REPORT

Tonkin+Taylor

Orchard/Orphanage hydraulic model update

Prepared for
Nelson City Council
Prepared by
Tonkin & Taylor Ltd
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Document control

Title: Orchard/Orphanage hydraulic model update					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
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Distribution:

Nelson City Council	1 electronic copy
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1 Introduction

Tonkin & Taylor Ltd (T+T) has been engaged by Nelson City Council (NCC) to update the existing Orchard and Orphanage Streams hydraulic model.

WSP previously reviewed the Orchard/Orphanage hydraulic model (version 202007 v32) in January 2021. Refer WSP's memorandum "Final Peer Review of T&T Orchard-Orphanage Catchment Model Update", 11 January 2022.

NCC has since requested that updates be made to the hydraulic model in preparation for a proposed Housing Plan Change in 2023.

This work is needed to maintain confidence in model results by including latest data and information. It is limited to what can be achieved in the available timeframes, with a number of future model improvements identified for the next release. A model version history is provided for context in Table 1.1 below.

The work has been undertaken under our conditions of engagement, Professional Services Brief Variation Order 15 dated 20 March 2023, T+T ref: 870888.0013.

Table 1.1: Orchard/Orphanage model version history

Hydrologic model version	Description
Source models *HEC-HMS*	• The models were originally built by MWH (now Stantec) in 2016 as separate "Orchard" and "Orphanage" catchment models under the "Nelson Urban Stream Flood Modelling" (MWH, June 2016). • Stantec supplied the Orphanage model to Tonkin & Taylor Ltd (T+T) in 2017 for the purpose of representing a culvert upgrade at Saxton Road East and bunding in the Saxton Reserve. • Stantec updated the Orchard model with HIRDs v4 rainfall data and MfE's updated climate change scenarios in 2019/2020. • Following this update, the Orchard model was handed over to T+T in July 2020 for the purpose of combining with the Orphanage model to create a single combined model.
202007v1 *HEC-HMS*	• This was the first peer reviewed version of the combined catchment model. Peer review was provided by WSP. • Hydrologic model used for Nelson Urban Streams hydraulic modelling project (July 2021).
202205v5 *MIKE by DHI*	• Hydrological schematisation approach updated with "overland flowpath" and "split-flow" subcatchments to improve modelling of overland flowpaths across the range of design events. • This model version is described as part of this model update report.
Hydraulic model version	**Description**
Source model *MIKE by DHI*	• The models were originally built by MWH (now Stantec) in 2016 as separate "Orchard" and "Orphanage" flood models under the "Nelson Urban Stream Flood Modelling" (MWH, June 2016). • Stantec provided the Orphanage model to Tonkin & Taylor Ltd (T+T) in 2017 for the purpose of representing a culvert upgrade at Saxton Road East and bunding in the Saxton Reserve. • Stantec updated the Orchard model with HIRDs v4 rainfall data and MfE's updated climate change scenarios in 2019/2020.

	• Following this update, the Orchard model was handed over to T+T in July 2020 for the purpose of combining with the Orphanage model to create a single combined model.
OrchOrph_202007v32 *MIKE by DHI*	• This was the first peer reviewed version of the combined flood model. Peer review was provided by WSP. • Hydraulic model used for Nelson Urban Streams hydraulic modelling project (July 2021).
OrchOrph_202210_V19 *MIKE by DHI*	• Hydraulic model schematisation, terrain data and vertical datum updated. • This model version was issued to WSP for peer review on 22/11/2022.
OrchOrph_202210_V20 *MIKE by DHI*	• Updates to hydraulic model following peer review comments (WSP, 14/12/2022). • This model version is described as part of this model update report.

2 Model updates

2.1 Hydrological model

This memo refers to the latest hydrological model, version: **202205v5.**

The hydrological model has been updated since the last peer-reviewed version. The update affects the delineation of some subcatchments, and maximum subcatchment rates of discharge to Orchard Stream, as described below. Base catchment loss parameters based on existing land-use and design rainfall data remain unchanged.

Runoff during rainfall events is conveyed through an urban catchment via a combination of the pipe network (**primary system**) and overland flowpaths (**secondary system**, typically including sheet flow, open drains, kerb and channels and watercourses). In Nelson, the design standard for capacity of new pipes is conveyance of the 2090 RCP8.5 6.67% AEP[1] flow. In larger events (and/or where pipes are currently undersized), any flow in excess of this capacity is conveyed overland. That is, during extreme events, runoff is often split between piped and overland flow, with the split amount governed by the capacity of the pipe network.

Secondary flowpaths often follow similar alignments to the primary (piped) network within a catchment. However, depending on topography and network layout for a given subcatchment, it is not uncommon for the piped component of a catchment's runoff to enter a receiving watercourse (e.g. Orchard Stream) at a different location to the overland flow component.

Orchard Stream subcatchments were previously delineated based on the piped stormwater network system. This assumed that all runoff from the subcatchment is conveyed into the Orchard Stream at the pipe discharge point, whether via pipe or overland flow. This is a reasonable approximation for some subcatchments, but less so for others. For some subcatchments within the urban area of the Orchard Stream catchment, the primary network conveys flows towards Orchard Stream, while flows in excess of the primary (piped) system capacity are expected to be conveyed overland away from Orchard Stream. Thus, an assumption that both the primary and overland flow catchments both discharge to the stream at the pipe outlet point in the stream is likely to lead to an over-estimation of flows at that point in the stream. This was discussed with NCC and the following approach agreed:

1 Identify locations where overland flowpaths are expected to flow away from Orchard Stream (based on topography) while the stormwater pipe network drains to Orchard Stream ('split-flow' subcatchments).

[1] Annual Exceedance Probability

2 Undertake hydrological modelling of these subcatchments to generate runoff hydrographs for design events, as per previous modelling.

3 The resulting runoff hydrographs from split-flow subcatchments are then capped at the maximum capacity of the outlet pipes (based on free full flow hand calculation). These are referred to as 'urban-only' subcatchments within the hydrological model, i.e. only runoff from the urban stormwater pipe network is included.

4 The residual flows would in reality follow overland flowpaths from the exceeded pipe intake location, according to local topography. However, as the focus of this model is on understanding flooding associated with river outbreak rather than pipe network capacity exceedance, NCC has elected not to add these residual flows to the 2d model. This means that any flooding due to this exceedance will be not represented in this model. This flooding would instead be represented in NCC's separate stormwater model.

Table 2.1 below outlines the updates made to the hydrological model (version *202205v5*).

Table 2.1: Hydrological model updates

Ref.		Model update (202205v5)
1	Subcatchments	• LiDAR used to generate subcatchments and indicative overland flowpath directions via GIS process. • Model subcatchments re-digitised based on: – Those flowing directly into stream – Those flowing away from stream but pipe network flows into stream (named 'split-flow' subcatchments). • Note that this results in a small overlap in subcatchments where pipe network flows into Orchard Stream but overland flowpath flows in Orphanage Stream (or vice versa). • Longest flowpaths re-digitised.
2	Hydrological parameters	• Hydrological parameters (CN, lag time) recalculated as per previous methodology.
3	Rainfall	• HIRDs v4 reports regenerated from approximate centroid of updated sub-catchments. • Hyetographs regenerated as per previous methodology.
4	Hydrological model	• Hydrological model converted from HEC-HMS to Mike Urban. This change improves the model as follows: – Same software as hydraulic model – Sits with hydraulic model – Easier to update storm scenarios – Run at 1 minute intervals (compare 5 minute intervals previously) to improve resolution.

Ref.		Model update (202205v5)
5	Runoff transform	• Runoff flows from the 'split-flow' subcatchments are transformed from the Mike Urban hydrology output (crf) file as follows: – Theoretical capacity of 'split-flow' subcatchments' outlet pipe is calculated assuming free full flow – Slope is calculated using inverts from Top of the South Maps – Where upstream/downstream inverts are not known, a slope of 1% is assumed – Runoff flow from the hydrological model is capped to the outlet pipe capacity for the 'split-flow' subcatchments – Transformed runoff is exported to dfs0 format ready for loading in to the hydraulic model. • Note that sensitivity tests of the assumed pipe slope indicates that the absolute error associated with this not significant compared to the overall catchment flows.
6	Runoff loading	• Loading locations of the runoff are updated based on the updated s ub-catchments. • Location is based on GIS-generated overland flowpaths.

2.2 Hydraulic model

This memo refers to the latest hydraulic model, version: **OrchOrph_202210_V20**

The hydraulic model has been updated since the last reviewed version.

Generally, updates have incorporated the following:

- Update of terrain from 2015 to 2021 LiDAR
- Addition of recently constructed flood protection works (stopbanks and flood walls) at Orphanage Stream
- Refinement of 1D channel/2D mesh extents
- Update of vertical datum from NCC Vertical Datum to NZVD2016.

