ATTACHMENTS FOR: AGENDA NO. 9/15
Works and Community Committee

Meeting Date: Tuesday 16 June 2015
Location: Committee Room 1, Level 5, Civic Centre, 1 Devlin Street, Ryde
Time: 5.00pm

ATTACHMENTS FOR WORKS AND COMMUNITY COMMITTEE

GHD City of Ryde

City of Ryde Council

Buffalo and Kittys Creek Flood Study
Flood Study Report

November 2014

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

This report has been prepared by GHD for City of Ryde Council and may only be used and relied on by City of Ryde Council for the purpose agreed between GHD and City of Ryde Council as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than City of Ryde Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by City of Ryde Council and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD excludes and disclaims all liability for all claims, expenses, losses, damages and costs, including indirect, incidental or consequential loss, legal costs, special or exemplary damages and loss of profits, savings or economic benefit, City of Ryde Council may incur as a direct or indirect result of the database being transferred to council, for any reason being inaccurate, incomplete or incapable of being processed on City of Ryde Council's equipment or systems or failing to achieve any particular purpose. To the extent permitted by law, GHD excludes any warranty, condition, undertaking or term, whether express or implied, statutory or otherwise, as to the condition, quality, performance, merchantability or fitness for purpose of the information database transferred to Council.

This study was commissioned by the City of Ryde with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 NSW Flood Prone Land Policy

The primary objective of the New South Wales Government's Flood Prone Land Policy (the Policy) is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.

Through the Office of Environment and Heritage (OEH), the Department of Planning and Infrastructure (DP&I) and the State Emergency Service (SES), the NSW Government provides specialist technical assistance to local government on all flooding and land use planning matters. The Floodplain Development Manual (NSW Government, 2005) (the Manual) is provided to assist Councils to meet their obligations through the preparation of floodplain risk management plans.

Figure 1-1 from the Manual documents the process for plan preparation, implementation and review.

City of Ryde Council (Council) is responsible for local land use planning in the Buffalo and Kittys Creek Catchments and its floodplains. Under the NSW Flood Prone Land Policy, the Council's Floodplain Risk Management Committee is proposing to undertake a comprehensive floodplain risk management plan for the study area. This flood investigation is conducted in accordance with the Manual.

GHD was commissioned by City of Ryde Council to undertake this flood investigation and to produce the Buffalo and Kittys Creek Flood Study, Floodplain Risk Management Study and Plan (FRMS&P).

1.2 Key Issues

The City of Ryde experienced several large storm events in the 1980s that caused widespread flooding. Since then, rainfall events in May 1998 and April 2003 caused significant problems but not to the extent experienced in the late 1980s; this was mainly due to stormwater improvements works completed in the area, acquisition of some of the worst affected properties and the adoption of more stringent development controls. The study area comprises the Buffalo Creek and Kittys Creek catchments, which drains to the Lane Cove River. The catchment areas of Buffalo Creek and Kittys Creek are 550 ha and 193 ha, respectively.

1.3 Study Objectives

Council has the responsibility to undertake a Flood Study (the study) and a Floodplain Risk Management Study and Plan (FRMS&P) in accordance with the manual in order to identify and assess flood management options for Buffalo and Kittys Creek, and prepare an effective Floodplain Risk Management Plan for the community.

This current report forms the Flood Study component only. The primary objective of this study is to define the flood behaviour under historical conditions and design flood behaviour under existing and future climate conditions in the study area. The study produced information on flood levels, depths, flows, hydraulic categories, and provisional hazard categories for a full range of design events.

The design events comprised the:

- 20% AEP (5 year ARI);

- 5% AEP (20 year ARI);
- 2% AEP (50 year ARI);
- 1% AEP (100 year ARI); and
- Probable Maximum Flood (PMF).

Hydrologic and hydraulic modelling was undertaken to satisfy the study objectives. The models and results produced in this flood study will form the basis for the subsequent floodplain risk management study and plan. The subsequent FRMS&P is also being undertaken by GHD and will provide detailed assessments on flood mitigation options and floodplain risk management measures.

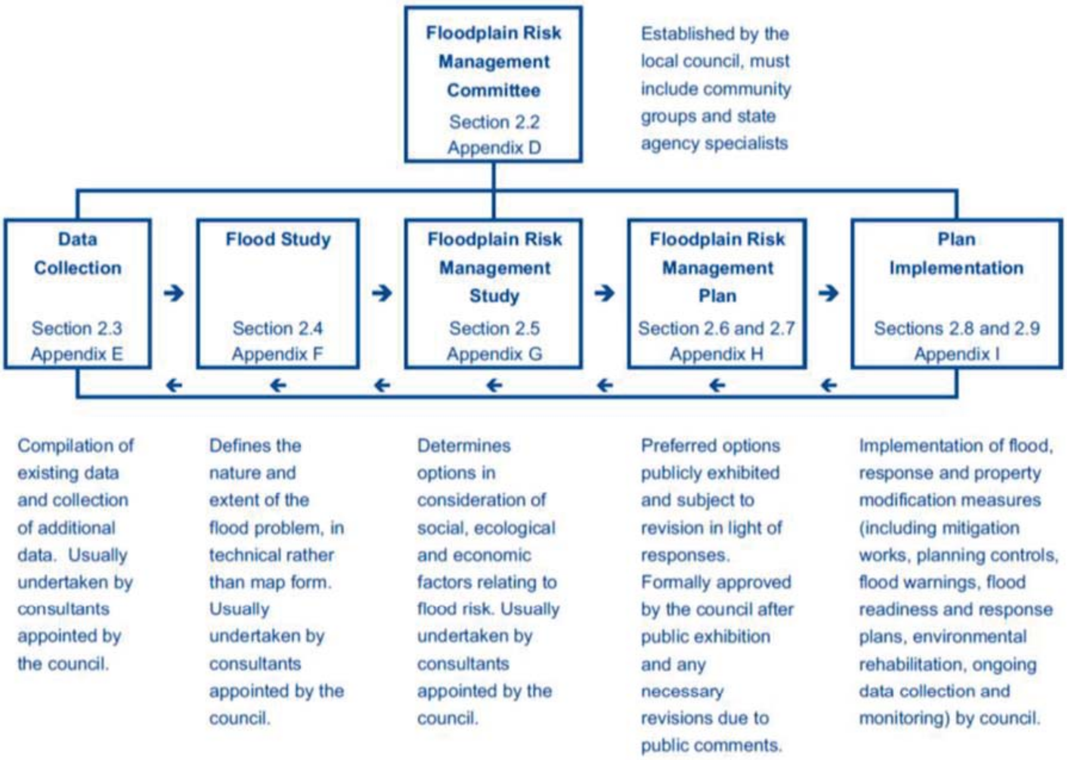


Figure 1-1 Floodplain Risk Management Process

2. Background

2.1 Study Location

The Buffalo and Kittys Creek catchments (the study area) are located within the City of Ryde local government area, an inner-city western suburb of Sydney, NSW, as shown in the Locality Plan in Appendix A, Figure A1. The catchments are bounded by Victoria Road to the west and by Pittwater Road to the east and south-east. Both creeks rise in the north-west and flows in a south easterly direction, draining into Lane Cove River.

2.2 Catchment Description

The combined catchment areas of Buffalo and Kittys Creek are approximately 689 ha. Table 2-1 below outlines the size of the individual catchments and an approximate length of the creeks.

Table 2-1 Catchment Information

Catchment	Creek Length (m)	Area (ha)
Buffalo Creek	4435	550
Kittys Creek	1750	193

Note: Figures are approximate and are measured off ArcGIS mapping layers provided by Council.

Buffalo Creek Catchment

The Buffalo Creek catchment is the larger catchment of the two and is located south-west of Kittys Creek. The topography of the area is predominantly steep with its highest elevations in excess of approximately 85 mAHD on the north western extent. The terrain generally slopes downwards in an easterly direction draining towards Lane Cove River. The downstream discharge point of the catchment (beneath Pittwater Road) exhibits an elevation of 0.44 mAHD.

Land use in the area is predominately urban and consists of mainly residential areas with minor commercial and industrial developments. Parks are found to be scattered throughout the catchment and forested reserves are dominant along the creek banks and in the floodplain areas.

Residential areas throughout the catchment exhibit slopes varying from 5 to 20% whereas the downstream creek banks can be as steep as 30 to 40%. The creek slope itself generally varies from 0.1 to 1.0% in the downstream region to approximately 1.0 to 2.5% in the upper reaches. Figure A2.1 in Appendix A presents a topographic map of the Buffalo Creek catchment.

Kittys Creek Catchment

The Kittys Creek catchment exhibits similar characteristics to the larger Buffalo Creek catchment. The terrain is also predominantly steep, exhibiting slopes in residential areas of 5 to 15% and approximately 20 to 30% slopes in the downstream creek banks.

Land use in the area is mainly residential with scattered parks and forested areas. Heavily forested areas such as Wallumatta Nature Reserve, Portius Park, Martin, Boobajool and Kittys Creek Reserve surrounds the creek, making the creek heavily vegetated throughout the entire reach. Appendix A, Figure A2.2 presents a topographic map of the Kittys Creek catchment.

Drainage Description

The existing trunk drainage system within the study area provides extensive drainage coverage within each catchment. Figure A3.1 and A3.2 in Appendix A, provides a layout plan for the drainage network within the Buffalo Creek catchment and Kittys Creek catchment, respectively.

The roads within both catchments have been formed with kerbs and gutters to influence and direct overland flow and rainfall into the catchpits. Table 2-2 below details the number of pits and total length of conduits within the study area.

Table 2-2 Drainage Network Data

Catchment	Number of Pits/Junctions	Total Length of Conduits (km)
Buffalo Creek	1572	32.5
Kittys Creek	458	7.9

Note: Total length of conduits has been rounded off to the nearest 0.1 km.

The existing pipe network is typically NSW standard RTA concrete pipes ranging from 300 mm to 1800 mm in diameter. The pipes ultimately discharge into the main creek of each catchment.

3. Available Data

3.1 Previous Flood Studies

No Flood Studies have previously been conducted for the Buffalo and Kittys Creek catchments. This current Flood Study prepared for City of Ryde will form the basis for all future floodplain management activities.

3.2 Data Received from Council

For the purposes of undertaking this Flood Study, the following information was received from Council on 17 April 2012 in the form of MapInfo GIS files.

- **Stormwater Asset Information**
  - Buffalo Creek Pipes Network (March 2012)
  - Buffalo Creek Pits/Junctions Network (March 2012)
  - Kittys Creek Pipes Network (February 2012)
  - Kittys Creek Pits/Junctions Network (February 2012)
- **Topographic Information**
  - Airborne Laser Scanning Data Set (ALS 2010)
  - Airborne Laser Scanning Data Set (ALS 2006)
- **Study Area Information**
  - Property Lot Cadastral
  - Catchment Extents
  - Overland Flow Paths
  - Park Areas
  - Street Names and Numbers
  - Easements
  - Aerial Photography (2006)

In addition, various AutoCAD files detailing stormwater assets were also provided for reference.

Stormwater Assets

Four MapInfo files containing stormwater asset data was provided by Council, these are listed above. The files contained key information on the pit and pipe networks such as pipe sizes, lengths, invert levels and pit types. Significant gaps of missing information (mainly pipe invert levels) were prevalent throughout the datasets. A survey by Garvin Morgan & Company, local registered surveyors, was conducted to obtain some of this missing information. Additional field work was conducted by GHD and the adoption of an ‘averaged’ pit depth method was applied in all other locations not surveyed.

Topographic Survey

Two sets of Airborne Laser Scanning (ALS) data in the form of ground spot heights were provided by Council, these were dated 2006 and 2010. A digital elevation model (DEM) used for modelling purposes was constructed using the more recent 2010 data set. Extents that were not covered by this version were complemented with the older 2006 data.

Due to the nature of ALS data, additional survey was required to pick up the bottom of creeks and channels. This additional survey was conducted by Garvin Morgan & Company.

Aerial Photography

The aerial photography dataset comprises a series of 12 1125 m x 1125 m photo tiles that covers the entire area of the Buffalo and Kittys Creek catchments. This data was used to assist with the development of sub-areal boundaries and impervious fractions for the hydrologic model and to assist with the generation of roughness data for use in the hydraulic model.

3.3 Additional Data Received

Additional survey data was conducted by Garvin Morgan & Company, local registered surveyors, in agreement with Council. This included the surveying of:

- Selected structures (including culverts and pit invert levels) – Data received on 28 August 2012; and
- Creek cross sections including invert levels – Data received on 4 February 2013.

Additional data was also received from Council on Lane Cove River design water surface levels for various ARI events. This information is understood from Council to be extracted from the Macquarie Park Flood Study Report (Bewsher Consulting, 2010).

3.4 Historical Rainfall and Flooding

3.4.1 Historical Rainfall

Historical rainfall data was unavailable for the immediate study area of Buffalo and Kittys Creek catchments. Nearby locations including North Ryde Golf Club (BOM Station ID 66213), Concord Golf Club (BOM Station ID 66013) and Macquarie Park (BOM Station ID 66156) was obtained from the Bureau of Meteorology (BOM). Other sources were considered including the Department of Primary Industries and Sydney Water, but were found to be lacking in data periods required for modelling.

All rainfall data collected was checked for continuity and similarity with adjacent gauges. The data was then assessed for its suitability for model calibration. Suitability for model calibration is reliant on:

- The data being from a location close to the catchment and therefore representative;
- The data being of high quality (no missing rainfall values);
- The data extending for the full duration of the storm;
- The event being of sufficient severity as to generate flooding of some consequence; and
- Corresponding historic flood level information being available in the study area (either from residents or data recorders such as Maximum Height Indicators (MHIs)).

Although three different gauging stations were found in the nearby vicinity, none of them qualified as suitable for use for model calibration as they did not satisfy the above criteria.

3.4.2 Historical Flooding

Historical flooding data was obtained from two different sources, these are listed below.

Council Flooding Database (1984 – 1999)

A flooding database was provided by Council covering the period from 1984 to 1999. These records provided information on lot location, flood depths and comments. The flood depths listed in the database are rounded to the nearest 50 mm and appear to be visual estimates rather than surveyed levels.

Community Consultation (2012)

Community consultation was conducted as part of this current Flood Study. A survey questionnaire was sent out to all the residents within the study area. Response from this survey included visual flood depths from the May 1998 flood event. This is detailed in Section 4 Community Consultation.

3.4.3 Streamflow

Streamflow stations and monitoring gauges are not present within the study area. Streamflow data for Lane Cove River is also not available.

4. Community Consultation

4.1 Overview

The primary aim of the community consultation program is to raise public awareness of the Buffalo and Kittys Creek Flood Study and FRMS&P and to involve their on-going participation and input throughout the project.

4.2 Floodplain Risk Management Committee

The purpose of the Floodplain Risk Management Committee is to:

- Act as both a focus and forum for the discussion of technical, economic, environmental and cultural issues and for the distillation of possibly differing viewpoints on these uses into a management plan; and
- Make sure that all stakeholders are equally represented.

The Floodplain Risk Management Committee performs an important advisory role. The principal objective of the committee is to assist the Council in the development and implementation of a management plan for the area(s) under its jurisdiction.

4.3 Consultation Activities

Newspaper Media Release and Newsletter

As part of the consultation activities for the project, a public notice was placed in the local newspaper to inform the general public of the Flood Study and to invite them for participation.

A newsletter was then prepared by GHD, providing key project information and a better understanding of the floodplain management process. The newsletter, along with a survey questionnaire was distributed by Council to residents living in the catchment areas.

Survey Questionnaire

GHD prepared a questionnaire to involve the community by seeking local knowledge and past flood experience in the Buffalo and Kitty Creek catchments. The main objectives of the survey were to:

- Obtain local knowledge from the community on key issues relating to flooding;
- Obtain information from property owners relating to previous flood experiences from 1984 to 2003; and
- To understand the concerns of the community to be considered and integrated into the Study.

Paper surveys were sent by mail to 3,247 owners of properties in the related areas around Buffalo and Kittys Creek catchments. In addition, the survey was available online on Council's website. Appendix B Figure B1 presents a copy of the mailed out survey. Data was collected from the 12 November until the 7 December 2012. A total of 622 surveys were completed (both online and through return mail), representing a 19% response rate. Key issues raised in the survey were:

- 8% of respondents reported previously being flood affected;
- 15% believed they could be affected by floods in the future;
- Positioning of property, drain blockages were the main reasons for future flooding; and

- 81% were not aware of any risk management measure.

The next stage of consultation activities for the Flood Risk Management Study and Plan Stage will include engaging the community to determine:

- The preferred floodplain risk management measures, controls on development, and how property owners want to be notified regarding potential flood effects on individual properties.

Figure B2 and B3 in Appendix B provides a full summary of the outcomes and results from the community survey.

5. Hydrological Model

5.1 Overview

Hydrologic modelling conducted for this Flood Study was undertaken using the DRAINS software package. DRAINS is a comprehensive program used for designing and analysing various types of catchments and urban stormwater drainage systems.

Its capabilities include, but are not limited to the modelling of drainage systems of various scales using the ILSAX hydrology method, Rational Method and storage routing models. It simulates the conversion of rainfall patterns to stormwater runoff hydrographs and routes these through network pipes, channels and streams

DRAINS was used to model the drainage networks within the Buffalo and Kittys Creek catchments using the ILSAX hydrologic method to simulate the catchment rain-fall runoff processes. Hydrographs produced from catchment run-off were used in the hydraulic model TUFLOW.

The DRAINS version used for this study is Version 2013.05 – 16 March 2013.

5.2 Subcatchment Delineation

The Buffalo and Kittys Creek catchments drain an area of approximately 550 ha and 139 ha respectively. Subcatchments were delineated from these to provide inflows to the pits within both the study area's drainage networks. Delineation was based on topographic information and aerial photography. The area of each sub-catchment was then divided and applied to the pits that fall within them. Figure A4.1 and A4.2 in Appendix A in provides details on the subcatchment delineations.

5.3 DRAINS Model Configuration

Model Extent

Two DRAINS models were developed for each catchment's stormwater networks to simulate different rainfall events. This was to allow for ease of use by Council. A total of four models were produced consisting of the below:

- Buffalo DRAINS model: Consisting of the 1%, 2%, 5% and 20% AEP rainfall events;
- Buffalo DRAINS model PMF: Consisting of the PMF rainfall durations;
- Kittys DRAINS model: Consisting of the 1%, 2%, 5% and 20% AEP rainfall events; and
- Kittys DRAINS model PMF: Consisting of the PMF rainfall durations.

The model extent within each model consists of the full set of pit and pipe network data for each catchment provided by Council.

Configuration of the Existing Stormwater System

The stormwater pit and pipe networks were provided directly from Council's stormwater asset database. Additional data sourcing, analysis and data extrapolation was required due to missing gaps in the data provided. The following lists the additional work conducted for the DRAINS model:

- Field work undertaken by GHD;
- Additional creek cross-section survey;
- Additional water conveying structures survey; and

- Adopting interpolated 'averaged' pit depths where depths were not provided in Council's database.

Subcatchment Delineation and Overland Flow Paths

Subcatchment boundaries were derived using topographic data and aerial photography provided by Council as described in Section 5.2. Overland flow paths were determined using the same medium as well as from site inspections.

Blockage Factors

Blockage factors adopted for the hydrologic model include a 20% blockage for on-grade pits and a 50% blockage for sag pits. These values were in agreement with Council and were incorporated into the design runs for all AEP events.

Percentage Impervious and Pervious Areas

Impervious and pervious percentages were delineated and directly measured according to land use as depicted in the digital aerial images provided by Council. Table 5-1 provides information on the impervious percentages applied in agreement with Council.

Table 5-1 Impervious Percentages

Land Use Classification	Impervious Percentage
Roads	95%
Industrial	80%
Commercial	90%
Residential	60%
Parks and Vegetated Areas	5%

Other Model Parameters

Table 5-2 Model Parameters

Parameter	Application in Model
Soil Type	ILSAX Type 3
Antecedent Moisture Content (AMC)	3
Initial Losses	1 mm for paved areas 5 mm for grassed areas
Pit and Lintel	Standard NSW RTA SA Inlet
Blockage	20% for on-grade pits 50% for sag pits (Recommended by AR&R)
Pipe Roughness	0.013
Pit Losses	Applied using Mills Equation
Rainfall Temporal Patterns	Derived from AR&R and BOM GSDM method IFD curves derived from BOM

5.4 Model Validation and Calibration

As detailed in Section 3.4, historical rainfall data suitable for model validation and calibration was found to be insufficient. Flow gauge data was also unavailable for the creeks. As a result of this, a full calibration of the hydrological model was not possible.

Manual checks were performed in selected areas and the results were used to compare and assess that of the hydrologic model. This was in the form of peak flow calculations using the Rational Method for Urban Catchments as prescribed in AR&R.

6. Hydraulic Modelling

6.1 Overview

Flood conveyance through the Buffalo and Kittys Creek catchments was modelled using the TUFLOW hydraulic model.

TUFLOW is a computer program for simulating depth-averaged, two and one-dimensional free-surface flows such as occurs from floods and tides. TUFLOW was originally developed for modelling twodimensional (2D) flows, and stands for Two-dimensional Unsteady FLOW. However, it incorporates the full functionality of the ESTRY 1D network or quasi-2D modelling system based on the full onedimensional (1D) free-surface St Venant flow equations.The 2D solution algorithm is based on Stelling 1984, and is documented in Syme 1991. It solves the full two-dimensional, depth averaged, momentum and continuity equations for free-surface flow. The scheme includes the viscosity or subgrid- scale turbulence term that other mainstream software omit. The initial development was carried out as a joint research and development project between WBM Oceanics Australia and The University of Queensland in 1990. The project successfully developed a 2D/1D dynamically linked modelling system (Syme 1991). Latter improvements from 1998 to today focus on hydraulic structures, flood modelling, advanced 2D/1D linking and using GIS for data management (Syme 2001a, Syme 2001b). TUFLOW has also been the subject of extensive testing and validation by WBM Pty Ltd and others (Barton 2001, Huxley, 2004).

6.2 Model Configuration

Model Extent

Two separate TUFLOW models were developed to model the Buffalo Creek and Kittys Creek catchments individually. The extent of each model covers the entire catchment boundary for each creek, as outlined in Red in Figure A1 of Appendix A. The downstream extent for each model was extended down to Lane Cove River to incorporate any flooding effects due to backwater from the river.

A linked 1D/2D model was developed to model both the one-dimensional stormwater drainage system and two-dimensional flow patterns. The modelling parameters and attributes are described below, these were applied consistently between both models.

6.2.1 Two Dimensional Inputs

Topographic Layers

ALS data provided by Council was imported into a digital terrain-modelling program (12D) and triangulated to represent the ground surface as a digital elevation model (DEM). A TUFLOW grid was generated using a cell size of 2 m by 2 m, with each point within the grid given an elevation based on its location in the DEM.

Additional topographic adjustments were performed to lower the creek beds of both Buffalo and Kittys creek. This was due to the nature of ALS data not being able to pick up bottom of creek invert levels. The creek beds were manually lowered according to the surveyed creek cross sections and through cross sections interpolation where survey was not conducted.

Additional terrain adjustments were made at Top Ryde Shopping Centre and at 461-495 Victoria Road to fill in the excavation zone that the ALS picked up during construction at those sites.

Terrain surface patches were placed at various locations across the catchments to smooth the elevation points that caused instabilities in TUFLOW.

Hydraulic Roughness

Based on aerial photography and site inspections, industry standard hydraulic roughness coefficients were applied in the 2D domain areas and input to the model. Table 6-1 below lists the Manning's 'n' roughness coefficients adopted.

Table 6-1 Manning's 'n' Values

Material Layer (Surface Type)	Manning's n value
Urban, housing with backyard vegetation.	0.05
Commercial, buildings not detailed separately.	0.06
Short grass, no bush cover.	0.03
Medium to dense shrub cover, forested areas.	0.10
Sealed roads.	0.02
Industrial Areas, highly concreted.	0.02

A sensitivity analysis for the hydraulic roughness was tested and is described in Section 8.5.3 of this report.

Boundary Conditions

An initial and continuing water level condition was applied at the downstream model boundary to simulate flow conditions at Lane Cove River. A constant water level time series was applied at this location for the duration of the modelled events.

As there is no flow gauge data available for Lane Cove River, water levels were extracted based on design surface water levels of the river provided by Council. These figures are understood from Council to have been extracted from the Macquarie Park Flood Study Report (Bewsher, 2010). A sensitivity analysis was conducted for the water levels adopted and is discussed in Section 8.5.4.

6.2.2 One Dimensional Inputs

Stormwater System

The stormwater system was imported directly from Council's MapInfo database and applied as one-dimensional (Estry) layers in TUFLOW. This included the entire pit inlet and pipe network drainage system. The properties applied for the 1D elements in the hydraulic model were industry standard and consistent with the hydrologic model.

Structures

All bridges and culverts within the floodplain were configured in TUFLOW using existing ALS data and additional survey data acquired by the registered surveyors, Garvin and Morgan. These structures were applied in TUFLOW as either 1D (Estry) components or incorporated into the 2D terrain.

Boundary Conditions

Catchment run-off hydrographs determined through the hydrologic model were applied to TUFLOW as flow vs. time inputs. These were applied to the corresponding drainage pits.

6.3 Model Validation and Calibration

As no historically recorded flooding and flow gauge data for the study area is available, a full calibration of the hydraulic model was not possible. Limited validation and calibration of the model was undertaken using the following approach:

- Review of community consultation flood survey results; and
- Construction of a HEC-RAS model to validate TUFLOW creek flood level results.

6.3.1 Community Consultation Flood Survey Results

As described in Section 4, a survey was sent to residents within the study area to provide relative information on flooding, with particular interest to the February 1990 Flood Event.

Most of the information gathered from the survey responses relates to instances of road and yard flooding. Flood depths at various locations affected by the flood were reported. However, it is understood that most of these reported flood depths are of visual interpretation. The locations with a reported flood depth are presented in the table below and were used as a reference to compare flood results predicted by the hydraulic model.

Table 6-2 Reported Locations of Flooding

Catchment	Street Address	Maximum Depth of Flooding in February 1990 Flood (m)
Buffalo Creek	3 Adam Street, Ryde	0.60
	4 Byron Avenue, Ryde	0.25 – 0.50
	16 Crescent Avenue, Ryde	0.25 – 0.50
	7 Ganora Street, Gladesville	0.10
	52 Higginbotham Road, Gladesville	0.10 – 0.20
	40 Lane Cove Road, Ryde	0.20
	6 Laura Street, Gladesville	0.08
	13 Martin Street, Ryde	0.25
	18 Minga Street, Ryde	0.08
	72 Monash Road, Gladesville	0.20 – 0.25
	106 Moncrieff Drive, East Ryde	0.56
	9 Semple Street	0.025
	33 Watt Avenue, Ryde	0.03
	48 Westminster Road, Gladesville	0.30
	51 Westminster Road, Gladesville	0.15
	63A Westminster Road, Gladesville	0.10
Kittys Creek	28 Melba Drive	0.02

6.3.2 Validation against HEC-RAS

As described in Section 6.2.1, the topographic data received from Council did not provide an accurate representation of the creek invert levels. The bottom of creek was manually adjusted in the model terrain to allow for low flow confluence. A more representative one-dimensional HEC-RAS model of the creeks using actual surveyed creek cross-sectional data was built to calibrate against the TUFLOW results.

Figure A6.1 and A6.2 in Appendix A presents the HEC-RAS models built for the two creeks. Surveyed cross-sections were applied in the model, with additional cross-sections interpolated between them to represent a more realistic and defined flow path. Flows were extracted from TUFLOW results and applied directly into HEC-RAS. The water levels at the surveyed cross-sections were then compared to TUFLOW flood levels in the same location.

For simplicity, the 1% AEP 1 hour duration storm event was used to calibrate against the models. Results at selected locations are presented in Table 6-3 below.

Table 6-3 Flow Level Comparison – TUFLOW and HEC-RAS

Catchment	Cross Section Reference	TUFLOW Predicted Flood Levels (mAHD)	HEC-RAS Predicted Flood Levels (mAHD)
Kittys Creek	XS1	40.60	40.60
Kittys Creek	XS2	29.93	29.91
Kittys Creek	XS4	3.90	4.05
Buffalo Creek	XS7	2.70	2.77
Buffalo Creek	XS9	41.98	42.2
Buffalo Creek	XS10	3.57	3.75
Buffalo Creek	XS13	16.87	16.82
Buffalo Creek	XS19	22.2	22.06
Buffalo Creek	XS21	31.70	31.78

The results showed that the predicted flood levels in HEC-RAS at observed locations along the creek matched consistently against the TUFLOW hydraulic model results.

7. Design Flood Conditions

7.1 Overview

A series of design floods were generated based on Australian Rainfall and Runoff (AR&R, 2001) guidelines to cover a range of flooding extents at Buffalo and Kittys Creek. The parameters and conditions used in generating the design floods are outlined in this section.

7.2 Design Rainfall

7.2.1 Design Rainfall Parameters

Design rainfall events were derived in accordance AR&R (2001). The Intensity Frequency Duration parameters adopted for the Buffalo and Kittys creek catchments are listed in Table 7-1.

Table 7-1 Catchment IFD Parameters

Duration	50% AEP	2% AEP
1 Hour Rainfall Intensity (mm/hour)	37.3	72.4
12 Hour Rainfall Intensity (mm/hour)	8.09	17.6
72 Hour Rainfall Intensity (mm/hour)	2.57	5.75
Skewness	0	
F2 Value	4.30	
F50 Value	15.85	
Zone	B	

7.2.2 Rainfall Depths

Design rainfall depths are based on the generation of intensity-frequency-duration (IFD) design rainfall curves utilising the procedures outlined in AR&R (2001). These curves provide rainfall depths for various design magnitudes (up to the 1% AEP) and for durations from 5 minutes to 72 hours.

Table 7-2 shows the average design rainfall intensities base on the adopted parameters outlined in Table 7-1 for the simulated events.

Table 7-2 Average Design Rainfall Intensities (mm/hr)

Duration (hrs)	Annual Exceedance Probability (AEP)			
	20%	5%	2%	1%
0.5	69.0	89.0	104.0	115.0
1	47.8	62.0	72.0	80.0
1.5	37.8	49.3	58.0	64.0
2	31.9	41.8	49.1	55.0
3	25.0	33.0	39.0	43.5
6	16.5	22.0	26.2	29.4

7.2.3 Probable Maximum Flood (PMF)

The Probable Maximum Precipitation (PMP) was compiled using the Bureau of Meteorology Australia Generalised Short Duration Method (GSDM – BOM 2003). The PMP rainfall depths derived for a range of durations using this method are tabulated below.

Durations of up to 6-hours have been considered for the PMP in accordance with the GSDM.

Table 7-3 PMP Rainfall Information

Duration (hrs)	PMP Rainfall Depth (mm)	PMP Rainfall Intensity (mm/hr)
0.5	220	440
1	330	330
1.5	420	280
2	500	250
3	600	200
6	800	133

The PMP rainfall depths were simulated in the hydrologic model to calculate the PMF hydrographs used for the hydraulic model.

7.2.4 Rainfall Losses

Initial rainfall losses were adopted in accordance with the Australian Rainfall and Runoff (AR&R 2001) and the DRAINS manual to simulate rainfall losses in the hydrologic model. These recommended values are listed below

- 1 mm for paved areas; and
- 5 mm for grassed areas.

7.2.5 Rational Method

The Rational Method for urban catchments was used to provide an additional estimate of the flood peak for the 1% AEP event, as identified in Section 5.4.

8. Design Flood Behaviour

8.1 Overview

To determine the design flood behaviour, both the hydrologic and hydraulic models were simulated using the parameters as outlined in Sections 5 and 6 of this report. The simulations were undertaken as follows:

- The hydrologic DRAINS models were simulated using design rainfall and rainfall loss parameters in accordance with AR&R;
- A range of design events were simulated, including the 20%, 5%, 2% and 1% AEP and the PMF for durations from 0.5 hours to 3 hours to capture the peak flows;
- Local catchment hydrographs produced from the hydrologic models were applied as rainfall for the hydraulic TUFLOW model and simulated for the same events; and
- A series of results were generated and is described in this section of the report.

8.2 Peak Flood Conditions

8.2.1 Peak Flows at Selected Locations

Predicted peak flows at selected locations within the Kittys Creek catchment is presented in Table 8-1. These locations are marked in Figure A7 in Appendix A.

Table 8-1 Peak flows at selected locations – Kittys Creek catchment

Location	Modelled Peak Flows (m^3/s)				
	20% AEP	5% AEP	2% AEP	1% AEP	PMF
Coxs Road	0.79	0.94	1.00	1.06	2.98
Long Avenue (Near)	0.79	0.99	1.09	1.19	3.25
Melba Drive (Near)	0.33	0.41	0.45	0.51	1.54
Melba Drive (South)	0.50	0.66	0.73	0.82	2.52
Jeanette Street (Near)	0.91	1.16	2.33	3.47	3.89
Bronhill Avenue	0.92	1.20	1.32	1.45	4.24
Fox Road	2.97	3.95	4.30	5.00	16.84
Badajoz Road	2.86	3.00	3.28	3.74	11.60
Blenheim Road	2.57	3.45	3.76	4.21	13.75
Nash Place	3.70	5.12	5.75	6.54	22.90

Predicted peak flows at selected locations within the Buffalo Creek catchment is presented in Table 8-2 below. These locations are marked in Figure A7 in Appendix A.

Table 8-2 Peak flows at selected locations – Buffalo Creek catchment

Location	Modelled Peak Flows (m^3/s)				
	20% AEP	5% AEP	2% AEP	1% AEP	PMF
Lane Cove Road	7.98	11.08	12.54	14.41	47.72
Smith Street	2.41	3.26	3.57	3.93	13.08
Dobson Crescent	6.31	8.81	11.59	14.73	66.86
Quarry Road	1.21	2.61	3.49	4.45	11.72
Gardener Road	4.44	5.83	6.93	8.72	32.50
Gannan Park	2.93	3.63	4.41	5.04	16.33

Location	Modelled Peak Flows (m^3/s)				
	20% AEP	5% AEP	2% AEP	1% AEP	PMF
Baird Avenue	3.18	4.81	5.43	8.44	22.21
Buffalo Road	0.95	1.55	1.78	3.23	5.29
Higginbotham Road	7.05	9.55	10.85	12.25	40.28
Lyndhurst Street	1.22	1.39	1.71	3.23	3.70
Finch Avenue	0.86	1.20	1.33	4.42	4.61

8.2.2 Peak Flood Levels at Selected Locations

Predicted peak flood levels at the observed locations within the Kittys Creek catchment is shown in Table 8-3 below.

Table 8-3 Peak flood levels at selected locations – Kittys Creek catchment

Location	Modelled Peak Flood Levels (mAHD)				
	20% AEP	5% AEP	2% AEP	1% AEP	PMF
Coxs Road	20.88	20.91	20.96	20.97	20.98
Long Avenue (Near)	33.17	33.23	33.28	33.43	33.97
Melba Drive (Near)	28.34	29.59	30.88	30.91	31.41
Melba Drive (South)	39.83	39.84	39.86	39.88	39.94
Jeanette Street (Near)	11.62	13.20	13.31	13.36	13.44
Bronhill Avenue	10.41	10.44	10.49	10.51	10.61
Fox Road	31.12	31.13	31.19	31.24	31.41
Badajoz Road	53.50	53.52	53.56	53.58	53.62
Blenheim Road	55.81	55.88	55.89	55.90	55.95
Nash Place	47.26	47.31	47.33	47.35	47.51

Predicted peak flood levels at the observed locations within the Buffalo Creek catchment is shown in Table 8-4 below.

Table 8-4 Peak flood levels at selected locations – Buffalo Creek catchment

Location	Modelled Peak Flood Levels (mAHD)				
	20% AEP	5% AEP	2% AEP	1% AEP	PMF
Lane Cove Road	47.04	47.11	47.13	47.15	47.37
Smith Street	44.37	44.39	44.40	44.41	44.56
Dobson Crescent	51.24	51.25	51.33	51.35	51.64
Quarry Road	56.95	57.24	57.28	57.30	57.47
Gardener Road	43.65	43.71	43.75	43.79	44.16
Gannan Park	50.52	50.53	50.54	50.55	50.57
Baird Avenue	29.29	29.34	29.35	29.39	29.64
Buffalo Road	29.28	29.30	29.31	29.32	29.35
Higginbotham Road	22.93	22.96	22.98	22.99	23.14
Lyndhurst Street	26.36	26.37	26.38	26.39	26.40
Finch Avenue	32.31	32.32	32.33	32.35	32.39

8.2.3 Flood Map Results

The results of the design flood simulations have been provided as maps in Appendix C. These are presented as a series of flood maps showing flood depth (in blue), overlain by flood level contours.

Referring to the flood maps, the following is noted:

Buffalo Creek Catchment

- Flooding is generally contained within the creek for the 20%, 5% and 2% AEP flood events. Minor road flooding occurs in the lower reaches of the catchments and in backyards of properties in the most upstream reaches;
- Flooding in the 1% AEP and PMF event is more widespread. Flood waters are expected to inundate a larger area of the catchment with increased backyard and road flooding;
- Flooding in property backyards is observed for all storm events, most visibly in the upstream catchment areas. Flood waters in these backyards ranges in depth from 100 mm to 250 mm. This is expected as these residential backyards naturally form part of the tributary draining into Buffalo Creek. However, it is unclear whether these houses will be flooded as floor survey levels have not yet been surveyed. This will be conducted as part of the next phase.
- Greater flood depths are observed in the lower reaches of Buffalo Creek. As observed in the creek topography, flood waters are attenuated in the lower creek reaches before discharging through the culverts underneath Pittwater Road and into Lane Cove River; and
- In the PMF flood event, flood levels are approximately in excess of 1 m deeper than the 1% AEP in the downstream reaches of the creek. Road flooding and flooding in residential and commercial areas in this vicinity may reach 200 to 300 mm in depth.

Kittys Creek Catchment

- Flooding is generally contained within the creek for the 20%, 5%, 2% and 1% AEP flood events. Minor road flooding occurs along Badajoz road, but flood depths are minor and are within 100 to 150 mm;
- In the downstream reach, flood waters can be expected to inundate Pittwater Road and the areas adjoining this road;
- Flooding in the PMF event is generally more widespread. Flooding is more apparent in various residential zones and on roads; and
- Minor flooding in backyards is observed mainly in the upper reaches of the catchment. This is expected as these residential backyards naturally form part of the tributary draining into Buffalo Creek. However, it is unclear whether these houses will be flooded as floor survey levels have not yet been surveyed. This will be conducted as part of the next phase.

8.3 Design Flood Hydrographs

8.3.1 Critical Storm Duration

A range of storm durations were modelled for the Buffalo and Kittys Creek catchments in order to identify the critical storm duration for design event flooding. Design durations modelled for each AEP event included the 0.5 hour, 1 hour, 1.5 hour, 2 hour, 3 hour, 4.5 hour and 6 hour durations.

Outputs from the hydrologic model simulations indicate that the maximum peak inflows for the Buffalo Creek catchment are generally derived when using storm durations of 1 to 2 hours. Similarly, maximum peak inflows for the Kittys Creek catchment also occur during the same storm durations.

Hydraulic model results based on the hydrographs produced by the hydrologic model indicates that for the 1% AEP event, the 2 hour storm is the critical storm duration and produces the peak flows in the Buffalo Creek Catchment. A peak flow of 88.7 m^3/s occurs at approximately 1 hour into the storm. This hydrograph was simulated just upstream of the creek discharge point located approximately at cross section 10 as shown in Figure A7 in Appendix A.

Similar conditions were also observed at Kittys Creek. The critical storm duration for the 1% AEP was identified as the 2 hour storm duration. This critical storm duration produced a peak flow of 58.1 m^3/s at approximately 45 minutes into the storm. This hydrograph was simulated just upstream of the Kittys Creek discharge point located near cross section 4.

The 1% AEP 2 hour storm duration hydrograph for Buffalo Creek is shown in Figure 8-1 and the same storm event for Kittys Creek is shown in Figure 8-2.

Figure 8-1 Buffalo Creek Peak Storm Duration Hydrograph

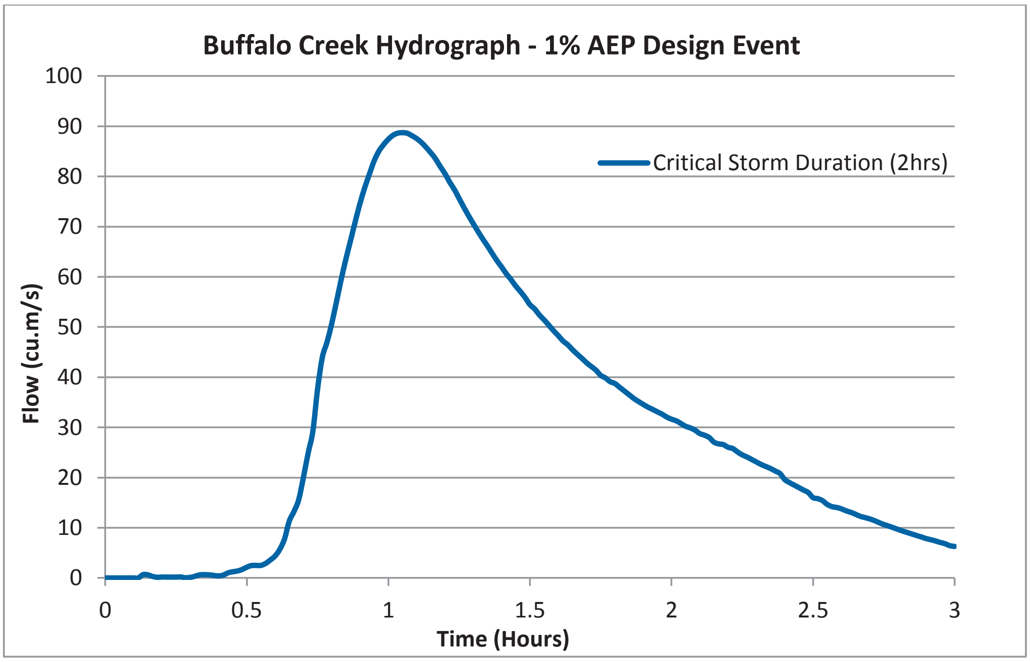
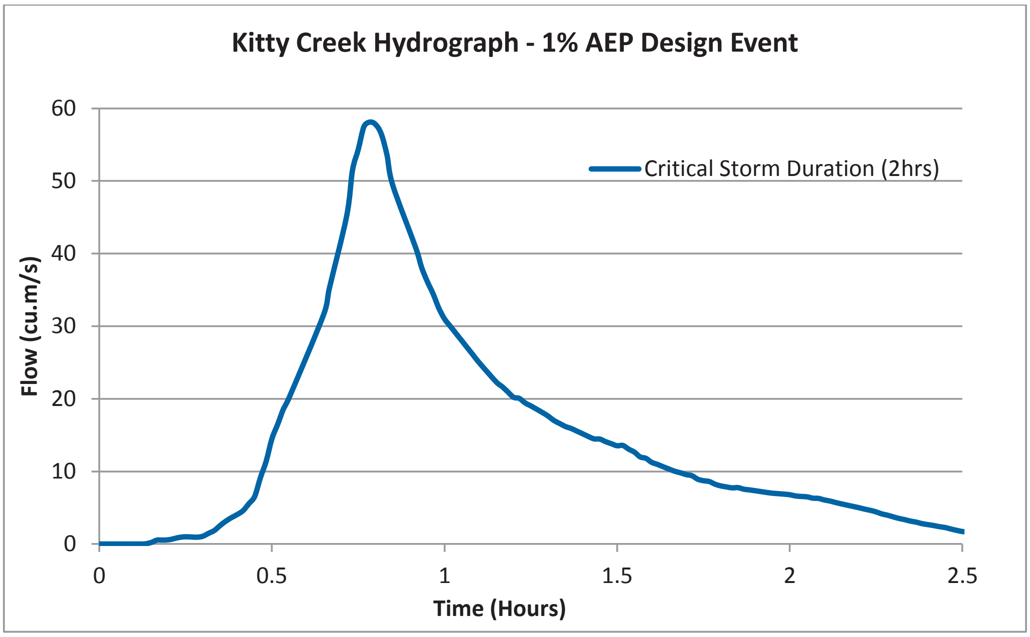


Figure 8-2 Kittys Creek Peak Storm Duration Hydrograph



8.4 Provisional Hazard Classifications

8.4.1 Provisional Hazard Classification Maps

A series of maps showing the provisional flood hazard for Buffalo and Kittys Creek are presented in Appendix D, these maps are prepared in accordance with the NSW Floodplain Development Manual (2005).

These maps were determined using the maximum velocity and maximum depth derived from the peak 1% AEP and PMF events. See Figure 8-3 for the hazard classification graphic as presented in the NSW Government Floodplain Development Manual.

For the purposes of this report, the hazard areas are defined as follows:

- **High Hazard** – 1% AEP where velocity-depth product is greater than 1;
- **Medium Hazard** – Areas where the 1% AEP velocity-depth product is less than 1; and
- **Low Hazard** – Remaining areas within the PMF extent not classified as either high or medium.

As a general guide, the NSW Government's Floodplain Development Manual defines the following Hazard categories as exhibiting the following characteristics:

- **High Hazard** - possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings; and
- **Low Hazard** - should it be necessary, truck could evacuate people and their possessions; able-bodied adults would have little difficulty in wading to safety.

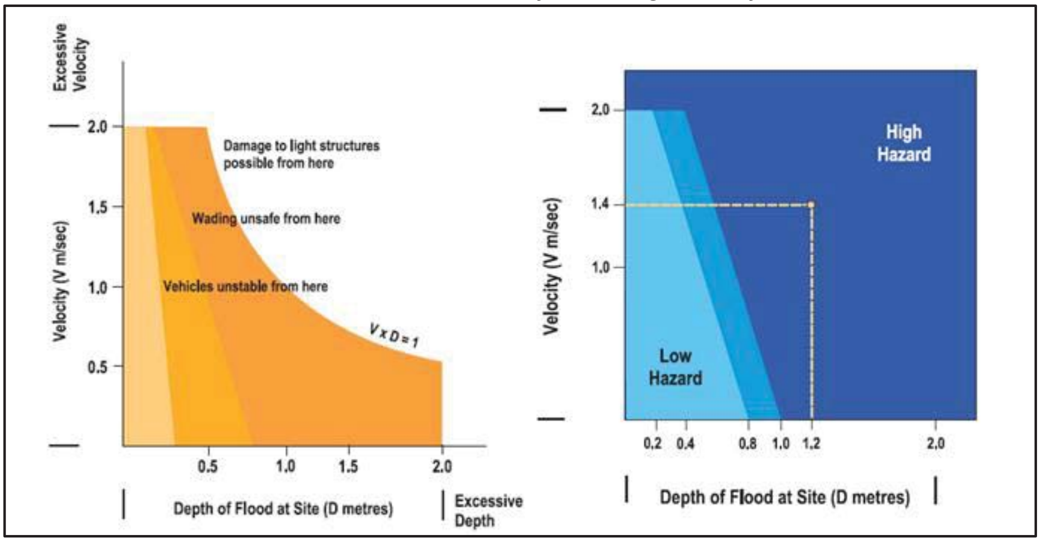


Figure 8-3 Floodplain Hazard Classification

Referring to the hazard maps, the following is noted:

- The majority of Buffalo Creek and Kittys Creek are designated as being high hazard. This is due to the excessive flow depths caused by the steep and relatively narrow creek banks; and
- High hazard is also designated to sections of Badajoz Road in the Kittys Creek catchment. In addition, the low lying depression zones on Princess Street and Pittwater Road within Buffalo Creek catchment are also classified as high hazard. This would mean that these roads may become isolated by high hazard flood waters during the 1% AEP and PMF events.

8.5 Sensitivity Analyses

8.5.1 Overview

A number of sensitivity analyses were undertaken to determine the impacts of parameters and assumptions on flood behaviour. This was achieved by adjusting the key model parameters and re-simulating both the hydrologic and hydraulic models. As the 1% AEP is an important benchmark for flood planning in NSW, this event formed the basis for all the sensitivity assessments.

The results are presented in the form of changes in flood depths compared with the 1% AEP event in Appendix E. The items and assumptions assessed in the sensitivity analysis include:

- Sensitivity of Manning's 'n' roughness;
- Sensitivity to downstream boundary conditions and initial water levels; and
- Future Climate Change impacts on increased rainfall and sea level rise.

8.5.2 Sensitivity to Culvert Blockage

Sensitivity to culvert blockages in the hydraulic models was not assessed in this study. This is because there are only two main culverts in the Buffalo Creek Catchment (underneath Buffalo Road and Lane Cove River) and these are quite substantial in size, both being larger than 2 m in width. It is noted however, that potential blockage of the pit and pipe network has already been incorporated as outlined in Section 5 and Section 6.

8.5.3 Sensitivity to Manning's 'n' Roughness

To assess the impacts of roughness assumptions, the hydraulic models were re-simulated using the amended roughness assumptions tabulated below. As the original values used for the design runs were industry standard, for conservative purposes the roughness values for the highly vegetated forested areas was increased to the upper limit of 0.15 from 0.10. In addition, as houses were not individually modelled, and to account for flooding caused by residential fences, a more conservative roughness value of 0.1 (from 0.05) was trialled for urban residential areas.

Table 8-5 Sensitivity Analysis – Adjusted Roughness Values

Material Layer (Surface Type)	Original Manning's 'n' values	Adjusted Manning's 'n' values
Urban, housing with backyard vegetation.	0.05	0.10
Commercial, buildings not detailed separately.	0.05	0.06
Short grass, no bush cover.	0.03	0.03
Medium to dense shrub cover, forested areas.	0.10	0.15
Sealed roads.	0.02	0.02
Industrial Areas, highly concreted.	0.02	0.02

The change in peak flood levels as a result of more conservative Manning's 'n' Roughness values are shown as afflux maps in Appendix E, Figures E1.1 and E1.2.

These generally represent between a 100 mm to 300 mm increase in flood levels along the creeks itself. Flood level changes along residential and road areas were found to be minimal, with changes of less than 100 mm.

8.5.4 Sensitivity to Downstream Boundary Conditions

The downstream boundary conditions for both Buffalo and Kittys Creek are governed by design surface water levels of Lane Cove River. Sensitivity testing for different water levels at the downstream boundary has been re-simulated in the hydraulic models. These include an increase of 0.4 m and 0.9 m to the existing 1% AEP design water levels. More detail is described in Section 8.5.5 of this report.

8.5.5 Sensitivity to Climate Change

Increase in Rainfall

Future climate impacts on rainfall have been assessed generally in accordance with the following guidelines:

- Floodplain Risk Management Guideline, Practical Consideration of Climate Change (NSW DECC 2007); and the
- Flood Risk Management Guide, Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments (DECCW, 2010).

For this assessment the hydrological DRAINS model was updated to represent future climate change rainfall increases suggested in the guidelines. A conservative approach of simulating the maximum suggested 30% increase in rainfall was adopted. The hydrographs produced from the hydrologic model was re-simulated in the hydraulic model. The change in peak flows are presented as afflux maps in Appendix E, Figures E2.1 and E2.2.

Referring to the afflux maps, the following is noted:

- Increase in flood levels generally occurred along the main creeks. Flood level increases in residential, commercial and road areas were minimal with the majority of the flooding increasing by less than 100 mm;
- Increases of flood levels of between 100 mm to 300 mm along the upper reaches of Buffalo Creek were observed. This occurred along the tributary areas adjoining the creek itself;
- Increases of flooding between 300 mm to in excess of 500 mm were observed along Buffalo Creek. However, flooding extents do not extend beyond the immediate creek floodplain, posing minimal affects to roads and residential areas; and
- Increases of flooding between 100 mm to 500 mm were generally observed along Kittys Creek.

Impacts of Sea Level Rise

In accordance with the sea level rise planning benchmarks provided by the DECCW 2009 NSW Sea Level Rise Policy Statement, the impacts of sea level rise for the 1% AEP event was assessed for this Study.

The benchmarks provided in this policy statement projected that the sea level will rise by 0.4 m by 2050 and 0.9 m by 2100. These levels were adopted in the hydraulic models and are presented in the table below.

Table 8-6 Sea Level Rise for 2050 and 2100

Catchment	Year	Existing Design Sea Level (mAHD)	Projected Increase in Sea Level (m)	Modelled Sea Level (mAHD)
Buffalo	2050	1.97	+0.40	2.37
Buffalo	2100	1.97	+0.90	2.87
Kittys	2050	2.40	+0.40	2.80
Kittys	2100	2.40	+0.90	3.30

The results from this analysis are presented as change in peak flow afflux maps in Appendix E, Figures E3.1, E3.2, E4.1 and E4.2.

Referring to the maps, the following is noted:

- An increase of 0.4 m in sea level rise for the year 2050 poses minimal flooding effects in the floodplain for either catchment; and
- Similarly, an increase of 0.9 m in sea level rise for the year 2100 poses minimal flooding effects in the floodplain for either catchment. However, it is observed that flood levels in the most downstream area of Buffalo Creek increased by up to 300 mm.

8.6 Low Flow Assessment

In order to facilitate estimates of the capacities of the drainage network at various locations within the system, low flow runs were also undertaken for both Buffalo Creek and Kittys Creek for the 50% AEP event, for the full range of rainfall durations,

The results are presented in Appendix F. This includes envelope hydraulic grade line plots for selected sections of the network, as well as summary tables for all the pits within the network. For comparison, the results for the 20% AEP event are also presented.

Overall, the low flow results indicate that the existing capacity of the entire underground pit and pipe drainage system is generally low, with most areas having capacities of less than either the 50% or 20% AEP events.

9. Summary and Conclusions

The objective of this Flood Study is to assist City of Ryde Council and its Floodplain Risk Management Committee in undertaking a detailed flooding assessment for the Buffalo and Kittys Creek catchments and its floodplains.

The outcomes from this flood study and the hydrologic and hydraulic models will form the basis for all future floodplain management activities. In particular, this flood investigation will be used directly to form the Buffalo and Kittys Creek floodplain management plan and study (FRMS&P).

The key tasks performed for this Flood Study include:

- The collection and review of existing data and the acquisition of additional data crucial to the study, including data required for the production of the hydrologic and hydraulic models;
- Involving the community by undertaking a community consultation and engagement program to identify local concerns, collect information on historical flood data and involving the community in the on-going floodplain management process;
- Establishment of appropriate hydrologic and hydraulic models and applying suitable validation and calibration methods;
- Determination of design flood conditions for the 1%, 5%, 20% and 50% AEP events and the Probable Maximum Flood (PMF) and assessing the output results;
- Conducting model sensitivity checks for various scenarios; and
- Assessing the impacts of climate change based on the latest guidelines.

The key study outputs include a full set of design flood maps incorporating peak flood depths and flood levels for the full range of design storm events. A set of provisional hazard categorisation flood maps were also produces based on the guidelines as outlined in the Floodplain Development Manual.

Below is a summary of the key findings of this Flood Study:

- Flooding in the Buffalo Creek catchment is generally contained within the creek itself, for the 20%, 5% and 2% AEP flood events. Flooding in the 1% AEP and PMF event is more widespread. Flood waters are expected to inundate larger areas of the catchment including increased backyard and road flooding for these extreme storm events;
- Greater flood depths are observed in the lower reaches of Buffalo Creek. As observed in the creek topography, flood waters are attenuated in the lower creek reaches before discharging through the culverts underneath Pittwater Road into Lane Cove River;
- In the PMF flood event, flood levels in Buffalo Creek are in excess of 1 m deeper than the 1% AEP in the downstream reaches along the creek. Road flooding, and flooding in residential and commercial areas may reach 200 to 300 mm in depth;
- Flooding in the Kittys Creek catchment is generally contained within the creek itself for the 20%, 5%, 2% and 1% AEP flood events. Minor road flooding occurs along Badajoz road;
- In the downstream reach, flood waters can be expected to inundate Pittwater Road and the areas surrounding this road;
- Flooding in the Kittys Creek catchment in the PMF event is generally more widespread. However, flood depths in the residential areas and on roads are generally minor;

- Minor flooding in backyards is observed mainly in the upper reaches of the catchment. This is expected as the residential backyards in these areas form part of the tributaries draining into Kittys Creek. Housing along this tributary is typically built on a higher elevation than the backyard; and

In addition, a full set of peak afflux maps were produced to assess the sensitivity of the results to various model parameters and climate change scenarios based on the 1% AEP 2 hour duration storm.

The key findings from this sensitivity analysis are listed below:

- A change in hydraulic Manning's 'n' roughness had minimal impacts to flooding in both catchments. Flood level changes along residential and road areas were found to be of less than 100 mm;
- The models were found to have minimal sensitivity against different boundary conditions. A change in initial and continual water levels had minimal impacts on flooding along the catchments; and
- The impacts of flooding caused by climate change are generally low for both the modelled sea level rise scenarios. Adversely, the impacts due to a 30% increase in rainfall are observed to be more significant in both catchments.

Additional low flow runs were undertaken to assess the capacities of the underground pits and pipes at various locations within the drainage system. The results indicated that the capacities are generally low, with much of the entire system having capacities of less than either the 50% or 20% AEP events.

10. Glossary

Annual Exceedance Probability (AEP) - AEP (measured as a percentage) is a term used to describe flood size. AEP is the long-term probability between floods of a certain magnitude. For example, a 1% AEP flood is a flood that occurs on average once every 100 years. It is also referred to as the '100 year flood' or 1 in 100 year flood'. The terms 100-year flood, 50-year flood, 20-year flood etc, have been used in this study. See also average recurrence interval (ARI):

- 1e-4% (approx) AEP sometimes referred to as the PMF Event;
- 0.2% AEP sometimes referred to as the 1 in 500 year ARI Event;
- 1% AEP sometimes referred to as the 1 in 100 year ARI Event;
- 2% AEP sometimes referred to as the 1 in 50 year ARI Event;
- 5% AEP sometimes referred to as the 1 in 20 year ARI Event;
- 10% AEP sometimes referred to as the 1 in 10 year ARI Event; and
- 20% AEP sometimes referred to as the 1 in 5 year ARI Event

Average recurrence interval (ARI) - ARI (measured in years) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 100-year ARI flood is a flood that occurs or is exceeded on average once every 100 years. The terms 100-year flood, 50-year flood, 20-year flood etc., have been used in this study. See also annual exceedance probability (AEP).

Development Control Plan (DCP) - A DCP is a plan prepared in accordance with Section 72 of the Environmental Planning and Assessment Act, 1979 that provides detailed guidelines for the assessment of development applications.

Design flood level - A flood with a nominated probability or average recurrence interval, for example the 1% AEP flood is commonly use throughout NSW.

DRAINS – The software programs used to develop a computer model that analyses the hydrology (rainfall-runoff processes) of the catchment and calculates hydrographs and peak discharges. Known as a hydrological model.

OEH (formerly DECCW, DECC, DNR, DLWC, DIPNR) - Office of Environment and Heritage. Covers a range of conservation and natural resources science and programs, including native vegetation, biodiversity and environmental water recovery to provide an integrated approach to natural resource management. The NSW State Government Office provides funding and support for flood studies.

Discharge - The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving.

EP&A Act - Act Environmental Planning and Assessment Act, 1979

Extreme flood - An estimate of the probable maximum flood (PMF), which is the largest flood likely to occur.

Flood - A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

Flood awareness - An appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response and evacuation procedures.

Flood hazard - The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.

Flood level - The height of the flood described either as a depth of water above a particular location (e.g. 1m above a floor, yard or road) or as a depth of water related to a standard level such as Australian

Height Datum (e.g. the flood level was 7.8m AHD). Terms also used include flood stage and water level.

Flood liable land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood prone land. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level, as indicated in the superseded Floodplain Development Manual (NSW Government, 2005).

Flood Planning Levels (FPLs) - The combination of flood levels and freeboards selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.

Flood Prone Land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood liable land.

Flood Study - A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.

Floodplain - The area of land that is subject to inundation by floods up to and including the Probable Maximum Flood event, that is, flood prone land or flood liable land.

Floodplain Risk Management Study – Studies carried out in accordance with the Floodplain Development Manual and assess options for minimising the danger to life and property during floods.

Floodplain Risk Management Plan - The outcome of a Floodplain Management Risk Study.

Floodway - Those areas of the floodplain where a significant discharge of water occurs during floods. Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.

High Flood Hazard - For a particular size flood, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.

Hydraulics Term - given to the study of water flow in waterways, in particular, the evaluation of flow parameters such as water level and velocity.

Hydrology Term - given to the study of the rainfall and runoff process; in particular, the evaluation of peak discharges, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).

LGA - Local Government Area, or Council boundary.

Local catchments - Local catchments are river sub-catchments that feed river tributaries, creeks, and watercourses and channelised or piped drainage systems.

Local Environmental Plan (LEP) – A Local Environmental Plan is a plan prepared in accordance with the Environmental Planning and Assessment Act, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.

Local overland flooding - Local overland flooding is inundation by local runoff within the local catchment.

Local runoff - local runoff from the local catchment is categorised as either major drainage or local drainage in the NSW Floodplain Development Manual, 2005.

Low flood hazard - For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.

Flows or discharges - It is the rate of flow of water measured in terms of volume per unit time.

Overland flow path - The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as ‘overland flows’, may or may not re-enter the main channel from which they left — they may be diverted to another watercourse.

Peak discharge - The maximum flow or discharge during a flood.

Present value - In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today’s value.

Probable Maximum Flood (PMF) - The largest flood likely to ever occur. The PMF defines the extent of flood prone land or flood liable land, that is, the floodplain.

Reliable access - During a flood, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within effective warning time, having regard to the depth and velocity of floodwaters, the suitability of the evacuation route, and other relevant factors.

Risk - Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

Runoff - the amount of rainfall that ends up as flow in a stream, also known as rainfall excess.

SES - State Emergency Service of New South Wales

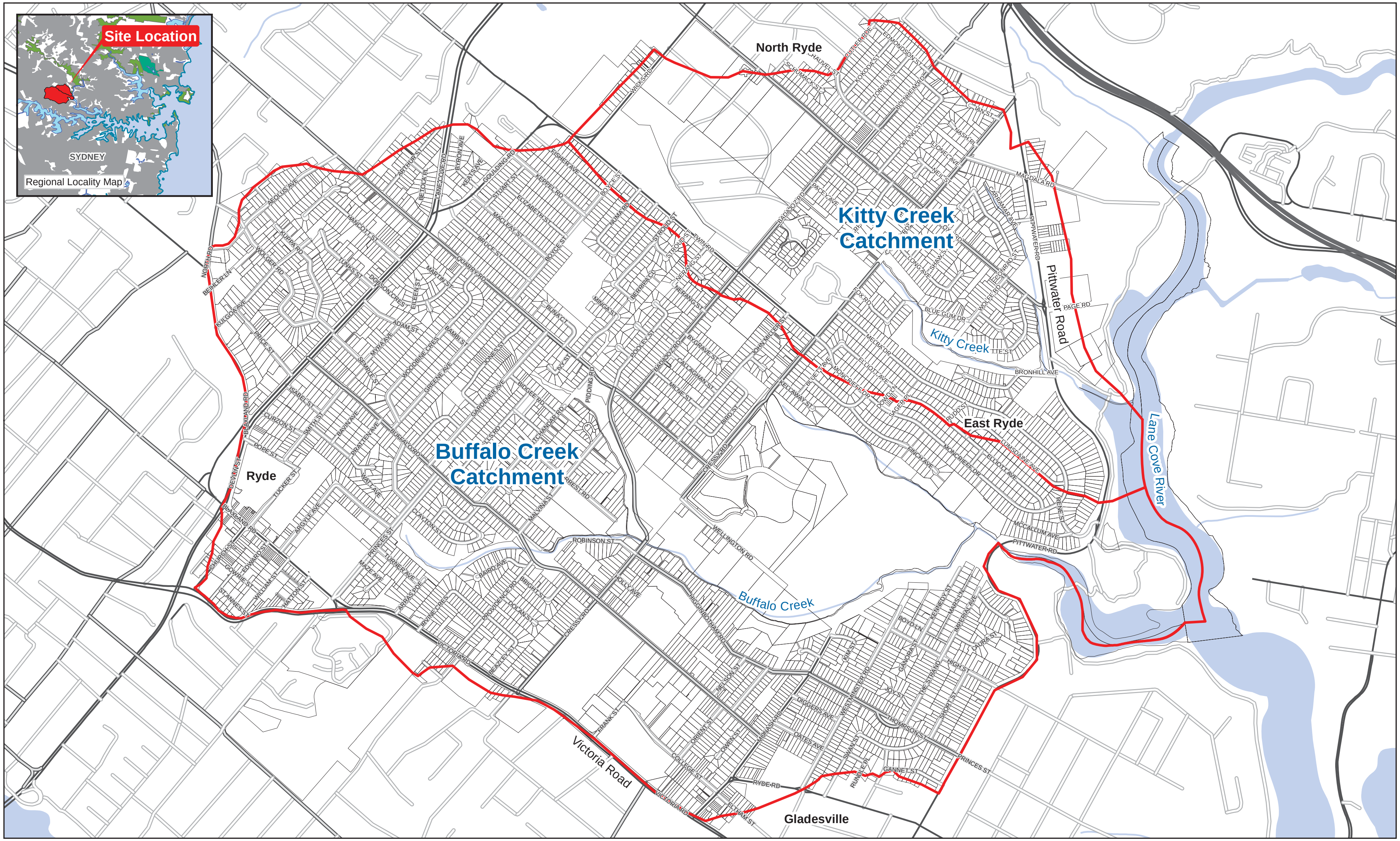
11. References

- AR&R 2001, Australian Rainfall and Runoff, 2001;
- BMT WBM 2010, TUFLOW User Manual;
- BOM 2003, Bureau of Meteorology Australia Generalised Tropical Storm Method – Revised Version, November 2003;
- NSW DECC 2005, NSW Government, Floodplain Development Manual, Management of Flood Liable Land 2005;
- NSW DECC 2007, Practical Consideration of Climate Change, NSW Department of Environment & Climate Change;
- NSW DECCM 2010, Flood Risk Management Guide, Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments
- OEH 2007, Department of Environment and Climate Change, Flood Risk Management Guideline,
- Watercom Pty Ltd. (2004) DRAINS User Manual

Appendices

Appendix A – Catchment and Supporting Information

A1	Locality Plan	
A2.1	Buffalo Creek	Catchment Topography
A2.2	Kittys Creek	Catchment Topography
A3.1	Buffalo Creek	Catchment Drainage Network
A3.2	Kittys Creek	Catchment Drainage Network
A4.1	Buffalo Creek	Subcatchment Plan
A4.2	Kittys Creek	Subcatchment Plan
A5	Surveyed Cross Section Locations	
A6.1	Buffalo Creek	HEC-RAS Model
A6.2	Buffalo Creek	HEC-RAS Model
A7	Observed Flood Locations	



1:13,000 (at A3)

0 65 130 260 390 520

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend

Catchment Boundary

Lot Cadastral

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Locality Plan

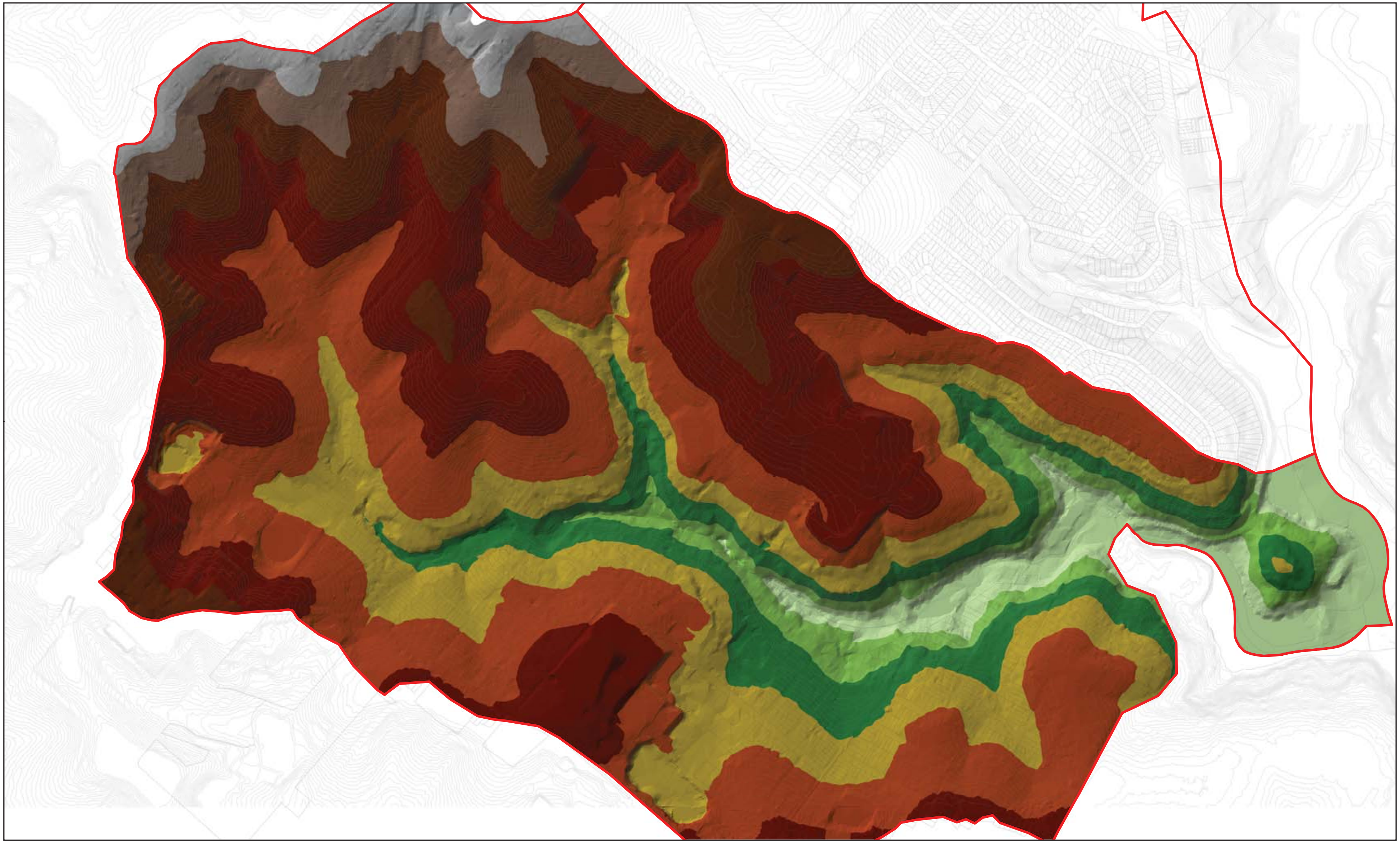
Job Number 21-21394
Revision A
Date 06 Nov 2014

Figure A1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\A1 Locality Plan.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam



1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Elevation (mAHD)

80 - 90, 70 - 80, 60 - 70, 50 - 60, 40 - 50, 30 - 40, 20 - 30, 10 - 20, 0 - 10

Catchment Boundary

Lot Cadastral

1m Contours

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment Topography

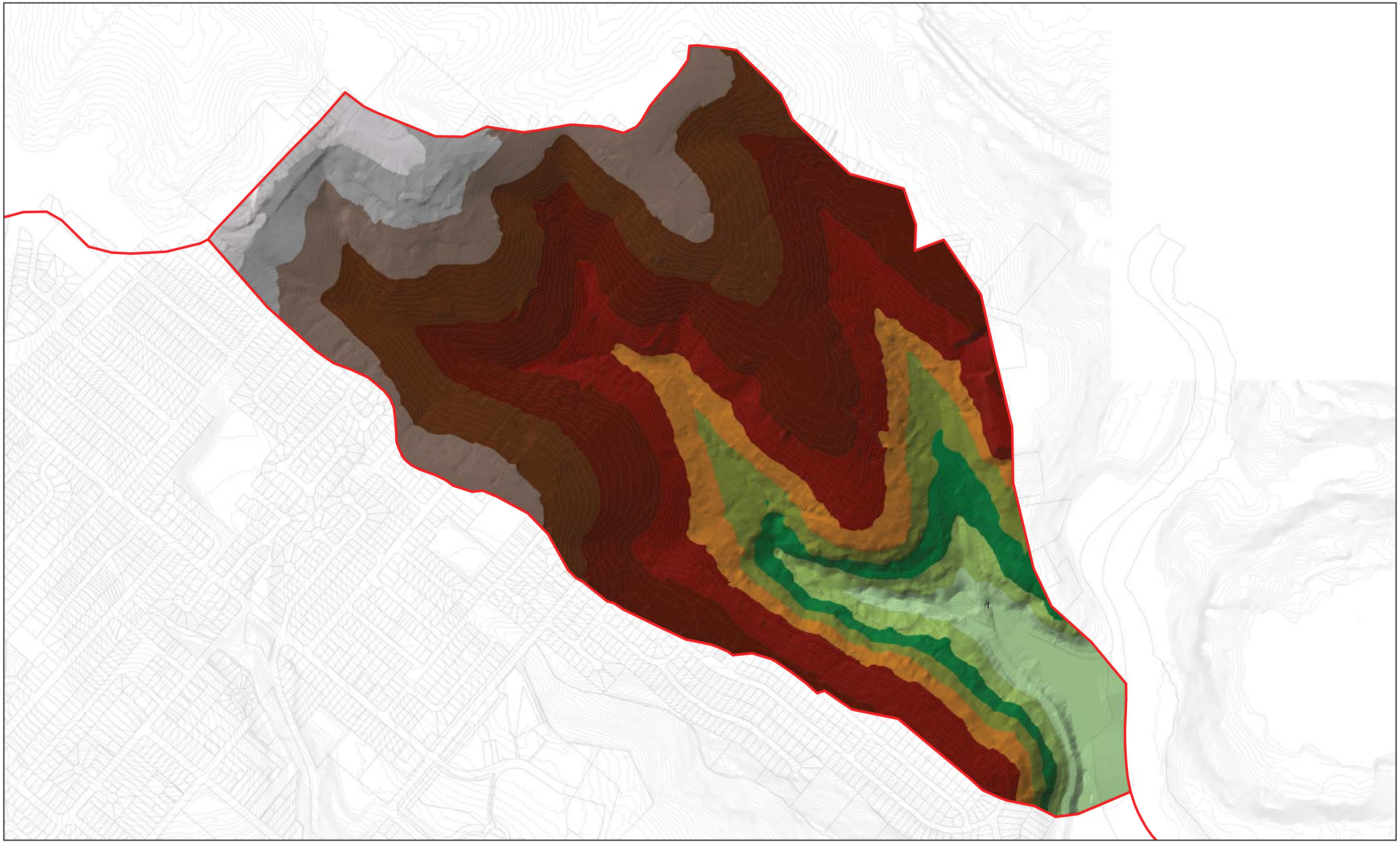
Job Number	21-21394
Revision	A
Date	06 Nov 2014

Figure A2.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\A2.1 TIN Buff.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au



1:8,000 (at A3)

0 40 80 160 240 320

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Elevation

80 - 88, 72 - 80, 64 - 72, 56 - 64, 48 - 56, 40 - 48, 32 - 40, 24 - 32, 16 - 24, 8 - 16, 0 - 8

Catchment Boundary

Lot Cadastral

1m Contours

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Kitty Creek Catchment
Topography

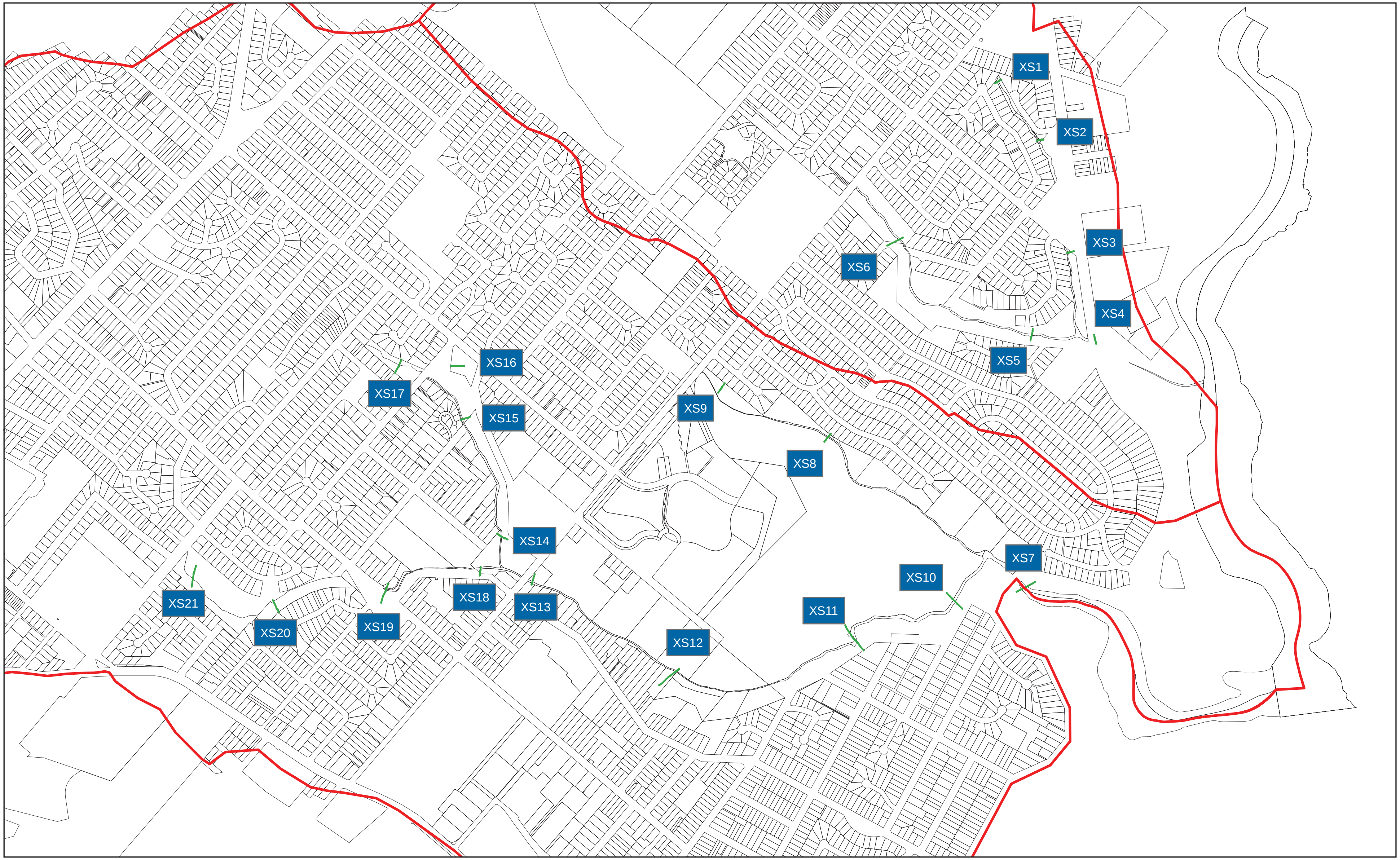
Job Number	21-21394
Revision	A
Date	06 Nov 2014

Figure A2.2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\A2.2 TIN Kitty.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au



Paper Size A3

0 45 90 180 270 360

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Legend

Catchment_region

Lot Cadastral

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Surveyed Cross Section Locations

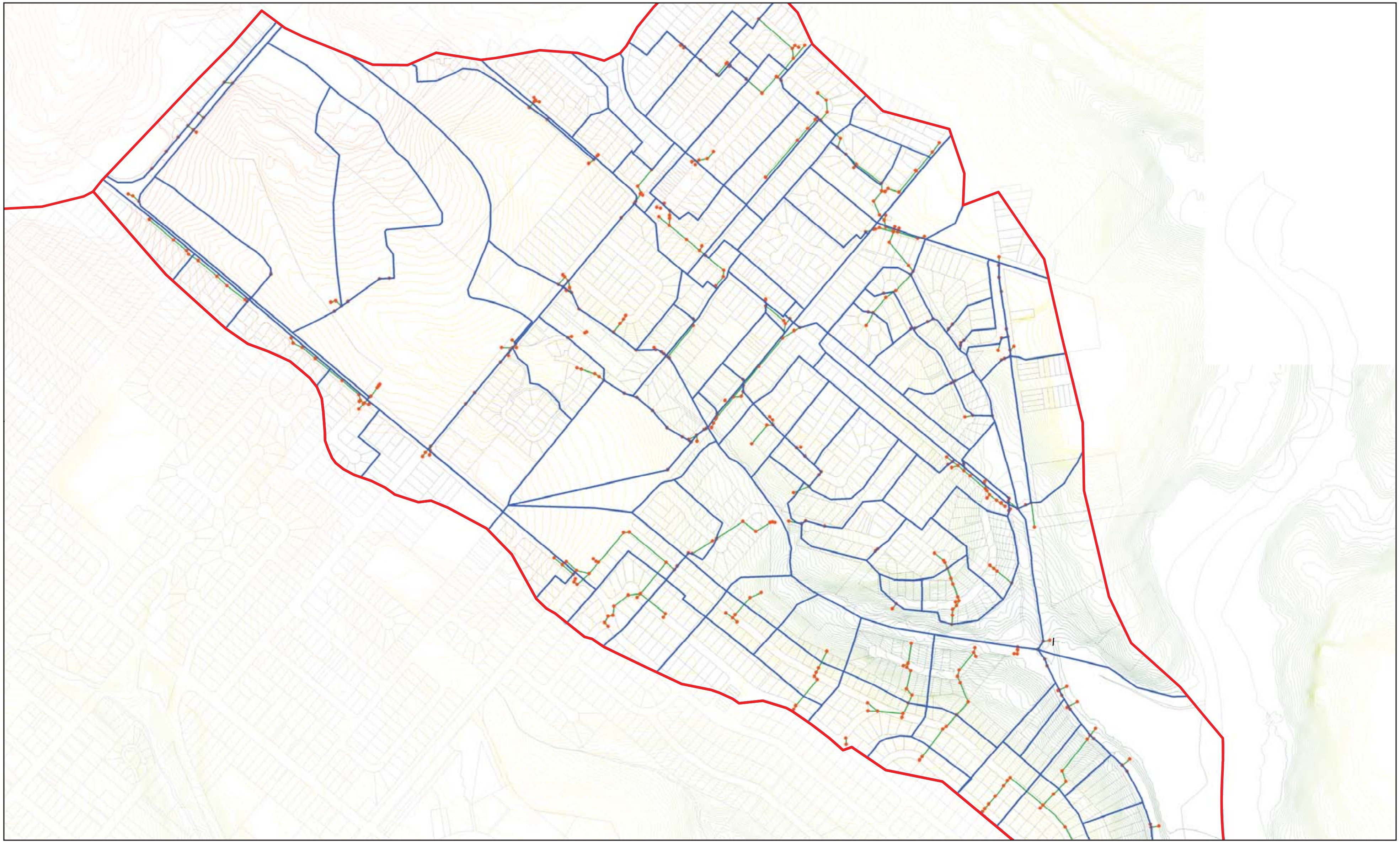
Job Number	21-21394
Revision	A
Date	06 Nov 2014

Figure A5

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\A5 XS Locations.mxd

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:jlam



1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Catchment Boundary
- Kitty Stormwater Pits/Junctions
- Kitty Creek Stormwater Pipes
- Lot Cadastral
- Subcatchments

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Kitty Creek Catchment Subcatchment Plan

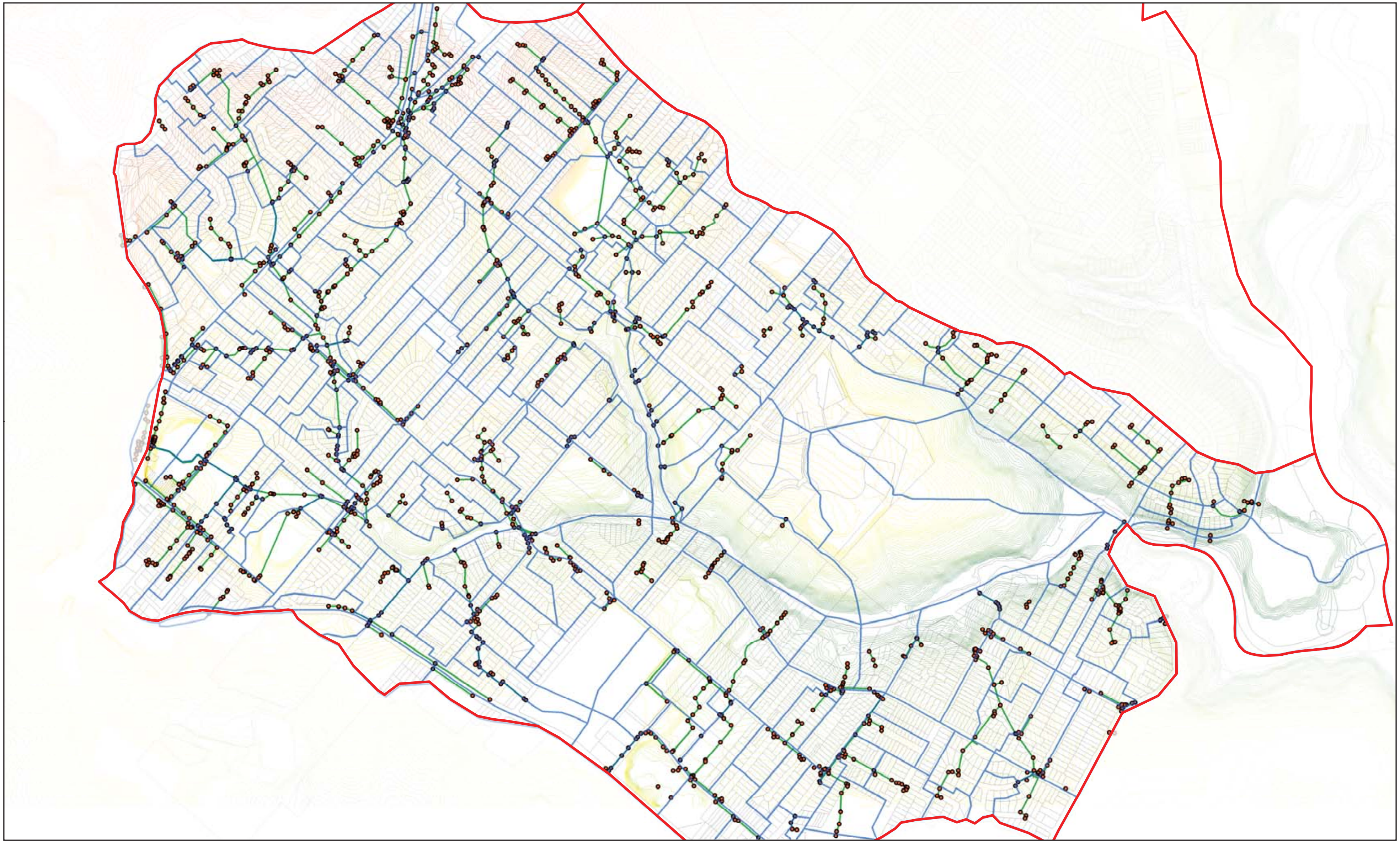
Job Number	21-21394
Revision	A
Date	06 Nov 2014

