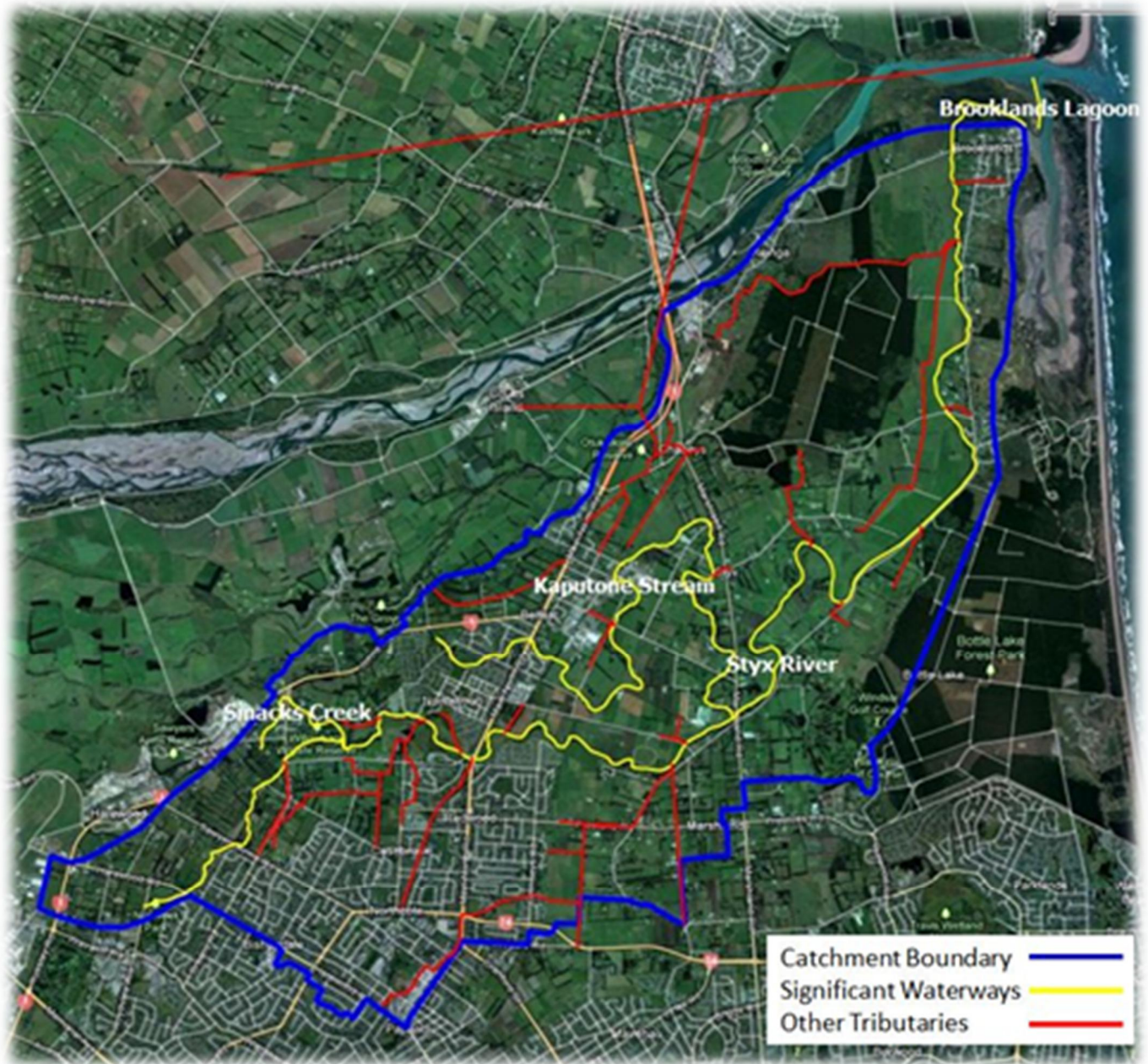




Christchurch City Council

Stormwater Modelling Consolidation

Styx River Model Status Report

14 November 2012

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Appendices

A. Model parameters

Preamble

This document is intended to be maintained as a living document, updated each time the Styx River hydrological and hydraulic models are updated. Its purpose is to ensure that detailed modelling information is kept and maintained, such that third party modellers can follow the modelling process and model development and, if needed, continue with this following similar principles.

This document is also intended to be used for comparative purposes, when comparing the way in which respective models have been built and run. The intention is to use these status reports to work towards conformity in modelling approach across the city.

This document should be read in conjunction with the *Stormwater Modelling Specification for Flood Studies* (GHD, 2012), developed for Christchurch City Council and the *Guidelines for using Stormwater Modelling Results in Statuary Processes* (GHD, 2012).

This report: has been prepared by GHD for Christchurch City Council and may only be used and relied on by Christchurch City Council for the purpose agreed between GHD and the Christchurch City Council as set out in the preamble to this report.

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

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1. Introduction

1.1 Styx model status

The following report outlines the status of the Styx catchment model with emphasis on the following points:

- Details of the company who developed the model;
- A short background on the software used within the model;
- The coverage of the model;
- Model calibration and limitations;
- Parameters used within the model;
- The physical status of the model i.e. is the model up to date post-earthquakes?
- Compliance with the developed Stormwater Modelling Specification for Flood Studies (GHD, 2012); and,
- Recommendations for additional work.

1.2 Model developer

The Styx model has been developed from GHD's Christchurch office:

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Christchurch 8011, New Zealand

Postal address:

GHD Christchurch

PO Box 26131
Christchurch 8141
New Zealand

Phone +64 3 378 0900

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The current modeller involved with the development of the Styx model is:

Tom Parsons

Tom.parsons@ghd.com

phone: +64 3 378 0936

2. Modelling software

The Styx model has been developed on MIKE software by DHI. The MIKE software is used to model a variety of processes from rainfall-runoff, river behaviour, pipe networks and 2D flood flows through to river morphology, coastline kinetics and 3D modelling of the coast and sea.

Table 1 outlines the software used for each process in the model and the methods adopted under this software.

Table 1 Model summary

Model Summary			
Process		Software	Method
1	Rainfall - Runoff	MIKE URBAN	Kinematic wave
2	Channel Flow	MIKE 11	St. Venant equations
3	Pipe Flow	MIKE URBAN	St. Venant equations / Colebrook White
4	Floodplains	MIKE 21	2D shallow water equations

There are two main components of the Styx model; the hydrology (i.e. rainfall – runoff) and the hydraulics (i.e. channel flow, pipe flow and floodplain flow).

2.1 Hydrology

Hydrological processes have been simulated using the MOUSE engine of the MIKE URBAN software.

MOUSE uses a runoff computational engine to apply a design rainfall event to urban catchments and estimate initial loss, infiltration loss and compute runoff hydrographs (which are contained in a .CRF file). The general catchment data defined within the MOUSE Runoff Model includes an ID, the catchment connection point, X and Y co-ordinates and the catchment area.

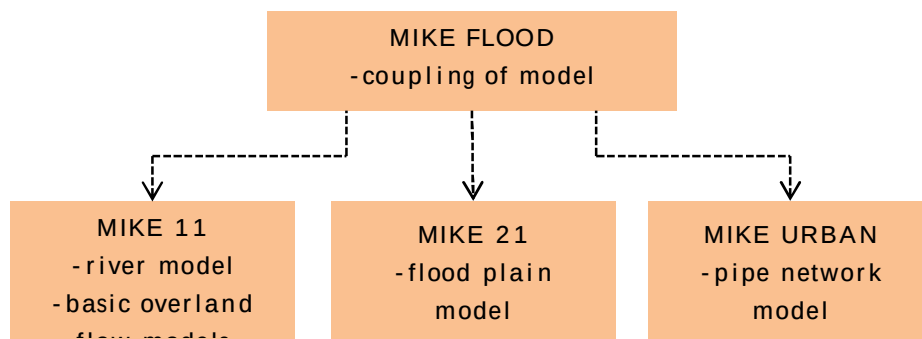
For the Styx model, Surface Runoff Model B has been used which is founded on the kinematic wave computation. The runoff volume is controlled by the hydrological losses and the size of the contributing area, whilst the shape of the runoff hydrograph is controlled by the catchment parameters. Horton's equations are used to calculate the infiltration losses. Details on the hydrological parameters adopted for each sub catchment are tabulated in Appendix A.

The methods used to compute the inflow hydrographs are consistent with Waterways, Wetlands and Drainage Guide (CCC, 2003).

2.2 Hydraulics

The Styx model uses the MIKE 11, MIKE 21 and MIKE URBAN software, which is coupled together using MIKE FLOOD. The structure of the modelling software is shown below in Figure 1.

Figure 1 Hydraulic modelling software structure



2.3 Software versions adopted with model

The MIKE software is updated from time to time with new service packs and occasionally a new version of software. These updates generally solve small errors or add a new feature to the software.

Although software updates are generally small, CCC has indicated that some of the models are showing different flood levels between different software versions.

Table 2 outlines the software used for the Styx model development and the newest software available.

Table 2 Software versions

Model Component	Software version used	Newest software available
MIKE 11	v.2011 SP6	v.2011 SP7
MIKE URBAN	v.2011 SP6	v.2011 SP7
MOUSE HD	v.2011 SP6	v.2011 SP7
MOUSE Pipe Flow	v.2011 SP6	v.2011 SP7
MIKE 21	v.2011 SP6	v.2011 SP7
MIKE FLOOD	v.2011 SP6	v.2011 SP7

Note: v. = Version, SP = Service Pack

The software used within the Styx model is version 2011 with service pack 6. The most recent software available is version 2011 with service pack 7.

Small changes have been made within the MOUSE components which may affect the MIKE URBAN to MIKE 21 link. The change is stated by DHI as follows:

“When running a network + 2D overland simulation the continuity balance is written incorrectly in the summary file (volume for the diverted runoff is not added correctly)”.

