FINAL REPORT

SUMMER HILLS FLOUR MILLS
2-32 Smith Street and 16-32 Edward Street, Summer Hill

HAWTHORNE CANAL – FLOOD ASSESMENT

Prepared for:

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LIST OF ACRONYMS AND TERMS

ARI	Average Recurrence Interval
DECC	Department of Environment and Climate Change
DWE	Department of Water and Energy
IFD	Intensity Frequency Duration
RTA	Roads and Traffic Authority
SEC	Storm Event Capacity
SWC	Sydney Water Corporation
SMFM	Summer Hills Flour Mills
DRAINS	Hydrologic simulation model for developing stormwater flows
HEC-RAS	One-dimensional hydraulic model for determining water surface profiles
ORTHOPHOTO	An *orthophoto* is an aerial photograph that has been geometrically corrected such that the scale of the photograph is uniform, meaning that the photo can be considered equivalent to a map. In the case of the *orthophoto* mapping completed by the NSW Department of Lands, these photomaps have been super imposed with land contours to enable the determination of levels.

1 EXECUTIVE SUMMARY

The following report aims to address the following:

1. Provide background information on the Hawthorne Canal including its location, physical composition and heritage significance;
2. List and discuss previous relevant reports written on the canal;
3. Describe the Summer Hill Flour Mills site, the proposed development and how the Hawthorne Canal relates to the site;
4. Provide details on the methodology used to undertake the Hydrologic and Hydraulic assessment of the canal and discuss the inputs and assumptions used in the assessment;
5. Present the results of the assessment, their limitations and sensitivity to the assumptions made; and
6. Discuss how water quality issues relate to the development of the site;
7. Identify issues relating how the Hawthorne Canal could be accommodated in the future development of the Summer Hill Flour Mills Site.

We understand that the future development of the Summer Hill Flour Mills (SHFM) site is expected to comprise a mix of retail, commercial and residential uses including townhouses, apartments and adaptive reuse of existing buildings and some of the silos.

The Hawthorne Canal Sydney Water Corporation Channel 62 (SWC 62) is an 8,640m long mixed pipe and open channel trunk drainage system, which lies within the local government areas of Ashfield, Leichhardt and Marrickville.

A major consideration in how the SHFM site will be developed in the future is dependent on how the Hawthorne Canal and flows are accommodated on site.

A hydrologic analysis was undertaken using the DRAINS computer model to quantify channel flows from the upstream catchment. These calculated flows were then compared with previous studies as a checking mechanism to validate the model's output.

The calculated flows were then evaluated within the SHFM site using the HEC-RAS hydraulic model to determine the site's flooding characteristics. The model indicates that under existing conditions, the peak 1 in 100 year ARI flows will breach the canal's banks and result in flooding of the north western section of the site.

With respect to the future development of the SHFM site, any development proposal will need to consider how the future users of the site such as residents, members of the public and pedestrians can be accommodated on-site without compromising the operation of the Hawthorne Canal.

Further, several inter-related technical, social, environmental and economic issues would need to be addressed. These post-development issues include:

- Reduce the main canal flood levels, flow velocities and flow-path widths to allow the northern section of the SHFM site to be developed;
- Provision for the safe passage of Over Land Flows (OLF) from Smith Street and the rail corridor into the main branch of the canal;
- Upgrade and potential amplification of the existing culvert under the Longport Street overpass;
- Upgrade of the existing Smith Street branch of the Hawthorne Canal to a 1 in 20 year ARI capacity in line with current Australian stormwater best practise;

- Co-ordination with any future Greenway and light rail development within the adjacent rail corridor with particular attention paid to site access and pedestrian linkages, flood levels and the safe passage of OLF.
- Stabilisation of any exposed overbank areas within the site to protect against the erosive forces of water.
- Provision of all weather access to the flat area of land on the eastern side of the main canal (adjacent to the rail corridor) should that portion of the site be selected for future development;
- Incorporation of fencing, covers and other appropriate barriers to prevent the public from entering (or being washed into) the canal;
- Management of potential debris within the canal that has the potential to block the canal and cause an increase in flood level.

The final solution for developing the SHFM will be subject to approval and consultation with several government authorities at a later development application stage.

2 INTRODUCTION

2.1 GENERAL

Meinhardt was engaged by EG Funds Management to undertake a preliminary flood assessment on the existing Hawthorne Canal open channel owned by Sydney Water Corporation (SWC), which traverses the Summer Hill Flour Mills (SHFM) site.

2.2 SCOPE

The aim of the analysis is to assess the likely flooding characteristics experienced within the SHFM site as a result of upstream stormwater flows, draining through the Hawthorne Canal during the critical 1 in 100 year ARI storm event.

2.3 BACKGROUND

2.3.1 Hawthorne Canal

The Hawthorne Canal Sydney Water Corporation Channel 62 (SWC 62) is an 8,640m long mixed pipe and open channel trunk drainage system, which lies within the local government areas of Ashfield, Leichhardt and Marrickville (Refer Figure 2.3.1 overleaf for the canal's street map location and Appendix 'A' for System Layout and Catchment Map).

The canal roughly follows the valley line from Gough Reserve on Old Canterbury Road in Ashfield in an easterly direction through to the main goods railway network at Dulwich Hill. From here the valley falls towards the north and the canal traverses adjacent to the goods railways line in a northerly direction through Lewisham, the SHFM site, under the main suburban Inner Western Rail Line at Summer Hill, under the Great Western Highway (Parramatta Road), and thence through Haberfiled, Leichhardt, Dobroyd Point before discharging to its receiving waters at Iron Cove on the Lower Parramatta River.

The Canal channel itself is owned by SWC up to Marion St, Leichhardt, while Ashfield and Leichhardt Councils own the walls of the channel.

Several Council owned stormwater network branches connect to the canal throughout its length, these include: Leichhardt 62A, Leichhardt Amplification, Petersham, Petersham Park, Smith Street, Henson Street, Victoria Street and Grove Street.