Updates that were not carried out and are flagged for future model improvements include the following:

- Software upgrade to MIKE+
- Incorporation of Saxton Creek. Currently, the Orphanage Stream flood extents interact with Saxton Creek. No allowances have been made for any interaction of flood flows between Orphanage Stream and Saxton Creek. Orphanage Stream outbreak flooding is artificially constrained in the model beyond (south of) Saxton Creek, as can be seen in the 2D model results. Results in this area are considered inaccurate; this area is expected to be covered in a separate model for the Saxton Creek catchment (although there is hydraulic interaction). Issued model results are therefore trimmed at Saxton Creek for the purposes of this flood mapping exercise.
- Adjustment of sea level rise values to incorporate NZSeaRise/VLM data. Current values (1.11 m to 2130 RCP8.5M) are based on MfE 2017.
- The tidal boundary is not represented in the 2D model as "bathtub modelling" of coastal inundation shows that the highest design tide level including projected sea level rise is not expected to overtop the state highway, which effectively acts as a flood barrier. Results downstream of the highway (i.e. in the estuary) are not considered accurate and will be trimmed in post-processing.

- Use of August 2021 and August 2022 observations (flood levels, rain radar and rainfall/flow gauge data) to recalibrate the hydrological and hydraulic models.
- Inclusion of new Orchard Stream culvert at approx. chainage 1,450 m (at 42 Curtis Street).
- LiDAR resolution at Orphanage North is very poor. 1D channel extents purposefully kept wide so that refinement can more easily be made in later stages. It is recommended that survey is obtained for this heavily vegetated area and incorporated into the model.

Table 2.2: Hydraulic model updates

Ref.		Previous model (202007_v32)	Updated model (202210_V20)
1	General information	• Orchard Stream and Orphanage Stream • Coordinate system: NZTM 2000 • Vertical Datum: **NCC Datum** • Base tidal condition: MHHW (1.21 mRL)	• Orchard Stream and Orphanage Stream • Coordinate system: NZTM 2000 • Vertical Datum: **NZVD2016** • Base tidal condition: MHHW (1.21 mRL)
2	Software	• MIKE by DHI 2017 (flexible mesh)	• unchanged
3	2D digital elevation model	• 2015 LiDAR	• 2021 LiDAR • 2021 Orphanage flood protection works (source: as-builts). Incorporated through use of dikes, mesh level adjustment and changes to cross section bank levels.
4	2D mesh size	• Constant mesh: Mesh elements <10 m^3 (sides typically <5 m). • Refinement mesh area – Railway reserve: Mesh elements < 5 m^2.	• River mesh arcs (1D extent): 1 m spacing. • Road mesh arcs: 4 m spacing. • Mesh boundary extent arc: 8 m spacing.
5	2D roughness	• Methodology unchanged from original models built by MWH (now Stantec) in 2016. This applies roughness values based on NCC Planning Zones. • Roughness map extended to cover both Orchard and Orphanage Streams. • Refer to Appendix B for 2D roughness values.	• unchanged
6	1D river	<u>Centreline</u> • Centreline unchanged from original models built by MWH (now Stantec) in 2016. <u>Cross sections</u> • Cross section data source 1: 2015 survey (ID recorded as 'CHxx' in cross sections file). • Cross section data source 2: 2015 LiDAR (ID recorded as 'GISxx' in cross sections files).	<u>Centreline</u> • Centreline adjusted using 2021 LiDAR. Note that changes mainly apply to upstream branches of Orphanage Stream. <u>Cross sections</u> • Cross section data source 1: 2021 LiDAR cross sections cut at approximately 10 m intervals. • Cross section data source 2: cross sections are updated to include Orphanage flood protection works

Ref.		Previous model (202007_v32)	Updated model (202210_V20)
		• Note that there was significant distance between cross sections in these models.	(stopbanks and flood walls) where they lie within the 1D extent. • Cross section data source 3: 2015 survey cross sections are retained in the model. <u>River 'no mesh' extent</u> • 1D river extent is refined using a combination of 2021 LiDAR cross sections, property boundaries and previous results.
7	1D (river) roughness	• Manning's n = 0.045 (following analysis of flooding and flows at Suffolk Road Bridge).	• unchanged
8	1D structures	• Refer structures table provided in Appendix C.	• Structures unchanged but converted to NZVD2016. • Addition of floodplain culvert at Storage World using as-builts provided by NCC. • Addition of culvert upstream of Nikau Street following peer review comments on V19 of the model. As-builts were provided by NCC. • Manning's n roughness of concrete structures updated from n = 0.013 to n = 0.015. • Refer structures table provided in Appendix C.
9	1D stormwater network	• Orchard Stream is piped for a portion. This is modelled in Mike Urban.	• Concrete roughness is reduced from n = 0.019 to n = 0.015 following peer review comments on V19 of the model. • Urban network is simplified from previous model version due to instabilities. • Simplification 1 –portion of Orchard Stream that is supposed to daylight between 7A/7B Titoki Street is ignored. 900mm dia. pipe is assumed to connect right through. No information about daylighting portion. Unstable when represented as open channel. • Simplification 2 – network is simplified (pipes merged) where grade is constant and manhole is shown not to spill in 1 hour duration testing (critical duration).
10	1D/2D coupling		• Mike urban spilling is reduced to a maximum flow of 0.05 m^3/s on the assumption of 2 catchpits being connected for each manhole.

Ref.		Previous model (202007_v32)	Updated model (202210_V20)
			• Orphanage Flood Protection works (2021) have a stopbanks and flood walls. The flood wall is very narrow and therefore represented in MIKE 11. Coupling at lateral link is therefore set to M11. Note that a dike in MIKE 21 at the upstream end is used to represent the flood wall return and prevent flows getting around the back of the wall at the upstream end. • Portion of Orchard stream that is supposed to daylight at 5 Polstead is coupled to M21 via centreline. Google streetview indicates an open drain is possible but uncertain at this location.
11	**Calibration/ validation**		• A preliminary validation exercise was undertaken using the August 2021 event. • Note that the 5th – 6th August 2021 event was a relatively small event (approximately a 0.2 AEP "5 year" event). • The scenario results confirmed modelled manning's n values are generally appropriate, and no changes to the model were made as a result.

3 Applicability

This report has been prepared for the exclusive use of our client Nelson City Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
	
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Appendix A Model schematic

Hydrology model version: *202205v5*

LEGEND

- Orphanage at Ngawhatu gauge (approx location)
- Orphanage subcatchments
- Orchard subcatchments
- Longest flowpath
- Indicative hydrological loading location
- Modelled 1D river network

Terrain: 2015 LiDAR

High : 500

Low : 0

Orphanage_11
Orphanage_19
Orphanage_14
Orphanage_17
Orphanage_18
Orphanage_15
Orphanage_09
Orphanage_06
Orphanage_20
Orphanage_10
Orphanage_16
Orphanage_12
Orphanage_13
Orphanage_07
Orphanage_04
Orphanage_08
Orphanage_21
Orphanage_05
Orphanage_03
Orphanage_02
Orphanage_01

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

Eagle Technology, Land Information New Zealand

PROJECT	ORCHARD/ORPHANAGE MODEL UPDATE 870888.0013
TITLE	MODEL SCHEMATIC: ORPHANAGE CATCHMENT HYDROLOGY MODEL 202205V5
SCALE (A3)	1:20,000

LEGEND

- Orphanage at Ngawhatu gauge (approx location)
- Orphanage subcatchments
- Orchard subcatchments
- Longest flowpath
- Indicative hydrological loading location
- Modelled 1D river network

Terrain: 2015 LiDAR

High : 500

Low : 0

Hydrology model version: *202205v5*

Orphanage_11
Orphanage_14
Orphanage_19
Orphanage_15
Orphanage_17
Orphanage_18
Orphanage_04
Orphanage_09
Orphanage_20
Orphanage_10
Orphanage_16
Orphanage_06
Orphanage_05
Orphanage_12
Orphanage_13
Orphanage_07
Orphanage_21
Orphanage_08

A3 SCALE 1:10,000

0 0.2 0.4 0.6 0.8 1 (km)

Eagle Technology, Land Information New Zealand

PROJECT	ORCHARD/ORPHANAGE MODEL UPDATE 870888.0013
TITLE	MODEL SCHEMATIC: ORPHANAGE CATCHMENT HYDROLOGY MODEL 202205V5
SCALE (A3)	1:10,000

Hydrology model version: *202205v5*

Orchard_01
Orchard_02
Orchard_03
Orchard_04
Orchard_05
Orchard_06
Orchard_07
Orchard_08
Orchard_09
Orchard_10
Orchard_11
Orchard_12
Orchard_13
Orchard_14
Orchard_15
Orchard_16
Orchard_17
Orchard_18
Orchard_19
Orchard_20
Orchard_21
Orchard_22
Orchard_23

LEGEND

- Orphanage at Ngawhatu gauge (approx location)
- Orphanage subcatchments
- Orchard subcatchments
- Longest flowpath
- Indicative hydrological loading location
- Modelled 1D river network

Terrain: 2015 LiDAR

High : 500

Low : 0

A3 SCALE 1:7,500

0 0.15 0.3 0.45 0.6 0.75 (km)

