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Mr Phillip Lambley
enstruct
Level 4, 2 Glen Street
Milsons Point NSW 2061

6th August, 2019

Dear Phillip,

QANTAS Group Flight Training Centre
Peer Review of TUFLOW Model

I refer to recent discussions regarding the proposed QANTAS Group Flight Training Centre. Based on these discussions, we understand that enstruct prepared a flood impact assessment to support the proposed development. The flood impact assessment was prepared with the assistance of a TUFLOW hydraulic model that was original developed as part of the "Mascot, Rosebery & Eastlakes Flood Study" (WMAwater, 2015).

However, we understand that Bayside Council has requested that an independent, detailed peer review of the TUFLOW model be completed to ensure the TUFLOW model updates that were completed as part of the flood assessment reflect modern best practice. Accordingly, Catchment Simulation Solution (CSS) has completed the peer review of the TUFLOW model and is pleased to present the outcomes of the review below.

TUFLOW Model Reviewers

The qualifications and experience of the CSS staff that undertook the TUFLOW model review are provided below. More detailed curriculum vitae can be provided on request.

David Tetley

David Tetley is a civil engineer and Director of Catchment Simulation Solutions with 18 years of experience in flood studies and floodplain risk management investigations in Australia. He graduated from the University of Wollongong with first class honours and the University Medal in 2001. He has experience with a range of hydrologic software as well as 1, 2 and 3-dimensional hydraulic software (including TUFLOW and Drains). David has been involved in the preparation of over 40 Government-funded flood and floodplain risk management studies in NSW and has also prepared several papers on floodplain management (this includes a highly commended paper award at the 2014 NSW Floodplain Management Australia Conference). David is also a member of the consultants' advisory group for the revision of the NSW Government's Floodplain Development Manual.

Daniel Fedczyna

Daniel Fedczyna is a civil and environmental engineer that graduated from the University of Wollongong in 2008 with Honours. During his 9 years with CSS, Daniel has become a highly proficient hydrologic and hydraulic modeller with a particular focus on TUFLOW, XP-RAFTS and WBNM. He has also been exposed to a range of other 1D and 2D hydraulic software including DRAINS, HEC-RAS and RMA-2 as well as GIS software (MapInfo and ArcGIS). Daniel was also awarded best poster presentation at the 2014 Floodplain Management Australia Conference. Daniel has been the principal hydraulic modeller for over 10 government funded flood and floodplain risk management studies in NSW.

Review Outcomes

The TUFLOW model review focussed on the updates that were completed by enstruct to Council's adopted flood study TUFLOW model. That is, a complete review of Council's "base" TUFLOW model was not completed.

The outcomes of the TUFLOW model review are documented in **Attachment A**. The following general comments are made with regard to the following model update components.

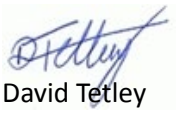
- Terrain and building updates for existing conditions: Revised terrain information for the site and adjoining areas was incorporated within the TUFLOW model. The survey information was reviewed and is considered to provide an improved description of local variations in terrain relative to the 2013 LiDAR that was used in the original TUFLOW model. Modifications to the representation of buildings was also completed in the local vicinity and is considered to provide an improved representation of contemporary catchment conditions.
- Boundary conditions: Modifications to several subcatchments (including one additional subcatchment) was completed in the vicinity of the site to provide a better representation of hydrologic conditions and allow more precise application of flows to the TUFLOW model. Rectification of a "split" subcatchment from the flood study model was also incorporated and is considered reasonable.
- Terrain and building updates to reflect "post-development" conditions: The proposed "design" terrain has been included within the post-development scenario together with an overland flowpath around the northern and western extent of the proposed carpark. Modifications to include the new flight training facility have also been implemented. All updates are considered to provide a reliable reflection of post-development conditions.

Overall, the outcomes of the review indicate that all TUFLOW model updates are reasonable and reflect modern best practice.

I trust that this document provides a suitable summary of the TUFLOW model review that was completed. However, if you have any questions or require anything further on this matter, please do

not hesitate to contact David Tetley (*ph: 8355 5501 email: david.tetley@csse.com.au*) or Daniel Fedczyna (*ph: 5355 5503 email: daniel.fedczyna@csse.com.au*).