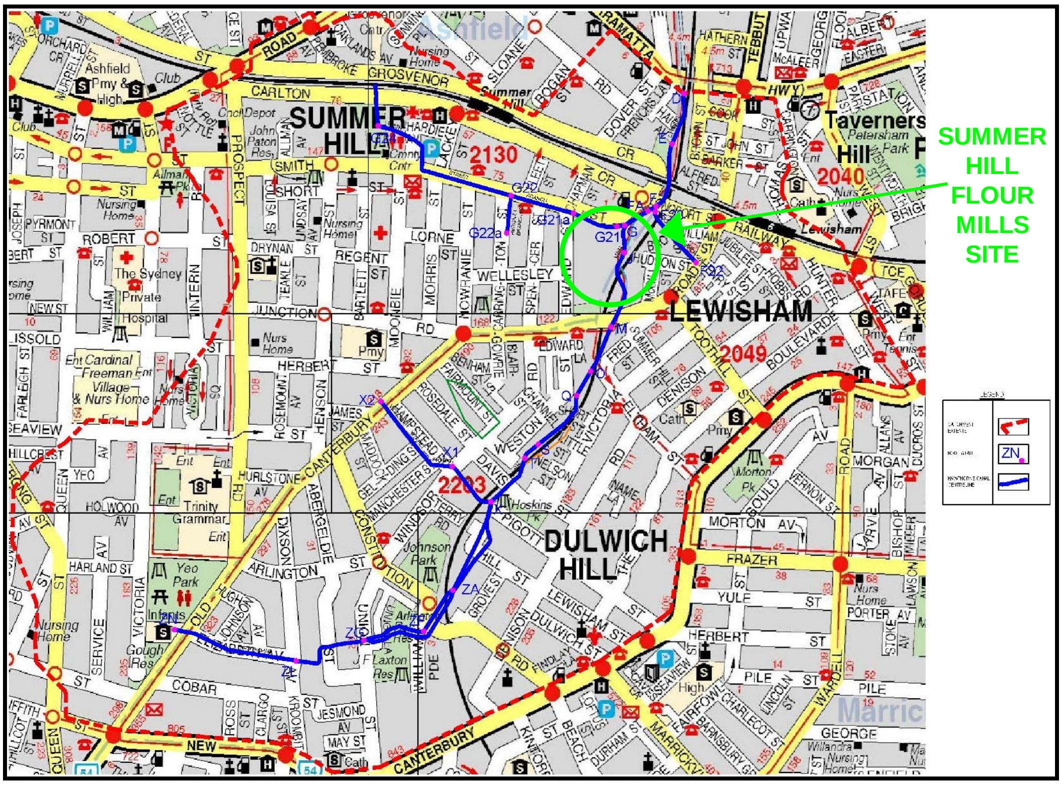

Figure 2.3.1 – Hawthorne Canal Street Map Location

2.3.2 Heritage Significance

Meinhardt understands that the Hawthorne Canal is listed as item of historical significance on Sydney Water's S170 Heritage and Conservation Register.

According to the Heritage Item data sheet appended at Appendix 'B', the Hawthorne Canal is of particular significance as it is one of the first of nine purpose built stormwater drains constructed in Sydney in the 1890's.

Up until this period the watercourses that served to carry stormwater were entirely in their natural state, and were receptacles of sewage from the large population that had settled in the suburbs. The then minister for public works, the Hon. Bruce Smith, MLA., appalled at the extremely unhealthy conditions prevailing at the time, proposed a separate system of stormwater drains be built to help alleviate the problem.

Today, the Hawthorne Canal provides a good representative example of these stormwater channels and remains the most intact.

2.3.3 SHFM Study Area

The study area considered is defined by the catchment area draining to the Hawthorne Canal and comprises a 294.7ha catchment bounded by New Canterbury Road in the south and southeast, a ridgeline in Ashfield / Ashbury to the west and the Parramatta Road in the north, as shown in Appendix 'A'.

The study area considered was carried past the SHFM site to Battle Bridge (just upstream of Parramatta Road), to determine how downstream backwater affects may interact with the upstream stormwater flows draining through the canal.

2.4 PREVIOUS STUDIES

At the time of writing this report we are aware of two previous studies that have been undertaken on the Hawthorne Canal, viz.:

- "Hawthorne Canal SWC 62, Capacity Assessment", May 1998, Sydney Water; and
- "Report on the Boards Stormwater Channels, Volume 2, Group B", 1970, J.F. McIllwraith (pp1-17).

These two reports are not directly comparable with the hydrologic assessment contained herein, as the methodology used to develop the canal flows in these reports were based upon application of the "Rational Method", of calculating stormwater runoff.

While the 'Rational Method' is a useful tool for estimating peak stormwater flows, more complex methods of time-area hydrological analysis have been developed in the last 20 years, which take into account a wide range of variables and are considered more accurate that the "Rational Method".

Apart from the information for which the SWC report has been relied upon (explained below), the flow rates reproduced in Section 5.6.1 have been included to provide a point of reference to check the accuracy of the hydrologic calculations contained herein.

Throughout the Hawthorne Canal assessment contained within this report, we have relied upon the SWC report for: channel position, length, longitudinal grade, cross section and pipe/ channel roughness coefficients for the DRAINS analysis, upstream of the SHFM site;

Additionally, we have adopted the Node[1] numbering system provided within the SWC report for use within this assessment. Nodes J to FA in the main Hawthorne Canal channel, and G21 to G of the Smith Street Branch are located within the SHFM site.

The J.F. McIllwraith report has not been referred to in the writing of this report.

[1] In a general sense, *nodes* are points or junctions at which *links* join together to form a drainage network.

3 SUMMER HILL FLOUR MILLS SITE

3.1 THE PROPOSED DEVELOPMENT

The future development of the SHFM site is expected to comprise a mix of retail, commercial and residential uses including townhouses, apartments and adaptive reuse of existing buildings and some of the silos. Additional areas will also be provided for open space and community facilities.