As this change only affects the writing of the summary file it is not significant in accuracy of results attained.

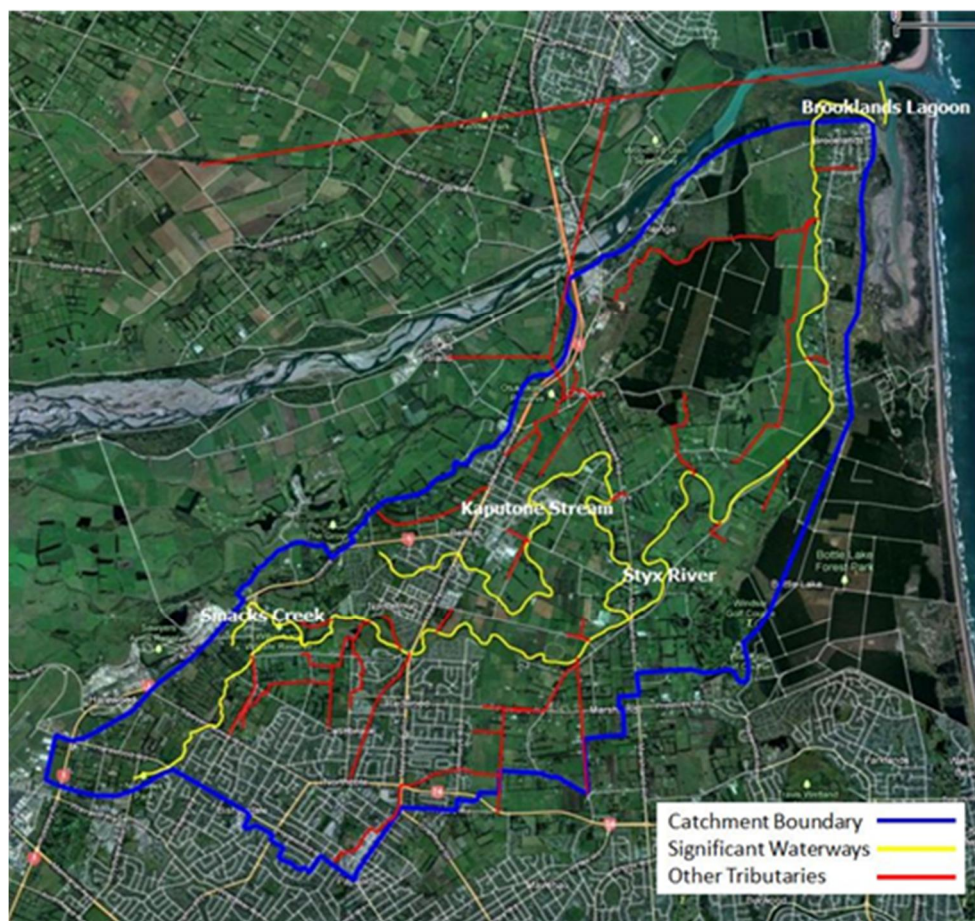
3. Model coverage

3.1 The Styx catchment

The Styx River is one of several spring fed river systems that originate and flow through Christchurch City. The catchment is located on the northern edge of the city and covers an area of about 50 km². It is bounded to the north by the Waimakariri catchment and to the south by the Avon catchment.

The Styx River has two main tributaries (Smacks Creek and Kaputone Stream) along with several other small waterways. The river originates in Harewood and flows through the suburbs of Belfast, Marshland and Spencerville before flowing into the Brooklands Lagoon and then entering the sea at the mouth of the Waimakariri River.

Figure 2 Model catchment



3.2 MIKE 21

The Styx model is made up of 39 branches in total; 32 of which belong to the Styx Catchment and 7 of which belong to the Waimakariri catchment to the north.

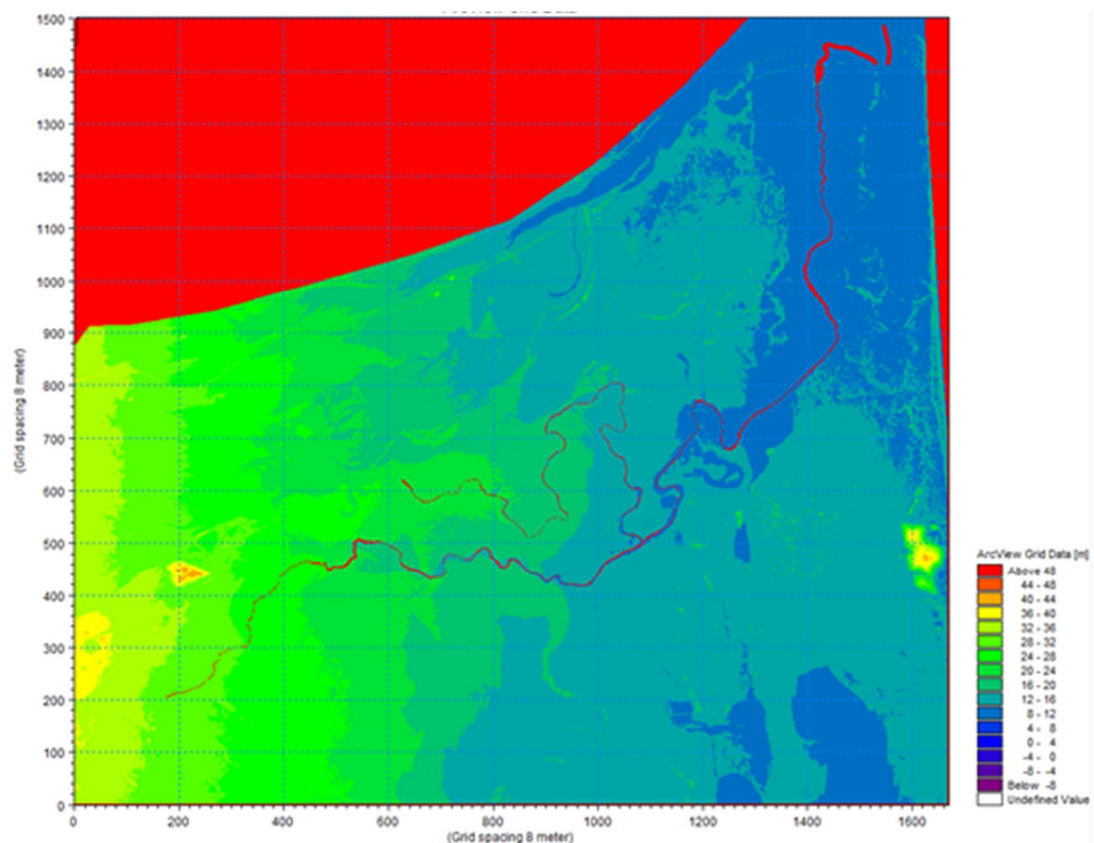
Five of the 7 Waimakariri branches contribute to the Otukaikino wetland reserve before flowing under the motorway into the Waimakariri catchment. At the outlet of the Otukaikino reserve a flapgate has been modelled. These branches are included within the Styx model to identify if any hydraulic connection exists during large events. All Waimakariri catchment branches are dummy channels, which have been inserted to route water to the sea.

Based on a brief review of aerial photos the model encompasses all significant tributaries within the catchment.

3.3 MIKE URBAN – MOUSE HD

Figure 3 Model network (topography grid file)

The MIKE 21 component of the model is made up from 8m x 8m grid covering approximately



12.0km x 13.4km. It is bounded by the Waimakariri River to the north and the sea to the east

The MIKE URBAN component has been modelled to a high level of detail for the Styx catchment with a total of 1252 pipes, 1239 manholes and 32 outlets.

Stormwater networks are typically sized to convey the flows in response to for a rainfall event of critical duration and of 1/5 AEP in the Christchurch area.

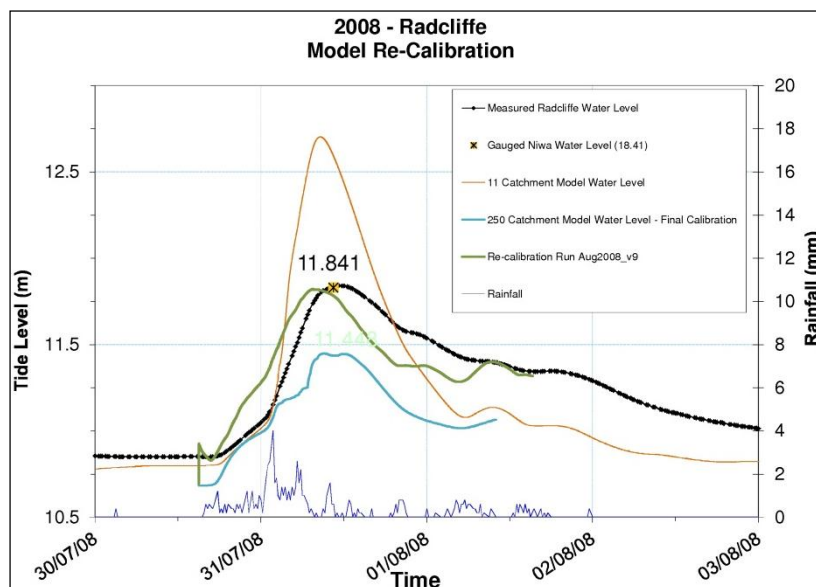
The model has been developed in the New Zealand Map Grid (NZGD49) co-ordinate reference system.

4. Model calibration

It is understood that the Styx model has been calibrated mainly using the long-term record gauged at Radcliffe Road, but also using sites at Harbour Road and at the Lower Styx. The calibration was undertaken by adjustment of both hydrological and hydraulic models. Loss parameters in the hydrological model were adjusted to ensure a volumetric balance between modelled and recorded, while frictional effects were adjusted in the hydraulic model to achieve a better fit.