Kind Regards,

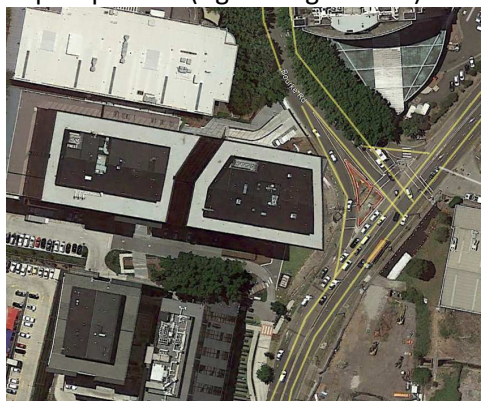


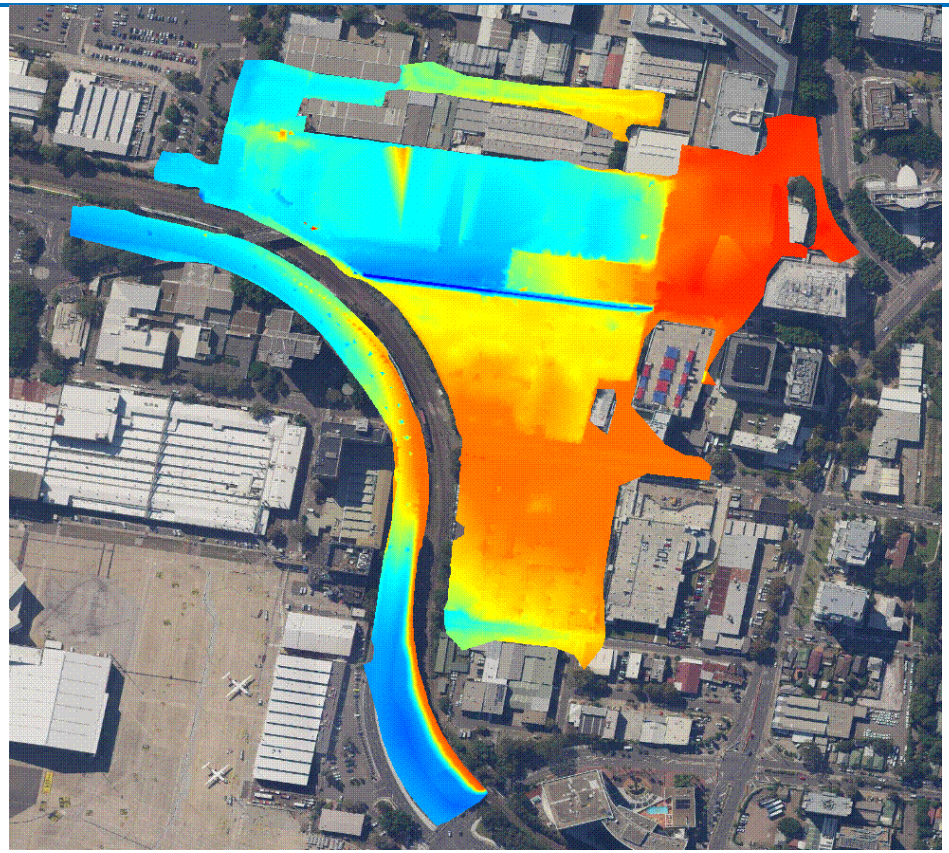
David Tetley
Catchment Simulation Solutions