3.2 EXISTING SITE CHARACTERISTICS

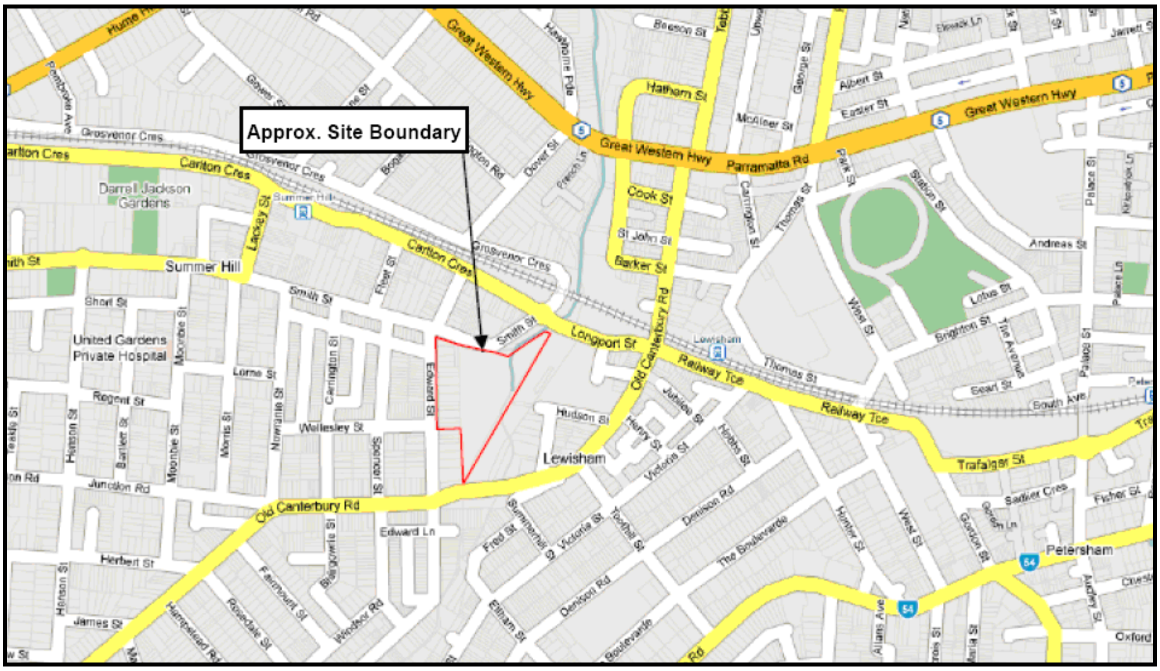

Figure 3.2 – Locality Plan

The site is located at 2-32 Smith Street and 2-32 Edward Street Summer Hill and comprises an area of 2.5ha. The site is bounded by Edward Street, Smith Street, Old Canterbury Road and a freight rail line to the east as shown in Figure 3.2.

The existing site development comprises several silos, processing buildings, administration offices, car parks, loadings docks, miscellaneous paved areas, landscaping, electricity substation as well as numerous other miscellaneous buildings.

The site generally falls at about 1% south to north and about 3% west to east with a low point located on the northeast corner (RL 8.7m AHD) and a high point on the southwest corner (RL14.93 AHD).

3.3 HAWTHORNE CANAL (SWC 62)

3.3.1 General

Several sections of open channel and Hawthorne Canal traverse the northern part of the site. Based on previous studies by SWC we have retained their numbering of nodes and points of interest along the canal.

Sectional Nodes J to FA of Hawthorne Canal (SWC 62) traverse the north eastern corner of the SHFM site as shown in Figure 3.3 below.

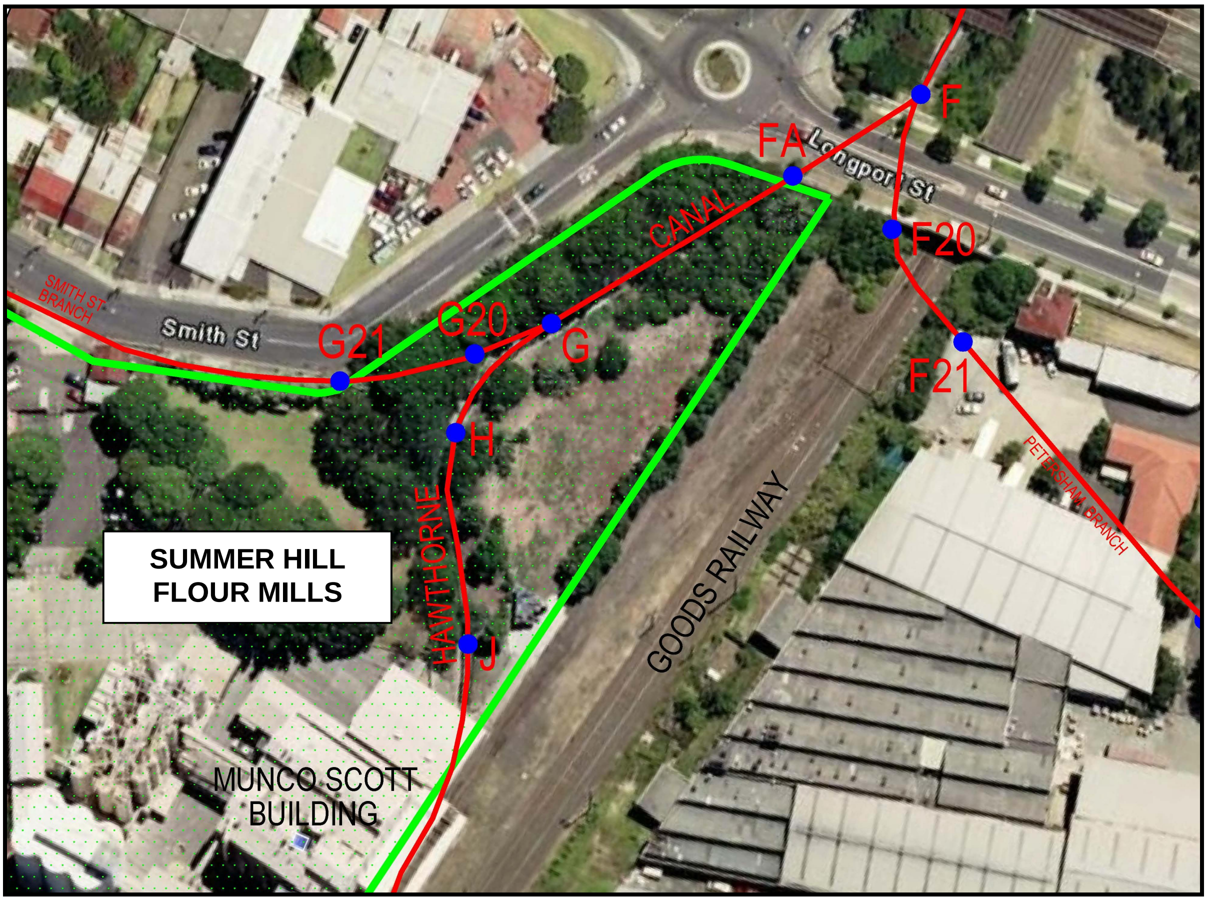

Figure 3.3 – Section J to FA Hawthorne Canal

The open channel starts upstream of the site, however passes through a pipe culvert under the goods rail line to where the pipe ends and the canal recommences within the site. The canal recommences at Node J just north of the Mungo Scott building and travels firstly in a northerly direct towards Smith street, and then in a north easterly direction adjacent to the Smith Street boundary, leaving the site through a covered section of channel underneath the Longport Street railway bridge at Node FA.

Approximately 70m downstream of Node J within the Hawthorne Canal main channel, the Smith Street Branch (62E) joins the main channel at Node G.

Outside the SHFM site, approximately 40m downstream of Node FA the Petersham Branch (62F) joins the main channel at Node F.

3.3.2 Physical Description

Within the SHFM site the canal is constructed of un-reinforced concrete, with the main channel dimensions ranging from 2.48m to 3.56m wide by 1.83m deep.

As can be seen from figures 3.3.1, 3.3.2 and 3.3.3 below the earth bank slopes on the side of the canal consist of bare earth and occasional vegetation (Nodes J to H). However as you travel towards the Longport Street culvert between Nodes H to FA, the earth banks are increasingly stabilised with mulch, leaf litter and shrub type vegetation.

