9 August 2021

North Nelson RFHA – 2021 Update

5-G3431.03

This letter report summarises the changes made to the existing North Nelson Rapid Flood Hazard Assessment (RFHA) model which was previously developed by WSP on behalf of Nelson City Council (NCC) and is an updated version of the letter report dated 05 August 2019. The changes made to the model are in accordance with the brief provided by NCC and the fee offer prepared by WSP. The scope of works completed is summarised below.

The prior model development is not discussed in this document as it is documented in the ***North Nelson Rapid Flood Hazard Modelling Methodology and Results*** report (Opus, 2016). The original model developed was also subjected to an independent peer review.

1 Model

No changes to the model itself were made. The latest version of the model was used which includes increased detail in the upper Wakapuaka catchment around the Teal Valley and Lud Valley Roads. This additional detail was added at the request of NCC in 2018.

The model scenarios with 60% of rainfall translated to run-off were used in line with the prior recommendations made by WSP. This was based on analysis of gauged flow data and was agreed with NCC to be used for this work.

The model remains in NCC Datum for consistency with prior work with a level adjustment to NZVD2016 made during post processing. The NCC datum cannot be adjusted directly to NZVD2016 with a fixed value, so an averaged adjustment value (12.3873) recommended by NCC was used. This will result in some small differences in elevation across the catchment.

2 Rainfall

HIRDS V4 (NIWA, 2021) rainfall depths were used to generate new hyetographs. HIRDS V4 design rainfall depths were obtained for five locations covering both catchment areas and were compared in terms of spatial variation. The locations were selected by eye to provide even coverage of the combined catchment area.

Table 1 shows the rainfall depths from these five locations. As the values were relatively consistent between the points (maximum standard deviation of ±6%) and catchments, an average value of the five locations was used for both catchments. This is in line with the approach previously taken for the Wakapuaka and Whangamoa catchments.

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The locations were:

1 HIRA (junction of Lud Valley Road and State Highway 6)
2 Wakapuaka coastal interface
3 Whangamoa estuary
4 Upper Whangamoa catchment
5 Mid Whangamoa catchment (near the junction of State Highway 6 and Kokorua Road)

Table 1: Comparison of HIRDS V4 historic data rainfall depths (mm) across the catchments (1% AEP)

	Event Duration											
	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
Site 1	22.7	33.6	42.5	63.1	92.5	161	218	280	339	367	383	391
Site 2	22.4	33.9	43.2	64.6	95.1	165	222	284	342	370	385	394
Site 3	20.5	30.5	38.8	58.7	88.3	161	225	297	369	403	422	433
Site 4	21.9	32.5	41	60.6	88.4	153	206	266	325	354	372	383
Site 5	21.1	32.5	41.6	62.4	91.2	155	207	263	317	344	360	371
Average	*21.7*	*32.6*	*41.4*	*61.9*	*91.1*	*159*	*215.6*	*278*	*338.4*	*367.6*	*384.4*	*394.4*

The rainfall depths were adjusted with an areal reduction factor. This was calculated in accordance with the ***High Intensity Rainfall Design System Version 4*** Client Report (NIWA, 2018) using Equation 6. It was found that the areal reduction factors were the same for both catchments due to their similar size.

Hyetographs were generated from the design rainfall depths using the HIRDS 'North of the South Island' normalised hyetograph using a 10-minute timestep. The 10-minute time-step was used as this smoothed out the step that is apparent using the NIWA equations with smaller timesteps. The first timestep was set to zero. These were then post adjusted to ensure the overall rainfall depth matched the design rainfall depth, as the NIWA methodology results in a difference otherwise.

Figure 1 shows the hyetographs generated for the 1-hour, 6-hour, 12-hour, and 24-hour events.

