FLOOD CHALLENGES AND COLLABORATIVE SOLUTIONS: COMPREHENSIVE STORMWATER MODELLING ON EASTERN BUSWAY

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ABSTRACT

The Eastern Busway Alliance will deliver Auckland's first urban busway, providing sustainable transportation options to link the suburbs of Botany and Pakūranga to Auckland's city centre. The busway is anticipated to accommodate 18,000 passengers daily by 2028 through 5 km of dedicated bus lanes while providing 12 km of separate walking and cycling paths.

Without the adoption of mitigation measures, the busway could result in detrimental environmental effects such as stream channel erosion and flooding. Leveraging flood modelling as a robust analytical tool, a comprehensive assessment of stormwater impacts to maintain flood neutrality was undertaken using ICM software.

The existing Pakūranga stormwater network was designed to convey the 5-year Annual Exceedance Probability (AEP) storm event without consideration of climate change, as was Manukau City Council’s requirement in the 1960s. This resulted in the stormwater network being significantly under-capacity for the 10-year AEP with allowance for climate change as now required in the Auckland Council Code of Practice, as well as the additional runoff from increased urbanisation. Consequently, the 10-year AEP flood modelling indicated significant overland flow paths through the project area.

To address the flooding issues that existed before the busway development, the pre-development flood model was used to determine the necessary stormwater network upgrades needed to accommodate the 10-year AEP with climate change runoff and additional urbanisation runoff. This approach identified existing pipes for upgrades and integration with the design pipe infrastructure. The pipe selection promoted a collaborative approach with Healthy Waters to enhance flood conditions in the area.

The busway design criteria required that busway lanes do not experience more than 10 mm flood depth during a 10-year AEP storm event and less than 100 mm flood depth during a 100-year AEP storm event, maintaining an operational transport link. Design scenarios were modelled to inform design requirements to prevent detrimental flood impacts and to determine the busway's operational continuity during future extreme stormwater events.

A 0.25 m^2 mesh zone was applied across the road corridor providing a higher-than-typical resolution to represent the proposed road design for the crest, crossfalls, kerbs and medians. Raingardens and passive drainage channels were represented using mesh level zones adjusting the underlying ground model. Grated drains were also modelled using mesh level zones, providing stable inflow into the stormwater network along the length of the grated drain.

Flood modelling of pipe blockage scenarios and Representative Concentration Pathway (RCP) 8.5 temperature increases offered valuable insights into project resilience. Flood risk from overland flow paths was assessed by reducing the pipe conveyance capacity. Modelling of the RCP 8.5 global warming temperature increase scenario, which is greater than the current design standard, provided further understanding of the potential effect of future storm events on the Eastern Busway.

This paper demonstrates the importance of detailed hydraulic modelling in project-wide assessment of flood mitigation measures and their performance using design scenarios to identify appropriate infrastructure measures to be applied. This is critical to accurately predict flood risk and ensure infrastructure can perform to the required level of service now and into the future.

KEYWORDS

Stormwater, flooding, resilience, hydraulic modelling, climate change

PRESENTER PROFILE

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Paul is a Principal Stormwater Engineer at Jacobs with 28 years' experience of providing technical leadership of major infrastructure, urban catchment management and large complex industrial projects throughout New Zealand. Paul is currently the Stormwater Technical Lead for Eastern Busway Alliance leading the stormwater design and stormwater effects assessments.

1 INTRODUCTION

Large infrastructure projects face numerous challenges in order to meet the project design criteria. These challenges include minimising flood impacts on surrounding properties, betterment to the community, and remaining operational during storm events under future climate scenarios.

As observed during the Auckland Anniversary weekend flooding (26 January – 3 February 2023) and Cyclone Gabrielle (12 – 16 February 2023), significant storm events have the potential to cause widespread damage and disruption. Moreover, the impacts of climate change may exacerbate the frequency and severity of such events. Without adequate mitigation against flood risk, future infrastructure projects may increase the flood risk profiles to the surrounding areas as well as operational issues.

Infrastructure projects in Auckland encounter challenges from urbanisation, aging pipe networks, and the impacts of climate change on flood mitigation. This paper aims to explore these challenges in the context of the Eastern Busway project. Additionally, it provides insight into how flood modelling has informed the busway design. Specifically, the paper presents the modelling exercises undertaken, outcomes of flood modelling, and the benefits to road infrastructure and surrounding areas.

2 EASTERN BUSWAY PROJECT OVERVIEW

The Eastern Busway project represents a significant infrastructure initiative aimed at providing alternative transportation options for East Auckland. The project aims to make local trips easier and more efficient by providing sustainable travel options for walkers, cyclists, motorists, bus and train commuters to central Auckland. The design philosophy has been developed to incorporate the aspirations of mana whenua and Healthy Waters for the project area.

The busway is projected to accommodate 18,000 passengers per day by 2028 which equates to more than four times the 3,700 passengers per day before Covid-19. This number is expected to increase to 24,000 passengers per day by 2048.

The Eastern Busway project will provide 5 km of busway between Pakūranga and Botany and introduce five new bus stations. The busway will be fully separated from other traffic, enabling reliable bus trips. Additionally, the project provides 12 km of safe and separated walking and cycling routes, providing alternative sustainable travel options. The Eastern Busway project will connect travellers to Pakūranga station where train connections to Central Auckland will provide sustainable and reliable transport options.

In addition to bus lanes and cycling routes, the project includes a flyover above Reeves Road to provide a new direct connection between Pakūranga Road and the South Eastern Highway. The flyover is expected to reduce vehicle congestion around Pakūranga Town Centre.

This paper will focus on the Eastern Busway project between Pakūranga Town Centre and Ti Rākau Drive Bridge shown in Figure 1. This section of the Eastern Busway project is split between two zones:

- EB2 – Pakūranga Town Centre to Ti Rākau Park.
- EB3R (EB3 Residential) – Ti Rākau Park to Ti Rākau Drive Bridge.

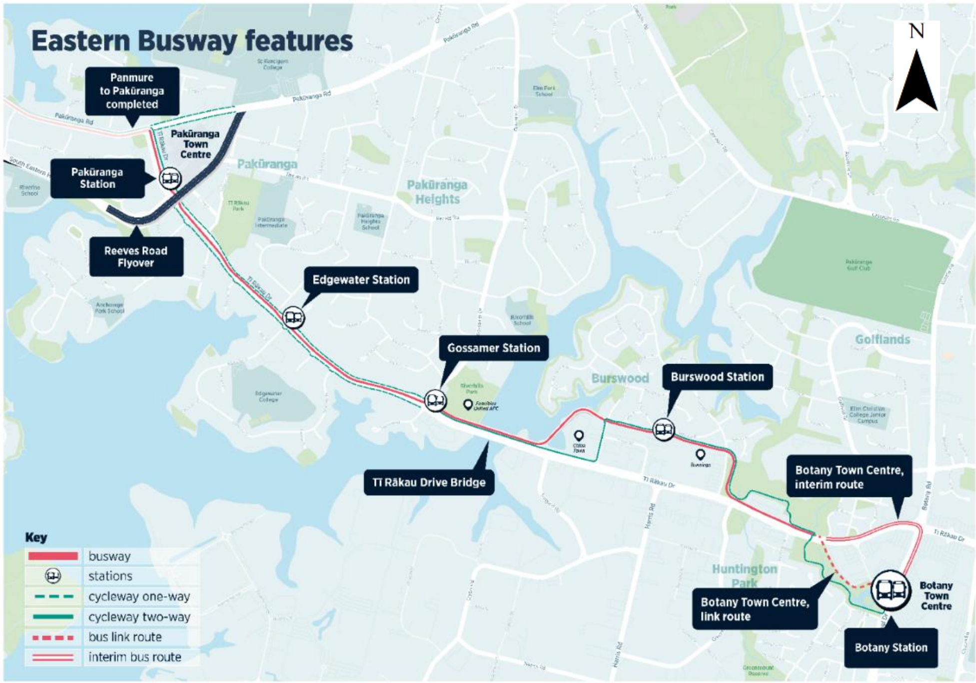

Figure 1: Eastern Busway zone 2 to zone 4 route map.