Figure A4.2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\Kitty_Catchment_Delineation.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au



1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Catchment Boundary
- Subcatchments
- Lot Cadastral
- Buffalo Catchment Stormwater Pits/Junctions
- Buffalo Catchment Stormwater Pipes

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment Subcatchment Plan

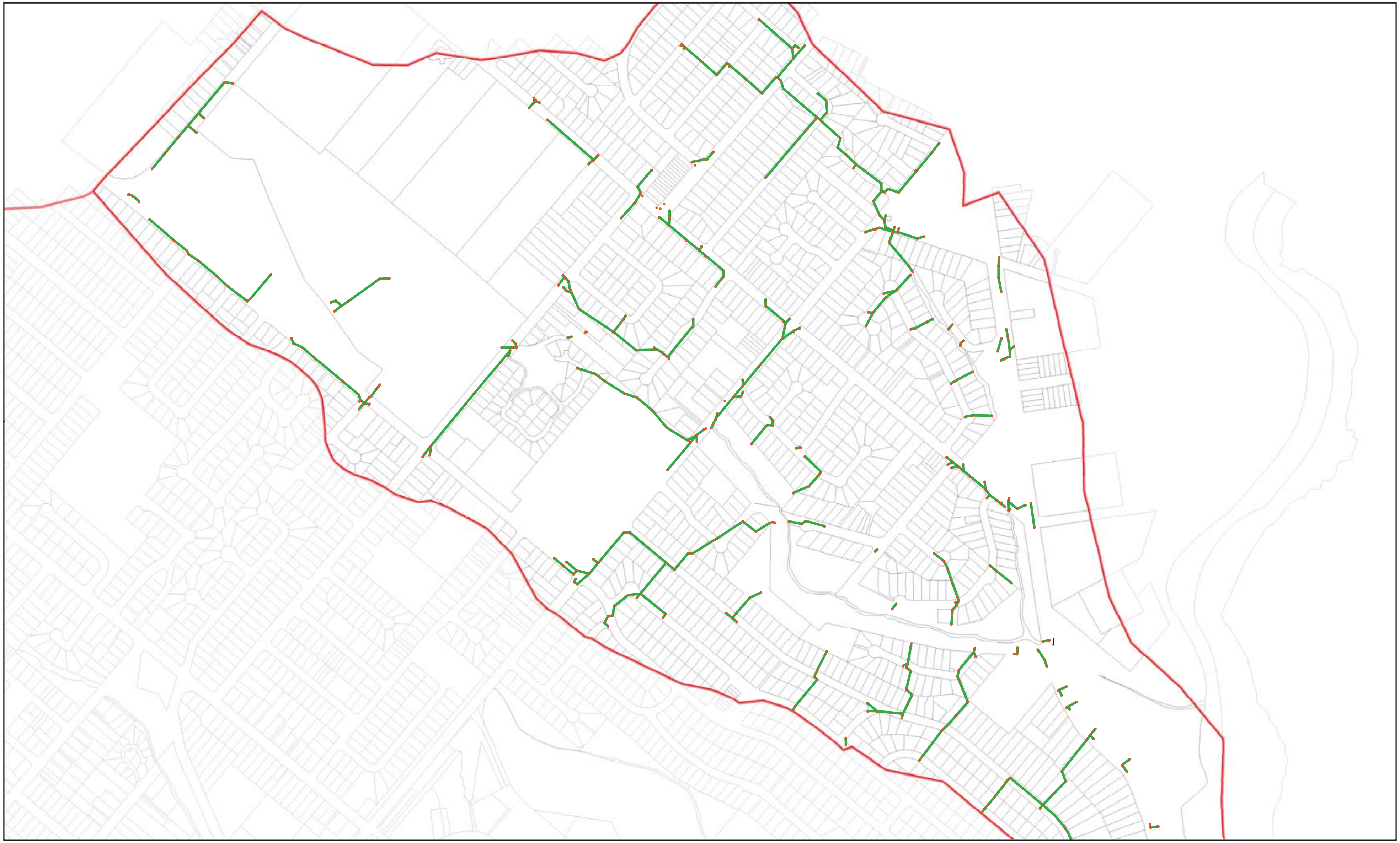
Job Number	21-21394
Revision	A
Date	06 Nov 2014

Figure A4.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\A4.1 Subcatchment Buff.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au



1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Kitty Stormwater Pits/Junctions
- Kitty Creek Stormwater Pipes
- Catchment Boundary
- Lot Cadastral

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Kitty Creek Catchment
Drainage Network

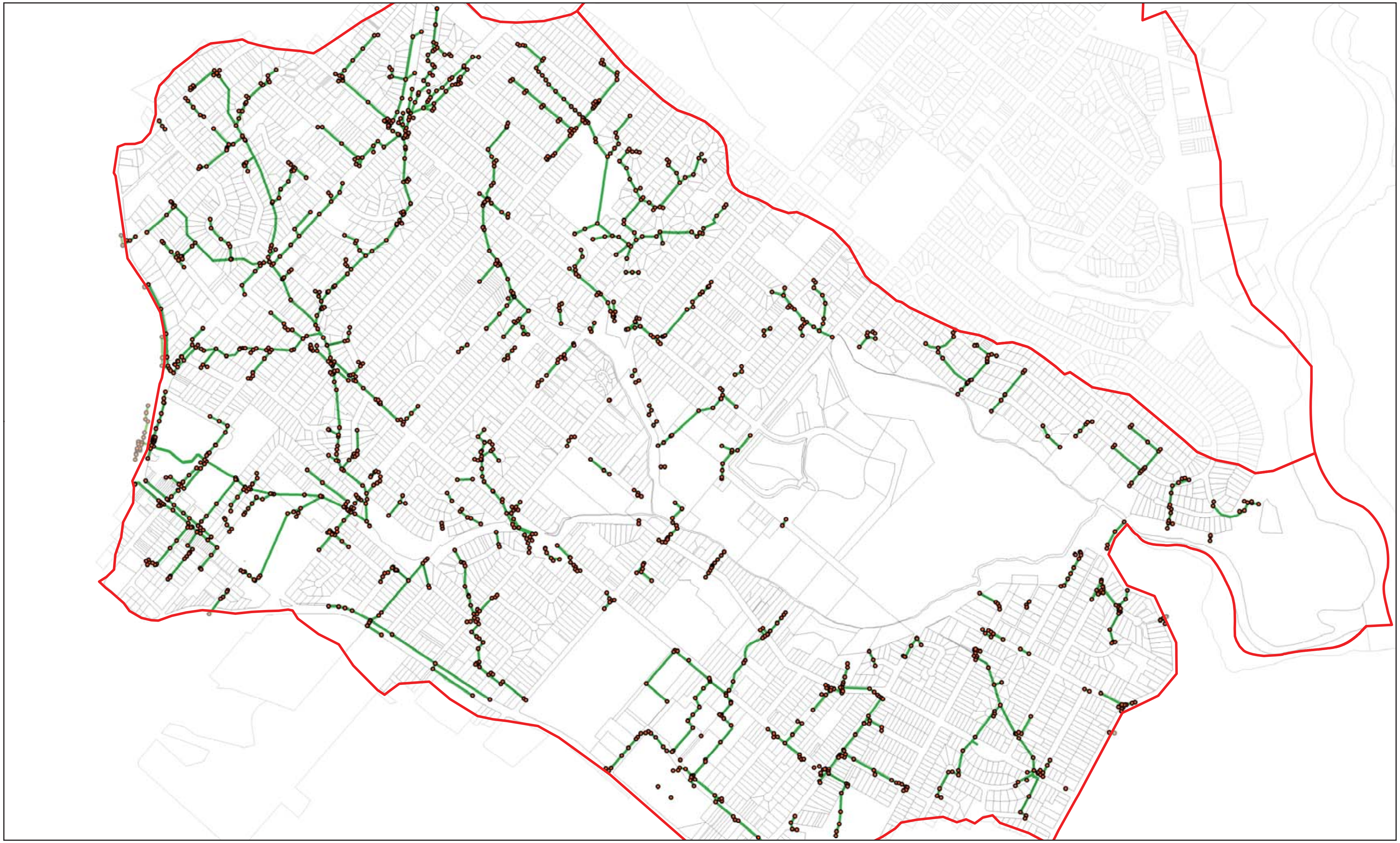
Job Number	21-21394
Revision	A
Date	06 Nov 2014

Figure A3.2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\A3.2 Pipe Network Kitty.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au



1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Catchment Boundary
- Lot Cadastral
- Buffalo Catchment Stormwater Pits/Junctions
- Buffalo Catchment Stormwater Pipes

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment Drainage Network

Job Number	21-21394
Revision	A
Date	06 Nov 2014

Figure A3.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\A3.1 Pipe Network Buff.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Figure 6.1 Buffalo Creek HEC-RAS Model

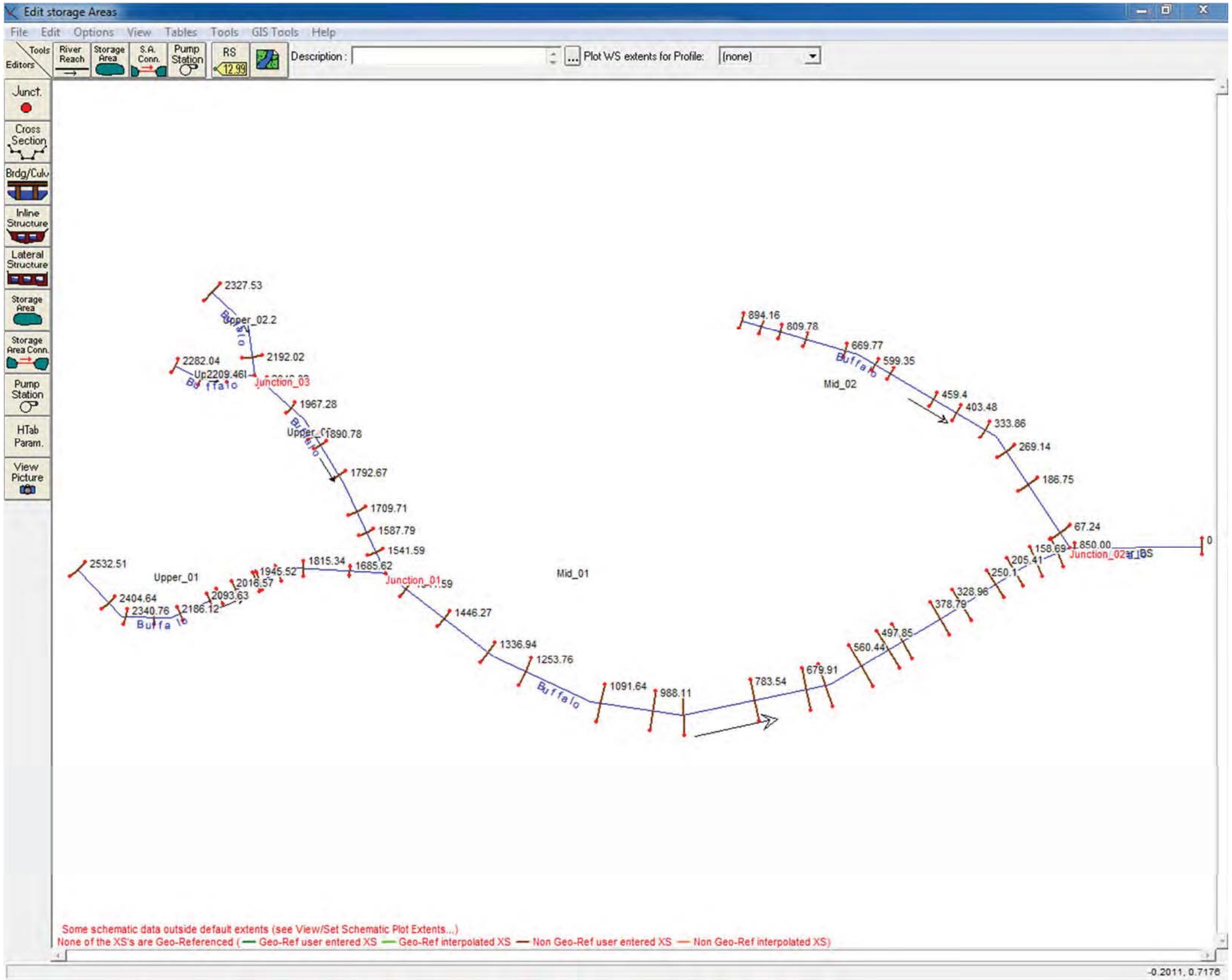
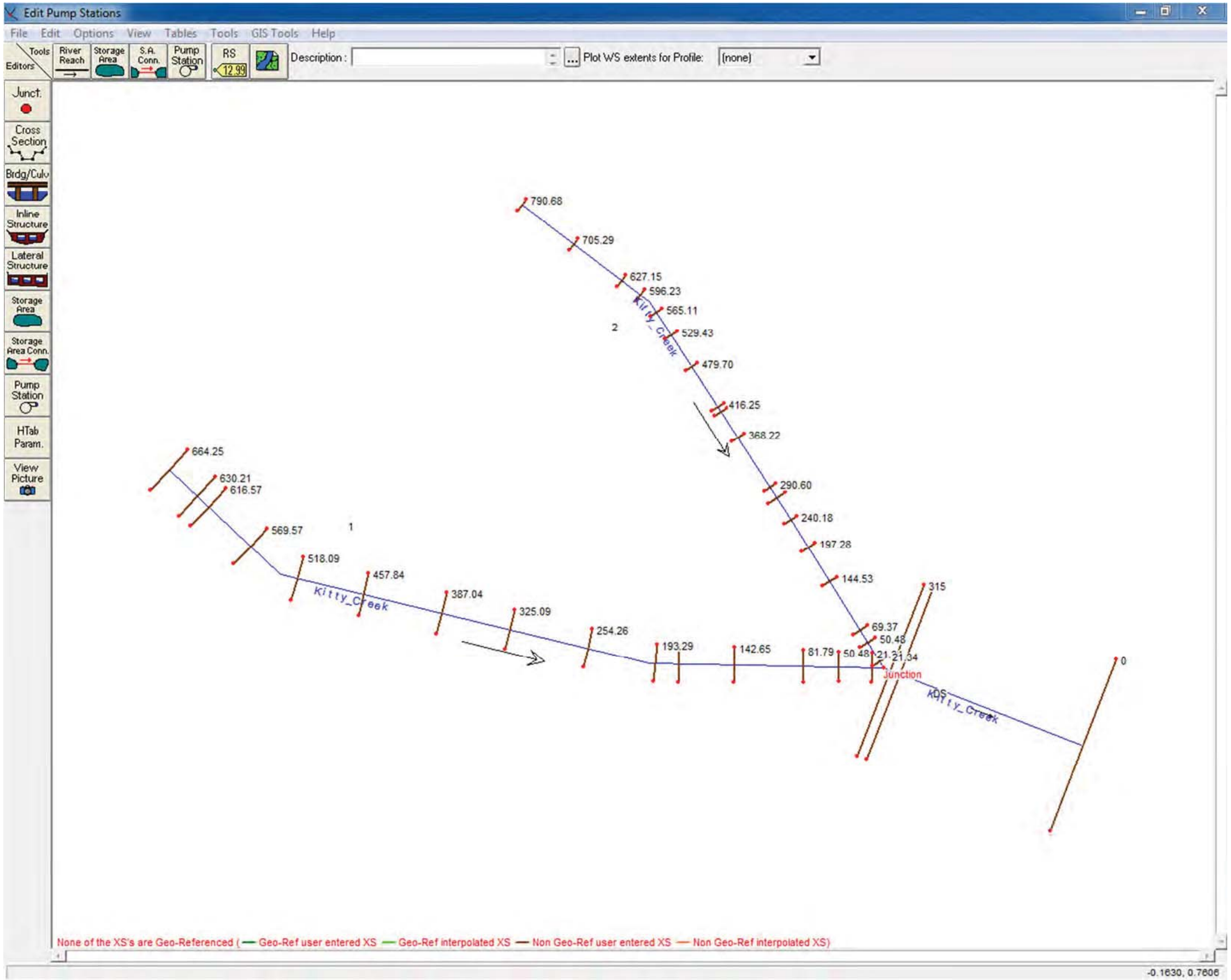
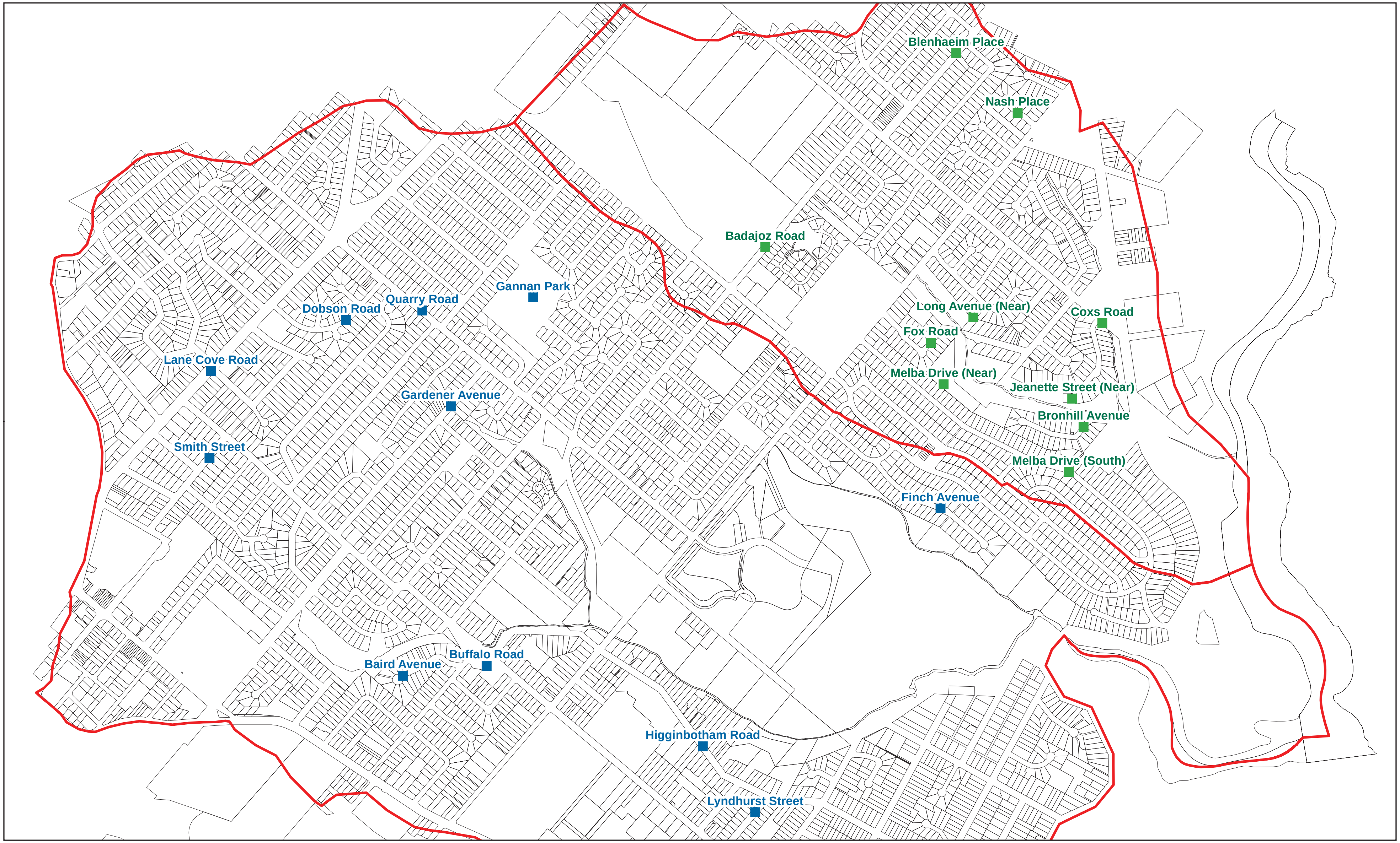


Figure 6.2 Kitty Creek HEC-RAS Model





1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Catchment Boundary
- Lot Cadastral
- Observed Location - Buffalo
- Observed Location - Kitty

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Observed Flood Locations

Job Number	21-21394
Revision	A
Date	06 Nov 2014

Figure A7

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\Monitoring Locations.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Appendix B – Community Consultation

B1 Survey Questionnaire

City of Ryde
Lifestyle and opportunity @ your doorstep

BUFFALO AND KITTYS CREEK FLOOD SURVEY

About this survey

City of Ryde is carrying out a Floodplain Risk Management Study for Buffalo and Kittys Creek. This important survey for landowners, residents and businesses will help us to determine the flood issues that are important to you. Please take a few minutes to complete and return it in the reply paid envelope provided. This will be helpful to us in collecting people's thoughts and ideas about flooding along Buffalo and Kittys Creek. If you cannot answer any question, or do not wish to answer a question, then leave it unanswered and proceed to the next question. If you need additional space, please add sheets.

How to submit this survey

Please complete this survey for Council by Friday 23 November in one of two ways:

1. Log on and complete the survey online **www.myplaceryde.com.au/floodstudy**
2. Complete and return the paper survey using the reply paid envelope

PART 1: RESPONDENT LOCATION

Please complete the survey for the property in which you have an interest. All information provided will remain anonymous and only used for the purpose of this study.

Unit / Suite No. ____ House No.* ____ Lot No. ____

Street Address* ____

Name (optional) ____

Business Name (if applicable) ____

PART 2: ABOUT YOUR PROPERTY

2.a) **How many storeys does your property have?**
- ☐ One ☐ Two ☐ Three

2. b) **What material is your property constructed from?**
- ☐ Full brick
- ☐ Brick veneer
- ☐ Weatherboard/fibro
- ☐ Timber
- ☐ Not sure

2. c) **What type is your property?**
- ☐ House
- ☐ Business
- ☐ Unit/flat/apartment
- ☐ Other, please specify ____

2. d) **Is your property?**
- ☐ Owner occupied
- ☐ Rented /tenant occupied

2. e) **How long have you owned, lived at or had your business or organisation at this property?**
____ years

PART 3: YOUR FLOOD EXPERIENCE

3.a) **Have you ever experienced a flood at the property?**
- ☐ Yes ☐ No, Please proceed to Part 3.g)

3. b) **If yes, which floods?**
- ☐ November 1984
- ☐ August 1986
- ☐ May 1988
- ☐ July 1988
- ☐ December 1989
- ☐ February 1990
- ☐ May 1998
- ☐ April 2003

3.c) **Did you tick February 1990 above?**
- ☐ Yes ☐ No, Please proceed to Part 3.g)

3.d) **In the February 1990 flood, was the property flooded above floor level?**
- ☐ Yes, If yes what was the depth of water over the floor (as best as you can remember)? ____ cm
- ☐ No

PART 3: CONTINUED

3.e) **In the February 1990 flood, what was the maximum depth of water over your grounds and total time your grounds were flooded (as best as you can remember)?**
____ cm
____ hours

3.f) **During the February 1990 flood, what was the approximate cost to you (at the time) from the damage caused by the flood?**

Property damage $ ____

Loss of rent $ ____

3.g) **Do you think your property could be flooded sometime in the future?**
- ☐ Yes ☐ No

3.h) **Why and/or how do you think the property would/wouldn't be flooded?**
____

PART 4: FOR BUSINESS ONLY

4.a) **Do you operate a business from this property?**
- ☐ Yes ☐ No, please proceed to Part 5

4.b) **Which of the following best describes the type of building you operate your business from?**
- ☐ Industrial unit in larger complex
- ☐ Stand alone factory
- ☐ Stand alone warehouse
- ☐ Shop
- ☐ Education
- ☐ Community building
- ☐ Other, please specify: ____

4.c) **Did your business experience the February 1990 flood?**
- ☐ Yes ☐ No, Please proceed to Part 5

4.d) **In the February 1990 flood, what action did you take to protect your property against flood damage?**
- ☐ None
- ☐ Moved vehicles
- ☐ Lifted stock and equipment
- ☐ Used sandbags to try to prevent water entering the premises
- ☐ Other, please specify: ____

PART 4: FOR BUSINESS ONLY

4.e) **In the February 1990 flood, was the business or facility closed or disturbed in any way (including any clean up)?**
- ☐ Yes ☐ No, please proceed to Part 4.f)

If yes, for how long was your business or facility closed or disrupted?
- ☐ Less than 1 day
- ☐ 1 to 2 days
- ☐ 2 days to 1 week
- ☐ More than 1 week, please specify length of time: ____

4.f) **During the February 1990 flood, did floodwaters damage any of the following? (Tick one or more)**
- ☐ No damage occurred
- ☐ Vehicles
- ☐ Electrical equipment, machinery, tools
- ☐ Stock and other goods
- ☐ Carpet, furniture, fittings and/or office equipment
- ☐ Your premises (paint, structurally etc.)
- ☐ Other, please specify: ____

4.g) **During the February 1990 flood, what was the approximate cost to you (at the time) from the damage caused by the flood?**

Property damage $ ____

Loss of rent $ ____

4.h) **As a result of the February 1990 flood, did any of the following happen to you or any of your staff during or after the flood? (Tick one or more)**
- ☐ No problems experienced
- ☐ Inconvenience or disruption to normal routine
- ☐ Isolation (blocked by floodwaters)
- ☐ Employee unable to come to work
- ☐ Loss of business trade
- ☐ Experienced general ill-health
- ☐ Higher employee absenteeism
- ☐ Higher insurance premiums
- ☐ Considered selling/moving the business
- ☐ Other, please specify: ____

PART 5 : YOUR OPINION
FLOODPLAIN RISK MANAGEMENT MEASURES

5.a) Are you aware of any works that have been carried out by either Council or the owner that you believe will reduce the flood problems at your property? (Tick one or more boxes)

- ☐ Not aware of any measures
- ☐ House built at specified floor level
- ☐ House raised
- ☐ Flood-compatible building materials used
- ☐ Creek capacity has been enlarged
- ☐ Bridges added or enlarged
- ☐ Other, please specify:

5.b) Are there any works that you think Council should consider to reduce the flood risk at your property?

- ☐ Yes, If yes please provide details:
- ☐ No

PART 6 : YOUR OPINION
COUNCIL'S CONTROLS ON DEVELOPMENT

6.a) What level of control do you consider Council should place on new development to minimise flood-related risks? (Tick one or more boxes)

- ☐ Stop all new development on land with any potential to flooding
- ☐ Stop all new development only in the most dangerous areas of the floodplain
- ☐ Place restrictions on development such as minimum floor levels and/or the use of flood compatible building materials
- ☐ Advise people of flood risks, and allow individuals to choose how they would reduce flood damage
- ☐ There should be no control on development in flood-affected areas.

6.b) What notifications do you consider Council should give about the potential flood effects on individual properties?

- ☐ Advise every resident and property owner on a regular basis of the known potential flood threat
- ☐ Advise only those who enquire to Council about the know potential flood threat
- ☐ Advise prospective purchasers of property of the known potential flood threat
- ☐ Other, please specify:

PART 7 : OTHER COMMENTS

Do you have any other comments? We are particularly interested in information regarding the February 1990 flood, but information about other events is welcome also.

PART 8 : CONTACT INFORMATION

8.a) Are you happy for us to contact you in order to clarify any information regarding your responses?

☐ Yes ☐ No

Contact Name

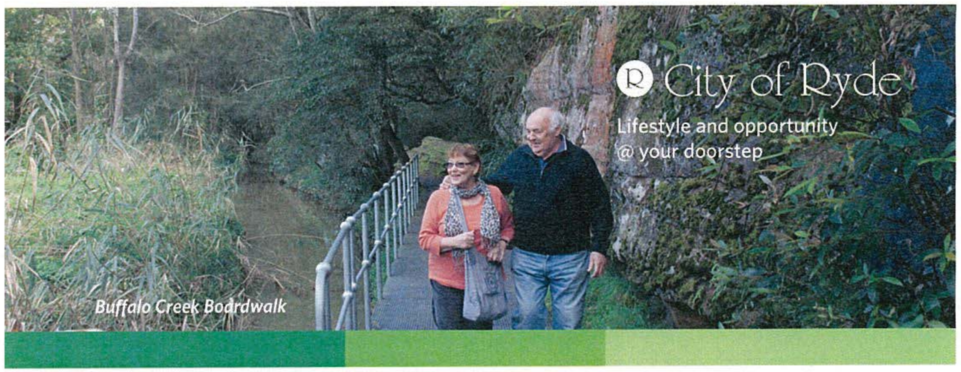
Home Phone

Office Phone

Email

How and when would you prefer to be contacted?

For additional surveys or further information about the Buffalo and Kittys Creek Floodplain Risk Management Study, please contact Guna Veerasingham at Council on (02) 9952 8441 or email gunav@ryde.nsw.gov.au



BUFFALO AND KITTYS CREEK FLOOD STUDY

About the project

City of Ryde has recently commissioned engineering consultants GHD Pty Ltd to undertake a Flood and Floodplain Risk Management Study for the Buffalo and Kittys Creek catchments.

The Study aims to reduce the impact of flooding and flood liability on residents who are living in flood prone areas and to reduce loss resulting from floods.

This study project is being undertaken with the financial and technical assistance from Council and the State Government in order to meet the objectives of the NSW Government's Flood Prone Land Policy.

Community consultation - we need your input

Community involvement is vital to this process

We believe the best source of information on the flooding issues can be gained from those of you living in the related areas as you are able to provide a clear indication of the options that are likely to succeed in managing the risks of flooding.

Council and GHD are committed to listening to the concerns and issues of the community to ensure that this information is integrated into the study.

How your input will assist us

Stage 1: Data collection and preparation of a Flood Study to define existing flood behaviour. This is the stage that we are asking for your involvement. Your input will help shape the plan

Stage 2: Preparation of a Floodplain Risk Management Study that identifies a range of floodplain management measures to address any problems and areas of concern.

Stage 3: Preparation of a Plan that documents the final floodplain management measures be adopted to address existing and potential flood problems.

Stage 4: The actual undertaking of the works, subject to availability of grants funds from the Government.

B2 Community Consultation Survey Results Full Summary

City of Ryde

Lifestyle and opportunity @ your doorstep

2012 Buffalo and Kittys Creek Flood Study Survey

Infrastructure Integration

February 2013

TABLE OF CONTENTS

Introduction

Background

City of Ryde has commissioned engineering consultants GHD Pty Ltd to undertake a Flood and Floodplain Risk Management Study for the Buffalo and Kittys Creek catchments. The Study aims to reduce the impact of flooding and flood liability on residents living in flood prone areas and to reduce loss resulting from floods.

As part of this study, City of Ryde has consulted with the community by undertaking a survey of residents living in the related areas. The main objectives of the survey are:

- To obtain information from property owners relating to previous flood experiences from 1984 to 2003.
- To determine preferred floodplain risk management measures, controls on development, and how property owners want to be notified regarding potential flood effects on individual properties.
- To understand the concerns and issues of the community to be considered and integrated into the Study.

Methodology

Paper surveys were sent by mail to 3,247 owners of properties in the related areas around the Buffalo and Kittys Creek catchments. Data was collected from the 12th of November until 7th of December 2012.

Surveys were returned either through reply paid post, or submitted online. Approximately 74 letters were returned as they were delivered to invalid addresses, or property owners were no longer at the address.

Start date	End date	Surveys sent	Completes	Response rate
12/11/12	7/12/12	3,247	622 (547 – Offline) (75 – Online)	19%

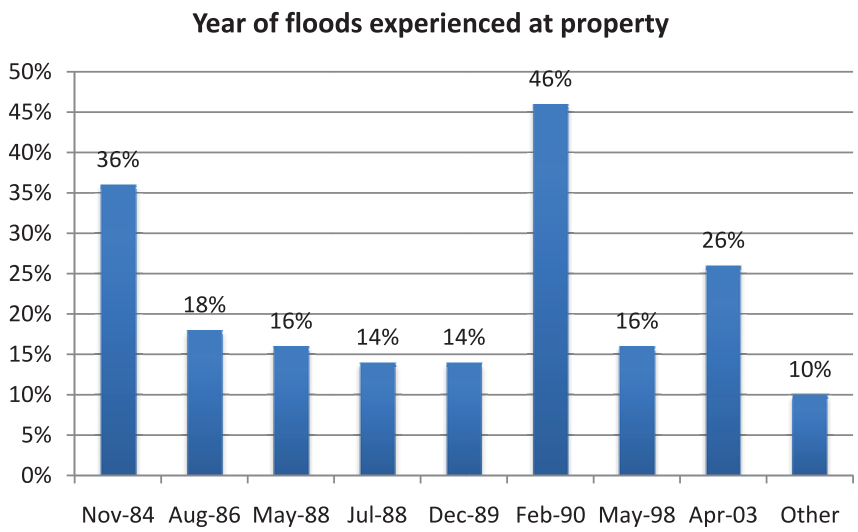
Sampling error

The final achieved sample of n=622 households provides a sampling error of +/-3.53 at 95% confidence.

Executive Summary

Previous Flood Experience

Overall, 8% (n=50) of respondents reported having experienced floods at their property between 1984 and 2003. Almost half of these flood affected properties had experienced the February 1990 floods. 37% had experienced the November 1984 floods, whilst 27% experienced more recent flooding of April 2003.



n=50 reported having ever experienced floods.
n=5 did not stipulate which floods – attributed to 'Other'

Those who experienced the February 1990 floods reported the following effects of the floods:

Effects:	Range	Average
Maximum depth of water over your grounds	2cm – 60 cm	22cm
Total time your grounds were flooded	½ hour – 72 hours	15 hours
Approximate cost (at the time) from the damage caused by the flood	$500 - $2,000	$1,330
Loss of rent	$0	$0

Comparison of properties:

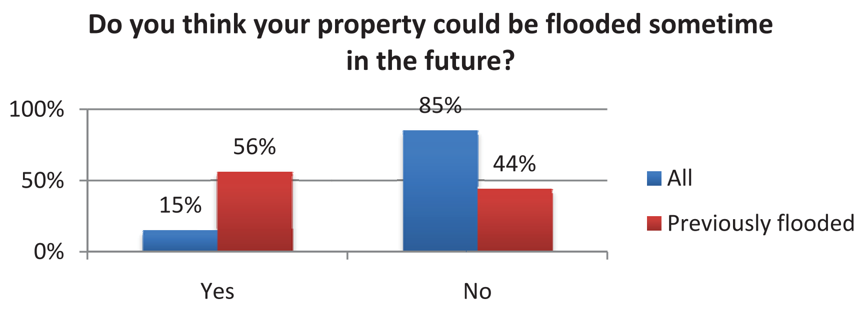
Below is a comparison between properties that have been flood affected and those that have not been flood affected.

- A higher percentage of non flood affected properties were 3 stories (9% non flood affected vs. 2% flood affected)
- A higher percentage of flood affected properties were full brick (47% flood affected vs. 36% non flood affected)
- All flood affected properties were residential (98% houses + 2% semi detached)
- A higher percentage of flood affected properties were owner occupied (96% vs. 90% non flood affected)
- The range of years the owners owned the property was wider for non flood affected properties, however the average tenure was longer for flood affected properties.
- A higher percentage of properties in the Buffalos Creek Catchment Area reported being affected by previous floods (9%) than Kittys Creek Catchment Area properties (See Appendix 1 for Property List)

		Flood affected	Non flood affected
No. of stories	1 story	49%	52%
	2 stories	49%	39%
	3 stories	2%	9%
Property Material	Full brick	47%	36%
	Brick veneer	35%	42%
	Weatherboard/fibro	22%	22%
	Timber	6%	7%
	Not sure	0%	1%
Property type	House	98%	86%
	Business	0%	2%
	Unit/flat/apartment/	0%	7%
	Other	2%	5%
Owned or rented	Owner occupied	96%	90%
	Rented/tenant occupied	4%	10%
Tenure	Range	3-58 years	1-79 years
	Average	34 years	23 years
Catchment	Kittys Creek Catchment Area	4%	96%
	Buffalos Creek Catchment Area	9%	91%

Future floods:

15% of property owners believed their property could be flooded some time in the future.
Of those who have previously experienced floods, 56% thought their property could be flooded in the future, whilst 44% did not believe floods to be a future threat.



Reasons for or against future flooding:

The most commonly cited reasons property owners thought their property could be flooded in the future were because of the position of their property being at the bottom of a hill, or the street sloping towards their property, followed by stormwater drain blockages, and also proximity to the creek.

Reasons for future flood potential	Frequency	Percent
Slope of road towards house/situated at bottom of hill/low side of street or below street	22	26.5%
Stormwater/drain blockages/inadequate runoff	17	20.5%
Near a creek/waterfall	13	15.7%
Bottom of property or garage gets flooded but not top	8	9.6%
Depends on the catchment/near catchment overflow	5	6.0%
Footpath/easements/street frequently floods	4	4.8%
Run off from nearby industrial estate/units/roads	4	4.8%
Backyard alterations changing course of floods/clearing of trees	3	3.6%
Flash flooding potential	3	3.6%
House in Kittys Creek catchment	3	3.6%
Backyard flooding	2	2.4%
House in Buffalo Creek catchment	2	2.4%
Excessive development	1	1.2%
Natural disasters	1	1.2%
Neighbours emptying pool	1	1.2%
Street gutters and stormwater drains not cleaned out regularly	1	1.2%
Tree roots causing broken pipes in property	1	1.2%

Conversely, the most commonly stated reasons for those who did not think their properties were at risk were; the property being on the higher end of a slope, the property itself being elevated, or the property being located far from the creek. New or improved drainage installation was commonly cited as having removed flood risk that had existed previously. Furthermore, some property owners had never experienced any flooding at their properties so did not perceive this to be a threat.

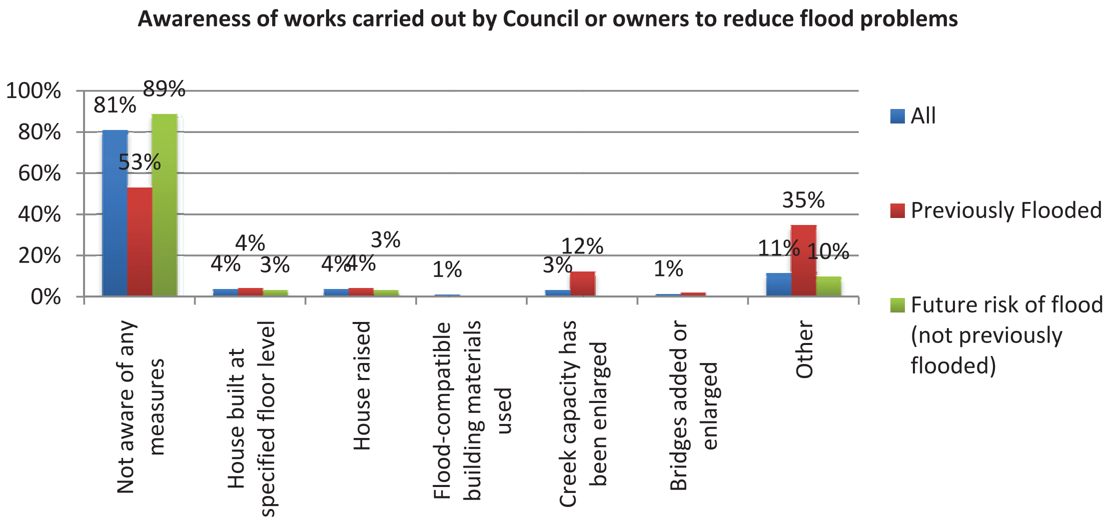
Reasons against future flood potential	Frequency	Percent
House is on higher end of slope/slope of block	137	39.8%
Elevation of blocks/land raised/live in upper floors	71	20.6%
House is high above or far from creek/flood area	52	15.1%
Drainage system - new, improved, or adequate	46	13.4%
Never had a flood problem before, even during heavy rain	28	8.1%
Above sea level	7	2.0%
Requires review (See Appendix 2.1)	5	1.5%
Council fixed the problem after flooding	4	1.2%
House near a waterfall cascade.	4	1.2%
Council approved pit in backyard/underground stormwater tank	3	0.9%
Council approved retaining walls	3	0.9%
Depends on weather in the future	2	0.6%
Specific road upgrades (See Appendix 2.2)	2	0.6%
Don't know	2	0.6%

Flood effects on Businesses

2 businesses were identified as having experienced the February 1990 floods. Both reportedly did not take any actions to protect their properties from flood damage. Only one reported damage occurring to carpet, furniture, fittings and/or office equipment. In terms of effects on staff, both reported just inconvenience or disruption to normal routine, and no other major effects.

Awareness of risk management measures

Overall, most respondents (81%) were not aware of any works carried out by either Council or the owners. However, looking at the properties that have previously been flooded 53% of those weren't aware of any measures. Furthermore, looking at those who had not previously experienced flooding but thought they were at risk of future floods, 89% (almost 9 in 10 people) weren't aware of any measures. This suggests there is scope for better education to property owners on risk management measures that have been taken, or that they themselves could undertake to reduce flood problems.



Other commonly known works that had been carried out related to drains and pipes being installed or improved in various streets, creeks, and parks, drainage installation undertaken by property owners or Council.

Other known works	Frequency	Percent
Drainage/pipes on streets/creek/park	37	55.2%
Drainage around house	11	16.4%
Alterations to land to channel water/raised roads	5	7.5%
Landscaping/building carried out in accordance with flood study recommendations (pump requirements)	4	6.0%
Owners maintain creek/creek cleaned by Council	4	6.0%
Built wetlands/gardens soak water	2	3.0%
Raised property/elevation	2	3.0%
Road bridge built	1	1.5%

24% thought there were other works Council should consider to reduce flood risks. The most commonly suggested additional works were improvements to drainage or installation of drain systems, clearing existing drains of leaves and other rubbish through regular street sweeping, and clearing the creek of weeds and other plants.

Suggestions	Frequency	Percent
Better drains/check drainage system/sewers/higher capacity	42	30.4%
Clearing drains, gutters and pipes of leaves/rubbish/weed/debris - regular street sweeping	36	26.1%
Clear the creek/river banks of weeds/plants	23	16.7%
Check redirection of water flow (footpaths)	6	4.3%
Enforce new building/development specifications/overdevelopment concerns	5	3.6%
Enforce open wire fences/restrict hard surface areas/nature strips/ for less run off	5	3.6%
Reuse rainwater	4	2.9%
Tree logs/branches keep falling into creek - tree maintenance	4	2.9%
Check easements flood coping capacity	3	2.2%
Council approved construction/previous decision has led to more flooding/requires review	3	2.2%
Enforce house owners to drain properties into drains provided	3	2.2%
Council should bear the cost	2	1.4%
Creek - adequately sized	2	1.4%
Survey to determine flood risk	2	1.4%
Check possible flood threat	1	0.7%
Creek bank erosion a problem - plants required	1	0.7%
Retaining wall around creek	1	0.7%
Risk assessment for every house in flood risk area	1	0.7%
Roof water to streets, not absorption pits	1	0.7%
Safer access way to creek - previously car went into creek	1	0.7%
Use rubbish collecting grates in rivers	1	0.7%
Specific locations mentioned (See Appendix 3)	19	13.8%
Don't know/not actionable	3	2.2%

Main issues identified

A relatively small percentage of properties surveyed reported being affected by floods previously (8%); however 15% believed their properties could be affected by floods in the future.

The positioning of the property (in terms of where it was situated on a slope as well as proximity to a flood prone area), and possibility of drain blockages were the main reasons people thought they could be affected by floods.

A very high percentage of respondents (81%) were not aware of any risk management measures carried out to reduce flood problems. The most commonly known works were related to drainage and pipe works on streets, creeks, and parks, drainage improvements inside or around the property itself, and changes to creek capacity.

Recommendations

The flood affected properties identified through this survey are to be reviewed and incorporated into GHD's mapping system.

Council will consider the suggestions for additional works to reduce flood risk to determine feasibility and key actions.

Council will also implement a communications strategy to ensure residents are made aware of the next stages of the flood plain risk management study.

Appendix 1 – Flood Affected Properties

Buffalos Creek Catchment Area (42 properties)

House no.	Street Address	Maximum depth of water in February 1990 flood	Maximum hours flooded in February 1990 flood
3	Adam Street, Ryde, NSW 2112	60 cm	
25	Baird Avenue, Ryde, NSW 2112		
224	Buffalo Road, Ryde, NSW 2112		
4	Byron Avenue, Ryde, NSW 2112	25 cm	
4	Byron Avenue, Ryde, NSW 2112	50 cm	
10	Crescent Avenue, Ryde, NSW 2112		
16	Crescent Avenue, Ryde, NSW 2112	Knee	A few hours
14	Finch Avenue, East Ryde, NSW 2113		
6	Ganora Street, Gladesville, NSW 2111		
7	Ganora Street, Gladesville, NSW 2111	10 cm	24 hours
51	Gardener Avenue, Ryde, NSW 2112		
63	Greene Avenue, Ryde, NSW 2112		
68	Greene Avenue, Ryde, NSW 2112	30 cm	Few days
52	Higginbotham Road, Gladesville, NSW 2111	10-20 cm	
62A	Higginbotham Road, Gladesville, NSW 2111		
17	Kulgoa Avenue, Ryde, NSW, 2112		
40	Lane Cove Road, Ryde, NSW 2112	20 cm	24 hours
46	Lane Cove Road, Ryde, NSW 2112		
6	Laura Street, Gladesville, NSW 2111	8 cm	1.5 hours
1	Laurel Place, Ryde, NSW 2112		
11	Martin Street, Ryde, NSW 2112		
13	Martin Street, Ryde, NSW 2112	25 cm	0.5 hours
15	Martin Street, Ryde, NSW 2112		
18	Minga Street, Ryde, NSW 2112	2 cm	
24	Minga Street, Ryde, NSW 2112		
25	Minga Street, Ryde, NSW 2112		
26	Minga Street, Ryde, NSW 2112		
47	Monash Road, Gladesville, NSW 2111		
72	Monash Road, Gladesville, NSW 2111	20-25 cm	2 hours
102	Moncrieff Drive, East Ryde, NSW 2113	56 cm	1 hour
14	Oates Avenue, Gladesville, NSW 2111		
16	Oates Avenue, Gladesville, NSW 2111		
42	Pooley Street, Ryde, NSW 2112		
142	Quarry Road, Ryde, NSW 2112		
3	Semple Street, Ryde, NSW 2112		
9	Semple Street, Ryde, NSW 2112	2.5 cm	

5	Short Street, Gladesville, NSW 2111		
5	The Strand, Gladesville, NSW 2111		
33	Watt Avenue, Ryde, NSW 2112	3 cm	10 hours
48	Westminster Road, Gladesville, NSW 2111	30 cm	
51	Westminster Road, Gladesville, NSW 2111	15 cm	72 hours
63A	Westminster Road, Gladesville, NSW 2111	10 cm	1-2 hours
6	Woodbine Crescent, Ryde, NSW 2112		

Kittys Creek Catchment Area (7 properties)

House no.	Street Address	Maximum depth of water in February 1990 flood	Maximum hours flooded in February 1990 flood
5	Conrad Street, North Ryde, NSW 2113		
41	Conrad Street, North Ryde, NSW 2113		
14	Harford Street, North Ryde, NSW 2113		
47A	Jopling Street, North Ryde, NSW 2113		
18	Kokoda Street, North Ryde, 2113		
28	Melba Drive, East Ryde, NSW 2113	2 cm	As long as the rain lasted
3	Nash Place, North Ryde, NSW 2113		

Appendix 2 – Reasons against future flood potential

2.1 – Comments requiring review

Respondent ID	House no.	Address	Catchment	Comment
171400	39-41	College Street, Gladesville, NSW 2111	Buffalos Creek Catchment Area	I have been at College St since 1957 on land that stored the fired bricks from the brick pit (now Enterprise Park/Bunnings/Wesfarmers). Even when empty, being used for sandstone sawing, I never saw it filled more than 2 feet (600mm), and the stormwater pipes and evaporation (2400mm per year) removed the accumulated water. Some 10 years ago Ryde engineer Hunt recommended that, for a one in 500 year flood, the Brickpit Owner be required to build a new stormwater pipe to Buffalo Creek, a fact which Bunnings/Wesfarmers would/should have known on purchase but has not mentioned in its DA. Even a 1 in 1000 year flood, the pit is deep enough to hold the accumulated stormwater if its drainage pipe failed. (I worked for Sydney Water 1985-2000).
W0220	99	Buffalo Road, Ryde, NSW 2112	Buffalos Creek Catchment Area	My property is on lower side of the road.
172465	1	Laurel Place, Ryde, NSW 2112	Buffalos Creek Catchment Area	Due to previous floorings and no assistance by Council to rectify the problem, we raised the land by 1.5 meters and that has kept the water within the boundaries of the creek. Our property boundary line was the centre-line of the creek and since my father purchased the property in 1959 the creek has always been maintained by the family, subsequently to a subdivision on the property we were compelled to hand back approximately 700 square meters of land under the then called "Foreshore Act" without any compensation in the early eighties and since that time even after making countless requests to Council to maintain the creek, absolutely nothing has happened. The creek has since been overtaken by 'wandering jew' and the embankment has significantly eroded to the point that the driveway at the southern part of the property that is actually in Council ownership is threatened by collapse due to undermining by the creek. Council was made aware of this occurrence when they undertook a site inspection some years ago and again, no action. To conclude, yes, we have seen some heavy rain but due to our own intervention, the land has no longer flooded BUT unless council does some stabilisation along the embankment I cannot advise as to how long the banks will remain. We have planted a considerable number of trees along the bank and this has helped somewhat.
W0080	9	Semple Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	The drainage behind the property in Myra Ave is too small to hold the water to which it overflows and carries into my property.
W0208	6	Ganora Street,	Buffalos Creek	Storm water has not been adequately managed.

		Gladesville, NSW 2111	Catchment Area	New property on the strand. Has caused issue in October 2011 and March 2012.

2.2 - Specific road upgrades mentioned

Respondent ID	House no.	Address	Catchment	Comment
W0166	9	Baird Avenue, Ryde, NSW 2112	Buffalos Creek Catchment Area	Fixed Buffalo Rd drainage. Even in great torrents it doesn't rise past river banks.
BK0260	14	Harford Street, North Ryde, NSW 2113	Kittys Creek Catchment Area	Because of remedial works on Coxs Road and Harford Street and the large pipes taking the creek water from Badajoz St to under the bridge in Hayford Street

Appendix 3 – Suggestions of other works to consider to reduce flood risk - specific locations mentioned

Respondent ID	House no.	Address	Catchment	Comment
171175	30	Jeanette Street, East Ryde, NSW 2113	Kittys Creek Catchment Area	Ensuring stormwater drains are well maintained and of sufficient size especially those in Wolfe Road and Rodney street. Overflowing drains there would runoff into our property
171821	65	Melba Drive, East Ryde, NSW 2113	Kittys Creek Catchment Area	TO ASSES STREET STORM WATER SYSTEM CAPACITY AND RISK OF FLOODING PROPERTIES ALONG EASTERN SIDE OF MELBA DR.
W0131	132A	Cressy Road, East Ryde, NSW 2113	Kittys Creek Catchment Area	Clear creek bed at culvert under Harford St. specifically clear weed species from creek. Baffles also at Culvert to change flow characteristics.
W0151	15	Fox Road, East Ryde, NSW 2113	Kittys Creek Catchment Area	Curb + gutter + drain the end of Fox Rd.
W0157	21	Jeanette Street, East Ryde, NSW 2113	Kittys Creek Catchment Area	Clear rubbish/weed from Kittys creek to aid flow. Put fence onside 19, Jeanette St storm water drain.
171126	11	Robinson Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	Stormwater drainage in to Buffalo Creek is too concentrated at the Laurel Park end of Robinson St. This should be improved to reduce the amount of run-off in to the creek in this area.
171940	107	Quarry Road, Ryde, NSW 2112	Buffalos Creek Catchment Area	Look at the residences above and check that the natural water has not been interrupted because we believe that the water has been directed to some backyards so it runs through neighbouring properties.
172070	24	Clayton Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	Putting in place drainage works at the rear of properties in Clayton Street (Burrows Park side)
BK0059	109	Buffalo Road, Ryde, NSW 2112	Buffalos Creek Catchment Area	Better drainage between the street and the front of our property (109 Buffalo Rd)
BK0126	49	Monash Road, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Improve Drainage in Westminster park
BK0257	8	Leawill Place, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Clear out the storm water drain leading to field of mars reserve at the base of Leawill Place
BK0320	34	Clayton Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	I do not know how the work you have done on 36 Clayton street will affect my property
W0099	6	Oates Avenue, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Council needs to ensure the drain at the lower end of the laneway at Westminster Park is cleared on a regular basis. If it is blocked during heavy rain, the water floods into adjoining properties.
W0139	8	Oates Avenue, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Drainage at rear; northern side of Westminster Park.
BK0079	24	Minga Street, Ryde, NSW	Buffalos Creek Catchment Area	Adjust stormwater drain in Gannan Reserve

		2112		
BK0114	72	Monash Road, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Improve stormwater drainage as has been done in other sections of Monash Road from buffalo to Higginbotham. Current drainage is on the wrong side of the road.
BK0139	142	Quarry Road, Ryde, NSW 2112	Buffalos Creek Catchment Area	Apply drains in Goulding Road
BK0183	42	Pooley Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	Fix the drainage problem on Pooley street in Ryde
W0242	46	Lane Cove Road, Ryde, NSW 2112	Buffalos Creek Catchment Area	Checking and clearing of easement pipes. It was blocked by Council i.e. we still had part of an old unblocked pipe on our property causing soil erosion and a partial collapse of part of our lawn with a toddler at our house.

B3 Community Consultation Survey Results Brief Summary

City of Ryde

Lifestyle and opportunity
@ your doorstep

2012 Buffalo and Kittys Creek Flood Study Survey Results

Agenda

- Examine results from Flood Study Survey
- Determine feasibility of suggested works to consider
- Determine next steps – i.e. mapping of results, communications plan

Background of research

- As part of the Floodplain risk management study for the Buffalo and Kittys Creek catchments, City of Ryde has consulted with the community by undertaking a survey of residents living in the related areas.

- The main objectives of the survey were:
  - Obtain information from property owners relating to previous floods from 1984 – 2003
  - Determine preferred risk management measures and controls, and notifications of potential flood effects
  - Understand issues and concerns to be considered

Methodology

- Surveys mailed to 3,247 property owners in Buffalo and Kittys Creek Catchment areas
- Data was collected over 4 weeks (12^{th} of November until 7^{th} of December 2012)

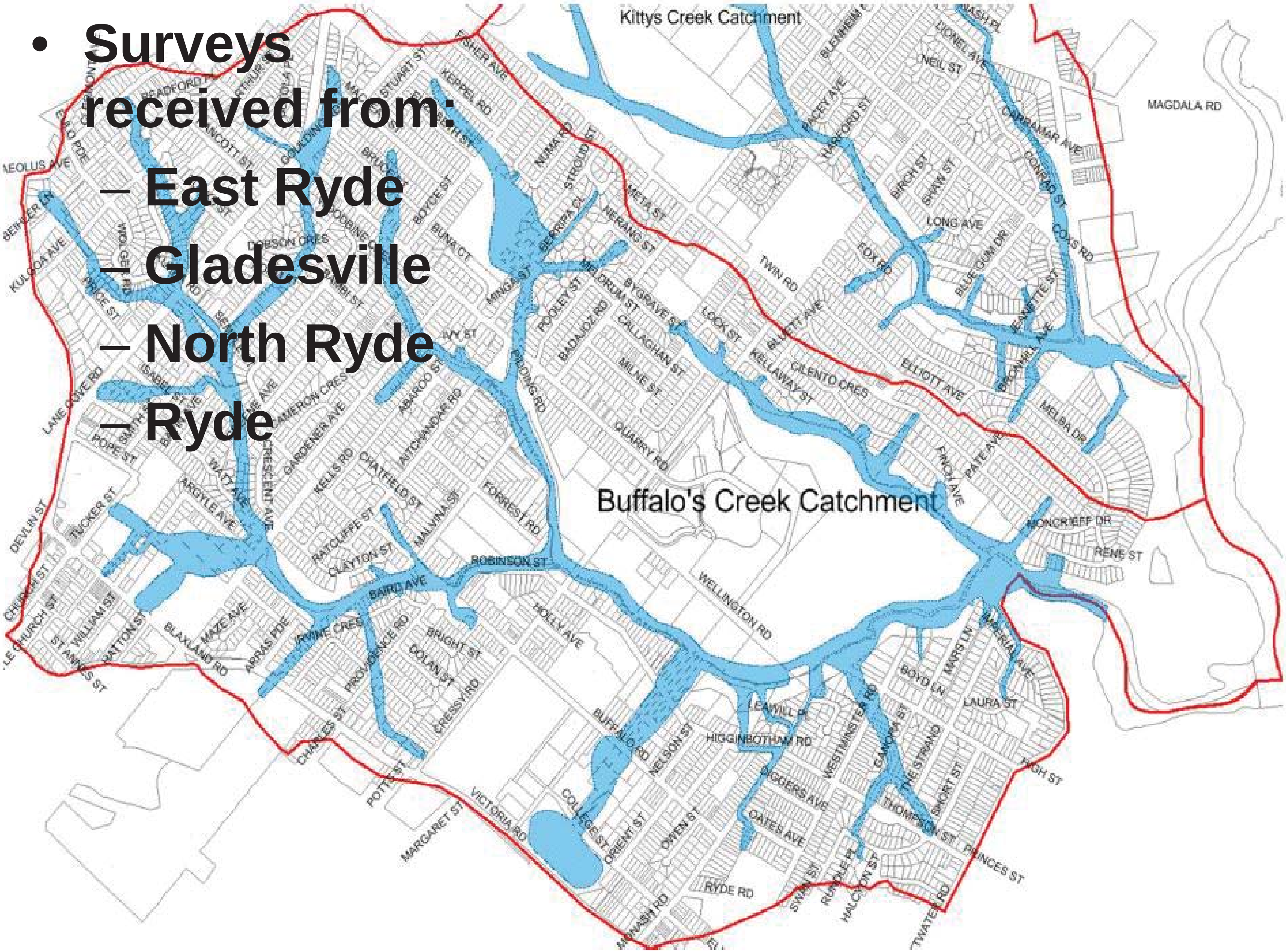
Start date	End date	Surveys sent	Completes	Response rate
12/11/12	7/12/12	3,247	622 (547 – Offline) (75 – Online)	19%

City of Ryde

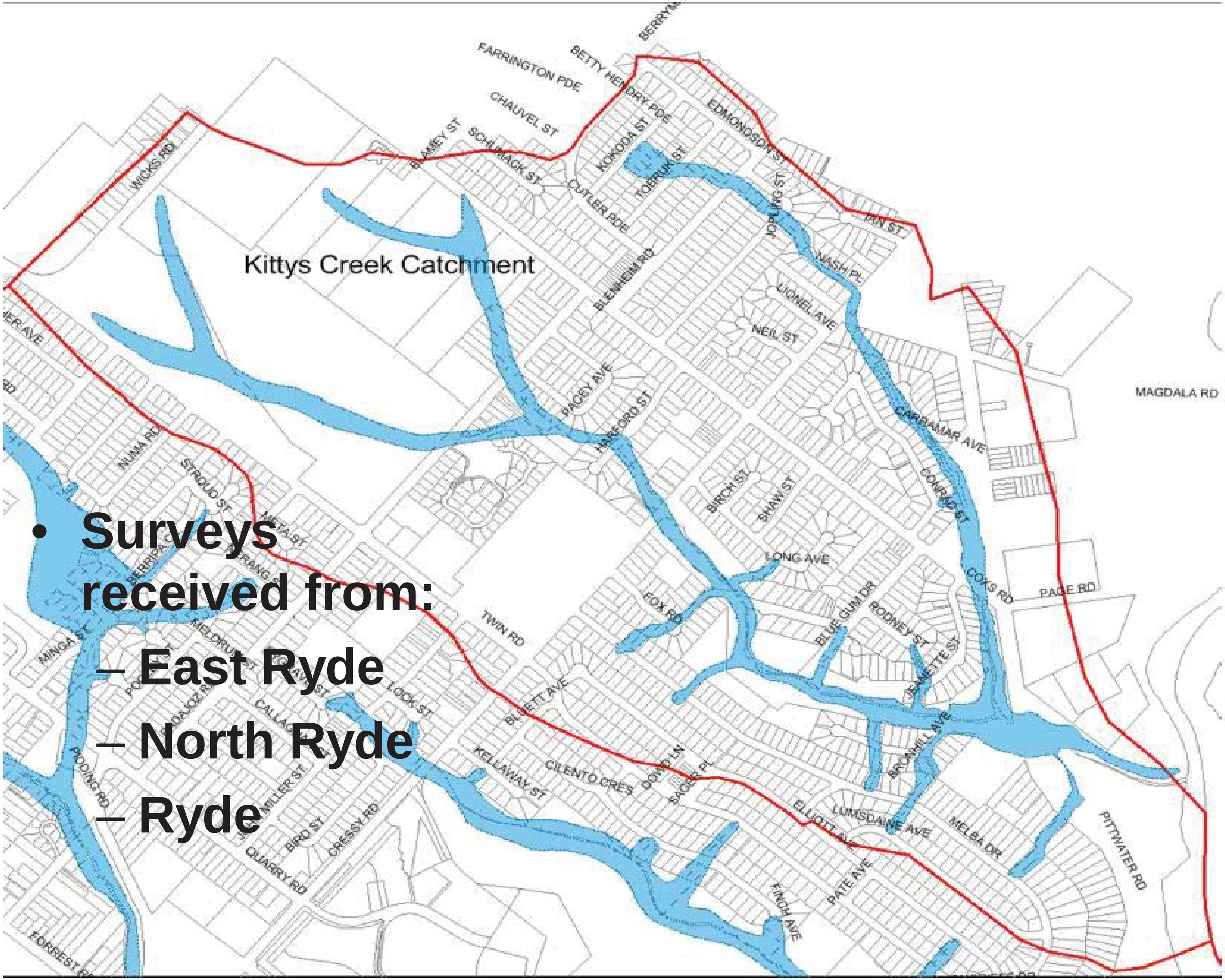
Lifestyle and opportunity @ your doorstep

Buffalo's Creek Catchment

- **Surveys received from:**
  - **East Ryde**
  - **Gladesville**
  - **North Ryde**
  - **Ryde**



Kittys Creek Catchment

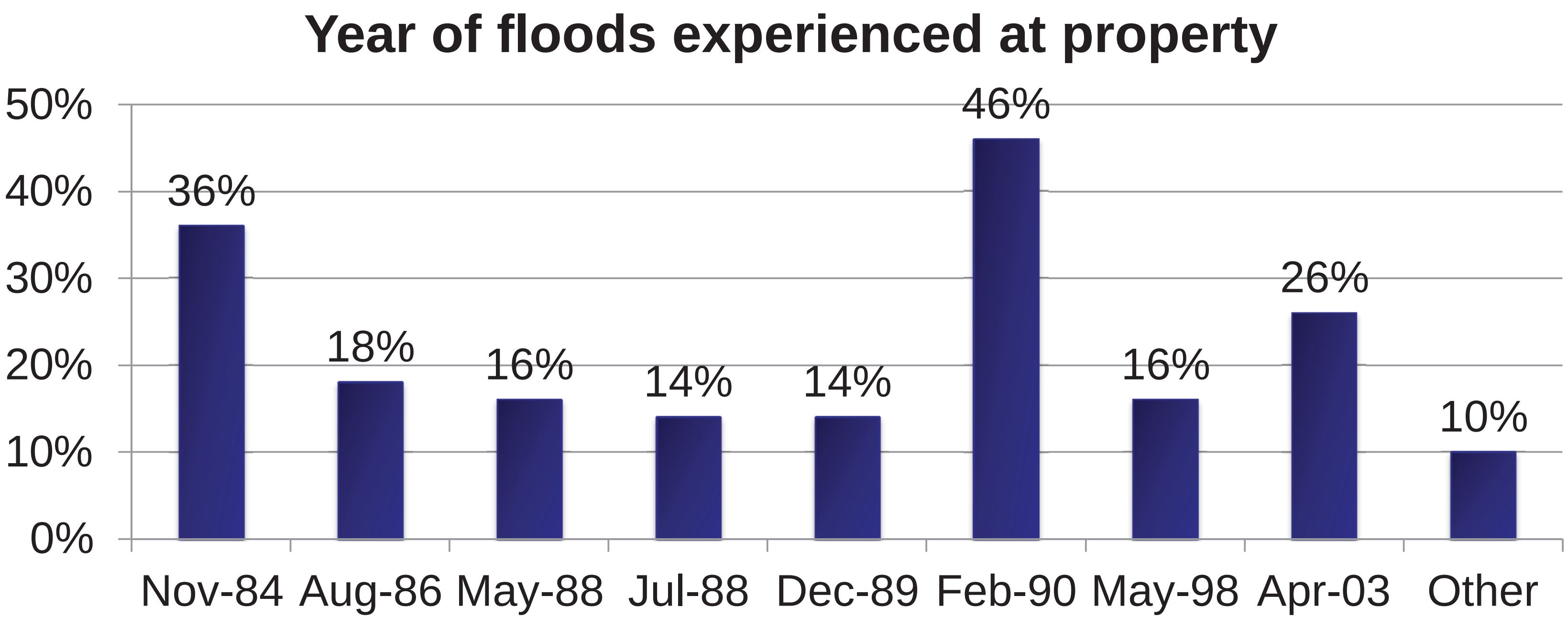


- **Surveys received from:**
  - **East Ryde**
  - **North Ryde**
  - **Ryde**

Methodology

- Sampling error:
  - Final achieved sample of n=622 households provides a sampling error of +/-3.53 at 95% confidence.
- Other considerations:
  - Approximately 74 letters were returned as they were delivered to invalid addresses, or property owners were no longer at the address.
  - As the survey related to floods over a long time span of 20 years, some flood affected residents may have already moved houses.

Previous flood experience



City of Ryde

Lifestyle and opportunity @ your doorstep

Flood effects - 1990

Effects:	Range	Average
Maximum depth of water over your grounds	2cm – 60 cm	22cm
Total time your grounds were flooded	½ hour – 72 hours	15 hours
Approximate cost (at the time) from the damage caused by the flood	\$500 - \$2,000	\$1,330
Loss of rent	\$0	\$0

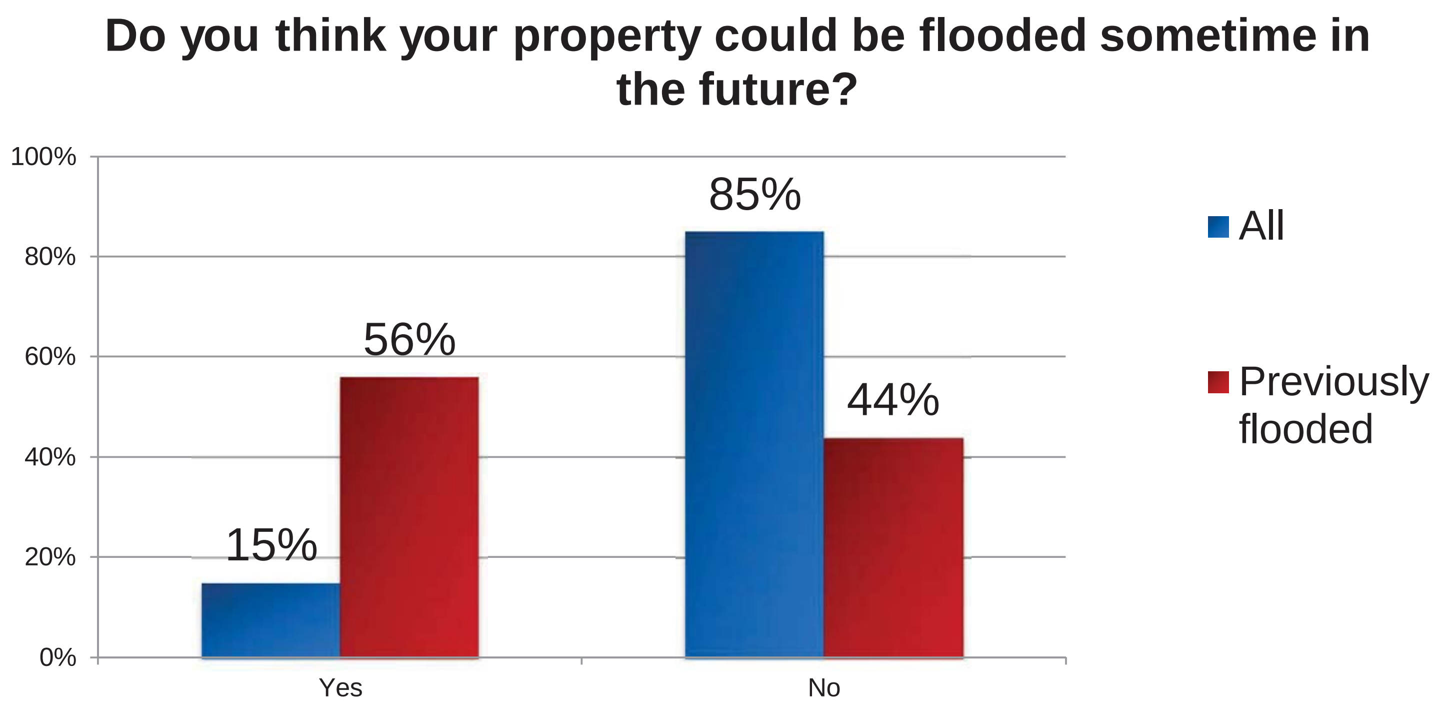
Comparison of flood vs. non flood affected properties

		Flood affected	Non flood affected
No. of stories	1 story	49%	52%
	2 stories	49%	39%
	3 stories	2%	9%
Property Material	Full brick	47%	36%
	Brick veneer	35%	42%
	Weatherboard/fibro	22%	22%
	Timber	6%	7%
	Not sure	0%	1%
Property type	House	98%	86%
	Business	0%	2%
	Unit/flat/apartment/	0%	7%
	Other	2%	5%
Owned or rented	Owner occupied	96%	90%
	Rented/tenant occupied	4%	10%
Tenure	Range	3-58 years	1-79 years
	Average	34 years	23 years
Catchment	Kittys Creek Catchment Area	4%	96%
	Buffalos Creek Catchment Area	9%	91%

City of Ryde

Lifestyle and opportunity @ your doorstep

Future floods



City of Ryde

Lifestyle and opportunity @ your doorstep

Reasons for future flooding

Reasons for future flood potential	Frequency	Percent
Slope of road towards house/situated at bottom of hill/low side of street or below street	22	26.5%
Stormwater/drain blockages/inadequate runoff	17	20.5%
Near a creek/waterfall	13	15.7%
Bottom of property or garage gets flooded but not top	8	9.6%
Depends on the catchment/near catchment overflow	5	6.0%
Footpath/easements/street frequently floods	4	4.8%
Run off from nearby industrial estate/units/roads	4	4.8%
Backyard alterations changing course of floods/clearing of trees	3	3.6%
Flash flooding potential	3	3.6%
House in Kittys Creek catchment	3	3.6%
Backyard flooding	2	2.4%
House in Buffalo Creek catchment	2	2.4%
Excessive development	1	1.2%
Natural disasters	1	1.2%
Neighbours emptying pool	1	1.2%
Street gutters and stormwater drains not cleaned out regularly	1	1.2%
Tree roots causing broken pipes in property	1	1.2%

Reasons against future flooding

Reasons against future flood potential	Frequency	Percent
House is on higher end of slope/slope of block	137	39.8%
Elevation of blocks/land raised/live in upper floors	71	20.6%
House is high above or far from creek/flood area	52	15.1%
Drainage system - new, improved, or adequate	46	13.4%
Never had a flood problem before, even during heavy rain	28	8.1%
Above sea level	7	2.0%
Requires review	5	1.5%
Council fixed the problem after flooding	4	1.2%
House near a waterfall cascade.	4	1.2%
Council approved pit in backyard/underground stormwater tank	3	0.9%
Council approved retaining walls	3	0.9%
Depends on weather in the future	2	0.6%
Specific road upgrades	2	0.6%
Don't know	2	0.6%

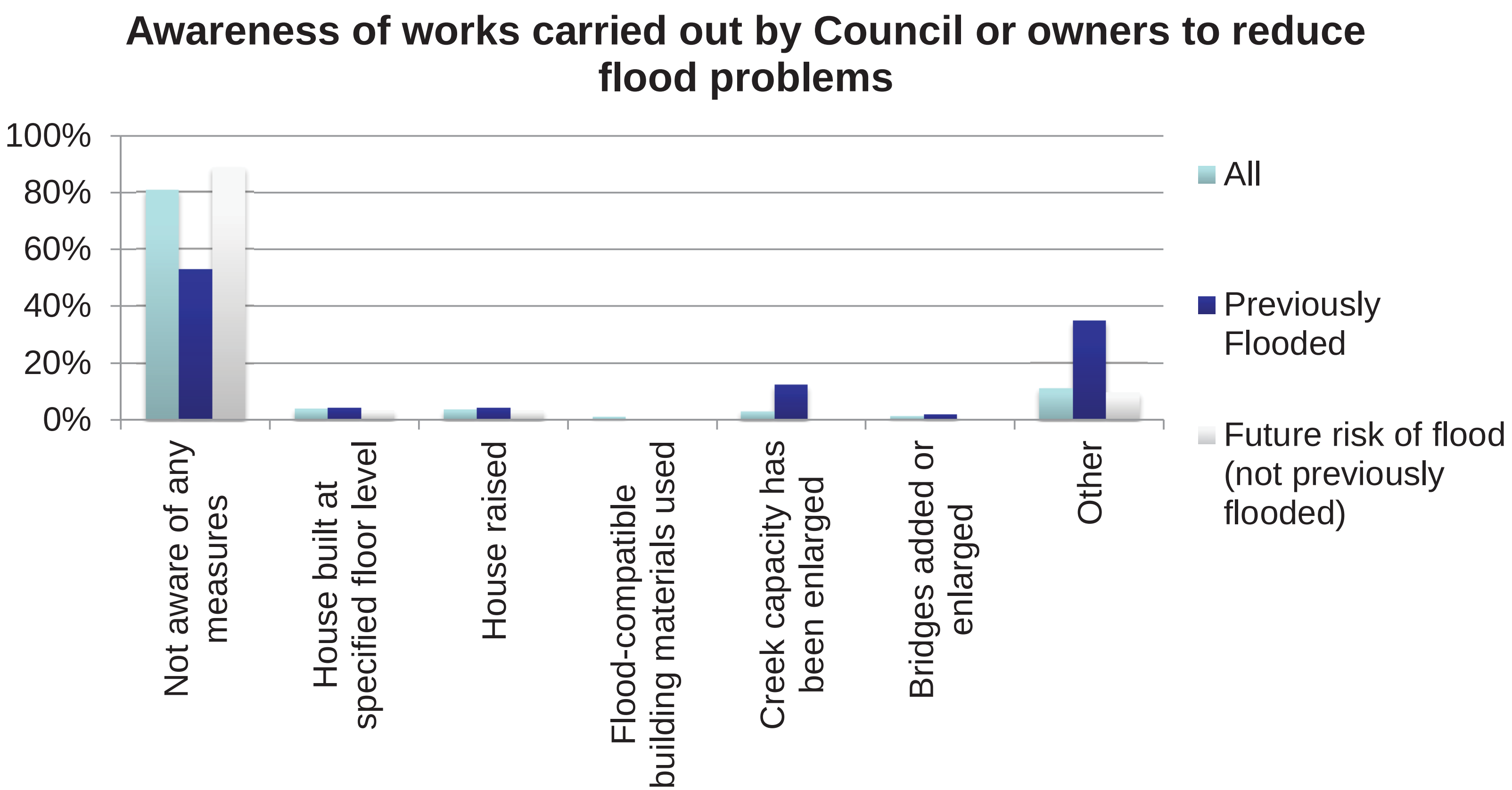
Flood effects on businesses

- 2 businesses identified as having experienced the February 1990 floods.
- No actions taken to protect from flood damage
- Damage occurred to carpet, furniture, fittings and/or office equipment
- Inconvenience/disruption to normal routine – no other major effects

City of Ryde

Lifestyle and opportunity @ your doorstep

Awareness of risk management



Other works to consider

Suggestions	Frequency	Percent
Better drains/check drainage system/sewers/higher capacity	42	30.4%
Clearing drains, gutters and pipes of leaves/rubbish/weed/debris - regular street sweeping	36	26.1%
Clear the creek/river banks of weeds/plants	23	16.7%
Check redirection of water flow (footpaths)	6	4.3%
Enforce new building/development specifications/overdevelopment concerns	5	3.6%
Enforce open wire fences/restrict hard surface areas/nature strips/ for less run off	5	3.6%
Reuse rainwater	4	2.9%
Tree logs/branches keep falling into creek - tree maintenance	4	2.9%
Check easements flood coping capacity	3	2.2%
Council approved construction/previous decision has led to more flooding/requires review	3	2.2%
Enforce house owners to drain properties into drains provided	3	2.2%

Other works to consider (cont.)

Suggestions	Frequency	Percent
Council should bear the cost	2	1.4%
Creek - adequately sized	2	1.4%
Survey to determine flood risk	2	1.4%
Check possible flood threat	1	0.7%
Creek bank erosion a problem - plants required	1	0.7%
Retaining wall around creek	1	0.7%
Risk assessment for every house in flood risk area	1	0.7%
Roof water to streets, not absorbtion pits	1	0.7%
Safer accessway to creek - previously car went into creek	1	0.7%
Use rubbish collecting grates in rivers	1	0.7%
Specific location mentioned	19	13.8%
Don't know/not actionable	3	2.2%

Specific locations mentioned

House no.	Address	Catchment	Comment
30	Jeanette Street, East Ryde, NSW 2113	Kittys Creek Catchment Area	Ensuring stormwater drains are well maintained and of sufficient size especially those in Wolfe Road and Rodney street. Overflowing drains there would runoff into our property
65	Melba Drive, East Ryde, NSW 2113	Kittys Creek Catchment Area	TO ASSES STREET STORM WATER SYSTEM CAPACITY AND RISK OF FLOODING PROPERTIES ALONG EASTERN SIDE OF MELBA DR.
132A	Cressy Road, East Ryde, NSW 2113	Kittys Creek Catchment Area	Clear creek bed at culvert under Harford St. specifically clear weed species from creek. Baffles also at Culvert to change flow characteristics.
15	Fox Road, East Ryde, NSW 2113	Kittys Creek Catchment Area	Curb + gutter + drain the end of Fox Rd.
21	Jeanette Street, East Ryde, NSW 2113	Kittys Creek Catchment Area	Clear rubbish/weed from Kittys creek to aid flow. Put fence onside 19, Jeanette St storm water drain.
11	Robinson Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	Stormwater drainage in to Buffalo Creek is too concentrated at the Laurel Park end of Robinson St. This should be improved to reduce the amount of run-off in to the creek in this area.

Specific locations mentioned (cont.)

House no.	Address	Catchment	Comment
107	Quarry Road, Ryde, NSW 2112	Buffalos Creek Catchment Area	Look at the residences above and check that the natuaral water has not been interrupted because we believe that the water has been directed to some backyards so it runs through neighbouring properties.
24	Clayton Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	Putting in place drainage works at the rear of properties in Clayton Street (Burrows Park side)
109	Buffalo Road, Ryde, NSW 2112	Buffalos Creek Catchment Area	Better drainage between the street and the front of our property (109 Buffalo Rd)
49	Monash Road, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Improve Drainage in westminster park
8	Leawill Place, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Clear out the storm water drain leading to field of mars reserve at the base of leawill place
34	Clayton Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	I do not know how the work you have dobne on 36 clayton street will affect my property

Specific locations mentioned (cont.)

House no.	Address	Catchment	Comment
6	Oates Avenue, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Council needs to ensure the drain at the lower end of the laneway at Westminster Park is cleared on a regular basis. If it is blocked during heavy rain, the water floods into adjoining properties.
8	Oates Avenue, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Drainage at rear; northern side of Westminster Park.
24	Minga Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	Adjust stormwater drain in Gannan Reserve
72	Monash Road, Gladesville, NSW 2111	Buffalos Creek Catchment Area	Improve stormwater drainage as has been done in other sections of Monash Road from buffalo to higginbotham. Curreent drainage is on the wrong side of the road.
142	Quarry Road, Ryde, NSW 2112	Buffalos Creek Catchment Area	Apply drains in goulding road
42	Pooley Street, Ryde, NSW 2112	Buffalos Creek Catchment Area	Fix the draiange problem on Pooley street in Ryde
46	Lane Cove Road, Ryde, NSW 2112	Buffalos Creek Catchment Area	Checking and clearing of easement pipes. It was blocked by Council i.e. we still had aprt of an old unblocked pipe on our property causing soil erosion and a partial collapse of part of our lawn with a toddler at our house.

