Memorandum

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From	Quoc Nguyen
Office	Auckland
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Subject	Weigh Right Bombay - Flood Assessment

1 Introduction and Background

Waka Kotahi have acquired a site at 253 Mill Road, Bombay to establish a Commercial Vehicle Safety Centre (CVSC). Adjacent to the site is a stream with a 100-year floodplain mapped for the Ngakoroa stream catchment on Auckland Council's Geomaps (Figure 1).

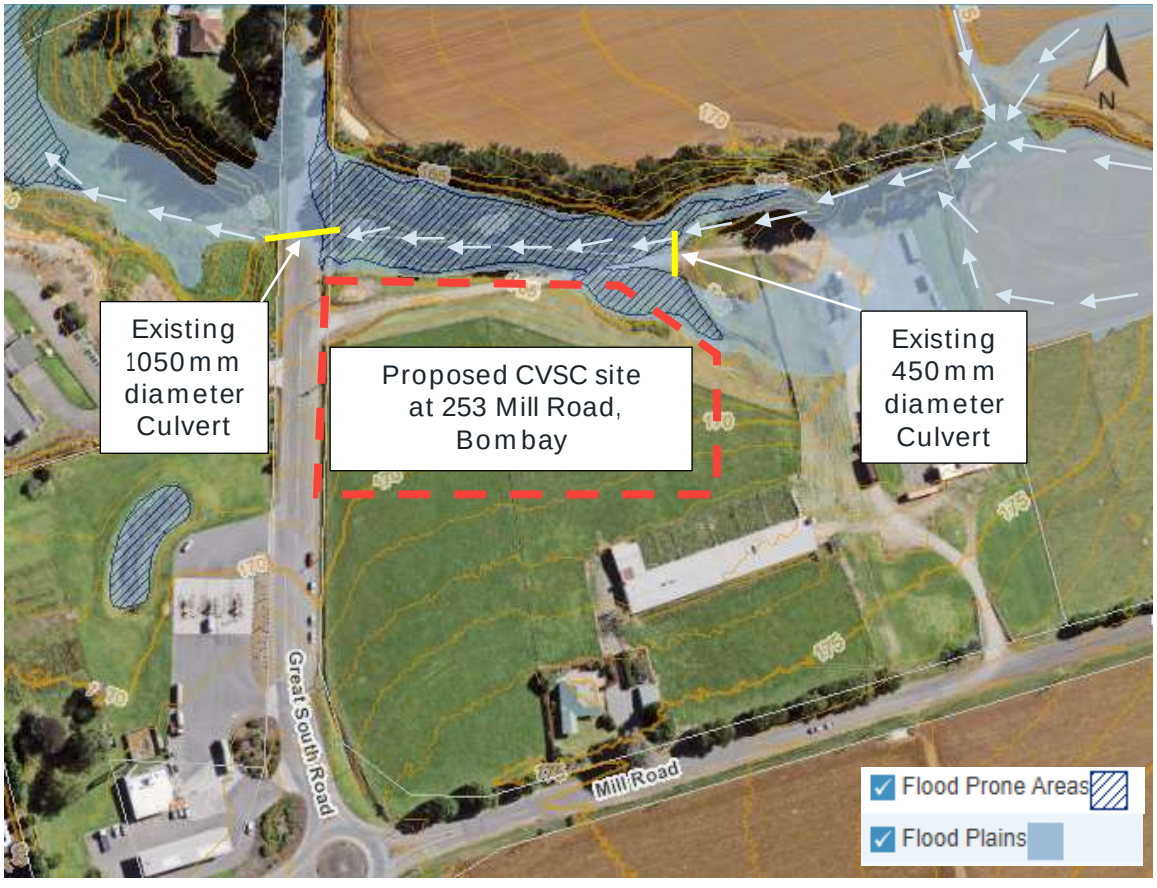

Figure 1: Location of the proposed CVSC and the existing culverts (Auckland Council Geomaps - 21 Oct 2022)

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The purpose of this memo is to document the flood assessment for the CVSCs Bombay site mentioned above. The flood assessment will analyse the predicted site flood situation for the 2yr, 5yr 10yr and 100yr and assess the potential impact of the proposed development on the predicted peak water levels for the aforementioned Average Recurrence Interval (ARI) storm events in two scenarios below:

1. Existing Development Case – ED: Pre and Post development with current rainfall depth and existing land development pervious/impervious percentage

2. Future Development Case – MPD: Pre and Post development with future rainfall depth-adjusted for climate change and future land development pervious/impervious percentage.

