1	60	0
BRS2	120	0
Perv Balance	8,200	45
Roof-1A	1,920	100
Road-1A	630	100
BRS3	135	0
Roof-2AB	960	100
Non Roof-23	1,200	70
Roof-3ABCD	1,490	100
Road-23	1,880	85
Non Roof-5AB	475	70
Roof-5AB	690	100
Roof-5CD	1,235	100
Non Roof 5CD	1,687	70
TOTAL	**25,002**	**75%av**

6.4.4 Soil Data and Model Calibration

For this preliminary modelling exercise the default MUSIC soil properties have been adopted. This data is summarised in **Table 22** and the resultant post developed volumetric run-off co-efficient for the site (*before treatment*) was equal to 0.78. This is within the anticipated range for the sites proposed impervious fraction.

Table 22 – Adopted Soil Data

	Units	Post Development	Pre Development
Impervious area parameters			
Rainfall threshold	mm/day	1.0	1.0
Pervious area parameters			
Soil storage capacity	mm	150	150
Initial storage	% of capacity	25	25
Field capacity	mm	50	50
Infiltration capacity coefficient – a		50	50
Infiltration capacity coefficient – b		2	2
Groundwater properties			
Initial depth	mm	50	50
Daily recharge rate	%	0.65	0.65

	Units	Post Development	Pre Development
Daily base flow rate	%	0.85	0.85
Daily deep seepage rate	%	0	0

6.4.5 Adopted EMC Values

The EMC values contained in **Table 23** have been adopted in the MUSIC model. These values were determined by the CRCCH following an extensive literature review by Duncan et al 1999, drawing on data from throughout Australia, but particularly from studies within NSW.

It is important to note that all of these values are the 'default' values used within MUSIC.

Table 23 – EMC Values

Land use	Storm Flow						Base Flow					
	TSS		TP		TN		TSS		TP		TN	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	(all values expressed as $\log_{10}$ mg/l)											
General urban / **Residential** / **Industrial** / **Commercial**	**2.20**	***0.32***	**-0.45**	***0.25***	**0.42**	***0.19***	**1.10**	***0.17***	**-0.82**	***0.19***	**0.32**	***0.12***
Forest/Natural	**1.90**	***0.20***	**-1.10**	***0.22***	**-0.075**	***0.24***	**0.9**	***0.13***	**-1.50**	***0.13***	**-0.14**	***0.13***

*Rural EMC values taken from Chapter 2 – Review of Stormwater Quality and Runoff, CRC for Catchment Hydrology, Oct.2003

6.5 PROPOSED DEVELOPMENT WITH TREATMENT

A post development (*with treatment*) MUSIC model was also prepared to ascertain the extent of treatment required to achieve the objectives in **Section 6.2**. An illustration of the adopted network is contained at **Diagram 3**. The resultant post development (*with treatment*) mean annual pollutant loads for each sub-catchment are presented in **Table 25.** For details of all input parameters and results refer to **Appendix B.**

6.5.1 Treatment Measures

For this preliminary modelling exercise a selection of commonly adopted best practice measures that were deemed to be suitable for this application were utilised in a treatment train approach to assess the viability of the proposed development.