Main issues identified

- 8% of respondents reported previously being flood affected
- 15% believed they could be affected by floods in the future
- Positioning of property, drain blockages were main reasons for future flooding
- 81% were not aware of any risk management measures

Recommendations

- To verify flood affected properties identified with GHD's mapping system
- Consider suggestions for additional works to reduce flood risk
- Communications strategy to ensure residents are made aware of the next stages of the flood plain risk management study

Appendix C – Design Flood Maps

C1.1 Buffalo Creek Flood Extents – 20%AEP

C1.2 Buffalo Creek Flood Extents – 5%AEP

C1.3 Buffalo Creek Flood Extents – 2%AEP

C1.4 Buffalo Creek Flood Extents – 1%AEP

C1.5 Buffalo Creek Flood Extents – PMF

C2.1 Kittys Creek Flood Extents – 20%AEP

C2.2 Kittys Creek Flood Extents – 5%AEP

C2.3 Kittys Creek Flood Extents – 2%AEP

C2.4 Kittys Creek Flood Extents – 1%AEP

C2.5 Kittys Creek Flood Extents – PMF

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Flood Depth (m)

0.00 - 0.05
0.05 - 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 1.00
1.00 - 2.00
2.00 - 3.00
Above 3.00

Catchment Boundary
Flood Level (mAHD)

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment
Flood Extents - 20% AEP

Job Number	21-21394
Revision	A
Date	27 Apr 2013

Figure C1.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C1 Buff 5yr.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Flood Depth (m)

0.00 - 0.05
0.05 - 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 1.00
1.00 - 2.00
2.00 - 3.00
Above 3.00

Catchment Boundary

Flood Level (mAHD)

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment
Flood Extents - 5% AEP

Job Number	21-21394
Revision	A
Date	27 Apr 2013

Figure C1.2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C1 Buff 20yr.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Flood Depth (m)

0.00 - 0.05
0.05 - 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 1.00
1.00 - 2.00
2.00 - 3.00
Above 3.00

Catchment Boundary

Flood Level (mAHD)

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment
Flood Extents - 2% AEP

Job Number	21-21394
Revision	A
Date	27 Apr 2013

Figure C1.3

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C1 Buff 50yr.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Flood Depth (m)

0.00 - 0.05
0.05 - 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
0.50 - 1.00
1.00 - 2.00
2.00 - 3.00
Above 3.00

Catchment Boundary

Flood Level (mAHD)

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment
Flood Extents - 1% AEP

Job Number	21-21394
Revision	A
Date	27 Apr 2013

Figure C1.4

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C1 Buff 100yr.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Flood Depth (m)

0.00 - 0.05, 0.05 - 0.10, 0.10 - 0.20, 0.20 - 0.40, 0.40 - 0.60, 0.06 - 1.00, 1.00 - 2.00, 2.00 - 3.00, 3.00 - 5.00, Above 5.00

Catchment Boundary
Flood Level (mAHD)

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment
Flood Extents - PMF Event

Job Number	21-21394
Revision	A
Date	27 Apr 2013

Figure C1.5

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C1 Buff PMF.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Flood Depth (m)

0.00 - 0.05, 0.05 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 1.75, 1.75 - 2.00, 2.00 - 2.25, 2.25 - 2.50, 2.50 - 2.75, 2.75 - 3.00, 3.00 - 3.25, 3.25 - 3.50, 3.50 - 3.75

Catchment Boundary
Flood Level (mAHD)

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Kitty Creek Catchment
Flood Extents - 20% AEP

Job Number	21-21394
Revision	A
Date	02 May 2013

Figure C2.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C6 Kitty 5yr.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Catchment Boundary — Flood Level (mAHD)

Flood Depth (m)

0.00 - 0.05, 0.05 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 1.75, 1.75 - 2.00, 2.00 - 2.25, 2.25 - 2.50, 2.50 - 2.75, 2.75 - 3.00, 3.00 - 3.25, 3.25 - 3.50, 3.50 - 4.50

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Job Number	21-21394
Revision	A
Date	27 Apr 2013

Kitty Creek Catchment
Flood Extents - 5% AEP

Figure C2.2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C6 Kitty 20yr.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Flood Depth (m)

0.00 - 0.05, 0.05 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 1.75, 1.75 - 2.00, 2.00 - 2.25, 2.25 - 2.50, 2.50 - 2.75, 2.75 - 3.00, 3.00 - 3.25, 3.25 - 3.50, 3.50 - 4.50

Catchment Boundary

Flood Level (mAHD)

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Job Number	21-21394
Revision	A
Date	27 Apr 2013

Kitty Creek Catchment
Flood Extents - 2% AEP

Figure C2.3

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C6 Kitty 50yr.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Catchment Boundary

Flood Level (mAHD)

Flood Depth (m)

0.00 - 0.05, 0.05 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 1.75, 1.75 - 2.00, 2.00 - 2.25, 2.25 - 2.50, 2.50 - 2.75, 2.75 - 3.00, 3.00 - 3.25, 3.25 - 3.50, 3.50 - 3.75

City of Ryde

GHD

City of Ryde Council
Buffalo and Kitty's Creek
Flood Study and FRMS

Kitty Creek Catchment
Flood Extents - 1% AEP

Job Number	21-21394
Revision	A
Date	27 Apr 2013

Figure C2.4

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C6 Kitty 100yr.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Flood Depth (m)

0.00 - 0.05, 0.05 - 0.50, 0.50 - 0.75, 0.75 - 1.00, 1.00 - 1.25, 1.25 - 1.50, 1.50 - 1.75, 1.75 - 2.00, 2.00 - 2.25, 2.25 - 2.50, 2.50 - 2.75, 2.75 - 3.00, 3.00 - 3.25, 3.25 - 3.50, 3.50 - 3.75

Catchment Boundary

Flood Level (mAHD)

City of Ryde

City of Ryde Council
Buffalo and Kitty's Creek
Flood Study and FRMS

Kitty Creek Catchment
Flood Extents - PMF Event

Job Number	21-21394
Revision	A
Date	27 Apr 2013

Figure C2.5

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Flood Mapping\C6 Kitty PMF.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Appendix D – Hazard Categorisation Maps

D1 Buffalo Creek Catchment Provisional Hazard Classification

D1 Kittys Creek Catchment Provisional Hazard Classification

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Catchment Boundary
- Properties Affected (From Survey)
- High Hazard
- Medium Hazard
- Low Hazard

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment
Hazard Classification

Job Number	21-21394
Revision	A
Date	07 Nov 2014

Figure D1

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Flood Study Report\Sensitivity Mapping\Buffalo_Creek_Results Hazard_Updated.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Catchment Boundary
- High Hazard
- Medium Hazard
- Low Hazard
- Properties Affected (From Survey)

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Kitty Creek Catchment
Hazard Classification

Job Number	21-21394
Revision	A
Date	07 Nov 2014

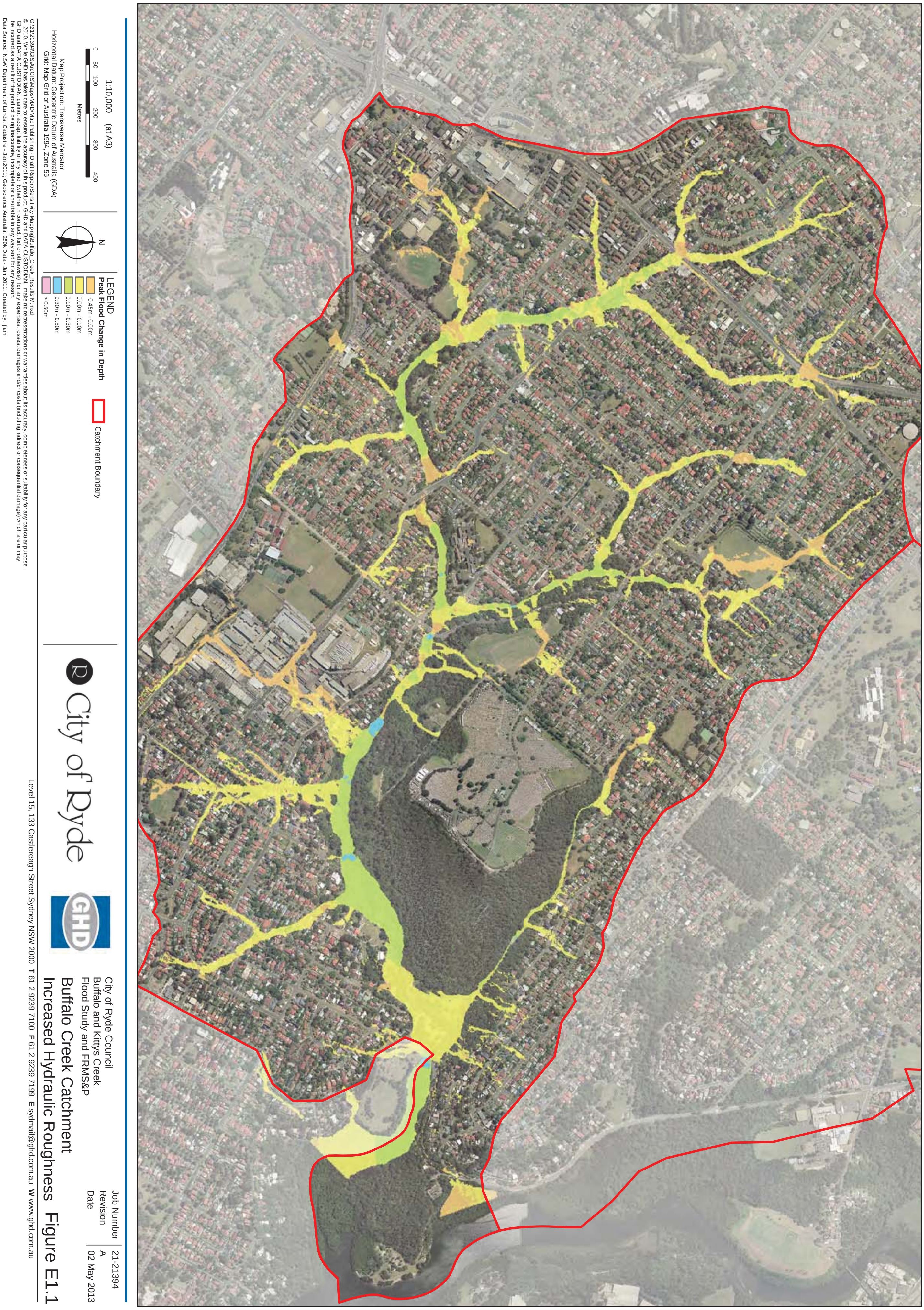
Figure D2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Flood Study Report\Sensitivity Mapping\Kitty_Creek_Results Hazard_Updated.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Appendix E – Sensitivity Analysis and Climate Change Maps


1:10,000 (at A3)
0 50 100 200 300 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56
N
LEGEND
Peak Flood Change in Depth
-0.45m - 0.00m
0.00m - 0.10m
0.10m - 0.30m
0.30m - 0.50m
> 0.50m
Catchment Boundary
City of Ryde
GHD
City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P
Buffalo Creek Catchment
Increased Hydraulic Roughness Figure E1.1
Job Number 21-21394
Revision A
Date 02 May 2013
Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:6,500 (at A3)
0 30 60 120 180 240
Metres
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56
N
LEGEND
Peak Flood Change in Depth (m)
-0.30m - 0.00m
0.00m - 0.10m
0.10m - 0.30m
0.30m - 0.50m
> 0.50m
Catchment Boundary
City of Ryde
GHD
Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au
City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P
Kitty Creek Catchment
Increased Hydraulic Roughness
Job Number 21-21394
Revision A
Date 02 May 2013
Figure E1.2

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Peak Flood Change in Depth (m)

- -0.45m - 0.00m
- 0.00m - 0.10m
- 0.10m - 0.30m
- 0.30m - 0.50m
- > 0.50m

Catchment Boundary

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment
30% Increase in Rainfall

Job Number	21-21394
Revision	A
Date	02 May 2013

Figure E2.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Sensitivity Mapping\Buffalo_Creek_Results CC.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Peak Flood Change in Depth (m)

- -0.30m - 0.00m
- 0.00m - 0.10m
- 0.10m - 0.30m
- 0.30m - 0.50m
- > 0.50m

Catchment Boundary

City of Ryde

GHD

City of Ryde Council
Buffalo and Kitty's Creek
Flood Study and FRMS

Kitty Creek Catchment
30% Increase in Rainfall

Job Number	21-21394
Revision	A
Date	02 May 2013

Figure E2.2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Sensitivity Mapping\Kitty_Creek_Results CC.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Peak Flood Depth Level Change (m)

- -0.45 - 0.00
- 0.00 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00

Catchment Boundary

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment
Sea Level Rise - year 2050

Job Number	21-21394
Revision	A
Date	02 May 2013

Figure E3.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Sensitivity Mapping\Buffalo_Creek_Results 2050.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Peak Flood Depth Level Change (m)

- -0.30m - 0.00m
- 0.00m - 0.10m
- 0.10m - 0.30m
- 0.30m - 0.50m
- > 0.50m

Catchment Boundary

City of Ryde

City of Ryde Council
Buffalo and Kitty's Creek
Flood Study and FRMS

Job Number	21-21394
Revision	A
Date	02 May 2013

Kitty Creek Catchment
Sea Level Rise - year 2050

Figure E3.2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Sensitivity Mapping\Kitty_Creek_Results SLR2050.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Peak Flood Change in Depth (m)

- -0.45 - 0.00
- 0.00 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- > 0.50

Catchment Boundary

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment
Sea Level Rise - year 2100

Job Number	21-21394
Revision	A
Date	02 May 2013

Figure E4.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Sensitivity Mapping\Buffalo_Creek_Results 2100.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

Peak Flood Change in Depth (m)

- -0.30m - 0.00m
- 0.00m - 0.10m
- 0.10m - 0.30m
- 0.30m - 0.50m
- > 0.50m

Catchment Boundary

City of Ryde

GHD

City of Ryde Council
Buffalo and Kitty's Creek
Flood Study and FRMS

Job Number	21-21394
Revision	A
Date	02 May 2013

Kitty Creek Catchment
Sea Level Rise - year 2100

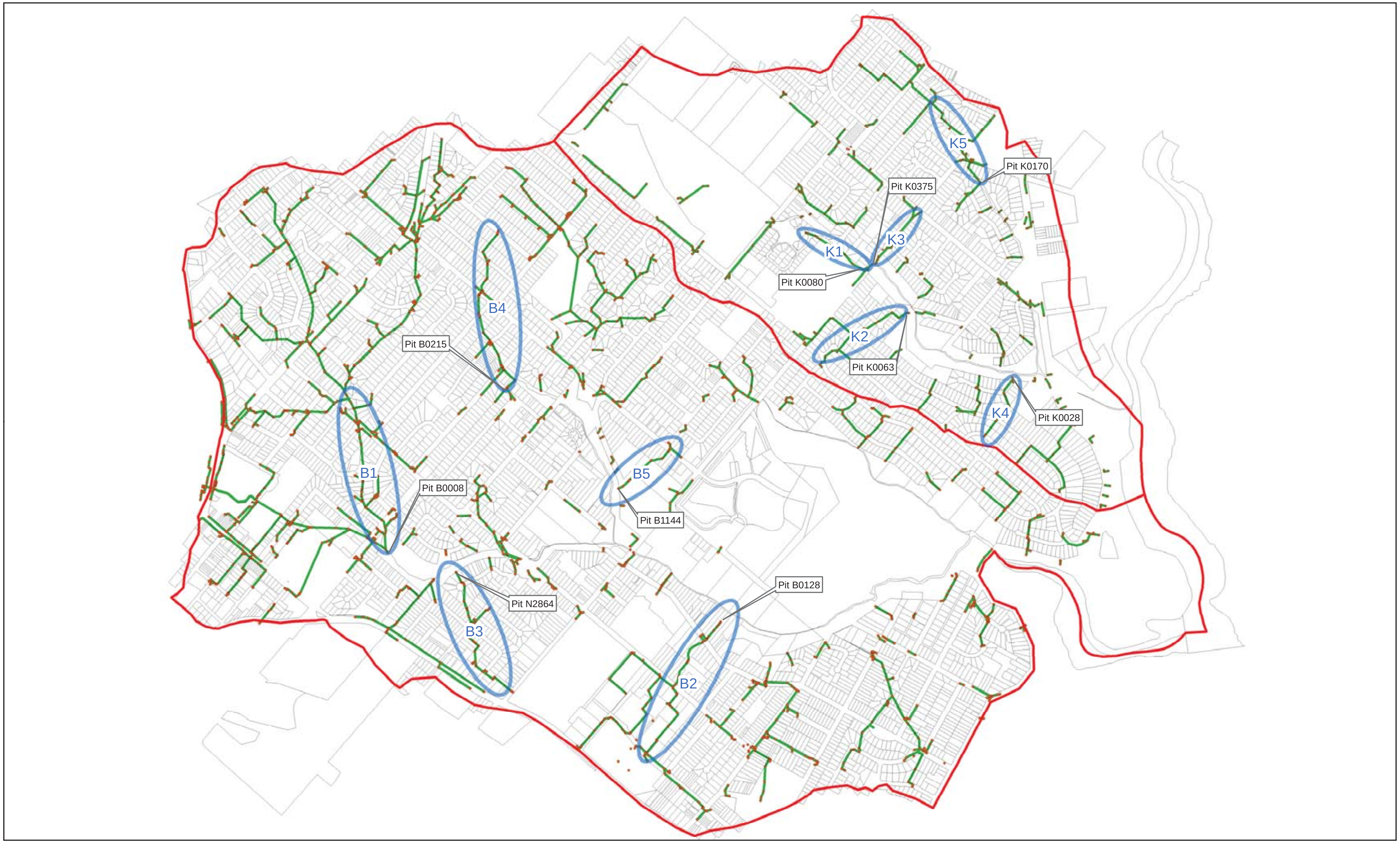
Figure E4.2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Report\Sensitivity Mapping\Kitty_Creek_Results SLR2100.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Appendix F – Low Flow Analysis



1:12,500 (at A3)

0 62.5 125 250 375 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Catchment Boundary
- Lot Cadastral
- Buffalo Catchment Stormwater Pits/Junctions
- Buffalo Catchment Stormwater Pipes
- Long Section Locations

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

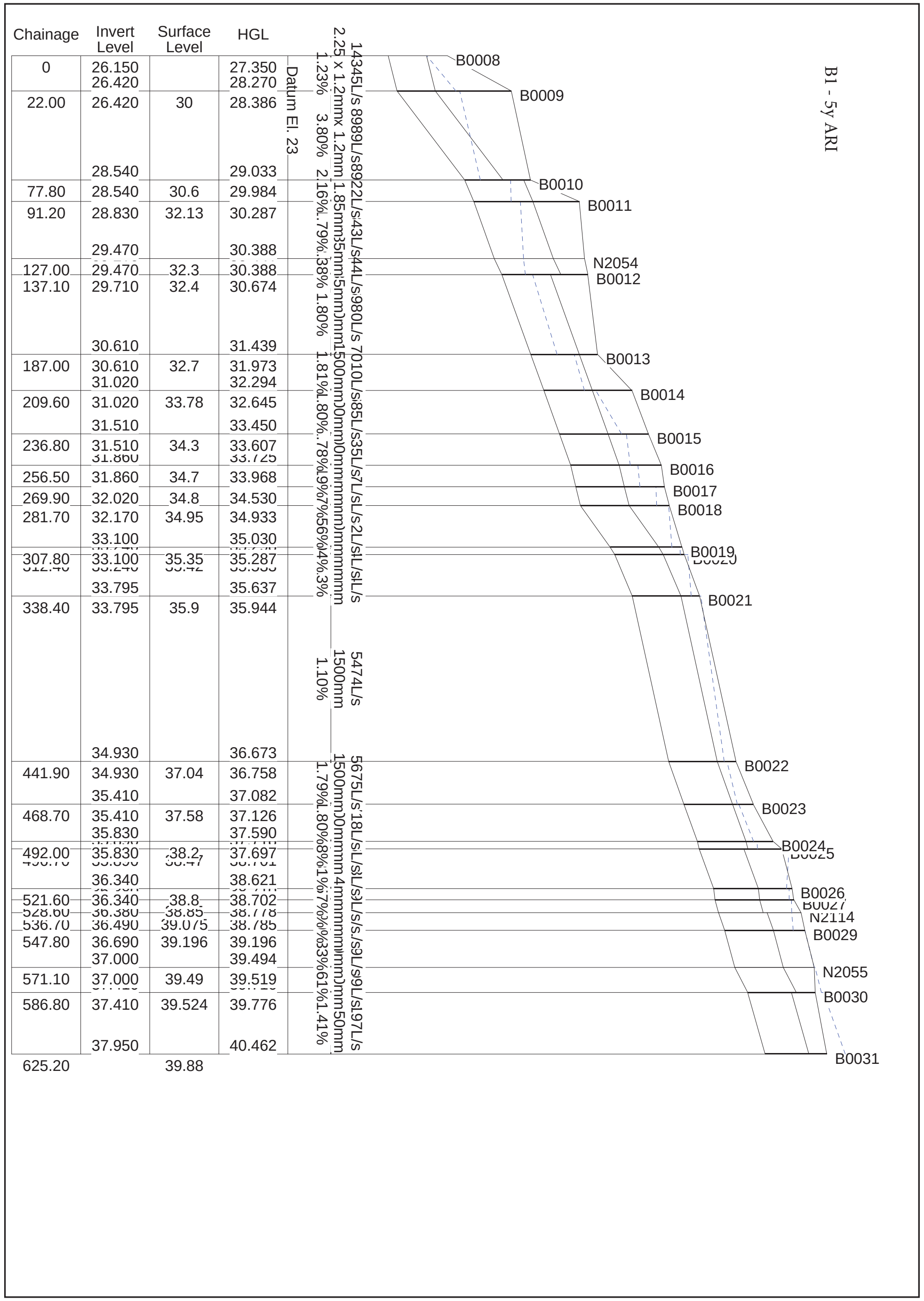
Low Flow Assessment
Long Section Locations

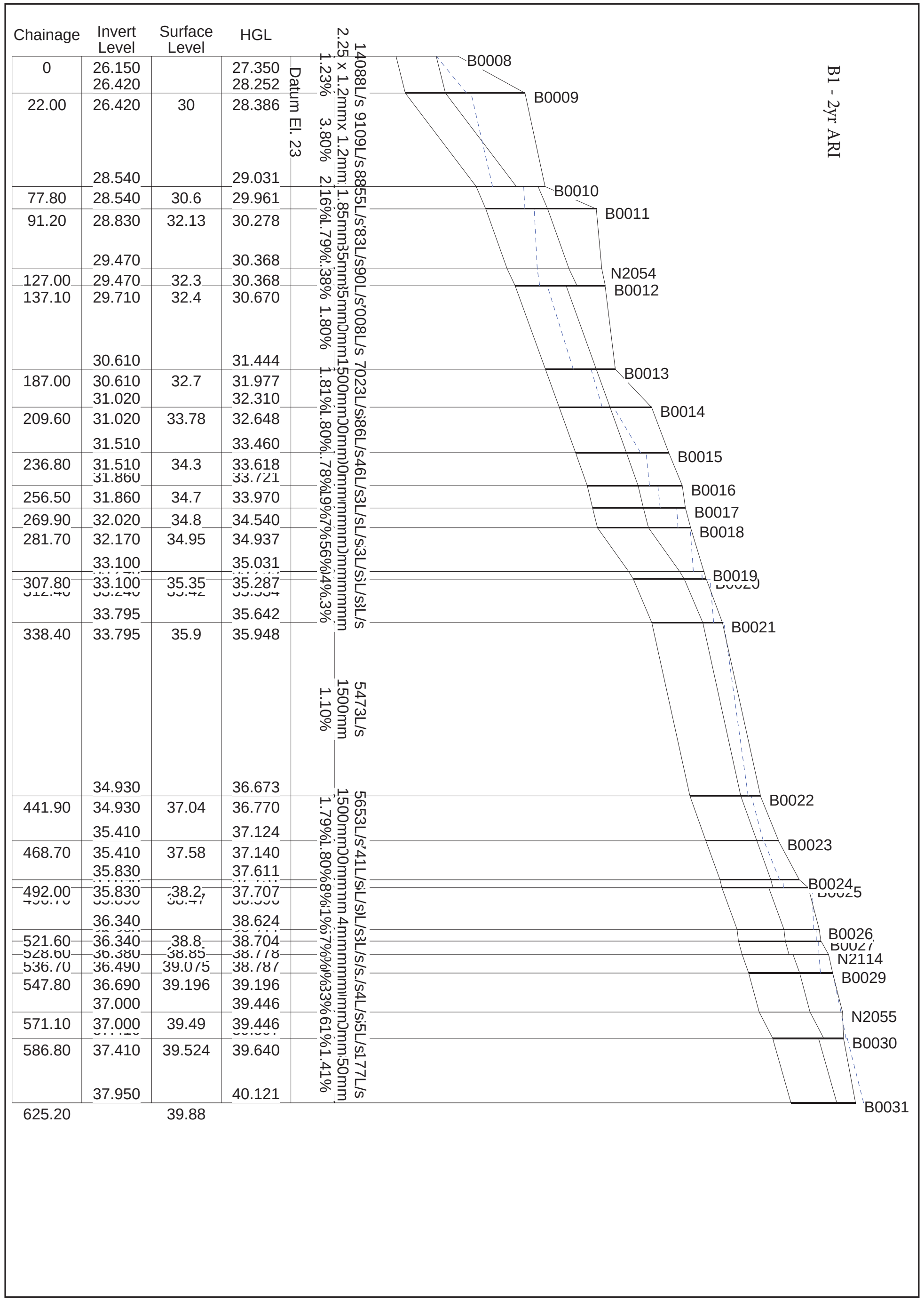
Job Number	21-21394
Revision	A
Date	06 Nov 2014

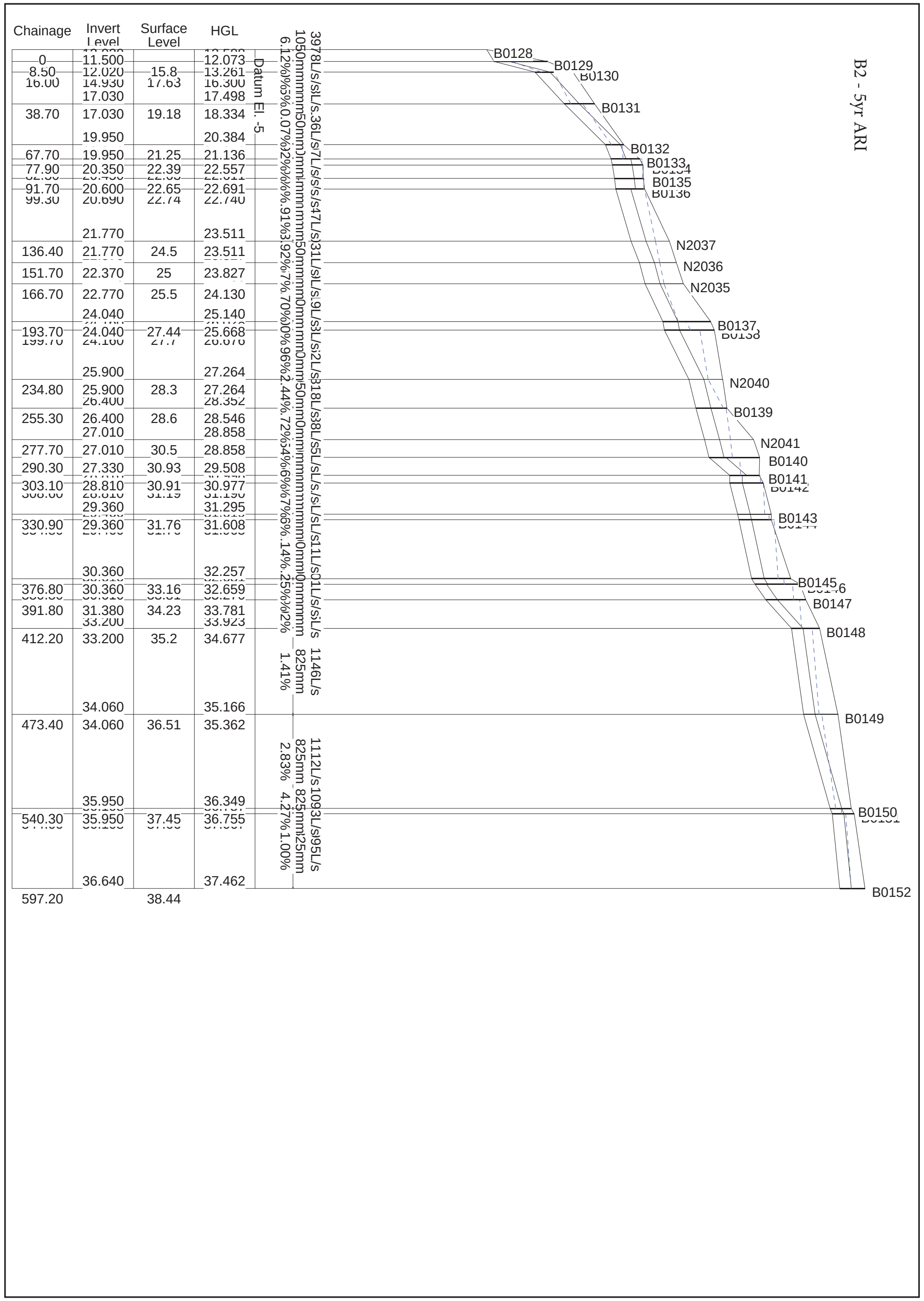
G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Low Flow\A3.1Low Flow Pipe Network Buff.mxd

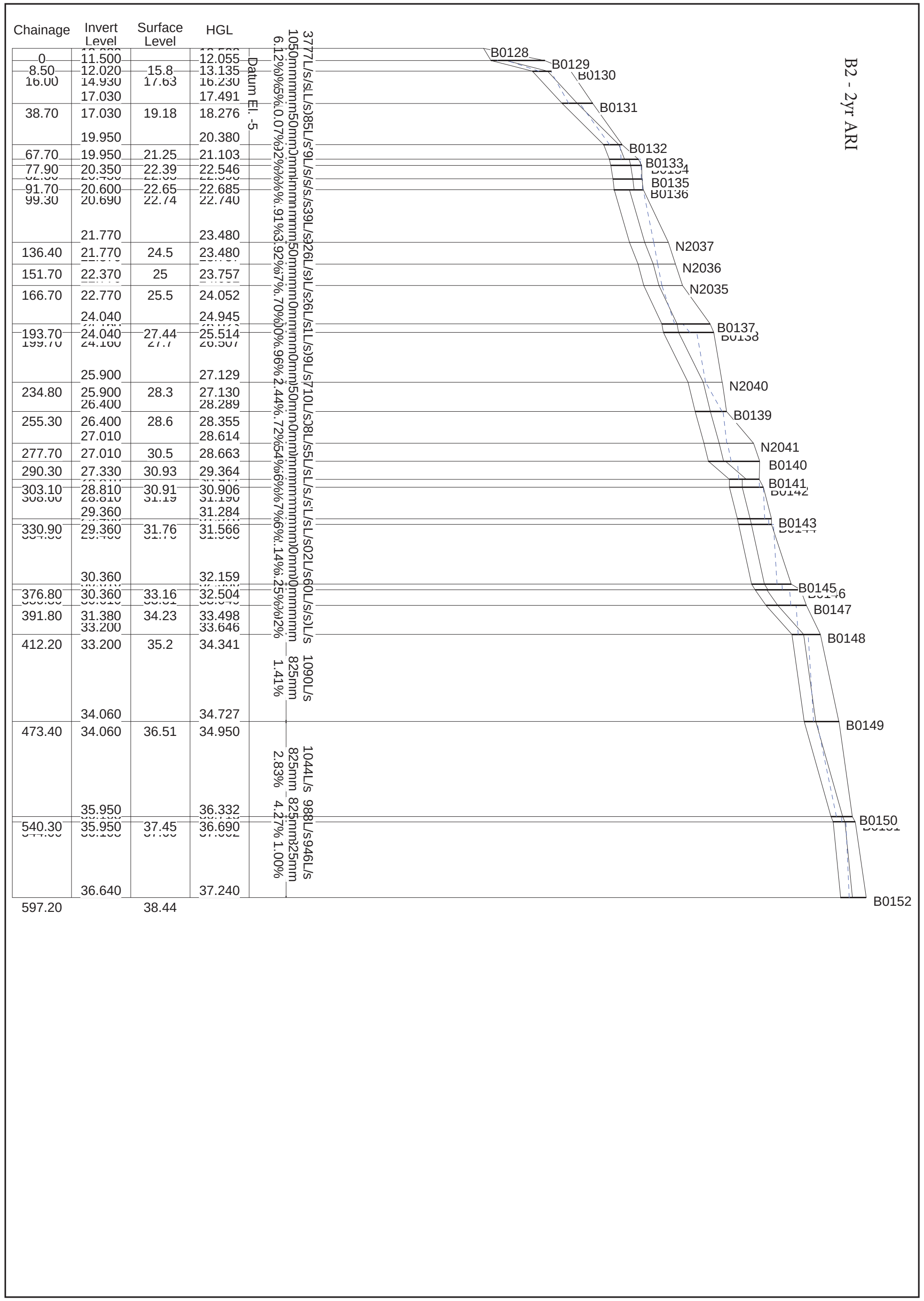
Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

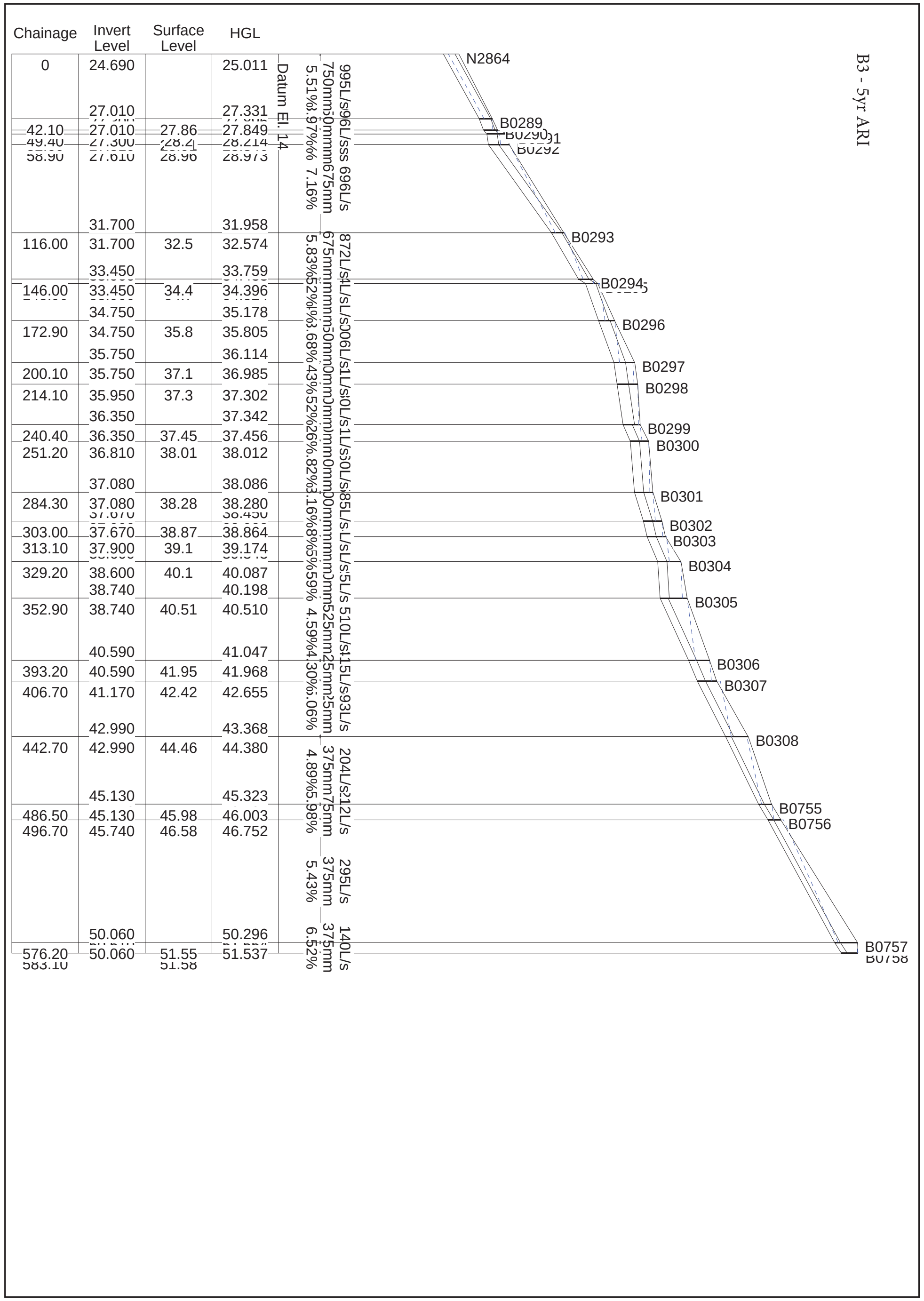
Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

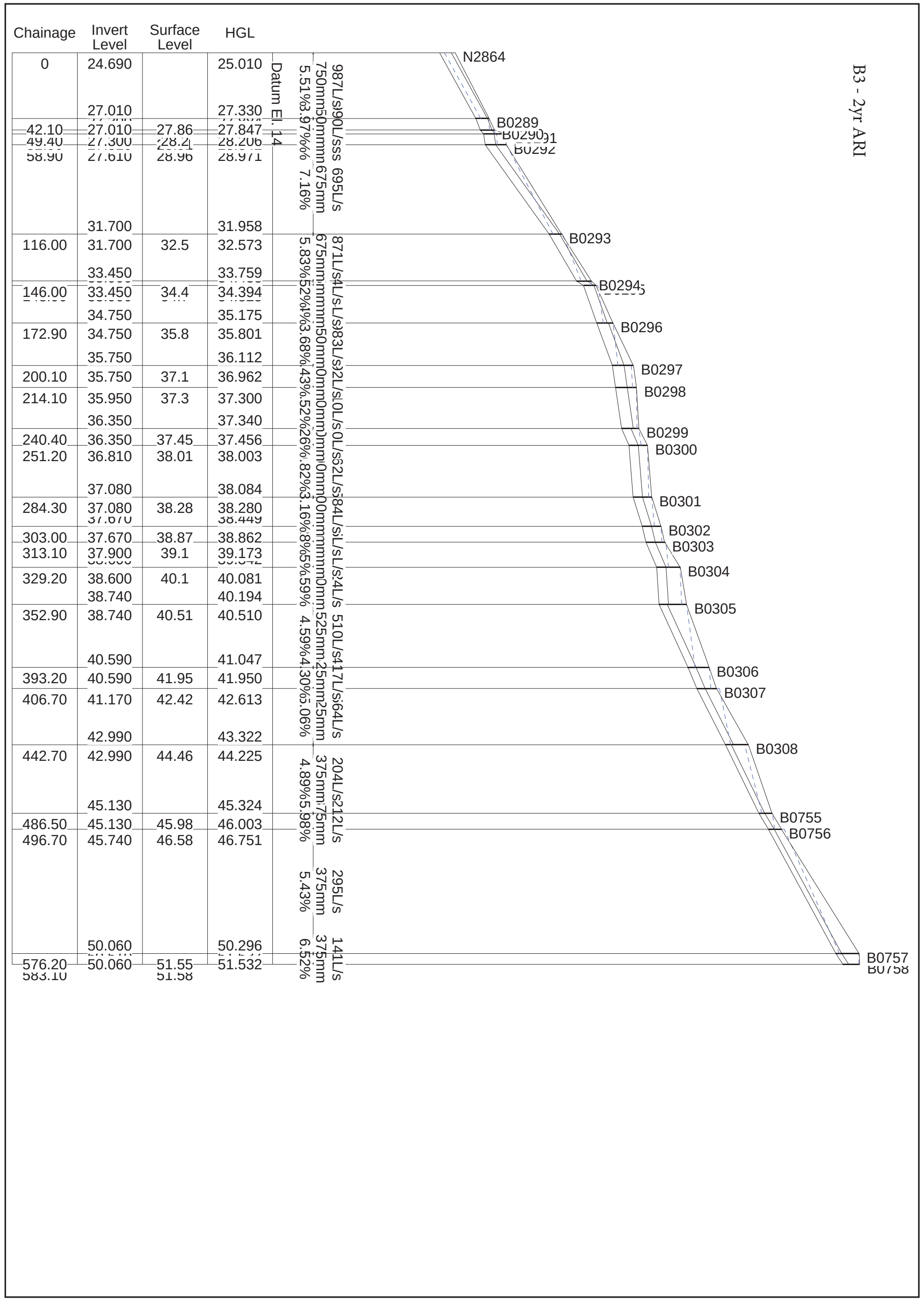

B1 - 5y ARI
Chainage
Invert Level
Surface Level
HGL
Datum El. 23
0 26.150 27.350
26.420 28.270
22.00 26.420 30 28.386
28.540 29.033
77.80 28.540 30.6 29.984
91.20 28.830 32.13 30.287
29.470 30.388
127.00 29.470 32.3 30.388
137.10 29.710 32.4 30.674
30.610 31.439
187.00 30.610 32.7 31.973
31.020 32.294
209.60 31.020 33.78 32.645
31.510 33.450
236.80 31.510 34.3 33.607
256.50 31.860 34.7 33.968
269.90 32.020 34.8 34.530
281.70 32.170 34.95 34.933
33.100 35.030
307.80 33.100 35.35 35.287
33.795 35.637
338.40 33.795 35.9 35.944
34.930 36.673
441.90 34.930 37.04 36.758
35.410 37.082
468.70 35.410 37.58 37.126
35.830 37.590
492.00 35.830 38.2 37.697
36.340 38.621
521.60 36.340 38.8 38.702
528.60 36.380 38.85 38.778
536.70 36.490 39.075 38.785
547.80 36.690 39.196 39.196
37.000 39.494
571.10 37.000 39.49 39.519
586.80 37.410 39.524 39.776
37.950 40.462
625.20 39.88
14345L/s
2.25 x 1.2mm
1.23%
5474L/s
1500mm
1.10%
B0008
B0009
B0010
B0011
N2054
B0012
B0013
B0014
B0015
B0016
B0017
B0018
B0019
B0021
B0022
B0023
B0024
B0026
N2114
B0029
N2055
B0030
B0031

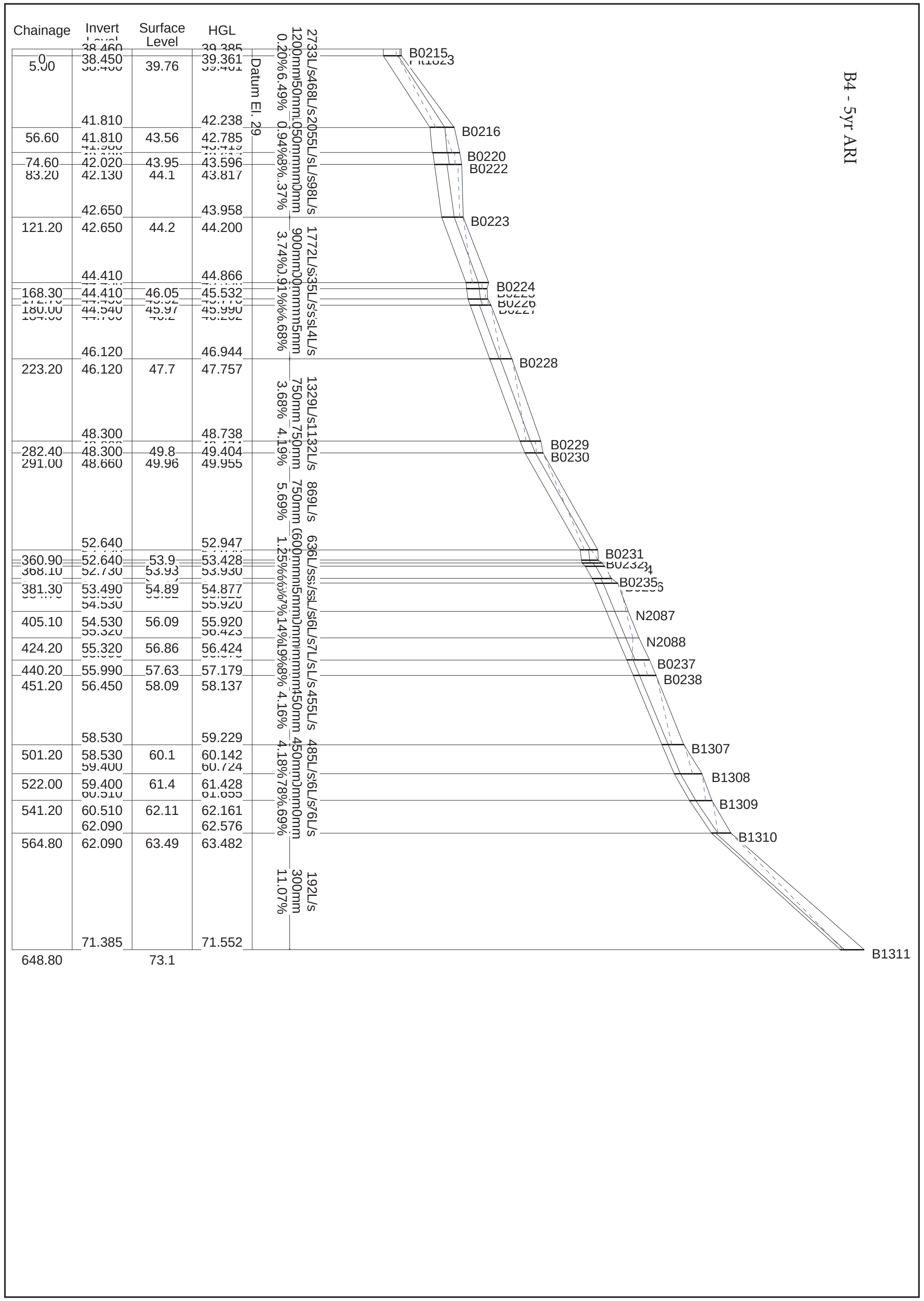

B1 - 2yr ARI
Chainage
Invert Level
Surface Level
HGL
Datum El. 23
0 26.150 27.350
26.420 28.252
22.00 26.420 30 28.386
28.540 29.031
77.80 28.540 30.6 29.961
91.20 28.830 32.13 30.278
29.470 30.368
127.00 29.470 32.3 30.368
137.10 29.710 32.4 30.670
30.610 31.444
187.00 30.610 32.7 31.977
31.020 32.310
209.60 31.020 33.78 32.648
31.510 33.460
236.80 31.510 34.3 33.618
256.50 31.860 34.7 33.970
269.90 32.020 34.8 34.540
281.70 32.170 34.95 34.937
33.100 35.031
307.80 33.100 35.35 35.287
33.795 35.642
338.40 33.795 35.9 35.948
34.930 36.673
441.90 34.930 37.04 36.770
35.410 37.124
468.70 35.410 37.58 37.140
35.830 37.611
492.00 35.830 38.2 37.707
36.340 38.624
521.60 36.340 38.8 38.704
528.60 36.380 38.85 38.778
536.70 36.490 39.075 38.787
547.80 36.690 39.196 39.196
37.000 39.446
571.10 37.000 39.49 39.446
586.80 37.410 39.524 39.640
37.950 40.121
625.20 39.88
14088L/s
2.25 x 1.2mm
1.23%
5473L/s
1500mm
1.10%
B0008
B0009
B0010
B0011
N2054
B0012
B0013
B0014
B0015
B0016
B0017
B0018
B0019
B0021
B0022
B0023
B0024
B0026
N2114
B0029
N2055
B0030
B0031

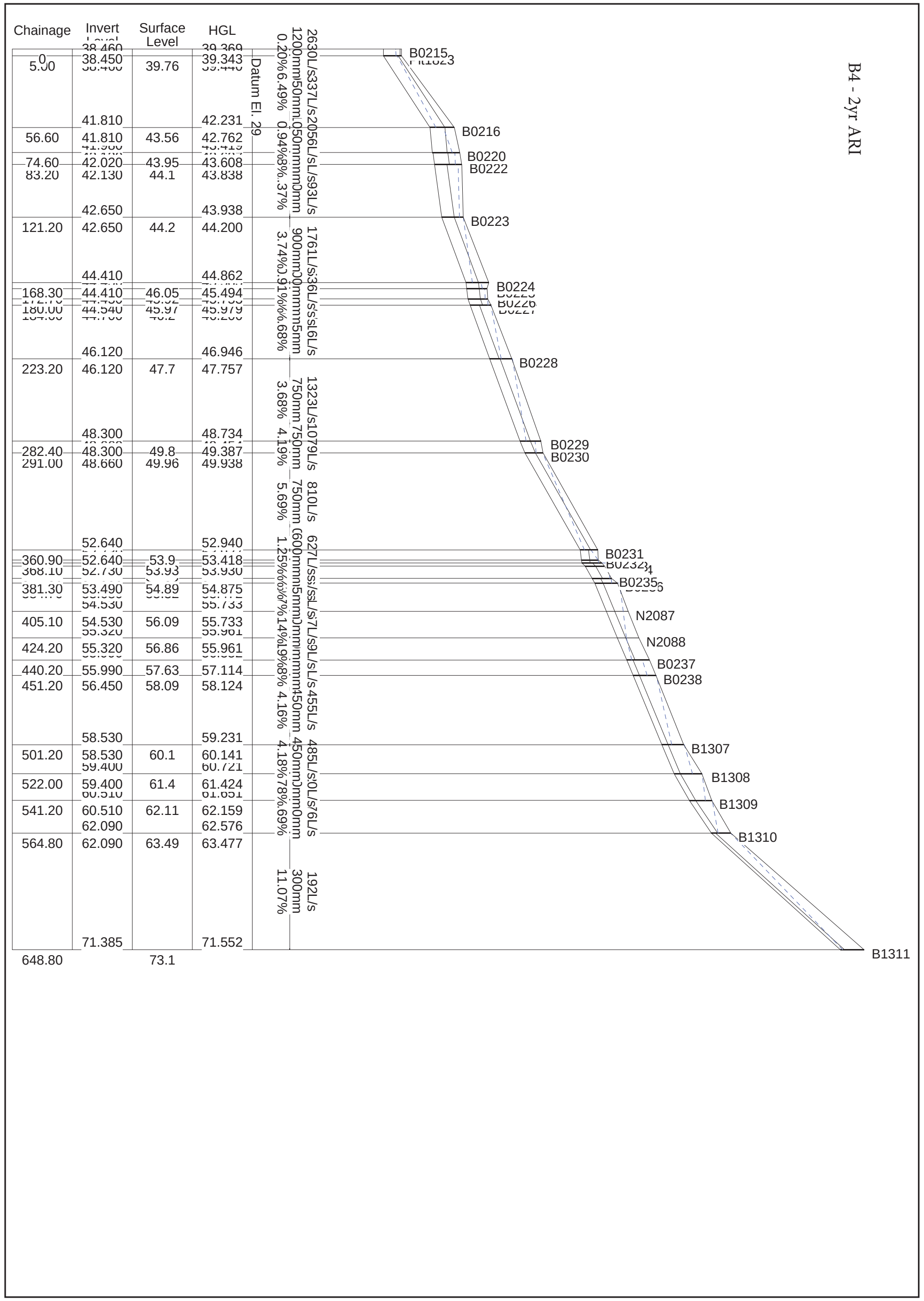

Chainage
Invert Level
Surface Level
HGL
Datum El. -5
B2 - 5yr ARI
0 | 11.500 | | 12.073
8.50 | 12.020 | 15.8 | 13.261
16.00 | 14.930 | 17.63 | 16.300
17.030 | 17.498
38.70 | 17.030 | 19.18 | 18.334
19.950 | 20.384
67.70 | 19.950 | 21.25 | 21.136
77.90 | 20.350 | 22.39 | 22.557
91.70 | 20.600 | 22.65 | 22.691
99.30 | 20.690 | 22.74 | 22.740
21.770 | 23.511
136.40 | 21.770 | 24.5 | 23.511
151.70 | 22.370 | 25 | 23.827
166.70 | 22.770 | 25.5 | 24.130
24.040 | 25.140
193.70 | 24.040 | 27.44 | 25.668
199.70 | 24.160 | 27.7 | 26.076
25.900 | 27.264
234.80 | 25.900 | 28.3 | 27.264
26.400 | 28.352
255.30 | 26.400 | 28.6 | 28.546
27.010 | 28.858
277.70 | 27.010 | 30.5 | 28.858
290.30 | 27.330 | 30.93 | 29.508
303.10 | 28.810 | 30.91 | 30.977
29.360 | 31.295
330.90 | 29.360 | 31.76 | 31.608
30.360 | 32.257
376.80 | 30.360 | 33.16 | 32.659
391.80 | 31.380 | 34.23 | 33.781
33.200 | 33.923
412.20 | 33.200 | 35.2 | 34.677
34.060 | 35.166
473.40 | 34.060 | 36.51 | 35.362
35.950 | 36.349
540.30 | 35.950 | 37.45 | 36.755
36.640 | 37.462
597.20 | | 38.44
1146L/s 825mm 1.41%
1112L/s 825mm 2.83%
1093L/s 825mm 4.27%
995L/s 825mm 1.00%
B0128
B0129
B0130
B0131
B0132
B0133
B0134
B0135
B0136
N2037
N2036
N2035
B0137
B0138
N2040
B0139
N2041
B0140
B0141
B0142
B0143
B0144
B0145
B0146
B0147
B0148
B0149
B0150
B0151
B0152

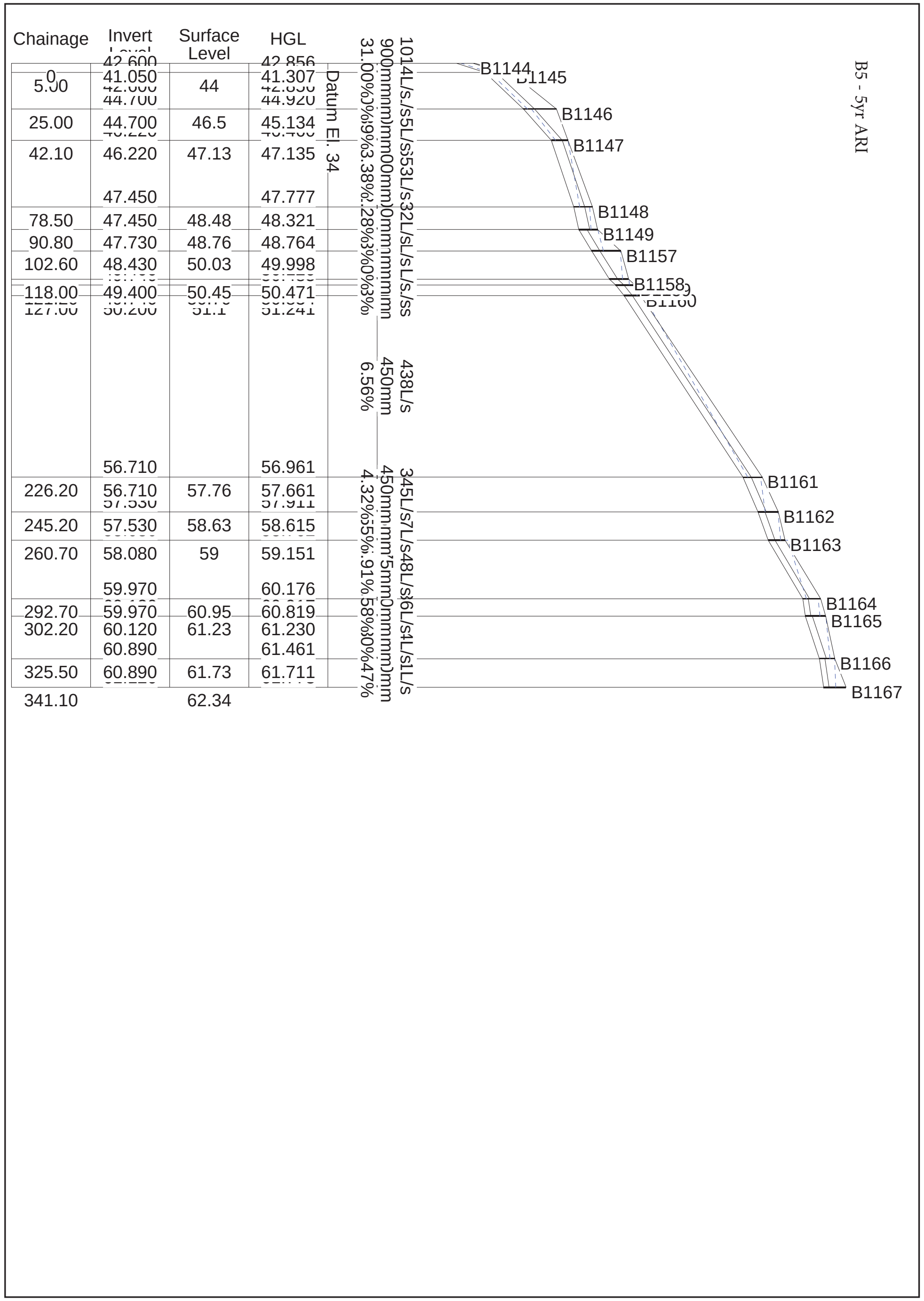

Chainage
Invert Level
Surface Level
HGL
Datum El. -5
B2 - 2yr ARI
0 | 11.500 | | 12.055
8.50 | 12.020 | 15.8 | 13.135
16.00 | 14.930 | 17.63 | 16.230
17.030 | 17.491
38.70 | 17.030 | 19.18 | 18.276
19.950 | 20.380
67.70 | 19.950 | 21.25 | 21.103
77.90 | 20.350 | 22.39 | 22.546
91.70 | 20.600 | 22.65 | 22.685
99.30 | 20.690 | 22.74 | 22.740
21.770 | 23.480
136.40 | 21.770 | 24.5 | 23.480
151.70 | 22.370 | 25 | 23.757
166.70 | 22.770 | 25.5 | 24.052
24.040 | 24.945
193.70 | 24.040 | 27.44 | 25.514
199.70 | 24.160 | 27.7 | 26.507
25.900 | 27.129
234.80 | 25.900 | 28.3 | 27.130
26.400 | 28.289
255.30 | 26.400 | 28.6 | 28.355
27.010 | 28.614
277.70 | 27.010 | 30.5 | 28.663
290.30 | 27.330 | 30.93 | 29.364
303.10 | 28.810 | 30.91 | 30.906
29.360 | 31.284
330.90 | 29.360 | 31.76 | 31.566
30.360 | 32.159
376.80 | 30.360 | 33.16 | 32.504
391.80 | 31.380 | 34.23 | 33.498
33.200 | 33.646
412.20 | 33.200 | 35.2 | 34.341
34.060 | 34.727
473.40 | 34.060 | 36.51 | 34.950
35.950 | 36.332
540.30 | 35.950 | 37.45 | 36.690
36.640 | 37.240
597.20 | | 38.44
1090L/s 825mm 1.41%
1044L/s 825mm 2.83%
998L/s 825mm 4.27%
946L/s 825mm 1.00%
B0128
B0129
B0130
B0131
B0132
B0133
B0134
B0135
B0136
N2037
N2036
N2035
B0137
B0138
N2040
B0139
N2041
B0140
B0141
B0142
B0143
B0144
B0145
B0146
B0147
B0148
B0149
B0150
B0151
B0152

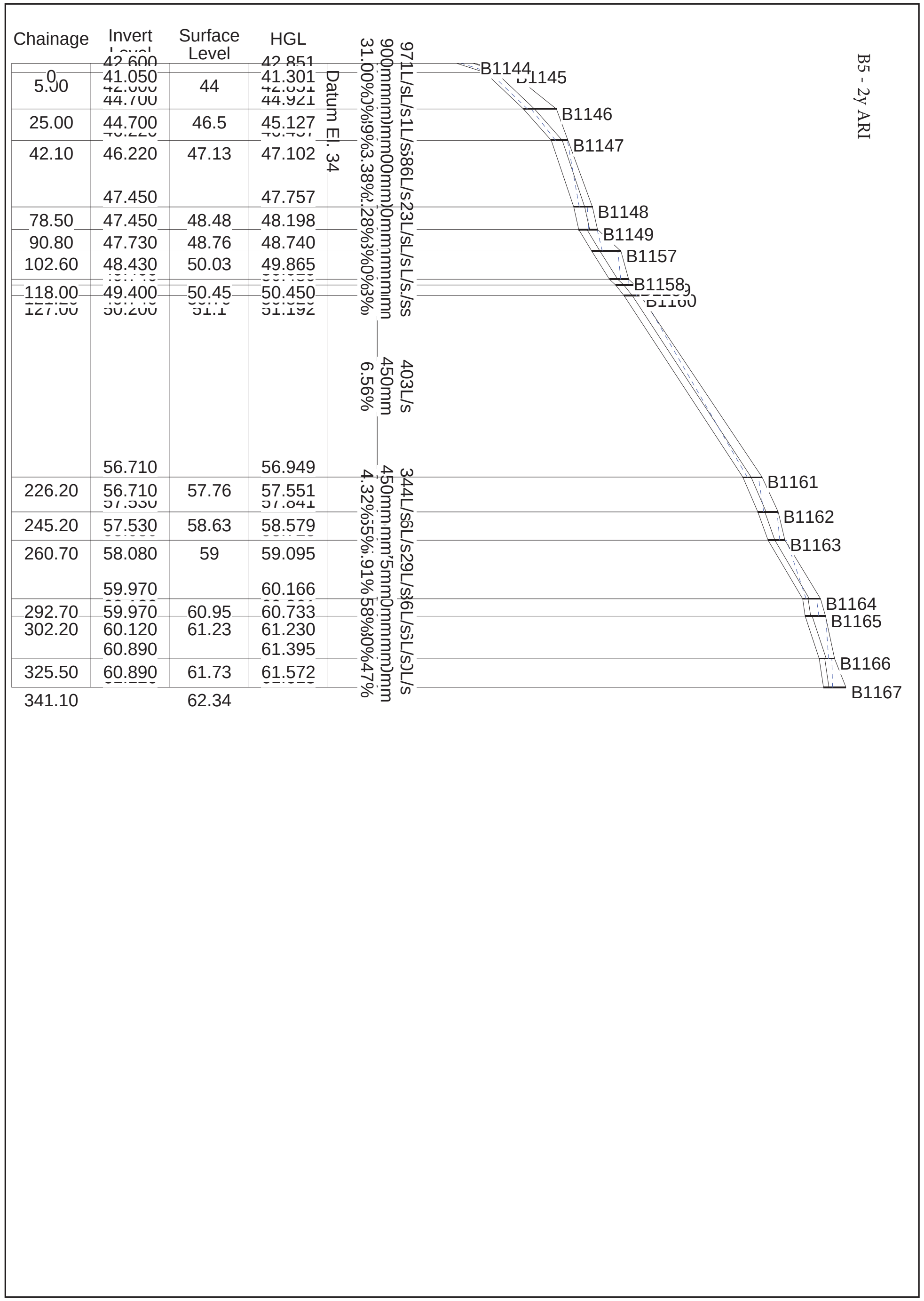

B3 - 5yr ARI
Chainage
Invert Level
Surface Level
HGL
Datum El. 14
0 24.690 25.011
27.010 27.331
42.10 27.010 27.86 27.849
49.40 27.300 28.214
58.90 27.610 28.96 28.973
31.700 31.958
116.00 31.700 32.5 32.574
33.450 33.759
146.00 33.450 34.4 34.396
34.750 35.178
172.90 34.750 35.8 35.805
35.750 36.114
200.10 35.750 37.1 36.985
214.10 35.950 37.3 37.302
36.350 37.342
240.40 36.350 37.45 37.456
251.20 36.810 38.01 38.012
37.080 38.086
284.30 37.080 38.28 38.280
303.00 37.670 38.87 38.864
313.10 37.900 39.1 39.174
329.20 38.600 40.1 40.087
38.740 40.198
352.90 38.740 40.51 40.510
40.590 41.047
393.20 40.590 41.95 41.968
406.70 41.170 42.42 42.655
42.990 43.368
442.70 42.990 44.46 44.380
45.130 45.323
486.50 45.130 45.98 46.003
496.70 45.740 46.58 46.752
50.060 50.296
576.20 50.060 51.55 51.537
583.10 51.58
N2864
B0289
B0290
B0292
B0293
B0294
B0296
B0297
B0298
B0299
B0300
B0301
B0302
B0303
B0304
B0305
B0306
B0307
B0308
B0755
B0756
B0757
B0758
995L/s 750mm 5.51%
696L/s 675mm 7.16%
872L/s 675mm 5.83%
510L/s 525mm 4.59%
204L/s 375mm 4.89%
295L/s 375mm 5.43%
140L/s 375mm 6.52%


B3 - 2yr ARI
Chainage
Invert Level
Surface Level
HGL
Datum El. 14
0 24.690 25.010
27.010 27.330
42.10 27.010 27.86 27.847
49.40 27.300 28.206
58.90 27.610 28.96 28.971
31.700 31.958
116.00 31.700 32.5 32.573
33.450 33.759
146.00 33.450 34.4 34.394
34.750 35.175
172.90 34.750 35.8 35.801
35.750 36.112
200.10 35.750 37.1 36.962
214.10 35.950 37.3 37.300
36.350 37.340
240.40 36.350 37.45 37.456
251.20 36.810 38.01 38.003
37.080 38.084
284.30 37.080 38.28 38.280
303.00 37.670 38.87 38.862
313.10 37.900 39.1 39.173
329.20 38.600 40.1 40.081
38.740 40.194
352.90 38.740 40.51 40.510
40.590 41.047
393.20 40.590 41.95 41.950
406.70 41.170 42.42 42.613
42.990 43.322
442.70 42.990 44.46 44.225
45.130 45.324
486.50 45.130 45.98 46.003
496.70 45.740 46.58 46.751
50.060 50.296
576.20 50.060 51.55 51.532
583.10 51.58
N2864
B0289
B0290
B0292
B0293
B0294
B0296
B0297
B0298
B0299
B0300
B0301
B0302
B0303
B0304
B0305
B0306
B0307
B0308
B0755
B0756
B0757
B0758
987L/s 750mm 5.51%
695L/s 675mm 7.16%
871L/s 675mm 5.83%
510L/s 525mm 4.59%
204L/s 375mm 4.89%
295L/s 375mm 5.43%
141L/s 375mm 6.52%


B4 - 5yr ARI
Chainage
Invert Level
Surface Level
HGL
Datum El. 29
B0215
B0216
B0220
B0222
B0223
B0224
B0228
B0229
B0230
B0231
B0235
N2087
N2088
B0237
B0238
B1307
B1308
B1309
B1310
B1311


B4 - 2yr ARI
Chainage
Invert Level
Surface Level
HGL
Datum El. 29
B0215
B0216
B0220
B0222
B0223
B0224
B0228
B0229
B0230
B0231
B0235
N2087
N2088
B0237
B0238
B1307
B1308
B1309
B1310
B1311

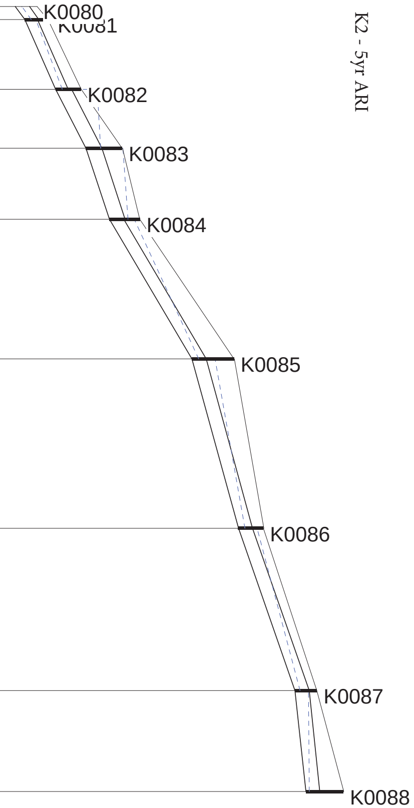

Chainage
Invert Level
Surface Level
HGL
Datum El. 34
B5 - 5yr ARI
0
5.00
25.00
42.10
78.50
90.80
102.60
118.00
127.00
226.20
245.20
260.70
292.70
302.20
325.50
341.10
42.600
41.050
44.700
44.700
46.220
47.450
47.450
47.730
48.430
49.400
50.200
56.710
56.710
57.530
57.530
58.080
59.970
59.970
60.120
60.890
60.890
44
46.5
47.13
48.48
48.76
50.03
50.45
51.1
57.76
58.63
59
60.95
61.23
61.73
62.34
42.856
41.307
44.920
45.134
47.135
47.777
48.321
48.764
49.998
50.471
51.241
56.961
57.661
57.911
58.615
59.151
60.176
60.819
61.230
61.461
61.711
438L/s
450mm
6.56%
B1144
B1145
B1146
B1147
B1148
B1149
B1157
B1158
B1160
B1161
B1162
B1163
B1164
B1165
B1166
B1167


Chainage
Invert Level
Surface Level
HGL
Datum El. 34
B5 - 2y ARI
0
5.00
25.00
42.10
78.50
90.80
102.60
118.00
127.00
226.20
245.20
260.70
292.70
302.20
325.50
341.10
42.600
41.050
44.700
44.700
46.220
47.450
47.450
47.730
48.430
49.400
50.200
56.710
56.710
57.530
57.530
58.080
59.970
59.970
60.120
60.890
60.890
44
46.5
47.13
48.48
48.76
50.03
50.45
51.1
57.76
58.63
59
60.95
61.23
61.73
62.34
42.851
41.301
44.921
45.127
47.102
47.757
48.198
48.740
49.865
50.450
51.192
56.949
57.551
57.841
58.579
59.095
60.166
60.733
61.230
61.395
61.572
403L/s
450mm
6.56%
B1144
B1145
B1146
B1147
B1148
B1149
B1157
B1158
B1160
B1161
B1162
B1163
B1164
B1165
B1166
B1167

K2 - 5yr ARI

Datum El. 21

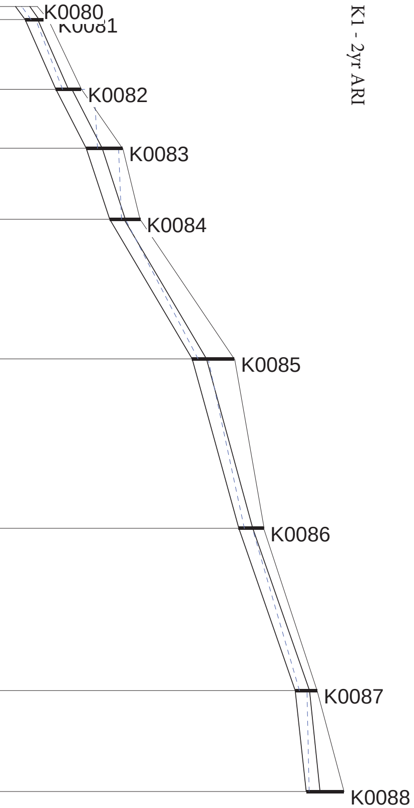
Chainage	Invert Level	Surface Level	HGL	Pipe
	29.680		29.986	
0	29.240		29.545	
3.20	29.680	30.78	30.202	1118L/s6L/s244L/s.296L/s 675mm)mm750mm750mm 13.75%2%10.21%6.63%
	31.160		31.479	
19.80	31.160	32.36	33.124	
	32.590		33.292	
33.80	32.590	34.32	34.354	
	33.710		34.586	
50.70	33.710	35.16	34.891	1106L/s 675mm 11.84%
	37.640		37.944	
83.90	37.640	39.64	38.723	869L/s 675mm 5.46%
	39.840		40.154	
124.20	39.840	41.04	40.726	567L/s 675mm 6.97%
	42.530		42.763	
162.80	42.530	43.57	43.175	187L/s 675mm 2.13%
	43.040		43.218	
186.80		44.84		



K1 - 2yr ARI

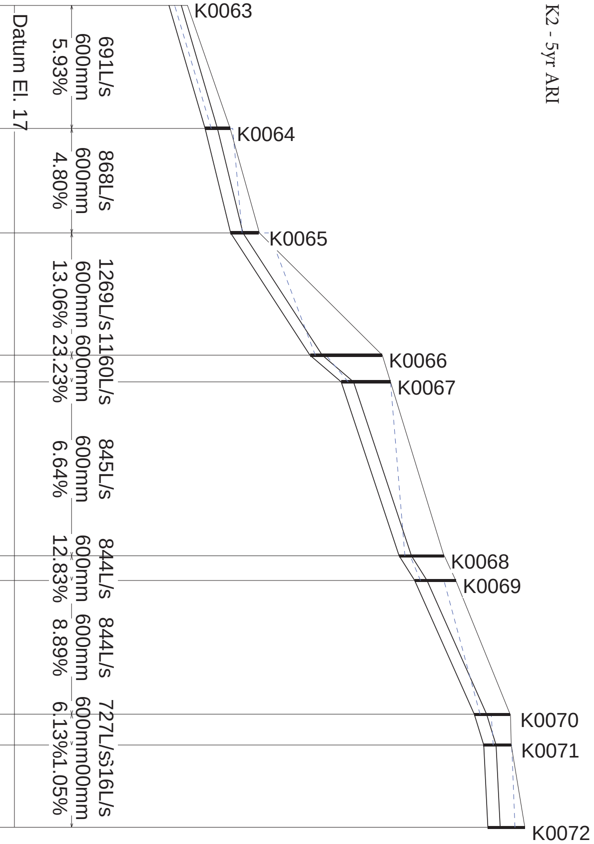
Datum El. 21

Chainage	Invert Level	Surface Level	HGL	Pipe
	29.680		29.978	
0	29.240		29.538	
3.20	29.680	30.78	30.189	1072L/sJL/sL185L/s.008L/s 675mm)mm750mm750mm 13.75%2%10.21%6.63%
	31.160		31.470	
19.80	31.160	32.36	32.969	
	32.590		33.137	
33.80	32.590	34.32	34.123	
	33.710		34.266	
50.70	33.710	35.16	34.451	875L/s 675mm 11.84%
	37.640		37.907	
83.90	37.640	39.64	38.395	701L/s 675mm 5.46%
	39.840		40.119	
124.20	39.840	41.04	40.497	463L/s 675mm 6.97%
	42.530		42.739	
162.80	42.530	43.57	43.084	147L/s 675mm 2.13%
	43.040		43.198	
186.80		44.84		



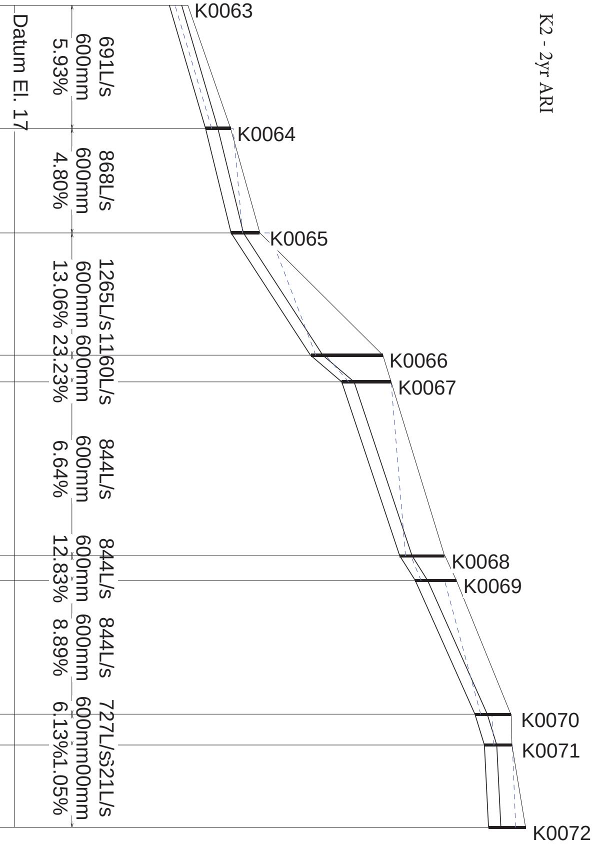
K2 - 5yr ARI

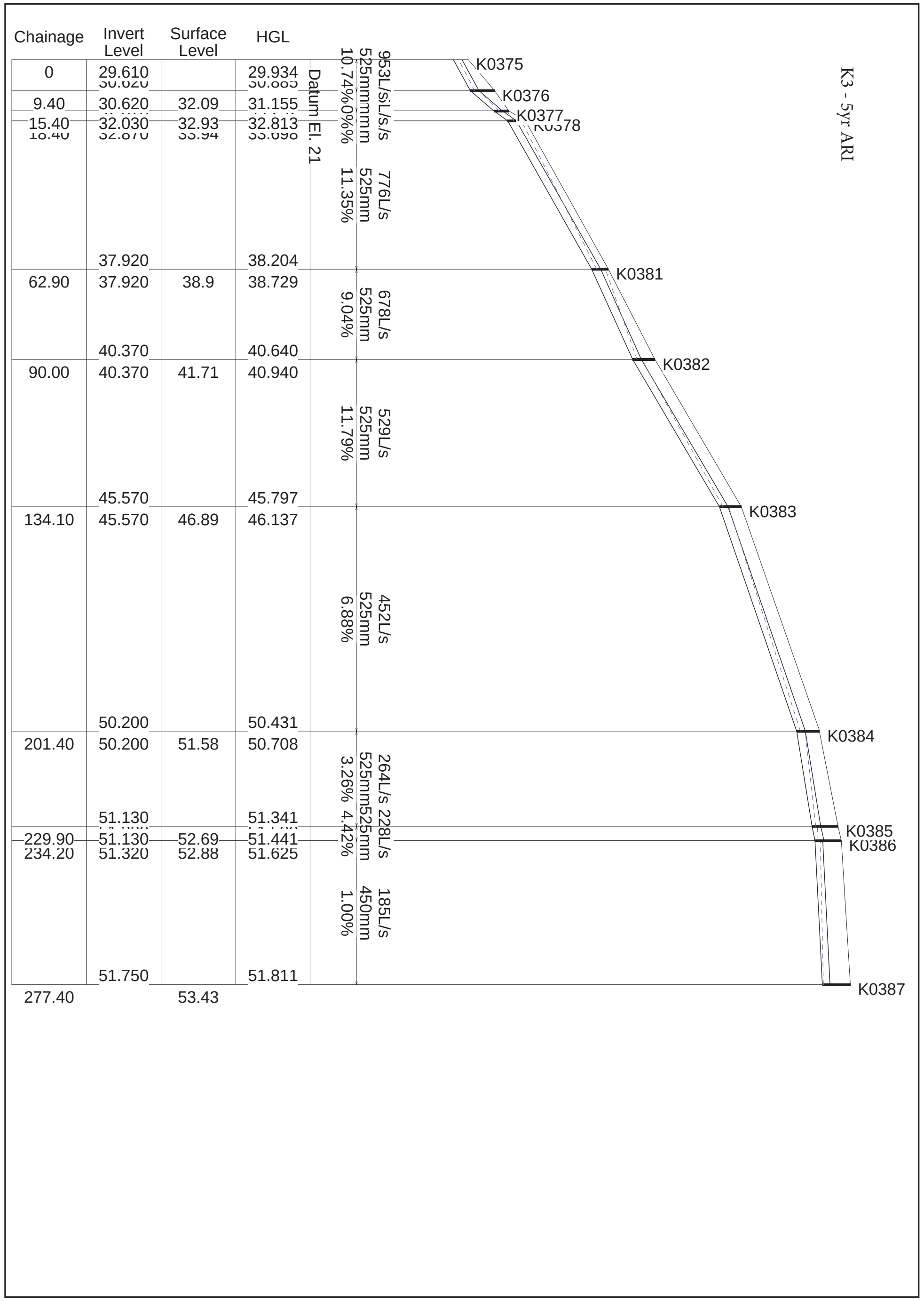
Chainage	Invert Level	Surface Level	HGL
0	24.520		24.806
	26.300		26.586
30.00	26.300	27.5	27.620
	27.520		28.095
55.40	27.520	28.92	29.401
	31.400		31.655
85.10	31.400	34.9	32.174
91.60	32.910	35.31	35.304
	35.720		36.013
133.90	35.720	37.92	36.280
139.90	36.490	38.49	37.904
	39.380		39.666
172.40	39.380	41.14	40.212
179.90	39.840	41.18	41.203
	40.050		41.369
199.90		41.85	

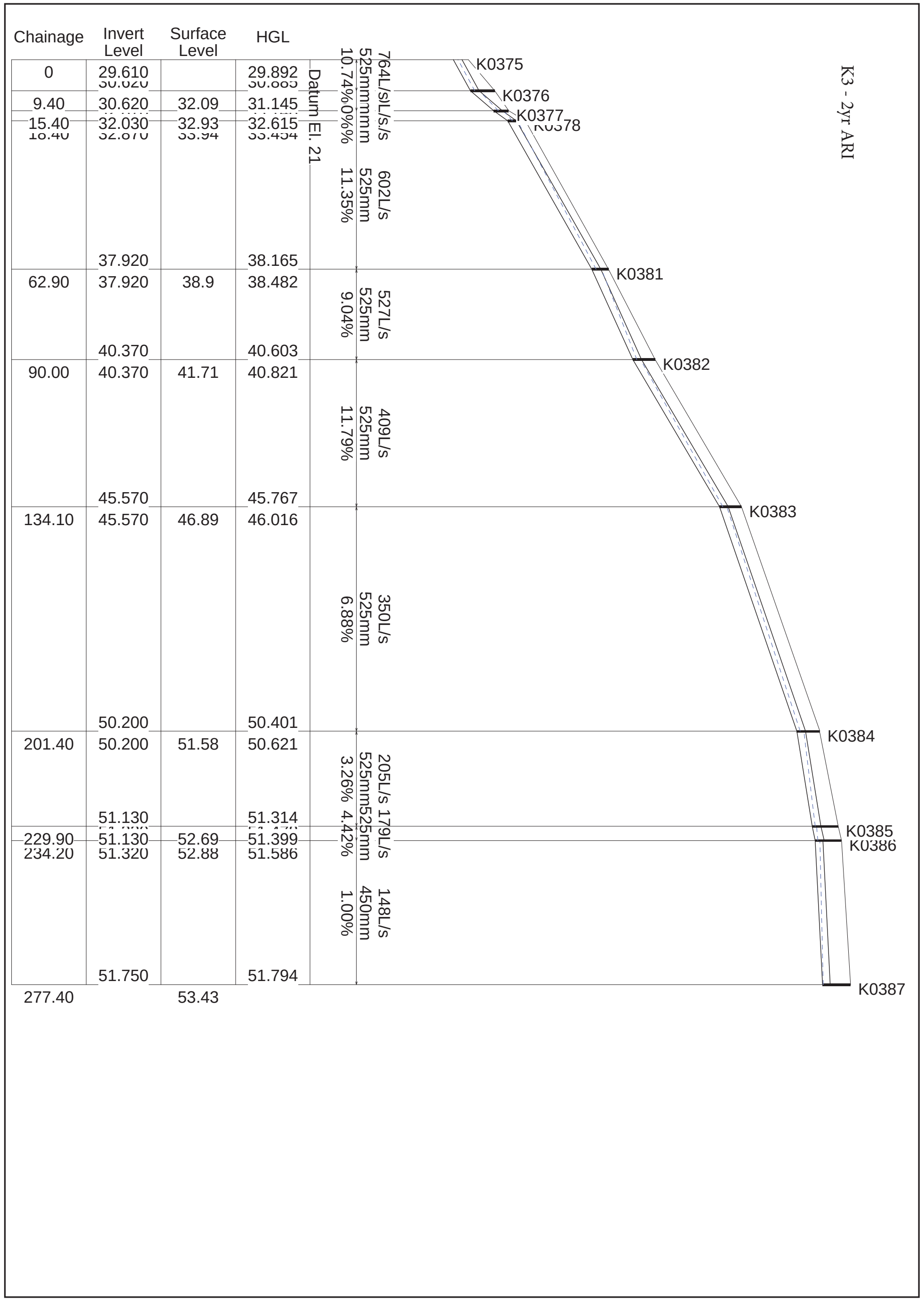


K2 - 2yr ARI

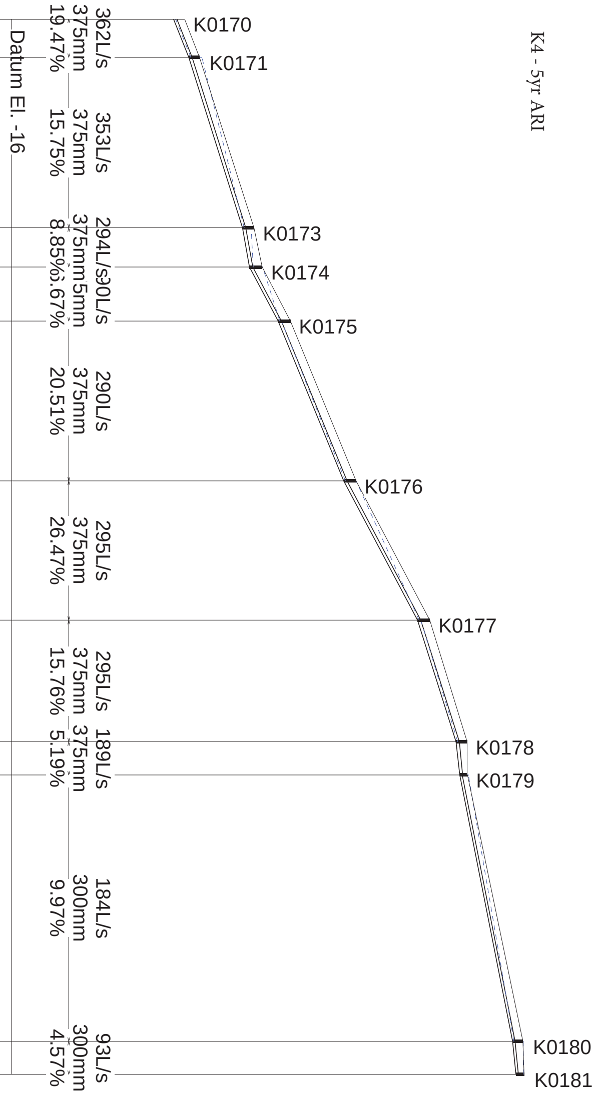
Chainage	Invert Level	Surface Level	HGL
0	24.520		24.806
	26.300		26.586
30.00	26.300	27.5	27.620
	27.520		28.095
55.40	27.520	28.92	29.397
	31.400		31.655
85.10	31.400	34.9	32.107
91.60	32.910	35.31	35.302
	35.720		36.011
133.90	35.720	37.92	36.279
139.90	36.490	38.49	37.903
	39.380		39.666
172.40	39.380	41.14	40.212
179.90	39.840	41.18	41.202
	40.050		41.369
199.90		41.85	



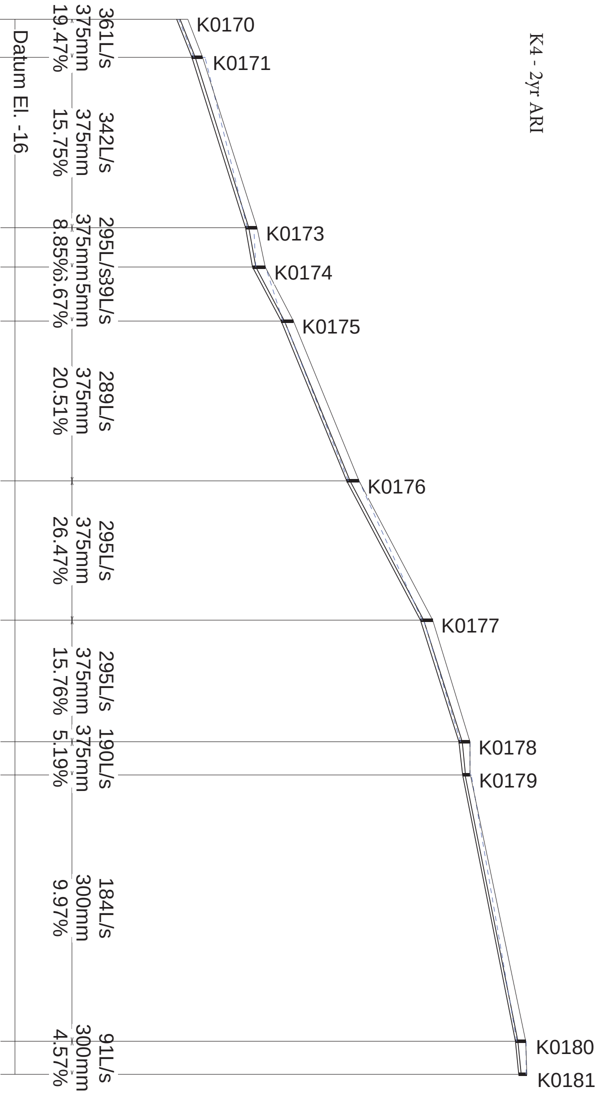

Chainage
Invert Level
Surface Level
HGL
Datum El. 21
K3 - 5yr ARI
0
29.610
29.934
9.40
30.620
32.09
31.155
15.40
32.030
32.93
32.813
953L/s
525mm
10.74%
776L/s
525mm
11.35%
37.920
38.204
62.90
37.920
38.9
38.729
678L/s
525mm
9.04%
40.370
40.640
90.00
40.370
41.71
40.940
529L/s
525mm
11.79%
45.570
45.797
134.10
45.570
46.89
46.137
452L/s
525mm
6.88%
50.200
50.431
201.40
50.200
51.58
50.708
264L/s
525mm
3.26%
228L/s
525mm
4.42%
51.130
51.341
229.90
51.130
52.69
51.441
234.20
51.320
52.88
51.625
185L/s
450mm
1.00%
51.750
51.811
277.40
53.43
K0375
K0376
K0377
K0378
K0381
K0382
K0383
K0384
K0385
K0386
K0387