Attachment A:
TUFLOW Model Review Outcomes

QANTAS FLIGHT TRAINING FACILITY TUFLOW MODEL REVIEW

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
General	Version of TUFLOW model used	• TUFLOW 2018-03-AC-iSP-w64 used for both existing and post development scenarios. "Defaults == PRE 2013" has been used to retain backward compatibility with original flood model for the Mascot, Rosebery & Eastlakes (MRE) Flood Study (WMAwater, 2015)	Nil	
Model Setup	TUFLOW Control and other files	• Folder structure is in accordance with the TUFLOW User Manual 2017-09.	Nil	
	Timestep	Specified timesteps in MRE_Timestep.tcf file: • 2D Model timestep = 0.5 seconds. This is considered suitable as it is in the order of the recommended timestep value of ¼ of the model grid size (i.e., ¼ x 2 = 0.5 seconds). • 1D Timestep = 0.5 seconds (defaults to minimum 2D timestep)	Nil	
Model Configuration	Model Configuration (1D, 2D or 1D/2D?)	• 1D representation of major watercourses and drainage structures dynamically linked to 2D representation of floodplain and overland flow areas	Nil	
	1D representation	• Major conveyance areas that would not be well represented in 2D (e.g., major drainage channels) are represented as a 1D domain. The geometry within the 1D domain is defined using cross-sections at an average spacing of 10-15 metres. As the channel geometry is relatively consistent along each "branch", this spacing is considered to be appropriate	Nil	
	2D representation	• 2 metre grid size • 2 metre grid size is commonly adopted for urban/overland flood studies and is considered sufficiently detailed to represent major topographic and drainage features (not represented as 1d elements) in an urban catchment	Nil	

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
Extent of Model	2D Model Extent	• Active 2D domain extent set by 2d_code_StudyArea_003 Subject site located sufficiently within active domain to ensure appropriate representation of upstream and downstream flood conditions	Nil	
	1D Model Extent	• Major open creek channels and structures within the catchments including channel adjacent subject site. Cross section geometry agrees well with detailed site survey, and is a significant improvement over the LiDAR representation, justifying the use of 1d elements.	Nil	
Terrain Data (2D)	Source of DEM data	• Catchment wide terrain assigned through z-points populated from 2013 LiDAR data (2d_zpt_MRE). • Additional zshp (2d_zsh_en_terrain_fix) included to 'fix' terrain where topography has changed since data collection, ie: a building on corner of Bourke Rd and O'Riordan St which was an open carpark (left image below) at the time of LIDAR collection, and now has a large building complex present (right image below).   • Detailed survey DEM (existing_190220.asc) included across and around the development site (extent shown below).	Nil	

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
				

- For the most part, there appears to be a good agreement between the 2013 LiDAR terrain and the detailed site survey (generally within 0.05m). However, a location ~50m west from the Bourke Road frontage of the site demonstrates a more significant difference of 0.15 metres, where the detailed survey is higher than the 2013 LiDAR DEM (see section provided below). The detailed survey appears to better reflect the crest of the driveway and has been collected more recently, using more accurate ground survey techniques. As a result, it is considered that the ground survey information is superior to the LiDAR and is more suitable for use in the TUFLOW model across this area.

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		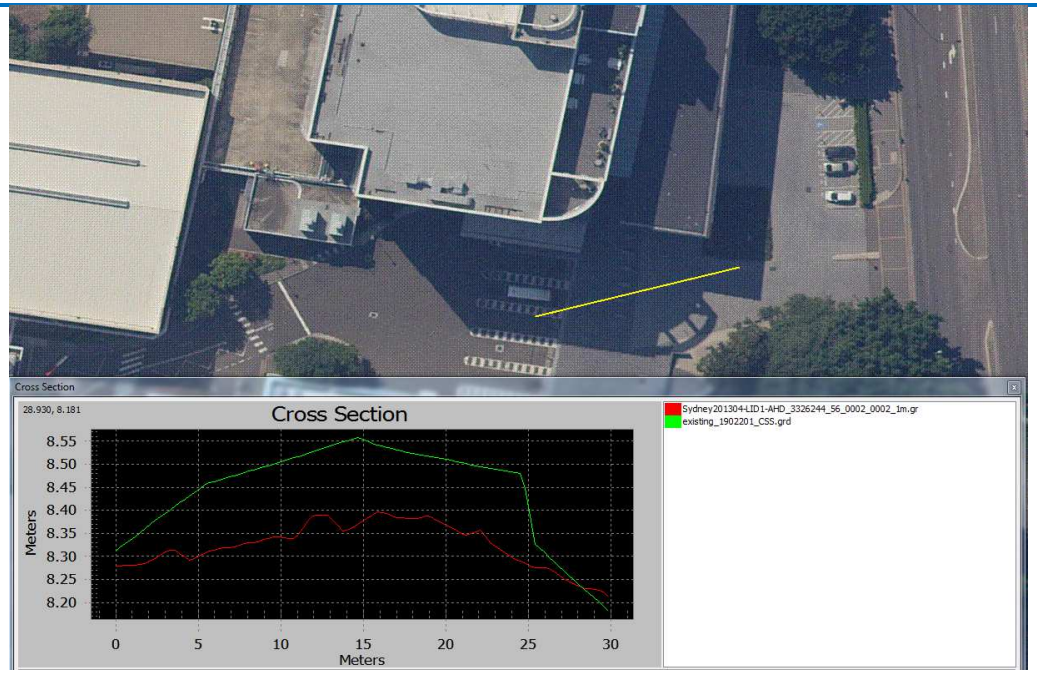 • The post development scenario includes a proposed terrain DEM (190716-proposed.asc), and a zshp (2d_zsh_en_north_olf_L , 2d_zsh_en_north_olf_P) to enforce an overland flowpath on the site that allows water movement along the northern and western extents of the proposed carpark (extent of proposed DEM shown below, and overland flowpath z shape shown as a red line)		