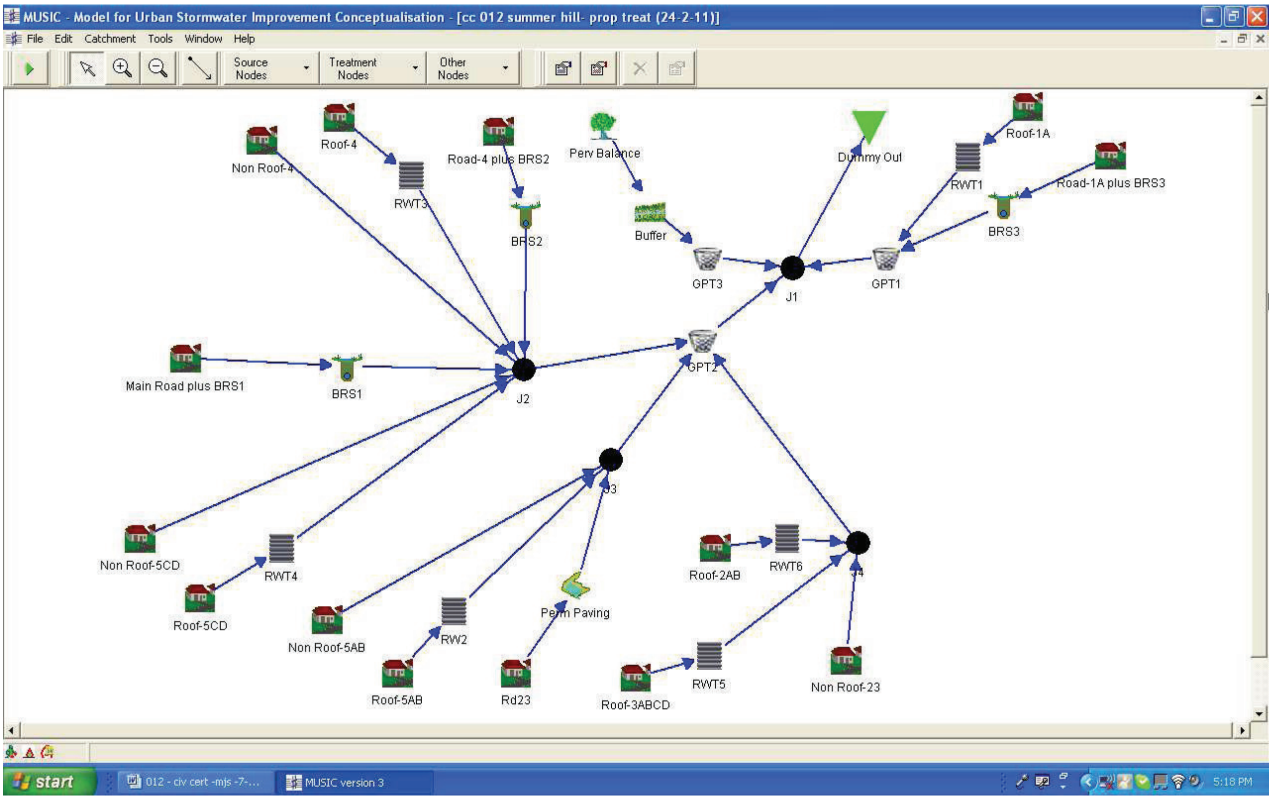
A summary of the adopted treatment measures is provided in the following sections. An illustration of the proposed treatment train is also contained in **Figure 5.**

6.5.1.1 Rainwater Tanks

Rainwater tanks indirectly reduce pollutant load by collecting and storing rainwater for reuse in non potable applications. Furthermore, rainwater tanks will assist in the reduction of potable water demand. For this site we have assumed adoption of a modest storage volume and reuse rate as summarised below:

	Storage V(KL)	***Daily Reuse Demand (KL/d)***
• Building 1A (*assume 60 res. apartments*)	125	8.1
• Buildings 4A,B & C (*assume 40 res. Apt*)	125	5.4
• Buildings 5C,D & E (*assume 30 res. Apt*)	125	4.0
• Buildings 5A&B (*assume 100 res. Apt.*)	250	13.5
• Buildings 3 D,C,B & A (*assume 120 res. Apt.*)	250	16.2
• Buildings 2A&B (*assume 10 res. Apt*)	25	1.35

Diagram 3 - Post Development MUSIC Network Diagram (*With Treatment*)



6.5.1.2 Gross Pollutant Traps

Gross Pollutant Traps or GPT's are a form of primary treatment designed to capture litter, debris, and coarse sediment. While the pollutant capture efficiency of various traps may vary from model to model, the following generic capture rates have been adopted:

- gross pollutants majority;
- total suspended sediments up to 85%;
- total phosphorous up to 30%; and
- total nitrogen 10%.

For this site we have assumed that all developable areas would be served by two primary gross pollutant traps located near the two proposed piped drainage outlets into Hawthorne Canal and litter baskets would be installed in all pits unable to drain to the proposed GPT's (*refer to **Figure 5***).