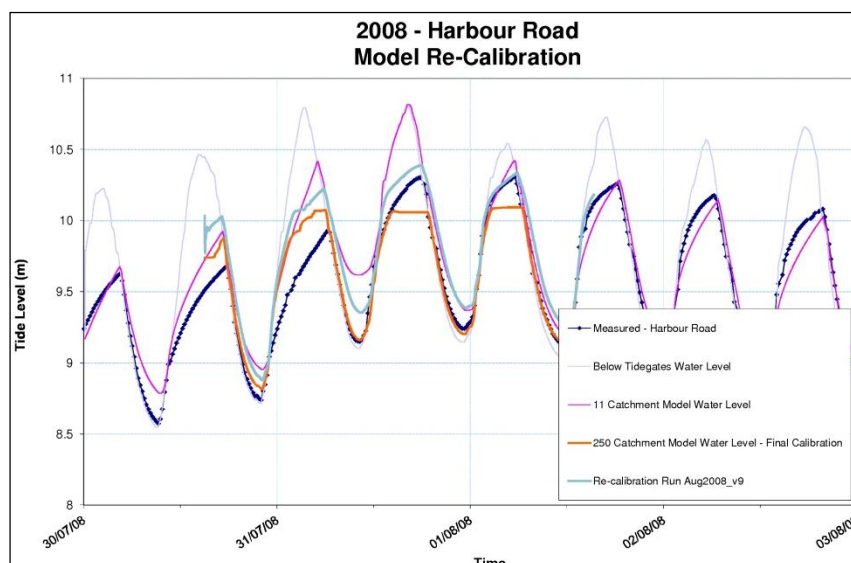
In Figure 4 a plot is given that shows results from gaugings, from recordings and from various model runs. The current version of the model (with results labelled “Re-calibration Run Aug2008_v9”) is shown to achieve a reasonable match with recorded and gauged peak water level, although time-to-peak is slightly different.

Figure 4 Calibration plot for Radcliffe Road, 2008 event



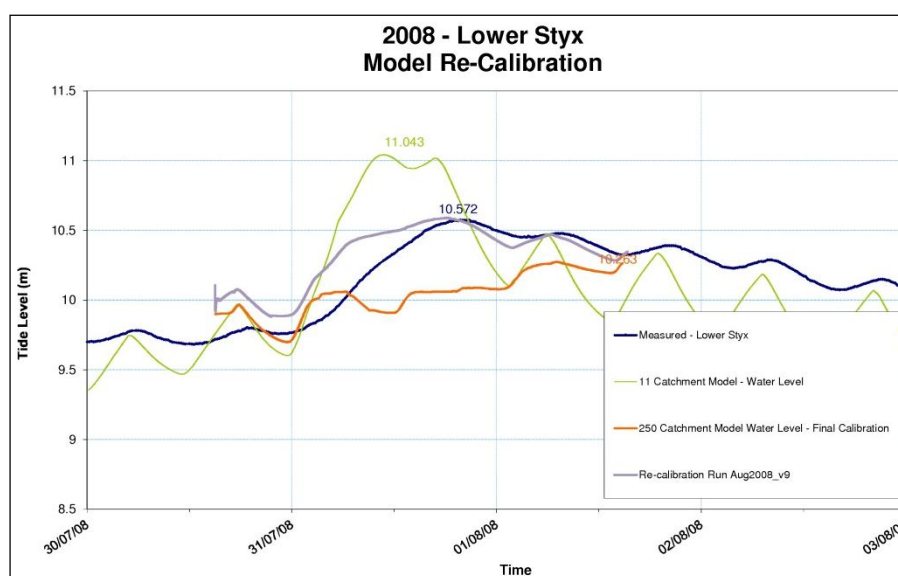
In Figure 4 a similar set of results is presented for the Harbour Road recorder site. The tidal influence in the recordings can clearly be seen at this location. Again, a reasonable fit with measured data is given by the model at the peak flood level.

Figure 5 Calibration plot for Harbour Road, 2008 event



In Figure 6 modelled and recorded water level time series for the same 2008 event are shown for the Lower Styx recorder site. Modelled and measured peak flood levels show a reasonable match.

Figure 6 Calibration plot for Lower Styx, 2008 event



5. Model parameters

The key parameters used within each model component are discussed in the following sections. These parameters are critical to the model behaviour and results.

Changes to model parameters shall be recorded within this section and within the summary of parameters in Appendix A. A modelling log shall be appended to this report when it is next updated and should be included as Appendix B in order to record model runs and allow recreation of model results.

5.1 MIKE 11

The MIKE 11 component is made up from 4 separate files;

- Network File (.nwk11);
- Cross Section File (.xns11);
- HD Parameters File (.hd11); and
- Boundary Data File (.bnd11).

One additional file (the MIKE 11 .ini file) offers the possibility of adjusting settings within the calculation engine of MIKE 11. The remainder of this section outlines the inputs and parameters specified for all 5 files.

5.1.1 Network file

A short summary of the network is provided in Table 3. The network has a total of 39 branches; 32 are in the Styx catchment and 7 are in the Waimakariri catchment. All branches are 'Regular' branches with cross sections at specified chainages.

Table 3 Network File Breakdown

Input / Parameter			Number
Network	Branches	No.	39
	Points	No.	4929
Structures	Weirs	No.	8
	Culverts	No.	25
	Bridges	No.	1

5.1.1.1 Points

All points within the network have been specified with x and y coordinates. The chainage between all points have been "system defined" based on the point coordinates except for the starting and end points of a few branches.

5.1.1.2 Branches

"Regular" branches are used for all the braches within the Styx model network. This is the normal branch type used within MIKE 11 and is composed of a number of calculation points defined by the cross sections specified in the cross section file.

A “Maximum dx” is specified for each branch. This determines the maximum distance between calculation points on a branch. E.g. if the distance between cross sections is larger than the maximum dx, additional calculation points will be inserted. These additional points are based on interpolation between the existing cross sections.

A **maximum dx of 8 metres** has been specified for the “styx”, “kaputone” and “brooklands” branches, whilst a maximum dx of 50m has been specified for most other significant tributaries within the network. This maximum dx correlates with the grid size of 8m in the 2D domain.

For three branches; “KRUSES2”, “WILSONSDRAIN2” and “smackdig” larger maximum dx’s have been specified. KRUSES2 and WILSONSDRAIN2 (with maximum dx’s of 100m) have identical cross sections along their length with varying elevations. Smackdig has a maximum dx of 800m; in this case all adjacent cross sections are closer than 800m and no additional computational points are added to the branch.

5.1.1.3 Weirs

All weirs specified within the Styx model have been modelled using the Broad Crested Weir formulation, which calculates a Q/h relationship based on the levels and widths specified for each weir.

All weirs have no valve regulation; therefore, depending on up and down stream conditions flow may travel in either direction.

The head loss factors adopted for the modelled weirs are all default values as shown in Table 4.

5.1.1.4 Culverts

A range of culvert geometries have been used within the Styx model. They are all “Regular” structures; which means flow passes through the culvert based on up and down stream flow conditions.

Valve regulation is generally none (where flow is permitted in both directions); however for “WILSONSDRAIN2” which is north of the Styx catchment and the tide gate culvert on the Styx River only positive flow is permitted.

Manning’s n varies from 0.013 up to 0.040 for the culverts specified.

Table 4 outlines the head loss factors used to model weirs and culverts within the Styx model. The values adopted are the default values for MIKE 11. Default values have been adopted for all head loss factors.

Table 4 Structure head loss factors

Structure Head Loss Factors			
Head loss factor	Structure		Default
	Broad crested weir	Culvert	
LPI	0.5	0.5	0.5
LPO	1	1	1
LPF	1	1	1
LPB	-	0	- / 0
LNI	0.5	0.5	0.5
LNO	1	1	1
LNF	1	1	1
LNB	-	0	- / 0

5.1.1.5 Bridges

One bridge has been modelled within the Styx model. This is at the point the Styx River goes under Radcliffe road, just prior to confluence with the Kaputone Stream.

The Federal Highway Administration (FHWA) WSPRO method has been used to model this bridge. This method takes into account contraction loss by the calculation of an effective length and expansion loss via experimentally based tables

If the bridge is submerged, the behaviour is used using the Pressure Flow FHWA method. Two different equations are used for this method depending on whether the downstream orifice is partially or fully submerged.

If overflow occurs; the behaviour is modelled using a standard MIKE 11 weir (in this case a broad crested weir as specified above). This is only active if overflow occurs.

5.1.2 Cross sections

For every cross section, the following information is required:

- River (branch) name;
- Chainage;
- Cross Section ID (optional);
- Topo ID;
- Section Type;
- Radius Type;
- Coordinates (optional); and
- Resistance.

Regular branches have been used for the entire network and as such cross sections are defined for every branch. The Topo ID's and key cross section properties have been specified below.

5.1.2.1 Topo ID

Generally there is only one set of cross-sections for each branch; given the model was developed pre-earthquakes no changes have been made to these cross sections. The exceptions to this are the "KAPUTONE" and "Styx" branches.

The Kaputone branch has an updated set of cross sections (default topoid dx8). This set adds 2 cross sections to the branch. The new Topo ID is identical to the original Topo ID (default topoid) apart from an additional 2 cross sections at chainages 2569 and 4563. The additional 2 cross sections are not related to post earthquake changes in channel shape.

The Styx branch has a range of Topo ID's. Apart from the inclusion of a few interpolated cross sections and some additional cross sections based on neighbouring cross sections, the chainages and total number of cross sections remain unchanged between the Topo ID's.

All cross sections above the Kaputone branch confluence remain the same for all Topo ID's. Post-earthquake changes in cross section profiles have been made to the Topo ID's below the Kaputone branch confluence for "PostFebEQ" and "PostFebEQ_dx8".