3 FLOOD MODELLING OVERVIEW

Flood modelling was undertaken across the EB2 and EB3R zones using Infoworks ICM 2021.7 to assess the existing flood risk to and potential impacts of the Eastern Busway development.

The Eastern Busway project extent faced significant challenges from existing flood risk. Much of the existing stormwater pipe network across Pakūranga was built in the 1960s. At this time, stormwater networks were designed to convey the 5-year AEP storm event within the piped network, allowing excess flows in more intense events to be conveyed overland. Further, Manukau City Council's requirements of the time made no consideration for climate change.

Consideration of climate change includes increased rainfall and tide level. As such, a 5-year AEP event without climate change is similar to a 2-year AEP event with climate change. This results in much of the existing stormwater network being significantly under-capacity for the 10-year AEP with an allowance for climate change as required by the Auckland Council Code of Practice.

The Auckland Unitary Plan permits increased urbanisation within the project extent and the surrounding area in Pakūranga. The maximum probable development (MPD) is assessed in flood modelling for large infrastructure projects that are expected to have a long lifetime. The increased urbanisation in the MPD scenarios means that there is more impervious area resulting in increased surface water runoff as less water can infiltrate the ground.

Increased urbanisation, rainfall from climate change, and under-capacity of the stormwater network results in significant overland flow paths running through the project extent, crossing the proposed busway in the 10-year and 100-year AEP events. Pre-busway flood depths within the project area ranged from shallow (10 – 40 mm) to deep (100 – 600 mm) in the 10-year AEP with deeper flooding occurring in the 100-year AEP.

For the busway to be compliant with Auckland Council's Code of Practice, there must be < 10 mm flood depth during a 10-year AEP and < 100 mm flood depth during a 100-year AEP. In addition, mitigation measures are also required to prevent increased flooding to private property. Flood modelling was used to ensure that compliance and mitigation could be achieved.

The Eastern Busway flood modelling utilised two existing Auckland Council flood models, Pakūranga Creek, and Tamaki River and Pakūranga. These models were combined and trimmed to create a flood model extent of the EB2 – EB3R zones shown in Figure 2.

The model was trimmed based on overland flow paths and pipe networks that were directed towards the project extent. Other flows in the Auckland Council models typically discharged to Pakūranga Creek and Tamaki River where the tidal boundary was of more concern within the EB2 – EB3R model. Trimming the model extent allowed for a higher level of detail to be incorporated into the model while maintaining reasonable model run times. The trimmed model was validated against the existing Auckland Council flood models that are already calibrated and validated.

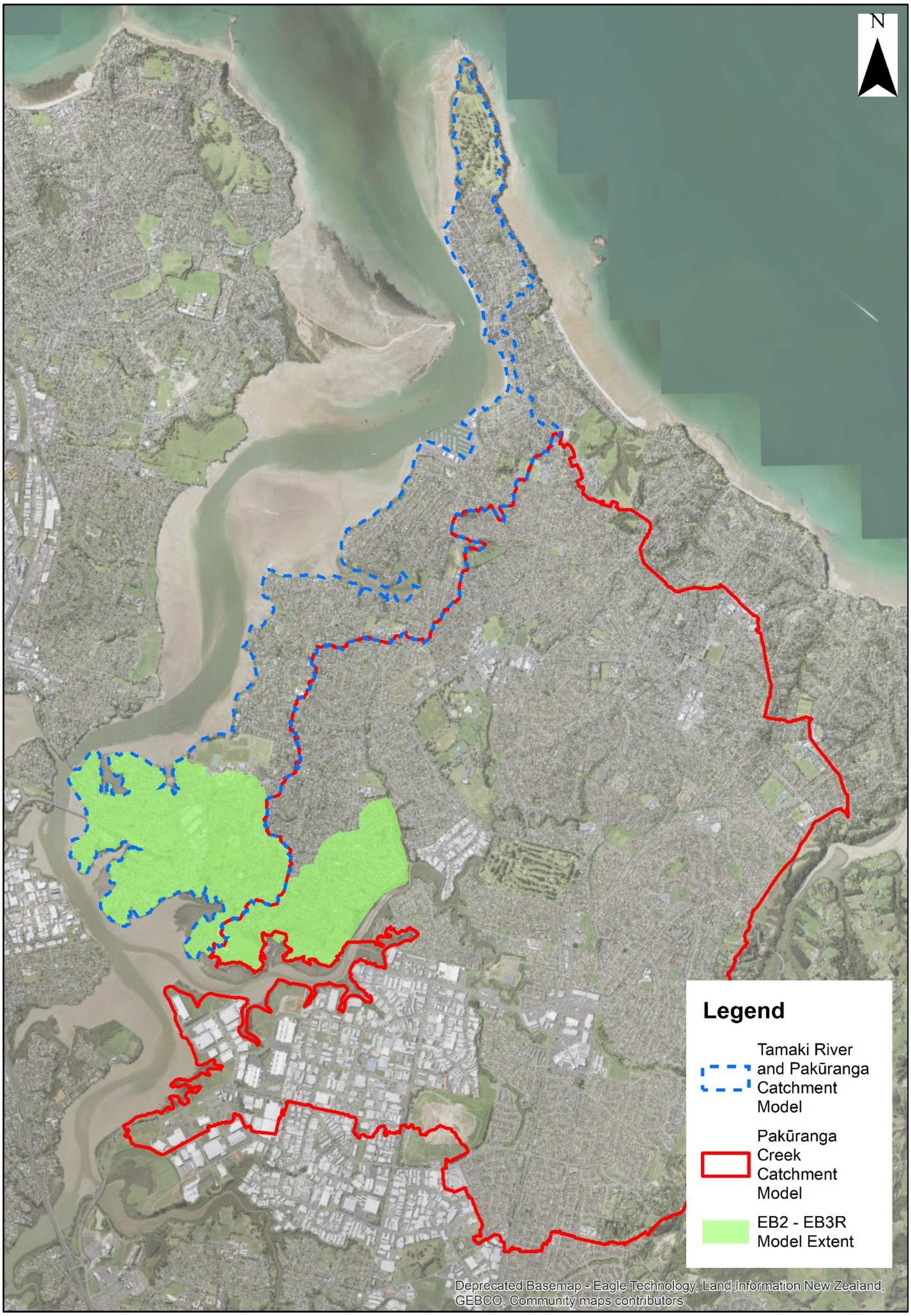

Figure 2:Eastern Busway and Auckland Council flood model extents.

Details that were added to the model for the proposed works include:

- A 0.25 m2 mesh zone applied across the road corridor.
- Raingardens and passive drainage channels represented with mesh level zones to adjust the underlying ground model.
- Grated drains represented with mesh level zones.
- Smaller sub-catchment zones than what is typical.
- Design Q/H relationships added based on catchpit types.