6.5.2 Bio-retention Systems

Bio-retention systems typically consist of a swale or above ground depression containing landscaping of native grasses, shrubs and trees underlain by an infiltration area and associated under drain. A typical bio-retention swale consists of 150mm sandy loam mixed topsoil, 1.0m filter media such as sandy loam, 150mm gravel transition layer under the filter media and subsoil drain at the base to collect filtered water through the media. The primary treatment mechanisms are detention/settling at the surface, take up of nutrients by plants, filtering treatment through the media and biological treatment from algal growth on the filter gravel.

For this site we have assumed adoption of a number of bio-retention systems as illustrated in **Figure 5** and summarised below in **Table 24**.

Table 24 – Assumed Configuration of Bio-Retention Systems

Inlet Properties	**BRS1**	**BRS2**	**BRS3**
Low Flow By-Pass (m^3/s)	0	0	0
High Flow By-Pass (m^3/s)	100	100	100
Storage			
Extended Detention Depth	0.25	0.25	0.25
Surface Area (m^2)	60	120	135
Seepage Loss (mm/hr)	10	10	10
Infiltration			
Filter Area (m^2) – 50% of surface area (approx.)	30	60	67.5
Filter Depth (m)	1	1	1
Filter Particle Effective Diameter (mm)	5	5	5

Inlet Properties	**BRS1**	**BRS2**	**BRS3**
Saturated Hydraulic Conductivity (mm/h)	100	100	100
Depth Below Underdrain Pipe (%)	0	0	0
Outlet			
Overflow Weir Width (m)	2	2	2

6.5.3 Permeable Paving

Bands of permeable paving are proposed along the two internal roads at the upper end of the site.

This permeable paving will treat the road surface and immediately adjoining footpath areas only. The bands will be similar to raised thresholds used to slow traffic only instead of being raised they will be slightly depressed below the surrounding finished surface level of the road (*ie the opposite to a raised threshold*). In this way they will capture and treat locally generated road runoff.

The permeable paving will be underlain by a no-fines basecourse and underdrain system to collect treated runoff.

The proposed area of permeable paving is equivalent to approximately 25% of the total road catchment area.

The permeable paving treats runoff by deposition of fines at the surface and filtering of fines and nutrients through the permeable basecourse.

The assumed properties of the proposed permeable paving are summarised below:

- Low flow bypass 0 m^3/s;
- High flow bypass 0.05 m^3/s;
- Depth to overflow 0.2m;
- Infiltration rate 25mm/h;
- Overflow weir 20m.

6.5.4 Vegetated Buffer Strip

A large vegetated buffer area is proposed to treat the local pervious catchment near the lower end of the site. The buffer strip will be landscaped with a dense planting of species designed to act as a barrier to flow. The total area of the proposed buffer strip is approximately 50% of the "Perv Balance" sub catchment. The buffer strip will only treat locally generated runoff prior to it discharging/sheeting into Hawthorne Canal.

The vegetated buffer strip treats runoff by and filtering/deposition of fines and takeup of nutrients.

For the purposes of the MUSIC model we have assumed the impervious fraction for the catchment draining to the buffer strip is approximately 45% and is subjected to a seepage loss of 10mm/h.

6.6 MUSIC MODELLING RESULTS

The MUSIC model results under the post development (*with treatment*) scenario is summarised in **Table 25**.