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		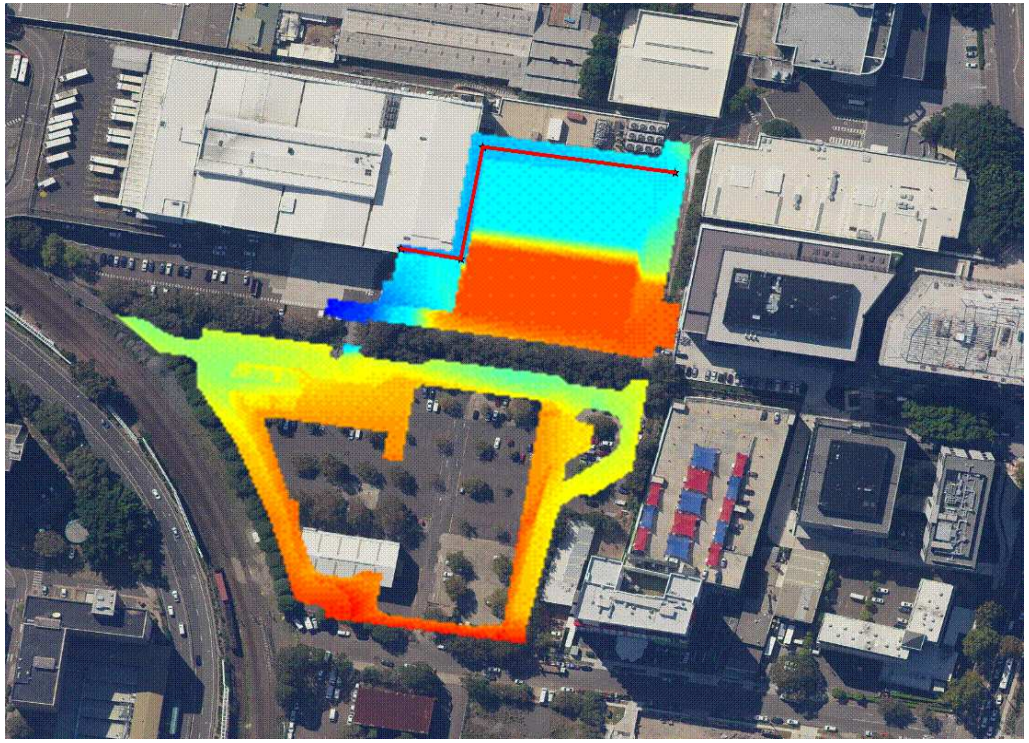		
Cross-section Data (1D)	Source of cross-section data	• Unchanged from original MRE Flood Study model, integrity of which has not been reviewed	Nil	
Hydraulic Structures	General	• Unchanged from original MRE Flood Study model, integrity of which has not been reviewed	Nil	
	Blockage	• Blockage has not been applied to hydraulic structures. Although this is not in accordance with modern best practice as outlined in ARR2019, it was common practice at the time the original MRE Flood Study was prepared. Furthermore, the hydraulic structures that span the channel adjoining the development site are single span structures where there is minimal potential for blockage.	Nil	