1.1 Existing Flooding Information

Figure 2 below, shows flooding the current floodplain information published on Auckland Councils Geomaps.

While the proposed site of the development is shown to only have a relatively small floodplain, significant floodplains are predicted downstream.

These existing floodplains include flood prone areas (depressions) which are restricted by culvert outlets.

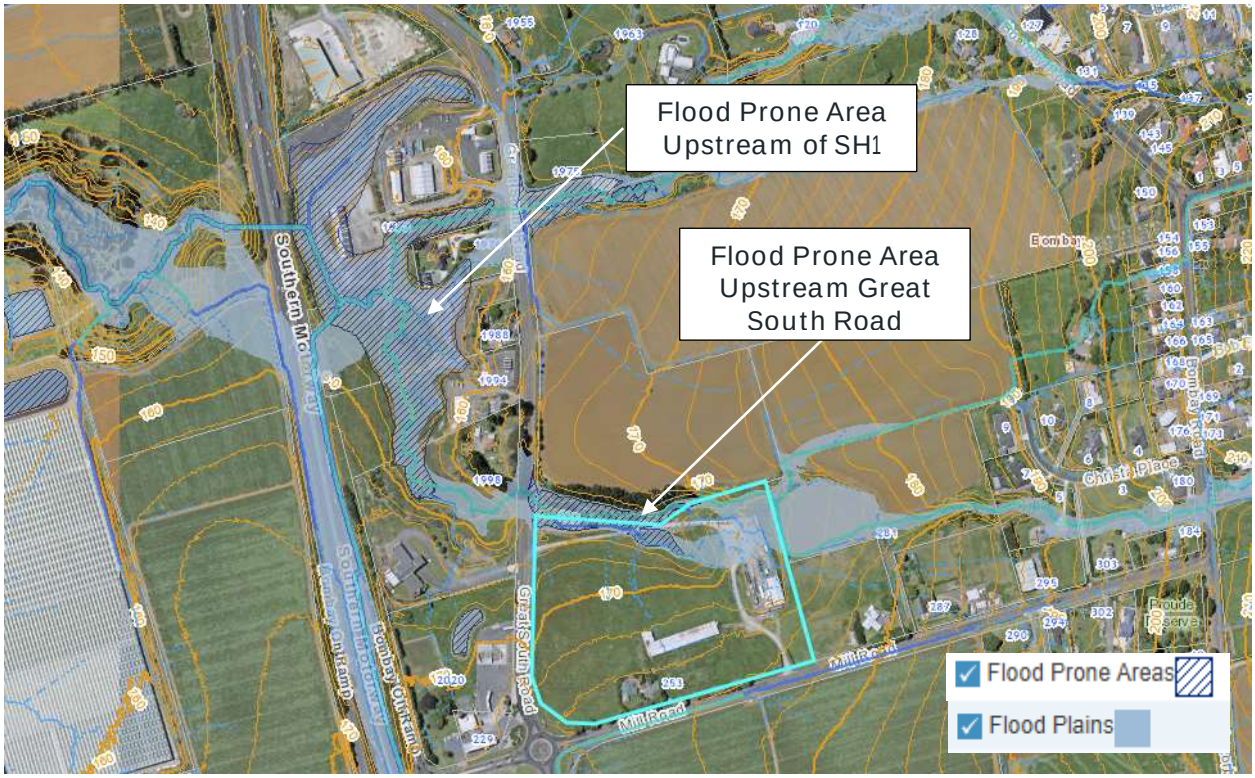

Figure 2: Downstream Flood Plain / Flood Prone Area (Auckland Geomaps - 21 Oct 2022)

Additionally, the flood prone areas upstream of Great South Road is divided into two, and connected by an existing 450mm culvert, located under a private accessway.

2 Summary of Methodology

The existing floodplain published for the Ngakaroa Oira catchment is based on a rapid flood hazard assessment (RFHA) which does not explicitly represent the key culvert at Great South Road (although representation of the downstream culvert at SH1 is incorporated).

The RFHA is therefore not considered suitable for assessing the existing flood level or future impacts on flood level associated with the development of this site.