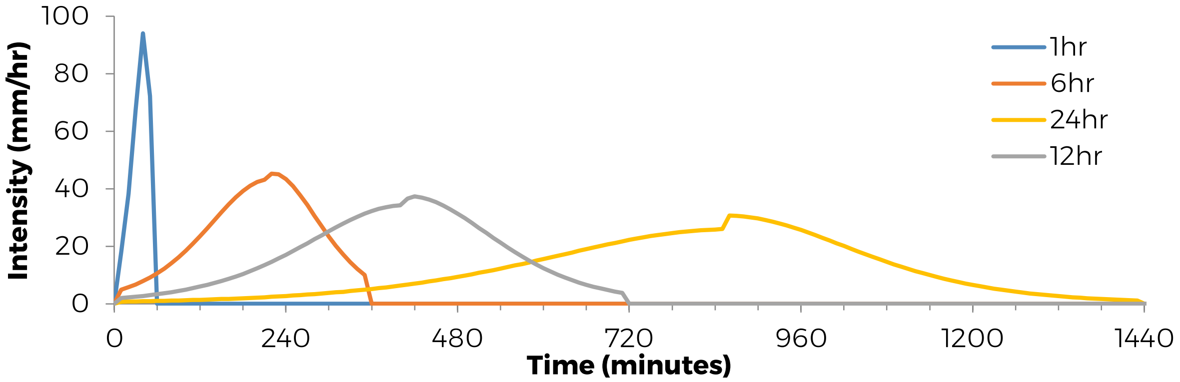

Figure 1: Example hyetographs generated from HIRDS V4 historic rainfall data (1% AEP, current)

The rainfall was applied within InfoWorks ICM with the default 'rain smoothing' function enabled.

3 Tide Profile

Tidal profiles were provided by Tonkin + Taylor for use with the model. These were requested by WSP to ensure consistency with prior modelling work for NCC.

The tidal profiles supplied were in terms of NZVD2016 Datum with a peak level equivalent to the mean higher high water (MHHW) tide.

The timing of the tidal peaks were shifted to coincide with the peak rainfall intensity for each storm duration, plus 3 hours, to allow for the catchment's time of concentration (see Figure 2).

The 3-hour offset value was derived by running the Wakapuaka catchment with a 1-hour duration event and looking at the time delay between the peak rainfall and peak flow at the coastal interface. A different tidal profile was generated for each rainfall duration considered to ensure the peaks were aligned with all events.

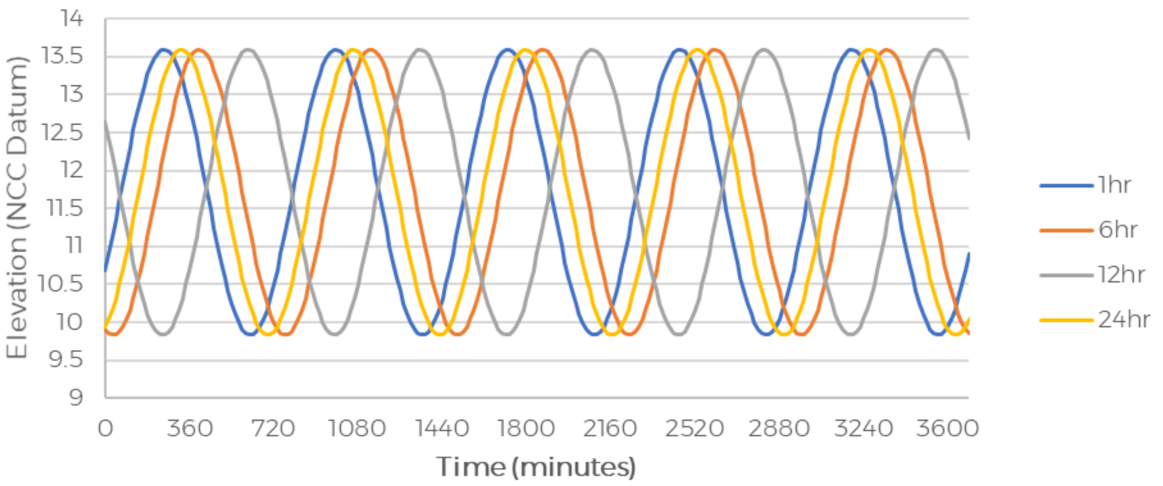

Figure 2: Tidal profiles (MHHW present day)

4 Climate Change

4.1 Rainfall

Rainfall hyetographs were adjusted for the projected increases in average temperate provided by NCC (Table 2). The adjustment was made in accordance with the methodology defined in the ***High Intensity Rainfall Design System Version 4*** Client Report (NIWA, 2018) using Table 6.