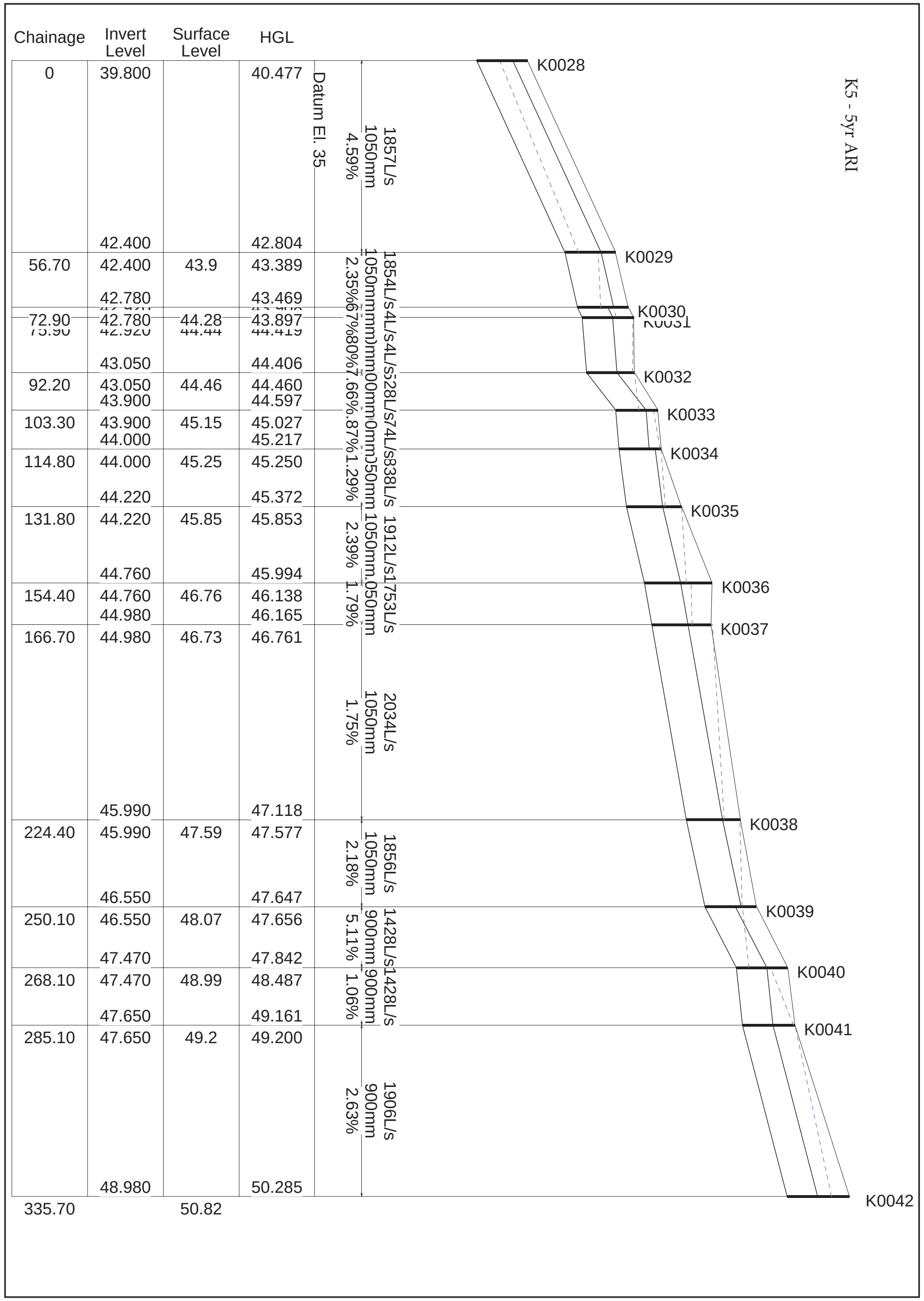

Chainage
Invert Level
Surface Level
HGL
Datum El. 21
K3 - 2yr ARI
0
29.610
29.892
9.40
30.620
32.09
31.145
15.40
32.030
32.93
32.615
764L/s
525mm
10.74%
602L/s
525mm
11.35%
37.920
38.165
62.90
37.920
38.9
38.482
527L/s
525mm
9.04%
40.370
40.603
90.00
40.370
41.71
40.821
409L/s
525mm
11.79%
45.570
45.767
134.10
45.570
46.89
46.016
350L/s
525mm
6.88%
50.200
50.401
201.40
50.200
51.58
50.621
205L/s
525mm
3.26%
179L/s
525mm
4.42%
51.130
51.314
229.90
51.130
52.69
51.399
234.20
51.320
52.88
51.586
148L/s
450mm
1.00%
51.750
51.794
277.40
53.43
K0375
K0376
K0377
K0378
K0381
K0382
K0383
K0384
K0385
K0386
K0387

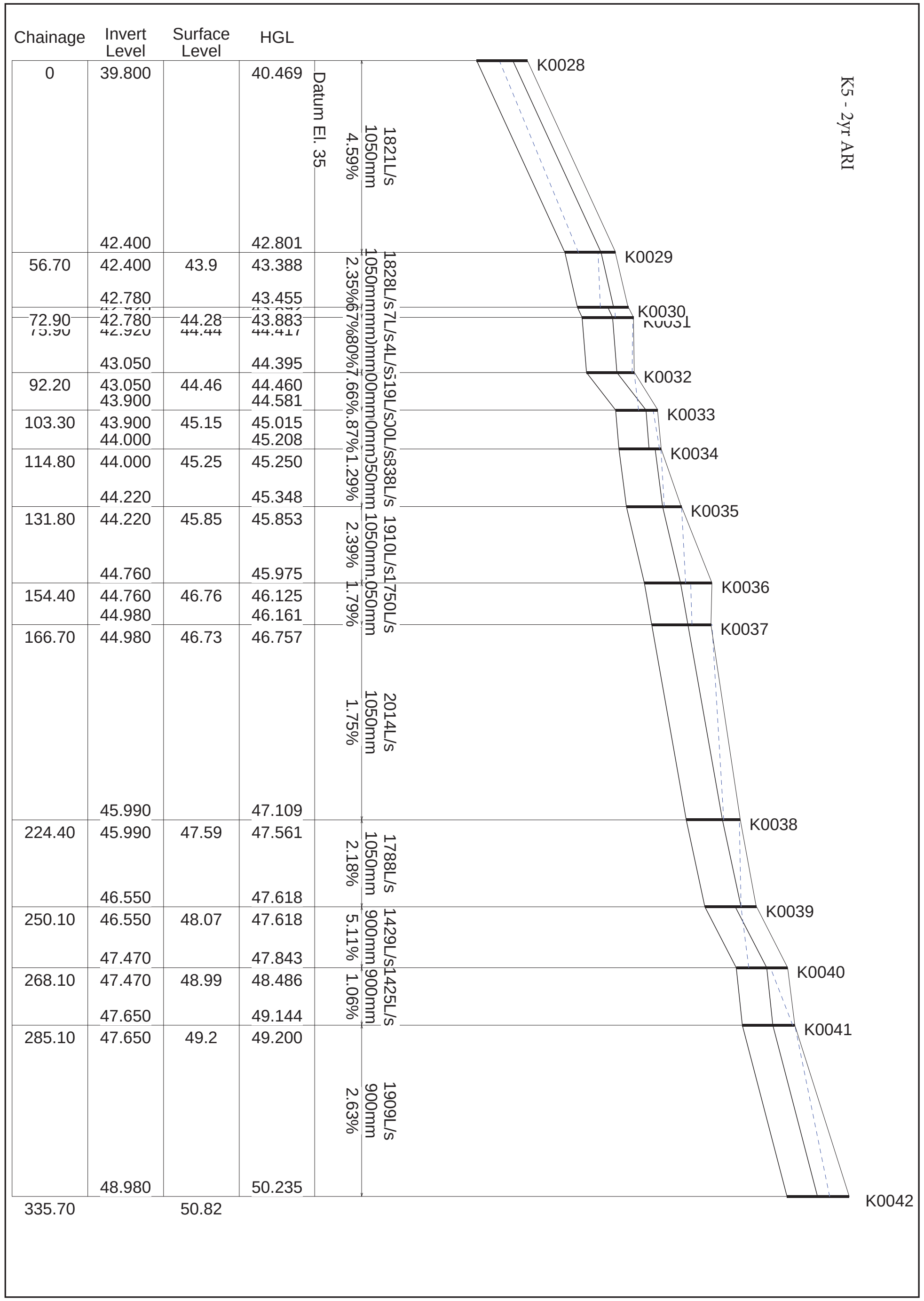
Chainage	Invert Level	Surface Level	HGL
0	3.800		4.021
9.40	5.630	6.93	7.217
	12.180		12.397
51.00	12.180	13.58	13.230
60.60	13.030	14.59	14.606
	16.550		16.742
73.80	16.550	18	16.919
	24.550		24.742
112.80	24.550	26	26.019
	33.550		33.745
146.80	33.550	35	33.927
	38.230		38.425
176.50	38.230	39.57	39.556
184.60	38.650	39.6	39.727
	45.130		45.298
249.60	45.130	46.38	46.400
257.70		46.5	



Chainage	Invert Level	Surface Level	HGL
0	3.800		4.021
9.40	5.630	6.93	7.209
	12.180		12.393
51.00	12.180	13.58	13.174
60.60	13.030	14.59	14.605
	16.550		16.742
73.80	16.550	18	16.919
	24.550		24.742
112.80	24.550	26	26.020
	33.550		33.745
146.80	33.550	35	33.927
	38.230		38.425
176.50	38.230	39.57	39.554
184.60	38.650	39.6	39.726
	45.130		45.298
249.60	45.130	46.38	46.400
257.70		46.5	




K5 - 5yr ARI
Chainage | Invert Level | Surface Level | HGL
0 | 39.800 | | 40.477
42.400 | 42.804
56.70 | 42.400 | 43.9 | 43.389
42.780 | 43.469
72.90 | 42.780 | 44.28 | 43.897
43.050 | 44.406
92.20 | 43.050 | 44.46 | 44.460
43.900 | 44.597
103.30 | 43.900 | 45.15 | 45.027
44.000 | 45.217
114.80 | 44.000 | 45.25 | 45.250
44.220 | 45.372
131.80 | 44.220 | 45.85 | 45.853
44.760 | 45.994
154.40 | 44.760 | 46.76 | 46.138
44.980 | 46.165
166.70 | 44.980 | 46.73 | 46.761
45.990 | 47.118
224.40 | 45.990 | 47.59 | 47.577
46.550 | 47.647
250.10 | 46.550 | 48.07 | 47.656
47.470 | 47.842
268.10 | 47.470 | 48.99 | 48.487
47.650 | 49.161
285.10 | 47.650 | 49.2 | 49.200
48.980 | 50.285
335.70 | | 50.82
Datum El. 35
1857L/s 1050mm 4.59%
1854L/s 1050mm 2.35%
1912L/s 1050mm 2.39%
1753L/s 1050mm 1.79%
2034L/s 1050mm 1.75%
1856L/s 1050mm 2.18%
1428L/s 900mm 5.11%
1428L/s 900mm 1.06%
1906L/s 900mm 2.63%
K0028
K0029
K0030
K0031
K0032
K0033
K0034
K0035
K0036
K0037
K0038
K0039
K0040
K0041
K0042


K5 - 2yr ARI
Chainage | Invert Level | Surface Level | HGL
0 | 39.800 | | 40.469
42.400 | 42.801
56.70 | 42.400 | 43.9 | 43.388
42.780 | 43.455
72.90 | 42.780 | 44.28 | 43.883
43.050 | 44.395
92.20 | 43.050 | 44.46 | 44.460
43.900 | 44.581
103.30 | 43.900 | 45.15 | 45.015
44.000 | 45.208
114.80 | 44.000 | 45.25 | 45.250
44.220 | 45.348
131.80 | 44.220 | 45.85 | 45.853
44.760 | 45.975
154.40 | 44.760 | 46.76 | 46.125
44.980 | 46.161
166.70 | 44.980 | 46.73 | 46.757
45.990 | 47.109
224.40 | 45.990 | 47.59 | 47.561
46.550 | 47.618
250.10 | 46.550 | 48.07 | 47.618
47.470 | 47.843
268.10 | 47.470 | 48.99 | 48.486
47.650 | 49.144
285.10 | 47.650 | 49.2 | 49.200
48.980 | 50.235
335.70 | | 50.82
Datum El. 35
1821L/s 1050mm 4.59%
1828L/s 1050mm 2.35%
1910L/s 1050mm 2.39%
1750L/s 1050mm 1.79%
2014L/s 1050mm 1.75%
1788L/s 1050mm 2.18%
1429L/s 900mm 5.11%
1425L/s 900mm 1.06%
1909L/s 900mm 2.63%
K0028
K0029
K0030
K0031
K0032
K0033
K0034
K0035
K0036
K0037
K0038
K0039
K0040
K0041
K0042

DRAINS OUTPUT – LOW FLOW ASSESSMENT
BUFFALO CREEK CATCHMENT – 2yr ARI

Exported DRAINS results - BUFFALO CREEK PEAK - 2YR ARI						
PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0009	28.39		6.593	1.61	6.593	Inlet Capacity
B0010	29.96		6.59	0.64	6.59	Inlet Capacity
B0011	30.28		7.229	1.85	6.587	Inlet Capacity
B0012	30.67		7.947	1.73	7.226	Inlet Capacity
B0014	32.65		7.904	1.13	7.904	Inlet Capacity
B0015	33.62		8.548	0.68	7.904	Inlet Capacity
B0016	33.97		8.519	0.73	8.519	Inlet Capacity
B0017	34.54		9.162	0.26	8.519	Inlet Capacity
B0018	34.94		9.802	0.01	9.16	Inlet Capacity
B0019	35.29		10.203	0.06	9.8	Inlet Capacity
B0022	36.77		8.785	0.27	8.785	Inlet Capacity
B0023	37.14		8.785	0.44	8.785	Inlet Capacity
B0024	37.71		9.428	0.49	8.785	Inlet Capacity
B0026	38.7		8.296	0.1	8.306	Inlet Capacity
B0027	38.78		0.252	0.07	0.252	Inlet Capacity
B0036	46.34	46.8	1.853	0.31	1.667	Inlet Capacity
B0038	46.98	47.35	1.326	0.17	1.032	Inlet Capacity
B0039	47.3		0.128	0.17	0.024	Inlet Capacity
B0040	47.78		1.959	0.08	1.318	Inlet Capacity
B0042	49.55		1.648	1.15	1.25	Inlet Capacity
B0044	56.83	58.03	1.809	1	1.55	Inlet Capacity
B0046	57.99		2.166	0.02	1.771	Inlet Capacity
B0049	75.06		0.169	0.97	0.085	Inlet Capacity
B0050	75.87		0.025	2.03	0.025	Inlet Capacity
B0052	76.99	78.23	0.173	1.09	0	Inlet Capacity
B0053	78.81		0.073	0.7	0.028	Inlet Capacity
B0054	78.91		0.033	0.83	0.007	Inlet Capacity
B0061	49.99	50.76	0.502	0.29	0	Inlet Capacity
B0062	50.41		0.335	0.28	0.204	Inlet Capacity
B0063	50.55		0.326	0.15	0.199	Inlet Capacity
B0064	50.76		0.06	0.06	0.022	Inlet Capacity
B0066	24.63		1.763	0.2	1.164	Inlet Capacity
B0068	27.53		1.148	0.02	0.695	Inlet Capacity
B0071	35.88		0.955	0.03	0.619	Inlet Capacity
B0072	36.5		1.095	0.01	0.832	Inlet Capacity
B0073	37.76		1.333	0.29	1.005	Inlet Capacity
B0080	44.05		0.367	0	0.289	Inlet Capacity
B0081	48.47		0.274	0.01	0.202	Inlet Capacity
B0082	49.53		0.218	0.01	0.103	Inlet Capacity
B0083	49.75		0.155	0.02	0.047	Inlet Capacity
B0085	38.45		0.336	0.02	0.223	Inlet Capacity
B0089	40.75		0.382	0.01	0.29	Inlet Capacity
B0090	44.26		0.432	0.01	0.305	Inlet Capacity
B0095	49.07		0.127	0.02	0.046	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0096	49.78		0.122	0.34	0.023	Inlet Capacity
B0097	50.2		0.104	0.49	0.018	Inlet Capacity
B0099	12.3		0.256	0.41	0.148	Inlet Capacity
B0100	13.48		0.455	4.24	0.192	Inlet Capacity
B0101	15.59		0.746	5.16	0.389	Inlet Capacity
B0102	18.01		1.135	3.16	0.675	Inlet Capacity
B0103	20.87		1.635	0.53	1.062	Inlet Capacity
B0104	20.97		1.582	0.53	1.232	Inlet Capacity
B0105	20.98		0.134	0.62	0.024	Inlet Capacity
B0106	20.99		0.163	0.71	0.033	Inlet Capacity
B0107	20.99		0.128	0.81	0.063	Inlet Capacity
B0108	23.52		2.124	0.32	1.575	Inlet Capacity
B0109	23.7		2.061	0.7	2.059	Inlet Capacity
B0110	25.86		2.475	0.01	2.011	Inlet Capacity
B0113	27.77		2.026	0.21	1.607	Inlet Capacity
B0115	29.4		1.67	0.5	1.666	Inlet Capacity
B0118	32.56		0.145	0.45	0.145	Inlet Capacity
B0119	35.34		0.238	0.76	0.134	Inlet Capacity
B0120	36.1		0.306	0.45	0.144	Inlet Capacity
B0121	36.72		0.014	0.35	0	Inlet Capacity
B0126	49.27		0.223	0.53	0.061	Inlet Capacity
B0127	49.8		0.287	0.01	0.185	Inlet Capacity
B0129	13.14		0.658	2.66	0.458	Inlet Capacity
B0130	16.23		0.905	1.4	0.657	Inlet Capacity
B0131	18.28		1.16	0.9	0.869	Inlet Capacity
B0132	21.1		1.456	0.15	1.12	Inlet Capacity
B0134	22.6	22.78	0.932	0.03	0.783	Inlet Capacity
B0137	25.51		0.799	1.93	0.533	Inlet Capacity
B0138	26.51		0.903	1.19	0.65	Inlet Capacity
B0139	28.36		1.039	0.24	0.745	Inlet Capacity
B0140	29.36	31.08	1.009	1.57	0.852	Inlet Capacity
B0141	30.91	31.06	1.13	0	0.978	Inlet Capacity
B0143	31.57		0.779	0.19	0.555	Inlet Capacity
B0145	32.5		0.217	0.66	0.113	Inlet Capacity
B0146	33.05		0.191	0.76	0.101	Inlet Capacity
B0147	33.5		0.195	0.73	0.104	Inlet Capacity
B0148	34.34		0.206	0.86	0.11	Inlet Capacity
B0149	34.95		0.214	1.56	0.117	Inlet Capacity
B0150	36.69		0.216	0.76	0.123	Inlet Capacity
B0151	37		0.279	0.66	0.165	Inlet Capacity
B0152	37.49		0.441	0.95	0.279	Inlet Capacity
B0153	37.79	38.61	0.751	0.67	0.403	Inlet Capacity
B0154	38.16		0.771	0.32	0.745	Inlet Capacity
B0157	41.04		0.533	0	0.426	Inlet Capacity
B0160	50.21		0.152	0.02	0.086	Inlet Capacity
B0161	51.64		0.259	0.34	0.149	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0162	52.25		0.306	0.01	0.219	Inlet Capacity
B0166	53.05		0.131	0.02	0.04	Inlet Capacity
B0167	31.91		0.853	0.56	0.608	Inlet Capacity
B0168	32.12		0.443	1.1	0.284	Inlet Capacity
B0169	33.63		0.536	0.16	0.356	Inlet Capacity
B0170	34.37		0.643	0.12	0.443	Inlet Capacity
B0171	35.33	36.49	0.7	1.01	0.547	Inlet Capacity
B0172	36.55		1.034	0.58	0.6	Inlet Capacity
B0175	39.7		0.889	0	0.743	Inlet Capacity
B0179	44.71		0.631	0	0.545	Inlet Capacity
B0181	46.72		0.722	0.01	0.459	Inlet Capacity
B0182	46.85		0.144	0.08	0.071	Inlet Capacity
B0184	47.37		0.506	0.13	0.333	Inlet Capacity
B0185	47.73		0.449	0.53	0.445	Inlet Capacity
B0193	40.48		0.859	0.59	0.518	Inlet Capacity
B0194	41.17		0.298	0.39	0.179	Inlet Capacity
B0195	42.45		0.086	4.05	0.011	Inlet Capacity
B0196	44.13		0.077	2.69	0.009	Inlet Capacity
B0201	40.39	42.66	0.321	2.12	0	Inlet Capacity
B0202	42.32		0.175	0.84	0.062	Inlet Capacity
B0203	43		0.111	1.06	0.052	Inlet Capacity
B0204	44.68		0.219	1.36	0.056	Inlet Capacity
B0205	45.39		0.336	1.12	0.162	Inlet Capacity
B0206	46.63	46.79	0.674	0.01	0.277	Inlet Capacity
B0207	46.89		0.761	0	0.644	Inlet Capacity
B0209	47.63		0.549	0.01	0.348	Inlet Capacity
B0211	53.59		0.115	0.59	0.053	Inlet Capacity
B0212	55.74		0.124	0.55	0.057	Inlet Capacity
B0213	59.37		0.128	0.9	0.038	Inlet Capacity
B0214	59.8		0.1	0.75	0.028	Inlet Capacity
B0216	42.76		0.757	0.8	0.545	Inlet Capacity
B0220	43.61		0.758	0.34	0.405	Inlet Capacity
B0222	43.84		0.799	0.26	0.502	Inlet Capacity
B0224	45.49		0.414	0.56	0.269	Inlet Capacity
B0225	45.75	46.07	0.559	0.17	0.308	Inlet Capacity
B0229	49.39	49.95	0.787	0.41	0.5	Inlet Capacity
B0230	49.94		0.822	0.02	0.591	Inlet Capacity
B0231	53.42		1.062	0.48	0.79	Inlet Capacity
B0235	54.87		1.201	0.02	0.821	Inlet Capacity
B0237	57.11		1.241	0.52	0.936	Inlet Capacity
B0239	41.25	42.64	0.421	1.24	0.319	Inlet Capacity
B0240	44.14		0.58	1.07	0.394	Inlet Capacity
B0241	45.42	47.45	0.704	1.88	0.554	Inlet Capacity
B0242	48.76		1.191	0.12	0.694	Inlet Capacity
B0243	50.4		1.281	1.01	0.95	Inlet Capacity
B0244	52.84		1.73	0.51	1.246	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0247	57.55		1.833	0.89	1.218	Inlet Capacity
B0248	58.32	58.59	1.98	0.12	1.749	Inlet Capacity
B0249	58.39		0.028	0.15	0.006	Inlet Capacity
B0257	63.22		0.055	1.39	0.003	Inlet Capacity
B0258	64.28		0.155	1.08	0.029	Inlet Capacity
B0259	65.74		0.23	1.12	0.128	Inlet Capacity
B0260	69.32		0.241	0.01	0.162	Inlet Capacity
B0261	69.38		0.075	0.02	0.021	Inlet Capacity
B0262	43.53		0.237	0.08	0.099	Inlet Capacity
B0263	46.14		0.318	0.54	0.194	Inlet Capacity
B0265	50.89		0.185	0.38	0.099	Inlet Capacity
B0266	52.19		0.105	0.99	0.03	Inlet Capacity
B0267	52.99		0.29	0.02	0.159	Inlet Capacity
B0269	54.53		0.424	0.02	0.29	Inlet Capacity
B0271	63.46		0.416	0.01	0.264	Inlet Capacity
B0272	63.48		0.219	0	0.197	Inlet Capacity
B0274	27.86		0.431	0.01	0.286	Inlet Capacity
B0275	30.15		0.056	0.8	0.02	Inlet Capacity
B0276	32.62		0.378	0.66	0.232	Inlet Capacity
B0278	35.26		0.038	1.22	0.01	Inlet Capacity
B0279	36.45	37.64	0.05	1.05	0	Inlet Capacity
B0280	37.26		0.044	0.83	0.013	Inlet Capacity
B0281	39.66		0.03	0.98	0.006	Inlet Capacity
B0283	40.5		0.096	1.25	0.015	Inlet Capacity
B0284	40.98		0.188	1.02	0.043	Inlet Capacity
B0285	43.13		0.154	0.22	0.075	Inlet Capacity
B0286	44.06		0.126	0.91	0.061	Inlet Capacity
B0287	46.46		0.079	0.8	0.033	Inlet Capacity
B0289	27.85		1.119	0.01	0.899	Inlet Capacity
B0291	28.34	29.06	1.248	0.57	1.056	Inlet Capacity
B0294	34.39		1.145	0.01	1.005	Inlet Capacity
B0297	36.96		0.999	0.14	0.811	Inlet Capacity
B0300	38		0.771	0.01	0.611	Inlet Capacity
B0302	38.86		0.653	0.01	0.538	Inlet Capacity
B0304	40.08		0.692	0.02	0.512	Inlet Capacity
B0308	44.22		0.663	0.24	0.331	Inlet Capacity
B0312	26.06		0.58	1.84	0.393	Inlet Capacity
B0313	28.02		0.715	0.02	0.513	Inlet Capacity
B0314	32.5		0.802	0.02	0.623	Inlet Capacity
B0317	40.21		1.037	0.02	0.657	Inlet Capacity
B0318	40.22		0.907	0.02	0.907	Inlet Capacity
B0319	40.22		0.907	0.02	0.907	Inlet Capacity
B0320	40.22		0.907	0.03	0.907	Inlet Capacity
B0322	40.26		0.106	0.01	0.063	Inlet Capacity
B0323	30.2		0.444	0.8	0.189	Inlet Capacity
B0324	32.07	34.11	0.578	1.89	0.428	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0325	32.62		0.61	1.35	0.357	Inlet Capacity
B0326	32.85		0.439	1.4	0.285	Inlet Capacity
B0327	33.21		0.607	1.01	0.353	Inlet Capacity
B0329	33.74		0.803	0.59	0.573	Inlet Capacity
B0331	34.21		0.714	1.34	0.732	Inlet Capacity
B0332	34.39		0.734	1.41	0.386	Inlet Capacity
B0333	35.69		1.122	0.58	0.672	Inlet Capacity
B0334	36.6		1.465	0	1.066	Inlet Capacity
B0336	37.43		1.51	0.32	1.513	Inlet Capacity
B0337	38.71		1.481	1.09	1.481	Inlet Capacity
B0344	41.77		0.366	0.84	0.36	Inlet Capacity
B0359	36.05		0.245	0.02	0.121	Inlet Capacity
B0360	39.23		0.179	0.94	0.066	Inlet Capacity
B0361	36.12		0.6	0.68	0.403	Inlet Capacity
B0362	37.93		0.362	1.22	0.22	Inlet Capacity
B0363	39.1		0.338	0.47	0.203	Inlet Capacity
B0364	50.37		0.439	0.02	0.212	Inlet Capacity
B0365	50.6	51.19	0.022	0.49	0	Inlet Capacity
B0366	50.89		0.499	0	0.424	Inlet Capacity
B0368	51.2		0.06	0.47	0.022	Inlet Capacity
B0370	51.45		0.062	0.59	0.023	Inlet Capacity
B0372	43.79		0.757	0.09	0.538	Inlet Capacity
B0375	47.07	48.87	0.096	1.65	0.024	Inlet Capacity
B0377	47.79		1.264	0.93	0.958	Inlet Capacity
B0378	47.96	48.88	1.403	0.77	1.23	Inlet Capacity
B0384	49.44		0.025	0.16	0.004	Inlet Capacity
B0385	49.79		0.024	0.61	0.004	Inlet Capacity
B0386	50.1		0.024	1	0.004	Inlet Capacity
B0387	55.67		0.024	0.73	0.003	Inlet Capacity
B0388	56.66		0.057	0.35	0.004	Inlet Capacity
B0389	56.78		0.084	0.54	0.036	Inlet Capacity
B0391	49.67		0.093	0.29	0.025	Inlet Capacity
B0392	52.49		0.145	1.36	0.045	Inlet Capacity
B0393	55.25		0.29	0.6	0.095	Inlet Capacity
B0394	55.94		0.26	0.01	0.176	Inlet Capacity
B0397	57.87		0.078	0.98	0.032	Inlet Capacity
B0403	40.91		1.04	0	0.879	Inlet Capacity
B0404	41.54		1.088	0	0.945	Inlet Capacity
B0408	46.02		0.704	0.01	0.525	Inlet Capacity
B0409	46.51		0.319	0.01	0.231	Inlet Capacity
B0418	45.96		0.197	0.84	0.106	Inlet Capacity
B0420	47.4		0.145	0.1	0.144	Inlet Capacity
B0421	48.03		0.126	0.35	0.122	Inlet Capacity
B0424	53.57		0.075	0.62	0.006	Inlet Capacity
B0425	54.07		0.092	0.49	0.041	Inlet Capacity
B0427	54.95		0.092	0.2	0.014	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0428	51.56		0.108	1.54	0.018	Inlet Capacity
B0429	51.77		0.201	1.56	0.078	Inlet Capacity
B0432	42.01		2.876	0.05	2.876	Inlet Capacity
B0434	42.46		0.498	0.35	0.503	Inlet Capacity
B0435	42.71		0.495	0.29	0.495	Inlet Capacity
B0436	42.73		0.495	0.67	0.495	Inlet Capacity
B0438	45.43		0.693	0.77	0.691	Inlet Capacity
B0439	46.29		0.677	0.32	0.677	Inlet Capacity
B0440	46.98	47.35	0.743	0.22	0.584	Inlet Capacity
B0442	48.53	49.64	0.821	0.96	0.675	Inlet Capacity
B0443	49.39		1.283	0.13	0.789	Inlet Capacity
B0448	53.78		0.888	1.59	0.888	Inlet Capacity
B0449	54.58	56.74	1.038	2.01	0.888	Inlet Capacity
B0451	56.56		1.34	1.62	1.033	Inlet Capacity
B0452	57.75	61.2	1.024	3.3	0.672	Inlet Capacity
B0453	58.83		0.844	2.29	0.604	Inlet Capacity
B0454	59.15		0.151	2.15	0.074	Inlet Capacity
B0455	59.76	61.17	0.899	1.26	0.732	Inlet Capacity
B0458	60.1		0.099	1	0.026	Inlet Capacity
B0459	60.84		0.234	0.31	0.066	Inlet Capacity
B0460	63.84		0.267	0	0.201	Inlet Capacity
B0461	68.38		0.221	0	0.15	Inlet Capacity
B0462	78.51		0.131	0.01	0.071	Inlet Capacity
B0463	79.21		0.117	0.68	0.057	Inlet Capacity
B0464	42.81		0.153	0.73	0.076	Inlet Capacity
B0465	43.54		0.173	0.71	0.062	Inlet Capacity
B0468	44.2		0.705	0.6	0.495	Inlet Capacity
B0472	59.98		0.765	0.1	0.764	Inlet Capacity
B0475	62.79		0.169	1.44	0.036	Inlet Capacity
B0476	62.91		0.023	2.35	0.004	Inlet Capacity
B0477	65		0.022	2.1	0.003	Inlet Capacity
B0478	65.79		0.02	1.41	0.002	Inlet Capacity
B0479	67.13	68.27	0.076	1.04	0	Inlet Capacity
B0480	68.56		0.124	0.7	0.06	Inlet Capacity
B0481	69.63		0.308	0.13	0.107	Inlet Capacity
B0484	73.09		0.083	0.66	0.035	Inlet Capacity
B0485	73.49	74.37	0.061	0.79	0	Inlet Capacity
B0486	73.9		0.076	0.39	0.009	Inlet Capacity
B0487	74.1		0.058	0.55	0.012	Inlet Capacity
B0488	47.1		1.765	0	1.633	Inlet Capacity
B0490	49.05		1.257	0.03	0.936	Inlet Capacity
B0492	51.95		0.451	1.37	0.288	Inlet Capacity
B0493	59.87		0.6	1.86	0.398	Inlet Capacity
B0494	60.16	61.87	0.777	1.56	0.548	Inlet Capacity
B0495	60.54		0.227	1.46	0.128	Inlet Capacity
B0496	52.89		0.064	0.49	0.025	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0497	54.94	55.52	0.078	0.43	0.011	Inlet Capacity
B0499	55.84		0.048	0.52	0.002	Inlet Capacity
B0500	57.95		0.038	0.81	0.01	Inlet Capacity
B0502	60.95		0.038	0.93	0.01	Inlet Capacity
B0503	49.57		0.003	1.14	0.003	Inlet Capacity
B0504	50.51		0.364	1.29	0.142	Inlet Capacity
B0505	52.89		0.453	4.21	0.297	Inlet Capacity
B0506	55.65		0.564	1.6	0.388	Inlet Capacity
B0508	57.63	58.25	0.28	0.47	0.165	Inlet Capacity
B0509	57.69	58.26	0.384	0.42	0.143	Inlet Capacity
B0511	59.06		0.175	0.01	0.08	Inlet Capacity
B0512	56.55		0.015	2.81	0.015	Inlet Capacity
B0514	56.59		0.051	2.71	0.002	Inlet Capacity
B0516	7.7	8.3	0.021	0.54	0	Inlet Capacity
B0518	8.09		0.34	0	0.3	Inlet Capacity
B0522	13.93		0.1	0.21	0.027	Inlet Capacity
B0523	17.47		0.204	0.02	0.081	Inlet Capacity
B0524	20.45		0.258	0	0.184	Inlet Capacity
B0525	21.03		0.408	0.01	0.237	Inlet Capacity
B0527	15.91		0.605	2.17	0.415	Inlet Capacity
B0528	18.16		0.728	0.01	0.602	Inlet Capacity
B0529	18.75		0.516	0	0.399	Inlet Capacity
B0531	19.24		0.216	0.02	0.081	Inlet Capacity
B0533	23.19		0.053	1.27	0.003	Inlet Capacity
B0534	24.53		0.041	0.83	0.012	Inlet Capacity
B0535	25.25		0.073	0.01	0.032	Inlet Capacity
B0536	25.36		0.041	0	0.032	Inlet Capacity
B0543	25.65		0.228	0.1	0.129	Inlet Capacity
B0545	33.03		0.131	0	0.11	Inlet Capacity
B0547	36.66		0.132	0.01	0.05	Inlet Capacity
B0549	26.51		0.235	0.01	0.122	Inlet Capacity
B0550	30.73		0.189	0.23	0.045	Inlet Capacity
B0551	24.83		0.191	0	0.144	Inlet Capacity
B0553	25.75		0.065	0.61	0.014	Inlet Capacity
B0554	26.56		0.06	0.7	0.005	Inlet Capacity
B0555	25.09		0.06	0.27	0.022	Inlet Capacity
B0562	38.87		0.163	0.25	0.083	Inlet Capacity
B0564	42.73		0.248	0.01	0.12	Inlet Capacity
B0566	44.66		0.079	0.37	0.033	Inlet Capacity
B0567	38.66		0.16	0.3	0.031	Inlet Capacity
B0568	38.86		0.21	0.26	0.054	Inlet Capacity
B0570	42.27		0.106	0.68	0.03	Inlet Capacity
B0572	23.26	24.16	0.043	0.83	0	Inlet Capacity
B0573	23.89		0.043	0.71	0	Inlet Capacity
B0576	12.22		0.043	2.15	0	Inlet Capacity
B0577	13.95	14.93	0.056	0.87	0	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0578	15.03		0.043	0.62	0.013	Inlet Capacity
B0580	24.27		0.084	0.01	0.045	Inlet Capacity
B0581	24.81		0.121	0.55	0.023	Inlet Capacity
B0582	27.52		0.226	0.26	0.062	Inlet Capacity
B0584	39.42		0.169	0.65	0.036	Inlet Capacity
B0586	22.14		0.033	2.28	0.008	Inlet Capacity
B0591	24.28		0.148	0.53	0.026	Inlet Capacity
B0592	24.95		0.146	0.31	0.025	Inlet Capacity
B0594	25.64		0.148	0.15	0.026	Inlet Capacity
B0595	29.96	31.13	0.347	1.02	0.24	Inlet Capacity
B0598	35.96		0.13	0.16	0.063	Inlet Capacity
B0599	36.06		0.117	0.19	0.035	Inlet Capacity
B0601	36.13		0.088	0.09	0.023	Inlet Capacity
B0603	40.75		0.249	0.19	0.141	Inlet Capacity
B0606	41.16		0.106	0.17	0.019	Inlet Capacity
B0607	40.69		0.083	0.21	0.011	Inlet Capacity
B0609	43.41		0.213	0.02	0.065	Inlet Capacity
B0610	43.88		0.175	0.66	0.038	Inlet Capacity
B0611	37.14		0.038	0.96	0.01	Inlet Capacity
B0612	37.34		0.119	1.09	0.035	Inlet Capacity
B0615	40.8		0.19	0	0.187	Inlet Capacity
B0616	40.88		0.117	0.01	0.073	Inlet Capacity
B0617	40.86		0.106	0.42	0.03	Inlet Capacity
B0621	18.94		0.153	0.73	0.077	Inlet Capacity
B0622	20.25		0.266	0.62	0.153	Inlet Capacity
B0624	15.93	16.84	0.272	0.76	0.191	Inlet Capacity
B0627	16.9	17.42	0.154	0.37	0	Inlet Capacity
B0628	17.17		0.131	0.12	0.024	Inlet Capacity
B0631	21.16	22.15	0.095	0.85	0	Inlet Capacity
B0637	23.77		0.626	0.02	0.371	Inlet Capacity
B0638	28.26		0.905	0.01	0.626	Inlet Capacity
B0640	35.73		0.55	0.02	0.401	Inlet Capacity
B0642	37.56		0.375	0	0.32	Inlet Capacity
B0645	37.71		0.111	0	0.086	Inlet Capacity
B0647	22.1		0.233	0.03	0.129	Inlet Capacity
B0648	22.15		0.133	0	0.1	Inlet Capacity
B0649	22.45		0.005	0.01	0.002	Inlet Capacity
B0651	23.91		0.096	0.44	0.015	Inlet Capacity
B0652	37.34		0.135	0.01	0.058	Inlet Capacity
B0653	28.53		0.091	0.39	0.024	Inlet Capacity
B0654	31.36		0.073	0.9	0.017	Inlet Capacity
B0655	31.76		0.073	0.89	0.017	Inlet Capacity
B0656	28.63		0.091	0.53	0.023	Inlet Capacity
B0659	33.68		0.421	0	0.347	Inlet Capacity
B0662	42.82		0.267	0.01	0.19	Inlet Capacity
B0663	43.3		0.161	0.2	0.081	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0665	44.98		0.108	0.11	0.019	Inlet Capacity
B0666	45.16		0.112	0.02	0.055	Inlet Capacity
B0667	45.2		0.122	0.05	0.059	Inlet Capacity
B0670	38.17		0.232	0.01	0.112	Inlet Capacity
B0672	28.53		0.073	0	0.028	Inlet Capacity
B0673	32.45		0.099	0.02	0.028	Inlet Capacity
B0677	39.94		0.412	0	0.293	Inlet Capacity
B0679	49.56		0.242	0.95	0.103	Inlet Capacity
B0680	50		0.026	0.92	0.005	Inlet Capacity
B0681	50.2		0.026	0.58	0.005	Inlet Capacity
B0682	39.88		0.13	0.09	0.129	Inlet Capacity
B0683	40.03		0.11	0.46	0.02	Inlet Capacity
B0687	18.5		0.214	0	0.167	Inlet Capacity
B0688	20.03		0.281	0.8	0.166	Inlet Capacity
B0689	21.04		0.376	0.99	0.235	Inlet Capacity
B0690	22.47		0.502	2.36	0.333	Inlet Capacity
B0692	25.82		0.526	0.24	0.527	Inlet Capacity
B0693	26.38	27.15	0.741	0.62	0.507	Inlet Capacity
B0694	27.31		0.458	2.1	0.454	Inlet Capacity
B0695	29.74		0.287	0.77	0.171	Inlet Capacity
B0697	20.65		0.254	0.08	0.076	Inlet Capacity
B0698	21.45		0.341	0.71	0.209	Inlet Capacity
B0699	21.59		0.293	0.86	0.292	Inlet Capacity
B0700	22.98		0.388	0.31	0.246	Inlet Capacity
B0702	23.88		0.154	0.02	0.094	Inlet Capacity
B0703	21.66	22.34	0.054	0.58	0	Inlet Capacity
B0704	23.05		0.046	0.33	0.008	Inlet Capacity
B0706	37.16		0.065	0.02	0.012	Inlet Capacity
B0707	37.58		0.066	1.32	0.014	Inlet Capacity
B0708	38.27		0.069	0.83	0.015	Inlet Capacity
B0709	39.67		0.057	0.74	0.012	Inlet Capacity
B0710	39.2		0.057	0.77	0.004	Inlet Capacity
B0712	33.5		0.085	0.01	0.045	Inlet Capacity
B0713	34.36		0.069	0.74	0.016	Inlet Capacity
B0717	38.62		1.398	0.01	1.073	Inlet Capacity
B0719	26.38		1.344	0.01	1.126	Inlet Capacity
B0725	37.87		0.213	0.02	0.096	Inlet Capacity
B0731	46.49		0.258	0.11	0.15	Inlet Capacity
B0732	45.95		0.609	0	0.516	Inlet Capacity
B0736	26.17	26.38	0.747	0.06	0.528	Inlet Capacity
B0737	26.51		0.763	0.02	0.596	Inlet Capacity
B0739	25.81		0.014	0.01	0.004	Inlet Capacity
B0741	27.2		0.125	0.86	0.024	Inlet Capacity
B0742	28.93		0.114	0.72	0.021	Inlet Capacity
B0744	28.98	29.63	0.133	0.5	0.057	Inlet Capacity
B0745	29.37		0.179	0.19	0.094	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0757	51.53		0.551	0.02	0.28	Inlet Capacity
B0759	37.45	37.8	0.026	0.3	0	Inlet Capacity
B0760	37.56	38.11	0.017	0.51	0	Inlet Capacity
B0761	35.31		0.287	0.19	0.085	Inlet Capacity
B0762	35.61		0.257	0.01	0.132	Inlet Capacity
B0763	35.29		0.264	0	0.214	Inlet Capacity
B0764	37.53		0.345	0.01	0.21	Inlet Capacity
B0765	37.93		0.058	0.74	0.012	Inlet Capacity
B0766	38.16		0.045	0.93	0.001	Inlet Capacity
B0767	38.32		0.043	1.06	0.007	Inlet Capacity
B0768	38.66		0.038	0.87	0.005	Inlet Capacity
B0769	34.56		0.695	0.01	0.517	Inlet Capacity
B0774	35.19		0.136	0.31	0.042	Inlet Capacity
B0775	35.76		0.062	0.34	0.013	Inlet Capacity
B0776	36.02		0.143	0.01	0.087	Inlet Capacity
B0777	36.17		0.101	0.36	0.017	Inlet Capacity
B0779	39.29		0.109	0.04	0.02	Inlet Capacity
B0781	42.84		0.109	0.68	0.032	Inlet Capacity
B0783	39.35		0.261	0.01	0.165	Inlet Capacity
B0786	40.71		0.051	0.34	0.01	Inlet Capacity
B0787	41.41		0.12	0.67	0.035	Inlet Capacity
B0788	41.6		0.14	0.56	0.044	Inlet Capacity
B0790	38.97		0.18	0.4	0.095	Inlet Capacity
B0791	51.86		0.344	0.01	0.236	Inlet Capacity
B0794	60.58		0.219	0	0.143	Inlet Capacity
B0796	62.47		0.147	1.18	0.026	Inlet Capacity
B0797	40.47		0.074	0	0.057	Inlet Capacity
B0799	41.64		0.1	0.46	0.028	Inlet Capacity
B0800	42.23		0.195	0.55	0.075	Inlet Capacity
B0803	44.32		0.085	0.33	0.011	Inlet Capacity
B0804	45.09		0.069	0.56	0.027	Inlet Capacity
B0805	46.82		0.058	0.89	0.012	Inlet Capacity
B0811	52.61		0.289	0	0.247	Inlet Capacity
B0812	55.22		0.249	0.18	0.132	Inlet Capacity
B0813	55.44		0.158	0.02	0.091	Inlet Capacity
B0818	58.64		0.255	0.01	0.16	Inlet Capacity
B0821	59.72		0.081	0.39	0.034	Inlet Capacity
B0822	59.82		0.073	0.9	0.008	Inlet Capacity
B0823	59.8		0.081	0.21	0.02	Inlet Capacity
B0824	59.88		0.073	0.61	0.008	Inlet Capacity
B0827	45.84		0.121	0	0.093	Inlet Capacity
B0829	54.24		0.061	0.2	0.012	Inlet Capacity
B0830	54.84		0.1	0.3	0.027	Inlet Capacity
B0831	55.18		0.178	0.73	0.065	Inlet Capacity
B0832	44.91		0.215	0.01	0.151	Inlet Capacity
B0834	49.88		0.184	0	0.142	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0836	51.24		0.039	0.38	0.011	Inlet Capacity
B0837	52.88		0.023	1.34	0.018	Inlet Capacity
B0838	54.26		0.046	0.86	0.001	Inlet Capacity
B0839	54.46		0.027	0.98	0.002	Inlet Capacity
B0840	55.67		0.06	2.39	0.005	Inlet Capacity
B0842	50.81		0.026	0.14	0.005	Inlet Capacity
B0843	50.91		0.025	1.13	0.004	Inlet Capacity
B0844	50.93		0.022	1.57	0.003	Inlet Capacity
B0845	43.63	44.78	0.022	1.09	0	Inlet Capacity
B0846	55.75		0.088	0.64	0.038	Inlet Capacity
B0847	56.22		0.078	0.4	0.01	Inlet Capacity
B0848	49.94		0.113	0.09	0.02	Inlet Capacity
B0849	52.79		0.076	0.96	0.009	Inlet Capacity
B0850	50.09		0.086	1.23	0.036	Inlet Capacity
B0853	31.17		0.028	0.82	0.005	Inlet Capacity
B0856	33.04		0.051	0.93	0.002	Inlet Capacity
B0857	33.62		0.142	0.2	0.025	Inlet Capacity
B0858	32.81	33.85	0.027	0.99	0	Inlet Capacity
B0859	33.26		0.018	0.61	0	Inlet Capacity
B0860	34.47		0.082	0.08	0.02	Inlet Capacity
B0861	36.09		0.17	0.43	0.056	Inlet Capacity
B0862	37.66		0.091	0.01	0.047	Inlet Capacity
B0863	38.26		0.069	0.02	0.022	Inlet Capacity
B0864	38.55		0.096	0.37	0.027	Inlet Capacity
B0866	35.27	36.19	0.105	0.77	0	Inlet Capacity
B0867	38.24		0.148	2.16	0.148	Inlet Capacity
B0868	39.02	39.45	0.29	0.28	0.087	Inlet Capacity
B0869	36.38		0.209	0.31	0.052	Inlet Capacity
B0871	37.26		0.068	0.07	0.015	Inlet Capacity
B0872	37.53		0.132	0.15	0.025	Inlet Capacity
B0873	38.25		0.112	0.55	0.021	Inlet Capacity
B0875	37.34		0.112	0	0.091	Inlet Capacity
B0876	37.71		0.036	0.61	0.009	Inlet Capacity
B0877	37.81	38.54	0.036	0.61	0	Inlet Capacity
B0879	38.67		0.054	0.16	0.01	Inlet Capacity
B0881	38.89		0.333	0.01	0.252	Inlet Capacity
B0883	39.95		0.244	0.01	0.128	Inlet Capacity
B0884	40.37		0.15	0.2	0.048	Inlet Capacity
B0885	40.61		0.175	0.06	0.062	Inlet Capacity
B0886	40.63		0.087	0.05	0.087	Inlet Capacity
B0887	40.67		0.087	0.02	0.018	Inlet Capacity
B0888	40.05		0.08	0.08	0.01	Inlet Capacity
B0893	43.97		0.082	0.56	0.011	Inlet Capacity
B0895	41.44		0.212	0.28	0.056	Inlet Capacity
B0896	44.3		0.118	0.48	0.023	Inlet Capacity
B0897	44.07		0.118	0.75	0.035	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0898	46.46		0.118	0.02	0.024	Inlet Capacity
B0903	37.77		0.101	1	0.017	Inlet Capacity
B0904	38.29		0.018	0.69	0	Inlet Capacity
B0905	43.09		0.112	0.88	0.031	Inlet Capacity
B0906	43.98		0.085	1.04	0.036	Inlet Capacity
B0907	44.15		0.069	1.06	0.016	Inlet Capacity
B0908	44.97		0.069	1.1	0.007	Inlet Capacity
B0910	45.37		0.305	0.27	0.142	Inlet Capacity
B0911	50.24		0.344	0.01	0.272	Inlet Capacity
B0913	51.57		0.241	0	0.203	Inlet Capacity
B0914	51.93		0.241	0.02	0.104	Inlet Capacity
B0916	44.65		0.089	1.03	0.039	Inlet Capacity
B0920	44.25		0.174	0.02	0.049	Inlet Capacity
B0921	46.52		0.121	0.06	0.121	Inlet Capacity
B0922	46.85		0.155	0	0.121	Inlet Capacity
B0923	47.1		0.131	0.2	0.025	Inlet Capacity
B0924	48.09		0.264	0.72	0.26	Inlet Capacity
B0925	51.19		0.207	0.17	0.054	Inlet Capacity
B0926	51.6		0.033	0.02	0.004	Inlet Capacity
B0927	44.82		0.583	0.22	0.329	Inlet Capacity
B0929	45.96		0.353	0.02	0.249	Inlet Capacity
B0930	46.9		0.353	0.01	0.231	Inlet Capacity
B0933	53.48		0.062	0	0.049	Inlet Capacity
B0934	53.49		0.062	0.01	0.035	Inlet Capacity
B0936	50.09		0.168	0.01	0.112	Inlet Capacity
B0937	50.11		0.096	0.01	0.072	Inlet Capacity
B0939	49.55		0.096	0.03	0.043	Inlet Capacity
B0940	49.56		0.096	0.01	0.07	Inlet Capacity
B0941	49.01		0.096	0.52	0.043	Inlet Capacity
B0942	56.83		0.062	0.95	0.004	Inlet Capacity
B0943	56.92		0.047	0.87	0.015	Inlet Capacity
B0944	57.04		0.047	0.76	0.015	Inlet Capacity
B0945	56.95		0.062	0.56	0.022	Inlet Capacity
B0948	54.09		0.14	0.02	0.043	Inlet Capacity
B0949	57.07		0.117	0.52	0.022	Inlet Capacity
B0950	59.45		0.117	0.71	0.022	Inlet Capacity
B0951	61.51	61.92	0.093	0.3	0	Inlet Capacity
B0952	62.03		0.332	0.01	0.227	Inlet Capacity
B0953	64.62		0.389	0.01	0.266	Inlet Capacity
B0958	79.2		0.146	0.56	0.047	Inlet Capacity
B0964	70.74		0.567	0.02	0.414	Inlet Capacity
B0966	70.91		0.113	0.17	0.021	Inlet Capacity
B0967	55.84	56.34	0.077	0.4	0	Inlet Capacity
B0968	56.41		0.13	0.02	0.037	Inlet Capacity
B0969	55.87		0.064	0.77	0.014	Inlet Capacity
B0970	55.24	56.27	0.064	0.91	0	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0972	71.77		0.227	0.85	0.128	Inlet Capacity
B0977	83.12		0.145	0.01	0.089	Inlet Capacity
B0978	83.51		0.113	0.02	0.032	Inlet Capacity
B0982	77.61	78.2	0.145	0.45	0	Inlet Capacity
B0983	77.92		0.145	0.54	0.025	Inlet Capacity
B0984	79.13		0.031	0.96	0.004	Inlet Capacity
B0986	70.65		0.148	0.02	0.034	Inlet Capacity
B0987	72.33		0.124	0.22	0.024	Inlet Capacity
B0988	72.49		0.124	0.29	0.038	Inlet Capacity
B0993	67.32		0.149	0.01	0.071	Inlet Capacity
B0996	74.86		0.058	1.08	0.004	Inlet Capacity
B0997	75.6		0.069	0.73	0.007	Inlet Capacity
B0998	80.27		0.058	0.82	0.012	Inlet Capacity
B1001	67.48		0.082	0.02	0.022	Inlet Capacity
B1002	72.99		0.065	0.01	0.025	Inlet Capacity
B1003	75.37		0.058	0.73	0.012	Inlet Capacity
B1005	59.37		0.077	0.57	0.009	Inlet Capacity
B1006	57.78	58.2	0.077	0.32	0	Inlet Capacity
B1007	67.76		0.162	0.01	0.094	Inlet Capacity
B1008	61.09		0.424	0	0.347	Inlet Capacity
B1011	72.72		0.217	0.05	0.113	Inlet Capacity
B1012	74.15		0.293	0.02	0.165	Inlet Capacity
B1015	80.54		0.157	0.01	0.095	Inlet Capacity
B1016	81.58		0.134	0.06	0.025	Inlet Capacity
B1017	81.72		0.273	0	0.191	Inlet Capacity
B1018	72.88		0.045	0.53	0.001	Inlet Capacity
B1019	72.94		0.046	0.72	0.014	Inlet Capacity
B1020	72.99		0.045	0.82	0.001	Inlet Capacity
B1021	74.86		0.045	0.29	0.001	Inlet Capacity
B1022	70.03	70.4	0.003	0.36	0	Inlet Capacity
B1024	70.62		0.194	0.17	0.047	Inlet Capacity
B1027	74.65		0.074	0	0.062	Inlet Capacity
B1028	75.2		0.07	0.41	0.016	Inlet Capacity
B1029	75.31		0.058	0.38	0.012	Inlet Capacity
B1030	73.36		0.067	1.64	0.025	Inlet Capacity
B1031	78.13		0.079	1.82	0.009	Inlet Capacity
B1032	82.4		0.058	1.21	0.021	Inlet Capacity
B1033	79.34		0.031	0.74	0.004	Inlet Capacity
B1036	44.58		0.042	1	0.042	Inlet Capacity
B1041	40.39		0.057	0.01	0.015	Inlet Capacity
B1043	28.53		0.58	0.01	0.467	Inlet Capacity
B1044	29.2		0.655	0	0.577	Inlet Capacity
B1051	7.05	7.97	0.058	0.81	0	Inlet Capacity
B1052	11.54		0.056	0.27	0.004	Inlet Capacity
B1053	17.8		0.027	4.4	0.005	Inlet Capacity
B1054	23.37		0.124	0.8	0.024	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1055	24.21		0.105	1.02	0.019	Inlet Capacity
B1056	24.52	25.36	0.136	0.7	0	Inlet Capacity
B1057	31.46		0.07	0.01	0.031	Inlet Capacity
B1059	37.6		0.123	0.02	0.038	Inlet Capacity
B1060	38.66		0.086	0.79	0.037	Inlet Capacity
B1061	38.82		0.07	0.91	0.016	Inlet Capacity
B1062	7.13		0.052	0.97	0.003	Inlet Capacity
B1064	9.18		0.059	1.01	0.059	Inlet Capacity
B1065	9.44	10.52	0.059	0.97	0	Inlet Capacity
B1066	39.44		0.07	0.7	0.016	Inlet Capacity
B1068	10.4	11.07	0.602	0.52	0.406	Inlet Capacity
B1071	30.42		0.136	0.02	0.061	Inlet Capacity
B1072	31.43		0.136	0.66	0.042	Inlet Capacity
B1074	19.59		0.314	0.03	0.145	Inlet Capacity
B1075	10.43		0.069	0.22	0.027	Inlet Capacity
B1079	34.87	35.25	0.375	0.23	0.224	Inlet Capacity
B1081	36.43		0.451	0.72	0.192	Inlet Capacity
B1085	46.05		0.161	0.02	0.075	Inlet Capacity
B1086	38.24		0.275	0.02	0.139	Inlet Capacity
B1088	45.33		0.121	0	0.093	Inlet Capacity
B1090	39.11		0.163	0	0.118	Inlet Capacity
B1091	41.31	41.89	0.162	0.43	0.03	Inlet Capacity
B1092	41.7		0.245	0	0.157	Inlet Capacity
B1093	42.05		0.162	0.01	0.082	Inlet Capacity
B1096	32.76		0.149	0.29	0.027	Inlet Capacity
B1098	30.72	32.01	0.23	1.14	0.074	Inlet Capacity
B1099	31.96		0.398	0.01	0.228	Inlet Capacity
B1101	43.65	44.18	0.322	0.38	0.168	Inlet Capacity
B1102	44.05		0.248	0.02	0.099	Inlet Capacity
B1109	43.87		0.051	0.01	0.024	Inlet Capacity
B1110	44.24		0.06	0.51	0.005	Inlet Capacity
B1111	44.49	45.83	0.082	1.21	0	Inlet Capacity
B1112	45.02		0.063	0.67	0.013	Inlet Capacity
B1113	45.21		0.028	0.28	0.003	Inlet Capacity
B1114	45.42		0.082	0.48	0.021	Inlet Capacity
B1115	45.85		0.027	0.75	0.002	Inlet Capacity
B1116	46.15		0.036	0.65	0.005	Inlet Capacity
B1117	42.93		0.145	0.01	0.049	Inlet Capacity
B1118	45.56		0.209	0.15	0.083	Inlet Capacity
B1119	46.27		0.289	0.01	0.206	Inlet Capacity
B1120	47.15		0.211	1.15	0.056	Inlet Capacity
B1121	47.97		0.014	0.88	0	Inlet Capacity
B1128	45.57		0.09	0.02	0.024	Inlet Capacity
B1129	45.62		0.09	0.01	0.059	Inlet Capacity
B1130	45.12		0.109	0.02	0.039	Inlet Capacity
B1132	48.22		0.055	0.69	0.055	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond	Max Surface	Min	Overflow	Constraint
		HGL	Flow Arriving	Freeboard	(cu.m/s)	
		(Sag Pits)	(cu.m/s)	(m)		
B1133	52.67	52.98	0.162	0.16	0.006	Inlet Capacity
B1134	53.13		0.21	0.74	0.113	Inlet Capacity
B1136	57.67		0.243	0.02	0.106	Inlet Capacity
B1139	48.76	49.03	0.152	0.01	0	Inlet Capacity
B1140	48.79		0.105	0	0.079	Inlet Capacity
B1141	50.36		0.075	0.55	0.031	Inlet Capacity
B1142	51.95		0.411	0.55	0.263	Inlet Capacity
B1143	53.84	54.52	0.638	0.53	0.385	Inlet Capacity
B1145	42.85		0.039	1.15	0.039	Inlet Capacity
B1146	45.13		0.015	1.37	0.015	Inlet Capacity
B1147	47.1		0.02	0.03	0.002	Inlet Capacity
B1148	48.2		0.081	0.28	0.01	Inlet Capacity
B1149	48.74		0.131	0.02	0.069	Inlet Capacity
B1150	48.75		0.015	0.76	0.001	Inlet Capacity
B1152	45.76		0.592	0.15	0.395	Inlet Capacity
B1153	46.02		0.363	0.01	0.221	Inlet Capacity
B1157	49.87		0.266	0.16	0.119	Inlet Capacity
B1161	57.55		0.134	0.21	0.061	Inlet Capacity
B1162	58.58		0.251	0.05	0.074	Inlet Capacity
B1164	60.73		0.194	0.22	0.073	Inlet Capacity
B1166	61.57		0.094	0.16	0.041	Inlet Capacity
B1167	61.71		0.063	0.63	0.013	Inlet Capacity
B1168	61.25		0.063	0.01	0.03	Inlet Capacity
B1169	61.61		0.076	0.55	0.031	Inlet Capacity
B1171	43.1		0.139	0.01	0.076	Inlet Capacity
B1172	46.63	47.14	0.139	0.36	0.011	Inlet Capacity
B1174	58.17		0.078	0.75	0.019	Inlet Capacity
B1178	35.42		1.654	0.83	1.073	Inlet Capacity
B1185	52.69		0.905	0	0.792	Inlet Capacity
B1188	59.55		0.295	0.02	0.178	Inlet Capacity
B1189	52.73		0.181	0	0.152	Inlet Capacity
B1190	53.01		0.181	0.28	0.096	Inlet Capacity
B1191	52.09		0.181	0.36	0.042	Inlet Capacity
B1193	42.49		0.298	0.51	0.179	Inlet Capacity
B1194	44.5		0.531	0.25	0.295	Inlet Capacity
B1196	47.42		0.446	0.17	0.173	Inlet Capacity
B1197	48.16		0.254	0.4	0.076	Inlet Capacity
B1198	52.05		0.203	0.72	0.052	Inlet Capacity
B1200	37.79		0.189	0.48	0.045	Inlet Capacity
B1202	34.31		0.131	1.65	0.025	Inlet Capacity
B1204	30.15		0.076	0.79	0.009	Inlet Capacity
B1205	30.77		0.065	0.79	0.014	Inlet Capacity
B1207	29.18		0.062	0.99	0.005	Inlet Capacity
B1209	28.09		0.136	0.02	0.03	Inlet Capacity
B1212	22.35		0.233	0.43	0.067	Inlet Capacity
B1215	24.97		0.586	0.02	0.309	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond	Max Surface	Min	Overflow	Constraint
		HGL	Flow Arriving	Freeboard	(cu.m/s)	
		(Sag Pits)	(cu.m/s)	(m)		
B1216	22.95	23.48	0.422	0.38	0.228	Inlet Capacity
B1218	39.85		0.236	0.01	0.116	Inlet Capacity
B1221	39.62	40.51	0.156	0.74	0.024	Inlet Capacity
B1225	39.6		0.196	0	0.158	Inlet Capacity
B1226	39.78		0.117	0.01	0.057	Inlet Capacity
B1228	42.03		0.069	1.01	0.016	Inlet Capacity
B1230	37.31	38.15	0.08	0.71	0	Inlet Capacity
B1231	37.62		0.13	0.47	0.04	Inlet Capacity
B1233	41.29		0.13	0.01	0.066	Inlet Capacity
B1234	41.76		0.148	0.02	0.061	Inlet Capacity
B1235	41.35		0.061	0.01	0.028	Inlet Capacity
B1237	41.07		0.13	2.47	0.064	Inlet Capacity
B1238	30.87		0.258	0.01	0.137	Inlet Capacity
B1239	30.5		0.162	0.02	0.04	Inlet Capacity
B1242	40.48	41.19	0.086	0.61	0	Inlet Capacity
B1243	40.57		0.088	0.67	0.013	Inlet Capacity
B1244	41.21		0.079	0.83	0.01	Inlet Capacity
B1245	43.34		0.079	0.99	0.019	Inlet Capacity
B1246	41.48		0.042	1.14	0.012	Inlet Capacity
B1247	41.95		0.042	1.16	0.012	Inlet Capacity
B1248	42.88		0.042	1.44	0	Inlet Capacity
B1249	41.94	42.48	0.042	0.41	0	Inlet Capacity
B1253	33.9		0.663	0.01	0.466	Inlet Capacity
B1257	47.28		0.236	0	0.192	Inlet Capacity
B1259	42.24	42.98	0.38	0.59	0.198	Inlet Capacity
B1262	47.64		0.073	0	0.062	Inlet Capacity
B1263	48.29		0.099	0.02	0.036	Inlet Capacity
B1264	50.93		0.132	0.47	0.063	Inlet Capacity
B1266	53.4		0.049	0.55	0.016	Inlet Capacity
B1267	46.88		0.229	0.01	0.15	Inlet Capacity
B1268	52.35		0.049	0.92	0.016	Inlet Capacity
B1270	42.12		0.616	0.21	0.423	Inlet Capacity
B1273	43.4		0.2	0.71	0.109	Inlet Capacity
B1274	42.78		0.032	0.1	0.004	Inlet Capacity
B1276	45.31		0.365	0.24	0.228	Inlet Capacity
B1278	49.81		0.196	0	0.174	Inlet Capacity
B1280	51.73		0.279	0.1	0.165	Inlet Capacity
B1281	45.38		0.223	0.43	0.124	Inlet Capacity
B1283	43.32		0.05	1.5	0.002	Inlet Capacity
B1284	46.59		0.049	0.78	0.002	Inlet Capacity
B1285	49.35		0.048	0.79	0.002	Inlet Capacity
B1286	44.08		0.264	0.02	0.104	Inlet Capacity
B1288	56.2		0.138	0.18	0.067	Inlet Capacity
B1289	56.77		0.116	1.17	0.022	Inlet Capacity
B1291	41.66		0.117	1.44	0.022	Inlet Capacity
B1292	43.42	45.3	0.053	1.78	0	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1293	44.58		0.058	0.78	0.012	Inlet Capacity
B1294	44.88		0.058	0.88	0.012	Inlet Capacity
B1295	45.67		0.079	0.32	0.01	Inlet Capacity
B1296	45.78		0.167	0.24	0.058	Inlet Capacity
B1297	47.83		0.113	0.46	0.054	Inlet Capacity
B1298	49.89		0.221	0.02	0.091	Inlet Capacity
B1301	55.86		0.048	0.02	0.006	Inlet Capacity
B1306	58.88		0.127	0.02	0.026	Inlet Capacity
B1310	63.48		0.985	0.01	0.789	Inlet Capacity
B1313	73.16		0.102	0	0.069	Inlet Capacity
B1316	47.93	49.76	0.07	1.71	0	Inlet Capacity
B1317	52.95	53.14	0.251	0.04	0.083	Inlet Capacity
B1318	42.39		0.147	0.99	0.026	Inlet Capacity
B1319	47.39		0.037	0.98	0.005	Inlet Capacity
B1321	49.26		0.344	0.02	0.132	Inlet Capacity
B1324	54.1		0.387	0.01	0.306	Inlet Capacity
B1325	54.52		0.423	0	0.313	Inlet Capacity
B1327	47.71		0.077	0.02	0.014	Inlet Capacity
B1328	47.29		0.077	0	0.058	Inlet Capacity
B1331	48		0.034	1.49	0.008	Inlet Capacity
B1332	49.24		0.176	0.02	0.094	Inlet Capacity
B1334	52.22	53.83	0.298	1.46	0.175	Inlet Capacity
B1335	53.7		0.25	0.01	0.174	Inlet Capacity
B1337	55.39		0.13	0.44	0.04	Inlet Capacity
B1338	55.83		0.101	0.43	0.028	Inlet Capacity
B1340	59.83		0.1	0.71	0.028	Inlet Capacity
B1341	51.75		0.449	0.01	0.31	Inlet Capacity
B1345	56.95		0.151	0.01	0.093	Inlet Capacity
B1346	64		0.126	0.56	0.024	Inlet Capacity
B1350	67.47		0.059	0.34	0.004	Inlet Capacity
B1351	71.86		0.057	0.13	0.011	Inlet Capacity
B1352	75.58		0.048	0.57	0.009	Inlet Capacity
B1353	75.89		0.055	0.74	0.011	Inlet Capacity
B1354	61.93		0.077	0.17	0.017	Inlet Capacity
B1355	64.72		0.087	0.21	0.023	Inlet Capacity
B1359	67.05		0.124	0.46	0.061	Inlet Capacity
B1360	67.58		0.079	0.59	0.033	Inlet Capacity
B1363	61.85		0.617	0	0.493	Inlet Capacity
B1369	69.54		0.188	0	0.139	Inlet Capacity
B1370	71.94		0.066	0.45	0.024	Inlet Capacity
B1371	57.66	58.4	0.044	0.67	0	Inlet Capacity
B1372	69.52		0.152	0.01	0.073	Inlet Capacity
B1381	76.39		0.165	0.01	0.067	Inlet Capacity
B1382	62.84		0.018	0.39	0	Inlet Capacity
B1383	63.89		0.137	0.01	0.072	Inlet Capacity
B1386	76		0.137	0.02	0.045	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1387	64.82		0.185	0.02	0.111	Inlet Capacity
B1389	77.28		0.111	0	0.093	Inlet Capacity
B1390	78.02		0.12	1.18	0.035	Inlet Capacity
B1391	79.32		0.141	0.54	0.044	Inlet Capacity
B1393	18.25	18.79	0.757	0.39	0.487	Inlet Capacity
B1402	53.6	54.21	0.033	0.55	0	Inlet Capacity
B1404	59.76		0.077	0.02	0.025	Inlet Capacity
B1405	60.63		0.195	0.21	0.075	Inlet Capacity
B1406	55.96		0.166	0.07	0.058	Inlet Capacity
B1407	57.42		0.27	0.4	0.158	Inlet Capacity
B1408	58.67		0.424	0.01	0.26	Inlet Capacity
B1411	59.31		0.357	0.05	0.221	Inlet Capacity
B1415	67.35		0.178	0.22	0.04	Inlet Capacity
B1418	47.6		0.058	0.57	0.004	Inlet Capacity
B1419	51.71		0.139	0.16	0.025	Inlet Capacity
B1421	32.35		0.096	0.28	0.015	Inlet Capacity
B1422	47.43		0.26	0.02	0.118	Inlet Capacity
B1426	52.35		0.119	0	0.079	Inlet Capacity
B1428	63.16		0.06	0.02	0.018	Inlet Capacity
B1429	64.54		0.05	0.69	0.009	Inlet Capacity
B1430	66.26		0.077	0.3	0.032	Inlet Capacity
B1432	57.81		0.122	0.65	0.036	Inlet Capacity
B1434	63.76		0.109	0.27	0.019	Inlet Capacity
B1435	61.49		0.08	1.61	0.01	Inlet Capacity
B1439	67.29		0.219	0.19	0.102	Inlet Capacity
B1441	60.51		0.041	1.45	0.011	Inlet Capacity
B1442	60.85		0.041	1.14	0	Inlet Capacity
B1443	59.9		0.052	2.05	0.017	Inlet Capacity
B1444	68.84		0.174	1.18	0.083	Inlet Capacity
B1445	61.94		0.098	0.02	0.035	Inlet Capacity
B1447	63.24		0.098	0.74	0.046	Inlet Capacity
B1448	65.48		0.096	0.77	0.015	Inlet Capacity
B1449	59.4	61.08	0.021	1.58	0	Inlet Capacity
B1450	60.72		0.014	0.77	0	Inlet Capacity
B1451	42.04		0.097	0.01	0.044	Inlet Capacity
B1452	42.76		0.105	0.7	0.018	Inlet Capacity
B1453	44.75		0.098	0.1	0.027	Inlet Capacity
B1454	45.99		0.078	0.69	0.019	Inlet Capacity
B1455	41.14		0.773	0	0.679	Inlet Capacity
B1456	42.44		0.299	0.01	0.19	Inlet Capacity
B1457	48.22		0.196	0.01	0.129	Inlet Capacity
B1458	49.5		0.132	0.11	0.064	Inlet Capacity
B1463	67.2		0.063	0	0.038	Inlet Capacity
B1464	68.77		0.085	0.23	0.012	Inlet Capacity
B1465	71.61		0.06	0.39	0.004	Inlet Capacity
B1466	72.22		0.077	0.5	0.009	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1467	75.03		0.055	1.6	0.018	Inlet Capacity
B1468	75.24		0.054	1.67	0.003	Inlet Capacity
B1469	78.97		0.051	1.08	0.003	Inlet Capacity
B1472	68.82		0.049	1.18	0.001	Inlet Capacity
B1473	70.73		0.05	1.06	0.016	Inlet Capacity
B1474	72.13		0.052	1.17	0.017	Inlet Capacity
B1475	72.76		0.046	0.78	0.014	Inlet Capacity
B1476	73.12		0.043	1.03	0.013	Inlet Capacity
B1477	73.42		0.037	1.08	0.01	Inlet Capacity
B1478	76.02		0.031	1	0.004	Inlet Capacity
B1479	45.92		0.524	0.37	0.293	Inlet Capacity
B1480	41.36		0.224	0.01	0.16	Inlet Capacity
B1481	41.67		0.158	0.01	0.055	Inlet Capacity
B1482	41.45		0.119	0.01	0.051	Inlet Capacity
B1484	52.9		0.075	0.02	0.029	Inlet Capacity
B1496	52.08		0.128	0.02	0.045	Inlet Capacity
B1499	53.09		0.211	0.02	0.066	Inlet Capacity
B1500	45.25		0.037	0.34	0.005	Inlet Capacity
B1501	52.26		0.116	0.67	0.022	Inlet Capacity
B1502	60.17		0.137	0.63	0.067	Inlet Capacity
B1507	72.51		0.034	1.18	0.004	Inlet Capacity
B1509	65.92		0.182	0	0.128	Inlet Capacity
B1510	66.26		0.13	0.01	0.052	Inlet Capacity
B1511	61.36		0.042	0.71	0.006	Inlet Capacity
B1513	48.36		0.104	0.01	0.066	Inlet Capacity
B1514	62.36		0.067	0.52	0.026	Inlet Capacity
B1516	58.94		0.042	0.86	0.006	Inlet Capacity
B1518	43.63	44.08	0.039	0.38	0	Inlet Capacity
B1520	49.25		0.453	0	0.385	Inlet Capacity
B1523	40.38		0.231	0	0.174	Inlet Capacity
B1524	43.35		0.17	0.61	0.061	Inlet Capacity
B1526	37.89		0.067	0.61	0.015	Inlet Capacity
B1555	54.01		0.105	0.7	0.03	Inlet Capacity
B1628	43.05		0.484	0.45	0.226	Inlet Capacity
B1629	43.42		0.245	0.58	0.072	Inlet Capacity
B1631	52.85	54.65	0.215	1.65	0.003	Inlet Capacity
B1641	48.31		0.09	0.01	0.032	Inlet Capacity
B1671	41.98		0.104	0.3	0.016	Inlet Capacity
B1672	42.12		0.213	0.31	0.056	Inlet Capacity
B1673	43.12	44.1	0.312	0.83	0.162	Inlet Capacity
B1674	43.29		0.062	1.02	0.005	Inlet Capacity
B1675	44.1		0.142	0.97	0.025	Inlet Capacity
B1676	45.02		0.125	0.87	0.024	Inlet Capacity
B1689	53.02		0.064	1.88	0.006	Inlet Capacity
B1690	53.11		0.06	2.29	0.005	Inlet Capacity
B1691	54.87		0.302	0.01	0.15	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1697	56.48		0.127	0.02	0.042	Inlet Capacity
B1699	56.8		0.057	0	0.038	Inlet Capacity
B1700	56.86		0.054	0.04	0.003	Inlet Capacity
B1703	54.99		0.054	0.06	0.003	Inlet Capacity
B1704	55.06		0.054	0.04	0.003	Inlet Capacity
B1705	55.11		0.054	0.04	0.003	Inlet Capacity
Pit1823	39.44		0.613	0.32	0.61	Inlet Capacity
B0013	31.98		0	0.72		None
B0051	75.91		0.006	0.95		None
B0055	78.96		0.029	0.8	0	None
B0197	32.51		0.003	1.27	0	None
B0199	39.34		0.003	2.76	0	None
B0250	58.39		0.003	0.23	0	None
B0251	58.42		0.028	0.71	0	None
B0252	58.5		0.028	0.7	0	None
B0253	58.51		0.028	1.32	0	None
B0254	60.03		0.028	2.4	0	None
B0255	61.42		0.028	1.45	0	None
B0256	62.31		0.031	1.19	0	None
B0282	40.29		0	1.01	0	None
B0357	33.76		0	0.28	0	None
B0437	43		0	0.65	0	None
B0444	49.7		0	0.35	0	None
B0450	54.83		0	1.7		None
B0466	42.71		0	0.74	0	None
B0474	61.79		0.009	1.75	0	None
B0498	54.94		0	1.26		None
B0501	60.46		0.01	0.92	0	None
B0513	56.57		0.018	2.66	0	None
B0537	25.39		0.041	0.15	0	None
B0575	10.72		0.003	3.19	0	None
B0587	24.33		0.003	0.88	0	None
B0600	37.55		0.003	1.2	0	None
B0605	40.87		0.022	0.13	0	None
B0625	16.66		0	0.97	0	None
B0629	19.98		0.003	0.91	0	None
B0633	21.59		0.005	0.31	0	None
B0634	21.59		0.005	0.33	0	None
B0684	22.63		0.021	0.19	0	None
B0685	22.73		0.012	0.11	0	None
B0722	30.22		0.022	0.17	0	None
B0726	37.88		0.016	0.45	0	None
B0738	26.53		0.003	0.02	0	None
B0778	39.02		0	0.18		None
B0784	39.02		0	0.1		None
B0806	39.98		0	0.57	0	None

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0807	39.98		0	0.47	0	None
B0825	56.72		0.012	0.46	0	None
B0828	51.76		0.015	0.85	0	None
B0841	51.27		0.022	0.33	0	None
B0851	47.83		0.023	0.94	0	None
B0852	48		0.023	0.99	0	None
B0854	32.1		0.003	0.88	0	None
B0855	32.66		0.02	1.31	0	None
B0880	39.11		0.003	0.98	0	None
B0892	43.33		0	0.64		None
B0899	46.53		0.003	0.96	0	None
B0900	48.01		0.003	1.24	0	None
B0901	49.7		0.003	2.01	0	None
B0909	47.65		0	1.14	0	None
B0915	52.15		0.003	0.91	0	None
B0917	45.44		0.033	0.59	0	None
B0973	71.77		0.003	1.27	0	None
B0974	73.79		0.003	0.85	0	None
B0975	73.01		0.003	0.58	0	None
B0980	36.54		0.003	0.44	0	None
B0981	36.79		0.003	0.77	0	None
B1004	57.66		0.012	0.56	0	None
B1025	70.62		0.003	0.44	0	None
B1026	67.2		0.02	0.83	0	None
B1034	56.56		0.015	2.77	0	None
B1039	56.59		0.015	2.74	0	None
B1122	48.59		0.014	0.95	0	None
B1123	48.77		0.014	0.88	0	None
B1151	48.75		0.015	0.63	0	None
B1156	46.31		0.012	0.79	0	None
B1175	58.66		0	0.87	0	None
B1220	40.65		0.011	1.28	0	None
B1240	30.08		0.003	0.9	0	None
B1241	40.32		0	0.62	0	None
B1279	50.36		0	0.85		None
B1282	50.37		0.009	0.82	0	None
B1300	57.03		0.003	0.84	0	None
B1315	54.54		0.01	2.42	0	None
B1320	48.53		0.037	0.76	0	None
B1322	49.28		0.037	0.18	0	None
B1339	47.18		0.029	0.1	0	None
B1356	55.42		0.003	0.9	0	None
B1357	56.21		0.003	1.04	0	None
B1358	56.83		0.003	1.24	0	None
B1375	62.78		0	0.42		None
B1376	63.15		0	0.53		None