N

PROJECT	**ORCHARD/ORPHANAGE MODEL UPDATE 870888.0013**
TITLE	**MODEL SCHEMATIC: ORCHARD CATCHMENT HYDROLOGY MODEL 202205V5**
SCALE (A3)	1:7,500

Hydraulic model version: *202210_V20*

LEGEND

- 1D structures
- 1D river network
- 1D pipe network
- 1D pipe outlets

Data source: Cross sections

- Hydraulic structure
- Cross section survey (Staig and Smith, 2015)
- LiDAR (2021)
- Previous model (MWH, 2016)
- Interpolated

Data source: Manhole invert level

- As-built
- Top of the South Maps
- Interpolated

A3 SCALE 1:10,000

0 0.2 0.4 0.6 0.8 1 (km)

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PROJECT	**ORCHARD/ORPHANAGE MODEL UPDATE 870888.0013**
TITLE	**MODEL SCHEMATIC AND DATA SOURCES ORPHANAGE STREAM HYDRAULIC MODEL: ORCHORPH_202210_V20**
SCALE (A3)	1:10,000

Hydraulic model version: *202210_V20*

LEGEND

- 1D structures
- 1D river network
- 1D pipe network
- 1D pipe outlets

Data source: Cross sections

- Hydraulic structure
- Cross section survey (Staig and Smith, 2015)
- LiDAR (2021)
- Previous model (MWH, 2016)
- Interpolated

Data source: Manhole invert level

- As-built
- Top of the South Maps
- Interpolated

A3 SCALE 1:5,000

0 100 200 300 400 500 Meters

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PROJECT	**ORCHARD/ORPHANAGE MODEL UPDATE 870888.0013**
TITLE	**MODEL SCHEMATIC AND DATA SOURCES ORPHANAGE STREAM HYDRAULIC MODEL: ORCHORPH_202210_V20**
SCALE (A3)	1:5,000

Hydraulic model version: *202210_V20*

LEGEND

- 1D structures
- 1D river network
- 1D pipe network
- 1D pipe outlets

Data source: Cross sections

- Hydraulic structure
- Cross section survey (Staig and Smith, 2015)
- LiDAR (2021)
- Previous model (MWH, 2016)
- Interpolated

Data source: Manhole invert level

- As-built
- Top of the South Maps
- Interpolated

A3 SCALE 1:5,000

0 100 200 300 400 500 Meters

N

PROJECT	**ORCHARD/ORPHANAGE MODEL UPDATE 870888.0013**
TITLE	**MODEL SCHEMATIC AND DATA SOURCES ORCHARD STREAM HYDRAULIC MODEL: ORCHORPH_202210_V20**
SCALE (A3)	1:5,000

LEGEND

1D river network

1D pipe network

2D terrain data sources

Floodplain mesh: 2021 LiDAR

Dikes: As-builts

Stopbank: As-builts

2D mesh level (mRL, NZVD 2016)

High : 150

Low : 0

Hydraulic model version: *202210_V20*

A3 SCALE 1:10,000

0 0.2 0.4 0.6 0.8 1 (km)

Eagle Technology, Land Information New Zealand

N

PROJECT	**ORCHARD/ORPHANAGE MODEL UPDATE 870888.0013**
TITLE	**MODEL SCHEMATIC AND DATA SOURCES HYDRAULIC MODEL: ORCHORPH_202210_V20**
SCALE (A3)	1:10,000

LEGEND

2D mesh extent

Manning's M roughness

- 2 (n = 0.50)
- 10 (n = 0.10)
- 11.1 (n = 0.09)
- 22.2 (n = 0.045)
- 50 (n = 0.02)

Hydraulic model version: *202210_V20*

A3 SCALE 1:12,500

0 0.2 0.4 0.6 0.8 1 (km)

N

PROJECT	**ORCHARD/ORPHANAGE MODEL UPDATE 870888.0013**
TITLE	**MODELLED 2D ROUGHNESS HYDRAULIC MODEL: ORCHORPH_202210_V20**
SCALE (A3)	1:12,500

Appendix B 2D roughness values

Excerpt from original model build report Nelson Urban Streams Flood Modelling Final Report, MWH, June 2016:

Table 4-1: 2D Model Roughness Values

Land Use Zone	Classification	Mannings n roughness Adopted for Parcels Excluding Building
CLA	Open Space	0.045
CONSVTN	Open Space	0.045
IC_CENTRE	Industrial/Commercial	0.1
IC_FRINGE	Industrial/Commercial	0.1
IC_INTDEV	Industrial/Commercial	0.1
IND	Industrial/Commercial	0.1
IND_NS	Industrial/Commercial	0.1
OS_REC	Open Space	0.045
RES	Urban Residential	0.09
RES_HI	Urban Residential	0.09
RES_LO	Urban Residential	0.09
RES_LO_NS	Urban Residential	0.09
ROAD	Road	0.02
RURAL	Rural	0.045
RURAL_HI_SH	Rural	0.045
RURAL_LO_SH	Rural	0.045
STRM	Open Space	0.045
SUB_COM	I Industrial/Commercial	0.1

Appendix C Hydraulic structures

HYDRAULIC STRUCTURES SUMMARY: OrchOrph_202210_V20

River and Structure ID	Structure Name	Physical location	Modelled structure type	
			Structure	Overflow[1]
Orchard Stream 1	SongerStCulvert *Added by T+T in model version OrchOrph_202007_v03. Not previously modelled.*	*Intersection of Songer Street and The Ridgeway*	MIKE 11 culvert	Represented in 2D model
Orchard Stream 2	TainuiStDiversionCulvert *Added by T+T in model version OrchOrph_202210_v20. Not previously modelled.*	*35 Nikau Street*	MIKE 11 culvert	MIKE 11 weir
Orchard Stream 3	NikauRdCulvert	*30 / 35 Nikau Street*	MIKE 11 culvert	MIKE 11 weir
Orchard Stream 4	11PolsteadCulvert *Added by T+T in model version OrchOrph_202007_v03. Not previously modelled.*	*11 Polstead Road*	MIKE 11 culvert	MIKE 11 weir
Orchard Stream 5	-	*Driveway over stream at 9 Polstead Road*	Not modelled	Not modelled
Orchard Stream 6	-	*Stream crossing at 7a Polstead Road*	Not modelled	Not modelled
Orchard Stream 7	5PolsteadCulvert	*5 Polstead Road / 639 Main Road Stoke*	MIKE 11 culvert	Represented in 2D model
Orchard Stream 8	OrchMainRdStokeCulvert	*632 / 639 Main Road Stoke*	MIKE 11 culvert	Represented in 2D model
Orchard Stream 9		*Shared pathway stream crossing at Railway Reserve near Byron Lane*	Not modelled	Not modelled
Orchard Stream 10	MarloweStCulvert	*Marlowe Street*	MIKE 11 culvert	MIKE 11 weir
Orchard Stream 11	NaylandRdCulvert	*Nayland Road*	MIKE 11 culvert	Represented in 2D model
Orchard Stream 12	CurtisStCulvert *To be surveyed and added in next model iteration*	*Stream crossing between Curtis Street and Monaco View*	MIKE 11 culvert	Not modelled
Orchard Stream 13a	OrchWhakatuDrCulvert_RightBox	*Whakatu Drive / SH6*	MIKE 11 culvert	Represented in 2D model
Orchard Stream 13b	OrchWhakatuDrCulvert_LeftBox	*Whakatu Drive / SH6*	MIKE 11 culvert	Represented in 2D model
Orphanage North 1		East/downstream of Huntaway Close	Not modelled	Not modelled
Orphanage North 2		East/downstream of Huntaway Close	Not modelled	Not modelled
Orphanage North 3	MontebelloCulvert	*Montebello Avenue / Ngawhatu Road*	MIKE 11 culvert	Represented in 2D model
Orphanage South 1		*Stream (farm) crossing at 467 Suffolk Road*	Not modelled	Not modelled
Orphanage South 2		*Stream (farm) crossing at 70 Sunningdale Drive*	Not modelled	Not modelled
Orphanage South 3		*Stream crossing at 70 Sunningdale Drived, access across from 28 Sunningdale Drive*	Not modelled	Not modelled
Orphanage South 4	WoodfordCulvert	*Woodford Lane*	MIKE 11 culvert	MIKE 11 weir
Orphanage South 5a	BridgewaterCulvert1	*Bridgewater Lane*	MIKE 11 culvert	MIKE 11 weir
Orphanage South 5b	BridgewaterCulvert2	*Bridgewater Lane*	MIKE 11 culvert	MIKE 11 weir
Orphanage South 6		*Orphanage Stream esplanade reserve crossing between 5 Montebello Avenue and 15 Bridgewater Lane*	Not modelled	Not modelled
Orphanage South Tributary 1	BridgewaterCulvert3	*9 / 26 Bridgewater Lane*	MIKE 11 culvert	Represented in 2D model
Orphanage South Tributary 2		*Stream crossing 7 Bridgewater Lane*	Not modelled	Not modelled
Orphanage Stream 1	SuffolkRdCulvert	*321 /324 Suffolk Road*	MIKE 11 culvert	Represented in 2D model
Orphanage Stream 2		*Orphanage Lane stream crossing*	Not modelled	Not modelled

