Project:	Ohura Flood Modelling HEC-RAS 2D	By :	Julia Jung Design Engineer Horizons Regional Council
Date :	14 May 2021		

Purpose

The Hazard Mapping Group has identified the need for flood modelling in the Ohura Catchment. The town of Ohura has experienced a number of floods in the past and Ruhapehu District Council have expressed the need for Horizons Regional Council to investigate the flood extent. Julia Jung, Design Engineer has therefore undertaken flood modelling to identify the town's safety and future development opportunities. This modelling could potentially provide the opportunity for the establishment of a new flood control scheme for the area.

A HEC-RAS 2D model is been created to understand the extent of flood events particularly in the township of Ohura. This memo is prepared to summarise the model inputs and the results from the models as well as model limitations and recommendations.

HEC RAS 2D Geometry

Figure 1. HEC-RAS 2D Geometry

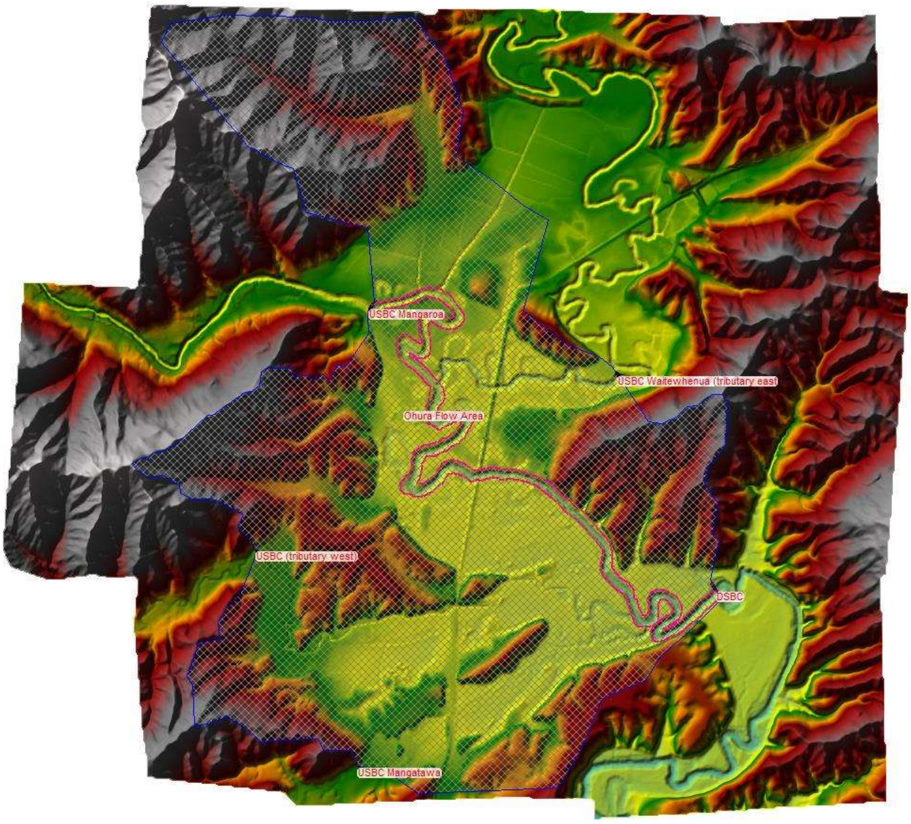


Figure 1 shows the 2D area of the model with the 4 upstream boundary conditions as well as downstream boundary conditions. The Mangaroa River is running from the north east to the south west direction and two tributaries upstream known as the Huhatahi and Mangawhena streams and two tributaries in the south are known as the Mangaparare and Mangatawa streams respectively. The downstream boundary condition is set as a tailwater level and this is discussed in the next section of this report.