As shown in Figure 2, there are two key downstream flood prone areas. These have been assessed using two different approaches, due to the differing hydraulic complexity.

The flood analysis due to the development will include two assessments:

1. **Volumetric Floodplain Assessment (Upstream of SH1)**
   A simple volumetric calculation to determine the potential increase in water level downstream due to the additional volume of runoff from the site. This is expected to be a conservative approach.

2. **2D Hydraulic Model (upstream of Great South Road)**
   A 2D model to represent a more complex hydraulic impact on the existing two culverts immediate downstream of the site.

These two approaches are presented in Sections 3 and 4 respectively.

Based on the relative catchment sizes, and relatively contained floodplain, it is assumed that effects on peak flow and water level further downstream of State Highway 1 will not present a change in flood risk.

3 Catchment Analysis

3.1 Catchment Analysis

The aim of this catchment delineation to facilitate both the assessments discussed above. While simple assessment of the proposed site only is required for the volumetric analysis, the 2D hydraulic model required representation of contributing catchment area upstream of the culvert under Great South Road (Culvert 2). Refer to and the Catchment Area summary in below for more details.

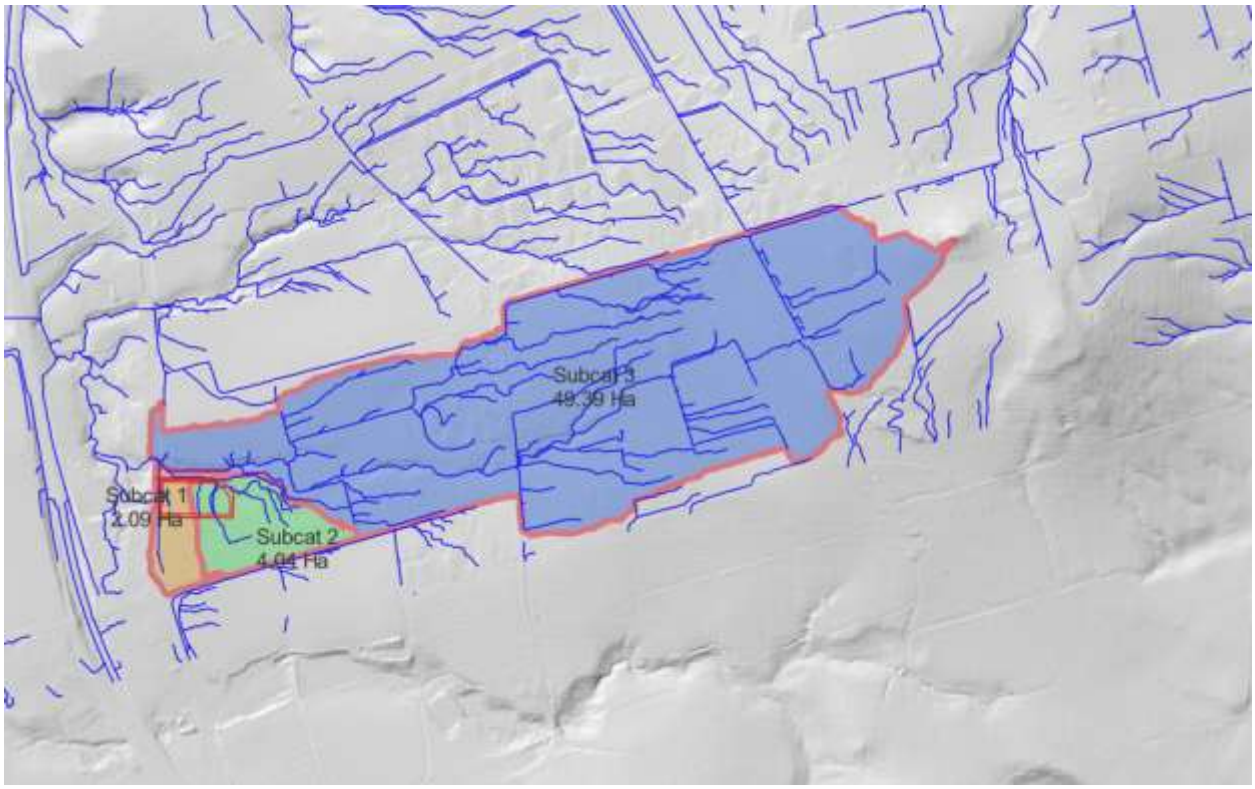

Figure 3: Sub catchment Delineation Map

Table 1: Sub-catchment Area Breakdown for Pre-development Scenarios

Catchment	Total Area (ha)	Impervious %	
		ED	MPD
Subcat 1	2.09	14.1 %	14.1%
Subcat 2	4.04	10.9 %	10.9 %
Subcat 3	49.39	8.1 %	19.1 %
Total	55.53	8.5 %	18.3 %