Figure 3.3.1 – Hawthorne Canal Channel and Bank Slopes

Figure 3.3.2 – Hawthorne Canal Channel, Smith Street Branch Junction and Bank Vegetation near Node G

Figure 3.3.3 – Hawthorne Canal Channel and Bank Slopes near Node FA

4 STUDY METHODOLOGY

4.1 GENERAL

The methodology for flood assessment contained herein is to use the flow rates calculated during the hydrologic assessment and apply these to the existing open channel within the site to determine flow velocity, width, depth and water surface elevation.

4.2 HYDROLOGIC ASSESSMENT

The Hydrologic assessment performed within this report was calculated using the DRAINS software.

DRAINS is a windows based full simulation model, capable of describing the behaviour of a catchment and pipe/ channel system for real storm events, as well as statistically - based design storms. It generates full hydrographs of flows arriving at each pit, and routes then through the pipe/ channel network and over catchment surfaces, combining them where appropriate.

4.3 HYDRAULIC ASSESSMENT

The water surface profiles and channel velocities calculated during the assessment were developed using the HEC-RAS software. The flow rates used in the HEC-RAS calculations were taken from the previous DRAINS analysis.

The HEC-RAS software is capable of performing one-dimensional water surface profile calculations for steady gradually varied flow in natural or constructed watercourses; where subcritical, supercritical and mixed flow regime water surface profiles can be calculated.

The basic computation procedure is based on the solution of the one-dimensional energy equations. Energy losses are evaluated by friction (Manning's equation) and contraction/ expansion (coefficient multiplied by the change in velocity head). The momentum equation is utilised in situations where the water surface profile is rapidly varied, such as during mixed flow regime calculations involved with hydraulic jumps, flow through bridges etc.

The effects of various obstructions such as bridges, culverts, dams, weirs and other structures in the flood plain can also be considered in the computations.

4.4 INPUT DATA

Due the large amount of data required to undertake a flood assessment of this kind, the data used in the assessment was gained from several sources. These include:

- SWC Report - Hawthorne Canal SWC 62 – Capacity Assessment (May 1998)
  - Channel position, length, longitudinal grade, cross section and pipe/ channel roughness coefficients for the DRAINS analysis upstream of the SHFM site. Refer Appendix 'B' for a full copy of the report;
- Ashfield Municipal Council
  - Council pit and pipe locations, pipe sizes, cadastral data and contour information (hard copy only).
- Marrickville Council
  - Council pit and pipe locations, pipe sizes, cadastral data and contour information (electronic data).

- Department of Lands
    - Orthophoto mapping used for contour information where Council mapping is incomplete and to validate its accuracy.

- Goggle Earth Arial Mapping
    - Used to determine the various Catchment Land Use percentage impervious required within the DRAINS model.

- Watson Buchan - Survey Plan (Ref: 07/0321BJ)
    - Open channel geometry used in the HEC-RAS calculations from the SHFM site to Parramatta road.

5 HYDROLOGIC ASSESMENT

5.1 CATCHMENTS

The catchments used in the DRAINS analysis were obtained from maps provided by Ashfield and Marrickville Council's, which show streets, lots and contours at 2m intervals. Refer Table 5.1 below for catchment areas and Appendix 'A' for Catchment Plan.

Catchment boundaries were defined by a combination of roads, railway lines, property boundaries and topography. Upon review of Sydney Water's report it was found that the catchment areas were similar to those we have proposed. Accordingly we have adopted a similar naming convention for nodes in order to compare flows at critical locations

Catchment Name	Connection Node	Catchment Area (ha)	Impervious Area (%)	Pervious Area (%)
C2	**D1**	11.3	68.9	31.1
C1	**D**	10.4	63.7	36.3
C15	**X**	1.3	56	44
C12A	**X**	4.8	52.4	47.6
C12	**T**	2.3	77.2	22.8
C11	**S**	18.1	70.1	29.9
C10	**Q**	6.5	74.6	25.4
C9	**O**	15.7	71.4	28.6
C8	**M**	2.5	79.9	20.1
C21	**ZN**	31.3	60.7	39.3
C19	**ZL**	6.6	82.9	17.1
C18	**ZG**	10.0	62.3	37.7
C17	**ZF**	10.0	53.1	46.9
C16	**ZA1**	11.4	77.8	22.2
C13	**X2**	27.4	69.7	30.3
C14	**X1**	16.3	76.4	23.6
C5	**G24**	8.8	74.3	25.7
C6	**G22**	29.8	66.7	33.3
C4A	**G21A**	11.2	73.1	26.9
C4	**G21**	5.8	87.4	12.6
C7	**G22A**	18.1	78.9	21.1
C20	**ZL1**	9.7	82.4	17.6
C3A	**F22**	19.7	73.3	26.7
C3	**F20**	5.6	86.4	13.6
	Total Area	**294.7**		

Table 5.1 – Catchment Areas

The percentage impervious for each land use type within sub-catchment was determined using aerial photomapping available from Goggle Earth. The assumed percentage impervious area for each land use type is shown in Figure 5.2 below. These assumed percentage impervious were validated by checking against the Catchment Land Use Zoning information contained within the SWC report and Council's LEP.

Land Use Type	Percentage Impervious (%)
Roadways	80
Open Spaces	10
Industrial Areas	95
Special Use Areas (Schools/ Railways Lands)	50
Residential (Low Density)	50
Residential (Medium Density)	65
Residential (High Density)	80

Table 5.2 – Land Use Percentage Impervious

5.2 LINKS AND NODES

The Links and Nodes used in the DRAINS analysis were obtained from the SWC report. In particular we adopted the same numbering system as used in the previous study to enable a direct comparison of flows, as well as obtaining pipe and channel dimensions for links. These links were then checked against data provided by Council.

5.3 RAINFALL DATA

For the analysis contained within this report, twelve (12) 1 in 20 and 1 in 100-year ARI, statistically based design storms were used, being storms of duration: 10, 15, 20, 25, 30, 45, 60, 90, 120, 180, 270, 540 minutes.

The analysis was also run for the same twelve 1 in 5-year ARI storms to allow for a direct comparison of flow rates with the previous study conducted by the SWC in 1998.

The average rainfall intensities used to develop these storms were obtained from Ashfield and Marrickville Council's Intensity Frequency Duration (IFD) rainfall data, which are identical (Refer Appendix 'C').

5.4 DRAINS DATA

The following parameters were used in the DRAINS Data input :-

Manning pipe/ channel friction for concrete	0.014 mm
Paved area initial loss	1 mm
Grassed area initial loss	5 mm
Paved area surface roughness coefficient (n*)	0.013
Grassed area surface roughness coefficient (n*)	0.2
Soil Group Type	3.0 (slow infiltration)
Antecedent moisture content	3.0 (rather wet conditions)

A full set of DRAINS input data and results, as well as a Node diagram can be found at Appendix 'D'.