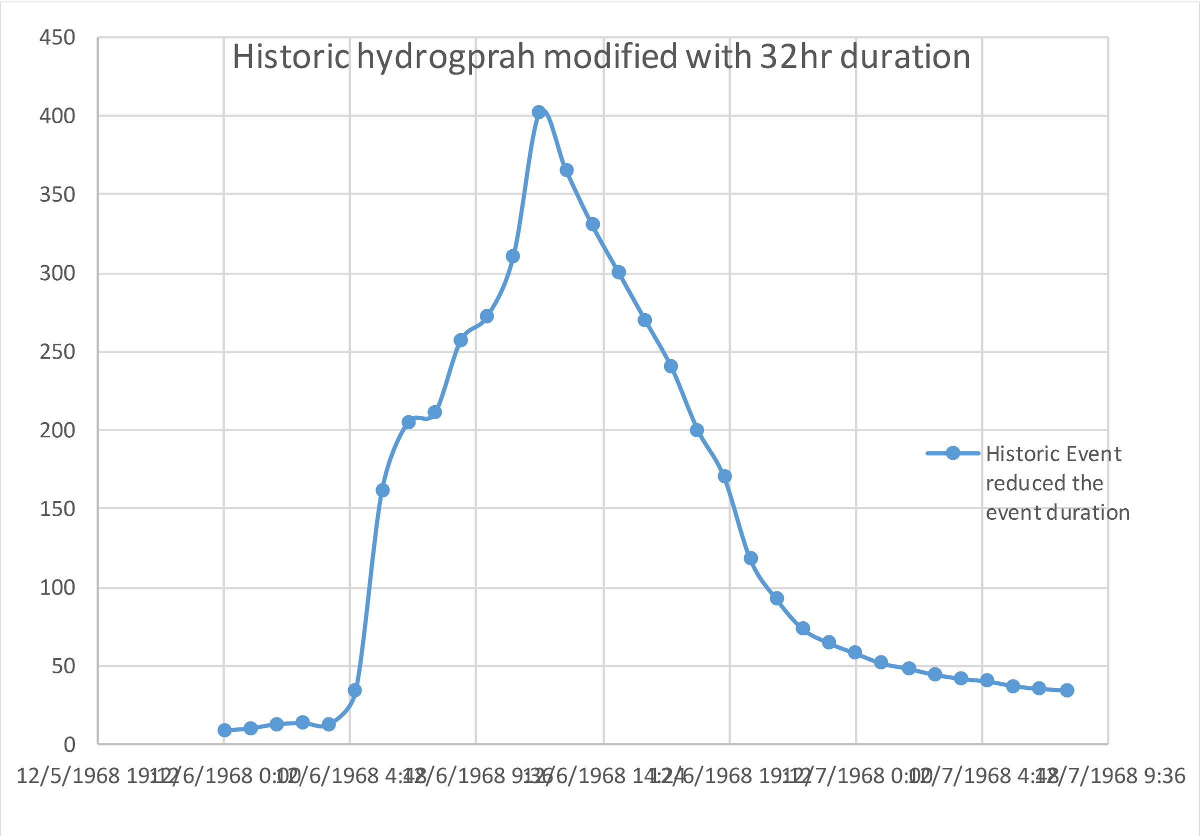
The 2D model area is set with 10m x 10m grid cells and the red line indicates the location of the break lines and roughness of 0.08 which is applied as manning's n. HEC-RAS has a sub-grid sampling function embedded in the 2D model domain, which means the cell face will calculate the terrain levels as opposed to the cell centre.

Hydrology

Hydrograph

The unsteady flow hydrographs were generated based on the historical flood which occurred in the 6-9 December 1968 (The peak flow of the historical event was 154.378 m3/sec at the Mangaora Stream, Ohura Town Bridge flow recording site). Figure 2 shows the historic hydrograph. This hydrograph shape was maintained for the modelling (i.e. peakflows) but the duration reduced to 32hrs. This hydrograph in Figure 2 is used to scale each design hydrograph for each of the 7 scenarios modelled and they were plotted as per the peak flows from Table 1.

Figure 2. Input Hydrographs



Model Boundary Conditions

Jeff Watson (HRC) provided the design flows from Tokirima gauging site and estimated flows in the Mangaroa River at the Town Bridge in Ohura. The peak flows at the Town Bridge were estimated compared to the gauged data from Tokirima. The flows derived from NIWA's Flood Estimation Tool and the flows derived from the application of the rational method resulted in flows that were considerably higher (i.e. approximately doubled in peak flow than the estimated flows from Tokirima for the the storm event that occurred in 1998.

The unsteady flow hydrogrpahs are scaled based on the historic event shown in Figure 2 using the peak flows for each design event shown in Table 1. The time of concentration was estimated to approximate 16 hours for the largest catchment (i.e. the Mangawhenua Stream) and that was used for the time taken to peak during design storm event. So, the input hydrograph is scaled to peak at 16 hour in the event and the total duration of 32hours. Base flow in the channel is also added in the input hydrograph to reflect the typical days of the channel flow prior to the design event occurs. Tail water depth is set as per the Table 1 for each design scenario as a constant level during the entire duration. The constant peak tail water depth allows for the backwater effect from the Ohura River within the model. This is something that can be refined in the future. For reference, the tail water depth is derived at the location of downstream boundary condition from the previous 2D model that uses design flows from NIWA.