* No change in Subcatchment 1 & 2 impervious % as the existing Impervious % is already more than the Unitary Plan Zone max impervious %

Table 2: Sub-catchment Area Breakdown for Post-development Scenarios

Catchment	Total Area (ha)	Impervious %	
		ED + DEV	MPD + DEV
Subcat 1	1.61	18.3 %	18.3 %
Subcat 2	3.48	12.7 %	12.7 %
Subcat 3	49.39	8.1 %	19.1%
Dev Area	1.04	78.6%	78.6%
Total	55.53	10.0 %	19.8 %

* No change in Subcatchments 1 & 2 impervious % as the existing Impervious % is already more than the Unitary Plan Zone max impervious %

4 Volumetric Floodplain Assessment (Upstream of SH1)

As shown in Figure 2, there is a large flood prone (depression) area downstream of the site at SH1. The aim of the assessment is to find out the maximum potential increase in the peak water level within the SH1 flood prone area due to the site development with respect to the 2 scenarios above (ED and MPD).

The approach taken for this area was to determine the additional volume of runoff due to the development, and divide it by the total area of the predicted floodplain. This is expected to represent a conservative, upper limit increase in water levels (for the assumed area), as it does not consider the effects of timing of runoff from the proposed development (i.e. likely to be drained prior to the peak runoff from the upper catchment).

4.1 Downstream Floodplain Assessment Result

The volume runoff for pre and post development is based on Auckland TP108 method for 100yr storm event. The result summary is shown in Table 3 and Table 4 below.

Table 3: Volumetric Analysis of the Current Event

Current Event - ED	100yr ARI	10yr ARI
Site Pre Dev Runoff Vol (m^3)	1189	565
Site Post Dev Runoff Vol (m^3)	1928	1142
Increase in Vol (m^3)	740	577

Flood Plain area within Flood Prone zone (m^2)	28652	28652*
Increase in Flood Depth downstream (mm)	25.8	20.1*

Table 4: Volumetric Analysis of the Future Event

Future Event - MPD	**100yr ARI**	**10yr ARI**
Site Pre Dev Runoff Vol (m^3)	1490	690
Site Post Dev Runoff Vol (m^3)	2281	1309
Increase in Vol (m^3)	791	619
Flood Plain area within Flood Prone zone (m^2)	28652	28652*
Increase in Flood Depth downstream (mm)	27.6	21.6*

*Discussion of Volumetric Analysis Results

The analysis indicated that the increase in peak water level due to development could range from up to 25.8mm for the 100y ED scenario and 27.6mm for 100y MPD scenario. While the 10yr ARI storm event for both scenarios indicates an increase of less than 22mm, it is noted that this is more dependent on the culvert performance which is not represented in this analysis.

It is noted that, the result shown above can be considered as the upper limit of impact of the development, considering the limitations / assumptions outlined in the following section.

4.2 Limitations and Assumptions of Analysis

It is noted the floodplain extents used for these calculations, is based on the 100y ARI RFHA model results. It is noted that smaller extents are expected for the smaller ARI events, with relative increases expected to be more dependent on culvert performance / capacity. In the case of the 10y ARI event above, the results are expected to be analogous to a partial blockage scenario in the SH1 culvert.

This approach is expected to represent a conservative, upper limit increase in water levels (for the assumed extents), as it does not consider Culvert performance. More detailed analysis, such as the inclusion of the culvert, as well as hydrodynamic modelling (to account for timing of runoff from the different parts of the catchment) is expected to result in a lower predicted increase in downstream flood risk.

5 2D Hydraulic Model

A 2D flood model for ED and MPD scenarios is developed using Infoworks ICM 2021.6 software to provide the flood extent and depth to the area immediately downstream of the development site. The model build parameters are described in the below section.