5.1.2.2 Cross Section Properties

Table 5 displays the cross section properties specified for the Styx model. A consistent set of properties have been used for all cross sections.

Table 5 Cross section properties

Property		Value
Section Type		Open
Hydraulic Radius		Total Area, Hydraulic Radius
Coordinates		Not used
Morphological Model		Not used
Resistance Number	Transversal Distribution	Distributed
	Resistance Type	Relative Resistance

The only exception to the above cross section properties is at chainage 21485 on the Styx branch. This is the Harbour / Kainga Road Bridge in Brooklands. At this point a closed irregular section is used with a uniform relative resistance of 1.

Relative resistances have been specified for all cross sections. This method relies on a globally specified resistance (within the HD parameters file) which is then scaled up or down for each X, Z data point within the cross section. A global Manning's n of 0.04 has been set within the HD parameters file (see Section 5.1.3.4).

The relative resistances within the main branches are summarised in Table 6.

Table 6 Resistance values

Branch / Chainage		Relative Resistance	
		Low Value (bed)	High Values (banks)
Styx River	0 to 6890	1	1.3
	6903 to 10574	1 to 1.1	2 to 2.4
	10650 to 19964	1 to 1.1	3*
	20512 to 21760	1	2*
	21766 to 23025	0.28 to 0.45	1.4 to 2
Kapotone Stream		0.8 to 1	1 to 1.3
Smacks Creek		1	1.3
All Other Branches		1*	1.3*
Note: * indicates there are occasional cross sections that differ from the value shown.			

Relative resistance within the main channel bed generally range between 0.8 and 1.1, whilst the relative resistance on the river banks range from 1.0 up to 3.0. Lower values of bed relative resistances (of 0.28 to 0.45) have been adopted for the lower Styx River prior to entry into Brooklands lagoon.

In terms of Manning's number (n), generally the bed resistance of the rivers / streams in the Styx model range from 0.032 to 0.044, whilst the river banks range from 0.04 to 0.12.

5.1.3 HD parameters

The Hydrodynamics (HD) editor is used for setting supplementary data used for the model runs. Most of the parameters are set default values upon creating a new HD Parameters file (.hd11).

For many parameters global values are set for the entire model, with local values specified in particular locations if required.

The following information is included within the HD Parameters file:

- Default Computational Parameters;
- Initial Conditions;
- Wind Factors;
- Bed Resistance;
- Wave Approximation;
- Quasi Steady Parameters;
- Heat Exchange Parameters;
- Stratification Parameters;
- Groundwater Leakage;
- Flood Plain Resistance; and
- Encroachment Simulations.

These parameters are summarised in the remainder of this section.

5.1.3.1 Default computational parameters

These parameters are essential for the computational scheme. The model can't run without values being set for these parameters, and as such have been given default values. Table 7 outlines the values adopted within the model.

Table 7 Default computational parameters

Parameter	Value
Delta	0.9*
Delhs	0.01
Delhs	0.1
Alpha	1
Theta	1
Eps	0.0001
Dh Node	0.01
Zeta Min	0.1
Struc Fac	0
Inter1Max	20
Nolter	1
MaxIterSteady	100
FroudeMax	-1
FroudeExp	-1
Note: * indicates non-default values	

Default values have been used for all computational parameters except Delta, which has a value of 0.9 (default value is 0.5). Delta changes the time-centering of the gravity term in the momentum equation; a high value of Delta (with a maximum of 1.0) has a dampening effect which can significantly influence model dynamics, whilst the lowest value (0.5) will produce the most accurate calculations (provided the model is stable).

The MIKE 11 user manual recommends a Delta of 0.85 for MIKE FLOOD models with small time steps. The adopted value (0.9) is slightly larger than this.

5.1.3.2 Initial conditions

Initial water heights and flows have been locally specified for all branches in the Styx model network. These local settings override the global settings specified.

5.1.3.3 Wind factors

Wind has not been taken into account within the model.

5.1.3.4 Bed resistance

Table 8 summarises the global bed resistance settings for the MIKE 11 component. A global Manning's number of 0.04 has been set for the network. This value is adjusted in individual cross sections using a relative resistance approach (see Section 5.1.2.2) which scales this value up or down.

Table 8 Bed resistance

Parameter	Value
Approach	Uniform Section
Resistance Formula	Manning (n)
Resistance Number	0.04
Bed Resistance Toolbox	Not Used

The bed resistance toolbox is not used within the model; this toolbox offers a possibility to calculate the bed resistance as a function of the hydraulic parameters by applying a Bed Resistance Equation during the computation.

5.1.3.5 Wave approximation

Wave approximations have been set globally for the entire network using a High Order Fully Dynamic approximation.

5.1.3.6 Quasi steady parameters

Quasi steady simulation computational parameters and steady state options for the model are summarised in Table 9.

Table 9 Quasi steady parameters

Quasi Steady Parameters	
Parameter	Value
Relax	0.5
Beta_Limit	1e-008
Fac_0	2.5
Qconv_factor	0.001
Hconv_factor	0.01
Min_Hconv_In_Branch	1e-005
Q_struc_factor	0.005
H_stop	0.0001
Steady State Options	Not Used

Default values have been adopted for all computational parameters and no steady state options have been used in the model.

5.1.3.7 Heat exchange parameters

Heat exchange has not been used within the model.

5.1.3.8 Stratification parameters

All stratification parameters adopted for the model are default values.

5.1.3.9 Groundwater leakage

Groundwater leakage has not been used within the model.

5.1.3.10 Flood plain resistance

A default value of -99 has been set for flood plain resistance. This value indicates that the flood plain resistance should be calculated from the raw data in the cross-section data base.

5.1.3.11 Encroachment simulations

Encroachment simulations are not used within the model.

5.1.4 Boundary data

Boundary conditions for the MIKE 11 component are held in a .bnd11 file. This file describes the boundary nature (open, point source, distributed etc.), the boundary type (for hydrodynamic models; inflow, water level or Q-h) and the branch name and chainage of the boundary.

Given the nature of this report (not being a model review), the boundary conditions have not been looked at in detail. However, the methods used by the modeller to compute the MIKE 11 inflow hydrographs and downstream (tidal) boundaries are consistent with the Waterways, Wetlands and Drainage Guide (CCC, 2003).

5.1.5 MIKE 11 INI file

The MIKE 11 .ini file offers the possibility of changing settings within the calculation engine of the software. There are a total of 48 variables that can be changed for hydrodynamic simulations. The following variables are those of importance for flood modelling which have been changed from the default value or alternately were not set a default value:

- HD-Variables no 3 (default = 4): This has been increased to 40. This variable controls the maximum exceedance of water level above any cross section bank-levels;
- HD-Variables no 40 (default = off): This has been changed to on. This variable is generally used for problem detecting when doing linked modelling such as MIKE FLOOD simulations; and
- HD-Variables no 46: This has been set to 50. This variable is used to dampen longitudinal flow oscillations in the XZ-model.

5.2 MIKE URBAN

The MIKE URBAN pipe flow component has not been looked at in detail for this report. It is not considered to be a critical part of the model due to the scale of the scale of the events being looked at. The basic components that make up the MIKE URBAN component are shown in Table 10.

Table 10 MIKE Urban (Mouse Pipe Flow) inputs

Structures	Number
Manholes	1239
Outlets	32
Circular Pipes	628
CRS defined pipes	624

Network flows are modelled using the MOUSE HD Pipe Flow Simulation which utilises the computed runoff hydrographs (.CRF file) from the MOUSE Runoff Model.

The “Model B” approach is used within the MOUSE Runoff component. This approach is founded on the kinematic wave computation. The MIKE URBAN hydrological parameters are summarized in Table 11.

Table 11 MIKE Urban (Mouse Runoff) inputs

Parameter	Impervious surface		Pervious surface	
	Steep	Flat	Medium infiltration	Large infiltration
Wetting (m)	5.00E-05	5.00E-05	5.00E-05	5.00E-05
Storage (m)	-	6.00E-04	6.00E-03	4.00E-03
Start Infiltration (m/s)	-	-	2.00E-05	5.00E-06
End Infiltration (m/s)	-	-	1.4 to 50E-07	1.00E-08
Exponent (s ⁻¹)	-	-	3.75E-04	1.50E-03
Inverse Horton's Equation (s ⁻¹)	-	-	5.00E-06	1 to 5.0E-06
Manning's number (M)	80	8 to 70	5	7.5
Manning's number (n)	0.0125	0.0143 to 0.125	0.2	0.133

5.3 MIKE 21

MIKE 21 uses a 2-dimensional engine and models the floodplain for the Styx catchment. It takes into account the topography of the land and determines overland flow paths and water depths during flood events.

The key parameters within the MIKE 21 model are presented in Table 12.

Table 12 MIKE 21 parameters

Parameter	Values
Module Selection	Hydrodynamic Only
Orientation of Grid	North (0°)
Grid Size	8 metre
Grid Dimensions	12.0 x 13.4 km
Surface Elevations	Combination of Feb 2012 and July-Sept 2011 LiDAR with some local adjustments.
Resistance	From file
Eddy Viscosity	0.85333
Start Type	Cold Start
Time Step	1.5 seconds
Modelling Duration	3.9 days

The MIKE 21 component has been setup as a hydrodynamic model with an 8m grid facing due north. The grid dimensions are 12.0 x 13.4 km encompassing the Styx catchment.

The model is run on a 1.5 second time step with duration of 3.9 days.

Eddy viscosity has been calculated from Tauranga City Council modelling guidelines (yet to be published). This has been reduced from a default value of 1.0.

Flooding and drying has been enabled with a drying depth of 0.01 and a flooding depth of 0.02.