5.5 ASSUMPTIONS

In completing the hydrologic assessment, a number of assumptions were made in how the DRAINS model was configured. These include:

- Within the DRAINS model, where an open channel joins a downstream pipe reach, the connection Node has been modeled as a Head Wall to allow an overflow route to be incorporated into the modeling.

  Overflow routes are critical to the continuity of flow, as without these, any flows in excess of the capacity of the downstream pipe reach would be lost from the system.

- Overflow routes within the DRAINS package are modeled using travel times entered by the user. The final calculated flow rates developed by DRAINS can be sensitive to these travel times.

  The travel times used within this assessment have been developed using assumed hypothetical channel sections to develop average flow velocities, which are then applied to their respective reach lengths to come up with a flow time for that overflow route.

  The following average flow velocities were used in our analysis:

  Urban Catchment Overflow Route (mix of roads and urban dwellings) = 0.5m/s
  Railway Lands Overflow Route = 0.33m/s

- With respect to urban stormwater drainage design, during a 1 in 100 ARI storm event, it is common practice within the stormwater industry to assume that the minor stormwater system is partially or completely blocked. This situation was confirmed during a site investigation of the stormwater network surrounding the site where several pit chambers were found to completely blocked with leaves and debris.

  This blocking of the minor network means that during large storm events the catchment flows will generally follow the lay of the land, irrespective of the actual route of the minor system pipe network.

  Using this approach, where a residential lot flows onto a road system below, the road will act as a cut off system (with Old Canterbury Road being an example in the Hawthorne Canal catchment), and channel these flows until they reach a low point in the road, flow around a kerb return to another road, or indeed reach the major trunk drainage network.

- The over bank batter slopes used in the DRAINS analysis were assumed to be 1 in 10 for all open channel reaches upstream of the SHFM site as they are unknown.

- Along the course of the Hawthorne Canal there are several locations where the main open channel transitions to a covered channel section as it passes under the railways lands or under a road overpass (such as at Nodes W, P, M and FA). In these locations it is assumed that any overflow developed at these Nodes, due to insufficient downstream capacity to convey upstream flows, re-enters the system at the next downstream open channel Node.

  With respect to Nodes W, P and M and their relative placement at least 300m upstream of the site, we feel the above-described assumption will result in negligible changes to the calculated flow rates within the site.

  However, at Node K where the open channel is covered as it passes under the railways lands and the SHFM site, the position where the overflows re-enter the system will have a significant impact on the calculated flow rates within the site, and this will be discussed in more detail in later sections of this report.

5.6 RESULTS

Refer to Table 5.6 below for a tabulation of calculated 1 in 100 year ARI flow rates for selected Node sections of the Hawthorne Canal.

Node Section	Calculated Flow Rate (m^3/s)
E-D	103.0
F-E	95.4
G-FA	86.6
J-H	53.2
X-W	33.7
ZH-ZG	17.1
ZN-ZM	12.3

Table 5.6 – Tabulation of flow rate results from DRAINS.

5.6.1 Previous Studies

The results of the previous SWC study conducted in 1998 have also been provided for comparison, however these flow rates are for the 1 in 5 year ARI storm event as these were the only flow rates provided in the report.

From inspection of Table 5.6.1 below, it can be seen that the SWC flows differ slightly from those calculated in this assessment.

	1 in 5 Year ARI	1 in 5 Year ARI	
Node Section	**Calculated Flow Rate (m^3/s)**	**SWC Flow Rate (m^3/s)**	**Ratio of Flow Compariso n**
F-E	56.1	46.1	1.22
G-FA	42.1	-	-
J-H	26	28.8	0.90
X-W	19.5	22.4	0.87
ZH-ZG	9.1	10.1	0.90
ZN-ZM	6.4	5.9	1.08

Table 5.6.1 – Comparison of flow rate results from DRAINS with previous SWC Report (1998).

Possible reasons for these differences are discussed below:

- The previous SWC report was calculated using a spreadsheet approach, with the flow rates being estimated by the Rational method as outlined in Australian Rainfall and Runoff, 1987, (AR&R87). In comparison, the flow rate calculations contained within this report were based on a time-area method of hydrologic analysis where hydrographs are added. This later methodology provides a greater level of accuracy to calculated flows.

- The previous report was a based upon a standard known as the Storm Event Capacity (SEC), which differs from 1 in 100 year ARI flood assessment. As we understand, the SEC is evaluated by determining what storm event Average Recurrence Interval (ARI), will cause a peak flow equal to the hydraulic capacity of the canal section.

- Separate sets of Intensity Frequency Duration (IFD) rainwater data was used for the two assessments. The SWC used IFD generated by the '*Rainman*' program, while the IFD data used in this reports assessment was sourced from Ashfield/ Marrickville Council who share the same IFD information (Refer Appendix 'C' for the various IFD data sheets). For example, the *Rainman* generated IFD data lists the 1 in 100 year ARI 25 minute rainfall intensity as 141.43 mm/h; where as the Ashfield/ Marrickville IFD data lists it as 145.1 mm/h (3.5% variance).

Given the SWC report's focus was the assessment of the SEC of the Hawthorne Canal, and the hydrologic assessment used to determine this assessment was based on the "Rational Method", we believe the two reports are not directly comparable.

The comparison of flows included in Table 5.6.1 have been provided as a point of reference to check the accuracy of the hydrologic calculations contained within this report, and on the basis that calculated flow rates between the two reports differ by no more than 20% the flow rates contained within this report are reasonable.

5.7 SENSITIVITY

To provide a further level of certainty that the flow rates we have calculated for the Hawthorne Canal within the SHFM site represent what would happen, we have trialed two different scenarios to assess the sensitivity of our analysis to differing overflow routes in the vicinity of the SHFM site.

Refer to Figure 5.7 below for a figure explaining the differences between Scenarios A and B, in terms of where the overflows are reintroduced the Hawthorne Canal system.