5.1 Model Schema

The approach taken for this model is to model a detailed 2D zones of the nearby site, including the two immediate downstream culverts. The model will capture runoff from upstream catchments and discharge to 2D zones, representing the area around the two existing culverts (Figure 4). The parameters for 2D zones are as per Table 5.

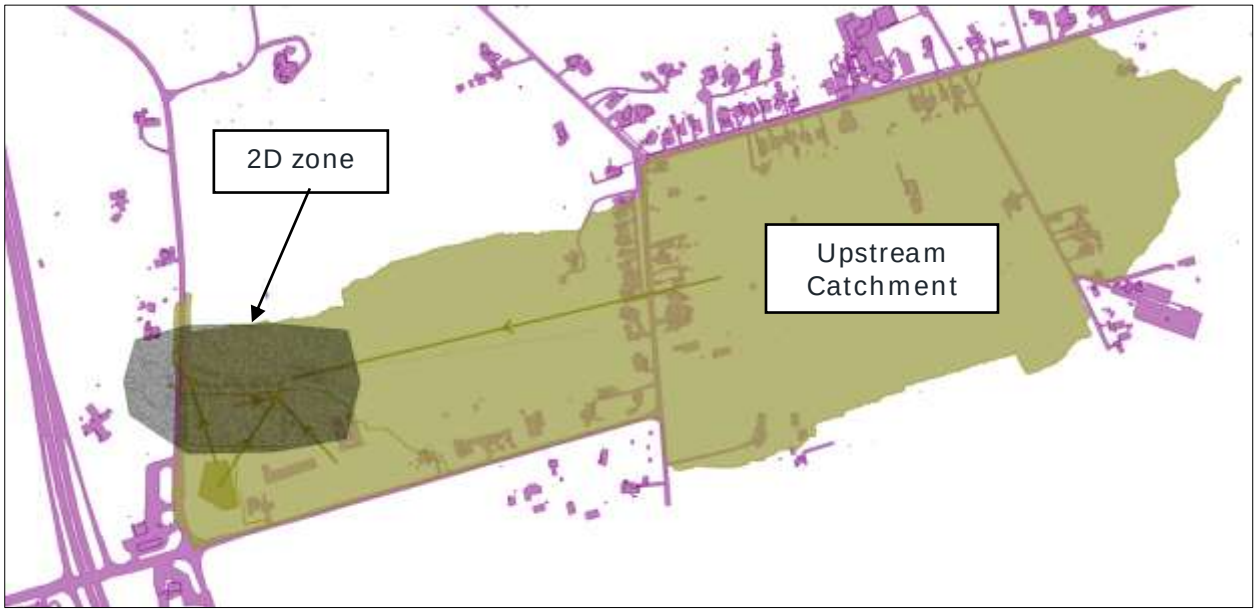

Figure 4: Model Schema Representation

Table 5: 2D zone Parameters set up in ICM

Parameter	Value	Source
DEM Surface	1m	Auckland Council 2016 1m DEM
Mesh size	Min 1m^2, Max 4m^2	ICM model
Manning's n	0.05	Assumed
Pervious Curve Number	61	Assumed
Impervious Curve Number	98	Assumed
Existing Impervious Surface	Varies	Auckland Council Geomaps Layers
Future Impervious Surface	Varies	Auckland Unitary Plan Zone
Tail water	Normal	Assumed

5.2 Culverts Details

The two culverts (Figure 5) were surveyed and the data used in the model as per below Table 6 and Table 7.