The most recent LiDAR data has been used to represent current topography, with some adjustments made due to the December 2011 earthquake. This is a combination of Feb 2012 and July-Sept 2011 data. Feb 2012 data is only available at a narrow band surrounding the final 5km of the Styx River and the Brooklands suburb, July-Sept LiDAR data is used elsewhere. Local adjustments (to the July-Sept data, subtracting 100mm) have been made on the eastern and western sides of the Feb 2012 LiDAR band to better represent current ground topography.

5.4 MIKE Flood

The three model components are coupled using MIKE FLOOD, allowing the transfer of water from the 1D engines (MIKE 11 and MIKE URBAN) to the 2D engine (MIKE 21) and vice versa in order to predict the flooding expected during various storm events.

Three links types have been adopted within the Styx model in order to link the MIKE 11, MIKE 21 and MIKE URBAN model components. These links are as follows:

- **Lateral Links:** These allow a string of MIKE 21 cells to be laterally linked to a reach in MIKE 11. This link is used to simulate overflow from a river channel onto a flood plain. Flow through the link is calculated using a structure equation, such as a weir;
- **Urban Links:** These links are used to model the interaction of water between a piped network (MIKE URBAN) and the MIKE 21 grid. This link is generally used to represent flow into or from a manhole. Flow through the link is described through either an orifice equation, weir equation or an exponential function; and
- **River / Urban Links:** These links are used to model interaction between a piped network (MIKE URBAN) and the river system (MIKE 11). They are generally used to represent a discharge point via an outlet or an overflow from a manhole. Flow through the link is

determined by the flow within the network and the river water level at the outlet. An adverse head difference at the outlet will drive flow into the network.

Table 13, Table 14 and Table 15 summarise the parameters used for each link type used within the model.

Table 13 Lateral link parameters

Parameter	Value
Number of links	106
Coupling Type	HD only
Method	Cell to cell
Structure Type	Weir 1
Source	Generally HGH with some M21
Depth tolerance	0.1
Weir Coefficient	1.838
Manning's n	0.05

There are a total of 106 lateral links between the river network (MIKE 11) and floodplain (MIKE 21). All links are hydrodynamic only.

Overflow from MIKE 11 to MIKE 21 is modelled using the standard weir formula with a default weir coefficient of 1.838.

The structure source determines where the levee level geometry information comes from, with the setting "HGH" selecting the highest elevation from the MIKE 11 bank marker or the MIKE 21 cell and the setting "M21" selecting the levee elevation based on the M21 cell.

Table 14 Urban link parameters

Parameter	Values
Number of links	1163
Coupling Type	HD only
Number of M21 cells	1
Type	M21 to inlet with 1 M21 to outlet
Max Flow	Generally 0.1 to 0.15 but up to 0.7
Inlet Method	Orifice equation
Inlet area	Generally 0.16 but up to 1.0
Discharge Coefficient	0.98
Qdh factor	0

There are a total of 1163 urban links between MIKE 21 and the piped network (MIKE URBAN). All links are hydrodynamic only. All links (except one) connect the MIKE 21 grid to an inlet, such as a manhole.

Maximum flows that can flow through the links are generally from 0.1 to 0.15 but values with values of up to 0.7.

The inlets are modelled using the standard orifice equation and the associated area are generally 0.16 but with values up to 1.0.

The discharge coefficient is used to scale the orifice flow with a default value of 1.0. This has been decreased to 0.98.

Table 15 River/urban link parameters

Parameter	Values
Number of links	30
Coupling Type	HD only
Type	MIKE URBAN Outlet to MIKE 11

There are a total of 30 links between MIKE URBAN and MIKE 11. All links are hydrodynamic only and represent flow from a MIKE URBAN outlet to MIKE 11.

6. Physical model status

6.1 LIDAR data

Several LiDAR surveys have been completed in the Christchurch area prior to and following the earthquakes. Table 16 outlines the date and approximate coverage of each survey.

Table 16 Christchurch LiDAR surveys

Survey	Date	Coverage
1	2003	All areas
2	October 2010	Eastern areas
3	March 2011	Eastern areas
4	May 2011	All areas
5	August 2011 (July – Sept)	All areas
6	December 2011	Partial
7	February 2012	Partial

Surveys 2 and 3 were partial surveys completed following the September 2010 and February 2011 earthquakes. A full survey was flown in May 2011; this is the most recent LiDAR data for the Christchurch area.

6.2 Model component status

Table 17 summarises the status of each component of the Styx model and what updates have been made following the earthquakes in September 2010 and February 2011.

Table 17 Physical model status

Component	Property	Status
MIKE 11	Cross Sections	Post-earthquake cross sections have been used below the confluence of the Kaputone Stream with the Styx River. The remainder of the cross sections remain unchanged from those pre-earthquakes.
MIKE 21	Surface Elevations	The most recent LiDAR data has been used where available. This is a combination of Feb 2012 and July-Sept 2011 data. Feb 2012 data is only available at a narrow band surrounding the final 5km of the Styx River and the Brooklands suburb. Local adjustments (to the July-Sept data, subtracting 100mm) have been made on the eastern and western sides of this band to better represent current ground topography.
MIKE URBAN	Pipe Networks	A significant portion of the piped stormwater network has been modelled, with a total of 1252 pipes, 1239 manholes and 32 outlets. No changes have been made following the earthquakes.

For the MIKE 11 component cross sections have been updated below the confluence of the Kaputone Stream and Styx River, otherwise this component is unchanged. The MIKE URBAN component remains unchanged following the earthquakes.

7. Compliance with specifications

The following section compares the Styx model against the recently developed *Stormwater Modelling Specifications for Flood Studies* (GHD, 2012), from here on called “modelling specifications”.

Table 18 outlines where the model is not in line with the modelling specifications. For more detail, refer to the modelling specifications. Section 8 recommends the changes to be undertaken to ensure compliance.

Table 18 Compliance with modelling specification

Compliance with Modelling Specification			
Section	Sub Section	Sub-sub Section	Compliance (yes / no or n/a)
Planning	Naming convention		No – Guess
	Co-ordinate system		Yes - Guess
	Documentation of data source		No
Model extents	Hydrological		Yes – Guess
	Hydraulic		Yes
	Rapid flood hazard assessment		n/a
Review of existing data	Stormwater reticulation		Yes - Guess
	Topographical data		Yes
	Meteorological data		Yes - Guess
Model build	Hydrology	Catchment delineation	Yes - Guess
		Rainfall, losses and routing	Yes
	1D hydraulic model	Build	Yes
		Boundary conditions	Yes
		Energy losses	Yes
	2D hydraulic model	Build	Yes
		Boundary conditions	Yes
		Energy losses	Yes
	Coupled 1D/2D models		Yes
	Model stability testing		Unsure
	Model calibration, validation and sensitivity analysis	Calibration	Unsure
		Validation / sensitivity analysis	Unsure
Performance assessment	Rainfall events		Unsure
	Level of service and capacity assessment		Unsure
	Flood mapping		Unsure
	Flood damage assessment		n/a

Key issues

- a. Many Topo ID's are set to default and do not identify the date of cross sections.
- b. Issues of Less Importance
- c. Naming convention of files does not include all the required information.
- d. The coordinate system used within the model is New Zealand Map Grid. New Zealand Transverse Mercator 2000 is the coordinate reference system of choice for CCC.
- e. No additional energy losses have been modelled at bends or at sudden contractions / expansions within the MIKE 11 network.

8. Recommendations for compliance

In order for the Styx model to comply with the modelling specifications, the following actions are recommended:

Actions for key issues

- a. Rename all Topo ID's to include a reference date. If a set of cross sections (Topo ID) contains some cross sections from both pre / post-earthquakes, this should be identified in each cross section ID.

Actions for issues of less importance

- a. Result files shall be renamed to include the following information; river/catchment identifier, land state, rainfall event / frequency and downstream boundary conditions.
- b. The model shall be converted to the New Zealand Traverse Mercator coordinate system.
- c. Ensure any significant bends / contractions / expansions within the MIKE 11 network have been modelled.

9. References

Christchurch City Council (2003). Waterways, Wetlands and Drainage Guide: Part B.

GHD (2012). Stormwater Modelling Specification for Flood Studies. Developed by GHD for Christchurch City Council.

GHD (2012). Guidelines for using Stormwater Modelling Results in Statutory Processes. Developed by GHD for Christchurch City Council.

Appendices

A. Model parameters

Content

Software Used	Model Version: EQ_Q100_10T_500SLR_ED_June11_Re-Cal_v55	
Process	Software	Version
Rainfall - Runoff	MIKE URBAN	v.2011 SP6
Channel Flow	MIKE 11	v.2011 SP6
Pipe Flow	MIKE URBAN	v.2011 SP6
Floodplains	MIKE 21	v.2011 SP6

MIKE 11 Parameters		Model Version: EQ_Q100_10T_500SLR_ED_June11_Re-Cal_v55	
Network File		Number	Details
Branches		39 regular branches with cross sections	Maximum dx of 8m in general
Points		4929 points with system defined coordinates	
Weirs		8 broad crested weirs	No valve regulation
Culverts		25 culverts with varying geometry	Manning's n of 0.013 to 0.040
Bridges		1 bridge; FHWA WSPRO method	FHWA submergence, MIKE 11 weir overflow
Cross Section File	Details	Values	Details
Section Type	One closed irregular section	Open	One closed irregular section
Hydraulic Radius		Total Area, Hyd. Radius	
Resistance Number		Relative Resistance	
-bed resistance (n)	Some exceptions	0.032 to 0.044	Some exceptions
-bank resistance (n)		0.040 to 0.120	
HD Parameters	Default Values	Model Values	Comments
Default Computational Parameters			
-Delta	0.5	0.9	
-Delhs	0.01	0.01	
-Delhs	0.1	0.1	
-Alpha	1	1	
-Theta	1	1	
-Eps	0.0001	0.0001	
-Dh Node	0.01	0.01	
-Zeta Min	0.1	0.1	
-Struc Fac	0	0	
-Inter1Max	20	20	
-Nolter	1	1	
-MaxIterSteady	100	100	