A hyetograph is plotted using total rainfall depth for each design scenario. The total depth in Table 1 for each design storm event is distributed over 16 hour duration with 4mm per hour being subtracted to account for infiltration loss.

Table 1 shows the boundary conditions for the model input (i.e. four upstream boundary conditions, one downstream boundary condition and precipitation (direct rainfall on the grids of 10m x 10m)).

Table 1. Model Boundary Conditions

Upstream (US), Downstream (DS) Boundary Condition (BC)		USBC	USBC	USBC	USBC	DSBC	Rain on Grid
		Huhatahi Stream	Mangawhena Stream	Mangatawa Stream	Mangapara-re Stream	Tailwater depth (m RL)	Total rainfall depth (mm)
E.G (m/m)		0.0044	0.0049	0.016	0.01182	-	-
Catchment Size (ha)		7125	10937	196	574	-	-
Base flow		20 cumecs $(>Q_{50})$ 5 cumecs $(<Q_{50})$		0.5 cumecs $(>Q_{100})$ 0.1 cumecs $(<Q_{100})$		-	-
Q (m^3/s) - ARI	MAF	56.22	70.02	3.37	6.34	145.8	61
	5yr	67.03	83.47	4.01	7.55	147.14	83
	10yr	75.84	94.44	4.54	8.55	147.55	97
	20yr	84.43	105.14	5.06	9.51	147.8	110
	50yr	95.39	118.79	5.71	10.75	148.18	130
	100yr	103.55	128.96	6.20	11.67	148.48	146
	200yr	111.32	138.63	6.84	12.88	148.64	160

As mentioned above regarding the peak design flows for the model, it is worth noting that the report of *Hydrology of Flood Events at Ohura by Marianne Watson* (1998) comments on flows at the Town Bridge in the Mangaroa River that occurred on the 28 October 1998. The report states that the peak flow in the Mangaroa River for 28 October 1998 has been estimated from the regression equations as being somewhere between 200 and 300 cumecs. Likely return period is around 50yrs but the analysis confidence interval ranges between 20yr and over 100yrs. This flow analysis aligns well with the design flows in Table 1.

Model Output Files

Results Information

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Plan Information for results file: 'h:\P\RD\08\08\HEC Data\HEC-RAS\Ohura-2021\Ohura.p47.hdf'
  Plan Title = PLAN MAF (126.24) n=0.08 TW145.8 10mGrds
  Plan Filename = Ohura.p47
  Plan ShortID = PLAN MAF (126.24) n=0.08 TW145.8 10mGrids
  Geometry Title = Ohura 2D 10m grid cells
  Geometry Filename = Ohura.g15
  Flow Title = MAF (126.24) TW145.8mRL
  Flow Filename = Ohura.u29
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  Simulation End Time = 22Jan2021 00:00:00
  Computation Time Step Base = 5SEC
  Base Output Interval = 10MIN
  Time Window = 18Jan2021 00:00:00 to 22Jan2021 00:00:00
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  Computation Time Step Min Courant = 0.5
  Computation Time Step Count To Double = 0
  Computation Time Step Max Doubling = 3
  Computation Time Step Max Halving = 0
  Computation Time Courant Method = Representative Length/Velocity
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Error: (None)

Results Information

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  Plan Filename = Ohura.p46
  Plan ShortID = PLAN 2. 5yr (150.5) n=0.08 TW147.14mRL 10m grids
  Geometry Title = Ohura 2D 10m grid cells
  Geometry Filename = Ohura.g15
  Flow Title = 5yr (150.5) TW147.14mRL
  Flow Filename = Ohura.u30
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  Simulation End Time = 22Jan2021 00:00:00
  Computation Time Step Base = 5SEC
  Base Output Interval = 10MIN
  Time Window = 18Jan2021 00:00:00 to 22Jan2021 00:00:00
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  Computation Time Step Max Courant = 3
  Computation Time Step Min Courant = 0.5
  Computation Time Step Count To Double = 0
  Computation Time Step Max Doubling = 3
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  Computation Time Courant Method = Representative Length/Velocity
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Results Information