River and Structure ID	Structure Name	Physical location	Modelled structure type	
			Structure	Overflow[1]
Orphanage Stream 3		*Orphanage Stream crossing between Woodstock Place and Gershwin Grove*	Not modelled	Not modelled
Orphanage Stream 4a	SaxtonRdCulvert	*117 Saxton Road*	MIKE 11 culvert	MIKE 11 weir
Orphanage Stream 4b	SaxtonRdCulvert2018	*117 Saxton Road*	MIKE 11 culvert	MIKE 11 weir
Orphanage Stream 5		*Orphanage Stream crossing at Saxton Way, Saxton Fields*	Not modelled	Not modelled
Orphanage Stream 6	SaxtonFieldPondWeir	*Pond at Saxton Field, immediately upstream of Saxton Road*	MIKE 11 weir	n/a
Orphanage Stream 7a	OrphMainRdStokeCulvert1	*Main Road Stoke near 9 Tokomaru Place*	MIKE 11 culvert	Represented in 2D model
Orphanage Stream 7b	OrphMainRdStokeCulvert2	*Main Road Stoke near 9 Tokomaru Place*	MIKE 11 culvert	Represented in 2D model
Orphanage Stream 8		*Stream crossing at Elms Street*	Not modelled	Not modelled
Orphanage Stream 9a	OrphWhakatuDrCulvert1	*Whakatu Drive/ SH6 near 23 Elms Street*	MIKE 11 culvert	Represented in 2D model
Orphanage Stream 9b	OrphWhakatuDrCulvert2	*Whakatu Drive/ SH6 near 23 Elms Street*	MIKE 11 culvert	Represented in 2D model
Floodplain 1	WhakatuEstateCulvert	*23 Elms Street to estuary*	MIKE 11 culvert	Represented in 2D model

1: Culvert overtopping within the 1D model is typically represented as a MIKE 11 weir. This is true when the structure is located at a crest or sag in the road. Overtopping is represented in the 2D model where there is the potential for flows across the road / perpendicular to the channel.

MODELLED MIKE 11 CULVERTS: OrchOrph_202210_V20

River and Structure ID	Structure Name	Physical location	Modelled structure type	Upstream IL (mRL, NZVD2016[3])	Data Source: USIL	Downstream IL (mRL, NZVD2016[3])	Data Source: DSIL	No. barrels Shape Geometry Valve regulation	Data source: barrels/geometry	Length (m)	Data source: length	Manning's n	Data source: Material and roughness
Orchard Stream 1	SongerStCulvert *Added by T+T in model version OrchOrph_202007_v03. Not previously modelled*	*Intersection of Songer Street and The Ridgeway*	MIKE 11 culvert	42.343	Modelled cross section invert, which is interpolated from 2015 LiDAR cross sections. *Note that this level is consistent with 2021 LiDAR also.*	41.55	Modelled cross section invert, which taken from 2021 LiDAR cross sections.	1x Circular 0.90 m dia.	TOTSM[1]	12.2	TOTSM[1]	0.015	Concrete (TOTSM[1])
						41.99	Modelled cross section invert, which taken from interpolated 2015 LiDAR cross sections.						
Orchard Stream 2	TainuiStDiversionCulvert *Added by T+T in model version OrchOrph_202210_v20. Not previously modelled.*	*35 Nikau Street*	MIKE 11 culvert	16.75	As-builts NCC Plan No: 26-0634 23/11/2001	16.72	As-builts NCC Plan No: 26-0634 23/11/2001	1x Circular 0.9 m dia.	As-builts NCC Plan No: 26-0634 23/11/2001	2.44	As-builts NCC Plan No: 26-0634 23/11/2001	0.015	Concrete (As-builts)
Orchard Stream 3	NikauRdCulvert	*30 / 35 Nikau Street*	MIKE 11 culvert	16.81	Orchard model received from Stantec[2]	16.65	Orchard model received from Stantec[2]	2x Circular 1.35 m dia.	Orchard model received from Stantec[2]	18.8	TOTSM[1]	0.015	Orchard model received from Stantec[2]
Orchard Stream 4	11PolsteadCulvert *Added by T+T in model version OrchOrph_202007_v03. Not previously modelled.*	*11 Polstead Road*	MIKE 11 culvert	15.63	Modelled cross section invert, which is interpolated from 2015 surveyed and 2015 LiDAR cross sections	15.60	Modelled cross section invert, which is interpolated from 2015 surveyed and 2021 LiDAR cross sections	1x Circular 1.35 m dia.	TOTSM[1]	11.6	TOTSM[1]	0.015	Concrete (TOTSM[1])
						15.527	Modelled cross section invert, which is interpolated from 2015 surveyed and 2015 LiDAR cross sections						
Orchard Stream 7	5PolsteadCulvert	*5 Polstead Road / 639 Main Road Stoke*	MIKE 11 culvert	14.79	Orchard model received from Stantec[2]	14.66	Orchard model received from Stantec[2]	1x Circular 1.35 m dia.	Orchard model received from Stantec[2]	27.6	TOTSM[1]	0.015	Orchard model received from Stantec[2]
Orchard Stream 8	OrchMainRdStokeCulvert	*632 / 639 Main Road Stoke*	MIKE 11 culvert	14.8	Orchard model received from Stantec[2]	13.65	Orchard model received from Stantec[2]	1x Rectangular 1.07 W x 1.30 H m	Orchard model received from Stantec[2]	44.8	TOTSM[1]	0.015	Orchard model received from Stantec[2]
Orchard Stream 10	MarloweStCulvert	*Marlowe Street*	MIKE 11 culvert	9.0	Orchard model received from Stantec[2]	8.91	Orchard model received from Stantec[2]	1x Rectangular 3.00 W x 1.80 H m	Orchard model received from Stantec[2]	14.2	TOTSM[1]	0.015	Orchard model received from Stantec[2]
Orchard Stream 11	NaylandRdCulvert	*Nayland Road*	MIKE 11 culvert	6.63	Orchard model received from Stantec[2]	6.45	Orchard model received from Stantec[2]	1x Rectangular 4.60 W x 1.79 H m	Orchard model received from Stantec[2]	15.4	TOTSM[1]	0.015	Orchard model received from Stantec[2]
Orchard Stream 12	CurtisStCulvert	*Curtis Street / Manaco View*	MIKE 11 culvert	To be added in next model version									
Orchard Stream 13a	OrchWhakatuDrCulvert_RightBox	*Whakatu Drive / SH6*	MIKE 11 culvert	0.78	Orchard model received from Stantec[2]	0.77	Orchard model received from Stantec[2]	1x Rectangular 3.70 W x 2.04 H m	Orchard model received from Stantec[2]	34.4	TOTSM[1]	0.015	Orchard model received from Stantec[2]