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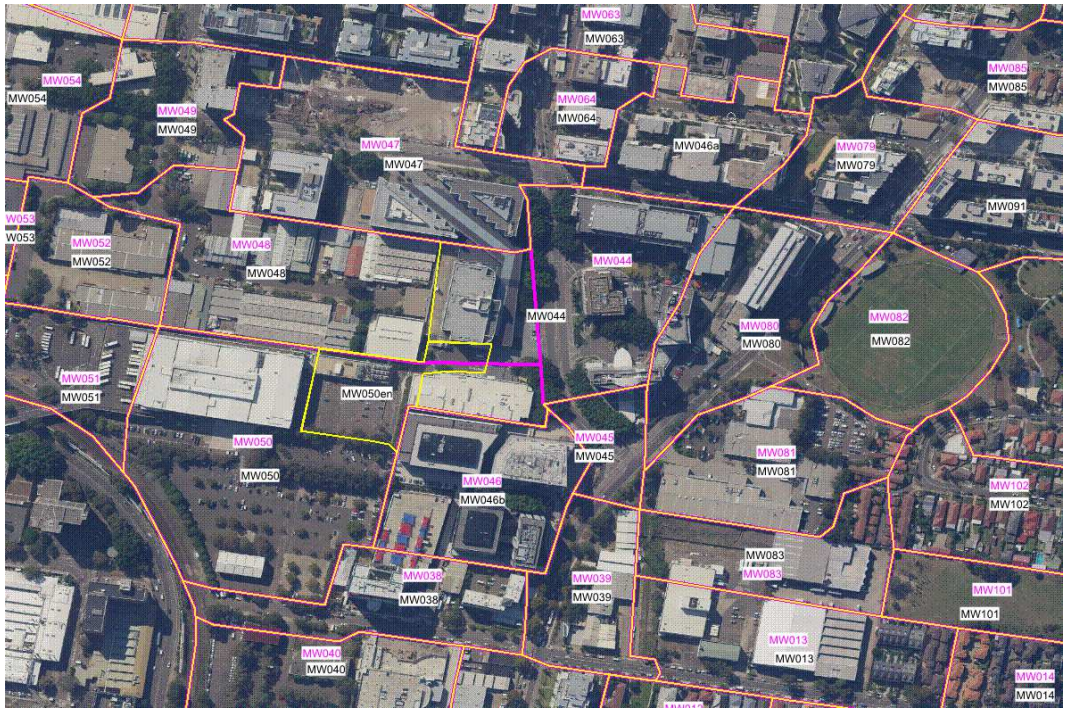
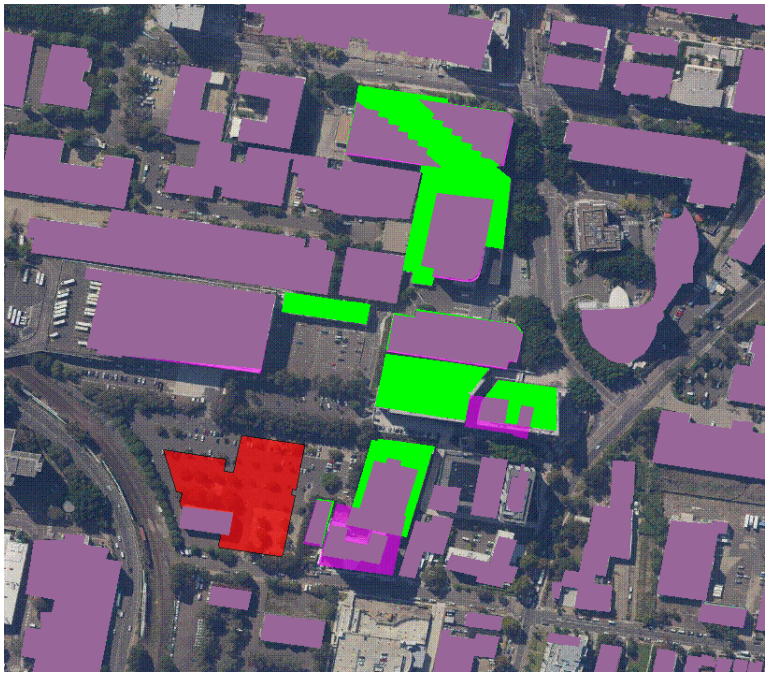
Stormwater Network	Representation	• The TUFLOW model includes a representation of the stormwater drainage system within the catchment. However, a number of stormwater pipes at the top of drainage lines have been set to "ignored". This appears to be unchanged from the original MRE Flood Study model and is assumed to be intentional.	Nil	
Boundary Conditions	Inflow boundary conditions -	• Inflows to the TUFLOW model have been defined using flow hydrographs generated by a DRAINS model and are applied to the 2D domain based on a 2d_SA layer with 'Local' inflow hydrographs applied. • The subcatchments/SA polygons in the vicinity of the site have been compared between that used within the original MRE Flood Study and that used within the current study. It has been identified within the current study, and verified within this review, that subcatchment "MW046" was originally representing two geographically separate catchment areas as a single subcatchment. As a result, flows were being inappropriately distributed to the 2D domain. This appears to be rectified within the current study by separating the two subcatchments in the DRAINS model, re-naming them MW046a and MW046b and applying the flows from both subcatchments separately to the TUFLOW model. The updates within the DRAINS model to facilitate this update have been reviewed and appear reasonable. • A refinement of the subcatchments, MW044, MW048 and MW050, which are in the vicinity of the study site, have also been made to better reflect the surveyed topography (particularly across the high point identified in the review of the detailed survey DEM). It has also allowed a more detailed and reliable application of local flows in the immediate vicinity of the site. The updates within the DRAINS model to facilitate this update have been reviewed and appear reasonable. Note that the underlying model hydrology has not been reviewed. • Subcatchment MW044 was also enlarged (in a westerly direction) to the high ground identified in the detailed site survey. MW048 and MW050 were reduced to balance the expanded subcatchment MW044. A new subcatchment was added within MW050, (named MW050en) to allow more detailed application of flow within the site (e.g., the low point in the car park for the existing scenario). The SA polygon boundaries and labels from the original MRE Flood Study are shown in pink and the	Nil	