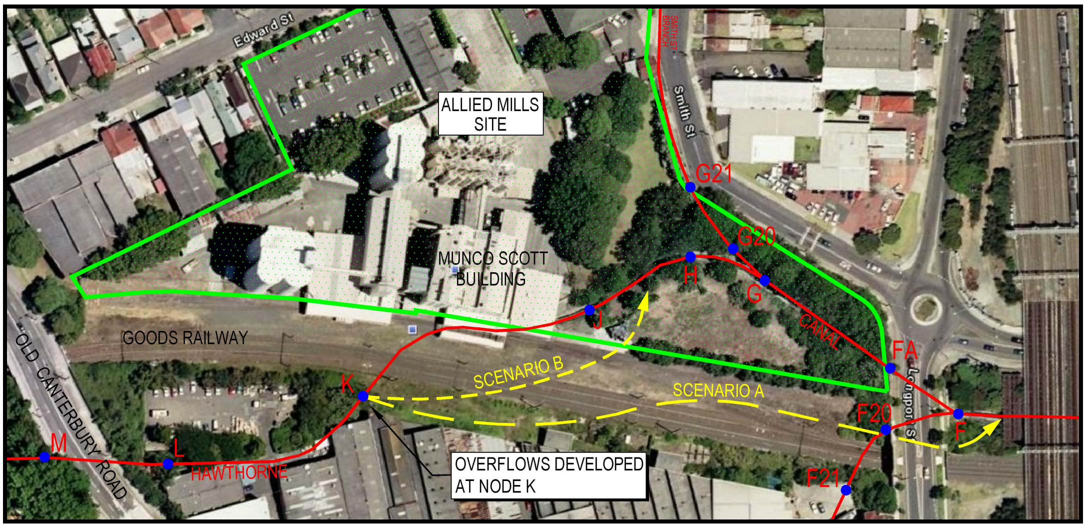

Figure 5.7 – Over flow Routes from Node K (Scenario A and Scenario B)

Node K is situated east of the SHFM site across the railways lands at the northern end of the carpark servicing the McGill Street industrial Area.

At Node K, the Hawthorne Canal transitions from an open channel to a covered channel where it travels under the railway lands, and in doing so, the over bank capacity of the system (or capacity to convey upstream flows in excess of the main channel's capacity) is lost where the channel is covered.

Refer to Figure 5.7.1 below for a photo showing where the Hawthorne Canal transitions from an open channel to a covered channel where it travels under the railway lands at Node K.

Figure 5.7.1 – Hawthorne Canal Channel Transitions to Covered Channel at Node K

As the covered channel downstream of Node K is not of adequate size to covey the calculated 1 in 100 year ARI flows, additional survey was obtained within the railways lands adjacent to the site to accurately determine where overland flows developed at Node K re-enter the canal.

From the additional survey obtained in December 2008 it is clear that the section of the railways lands between Nodes K to J falls towards the SHFM site and that any overflows developed at Node K will re-enter the Hawthorne Canal within the site just north of the Mungo Scott building. Meaning that Scenario B flows apply.

From inspection of Figure 5.7.2 below, it can be seen that eastern batter slope of the canal (LHS of photo) has received a bank stabilisation treatment in the form of rubber car tyres.

This stabilisation treatment is not evident at any other section of the canal within the SHFM site, and this would suggest that overland flows from the railways lands have travelled over this bank and back into the trunk drainage system at sometime since the canal's inception.

Figure 5.7.2 – Hawthorne Canal Channel and Bank Slopes near Node J (North of Mungo Scott Building)

5.8 LIMITATIONS

Having completed the hydrologic assessment of the Hawthorne Canal, the following limitations have been identified:

- Partial Area affects – When calculating overland flow times in large urban catchments, the peak flow rate can some times occur at a shorter time than the time of concentration due to topography, slope and land use factors.

  This situation can be overcome by dividing the large urban catchment into smaller more representative catchments, however to do this properly adds considerable time and cost to flood assessment calculations, and is beyond the scope of this report.

  Due to the large size of the catchment (approximately 300ha), it is not considered economically viable to complete a flood investigation of this kind, as this is more often the realm of government agencies and statutory authorities rather than private developers.

6 HYDRAULIC ASSESSMENT

6.1 CHANNEL CROSS-SECTIONAL INFORMATION

The open channel cross-sectional geometry details used in the hydraulic assessment were sourced from the Watson Buchan site survey completed in December 2008.

6.2 BOUNDARY CONDITIONS

For the 1 in 20 year ARI storm event, the downstream boundary condition used in the hydraulic analysis was defined by the normal depth of flow based on the down stream channel slope of 0.17%, and the peak flow rate of 103.0m^3/s at Node D.

However, for the 1 in 100 year ARI storm event, the 1 in 100 year flood level (RL 4.79) just upstream of Battle Bridge (where Parramatta Road crosses the Hawthorne Canal) was provided by SWC for use in our hydraulic assessment.

Following the subcritical Steady Flow Analysis, the calculated upstream water levels were used as the upstream boundary conditions for the subsequent mixed Steady Flow Analysis.

6.3 RESULTS

Refer to Figure 6.3.1 below for the Longitudinal Channel Profile of the 1 in 20 and 1 in 100-year ARI Hawthorne Canal flows within the SHFM site.