Modelling exercises undertaken during the project include:

- Identification of existing stormwater network pipes requiring upgrades to accommodate the 10-year AEP with climate change for integration with Eastern Busway pipe infrastructure to provide betterment.
- Assessment of pipe capacity reduction scenarios to ascertain the impact of the busway on overland flow paths.
- Modelling of the RCP 8.5 global warming temperature increase scenario to assess the effects of a greater climate change impact as a sensitivity analysis.

4 FLOOD MODELLING METHODOLOGY

This section discusses the methodology of detailed modelling for the proposed works and the modelling exercises undertaken.

4.1 DETAILED MODELLING UPDATES

4.1.1 MESH ZONE

The EB2-EB3R flood model is a 1D-2D ICM model where the pipe network is represented in the 1D, and the overland flow is represented in the 2D. The mesh zone is a triangular mesh that is used to represent the 2D ground levels, Manning's roughness, and other elements not within the 1D network. As such, using a smaller triangle mesh size allows for a higher level of detail to be modelled at the expense of longer model run times.

A comparison of Auckland Council Healthy Waters models and the EB2-EB3R model mesh triangle size is shown in Table 1. The Eastern Busway road corridor is represented with a relatively small mesh size of 0.25 m^2. A visualisation of the comparison between mesh triangle area sizes is shown in Figure 3.

The fine mesh size in the EB2-EB3R road corridor, combined with break lines in key areas, allowed for improved representation of kerb lines, road crests, crossfalls, and medians. This level of detail ensured that overland flow direction was better represented where flows crossed kerb and road crest levels that are often not as accurately represented by models with less detail.

Accurately picking up kerb heights and kerb lines was particularly useful in the EB2-EB3R model where manhole inlets and pipes were along the kerb line allowing overland flow to enter the stormwater network. In addition, this allows for the surcharging to be applied along the kerb line.

Table 1: Comparison of mesh triangle area size between the Auckland Council Healthy Waters models and the EB2-EB3R model.

Model	**2D Area (ha)**	**Max Triangle Size (m²)**	**Min Triangle Size (m²)**
Tamaki River and Pakūranga	739	4	2
Pakūranga Creek	2,880	25 (8 for major overland flow paths)	10 (2 for major overland flow paths)
EB2-EB3R	425	4 (0.25 for the road corridor)	2 (0.24 for the road corridor)

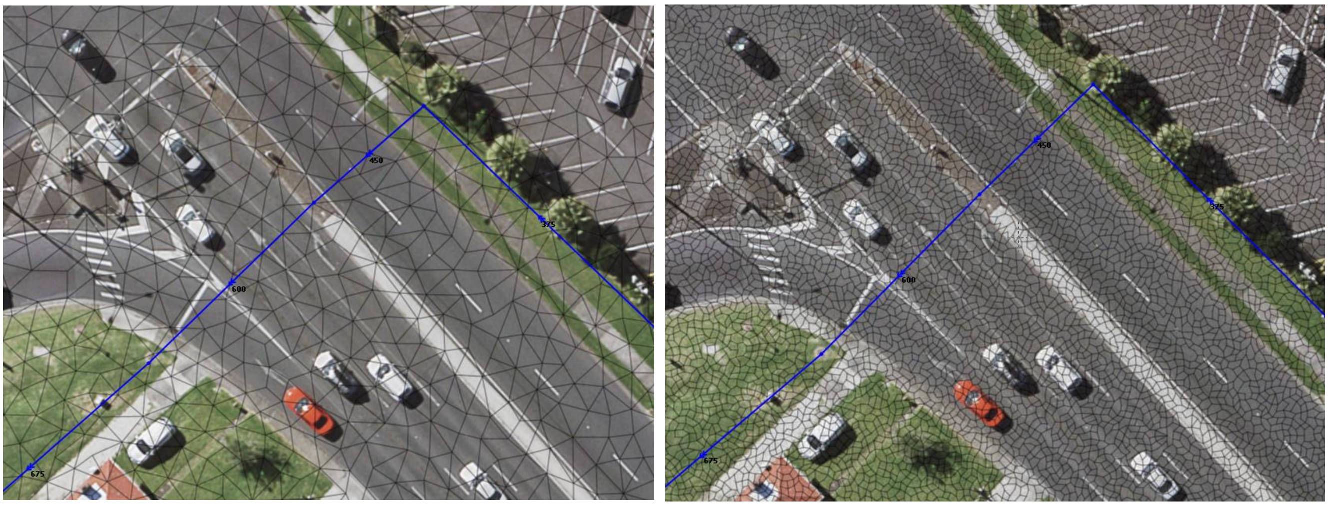

Figure 3: Comparison of mesh triangle area size shown by the black triangles with the Tamaki River and Pakūranga model shown on the left and EB2-EB3R model on the right.

4.1.2 RAINGARDENS AND PASSIVE DRAINAGE

Raingardens and passive drainage channels (i.e., swales) were incorporated into the design to provide green infrastructure treatment for runoff from the busway and Reeves Road flyover. Raingardens and swales are channels typically lined with plants or grass as shown in

Figure 4.

Although the primary purpose of raingardens and swales is to provide stormwater treatment, they can change the direction of overland flows and provide some stormwater retention. As such, it was important to represent these channels in the flood model.

The geometry of the channels was represented through two methods. The first method used mesh level zones to outline the extent of the channel. The centre of the channel extent was used to lower the ground level to the invert level of the channel while the outer channel extent was used to form the trapezoidal shape of the channel. The second method used GIS to add the shape and levels of the channels directly into the LiDAR ground model.

Figure 4: Example of a raingarden (left) and swale (right), (Auckland Council Raingarden Construction Guide and Auckland Council Swales & Filter Strip Construction Guide).

Grass and plants were represented using roughness zones in addition to representing the geometry of the channels. Roughness zones increased the Manning's roughness value within the channel extent. This has the effect of reducing the velocity through the channels in comparison to lower Manning's roughness zones representing runoff over impervious areas. Sub-catchments also allowed for the loss factor representation of initial abstraction and rainfall infiltration into the soil in the raingardens and swales.

4.1.3 GRATED DRAINS

Grated drains or slot drains (e.g. ACO drains used in EB2-EB3R shown in Figure 5) provide longitudinal stormwater inletting along the drain as opposed to a single point of entry like a catchpit.

Drains such as these can be modelled as linear drainage 2D structures. However, as the EB2-EB3R flood model used a 0.25 m^2 mesh size in the road corridor, the mesh was small enough to represent the width of the grated drains. These drains were therefore represented using 2D mesh zones to set the ground model to the invert level of the drains.

The mesh level zone approach did not account for inlet curves or a vertical connection coefficient that is available when using the linear drainage 2D structure. However, it was found that using mesh level zones provided better model stability when the drains had a significant flood depth flowing over them. A blockage factor was applied for flows from the slot drains into the connecting pipes on the assumption that the drains could be blocked by leaves and other debris.

Figure 5: ACO Drain example (ACO Limited, 2015)

4.1.4 CATCHPITS

The existing Auckland Council Healthy Waters flood models used to create the EB2-EB3R flood model typically did not represent catchpits individually. Rather than model stormwater catchpits (shown in red in Figure 6), sub catchments were loaded directly to the stormwater manholes (shown in blue in Figure 6). The Q/H (flow/water depth) inflow rate into the manhole was then typically set as 0.25 m^3/s per catchpit that was connected to the manhole.