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1403	59.35		0.027	0.2	0	None
B1409	58.77		0	0.29	0	None
B1420	51.92		0.003	0.8	0	None
B1433	63.29		0	0.06	0	None
B1470	79.14		0.003	1.95	0	None
B1483	44.38		0.003	0.25	0	None
B1485	39.97		0.012	0.03	0	None
B1503	60.17		0.003	0.74	0	None
B1506	73.2		0.034	0.77	0	None
B1515	68.18		0.038	0.73	0	None
B1521	52.45		0.003	0.65	0	None
B1525	37.83		0.01	0.65	0	None
B1527	38.5		0.007	1.1	0	None
B1528	39.21		0.007	0.41	0	None
B1529	40.86		0.007	0.49	0	None
B1530	42.34		0.003	0.56	0	None
B1531	43.2		0.007	0.6	0	None
B1532	43.65		0.007	0.35	0	None
B1533	39.24		0.007	0.66	0	None
B1636	45.03		0.022	0.57	0	None
B1637	45.67		0.035	2.13	0	None
B1638	47.32		0.019	2.18	0	None
B1640	45.86		0.029	0.04	0	None
B1642	48.32		0.029	0.18	0	None
B1678	52.1		0.03	0.85	0	None
B1679	52.63		0.03	0.62	0	None
B1681	43.14		0.038	0.86	0	None
B1682	55.53		0.013	0.89	0	None
B1683	56.28		0.013	1.07	0	None
B1684	56.94		0.013	1.23	0	None
B1701	56.87		0.008	0.08	0	None
B0020	35.53		9.38	-0.11	10.195	Outlet System
B0021	35.95		8.855	-0.05	9.34	Outlet System
B0025	38.6		8.363	-0.13	9.417	Outlet System
B0029	39.2		5.692	0	6.891	Outlet System
B0030	39.64		5.435	-0.12	5.427	Outlet System
B0031	40.52		5.278	-0.64	5.254	Outlet System
B0032	41.03		4.925	-0.53	4.925	Outlet System
B0033	41.11		4.977	-0.57	4.925	Outlet System
B0034	42.83		2.157	-0.11	2.683	Outlet System
B0035	44.53		1.893	-0.03	2.127	Outlet System
B0041	47.96		1.317	0	1.91	Outlet System
B0047	58.34		0.838	-0.18	1.053	Outlet System
B0048	60.57		0.647	-0.07	0.769	Outlet System
B0057	46.59		0.915	-0.19	1.146	Outlet System
B0058	47.11		0.732	-0.01	0.776	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0059	48.03		0.526	-0.2	0.729	Outlet System
B0060	49.14		0.075	-0.38	0.378	Outlet System
B0067	25.5		0.965	-0.38	1.645	Outlet System
B0069	29.12		0.842	0	1.042	Outlet System
B0070	31.43		0.764	-0.02	0.759	Outlet System
B0074	40.58		1.163	-0.14	1.253	Outlet System
B0084	32.41		0.178	0	0.11	Outlet System
B0092	44.86	44.93	0.456	-0.08	0.34	Outlet System
B0093	45.36		0.312	-0.05	0.344	Outlet System
B0094	46.19		0.164	-0.03	0.197	Outlet System
B0111	26.03		2.327	-0.02	2.423	Outlet System
B0112	26.62		2.015	-0.06	2.274	Outlet System
B0114	28.23		1.716	-0.13	1.971	Outlet System
B0116	31.64		0.183	-0.03	0.287	Outlet System
B0117	32.3		0.156	0	0.126	Outlet System
B0122	39.78		0.629	-0.03	0.592	Outlet System
B0123	42.14		0.45	-0.06	0.459	Outlet System
B0124	43.89		0.296	0	0.363	Outlet System
B0125	44.87		0.165	-0.03	0.19	Outlet System
B0133	22.55		0.811	-0.16	1.413	Outlet System
B0135	22.68	22.8	1.318	-0.03	0.919	Outlet System
B0136	22.74		0.672	0	1.309	Outlet System
B0142	31.19		0.576	0	0.565	Outlet System
B0144	31.9		0.336	-0.14	0.758	Outlet System
B0156	40.45		0.279	0	0.276	Outlet System
B0158	44.38		0.403	-0.02	0.4	Outlet System
B0159	45.55		0.15	-0.07	0.199	Outlet System
B0163	52.5		0.297	-0.02	0.306	Outlet System
B0164	52.73		0.249	-0.01	0.257	Outlet System
B0165	52.88		0.115	-0.06	0.144	Outlet System
B0173	37.36		0.827	-0.06	0.937	Outlet System
B0176	40.42		0.813	-0.05	0.887	Outlet System
B0177	41.33		0.668	-0.05	0.746	Outlet System
B0178	43.49		0.602	-0.01	0.615	Outlet System
B0180	45.67		0.356	-0.31	0.571	Outlet System
B0183	46.95		0.459	-0.04	0.534	Outlet System
B0186	49.28		0.438	0	0.383	Outlet System
B0188	49.3		0.268	0	0.268	Outlet System
B0208	47.28		0.467	0	0.701	Outlet System
B0210	52.49		0.469	-0.02	0.481	Outlet System
B0223	44.2		0.429	0	0.73	Outlet System
B0226	45.98	46.12	0.801	-0.01	0.539	Outlet System
B0227	46.2		0.739	0	0.716	Outlet System
B0228	47.76		0.551	-0.06	0.654	Outlet System
B0232	53.93		1.163	0	1.055	Outlet System
B0233	54.53		0.877	-0.33	1.155	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0234	54.71	54.54	0.823	-0.32	0.87	Outlet System
B0236	55.47		0.95	-0.15	1.107	Outlet System
B0238	58.12		1.293	-0.03	1.221	Outlet System
B0245	53.76		1.537	-0.15	1.71	Outlet System
B0246	56.49		1.293	-0.14	1.516	Outlet System
B0264	47.02		0.151	-0.13	0.316	Outlet System
B0270	59.72		0.369	0	0.326	Outlet System
B0277	33.38		0.048	0	0.291	Outlet System
B0290	28.21		1.076	-0.01	1.099	Outlet System
B0292	28.97		1.202	-0.01	1.246	Outlet System
B0293	32.57		1.038	-0.07	1.2	Outlet System
B0295	34.82		0.886	-0.12	1.106	Outlet System
B0296	35.8		0.849	0	0.845	Outlet System
B0298	37.3		0.671	0	0.583	Outlet System
B0299	37.46		0.644	-0.01	0.649	Outlet System
B0301	38.28		0.539	0	0.737	Outlet System
B0303	39.17		0.514	-0.07	0.651	Outlet System
B0305	40.51		0.613	0	0.676	Outlet System
B0306	41.95		0.615	0	0.594	Outlet System
B0307	42.61		0.39	-0.19	0.559	Outlet System
B0309	44.24	44.27	0.023	-0.03	0	Outlet System
B0310	44.24	44.28	0.023	-0.02	0	Outlet System
B0321	40.27		0.975	-0.01	0.907	Outlet System
B0335	37.36		1.573	-0.01	1.419	Outlet System
B0338	39.98	40.04	2.121	-0.09	1.481	Outlet System
B0339	40.81		1.525	-0.21	2.043	Outlet System
B0358	34		0.121	-0.01	0.126	Outlet System
B0367	51.18		0.434	-0.09	0.453	Outlet System
B0369	51.36		0.306	0	0.372	Outlet System
B0371	41.37		0.84	-0.25	1.525	Outlet System
B0373	44.97		0.805	0	0.755	Outlet System
B0374	45.72		0.958	0	0.805	Outlet System
B0379	48.78		1.262	-0.05	1.397	Outlet System
B0380	48.79		0.153	0	0.144	Outlet System
B0381	49.04		0.136	-0.04	0.135	Outlet System
B0382	49.14		0.081	-0.04	0.121	Outlet System
B0383	49.26		0.025	0	0.065	Outlet System
B0390	49.36		0.535	-0.04	0.612	Outlet System
B0395	56.02		0.17	-0.01	0.182	Outlet System
B0396	56.16		0.111	0	0.094	Outlet System
B0398	39.08		8.283	-0.18	8.283	Outlet System
B0399	39.08		0	0		Outlet System
B0400	39.5	39.25	8.139	-0.4	8.283	Outlet System
B0401	40.38		2.222	-0.03	2.251	Outlet System
B0402	40.64		1.091	-0.06	1.27	Outlet System
B0405	43.71		1.057	0	0.987	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0406	44.15		0.832	-0.1	0.915	Outlet System
B0407	44.57		0.637	-0.06	0.702	Outlet System
B0410	46.3		0.319	-0.02	0.33	Outlet System
B0419	47		0.144	0	0.177	Outlet System
B0426	54.41	54.52	0.105	-0.04	0	Outlet System
B0430	41.96		2.994	-0.83	2.994	Outlet System
B0431	41.99		2.928	-0.46	2.994	Outlet System
B0433	42.08		0.525	0	2.876	Outlet System
B0441	47.7		0.675	-0.05	0.675	Outlet System
B0445	50.06		0.909	0	1.277	Outlet System
B0446	51.62		0.888	-0.17	0.888	Outlet System
B0447	53.45		0.888	-0.02	0.888	Outlet System
B0469	58.33		0.95	-0.01	0.991	Outlet System
B0470	58.58		0.892	-0.24	0.892	Outlet System
B0471	59.68		0.766	-0.02	0.887	Outlet System
B0473	60.48		0.524	-0.07	0.688	Outlet System
B0482	70.1		0.147	-0.25	0.29	Outlet System
B0483	71.53		0.055	-0.07	0.128	Outlet System
B0489	47.2		0.139	0	0.567	Outlet System
B0491	49.35		0.762	-0.26	1.16	Outlet System
B0507	57.52		0.354	-0.12	0.442	Outlet System
B0510	58.6		0.255	0	0.209	Outlet System
B0519	8.52		0.282	-0.09	0.34	Outlet System
B0520	9.13		0.108	0	0.266	Outlet System
B0521	11.42		0.045	-0.06	0.09	Outlet System
B0530	18.85		0.254	-0.05	0.265	Outlet System
B0538	25.3	25.35	0.041	-0.07	0	Outlet System
B0540	24.71		0.463	-0.21	0.551	Outlet System
B0541	24.91		0.249	0	0.27	Outlet System
B0542	25.25		0.185	0	0.191	Outlet System
B0544	26.13		0.146	-0.08	0.192	Outlet System
B0546	36.49	36.61	0.261	-0.03	0.088	Outlet System
B0552	25.01		0.096	-0.03	0.131	Outlet System
B0556	36.54		0.132	-0.01	0.09	Outlet System
B0558	37.02		0.634	-0.01	0.647	Outlet System
B0559	38.01		0.559	-0.01	0.572	Outlet System
B0560	38.16		0.316	-0.15	0.422	Outlet System
B0561	38.14		0.106	-0.01	0.112	Outlet System
B0563	39.18		0.185	0	0.16	Outlet System
B0588	24.75	24.85	0.146	-0.05	0.037	Outlet System
B0590	22.57		0.172	0	0.179	Outlet System
B0593	25.5		0.174	-0.05	0.236	Outlet System
B0596	33.12	33.25	0.343	-0.02	0.135	Outlet System
B0597	33.16		0.291	-0.03	0.27	Outlet System
B0602	40.79	40.87	0.72	-0.07	0.589	Outlet System
B0604	40.63		0.106	0	0.354	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0614	41.69		0.234	0	0.224	Outlet System
B0632	21.58	21.71	0.836	-0.02	0.715	Outlet System
B0635	21.88		0.746	-0.02	0.827	Outlet System
B0636	22.45		0.376	-0.01	0.429	Outlet System
B0641	37.18		0.509	0	0.464	Outlet System
B0643	37.61		0.207	0	0.183	Outlet System
B0644	37.68		0.111	0	0.097	Outlet System
B0646	21.96		0.362	0	0.356	Outlet System
B0650	22.44		0.148	0	0.1	Outlet System
B0657	31.75		1.299	-0.02	1.366	Outlet System
B0658	32.46		0.379	0	0.552	Outlet System
B0660	37.87		0.292	-0.25	0.385	Outlet System
B0661	41.54		0.241	-0.03	0.247	Outlet System
B0664	44.4		0.071	-0.1	0.108	Outlet System
B0668	45.07		0.122	-0.01	0.135	Outlet System
B0669	32.65		0.745	-0.08	0.714	Outlet System
B0671	26.86		1.78	-0.05	1.784	Outlet System
B0674	32.44		0.768	-0.06	0.765	Outlet System
B0675	32.8		0.156	-0.02	0.087	Outlet System
B0676	39.27		0.216	-0.02	0.224	Outlet System
B0691	25.68	25.79	0.579	-0.04	0.458	Outlet System
B0701	23.81		0.397	0	0.336	Outlet System
B0714	35.28		1.485	-0.06	1.549	Outlet System
B0715	36.57		1.411	-0.1	1.458	Outlet System
B0716	37.54		1.263	-0.21	1.382	Outlet System
B0720	28.1	28.23	1.425	-0.02	1.266	Outlet System
B0721	30.15		1.604	0	1.4	Outlet System
B0728	45.02		1.217	0	1.038	Outlet System
B0729	45.52		1.142	-0.27	1.201	Outlet System
B0730	45.7		0.368	-0.12	0.408	Outlet System
B0733	32.22		1.561	-0.14	1.583	Outlet System
B0735	25.8	25.86	0.673	-0.09	0.358	Outlet System
B0740	26.5		0.127	-0.03	0.161	Outlet System
B0746	37.17	37.3	0.862	-0.02	0.686	Outlet System
B0747	37.21		0.763	-0.05	0.814	Outlet System
B0748	38.64		0.669	-0.03	0.673	Outlet System
B0749	38.7		0.644	-0.08	0.647	Outlet System
B0750	38.7		0.308	-0.03	0.316	Outlet System
B0751	37.22	37.29	0.102	-0.08	0.07	Outlet System
B0752	37.46		0.026	0	0.018	Outlet System
B0753	42.1	42.24	0.118	-0.01	0.003	Outlet System
B0754	42.1		0.062	0	0.056	Outlet System
B0755	46		0.531	-0.02	0.525	Outlet System
B0756	46.75		0.301	-0.17	0.382	Outlet System
B0758	51.58		0.397	0	0.345	Outlet System
B0770	34.06		0.812	-0.05	0.801	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0771	34.32		0.634	-0.16	0.788	Outlet System
B0772	34.52		0.138	-0.09	0.221	Outlet System
B0773	34.73		0.077	-0.01	0.103	Outlet System
B0780	39.28		0.258	0	0.277	Outlet System
B0785	40.19		0.026	-0.04	0.066	Outlet System
B0789	37.91		0.275	0	0.22	Outlet System
B0793	59.2		0.213	-0.03	0.224	Outlet System
B0798	40.88		0.054	0	0.074	Outlet System
B0802	43.24		0.069	0	0.074	Outlet System
B0808	48.77		0.611	0	0.611	Outlet System
B0809	49.06		0.569	0	0.595	Outlet System
B0810	50.38		0.405	-0.39	0.473	Outlet System
B0814	49.36		0.054	0	0.054	Outlet System
B0815	49.68		0.398	-0.06	0.444	Outlet System
B0816	50.47		0.257	0	0.356	Outlet System
B0817	52.15		0.238	-0.02	0.254	Outlet System
B0819	59.23		0.199	0	0.174	Outlet System
B0820	59.49		0.127	0	0.139	Outlet System
B0835	50.71		0.032	-0.37	0.11	Outlet System
B0865	34.55	34.65	0.105	-0.05	0	Outlet System
B0870	37.01		0.092	-0.17	0.159	Outlet System
B0874	37.33	37.45	0.134	-0.03	0.036	Outlet System
B0878	38.59		0.046	-0.05	0.085	Outlet System
B0882	39.11		0.162	-0.12	0.298	Outlet System
B0889	40.59		0.105	-0.01	0.11	Outlet System
B0890	40.9		0.851	-0.04	0.885	Outlet System
B0891	41.67		0.825	0	0.765	Outlet System
B0894	44		0.741	-0.08	0.745	Outlet System
B0912	51.01		0.242	0	0.207	Outlet System
B0918	41.97	41.9	0.084	-0.22	0.075	Outlet System
B0919	41.71		0.042	-0.01	0.063	Outlet System
B0928	44.96		0.601	-0.09	0.659	Outlet System
B0931	53.48	53.59	0.097	-0.04	0.047	Outlet System
B0932	53.47		0.111	0	0.106	Outlet System
B0935	50.06		1.335	-0.16	1.231	Outlet System
B0938	50.07		0.096	0	0.097	Outlet System
B0946	52.29		0.388	-0.07	0.411	Outlet System
B0947	52.72		0.16	-0.22	0.251	Outlet System
B0955	69.63		0.211	-0.05	0.225	Outlet System
B0956	73.16		0.165	-0.04	0.165	Outlet System
B0957	78.2		0.096	-0.11	0.116	Outlet System
B0959	61.11		1.1	-0.04	1.139	Outlet System
B0960	62.27		0.813	-0.06	0.831	Outlet System
B0961	62.51		0.702	-0.07	0.754	Outlet System
B0962	63.01		0.6	-0.27	0.7	Outlet System
B0963	68.67		0.523	-0.02	0.536	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0965	70.89		0.52	0	0.435	Outlet System
B0985	67.56		0.158	-0.21	0.244	Outlet System
B0989	61.44		0.448	-0.17	0.526	Outlet System
B0990	63.22		0.26	-0.06	0.305	Outlet System
B0991	64.78		0.245	0	0.209	Outlet System
B0992	65.61		0.123	-0.14	0.195	Outlet System
B0994	72.92		0.097	-0.01	0.097	Outlet System
B0995	73.35		0.019	-0.03	0.04	Outlet System
B0999	62.82		0.08	-0.01	0.096	Outlet System
B1000	63.32	63.4	0.058	-0.11	0	Outlet System
B1009	61.75		0.253	-0.25	0.393	Outlet System
B1010	66.76		0.142	-0.13	0.229	Outlet System
B1013	75.56		0.236	-0.01	0.25	Outlet System
B1014	78.71		0.229	0	0.192	Outlet System
B1023	70		0.05	0	0.057	Outlet System
B1035	44.51		0.084	0	0.318	Outlet System
B1037	46.32	46.46	0.189	-0.01	0.009	Outlet System
B1038	46.37		0.179	0	0.146	Outlet System
B1040	40.35		0.015	0	0.285	Outlet System
B1045	29.28		0.724	0	0.606	Outlet System
B1047	2.54		1.869	0	1.871	Outlet System
B1048	3.78		1.705	-0.15	1.727	Outlet System
B1049	4.17		1.538	-0.08	1.545	Outlet System
B1058	36.9	37	0.109	-0.05	0.003	Outlet System
B1069	13.51		0.459	-0.44	0.538	Outlet System
B1070	18.03		0.13	-0.46	0.21	Outlet System
B1073	13.55		0.214	0	0.184	Outlet System
B1077	30.21		0.416	-4.03	0.665	Outlet System
B1078	32.22		0.275	-0.04	0.314	Outlet System
B1080	35.25		0.252	-0.11	0.196	Outlet System
B1082	45.29	45.43	0.526	-0.01	0.389	Outlet System
B1083	45.5		0.342	0	0.319	Outlet System
B1084	45.7		0.236	0	0.221	Outlet System
B1087	38.29		0.236	0	0.201	Outlet System
B1095	29.95	30.05	0.176	-0.05	0.064	Outlet System
B1100	32.05		0.288	0	0.286	Outlet System
B1104	29.09		0.509	-0.01	0.54	Outlet System
B1105	32.11		0.395	-0.03	0.462	Outlet System
B1106	33.08	33.19	0.462	-0.04	0.344	Outlet System
B1107	33.18		0.27	-0.1	0.357	Outlet System
B1108	33.56		0.087	-0.38	0.208	Outlet System
B1125	44.8		0.744	0	0.689	Outlet System
B1126	44.99	45.08	0.583	-0.06	0.444	Outlet System
B1127	45.03		0.27	-0.06	0.318	Outlet System
B1131	47.38		0.11	-0.01	0.119	Outlet System
B1135	55.61		0.16	-0.01	0.16	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1137	57.77		0.243	-0.05	0.248	Outlet System
B1138	48.36		0.075	-0.02	0.098	Outlet System
B1154	46.04		0.333	-0.01	0.361	Outlet System
B1155	46.18		0.432	-0.01	0.359	Outlet System
B1158	50.45		0.279	0	0.254	Outlet System
B1159	50.82		0.217	-0.03	0.266	Outlet System
B1160	51.19		0.122	-0.09	0.204	Outlet System
B1163	59.1		0.131	-0.1	0.19	Outlet System
B1165	61.23		0.134	0	0.138	Outlet System
B1177	29.34		1.18	0	1.276	Outlet System
B1179	36.39		1.555	0	1.546	Outlet System
B1181	46.24		1.475	-0.04	1.348	Outlet System
B1182	48.81		1.363	-0.01	1.364	Outlet System
B1183	52.03		1.213	-0.03	1.205	Outlet System
B1184	52.5		1.044	0	1.016	Outlet System
B1187	58.82		0.473	-0.05	0.474	Outlet System
B1195	45.23		0.292	-0.1	0.412	Outlet System
B1211	21.48		1.172	0	1.099	Outlet System
B1214	23.53		0.604	-0.03	0.612	Outlet System
B1223	37.5		0.162	0	0.161	Outlet System
B1224	38.94	39.08	0.268	-0.01	0.12	Outlet System
B1250	28.4		0.112	0	0.198	Outlet System
B1251	29.39		0.647	-0.01	0.669	Outlet System
B1252	31.5		0.649	-0.04	0.644	Outlet System
B1255	47		0.401	0	0.352	Outlet System
B1256	47.24		0.428	0	0.398	Outlet System
B1260	46.54		0.161	-0.09	0.197	Outlet System
B1261	46.99		0.099	-0.04	0.124	Outlet System
B1269	39.91		0.443	-0.25	0.546	Outlet System
B1271	42.67	42.54	0.664	-0.28	0.594	Outlet System
B1272	42.72	42.66	0.145	-0.21	0.123	Outlet System
B1275	43.98		0.559	-0.08	0.577	Outlet System
B1299	49.97	50.06	0.151	-0.06	0.031	Outlet System
B1302	56.96	57.09	0.446	-0.02	0.349	Outlet System
B1303	57.11		0.363	-0.09	0.398	Outlet System
B1304	57.74		0.317	0	0.312	Outlet System
B1305	58.35		0.264	0	0.262	Outlet System
B1307	60.14		1.225	-0.04	1.267	Outlet System
B1308	61.42	61.55	1.281	-0.02	1.15	Outlet System
B1309	62.16		0.874	-0.05	0.912	Outlet System
B1311	73.16		0.917	-0.06	0.898	Outlet System
B1312	73.12		0.102	-0.02	0.113	Outlet System
B1314	61.61		1.152	-0.11	1.17	Outlet System
B1323	52.89		0.359	-0.02	0.373	Outlet System
B1326	54.54		0.227	0	0.196	Outlet System
B1329	46.68	46.73	0.029	-0.02	0	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1330	47.1		0.118	0	0.107	Outlet System
B1333	50.05		0.201	0	0.152	Outlet System
B1336	54.1		0.141	-0.01	0.149	Outlet System
B1342	52.16		0.374	-0.01	0.394	Outlet System
B1343	54.7		0.353	-0.03	0.352	Outlet System
B1344	55.67		0.22	-0.01	0.229	Outlet System
B1347	58.5		0.92	-0.05	0.909	Outlet System
B1348	61.76		0.087	-0.18	0.17	Outlet System
B1349	64.53		0.052	0	0.041	Outlet System
B1361	60.28		0.775	-0.59	0.918	Outlet System
B1362	60.82		0.669	-0.11	0.736	Outlet System
B1364	62.35		0.557	-0.03	0.573	Outlet System
B1365	67.95		0.523	-0.01	0.513	Outlet System
B1366	68.58		0.444	-0.02	0.445	Outlet System
B1367	69.29		0.375	-0.02	0.368	Outlet System
B1368	69.45		0.215	-0.02	0.221	Outlet System
B1373	61.94		0.999	-0.38	1.072	Outlet System
B1374	62.36		0.904	-0.22	0.962	Outlet System
B1377	64.11		0.808	-0.01	0.814	Outlet System
B1378	72.11		0.696	-0.07	0.68	Outlet System
B1379	73.34		0.327	-0.27	0.388	Outlet System
B1380	75.85		0.181	-0.02	0.19	Outlet System
B1384	64.53		0.802	0	0.684	Outlet System
B1385	73.47		0.232	0	0.173	Outlet System
B1388	77.01		0.168	-0.01	0.162	Outlet System
B1395	40.4		0.43	0	0.335	Outlet System
B1410	58.92		0.221	0	0.414	Outlet System
B1412	59.74		0.324	0	0.284	Outlet System
B1413	61.42		0.243	0	0.252	Outlet System
B1414	64.82		0.238	-0.03	0.243	Outlet System
B1416	67.35		0.198	0	0.193	Outlet System
B1417	47.22		1.039	-0.03	1.046	Outlet System
B1423	46.69		0.265	-0.01	0.275	Outlet System
B1424	47.12		0.171	0	0.226	Outlet System
B1425	49.4		0.125	-0.01	0.124	Outlet System
B1427	59.47		0.067	-0.01	0.07	Outlet System
B1431	52.84		0.139	-0.02	0.139	Outlet System
B1436	63.26		0.903	0	0.854	Outlet System
B1437	64.58		0.669	-0.38	0.786	Outlet System
B1438	66.77		0.457	-0.29	0.553	Outlet System
B1446	62.11		0.058	-0.1	0.09	Outlet System
B1460	65.19		0.05	-0.1	0.113	Outlet System
B1461	65.64		0.041	0	0.041	Outlet System
B1462	65.37		0.056	0	0.153	Outlet System
B1471	66.75		0.132	-0.72	0.239	Outlet System
B1487	39.21		0.364	-0.02	0.281	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1488	39.95	40.1	0.529	0	0.355	Outlet System
B1489	40.51		0.428	-0.23	0.52	Outlet System
B1490	42.53		0.389	-0.05	0.412	Outlet System
B1491	45.23		0.413	0	0.354	Outlet System
B1492	45.65		0.037	0	0.04	Outlet System
B1493	46.07		0.228	-0.32	0.34	Outlet System
B1494	50.86		0.142	0	0.119	Outlet System
B1495	51.56		0.095	0	0.106	Outlet System
B1497	52.29		0.106	-0.01	0.109	Outlet System
B1498	52.59		0.087	0	0.086	Outlet System
B1504	38.5	38.64	0.685	-0.01	0.571	Outlet System
B1505	38.5		0.552	0	0.55	Outlet System
B1508	64.8		0.49	0	0.477	Outlet System
B1512	47.98		0.191	0	0.171	Outlet System
B1519	48.4		0.705	-0.05	0.646	Outlet System
B1635	43.6		0.223	0	0.317	Outlet System
B1639	44.5		0.181	0	0.205	Outlet System
B1669	40.96		1.08	-0.05	1.327	Outlet System
B1670	41.7		0.109	-0.48	0.887	Outlet System
B1677	49.75		0.046	0	0.1	Outlet System
B1680	44.15		0.176	0	0.279	Outlet System
B1692	54.98		0.214	0	0.214	Outlet System
B1693	55.05		0.212	0	0.212	Outlet System
B1694	55.1		0.135	0	0.197	Outlet System
B1695	55.5		0.114	0	0.121	Outlet System
B1696	55.9		0.093	0	0.1	Outlet System
B1698	56.7		0.092	0	0.074	Outlet System
B1702	54.9		0.054	0	0.086	Outlet System
Pit1832	38.9		0.292	0	0.288	Outlet System

DRAINS OUTPUT – LOW FLOW ASSESSMENT
BUFFALO CREEK CATCHMENT – 5yr ARI

Exported DRAINS results - BUFFALO CREEK - PEAK 5YR ARI						
PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0009	28.39		8.929	1.61	8.929	Inlet Capacity
B0010	29.98		8.925	0.62	8.923	Inlet Capacity
B0011	30.29		9.558	1.84	8.915	Inlet Capacity
B0012	30.67		10.078	1.73	9.547	Inlet Capacity
B0014	32.64		9.948	1.14	9.948	Inlet Capacity
B0015	33.61		10.597	0.69	9.948	Inlet Capacity
B0016	33.97		10.505	0.73	10.505	Inlet Capacity
B0017	34.53		11.147	0.27	10.505	Inlet Capacity
B0018	34.93		11.783	0.02	11.14	Inlet Capacity
B0019	35.29		12.18	0.06	11.776	Inlet Capacity
B0022	36.76		10.295	0.28	10.295	Inlet Capacity
B0023	37.13		10.295	0.45	10.295	Inlet Capacity
B0024	37.7		10.937	0.5	10.295	Inlet Capacity
B0026	38.7		9.772	0.1	9.772	Inlet Capacity
B0027	38.78		0.437	0.07	0.437	Inlet Capacity
B0036	46.34	46.8	2.229	0.31	2.071	Inlet Capacity
B0038	46.98	47.35	2.189	0.17	1.946	Inlet Capacity
B0039	47.31		0.167	0.16	0.035	Inlet Capacity
B0040	47.83		2.95	0.03	2.184	Inlet Capacity
B0042	49.73		2.435	0.97	1.938	Inlet Capacity
B0044	56.85	58.03	2.575	0.98	2.337	Inlet Capacity
B0046	57.99		2.957	0.02	2.526	Inlet Capacity
B0049	75.15		0.233	0.88	0.119	Inlet Capacity
B0050	76.03		0.046	1.87	0.046	Inlet Capacity
B0052	77.03	78.23	0.234	1.05	0	Inlet Capacity
B0053	78.83		0.1	0.68	0.044	Inlet Capacity
B0054	78.97		0.044	0.77	0.013	Inlet Capacity
B0061	50	50.78	0.512	0.28	0	Inlet Capacity
B0062	50.53		0.509	0.16	0.337	Inlet Capacity
B0063	50.69		0.44	0.01	0.331	Inlet Capacity
B0064	50.81		0.079	0.01	0.033	Inlet Capacity
B0066	24.73		2.098	0.1	1.435	Inlet Capacity
B0068	27.5		1.239	0.05	0.743	Inlet Capacity
B0071	35.86		0.863	0.05	0.563	Inlet Capacity
B0072	36.51		1.021	0	0.743	Inlet Capacity
B0073	37.82		1.284	0.23	0.958	Inlet Capacity
B0080	44.05		0.564	0	0.48	Inlet Capacity
B0081	48.48		0.426	0	0.348	Inlet Capacity
B0082	49.53		0.319	0.01	0.202	Inlet Capacity
B0083	49.76		0.203	0.01	0.095	Inlet Capacity
B0085	38.46		0.316	0.01	0.18	Inlet Capacity
B0089	40.75		0.39	0.01	0.274	Inlet Capacity
B0090	44.26		0.447	0.01	0.317	Inlet Capacity
B0095	49.09		0.179	0	0.128	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0096	50.1		0.171	0.02	0.043	Inlet Capacity
B0097	50.67		0.136	0.02	0.034	Inlet Capacity
B0100	14.44		0.987	3.28	0.561	Inlet Capacity
B0101	16.05		1.457	4.7	0.919	Inlet Capacity
B0102	18.25		2.064	2.92	1.407	Inlet Capacity
B0103	21.25		2.767	0.15	2.014	Inlet Capacity
B0104	21.33		2.663	0.17	2.192	Inlet Capacity
B0105	21.34		0.19	0.26	0.045	Inlet Capacity
B0106	21.34		0.218	0.36	0.058	Inlet Capacity
B0107	21.34		0.168	0.46	0.087	Inlet Capacity
B0108	23.68		3.34	0.16	2.639	Inlet Capacity
B0109	23.81		3.234	0.59	3.231	Inlet Capacity
B0110	25.86		3.61	0.01	3.154	Inlet Capacity
B0113	27.96		2.819	0.02	2.328	Inlet Capacity
B0115	29.4		2.303	0.5	2.324	Inlet Capacity
B0118	32.62		0.199	0.39	0.199	Inlet Capacity
B0119	35.37		0.308	0.73	0.184	Inlet Capacity
B0120	36.13		0.415	0.42	0.217	Inlet Capacity
B0121	36.8		0.018	0.27	0.001	Inlet Capacity
B0126	49.52		0.363	0.28	0.139	Inlet Capacity
B0129	13.26		1.027	2.54	0.76	Inlet Capacity
B0130	16.3		1.342	1.33	1.025	Inlet Capacity
B0131	18.33		1.663	0.85	1.301	Inlet Capacity
B0132	21.14		2.027	0.11	1.62	Inlet Capacity
B0134	22.61	22.78	1.482	0.02	1.317	Inlet Capacity
B0137	25.67		0.783	1.77	0.556	Inlet Capacity
B0138	26.68		0.919	1.02	0.671	Inlet Capacity
B0139	28.55		1.139	0.05	0.831	Inlet Capacity
B0140	29.51	31.08	1.439	1.42	1.023	Inlet Capacity
B0143	31.61		0.989	0.15	0.727	Inlet Capacity
B0145	32.66		0.305	0.5	0.174	Inlet Capacity
B0146	33.27		0.263	0.54	0.151	Inlet Capacity
B0147	33.78		0.25	0.45	0.145	Inlet Capacity
B0148	34.68		0.247	0.52	0.144	Inlet Capacity
B0149	35.36		0.327	1.15	0.199	Inlet Capacity
B0150	36.75		0.433	0.7	0.28	Inlet Capacity
B0151	37.07		0.567	0.59	0.385	Inlet Capacity
B0152	37.62		0.799	0.82	0.566	Inlet Capacity
B0153	37.91	38.61	1.078	0.55	0.744	Inlet Capacity
B0154	38.27		1.106	0.21	1.072	Inlet Capacity
B0160	50.22		0.269	0.01	0.212	Inlet Capacity
B0161	51.83		0.416	0.15	0.266	Inlet Capacity
B0162	52.26		0.422	0	0.363	Inlet Capacity
B0166	53.06		0.171	0.01	0.079	Inlet Capacity
B0167	32.22		1.17	0.25	0.863	Inlet Capacity
B0168	32.4		0.664	0.82	0.453	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0169	33.78		0.821	0.01	0.578	Inlet Capacity
B0170	34.48		0.981	0.01	0.727	Inlet Capacity
B0171	35.58	36.49	1.162	0.76	0.901	Inlet Capacity
B0172	36.84		1.603	0.29	1.036	Inlet Capacity
B0181	46.72		1.03	0.01	0.809	Inlet Capacity
B0182	46.88		0.19	0.05	0.102	Inlet Capacity
B0184	47.48		0.723	0.02	0.52	Inlet Capacity
B0185	47.73		0.648	0.53	0.642	Inlet Capacity
B0193	40.69		1.221	0.38	0.815	Inlet Capacity
B0194	41.54		0.411	0.02	0.29	Inlet Capacity
B0195	42.96		0.12	3.54	0.022	Inlet Capacity
B0196	44.17		0.102	2.65	0.018	Inlet Capacity
B0201	40.43	42.66	0.637	2.08	0.262	Inlet Capacity
B0202	42.38		0.312	0.78	0.146	Inlet Capacity
B0203	43.07		0.28	0.99	0.162	Inlet Capacity
B0204	44.88		0.513	1.16	0.229	Inlet Capacity
B0205	45.51		0.746	1	0.458	Inlet Capacity
B0206	46.64	46.79	0.908	0	0.705	Inlet Capacity
B0207	46.89		0.912	0	0.81	Inlet Capacity
B0209	47.63		0.875	0.01	0.673	Inlet Capacity
B0211	53.84		0.161	0.34	0.08	Inlet Capacity
B0212	56.08		0.175	0.21	0.087	Inlet Capacity
B0213	59.51		0.172	0.76	0.06	Inlet Capacity
B0214	59.84		0.131	0.71	0.04	Inlet Capacity
B0216	42.78		1.026	0.78	0.743	Inlet Capacity
B0220	43.6		0.84	0.35	0.452	Inlet Capacity
B0222	43.82		0.849	0.28	0.539	Inlet Capacity
B0224	45.53		0.709	0.52	0.499	Inlet Capacity
B0225	45.78	46.07	0.798	0.14	0.649	Inlet Capacity
B0229	49.4	49.95	1.022	0.4	0.797	Inlet Capacity
B0230	49.95		1.149	0.01	0.864	Inlet Capacity
B0231	53.43		1.434	0.47	1.105	Inlet Capacity
B0235	54.88		1.516	0.01	1.116	Inlet Capacity
B0237	57.18		1.405	0.45	1.073	Inlet Capacity
B0239	41.3	42.64	0.735	1.19	0.633	Inlet Capacity
B0240	44.27		0.959	0.94	0.703	Inlet Capacity
B0241	45.47	47.45	1.085	1.83	0.937	Inlet Capacity
B0242	48.86		1.674	0.02	1.077	Inlet Capacity
B0243	50.75		1.771	0.66	1.343	Inlet Capacity
B0244	52.86		2.267	0.49	1.699	Inlet Capacity
B0247	57.65		2.808	0.79	2.049	Inlet Capacity
B0248	58.43	58.59	2.903	0.01	2.688	Inlet Capacity
B0249	58.54		0.04	0	0.019	Inlet Capacity
B0256	62.42		0.058	1.08	0.004	Inlet Capacity
B0257	63.31		0.129	1.3	0.024	Inlet Capacity
B0258	64.45		0.289	0.91	0.096	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0259	65.79		0.402	1.07	0.255	Inlet Capacity
B0260	69.33		0.389	0	0.31	Inlet Capacity
B0261	69.39		0.099	0.01	0.043	Inlet Capacity
B0262	43.6		0.327	0.01	0.2	Inlet Capacity
B0263	46.22		0.42	0.46	0.27	Inlet Capacity
B0265	50.96		0.284	0.31	0.169	Inlet Capacity
B0266	52.22		0.138	0.96	0.043	Inlet Capacity
B0267	53		0.472	0.01	0.348	Inlet Capacity
B0269	54.54		0.608	0.01	0.471	Inlet Capacity
B0274	27.86		0.501	0.01	0.388	Inlet Capacity
B0275	30.15		0.074	0.8	0.03	Inlet Capacity
B0276	32.66		0.442	0.62	0.278	Inlet Capacity
B0278	35.34		0.049	1.14	0.016	Inlet Capacity
B0279	36.5	37.65	0.071	1	0	Inlet Capacity
B0280	37.82		0.06	0.27	0.022	Inlet Capacity
B0281	39.97		0.039	0.67	0.011	Inlet Capacity
B0283	40.95		0.172	0.8	0.037	Inlet Capacity
B0284	41.47		0.292	0.53	0.096	Inlet Capacity
B0285	43.34		0.208	0.01	0.141	Inlet Capacity
B0286	44.16		0.17	0.81	0.086	Inlet Capacity
B0287	46.48		0.103	0.78	0.047	Inlet Capacity
B0289	27.85		1.397	0.01	1.18	Inlet Capacity
B0291	28.35	29.06	1.534	0.56	1.385	Inlet Capacity
B0294	34.4		1.402	0	1.265	Inlet Capacity
B0297	36.99		1.378	0.11	1.008	Inlet Capacity
B0302	38.86		0.898	0.01	0.781	Inlet Capacity
B0304	40.09		0.938	0.01	0.754	Inlet Capacity
B0308	44.38		0.973	0.08	0.553	Inlet Capacity
B0312	26.2		1.435	1.7	1.101	Inlet Capacity
B0313	28.04		1.499	0	1.345	Inlet Capacity
B0314	32.51		1.526	0.01	1.344	Inlet Capacity
B0317	40.22		1.566	0.01	1.199	Inlet Capacity
B0318	40.23		1.283	0.01	1.283	Inlet Capacity
B0319	40.23		1.283	0.02	1.283	Inlet Capacity
B0320	40.23		1.283	0.02	1.283	Inlet Capacity
B0322	40.26		0.138	0.01	0.096	Inlet Capacity
B0323	30.21		0.525	0.79	0.241	Inlet Capacity
B0324	32.13	34.11	1.023	1.83	0.509	Inlet Capacity
B0325	32.68		0.89	1.29	0.571	Inlet Capacity
B0326	32.94		0.562	1.31	0.381	Inlet Capacity
B0327	33.31		0.787	0.91	0.488	Inlet Capacity
B0329	33.86		0.995	0.47	0.732	Inlet Capacity
B0331	34.28		0.922	1.27	0.888	Inlet Capacity
B0332	34.45		0.905	1.35	0.509	Inlet Capacity
B0333	35.69		1.347	0.58	0.839	Inlet Capacity
B0334	36.6		1.729	0	1.334	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0336	37.48		2.006	0.27	2.004	Inlet Capacity
B0337	38.71		1.973	1.09	1.973	Inlet Capacity
B0344	41.82		0.591	0.79	0.583	Inlet Capacity
B0359	36.06		0.334	0.01	0.225	Inlet Capacity
B0360	39.33		0.235	0.84	0.099	Inlet Capacity
B0361	36.2		0.985	0.6	0.678	Inlet Capacity
B0362	38.08		0.582	1.07	0.389	Inlet Capacity
B0363	39.2		0.55	0.37	0.363	Inlet Capacity
B0364	50.38		0.56	0.01	0.339	Inlet Capacity
B0365	50.57	51.2	0.029	0.52	0	Inlet Capacity
B0366	50.89		0.601	0	0.533	Inlet Capacity
B0368	51.22		0.079	0.45	0.033	Inlet Capacity
B0370	51.48		0.081	0.56	0.034	Inlet Capacity
B0372	43.87		0.892	0.01	0.647	Inlet Capacity
B0375	47.05	48.87	0.18	1.67	0.026	Inlet Capacity
B0377	47.82		1.53	0.9	1.185	Inlet Capacity
B0378	47.92	48.88	1.848	0.81	1.493	Inlet Capacity
B0384	49.55		0.036	0.05	0.009	Inlet Capacity
B0385	49.93		0.035	0.47	0.009	Inlet Capacity
B0386	50.19		0.035	0.91	0.008	Inlet Capacity
B0387	55.71		0.037	0.69	0.008	Inlet Capacity
B0388	56.76		0.079	0.25	0.01	Inlet Capacity
B0389	56.85		0.11	0.47	0.052	Inlet Capacity
B0391	49.94		0.176	0.02	0.064	Inlet Capacity
B0392	52.66		0.26	1.19	0.112	Inlet Capacity
B0393	55.53		0.458	0.32	0.195	Inlet Capacity
B0397	57.9		0.102	0.95	0.046	Inlet Capacity
B0403	40.91		1.585	0	1.431	Inlet Capacity
B0408	46.02		0.974	0.01	0.796	Inlet Capacity
B0409	46.52		0.418	0	0.332	Inlet Capacity
B0418	45.99		0.257	0.81	0.148	Inlet Capacity
B0420	47.4		0.206	0.1	0.205	Inlet Capacity
B0421	48.04		0.189	0.34	0.185	Inlet Capacity
B0424	53.77		0.231	0.42	0.06	Inlet Capacity
B0425	54.25		0.12	0.31	0.058	Inlet Capacity
B0427	55.13		0.12	0.02	0.033	Inlet Capacity
B0428	51.62		0.156	1.48	0.028	Inlet Capacity
B0429	51.83		0.263	1.5	0.117	Inlet Capacity
B0432	42.06		3.199	0	3.199	Inlet Capacity
B0434	42.47		1.103	0.34	1.105	Inlet Capacity
B0435	42.8		1.091	0.2	1.091	Inlet Capacity
B0436	42.81		1.091	0.59	1.091	Inlet Capacity
B0438	45.44		1.401	0.76	1.401	Inlet Capacity
B0439	46.44		1.378	0.17	1.378	Inlet Capacity
B0440	47.12	47.35	1.421	0.08	1.271	Inlet Capacity
B0442	48.59	49.64	1.474	0.9	1.327	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0443	49.49		2.015	0.03	1.371	Inlet Capacity
B0448	54.14		1.471	1.23	1.471	Inlet Capacity
B0449	54.6	56.74	1.748	1.99	1.471	Inlet Capacity
B0451	56.58		2.195	1.6	1.737	Inlet Capacity
B0452	57.75	61.2	1.571	3.3	1.173	Inlet Capacity
B0453	58.88		1.175	2.24	0.879	Inlet Capacity
B0454	59.2		0.224	2.1	0.123	Inlet Capacity
B0455	59.93	61.17	1.281	1.09	1.048	Inlet Capacity
B0458	60.36		0.33	0.74	0.157	Inlet Capacity
B0459	61.14		0.481	0.01	0.288	Inlet Capacity
B0462	78.52		0.171	0	0.126	Inlet Capacity
B0463	79.29		0.152	0.6	0.077	Inlet Capacity
B0464	42.85		0.251	0.69	0.143	Inlet Capacity
B0465	43.57		0.227	0.68	0.094	Inlet Capacity
B0468	44.4		1.419	0.4	1.091	Inlet Capacity
B0472	60.02		1.245	0.06	1.243	Inlet Capacity
B0475	62.85		0.171	1.38	0.036	Inlet Capacity
B0476	62.98		0.033	2.28	0.007	Inlet Capacity
B0477	65.23		0.031	1.87	0.007	Inlet Capacity
B0478	65.95		0.026	1.25	0.005	Inlet Capacity
B0479	67.22	68.32	0.176	0.95	0	Inlet Capacity
B0480	68.7		0.267	0.56	0.155	Inlet Capacity
B0481	69.75		0.44	0.01	0.244	Inlet Capacity
B0484	73.53		0.116	0.22	0.055	Inlet Capacity
B0485	74.06	74.43	0.202	0.22	0	Inlet Capacity
B0487	74.47		0.076	0.18	0.018	Inlet Capacity
B0488	47.1		2.011	0	1.845	Inlet Capacity
B0490	49.07		1.548	0.01	1.281	Inlet Capacity
B0492	51.98		0.479	1.34	0.305	Inlet Capacity
B0493	59.87		0.662	1.86	0.444	Inlet Capacity
B0494	60.17	61.87	1.04	1.55	0.61	Inlet Capacity
B0495	60.57		0.298	1.43	0.179	Inlet Capacity
B0496	52.96		0.084	0.42	0.036	Inlet Capacity
B0497	55.11	55.52	0.106	0.26	0.01	Inlet Capacity
B0499	55.88		0.066	0.48	0.006	Inlet Capacity
B0500	57.98		0.05	0.78	0.016	Inlet Capacity
B0502	60.97		0.052	0.91	0.017	Inlet Capacity
B0503	49.77		0.004	0.94	0.004	Inlet Capacity
B0504	50.5		0.456	1.3	0.194	Inlet Capacity
B0505	53.04		0.542	4.06	0.362	Inlet Capacity
B0506	56		0.66	1.25	0.449	Inlet Capacity
B0508	57.75	58.25	0.337	0.35	0.151	Inlet Capacity
B0509	57.8	58.26	0.599	0.31	0.199	Inlet Capacity
B0511	59.06		0.229	0.01	0.136	Inlet Capacity
B0512	56.58		0.02	2.78	0.02	Inlet Capacity
B0514	56.61		0.067	2.69	0.006	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0516	7.72	8.31	0.028	0.52	0	Inlet Capacity
B0518	8.09		0.409	0	0.37	Inlet Capacity
B0522	14.13		0.242	0.01	0.16	Inlet Capacity
B0523	17.48		0.342	0.01	0.216	Inlet Capacity
B0525	21.03		0.535	0.01	0.363	Inlet Capacity
B0527	16.1		0.906	1.98	0.659	Inlet Capacity
B0528	18.17		1.029	0	0.902	Inlet Capacity
B0531	19.25		0.283	0.01	0.147	Inlet Capacity
B0533	23.42		0.072	1.04	0.008	Inlet Capacity
B0534	24.61		0.054	0.75	0.019	Inlet Capacity
B0535	25.26		0.11	0	0.081	Inlet Capacity
B0537	25.41		0.054	0.13	0.003	Inlet Capacity
B0543	25.64		0.208	0.11	0.116	Inlet Capacity
B0545	33.03		0.134	0	0.102	Inlet Capacity
B0547	36.66		0.173	0.01	0.078	Inlet Capacity
B0549	26.52		0.322	0	0.234	Inlet Capacity
B0550	30.9		0.248	0.06	0.074	Inlet Capacity
B0553	25.8		0.089	0.56	0.023	Inlet Capacity
B0554	26.59		0.079	0.67	0.01	Inlet Capacity
B0555	25.18		0.079	0.18	0.033	Inlet Capacity
B0562	38.95		0.29	0.17	0.173	Inlet Capacity
B0564	42.73		0.325	0.01	0.195	Inlet Capacity
B0566	44.69		0.103	0.34	0.047	Inlet Capacity
B0567	38.91		0.256	0.05	0.076	Inlet Capacity
B0568	39.1		0.275	0.02	0.118	Inlet Capacity
B0570	42.35		0.139	0.6	0.043	Inlet Capacity
B0572	23.31	24.18	0.06	0.78	0	Inlet Capacity
B0573	23.91		0.056	0.69	0.004	Inlet Capacity
B0576	12.27		0.056	2.1	0.004	Inlet Capacity
B0577	13.99	14.94	0.076	0.83	0	Inlet Capacity
B0578	15.04		0.056	0.61	0.02	Inlet Capacity
B0581	24.97		0.176	0.39	0.038	Inlet Capacity
B0582	27.72		0.295	0.06	0.098	Inlet Capacity
B0584	39.76		0.22	0.31	0.06	Inlet Capacity
B0586	22.15		0.043	2.27	0.013	Inlet Capacity
B0591	24.4		0.194	0.41	0.047	Inlet Capacity
B0592	25.18		0.192	0.08	0.047	Inlet Capacity
B0594	25.75		0.194	0.04	0.047	Inlet Capacity
B0595	29.97	31.13	0.454	1.01	0.252	Inlet Capacity
B0598	36.03		0.18	0.09	0.092	Inlet Capacity
B0599	36.09		0.153	0.16	0.051	Inlet Capacity
B0601	36.16		0.116	0.06	0.034	Inlet Capacity
B0603	40.79		0.329	0.15	0.2	Inlet Capacity
B0606	41.29		0.139	0.04	0.025	Inlet Capacity
B0607	40.77		0.109	0.13	0.02	Inlet Capacity
B0609	43.42		0.295	0.01	0.171	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0610	44.04		0.23	0.5	0.065	Inlet Capacity
B0611	37.21		0.057	0.89	0.02	Inlet Capacity
B0612	37.43		0.155	1	0.053	Inlet Capacity
B0616	40.89		0.153	0	0.109	Inlet Capacity
B0617	40.97		0.139	0.31	0.043	Inlet Capacity
B0621	19.11		0.217	0.56	0.12	Inlet Capacity
B0622	20.35		0.352	0.52	0.217	Inlet Capacity
B0624	15.93	16.84	0.36	0.76	0.208	Inlet Capacity
B0627	16.96	17.42	0.229	0.31	0	Inlet Capacity
B0628	17.27		0.174	0.02	0.055	Inlet Capacity
B0631	21.63	22.16	0.125	0.38	0	Inlet Capacity
B0637	23.78		0.909	0.01	0.678	Inlet Capacity
B0638	28.26		1.189	0.01	0.909	Inlet Capacity
B0640	35.74		0.785	0.01	0.632	Inlet Capacity
B0642	37.56		0.512	0	0.444	Inlet Capacity
B0645	37.71		0.145	0	0.12	Inlet Capacity
B0647	22.11		0.319	0.02	0.202	Inlet Capacity
B0648	22.15		0.173	0	0.145	Inlet Capacity
B0649	22.46		0.007	0	0.004	Inlet Capacity
B0651	23.99		0.125	0.36	0.024	Inlet Capacity
B0652	37.34		0.177	0.01	0.098	Inlet Capacity
B0653	28.89		0.122	0.03	0.036	Inlet Capacity
B0654	31.45		0.096	0.81	0.026	Inlet Capacity
B0655	31.79		0.096	0.86	0.026	Inlet Capacity
B0656	29.14		0.122	0.02	0.047	Inlet Capacity
B0662	42.83		0.383	0	0.33	Inlet Capacity
B0663	43.41		0.258	0.09	0.148	Inlet Capacity
B0665	45.07		0.2	0.02	0.08	Inlet Capacity
B0666	45.18		0.159	0	0.132	Inlet Capacity
B0667	45.23		0.159	0.02	0.09	Inlet Capacity
B0670	38.17		0.305	0.01	0.184	Inlet Capacity
B0672	28.53		0.096	0	0.03	Inlet Capacity
B0673	32.46		0.186	0.01	0.113	Inlet Capacity
B0679	49.83		0.318	0.68	0.152	Inlet Capacity
B0680	50.02		0.033	0.9	0.008	Inlet Capacity
B0681	50.22		0.033	0.56	0.008	Inlet Capacity
B0683	40.24		0.146	0.25	0.026	Inlet Capacity
B0688	20.26		0.277	0.57	0.165	Inlet Capacity
B0689	21.31		0.362	0.72	0.228	Inlet Capacity
B0690	22.31		0.475	2.52	0.314	Inlet Capacity
B0692	25.88		0.523	0.18	0.522	Inlet Capacity
B0693	26.41	27.15	0.978	0.59	0.504	Inlet Capacity
B0694	27.32		0.61	2.09	0.604	Inlet Capacity
B0695	29.83		0.374	0.68	0.236	Inlet Capacity
B0697	20.72		0.406	0.01	0.267	Inlet Capacity
B0698	21.6		0.52	0.56	0.346	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0699	21.76		0.457	0.69	0.455	Inlet Capacity
B0700	23.23		0.579	0.06	0.393	Inlet Capacity
B0702	23.89		0.202	0.01	0.138	Inlet Capacity
B0703	21.94	22.36	0.07	0.3	0	Inlet Capacity
B0704	23.33		0.06	0.05	0.012	Inlet Capacity
B0707	37.69		0.092	1.21	0.024	Inlet Capacity
B0708	38.33		0.093	0.77	0.025	Inlet Capacity
B0709	39.69		0.075	0.72	0.018	Inlet Capacity
B0710	39.23		0.075	0.74	0.009	Inlet Capacity
B0712	33.51		0.116	0	0.082	Inlet Capacity
B0713	34.4		0.092	0.7	0.025	Inlet Capacity
B0719	26.39		1.967	0	1.727	Inlet Capacity
B0725	37.88		0.281	0.01	0.167	Inlet Capacity
B0731	46.58		0.345	0.02	0.231	Inlet Capacity
B0736	26.2	26.38	1.301	0.03	0.841	Inlet Capacity
B0737	26.52		1.246	0.01	1.077	Inlet Capacity
B0738	26.54		0.004	0.01	0.001	Inlet Capacity
B0739	25.82		0.018	0	0.011	Inlet Capacity
B0741	27.73		0.162	0.33	0.032	Inlet Capacity
B0742	29		0.149	0.65	0.027	Inlet Capacity
B0744	29.06	29.63	0.187	0.42	0.061	Inlet Capacity
B0745	29.54		0.234	0.02	0.136	Inlet Capacity
B0757	51.54		0.807	0.01	0.505	Inlet Capacity
B0759	37.44	37.81	0.034	0.31	0	Inlet Capacity
B0760	37.62	38.12	0.023	0.45	0	Inlet Capacity
B0761	35.44		0.44	0.06	0.172	Inlet Capacity
B0762	35.61		0.336	0.01	0.237	Inlet Capacity
B0764	37.54		0.471	0	0.368	Inlet Capacity
B0765	38.19		0.08	0.48	0.02	Inlet Capacity
B0766	38.51		0.062	0.58	0.005	Inlet Capacity
B0767	38.66		0.059	0.72	0.012	Inlet Capacity
B0768	38.7		0.05	0.83	0.009	Inlet Capacity
B0769	34.57		1.252	0	1.088	Inlet Capacity
B0774	35.33		0.244	0.17	0.104	Inlet Capacity
B0775	35.85		0.081	0.25	0.02	Inlet Capacity
B0777	36.29		0.132	0.24	0.025	Inlet Capacity
B0779	39.31		0.143	0.02	0.037	Inlet Capacity
B0781	43.01		0.143	0.51	0.045	Inlet Capacity
B0783	39.35		0.342	0.01	0.245	Inlet Capacity
B0786	41.03		0.089	0.02	0.029	Inlet Capacity
B0787	41.97		0.189	0.11	0.069	Inlet Capacity
B0788	42.14		0.182	0.02	0.089	Inlet Capacity
B0790	39.12		0.236	0.25	0.134	Inlet Capacity
B0791	51.86		0.431	0.01	0.323	Inlet Capacity
B0796	62.89		0.19	0.76	0.046	Inlet Capacity
B0799	41.84		0.13	0.26	0.039	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0800	42.28		0.233	0.5	0.098	Inlet Capacity
B0803	44.63		0.117	0.02	0.034	Inlet Capacity
B0804	45.38		0.094	0.27	0.041	Inlet Capacity
B0805	46.85		0.075	0.86	0.018	Inlet Capacity
B0812	55.37		0.372	0.03	0.217	Inlet Capacity
B0813	55.46		0.207	0	0.165	Inlet Capacity
B0818	58.65		0.352	0	0.247	Inlet Capacity
B0821	59.83		0.11	0.28	0.052	Inlet Capacity
B0822	59.95		0.095	0.77	0.015	Inlet Capacity
B0823	59.98		0.11	0.03	0.032	Inlet Capacity
B0824	60.11		0.095	0.38	0.015	Inlet Capacity
B0828	51.97		0.06	0.64	0.012	Inlet Capacity
B0829	54.43		0.119	0.01	0.057	Inlet Capacity
B0830	55.13		0.142	0.01	0.074	Inlet Capacity
B0831	55.61		0.232	0.3	0.097	Inlet Capacity
B0836	51.57		0.055	0.05	0.019	Inlet Capacity
B0837	52.91		0.033	1.31	0.027	Inlet Capacity
B0838	54.36		0.061	0.76	0.005	Inlet Capacity
B0839	54.51		0.038	0.93	0.005	Inlet Capacity
B0840	55.69		0.077	2.37	0.01	Inlet Capacity
B0841	51.58		0.028	0.02	0.004	Inlet Capacity
B0843	51.12		0.034	0.92	0.008	Inlet Capacity
B0844	51.15		0.028	1.35	0.006	Inlet Capacity
B0845	43.65	44.79	0.028	1.07	0	Inlet Capacity
B0846	55.85		0.119	0.54	0.057	Inlet Capacity
B0847	56.25		0.102	0.37	0.018	Inlet Capacity
B0848	50.02		0.155	0.01	0.08	Inlet Capacity
B0849	52.9		0.1	0.85	0.017	Inlet Capacity
B0850	50.26		0.117	1.06	0.055	Inlet Capacity
B0853	31.18		0.036	0.81	0.009	Inlet Capacity
B0856	33.08		0.066	0.89	0.006	Inlet Capacity
B0857	33.81		0.297	0.01	0.152	Inlet Capacity
B0858	33.66	33.95	0.156	0.14	0	Inlet Capacity
B0859	33.27		0.023	0.6	0.001	Inlet Capacity
B0860	34.55		0.149	0	0.118	Inlet Capacity
B0861	36.38		0.27	0.14	0.114	Inlet Capacity
B0862	37.67		0.151	0	0.106	Inlet Capacity
B0863	38.28		0.09	0	0.061	Inlet Capacity
B0864	38.71		0.126	0.21	0.038	Inlet Capacity
B0866	35.38	36.19	0.138	0.66	0	Inlet Capacity
B0867	38.24		0.194	2.16	0.194	Inlet Capacity
B0868	39.03	39.45	0.379	0.27	0.09	Inlet Capacity
B0869	36.67		0.371	0.02	0.156	Inlet Capacity
B0872	37.67		0.172	0.01	0.082	Inlet Capacity
B0873	38.67		0.146	0.13	0.026	Inlet Capacity
B0876	37.71		0.047	0.61	0.014	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0877	37.81	38.56	0.047	0.61	0	Inlet Capacity
B0879	38.69		0.07	0.14	0.016	Inlet Capacity
B0881	38.89		0.518	0.01	0.437	Inlet Capacity
B0883	39.96		0.383	0	0.298	Inlet Capacity
B0884	40.44		0.222	0.13	0.089	Inlet Capacity
B0885	40.65		0.228	0.02	0.108	Inlet Capacity
B0886	40.66		0.114	0.02	0.114	Inlet Capacity
B0887	40.68		0.114	0.01	0.061	Inlet Capacity
B0888	40.11		0.105	0.02	0.021	Inlet Capacity
B0893	44		0.108	0.53	0.02	Inlet Capacity
B0895	41.64		0.277	0.08	0.09	Inlet Capacity
B0896	44.37		0.155	0.41	0.03	Inlet Capacity
B0897	44.11		0.155	0.71	0.052	Inlet Capacity
B0898	46.47		0.155	0.01	0.061	Inlet Capacity
B0903	37.89		0.132	0.88	0.024	Inlet Capacity
B0904	38.3		0.023	0.68	0.001	Inlet Capacity
B0905	43.71		0.159	0.26	0.051	Inlet Capacity
B0906	44.17		0.114	0.85	0.055	Inlet Capacity
B0907	44.42		0.09	0.79	0.024	Inlet Capacity
B0908	45		0.09	1.07	0.014	Inlet Capacity
B0910	45.62		0.489	0.02	0.282	Inlet Capacity
B0911	50.25		0.518	0	0.44	Inlet Capacity
B0914	51.93		0.315	0.02	0.177	Inlet Capacity
B0916	44.69		0.117	0.99	0.056	Inlet Capacity
B0917	45.47		0.044	0.56	0.001	Inlet Capacity
B0920	44.26		0.228	0.01	0.102	Inlet Capacity
B0921	46.53		0.218	0.05	0.218	Inlet Capacity
B0923	47.23		0.172	0.07	0.037	Inlet Capacity
B0924	48.11		0.362	0.7	0.356	Inlet Capacity
B0925	51.32		0.271	0.04	0.087	Inlet Capacity
B0927	44.94		0.804	0.1	0.494	Inlet Capacity
B0929	45.97		0.462	0.01	0.362	Inlet Capacity
B0933	53.48		0.081	0	0.068	Inlet Capacity
B0936	50.09		0.227	0.01	0.167	Inlet Capacity
B0937	50.12		0.125	0	0.102	Inlet Capacity
B0939	49.58		0.125	0	0.064	Inlet Capacity
B0940	49.57		0.125	0	0.109	Inlet Capacity
B0941	49.04		0.125	0.49	0.061	Inlet Capacity
B0942	57.04		0.084	0.74	0.009	Inlet Capacity
B0943	57.14		0.061	0.65	0.023	Inlet Capacity
B0944	57.21		0.061	0.59	0.023	Inlet Capacity
B0945	57.2		0.084	0.31	0.036	Inlet Capacity
B0948	54.11		0.183	0	0.142	Inlet Capacity
B0949	57.38		0.153	0.21	0.029	Inlet Capacity
B0950	59.52		0.153	0.64	0.029	Inlet Capacity
B0952	62.04		0.47	0	0.368	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0958	79.39		0.193	0.37	0.073	Inlet Capacity
B0964	70.75		0.824	0.01	0.676	Inlet Capacity
B0966	71.04		0.148	0.04	0.026	Inlet Capacity
B0967	56.11	56.39	0.153	0.13	0	Inlet Capacity
B0968	56.42		0.17	0.01	0.097	Inlet Capacity
B0969	55.9		0.084	0.74	0.022	Inlet Capacity
B0970	55.3	56.29	0.084	0.85	0	Inlet Capacity
B0972	72.27		0.298	0.35	0.179	Inlet Capacity
B0977	83.12		0.215	0.01	0.157	Inlet Capacity
B0978	83.52		0.148	0.01	0.067	Inlet Capacity
B0982	77.67	78.21	0.19	0.39	0	Inlet Capacity
B0983	78.2		0.19	0.26	0.046	Inlet Capacity
B0984	79.15		0.04	0.94	0.006	Inlet Capacity
B0986	70.66		0.201	0.01	0.123	Inlet Capacity
B0987	72.53		0.163	0.02	0.038	Inlet Capacity
B0988	72.76		0.163	0.02	0.058	Inlet Capacity
B0993	67.33		0.232	0	0.155	Inlet Capacity
B0996	75.07		0.075	0.87	0.009	Inlet Capacity
B0997	75.68		0.094	0.65	0.014	Inlet Capacity
B0998	80.3		0.075	0.79	0.018	Inlet Capacity
B1001	67.49		0.127	0.01	0.065	Inlet Capacity
B1002	72.99		0.089	0.01	0.051	Inlet Capacity
B1003	75.4		0.075	0.7	0.018	Inlet Capacity
B1005	59.48		0.101	0.46	0.017	Inlet Capacity
B1006	58.09	58.22	0.101	0.01	0	Inlet Capacity
B1007	67.77		0.221	0	0.154	Inlet Capacity
B1011	72.77		0.412	0	0.326	Inlet Capacity
B1012	74.16		0.451	0.01	0.337	Inlet Capacity
B1015	80.55		0.224	0	0.154	Inlet Capacity
B1016	81.62		0.176	0.02	0.048	Inlet Capacity
B1017	81.72		0.358	0	0.289	Inlet Capacity
B1018	72.93		0.059	0.48	0.005	Inlet Capacity
B1019	73.12		0.064	0.54	0.024	Inlet Capacity
B1020	73.17		0.059	0.64	0.005	Inlet Capacity
B1021	74.89		0.059	0.26	0.005	Inlet Capacity
B1022	70.09	70.41	0.004	0.3	0	Inlet Capacity
B1024	70.77		0.293	0.02	0.127	Inlet Capacity
B1028	75.52		0.098	0.09	0.026	Inlet Capacity
B1029	75.67		0.076	0.02	0.022	Inlet Capacity
B1030	73.95		0.094	1.05	0.041	Inlet Capacity
B1031	78.36		0.107	1.59	0.018	Inlet Capacity
B1032	82.43		0.076	1.18	0.031	Inlet Capacity
B1033	79.36		0.04	0.72	0.006	Inlet Capacity
B1036	44.59		0.055	0.99	0.055	Inlet Capacity
B1041	40.39		0.067	0.01	0.023	Inlet Capacity
B1043	28.54		1.055	0	0.947	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1051	7.19	8.01	0.131	0.67	0	Inlet Capacity
B1053	17.83		0.036	4.37	0.009	Inlet Capacity
B1054	23.89		0.161	0.28	0.032	Inlet Capacity
B1055	24.49		0.138	0.74	0.025	Inlet Capacity
B1056	24.66	25.37	0.19	0.56	0	Inlet Capacity
B1057	31.46		0.092	0.01	0.053	Inlet Capacity
B1059	37.62		0.172	0	0.121	Inlet Capacity
B1060	38.82		0.117	0.63	0.056	Inlet Capacity
B1061	39.05		0.092	0.68	0.025	Inlet Capacity
B1062	7.22		0.069	0.88	0.007	Inlet Capacity
B1064	9.2		0.079	0.99	0.079	Inlet Capacity
B1065	9.48	10.54	0.079	0.93	0	Inlet Capacity
B1066	39.48		0.092	0.66	0.025	Inlet Capacity
B1068	10.43	11.07	0.833	0.49	0.481	Inlet Capacity
B1071	30.43		0.178	0.01	0.121	Inlet Capacity
B1072	31.6		0.178	0.49	0.065	Inlet Capacity
B1074	19.6		0.421	0.02	0.245	Inlet Capacity
B1075	10.48		0.09	0.17	0.04	Inlet Capacity
B1079	34.84	35.25	0.435	0.26	0.192	Inlet Capacity
B1081	36.65		0.53	0.5	0.243	Inlet Capacity
B1085	46.06		0.211	0.01	0.125	Inlet Capacity
B1086	38.25		0.453	0.01	0.301	Inlet Capacity
B1088	45.33		0.159	0	0.129	Inlet Capacity
B1090	39.11		0.212	0	0.163	Inlet Capacity
B1091	41.31	41.89	0.212	0.43	0.025	Inlet Capacity
B1092	41.7		0.344	0	0.25	Inlet Capacity
B1093	42.05		0.212	0.01	0.132	Inlet Capacity
B1096	33.03		0.2	0.02	0.054	Inlet Capacity
B1098	30.74	32.01	0.247	1.12	0.085	Inlet Capacity
B1099	31.96		0.43	0.01	0.245	Inlet Capacity
B1101	43.66	44.18	0.498	0.37	0.197	Inlet Capacity
B1102	44.06		0.364	0.01	0.206	Inlet Capacity
B1110	44.39		0.082	0.36	0.011	Inlet Capacity
B1111	44.72	45.85	0.107	0.98	0	Inlet Capacity
B1112	45.33		0.083	0.36	0.021	Inlet Capacity
B1114	45.83		0.108	0.07	0.031	Inlet Capacity
B1115	45.9		0.037	0.7	0.004	Inlet Capacity
B1116	46.17		0.047	0.63	0.009	Inlet Capacity
B1118	45.69		0.41	0.02	0.226	Inlet Capacity
B1120	47.39		0.276	0.91	0.09	Inlet Capacity
B1121	47.99		0.019	0.86	0.002	Inlet Capacity
B1122	48.62		0.019	0.92	0	Inlet Capacity
B1123	48.79		0.019	0.86	0	Inlet Capacity
B1128	45.58		0.118	0.01	0.05	Inlet Capacity
B1129	45.62		0.118	0.01	0.087	Inlet Capacity
B1130	45.13		0.144	0.01	0.073	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1132	48.23		0.073	0.68	0.073	Inlet Capacity
B1134	53.35		0.313	0.52	0.187	Inlet Capacity
B1136	57.68		0.318	0.01	0.177	Inlet Capacity
B1141	50.39		0.098	0.52	0.045	Inlet Capacity
B1142	51.96		0.457	0.54	0.295	Inlet Capacity
B1143	53.85	54.52	0.837	0.52	0.431	Inlet Capacity
B1145	42.86		0.051	1.14	0.05	Inlet Capacity
B1146	45.13		0.019	1.37	0.019	Inlet Capacity
B1148	48.32		0.281	0.16	0.092	Inlet Capacity
B1150	48.78		0.019	0.73	0.002	Inlet Capacity
B1152	45.9		0.892	0.01	0.706	Inlet Capacity
B1156	46.54		0.152	0.56	0.029	Inlet Capacity
B1157	50		0.429	0.03	0.227	Inlet Capacity
B1161	57.66		0.254	0.1	0.136	Inlet Capacity
B1162	58.62		0.347	0.01	0.176	Inlet Capacity
B1164	60.82		0.277	0.13	0.122	Inlet Capacity
B1166	61.71		0.129	0.02	0.07	Inlet Capacity
B1167	61.93		0.082	0.41	0.021	Inlet Capacity
B1168	61.25		0.082	0.01	0.047	Inlet Capacity
B1169	61.77		0.103	0.39	0.047	Inlet Capacity
B1171	43.11		0.183	0	0.119	Inlet Capacity
B1172	46.63	47.14	0.183	0.36	0.007	Inlet Capacity
B1174	58.2		0.102	0.72	0.029	Inlet Capacity
B1178	35.75		2.438	0.5	1.723	Inlet Capacity
B1185	52.69		1.178	0	1.064	Inlet Capacity
B1188	59.55		0.386	0.02	0.27	Inlet Capacity
B1189	52.73		0.238	0	0.208	Inlet Capacity
B1190	53.22		0.238	0.07	0.135	Inlet Capacity
B1191	52.14		0.238	0.31	0.069	Inlet Capacity
B1193	42.53		0.556	0.47	0.376	Inlet Capacity
B1194	44.73		0.871	0.02	0.553	Inlet Capacity
B1196	47.57		0.669	0.02	0.371	Inlet Capacity
B1197	48.54		0.348	0.02	0.139	Inlet Capacity
B1198	52.24		0.264	0.53	0.083	Inlet Capacity
B1200	38.04		0.247	0.23	0.074	Inlet Capacity
B1202	34.34		0.171	1.62	0.037	Inlet Capacity
B1204	30.2		0.105	0.74	0.018	Inlet Capacity
B1205	30.8		0.085	0.76	0.022	Inlet Capacity
B1207	29.21		0.083	0.96	0.011	Inlet Capacity
B1209	28.1		0.182	0.01	0.075	Inlet Capacity
B1212	22.47		0.314	0.31	0.111	Inlet Capacity
B1215	24.98		0.786	0.01	0.514	Inlet Capacity
B1216	22.94	23.48	0.56	0.39	0.273	Inlet Capacity
B1218	39.85		0.309	0.01	0.188	Inlet Capacity
B1221	39.62	40.51	0.204	0.74	0.02	Inlet Capacity
B1226	39.78		0.153	0.01	0.093	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1228	42.07		0.09	0.97	0.024	Inlet Capacity
B1230	37.52	38.17	0.116	0.5	0	Inlet Capacity
B1231	37.77		0.175	0.32	0.064	Inlet Capacity
B1233	41.29		0.208	0.01	0.142	Inlet Capacity
B1234	41.77		0.194	0.01	0.107	Inlet Capacity
B1235	41.35		0.08	0.01	0.048	Inlet Capacity
B1237	41.11		0.17	2.43	0.088	Inlet Capacity
B1238	30.87		0.304	0.01	0.182	Inlet Capacity
B1239	30.5		0.206	0.02	0.083	Inlet Capacity
B1243	41.18		0.121	0.06	0.023	Inlet Capacity
B1244	41.8		0.103	0.24	0.018	Inlet Capacity
B1245	43.49		0.103	0.84	0.029	Inlet Capacity
B1246	42.31		0.058	0.31	0.02	Inlet Capacity
B1247	42.64		0.055	0.47	0.019	Inlet Capacity
B1248	42.91		0.055	1.41	0.004	Inlet Capacity
B1257	47.28		0.309	0	0.264	Inlet Capacity
B1259	42.24	42.98	0.521	0.59	0.208	Inlet Capacity
B1263	48.3		0.132	0.01	0.084	Inlet Capacity
B1264	51.03		0.173	0.37	0.087	Inlet Capacity
B1266	53.43		0.064	0.52	0.024	Inlet Capacity
B1267	46.88		0.301	0.01	0.22	Inlet Capacity
B1268	52.38		0.064	0.89	0.024	Inlet Capacity
B1270	42.14		0.702	0.19	0.491	Inlet Capacity
B1273	43.43		0.262	0.68	0.153	Inlet Capacity
B1274	42.76		0.042	0.12	0.006	Inlet Capacity
B1276	45.53		0.482	0.02	0.328	Inlet Capacity
B1280	51.81		0.366	0.02	0.244	Inlet Capacity
B1281	45.57		0.292	0.24	0.175	Inlet Capacity
B1282	50.48		0.011	0.71	0	Inlet Capacity
B1283	43.36		0.069	1.46	0.007	Inlet Capacity
B1284	46.63		0.068	0.74	0.006	Inlet Capacity
B1285	49.37		0.063	0.77	0.005	Inlet Capacity
B1286	44.09		0.343	0.01	0.192	Inlet Capacity
B1288	56.36		0.181	0.02	0.098	Inlet Capacity
B1289	56.87		0.152	1.07	0.029	Inlet Capacity
B1291	42.04		0.153	1.06	0.029	Inlet Capacity
B1292	43.52	45.32	0.075	1.68	0	Inlet Capacity
B1293	44.63		0.076	0.73	0.019	Inlet Capacity
B1294	44.91		0.076	0.85	0.019	Inlet Capacity
B1295	45.85		0.123	0.14	0.024	Inlet Capacity
B1296	46		0.221	0.02	0.097	Inlet Capacity
B1297	47.86		0.148	0.43	0.073	Inlet Capacity
B1298	49.9		0.29	0.01	0.15	Inlet Capacity
B1301	55.86		0.063	0.02	0.012	Inlet Capacity
B1306	58.89		0.167	0.01	0.065	Inlet Capacity
B1310	63.48		1.321	0.01	1.116	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1313	73.16		0.134	0	0.099	Inlet Capacity
B1316	48.07	49.78	0.092	1.57	0	Inlet Capacity
B1317	52.97	53.14	0.473	0.02	0.181	Inlet Capacity
B1318	42.52		0.193	0.86	0.047	Inlet Capacity
B1319	47.42		0.051	0.95	0.01	Inlet Capacity
B1320	48.55		0.049	0.74	0.002	Inlet Capacity
B1321	49.27		0.486	0.01	0.329	Inlet Capacity
B1322	49.33		0.049	0.13	0.002	Inlet Capacity
B1324	54.11		0.55	0	0.468	Inlet Capacity
B1327	47.72		0.101	0.01	0.037	Inlet Capacity
B1331	48.04		0.045	1.45	0.014	Inlet Capacity
B1332	49.24		0.197	0.02	0.113	Inlet Capacity
B1333	50.05		0.225	0	0.173	Inlet Capacity
B1334	52.22	53.83	0.459	1.46	0.199	Inlet Capacity
B1335	53.7		0.367	0.01	0.296	Inlet Capacity
B1337	55.54		0.173	0.29	0.062	Inlet Capacity
B1338	56.02		0.133	0.24	0.041	Inlet Capacity
B1340	59.87		0.131	0.67	0.04	Inlet Capacity
B1346	64.3		0.166	0.26	0.034	Inlet Capacity
B1350	67.74		0.105	0.07	0.016	Inlet Capacity
B1351	71.98		0.076	0.01	0.043	Inlet Capacity
B1352	75.73		0.063	0.42	0.013	Inlet Capacity
B1353	75.93		0.072	0.7	0.017	Inlet Capacity
B1354	62.08		0.112	0.02	0.038	Inlet Capacity
B1355	64.91		0.123	0.02	0.04	Inlet Capacity
B1359	67.28		0.163	0.23	0.083	Inlet Capacity
B1360	67.9		0.109	0.27	0.051	Inlet Capacity
B1370	72.1		0.089	0.29	0.037	Inlet Capacity
B1371	57.86	58.42	0.059	0.47	0	Inlet Capacity
B1372	69.52		0.209	0.01	0.124	Inlet Capacity
B1381	76.39		0.216	0.01	0.117	Inlet Capacity
B1382	62.88		0.024	0.35	0.002	Inlet Capacity
B1383	63.89		0.179	0.01	0.113	Inlet Capacity
B1386	76.01		0.179	0.01	0.086	Inlet Capacity
B1387	64.83		0.246	0.01	0.171	Inlet Capacity
B1390	78.07		0.167	1.13	0.058	Inlet Capacity
B1391	79.5		0.184	0.36	0.069	Inlet Capacity
B1393	18.25	18.79	0.998	0.39	0.557	Inlet Capacity
B1402	53.8	54.22	0.044	0.35	0	Inlet Capacity
B1403	59.49		0.122	0.06	0.024	Inlet Capacity
B1405	60.82		0.263	0.02	0.116	Inlet Capacity
B1407	57.65		0.437	0.17	0.283	Inlet Capacity
B1408	58.67		0.599	0.01	0.427	Inlet Capacity
B1411	59.34		0.497	0.02	0.327	Inlet Capacity
B1415	67.37		0.234	0.2	0.068	Inlet Capacity
B1418	47.84		0.098	0.33	0.015	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1419	51.85		0.182	0.02	0.053	Inlet Capacity
B1421	32.52		0.125	0.11	0.024	Inlet Capacity
B1422	47.44		0.356	0.01	0.206	Inlet Capacity
B1426	52.35		0.194	0	0.16	Inlet Capacity
B1428	63.18		0.079	0	0.06	Inlet Capacity
B1429	64.65		0.065	0.58	0.014	Inlet Capacity
B1430	66.29		0.101	0.27	0.046	Inlet Capacity
B1432	58.04		0.172	0.42	0.06	Inlet Capacity
B1434	64.01		0.147	0.02	0.038	Inlet Capacity
B1435	61.54		0.104	1.56	0.018	Inlet Capacity
B1439	67.46		0.317	0.02	0.188	Inlet Capacity
B1441	60.56		0.057	1.4	0.02	Inlet Capacity
B1442	60.89		0.058	1.1	0.004	Inlet Capacity
B1443	60.16		0.073	1.79	0.029	Inlet Capacity
B1444	69.06		0.229	0.96	0.12	Inlet Capacity
B1445	61.96		0.158	0	0.113	Inlet Capacity
B1447	63.96		0.127	0.02	0.074	Inlet Capacity
B1448	65.56		0.137	0.69	0.025	Inlet Capacity
B1449	59.43	61.09	0.028	1.55	0	Inlet Capacity
B1450	60.73		0.018	0.76	0.001	Inlet Capacity
B1452	43.16		0.167	0.3	0.033	Inlet Capacity
B1453	44.84		0.131	0.01	0.065	Inlet Capacity
B1454	46.02		0.102	0.66	0.029	Inlet Capacity
B1456	42.45		0.418	0	0.304	Inlet Capacity
B1457	48.23		0.27	0	0.197	Inlet Capacity
B1458	49.59		0.173	0.02	0.098	Inlet Capacity
B1464	68.99		0.111	0.01	0.052	Inlet Capacity
B1465	71.91		0.106	0.09	0.016	Inlet Capacity
B1466	72.71		0.107	0.01	0.04	Inlet Capacity
B1467	75.08		0.076	1.55	0.03	Inlet Capacity
B1468	75.3		0.074	1.61	0.008	Inlet Capacity
B1469	79		0.067	1.05	0.006	Inlet Capacity
B1472	69.98		0.072	0.02	0.015	Inlet Capacity
B1473	71.38		0.074	0.41	0.028	Inlet Capacity
B1474	72.29		0.075	1.01	0.03	Inlet Capacity
B1475	72.82		0.066	0.72	0.024	Inlet Capacity
B1476	73.16		0.06	0.99	0.022	Inlet Capacity
B1477	73.46		0.05	1.04	0.016	Inlet Capacity
B1478	76.04		0.04	0.98	0.006	Inlet Capacity
B1479	46.27		0.884	0.02	0.569	Inlet Capacity
B1480	41.37		0.328	0	0.279	Inlet Capacity
B1481	41.66		0.206	0.02	0.083	Inlet Capacity
B1482	41.45		0.156	0.01	0.089	Inlet Capacity
B1484	52.91		0.1	0.01	0.053	Inlet Capacity
B1485	39.98		0.016	0.02	0	Inlet Capacity
B1496	52.09		0.211	0.01	0.128	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1499	53.1		0.277	0.02	0.131	Inlet Capacity
B1500	45.27		0.048	0.32	0.009	Inlet Capacity
B1501	52.35		0.152	0.58	0.029	Inlet Capacity
B1502	60.2		0.177	0.6	0.093	Inlet Capacity
B1506	73.26		0.044	0.71	0.001	Inlet Capacity
B1507	72.53		0.044	1.16	0.007	Inlet Capacity
B1509	65.92		0.263	0	0.204	Inlet Capacity
B1510	66.26		0.171	0.01	0.092	Inlet Capacity
B1511	61.38		0.055	0.69	0.011	Inlet Capacity
B1513	48.36		0.135	0.01	0.098	Inlet Capacity
B1514	62.44		0.088	0.44	0.038	Inlet Capacity
B1515	68.21		0.05	0.7	0.002	Inlet Capacity
B1516	58.96		0.055	0.84	0.011	Inlet Capacity
B1518	43.64	44.09	0.051	0.37	0	Inlet Capacity
B1520	49.25		0.595	0	0.529	Inlet Capacity
B1524	43.6		0.225	0.36	0.093	Inlet Capacity
B1526	38.01		0.087	0.49	0.023	Inlet Capacity
B1555	54.06		0.138	0.65	0.043	Inlet Capacity
B1628	43.13		0.731	0.37	0.361	Inlet Capacity
B1629	43.58		0.396	0.42	0.159	Inlet Capacity
B1631	52.87	54.65	0.266	1.63	0.047	Inlet Capacity
B1637	45.74		0.048	2.06	0.001	Inlet Capacity
B1638	47.41		0.052	2.09	0.003	Inlet Capacity
B1671	42.21		0.104	0.07	0.018	Inlet Capacity
B1672	42.38		0.169	0.05	0.035	Inlet Capacity
B1673	43.15	44.1	0.384	0.8	0.115	Inlet Capacity
B1674	43.32		0.099	0.99	0.015	Inlet Capacity
B1675	44.13		0.201	0.94	0.049	Inlet Capacity
B1676	45.03		0.165	0.86	0.033	Inlet Capacity
B1679	52.75		0.069	0.5	0.007	Inlet Capacity
B1681	43.19		0.05	0.81	0.002	Inlet Capacity
B1689	53.16		0.087	1.74	0.012	Inlet Capacity
B1690	53.29		0.077	2.11	0.01	Inlet Capacity
B1691	54.87		0.322	0.01	0.168	Inlet Capacity
B1697	56.49		0.189	0.01	0.101	Inlet Capacity
B1700	56.88		0.07	0.02	0.015	Inlet Capacity
B1703	55		0.07	0.05	0.007	Inlet Capacity
B1704	55.07		0.07	0.03	0.007	Inlet Capacity
B1705	55.11		0.07	0.04	0.007	Inlet Capacity
Pit1823	39.46		0.85	0.3	0.84	Inlet Capacity
B0013	31.97		0	0.73		None
B0051	76.08		0.008	0.78		None
B0055	79.04		0.038	0.72	0	None
B0197	32.66		0.004	1.12	0	None
B0199	39.35		0.004	2.75	0	None
B0251	58.77		0.037	0.36	0	None

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0252	58.81		0.037	0.39	0	None
B0253	59.07		0.037	0.76	0	None
B0254	60.23		0.037	2.2	0	None
B0255	61.54		0.039	1.33	0	None
B0282	40.77		0	0.53	0	None
B0357	33.86		0	0.18	0	None
B0437	43.07		0	0.58	0	None
B0444	49.73		0	0.32	0	None
B0450	54.86		0	1.67		None
B0466	42.73		0	0.72	0	None
B0474	61.84		0.012	1.7	0	None
B0498	55.12		0	1.08		None
B0501	60.49		0.017	0.89	0	None
B0513	56.59		0.026	2.64	0	None
B0575	10.76		0.008	3.15	0	None
B0587	24.33		0.004	0.88	0	None
B0600	37.56		0.004	1.19	0	None
B0605	40.89		0.028	0.11	0	None
B0625	16.66		0	0.97	0	None
B0629	19.99		0.004	0.9	0	None
B0633	21.74		0.007	0.16	0	None
B0634	21.73		0.007	0.19	0	None
B0684	22.65		0.028	0.17	0	None
B0685	22.72		0.016	0.12	0	None
B0722	30.35		0.029	0.04	0	None
B0726	37.9		0.021	0.43	0	None
B0778	39.03		0	0.17		None
B0784	39.03		0	0.09		None
B0806	39.99		0	0.56	0	None
B0807	39.99		0	0.46	0	None
B0825	56.77		0.016	0.41	0	None
B0851	47.94		0.03	0.83	0	None
B0852	48.03		0.03	0.96	0	None
B0854	32.16		0.005	0.82	0	None
B0855	32.69		0.031	1.28	0	None
B0880	39.12		0.004	0.97	0	None
B0892	43.37		0	0.6		None
B0899	46.54		0.004	0.95	0	None
B0900	48.02		0.004	1.23	0	None
B0901	49.71		0.004	2	0	None
B0909	47.65		0	1.14	0	None
B0915	52.16		0.004	0.9	0	None
B0973	72.26		0.004	0.78	0	None
B0974	73.8		0.004	0.84	0	None
B0975	73.02		0.004	0.57	0	None
B0980	36.55		0.004	0.43	0	None