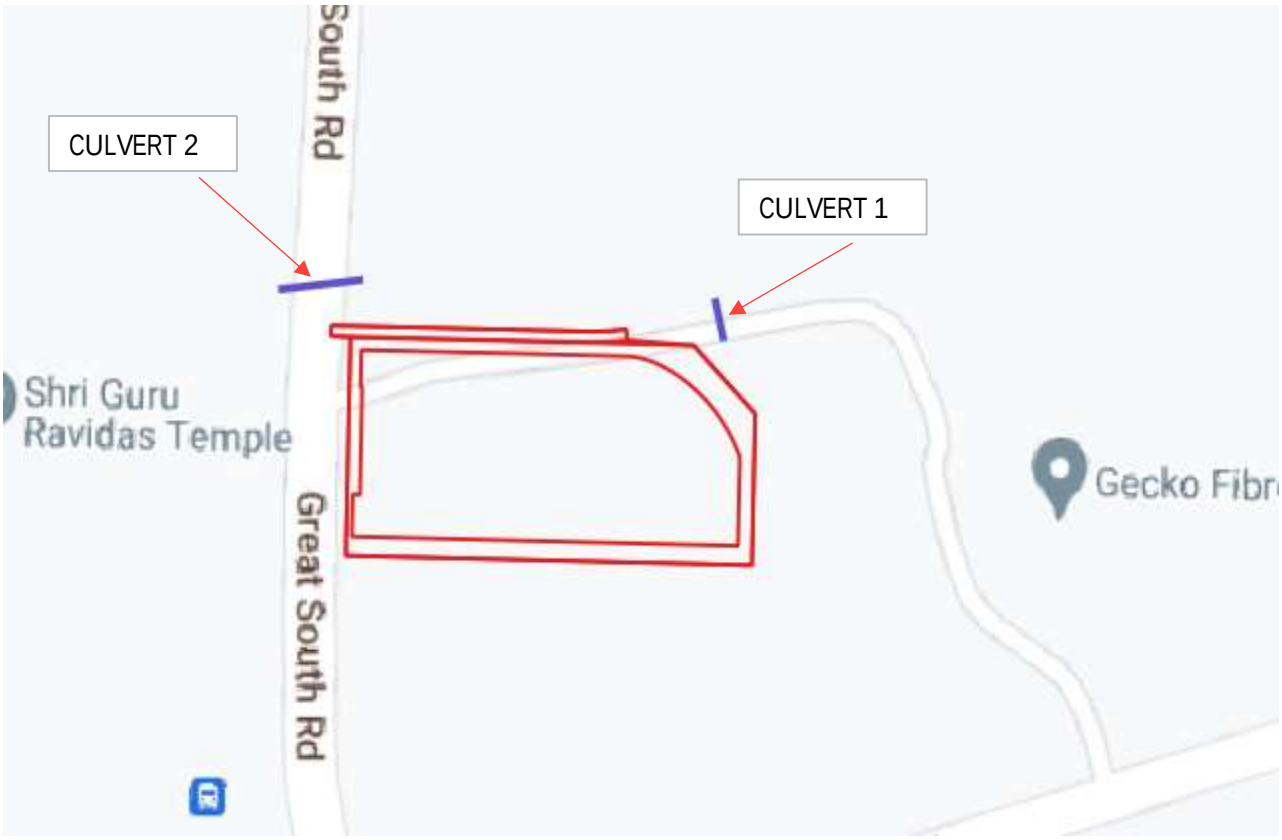

Figure 5: Existing Culverts' location

Table 6: Culvert 1 - Under Private Access

Parameter	Value	Source
Diameter	450mm	Survey
Number of barrels	1	Survey – Existing Condition
Number of barrels	1	Proposed Development
Length	11.8m	Survey
Material	Plastic	Survey
Manning's n	0.014	Assumed
Upstream invert level	162.795m RL	Survey
Downstream invert level	162.367m RL	Survey
Roadway crest length (flow width)	26m	Assumed
Roadway crest elevation	163.46m RL	Auckland Council's 1m DEM

Table 7: Culvert 2 - Under Great South Road

Parameter	Value	Source
Diameter	1050mm	Survey
Number of barrels	1	Survey – Existing Condition
Number of barrels	1	Proposed Development
Length	27.2m	Survey
Material	Concrete	Survey
Manning's n	0.014	Assumed
Upstream invert level	158.692m RL	Survey
Downstream invert level	157.782m RL	Survey
Roadway crest length (flow width)	19m	Assumed
Roadway crest elevation	163.40m RL	Auckland Council's 1m DEM

5.3 2D Flood Model Simulation Result

After running a total of 16 simulations, the results are shown in Figure 6, Table 8 and * negative values indicate reduction in flood level in development case

** negative values indicate overtopping

Table 9 below.