This method allows for the models to be simplified improving run times and reducing chances for model instability to occur. However, in a detailed model such as EB2-EB3R, overland flow at the catchpits may not be captured into the stormwater network where capacity is available. In addition, the inflow rate through the catchpits into the stormwater network may not be accurately represented. Surcharging networks may also show water surcharging out of manholes, while in reality, the surcharging could occur out of the catchpit. This could change the overland flow path direction and depth of water on the roadway.

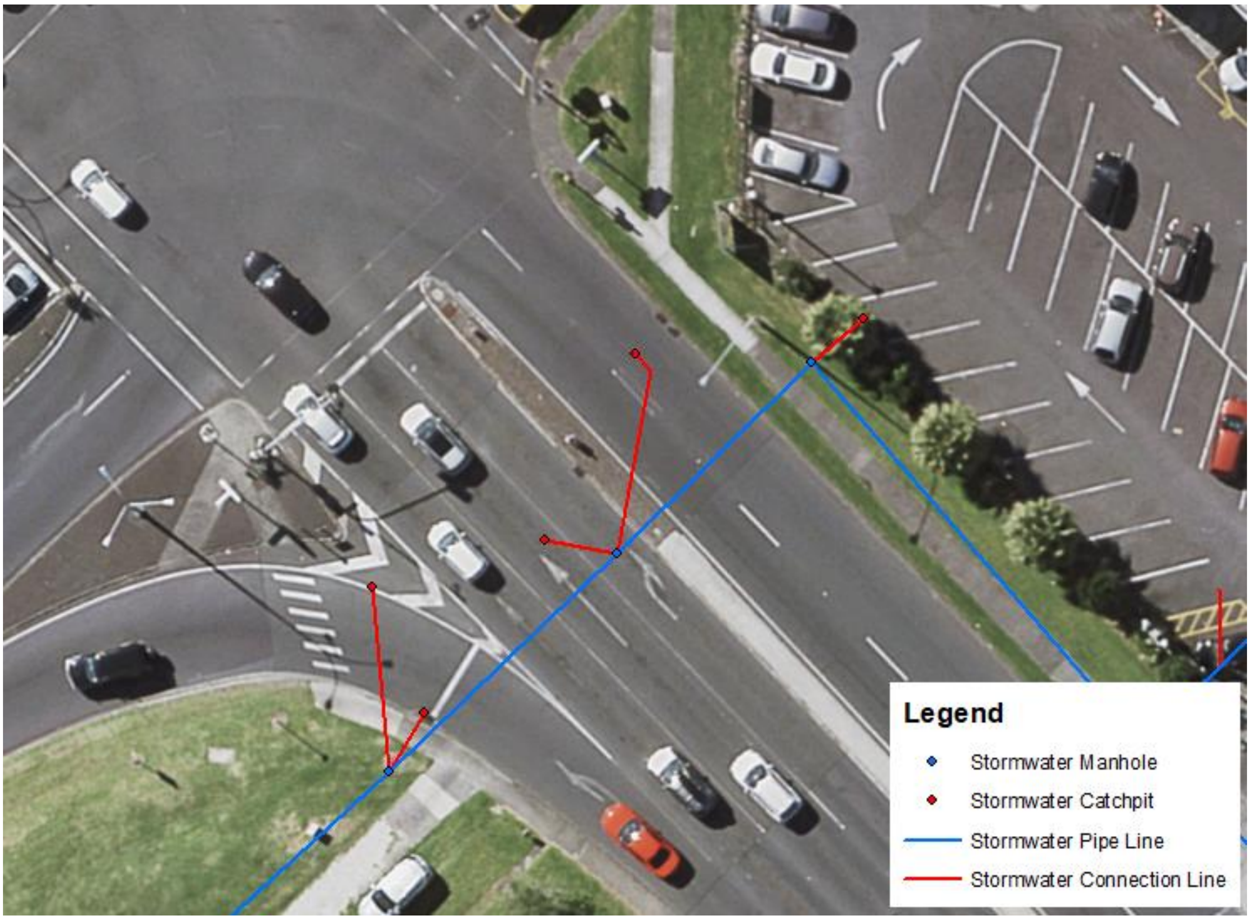

Figure 6: Example of existing stormwater network from Auckland Council GeoMaps near the Ti Rakau Drive - Reeves Road intersection. In less detailed models, only the manholes and pipes shown in blue would be modelled. In the detailed model, the catchpits shown in red were included.

Figure 7 shows the design model with catchpits highlighted in red that are within the overland flow shown in blue. Overland flow is flowing from the bottom right of the figure and can then enter the stormwater network through the catchpits, whereas the manholes shown in green are not within the flow path. The modelling of the catchpits along with the finer 0.25 m^2 mesh allows for a more accurate representation of the overland flow path along the edge of the kerb line that can then flow into the stormwater network through the catchpits.