River and Structure ID	Structure Name	Physical location	Modelled structure type	Upstream IL (mRL, NZVD2016[3])	Data Source: USIL	Downstream IL (mRL, NZVD2016[3])	Data Source: DSIL	No. barrels Shape Geometry Valve regulation	Data source: barrels/geometry	Length (m)	Data source: length	Manning's n	Data source: Material and roughness
Orchard Stream 13b	OrchWhakatuDrCulvert_LeftBox	*Whakatu Drive / SH6*	MIKE 11 culvert	1.1	Orchard model received from Stantec[2]	0.81	Orchard model received from Stantec[2]	1x Rectangular 3.70 W x 1.80 H m	Orchard model received from Stantec[2]	34.4	TOTSM[1]	0.015	Orchard model received from Stantec[2]
Orphanage North 3	MontebelloCulvert	*Montebello Avenue / Ngawhatu Road*	MIKE 11 culvert	36.02	Orphanage model received from Stantec[2]	35.65	Orphanage model received from Stantec[2]	1x Rectangular 3.70 W x 1.80 H m	Orphanage model received from Stantec[2]	17.6	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Orphanage South 4	WoodfordCulvert	*Woodford Lane*	MIKE 11 culvert	42.63	Orphanage model received from Stantec[2]	42.55	Orphanage model received from Stantec[2]	1x Circular 1.80 m dia.	Orphanage model received from Stantec[2]	13.7	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Orphanage South 2a	BridgewaterCulvert1	*Bridgewater Lane*	MIKE 11 culvert	35.3	Orphanage model received from Stantec[2]	34.8	Orphanage model received from Stantec[2]	1x Circular 1.50 m dia.	Orphanage model received from Stantec[2]	25.1	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Orphanage South 2b	BridgewaterCulvert2	*Bridgewater Lane*	MIKE 11 culvert	38.6	Orphanage model received from Stantec[2]	36.78	Orphanage model received from Stantec[2]	1x Circular 1.05 m dia.	Orphanage model received from Stantec[2]	25.1	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Orphanage South Tributary 1	BridgewaterCulvert3	*9 / 26 Bridgewater Lane*	MIKE 11 culvert	38.8	Orphanage model received from Stantec[2]	38.41	Orphanage model received from Stantec[2]	1x Circular 1.20 m dia.	Orphanage model received from Stantec[2]	24.2	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Orphanage Stream 1	SuffolkRdCulvert	*321 /324 Suffolk Road*	MIKE 11 culvert	22.827	T+T onsite measurements as per TUFLOW 2D Suffolk bend model (#1006675.0420)	22.547	T+T onsite measurements as per TUFLOW 2D Suffolk bend model (#1006675.0420)	1x Rectangular 8.7 W x 2.20 H m	T+T onsite measurements as per TUFLOW 2D Suffolk bend model (#1006675.0420)	13	TOTSM[1]	0.015	T+T onsite measurements as per TUFLOW 2D Suffolk bend model (#1006675.0420)
			MIKE 11 culvert	22.63	Extracted from bridge structure in Orphanage model received from Stantec[2]	22.61	Extracted from bridge structure in Orphanage model received from Stantec[2]	1x Irregular level-width table (A). *Note that default head loss factors are changed to 0.1, 0.1, 1.0, 0.0*	Extracted and modified from bridge structure in Orphanage model received from Stantec[2]	11.2	Extracted from bridge structure in Orphanage model received from Stantec[2]	0.015	Modified from bridge structure in Orphanage model received from Stantec[2]
			FHWA WSPRO bridge (submergence only)	22.621	Orphanage model received from Stantec[2]	22.621	Orphanage model received from Stantec[2]	1x Bridge x-z table (B) *With zero slope.* Soffit at 37.051 mRL	Orphanage model received from Stantec[2]	11.2	Orphanage model received from Stantec[2]	0.0143	Orphanage model received from Stantec[2]
Orphanage Stream 4a	SaxtonRdCulvert	*117 Saxton Road*	MIKE 11 culvert	7.3	Orphanage model received from Stantec[2]	7.12	Orphanage model received from Stantec[2]	1x Rectangular 5.93 W x 2.03 H m	Orphanage model received from Stantec[2]	16.0	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Orphanage Stream 4b	SaxtonRCulvert2018	*117 Saxton Road*	MIKE 11 culvert	7.3	Orphanage model received from Stantec[2]	7.12	Modified from Orphanage model received from Stantec[2]	1x Rectangular 5.0 W x 2.0 H m	As-builts	16.0	TOTSM[1]	0.015	Orphanage model received from Stantec[2]

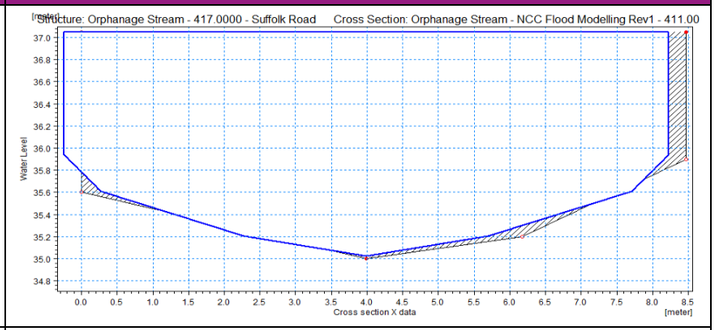
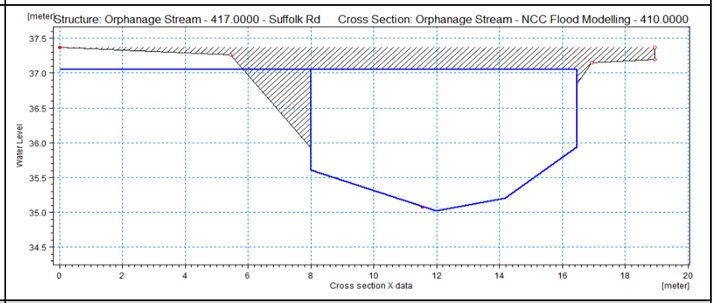
River and Structure ID	Structure Name	Physical location	Modelled structure type	Upstream IL (mRL, NZVD2016[3])	Data Source: USIL	Downstream IL (mRL, NZVD2016[3])	Data Source: DSIL	No. barrels Shape Geometry Valve regulation	Data source: barrels/geometry	Length (m)	Data source: length	Manning's n	Data source: Material and roughness
	Same culvert as above, called "Saxton Road Culvert 2". Proposed culvert at time of model build, now built.		MIKE 11 culvert	7.3	Orphanage model received from Stantec[2]	7.1	Orphanage model received from Stantec[2]	1x Rectangular 5.0 W x 2.0 H m	Orphanage model received from Stantec[2]	16.9	Orphanage model received from Stantec[2]	0.013	Orphanage model received from Stantec[2]
Orphanage Stream 7a	OrphMainRdStokeCulvert1	*Main Road Stoke near 9 Tokomaru Place*	MIKE 11 culvert	3.94	Orphanage model received from Stantec[2]	3.96	Orphanage model received from Stantec[2]	1x Rectangular 3.6 W x 1.9 H m	Orphanage model received from Stantec[2]	20.2	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Orphanage Stream 7b	OrphMainRdStokeCulvert2	*Main Road Stoke near 9 Tokomaru Place*	MIKE 11 culvert	4.02	Orphanage model received from Stantec[2]	3.93	Orphanage model received from Stantec[2]	1x Rectangular 4.12 W x 2.25 H m	Orphanage model received from Stantec[2]	20.2	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Orphanage Stream 9a	OrphWhakatuDrCulvert1	*Whakatu Drive/ SH6 near 23 Elms Street*	MIKE 11 culvert	1.3	Orphanage model received from Stantec[2]	1.22	Orphanage model received from Stantec[2]	1x Rectangular 5.91 W x 2.85 H m	Orphanage model received from Stantec[2]	32.8	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Orphanage Stream 9b	OrphWhakatuDrCulvert2	*Whakatu Drive/ SH6 near 23 Elms Street*	MIKE 11 culvert	2.12	Orphanage model received from Stantec[2]	2.03	Orphanage model received from Stantec[2]	1x Rectangular 3.9 W x 2.05 H m	Orphanage model received from Stantec[2]	32.8	TOTSM[1]	0.015	Orphanage model received from Stantec[2]
Floodplain 1	WhakatuEstateCulvert	*23 Elms Street to estuary*	MIKE 11 culvert	1.376	As-builts NCC Plan No: 26-0802 01/10/2021	0.786	As-builts NCC Plan No: 26-0802 01/10/2021	1x Circular 1.00 m dia.	As-builts NCC Plan No: 26-0802 01/10/2021	38.0	As-builts NCC Plan No: 26-0802 01/10/2021	0.009	Roughness value for GRP pipe, retrieved https://grandpipe.com/en/product-information

1: TOTSM = *Top of the South Maps*

2: The Orchard and Orphanage models were originally built by MWH in 2016 (now Stantec). These were two separate models. As part of the model build, Staig & Smith undertook survey of structures in 2015. However, the total number of structures and the reported number of survey carried out is inconsistent. This means that it is unclear whether specific structures have or have not been surveyed. For the purpose of the flood modelling, it is assumed that structure information in the received models is accurate (i.e. likely from survey) unless there are inconsistencies with surrounding data. These models represented concrete structures with a roughness of Manning's n=0.013. Concrete roughness has been set to a consistent and slightly higher roughness of n=0.015 to account for aging of infrastructure in V20.

3: Models were originally built to NCC vertical datum. (NCC datum has a 12.07 m vertical offset from Nelson Vertical Datum NVD-55). To convert structure invert levels from source NCC datum to NZVD2016, a 12.4 m offset is applied (NZVD2016 = NCC Datum – 12.4), i.e. NZVD2016 levels are lower.

Additional culvert geometry data:

Reference	Structure	Structure data (NCC Datum)	Figure
A	Suffolk Road culvert: irregular level-width table	*35.021 0* *35.204 3.43* *35.608 7.435* *35.94 8.472* *37.051 8.472*	
B	Suffolk Road bridge: irregular level-width table	*0 37.051* *0 35.608* *3.987 35.021* *6.174 35.204* *8.474 35.94* *8.474 37.051*	

