Modelling Group
WATER NEW ZEALAND

Modelling Symposium

Updating models – Paraparaumu Beach case study

(MIKE FLOOD vs. TUFLOW)

Presented by
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water
NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa

Your amazing title goes here!

- ✓ Some of first detailed hydraulic models of the entire stormwater network
- ✓ Last major update between 2007 and 2012
- ✓ New models to address groundwater, urban intensification and climate change
- ✓ Understand effects of a software change on flood maps.

- ❖ What we did.
- ❖ Results and discussion
- ❖ Questions on specifics

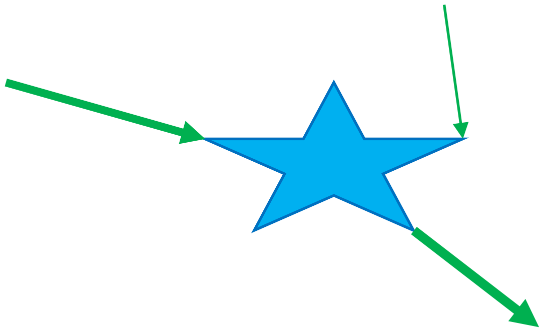
What did we do?

Old models -> MIKE FLOOD (Classic)

New models -> TUFLOW

Paraparaumu Beach as pilot model

- **Open channels in 2D in TUFLOW**
- **1D channels in MIKE FLOOD**
- **Uniform resistance**
- **Buildings not represented**
- Culverts, pipe network and stormwater inlets
- ~ 1.45 million 2 m x 2 m cells/elements
- Smagorinsky vs. Wu 3D eddy viscosity
- NVIDIA Geforce RTX 3090 GPU
- Runoff calculated in HEC HMS and connected as inflows



Some of the things considered

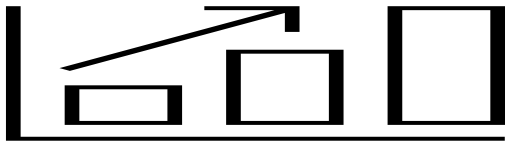
single vs. double precision

implicit vs. explicit

finite difference vs. finite volume

CPU vs. GPU

lowest and higher order flux limiting



adaptive vs. fixed timestepping

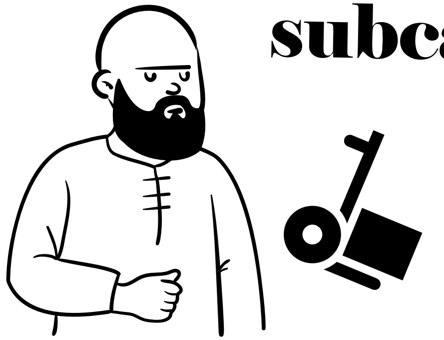
coupled-1D vs. 2D open channels

uniform vs. spatially varied surface resistance

subcatchment-based vs. rain-on-grid

software version

high-resistance building vs. porous obstruction



Configurations and runtime results

Software version	Overland	Network	Channels	GPU precision	Scheme	Su… …istance (Manning…	Channel resistance (Mannings n)	Hydrology	Run time / simulated period
MIKE 2019 U1	M21 Classic	MOUSE	M11	-	2nd-3rd	0.0480769	[illegible]	Subcat…	311%
MIKE 2019 U1	M21 FM	MOUSE	M11	double	Higher	0.0480769	0.03	Su…	32%
MIKE 2019 U1	M21 FM	MOUSE	M11	single	Higher	0.0480769	0.03	…catchment	51%
MIKE 2019 U1	M21 FM	MOUSE	M11	double	Lower	0.0480769	0.0…	Sub…	26%
MIKE 2019 U1	M21 FM	M1D	M1D	double	Higher	0.0…	…03	Subcatchment	16%
MIKE 2021 U1	M21 FM	M1D	M1D	…uble	Higher	0.04…	[illegible]	Subcatchment	22%
MIKE 2021 U1	M21 FM	M1D	M1D	double	Hi…	[illegible]	0.03	Subcatchment	23%
MIKE 2022	M21 FM	M1D	M1D	doubl…	…gher	0.048…769	[illegible]	[illegible]	-
TUFLOW-2020-10-AA	TUFLOW HPC	ESTRY	TUFLOW SG…	…gle	Higher	0.048076…	…04807…	Subc…	7%
TUFLOW-2020-10-AA	TUFLOW HPC	ESTRY	TUFLO… SGS	double	Higher	0.0480769	0.04…	[illegible]	11%
TUFLOW-2020-10-AA	TUFLOW HPC	ESTRY	TUFLOW SG…	[illegible]	Hi…	[illegible]	[illegible]	[illegible]	10%
TUFLOW-2020-10-AA	TUFLOW HPC	ESTRY	TUFLOW SG…	[illegible]	Higher	…0480769	0.048…	[illegible]	19%
TUFLOW-2020-10-AC	TUFLOW HPC	ESTRY	TUFLOW SGS	double	Higher	0.048…69	…0480769	…rid	18%
TUFLOW-2020-10-AC	TUFLOW Quadtree	E…	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56%
TUFLOW-2020-10-AC	TUFLOW HPC	ESTRY	TUFLOW SGS	doubl…	Higher	0.048 - 5.0	0.0480769	…catchme…	28%
TUFLOW-2020-10-AC	TUFLOW HPC	ESTRY	TUFLOW SG…	double	Higher	0.048 - 0.22	0.0480769	Subcatchme…	13%

Why the difference in speed?

Possible explanations

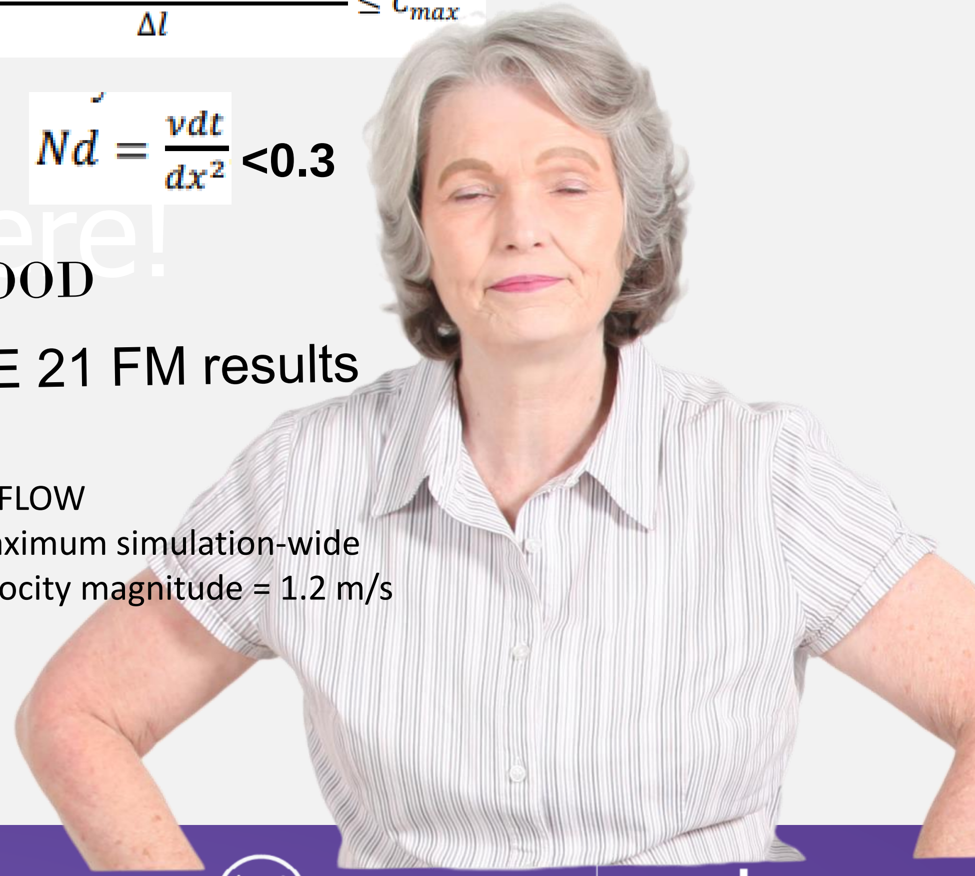
- Probably not the runtime per timestep: MIKE -> 36 steps/s; TUFLOW -> 21 steps/s
- Probably partially the stability criteria:
  - MIKE 21 FM uses $C = \Delta t \frac{|u| + |v|}{\Delta l} \leq C_{max}$ or (?) $C = \Delta t \frac{(\sqrt{gh} + |u|) + (\sqrt{gh} + |v|)}{\Delta l} \leq C_{max}$
  - TUFLOW uses $Nu = \frac{udt}{dx}$ <1.0 … <1.0 and $Nd = \frac{vdt}{dx^2}$ <0.3

Your amazing title …s here!