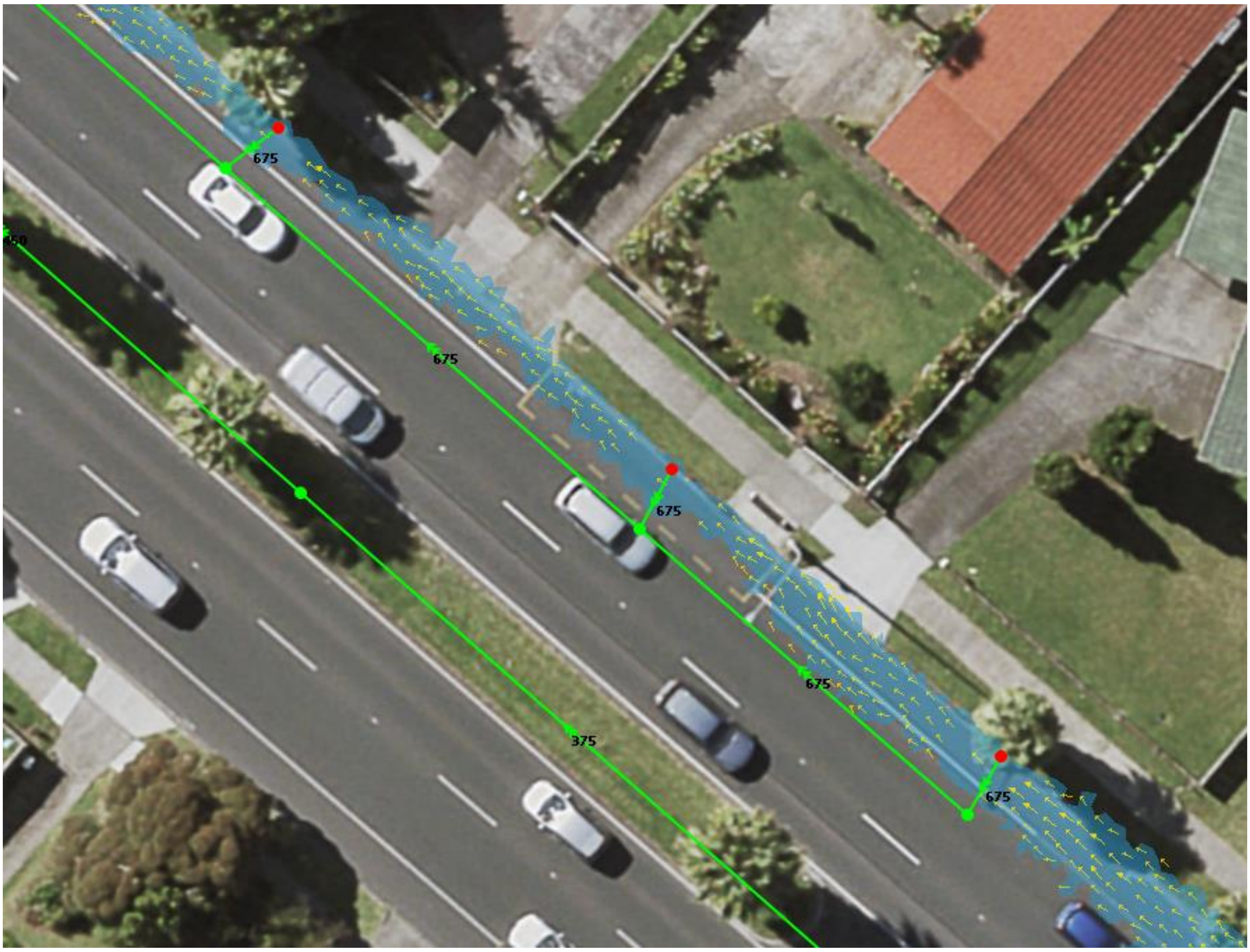

Figure 7: Example of the design model catchpits shown in red within the overland flow path and the manholes shown by the green nodes not within the overland flow path.

The design catchpits used varying Q/H inflow rates. The application of a Q/H relationship to a catchpit allowed the model to pass greater inflow through the catchpit as the depth of water over the catchpit increased. In comparison, the modelling approach in less detailed models sets the inflow rate at a constant Q/H of 0.25 m^3/s per catchpit which is connected to the manhole as shown in Figure 8. The varying Q/H inflow rates allowed for the design to be assessed for whether additional inflow into the stormwater network was required to capture overland flows from surcharging networks upstream of the project extent. A 20% and 50% blockage of inflow rates was assessed for catchpits on grade and in sag locations, respectively.

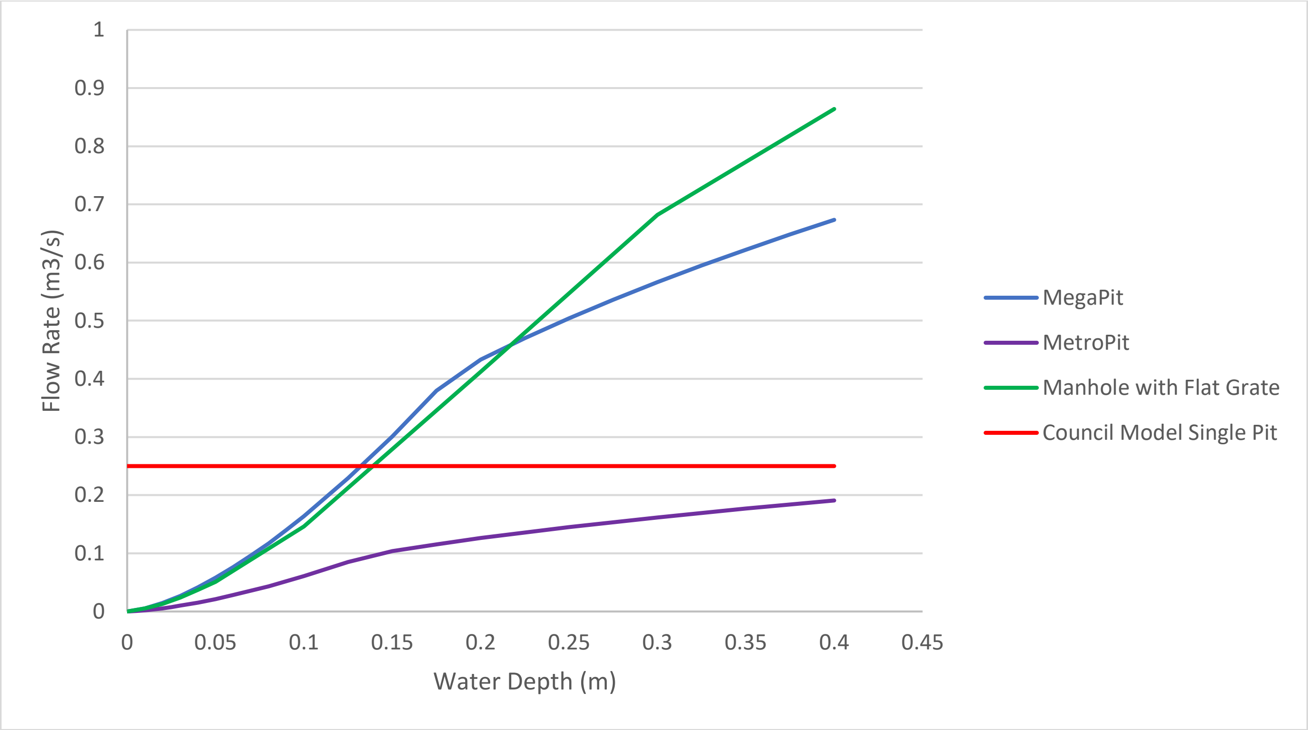

Figure 8: Varying Q/H relationships of several design catchpits compared to a less detailed model methodology of catchpit representation used in the Auckland Council catchment models.

4.1.5 SUBCATCHMENTS

Additional catchpits in the EB2-EB3R design model allowed for a reduction in sub-catchment size within the road corridor as shown in Figure 9. This allows sub-catchment rainfall flows to be spread throughout the stormwater network. Smaller sub-catchments can be used for identification of where manhole surcharging may occur in comparison to larger sub-catchments which would likely surcharge from the single manhole where the sub-catchment is loaded to. Pipes requiring upsizing due to surcharging could be identified more accurately allowing for shorter sections of pipes to be upsized rather than upsizing entire lengths of pipelines.

Figure 9: Comparison of a 0.3 ha subcatchment outlined in red in the Auckland Council flood model on the left with a 0.03 ha subcatchment in the EB2-EB3R flood model on the right.

4.2 MODELLING EXERCISES

4.2.1 EXISTING STORMWATER NETWORK BETTERMENT

A modelling exercise was undertaken to identify existing stormwater network pipes that were surcharging in the 10-year AEP with climate change. An assessment was made to ascertain the required pipe size to accommodate the surcharging flows to meet Auckland Council's Code of Practice. The Auckland Council Code of Practice states that the primary stormwater pipe network must be designed to accommodate the 10-year AEP flows.

This exercise supported discussions between the Eastern Busway Alliance, Auckland Transport and Healthy Waters on their aspirations for project-wide renewals and upgrades of the stormwater network. These discussions provided an opportunity for best-for-Auckland solutions to overland flows, flooding, and stormwater treatment. By identifying areas for upgrades as part of the Eastern Busway project, pipe upgrades could be made during the construction phase preventing additional requirements for traffic management and utility congestion in the road corridor for existing network upgrades post-busway construction.

4.2.2 PIPE CAPACITY REDUCTION SCENARIOS

The flood modelling was used to ensure that the busway remained compliant with < 10 mm and < 100 mm during a 10-year AEP and 100-year AEP flood event respectively. The model was also used to ensure flood impact mitigation was achieved so that no properties would experience worse flooding in the 10-year or 100-year AEP flood events due to the project.