Table 2: Climate change temperature increase

Scenario	Temperature Increase
Present day	-
RCP 8.5M to 2070	1.84˚C
RCP 8.5M to 2090	2.58˚C
RCP 8.5M to 2130	3.40˚C

4.2 Tidal Profiles

Table 3 summarises the tidal profiles that were supplied by Tonkin + Taylor for their Nelson City Stream Catchment Models. The elevations in New Zealand Vertical Datum 2016 (NZVD2016) were converted to Nelson City Council Vertical Datum (NCC) by adding 12.3873 to match the LiDAR used in the model.

Table 3: Tidal profiles

Mean higher high water (MHHW) + sea level rise (SLR)			
Scenario	Tidal condition	SLR*	Maximum tidal boundary level (NZVD 2016)
Present day	MHHW	-	+1.21 m
RCP 8.5M to 2070	MHHW + SLR	+0.38 m	+1.59 m
RCP 8.5M to 2090	MHHW + SLR	+0.60 m	+1.81 m
RCP 8.5M to 2130	MHHW + SLR	+1.11 m	+2.32 m

*Sea level rise for the Nelson area applies levels from Table 10 of ***Coastal Hazards and Climate Change: Guidance for Local Government*** (MfE, December 2017), reduced by 0.07 m as per Table 3.3 from ***Coastal Inundation in Nelson City*** (T+T, 2020).

An updated MSL baseline is used for deriving the SLR values.

The present day timeseries have been shifted up with the SLR - this is considered to be a reasonable approach.

The MfE guidelines indicate that the MSL rises when taking into account SLR, so assuming the low and high tide level rise with the same value seems like the best approach. In reality both high tide and low tide levels may change as a result of changing tidal prisms and other coastal processes, but detailed analysis will be needed to see these effects (which may be negligible).

Tonkin + Taylor, notes on MHHW profiles

5 Model Initialisation

The model was initialised using an initial condition file. This acts to pre-fill any depressions with no secondary flow path, pre-wet the river channels and pre-flood areas below the tidal range. This prevents any flow attenuation or results due to artificial storage and gives the model realistic starting conditions. The end of a 50% AEP 24-hour duration simulation event (once the flood flow had drained out of the catchment) was used to generate the initial condition file.

In addition to the initial condition file, the 2D surface was pre-flooded to match the starting elevation of the tidal profile to suit each storm duration. This is to ensure the model is at equilibrium and no artificial storage or flow effects are created at the onset of the simulation.

6 Model Runs

Table 4 lists the 24 model runs that were created for each catchment, creating a total of 48 simulation results files.

- All rainfall was HIRDS V4 depths and profiles (section 2) adjusted with the given temperature increase (Table 2).
- All tidal boundary conditions were MHHW (section 3) plus the given sea level rise (Table 3).
- Run IDs prefixed with a C refer to 'current' (present day) scenarios. Runs prefixed with an F refer to 'future' scenarios with projected climate change.