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  Plan Filename = Ohura.p48
  Plan ShortID = PLAN 3. 10yr(170.28) TW147.4 n=0.08 10m Grids
  Geometry Title = Ohura 2D 10m grid cells
  Geometry Filename = Ohura.g15
  Flow Title = 10yr (170.28) TW147.4m RL
  Flow Filename = Ohura.u31
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  Simulation End Time = 22Jan2021 00:00:00
  Computation Time Step Base = 5SEC
  Base Output Interval = 10MIN
  Time Window = 18Jan2021 00:00:00 to 22Jan2021 00:00:00
  Plan Name = PLAN 3. 10yr(170.28)TW147.4 n=0.08 10mG
  Computation Time Step Max Courant = 3
  Computation Time Step Min Courant = 0.5
  Computation Time Step Count To Double = 0
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Results Information

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  Geometry Filename = Ohura.g15
  Flow Title = 20yr 189.6 TW 147.8m RL
  Flow Filename = Ohura.u26
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Results Information

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  Plan Filename = Ohura.p50
  Plan ShortID = PLAN 5. 50yr (214.2) TW148.18n=0.08 10mG
  Geometry Title = Ohura 2D 10m grid cells
  Geometry Filename = Ohura.g15
  Flow Title = 50yr (214.2)  TW 148.18
  Flow Filename = Ohura.u32
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  Computation Time Step Min Courant = 0.5
  Computation Time Step Count To Double = 0
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  Computation Time Courant Method = Representative Length/Velocity
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Results Information

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  Plan Filename = Ohura.p43
  Plan ShortID = PLAN 100yr(232.5) TW148.48m, n=0.08,0.14
  Geometry Title = Ohura 2D Varing n
  Geometry Filename = Ohura.g14
  Flow Title = 100yr (232.5) TW148.48m RL
  Flow Filename = Ohura.u27
  Simulation Start Time = 18Jan2021 00:00:00
  Simulation End Time = 22Jan2021 00:00:00
  Computation Time Step Base = 5SEC
  Base Output Interval = 10MIN
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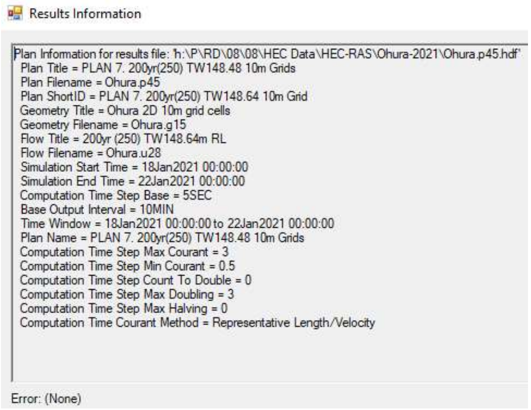

Limitations and Recommendations

This Ohura 2D flood modelling ran with 7 different scenarios (i.e. MAF, 5yr, 10yr, 20yr, 50yr, 100yr, 200yr ARI) and created the result layers for the each design flood event however, the model results are only indicative and potentially require sensitivity checks and refinement. The items that would make the model more accurately represent the scenarios are as follows:

- Varying grid cell size – the current model has grid cell size of 10m x 10m for the 2D area
- Varying storm duration for each design event – current model has 32hr duration and the rest of the time in the hydrograph has a constant base flow;
- Investigating the base flow representable for each design storm event – on-going flow monitoring is recommended;
- Creating more representable hydrograph for each design event – the hydrograph used for this modelling came from December 1968 with the peak flow of 154.3 cumecs at the Town Bridge, Ohura. It is approximately slightly larger than the 5yr ARI from the Table 1. It is recommended to compare the peak flow with the historical event then adopt the hydrograph for each design storm event, however this recording site has a relatively short period of record hence it would be hard to obtain the hydrograph that matches with the peak design flow;
- Investigating infiltration loss - 4mm infiltration loss has applied for the entire duration of 16hr rainfall for this model;
- Importing land cover information for Manning's n for various locations (i.e. residential area vs flow channel) - the current model adopts n=0.08 and this is deemed high for the Mangaroa River but may be too low to represent the residential lots;
- Including hydraulically significant 1D features – There is a large area of ponding observed in downstream side of the catchment, this shall be resolved by inserting 1D features such as culverts;
- Creating a 1D & 2D coupled model in order to modify the channel terrain to represent the bathymetry – the cross sections in the Mangaroa River were surveyed on 27-28 April 2017. This can be re-surveyed or the surveyed cross sections are recommended to be used in a 1D model domain to define more accurate bathymetry, and

- Investigating the DEM which can appropriately represent the topography – the DEM used for this model shows some unusually high ground level at certain places and it is deemed to be incorrect (i.e. vegetation not removed).