Flood mitigation also assessed the secondary stormwater system. The secondary stormwater system consists of ponding areas and overland flow paths that convey flows in storm events greater than the 10-year AEP. The secondary stormwater system was assessed assuming the following pipe capacity reductions for the primary stormwater network from Auckland Council's Code of Practice:

- For pipelines up to and including DN600, assume that the pipeline is 100% blocked.
- For pipelines between DN600 and DN1050, assume that the pipeline's capacity has been reduced by 50%.
- For pipelines in excess of DN1050, assume that the pipeline's capacity has been reduced by 10%.

The pipeline capacity reductions were assessed by reducing the pipe diameter size. A comparison was then made between the pre and post project scenarios to ensure that no private property was made worse off in a flood event. Pipe design diameters were increased to allow more flow into the primary system where properties where flooding and mitigation was required.

4.2.3 RCP 8.5 MODELLING

Climate change is accounted for in the flood model according to the Auckland Council Code of Practice requirements assuming a 2.1°C increase in temperature by 2090. The RCP 8.5 model scenario provided a sensitivity analysis to understand the potential risk from a temperature increase to 3.8°C by 2090.

The design was not required to convey the additional flow from greater rainfall in the 3.8°C temperature increase scenario. However, modelling this scenario is used to identify potential future risks to the project and surrounding areas, and to inform the resilience of the project.

Table 2 provides a comparison of the increase in rainfall when considering the 2.1°C and 3.8°C temperature increases. The mean high water springs tide level +1m was used in both scenarios.

Table 2: A comparison of the rainfall increase in different climate change temperature increase scenarios.

Temperature Increase	**10-year AEP Rainfall Increase**	**100-year AEP Rainfall Increase**	**Tide Level Increase**
2.1°C	13.2%	16.8%	1 m
3.8°C	30.8%	32.7%	1 m

5 FLOODING RESULTS AND OUTCOMES

This section discusses the results from the flood modelling exercises and the overall outcomes of stormwater modelling on the Eastern Busway project.

5.1 FLOOD MODELLING OUTCOMES

Flood modelling on the Eastern Busway project was an iterative process with each model design scenario building on the previous one to deliver the best outcome for Auckland.

The first stage of flood modelling was assessing existing flood risk to the project extent and surround areas. Large areas of Pakūranga across the project extent were at risk of flooding given the undercapacity of much of the pre-busway stormwater network in the 10-year AEP with an allowance for climate change. Upgrades to the stormwater network would be required in order to meet the Auckland Council Code of Practice and to reduce flood risk to the community. Eastern Busway provided an opportunity to achieve these upgrades through a collaborative approach between the Eastern Busway Alliance, Auckland Transport and Healthy Waters.

The first stage of design flood modelling was to assess the 'Do Minimum Reference Design' that provided drainage for the road. The Reference Design sized pipes based on the road sub-catchments and consisted of pipe networks separate to the existing stormwater network. The Reference Design pipes connected to the existing network near the outfalls. The outfalls were designed to be upgraded to the minimum requirement to accommodate the additional flows from the project.

Comparing the Reference Design model results to the existing flood results highlighted several areas that caused flooding to private property due to a combination of undersized existing stormwater network and overland flow paths cut off by higher road crest levels in the proposed busway.

The Reference Design was developed further into the 'Flood Mitigation Design' to address flooding impacts on private property. The pipe sizes were determined by the flood level comparisons between the existing and design scenarios for the 100-year AEP event. The Flood Mitigation Design extended into the eastbound road lanes to capture overland flows that were cut off from the raised busway crest level. The existing pipes from the design connection point to the outfalls were upgraded to avoid impacts to private property.

The Flood Mitigation design removed any increase in flood level within private property boundaries. However, the results showed that some flooding occurred in the bus lanes.

The Minimum Requirement (MR) Compliant Design developed on the Flood Mitigation design to reduce flooding within the bus lanes to a depth < 10 mm and less than < 100 mm in the 10-year and 100-year AEP events respectively. The MR Compliant Design achieved this by upgrading pipe sizes where surcharging occurred and increasing inlet capacity to capture overland flow paths before they crossed the bus lanes.

Although the MR Compliant Design achieved flood mitigation and compliance for the bus lanes, an opportunity remained to enhance the outcomes for the surrounding community by reducing flooding impacts further. The final scenario modelled for EB2-EB3R was to upgrade the existing network with the Reference Design to provide betterment to the community.

This scenario sought to combine and upgrade the existing stormwater network with the design so that the existing network would comply with the Stormwater Code of Practice while providing drainage to mitigate any remaining flooding issues from the Reference Design. Achieving betterment to the existing stormwater network during the construction phase provided the benefit of reduced social and traffic disruptions compared to providing the betterment after the construction was completed. Cost savings were also made by preventing additional requirements for traffic management and utility congestion in the road corridor.

The outcome of the EB2-EB3R flood modelling showed a significant reduction in flood risk across Pakūranga Town Centre and the road corridors across the project extent. A dry busway was achieved in the 10-year AEP event with very little ponding or overland flows on the road corridor and only shallow depths well below the 100 mm requirement occurred during the 100-year AEP event.

Error! Reference source not found. provides a breakdown of how many hectares of reduced flooding there is across EB2-EB3R for different depth bandings in the 100-year AEP event. The depth bandings in **Error! Reference source not found.** are referred to in Figure 10 and Figure 11 that visualise the locations of the reduced flooding areas across the town centre and in the road corridors.

Table 3: Reduction in flooding across different depth bandings when comparing the existing and design 100-year AEP events.

Flood Depth Banding (m)	**Existing 100-year Scenario Hectares of Flooding**	**Design 100-year Scenario Hectares of Flooding**	**Flooded Hectares Difference (Existing – Design)**	**% Difference (Existing – Design)**
0.05	59.13	49.93	-9.2	-15.55
0.1	43.25	36.48	-6.77	-15.65
0.2	30.86	26.48	-4.39	-14.21
0.5	20.55	19.65	-0.9	-4.39

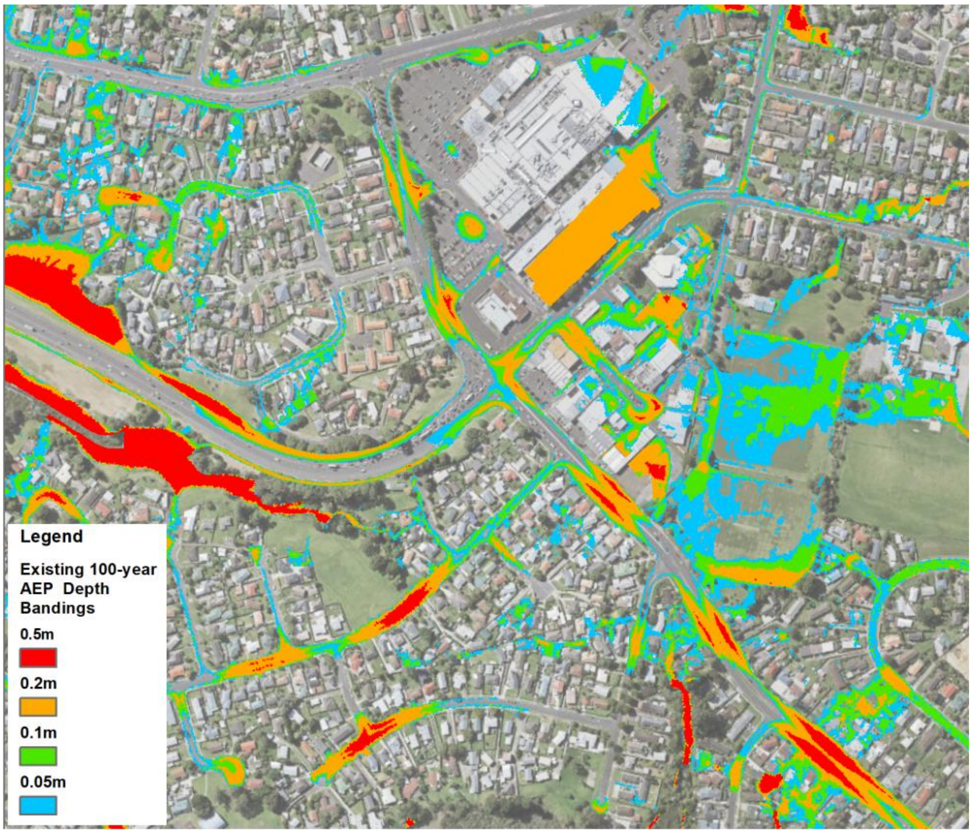

Figure 10: Existing 100-year AEP Depth Bandings.