Table 25 – MUSIC MODELLING RESULTS

Music model	Location	Annual Flow and Pollutant Load Results				
		Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	GP (kg/yr)
Developed (With Treatment)						
	All Source Nodes	27.4	4,790	9.01	65.5	651
	Residual Load at Outlet	14.3	263	2.50	26.8	5.84
% Treat Train Effectiveness		**48%**	**95%**	**72%**	**59%**	**99%**
Achieve Objectives (S6.3)			>85%	>65%	>45%	>90%
			Yes	Yes	Yes	Yes

The results presented in **Table 25** illustrate the following:

- Implementation of a reasonably sized treatment system as proposed readily allows achievement of the stated objectives in **Section 6.3**; and
- Proposed roofwater capture and reuse provides a substantial effect on reducing the quantity of flows discharging from the site (*Total annual flow reduced by up to 48%).*

6.7 MAINTENANCE OF WATER QUALITY CONTROL MEASURES

To maintain effectiveness a maintenance regime would be required for all proposed treatment measures on the site. This would typically consist of the following:

- Periodic (*6 monthly*) inspection and removal of any gross pollutants & coarse sediment that is deposited in the bio-retention systems and replacement of vegetation as necessary;
- Periodic (*3 monthly*) and episodic (*post storm greater than 1 yr ARI*) inspection and removal of trapped pollutants from all GPTs/litter baskets;
- Periodic (*annually)* inspection (*and flushing if required*) of the bio-retention systems; and
- Regular maintenance of the permeable paving system (*6 monthly*).

7 STORMWATER DRAINAGE CONCEPT PLAN

The elements of the proposed stormwater drainage concept plan for the subject site are illustrated in **Figure 5** and summarised as follows:

- The initial phases of the SDCP for the site have a significant emphasis on source control;
- All roof water is firstly captured by rainwater tanks and then reused for toilet flushing, garden irrigation, car washing and laundry hot water;
- Overflow from each rainwater tank and the majority of pervious surfaces on site are then directed to the central piped drainage system for the site;
- A minor/major storm drainage philosophy has been adopted for the site;
- A 20yr ARI capacity trunk drainage line will convey flows to two outlets into Hawthorne Canal. Flows in excess of the 20yr ARI up to the 100yr ARI will be safely conveyed aboveground (*ie d x v <0.4*) within the internal roads/overland flow paths;
- Piped runoff will be treated by two GPT's (*placed near each outlet into the Canal*) and litter baskets installed in all other pits that are unable to drain to the GPT's. For ease of maintenance access the two main GPTs will be sited close to accessible internal roads;
- Three bio-retention swales are proposed to treat road runoff in the lower parts of the site;
- Bands of permeable paving are proposed to treat road runoff in the upper parts of the site; and
- A vegetated buffer area is proposed to control runoff quality in the lower open parts of the site.

7.1 REHABILITATION OF HAWTHORNE CANAL

The DGRs require consideration of the NSW Office of Water (NOW) comments regarding the rehabilitation of the Hawthorne Canal on the site to enhance flora/fauna connectivity. The DGRs also require liaison with NOW however they declined to meet for discussions on the issue. Our assessment of this issue is outlined in the following discussion which was also conveyed to NOW with a request for a reply.

The Preliminary Environmental Assessment was supported by a detailed flora and fauna assessment, as well as a targeted bandicoot survey. The assessments concluded that the proposed development of the Flour Mills site can be undertaken without adverse impacts upon native flora and fauna.

It is important that the NOW comments are considered within the overall context of the proposed Greenway along the goods railway corridor as part of the Sydney Light Rail Extension. NOW's call for rehabilitation of the canal and the creation of riparian setbacks and vegetation provision consistent with the Guidelines for Controlled Activities appear to fail to recognise that the

Hawthorne Canal in the vicinity of the subject site is largely covered over and "capped" by the goods railway line. As can be seen in the Environmental Assessment for the proposed Sydney Light Rail Extension, the treatment of the light rail and Greenway through this area is an urbanised treatment reflecting that the canal is in an enclosed system and recognises the desirable retention of the current mill buildings on the site. The Greenway will achieve the objectives of a flora and fauna corridor as it will be mostly continuous. The canal cannot provide a significant benefit in this upstream area because it is generally capped. Also, the former goods rail corridor immediately adjacent to the subject site has been identified as a light rail station location which introduces further urban development along with the need for wide and easy pedestrian connections through both the subject site and the McGill St Masterplan area. This will not allow extensive areas of vegetation on the subject site. Also the urban outcome being promoted on this "transport orientated development" and the more regional benefits from these types of development outweigh the limited benefits of isolated riparian vegetation in small areas.