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
		yellow boundaries and black text represents the modified subcatchment boundaries used in the current study.  • The flow application location from the refined subcatchment MW050en has been altered between the "existing" conditions and "proposed" conditions models to account for the location of the proposed carpark. In the proposed conditions model, this is applied directly to the overland flowpath skirting around the carpark. As this will be the lowest point in the area, this is reasonable.		
	Downstream boundary conditions	• Unchanged from original MRE Flood Study model. Located a sufficient distance downstream of site to not impact directly on results at the site itself.	Nil	
Flowpath Obstructions	Buildings	• Buildings have been represented within in the model as complete flow obstructions by complete removal of the 2d cells contained within building footprints.	Nil	

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
and Constrictions		• Buildings in the vicinity of the site have been modified to better reflect contemporary conditions. Green buildings are from the original flood model, pink/purple are overlaid from the modified existing conditions model, and the red polygons are the modified buildings for the post development scenario. The modified location and extents of buildings for both existing and post development scenarios as part of this study are considered appropriate for use. 		
Model Parameters	Roughness (Manning's 'n') values	• Unchanged from original MRE Flood Study model. All Manning's 'n' values are within reasonable ranges. • Material polygons implemented as part of post-development model are unchanged compared to existing conditions. As the modified carpark is currently a carparking area, and the new flight training facility building is represented as null 2d cells, it is considered reasonable to retain the existing material definition in the post development scenario.	Nil	

ITEM	REQUIREMENTS / CRITERIA	COMMENTS	REQUIRED UPDATES	ACTION
Checks, Warnings and Errors	Outputs in the _messages layer	• The _messages layer was checked for the "MRE_100y120m_AC020y_T1_en03" simulation. No major problems are identified, particularly relating to the model changes made as part of the current study.	Nil	