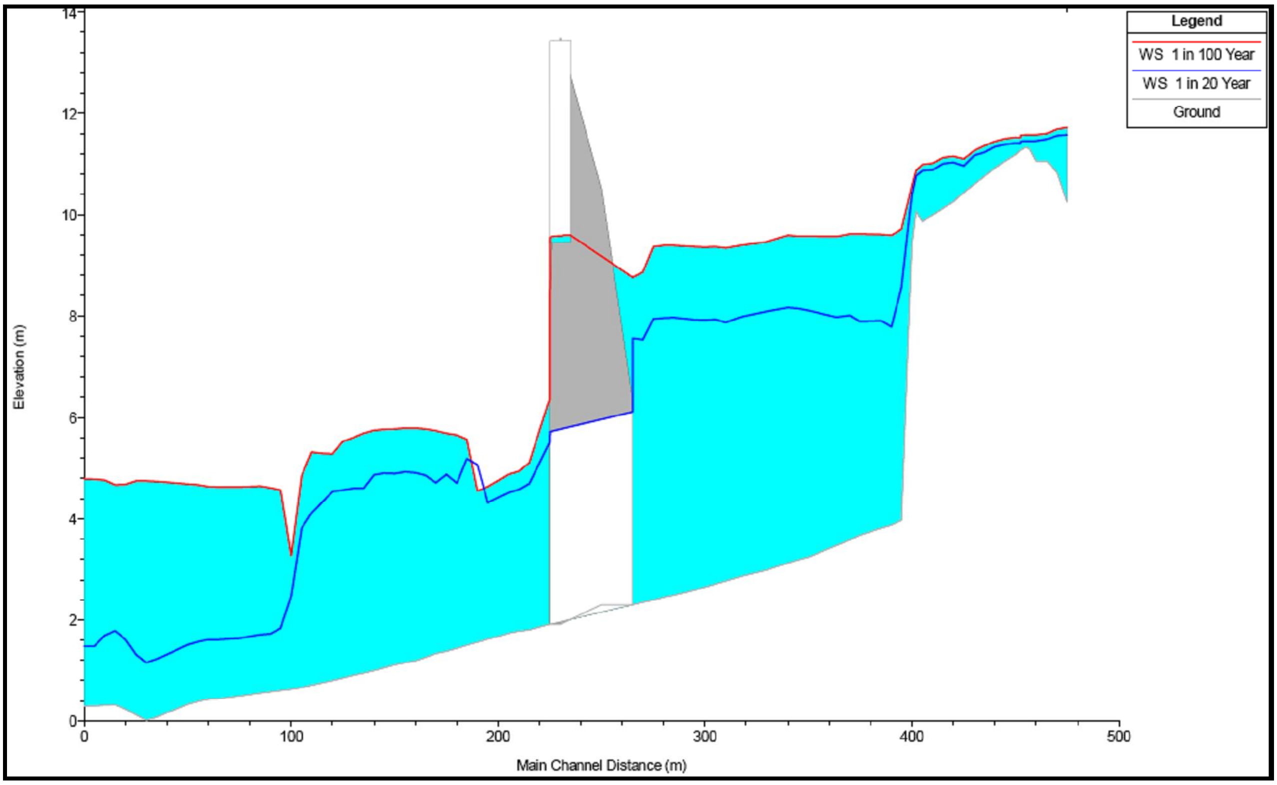

Figure 6.3.1 – Longitudinal Channel Profile

1 in 100-year ARI water surface elevations, channel velocities, flow depths and velocity x depth products are also tabulated in Table 6.3.2 below.

	River Station	Q Total	Minimum Channel Elevation	W.S. Elevation	Velocity Channel	Flow Area	Top Width	Flow Depth	Velocity X Depth
		(m^3/s)	(m)	(m)	(m/s)	(m^2)	(m)	(m)	
NODE K	**480.00**	27.90	10.25	11.72	1.02	32.65	41.12	1.47	1.50
	475.00	27.90	10.83	11.69	1.01	26.24	42.71	0.86	0.87
	470.00	27.90	11.06	11.60	1.30	18.55	41.33	0.54	0.70
	465.00	27.90	11.06	11.57	0.87	19.01	42.06	0.51	0.44
	461.79	27.90	11.30	11.57	0.62	21.51	42.31	0.27	0.17
	460.00	27.90	11.33	11.57	0.57	23.34	42.81	0.24	0.14
	457.48	27.90	11.27	11.56	0.61	23.55	41.85	0.29	0.18
	457.11	27.90	11.26	11.51	0.72	18.47	38.69	0.25	0.18
	455.00	27.90	11.19	11.53	0.72	22.78	43.00	0.34	0.24
	450.00	27.90	11.06	11.49	1.00	21.75	43.08	0.43	0.43
	445.00	27.90	10.92	11.45	1.33	20.19	43.17	0.53	0.70
	440.00	27.90	10.76	11.36	1.80	17.37	41.67	0.60	1.08
	435.00	27.90	10.60	11.27	2.26	15.47	38.89	0.67	1.51
	430.00	27.90	10.44	11.10	3.00	13.00	37.84	0.66	1.98
	425.00	27.90	10.26	11.15	2.22	17.59	42.90	0.89	1.98
	420.00	27.90	10.12	11.13	1.06	18.77	41.75	1.01	1.07
	415.00	27.90	9.99	11.01	2.84	15.93	35.73	1.02	2.90
	410.00	27.90	9.85	10.99	0.02	16.93	35.66	1.14	0.02
	406.86	27.90	10.06	10.87	3.06	14.03	33.67	0.81	2.48
	405.00	27.90	9.42	10.57	5.00	10.29	28.76	1.15	5.75
	400.00	27.90	3.97	9.71	1.41	69.46	61.09	5.74	8.09
NODE J	**395.00**	51.80	3.87	9.59	2.39	87.11	74.57	5.72	13.67
	390.00	51.80	3.81	9.60	2.25	93.81	78.11	5.79	13.03
	380.00	51.80	3.67	9.61	2.27	95.43	76.12	5.94	13.48
	375.00	51.80	3.58	9.61	2.17	93.38	76.58	6.03	13.09
	368.38	51.80	3.47	9.56	2.42	83.23	78.16	6.09	14.74
NODE H	**355.18**	51.80	3.24	9.57	2.27	73.85	73.75	6.33	14.37
	350.00	51.80	3.18	9.57	2.24	72.37	60.75	6.39	14.31
	345.00	51.80	3.12	9.58	2.06	76.49	41.59	6.46	13.31
NODE G	**334.53**	86.50	2.99	9.45	2.93	84.48	24.87	6.46	18.93
	321.93	86.50	2.86	9.39	3.19	75.15	23.61	6.53	20.83
	315.00	86.50	2.77	9.33	3.34	70.86	23.25	6.56	21.91
	310.00	86.50	2.71	9.36	3.20	74.16	22.86	6.65	21.28
	305.00	86.50	2.65	9.35	3.22	73.55	22.93	6.70	21.57
	300.00	86.50	2.59	9.36	3.16	75.12	23.13	6.77	21.39
	290.00	86.50	2.49	9.39	2.99	81.81	33.39	6.90	20.63
	285.00	86.50	2.44	9.39	2.99	82.65	37.31	6.95	20.78
	280.00	86.50	2.39	9.36	3.07	69.11	39.40	6.97	21.40
	275.00	86.50	2.35	8.87	4.27	40.82	19.08	6.52	27.84
NODE FA	**270.00**	86.50	2.30	8.76	4.21	30.35	13.33	6.46	27.20
	250.00	Culvert							
NODE F	**230.00**	95.40	1.91	6.36	6.14	28.39	10.82	4.45	27.32

Table 6.3.2 – Tabulation of Channel Flow Characteristics

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 100 year ARI storm event, cannot be contained within the Hawthorne Canal channel in its existing condition. Refer Appendix 'E' for Flood Extents map.

As can been seen from the flood extents map, the 1 in 100 year ARI flows will breach the top of bank on the western side of the canal and cause flood water to inundate the SHFM site on the western side of the Mungo Scott building to an approximate RL 9.60.

The dominant influence for the flood levels calculated within the SHFM site is the presence of the Longport Street road overpass and culvert found at the downstream of the SHFM site, Refer Figures 6.3.4 and 6.3.5 below.

Figure 6.3.4 – Longport Street Culvert

Figure 6.3.5 – Longport Street Railway Tunnel under the Road Overpass

As the Longport Street culvert is not of adequate size to covey the calculated 1 in 100 year ARI flows, the overpass acts as a barrier and causes the canal flows to rise up to an approximate RL of 9.59m to drive the stormwater though the culvert (under pressure head). As with a small proportion of flow traveling under the Longport Street Railway Tunnel as shown in Figure 6.3.6.