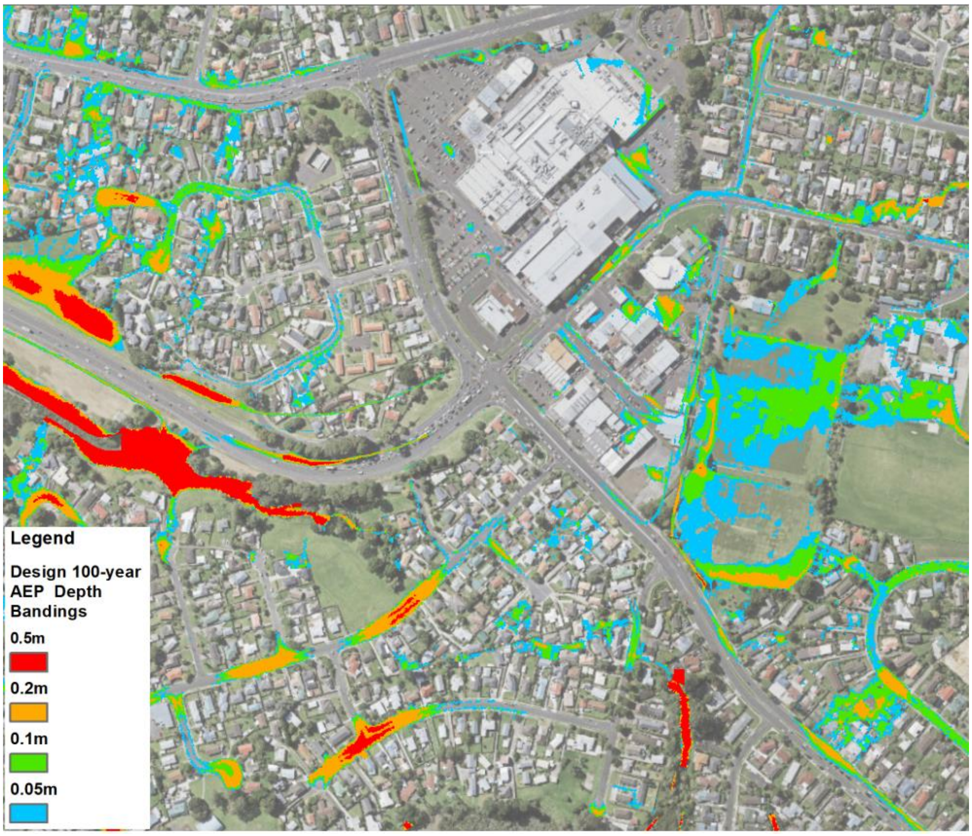

Figure 11: Design 100-year AEP Depth Bandings.

5.2 PIPE CAPACITY REDUCTION RESULTS

The pipe capacity reduction modelling identified several locations where flooding was worsened in the design scenario compared to the existing scenario. This mostly occurred around pipes that were < 600 mm in diameter so were considered fully blocked. The modelling identified pipes requiring a diameter of 675 mm to be considered partially blocked which results in improvements in flooding in the design scenario compared to the existing scenario as shown in Figure 12.

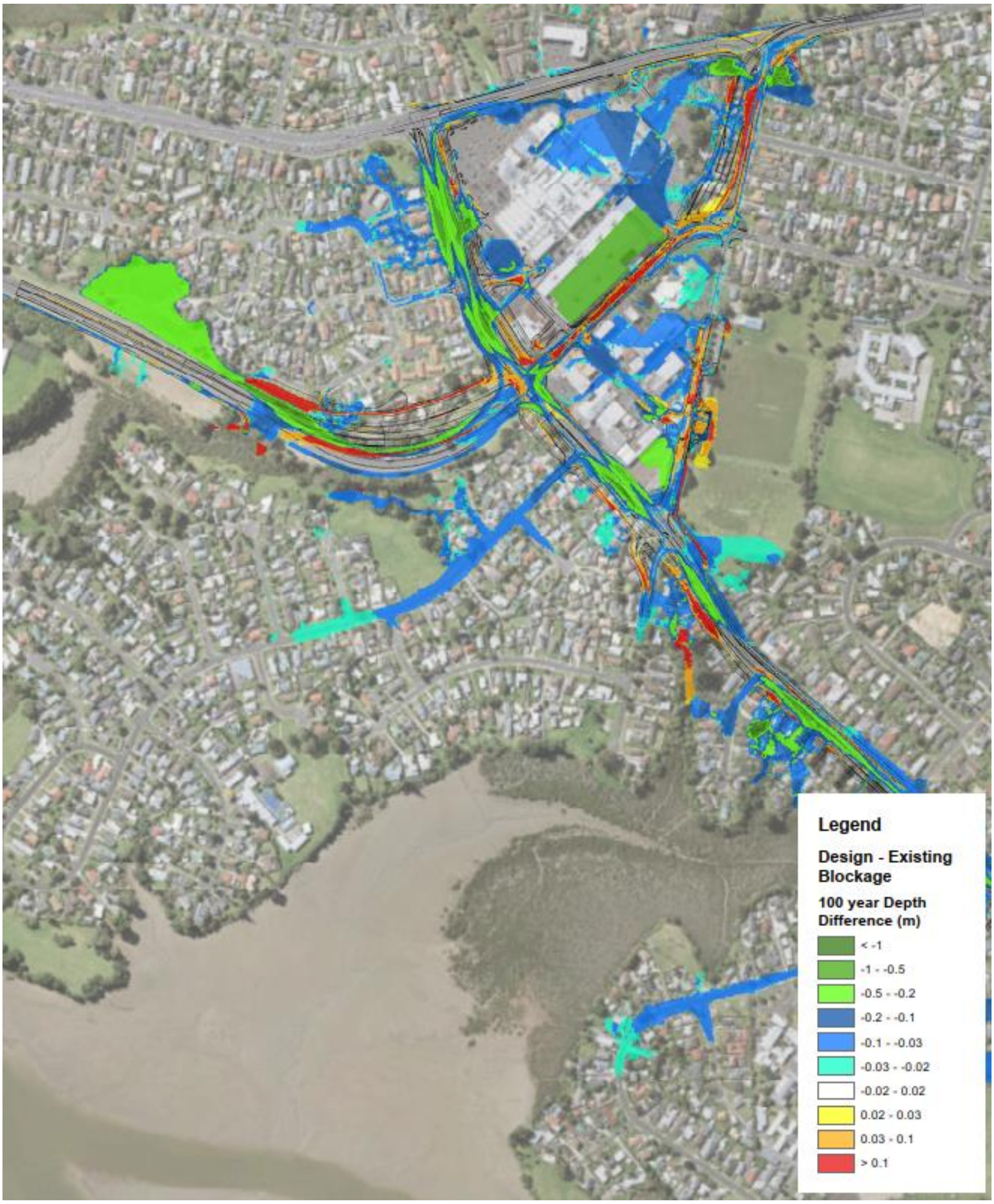

Figure 12: Design - Existing Blockage Scenario 100-year AEP Depth Difference (m), green and blue shows a reduction in depth in the design and red and yellow shows an increase in depth.