- Probably parti… the synchronising times… …IKE FLOOD
- Probably t…e spurious velocities that are … in MIKE 21 FM results

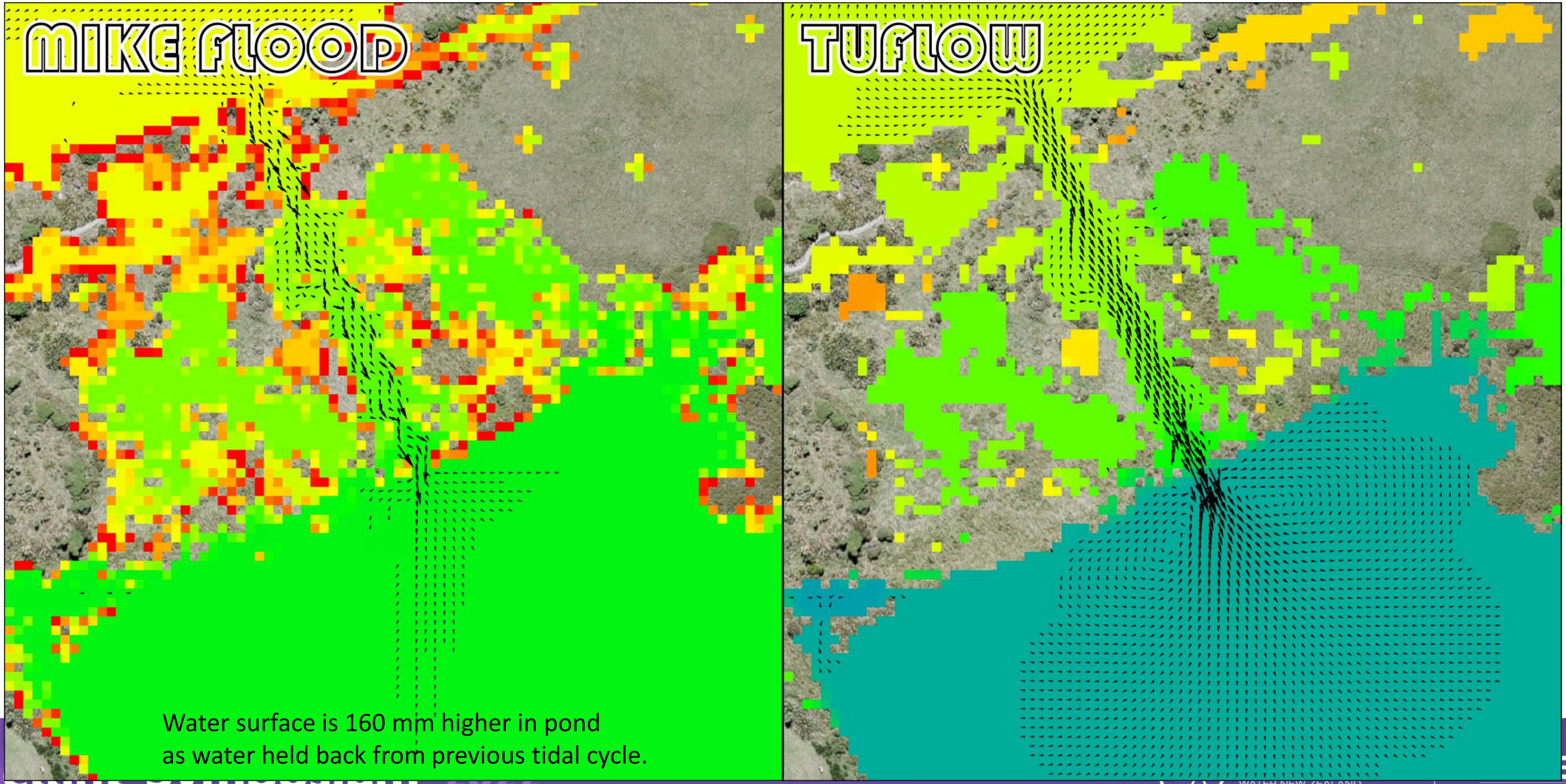
MIKE FLOOD
Maximum simulation-wide
velocity magnitude = 2 m/s

TUFLOW
Maximum simulation-wide
velocity magnitude = 1.2 m/s

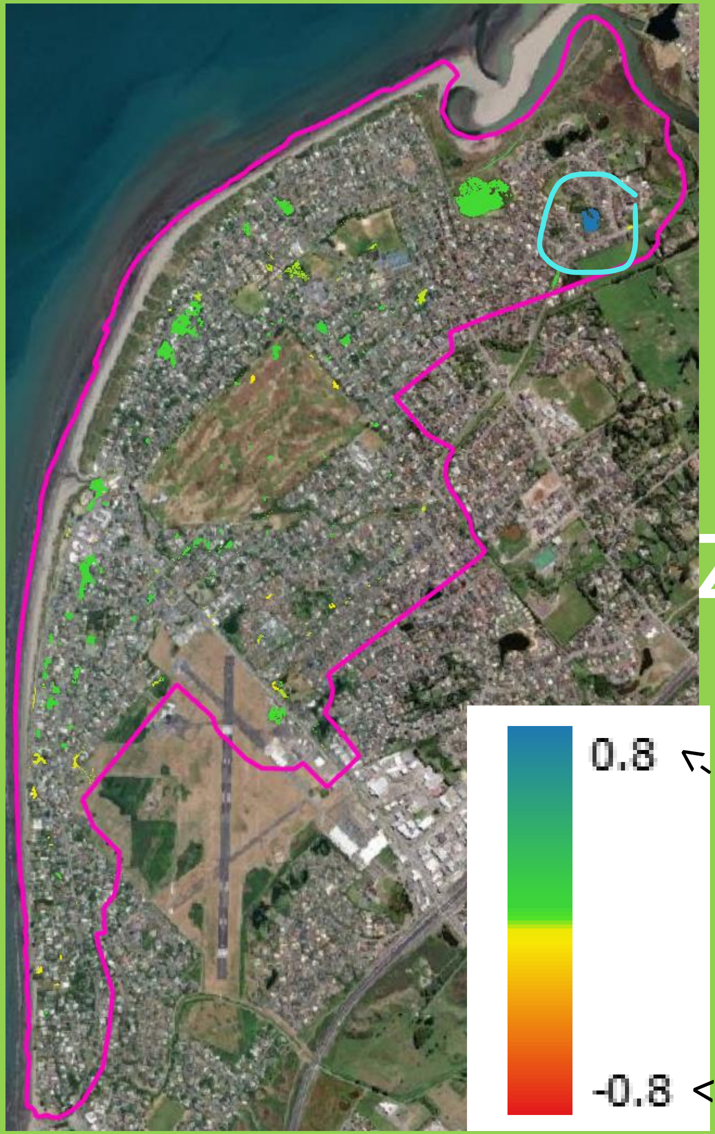


Velocity?

- Maybe eddy viscosity model?
  - MIKE uses Smagorinsky with a minimum value (recommended by BMT)
  - TUFLOW uses the Wu 3D formulation



What is the effect on flood maps?



Difference between TUFLOW and MIKE FLOOD Classic

- Most differences are within 50 mm with small bias towards higher levels in TUFLOW
- Largest difference is due to an initial conditions mistake.