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0981	36.79		0.004	0.77	0	None
B1004	57.81		0.021	0.41	0	None
B1025	70.77		0.004	0.29	0	None
B1026	67.26		0.026	0.77	0	None
B1034	56.59		0.02	2.74	0	None
B1039	56.61		0.02	2.72	0	None
B1151	48.78		0.019	0.6	0	None
B1175	58.66		0	0.87	0	None
B1220	40.66		0.015	1.27	0	None
B1240	30.09		0.004	0.89	0	None
B1241	40.82		0	0.12	0	None
B1279	50.48		0	0.73		None
B1300	57.03		0.004	0.84	0	None
B1315	54.54		0.014	2.42	0	None
B1339	47.2		0.038	0.08	0	None
B1356	55.45		0.004	0.87	0	None
B1357	56.24		0.004	1.01	0	None
B1358	56.84		0.004	1.23	0	None
B1375	62.78		0	0.42		None
B1376	63.16		0	0.52		None
B1409	58.82		0	0.24	0	None
B1420	51.93		0.004	0.79	0	None
B1470	79.15		0.004	1.94	0	None
B1483	44.39		0.004	0.24	0	None
B1503	60.2		0.005	0.71	0	None
B1521	52.45		0.004	0.65	0	None
B1525	37.94		0.012	0.54	0	None
B1527	38.54		0.01	1.06	0	None
B1528	39.24		0.01	0.38	0	None
B1529	40.9		0.009	0.45	0	None
B1530	42.36		0.004	0.54	0	None
B1531	43.22		0.01	0.58	0	None
B1532	43.66		0.009	0.34	0	None
B1533	39.28		0.009	0.62	0	None
B1636	45.22		0.029	0.38	0	None
B1640	45.87		0.038	0.03	0	None
B1642	48.35		0.038	0.15	0	None
B1678	52.17		0.04	0.78	0	None
B1682	55.62		0.017	0.8	0	None
B1683	56.34		0.017	1.01	0	None
B1684	56.95		0.017	1.22	0	None
B1701	56.88		0.011	0.07	0	None
B0020	35.53		11.159	-0.11	12.156	Outlet System
B0021	35.94		10.502	-0.04	11.036	Outlet System
B0025	38.7		9.882	-0.23	10.91	Outlet System
B0029	39.2		6.482	0	7.894	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0030	39.78		6.214	-0.25	6.206	Outlet System
B0031	40.81		6.133	-0.93	6.104	Outlet System
B0032	41.33		5.214	-0.83	5.214	Outlet System
B0033	41.4		5.374	-0.86	5.214	Outlet System
B0034	42.88		2.499	-0.16	3.031	Outlet System
B0035	44.53		2.237	-0.03	2.476	Outlet System
B0041	47.96		1.975	0	2.912	Outlet System
B0047	58.38		1.231	-0.22	1.465	Outlet System
B0048	60.63		0.969	-0.13	1.145	Outlet System
B0057	46.59		1.107	-0.19	1.318	Outlet System
B0058	47.11		0.809	-0.01	0.86	Outlet System
B0059	48.03		0.592	-0.2	0.806	Outlet System
B0060	49.14		0.098	-0.38	0.39	Outlet System
B0067	25.56		1.128	-0.44	1.876	Outlet System
B0069	29.12		1.038	0	1.166	Outlet System
B0070	31.42		0.714	-0.01	0.786	Outlet System
B0074	40.59		1.29	-0.15	1.199	Outlet System
B0084	32.41		0.187	0	0.156	Outlet System
B0092	44.85	44.93	0.653	-0.07	0.354	Outlet System
B0093	45.36		0.471	-0.05	0.502	Outlet System
B0094	46.2		0.283	-0.04	0.317	Outlet System
B0099	12.75		0.62	-0.04	0.865	Outlet System
B0111	26.03		3.413	-0.02	3.527	Outlet System
B0112	26.65		2.989	-0.09	3.328	Outlet System
B0114	28.31		2.397	-0.21	2.703	Outlet System
B0116	31.64		0.321	-0.03	0.43	Outlet System
B0117	32.31		0.213	-0.01	0.243	Outlet System
B0122	39.82		0.891	-0.07	0.861	Outlet System
B0123	42.15		0.587	-0.07	0.592	Outlet System
B0124	43.89		0.47	0	0.457	Outlet System
B0125	44.94		0.276	-0.1	0.326	Outlet System
B0127	49.81		0.401	0	0.325	Outlet System
B0133	22.56		1.362	-0.17	1.982	Outlet System
B0135	22.69	22.8	1.555	-0.04	1.449	Outlet System
B0136	22.74		0.87	0	1.549	Outlet System
B0141	30.98	31.06	1.626	-0.07	1.408	Outlet System
B0142	31.19		0.755	0	0.824	Outlet System
B0144	31.96		0.464	-0.2	0.96	Outlet System
B0156	40.45		0.433	0	0.428	Outlet System
B0157	41.04		0.829	0	0.723	Outlet System
B0158	44.38		0.656	-0.02	0.639	Outlet System
B0159	45.57		0.301	-0.09	0.358	Outlet System
B0163	52.5		0.42	-0.02	0.422	Outlet System
B0164	52.74		0.36	-0.02	0.364	Outlet System
B0165	52.88		0.179	-0.06	0.208	Outlet System
B0173	37.45		1.311	-0.15	1.486	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0175	39.7		1.292	0	1.189	Outlet System
B0176	40.42		1.212	-0.05	1.289	Outlet System
B0177	41.32		1.042	-0.04	1.121	Outlet System
B0178	43.49		0.968	-0.01	0.973	Outlet System
B0179	44.71		0.955	0	0.896	Outlet System
B0180	45.78		0.643	-0.42	0.882	Outlet System
B0183	46.99		0.686	-0.08	0.786	Outlet System
B0186	49.36		0.571	-0.08	0.564	Outlet System
B0188	49.3		0.35	0	0.35	Outlet System
B0208	47.28		0.832	0	0.834	Outlet System
B0210	52.56		0.691	-0.09	0.758	Outlet System
B0223	44.2		0.642	0	0.816	Outlet System
B0226	45.99	46.12	0.973	-0.02	0.792	Outlet System
B0227	46.2		1.005	0	0.909	Outlet System
B0228	47.76		0.883	-0.06	0.969	Outlet System
B0232	53.93		1.516	0	1.424	Outlet System
B0233	54.53		1.234	-0.33	1.506	Outlet System
B0234	54.72	54.54	1.12	-0.33	1.223	Outlet System
B0236	55.52		1.095	-0.2	1.245	Outlet System
B0238	58.14		1.489	-0.05	1.376	Outlet System
B0245	53.83		2.02	-0.22	2.243	Outlet System
B0246	56.58		2.159	-0.23	1.995	Outlet System
B0250	58.62		0.004	0	0.004	Outlet System
B0264	47.11		0.22	-0.22	0.416	Outlet System
B0270	59.72		0.529	0	0.483	Outlet System
B0271	63.47		0.553	0	0.396	Outlet System
B0272	63.48		0.286	0	0.267	Outlet System
B0277	33.38		0.065	0	0.354	Outlet System
B0290	28.21		1.429	-0.01	1.357	Outlet System
B0292	28.97		1.488	-0.01	1.53	Outlet System
B0293	32.57		1.31	-0.07	1.483	Outlet System
B0295	34.82		1.134	-0.12	1.357	Outlet System
B0296	35.8		1.045	0	1.089	Outlet System
B0298	37.3		0.99	0	0.87	Outlet System
B0299	37.46		0.95	-0.01	0.964	Outlet System
B0300	38.01		1.065	0	0.903	Outlet System
B0301	38.28		0.784	0	1.026	Outlet System
B0303	39.17		0.757	-0.07	0.896	Outlet System
B0305	40.51		0.918	0	0.916	Outlet System
B0306	41.97		0.881	-0.02	0.894	Outlet System
B0307	42.65		0.625	-0.23	0.81	Outlet System
B0309	44.36	44.36	0.03	-0.15	0	Outlet System
B0310	44.36	44.37	0.03	-0.14	0	Outlet System
B0321	40.27		1.332	-0.01	1.283	Outlet System
B0335	37.36		2.035	-0.01	1.706	Outlet System
B0338	39.99	40.04	2.091	-0.1	1.973	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0339	40.81		1.419	-0.21	1.923	Outlet System
B0358	34.04		0.225	-0.05	0.277	Outlet System
B0367	51.18		0.506	-0.09	0.529	Outlet System
B0369	51.36		0.414	0	0.444	Outlet System
B0371	41.37		0.817	-0.25	1.419	Outlet System
B0373	44.97		0.991	0	0.89	Outlet System
B0374	45.73		1.185	-0.01	0.991	Outlet System
B0379	48.78		1.716	-0.05	1.837	Outlet System
B0380	48.79		0.163	0	0.156	Outlet System
B0381	49.04		0.141	-0.04	0.151	Outlet System
B0382	49.14		0.086	-0.04	0.126	Outlet System
B0383	49.26		0.036	0	0.07	Outlet System
B0390	49.44		0.649	-0.12	0.815	Outlet System
B0394	55.95		0.367	0	0.301	Outlet System
B0395	56.02		0.257	-0.01	0.268	Outlet System
B0396	56.19		0.148	-0.03	0.155	Outlet System
B0398	39.08		9.683	-0.18	9.683	Outlet System
B0399	39.08		0	0		Outlet System
B0400	39.5	39.25	9.332	-0.4	9.683	Outlet System
B0401	40.38		3.179	-0.03	3.192	Outlet System
B0402	40.65		1.711	-0.07	1.908	Outlet System
B0404	41.54		1.598	0	1.462	Outlet System
B0405	43.75		1.465	-0.04	1.468	Outlet System
B0406	44.18		1.182	-0.13	1.277	Outlet System
B0407	44.58		0.944	-0.07	1.015	Outlet System
B0410	46.29		0.418	-0.01	0.429	Outlet System
B0419	47		0.205	0	0.238	Outlet System
B0426	54.46	54.52	0.153	-0.09	0.001	Outlet System
B0430	42.24		3.274	-1.11	3.274	Outlet System
B0431	42.11		3.275	-0.58	3.274	Outlet System
B0433	42.08		1.138	0	3.199	Outlet System
B0441	47.81		1.327	-0.16	1.327	Outlet System
B0445	50.06		1.503	0	2.036	Outlet System
B0446	51.8		1.475	-0.35	1.475	Outlet System
B0447	53.85		1.494	-0.42	1.475	Outlet System
B0460	63.84		0.507	0	0.439	Outlet System
B0461	68.38		0.411	0	0.354	Outlet System
B0469	58.34		1.497	-0.02	1.578	Outlet System
B0470	58.6		1.42	-0.26	1.42	Outlet System
B0471	59.7		1.246	-0.04	1.414	Outlet System
B0473	60.55		0.807	-0.14	1.096	Outlet System
B0482	70.22		0.242	-0.37	0.416	Outlet System
B0483	71.69		0.082	-0.23	0.217	Outlet System
B0486	74.29		0.16	0	0.131	Outlet System
B0489	47.2		0.182	0	0.593	Outlet System
B0491	49.42		0.963	-0.33	1.405	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0507	57.63		0.337	-0.23	0.46	Outlet System
B0510	58.69		0.365	-0.09	0.37	Outlet System
B0519	8.52		0.351	-0.09	0.409	Outlet System
B0520	9.13		0.277	0	0.335	Outlet System
B0521	11.49		0.185	-0.13	0.254	Outlet System
B0524	20.45		0.391	0	0.314	Outlet System
B0529	18.75		0.669	0	0.55	Outlet System
B0530	18.88		0.332	-0.08	0.341	Outlet System
B0536	25.36		0.057	0	0.057	Outlet System
B0538	25.32	25.38	0.054	-0.09	0	Outlet System
B0540	24.71		0.63	-0.21	0.717	Outlet System
B0541	24.91		0.303	0	0.322	Outlet System
B0542	25.25		0.238	0	0.229	Outlet System
B0544	26.12		0.128	-0.07	0.173	Outlet System
B0546	36.49	36.61	0.381	-0.03	0.093	Outlet System
B0551	24.83		0.269	0	0.235	Outlet System
B0552	25.06		0.135	-0.08	0.19	Outlet System
B0556	36.55		0.173	-0.02	0.13	Outlet System
B0558	37.02		0.949	-0.01	0.946	Outlet System
B0559	38.03		0.823	-0.03	0.869	Outlet System
B0560	38.23		0.449	-0.22	0.573	Outlet System
B0561	38.14		0.139	-0.01	0.15	Outlet System
B0563	39.2		0.282	-0.02	0.287	Outlet System
B0580	24.29		0.118	-0.01	0.14	Outlet System
B0588	24.78	24.85	0.192	-0.08	0.05	Outlet System
B0590	22.62		0.24	-0.05	0.265	Outlet System
B0593	25.56		0.241	-0.11	0.324	Outlet System
B0596	33.13	33.25	0.353	-0.03	0.133	Outlet System
B0597	33.16		0.253	-0.03	0.252	Outlet System
B0602	40.8	40.87	1.065	-0.08	0.707	Outlet System
B0604	40.63		0.139	0	0.345	Outlet System
B0614	41.69		0.395	0	0.382	Outlet System
B0615	40.8		0.262	0	0.259	Outlet System
B0632	21.61	21.71	1.289	-0.05	1.089	Outlet System
B0635	21.92		1.15	-0.06	1.275	Outlet System
B0636	22.46		0.687	-0.02	0.749	Outlet System
B0641	37.18		0.713	0	0.668	Outlet System
B0643	37.61		0.277	0	0.248	Outlet System
B0644	37.68		0.145	0	0.132	Outlet System
B0646	21.96		0.514	0	0.507	Outlet System
B0650	22.44		0.197	0	0.139	Outlet System
B0657	31.75		1.957	-0.02	1.866	Outlet System
B0658	32.46		0.573	0	0.677	Outlet System
B0659	33.68		0.597	0	0.53	Outlet System
B0660	37.87		0.46	-0.25	0.552	Outlet System
B0661	41.54		0.396	-0.03	0.402	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0664	44.45		0.146	-0.15	0.193	Outlet System
B0668	45.07		0.159	-0.01	0.174	Outlet System
B0669	32.69		1.08	-0.12	1.109	Outlet System
B0671	26.93		2.596	-0.12	2.63	Outlet System
B0674	32.44		1.184	-0.06	1.178	Outlet System
B0675	32.8		0.233	-0.02	0.171	Outlet System
B0676	39.27		0.282	-0.02	0.29	Outlet System
B0677	39.94		0.537	0	0.396	Outlet System
B0682	39.97		0.172	0	0.181	Outlet System
B0687	18.5		0.216	0	0.202	Outlet System
B0691	25.7	25.79	0.568	-0.06	0.428	Outlet System
B0701	23.91		0.511	-0.1	0.518	Outlet System
B0706	37.18		0.094	0	0.088	Outlet System
B0714	35.29		2.237	-0.07	2.302	Outlet System
B0715	36.59		2.154	-0.12	2.201	Outlet System
B0716	37.55		1.981	-0.22	2.116	Outlet System
B0717	38.63		2.031	0	1.725	Outlet System
B0720	28.1	28.23	2.431	-0.02	1.894	Outlet System
B0721	30.21		2.389	-0.06	2.395	Outlet System
B0728	45.11		1.649	-0.09	1.654	Outlet System
B0729	45.53		1.571	-0.28	1.63	Outlet System
B0730	45.72		0.522	-0.14	0.563	Outlet System
B0732	45.95		0.818	0	0.718	Outlet System
B0733	32.36		2.318	-0.28	2.36	Outlet System
B0735	25.82	25.86	0.949	-0.11	0.909	Outlet System
B0740	26.62		0.167	-0.15	0.242	Outlet System
B0746	37.17	37.3	1.115	-0.02	0.68	Outlet System
B0747	37.21		0.995	-0.05	1.052	Outlet System
B0748	38.71		0.869	-0.1	0.878	Outlet System
B0749	38.7		0.844	-0.08	0.839	Outlet System
B0750	38.73		0.403	-0.06	0.414	Outlet System
B0751	37.22	37.29	0.134	-0.08	0.068	Outlet System
B0752	37.47		0.034	-0.01	0.022	Outlet System
B0753	42.1	42.24	0.167	-0.01	0	Outlet System
B0754	42.11		0.081	-0.01	0.087	Outlet System
B0755	46		0.799	-0.02	0.794	Outlet System
B0756	46.75		0.531	-0.17	0.613	Outlet System
B0758	51.64		0.517	-0.06	0.534	Outlet System
B0763	35.29		0.439	0	0.389	Outlet System
B0770	34.12		1.477	-0.11	1.523	Outlet System
B0771	34.33		1.289	-0.17	1.446	Outlet System
B0772	34.53		0.251	-0.1	0.341	Outlet System
B0773	34.76		0.151	-0.04	0.205	Outlet System
B0776	36.03		0.188	0	0.176	Outlet System
B0780	39.28		0.341	0	0.339	Outlet System
B0785	40.26		0.049	-0.11	0.115	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0789	38.01		0.37	-0.1	0.378	Outlet System
B0793	59.2		0.286	-0.03	0.296	Outlet System
B0794	60.58		0.285	0	0.193	Outlet System
B0797	40.47		0.082	0	0.067	Outlet System
B0798	40.88		0.072	0	0.082	Outlet System
B0802	43.24		0.11	0	0.108	Outlet System
B0808	48.77		0.782	0	0.782	Outlet System
B0809	49.06		0.768	0	0.759	Outlet System
B0810	50.38		0.579	-0.39	0.643	Outlet System
B0811	52.61		0.423	0	0.377	Outlet System
B0814	49.36		0.071	0	0.071	Outlet System
B0815	49.7		0.48	-0.08	0.524	Outlet System
B0816	50.47		0.359	0	0.437	Outlet System
B0817	52.16		0.348	-0.03	0.355	Outlet System
B0819	59.23		0.271	0	0.241	Outlet System
B0820	59.49		0.179	0	0.176	Outlet System
B0827	45.84		0.238	0	0.221	Outlet System
B0832	44.92		0.315	0	0.292	Outlet System
B0834	49.88		0.243	0	0.216	Outlet System
B0835	50.88		0.047	-0.54	0.141	Outlet System
B0842	50.95		0.036	0	0.034	Outlet System
B0865	34.56	34.65	0.138	-0.06	0.001	Outlet System
B0870	37.1		0.198	-0.26	0.297	Outlet System
B0871	37.33		0.138	0	0.123	Outlet System
B0874	37.34	37.45	0.191	-0.04	0.044	Outlet System
B0875	37.34		0.146	0	0.134	Outlet System
B0878	38.58		0.063	-0.04	0.102	Outlet System
B0882	39.12		0.34	-0.13	0.478	Outlet System
B0889	40.59		0.175	-0.01	0.182	Outlet System
B0890	40.9		1.25	-0.04	1.284	Outlet System
B0891	41.73		1.13	-0.06	1.138	Outlet System
B0894	44.08		1.008	-0.16	1.018	Outlet System
B0912	51.01		0.327	0	0.295	Outlet System
B0913	51.57		0.315	0	0.277	Outlet System
B0918	42.04	41.9	0.11	-0.29	0.072	Outlet System
B0919	41.71		0.055	-0.01	0.076	Outlet System
B0922	46.88		0.21	-0.03	0.218	Outlet System
B0926	51.63		0.047	-0.01	0.051	Outlet System
B0928	45.03		0.824	-0.16	0.9	Outlet System
B0930	46.91		0.462	0	0.342	Outlet System
B0931	53.51	53.59	0.158	-0.07	0.088	Outlet System
B0932	53.47		0.149	0	0.146	Outlet System
B0934	53.51		0.081	-0.01	0.082	Outlet System
B0935	50.06		2.102	-0.16	1.897	Outlet System
B0938	50.07		0.125	0	0.125	Outlet System
B0946	52.3		0.567	-0.08	0.588	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B0947	52.73		0.295	-0.23	0.386	Outlet System
B0951	61.81	61.94	0.126	0	0	Outlet System
B0953	64.63		0.511	0	0.386	Outlet System
B0955	69.63		0.299	-0.05	0.314	Outlet System
B0956	73.16		0.233	-0.04	0.239	Outlet System
B0957	78.34		0.138	-0.25	0.169	Outlet System
B0959	61.11		1.537	-0.04	1.527	Outlet System
B0960	62.34		1.105	-0.13	1.137	Outlet System
B0961	62.52		0.989	-0.08	1.039	Outlet System
B0962	63.01		0.887	-0.27	0.987	Outlet System
B0963	68.67		0.805	-0.02	0.815	Outlet System
B0965	70.93		0.666	-0.04	0.667	Outlet System
B0985	67.6		0.286	-0.25	0.381	Outlet System
B0989	61.45		0.721	-0.18	0.797	Outlet System
B0990	63.22		0.454	-0.06	0.5	Outlet System
B0991	64.83		0.371	-0.05	0.385	Outlet System
B0992	65.61		0.227	-0.14	0.299	Outlet System
B0994	72.92		0.155	-0.01	0.158	Outlet System
B0995	73.48		0.031	-0.16	0.08	Outlet System
B0999	62.82		0.14	-0.01	0.154	Outlet System
B1000	63.33	63.41	0.075	-0.12	0	Outlet System
B1008	61.12		0.696	-0.03	0.721	Outlet System
B1009	61.75		0.513	-0.25	0.657	Outlet System
B1010	66.77		0.369	-0.14	0.472	Outlet System
B1013	75.57		0.387	-0.02	0.397	Outlet System
B1014	78.75		0.329	-0.04	0.33	Outlet System
B1023	70.04		0.131	-0.04	0.156	Outlet System
B1027	74.74		0.102	-0.09	0.138	Outlet System
B1035	44.51		0.11	0	0.316	Outlet System
B1037	46.32	46.46	0.254	-0.01	0.016	Outlet System
B1038	46.37		0.235	0	0.198	Outlet System
B1040	40.35		0.023	0	0.301	Outlet System
B1044	29.2		1.152	0	1.053	Outlet System
B1045	29.36		1.088	-0.08	1.097	Outlet System
B1047	2.54		2.345	0	2.338	Outlet System
B1048	3.8		2.122	-0.17	2.14	Outlet System
B1049	4.22		1.896	-0.13	1.905	Outlet System
B1052	11.81		0.077	0	0.058	Outlet System
B1058	36.9	37	0.213	-0.05	0.006	Outlet System
B1069	13.51		0.679	-0.44	0.751	Outlet System
B1070	18.04		0.211	-0.47	0.294	Outlet System
B1073	13.55		0.335	0	0.3	Outlet System
B1077	30.21		0.434	-4.03	0.681	Outlet System
B1078	32.22		0.254	-0.04	0.308	Outlet System
B1080	35.23		0.302	-0.09	0.278	Outlet System
B1082	45.29	45.43	0.725	-0.01	0.468	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1083	45.5		0.474	0	0.45	Outlet System
B1084	45.7		0.335	0	0.315	Outlet System
B1087	38.34		0.353	-0.05	0.354	Outlet System
B1095	29.97	30.05	0.254	-0.07	0.088	Outlet System
B1100	32.05		0.32	0	0.313	Outlet System
B1104	29.09		0.655	-0.01	0.685	Outlet System
B1105	32.11		0.542	-0.03	0.609	Outlet System
B1106	33.09	33.19	0.741	-0.05	0.491	Outlet System
B1107	33.18		0.388	-0.1	0.476	Outlet System
B1108	33.57		0.181	-0.39	0.304	Outlet System
B1109	43.89		0.071	-0.01	0.095	Outlet System
B1113	45.49		0.037	0	0.036	Outlet System
B1117	42.94		0.309	0	0.242	Outlet System
B1119	46.3		0.394	-0.02	0.407	Outlet System
B1125	44.8		0.791	0	0.703	Outlet System
B1126	44.99	45.08	0.754	-0.06	0.474	Outlet System
B1127	45.03		0.354	-0.06	0.403	Outlet System
B1131	47.4		0.147	-0.03	0.189	Outlet System
B1133	52.83	52.98	0.251	0	0.037	Outlet System
B1135	55.61		0.249	-0.01	0.247	Outlet System
B1137	57.77		0.318	-0.05	0.329	Outlet System
B1138	48.38		0.098	-0.04	0.135	Outlet System
B1139	48.79	49.12	0.24	-0.02	0	Outlet System
B1140	48.79		0.143	0	0.142	Outlet System
B1147	47.14		0.104	-0.01	0.14	Outlet System
B1149	48.76		0.242	0	0.267	Outlet System
B1153	46.11		0.504	-0.08	0.42	Outlet System
B1154	46.08		0.466	-0.05	0.501	Outlet System
B1155	46.2		0.566	-0.03	0.477	Outlet System
B1158	50.47		0.401	-0.02	0.413	Outlet System
B1159	50.83		0.325	-0.04	0.386	Outlet System
B1160	51.24		0.203	-0.14	0.31	Outlet System
B1163	59.15		0.197	-0.15	0.27	Outlet System
B1165	61.23		0.199	0	0.197	Outlet System
B1177	29.34		1.865	0	1.869	Outlet System
B1179	36.39		2.297	0	2.292	Outlet System
B1181	46.24		2.046	-0.04	2.01	Outlet System
B1182	48.81		1.901	-0.01	1.897	Outlet System
B1183	52.04		1.7	-0.04	1.691	Outlet System
B1184	52.5		1.413	0	1.407	Outlet System
B1187	58.83		0.656	-0.06	0.653	Outlet System
B1195	45.4		0.526	-0.27	0.721	Outlet System
B1211	21.48		1.57	0	1.562	Outlet System
B1214	23.53		0.881	-0.03	0.886	Outlet System
B1223	37.5		0.168	0	0.166	Outlet System
B1224	38.94	39.08	0.383	-0.01	0.126	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1225	39.6		0.257	0	0.22	Outlet System
B1242	41.1	41.23	0.133	-0.01	0	Outlet System
B1249	42.37	42.5	0.055	-0.02	0	Outlet System
B1250	28.4		0.146	0	0.198	Outlet System
B1251	29.4		1.003	-0.02	1.026	Outlet System
B1252	31.57		0.995	-0.11	1	Outlet System
B1253	33.91		0.955	0	0.768	Outlet System
B1255	47.08		0.55	-0.08	0.557	Outlet System
B1256	47.24		0.573	0	0.546	Outlet System
B1260	46.55		0.242	-0.1	0.277	Outlet System
B1261	46.99		0.17	-0.04	0.195	Outlet System
B1262	47.64		0.131	0	0.122	Outlet System
B1269	39.92		0.51	-0.26	0.608	Outlet System
B1271	42.67	42.54	0.764	-0.28	0.68	Outlet System
B1272	42.71	42.66	0.201	-0.2	0.12	Outlet System
B1275	43.98		0.76	-0.08	0.753	Outlet System
B1278	49.81		0.284	0	0.274	Outlet System
B1299	49.99	50.06	0.197	-0.08	0.045	Outlet System
B1302	56.96	57.09	0.599	-0.02	0.451	Outlet System
B1303	57.11		0.502	-0.09	0.536	Outlet System
B1304	57.74		0.441	0	0.436	Outlet System
B1305	58.35		0.376	0	0.369	Outlet System
B1307	60.14		1.419	-0.04	1.458	Outlet System
B1308	61.43	61.55	1.744	-0.03	1.33	Outlet System
B1309	62.16		1.224	-0.05	1.268	Outlet System
B1311	73.19		1.204	-0.09	1.204	Outlet System
B1312	73.12		0.134	-0.02	0.138	Outlet System
B1314	61.63		1.571	-0.13	1.585	Outlet System
B1323	52.89		0.537	-0.02	0.546	Outlet System
B1325	54.52		0.559	0	0.452	Outlet System
B1326	54.54		0.298	0	0.261	Outlet System
B1328	47.29		0.101	0	0.081	Outlet System
B1329	46.68	46.74	0.038	-0.02	0	Outlet System
B1330	47.1		0.136	0	0.092	Outlet System
B1336	54.14		0.195	-0.05	0.235	Outlet System
B1341	51.76		0.636	0	0.541	Outlet System
B1342	52.17		0.539	-0.02	0.562	Outlet System
B1343	54.8		0.505	-0.13	0.51	Outlet System
B1344	55.68		0.333	-0.02	0.341	Outlet System
B1345	56.96		0.2	0	0.167	Outlet System
B1347	58.6		1.312	-0.15	1.345	Outlet System
B1348	61.85		0.184	-0.27	0.285	Outlet System
B1349	64.61		0.076	-0.08	0.125	Outlet System
B1361	60.34		1.152	-0.65	1.309	Outlet System
B1362	60.84		1.025	-0.13	1.099	Outlet System
B1363	61.85		0.842	0	0.718	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1364	62.35		0.759	-0.03	0.776	Outlet System
B1365	67.94		0.717	0	0.703	Outlet System
B1366	68.57		0.615	-0.01	0.614	Outlet System
B1367	69.29		0.523	-0.02	0.509	Outlet System
B1368	69.46		0.28	-0.03	0.29	Outlet System
B1369	69.54		0.236	0	0.185	Outlet System
B1373	61.96		1.5	-0.4	1.574	Outlet System
B1374	62.37		1.393	-0.23	1.451	Outlet System
B1377	64.11		1.247	-0.01	1.252	Outlet System
B1378	72.11		0.951	-0.07	0.929	Outlet System
B1379	73.34		0.453	-0.27	0.513	Outlet System
B1380	75.85		0.265	-0.02	0.274	Outlet System
B1384	64.62		1.089	-0.09	1.093	Outlet System
B1385	73.47		0.334	0	0.261	Outlet System
B1388	77.02		0.275	-0.02	0.264	Outlet System
B1389	77.29		0.156	-0.01	0.176	Outlet System
B1395	40.4		0.564	0	0.46	Outlet System
B1404	59.78		0.12	0	0.119	Outlet System
B1406	56.03		0.292	0	0.214	Outlet System
B1410	58.92		0.345	0	0.589	Outlet System
B1412	59.74		0.428	0	0.395	Outlet System
B1413	61.42		0.323	0	0.323	Outlet System
B1414	64.83		0.327	-0.04	0.323	Outlet System
B1416	67.35		0.259	0	0.259	Outlet System
B1417	47.22		1.445	-0.03	1.478	Outlet System
B1423	46.69		0.344	-0.01	0.355	Outlet System
B1424	47.12		0.273	0	0.305	Outlet System
B1425	49.4		0.217	-0.01	0.217	Outlet System
B1427	59.49		0.126	-0.03	0.137	Outlet System
B1431	52.85		0.195	-0.03	0.189	Outlet System
B1433	63.35		0	0	0	Outlet System
B1436	63.26		1.248	0	1.217	Outlet System
B1437	64.59		0.98	-0.39	1.097	Outlet System
B1438	66.86		0.723	-0.38	0.83	Outlet System
B1446	62.21		0.091	-0.2	0.147	Outlet System
B1451	42.05		0.134	0	0.124	Outlet System
B1455	41.14		1.052	0	0.944	Outlet System
B1460	65.19		0.144	-0.1	0.208	Outlet System
B1461	65.64		0.134	0	0.134	Outlet System
B1462	65.37		0.078	0	0.154	Outlet System
B1463	67.21		0.12	-0.01	0.13	Outlet System
B1471	67.33		0.181	-1.3	0.32	Outlet System
B1487	39.21		0.57	-0.02	0.58	Outlet System
B1488	39.95	40.1	0.812	0	0.56	Outlet System
B1489	40.51		0.708	-0.23	0.801	Outlet System
B1490	42.55		0.666	-0.07	0.69	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B1491	45.32		0.613	-0.09	0.627	Outlet System
B1492	45.66		0.048	-0.01	0.057	Outlet System
B1493	46.08		0.418	-0.33	0.527	Outlet System
B1494	50.89		0.268	-0.03	0.278	Outlet System
B1495	51.59		0.192	-0.03	0.221	Outlet System
B1497	52.29		0.182	-0.01	0.186	Outlet System
B1498	52.59		0.158	0	0.157	Outlet System
B1504	38.51	38.64	1.086	-0.02	0.872	Outlet System
B1505	38.5		0.902	0	0.9	Outlet System
B1508	64.8		0.763	0	0.75	Outlet System
B1512	48.03		0.261	-0.05	0.266	Outlet System
B1519	48.4		0.949	-0.05	0.886	Outlet System
B1523	40.44		0.318	-0.06	0.321	Outlet System
B1635	43.6		0.389	0	0.386	Outlet System
B1639	44.5		0.337	0	0.333	Outlet System
B1641	48.33		0.122	-0.01	0.124	Outlet System
B1669	41.01		1.328	-0.1	1.655	Outlet System
B1670	41.87		0.16	-0.65	1.065	Outlet System
B1677	49.75		0.063	0	0.163	Outlet System
B1680	44.15		0.328	0	0.332	Outlet System
B1692	54.98		0.246	0	0.246	Outlet System
B1693	55.05		0.245	0	0.244	Outlet System
B1694	55.1		0.209	0	0.23	Outlet System
B1695	55.5		0.185	0	0.183	Outlet System
B1696	55.9		0.167	0	0.163	Outlet System
B1698	56.7		0.14	0	0.124	Outlet System
B1699	56.8		0.085	0	0.071	Outlet System
B1702	54.9		0.07	0	0.087	Outlet System
Pit1832	38.9		0.411	0	0.406	Outlet System

DRAINS OUTPUT – LOW FLOW ASSESSMENT
KITTYS CREEK CATCHMENT – 2yr ARI

Exported DRAINS results - KITTYS CREEK - PEAK 2YR ARI						
PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0002	0.43		0.69	5.32	0.353	Inlet Capacity
K0004	34.41	35.75	8.886	1.19	8.515	Inlet Capacity
K0005	34.59	35.82	9.552	1.03	8.773	Inlet Capacity
K0006	34.6		0	1.02		None
K0007	35.28		9.726	0.92	9.082	Inlet Capacity
K0008	36		10.314	0.91	9.665	Inlet Capacity
K0012	40.49		9.206	-0.19	9.154	Outlet System
K0014	40.87		9.17	1.43	8.523	Inlet Capacity
K0017	46.31		4.549	0.57	3.778	Inlet Capacity
K0018	46.27		1.729	0.61	1.139	Inlet Capacity
K0019	58.04		0.339	1.16	0.125	Inlet Capacity
K0020	57.79		0.464	1.31	0.441	Inlet Capacity
K0022	55		2.134	1.5	2.106	Inlet Capacity
K0023	56.2		0.553	1.3	0.261	Inlet Capacity
K0028	40.47		2.746	0.83	2.744	Inlet Capacity
K0029	43.39		2.722	0.51	2.717	Inlet Capacity
K0030	43.88		2.65	0.4	2.688	Inlet Capacity
K0031	44.42		2.884	0.02	2.242	Inlet Capacity
K0032	44.46		2.034	0	2.84	Outlet System
K0033	45.01		2.462	0.14	2.009	Inlet Capacity
K0034	45.25		1.654	0	2.424	Outlet System
K0035	45.85		0.182	0	0.235	Outlet System
K0036	46.12		0.136	0.64	0.136	Inlet Capacity
K0037	46.76		1.143	-0.03	1.383	Outlet System
K0038	47.56		1.735	0.03	1.142	Inlet Capacity
K0039	47.62		1.708	0.45	1.707	Inlet Capacity
K0040	48.49		1.681	0.5	1.68	Inlet Capacity
K0041	49.2		1.301	0	1.653	Outlet System
K0042	50.46	51.02	1.523	0.36	1.272	Inlet Capacity
K0043	50.73	51.08	1.644	0.15	1.364	Inlet Capacity
K0044	54.63		2.235	0.32	1.539	Inlet Capacity
K0045	54.76	55.01	2.262	0.1	2.163	Inlet Capacity
K0046	56.61	58.1	0.094	1.34	0.09	Inlet Capacity
K0048	3.36		0.383	0.84	0.195	Inlet Capacity
K0049	3.99		0.355	1.81	0.355	Inlet Capacity
K0050	21.79		0.354	0.59	0.353	Inlet Capacity
K0051	27.68		0.352	0.62	0.352	Inlet Capacity
K0052	31.73		0.351	1.02	0.35	Inlet Capacity
K0053	39.27		0.312	-0.02	0.348	Outlet System
K0054	40.2		0.234	0.09	0.093	Inlet Capacity
K0055	40.34		0.205	0	0.184	Outlet System
K0056	41.71		0.156	0.64	0.154	Inlet Capacity
K0057	44.31		0.107	0.64	0.104	Inlet Capacity
K0058	45.62		0.056	0.63	0.055	Inlet Capacity

Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0059	46.57		0.055	0.23	0.004	Inlet Capacity
K0060	46.7		0.052	0.15	0.003	Inlet Capacity
K0062	25.25		2.658	-0.28	2.715	Outlet System
K0064	27.62		1.7	-0.12	1.868	Outlet System
K0065	29.4	29.07	1.282	-0.48	1.596	Outlet System
K0066	32.11		0.135	2.79	0.042	Inlet Capacity
K0067	35.3		1.448	0.01	1.149	Inlet Capacity
K0068	36.28		1.351	1.64	1.346	Inlet Capacity
K0069	37.9		1.259	0.59	1.254	Inlet Capacity
K0070	40.21	41.29	1.327	0.93	1.166	Inlet Capacity
K0071	41.2	41.33	1.33	-0.02	1.204	Outlet System
K0072	41.85		0.856	0	1.201	Outlet System
K0073	46.77	46.93	0.564	0.01	0.395	Inlet Capacity
K0074	47.28		0.143	0.63	0.14	Inlet Capacity
K0075	49.29		0.063	1.26	0.063	Inlet Capacity
K0076	49.9		0.076	0.37	0.018	Inlet Capacity
K0077	50.13		0.057	0.43	0.011	Inlet Capacity
K0078	50.43		0.053	0.6	0.003	Inlet Capacity
K0079	50.46		0.027	0.42	0.003	Inlet Capacity
K0081	30.19	30.93	0.681	0.59	0.579	Inlet Capacity
K0082	32.97		0.312	-0.61	0.678	Outlet System
K0083	34.12		0.209	0.2	0.08	Inlet Capacity
K0084	34.45		0.171	0.71	0.035	Inlet Capacity
K0085	38.4		0.258	1.24	0.075	Inlet Capacity
K0086	40.5		0.405	0.54	0.162	Inlet Capacity
K0087	43.08		0.626	0.49	0.307	Inlet Capacity
K0088	43.25		0.101	1.59	0.101	Inlet Capacity
K0089	43.6		0.448	0.89	0.434	Inlet Capacity
K0090	43.68		0.274	1.31	0.272	Inlet Capacity
K0091	44.09		0.192	1.3	0.192	Inlet Capacity
K0092	44.54		0.094	1.23	0.014	Inlet Capacity
K0093	44.62		0.083	1.54	0.011	Inlet Capacity
K0094	41.78		0.083	1.25	0.011	Inlet Capacity
K0096	64.56		0.321	0.72	0.145	Inlet Capacity
K0097	64.95		0.045	0.46	0.001	Inlet Capacity
K0098	65.11		0.097	0.47	0.016	Inlet Capacity
K0099	65.32		0.05	0.75	0.002	Inlet Capacity
K0100	65.96		0.062	0.77	0.005	Inlet Capacity
K0101	68.23		0.087	0.31	0.021	Inlet Capacity
K0102	69.91		0.128	0.02	0.045	Inlet Capacity
K0103	70.33		0.167	0	0.128	Inlet Capacity
K0104	71.74		0.089	0.78	0.088	Inlet Capacity
K0105	76.79		0.079	0.43	0.01	Inlet Capacity
K0107	77.65		0.095	1.36	0.026	Inlet Capacity
K0108	78.4		0.141	0.75	0.043	Inlet Capacity
K0109	78.77		0.119	0.54	0.035	Inlet Capacity
K0110	79.19		0.111	0.47	0.032	Inlet Capacity

Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0111	79.86		0.088	0.74	0.023	Inlet Capacity
K0113	12.52		0.169	0.75	0.167	Inlet Capacity
K0114	14.74		0.13	0.71	0.128	Inlet Capacity
K0115	15.19	16.35	0.044	1.09	0	Inlet Capacity
K0116	15.49		0.381	0.75	0.15	Inlet Capacity
K0117	15.85		0.343	1.66	0.342	Inlet Capacity
K0118	19.49		0.306	2.81	0.303	Inlet Capacity
K0119	23.18		0.263	2.91	0.263	Inlet Capacity
K0120	27.78		0.217	2.82	0.22	Inlet Capacity
K0121	31.49	32.81	0.234	1.17	0.118	Inlet Capacity
K0122	32.13		0.132	0.81	0.131	Inlet Capacity
K0123	34.6		0.103	0.53	0.029	Inlet Capacity
K0124	56.1		1.637	-0.3	1.908	Outlet System
K0125	56.2		1.013	0	1.246	Outlet System
K0126	56.95		1.36	0.01	0.998	Inlet Capacity
K0127	57.11		1.11	-0.06	1.138	Outlet System
K0128	57.21		1.012	-0.12	1.08	Outlet System
K0129	57.96		0.985	-0.03	0.982	Outlet System
K0130	59.15		0.82	0.83	0.816	Inlet Capacity
K0131	63.07		0.768	-0.15	0.784	Outlet System
K0132	63		0.379	-0.01	0.392	Outlet System
K0133	63.14		0.355	0	0.292	Outlet System
K0134	40.07		1.651	1.43	1.065	Inlet Capacity
K0135	41.06		2.284	1.34	1.543	Inlet Capacity
K0136	41.8		1.358	2.2	1.337	Inlet Capacity
K0137	43.03	45.49	1.413	2.26	1.25	Inlet Capacity
K0138	43.13	45.6	0.617	2.27	0.591	Inlet Capacity
K0139	43.44		1.203	2.06	0.713	Inlet Capacity
K0141	58.6		0.202	1.5	0.05	Inlet Capacity
K0142	58.6		0.003	1.6	0.001	Inlet Capacity
K0145	6.89		0.03	0.88	0	None
K0146	6.38		0.03	1.26	0.03	Inlet Capacity
K0148	6.09		0.187	0.84	0.043	Inlet Capacity
K0150	5.83		0.142	0.78	0.025	Inlet Capacity
K0152	6.35		0.2	0.26	0.048	Inlet Capacity
K0153	6.6		0.146	0.02	0.03	Inlet Capacity
K0155	5.9		0.18	0.35	0.038	Inlet Capacity
K0156	6.23		0.151	0.21	0.028	Inlet Capacity
K0157	3.76		0.079	0.68	0.019	Inlet Capacity
K0159	2.28		0.112	1.02	0.033	Inlet Capacity
K0160	2.31		0.095	1.13	0.095	Inlet Capacity
K0161	2.43		0.095	0.92	0.015	Inlet Capacity
K0162	2.21		0.082	0.93	0.011	Inlet Capacity
K0164	1.92		0.102	1.26	0.101	Inlet Capacity
K0165	1.92		0.051	1.37	0.051	Inlet Capacity
K0167	2.13		0.102	0.47	0.028	Inlet Capacity
K0168	2.29		0.105	0.41	0.019	Inlet Capacity

Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0169	2.37		0.084	0.37	0.021	Inlet Capacity
K0171	7.21	7.08	0.51	-0.28	0.582	Outlet System
K0172	7.39		0.538	0	0.432	Inlet Capacity
K0173	13.17		0.084	0.41	0.021	Inlet Capacity
K0174	14.6		0.472	-0.01	0.471	Outlet System
K0175	16.92		0.407	1.08	0.404	Inlet Capacity
K0176	26.02		0.34	-0.02	0.338	Outlet System
K0177	33.93		0.272	1.07	0.266	Inlet Capacity
K0178	39.55		0.383	0.02	0.199	Inlet Capacity
K0179	39.73		0.235	-0.13	0.31	Outlet System
K0180	46.4	46.53	0.208	-0.02	0.072	Outlet System
K0181	46.63	46.7	0.103	-0.13	0.03	Outlet System
K0183	15.22		0.711	0	0.547	Inlet Capacity
K0184	15.65		0.519	-0.31	0.625	Outlet System
K0185	16.61		0.352	-0.06	0.395	Outlet System
K0186	26.56		0.271	-0.01	0.266	Outlet System
K0187	28.13		0.191	0.12	0.189	Inlet Capacity
K0188	31.88		0.116	3.17	0.113	Inlet Capacity
K0189	39.9	39.98	0.095	-0.07	0.029	Outlet System
K0190	40.03	40.11	0.105	-0.11	0	Outlet System
K0191	15.32		0.089	0.04	0.039	Inlet Capacity
K0192	39.3		0	0.08	0	None
K0193	40.51		0.169	0.64	0.16	Inlet Capacity
K0194	43.14		0.124	0	0.097	Outlet System
K0195	43.99		0.129	0.02	0.049	Inlet Capacity
K0196	44.06		0.038	0.47	0	None
K0197	40.89		0.083	0.39	0.011	Inlet Capacity
K0199	38.59		0.612	-0.09	0.66	Outlet System
K0200	40.83	41.45	0.711	0.47	0.553	Inlet Capacity
K0201	41.43		0.659	-0.05	0.644	Outlet System
K0202	41.83		0.593	0.22	0.591	Inlet Capacity
K0203	47.97	48.1	0.664	-0.02	0.522	Outlet System
K0204	48.14		0.324	-0.08	0.34	Outlet System
K0206	30.1		0.049	0.91	0.047	Inlet Capacity
K0207	39.51		0.117	0.43	0.022	Inlet Capacity
K0208	39.77		0.048	0.18	0.015	Inlet Capacity
K0209	39.88		0.046	0.09	0.001	Inlet Capacity
K0210	39.9		0.046	0.32	0.001	Inlet Capacity
K0212	47.69		0.02	0.71	0	None
K0213	48.86		0.476	0.56	0.463	Inlet Capacity
K0214	49.08		0.42	1.35	0.418	Inlet Capacity
K0215	50.03		0.34	0.45	0.36	Inlet Capacity
K0216	50.78		0.266	0.69	0.27	Inlet Capacity
K0217	52.22		0.079	0.16	0.01	Inlet Capacity
K0218	52.42		0.114	0	0.154	Outlet System
K0219	53.63		0.109	0.41	0.02	Inlet Capacity
K0220	55.1		0.095	0.83	0.015	Inlet Capacity

Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0221	33.79		0.193	0.29	0.047	Inlet Capacity
K0222	33.03		0.083	0.19	0.011	Inlet Capacity
K0223	46.88		0.404	-0.09	0.403	Outlet System
K0224	48.45		0.226	0.02	0.108	Inlet Capacity
K0225	48.46		0.226	0	0.203	Outlet System
K0226	50.41	50.53	0.152	-0.03	0.037	Outlet System
K0227	50.41		0.081	-0.01	0.081	Outlet System
K0228	52.02		0.051	0.26	0.002	Inlet Capacity
K0229	52.26		0.053	0.08	0.01	Inlet Capacity
K0230	52.3		0.041	0.2	0.012	Inlet Capacity
K0231	52.84		0.071	1.09	0.008	Inlet Capacity
K0232	46.76	46.98	0.334	0.07	0.16	Inlet Capacity
K0233	46.89		0.281	0	0.2	Inlet Capacity
K0235	48.93		2.208	-0.12	2.202	Outlet System
K0236	55.14		1.82	-0.28	1.847	Outlet System
K0237	56.53		1.438	0.22	1.42	Inlet Capacity
K0238	63.97		1.063	0.02	1.027	Inlet Capacity
K0239	64.17		0.253	0	0.25	Outlet System
K0240	64.89		0.184	0.17	0.069	Inlet Capacity
K0241	47.17		0.147	0.34	0.073	Inlet Capacity
K0242	64.12		0.399	0.05	0.395	Inlet Capacity
K0243	64.63		0.184	0.01	0.081	Inlet Capacity
K0245	59.11		1.312	-0.11	1.335	Outlet System
K0246	60.07		0.97	-0.77	1.073	Outlet System
K0247	60.1		0.486	0	0.726	Outlet System
K0248	60.41	60.65	0.648	0.09	0.484	Inlet Capacity
K0249	60.44		0.089	0.22	0.038	Inlet Capacity
K0250	60.65		0.25	0	0.275	Outlet System
K0251	60.85		0.2	-0.01	0.212	Outlet System
K0252	61.59		0.223	0	0.165	Inlet Capacity
K0253	63.25		0.188	-0.03	0.188	Outlet System
K0254	64.02		0.164	0.01	0.111	Inlet Capacity
K0255	64.21		0.09	0	0.087	Outlet System
K0256	64.42		0.076	0.02	0.013	Inlet Capacity
K0257	60.51		0.046	0.84	0.008	Inlet Capacity
K0258	60.6		0.041	0.98	0.006	Inlet Capacity
K0259	60.44		0.041	0.31	0.041	Inlet Capacity
K0260	60.47		0.041	0.31	0	None
K0261	60.72		0.041	0.03	0.006	Inlet Capacity
K0262	78.52		0.111	0.73	0.018	Inlet Capacity
K0263	78.95		0.088	0.79	0.023	Inlet Capacity
K0265	78.53	78.93	0.003	0.39	0	Inlet Capacity
K0267	15.74		0.102	0.71	0.029	Inlet Capacity
K0268	16.17		0.187	0.02	0.087	Inlet Capacity
K0270	39.93	40.26	0.089	0.22	0	Inlet Capacity
K0272	26.62	27.81	0.286	1.04	0.116	Inlet Capacity
K0273	28.03		0.26	0.11	0.08	Inlet Capacity

Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0274	31.58		0.206	0.73	0.053	Inlet Capacity
K0276	16.78		0.261	0.69	0.253	Inlet Capacity
K0277	18.4		0.208	0.24	0.081	Inlet Capacity
K0278	18.72		0.155	0.43	0.052	Inlet Capacity
K0279	18.63		0.003	1.05	0	None
K0280	19.21		0.13	0.59	0.025	Inlet Capacity
K0281	19.4		0.11	0.94	0.02	Inlet Capacity
K0284	19.64		0.564	0.78	0.563	Inlet Capacity
K0285	20.41		0.53	0.7	0.529	Inlet Capacity
K0286	21.48		0.49	0.74	0.489	Inlet Capacity
K0287	22.39		0.455	0.53	0.454	Inlet Capacity
K0288	23.63		0.291	-0.17	0.417	Outlet System
K0289	27.01		0.265	0.01	0.166	Inlet Capacity
K0290	28.85		0.106	-0.35	0.224	Outlet System
K0291	30.19		0.122	0	0.104	Outlet System
K0292	31.28		0.158	0.01	0.078	Inlet Capacity
K0293	31.74		0.115	0.8	0.022	Inlet Capacity
K0294	19.79		0.044	0.58	0.001	Inlet Capacity
K0295	21.99		0.044	0.16	0.007	Inlet Capacity
K0296	24.34		0.297	0.02	0.109	Inlet Capacity
K0297	29.37		0.309	0.02	0.148	Inlet Capacity
K0298	31.23		0.003	0.84	0	None
K0299	31.77		0.115	0.66	0.022	Inlet Capacity
K0301	29.51	30.21	0.036	0.64	0	Inlet Capacity
K0302	29.61		0.075	0.7	0.009	Inlet Capacity
K0304	32.88		0.243	0.15	0.072	Inlet Capacity
K0305	44.49		0.08	0.01	0.039	Inlet Capacity
K0306	44.22		0.584	0.7	0.582	Inlet Capacity
K0307	44.71		0.537	0.78	0.535	Inlet Capacity
K0308	45.59		0.597	0	0.486	Inlet Capacity
K0309	46.29		0.965	0.02	0.594	Inlet Capacity
K0310	44.11	44.53	0.09	0.28	0	Inlet Capacity
K0311	44.27		0.053	0.7	0.01	Inlet Capacity
K0312	44.77		0.08	0.61	0.02	Inlet Capacity
K0313	44.38		0.101	0.04	0.027	Inlet Capacity
K0314	45.47		0.089	0.02	0.015	Inlet Capacity
K0315	46.69		1.526	-0.1	1.467	Outlet System
K0316	46.86		1.405	-0.27	1.505	Outlet System
K0317	47.83		0.146	-0.04	0.163	Outlet System
K0318	49.94		0.176	0.01	0.107	Inlet Capacity
K0319	51.03		0.2	0.02	0.083	Inlet Capacity
K0320	51.21		0.144	0.02	0.056	Inlet Capacity
K0321	47.61		0.046	-0.01	0.04	Outlet System
K0322	49.94		0.046	0.27	0.046	Inlet Capacity
K0324	43.84		0.158	0.52	0.03	Inlet Capacity
K0325	45.54		0.13	0	0.11	Outlet System
K0326	48.44		0.125	0	0.093	Inlet Capacity

Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0327	48.79		0.078	0.67	0.01	Inlet Capacity
K0328	44.74		0.087	0.83	0.012	Inlet Capacity
K0329	48.65		0.078	0.02	0.013	Inlet Capacity
K0331	36.77		0.112	1.24	0.111	Inlet Capacity
K0332	40.95		0.089	0.99	0.023	Inlet Capacity
K0333	41.25		0.037	0.74	0	None
K0335	31.32		0.083	0.84	0.021	Inlet Capacity
K0336	31.66		0.033	0.65	0	None
K0338	27.15		0.119	0.09	0.023	Inlet Capacity
K0339	27.44	27.54	0.09	-0.03	0	Outlet System
K0340	51.15		0.195	0	0.097	Inlet Capacity
K0341	51.41		0.132	0	0.092	Inlet Capacity
K0342	51.76		0.103	0.02	0.029	Inlet Capacity
K0343	50.79		0.205	0.1	0.079	Inlet Capacity
K0344	50.88		0.115	0.61	0.114	Inlet Capacity
K0345	52.86		0.091	0.48	0.024	Inlet Capacity
K0346	57.56		0.003	0.59	0	None
K0347	56.17		0.299	0	0.275	Outlet System
K0348	57.65		0.202	0	0.163	Inlet Capacity
K0349	61.7		0.274	0.02	0.133	Inlet Capacity
K0350	57.63		0.07	0.1	0.027	Inlet Capacity
K0351	57.54		0.027	0	0.068	Outlet System
K0352	56.71		0.07	1.05	0.016	Inlet Capacity
K0353	57.09		0.161	0.01	0.106	Inlet Capacity
K0354	63.04		0.355	0	0.295	Outlet System
K0356	63.31		0.209	0.66	0.208	Inlet Capacity
K0357	64.21		0.003	0.79	0	None
K0359	47.84		0.418	0	0.36	Outlet System
K0360	48.25		0.336	0.99	0.332	Inlet Capacity
K0361	49.17		0.456	0.57	0.246	Inlet Capacity
K0363	36.25		0.272	1.4	0.272	Inlet Capacity
K0364	41.26	42.09	0.167	0.64	0	Inlet Capacity
K0365	42.01	42.19	0.264	-0.02	0.02	Outlet System
K0366	42.48		0.198	0.35	0.105	Inlet Capacity
K0368	42.81		0.098	0.71	0.027	Inlet Capacity
K0371	42.58		0.243	0.02	0.149	Inlet Capacity
K0372	42.99		0.122	0	0.103	Inlet Capacity
K0373	43.27		0.096	0.27	0.026	Inlet Capacity
K0374	43.36		0.096	0.23	0.026	Inlet Capacity
K0376	31.15		0.107	0.94	0.107	Inlet Capacity
K0377	32.61		0.092	0.32	0.092	Inlet Capacity
K0378	33.45		0.077	0.49	0.077	Inlet Capacity
K0379	34.35	35.11	0.224	0.61	0.062	Inlet Capacity
K0381	38.48		0.016	0.42	0	None
K0382	40.82		0.006	0.89	0	None
K0383	46.02		0.07	0.87	0.006	Inlet Capacity
K0384	50.62		0.082	0.96	0.02	Inlet Capacity

Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0385	51.4		0.021	1.29	0.02	Inlet Capacity
K0386	51.59		0.031	1.29	0	None
K0387	52.06		0.098	1.37	0.015	Inlet Capacity
K0388	52.65		0.081	0.9	0.081	Inlet Capacity
K0389	52.84		0.081	0.81	0.011	Inlet Capacity
K0390	39.56		0.017	1.23	0.001	Inlet Capacity
K0391	40.25		0.05	0.74	0.002	Inlet Capacity
K0392	42.28		0.191	0.44	0.072	Inlet Capacity
K0393	51.51		0.06	1.05	0.012	Inlet Capacity
K0394	51.84		0.05	0.74	0.009	Inlet Capacity
K0395	52.71		0.032	0.74	0.004	Inlet Capacity
K0396	44.49		0.143	0.02	0.081	Inlet Capacity
K0397	46.26		0.864	-0.06	0.866	Outlet System
K0399	52.84		0.343	0.81	0.341	Inlet Capacity
K0400	54.49	54.84	0.453	0.2	0.303	Inlet Capacity
K0401	55.2		0.528	0	0.412	Inlet Capacity
K0402	55.57		0.366	-0.12	0.434	Outlet System
K0403	56.3		0.067	0	0.146	Outlet System
K0404	58.37		0.054	0.02	0.015	Inlet Capacity
K0405	58.49		0.052	1.12	0.003	Inlet Capacity
K0406	55.57		0.193	0	0.18	Outlet System
K0407	58.96		0.207	0.01	0.149	Inlet Capacity
K0408	59.73		0.209	0.32	0.207	Inlet Capacity
K0409	60.44		0.325	0.21	0.157	Inlet Capacity
K0410	36.45		10.23	1.26	10.223	Inlet Capacity
K0411	42.18		0.122	0.72	0.024	Inlet Capacity
K0412	43.47	44.63	0.122	1.03	0	Inlet Capacity
K0413	43.6	44.7	0.122	1	0	Inlet Capacity
K0414	43.42		0.948	0.88	0.947	Inlet Capacity
K0415	45.17	45.32	1.07	-0.05	0.946	Outlet System
K0416	45.15	45.35	1.32	0	1.068	Outlet System
K0418	57.71		0.393	1.28	0.39	Inlet Capacity
K0419	58.66		0.36	0.8	0.359	Inlet Capacity
K0420	59.19		0.325	0.52	0.325	Inlet Capacity
K0421	60.13		0.432	0	0.322	Outlet System
K0422	60.13		0.395	0.99	0.394	Inlet Capacity
K0423	62.82		0.356	1.18	0.356	Inlet Capacity
K0425	57.22	58.8	0.211	1.41	0	Inlet Capacity
K0426	57.77	58.85	0.261	0.88	0.098	Inlet Capacity
K0427	57.77		0.13	1.78	0.13	Inlet Capacity
K0428	58.87		0.118	0.65	0.023	Inlet Capacity
K0429	59.41		0.135	0.89	0.066	Inlet Capacity
K0430	59.98		0.136	0.05	0.025	Inlet Capacity
K0432	3.06		0.224	0.02	0.081	Inlet Capacity
K0433	3.1		0.185	0	0.141	Inlet Capacity
K0435	19.87		0.103	0.4	0.018	Inlet Capacity
K0437	81.33		0.07	0.31	0.007	Inlet Capacity

Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0438	81.68		0.052	0.39	0.018	Inlet Capacity
K0440	36.83		0.881	0.54	0.88	Inlet Capacity
K0441	37.75		0.974	0	0.86	Inlet Capacity
K0442	38.55		0.558	-0.09	0.612	Outlet System
K0443	40.47		0.551	0	0.498	Outlet System
K0444	41.62		0.689	0.02	0.488	Inlet Capacity
K0445	38.98		0.071	0.56	0.028	Inlet Capacity
K0447	39.29		0.02	0.97	0	None
K0448	35.5		0.036	1	0.036	Inlet Capacity
K0449	56.95		0.992	-0.15	0.998	Outlet System
K0450	57.3		0.553	0	0.439	Inlet Capacity
K0451	40.54		0.055	0.4	0.01	Inlet Capacity
K0452	41.67		0.083	0.83	0.021	Inlet Capacity
K0462	64.03		0.094	0.47	0.026	Inlet Capacity
Pit1822	34.24		0	1.41		None

DRAINS OUTPUT – LOW FLOW ASSESSMENT
KITTYS CREEK CATCHMENT – 5yr ARI

Exported DRAINS results - KITTYS CREEK - PEAK 5YR ARI						
PIT / NODE DETAILS						
Name	Max HGL	Max Pond	Max Surface	Min	Overflow	Constraint
		HGL	Flow Arriving	Freeboard	(cu.m/s)	
		(Sag Pits)	(cu.m/s)	(m)		
K0002	0.48		0.996	5.27	0.574	Inlet Capacity
K0014	40.87		11.343	1.43	10.698	Inlet Capacity
K0017	46.3		6.237	0.58	5.595	Inlet Capacity
K0018	46.34		1.823	0.54	1.213	Inlet Capacity
K0019	58.08		0.443	1.12	0.19	Inlet Capacity
K0020	57.81		0.633	1.29	0.605	Inlet Capacity
K0023	56.25		0.745	1.25	0.392	Inlet Capacity
K0022	55.02		2.949	1.48	2.903	Inlet Capacity
K0060	46.84		0.068	0.01	0.024	Inlet Capacity
K0059	46.74		0.092	0.06	0.013	Inlet Capacity
K0058	45.64		0.081	0.61	0.079	Inlet Capacity
K0057	44.33		0.147	0.62	0.143	Inlet Capacity
K0056	41.74		0.21	0.61	0.207	Inlet Capacity
K0054	40.27		0.368	0.02	0.197	Inlet Capacity
K0052	31.73		0.575	1.02	0.574	Inlet Capacity
K0051	27.68		0.577	0.62	0.577	Inlet Capacity
K0050	21.72		0.58	0.66	0.58	Inlet Capacity
K0049	3.99		0.58	1.81	0.583	Inlet Capacity
K0048	3.54		0.642	0.66	0.38	Inlet Capacity
K0079	50.87		0.036	0.01	0.021	Inlet Capacity
K0078	50.87		0.07	0.16	0.007	Inlet Capacity
K0077	50.54		0.077	0.02	0.019	Inlet Capacity
K0076	50.25		0.123	0.02	0.049	Inlet Capacity
K0075	49.42		0.082	1.13	0.082	Inlet Capacity
K0074	47.31		0.213	0.6	0.204	Inlet Capacity
K0070	40.21	41.29	1.659	0.93	1.494	Inlet Capacity
K0069	37.9		1.592	0.59	1.587	Inlet Capacity
K0068	36.28		1.679	1.64	1.662	Inlet Capacity
K0067	35.3		1.738	0.01	1.431	Inlet Capacity
K0066	32.17		0.177	2.73	0.065	Inlet Capacity
K0093	44.66		0.108	1.5	0.02	Inlet Capacity
K0092	44.58		0.128	1.19	0.024	Inlet Capacity
K0091	44.12		0.262	1.27	0.261	Inlet Capacity
K0090	43.72		0.37	1.27	0.366	Inlet Capacity
K0089	43.62		0.601	0.87	0.583	Inlet Capacity
K0088	43.28		0.137	1.56	0.137	Inlet Capacity
K0087	43.18		0.845	0.39	0.462	Inlet Capacity
K0086	40.73		0.593	0.31	0.285	Inlet Capacity
K0085	38.72		0.412	0.92	0.167	Inlet Capacity
K0084	34.89		0.29	0.27	0.097	Inlet Capacity
K0081	30.2	30.93	1.242	0.58	1.061	Inlet Capacity
K0094	41.81		0.111	1.22	0.02	Inlet Capacity
K0105	76.91		0.104	0.31	0.018	Inlet Capacity
K0104	71.77		0.122	0.75	0.12	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond	Max Surface	Min	Overflow	Constraint
		HGL	Flow Arriving	Freeboard	(cu.m/s)	
		(Sag Pits)	(cu.m/s)	(m)		
K0102	69.92		0.201	0.01	0.122	Inlet Capacity
K0101	68.43		0.176	0.11	0.062	Inlet Capacity
K0100	66.34		0.113	0.39	0.02	Inlet Capacity
K0099	65.94		0.077	0.13	0.008	Inlet Capacity
K0098	65.58		0.127	0	0.085	Inlet Capacity
K0097	65.37		0.059	0.04	0.005	Inlet Capacity
K0096	64.83		0.498	0.45	0.261	Inlet Capacity
K0111	79.91		0.116	0.69	0.034	Inlet Capacity
K0110	79.65		0.15	0.01	0.079	Inlet Capacity
K0109	79.18		0.194	0.13	0.07	Inlet Capacity
K0108	78.66		0.205	0.49	0.079	Inlet Capacity
K0107	77.71		0.144	1.3	0.045	Inlet Capacity
K0123	34.75		0.135	0.38	0.042	Inlet Capacity
K0122	32.14		0.176	0.8	0.175	Inlet Capacity
K0121	31.56	32.81	0.31	1.1	0.127	Inlet Capacity
K0120	27.8		0.23	2.8	0.233	Inlet Capacity
K0119	23.19		0.279	2.9	0.28	Inlet Capacity
K0118	19.5		0.326	2.8	0.328	Inlet Capacity
K0117	15.87		0.376	1.64	0.378	Inlet Capacity
K0116	15.52		0.43	0.72	0.182	Inlet Capacity
K0115	15.23	16.36	0.057	1.05	0	Inlet Capacity
K0114	14.76		0.165	0.69	0.166	Inlet Capacity
K0113	12.53		0.218	0.74	0.217	Inlet Capacity
K0130	59.15		1.107	0.83	1.103	Inlet Capacity
K0126	56.95		1.816	0.01	1.464	Inlet Capacity
K0046	56.61	58.1	0.124	1.34	0.094	Inlet Capacity
K0044	54.75		2.769	0.2	1.998	Inlet Capacity
K0043	50.8	51.08	2.097	0.08	1.681	Inlet Capacity
K0042	50.42	51.02	1.871	0.4	1.65	Inlet Capacity
K0040	48.49		2.154	0.5	2.153	Inlet Capacity
K0039	47.66		2.179	0.41	2.177	Inlet Capacity
K0038	47.58		2.2	0.01	1.581	Inlet Capacity
K0036	46.14		0.178	0.62	0.178	Inlet Capacity
K0033	45.03		2.476	0.12	2.022	Inlet Capacity
K0031	44.42		3.022	0.02	2.364	Inlet Capacity
K0030	43.9		2.855	0.38	2.82	Inlet Capacity
K0029	43.39		2.873	0.51	2.878	Inlet Capacity
K0028	40.48		2.936	0.82	2.938	Inlet Capacity
K0139	43.49		1.455	2.01	0.914	Inlet Capacity
K0138	43.16	45.6	0.821	2.24	0.72	Inlet Capacity
K0137	43.06	45.49	1.897	2.23	1.666	Inlet Capacity
K0136	41.81		1.765	2.19	1.752	Inlet Capacity
K0135	41.09		3.053	1.31	2.179	Inlet Capacity
K0134	40.06		2.286	1.44	1.579	Inlet Capacity
K0410	36.48		11.93	1.23	11.773	Inlet Capacity
K0008	36.04		11.913	0.87	11.262	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0007	35.32		11.358	0.88	10.713	Inlet Capacity
K0005	34.63	35.82	11.616	0.99	11.186	Inlet Capacity
K0004	34.45	35.75	11.316	1.15	11.169	Inlet Capacity
K0142	58.95		0.004	1.25	0.001	Inlet Capacity
K0141	58.94		0.27	1.16	0.084	Inlet Capacity
K0146	6.4		0.04	1.24	0.04	Inlet Capacity
K0148	6.27		0.246	0.66	0.072	Inlet Capacity
K0150	6.01		0.203	0.6	0.048	Inlet Capacity
K0153	6.61		0.193	0.01	0.113	Inlet Capacity
K0152	6.49		0.353	0.12	0.13	Inlet Capacity
K0156	6.42		0.20	0.02	0.067	Inlet Capacity
K0155	6.06		0.264	0.19	0.067	Inlet Capacity
K0157	3.81		0.12	0.63	0.036	Inlet Capacity
K0160	2.63		0.125	0.81	0.125	Inlet Capacity
K0159	2.63		0.153	0.67	0.051	Inlet Capacity
K0161	2.82		0.125	0.53	0.024	Inlet Capacity
K0162	2.26		0.116	0.88	0.021	Inlet Capacity
K0164	1.95		0.135	1.23	0.134	Inlet Capacity
K0165	1.96		0.068	1.33	0.068	Inlet Capacity
K0169	2.72		0.111	0.02	0.04	Inlet Capacity
K0168	2.62		0.151	0.08	0.026	Inlet Capacity
K0167	2.35		0.136	0.25	0.042	Inlet Capacity
K0172	7.39		0.74	0	0.632	Inlet Capacity
K0178	39.56		0.426	0.01	0.246	Inlet Capacity
K0177	33.93		0.326	1.07	0.331	Inlet Capacity
K0175	16.92		0.537	1.08	0.537	Inlet Capacity
K0173	13.23		0.111	0.35	0.032	Inlet Capacity
K0188	31.88		0.125	3.17	0.125	Inlet Capacity
K0187	28.18		0.242	0.07	0.239	Inlet Capacity
K0191	15.29		0.117	0.07	0.057	Inlet Capacity
K0196	44.11		0.05	0.42	0.002	Inlet Capacity
K0195	44		0.171	0.01	0.099	Inlet Capacity
K0193	40.52		0.26	0.63	0.25	Inlet Capacity
K0197	41.26		0.109	0.02	0.032	Inlet Capacity
K0451	40.87		0.093	0.07	0.023	Inlet Capacity
K0202	41.92		0.68	0.13	0.677	Inlet Capacity
K0200	40.83	41.45	0.823	0.47	0.672	Inlet Capacity
K0209	39.97		0.06	0	0.037	Inlet Capacity
K0208	39.94		0.102	0.01	0.066	Inlet Capacity
K0207	39.72		0.2	0.22	0.045	Inlet Capacity
K0206	30.11		0.078	0.9	0.075	Inlet Capacity
K0210	40.11		0.06	0.11	0.005	Inlet Capacity
K0220	55.15		0.124	0.78	0.024	Inlet Capacity
K0219	53.89		0.148	0.15	0.026	Inlet Capacity
K0217	52.3		0.109	0.08	0.02	Inlet Capacity
K0216	50.98		0.318	0.49	0.307	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0215	50.12		0.399	0.36	0.39	Inlet Capacity
K0214	49.1		0.467	1.33	0.467	Inlet Capacity
K0213	48.87		0.557	0.55	0.551	Inlet Capacity
K0221	33.84		0.258	0.24	0.08	Inlet Capacity
K0222	33.21		0.111	0.01	0.044	Inlet Capacity
K0224	48.46		0.296	0.01	0.176	Inlet Capacity
K0230	52.4		0.054	0.1	0.019	Inlet Capacity
K0228	52.25		0.114	0.03	0.021	Inlet Capacity
K0231	52.88		0.094	1.05	0.015	Inlet Capacity
K0233	46.89		0.373	0	0.291	Inlet Capacity
K0232	46.77	46.98	0.466	0.06	0.207	Inlet Capacity
K0240	65.04		0.241	0.02	0.111	Inlet Capacity
K0238	63.98		1.445	0.01	1.387	Inlet Capacity
K0237	56.53		1.93	0.22	1.907	Inlet Capacity
K0241	47.32		0.193	0.19	0.104	Inlet Capacity
K0243	64.63		0.241	0.01	0.137	Inlet Capacity
K0242	64.13		0.553	0.04	0.548	Inlet Capacity
K0256	64.43		0.1	0.01	0.036	Inlet Capacity
K0254	64.03		0.232	0	0.174	Inlet Capacity
K0252	61.59		0.315	0	0.257	Inlet Capacity
K0249	60.48		0.123	0.18	0.059	Inlet Capacity
K0248	60.46	60.65	0.857	0.04	0.57	Inlet Capacity
K0258	60.66		0.053	0.92	0.01	Inlet Capacity
K0257	60.6		0.06	0.75	0.013	Inlet Capacity
K0260	60.54		0.053	0.24	0.003	Inlet Capacity
K0259	60.49		0.056	0.26	0.056	Inlet Capacity
K0261	60.73		0.053	0.02	0.011	Inlet Capacity
K0263	79		0.12	0.74	0.034	Inlet Capacity
K0262	78.85		0.15	0.4	0.025	Inlet Capacity
K0265	78.84	78.94	0.004	0.08	0	Inlet Capacity
K0267	15.89		0.134	0.56	0.041	Inlet Capacity
K0268	16.18		0.235	0.01	0.113	Inlet Capacity
K0270	40.13	40.28	0.116	0.02	0	Inlet Capacity
K0274	31.63		0.271	0.68	0.087	Inlet Capacity
K0273	28.13		0.357	0.01	0.188	Inlet Capacity
K0272	26.81	27.81	0.458	0.85	0.136	Inlet Capacity
K0278	18.95		0.203	0.2	0.08	Inlet Capacity
K0277	18.62		0.283	0.02	0.137	Inlet Capacity
K0276	16.82		0.371	0.65	0.358	Inlet Capacity
K0281	19.95		0.144	0.39	0.025	Inlet Capacity
K0280	19.63		0.169	0.17	0.035	Inlet Capacity
K0293	31.82		0.151	0.72	0.028	Inlet Capacity
K0289	27.02		0.424	0	0.323	Inlet Capacity
K0287	22.39		0.78	0.53	0.779	Inlet Capacity
K0286	21.48		0.827	0.74	0.825	Inlet Capacity
K0285	20.42		0.879	0.69	0.879	Inlet Capacity

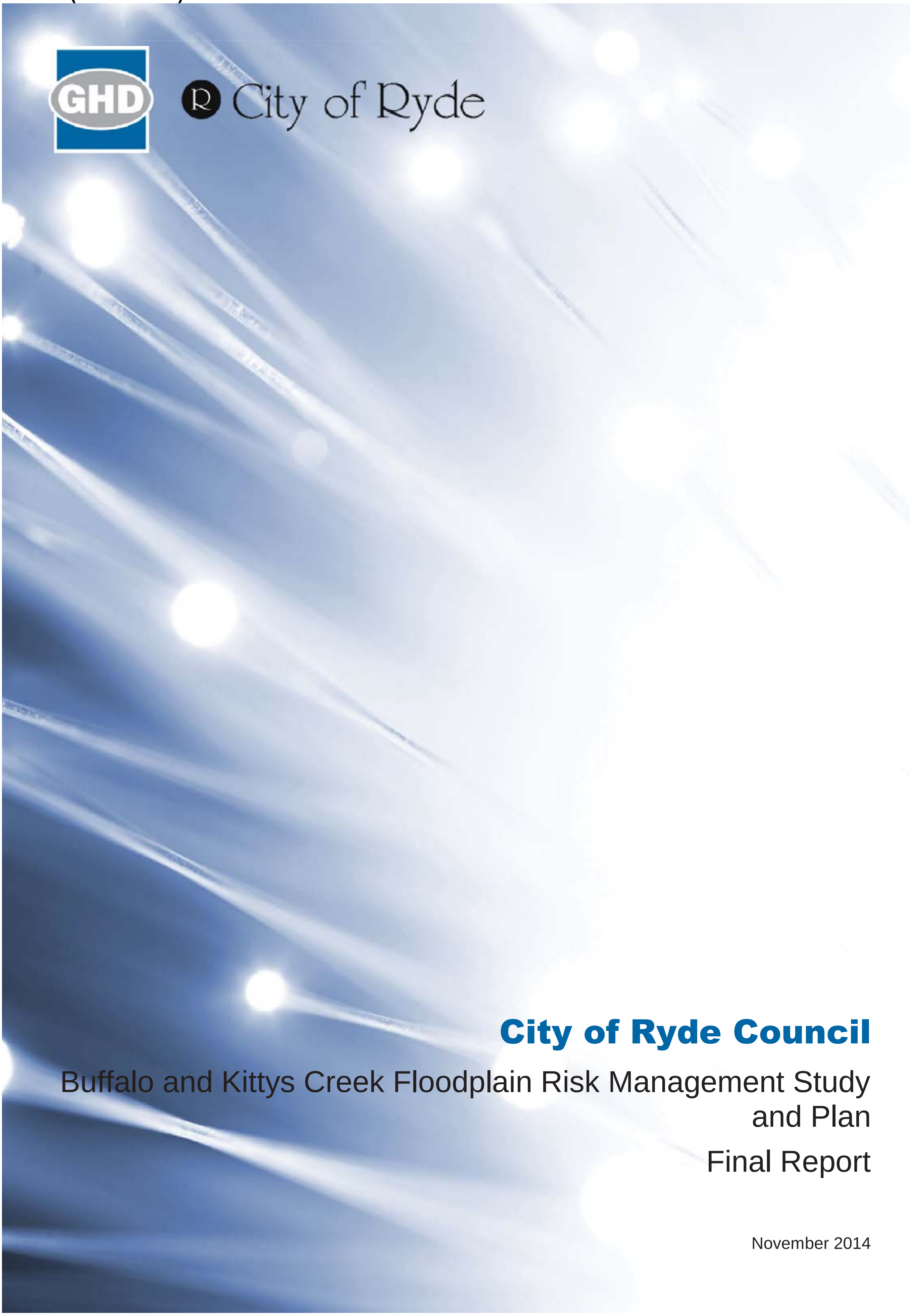
PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0284	19.65		0.924	0.77	0.923	Inlet Capacity
K0294	19.89		0.058	0.48	0.004	Inlet Capacity
K0295	22.02		0.058	0.13	0.012	Inlet Capacity
K0296	24.35		0.44	0.01	0.249	Inlet Capacity
K0297	29.38		0.404	0.01	0.243	Inlet Capacity
K0299	32.1		0.151	0.33	0.028	Inlet Capacity
K0302	29.68		0.098	0.63	0.016	Inlet Capacity
K0301	29.56	30.23	0.052	0.59	0	Inlet Capacity
K0304	33.01		0.318	0.02	0.127	Inlet Capacity
K0305	44.49		0.108	0.01	0.036	Inlet Capacity
K0309	46.3		1.267	0.01	0.896	Inlet Capacity
K0308	45.59		0.90	0	0.784	Inlet Capacity
K0307	44.71		0.851	0.78	0.849	Inlet Capacity
K0306	44.23		0.913	0.69	0.91	Inlet Capacity
K0312	44.81		0.108	0.57	0.031	Inlet Capacity
K0311	44.31		0.069	0.66	0.016	Inlet Capacity
K0310	44.14	44.54	0.127	0.25	0	Inlet Capacity
K0313	44.33		0.139	0.09	0.042	Inlet Capacity
K0314	45.48		0.119	0.01	0.052	Inlet Capacity
K0320	51.22		0.188	0.01	0.101	Inlet Capacity
K0319	51.04		0.29	0.01	0.169	Inlet Capacity
K0318	49.95		0.29	0	0.218	Inlet Capacity
K0322	49.95		0.06	0.26	0.06	Inlet Capacity
K0327	48.95		0.102	0.51	0.018	Inlet Capacity
K0324	44.34		0.292	0.02	0.096	Inlet Capacity
K0328	45.23		0.134	0.34	0.025	Inlet Capacity
K0329	48.65		0.102	0.02	0.037	Inlet Capacity
K0333	41.31		0.048	0.68	0.002	Inlet Capacity
K0332	41.16		0.118	0.78	0.035	Inlet Capacity
K0331	36.8		0.151	1.21	0.15	Inlet Capacity
K0336	31.69		0.044	0.62	0.001	Inlet Capacity
K0335	31.53		0.111	0.63	0.032	Inlet Capacity
K0338	27.22		0.158	0.02	0.05	Inlet Capacity
K0342	51.76		0.134	0.02	0.059	Inlet Capacity
K0341	51.41		0.193	0	0.153	Inlet Capacity
K0340	51.15		0.287	0	0.162	Inlet Capacity
K0345	52.9		0.119	0.44	0.036	Inlet Capacity
K0344	50.9		0.155	0.59	0.153	Inlet Capacity
K0343	50.88		0.272	0.01	0.12	Inlet Capacity
K0349	61.7		0.36	0.02	0.217	Inlet Capacity
K0350	57.65		0.091	0.08	0.04	Inlet Capacity
K0352	56.76		0.091	1	0.024	Inlet Capacity
K0353	57.1		0.212	0	0.156	Inlet Capacity
K0462	64.19		0.124	0.31	0.037	Inlet Capacity
K0356	63.34		0.278	0.63	0.277	Inlet Capacity
K0361	49.72		0.60	0.02	0.351	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0360	48.41		0.468	0.83	0.463	Inlet Capacity
K0366	42.53		0.26	0.3	0.148	Inlet Capacity
K0364	41.31	42.1	0.207	0.59	0	Inlet Capacity
K0363	36.25		0.354	1.4	0.354	Inlet Capacity
K0368	42.85		0.129	0.67	0.04	Inlet Capacity
K0374	43.57		0.125	0.02	0.041	Inlet Capacity
K0373	43.43		0.125	0.11	0.038	Inlet Capacity
K0371	42.59		0.371	0.01	0.27	Inlet Capacity
K0379	34.35	35.11	0.308	0.61	0.072	Inlet Capacity
K0378	33.7		0.087	0.24	0.088	Inlet Capacity
K0377	32.81		0.103	0.12	0.104	Inlet Capacity
K0376	31.16		0.119	0.93	0.12	Inlet Capacity
K0389	52.88		0.106	0.77	0.019	Inlet Capacity
K0388	52.67		0.106	0.88	0.106	Inlet Capacity
K0387	52.12		0.129	1.31	0.024	Inlet Capacity
K0386	51.62		0.046	1.26	0.001	Inlet Capacity
K0385	51.44		0.032	1.25	0.03	Inlet Capacity
K0384	50.71		0.114	0.87	0.032	Inlet Capacity
K0383	46.14		0.097	0.75	0.015	Inlet Capacity
K0391	40.27		0.066	0.72	0.006	Inlet Capacity
K0390	39.6		0.026	1.19	0.005	Inlet Capacity
K0392	42.53		0.25	0.19	0.108	Inlet Capacity
K0394	51.88		0.066	0.7	0.014	Inlet Capacity
K0393	51.52		0.08	1.04	0.02	Inlet Capacity
K0395	52.75		0.047	0.7	0.008	Inlet Capacity
K0396	44.5		0.188	0.01	0.124	Inlet Capacity
K0405	58.51		0.067	1.1	0.007	Inlet Capacity
K0404	58.38		0.074	0.01	0.045	Inlet Capacity
K0401	55.2		0.688	0	0.567	Inlet Capacity
K0400	54.5	54.84	0.618	0.19	0.424	Inlet Capacity
K0399	52.84		0.462	0.81	0.46	Inlet Capacity
K0409	60.63		0.426	0.02	0.23	Inlet Capacity
K0408	59.76		0.297	0.29	0.295	Inlet Capacity
K0413	43.69	44.72	0.159	0.91	0	Inlet Capacity
K0412	43.55	44.65	0.16	0.95	0	Inlet Capacity
K0411	42.3		0.159	0.6	0.032	Inlet Capacity
K0414	43.43		1.279	0.87	1.278	Inlet Capacity
K0423	62.82		0.464	1.18	0.464	Inlet Capacity
K0422	60.14		0.515	0.98	0.514	Inlet Capacity
K0420	59.19		0.468	0.52	0.468	Inlet Capacity
K0419	58.66		0.515	0.8	0.513	Inlet Capacity
K0418	57.71		0.56	1.28	0.555	Inlet Capacity
K0427	57.78		0.169	1.77	0.169	Inlet Capacity
K0426	57.77	58.85	0.34	0.88	0.109	Inlet Capacity
K0425	57.42	58.81	0.227	1.21	0	Inlet Capacity
K0428	59.2		0.186	0.32	0.041	Inlet Capacity

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0429	59.44		0.177	0.86	0.093	Inlet Capacity
K0430	60.01		0.179	0.02	0.062	Inlet Capacity
K0432	3.07		0.31	0.01	0.163	Inlet Capacity
K0435	19.92		0.14	0.35	0.025	Inlet Capacity
K0438	81.7		0.07	0.37	0.026	Inlet Capacity
K0437	81.37		0.09	0.27	0.014	Inlet Capacity
K0444	41.62		0.93	0.02	0.724	Inlet Capacity
K0440	36.83		1.315	0.54	1.314	Inlet Capacity
K0445	39		0.091	0.54	0.04	Inlet Capacity
K0448	35.5		0.047	1	0.047	Inlet Capacity
K0452	41.75		0.109	0.75	0.031	Inlet Capacity
K0006	34.64		0	0.98		None
Pit1822	34.28		0	1.37		None
K0145	6.92		0.04	0.85	0	None
K0192	39.29		0	0.09	0	None
K0212	47.71		0.027	0.69	0	None
K0279	18.63		0.004	1.05	0	None
K0298	31.24		0.004	0.83	0	None
K0346	57.56		0.004	0.59	0	None
K0357	64.22		0.004	0.78	0	None
K0382	40.94		0.015	0.77	0	None
K0381	38.73		0.025	0.17	0	None
K0447	39.31		0.027	0.95	0	None
K0012	40.49		11.402	-0.19	11.4	Outlet System
K0055	40.36		0.274	-0.02	0.303	Outlet System
K0053	39.28		0.526	-0.03	0.571	Outlet System
K0062	25.26		2.762	-0.29	2.8	Outlet System
K0073	46.79	46.93	0.782	-0.01	0.566	Outlet System
K0072	41.85		1.159	0	1.511	Outlet System
K0071	41.2	41.33	1.652	-0.02	1.525	Outlet System
K0065	29.4	29.07	1.526	-0.48	1.722	Outlet System
K0064	27.62		1.817	-0.12	1.984	Outlet System
K0083	34.35		0.338	-0.03	0.481	Outlet System
K0082	33.12		0.797	-0.76	1.239	Outlet System
K0103	70.33		0.223	0	0.201	Outlet System
K0133	63.14		0.465	0	0.406	Outlet System
K0132	63.01		0.521	-0.02	0.533	Outlet System
K0131	63.11		1.058	-0.19	1.059	Outlet System
K0129	57.96		1.337	-0.03	1.329	Outlet System
K0128	57.22		1.371	-0.13	1.438	Outlet System
K0127	57.11		1.479	-0.06	1.494	Outlet System
K0125	56.2		1.487	0	1.688	Outlet System
K0124	56.1		2.198	-0.3	2.451	Outlet System
K0045	54.87	55.01	2.847	-0.01	2.695	Outlet System
K0041	49.2		1.678	0	2.127	Outlet System
K0037	46.76		1.583	-0.03	1.762	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0035	45.85		0.238	0	0.269	Outlet System
K0034	45.25		2.08	0	2.45	Outlet System
K0032	44.46		2.04	0	2.983	Outlet System
K0171	7.22	7.08	0.76	-0.29	0.757	Outlet System
K0181	46.63	46.7	0.14	-0.13	0.034	Outlet System
K0180	46.4	46.53	0.243	-0.02	0.093	Outlet System
K0179	39.73		0.274	-0.13	0.349	Outlet System
K0176	26.02		0.425	-0.02	0.437	Outlet System
K0174	14.61		0.637	-0.02	0.643	Outlet System
K0186	26.57		0.356	-0.02	0.349	Outlet System
K0185	16.62		0.463	-0.07	0.511	Outlet System
K0184	15.65		0.68	-0.31	0.786	Outlet System
K0183	15.22		0.9	0	0.742	Outlet System
K0190	40.04	40.12	0.143	-0.12	0.017	Outlet System
K0189	39.93	39.98	0.13	-0.1	0.038	Outlet System
K0194	43.14		0.20	0	0.168	Outlet System
K0204	48.14		0.425	-0.08	0.434	Outlet System
K0203	47.97	48.1	0.855	-0.02	0.605	Outlet System
K0201	41.43		0.748	-0.05	0.753	Outlet System
K0199	38.59		0.74	-0.09	0.789	Outlet System
K0218	52.42		0.15	0	0.167	Outlet System
K0223	46.87		0.573	-0.08	0.559	Outlet System
K0225	48.46		0.296	0	0.294	Outlet System
K0227	50.41		0.114	-0.01	0.115	Outlet System
K0226	50.42	50.53	0.209	-0.04	0.05	Outlet System
K0229	52.34		0.073	0	0.061	Outlet System
K0239	64.17		0.352	0	0.344	Outlet System
K0236	55.14		2.436	-0.28	2.452	Outlet System
K0235	48.95		2.933	-0.14	2.929	Outlet System
K0255	64.21		0.136	0	0.132	Outlet System
K0253	63.25		0.27	-0.03	0.268	Outlet System
K0251	60.85		0.302	-0.01	0.298	Outlet System
K0250	60.65		0.35	0	0.351	Outlet System
K0247	60.1		0.573	0	0.781	Outlet System
K0246	60.08		1.08	-0.78	1.18	Outlet System
K0245	59.1		1.469	-0.1	1.476	Outlet System
K0292	31.29		0.21	0	0.182	Outlet System
K0291	30.21		0.24	-0.02	0.25	Outlet System
K0290	28.85		0.253	-0.35	0.372	Outlet System
K0288	23.64		0.59	-0.18	0.731	Outlet System
K0317	47.83		0.27	-0.04	0.29	Outlet System
K0316	46.86		1.79	-0.27	1.884	Outlet System
K0315	46.71		1.906	-0.12	1.915	Outlet System
K0321	47.6		0.06	0	0.041	Outlet System
K0326	48.47		0.168	-0.03	0.172	Outlet System
K0325	45.56		0.219	-0.02	0.221	Outlet System

PIT / NODE DETAILS						
Name	Max HGL	Max Pond HGL (Sag Pits)	Max Surface Flow Arriving (cu.m/s)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
K0339	27.47	27.56	0.117	-0.06	0.006	Outlet System
K0348	57.65		0.308	0	0.269	Outlet System
K0347	56.17		0.421	0	0.375	Outlet System
K0351	57.54		0.04	0	0.071	Outlet System
K0354	63.04		0.47	0	0.416	Outlet System
K0359	47.88		0.574	-0.04	0.582	Outlet System
K0365	42.02	42.19	0.355	-0.03	0.036	Outlet System
K0372	43		0.163	-0.01	0.178	Outlet System
K0397	46.27		0.971	-0.07	0.951	Outlet System
K0403	56.3		0.113	0	0.152	Outlet System
K0402	55.57		0.492	-0.12	0.556	Outlet System
K0406	55.59		0.326	-0.02	0.332	Outlet System
K0407	58.97		0.295	0	0.27	Outlet System
K0415	45.19	45.32	1.399	-0.07	1.276	Outlet System
K0416	45.15	45.35	1.707	0	1.396	Outlet System
K0421	60.13		0.564	0	0.465	Outlet System
K0433	3.1		0.245	0	0.203	Outlet System
K0443	40.52		0.811	-0.05	0.789	Outlet System
K0442	38.57		0.858	-0.11	0.913	Outlet System
K0441	37.75		1.406	0	1.288	Outlet System
K0450	57.35		0.745	-0.05	0.634	Outlet System
K0449	56.95		1.378	-0.15	1.384	Outlet System



GHD City of Ryde

City of Ryde Council

Buffalo and Kittys Creek Floodplain Risk Management Study and Plan

Final Report

November 2014

This report has been prepared by GHD for City of Ryde Council and may only be used and relied on by City of Ryde Council for the purpose agreed between GHD and the City of Ryde Council as set out in section 1of this report.

GHD otherwise disclaims responsibility to any person other than City of Ryde Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by City of Ryde Council and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared the preliminary cost estimate set out in section 8.5.3 of this report ("Preliminary Cost of Potential Options") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD.

The Cost Estimate has been prepared for the purpose of comparing potential flood mitigation options and must not be used for any other purpose.The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimate.

GHD excludes and disclaims all liability for all claims, expenses, losses, damages and costs, including indirect, incidental or consequential loss, legal costs, special or exemplary damages and loss of profits, savings or economic benefit, City of Ryde Council may incur as a direct or indirect result of the database being transferred to council, for any reason being inaccurate, incomplete or incapable of being processed on City of Ryde Council's equipment or systems or failing to achieve any particular purpose. To the extent permitted by law, GHD excludes any warranty, condition, undertaking or term, whether express or implied, statutory or otherwise, as to the condition, quality, performance, merchantability or fitness for purpose of the information database transferred to Council.

This study was commissioned by the City of Ryde with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

This page has been left blank intentionally

Table of contents

Table index

Figure index

Appendices

1. Introduction

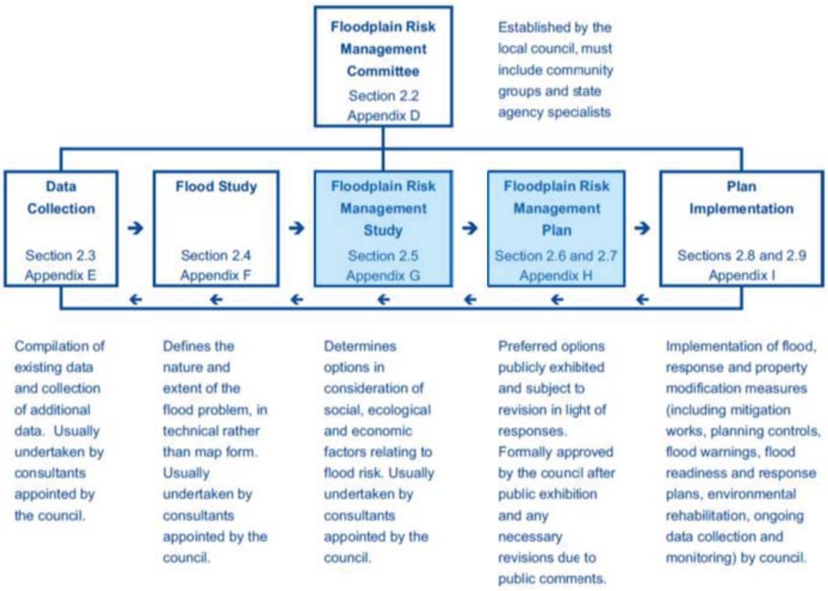
1.1 NSW Floodplain Management Policy

The primary objective of the New South Wales Government's Flood Prone Land Policy (the Policy) is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.