The small section of the Hawthorne Canal that is an open channel on the site is located on the northern part of the site. The western side of the channel in this area is not in the applicant's ownership. Further it is noted that the options for this section of the canal are highly constrained by the ownership of the canal by Sydney Water, the canal's status as a heritage item and the function the canal performs in its current configuration in conveying flood flows. The canal has a flood capacity of around a 20yr ARI severity storm which is limited and which results in significant flooding in the local area. Any restrictions to this flow with more vegetation on the canal banks or further rehabilitation would cause increased flooding and further adverse impacts on surrounding development. This is not acceptable.

The best opportunity to enhance the flora and fauna attributes of this inner city urban area is vested in the proposed Greenway which will take advantage of the extensive corridor formed by the former goods railway line. This provides a more continuous corridor with less potential adverse impacts on the existing range of purposes and roles played by this corridor.

8 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations from this study are provided below.

- It is concluded from a stormwater management perspective that the development in its proposed conceptual form is suitable for the subject site and can be implemented in accordance with the principles of the NSW Floodplain Development Manual (*2005*);
- It is concluded from a stormwater management perspective that the development in its proposed form is able to coexist with the Sydney Light Rail extension and McGill Street Masterplan without detrimental cumulative impact subject to best practice stormwater design by all parties;
- The design of the proposed development has responded to the flooding conditions on the site such that it conforms to the NSW Floodplain Development Manual by minimising risk to flood damages and personal safety. The adopted residential and commercial floor levels and driveway entry crest to basement car parking provide freeboards above the 100yr ARI flood levels which are considered appropriate and readily exceed the requirements.
- The proposed stormwater management strategy for the site has incorporated consideration for climate change impacts by utilising an increase in rainfall intensities of 15% to account for predicted future changes in rainfall patterns. Due to the location of the site it will not be directly impacted by any future sea level rise;
- The proposed stormwater management strategy for the site has incorporated consideration for blockage of the Longport Street culvert by adopting a 10% blockage factor in all hydraulic calculations;
- A minimum residential floor level of RL 11.5m AHD is recommended for the site to provide 500mm freeboard to the 100yr ARI in Hawthorne canal and to account for possible climate change impacts (*15% increase in intensity scenario*) and possible blockage of the Longport Street culvert (*10% blockage scenario*);
- It is recommended that the proposed vehicular access road to the portion of the development on the east side of the canal be raised above the 100yr ARI flood and allow for the free passage of flow beneath;
- It is recommended that all basement entries and other openings to proposed basements be sited above RL 10.8m AHD;
- There are a number of proposed small retail land uses on the site which out of necessity, in terms of urban amenity and outcomes, will have floor levels below the 100 yr ARI flood level. Some of the retail areas have been located in significant heritage buildings in which floor levels cannot be changed. These will include the significant heritage buildings 2A/2B (*Mungo Scott Building*), 5E (*Amenities Building*) and 2C (*former EA substation*) as well as the new building 1C. The other new retail areas in buildings 4A, 5A and 5E will have reduced freeboards in the sensitivity testing conditions. These retail

areas would be flood proofed to minimise flood damages and would have ready access to vertical evacuation to ensure personal safety. This combination of controls along with implementation of an emergency flood response management plan is considered to provide an appropriate balance between flood management and the desired public amenity outcomes in this development which have considerable wider benefits to the broader inner city community;