HD Parameters - cont.	Default Values	Values	Comments
-FroudeMax	-1	-1	
-FroudeExp	-1	-1	
Initial Conditions		Initial water heights and flows specified	
Wind			
Bed Resistance			
-Approach		Uniform Section	
-Resistance Formula		Manning's n	
-Resistance Number		0.04	
Wave Approximation		High Order Fully Dynamic	
Quasi Steady Parameters			
-Relax	0.5	0.5	
-Beta_Limit	1.00E-08	1.00E-08	
-Fac_0	2.5	2.5	
-Qconv_factor	0.001	0.001	
-Hconv_factor	0.01	0.01	
-Min_Hconv_In_Branch	0.00001	0.00001	
-Q_struc_factor	0.005	0.005	
-H_stop	0.0001	0.0001	
-Steady State Options	Not Used	Not Used	
Heat Exchange	Not Used	Not Used	
Stratification	Default Values	Default Values	
Groundwater Leakage	Not Used	Not Used	
Flood Plain Resistance	-99	-99	
Encroachment Simulations	Not Used	Not Used	
Boundary Data		Consistent with CCC methodology	
MIKE .ini file		Default values unless specified	
-Variable #40		On	
-Variable #46		50	

MIKE 21 Parameters		Model Version: EQ_Q100_10T_500SLR_ED_June11_Re-Cal_v55	
Parameter	Default Values	Values	Comments
Module Selection	1.0	Hydrodynamic Only	Velocity based
Orientation of Grid		North (0°)	
Grid Size		8 metre	
Grid Dimensions		12.0 x 13.4 km	
Surface Elevations		June 2011 LiDAR data	
Resistance		From file	
Eddy Viscosity		0.85333	
Start Type		Cold Start	
Time Step		1.5 seconds	
Modelling Duration		3.9 days	
Flooding and Drying		0.01 drying, 0.02 flooding	

MIKE FLOOD Parameters		Model Version: EQ_Q100_10T_500SLR_ED_June11_Re-Cal_v55	
Lateral Links	Default Values	Values	Comments
-Number of links -Coupling Type -Method -Structure Type -Source -Depth tolerance -Weir Coefficient -Manning's n	1.838	106 HD only Cell to cell Weir 1 Generally HGH with some M21 0.1 1.838 0.05	
Urban Links	Default Values	Values	Comments
-Number of links -Coupling Type -Number of M21 cells -Type -Max Flow -Inlet Method -Inlet area -Discharge Coefficient -Qdh factor	Orifice equation 0.98 0	1163 HD only 1 M21 to inlet with 1 M21 to outlet Generally 0.1 to 0.15 but up to 0.7 Orifice equation Generally 0.16 but up to 1.0 0.98 0	
River / Urban Links		Values	Comments
-Number of links -Coupling Type -Type		30 HD only MIKE URBAN Outlet to MIKE 11	

Hydrological Model Parameters					Model Version: EQ_Q100_10T_500SLR_ED_June11_Re-Cal_v55				
Name	Area	Length	Slope	ParBID	AISteep	AIFlat	APSmall	APMedium	APLarge
C1	99.6	500	3.5	STYX2-5	1.7	7	0	91.3	0
C10	7.2	270	5	STYX3	1.5	6.2	0	92.3	0
C100A	5.8	196	1.1	STYX2-5	8	32	0	60	0
C100B	7.4	304	28.1	STYX2-5	8	32	0	60	0
C100C	5.2	225	16.2	STYX2-5	10	40	0	50	0
C100D	1.9	107	22.3	STYX2-5	10	40	0	50	0
C101Aa	10.8	406	3.6	STYX4	14	56	0	30	0
C101Ab	1.9	213	1.7	STYX4	11.2	44.8	0	44	0
C101Ba	13.4	839	4.2	STYX2-5	6	24	0	70	0
C101Bb	1.7	166	6.1	STYX2-5	2.4	9.6	0	88	0
C101Bc	1.9	142	1.1	STYX2-5	0	0	0	100	0
C101Ca	12.5	384	6.9	STYX4	5	20	0	75	0
C101Cb	1.6	284	1.3	STYX4	3.6	14.4	0	82	0
C102Aa	1.9	202	5.1	STYX3	9.9	40.1	0	50	0
C102Ab	5.3	208	2.5	STYX3	8	32	0	60	0
C102Ac	0.7	101	8.3	STYX3	8	32	0	60	0
C102Ba	0.5	66	4.4	STYX3	12.9	52.1	0	35	0

C102Bb	10	293	1.9	STYX3	12	48	0	40	0
C103A	2.6	174	4.6	STYX3	10	40	0	50	0
C103B	4.6	298	2.2	STYX3	9	36	0	55	0
C103C	1.8	198	1	STYX3	12	48	0	40	0
C103D	0.8	100	6.5	STYX3	10	40	0	50	0
C103E	3.8	397	1.8	STYX3	12	48	0	40	0
C104a	0.5	194	3.6	STYX3	4.9	20.1	0	75	0
C104b	4.4	266	2.5	STYX3	1	4	0	95	0
C105a	14.2	778	6.1	STYX3	11	44	0	45	0
C105b	4.4	280	3.2	STYX3	11.4	45.6	0	43	0
C106a	1.8	130	5.9	STYX3	9.6	38.4	0	52	0
C106b	8.5	357	0.8	STYX3	10	40	0	50	0
C106c	3.3	200	8.1	STYX3	10	40	0	50	0
C107a	5.2	352	14.9	STYX3	11	44	0	45	0
C107b	7.7	266	5	STYX3	13.5	54.5	0	32	0
C107c	1.7	131	4.4	STYX3	11	44	0	45	0
C107d	0.6	86	7.6	STYX3	13.9	56.1	0	30	0
C107e	12.5	380	2.7	STYX3	6	24	0	70	0
C107f	7	348	6	STYX3	13.9	56.1	0	30	0
C108a	4.5	537	1.2	STYX3	1.2	4.8	0	74	20
C108b	2.9	417	1.6	STYX3	0.4	1.6	0	78	20
C108c	18.6	637	9.7	STYX3	0.3	1.2	0	78.5	20
C108d	8.5	639	3.4	STYX3	0.5	1.9	0	77.6	20
C108e	0.3	69	2.2	STYX3	7	28	0	45	20
C109a	7.7	247	9.4	STYX3	1.1	4.9	0	74	20
C109b	3.8	241	4.5	STYX3	0	0	0	80	20
C110	37.4	306	5.5	STYX2	0.5	2	0	77.5	20
C111	12.9	179	3	STYX2	0.3	1.2	0	78.5	20
C112	8.3	626	3.6	STYX2	0	0	0	80	20
C113	17.8	211	8.3	STYX2	0.4	1.7	0	77.9	20
C114	33.8	290	2.9	STYX4	0.8	3.2	0	76	20
C115	6.3	125	6.9	STYX4	1.1	4.5	0	74.4	20
C116	18	328	27.4	STYX4	8.7	34.7	0	56.6	0
C117A	15.1	359	22.9	STYX4	6.8	27	0	66.2	0
C117B	34.2	400	21.1	STYX4	4.5	18.1	0	77.4	0
C118	13.3	262	16.7	STYX2	7.8	31.2	0	61	0
C119	35.5	400	22.7	STYX2	7.6	30.4	0	62	0
C11a	4.3	296	9.4	STYX3	1.9	8.1	0	90	0
C11b	1.2	601	2.8	STYX3	12.6	52.4	0	35	0
C11c	11.4	316	11.5	STYX3	1.5	6.5	0	92	0
C11d	0.9	278	2.2	STYX3	0	0	0	100	0
C11e	15.6	429	5.9	STYX3	0	0	0	100	0
C120	21	476	22.9	STYX1-75	7.9	31.4	0	60.7	0
C121	16.6	251	4.7	STYX2-5	1	3.9	0	95.1	0
C122	1.5	308	1.2	STYX2-5	8	32.1	0	59.9	0
C123	14	462	5.1	STYX2-5	1	3.8	0	95.2	0
C124	29	400	3.4	STYX2-5	1.4	5.5	0	93.1	0
C125	4.1	242	4.8	STYX2-5	0.8	3	0	96.2	0
C126	8.5	420	2.9	STYX2-5	1	3.9	0	95.1	0
C127	7.8	337	3.4	STYX2-5	0.6	2.5	0	96.9	0
C128	7.3	390	3.3	STYX2-5	2	8	0	90	0
C129a	7.5	455	2.9	STYX2-5	2.4	9.6	0	88	0
C129b	1.1	111	3.9	STYX2-5	2	8	0	90	0
C12a	1.7	169	18.8	STYX3	0	0	0	100	0