Through the Office of Environment and Heritage (OEH), the Department of Planning and Infrastructure (DP&I) and the State Emergency Service (SES), the NSW Government provides specialist technical assistance to local government on all flooding and land use planning matters. The Floodplain Development Manual (NSW Government, 2005) (the Manual) is provided to assist Councils to meet their obligations through the preparation of floodplain risk management plans.

To meet this objective, Councils in New South Wales have an obligation to prepare Floodplain Risk Management Plans within their Local Government Areas to define how they will reduce flood impact. As shown in Figure 1-1, the Manual sets out a process by which this can be achieved, this includes:

- Preparation of a Flood Study - to define the existing flooding behaviour within the catchment;
- Preparation of a Floodplain Risk Management Study - to determine potential flood mitigation/reduction options considering social, economic and environmental factors;
- Preparation of a Floodplain Risk Management Plan - to provide a plan for implementation of mitigation options through a process of public consultation; and
- Plan Implementation.



Stages comprised in this report

Figure 1-1 Floodplain Risk Management Process

1.2 Background of the Study

The Buffalo and Kittys Creek catchments (the study area) are located within the City of Ryde local government area (LGA). The suburbs within the catchments include North Ryde, West Ryde, Gladesville and Hunters Hill. Both catchments are tributaries of the Lane Cove River and drain a combined area of approximately 740 ha.

Both catchments in the past have experienced several large storm events in the 1980s that have caused widespread flooding. Since then, rainfall events in May 1998 and April 2003 have caused significant problems but not to the extent experienced in the late 1980s; this was mainly due to stormwater improvement works completed in the area, acquisition of some of the worst affected properties and the adoption of more stringent development controls.

As City of Ryde Council (Council) is responsible for local land use planning in the study area and its floodplains. Council's Floodplain Risk Management Committee (the committee) commissioned GHD in early 2012 to undertake a comprehensive floodplain risk management plan (the Plan) for the study area. This was conducted under the NSW Flood Prone Land Policy.

This plan is inclusive of the stages as outlined in the Manual and described in Section 1.1. Key outcomes of this plan will include the development of the Buffalo and Kittys Creek Flood Study (Flood Study) and the Floodplain Risk Management Study and Plan (FRMS&P), hereby referred to as 'the Study'.

The draft Flood Study (GHD, 2013) was submitted to Council in March 2013 for review by the committee. In addition, the draft Flood Study and will be on public exhibition for community consultation prior to finalisation.

The focus on this current stage of the Plan is the FRMS&P and is presented in this report. The development of this report was overseen by the committee. The committee consists of members from City of Ryde Council, State Emergency Services (SES), Office of Environment and Heritage (OEH) and members of the community.

This report should be read in conjunction with the Flood Study.

1.3 Report Outline

The structure of this report contains the following sections:

Section 1 – An Introduction to the Study;

Section 2 – Background information, including a description of the catchment, history of flooding and previous flood investigations;

Section 3 – A review of community consultation activities undertaken during the study;

Section 4 – Description of the existing flood behaviour as identified from the Flood Study, including existing flood hazards;

Section 5 – Social-Economic description of the Study area and potential effects;

Section 6 – Flood damage assessments identifying the average annual damage (AAD) costs;

Section 7 – The types of floodplain management measures and options currently used in practice to mitigate and/or reduce flood impacts;

Section 8 – A review of the potential flood mitigation options and an assessment of these options based on the social, economic and environment criterion;

Section 9 – Detailed Assessment of Preliminary Options; and

Section 10 – The recommended Floodplain Management Plan for the Buffalo and Kittys Creek Floodplain.

2. Background Information

2.1 Catchment Background

Detailed information on the catchment characteristics of the Buffalo and Kittys Creek catchments are provided in the Flood Study (GHD, 2013), a summary is provided in this report.

2.1.1 Description of the Catchment

As previously described, the Buffalo and Kittys Creek catchments are located within the City of Ryde local government area. This is shown in locality plan Figure 2-1. The catchments are bounded by Victoria Road to the west and by Pittwater Road to the east and south-east. Both creeks rise in the north-west and flows in a south easterly direction, draining into Lane Cove River.

Buffalo Creek Catchment

The Buffalo Creek catchment is the larger catchment of the two and is located south-west of Kittys Creek catchment. The topography of the catchment is predominantly steep with its highest elevations in excess of approximately 85 mAHD on the north western extent. The terrain generally slopes downwards in an easterly direction draining towards Lane Cove River. The downstream discharge point of the catchment (beneath Pittwater Road) exhibits an elevation of 0.44 mAHD.

Land use in the area is predominately urban and consists of mainly residential precincts with minor commercial and industrial developments. Parks are found to be scattered throughout the catchment and forested reserves are dominant along the creek banks and within the floodplain.

Residential areas throughout the catchment generally exhibit slopes varying from 5 to 20%, creek banks in the downstream areas can be as steep as 30 to 40%. The creek slope itself generally varies from 0.1 to 1.0% in the lower reaches to approximately 1.0 to 2.5% in the upper reaches.

Kittys Creek Catchment

The Kittys Creek catchment exhibits similar characteristics to the larger Buffalo Creek catchment. The terrain is also predominantly steep, exhibiting slopes in residential areas of 5 to 15% and approximately 20 to 30% in the downstream creek banks.

Land use in the area is primarily residential with scattered parks and forested areas. Heavily forested areas such as Wallumatta Nature Reserve, Portius Park, Martin, Boobajool and Kittys Creek Reserve surrounds the creek, making the creek heavily vegetated throughout the entire reach.

2.2 Heritage

Heritage issues are important in forming an understanding of the social and cultural context of the floodplain. Advice from the Heritage Council is advised prior to any item of State Significance being demolished, defaced or damaged. The Ryde Local Environmental Plan No. 105 provides a schedule of heritage items within the City of Ryde and should be referenced prior to implementation of any flood mitigation works.

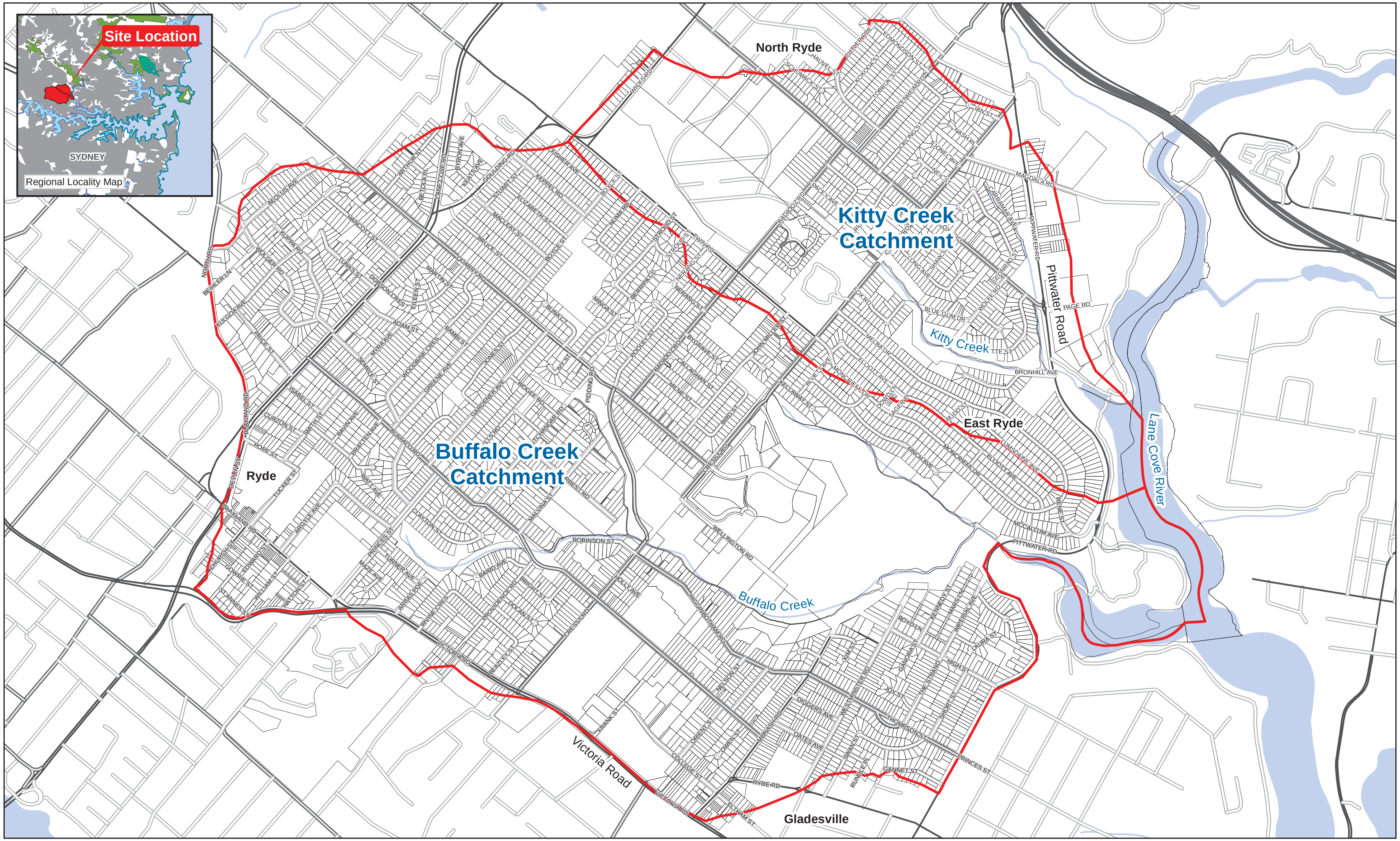
2.3 History of Flooding

The City of Ryde experienced several large storm events in the 1980s that caused widespread flooding. Since then, rainfall events in May 1998 and April 2003 caused significant problems but not to the extent experienced in the late 1980s; this was mainly due to stormwater improvement works completed in the area, acquisition of some of the worst affected properties and the adoption of more stringent development controls.

2.4 Previous Flood Investigations

GHD completed the draft Buffalo and Kittys Creek Flood Study in March 2013. This report was reviewed by Council in conjunction with members of the City of Ryde Floodplain Risk Management Committee. This report will be placed on public exhibition prior to finalisation.

No previous Flood Studies have been conducted for the catchment prior to GHDs investigation. The GHD Flood Study report will form the basis for all future floodplain management activities.



1:13,000 (at A3)

0 65 130 260 390 520
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend

- Catchment Boundary
- Lot Cadastral

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Locality Plan

Job Number	21-21394
Revision	A
Date	06 Nov 2014

Figure 2-1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL Flood Study Report\Catchment Info Mapping\A1 Locality Plan.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

3. Community Consultation

3.1 General

The community's involvement in preparation of the Floodplain Risk Management Plan is integral. The mitigation options selected within the catchment will affect residents and business owners and Council is committed to considering their views in developing the Plan.

The community may also have important information relating to flood history which can help to confirm flood behaviour within the catchment and identify areas of concern.

As part of the community consultation conducted for the Flood Study and the FRMS&P, a survey was sent to residents of the catchment to ask for their input. A copy of this Questionnaire can be found in Appendix C of the Flood Study report. The views, information and suggestions have been considered throughout the course of this Study.

3.2 Floodplain Risk Management Committee

The Buffalo and Kittys Creek Floodplain Risk Management Committee was involved in the preparation of this FRMS&P. The committee comprised of representatives from:

- City of Ryde Council;
- State Emergency Service (SES);
- Office of Environment and Heritage (OEH); and
- Community representatives.

The Committee played an active role in reviewing the Flood Study, selecting floodplain management options to be investigated, evaluating results and outcomes from those options and identifying the preferred floodplain management measures to be included in the final plan.

A presentation of the results and recommendations of the Flood Study and Floodplain Risk Management Study was given to the full Committee on the 2 April 2014 as part of the process.

3.3 Community Questionnaire

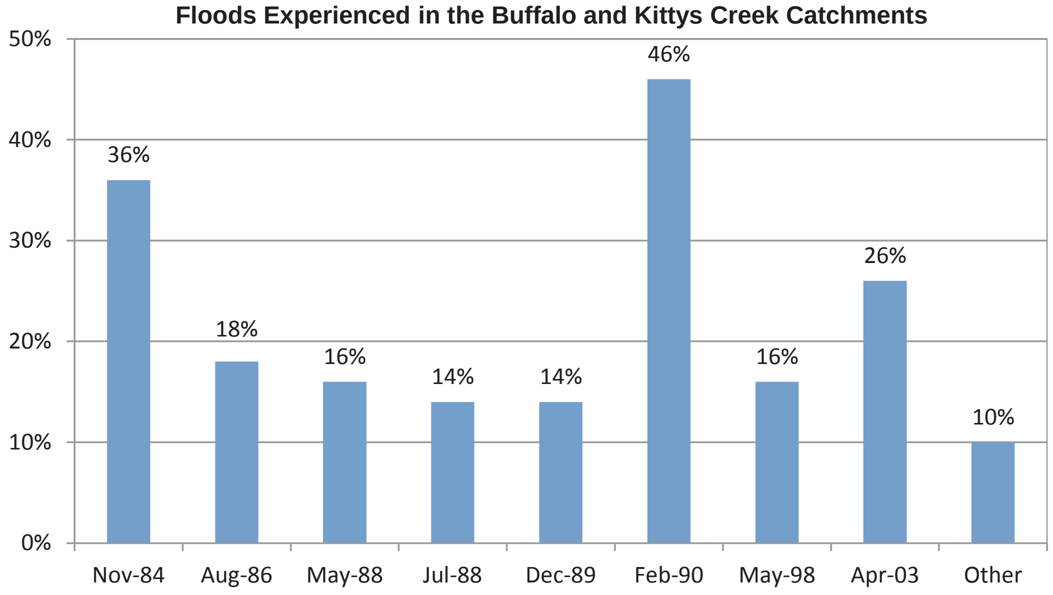
In November of 2012, a newsletter and questionnaire was sent to residents and business owners of the Buffalo and Kittys Creek Catchments. It was agreed with Council that all residents within the study area be consulted regarding flood experience and potential flood mitigation measures within the catchment.

Questionnaires, together with newsletters and reply paid response envelopes were printed and posted to all properties and businesses on Council's address list. A link to an online version of the questionnaire was also provided on the City of Ryde Council website.

Of the 3247 surveys sent, 622 provided a response, either through reply paid response or through Council's website, this represented a 19% response rate. These results were analysed and are summarised in the following sections.

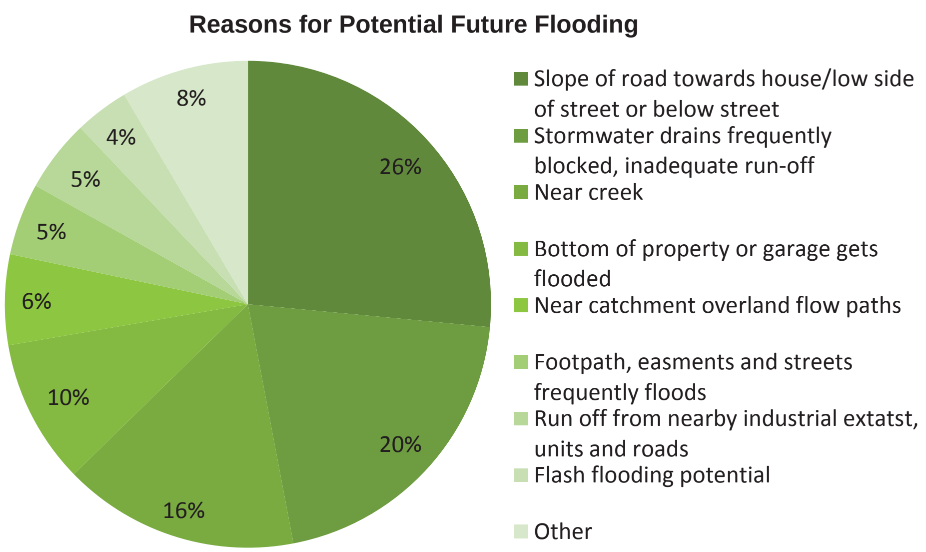
3.3.1 Questionnaire Responses

Of the 622 residents that responded, only 8% of them have been affected by flooding. Of these, just under half (46%) of them had experienced the February 1990 flood event. The last recorded major flood event was the April 2003 event, of which a lower 23% of residents had experienced.



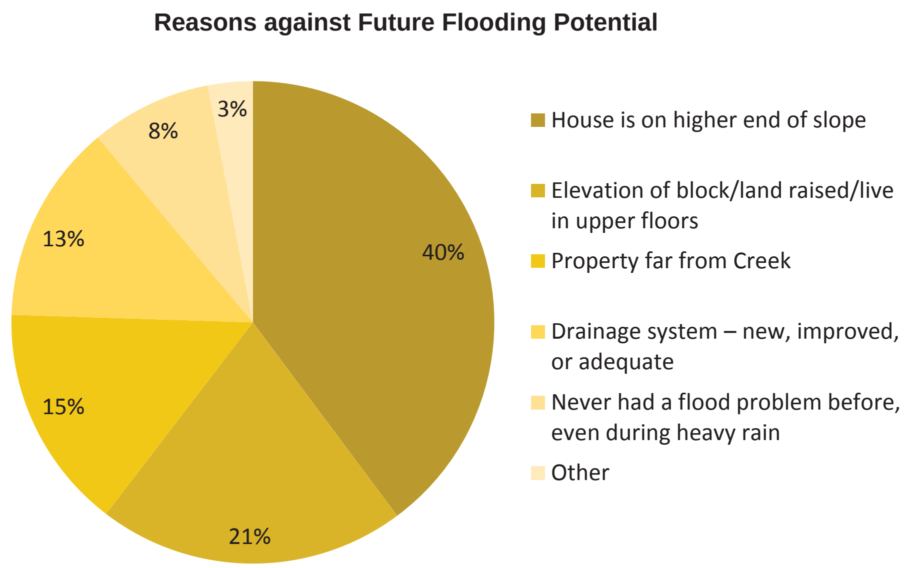
Reasons for Potential Future Flooding

The most commonly cited reasons property owners thought their property could be flooded in the future were because of the position of their property being at the bottom of a hill, or the street sloping towards their property. This was then followed by stormwater drain blockages, and their proximity to the creek itself.



Reasons against Future Potential Flooding

The most commonly stated reasons for those who did not think their properties were at risk were; the property being on the higher end of a slope, the property itself being elevated, or the property being located far from the creek. New or improved drainage installation was commonly cited as having removed flood risk that had existed previously. Furthermore, some property owners had never experienced any flooding at their properties so did not perceive this to be a threat.



Mitigation Works and Development Controls

Residents were asked about their preference for types of mitigation works within the catchment. These preferences are presented in Table 3-1.

Table 3-1 Preferences for mitigation measures within the catchment

Rank	Suggestion	Precent of Respondents
1	Better drains/check drainage system/sewers/higher capacity.	30.4
2	Clearing drains, gutters and pipes full of leaves, rubbish, weed, debris – regular street sweeping.	26.1
3	Clear the creek, river banks of weeds and plants	16.7
4	Check redirection of water flow (footpaths)	4.3
5	Enforce new building, development specifications, over development concerns.	3.6
6	Enforce open wire fences, restrict hard surface areas, nature strips, for less run-off	3.6
7	Re-use rainwater	2.9
8	Tree logs, branches keep falling into creek – tree maintenance	2.9
9	Check easements flood coping capacity	2.2
10	Council approved constructions, previous decision has led to more flooding, requires review	2.2
	Other	5.1%

The most commonly suggested preference of additional works were improvements to drainage or installation of drain systems, clearing existing drains of leaves and other rubbish through regular street sweeping, and clearing the creek of weeds and other plants.

3.4 Public Exhibition

As part of the public exhibition process, a letter was sent to each of the Committee Members, and newsletters were sent to residents in the catchment area informing them of the Public Exhibition. Advertisements were also placed in the local newspapers and Council's website inviting participation from the community.

The Public Exhibition was conducted from the 10th September 2014 to the 3 October 2014. Hard copies of the reports and posters were presented as part of the exhibition. An information session was also held at North Ryde Library where the community could come to speak to Council and Consultant representatives.

Additional details of the Public Exhibition program are included in Appendix C.

Two written responses were received from the community during the Exhibition period. The first response expressed appreciation and satisfaction of the work done to date. The second response suggested potential dredging of the lower reaches of Kittys Creek to alleviate flooding and sought discussions related to wildlife protection and the management of domestic pets.

Dredging of the lower reaches of Kittys Creek was investigated further after the exhibition period. It was confirmed to be ineffective under design flood conditions, and was therefore not pursued further as a potential option. Issues related to wildlife protection and domestic pets have been referred to the relevant departments within Council.

An additional item was discussed with Council during a subsequent site visit. This relates to an inlet and culvert under Pittwater Road at the end of Imperial Avenue within the Buffalo Creek catchment. It is noted that this drainage node has no bearing on the overall flood behaviour of Buffalo Creek and does not impact on any housing in the area. This is because this area is very steep and discharges directly into the downstream reaches of Buffalo Creek.

Additional DRAINS modelling was undertaken to investigate the flow behaviour at this location. The results indicate that overflows across the road are likely to occur for flood events greater than the 20% AEP event. Preliminary details of these results are presented in Appendix C.2. Based on discussions with Council, it was considered that further and more detailed investigations would be required before a recommendation can be made on how drainage can be improved at this location.

4. Existing Flood Behaviour

4.1 Buffalo and Kittys Creek Flood Study

The Buffalo and Kittys Creek Flood Study was carried out by GHD as part of the first phase of the floodplain risk management plan. This report was submitted to Council in March 2013 (Draft) and will be made available for public exhibition prior to finalisation.

The primary objectives of the Flood Study was to define the flood behaviour of the Buffalo and Kittys Creek catchments under historical and existing floodplain conditions, while addressing possible future variations to climate change. The Flood Study provided information on;

- Flood extents and flows;
- Hydraulic Categories;
- Preliminary hazard categories; and
- Result sensitivity due to climate change.

Process of the Flood Study

The flood study provided an assessment of flood behaviour under the existing conditions and highlighted the flooding problems in the area.

DRAINS was used to model the drainage networks within the Buffalo and Kittys Creek catchments using the ILSAX hydrologic method to simulate the catchment rain-fall runoff processes. Hydrographs produced from catchment run-off were then used in the hydraulic TUFLOW model.

The TUFLOW model was constructed using information provided by Council in addition to externally sourced information. The model was then validated and calibrated through flood survey results provided through community consultation, as well as the validation against a HEC-RAS hydraulic model.

Model parameters and assumptions were adjusted and modified as part of the validation and calibration process.

The models were used to simulate a range of design storm events including the 1% 2%, 5% and 20% AEPs as well as the PMF event. These results were then used to analyse the flood behaviour of the catchments. A set of additional model runs were conducted to assess the models sensitivity against particular parameters and changes to due climate change.

Maps showing the extents of the flood inundation and flood levels have been produced for the different design floods and have been included in the Flood Study.

4.2 Flood Risk and Flood Hazard

Floodplain management is about managing the risk of flooding across the floodplain. It should be recognised that different parts of the floodplain are subject to different degrees of flood risk.

Provisional flood hazard is determined in accordance with the Floodplain Development Manual as part of the Flood Study. Flooded areas are defined as being either low, medium or high hazard based on a combination of velocity and depth ratio. This “velocity-depth” product is measured in square metres per second (m^2/s) and recognises that both the velocity of flood waters and the depth of flood waters influence the potential flood hazard.

Figure 4-1 and Figure 4-2 presents the existing hazard conditions for the catchments.

1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Catchment Boundary
- High Hazard
- Medium Hazard
- Low Hazard

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Buffalo Creek Catchment Hazard Classification

Job Number	21-21394
Revision	A
Date	12 Nov 2013

Figure 4-1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft FRMS Report\Buffalo_Creek_Results Hazard.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

0 30 60 120 180 240
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Catchment Boundary
High Hazard
Medium Hazard
Low Hazard

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Kitty Creek Catchment
Hazard Classification

Job Number	21-21394
Revision	A
Date	12 Nov 2013

Figure 4-2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft Flood Study Report\Sensitivity Mapping\Kitty_Creek_Results Hazard.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

4.3 Existing Flooding Conditions

4.3.1 Peak Flood Levels at Selected Locations

As part of the Flood Study, peak flood levels for various locations within the study area were monitored for a range of design storm events. These locations were mainly located on roads to assess the degree of road inundation, this is of particular interest for flood evacuation.

The predicted peak flood levels extracted from the Flood Study at the observed locations within the Kittys Creek and Buffalo's Creek catchment is shown in Table 4-1 and Table 4-2 respectively.

Table 4-1 Peak flood levels at selected locations – Kittys Creek catchment

Location	Modelled Peak Flood Levels (mAHD)				
	20% AEP	5% AEP	2% AEP	1% AEP	PMF
Coxs Road	20.88	20.91	20.96	20.97	20.98
Long Avenue (Near)	33.17	33.23	33.28	33.43	33.97
Melba Drive (Near)	28.34	29.59	30.88	30.91	31.41
Melba Drive (South)	39.83	39.84	39.86	39.88	39.94
Jeanette Street (Near)	11.62	13.20	13.31	13.36	13.44
Bronhill Avenue	10.41	10.44	10.49	10.51	10.61
Fox Road	31.12	31.13	31.19	31.24	31.41
Badajoz Road	53.50	53.52	53.56	53.58	53.62
Blenheim Road	55.81	55.88	55.89	55.90	55.95
Nash Place	47.26	47.31	47.33	47.35	47.51

Table 4-2 Peak flood levels at selected locations – Buffalo Creek catchment

Location	Modelled Peak Flood Levels (mAHD)				
	20% AEP	5% AEP	2% AEP	1% AEP	PMF
Lane Cove Road	47.04	47.11	47.13	47.15	47.37
Smith Street	44.37	44.39	44.40	44.41	44.56
Dobson Crescent	51.24	51.25	51.33	51.35	51.64
Quarry Road	56.95	57.24	57.28	57.30	57.47
Gardener Road	43.65	43.71	43.75	43.79	44.16
Gannan Park	50.52	50.53	50.54	50.55	50.57
Baird Avenue	29.29	29.34	29.35	29.39	29.64
Buffalo Road	29.28	29.30	29.31	29.32	29.35
Higginbotham Road	22.93	22.96	22.98	22.99	23.14
Lyndhurst Street	26.36	26.37	26.38	26.39	26.40
Finch Avenue	32.31	32.32	32.33	32.35	32.39

4.3.1 Critical Storm Duration

A range of storm durations were modelled for the Buffalo and Kittys Creek catchments in order to identify the critical storm duration for design event flooding. Design durations modelled for each AEP event included the 0.5 hour, 1 hour, 1.5 hour, 2 hour, 3 hour, 4.5 hour and 6 hour durations. Outputs from the hydrologic model simulations indicate that the maximum peak inflows for the Buffalo Creek catchment are generally derived when using storm durations of 1.5 to 2 hours. Similarly, Hydraulic modelling also identifies that peak flows within that catchment occurs within the 1.5 to 2 hours. This information, in conjunction with road inundation levels is important for emergency flood evacuation planning.

4.3.2 Flood Map Results

The results from the design flood simulations can be found in Appendix C of the Flood Study. These are presented as a series of flood maps showing flood depth (in blue), overlain by flood level contours.

Referring to the flood maps, the following is noted:

Buffalo Creek Catchment

- Flooding is generally contained within the creek for the 20%, 5% and 2% AEP flood events. Minor road flooding occurs in the lower reaches of the catchments and in backyards of properties in the most upstream reaches;
- Flooding in the 1% AEP and PMF event is more widespread. Flood waters are expected to inundate a larger area of the catchment with increased backyard and road flooding;
- Flooding in property backyards is observed for all storm events, most visibly in the upstream catchment areas. Flood waters in these backyards ranges in depth from 100 mm to 250 mm. This is expected as these residential backyards naturally form part of the tributary draining into Buffalo Creek. However, it is unclear whether these houses will be flooded as floor survey levels have not yet been surveyed. This will be conducted as part of the next phase.
- Greater flood depths are observed in the lower reaches of Buffalo Creek. As observed in the creek topography, flood waters are attenuated in the lower creek reaches before discharging through the culverts underneath Pittwater Road and into Lane Cove River; and
- In the PMF flood event, flood levels are approximately in excess of 1 m deeper than the 1% AEP in the downstream reaches of the creek. Road flooding and flooding in residential and commercial areas in this vicinity may reach 200 to 300 mm in depth.

Kittys Creek Catchment

- Flooding is generally contained within the creek for the 20%, 5%, 2% and 1% AEP flood events. Minor road flooding occurs along Badajoz road, but flood depths are minor and are within 100 to 150 mm;
- In the downstream reach, flood waters can be expected to inundate Pittwater Road and the areas adjoining this road;
- Flooding in the PMF event is generally more widespread. Flooding is more apparent in various residential zones and on roads; and
- Minor flooding in backyards is observed mainly in the upper reaches of the catchment. This is expected as these residential backyards naturally form part of the tributary draining into Buffalo Creek. However, it is unclear whether these houses will be flooded as floor survey levels have not yet been surveyed. This will be conducted as part of the next phase.

5. Social and Economic Impacts of Flooding

5.1 Impacts of Flooding

Impacts from flood events can be measured in the form of flood damages, these damages can be considered as either social or financial and can be categorised as:

- Direct costs – Direct damages quantified in monetary terms. These include damages such as structural damage, contents damage and clean-up costs;
- Indirect costs – Indirect damages can be translated into monetary values but are secondary impacts, such as the loss of business revenue and changes to employment patterns; and
- Intangible costs – Intangible damages are difficult to quantify in meaningful dollar terms and include impacts such as individual health impacts and the loss of sentimental items.

5.2 Social Impacts of Flooding

The major impacts of flooding can be devastating, causing a great deal of distress to people's lives. Impacts can range from death, injury and harm from sources such as contaminated water through to lasting psychological consequences caused by damages to homes, loss of personal possessions and financial worries.

Social costs are often intangible damages and relate to changes to social networks, lifestyles, community activities and individual state of well-being. The degree of disruption to people's lives depends on the severity of flooding and the ability of the community and individuals to recover from the flood event.

Residential damages may also have the potential to cause lifestyle changes as members of the community adjust personal activities to address food damages.

Flooding may also cause stress and depression for individual community members related to the loss of sentimental and personally valuable items. These social costs are particularly difficult to quantify as the personal and emotional value of loss often exceeds that of material value. Anxiety, panic and insecurity may also increase amongst the community as a response to the possibility of future flood events.

It is generally acknowledged that the degree of social impact caused by flooding is likely to reduce if the community is prepared for a flood event and has adequate access to support services.

Age and Population Profile

Analysis of the population and age profile was drawn from the Australia Bureau of Statistics, 2011, Population and Housing Census. The population within the catchment was calculated utilising the statistical local division tool within the Table Builder profiles. This information is presented in Table 5-1.

Understanding the age profile of the catchment is important, particularly in planning for emergency services or evacuations. Of particular interest would be of infants, young children or the elderly that may require additional assistance in the event of emergencies. As presented in Table 5-1, the age group categories of 0-14 years and 65 years and over accounts for 30.8% of the population in the catchment.

Table 5-1 Age and Population Profile

Age	Buffalo and Kittys Creek Catchment		Ryde LGA
	No.	% of Total Population	% of Total Population
0-4 years	2,170	6.4%	6.2%
5-14 years	4,008	11.8%	10.4%
15-19 years	1,828	5.4%	5.4%
20-24 years	2,208	6.5%	8.7%
25-34 years	4,736	13.9%	16.4%
35-44 years	5,208	15.3%	14.8%
45-54 years	4,756	14.0%	13.3%
55-64 years	3,613	10.6%	10.5%
65-74 years	2,469	7.3%	6.7%
75-84 years	2,138	6.3%	5.1%
85 years and over	915	2.7%	2.4%
Total	34049	100%	100%

5.3 Economic Impacts

Damages to local businesses pose economic impacts for the local community. Flooding has the potential to cause disruption to business activities such as trading capacity and employment routines due to the isolation caused by flood waters.

A summary of the potential impacts of the social-economic working of the community is summarised in Table 5-2.

Table 5-2 Potential Socio-Economic Impacts

Direct	Indirect	Intangible
Residential		
Structural Damages	Relocation Costs	Stress and Anxiety
Contents Damages	Loss of ability to work	Loss of sentimental items
Outside Damage	Changes to work routines	Lifestyle changes
Clean-up Costs	Disruption to social capital	Loss of amenity
Replacement and repairs	Restricted access	
Commercial Businesses and Community Facilities		
Structural Damages	Loss of revenue/profit	Stress and Anxiety
Contents Damages	Loss of productivity	Loss of sentimental items
Outside Damage	Disruption to employment	Lifestyle changes
Clean-up Costs	Loss of Patronage	Loss of amenity
Infrastructure Damages	Drop in Property Value	
Restricted Access	Disruption to community services and social capital	

Housing Profile

The housing profile of the study area was drawn from realty specialist RealEstate.com.au, an Australian property website owned and operated by ASX-listed REA Group. An understanding of the property prices is essential in estimating the damages to properties due to floods. In particular, when implementing a voluntary house purchasing scheme as a flood mitigation option, properties should be purchased at an equitable price. Table 5-2 should be used as a planning and cost indication tool for estimates in costs due to house purchasing.

Table 5-3 Housing Profile

Suburb	Year	Median House Price	Median Unit Price
Ryde	2004	$624,981	$295,000
	2005	$582,000	$310,000
	2006	$617,000	$320,000
	2007	$656,500	$375,000
	2008	$720,000	$355,000
	2009	$727,500	$480,000
	2010	$850,000	$520,000
	2011	$840,000	$517,500
	2012	$834,000	$575,000
Suburb	Year	Median House Price	Median Unit Price
North Ryde	2004	$620,000	$530,000
	2005	$580,000	$550,500
	2006	$608,000	$520,875
	2007	$658,000	$550,000
	2008	$675,000	$577,500
	2009	$733,000	$630,000
	2010	$830,000	$715,000
	2011	$825,000	$679,000
	2012	$835,000	$721,500
Suburb	Year	Median House Price	Median Unit Price
East Ryde	2004	$720,055	$512,500
	2005	$670,000	$495,000
	2006	$710,000	$530,000
	2007	$760,000	$555,000
	2008	$774,000	$543,000
	2009	$855,000	$701,000
	2010	$880,000	-
	2011	$910,500	-
	2012	$932,500	$707,000

6. Potential Flood Damage

Flood damage assessments were undertaken to identify the extent of the damages in economic terms for the existing flood conditions. This assessment included an analysis of all the properties within the catchments susceptible to flooding. The purpose of this analysis was to provide an assessment of the relative merit of potential flood mitigation options by a means of a cost-benefit analysis.

The process for undertaking a flood damages assessment is documented in this section, but generally includes the following steps:

- The identification of properties susceptible to flooding;
- Determination of the flood depths per property and identifying the depth of inundation above floor level;
- Defining appropriate stage-damage relationships for various property types and uses;
- Estimating the potential flood damage for each property; and
- Determining the total flood damage for a range of design events.

Flood damages are typically determined by first making an assessment of which properties are flood affected, then estimating a direct damage cost for a range of flooding events. The resulting stage-damage curves are used as a basis for estimating other direct and indirect costs from flooding, such as those listed in Table 5-2.

6.1 Types of Flood Damage

As previously described in Section 5, the types of economic impacts due to flood damages can be categorised as Direct, Indirect and Intangible costs, this is summarised in Table 5-2.

This can be further categorised into the broader terms of 'tangible' and 'intangible' flood damages. Tangible flood damages are those that can be more readily evacuated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

Tangible flood damages are further divided into direct and indirect damages. Direct flood damages related to the loss or loss in value of an object or a piece of property caused by direct contact with floodwaters. Indirect damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlay that occurs because of the flood. This is summarised in Table 6-1.

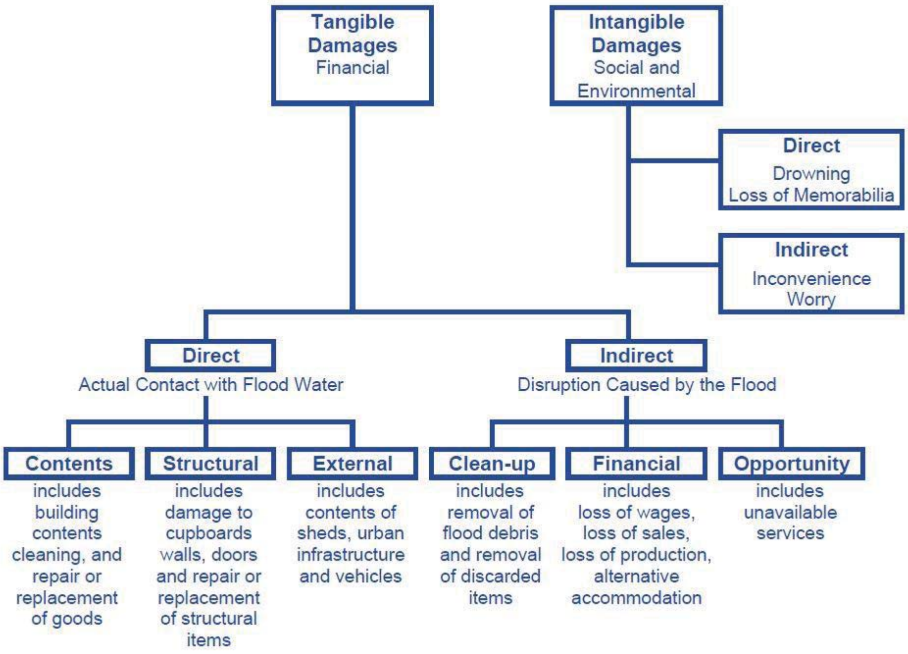


Figure 6-1 Types of Flood Damage

6.2 Flood Damages Database

A database was generated to form the basis of the flood damages assessment. This included extracting information from the flood study, such as:

- Identifying the properties that were susceptible to flooding;
- The number and type of buildings within the property;
- Ground levels near each building, based on ALS survey; and
- Flood levels for the 1:5, 1:10, 1:20, 1:100 AEP and PMF floods.

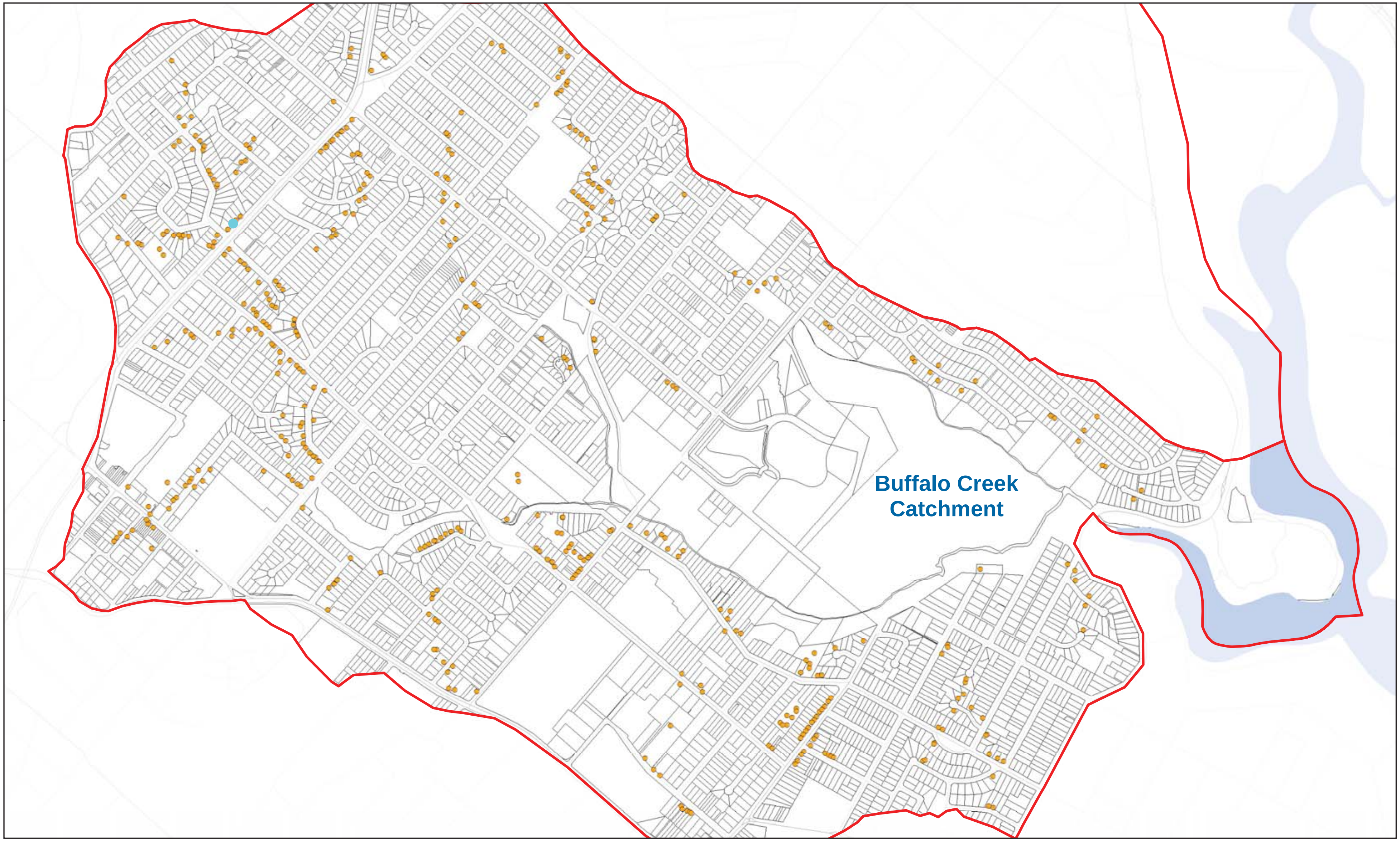
In addition, GHD commissioned registered surveyors, CEH Dapto, to complete the flood damages database, this included attaining information on:

- Surveyed floor levels for those buildings susceptible to flooding (508 properties);
- The type and location of these property; and
- The predominant building materials of each surveyed property.

Ground and Floor Level of Properties

A floor level survey of the identified properties susceptible to flooding within the Probable Maximum Flood extent was undertaken by CEH Dapto. This survey provided floor levels of the property's lowest habitable floor. Figure 6-2 and Figure 6-3 provides a map of the properties surveyed within the Buffalo Creek Catchment and Kittys Creek Catchments respectively,

Ground levels were extracted from Council's ALS dataset. Both the ground and floor levels were entered in the flood damages database and compared against the flood levels.



0 50 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend
- Catchment Boundary
- Surveyed Properties
- Lot Cadastral

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Job Number	21-21394
Revision	A
Date	12 Nov 2013

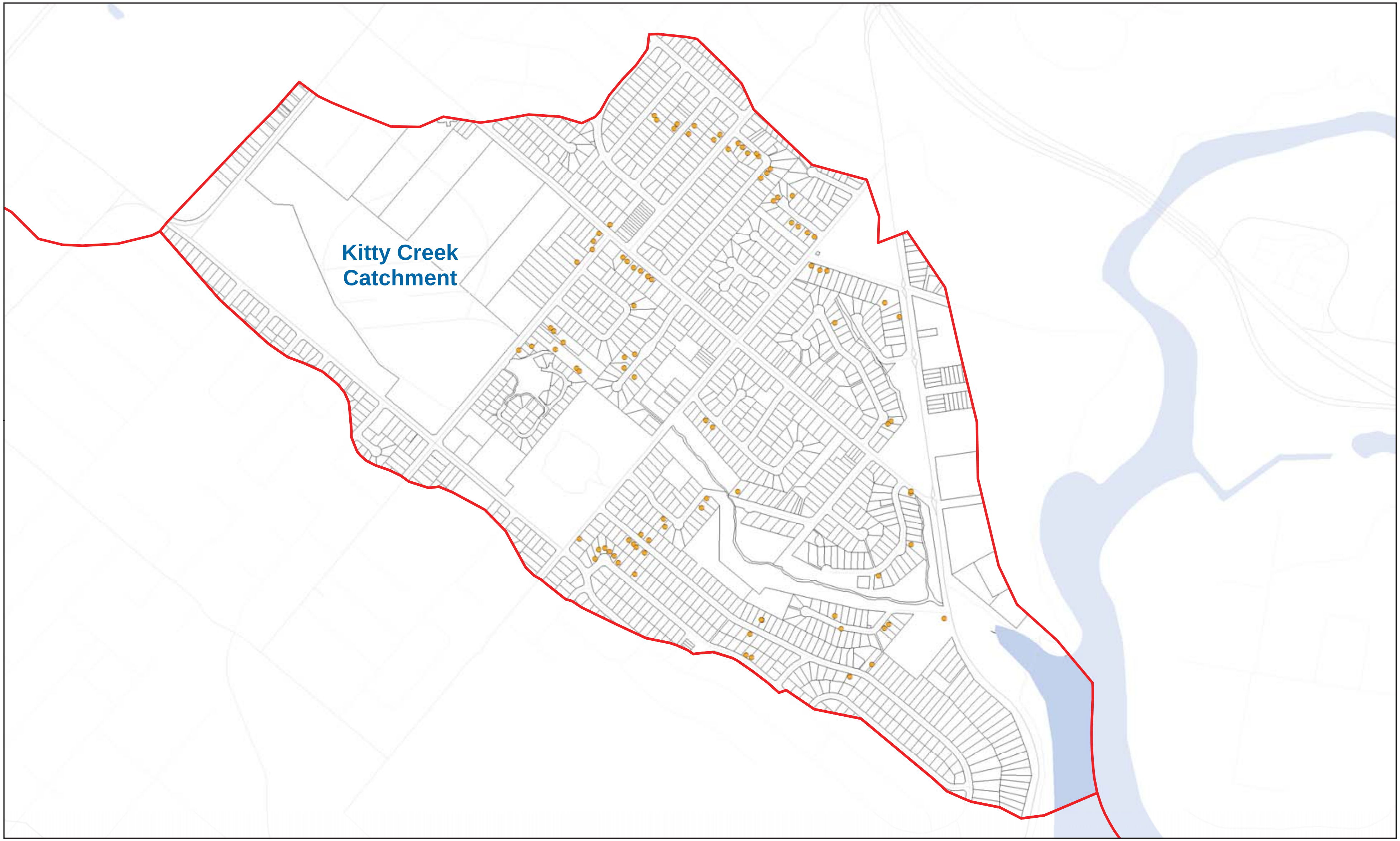
Floor Level Surveyed Locations
Buffalo Catchment

Figure 6-2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft FRMS Report\Surveyed Properties - Buffalo.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au



0 40 80 160 240 320
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend

- Catchment Boundary
- Surveyed Properties
- Lot Cadastral

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Job Number 21-21394
Revision A
Date 12 Nov 2013

Floor Level Surveyed Locations
Kittys Creek Catchment

Figure 6-3

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft FRMS Report\Surveyed Properties - Kitty.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Flood Levels

Flood levels predicted from the TUFLOW model during the Flood Study stage were extracted for each of the 508 properties. These levels were entered into the flood damages database and assessed against its flooding above ground level and property floor level.

6.3 Basis of Flood Damage Calculations

As a general guide for most residential buildings, flood damage increases with the depth of flooding. The Floodplain Management and Coastal Support section of the Department of Environment, Climate Change and Water (DECCW) has developed a relationship between flood depth and damage based on various parameters for house and contents value, and flooding characteristics. A spreadsheet was supplied by DECCW for this calculation. The resulting relationship is illustrated in Figure 6-4 and has been simplified as shown in Table 6-1.

Figure 6-4 Relationship between Depth of Flooding and Damage

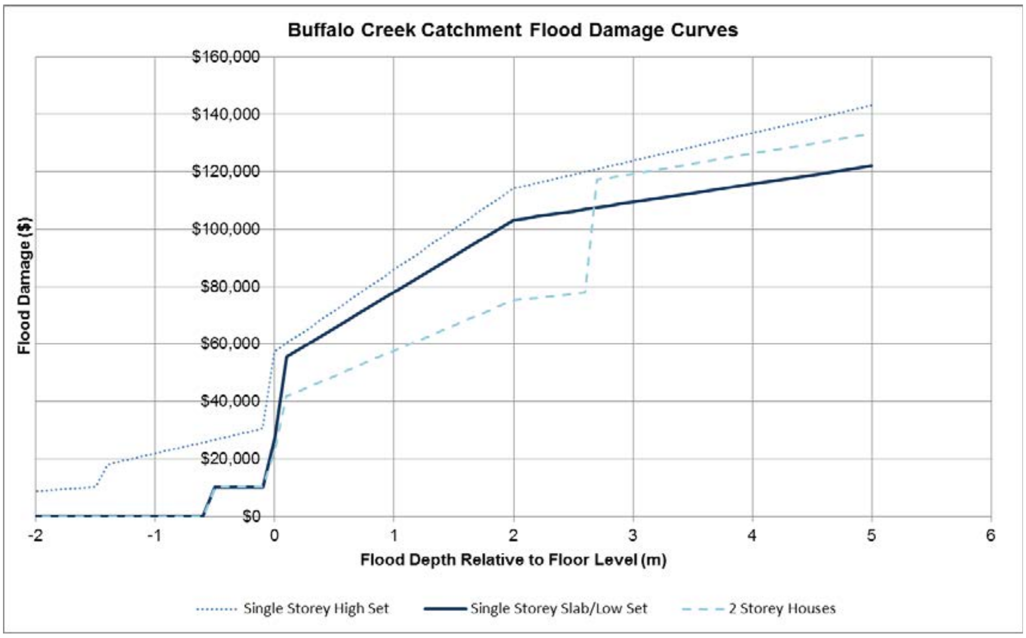


Table 6-1 Relationship between Depth of Flooding and Damage (After DECCW Flood Damage Curve Spreadsheet)

Flooding Depth above Floor Level	Damage to Dwelling (Single Storey Slab/Low Set)
< -0.5	$0
-0.1	$10,183
0	$27,188
0.1	$55,525
0.5	$65,542
1.0	$78,063
1.5	$90,584
2.0	$103,105
>2.0	$104,364

Residential

The damage curves have been adjusted based on a number of parameters specific to the Buffalo and Kittys Creek catchments. These include:

- Regional cost variations;
- Average house size;
- Typical duration of immersion;
- Average contents value;
- Level of flood awareness;
- Effective warning time (1 hours); and
- Damage reduction factor (ratio of actual potential losses) of 0.96 based on the flood awareness and effective warning time.

Table 6-2 presents the typical property contents value assumptions and term.

Table 6-2 Property and Contents Value Assumption and Term

Parameter	Value
Typical contents value	$60,000 (Recommended estimate)
Term	30 years

Using the above information, the following methodology was used to estimate the Average Annual Damage (AAD) and present value of the AAD over a 30-year period:

- Based on the flood maps produced in the Flood Study, properties affected by flooding were identified;
- The cost of damage for the flooding was estimated for each flood event and depth range by multiplying the number of buildings with typical house and contents cost and the percentage of damage for the particular depth (a stage-damage curve);
- A direct damage bill for each storm was calculated;
- Flood AEP was plotted against storm damage and integrated to find the area under the graph, which provides the AAD; and
- A present value for the AAD was estimated based on a 7% discount rate over a 30-year period (In accordance with the NSW Treasury Policy Paper “Economic Appraisal Principles and Procedures Simplified” July 2007.

The results of this investigation are further detailed in Section 6.4.

6.4 Potential Flood Damages for Existing Catchments

Potential flood damages under existing conditions (2013) have been calculated for each property in the flood damages database for the following storm events:

- 20% AEP (5 year ARI);
- 5% AEP (20 year ARI);
- 2% AEP (50 year ARI);
- 1% AEP (100 year ARI); and
- Probable Maximum Flood (PMF).

According to the flood damages database, Table 6-3 presents the number of properties within the Buffalo Creek and Kittys Creek catchments that exhibited above flool level flooding for each storm event.

Table 6-3 Properties Inundated Above Floor Level

Design Event	Inundated Properties	
	Buffalo Creek Catchment	Kittys Creek Catchment
20% AEP	25	4
5% AEP	38	5
2% AEP	45	6
1% AEP	50	6
PMF	162	21

The results of this investigation are tabulated in Table 6-4 and the damage curves shown in

Figure 6-5 and Figure 6-6. Referring to the figures, the area under the line represents the estimated Average Annual Damage (AAD). For Buffalo Creek, the AAD is estimated as $1.01 million over a 30-year period, this has a present value of $13.9 million. For Kittys Creek, The AAD is estimated as $0.14 million, this corresponds to a present value of $1.8 million over a 30-year period.

Table 6-4 Predicted Total Flood Damages under Existing Conditions

Catchment	Damage in Flood Event ($ M)					Average Annual Damage ($M)	Present Value of Damage ($M)
	20% AEP	5% AEP	2% AEP	1% AEP	PMF		
Buffalo Creek	2.40	3.52	4.16	4.65	12.31	1.01	13.89
Kittys Creek	0.35	0.45	0.54	0.61	1.79	0.14	1.84
Total	2.75	3.97	4.70	5.33	14.10	1.15	15.73

Present value of damage is over 30 years on 7% discount factor

Figure 6-5 Average Annual Damage Curve – Buffalo Creek

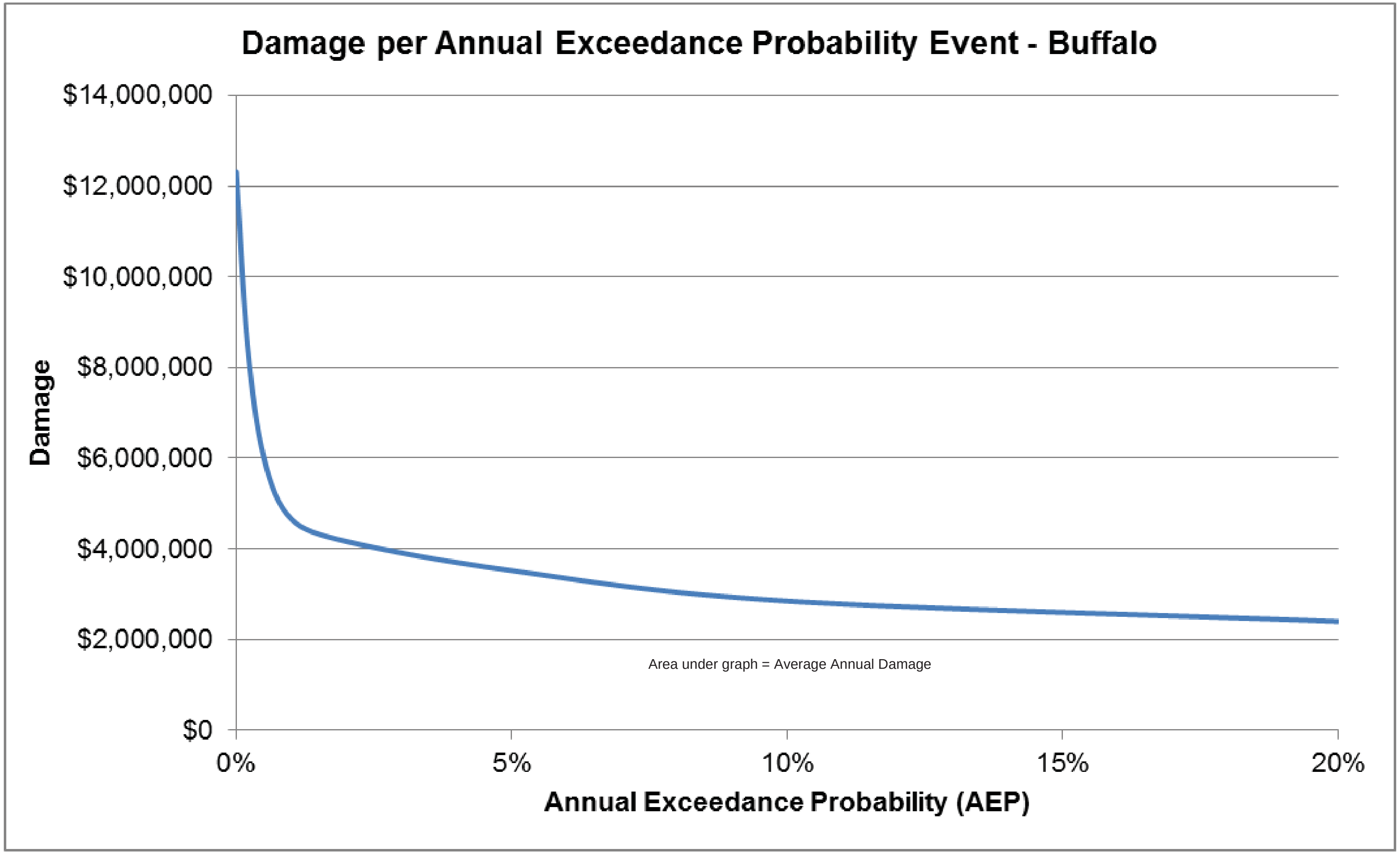
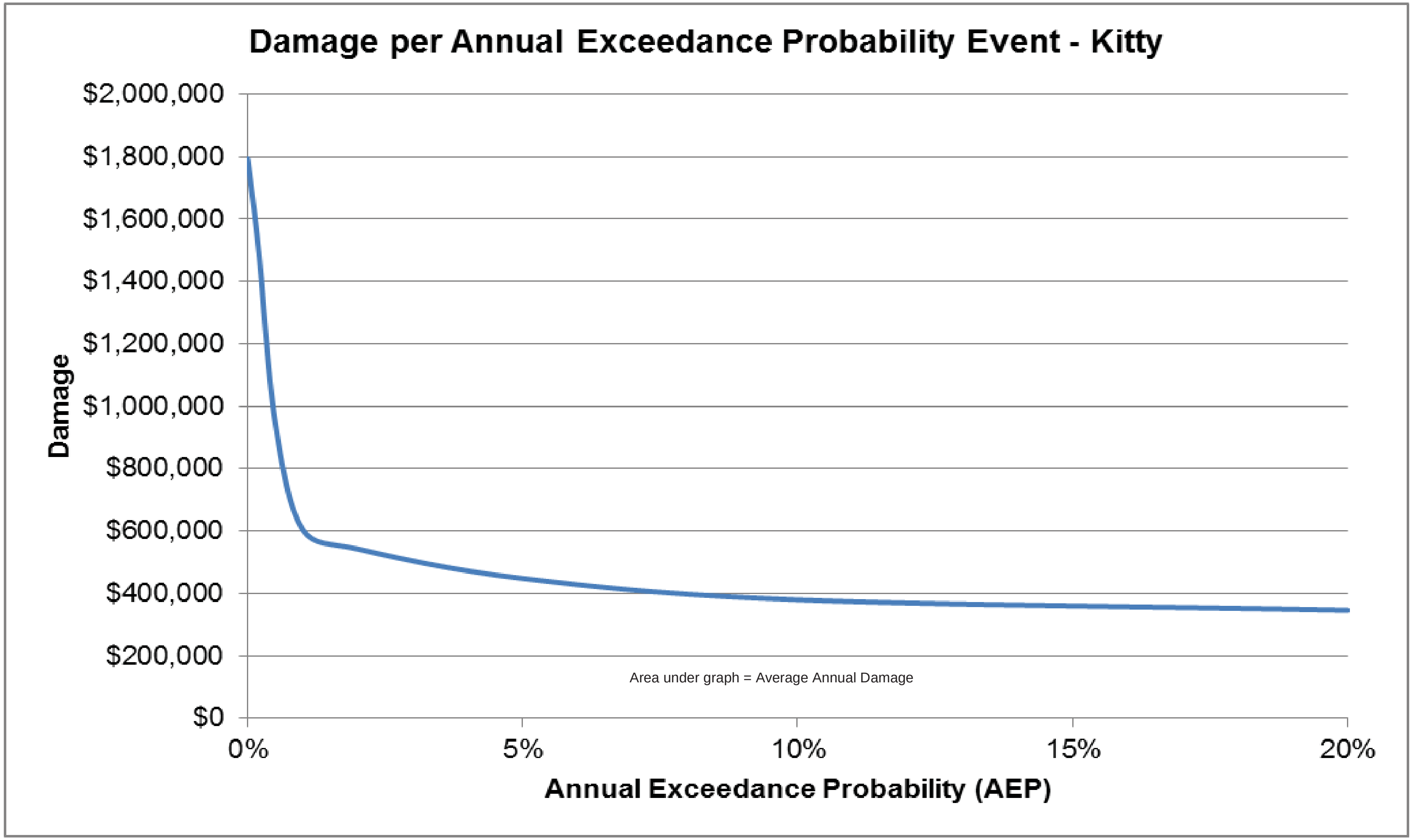


Figure 6-6 Average Annual Damage Curve – Kitty Creek



7. Floodplain Management Measures

7.1 Floodplain Management Approach

In accordance with the Manual, this report considers various floodplain risk management measures that are commonly used in practice. These measures can be grouped into three main categories as shown in Figure 7-1.

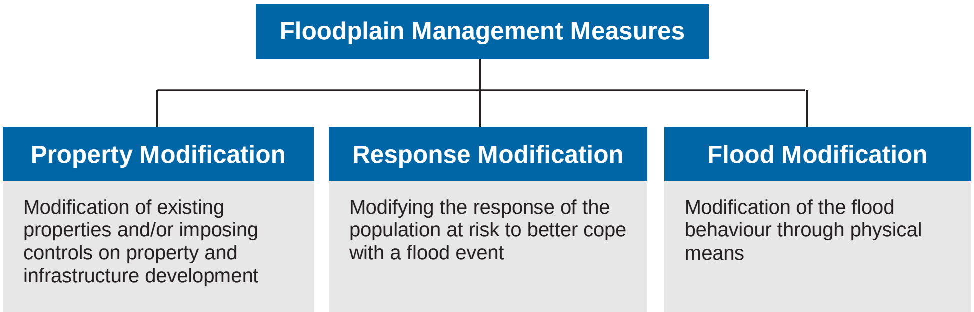


Figure 7-1 Floodplain Management Measures

A floodplain management plan needs to consider all three types of management measures and adopt an integrated and effective mix. Each floodplain and its catchment constitute a unique set of characteristics and flooding issues. It is therefore, important that these measures must be specific to the circumstances of the individual flood prone community and should not follow a generic plan.

This section of the report describes the most common types of floodplain risk management options within each of these measure types, including some of their advantages and suitability for application within this plan.

7.2 Property Modification Measures

Property modification measures refer to modifications to existing developments that are at risk of flooding or are susceptible to flood inundation. This may also include development controls to properties and controls on future infrastructure developments. Property modification measures may include:

- Land use planning including zonings and development controls;
- Voluntary purchase of properties;
- Voluntary house raising; and
- Flood proofing of buildings.

An important focus for implementing property modification measures is to steer away inappropriate developments from areas with a high potential for flood damage and to limit any potential flood damage to properties to be within acceptable levels, by means of minimum flood levels.

Whilst these modifications may reduce damages and risk to life and property, they will not prevent flooding of the premises. Thus they will not necessarily address all the social impacts of flooding.

7.2.1 Development Control Planning

Appropriate zoning provides control on future land uses considering the flood risk. In the areas where development is considered acceptable, development controls are the appropriate means of implementing detailed aspects of council's floodplain risk management plan, particularly when addressing future flood risk. Development control planning may take into consideration the following aspects:

- Access to the Site During Flood Events;
- Fill or Excavation in the Floodplain;
- Freeboard;
- Floor Levels;
- Differences between Land uses;
- Services;
- Impact on Flood Behaviour;
- Structural Soundness When Flooded;
- Building Materials; and
- Fencing.

7.2.2 Land Use Planning

Land use planning limits and controls are an essential element in managing flood risk and an effective way of ensuring flood risk is managed appropriately. Effective consideration of future development involves a strategic assessment of flood risk to future development areas to guide councils, in wisely and rationally controlling development to reduce the risk exposure of new development in an acceptable level. For example, areas within a floodplain identified to be of high hazard should be zoned against future development.

7.2.3 Voluntary Purchase of High Hazard Properties

In certain high hazard areas of the floodplain it may be impractical or uneconomical to mitigate or reduce the severity of flooding to the existing properties. In such circumstances it may be appropriate to cease occupation of such properties in order to free both residents and potential rescuers from the danger and cost of future floods. This is achieved by the purchase of the properties and their removal or demolition as part of an adopted floodplain risk management plan.

Under such circumstances, the properties should be purchased at an equitable price.

7.2.4 Voluntary House Raising

Voluntary house raising includes the elevation of a property's floor level to above a safe flood level, minimising the potential for inundation. In the instance that a dwelling is located within a flood zone, and whereby no other modification measures are appropriate, voluntary house raising may be a viable option. Home owners generally have strong sentimental and emotional attachments to their dwellings and house raising will contribute positively towards social impacts compared with vacating the premise through house purchase.

Avoidance of flood damage by house raising may achieve the following:

- A reduction in personal loss;

- A reduction in danger to personal safety and in the costs of servicing isolated people who remain in their homes to protect possessions; and
- A reduction in stress and post-flood trauma.

Capital costs for house raising may be significant, and is dependent on the property's predominant construction material.

In general, voluntary house raising is a suitable management measure only for low hazard areas on the floodplain. In high hazard areas, this option does not mitigate against other potential risk factors such as high flood velocities, deep flood depths and isolation for extended period of times.

7.2.5 Flood Proofing

Flood proofing of building involves the designing and constructing of buildings with appropriate water resistant building materials to reduce flood damage. This solution reduces damage to the building structure but in most cases does not protect building contents. In this situation, flood proofing will need to be retrofitted to existing buildings or included as a development control.

Since much of the catchment comprises of substantial dwellings flood proofing is not considered as a broad floodplain risk management option. Flood proofing will not be looked at further as a potential option.

7.3 Response Modification Measures

Flood response measures encompass various means of modifying the response of the population to the flood threat. Such measures include plans for:

- Flood warning and effective warning time;
- The protection and/or evacuation of an area;
- The relief of evacuees; and
- The recovery of the area once the flood subsides.

Planning for these measures are generally incorporated in the local flood plan guide usually prepared under the guidance of the SES. The local flood plan is complementary to the floodplain risk management plan.

7.3.1 Flood Warning Systems

Flood warning systems and evacuation plans are used to prepare a community for an impending flood. Depending on the warning time and resources available, flood warning systems and evacuation plans can be used to protect buildings, evacuate people and provide relief to evacuees and recover the flood affected areas.

7.3.2 Public Awareness and Evacuation Plan

A public awareness and evacuation plan would assist in raising flood awareness and readiness, and increase the appreciation of the flood problem and prevention activities. Implementation of a flood awareness scheme will also assist in minimizing the social and economic impacts of flooding. Measures to increase flood awareness could include:

- The dissemination of a Flood Information Pack that could be sent to all owners, business operators and residents of potential flood impacted properties;
- The dissemination of flood certificates on a regular basis which would inform each property owner of the flood situation at their particular property, flood data and advice;
- Signage in flood prone areas giving notification of potential and historical flood levels; and
- Make real time data (creek levels and rainfall) available to the public, and providing a readily accessible information portal on Council’s website.

7.4 Flood Modification Measures

The purpose of flood modification measures is to modify the behaviour of the flood itself by reducing flood levels or velocities or by excluding floodwaters from areas under threat. It is essential that these measures are assessed individually or in isolation. Such measures include plans for:

- Flood Mitigation Dams;
- Detention Basins; and
- Stormwater Infrastructure Upgrades.

7.4.1 Flood Mitigation Dams

Flood mitigation dams reduce downstream flood discharges. As the flood wave passes through the dam, the dam is progressively filled to the point of overflow, trapping a portion of the floodwaters. The full dam then provides temporary storage for floodwaters subsequently passing through it.

The mitigating effects of a large dam on a major flood are often surprisingly small for the following reasons:

- The volume of water in a major flood may be greater than the storage capacity of even a large dam;
- The dam may be nearly full at the start of a flood; and
- Floods may result from rainfall in parts of the catchment that are not commanded by dams.

Flood mitigation dams are generally more appropriate for rural catchments with large available amounts of land. Conversely, the Buffalo and Kittys Creek catchments are highly urbanised catchments within an inner city suburb, making it inappropriate as part of this plan. Flood mitigation dams will not be considered further, although a smaller version, namely detention basins, may be more appropriate based the physical characteristics of the catchment.

7.4.2 Detention Basins

A detention basin is a small dam that provides temporary storage for floodwaters. Detention basins are being used increasingly as a means of controlling the peak discharge from newly urbanised areas. Some of these basins are becoming quite large, and in fact, are more properly regarded as small dams and have to be designed as such.

A detention basin behaves in the same way as a flood mitigation dam, but on a much smaller scale. In urban areas, detention basins are most suitable for small streams that respond quickly to rapidly rising flooding. In particular, detention basins are associated with the following points:

- Require a substantial area to achieve the necessary storage;
- Where they involve multi-purpose uses, safety aspects during flooding need to be addressed;
- Long durations of multi-peak storms (when the basin is filled by the first peak) can increase the likelihood of overtopping or embankment breaching or failure, and the resulting personal danger and damage; and
- They provide little attenuation effect when overtopping occurs.

A number of vegetated open spaces are present within the Buffalo and Kittys Creek catchments. As overland flooding is an issue in parts of the floodplain, detention basins have been further assessed. This is detailed in Section 8.

7.4.3 Stormwater Infrastructure Upgrade

Stormwater infrastructure upgrades include the improvement of council's local stormwater drainage network. This may be in the form of amplifying the dimensions of an existing pipe network, supplementing an existing drainage line with additional pipes, or the servicing of new areas currently not covered by the existing drainage network.

The benefits of providing the aforementioned drainage work upgrades could include allowing for a greater flow conveyance and pipe capacity. In addition, it could also redirect flows away from properties or targeted flood prone areas.

Typically, local drainage networks across NSW are designed to pass through peak storm events of between the 20 to 10% AEP. Newer drainage networks in highly urbanised areas may be designed for up to the 5% AEP. Through the Flood Study, it was identified that pipe capacity issues caused overland flooding in certain residential areas. Stormwater infrastructure upgrades can potentially benefit the Buffalo and Kittys Creek catchment and is considered as part of this plan. More details on this assessment are provided in Section 8.

8. Preliminary Floodplain Management Options Identified

To mitigate and/or improve the flooding issues within the Buffalo and Kittys Creek catchments, the options described in Section 7 were considered as part of this Floodplain Risk Management Plan. As described, these options fall within the groups of:

- Property Modification Measures;
- Response Modification Measures; and
- Flood Modification Measures.

Each option listed under these measure groups were each individually considered for its suitability for implementation for the flood prone community. It is important to recognise the needs of the flood prone community and its unique flooding issues as the key criterion for option selection. Preliminary options for the Buffalo and Kittys Creek catchments were identified based on the three measures groups and are described in this Section. Each option was then assessed based on its impacts to mitigate and/or reduce flood damage, its cost-benefit analysis, and contribution against social, economic and environmental considerations. This assessment is presented in Section 9.

8.1 Preliminary Floodplain Management Options Identified

The following tables provide an overview of the preliminary options identified for the Floodplain Risk Management Plan.

Table 8-1 provides an overview of the preliminary flood modification options, these are also presented in Figure 8-1 (detention basins) and Figure 8-2 (stormwater infrastructure upgrades). A detailed description of each option is discussed in Section 8.2.

Table 8-1 Preliminary Flood Modification Options

Option ID	Type	Description
DB1	Detention Basin	Basin in Ryde Park (East oval)
DB2	Detention Basin	Basin in Ryde Public School (oval)
DB3	Detention Basin	Basin in Gannan Park
DB4	Detention Basin	Basin in Holy Cross College (North-eastern field)
DB5	Detention Basin	Basin in North Ryde Park
SI1	Stormwater Infrastructure Upgrade	Drainage Pipe Upgrade – Additional stormwater pipe along Quarry Rd
SI2	Stormwater Infrastructure Upgrade	Drainage Pipe Upgrade – Additional drainage network along Irvine Crescent
SI3	Stormwater Infrastructure Upgrade	Drainage Pipe Upgrade – Additional drainage network along Buffalo Rd
SI4	Stormwater Infrastructure Upgrade	Drainage Pipe Upgrade – Additional drainage line along Monash Road
SI5	Stormwater Infrastructure Upgrade	Drainage Pipe Upgrade – Increasing capacity of existing drainage line.

Table 8-2 provides an overview of the preliminary response modification options. Detailed description of each option is discussed in Section 8.3.

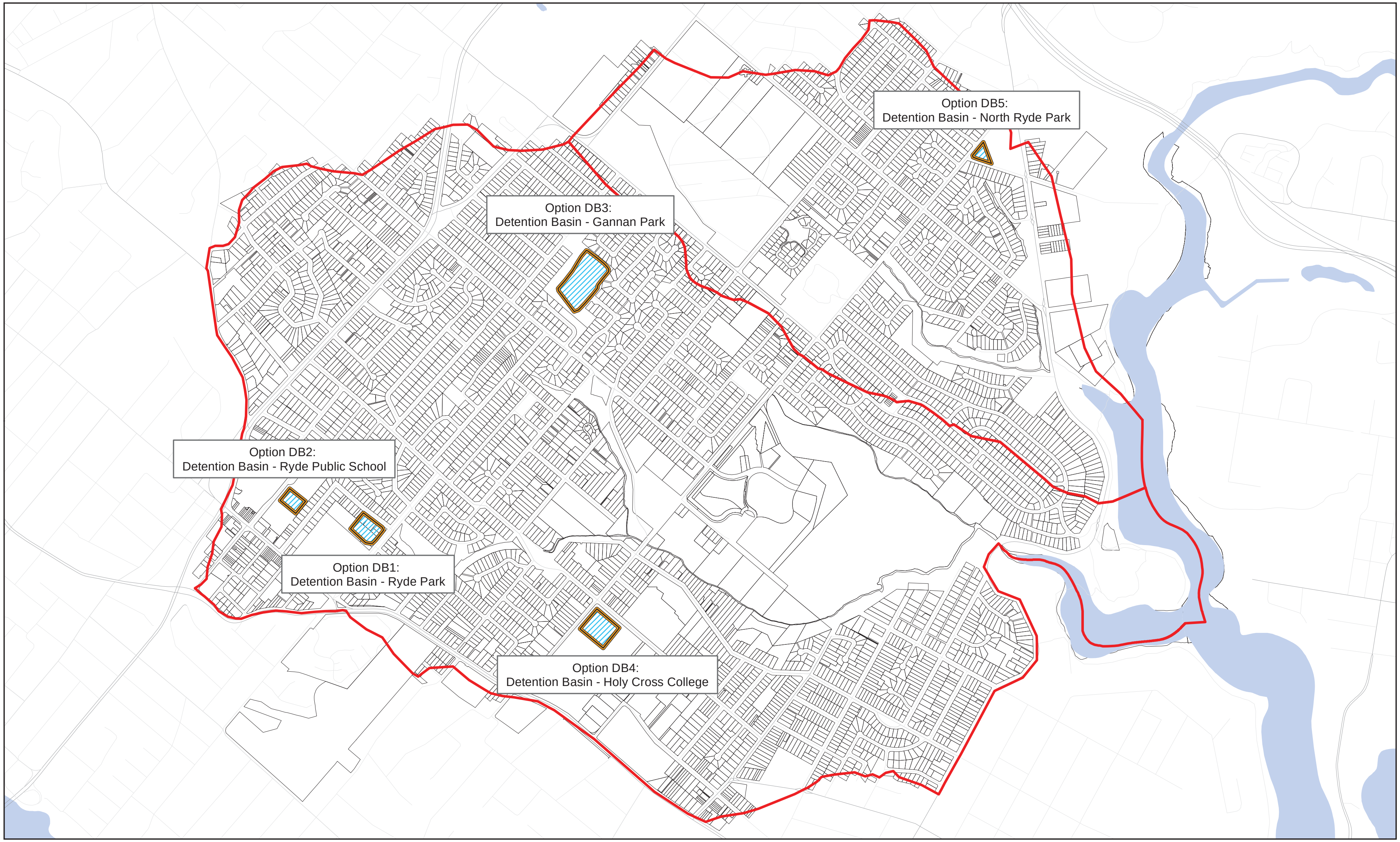
Table 8-2 Preliminary Property Modification Options

Option ID	Type	Description
VHR	Voluntary House Raising	Voluntary house raising of properties within medium to low hazard zones.
VHP Buffalo VHP Kittys	Voluntary House Purchase	Voluntary house purchase of properties within high hazard zones.

Table 8-3 provides an overview of the preliminary response modification options. Detailed description of each option is discussed in Section 8.4

Table 8-3 Preliminary Response Modification Options

Option ID	Type	Description
PA1	Public Awareness	Ongoing Public Awareness Campaign
FW1	Flood Warning and Emergency Evacuation	SES emergency flood management and evacuations plan



0 65 130 260 390 520
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend
- Detention Basin
- Catchment Boundary
- Lot Cadastral

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Job Number	21-21394
Revision	A
Date	13 Nov 2013

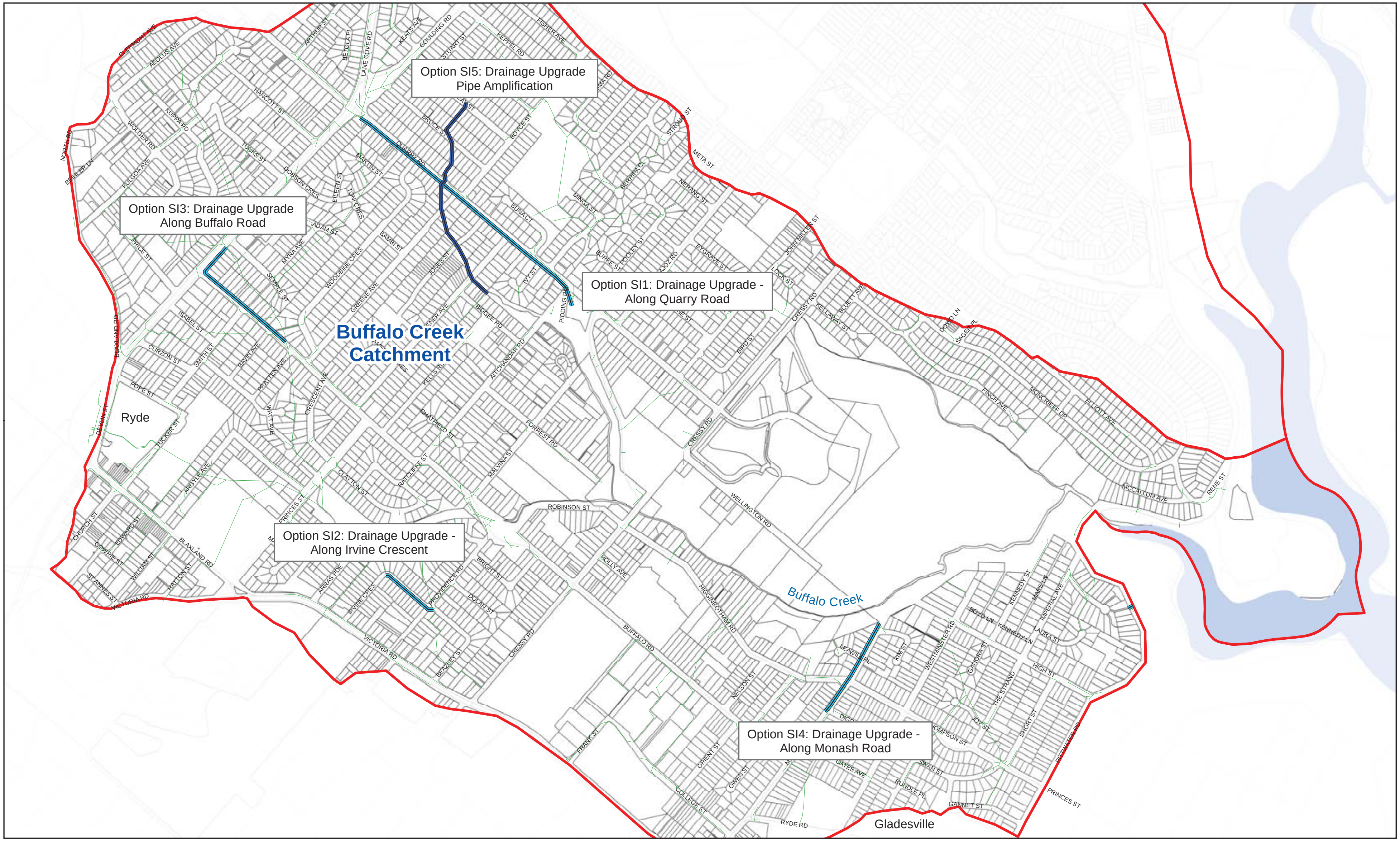
Preliminary Flood Modification Options - Detention Basin

Figure 8-1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft FRMS Report\Option - Basin.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au



1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend

- Pipe Amplification
- New Stormwater Pipe
- Buffalo Catchment Stormwater Pipes
- Catchment Boundary
- Lot Cadastral

City of Ryde

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Potential Stormwater
Drainage Upgrading Options

Job Number	21-21394
Revision	A
Date	07 Nov 2014

Figure 8-2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft FRMS Report\9.07.2014 Options Map for Public Exhibition\Option - Stormwater Pipes For Community Consult.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

8.2 Identified Flood Modification Options

As listed in Table 8-1, ten flood modification options were identified as having potential in mitigating and/or reducing flood impacts within the floodplain. This included the implementation of detention basins and upgrading sections of the existing stormwater infrastructure network. These options are detailed in Section 8.2.1 for detention basins and 8.2.2 for stormwater infrastructure network.

8.2.1 Preliminary Detention Basin Options

A number of sites within the Buffalo and Kittys Creek catchments were identified as being possible locations for the implementation of detention basins. These were predominantly located within the Buffalo Creek catchment (Options DB1, DB2, DB3 and DB4). A single location was identified for the Kittys Creek catchment (Option DB5).

A summary describing each of these preliminary options is discussed in Table 8-4.

Table 8-4 Preliminary Detention Basin Options

Option No.	Type	Description	Location
DB1	Detention Basin	Basin in Ryde Park (East Oval)	Cnr. Princes St and Argyle Avenue, Ryde

A basin in Ryde Park will involve the conversion of an existing sports field into a stormwater detention basin. The size of this basin will cover an area of approximately 7850 m^2 and will involve the lowering of the ground depth by over 0.5 metres. In addition, this option will also involve the replacement of the existing stormwater pipes underneath the basin with smaller pipes to encourage pit surcharging into the basin during large storm events.

Currently, the stormwater pipes shown in the figure above are running at capacity for the 1% AEP peak storm event, restricting the capacity to convey any additional catchment run-off.

This congestion is resulting to excessive overland flooding and creating an overland flow path crossing residential properties. Analysis of this stormwater network for the peak 1% AEP event shows that the discharge pipe (discharging into Buffalo Creek) in which the two main drainage arms combine exceeds the capacity that the pipes can handle and causes the aforementioned problems. A potential solution is to place a detention basin at Ryde Park and to contain the flows from the left drainage arm (pipe network which runs underneath the park) and enabling flows from the adjacent arm to pass through first.

Option No.	Type	Description	Location
DB2	Detention Basin	Basin in Ryde Public School (Oval)	18 Tucker St, Ryde

A basin in Ryde Park School will involve the conversion of an existing school sports field into a stormwater detention basin. This option will involve the lowering of the field's ground level to approximately 0.5 – 1m deep. Excavation of the basin will follow that of the natural gradient to reduce costs and disturbance to its usual activities.

The purpose of this detention basin is to capture the excessive overland flows from the Top Ryde Shopping Centre precinct and its upstream catchments during large storm events. Analysis from the 1% AEP storm event identifies that overland flooding from this region inundates the low sections of Tucker St prior to flowing through the park, affecting the properties downstream of the school on Argyle Street. Various properties along Argyle Street are also identified as being within the medium hazard zone.

In addition to capturing overland flows from Tucker Street, the existing 1.2m diameter stormwater pipe underneath the basin will be replaced with a smaller 0.375m diameter pipe to encourage pit surcharge into the basin. The purpose of this is to attenuate and to reduce the peak flows through the stormwater system, and to also allow for more capacity for downstream catchment flows.

An additional pipe or low flow pipe will connect the basin with the existing stormwater drainage network.

Option No.	Type	Description	Location

DB3	Detention Basin	Basin in Gannan Park	Buna Ct, Ryde

A basin in Gannan Park will involve the conversion of an existing field into a stormwater detention basin. This option will involve lowering the 22,000m^2 field by over 0.5 metres in depth to provide the necessary required detention volume. This option will also include the replacement of the existing 1.05 m pipe beneath the park with a smaller 0.3m pipe to encourage flow surcharge into the basin during large storm events. A stormwater pit will be placed on the northern end of the basin to encourage this flow surcharge.

Potential benefits from this basin may include alleviating flooding downstream of the park. Currently, properties adjacent to the park are affected by flood inundation, especially in flood events greater than the 1% AEP. Various properties along Minga St are identified as being within the medium hazard zone.

Option No.	Type	Description	Location
DB4	Detention Basin	Basin in Holy Cross College (North-eastern field). It is noted that this is located on privately owned land.	Cnr. Cressy Rd and Buffalo Rd.

Currently, Holy Cross College is not predicted to be subject to any flooding for any storm event.

A basin in Holy Cross College will involve the conversion of the northern sports field into a stormwater detention basin. This option will involve lowering the 10,800 m^2 park to provide the necessary required detention volume. It is noted, however, that this option is located on privately owned land.

The college itself including the sports fields are located on high ground and is not subject to any flooding issues. However, the purpose of this basin is to capture run-off from its immediate and adjacent catchment area and to attenuate this flow from discharging down Buffalo Road. Flood waters are identified to be escaping this low point on Buffalo Road and onto the paved areas of the commercial zone and again ponding on Higginbotham Road.

As Holy Cross College drains a moderately sized catchment, it may be beneficial to place a detention basin in its vicinity to capture flows running off from this immediate sub catchment.

Option No.	Type	Description	Location
DB5	Detention Basin	Basin in North Ryde Park	Basin in North Ryde Park

A basin was considered for implementation in corner of North Ryde Park to attenuate some of the overland flows identified from the Flood Study. This overland flow, predominantly inundating minor sections of Magdala Road and Cressy Road in the 1% AEP storm event was intended to be diverted to the basin to reduce road flood levels and minor flooding in adjacent properties.