5.3 RCP 8.5 RESULTS

The RCP 8.5 modelling provided insights into what future flood risk might look like in a higher climate change temperature increase scenario. The modelling shows how a higher temperature increase in future may result in enough rainfall to cause more flooding within the bus lanes, road corridors, and town centre across Pakūranga. This highlights the importance of considering flood risk and climate change for future infrastructure projects across New Zealand.

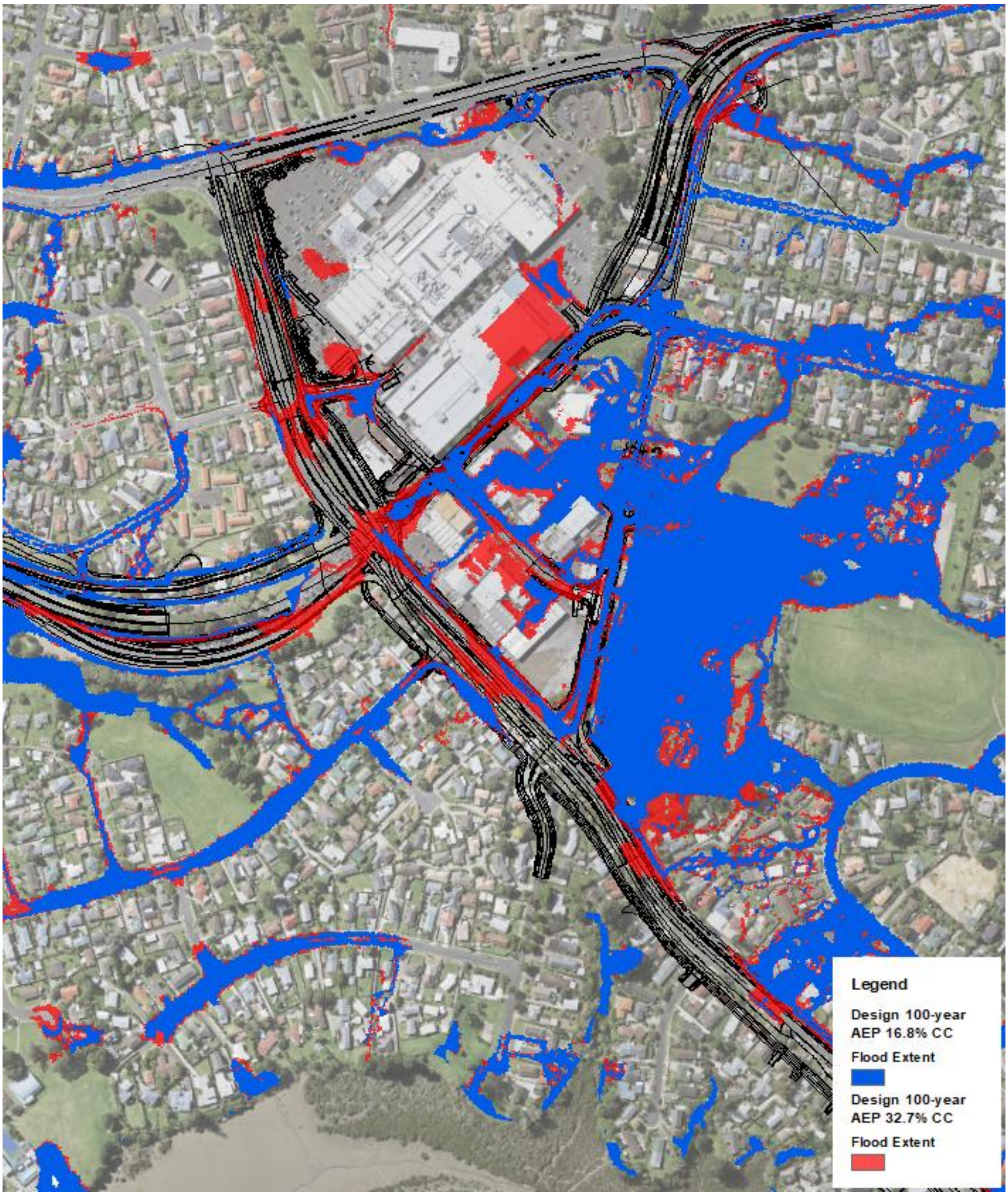

Figure 13: A comparison between the > 10 mm depth flood extents of different climate change scenarios for the 100-year AEP Design flood modelling.

6 CONCLUSIONS

Eastern Busway will provide a strategic transport connection between Botany and Pakūranga to the city centre through busways and train links along with other sustainable transport options. The project extent experienced significant overland flow paths and flooding due to under sizing of the pre-busway stormwater network. Without mitigation of flooding impacts, the project could cause detrimental environment impacts including stream erosion and flooding of private property.

ICM flood modelling software was utilised to create a detailed flood model of EB2-EB3R to undertake a comprehensive assessment of flooding impacts across the project and surrounding areas.

A detailed modelling methodology was used to assess the impacts of the proposed Eastern Busway Design including:

- Fine mesh in the road corridor combined with break lines in key areas to pick up kerb lines and road crest levels more accurately.
- Rainfall gardens and passive drainage modelled using mesh levels zones and roughness zones.
- Grated drains modelled in the 2D zone to provide improved model stability during surcharging.
- Catchpits modelled including varying Q/H relationships of the catchpits to assess the capture of overland flow paths into the stormwater network.
- Smaller road sub-catchments were used to spread the sub-catchment loading throughout the design stormwater pipe network.

Modelling exercises were undertaken using the detailed model created for EB2-EB3R including:

- An assessment undertaken of the pipe upgrades that would be required for the existing stormwater pipe network to comply with the Auckland Council Code of Practice.
- Pipe capacity reduction modelled to assess the secondary stormwater network of overland flow paths to ensure that the design did not cause overland flow to enter private properties.
- Potential future risks of increased temperature changes due to climate change was assessed to provide an understanding of the sustainability of the Eastern Busway project.

The flood modelling was an iterative process working with stormwater designers to improve the design through various stages from the Reference and Mitigation Design to the MR Compliant Design and existing pipe network betterment combined with the Reference Design.

The Eastern Busway project provided the opportunity for a collaborative approach between the Eastern Busway Alliance, Auckland Transport and Healthy Waters to upgrade the stormwater pipe network to provide a best-for-Auckland outcome on flooding. The outcome of this collaborative approach resulted in the Eastern Busway project reducing flooding across Pakūranga Town Centre and surrounding road corridors while providing a rapid transit bus route that would remain MR Compliant during a 10-year and 100-year AEP event.

ACKNOWLEDGEMENTS

Eastern Busway Alliance

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