Table 4: Model runs for each catchment

Number	Run ID	AEP	Duration (hour)	Climate	Temperature Increase	Sea Level Rise
1	C1a	5%	1	Present day	-	-
2	C1b	5%	6	Present day	-	-
3	C1c	5%	12	Present day	-	-
4	C1d	5%	24	Present day	-	-
5	C2a	2%	1	Present day	-	-
6	C2b	2%	6	Present day	-	-
7	C2c	2%	12	Present day	-	-
8	C2d	2%	24	Present day	-	-
9	C3a	1%	1	Present day	-	-
10	C3b	1%	6	Present day	-	-
11	C3c	1%	12	Present day	-	-
12	C3d	1%	24	Present day	-	-
13	F1a	1%	1	RCP 8.5M to 2070	1.84˚C	+ 0.38 m
14	F1b	1%	6	RCP 8.5M to 2070	1.84˚C	+ 0.38 m
15	F1c	1%	12	RCP 8.5M to 2070	1.84˚C	+ 0.38 m
16	F1d	1%	24	RCP 8.5M to 2070	1.84˚C	+ 0.38 m
17	F2a	1%	1	RCP 8.5M to 2090	2.58˚C	+ 0.60 m
18	F2b	1%	6	RCP 8.5M to 2090	2.58˚C	+ 0.60 m
19	F2c	1%	12	RCP 8.5M to 2090	2.58˚C	+ 0.60 m
20	F2d	1%	24	RCP 8.5M to 2090	2.58˚C	+ 0.60 m
21	F3a	1%	1	RCP 8.5M to 2130	3.40˚C	+ 1.11 m
22	F3b	1%	6	RCP 8.5M to 2130	3.40˚C	+ 1.11 m
23	F3c	1%	12	RCP 8.5M to 2130	3.40˚C	+ 1.11 m
24	F3d	1%	24	RCP 8.5M to 2130	3.40˚C	+ 1.11 m

7 Outputs

The simulation results were exported from the model excluding flood depths less than 100 mm. The different duration events with the same climate, boundary condition, and Annual Exceedance Probability (AEP) rainfall (i.e. suffixes a-d) were then combined to create a maximum results file via post-processing using GIS software. The GIS process model used to post-process the data is summarised below:

1. The exported 2D flexible mesh triangles were aggregated to ensure the geometry from all durations after excluding depths less than 100 mm was accounted for.
2. The data (depth, speed, water elevation) from all durations were joined to the combined geometry and any blank values (where a given duration did not predict flooding greater than 100 mm) set to -9999.
3. The triangles were dissolved (combined) using a 1 m buffer, and only triangles within the largest combined buffer polygon were retained. This removed isolated ponding areas that were not connected to the main valley flood plain. This was output as a separate shapefile to show the extent of the filtered results.
4. The maximum for each data value was calculated.
5. Maximum NZVD2016 water elevation was calculated by subtracting 12.3873 from the model water elevation.
6. Gridded 2x2m rasters for maximum depth, speed, and water elevation (in both NCC and NZVD2016 datums) were created using a common raster extent calculated from the extent of all the outputs for each catchment so that the raster grid squares for all scenarios aligned.
7. Flood hazard rating areas were combined based on their hazard rating and split into individual polygons. This was output as a separate shapefile for overlay.

The 2D surface extent was also supplied for each catchment as a shapefile to denote the extent of the modelled surface. Note that the boundary extends beyond the topographical catchment and overlaps in areas to allow the 2D mesh to automatically derive the topographical extent.

Appendix A shows the flood extent for Q100 Present Day (Scenario C3) overlaid on Q100 2130 (Scenario F3).

8 Summary

We believe that the work has been completed correctly and in accordance with the agreed scope / methodology. The results are suitable for their intended use, subject to acknowledging the uncertainty and limitations associated with work of this nature.

Though the model has been refined since its inception, we recommend that the model and the results should be used primarily for high level planning assessment of flood risk. If these outputs are used for the setting of floor levels, it should be with an appropriate freeboard allowance that reflects the scale and uncertainty and complimented with specific site assessment where deemed appropriate.

9 References

MfE. (December 2017). *Coastal Hazards and Climate Change: Guidance for Local Government.* Ministry for the Environment.

NIWA. (2018). *High Intensity Rainfall Design System Version 4.* NIWA Client Report No: 2018022CH: The National Institute of Water & Atmospheric Research / Taihoro Nukurangi.

NIWA. (2021). *High Intensity Rainfall Design System V4*. Retrieved from The National Institute of Water & Atmospheric Research / Taihoro Nukurangi: https://hirds.niwa.co.nz/

Opus. (2016). *North Nelson Rapid Flood Hazard Modelling Methodology and Results.* WSP Project Number: 5-G2392.05.

T+T. (2020). *Coastal Inundation in Nelson City.* T+T Job Number: 1006718.v7: Tonkin + Taylor.

Regards

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Appendix A

Flood extent for Q100 Present Day overlaid on Q100 2130 (Scenarios C3 & F3)