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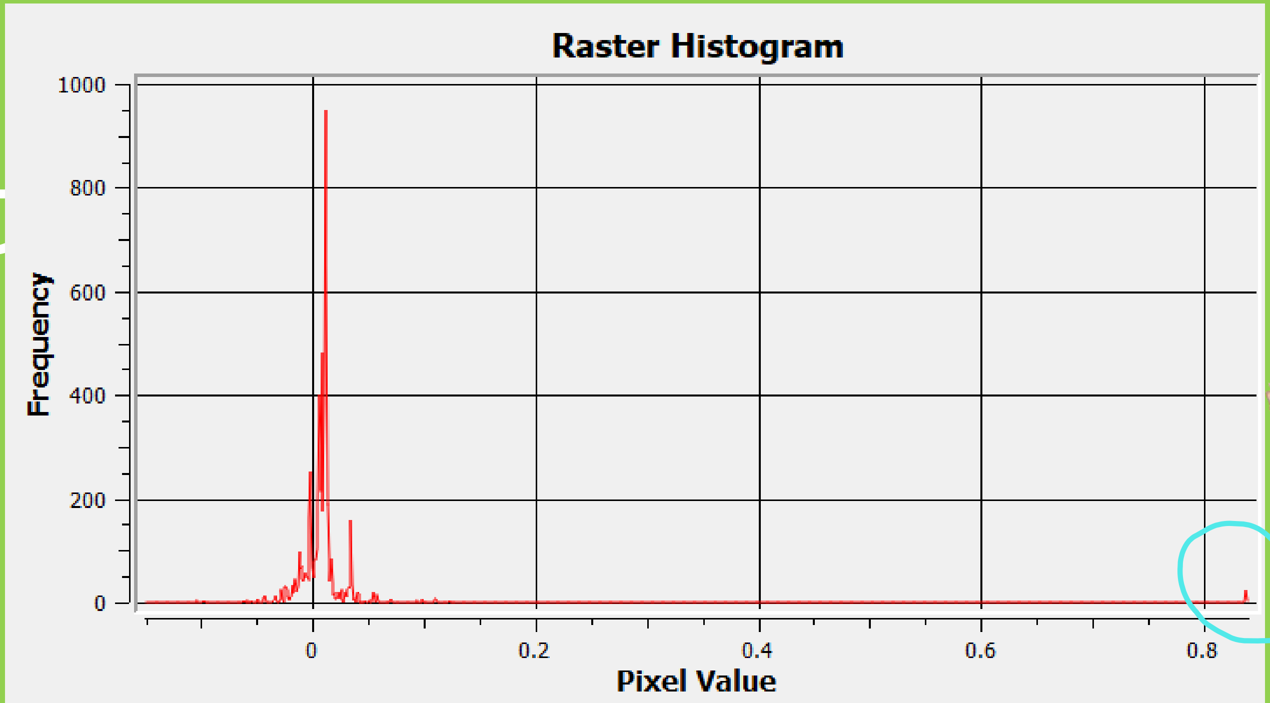
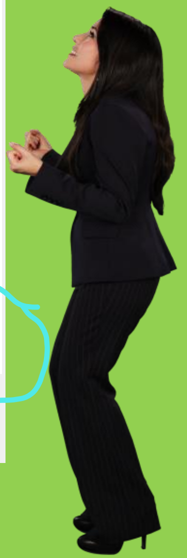
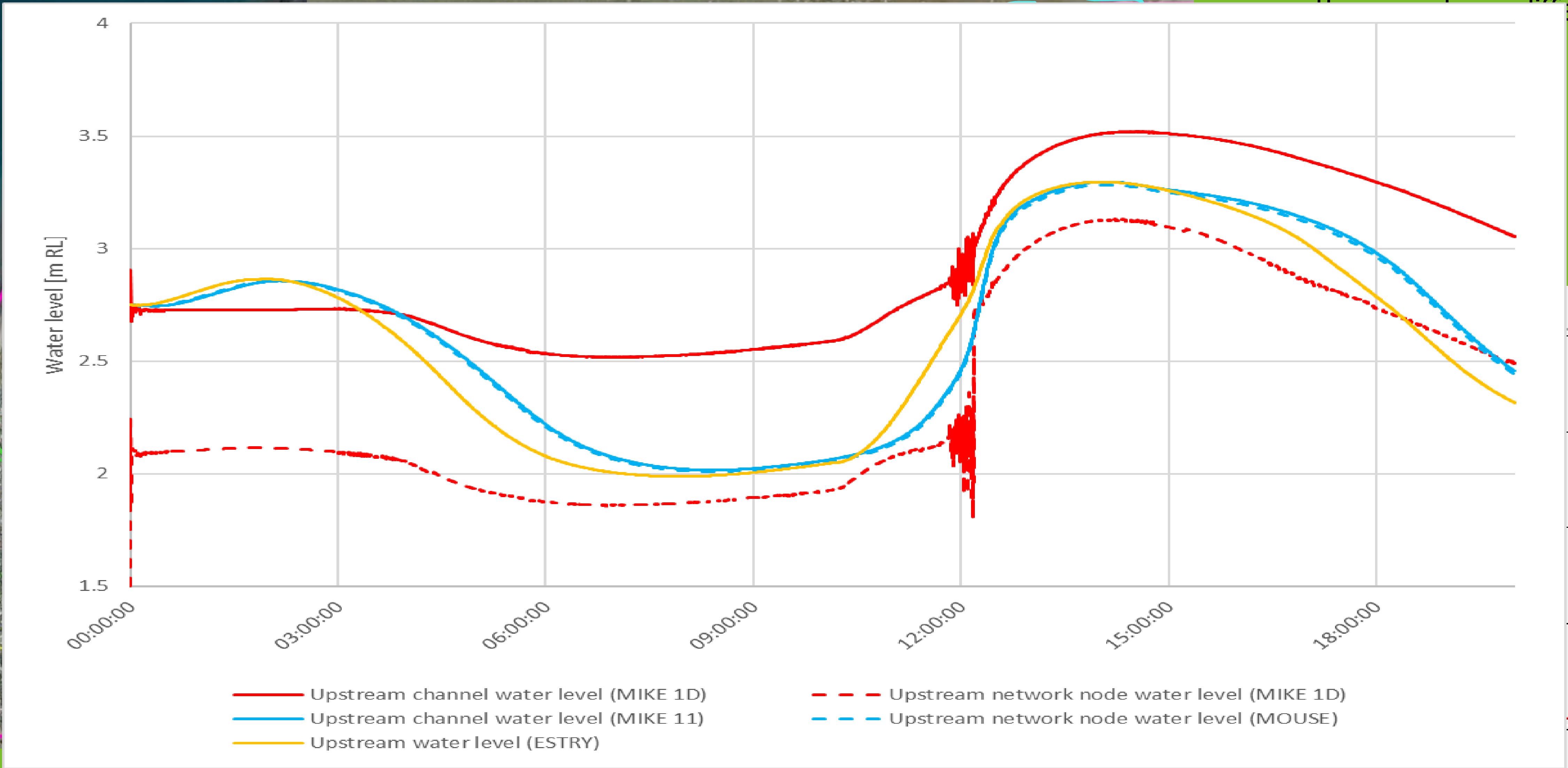
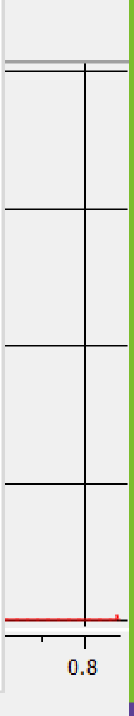




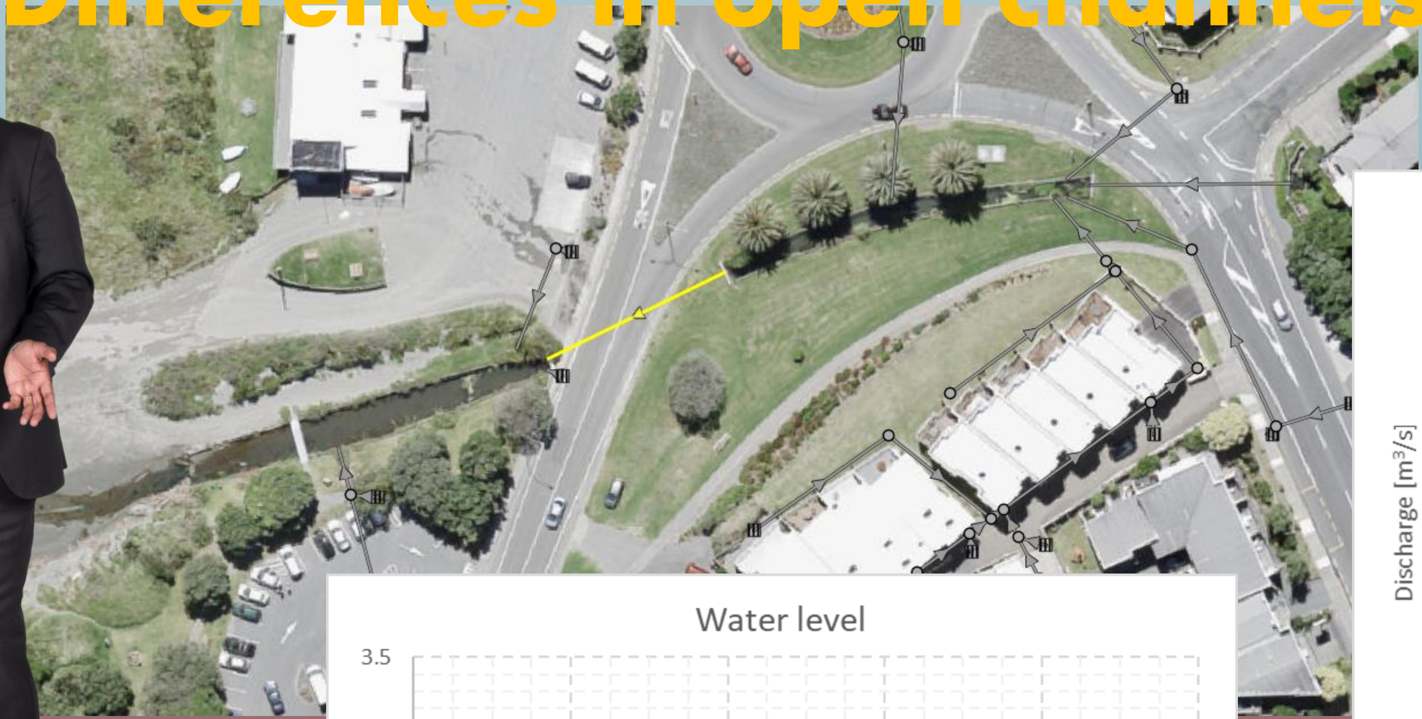
What is the effect on flood maps?

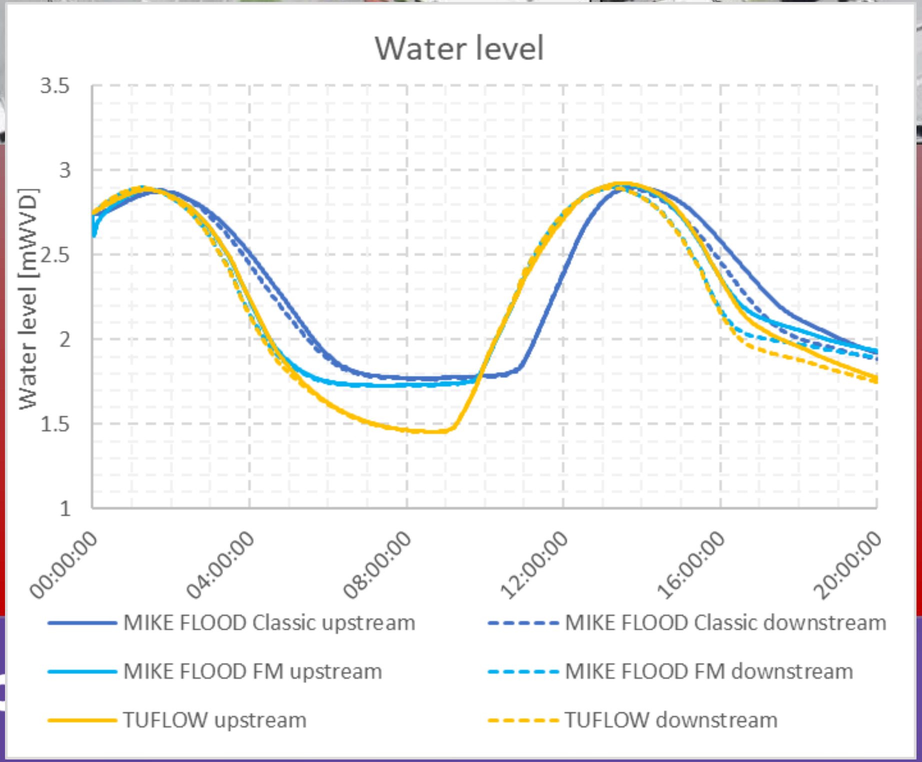
Difference between TUFLOW and MIKE FLOOD FM