C12b	3.9	336	6	STYX3	0.4	1.6	0	98	0
C12c	0.5	70	11.8	STYX3	0	0	0	100	0
C130a	1.7	185	8.8	STYX2-5	0	0	0	100	0
C130b	4.1	202	38.3	STYX2-5	0.3	1.3	0	98.4	0
C131	7.8	453	4.5	STYX2-5	0	0.1	0	99.9	0
C132A	15	514	30.7	STYX2-5	10	40	0	50	0
C132B	11.3	466	2.9	STYX2-5	0	0	0	100	0
C132C	14.2	400	16.2	STYX4	2	7.9	0	90.1	0
C132D	10.4	400	16.4	STYX4	10	40	0	50	0
C132E	4.6	300	23.3	STYX4	10	40	0	50	0
C132F	8.3	285	18.9	STYX2-5	10	40	0	50	0
C132G	5	238	26.1	STYX2-5	8	32	0	60	0
C133	34.9	295	5	STYX2	0.6	2.6	0	76.8	20
C134a	1.8	195	3.5	STYX3	1.4	5.6	0	93	0
C134b	1.5	173	5.8	STYX3	0	0	0	100	0
C135	9.5	343	3.2	STYX4	6.6	26.4	0	67	0
C136	9	311	21.5	STYX4	8.1	32.6	0	59.3	0
C137	7.3	245	32.5	STYX4	3.2	13	0	83.8	0
C138	42.3	995	1.6	STYX1-75	6.7	26.9	0	66.4	0
C139	10.5	300	19	STYX1-75	8.3	33.1	0	58.6	0
C13a	12.4	522	0.9	STYX3	0.5	1.9	0	97.6	0
C13b	1.5	204	9.5	STYX3	0.2	0.8	0	99	0
C13c	0.6	167	2.6	STYX3	1.6	6.4	0	92	0
C13d	4	251	3.1	STYX3	4.4	17.6	0	78	0
C140	5.3	343	1	STYX2-5	2.8	11.4	0	85.8	0
C141	7.6	232	2.8	STYX2-5	8	32	0	60	0
C142	8.2	294	1	STYX2-5	0.7	2.9	0	96.4	0
C143	8.9	371	3.1	STYX2-5	1.1	4.3	0	94.6	0
C144	5.5	331	1	STYX2-5	0.6	2.5	0	96.9	0
C145	3.4	213	6.3	STYX2-5	0	0	0	100	0
C146	2.5	144	40.2	STYX2-5	0.3	1.2	0	98.5	0
C147	3.2	228	14.2	STYX2-5	0	0	0	100	0
C148	4.1	266	8.6	STYX2-5	5	20	0	75	0
C149a	11.8	372	15.2	STYX2-5	1	4	0	95	0
C149b	2	152	48.3	STYX2-5	0	0	0	100	0
C149c	7.2	374	6.9	STYX2-5	6	24	0	70	0
C14a	5.7	299	6.5	STYX3	0.5	2	0	97.5	0
C14b	2.5	235	5	STYX3	8	32	0	60	0
C14c	3.5	264	2	STYX3	7	28	0	65	0
C14d	3.9	239	2	STYX3	6	24	0	70	0
C14e	1.2	142	4.5	STYX3	0.4	1.6	0	98	0
C14f	5.3	442	5.1	STYX3	9	36	0	55	0
C15	11.8	400	3.3	STYX3	1.1	4.4	0	74.5	20
C150a	2.6	179	4.1	STYX2-5	1	4	0	95	0
C150b	0.5	84	16.5	STYX2-5	2	8	0	90	0
C150c	0.8	99	7.8	STYX2-5	3.5	14.5	0	82	0
C151	4.5	215	1.7	STYX3	0.8	3.2	0	76	20
C152	2.6	209	1.6	STYX3	0.8	3.2	0	76	20
C153	2.7	240	1.5	STYX3	0	0	0	80	20
C154	3.7	236	3.6	STYX3	0.3	1.2	0	78.5	20
C155	299.5	300	2	STYX4	0.8	3.2	0	76	20
C156	303.4	350	1.3	STYX2	1	1.2	0	72.8	25
C157	212.4	600	2	STYX10	0	1.2	0	98.8	0
C158	220	350	1	STYX2	1	4	0	70	25

C159a	523.3	2060	1.4	STYX5	0.3	1.2	0	78.5	20
C159b	26.9	755	2	STYX5	0	1.5	0	98.5	0
C16	4.8	300	1	STYX3	4.6	18.4	0	57	20
C160A	18.8	276	1	STYX3	5	20	0	55	20
C160B	1.6	138	2.3	STYX3	13.6	54.4	0	12	20
C160C	3	210	2.3	STYX3	5.6	22.4	0	52	20
C160D	48.2	869	1.8	STYX5	5.6	22.4	0	52	20
C160E	1.7	117	9.5	STYX5	2	8	0	70	20
C161a	27.9	1166	1.2	STYX5	5	20	0	55	20
C161b	5	501	2.9	STYX5	3.6	14.4	0	62	20
C162	107.2	300	5.2	STYX3	5	20	0	65	10
C163	149.4	350	1.6	STYX4	0.3	1.4	0	73.3	25
C164	63.3	300	5.2	STYX3	1.9	7.5	0	70.6	20
C165	95.8	250	4	STYX3	7	30	0	43	20
C166	172.1	400	3	STYX3	0	1.2	0	58.5	40
C167	86.2	350	2	STYX2	0	1.2	0	68.6	30
C17	16.7	300	3.6	STYX3	3	12	0	65	20
C19a	4.5	563	17.5	STYX5	2	8	0	70	20
C19b	3	229	3.1	STYX5	2.4	9.6	0	68	20
C19c	1.5	192	2.7	STYX5	1	4	0	75	20
C19d	31.5	712	4	STYX5	2.4	9.6	0	68	20
C2	83.9	500	4.9	STYX2-5	2	8	0	90	0
C20a	47.6	792	3.7	STYX3	0.5	2	0	77.5	20
C20b	7.6	397	5.1	STYX3	0	0	0	80	20
C23	7.2	135	2.7	STYX4	1	4	0	75	20
C24a	77.6	796	5.7	STYX3	0.6	2.4	0	77	20
C24b	1	220	4.8	STYX3	14	56	0	10	20
C24c	19	920	2.2	STYX3	4	16	0	60	20
C25	31.6	280	3.1	STYX3	1.3	5	0	73.7	20
C26	216.5	215	1	STYX2	1.3	5.1	0	73.6	20
C27	8.2	498	3	STYX2	1.1	4.4	0	74.5	20
C28	14.1	400	4.6	STYX2	0.4	1.6	0	78	20
C29	15.4	400	2	STYX3	0.8	3.2	0	76	20
C3	10.2	380	9.7	STYX2-5	4	16	0	80	0
C30A	12.5	294	15.6	STYX2	4.9	19.6	0	75.5	0
C30B	22.3	500	20	STYX2	8	32	0	60	0
C30C	15.8	500	24	STYX2	5	20	0	75	0
C31A	25.9	500	21.2	STYX2	12	48	0	40	0
C31B	3	131	16.9	STYX2	10	40	0	50	0
C31C	2.6	87	13.2	STYX2	10	40	0	50	0
C31D	2.8	123	16.7	STYX2	10	40	0	50	0
C31E	4	177	20.9	STYX2	8	32	0	60	0
C32	35.8	400	2.5	STYX2	12	48	0	40	0
C33	9.2	250	4.2	STYX2	12	48	0	40	0
C34A	4.3	209	22.6	STYX2	9	36	0	55	0
C34B	6.5	111	19.9	STYX2	9	36	0	55	0
C34C	4	201	17.4	STYX2	9	36	0	55	0
C34D	6.5	212	14.5	STYX2	9	36	0	55	0
C35A	9.1	374	18.5	STYX1-75	9	36.1	0	54.9	0
C35B	3.9	194	26.9	STYX1-75	9	36	0	55	0
C35C	6.1	152	15.3	STYX1-75	9	36	0	55	0
C35D	3.3	115	10.9	STYX1-75	9	36	0	55	0
C35E	9.7	300	16.9	STYX1-75	9	36	0	55	0
C35F	3.3	241	24.1	STYX1-75	9	36	0	55	0

C35G	7	338	25.1	STYX1-75	8	32	0	60	0
C35H	8.9	399	18.3	STYX1-75	8	32	0	60	0
C36A	19.7	431	16.9	STYX2-5	8	32	0	60	0
C36B	11.4	416	25	STYX2-5	8	32	0	60	0
C36C	6.5	360	28.2	STYX2-5	8	32	0	60	0
C36D	3	191	18.4	STYX2-5	8	32	0	60	0
C36E	7.7	302	25.4	STYX2-5	7.7	30.7	0	61.6	0
C36F	14.8	375	20	STYX2-5	8.2	32.8	0	59	0
C36G	1.5	155	19.6	STYX2-5	9	36	0	55	0
C37A	7.8	445	21.8	STYX2-5	8.9	35.5	0	55.6	0
C37B	8.1	300	24.1	STYX2-5	8.4	33.7	0	57.9	0
C37C	8.8	300	15.9	STYX2-5	8.7	34.9	0	56.4	0
C37D	8.8	455	35	STYX2-5	7.2	28.9	0	63.9	0
C37E	4.4	229	14.6	STYX2-5	8.5	34	0	57.5	0
C38	99.4	1740	3.7	STYX2-5	2	8	0	90	0
C39	5.6	312	3.6	STYX2-5	0	0	0	100	0
C4	6.1	297	8	STYX2-5	4	16	0	80	0
C40	6	251	1.8	STYX2-5	1.3	5	0	93.7	0
C41	8.2	296	1.7	STYX2-5	1.4	5.6	0	93	0
C42	8.9	351	9.6	STYX2-5	6	24	0	70	0
C43a	7.7	259	4.9	STYX2-5	2	8	0	90	0
C43b	8	316	2.7	STYX2-5	1	4	0	95	0
C44	2	114	21.3	STYX3	8	32	0	60	0
C45a	3	283	12	STYX2-5	0.6	2.7	0	96.7	0
C45b	17.9	533	2.5	STYX2-5	1	4	0	95	0
C46a	0.8	154	6.2	STYX2-5	9	36	0	55	0
C46b	0.3	246	3.3	STYX2-5	8	32	0	60	0
C46c	0.4	282	2.6	STYX2-5	12	48	0	40	0
C46d	7.6	351	1.2	STYX2-5	2.4	9.6	0	88	0
C46e	19.7	556	1.2	STYX2-5	1.6	6.4	0	92	0
C46f	9.2	404	2.3	STYX2-5	0.4	1.6	0	98	0
C47	13.6	390	5	STYX2-5	0.2	0.8	0	99	0
C48	5.1	214	3	STYX3	0.4	1.6	0	98	0
C49a	0.6	97	21	STYX3	2.4	9.6	0	88	0
C49b	8	359	2.2	STYX3	2.4	9.6	0	88	0
C5	3.1	145	3.9	STYX2-5	4	16	0	80	0
C50	7	332	4	STYX3	2.4	9.6	0	88	0
C51A	8.3	345	1.5	STYX3	5.6	22.4	0	72	0
C51Ba	2.5	205	1.1	STYX3	11.6	46.4	0	42	0
C51Bb	2.5	145	1.6	STYX3	11	44	0	45	0
C51Ca	2.1	179	4.1	STYX3	11	44	0	45	0
C51Cb	10	359	1	STYX3	9	36	0	55	0
C51D	3.6	205	4.1	STYX3	11	44	0	45	0
C52a	0.5	217	4.2	STYX3	4.2	15.8	0	80	0
C52b	9.4	264	8.7	STYX3	1	4	0	95	0
C53a	0.3	103	3.3	STYX3	7.5	27.5	0	65	0
C53A	0.9	106	3.3	STYX3	9	36	0	55	0
C53b	0.2	114	5.4	STYX3	0	0	0	100	0
C53c	5.6	446	5.4	STYX3	2.1	7.9	0	90	0
C53d	3.6	170	5.5	STYX3	0.2	0.8	0	99	0
C54a	0.4	202	4.7	STYX3	0	0	0	100	0
C54A	1.4	151	12.7	STYX3	12	48	0	40	0
C54b	7.4	365	7.3	STYX3	0	0	0	100	0
C54c	4.4	188	7.6	STYX3	0	0	0	100	0