MODELLED MIKE 11 WEIRS: OrchOrph_202210_V20

River and structure ID	Structure name	Physical location	Modelled structure type	Geometry (mRL NZVD2016, m)	Data source: Geometry	Weir type, valve regulation	Data source: type/regulation
Orchard Stream 2	TainuiStDiversionCulvert *Added by T+T in model version OrchOrph_202210_v20. Not previously modelled.*	*35 Nikau Street*	MIKE 11 weir (culvert overtopping structure)	**Level-width table** 18.30 mRL 0.50 m 18.59 mRL 1.45 m 18.60 mRL 6.50 m	As-builts NCC Plan No: 26-0634 23/11/2001	Broad Crested Weir; None	Default
Orchard Stream 3	NikauRdCulvertWEIR	*30 / 35 Nikau Street*	MIKE 11 weir (culvert overtopping structure)	**Level-width table** Minimum elevation: 18.1 mRL Maximum elevation: 18.39 mRL Width: 4.6 m	*2021 LiDAR*[1]	Broad Crested Weir; None	Default
Orchard Stream 4	11PolsteadCulvertWEIR	*11 Polstead Road*	MIKE 11 weir (culvert overtopping structure)	**Level-width table** Minimum elevation: 16.7 mRL Maximum elevation: 16.84 mRL Width: 4.0 m	*2021 LiDAR*[1]	Broad Crested Weir; None	Default
Orchard Stream 10	MarloweStCulvertWEIR	*Marlowe Street*	MIKE 11 weir (culvert overtopping structure)	**Level-width table** Minimum elevation: 11.1 mRL Maximum elevation: 11.35 mRL Width: 9.2 m	*2021 LiDAR*[1]	Broad Crested Weir; None	Default
Orphanage South 4	WoodfordCulvertWEIR	*Woodford Lane*	MIKE 11 weir (culvert overtopping structure)	**Level-width table** Minimum elevation: 44.7 mRL Maximum elevation: 45.5 mRL Width: 10.4 m	*2021 LiDAR*[1]	Broad Crested Weir; None	Default
Orphanage South 5	BridgewaterCulvertWEIR	*Bridgewater Lane*	MIKE 11 weir (culvert overtopping structure)	**Level-width table** Minimum elevation: 39.6 mRL Maximum elevation: 41.4 mRL Width: 21.1 m	*2021 LiDAR*[1]	Broad Crested Weir; None	Default
Orphanage Stream 4	OrphSaxtonRdCulvertWEIR	*117 Saxton Road*	MIKE 11 weir (culvert overtopping structure)	**Level-width table** Minimum elevation: 9.7 mRL Maximum elevation: 9.86 mRL Width: 22.2 m	*2021 LiDAR*[1]	Broad Crested Weir; None	Default
Orphanage Stream 6	SaxtonFieldPondWeir	*Pond at Saxton Field, immediately upstream of Main Road Stoke*	MIKE 11 weir	**Cross Section Database**[2] 0 6.94 7.608 6.92 15.519 5.11 22.291 5.115 29.063 5.12 32.974 5.29 36.885 5.12 40.796 5.29 41.045 4.38 49.547 4.69 49.56 5.44	Orphanage model received from Stantec[3]	Broad Crested Weir; None	Default

1: Weir geometry is simplified and uses 2021 LiDAR. LiDAR elevations at the road/bridge area excluded from the mesh (i.e. within the 1D model) are checked. Overtopping starts (0.1 m width) at the minimum elevation within this area, and extends to the full cross section / 1D extent width at the maximum elevation in the area. The MIKE 11 weir geometry is extended 5 m above the maximum 2021 LiDAR elevation in the mesh excluded area.

2: Models were originally built to NCC vertical datum. (NCC datum has a 12.07 m vertical offset from Nelson Vertical Datum NVD-55). To convert structure invert levels from source NCC datum to NZVD2016, a 12.4 m offset is applied (NZVD2016 = NCC Datum – 12.4), i.e. NZVD2016 levels are lower.

3: The Orchard and Orphanage models were originally built by MWH in 2016 (now Stantec). These were two separate models. As part of the model build, Staig & Smith undertook survey of structures in 2015. However, the total number of structures and the reported number of survey carried out is inconsistent. This means that it is unclear whether specific structures have or have not been surveyed. For the purpose of the flood modelling, it is assumed that structure information in the received models is accurate (i.e. likely from survey) unless there are inconsistencies with surrounding data.

MODELLED MIKE 21 Dikes: OrchOrph_202210_V20

River	Structure ID	Physical location	Modelled structure type	Structure type	Modelled geometry[1]	Modelled structure moved outside of the 1d model area	Data source
Orphanage Stream	2021 Orph Stream Flood Wall Left bank chg1270 15.1	*52 Kingsford Drive, Stoke*	MIKE 21 Dike	Floodwall	Coord No. / X / Y / RL 1 / 1618643 / 5425026 / 15.1 2 / 1618637.19 / 5425042.269 / 15.13	*No*	As-builts NCC Plan No: 26-0822 17/08/2021 Sheet 1
Orphanage Stream	2021 Orph Stream Flood Wall Left bank chg1640 10.1	*117 Saxton Road, Stoke*	MIKE 21 Dike	Floodwall	Coord No. / X / Y / RL 1 / 1618296.431 / 5424922.637 / 10.18 2 / 1618298.968 / 5424919.508 / 10.013	*No*	As-builts NCC Plan No: 26-0822 17/08/2021 Sheet 3
Orphanage Stream	2016 Saxton Field North Bund Crest 7.56	*Saxton Fields*	MIKE 21 Dike	Stopbank	Coord No. / X / Y / RL 1 / 1617977.317 / 5425043.691 / 7.56 2 / 1617990.09 / 5425045.63 / 7.56 3 / 1618001.25 / 5425053.95 / 7.56 4 / 1618015.32 / 5425060.8 / 7.56 5 / 1618036.95 / 5425071.53 / 7.56	*Yes*	As-builts NCC Plan No: 26-0782 19/01/2016 Sheets 203/204
Orphanage Stream	2016 Saxton Field Bridge Wall 7.70	*Saxton Fields*	MIKE 21 Dike	Stopbank	Coord No. / X / Y / RL 1 / 1617977.317 / 5425043.691 / 7.7 2 / 1617990.09 / 5425045.63 / 7.7	*Yes*	As-builts NCC Plan No: 26-0782 19/01/2016 Sheet 204
Orphanage Stream	2016 Saxton Field South Ramp Stopbank 7.56	*Saxton Fields*	MIKE 21 Dike	Stopbank	Coord No. / X / Y / RL 1 / 1617961.051 / 5425029.498 / 7.56 2 / 1617965.939 / 5425016.354 / 7.56 3 / 1617960.62 / 5424996.54 / 7.56 4 / 1617959.39 / 5424993.79 / 7.56	*Yes*	As-builts NCC Plan No: 26-0782 19/01/2016 Sheets 204/205
Orphanage Stream	2016 Saxton Field South Ramp Stopbank 7.66	*Saxton Fields*	MIKE 21 Dike	Stopbank	Coord No. / X / Y / RL 1 / 1617959.39 / 5424993.79 / 7.66 2 / 1617946.326 / 5424987.471 / 7.66 3 / 1617902.713 / 5424952.983 / 7.66 4 / 1617872.671 / 5424927.873 / 7.66 5 / 1617872.721 / 5424925.908 / 7.66 6 / 1617847.687 / 5424904.191 / 7.66 7 / 1617848.695 / 5424900.018 / 7.66 8 / 1617848.745 / 5424893.017 / 7.66 9 / 1617801.65 / 5424853.074 / 7.66	*No*	As-builts NCC Plan No: 26-0782 19/01/2016 Sheet 205

[1] Models were originally built to NCC vertical datum. (NCC datum has a 12.07 m vertical offset from Nelson Vertical Datum NVD-55). To convert structure levels from source NCC datum to NZVD2016, a 12.4 m offset is applied (NZVD2016 = NCC Datum – 12.4), i.e. NZVD2016 levels are lower.

River	Structure ID	Physical location	Modelled structure type	Structure type	Modelled geometry[1]				Modelled structure moved outside of the 1d model area	Data source
					10	1617770.018	5424827.788	7.66		
					11	1617762.966	5424822.852	7.66		
					12	1617758.886	5424821.946	7.66		
					13	1617757.879	5424815.901	7.66		
					14	1617762.815	5424809.907	7.66		
					15	1617818.221	5424750.572	7.66		

Appendix D Model results

T:\Nelson\Projects\870888\870888.0013\WorkingMaterial\GIS\FIGURES\20230615 - V20 2130 Q100\OrchOrph_202210_V20_TT_DHI2017_RCP8pt5M_2130_100Y_PoP_2D_Depth_2mGRID.mxd 2023-Jun-15 3:19:00 pm Drawn by CHGR

LEGEND

- Orphanage flood protection works (2021)
- Modelled SW network
- Modelled SW network
- 1D structures
- Modelled 1D channel extent
- Trim extent of model results

Modelled flood depth (m)

- < 0.05 (not shown)
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- > 3.0

Whakatu Drive
Aldinga Avenue
Tyree Drive
Tennyson Crescent
Songer Street
Nayland Road
Masefield Street
Marlowe Street
The Ridgeway
Slip Road
Polstead Road
Somerset Terrace
Manson Avenue
Saxton Road West
Main Road Stoke
Suffolk Road
Elms Street
Covent Drive
Saxton Road East
Montebello Avenue
Kerry Marshall Drive
Sunningdale Drive

A3 SCALE 1:10,000

0 0.1 0.2 0.3 0.4 0.5 (km)

ORIGINAL IN COLOUR

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NOTES:
Baseline model: *OrchOrph_202210_V20*
Model vertical datum is NZVD2016.
Basemap: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
Eagle Technology, Land Information New Zealand, Kiwirail, OpenStreetMap Contributors