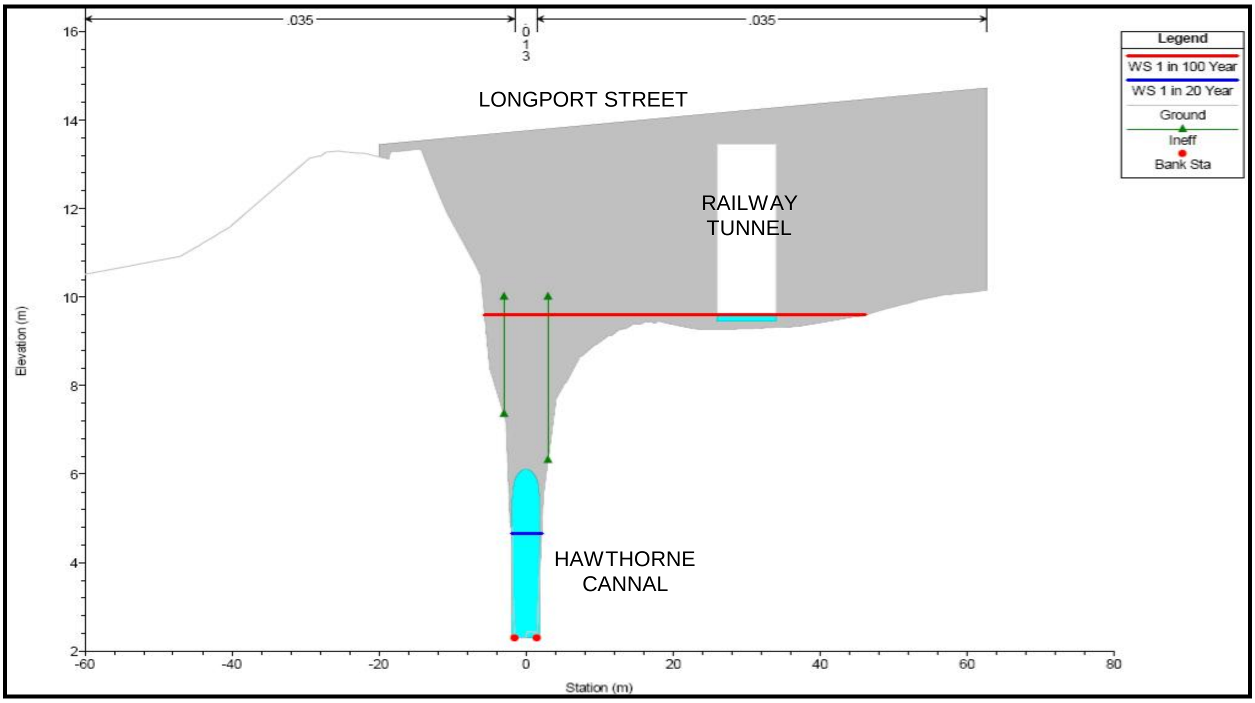

Figure 6.3.6 – HEC-RAS Section - Longport Street Culvert and Railway Tunnel

6.4 LIMITATIONS

Having completed the hydraulic assessment of the Hawthorne Canal downstream of the SHFM site, the following limitations have been identified which may require further investigation:

- According to the SWC report, the main channel is subject to tidal influences to 60m north of the Western Rail Line at Node E (130m downstream of Longport Street). Should the coincidence of high tide and a large storm event occur, this could have significant backwater effects and alter down stream boundary condition for the channel flows.

  This situation could in turn affect the calculated top water levels (flooding levels) and flow velocities experienced within the SHFM sections of the canal.

  However, considering that the Longport Street Culvert acts as the downstream control for floodwaters calculated within the SHFM site, it is likely that tidal influences will have a negligible affect on calculated water levels.

- Extreme flood events such as the Probable Maximum Flood (PMF) and flood events between the 1 in 100 year ARI and the PMF have not been considered within the scope of this report.

- The expected sea-level rise associated with global warming has not been addressed within the scope of this report. However, 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.

7 FUTURE DEVELOPMENT OF THE SITE

7.1 WATER QUALITY

It is envisaged that stormwater runoff from the site will need to be treated to remove pollutants from the site such as litter, nutrients and hydrocarbons. As such, it is envisaged the site stormwater system will comprise Water Sensitive Urban Design (WSUD) principals and incorporate a treatment train approach with water retention and re-use in accordance with industry best practise.

Aside from managing the floodwaters with respect to future development of the SHFM site, The Department of Water and Energy (DWE) has requested that water quality issues be addressed in any development involving the Hawthorne Canal.

According to the HEC-RAS analysis as described in Section 4, the calculations indicate flow velocities of between 1.16 – 2.7 m/s during the peak 1 in 100 year ARI storm.

These velocities coupled with the top water surface being above the concrete lined channel section, suggest that the existing earth batter slopes either side of the main channel could be subject to erosion and sediment transport downstream during large storm events. Accordingly these banks within the site could be stabilised with rock, concrete or vegetation.

7.2 FUTURE DEVELOPMENT ISSUES

With respect to the future development of the SHFM site, any development proposal will need to consider how the future users of the site such as residents, members of the public and pedestrians can be accommodated on-site without compromising the operation of the Hawthorne Canal.

Further, several inter-related technical, social, environmental and economic issues would need to be addressed. These post-development issues include:

- Reduce the main canal flood levels, flow velocities and flow-path widths to allow the northern section of the SHFM site to be developed;
- Provision for the safe passage of Over Land Flows (OLF) from Smith Street and the rail corridor into the main branch of the canal;
- Upgrade and potential amplification of the existing culvert under the Longport Street overpass;
- Upgrade of the existing Smith Street branch of the Hawthorne Canal to a 1 in 20 year ARI capacity in line with current Australian stormwater best practise;
- Co-ordination with any future Greenway and light rail development within the adjacent rail corridor with particular attention paid to site access and pedestrian linkages, flood levels and the safe passage of OLF.
- Stabilisation of any exposed overbank areas within the site to protect against the erosive forces of water.
- Provision of all weather access to the flat area of land on the eastern side of the main canal (adjacent to the rail corridor) should that portion of the site be selected for future development;
- Incorporation of fencing, covers and other appropriate barriers to prevent the public from entering (or being washed into) the canal;
- Management of potential debris within the canal that has the potential to block the canal and cause an increase in flood level.

The final solution for developing the SHFM will be subject to approval and consultation with several government authorities at a later development application stage.

8 REFERENCES

1. "Hawthorne Canal SWC 62, Capacity Assessment", May 1998, Sydney Water.

9 APPENDIX 'A'

- SWC Drainage Area & System Layout
- Catchment Map

10 APPENDIX 'B'

- **SWC – Hawthorne Canal Heritage Item data sheet**

11 APPENDIX 'C'

- Marrickville Council IFD data
- Ashfield Council IFD data
- RAINMAN IFD data

12 APPENDIX 'D'

- Node Diagram
- DRAINS Data

13 APPENDIX ‘E’

SCENARIO B

- Flood Extents Map
- HEC-RAS Results Table
- Water Surface Profile (Long Section)
- Canal Cross-Sections