However, upon inspection of this site, it was identified that this corner of the field is too small for implementation of a basin for any beneficial purpose. Option DB5 was not considered for further assessment as it is not feasible.

8.2.2 Preliminary Stormwater Infrastructure Upgrade Options

Through the Flood Study, it was identified that a large proportion of overland flooding within the Buffalo and Kittys Creek catchment was due to capacity constraints of the existing stormwater network.

Hydraulic analysis identified that majority of council's local stormwater drainage network was designed to cater for storm events less than the 20% AEP, this is common for local council stormwater networks. A method of resolving these flooding issues is to upgrade the network to convey additional flow.

Potential solutions identified for the Buffalo and Kittys Creek floodplain is to upgrade the stormwater drainage network in the form of pipe dimension amplification, supplementing existing drainage lines with additional pipes, or the servicing of new areas currently not covered by the existing drainage network. This option was also raised as part of community consultation and had the strongest community agreement. Approximately 30% of the respondents suggested this option as a floodplain mitigation option.

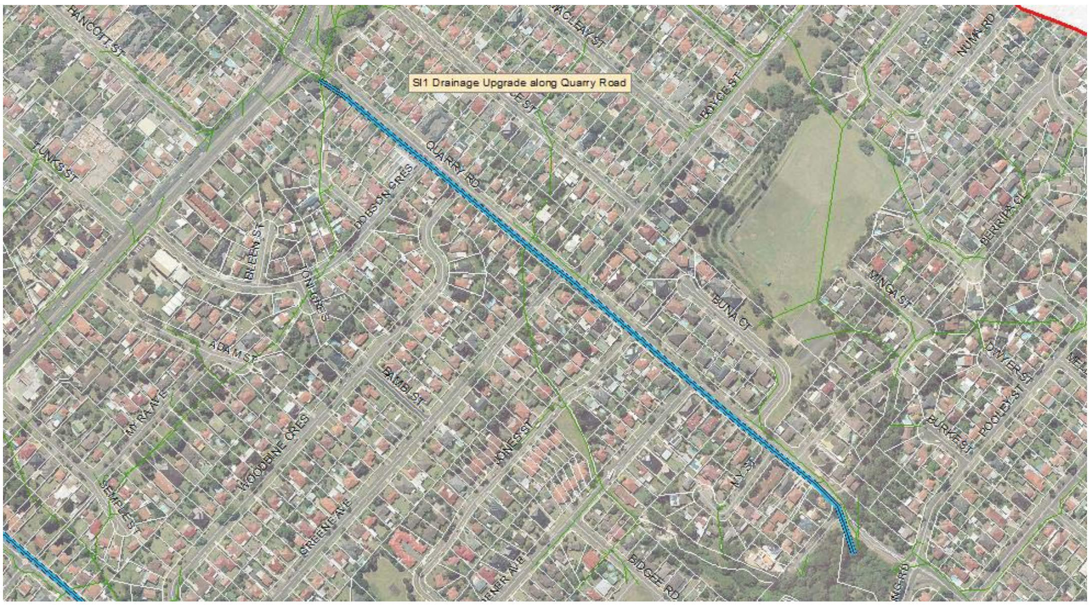
Table 8-5 describes the preliminary stormwater infrastructure upgrades considered for this plan.

Table 8-5 Preliminary Stormwater Infrastructure Upgrade Options

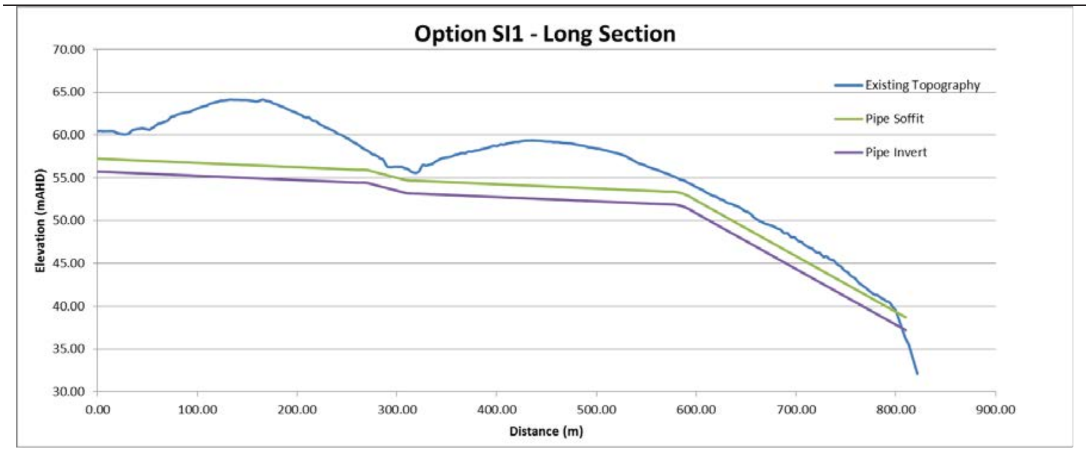
Option No.	Type	Description	Location
SI1	Stormwater Infrastructure	Drainage Upgrade – Additional drainage network along Quarry Rd.	Quarry Rd, North Ryde

As part of Option SI1, a new stormwater pipeline is to be constructed along Quarry Rd. This redirects the entire upstream (north-western) subcatchments through to this new alternative drainage line. Potential effects may include alleviating congestion from the existing system in which it currently drains through to and redirecting the flow directly into Buffalo Creek.

A feasibility issue would be the constructability and costs associated with either deep narrow excavations or tunnelling.



As shown in the long section, the new pipe length to be constructed is 810m with a pipe diameter of 1.5m. It can be seen, however, that an excavation depth of up to 9m would be required, which would make any excavation process very difficult in this area.

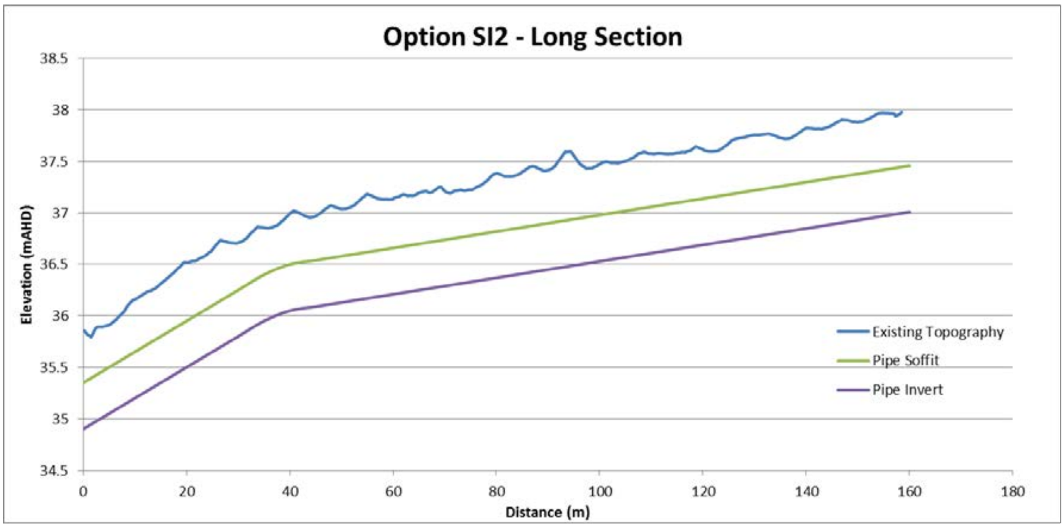

Option SI1 - Long Section
Elevation (mAHD)
Distance (m)
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
800.00
900.00
Existing Topography
Pipe Soffit
Pipe Invert

Option No.	Type	Description	Location
SI2	Stormwater Infrastructure	Drainage Upgrade – Additional drainage network along Irvine Crescent	Irvine Rd

As part of Option SI2, a new stormwater pipeline is to be constructed down Irvine Crescent. The purpose of this additional pipeline is to alleviate congestion of the existing pipe network currently causing overland flooding to properties in events larger than the 1% AEP.

Potential benefits of this new stormwater pipeline may redirect flooding away from the residential areas and onto Irvine Road.

As shown in the long section, the new pipe length to be constructed is 160m with a pipe diameter of 0.675m.



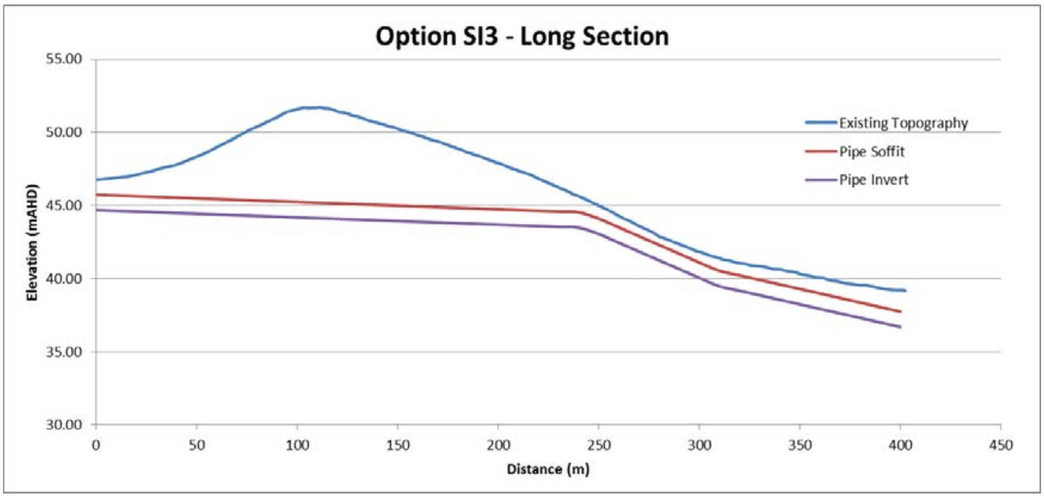
Option No.	Type	Description	Location
SI3	Stormwater Infrastructure	Drainage Upgrade – Additional drainage network along Buffalo Rd	Buffalo Rd

As part of Option SI3, a new stormwater pipe is to be constructed along Buffalo Road. The purpose of this new pipeline is to re-direct flow from the low point of Lane Cove Road and down through to Buffalo Road, connecting into the existing pipe network downstream. Potential benefits may reduce overland flow and inundation of properties immediately downstream of Lane Cove Rd, in which some are classified as being in a medium hazard zone.

Potential difficulties in this option include grading a drainage pipe against the grading of the topography. Large capital works, including deep temporary excavation for pipe laying will be included in this option.

A feasibility issue would be the constructability and costs associated with either deep narrow excavations or tunnelling.

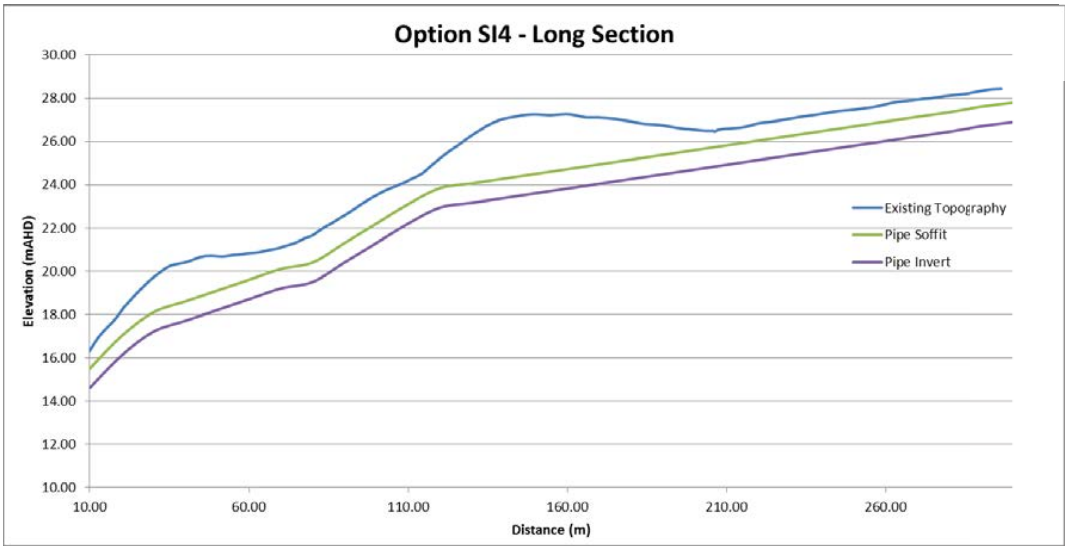
As shown in the long section, the new pipe length to be constructed is 400m with a pipe diameter of 1.05m.



Option No.	Type	Description	Location
SI4	Stormwater Infrastructure	Drainage Upgrade – Additional drainage line along Monash Road	Monash Rd

As part of Option SI4, this involves the construction of a new stormwater pipeline down Monash Road. This supplements the existing adjacent drainage network by partially diverting a portion of the flows into an alternative pipe route and directly discharging into Buffalo Creek. For the 1% AEP storm event, excessive overland flooding occurs along the adjacent pipeline. The benefit of this new pipeline is to alleviate a portion of this flooding and potentially reducing the flood levels on Higginbotham Road.

As shown in the long section, the new pipe length to be constructed is 300m with a pipe diameter of 0.9m.



Option No.	Type	Description	Location
SI5	Stormwater Infrastructure	Drainage Upgrade – Increasing capacity of existing drainage line.	

As part of Option SI5, this includes the amplification of the entire stormwater pipeline (pictured) to a larger capacity. Current sections of this pipeline vary in dimension but are predominantly between 0.75m to 1.05 m in diameter. Results from the Flood Study indicate that a number of the properties located above this drainage line are classified as being in low to medium hazard zones. A single property located along Quarry Road is classified as being in a high hazard zone. The amplification of this drainage to a larger capacity (1.5m diameter), may alleviate the flooding conditions along this overland flow path.

Potential difficulties of this option include large capital works of replacing approximately 950 metres of stormwater pipeline. In addition to this, large capital expenditure is required to purchase high strength 1.5m diameter reinforced concrete pipes due to minimal cover along particular sections of the network. Disruption will also be caused to residents as parts of the stormwater pipeline are located within the backyards of properties.

Overall, while the aim of this option is to seek to upgrade the existing drainage line within its drainage easement area, it is unlikely to be feasible, in view of the fact that the works would have to take place along the backyards of many private properties.

The alternative would be to realign the drainage path to follow mostly the roadway. However, this is also considered to be not feasible due to the relatively large 1.5 m diameter pipe size required.

8.3 Identified Property Modification Options

As listed in Table 8-2, two preliminary property modification options were identified as having potential in assisting the flood prone community. This included voluntary house raising and voluntary house purchase of high hazard properties. These preliminary identified options are detailed in Section 8.3.1 and 8.3.2.

8.3.1 Option VHR: Voluntary House Raising

Voluntary house-raising is considered to be a viable option for protecting properties classified as being in a low to medium hazard zone. However, as house-raising does not physically modify the flood characteristics itself, it is not recommended for properties within high hazard zones.

A review of the Buffalo and Kittys Creek flood damages database indicates that properties susceptible to flood water inundation are predominantly of brick type buildings. House raising is not suitable for buildings predominantly constructed using brick. Houses of single or double brick construction or slab-on ground construction are generally too expensive to raise. Houses that are best suited to raising are timber framed and clad with non-masonry materials.

A potential option would be to house raise suitable properties that are located within the medium to low hazard zone. However, according to the flood damages database, only one residential property was identified as being made of predominantly wood. This property is also two storeys, so may pose issues in house-raising.

As a result of this, house-raising is not viable on a catchment wide scale, a scheme for voluntary house-raising is not considered to be feasible. Residents living in properties within the flood planning zones concerned about flooding may choose to voluntarily raise their property through self-funding.

8.3.2 Option VHP: Voluntary House Purchase of High Hazard Properties

As identified in the flood damages database and hazard flood maps from the Flood Study, there is a total of three properties within the study area located within the high hazard zone. These properties and their predominant building materials are as follows:

Option VHP $_{\text{Buffalo}}$ (Buffalo Catchment):

- Property along Quarry Road, Ryde – Combination of brick and fibro; and
- Property along Buffalo Road, Ryde – Combination of brick and timber.

Option VHP $_{\text{Kittys}}$ (Kittys Creek Catchment):

- Property along Pittwater Road, North Ryde – Combination of brick and rendered.

Potential Actions for Consideration

As these properties are located within the high hazard zone, voluntary house purchase (VHP) of these three properties may provide an effective solution in reducing flood damage and flood impacts. It is noted, however, that OEH has recently tightened its VHP guidelines, in that there must be a risk to life and limited evacuation options for any property to be included in a voluntary purchase program. This will be discussed further in Section 9.2 and Section 9.3.

8.4 Identified Response Modification Options

As listed in Table 8-3, two preliminary response modification options were identified as having potential in assisting the floodplain. This included raising public awareness and improvements to flood warning and emergency evacuation plans. These preliminary options are detailed in Sections 8.4.1 and 8.4.2.

8.4.1 Option PWA: Public Awareness

Raising public awareness is vital in informing the residents of the floodplain the key flooding issues they are likely being exposed to. It will also assist the community in understanding of the necessary measures to be undertaken if required, and be generally more flood prepared.

City of Ryde Council is understood to have been continually providing its residents and business owners with awareness of the risks of flooding throughout its local government area. The process of council undertaking floodplain risk management studies and plans is an example of Councils commitment to community flood safe awareness.

Potential Actions for Consideration

An ongoing public awareness campaign is recommended to provide continual and up-to-date flood information to the community. As part of the campaign, it is recommended that:

- Council should provide the Buffalo and Kittys Creek Flood Study and Flood Risk Management Plan on public exhibition. This will provide for valuable information to the community in their understanding of the flooding issues within the study area;
- Council should adopt the flood extent maps, hazard maps, flood data and flood damages data from this Study and the recently completed Flood Study into its computer database. This will provide for important flood information that can be easily retrieved for future development purposes and addressing resident's queries on flooding on their property; and
- Council should also maintain flood markers indicating the height of past floods and flood warning signs in flood zones.

The cost of a public awareness campaign is relatively low. Flood information can be provided Council's website.

8.4.2 Option FEW: Improve Flood Warning and Emergency Evacuation

The State Emergency Services (SES) has responsibility in emergency management operations during flood events. Adequate flood warning time, especially for when evacuation is required, plays an important role in the safety of residents.

As described in the flood study, the storm duration that causes peak flooding occurs during the 2 hour storm event. This is inclusive of storm intensities up to the 1% AEP, and 1 hour for the PMF. Further analysis identifies that that peak flooding for the 1% AEP 2 hour flood event for both catchments occur approximately 45 - 60 minutes into the storm . As such, limited flood warning time is available.

Potential Actions for Consideration

Flood warning and emergency evacuation plans are vital to the community of Buffalo and Kittys Creek. As part of this floodplain risk management study, it is recommended that:

- SES emergency flood management and evacuations plans should be made available to both SES and Council's website.

- SES should also take into consideration the Emergency Flood Evacuation plan as detailed in Section 10.1.2 to provide information for their flood emergency management operations.

9. Detailed Assessment of Preliminary Options

9.1 Hydraulic Assessment of Preliminary Flood Modification Options

Hydraulic assessment of the preliminary flood modification options were conducted using TUFLOW modelling. TUFLOW is a modelling software that simulates one and two dimensional free surface flows, such as that of floods. This software was used to model the existing flood behaviour of the Buffalo and Kittys Creek catchments during the Flood Study stage. The same models were adopted as part of the Floodplain Risk Management stage, with amendments applied accordingly to assess the preliminary flood modification options.

Hydraulic assessment is limited to flood modification options only as these can be physically modelled using TUFLOW to assess the changes in flow conditions. Options classified as property modification or response modifications are not applicable for hydraulic assessment, as these options do not directly modify the behaviour of flooding.

As previously described in Section 8.1, and presented in Table 8-1, a total of ten preliminary flood modification options were identified as having a potential in improving flooding issues within the floodplain.

These preliminary option types are either detention basins or stormwater infrastructure upgrades. Hydraulic assessments for these ten options were conducted through a staged ‘top down’ approach. This was in the form of modelling options within its category to identify the ‘best possible’ effects for the floodplain based on its category type. Each individual option was then evaluated separately to assess its individual impacts in reducing flood damage and flood hazard. Table 9-1 below presents the initial two scenarios modelled and the preliminary options that fall within its category type.

Table 9-1 Flood Mitigation Options

Model Scenario	Option Category Type	Option IDs
Scenario 1	Implementation of all Detention Basins	DB1, DB2, DB3 and DB4 (DB5 not modelled)
Scenario 2	Upgrading of all Stormwater Infrastructure options	SI1, SI2, SI3, SI4 and SI5

As noted in Table 9-1, option DB5: Detention Basin in North Ryde Park was not hydraulically modelled. Further investigation identified that due to the main oval in North Ryde Park being elevated to a much higher level, only a very small area adjacent to the road is allowable for a detention basin. This allowable area is considered too small to have any effects for flow attenuation. As such Option DB5 was not considered any further.

A review of the flooding issues within the Kittys Creek catchment did no prompt for a need of an alternative or additional detention basin. In light of this, no flood modification measures and hydraulic modelling has been assessed for Kittys Creek Catchment.

9.1.1 Flood Hazard Assessment of Preliminary Options

A key objective of the Floodplain Risk Management Plan is to identify potential flood mitigation options that have potential in reducing flood impact. A method of assessing an options effectiveness is through hydraulic modelling and assessing the option’s reduction in flood hazard and flood damages.

Flood Hazard Assessment of the Preliminary Options

Scenarios 1 and 2 were hydraulically modelled for this purpose and the flood hazard maps are presented in Figures 8.1 and 8.2 respectively.

Results from this assessment identified that flood impacts had minimal improvements as a result of implementing the ten preliminary options.

Scenario 1 and its five detention basins had minimal impact on reducing flood hazard. The existing high, medium and low hazard extents remained mostly unchanged. In particular, the three properties identified as being in high hazard zone are still identified as being in high hazard.

Minimal impacts were also identified for the medium hazard zones (the 1% AEP flood extent) with the exception of two properties where inundation of flood waters above floor level receded to below floor level. These two properties were identified to be as a result of Option DB3: basin in Gannan Park. Hydraulic analysis for DB3 predicted that flood waters were contained within the basin prior to draining through the stormwater drainage network, reducing flood levels. As a result of this, the two properties immediately downstream of the basin is no longer flooded above floor level. Flood extents for low hazard (PMF flood extent) remained relatively unchanged as per existing conditions.

Assessments of the other three options (DB1, DB2 and DB4) identified that these basins do not provide substantial benefits to flood impact reduction.

Similarly, hydraulic modelling of scenario 2 identified minimal flood improvements in flood hazard and flood levels. As per scenario 1, flood hazard extents remained mostly unchanged. Properties classified as being in the high hazard zone remained as high hazard classifications.

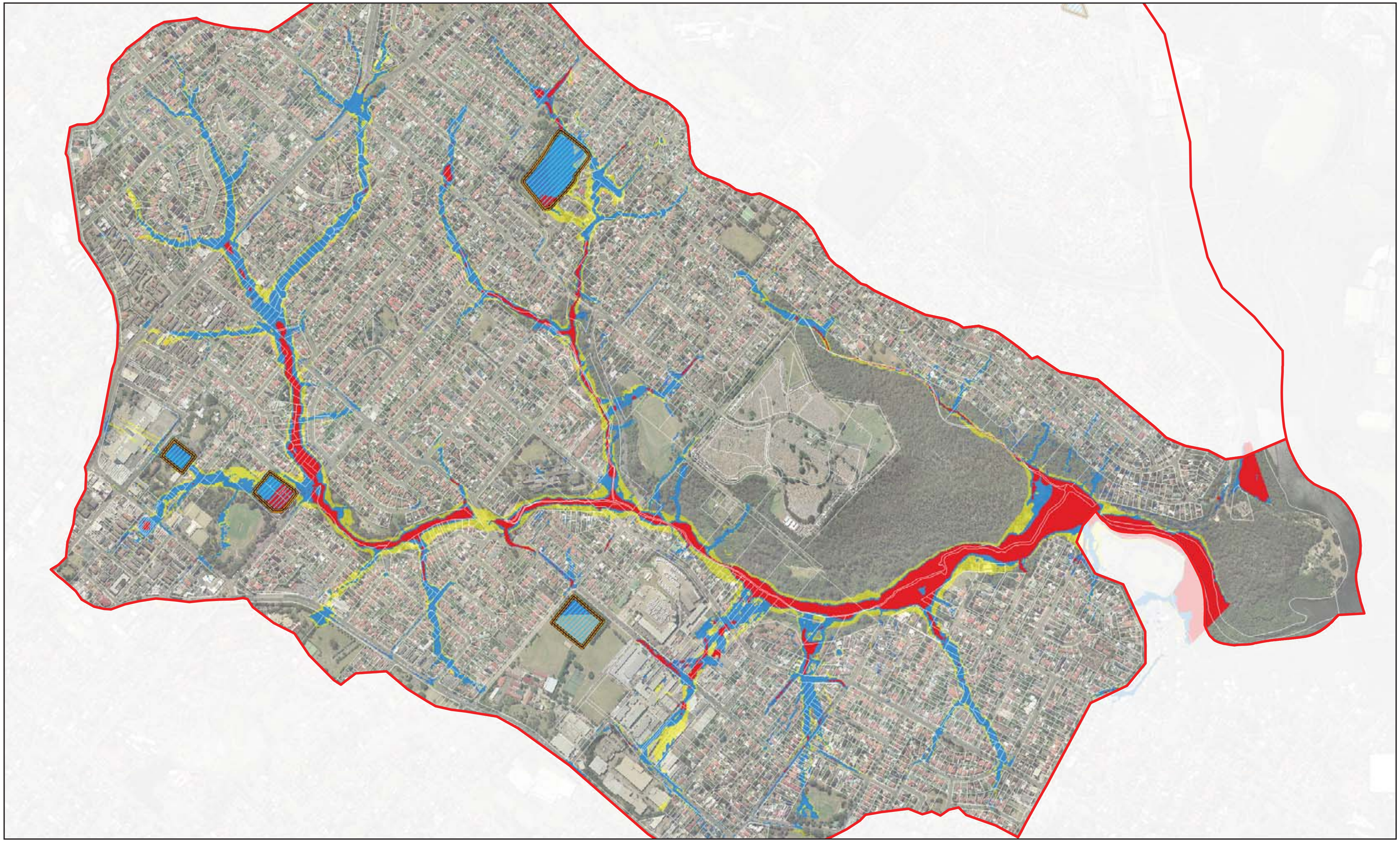
Options SI4 and SI5 however, provided minor improvements to flood conditions especially in the upper sections of Quarry Road and the northern parts of Ryde. In particular, the pipe amplification option (option SI5) improved overland flooding through its increased flood conveyance capacity. A single property is identified to have benefitted with flooding to be no longer above floor level for the 1% AEP. This property's medium hazard classification also reduced to a low hazard zone.

Option SI4, the redirection of a portion of flow from northern Ryde down Quarry Road and directly discharging this flow into Buffalo Creek decongested the existing pipe network the system was previously connected to. Flood levels in this area have reduced by approximately 100 mm, although, no existing medium hazard properties reduced to low hazard.

Table 8-7 highlights the number of properties that are no longer experiencing flooding above floor level for the 1% AEP flood event as a result of implementing the options in the Buffalo Creek Catchment. As no flood modification options were suitable for Kittys Creek Catchment, no hydraulic assessments were modelled for the catchment.

Table 9-2 Options Assessment - Properties Affected Above Floor Level (Buffalo Catchment)

Model Scenario	Properties Affected Above Floor Level (1% AEP event)	Number of Properties Benefitting
Existing Scenario	50	-
Scenario 1	48	2
Scenario 2	49	1



0 50 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend

- High Hazard
- Medium Hazard
- Low Hazard
- Catchment Boundary
- Detention Basin

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Flood Hazard Map
Scenario 1

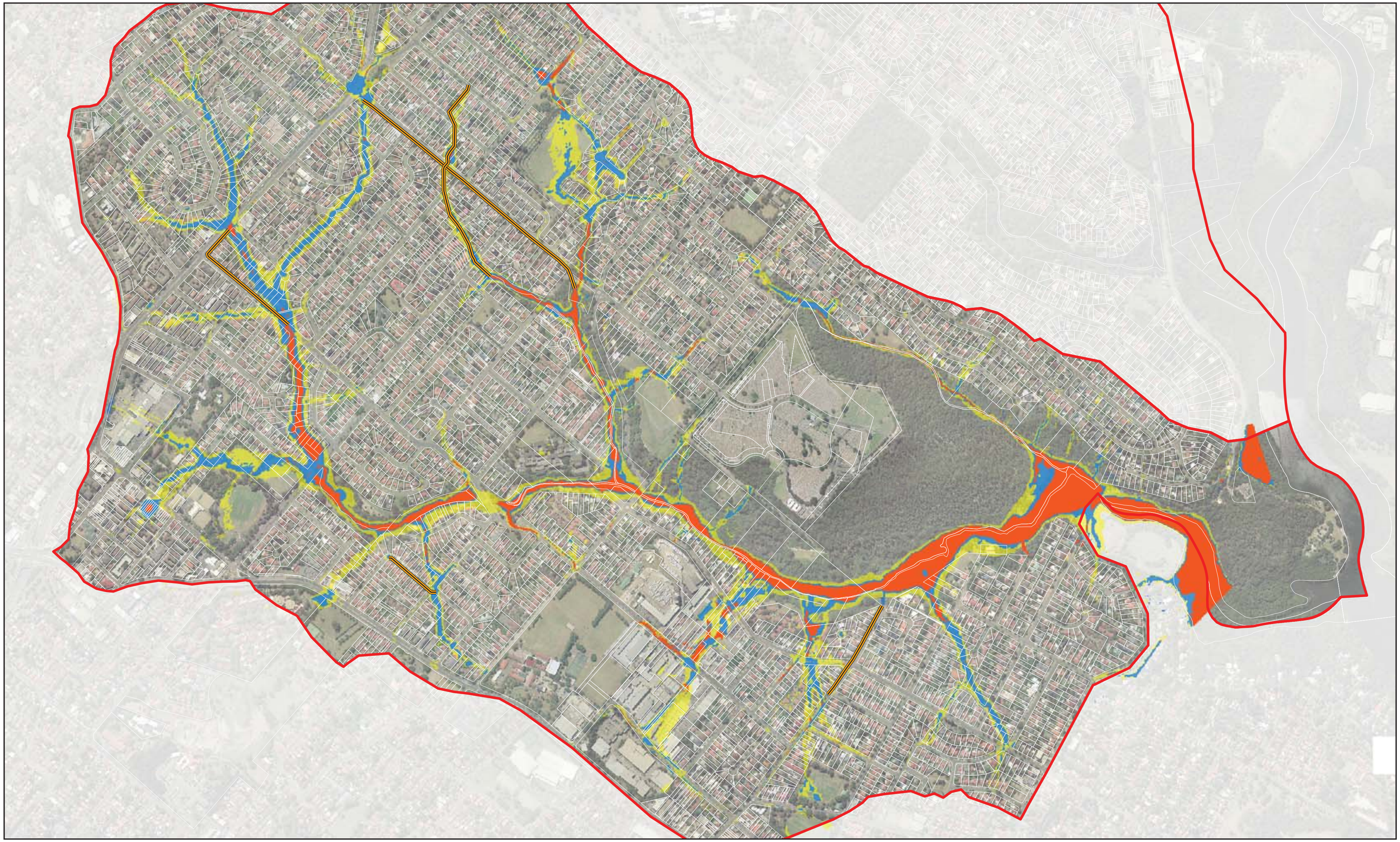
Job Number	21-21394
Revision	A
Date	13 Nov 2013

Figure 9-1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft FRMS Report\Option - Hazard Scenario 1.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au



0 50 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend

- High Hazard
- Medium Hazard
- Low Hazard
- Catchment Boundary
- Stormwater Pipes

City of Ryde

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Flood Hazard Map Scenario 2

Job Number	21-21394
Revision	A
Date	13 Nov 2013

Figure 9-2

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft FRMS Report\Option - Hazard Scenario 2.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

9.1.2 Flood Damage Assessment of Preliminary Options

A flood damage assessment was conducted for both Scenario 1 and 2, these are presented in Table 9-3. The purpose of this assessment was to identify the extent of the flood damages in economic terms to provide a comparison between the proposed scenarios and existing conditions. Flood damage assessments also provides for an assessment of the relative merit of the potential options by a means of a cost-benefit analysis.

As presented in Table 9-3, the reduction in damage per 1% AEP storm event for the proposed options are minimal, equating to 2% for Scenario 1 and 8.3% for scenario 2.

Table 9-9 in Section 9.4, will assess the scenarios in a cost-benefit analysis and compare the options against environmental, social and economic impacts.

Table 9-3 Options Assessment – Flood Damage

Model Scenario	Damage per Storm Event -1% AEP *(Rounded to nearest '000)*	Reduction in Damage per Storm Event -1% AEP
Existing Scenario	$4,654,000	-
Scenario 1	$4,559,000	$95,000 (2.0% reduction)
Scenario 2	$4,297,000	$357,000 (8.3% reduction)

Figure 9-3 presents the damage curve for the two scenarios compared to the existing condition. The area under the curve represents the Average Annual Damage (AAD) for all three cases; these values are presented in Table 9-4. As per this table, it can be identified that the implementation of Scenarios 1 and 2 has minimal impact on the AAD.

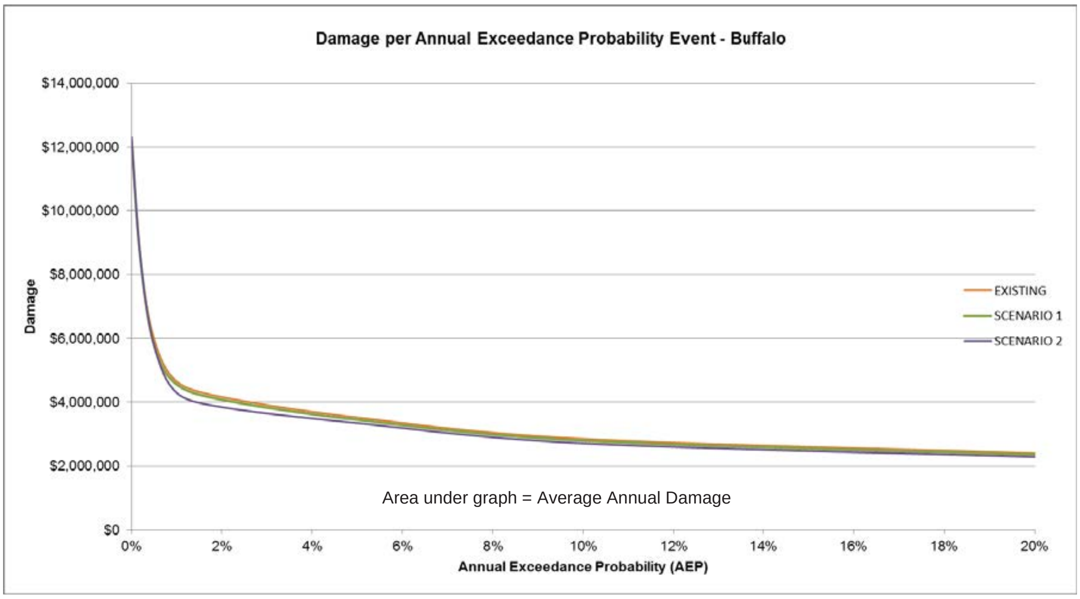


Figure 9-3 Damage Curve of Modelled Scenarios

Table 9-4 Options Considered for Further Assessment

Model Scenario	Annual Average Damage (AAD)	Reduction in AAD
Existing Scenario	$1,010,068	-
Scenario 1	$989,853	$20,215 (2.0% reduction)
Scenario 2	$958,494	$51,574 (5.1% reduction)

Based on the hydraulic assessment of the preliminary flood modification options identified, a summary is presented in Table 9-5.

Table 9-5 Summary of Flood Modification Options

Option ID	Description		Hydraulic Assessment Results
DB1	Basin in Ryde Park	☒	Not recommended for further assessment - minimal to no impact on flood hazard.
DB2	Basin in Ryde Public School	☒	Not recommended for further assessment - minimal to no impact on flood hazard.
DB3	Basin in Gannan Park	☑	Recommended for further assessment *(Social, Environmental and Economic Analysis)*
DB4	Basin in Holy Cross College	☒	Not recommended for further assessment - minimal to no impact on flood hazard.
DB5	Basin in North Ryde Park	☒	Not recommended for further assessment - minimal to no impact on flood hazard.
SI1	Additional stormwater pipe along Quarry Rd	☑	Recommended for further assessment. *(Social, Environmental and Economic Analysis)*
SI2	Additional drainage network along Irvine Crescent	☒	Not recommended for further assessment - minimal to no impact on flood hazard.
SI3	Additional drainage network along Buffalo Rd	☒	Not recommended for further assessment - minimal to no impact on flood hazard.
SI4	Additional drainage line along Monash Road	☒	Not recommended for further assessment - minimal to no impact on flood hazard.
SI5	Increasing capacity of existing drainage line.	☑	Recommended for further assessment. *(Social, Environmental and Economic Analysis)*

Options DB3, SI1 and SI5 are shortlisted as options that provide a benefit in improving flood hazards and flood damages. These options are further assessed in Section 9.4 to compare against social and environmental impacts and a cost-benefit assessment prior to further recommendation.

9.2 Assessment of Property and Response Modification Measures

9.2.1 Property Modification Measures

As discussed in Section 8.3.1, Option VHR – Voluntary House Raising was initially identified to be potentially viable for a few properties located within the catchment. However, further investigations indicated that this option was not feasible due to the type of construction of the properties identified. As a result, voluntary house-raising is not considered to be a viable floodplain risk management option and will not be further considered.

Option VHP – Voluntary House Purchase has previously been identified as potentially viable for a number of properties located within the high hazard zone. This takes into account the finding from the hydraulic assessment, that potential flood modification measures are not effective in reducing the flood impact on properties located within these high hazard zones. This is the case for both the Buffalo Creek and Kittys Creek catchment.

Voluntary house purchase may be viable for 2 properties located within the Buffalo Creek catchment, and 1 property located within the Kittys Creek catchment.

Option VHP will be further assessed against social and environmental impacts and cost-benefit analysis prior to any recommendation; this is detailed in Section 9.4. As noted earlier, OEH has also tightened its VHP guidelines in that there must be a risk to life and limited evacuation options, for such properties to be included in the VHP program.

9.2.2 Response Modification Measures

Option PAW – Public Awareness and Option FWE – Flood Warning and Emergency Evacuation are considered to be viable options for further assessment. As the aim of the current Buffalo and Kittys Creek Flood Study and Flood Risk Management Study and Plan is to identify the flooding behaviour and identify options to reduce flood impact, the outcomes from these two reports should be incorporated to future council awareness campaigns and SES emergency plans.

A summary of the property and response modifications listed for further consideration is given in Table 9-6.

Table 9-6 Summary of Property and Response Modification Options

Option ID	Description		Assessment Recommendation
VHR	Voluntary House Raising	☒	Not recommended as a flood mitigation strategy
VHP Buffalo VHP Kittys	Voluntary House Purchase	☑	Recommended for further consideration
PAW	Public Awareness	☑	Recommended for further consideration
FEW	Flood Warning and Emergency Evacuation	☑	Recommended for further consideration

Property modification options VHP and response modification options PAR and FEW are identified as providing benefits to the floodplain community.

9.3 Preliminary Cost of Potential Options

The preliminary cost estimates presented in this section have been developed for the purposes of comparing options. They are not to be used for any other purpose. The scope and quality of the works has not been fully defined and therefore the estimates are not warranted by GHD. Cost estimates for options DB3, SI1 and SI5 were developed based on cost curves, budget quotes for some equipment items, extrapolation or recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than approximately ±30% for the items described in this report. A functional design is recommended for budget setting purposes.

The preliminary cost estimates for the shortlisted options are summarised in Table 9-7.

Cost estimates for the shortlisted flood modification options are detailed in in Appendix A. Cost estimates for Option VHP was based on the median house prices as presented in Table 5-3. In summary, the cost breakdown for this estimate is detailed as follows:

Buffalo Catchment (2 properties within High Hazard)

- A property along Quarry Road, Ryde – Median House Price Ryde (2012): $834,000.
- A property along Buffalo Road, Ryde – Median House Price Ryde (2012): $834,000.

Combined cost of the two properties within the Buffalo Creek Catchment equates to $1,668,000.

Kitty Creek Catchment (1 property within High Hazard)

- A property along Pittwater Road, North Ryde – Median House Price North Ryde (2012): $932,500.

Cost considerations for response modification options PAW and FWE have not been considered in this study. More detailed investigations on the plan and development of these options are required for a useful cost estimate.

Table 9-7 Capital Cost of Floodplain Management Options

Option ID	Measure Type	Description	Cost
DB1	Flood Modification	Gannan Park Detention Centre	$1,600,000
SI1	Flood Modification	Quarry Road Diversion	$2,300,000
SI5	Flood Modification	Pipe Amplification	$2,200,000
VHP Buffalo VHP Kittys	Property Modification	Voluntary House Purchase of High Hazard Properties	$1,668,000 (Buffalo) $932,500 (Kittys)
PAW	Response Modification	Public Awareness	-
FWE	Response Modification	Flood Warning and Emergency Evacuation	-

9.4 Multi-Criteria Analysis of Options

The floodplain management options were assessed both hydraulically and with a broader assessment procedure to consider the social, economic and environmental considerations. These issues are listed in in Table 9-8. For each of these considerations, weightings were applied to give an 'intangibles' score, listed in Table 9-9 and Table 9-10.

Table 9-8 Social, Economic and Environmental Issues for Assessing Options

Category	Issues
Social	• The capacity of the option to reduce flood hazards and personal safety risks to the community; • How the option will influence property values; • The capacity of the option to promote community growth; and • The level of disruption to the community, either through implementing the option or through the resulting floodplain behaviour.
Economic and Financial	• The capital costs associated with implementing the option; • The ongoing or maintenance costs of the option; and • The costs or saving of flood damage after the option is implemented.
Environmental	• Change to ecology, habitats, riparian vegetation, and the "natural state" of the creek; • Pollution; • Energy and resources required to implement the option; and • Energy and resources required for maintaining and decommissioning the option.

The considerations listed in Table 9-8 were weighted as a score of 1 to 5 (where 1 is the worst, 3 represents no change or neutral effect and 5 is the best). Details of this assessment matrix, is provided in Appendix B. A do nothing option has been included to compare the options against existing conditions. The results of the final ranking, once weightings were applied, is provided in Table 9-9 for Buffalo Creek catchment and Table 9-10 for Kittys Creek catchment.

Table 9-9 Option Assessment Matrix – Buffalo Creek Catchment

Scenario / Option	Social and Environmental Score	Social and Environmental Ranking	Capital Costs Estimate	Capital Costs Ranking	Economic Benefit / Cost	Economic Ranking
Do Nothing	56	3	-	**1**	1	**1**
DB3	56	4	$1,600,000	2	0.17	3
SI1 & SI5	58	2	$4,500,000	4	0.16	4
VHP Buffalo	68	**1**	$1,668,000	3	0.18	2

Note: Option VHP for Buffalo Creek Catchment considers the 2 properties within its catchment only.

Table 9-10 Option Assessment Matrix – Kitty Creek Catchment

Scenario / Option	Social and Environmental Score	Social and Environmental Ranking	Capital Costs Estimate	Capital Costs Ranking	Economic Benefit / Cost	Economic Ranking
Do Nothing	56	2	-	**1**	1	**1**
VHP Kittys	68	**1**	$932,000	2	0.33	2

Note: Option VHP for Kittys Creek Catchment considers the 1 property within its catchment only.

As identified in Table 9-9, Option VHP (Buffalo) ranked the highest in terms of social and environmental considerations. This gives merit to the fact that Option VHP (Buffalo) completely removes the hazard and flood risk to those properties affected within the high hazard zone.

As per Table 9-9, it can also be deduced that the cost-benefit ratio for the shortlisted options all ranked poorly. This indicates that the capital costs required to implement these options do not provide for a particularly strong return in terms of cost savings due to flood damages.

Similarly, as presented in Table 9-10, the implementation of Option VHP (Kittys) also identifies a low cost-benefit ratio. Although, the implementation of this option does improve the social and environmental conditions for the Kittys Creek catchment compared to existing conditions.

Through this multi-criteria assessment of the preliminary options, it is deduced that Options BD3, SI1 and SI5 are not feasible for further consideration. This is primarily due to the high capital costs of implementation, low cost-benefit ratio, low social and environmental impacts and inability to reduce hazard to the three high hazard properties.

9.5 Feasible Options for Consideration

Based on detailed assessments of the preliminary options identified, Table 9-11 presents the feasible options for consideration as part of the Buffalo and Kittys Creek Floodplain Management Plan. These options were shortlisted based on its merit in reducing flood impact and flood hazard and considered against social, economic and environment factors.

As noted earlier, OEH has recently tightened its voluntary house purchase (VHP) guidelines in that there must be a risk to life and limited evacuation options before a property can be included on the voluntary purchase program. For the 3 properties considered for VHP (2 in Buffalo Creek and 1 in Kittys Creek), it is evident that there is a potential risk to life, in that these properties are located in a high hazard zone. However, it would appear that egress from these properties to higher ground would still be available, and it is unlikely that these properties would become isolated during floods. On this basis, it is suggested that the following actions be undertaken to further assess if the of a VHP program for these properties can be justified:

- Accurately survey the floor levels and egress routes for the above 3 properties that have provisionally been identified as being in a high hazard area; and
- Develop criteria for properties to be included on the voluntary purchase program.

Table 9-11 Feasible Options for Consideration

Option ID	Measure Type	Description	
PAW	Response Modification	Public Awareness	☑
FEW	Response Modification	Flood Warning and Emergency Evacuation	☑
VHP Buffalo VHP Kittys	Property Modification	Voluntary House Purchase of High Hazard Properties	☑

10. Recommended Floodplain Management Plan

10.1 The Recommended Measures

The floodplain management measures recommended for inclusion as part of the Buffalo and Kittys Creek Floodplain Risk Management Plan is detailed in Table 10-1. This plan is inclusive of options within the three main categories of:

- Property Modification Measures;
- Response Modification Measures; and
- Flood Modification Measures.

It is important for a floodplain management plan to consider all three types of management measures and to adopt an integrated and effective mix. These measures outlined in Table 10-1 are specific to the flooding issues and circumstances of the Buffalo and Kittys Creek catchment floodplains.

Table 10-1 Floodplain Risk Management Option Assessment Matrix

Option ID	Measure Type	Description	Priority
PAW	Response Modification	Public Awareness	High
FWE	Response Modification	Flood Warning and Emergency Evacuation	Low
VHP Buffalo VHP Kittys	Property Modification	Voluntary House Purchase of High Hazard Properties	Medium*

* subject to further investigation and survey of floor levels and egress routes

10.1.1 Option PAW: Public Awareness

An ongoing public awareness campaign is recommended to provide regular and up-to-date flood information to the community. As part of the campaign, it is recommended that:

- Information and correspondences from the Public Exhibition period should be retained for future reference;
- Council should adopt the flood extent maps, hazard maps, flood data and flood damages data from this Study and the recently completed Flood Study into its computer database. This will provide for important flood information that can be easily retrieved for future development purposes and addressing resident’s queries on flooding on their property;
- Council should maintain flood markers indicating the height of past floods and flood warning signs in flood zones;
- Flood information should be provided on Council’s website.

It is considered that the cost of a public awareness campaign is relatively low when compared with other flood risk management options.

10.1.2 Option FWE: Flood Warning and Emergency Evacuation

Flood warning and emergency evacuation plans are vital to the community of Buffalo and Kittys Creek. As part of this floodplain risk management study, it is recommended that:

- SES emergency flood management and evacuation plans be produced by SES and be made available on Council's website. Information from the current floodplain management study should be incorporated into SES plans. In particular, SES should take into consideration the Emergency Flood Evacuation plans as presented in Figure 10-1 and Figure 10-2 and as discussed below.

Emergency Flood Evacuation Plan

Figure 10-1 and Figure 10-2 provides indicative information on road conditions for the purposes of egress and evacuation during a critical storm event.

As identified in the Flood Study, the critical storm duration for the catchment (for a 1% AEP event) is the 2 hour storm event. This storm produces peak flood depths of above 0.3m along particular road sections, potentially resulting in egress cut-off and inhibiting evacuation. Flooding above 0.3m is expected to occur approximately 30 to 55 minutes within the onset of the storm.

Given that very limited warning time is made possible due to the fast peaking nature of storms within the study area, adequate time for warning and evacuation for residents in flood affected areas is very limited.

As such, it is recommended that during a critical storm event, residents along roads with potential egress cut-off (as identified in Figure 10-1 and Figure 10-2) should remain in their properties for at least 60 minutes from the onset of the storm, allowing time for flood depths to recede below 0.3m if evacuation is required.

Potential sites for flood assembly are also highlighted in the Figures.

10.1.3 Option VHP: Property Modification

Three properties within the Buffalo and Kittys Creek Catchments were identified to be within the high hazard zone. Hydraulic modelling of all the flood modification options indicated that, as a result of the topographic characteristics of the catchment, these properties would remain at high hazard from a hydraulic perspective.

Therefore, it is recommended that the following properties be considered for voluntary house purchase (VHP):

Buffalo Catchment:

- One property along Quarry Road, Ryde – Combination of brick and fibro; and
- One property along Buffalo Road, Ryde – Combination of brick and timber.

  Kittys Creek Catchment:

- One property along Pittwater Road, North Ryde – Combination of brick and rendered.

Due to recent changes in OEH's VHP guidelines, it is recommended that the following actions be first undertaken to confirm if the above properties can be placed under the VHP program:

- Accurately survey the floor levels and egress routes for the above 3 properties that have provisionally been identified as being in a high hazard area; and
- Develop criteria for properties to be included on the voluntary purchase program.

Upon confirmation of a risk to life and limited evacuation options, Council and OEH can then discuss with the home owners the option of voluntary house purchase.

10.1.4 Flood Modification Measures

None of the flood modification measures investigated in Sections 8 and 9 were found to be cost effective. No flood modification option is therefore recommended as part of this Floodplain Management Plan.

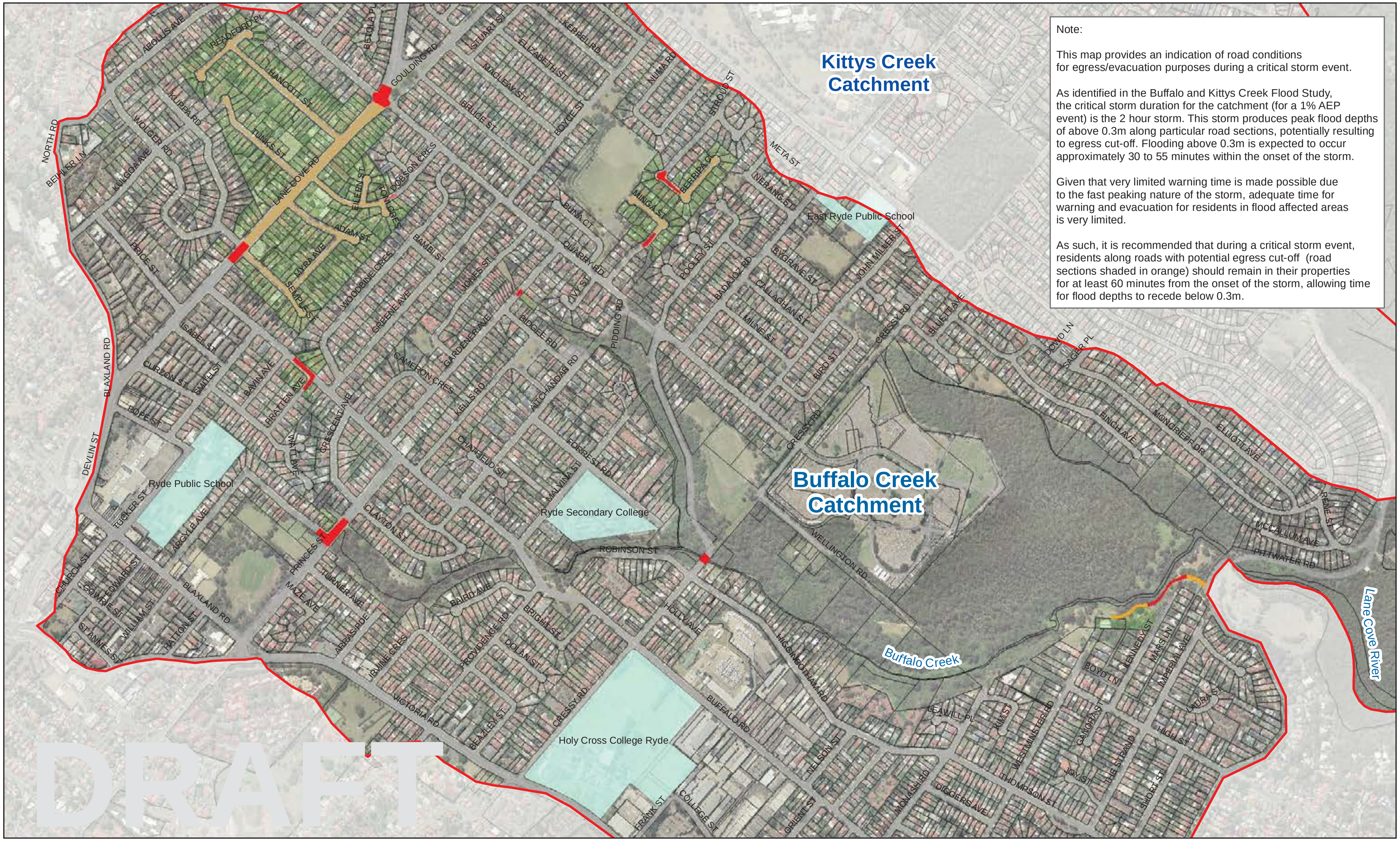
Further to the exhibition period, an additional investigation was undertaken on the possibility of dredging the lower reaches of Kittys Creek. This was found to be ineffective and not pursued further.

A further option was investigated on the possibility of improving the local flow behaviour in a culvert section at Pittwater Road at the downstream end of Imperial Avenue within the Buffalo Creek catchment. Preliminary investigations indicated that this area is relatively steep, discharges directly into the downstream reaches of Buffalo Creek, and has no impact on the overall flow behaviour within Buffalo Creek. Based on discussions with Council, it is recommended that this improvement measure be investigated further and in detail when necessary.

10.2 On-going review of Floodplain Risk Management Plan

This plan should be regarded as an on-going dynamic planning tool for the purposes of monitoring flood risk and mitigation options for the Study area.

A thorough review of the Plan every 5 years is recommended to ensure on-going relevance of the Plan.



1:8,767 (at A3)

0 40 80 160 240 320

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend

- Catchment Boundary
- Lot Cadastral
- Potential Flood Assembly Area
- Road Condition - Egress cut-off not expected
- Road Condition - Flooding above 0.3m (potentially unsafe to cross)
- Road Condition - Egress cut-off
- Properties subject to egress cut-off during flood event

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Job Number	21-21394
Revision	A
Date	18 Aug 2014

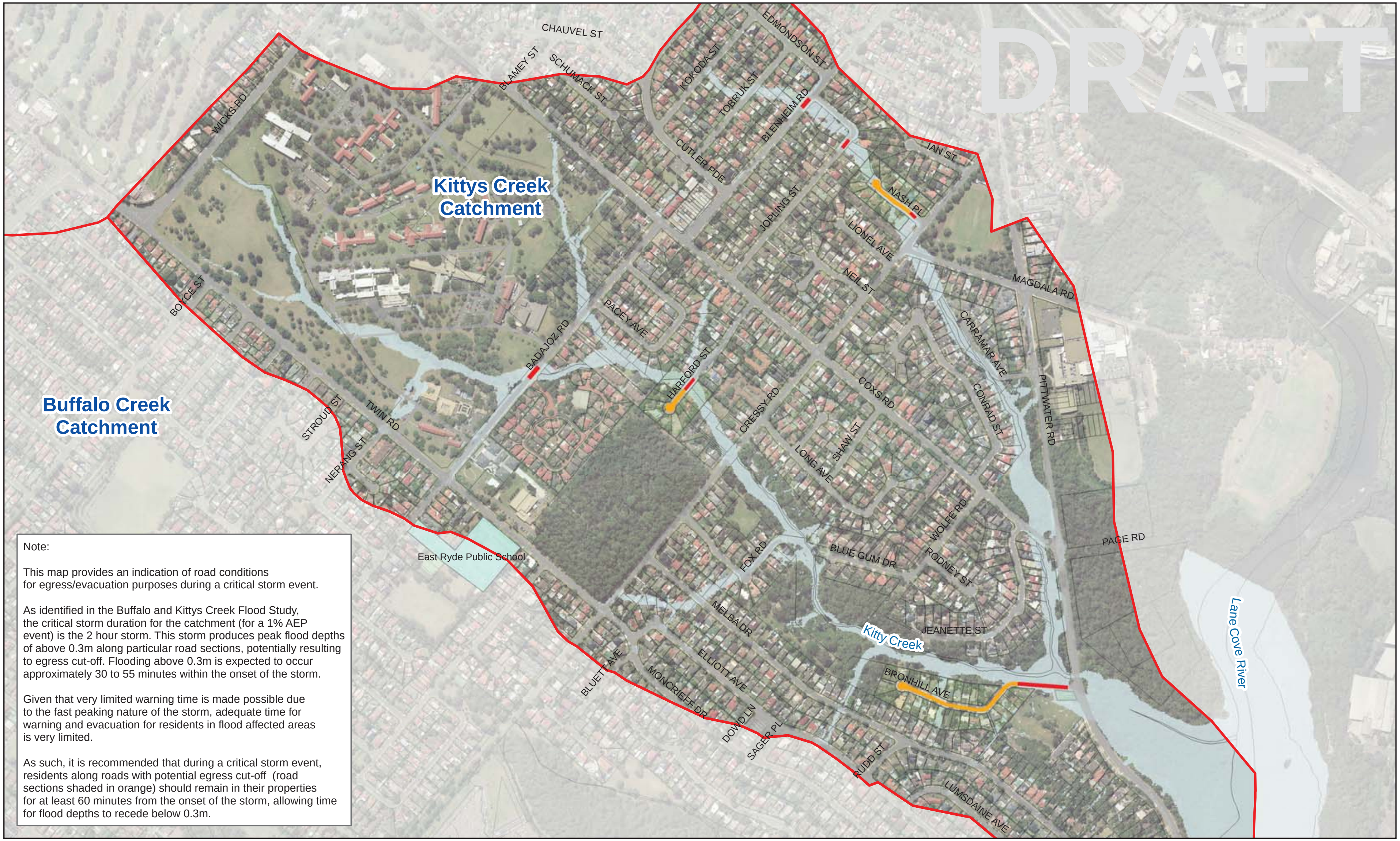
Emergency Flood Evacuation
Buffalo Creek Catchment

Figure 10.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft FRMS Report\11.07.2014 SES Property Isolation Maps\Buffalo SES Map.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: Sydhydro

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au



Note:

This map provides an indication of road conditions for egress/evacuation purposes during a critical storm event.

As identified in the Buffalo and Kittys Creek Flood Study, the critical storm duration for the catchment (for a 1% AEP event) is the 2 hour storm. This storm produces peak flood depths of above 0.3m along particular road sections, potentially resulting to egress cut-off. Flooding above 0.3m is expected to occur approximately 30 to 55 minutes within the onset of the storm.

Given that very limited warning time is made possible due to the fast peaking nature of the storm, adequate time for warning and evacuation for residents in flood affected areas is very limited.

As such, it is recommended that during a critical storm event, residents along roads with potential egress cut-off (road sections shaded in orange) should remain in their properties for at least 60 minutes from the onset of the storm, allowing time for flood depths to recede below 0.3m.

1:6,500 (at A3)

0 30 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend

- Catchment Boundary
- Lot Cadastral

Flood Extent

- 1% AEP Flood
- Potential Flood Assembly Area
- Road Condition - Flooding above 0.3m (potentially unsafe to cross)
- Road Condition - Egress cut-off
- Road Condition - Egress cut-off not expected
- Properties subject to egress cut-off during flood event

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Emergency Flood Evacuation
Kittys Creek Catchment

Job Number	21-21394
Revision	A
Date	25 Sep 2014

Figure 10.2

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - Draft FRMS Report\11.07.2014 SES Property Isolation Maps\Kitty SES Map.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: Sydhydro

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

11. Glossary

Annual Exceedance Probability (AEP) - AEP (measured as a percentage) is a term used to describe flood size. AEP is the long-term probability between floods of a certain magnitude. For example, a 1% AEP flood is a flood that occurs on average once every 100 years. It is also referred to as the '100 year flood' or 1 in 100 year flood'. The terms 100-year flood, 50-year flood, 20-year flood etc, have been used in this study. See also average recurrence interval (ARI):

- 1e-4% (approx) AEP sometimes referred to as the PMF Event;
- 0.2% AEP sometimes referred to as the 1 in 500 year ARI Event;
- 1% AEP sometimes referred to as the 1 in 100 year ARI Event;
- 2% AEP sometimes referred to as the 1 in 50 year ARI Event;
- 5% AEP sometimes referred to as the 1 in 20 year ARI Event;
- 10% AEP sometimes referred to as the 1 in 10 year ARI Event; and
- 20% AEP sometimes referred to as the 1 in 5 year ARI Event

Average recurrence interval (ARI) - ARI (measured in years) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 100-year ARI flood is a flood that occurs or is exceeded on average once every 100 years. The terms 100-year flood, 50-year flood, 20-year flood etc., have been used in this study. See also annual exceedance probability (AEP).

Development Control Plan (DCP) - A DCP is a plan prepared in accordance with Section 72 of the Environmental Planning and Assessment Act, 1979 that provides detailed guidelines for the assessment of development applications.

Design flood level - A flood with a nominated probability or average recurrence interval, for example the 1% AEP flood is commonly use throughout NSW.

DRAINS – The software programs used to develop a computer model that analyses the hydrology (rainfall-runoff processes) of the catchment and calculates hydrographs and peak discharges. Known as a hydrological model.

OEH (formerly DECCW, DECC, DNR, DLWC, DIPNR) - Office of Environment and Heritage. Covers a range of conservation and natural resources science and programs, including native vegetation, biodiversity and environmental water recovery to provide an integrated approach to natural resource management. The NSW State Government Office provides funding and support for flood studies.

Discharge - The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving.

EP&A Act - Act Environmental Planning and Assessment Act, 1979

Extreme flood - An estimate of the probable maximum flood (PMF), which is the largest flood likely to occur.

Flood - A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

Flood awareness - An appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response and evacuation procedures.

Flood hazard - The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.

Flood level - The height of the flood described either as a depth of water above a particular location (e.g. 1m above a floor, yard or road) or as a depth of water related to a standard level such as Australian

Height Datum (e.g. the flood level was 7.8m AHD). Terms also used include flood stage and water level.

Flood liable land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood prone land. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level, as indicated in the superseded Floodplain Development Manual (NSW Government, 2005).

Flood Planning Levels (FPLs) - The combination of flood levels and freeboards selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.

Flood Prone Land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood liable land.

Flood Study - A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.

Floodplain - The area of land that is subject to inundation by floods up to and including the Probable Maximum Flood event, that is, flood prone land or flood liable land.

Floodplain Risk Management Study – Studies carried out in accordance with the Floodplain Development Manual and assess options for minimising the danger to life and property during floods.

Floodplain Risk Management Plan - The outcome of a Floodplain Management Risk Study.

Floodway - Those areas of the floodplain where a significant discharge of water occurs during floods. Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.

High Flood Hazard - For a particular size flood, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.

Hydraulics Term - given to the study of water flow in waterways, in particular, the evaluation of flow parameters such as water level and velocity.

Hydrology Term - given to the study of the rainfall and runoff process; in particular, the evaluation of peak discharges, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).

LGA - Local Government Area, or Council boundary.

Local catchments - Local catchments are river sub-catchments that feed river tributaries, creeks, and watercourses and channelised or piped drainage systems.

Local Environmental Plan (LEP) – A Local Environmental Plan is a plan prepared in accordance with the Environmental Planning and Assessment Act, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.

Local overland flooding - Local overland flooding is inundation by local runoff within the local catchment.

Local runoff - local runoff from the local catchment is categorised as either major drainage or local drainage in the NSW Floodplain Development Manual, 2005.

Low flood hazard - For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.

Flows or discharges - It is the rate of flow of water measured in terms of volume per unit time.

Overland flow path - The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another watercourse.

Peak discharge - The maximum flow or discharge during a flood.

Present value - In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value.

Probable Maximum Flood (PMF) - The largest flood likely to ever occur. The PMF defines the extent of flood prone land or flood liable land, that is, the floodplain.

Reliable access - During a flood, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within effective warning time, having regard to the depth and velocity of floodwaters, the suitability of the evacuation route, and other relevant factors.

Risk - Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

Runoff - the amount of rainfall that ends up as flow in a stream, also known as rainfall excess.

SES - State Emergency Service of New South Wales

12. References

- AR&R 2001, Australian Rainfall and Runoff, 2001;
- BOM 2003, Bureau of Meteorology Australia Generalised Tropical Storm Method – Revised Version, November 2003;
- NSW DECC 2005, NSW Government, Floodplain Development Manual, Management of Flood Liable Land 2005;
- NSW DECC 2007, Practical Consideration of Climate Change, NSW Department of Environment & Climate Change;
- NSW DECCM 2010, Flood Risk Management Guide, Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments
- OEH 2007, Department of Environment and Climate Change, Flood Risk Management Guideline,

Appendices

Appendix A – Preliminary Cost of Options

GHD
Client : Ryde City Council
Title : Buffalo and Kittys Creek
Job No : 21/21394

www.ghd.com.au
Tel. Fax.

Buffalo and Kittys Creek

FRMS

DB3: Gannan Park Detention Basin

NOTE: The preliminary cost estimates presented in this section have been developed solely for the purpose of comparing and evaluating competing options. They are sufficiently accurate to serve this purpose. They cannot be used for budget-setting purposes as common elements between options may have been omitted and/or the works not fully scoped. A functional design is recommended if a budget estimate is required.

SCHEDULE OF ESTIMATED QUANTITIES

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	10000	$ 10,000	Allowance only
1.3	Traffic control	1	item	10000	$ 10,000	Allowance only
	SUBTOTAL				$ 30,000	
2	**Earthworks & General**					
2.1	Clear site of vegetation - medium vegetation, over 500m2	22,060	m2	1	$ 13,236	-
2.2	Excavate over site to reduce levels in light soil	44,120	m3	24	$ 1,058,880	-
2.3	Landscaping - hydro mulch sprayed grass seed	22,060	m2	1	$ 11,030	-
2.4	Footpath - Concrete; 100mm thick 20MPa with F72 mesh; including formwork, expansion joints and finishing		m2	54	$ -	-
2.5	Fence - supply and erect galvanised steel welded mesh 1.2m high		m	70	$ -	
	SUBTOTAL				$ 1,083,146	
3	**Drainage**					
3.1	Pipe - Supply, deliver, lay and join 300mm RCP (Class 2)	155	m	98	$ 15,190	Rubber ring joint; excavation excluded
3.2	Manhole/pit - Replace existing pits, reusing components where possible	2	each	2800	$ 5,600	Assume grates are salvaged
3.3						
	SUBTOTAL				$ 20,790	
	SUBTOTAL ITEMS 1-3				$ 1,133,936	
4	**Supervision, Project Management & Contractor On-Costs**					
4.1	Supervision, Project Management & Contractor On-Costs (20%)	20	%	-	$ 226,787	-
	SUBTOTAL				$ 226,787	
5	**Contingencies**					
5.1	Contingencies - General (25%)	25	%	-	$ 283,484	-
	SUBTOTAL				$ 283,484	
	TOTAL (Ex-GST)				**$ 1,644,207**	

GHD
Client : Ryde City Council
Title : Buffalo and Kittys Creek
Job No : 21/21394

www.ghd.com.au
Tel. Fax.

Buffalo and Kittys Creek

FRMS

SI1: Quarry Road Diversion

NOTE: The preliminary cost estimates presented in this section have been developed solely for the purpose of comparing and evaluating competing options. They are sufficiently accurate to serve this purpose. They cannot be used for budget-setting purposes as common elements between options may have been omitted and/or the works not fully scoped. A functional design is recommended if a budget estimate is required.

SCHEDULE OF ESTIMATED QUANTITIES

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	50000	$ 50,000	Allowance only
1.3	Traffic control	1	item	50000	$ 50,000	Allowance only
	SUBTOTAL				**$ 110,000**	
2	**Earthworks & General**					
2.1	Demolition - break up and remove bitumen paving	1,600	m2	3.60	$ 5,760	Disposal extra
2.2	Demolition - break up and remove kerb and gutter	810	m	35.00	$ 28,350	Disposal extra
2.3	Excavated material as fill (on site)	7,800	m3	9.00	$ 70,200	-
2.4	Fill - Place and compact clay (over 10,000m3)	6,000	m3	27	$ 162,000	
2.5	Kerb and gutter - Cast in-situ with reinforcement, formwork and surf	810	m	160	$ 129,600	-
2.6	Pavement - Concrete footpath; 2.0m wide; 150mm thick cast in-situ	820	m	120.00	$ 98,400	
2.7						
2.8						
2.9						
2.10						
	SUBTOTAL				**$ 494,310**	
3	**Drainage**					
3.1	Pipe - Supply and deliver 1500mm RCP (Class 3)	810	m	1200	$ 972,000	Rubber ring joint; excavation excluded
3.2	Manhole/pit - Cast in-situ double grate pit with extended kerb inlet u	5	each	3600	$ 18,000	-
	SUBTOTAL				**$ 990,000**	
	SUBTOTAL ITEMS 1-3				**$ 1,594,310**	
4	**Supervision, Project Management & Contractor On-Costs**					
4.1	Supervision, Project Management & Contractor On-Costs (20%)	20	%	-	$ 318,862	-
	SUBTOTAL				**$ 318,862**	
5	**Contingencies**					
5.1	Contingencies - General (25%)	25	%	-	$ 398,578	-
	SUBTOTAL				**$ 398,578**	
	TOTAL (Ex-GST)				**$ 2,311,750**	

GHD
Client : Ryde City Council
Title : Buffalo and Kittys Creek
Job No : 21/21394

www.ghd.com.au
Tel. Fax.

Buffalo and Kittys Creek

FRMS

SI5: Pipe Network Amplification

NOTE: The preliminary cost estimates presented in this section have been developed solely for the purpose of comparing and evaluating competing options. They are sufficiently accurate to serve this purpose. They cannot be used for budget-setting purposes as common elements between options may have been omitted and/or the works not fully scoped. A functional design is recommended if a budget estimate is required.

SCHEDULE OF ESTIMATED QUANTITIES

PAY ITEM	DESCRIPTION OF WORK	QTY	UNIT	RATE	AMOUNT	NOTES
1	**Preliminaries**					
1.1	Establishment	1	item	10000	$ 10,000	Allowance only
1.2	Erosion and sediment control	1	item	50000	$ 50,000	Allowance only
1.3	Traffic control	1	item	50000	$ 50,000	Allowance only
	SUBTOTAL				**$ 110,000**	
2	**Earthworks & General**					
2.1	Demolition - break up and remove bitumen paving	1,000	m2	3.60	$ 3,600	Disposal extra
2.2	Excavated material as fill (on site)	2,600	m3	9.00	$ 23,400	-
2.3	Fill - Place and compact clay (over 10,000m3)	2,000	m3	27	$ 54,000	-
2.4	Kerb and gutter - Cast in-situ with reinforcement, formwork and surf	500	m	160	$ 80,000	
2.5	Pavement - Concrete footpath; 2.0m wide; 150mm thick cast in-situ	500	m	120.00	$ 60,000	-
2.6						
2.7						
2.8						
2.9						
2.10						
	SUBTOTAL				**$ 221,000**	
3	**Drainage**					
3.1	Pipe - Supply and deliver 1500mm RCP (Class 3)	940	m	1200	$ 1,128,000	Rubber ring joint; excavation excluded
3.2	Manhole/pit - Cast in-situ double grate pit with extended kerb inlet u	10	each	3600	$ 36,000	-
	SUBTOTAL				**$ 1,164,000**	
	SUBTOTAL ITEMS 1-3				**$ 1,495,000**	
4	**Supervision, Project Management & Contractor On-Costs**					
4.1	Supervision, Project Management & Contractor On-Costs (20%)	20	%	-	$ 299,000	-
	SUBTOTAL				**$ 299,000**	
5	**Contingencies**					
5.1	Contingencies - General (25%)	25	%	-	$ 373,750	-
	SUBTOTAL				**$ 373,750**	
	TOTAL (Ex-GST)				**$ 2,167,750**	

Appendix B – Multi-Criteria Analysis

Multi-Criteria Analysis of Options

GHD
Client : City of Ryde Council
Title : Buffalo and Kittys Creek FRMS (Buffalo Creek Floodplain Only)
Job No : 21-21394

www.ghd.com.au
sydmail@ghd.com
Tel. +61 2 9239 7100 Fax. +61 2 9239 7199
L15, 133 Castlereagh St, Sydney

Buffalo and Kittys Creek FRMS (Buffalo Creek Floodplain Only)

Floodplain Risk Management Option Assessment Matrix

[Score out of 5 - 1 is worst, 3 intermediate or neutral effect and 5 is best]

Revision: Final

Issues	**Options**							
	Do Nothing	Scenario 1	Scenario 2	VHP				
Social issues								
Flood hazard reduction	2	4	4	4				
Flood risk reduction	2	3	4	4				
Increase in property values	3	3	3	3				
Community growth	3	3	3	3				
Short Term Community disruption	2	2	3	4				
Long Term Community disruption	2	2	3	4				
Environmental issues								
Ecology, WSUD	3	4	3	3				
Pollution	3	3	3	3				
Energy and resources to implement	5	1	1	2				
Future energy and resources	3	3	2	4				
Intangible Score	56%	56%	58%	68%				
Rank	3	4	2	1				
Economic Issues								
Costs								
Present Value Capital Costs	$ -	$ 1,600,000	$ 4,500,000	$ 1,668,000				
Rank (Cheapest)	1	2	4	3				
Benefits								
Average Annual Damage	$ 1,010,068	$ 989,853	$ 958,494	$ 988,590				
Present Value Damage Savings (30 yrs)	$ -	$278,029	$ 709,331	$ 295,393				
Benefit - Cost Ratio								
Benefit/ Cost Ratio	1.00	0.17	0.16	0.18				
Rank	1	3	4	2				

GHD
Client : City of Ryde Council
Title : Buffalo and Kittys Creek FRMS (Kitty Creek Floodplain Only)
Job No : 21-21394

www.ghd.com.au
sydmail@ghd.com
Tel. +61 2 9239 7100 Fax. +61 2 9239 7199
L15, 133 Castlereagh St, Sydney

Buffalo and Kittys Creek FRMS (Kitty Creek Floodplain Only)

Floodplain Risk Management Option Assessment Matrix

[Score out of 5 - 1 is worst, 3 intermediate or neutral effect and 5 is best]

Revision: Final

Issues	**Options**							
	Do Nothing	VHP						
Social issues								
Flood hazard reduction	2	4						
Flood risk reduction	2	4						
Increase in property values	3	3						
Community growth	3	3						
Short Term Community disruption	2	4						
Long Term Community disruption	2	4						
Environmental issues								
Ecology, WSUD	3	3						
Pollution	3	3						
Energy and resources to implement	5	2						
Future energy and resources	3	4						
Intangible Score	56%	68%						
Rank	2	**1**						
Economic Issues								
Costs								
Present Value Capital Costs	$ -	$ 932,500						
Rank (Cheapest)	**1**	2						
Benefits								
Average Annual Damage	$ 140,503	$ 117,793						
Present Value Damage Savings (30 yrs)	$ -	$304,520						
Benefit - Cost Ratio								
Benefit/ Cost Ratio	1.00	0.33						
Rank	**1**	2						

Appendix C – Public Exhibition

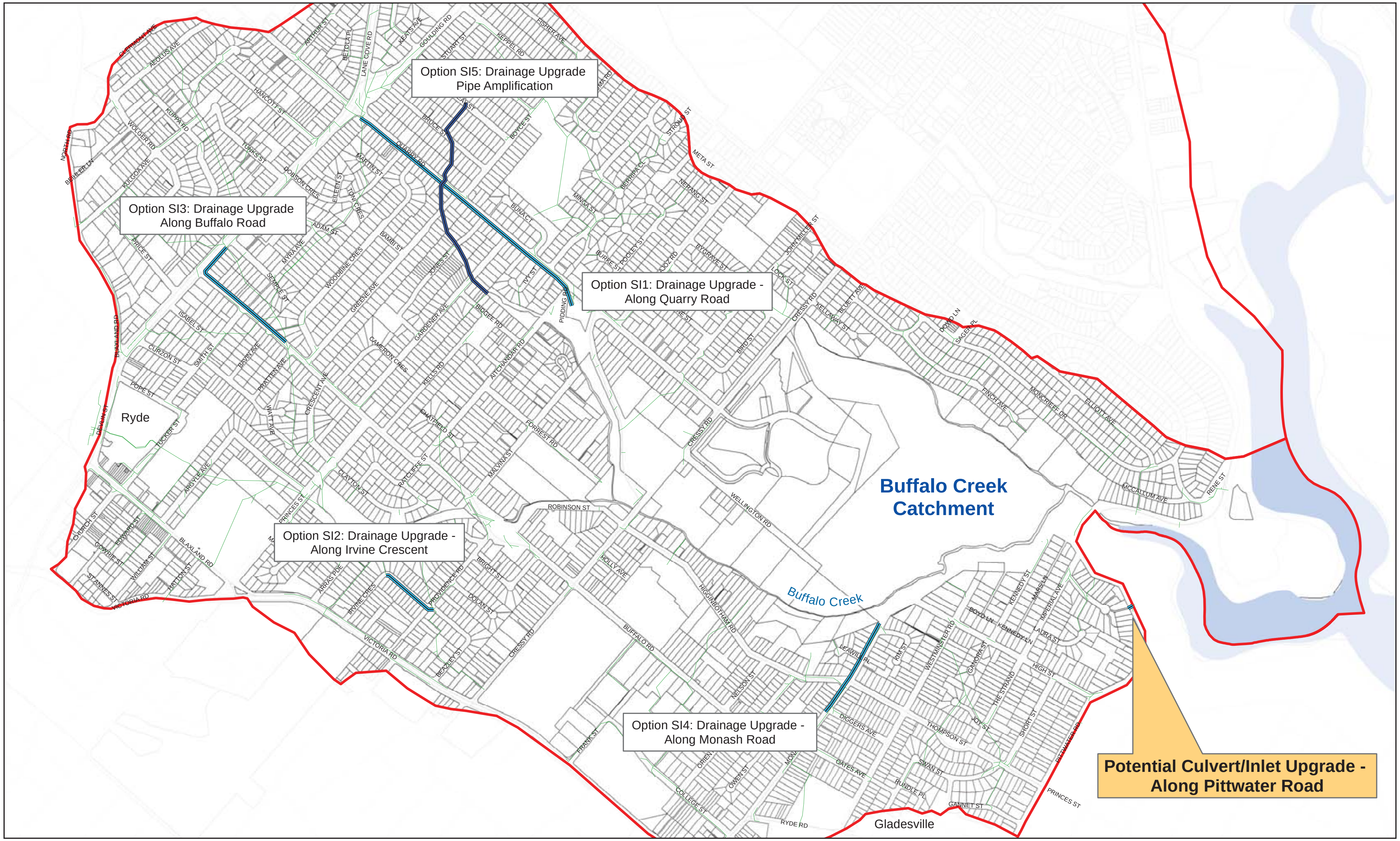
C.1 Public Exhibition Program

C.2 Potential Stormwater Drainage Upgrading Option at Pittwater Road and Preliminary DRAINS analysis

Appendix C.1 - Public Exhibition Program

#	Activity	Description	Information Provided	Stakeholders	Date Completed / Implemented
1	Letters to Committee	A letter was sent to the Committee Members, plus a copy of the exhibition material (newsletter) sent to the residents in the catchment area.	• Exhibition Process • Exhibition Period for Community Comment	Committee Members	Thursday 04/09/14
2	Newsletter	An A4, two page information sheet that was mailed out to 3,800 residents in the catchment area.	• Project Update • Exhibition Process • Exhibition Period for Community Comment • Where to view the Reports • How to make a Submission / Comment • Date of the Drop In Session	Residents in the catchment area	Tuesday 09/09/14
3	Advertisement in City News	An advertisement was placed in the City of Ryde - City News section of the Northern District Times Newspaper.	• Exhibition Period for Community Comment • Where to view the Reports • How to make a Submission / Comment • Date of the Drop In Session	City of Ryde Residents	Wednesday 10/09/14
4	Website	A Buffalo and Kittys Creeks page was created on the 'Have Your Say' section of the City of Ryde Website.	• Exhibition Period for Community Comment • Soft copy of the Draft Reports and related information / maps • How to make a Submission / Comment • Date of the Drop In Session	City of Ryde Customers	Wednesday 10/09/14
5	Hard copies of the Reports	Hard copies were printed and provided to Customer Service and North Ryde Library during the exhibition period for stakeholders.	• Hard copy of the Draft Reports and related information / maps	City of Ryde Customers	Wednesday 10/09/14
5	Community Drop In Session	An information session was held at North Ryde Library (3.30pm to 7.30pm) where stakeholders could come and speak to Council representatives and Consultant representatives.	• Hard copy of the Draft Reports and related information / maps • Any stakeholder questions / specific enquires	Interested Residents	Thursday 25/09/14

Please note: The exhibition period was from Wednesday 10 September 2014 to Friday 3 October 2014.



1:10,000 (at A3)

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

Legend

- Pipe Amplification
- New Stormwater Pipe
- Buffalo Catchment Stormwater Pipes
- Catchment Boundary
- Lot Cadastral

City of Ryde

GHD

City of Ryde Council
Buffalo and Kittys Creek
Flood Study and FRMS&P

Potential Stormwater
Drainage Upgrading Options

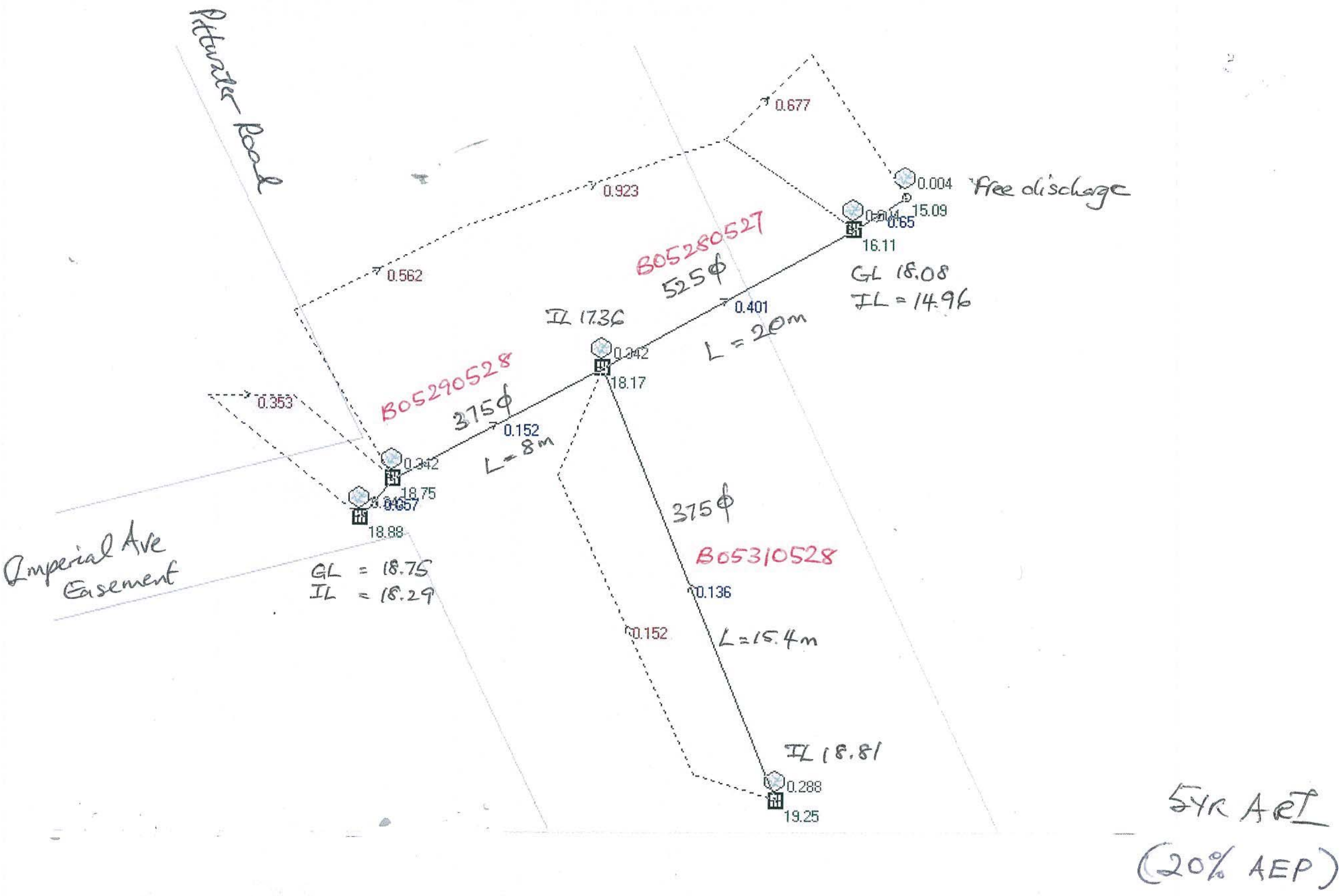
Job Number	21-21394
Revision	A
Date	07 Nov 2014

Figure C.1

G:\21\21394\GIS\ArcGIS\Maps\MXD\Map Publishing - FINAL FRMS Report\Option - Stormwater Pipes For Community Consult.mxd

Data Source: NSW Department of Lands: Cadastre - Jan 2011; Geoscience Australia: 250k Data - Jan 2011. Created by: jlam

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au



Preliminary DRAINS analysis at Pittwater Road Culvert