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	CHGR	KBBB	15/06/23

LOCATION PLAN: Richmond

PROJECT No.	870888.0013	
DESIGNED	CHGR	JUN.23
DRAWN	CHGR	JUN.23
CHECKED	KBBB	JUN.23
APPROVED		16/06/2023

CLIENT **NELSON CITY COUNCIL**
PROJECT **ORCHARD/ORPHANAGE MODEL UPDATE**
TITLE ORCHARD/ORPHANAGE MODEL RESULTS: FLOOD DEPTH
2130 RCP8.5M 1% AEP 'PEAK OF PEAKS'

SCALE (A3) 1:10,000 FIG No. FIGURE 1. REV 0

Appendix E Peer review table

Data Provided

0	No Issues
1	Clarification required. Unlikely to alter results
2	Moderate Issue that may affect results
3	Major Issue that will likely affect results

Item	Category	Category	WSP Comments *[Hydrology model **202205v5**]* *[Hydraulic model version **OrchOrph_202210_v19**]*	WSP Rating ***[Hydrology model 202205v5]*** ***[Hydraulic model version OrchOrph_202210_v19]***	T+T Response *[Hydrology model **202205v5** - i.e. unchanged]* *[Hydraulic model version **OrchOrph_202210_v20**]*	WSP Comments *[Hydrology model **202205v5**]* *[Hydraulic model version **OrchOrph_202210_v20**]*	WSP Rating *[Hydrology model **202205v5**]* *[Hydraulic model version **OrchOrph_202210_v20**]*
INP-1	Model Data	Mike Flood files	All files provided for RCP8.5 2130 100yr ARI with durations of 1, 6, and 12	0	n/a	n/a	0
INP-2	Model Data	Mike 11 files	All files provided	0	n/a	n/a	0
INP-3	Model Data	Mike 21 files	All files provided	0	n/a	n/a	0
INP-4	Model Data	Mike Urban files	All files provided	0	n/a	n/a	0
INP-5	Report	Report	All files provided	0	n/a	n/a	0
INP-6	Results	1% AEP, 1hr duration for 2130 climate assuming RCP 8.5	All files provided	0	n/a	n/a	0
INP-7	Results	1% AEP, 6hr duration for 2130 climate assuming RCP 8.5	All files provided	0	n/a	n/a	0
INP-8	Results	1% AEP, 12hr duration for 2130 climate assuming RCP 8.5	All files provided	0	n/a	n/a	0

Hydrology

0	No Issues
1	Clarification required. Unlikely to alter results
2	Moderate Issue that may affect results
3	Major Issue that will likely affect results

Item	Category	Setting	WSP Comments *(Hydrology model **202205v5**)*	WSP Rating ***(202205v5)***	T+T Response *(Hydrology model **202205v5** - i.e. unchanged)*	WSP Comments *(Hydrology model **202205v5**)* *1 minute time series*	WSP Rating ***(202205v5)*** *1 minute time series*
Hyd-1	Method	Curve Number	We recommend doing sensitivity test on curve number to see the impact on calculated runoff. Please discuss with NCC Engineering Manager for agreement on the hydrological parameters. Note that TP108 may not always be appropriate for catchments outside of Auckland	0	n/a	n/a	0
Hyd-2	Method	Time of Concentration (ToC)	Use of TP108 to determne TOC. Note that TP108 may not always be appropriate for catchments outside of Auckland	0	n/a	n/a	0
Hyd-3	Method	Update to MIKE URBAN hydrology	Has a result hydrograph comparison between the calibrated HEC-HMS model and the MU catchment hydrology been performed?	1	Yes. T+T are satisfied that the two model provide the same results.	**[No action required]**	0
Hyd-4	Method	Results and inputs to hydraulic model	Inputs to the hydraulic model use a time step of 5minutes. Memo mentions 1min time step. WSP has also been provided a version of hydraulic model inputs with 1minute time steps. It appears that there are two versions of the hydrology and the older (5minute) version of hydrology has been run in the hydraulic models.	**3**	Agreed. This is a filing error. 1 minute version has been used for the model. 5 minute timestep version has been removed **[action taken].**	**[No further action required]**	0

MIKE URBAN

0	No Issues
1	Clarification required. Unlikely to alter results
2	Moderate Issue that may affect results
3	Major Issue that will likely affect results

Item	Category	Setting	WSP Comments *(Model version **OrchOrph_202210_v19**)*	WSP Rating ***(OrchOrph_202210_v19)***	T+T Response *(Model version **OrchOrph_202210_v20**)*	WSP Comments *(Model version **OrchOrph_202210_v20**)*	WSP Rating ***(OrchOrph_202210_v20)***
MUSetting-1	Roughness	Concrete Normal to 52.63 (0.019) All others MU standard	All pipes use Concrete Normal. Value has been increased from standard for all pipes and may affect results. Is there justification for the increase?	2	This is a legacy error from overtopping road weirs being set at n=0.019. Roughness values have been lowered to n=0.015 in the model. This has been set to be consistent with other concrete structures within the model which also have manning's n = 0.015 **[action taken].**	**[No further action required]**	0
MUSetting-2	BCs	6 Network Loads applied as inflow hydrographs	OK	0	n/a	n/a	0
MUSetting-3	Network Sense	Longsection Manholes are sized appropriately Pipe diameters increase downstream	One negative slope at PalmAvenue4 - confirm OK	1	Data sources of manhole inverts are Top of the South Maps (upstream) and as-builts (downstream). Without additional as-built or survey data, there is not justification to change the network inverts. This has been added to the list of future updates for the model **[no action].**	Link TainuiStOverflow3_2 and MH D625704 have inconsistent invert levels. Recommend using As-built status marker in MU if levels are correct.	1
MUSetting-4	Head Loss	Types: Half Benching (0.3, Velocity Head) Inlet (Velocity Head) Outfall (1, Velocity Head)	OK	0	n/a	n/a	0

MIKE 11

0	No Issues
1	Clarification required. Unlikely to alter results
2	Moderate Issue that may affect results
3	Major Issue that will likely affect results

Item	Category	Setting	WSP Comments *(Model version **OrchOrph_202210_v19**)*	WSP Rating *(OrchOrph_202210_v19)*	T+T Response *(Model version **OrchOrph_202210_v20**)*	WSP Comments *(Model version **OrchOrph_202210_v20**)*	WSP Rating *(OrchOrph_202210_v20)*
M11Setting-1	Network	Max dx: Channel 5m Culverts 1000m	Max channel dx seems low. Where h points are close (around culverts/ assets/ etc) there is potential for instability. See Results	**2**	Agreed, max dx initially chosen from testing of the 1D only model, which is not necessarily applicable to the coupled model. Max dx of Orphanage branches has been increased to 10m in the model. Note that testing indicating the max dx of 5m for Orchard Stream was okay **[action taken].**	**[No further action required]**	**0**
M11Setting-2	Network	Weirs: 7ea - Broadcrested. Varying levels and dimenstions.	Appear to be appropriately represented - have not checked Q/h relationships Head loss factors OK Levels and dimensions not verified	**0**	n/a	n/a	**0**
M11Setting-3	Network	Culverts: 22ea. Varying levels and dimensions. Losses 0.5 Inflow/ 1 outflow for all culverts Mannings values 0.013 (excluding WhakatuEstate 0.009)	* Would be benefical to check headwalls * Have not verified Q/h relationships * Mannings values are low (0.013) (essentially always new) and especially when compared to pipe default Concrete (Normal) values (0.019). * Whakatu Estate Manning's value is 0.009, which seems very low * Check Whakatu Dr Estate Culvert (second culvert does not appear to be represented). * Many culverts in Whakatu Estate not represented under SH6 and may lead to overrepresentation of flood levels	**3**	1. Agreed, but out of scope of this project. Limitations around the hydraulic performance of structures has been noted and flagged for future improvements to the model **[no action].** 2. As above **[no action].** 3. Manning's n values for culverts have been set to n=0.015 and are now consistent with stormwater network pipes, i.e. represent some aging of the concrete. **[no action]**. 4. This culvert was incorporated at the request of NCC using as-builts (2021) provided. Manning's n roughness is taken from product information for GRP pipe (refer to the provided 'structures' documentation for reference) **[no action].** 5. Single culvert was added at the request of NCC **[no action]**. 6. Hydraulic connection between the floodplain and estuary is not within the scope of this project. This is at the request of NCC. These models are intended to represent flooding from streams only (i.e. no stormwater network.) Note that the Nelson/Tasman Land Development Manual assumes full blockage of culverts which are less than 1.5m diameter, which is consistent with not incorporating the culverts through SH6. T+T agree that not including these culverts is likely to impact on floodplain results. This model assumption has been documented for future model users **[no action].**	As updates to culverts is out of scope, **[No further action required]**. Recommend adding culvert checks to future model improvements.	0
M11Setting-4	Network	Energy loss: 5 loss factors in Orphanage Stream representing 90° bends	OK	0	n/a	n/a	0
M11Setting-5	Network	Open Channels	Orchard Stream at Nikau Road appears to be represented incorrectly in M11 when queried with Google StreetView and aerial imagery. There's either a missing culvert in M11 or it is piped for longer than modelled. Others OK	1	Agreed, culverts have been added using provided model or Top of the South Maps only. As-builts of this additional culvert have now been supplied. Additional culvert upstream of Nikau Street (*TainuiStDiversionCulvert*) has been added to model. Note that as-builts of the Tainui Street overflow (pipe network) were also provided and have been updated in the model. **[action taken].**	**[No further action required]**	0
M11Setting-6	Boundary Conditions	Inflows applied as distributed source.	Appear OK. Boundary IDs/ MU catchments are random (not in sequential order), so it's difficult to visually link the catchment to the channel chainage. Doesn't change model results, but could be difficult for others to use/ update.	1	GIS files/map of subcatchments provided with model for ease of future use **[no action].**	**[No action required]**	0
M11Setting-7	Boundary Conditions	DSBC - 3WL- Tidal RCP8.5M 2130 Orch_Orchard Stream Orph_OrphanageStream Whakatu Estate Culvert	OK	0	n/a	n/a	0
M11Setting-8	IC	WL 1.99, Q 0.1	OK	0	n/a	n/a	0
M11Setting-9	Std Resistance	30 (Not Used)	OK	0	n/a	n/a	0
M11Setting-10	Wave Approx	High Order Fully Dynamic	OK	0	n/a	n/a	0
M11Setting-11	XS	Resistance: Primarily 0.045	0.045 = Main Channel, some weeds and stones (Chow, 1959) Some open channels look very overgrown. 0.045 Manning's value may be too low.	2	It is beyond the scope of this project to change manning's n roughness values in localised areas without additional validation data. Manning's n roughness has been increased from the original model build value of n=0.03 following testing by NCC/T+T **[no action]**.	**[No action required]**	0
M11Setting-12	XS	Primarily interpreted from LiDAR	OK	0	n/a	n/a	0
M11Setting-13	Other Settings	Timestep: Controlled by M21 Save Timestep: 1min Engine: M11	OK	0	n/a	n/a	0
M11Setting-14	Results	Some issues with wave propogation in 1hr event	See 1D results	2	Agreed. Increasing the max dx of the branches has improved stability of the model **[action taken].**	**[No further action required]**	0
M11Setting-15	Mike11.ini	WL_EXCEEDANCE_FACTOR = 10000	Potential to mask model instabilities. Should try lower values, eg 10	1	Exceedance factor has been reduced to 100 **[action taken].**	**[No further action required]**	0