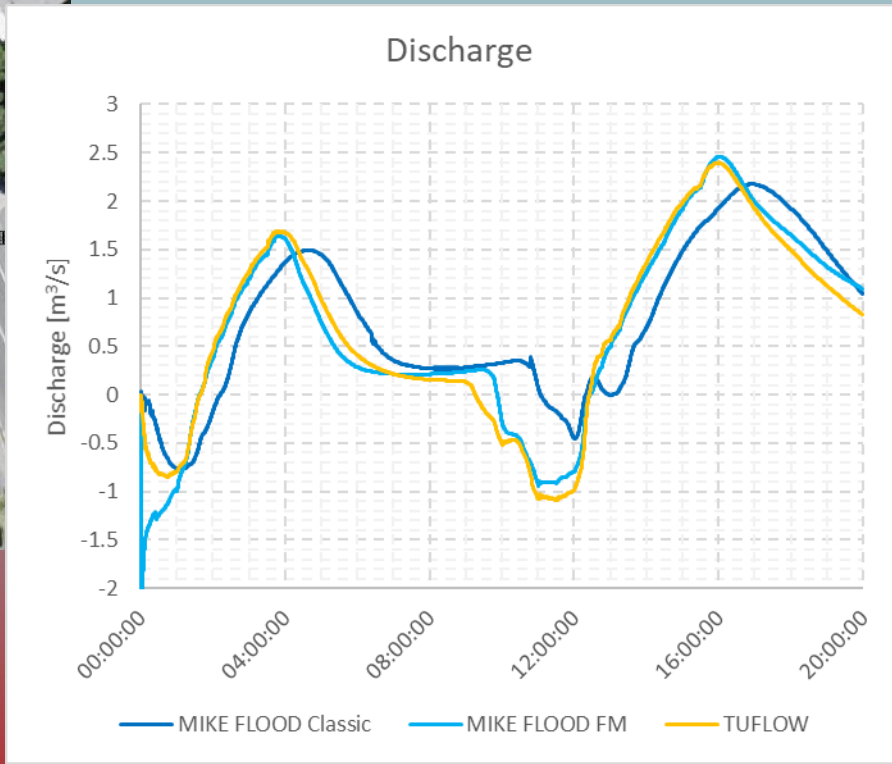




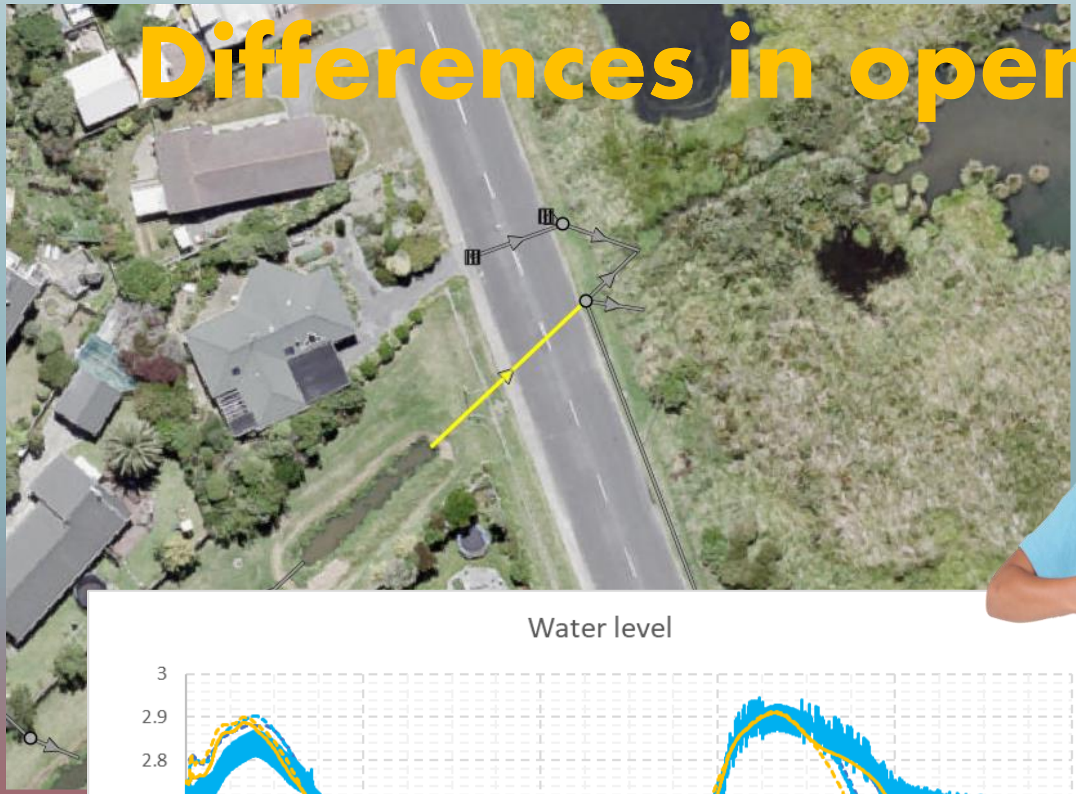
Differences in open channels

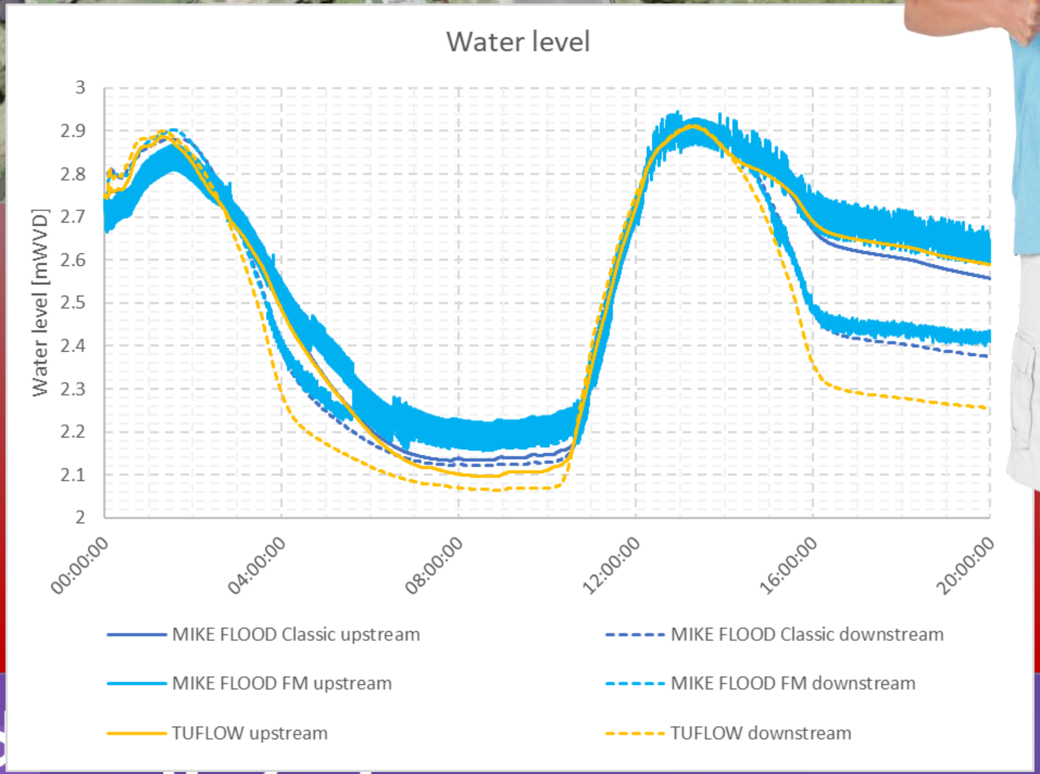


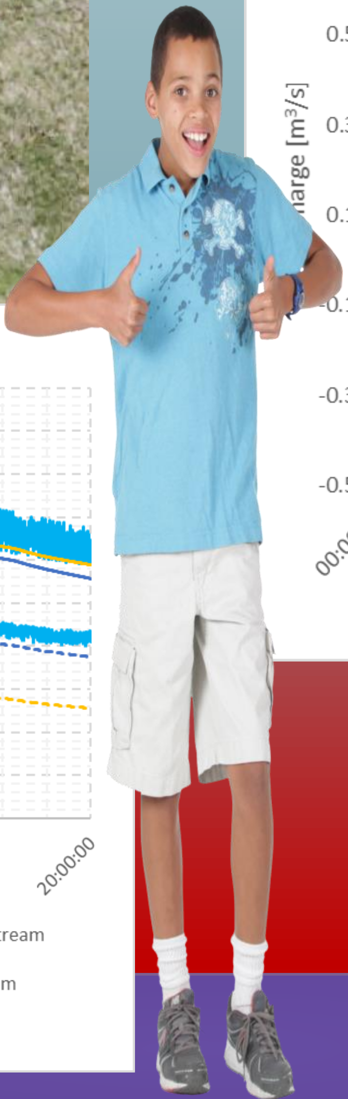


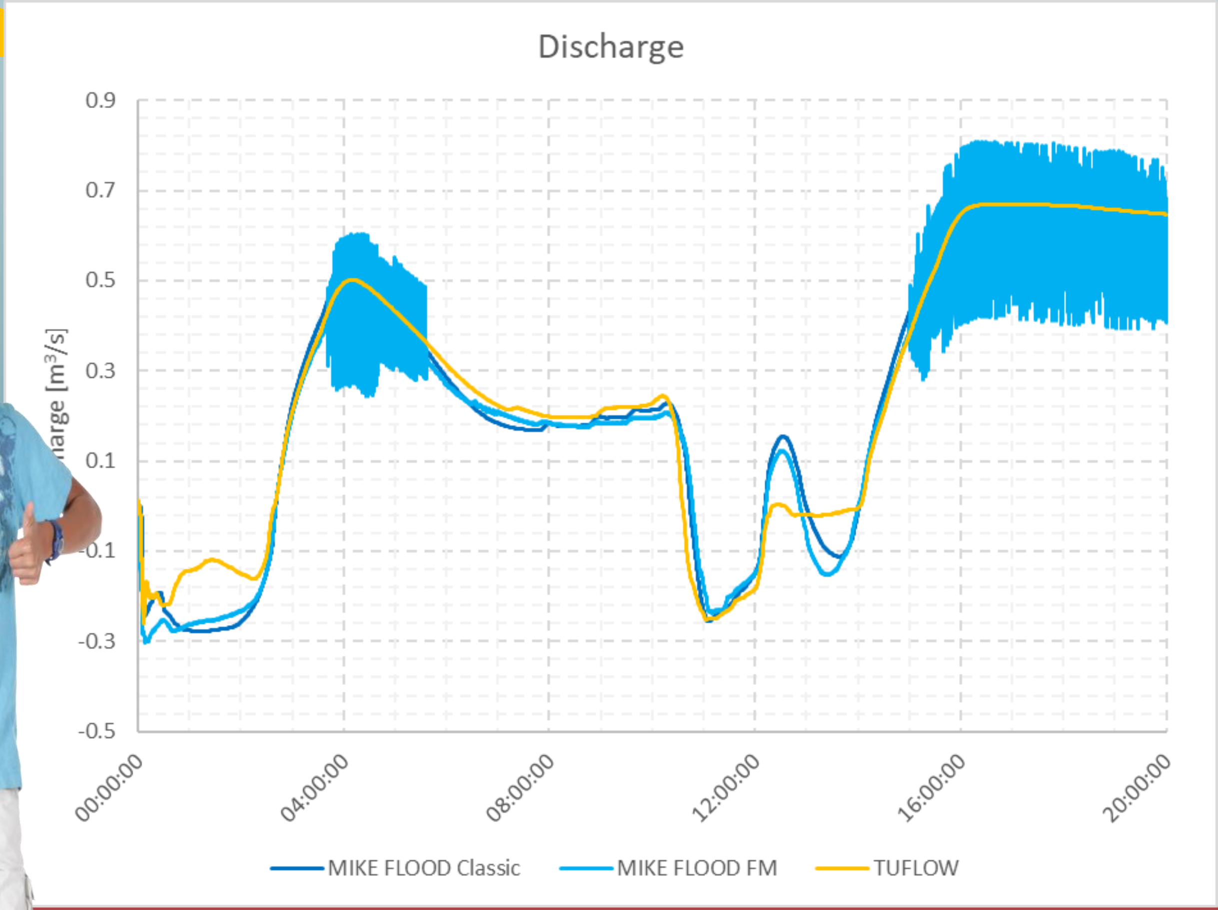


Differences in open ch

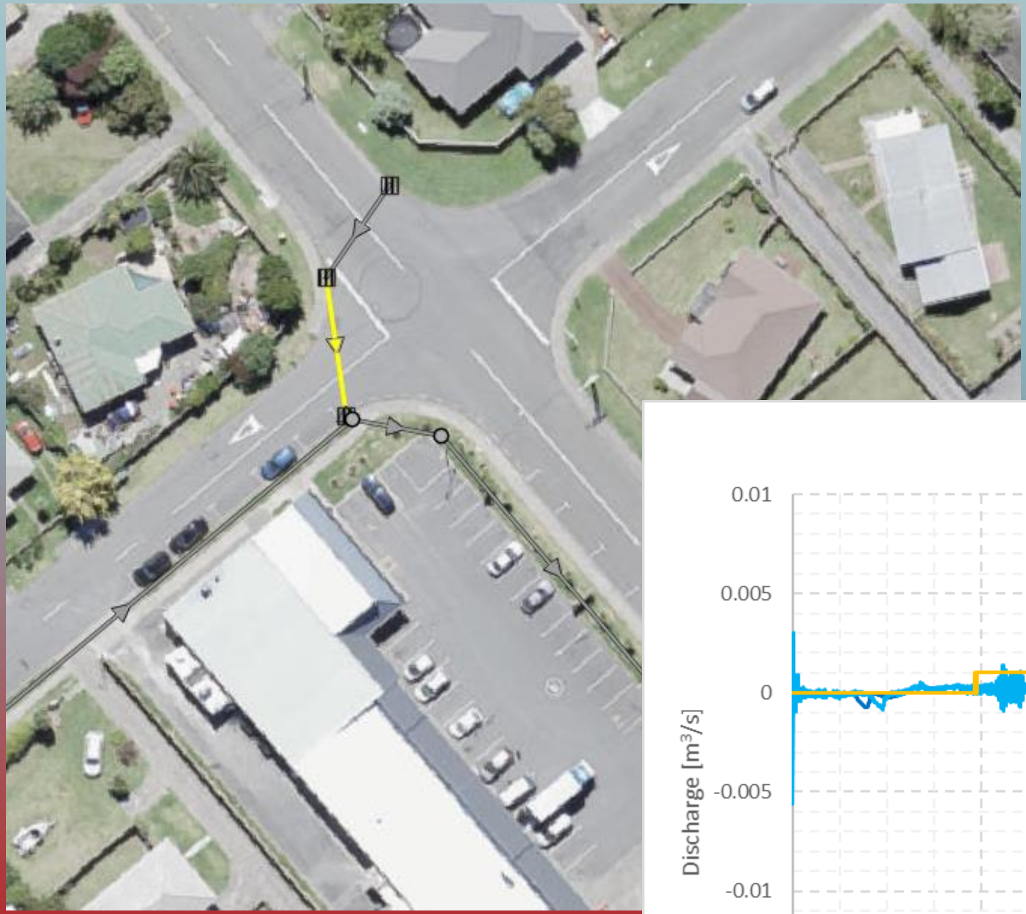


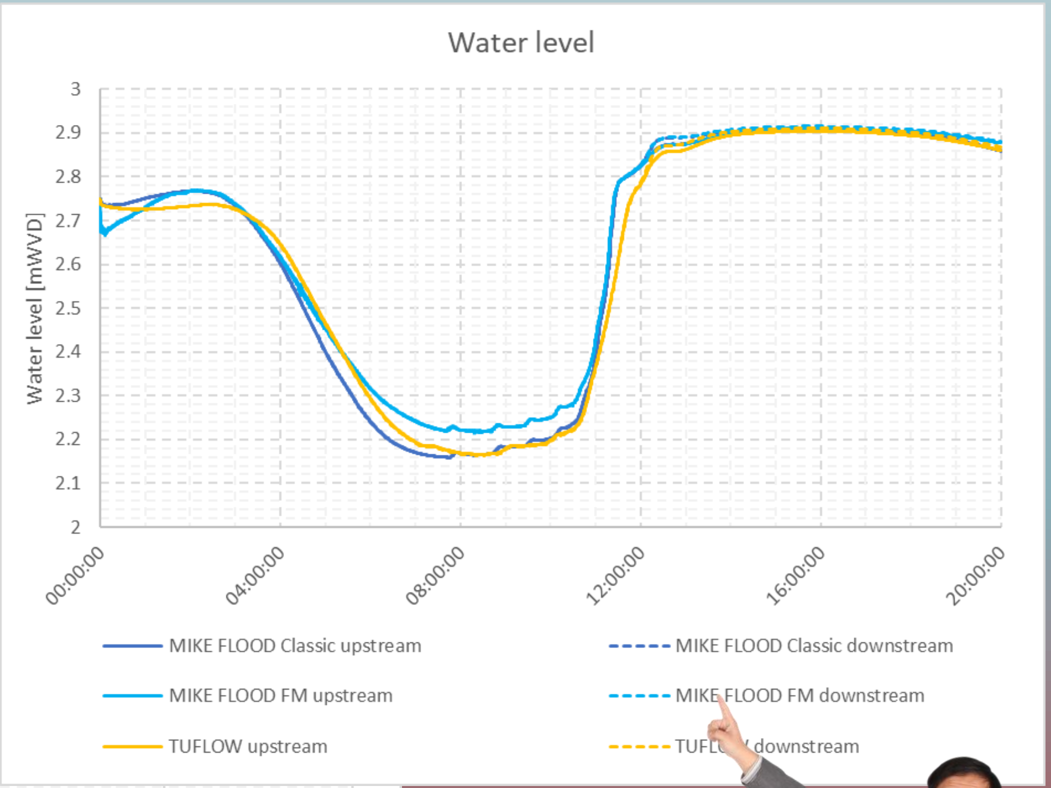


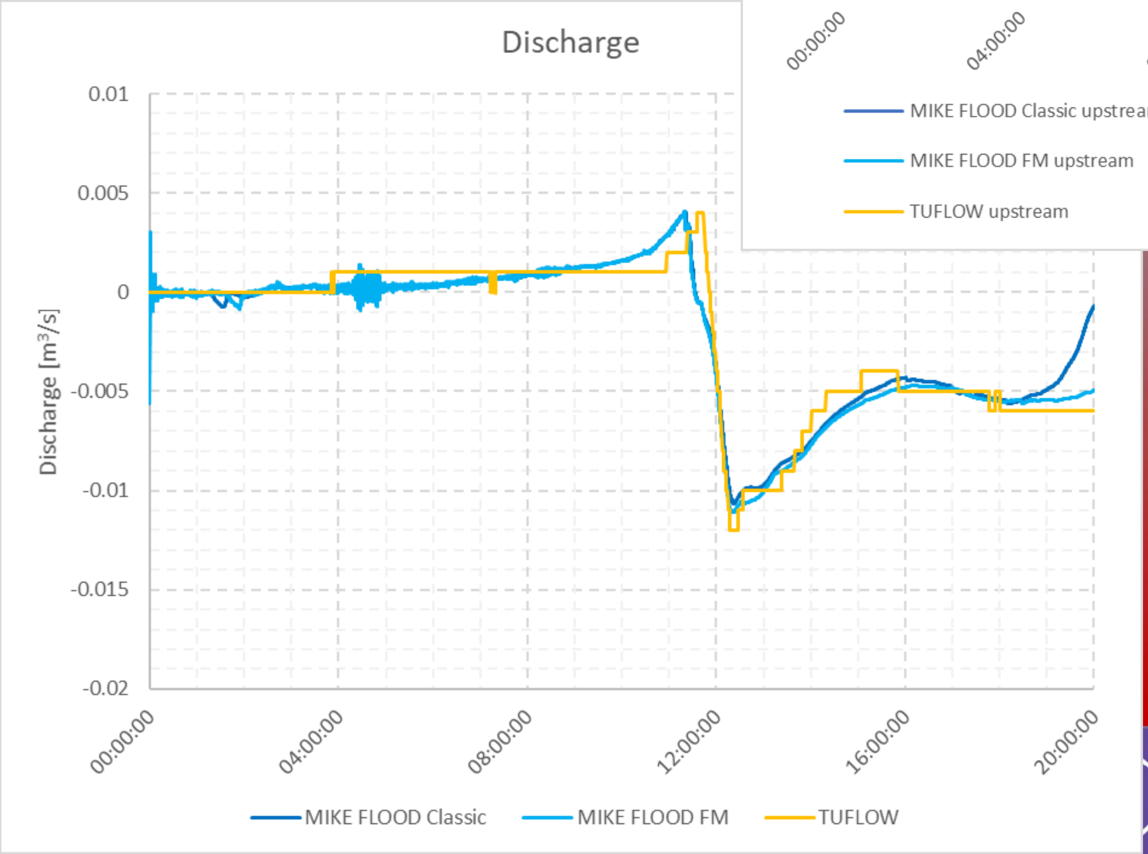




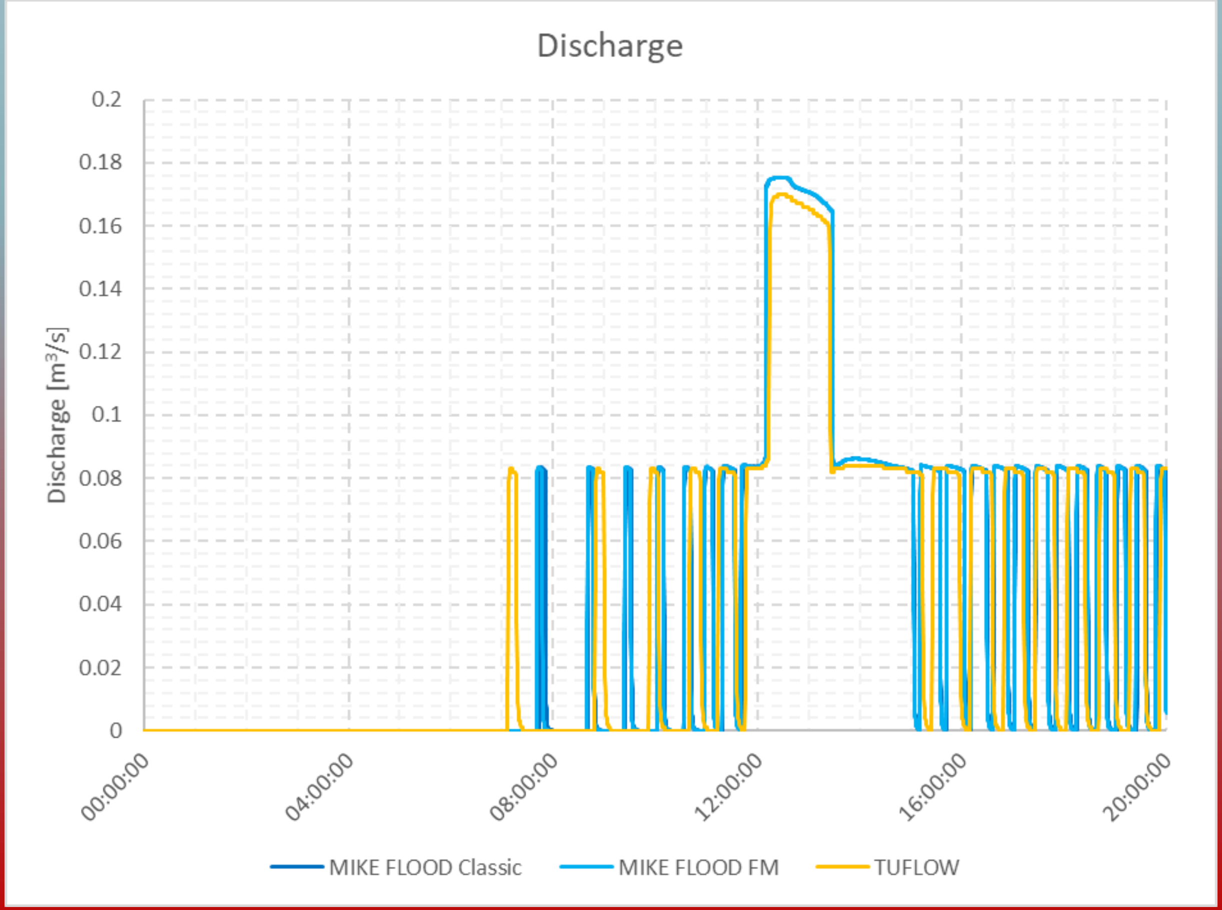
Differences in sump leads

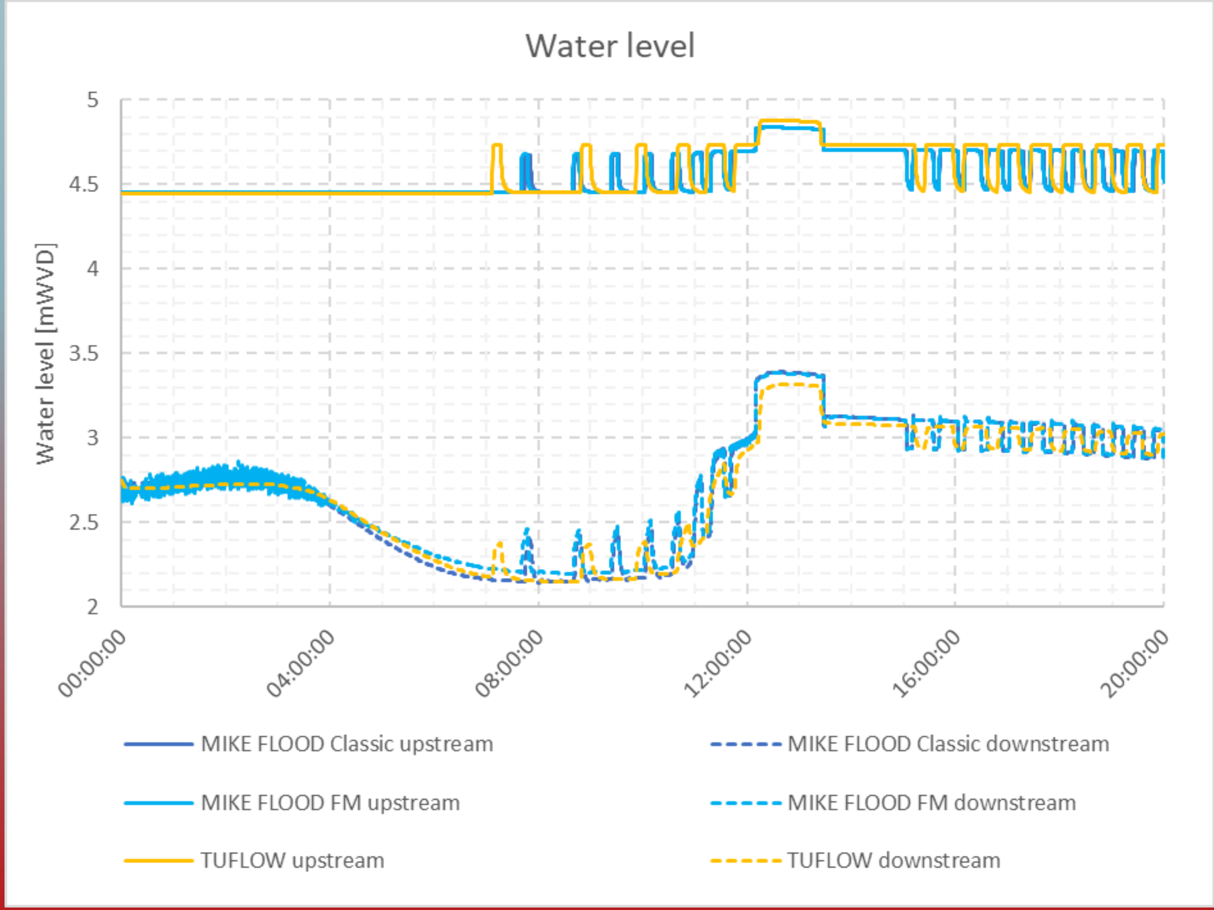




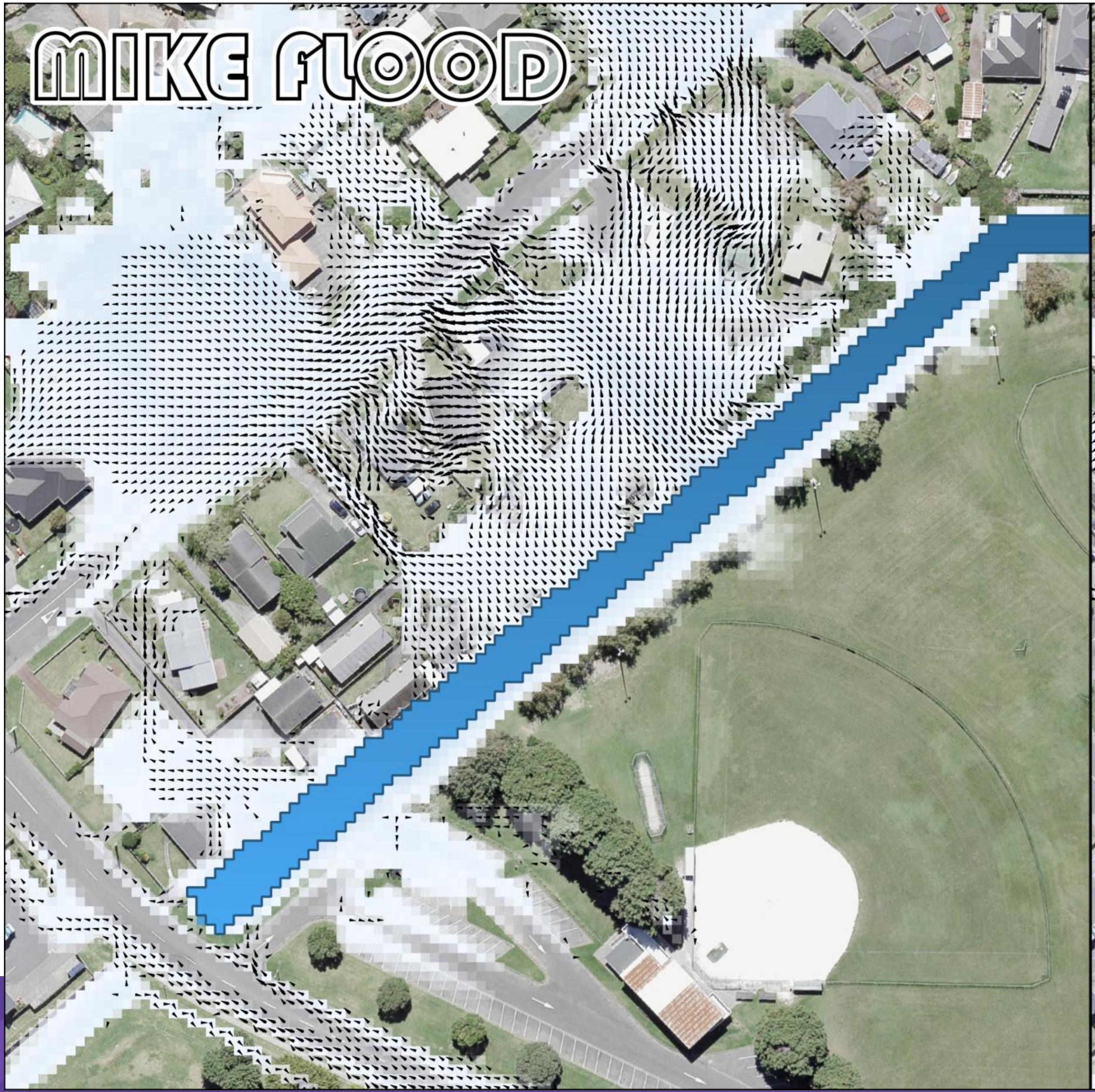


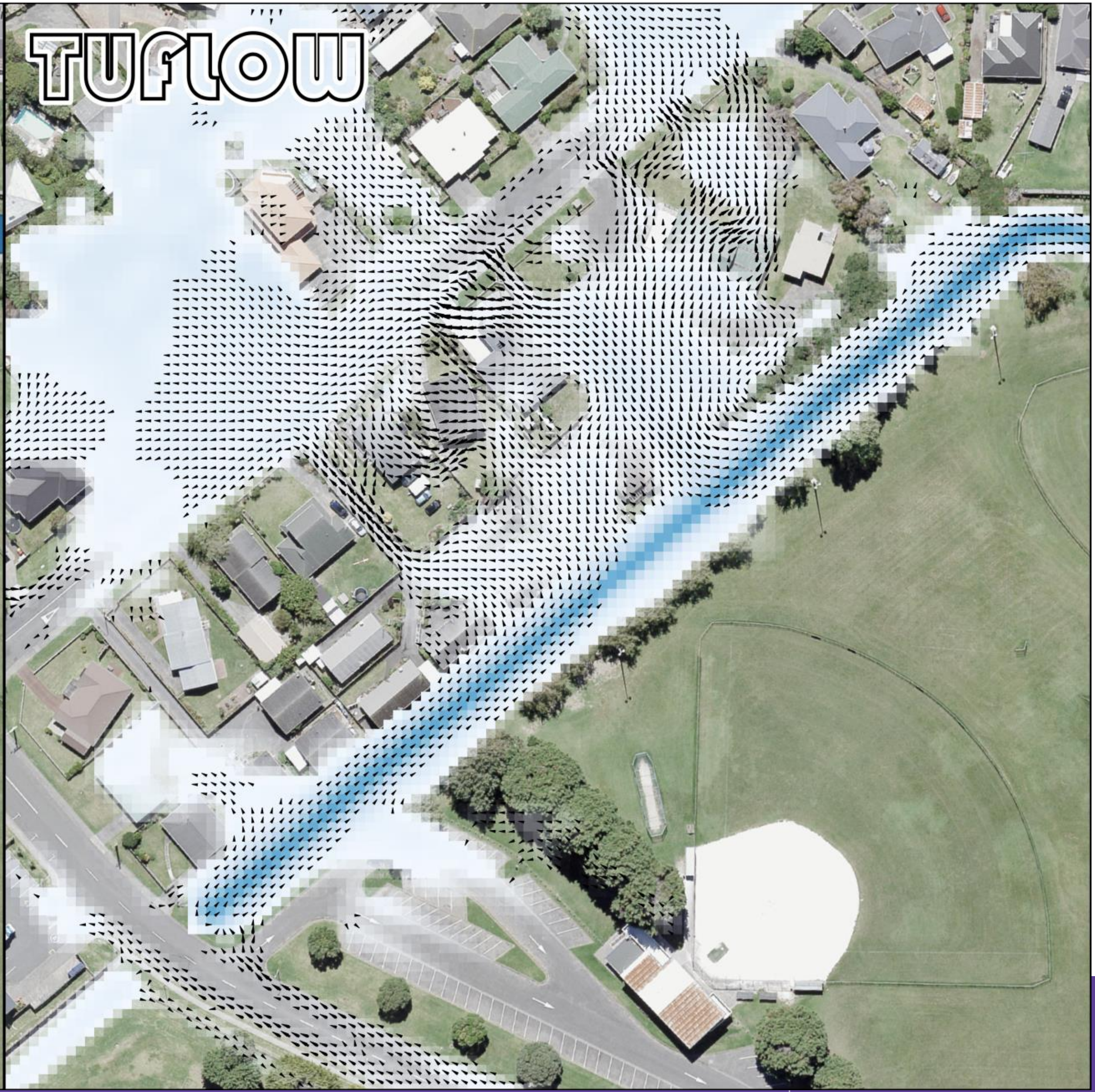
Differences in pipe downstream of pump