- While the NSW Floodplain Development Manual recommends the 100yr ARI flood as the flood standard for planning of appropriate floor levels, it also recommends a merit based assessment considering a broader range of social, economic and environmental issues to ensure against the unnecessary sterilisation of urban sites. As such, it is considered that the adoption of the proposed retail floor levels is appropriate given the broader community and heritage benefits along with the commitment to flood proofing and availability of safe evacuation options;
- The NSW Floodplain Development Manual also requires consideration of extreme floods above the 100yr ARI flood up to the PMF to appropriately manage personal safety. In accordance with the NSW Floodplain Development Manual, an emergency flood response plan would be implemented for each building on the site to adequately manage risk to personal safety in floods up to the PMF level. In this plan, there will be vertical evacuation available in each building to levels above the PMF and also access available to surrounding streets rising to levels above the PMF level if necessary. This plan would incorporate a warning alarm in case of a flood, flood response education and training, dedication of flood wardens and annual flood response drills;
- The proposed development on the subject site would not adversely impact on flood levels in adjacent areas. The flooding on the subject site is mainly controlled by the Longport Street overpass and culvert and development on the rail corridor and McGill Street Precinct Masterplan site would not affect flooding of the subject site. The Sydney Light Rail Extension project has the potential to influence flood levels in the McGill Street Precinct Masterplan area as these flood levels are influenced by the crest level of the rail corridor. Similarly the proposed station structure or access ramps should not concentrate flood flows from the rail corridor onto the subject site. These flows should maintain their wide distributed flow onto the subject site from the rail corridor;
- It is recommended that suitable fencing be incorporated along the perimeter of the open channel section of Hawthorne Canal to prevent unauthorised access, ensure safety but to also prevent the accumulation of debris;
- Assuming best practice stormwater management principles are applied to any future development on the McGill Street Precinct it is not considered that this site will either impact or be impacted by the proposed development on the Flour Mill site;
- It is considered that the Sydney Light Rail extension project may have a minor impact on flooding in the vicinity of the site and the adjacent McGill Street site due to the sighting of raised platforms within an existing overland flow path (*ie crossing the Goods Railway line above the existing limited capacity SWC trunk culvert*). It is assumed that the future detailed design for the Light Rail proposal will take into consideration the requirement to mitigate these potential impacts;

- It is not considered appropriate to upgrade the existing Longport Street culvert as this could lead to potential downstream impacts;
- It is considered appropriate to increase the capacity of the downstream reach of the Smith Street trunk drainage system to reduce the extent and hazard of overland flows currently entering the site from Smith Street in the 100yr ARI. This could be achieved by amplifying the existing SWC line or constructing a new parallel line;
- A suite of WSUD treatment measures is proposed as part of the development utilising a treatment train approach to achieve best practice outcomes in terms of sustainability and stormwater quality. Considering the past industrial use of the site this will result in a marked improvement in water quality conditions downstream of the site;
- It is considered appropriate to maintain the existing open channel of Hawthorne Canal in its current form, however it is recommended that the unlined upper banks of the channel be stabilised with vegetation to provide stability, prevent erosion in larger storm events and to provide riparian habitat
- It is not considered that stormwater detention is required for the subject site due to its proximity to Hawthorne Canal and the benefit for the overall catchment of early release of flows from the site;
- The NSW Office of Water has requested consideration of rehabilitation of the Hawthorne Canal to enhance the flora/fauna connectivity value. The ability to rehabilitate the canal is restricted by the heritage nomination of the SWC section of the canal, the disruptions to the canal corridor due to extensive areas of covered sections and numerous road/rail crossings and the need to retain the limited flood flow capacity. Also on the subject site, there is only a small section of the eastern bank in the site ownership. The potential for rehabilitation also has to be balanced against the conflicting greater overall community benefit of achieving a high value urban amenity associated with this proposed transport orientated development adjacent to the proposed Lewisham West light rail station. In contrast to this limited opportunity to rehabilitate the canal, there is a tremendous opportunity to enhance local flora/fauna connectivity via the proposed Greenway aspect of the Sydney Light Rail Extension Project. The Greenway has the ability to provide significant benefits and resources should be concentrated on this proposal to enhance connectivity rather than rehabilitation of Hawthorne Canal through the subject site. The Flour Mill redevelopment has the potential to contribute to the Greenway;
- It is recommended that structural design for all new buildings ensures that no additional load is placed on existing SWC stormwater assets (*ie is outside of the zone of influence*); and
- In summary, it is considered that the proposed redevelopment on the former Flour Mill site would adequately address and manage the flood risk. It would also provide an integrated WSUD outcome for the drainage concept contributing to the long term improvement in water quality in Hawthorne Canal.

9 REFERENCES

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FIGURES