MIKE 21

0	No Issues
1	Clarification required. Unlikely to alter results
2	Moderate Issue that may affect results
3	Major Issue that will likely affect results

Item	Category	Setting	WSP Comments *(Model version **OrchOrph_202210_v19**)*	WSP Rating *(OrchOrph_202210_v19)*	T+T Response *(Model version **OrchOrph_202210_v20**)*	WSP Comments *(Model version **OrchOrph_202210_v20**)*	WSP Rating *(OrchOrph_202210_v20)*
M21Setting-1	Domain	No Boundaries, Material, Infrastructure	OK	0	n/a	n/a	0
M21Setting-2	Time	Timestep - 0.2s	OK	0	n/a	n/a	0
M21Setting-3	Inland Flooding	Ticked on	OK	0	n/a	n/a	0
M21Setting-4	Technique	High order Time step 0.2 - 0.01 CFL 0.9	OK	0	n/a	n/a	0
M21Setting-5	Depth	No DC	OK	0	n/a	n/a	0
M21Setting-6	Flood Dry	Dry - 0.02 Wet 0.04	Higher than standard modelling values. May negate some sheet flow	2	Agreed, values taken from outdated guidance. Dry/Flood/Wet have been lowered to recommended values 0.0001/0.001/0.002 in the model **[action taken].**	Updated values seem low but do not appear to increase run times **[No further action required]**	0
M21Setting-7	Density	Barotropic	OK	0	n/a	n/a	0
M21Setting-8	Viscosity	Eddy: Smagorinsky Constant - 0.28 Min and Max OK	OK	0	n/a	n/a	0
M21Setting-9	Roughness	Mannings	OK	0	n/a	n/a	0
M21Setting-10	Coriolis	None	OK	0	n/a	n/a	0
M21Setting-11	Ice	None	OK	0	n/a	n/a	0
M21Setting-12	Tidal	None	OK	0	n/a	n/a	0
M21Setting-13	Precipitation	None	OK	0	n/a	n/a	0
M21Setting-14	Infiltration	None	OK	0	n/a	n/a	0
M21Setting-15	Wave Radiation	None	OK	0	n/a	n/a	0
M21Setting-16	Sources	None	OK	0	n/a	n/a	0
M21Setting-17	Structures	4 Dikes	Saxton Field South Ramp 19.96 is partially outside of mesh zone. Consequently, flooding appears to occur over and around this dike despite the water level being lower than the crest of the dike. Unsure of why dike Saxton Field North Bund extends across road All other dikes appropriately incorporated. Levels and locations have not been verified. Possible missing culverts in Whakatu Estate (see M11Setting_3)	3	Agreed, dike has been digitised incorrectly. All dikes have been check and updated using available information. A table of 2D structures (similar to that of 1D structures) has been provided **[action taken].**	All dikes digitised within domain and appear correct. Levels and locations not verified **[No further action required]**	0
M21Setting-18	ICs	None	OK	0	n/a	n/a	0
M21Setting-19	BCs	All land boundary	OK A 2D boundary condition on the outside of SH6 may be required if representing additional culverts in Whakatu Estate	1	Hydraulic connection between the floodplain and estuary is not within the scope of this project. This is at the request of NCC. These models are intended to represent flooding from streams only (i.e. no stormwater network.) Note that the Nelson/Tasman Land Development Manual assumes full blockage of culverts which are less than 1.5m diameter, which is consistent with not incorporating the culverts through SH6. T+T agree that not including these culverts is likely to impact on floodplain results. This model assumption has been documented for future model users **[no action].**	**[No action required]**	0
M21Setting-20	Decoupling	None	OK	0	n/a	n/a	0
M21Setting-21	Outputs	Results	Saving timestep: 5min Separate Inundation file	0	n/a	n/a	0

Item	Category	Setting	WSP Comments *(Model version **OrchOrph_202210_v19**)*	WSP Rating	T+T Response	WSP Comments *[Hydrology model **202205v5**]* *[Hydraulic model version **OrchOrph_202210_v20**]*	WSP Rating
M21Input-1	Mesh		# of elements 1119257	0	n/a	n/a	0
M21Input-2	Mesh	Sizing	OK	0	n/a	n/a	0

MIKE FLOOD

Item	Category	Setting	WSP Comments *(Model version **OrchOrph_202210_v19**)*	WSP Rating ***(OrchOrph_202210_v19)***	T+T Response *(Model version **OrchOrph_202210_v20**)*	WSP Comments *(Model version **OrchOrph_202210_v20**)*	WSP Rating ***(OrchOrph_202210_v20)***
MFSetting-1	Lateral Links	Type: Weir 1 Source: M21 (excepth Orph_OrphanageStream1240-1450 Left = M11) Depth: 0.1 Weir Coefficient: 1.838	OK	0	n/a	n/a	0
MFSetting-2	Urban Links - M21 to Inlet	Max Flow - 0.05 for all Inlet area 0.08 Discharge Coefficient - 0.98 QdH factor - 0	OK, although the inlet area is small and may further decrease discharge between M21 and MU. Appears that weirs are used to represent most of the overflow from the SW network	0	n/a	n/a	0
MFSetting-3	Urban Links - Weir to M21	No settings	OK	0	n/a	n/a	0
MFSetting-4	River/Urban Links	M11 water level and MU Outlet	OK	0	n/a	n/a	0

Result Review Comments - 1% AEP, 12hr, 2120 (RCP8.5)

0	No Issues
1	Clarification required. Unlikely to alter results
2	Moderate Issue that may affect results
3	Major Issue that will likely affect results

Item	Category	Setting	WSP Comments *(Model version **OrchOrph_202210_v19**)*	WSP Rating ***(OrchOrph_202210_v19)***	T+T Response *(Model version **OrchOrph_202210_v20**)*	WSP Comments *(Model version **OrchOrph_202210_v20**)*	WSP Rating ***(OrchOrph_202210_v20)***
RES-1	Results	1D Result Stability	Some discharge wave propogation in lower reaches of Orphanage Sth Branch during 1-hr event. There are multiple waves of very high, low discharge. This could potentially cause discharge to the 2D surface Some issues around Tanui St Overflow	2	Agreed. Instabilities in 1D model have been improved by increasing the max dx value to 10m. Note that there are remaining persistent instabilities located at Tainui Street Overflow which are associated with the M11-MU couplings. These model issues/limitations have been documented for future model users **[action taken].**	M11 Instabilities no longer present. Tainui Street instabilities significantly decreased. **[No further action required]**	0
RES-2	Results	2D Result Stability	OK	0	n/a	n/a	0
RES-3	Results	Mass Balance	OK	0	n/a	n/a	0

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