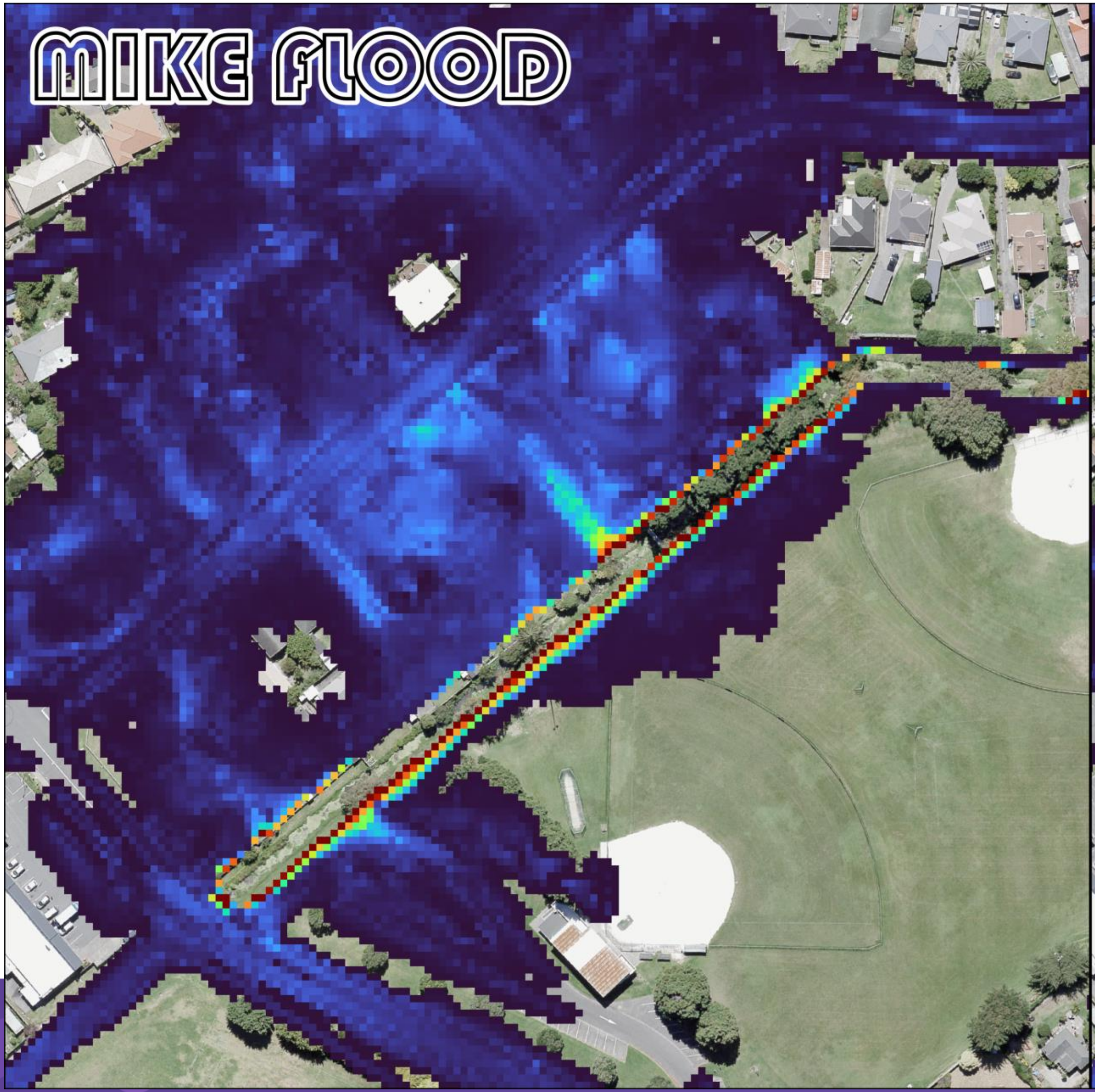


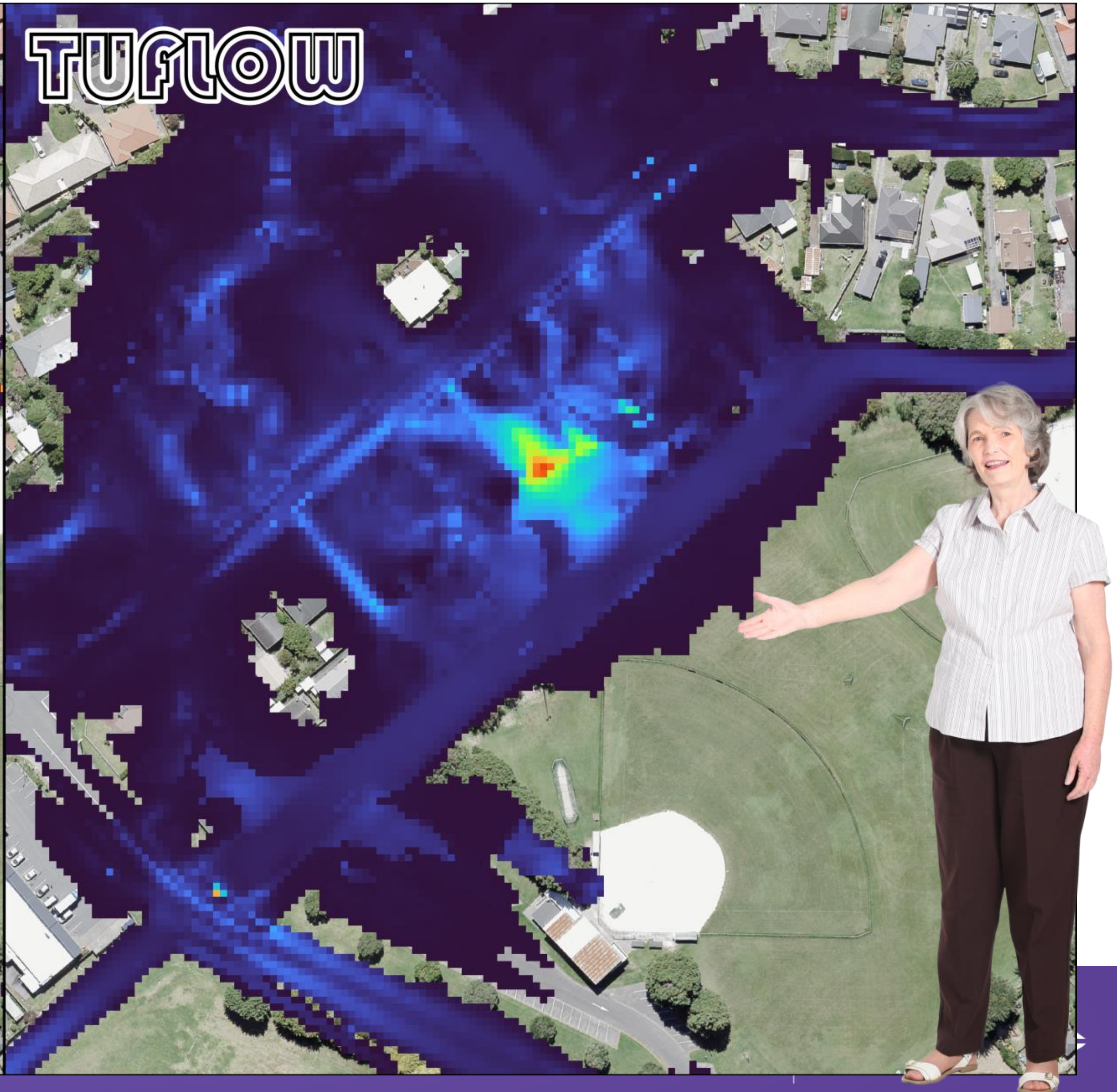
Open channels





Open channels





Usability

MIKE FLOOD	TUFLOW
Stabilising MIKE FLOOD Classic required a **different strategy for each culvert**. There is still work to do for the FM model. Maybe this is resolved in MIKE+?	The same approach worked for all culverts
The MIKE Zero MIKE FLOOD interface is very difficult to use and has been for 15 years. MIKE+ seems to integrate all tables. A lot of clicking is still required.	No common interface, mostly text editor and a GIS interface. Fast to get running as the settings are mostly exception based. Editing input layers is familiar for GIS users.