C55a	2.2	188	7.2	STYX3	0	0	0	100	0
C55A	0.7	64	7.3	STYX3	10	40	0	50	0
C55b	2.2	168	5.1	STYX3	0	0	0	100	0
C55c	0.4	39	12.3	STYX3	0	0	0	100	0
C56a	2.2	204	7.6	STYX3	0	0	0	100	0
C56A	0.7	71	6.8	STYX3	11	44	0	45	0
C56b	2.2	113	9.3	STYX3	0	0	0	100	0
C56c	0.3	27	8.7	STYX3	0	0	0	100	0
C57a	2	195	7.2	STYX3	0	0	0	100	0
C57A	0.7	82	2.8	STYX3	10	40	0	50	0
C57b	2.4	126	12.7	STYX3	0	0	0	100	0
C58a	0.4	93	6.4	STYX3	0	0	0	100	0
C58A	0.9	99	1	STYX3	11	44	0	45	0
C58b	4.1	281	5.1	STYX3	0	0	0	100	0
C59a	1.5	171	11.9	STYX3	0.4	1.6	0	98	0
C59b	0.9	163	7.9	STYX3	6	24	0	70	0
C6	30.8	843	4.2	STYX3	1	3.7	0	95.3	0
C60a	0.9	84	6.8	STYX3	0.4	1.6	0	98	0
C60b	0.4	63	2.6	STYX3	8	32	0	60	0
C60c	0.9	98	14.7	STYX3	7	28	0	65	0
C61a	2.3	148	5	STYX3	8	32	0	60	0
C61b	5.9	241	5.4	STYX3	4.4	17.6	0	78	0
C61c	1	150	3.5	STYX3	12	48	0	40	0
C61d	9.5	368	2	STYX3	11.6	46.4	0	42	0
C62a	0.3	70	8.2	STYX3	11	44	0	25	20
C62b	8	387	0.6	STYX3	3	12	0	65	20
C63a	0.2	53	10.9	STYX3	13	52	0	15	20
C63b	14.1	480	1.9	STYX3	0.5	2	0	77.5	20
C64	29.5	859	4.3	STYX3	0.7	2.8	0	76.5	20
C65	6.1	358	11.9	STYX3	0.6	2.4	0	87	10
C66a	3.8	284	2.9	STYX3	2	8	0	70	20
C66b	7.4	272	8.4	STYX3	2.6	10.4	0	67	20
C67	11.9	382	4.4	STYX3	0	0	0	80	20
C68	5.9	395	1.8	STYX3	0	1	0	79	20
C69a	21.9	415	3.8	STYX3	1	3.8	0	75.2	20
C69b	0.6	74	2.6	STYX3	1	4	0	75	20
C69c	0.3	41	9.5	STYX3	1	4	0	75	20
C69d	2.4	122	12	STYX3	0	0	0	80	20
C7	24	480	5	STYX3	0.4	1.4	0	98.2	0
C70	20.7	227	1	STYX3	1.4	5.6	0	73	20
C71a	3.1	416	1.8	STYX3	0.4	1.6	0	78	20
C71b	10.7	486	1.4	STYX3	13	52	0	15	20
C71c	21.1	512	3.3	STYX3	5	20	0	55	20
C71d	0.9	120	1.3	STYX3	6	24	0	50	20
C71e	1.5	340	6	STYX3	0.6	2.4	0	77	20
C72a	6.2	269	10.2	STYX3	1	4	0	75	20
C72b	2.7	265	4.8	STYX3	7.1	27.9	0	45	20
C72c	5.1	255	1.8	STYX3	0	0	0	80	20
C72d	7.4	308	1.8	STYX3	0	0	0	80	20
C72e	30.2	682	1.5	STYX3	4	16	0	60	20
C72f	0.4	51	11.1	STYX3	3	12	0	65	20
C73a	72.2	957	5.4	STYX3	0.8	3.2	0	76	20
C73b	1.5	122	1.1	STYX3	1	4	0	75	20
C74	4.6	107	2.4	STYX3	1.8	7.3	0	70.9	20

C75	23	240	4.7	STYX3	0.8	3.2	0	76	20
C76	12.4	176	3.9	STYX2	0.6	2.4	0	77	20
C77	11.5	170	4.6	STYX2	1.1	4.5	0	74.4	20
C78	22.3	236	8.2	STYX2	0.5	2.2	0	77.3	20
C79	20.2	225	4.1	STYX2	0.7	2.9	0	76.4	20
C8	3.5	194	2.5	STYX3	4	16	0	80	0
C80	36.4	453	5	STYX2	1.1	4.6	0	74.3	20
C81	25	365	5	STYX2	0.2	0.9	0	78.9	20
C82A	35.6	400	26.1	STYX2	9.2	36.9	0	53.9	0
C82B	10.3	246	20.3	STYX2	7.4	29.4	0	63.2	0
C82C	12.5	424	23.6	STYX2	8.5	33.8	0	57.7	0
C83	51.4	500	21.3	STYX2	7.4	29.6	0	63	0
C84	35.3	500	21.4	STYX2	7.3	29.1	0	63.6	0
C85A	5.5	336	19.4	STYX1-75	7.8	31.4	0	60.8	0
C85B	4.2	186	17	STYX2-5	9.5	37.8	0	52.7	0
C85C	10.2	316	13.8	STYX1-75	6.4	25.6	0	68	0
C85D	9.5	292	22	STYX2-5	9.8	39.1	0	51.1	0
C86A	1.7	134	15	STYX1-75	8	32	0	60	0
C86B	3.8	143	18.3	STYX2	5.4	21.6	0	73	0
C86C	4	253	21.7	STYX2	9	36	0	55	0
C86D	3.8	110	19.2	STYX2	10	40	0	50	0
C86E	3	178	15.7	STYX2	14	56	0	30	0
C86F	1.8	101	14.8	STYX2	8	32	0	60	0
C86G	1	119	19.4	STYX2	8	32	0	60	0
C86H	1.7	105	16	STYX2	8	32	0	60	0
C86I	4.8	312	14.6	STYX1-75	11	44	0	45	0
C87A	12.8	315	12.6	STYX2	10	40	0	50	0
C87B	6.4	240	24.2	STYX2	10	40	0	50	0
C88A	2.2	166	21.6	STYX1-75	8	32	0	60	0
C88B	5.2	233	16.6	STYX2	8	32	0	60	0
C88C	3.9	231	18.3	STYX1-75	8	32	0	60	0
C88D	6.6	304	19	STYX2	8	32	0	60	0
C88E	6.9	278	18.1	STYX2	8	32	0	60	0
C88F	3.1	241	16.5	STYX1-75	8	32	0	60	0
C89A	14.1	501	17.5	STYX2-5	8.3	33.2	0	58.5	0
C89B	27	843	26.4	STYX2-5	9.2	36.7	0	54.1	0
C89C	11	442	23.7	STYX2-5	8.8	35.4	0	55.8	0
C9	4.9	221	7.6	STYX3	2.4	9.6	0	88	0
C90A	10.8	300	23.3	STYX2-5	8	32	0	60	0
C90B	4.1	218	22.2	STYX2-5	8	32	0	60	0
C90C	7.7	300	31.5	STYX2-5	8	32	0	60	0
C90D	3.1	272	15.6	STYX2-5	8	32	0	60	0
C91	31.4	725	3.1	STYX2-5	1	4.1	0	94.9	0
C92	5.9	319	3	STYX2-5	1.5	6	0	92.5	0
C93	18	779	3.1	STYX2-5	1.6	6.5	0	91.9	0
C94a	1.6	86	7.9	STYX2-5	0.4	1.6	0	98	0
C94b	12.7	663	2.9	STYX2-5	0.6	2.4	0	97	0
C95	3	201	5.2	STYX2-5	0	0	0	100	0
C96	2.7	354	1.2	STYX2-5	0	0	0	100	0
C97	5.3	277	14	STYX2-5	1.5	5.9	0	92.6	0
C98	17.3	400	6.9	STYX2-5	0.1	0.5	0	99.4	0
C99	5.8	289	3	STYX2-5	1.1	4.3	0	94.6	0

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0	Mark Pennington	Tom Parsons		Evan Mayson		02/11/2012

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