Proprietary formats mean extra steps to build model.	All open formats (except cached datasets), many are in text format. Some of these formats are inefficient and so caching is used to mitigate the impacts of this.
All edits are required to input layers before starting simulation.	A lot of topography editing and network configuration occurs at simulation start up.
Scenarios in MIKE+ are built into the interface.	Multiple versions of the same input file type can be layered to update the model for particular scenarios.
Relatively straight-forward for a new-comer to understand, but going through all the tables takes time.	Lower case acronyms are difficult to get used to and are a significant part of learning the software.
Model structure is largely imposed.	Completely customisable layout of files, so can lead to very untidy models. Template folder layouts are available and there is some convention.
Can view results while the simulation is running.	Must wait for simulation to complete before viewing results.

Summary

- TUFLOW generally runs faster than MIKE FLOOD.
- High roughness can slow TUFLOW down significantly and hence it is not recommended for simulating building blockages.
- TUFLOW produces more realistic flow patterns and the Wu 3D approach maintains eddy viscosity where Smagorinsky does not.
- MIKE FLOOD Classic, MIKE FLOOD FM and TUFLOW produce very similar estimates for peak flood levels.
- The solution scheme (explicit vs. implicit) has a greater impact on the results than the specific implementation, i.e. MIKE FLOOD FM and TUFLOW results are more similar than those of MIKE FLOOD FM and Classic.
- TUFLOW's implementation of sub-grid sampling overcomes most of the difficulties and limitations associated with modelling open channels.
- Kāpiti Coast District Council has made a good choice in moving to TUFLOW.

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Thank you!
Questions? Pātai?