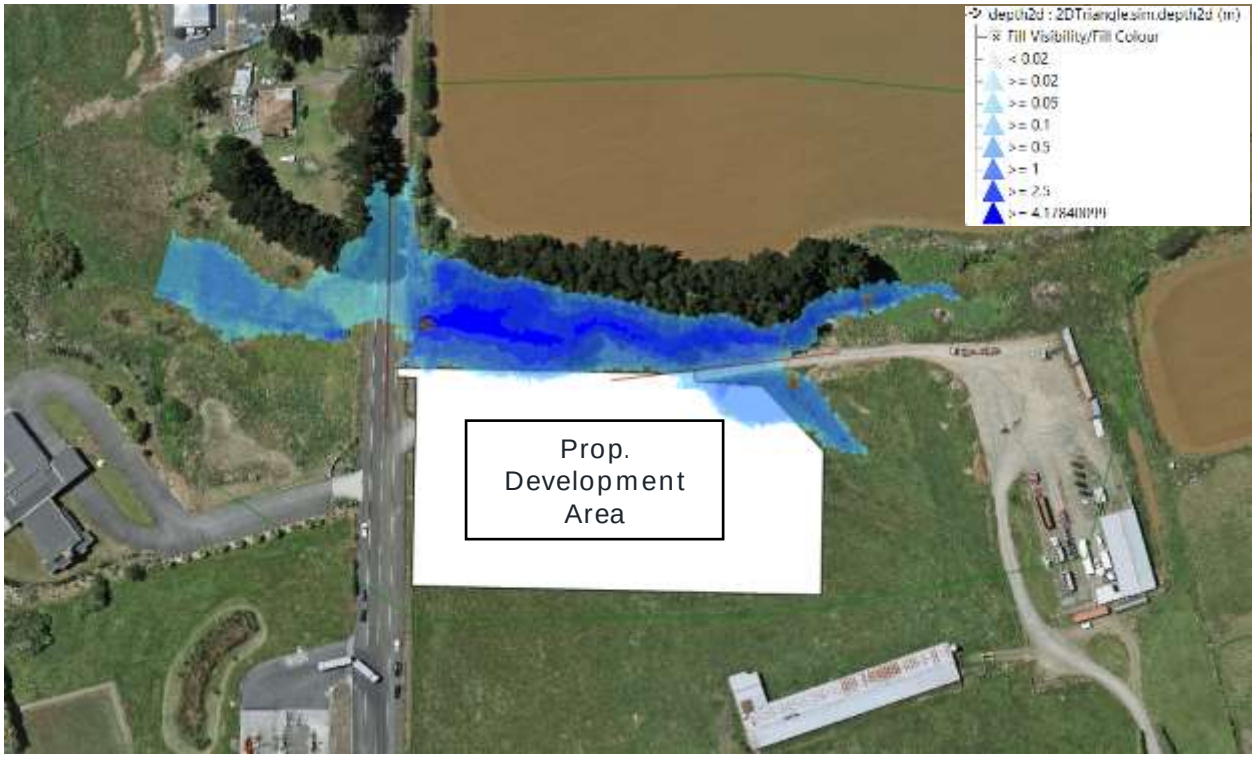

Figure 6: Maximum Flood Depth for Post Development 100yr MPD

Table 8: Peak water level (m RL) at Upstream of Culverts 1 & 2 for **ED Existing Climate** scenario (unit in meter)

Current Event - ED	2yr ARI		5yr ARI		10yr ARI		100yr ARI	
	Upstream Culvert 1	Upstream Culvert 2	Upstream Culvert 1	Upstream Culvert 2	Upstream Culvert 1	Upstream Culvert 2	Upstream Culvert 1	Upstream Culvert 2
Pre Dev	163.13	159.71	163.33	160.62	163.40	161.28	163.54	163.48
Post Dev	163.11	159.72	163.28	160.62	163.35	161.29	163.55	163.50
Increase due to Dev	**-0.02**	0.01	**-0.05**	0.00	**-0.05**	0.01	0.01	0.01
Crest Level	163.46	163.4	163.46	163.4	163.46	163.4	163.46	163.4
Pre Dev Freeboard	0.33	3.69	0.13	2.78	0.06	2.12	-0.08	-0.08
Post Dev Freeboard	0.35	3.69	0.19	2.78	0.11	2.11	-0.08	-0.10

* negative values indicate reduction in flood level in development case

** negative values indicate overtopping

Table 9: Peak water level at Upstream of Culverts 1 & 2 for **MPD Future Climate** scenario (unit in meter)

Future Event - MPD	2yr ARI		5yr ARI		10yr ARI		100yr ARI	
	Upstream Culvert 1	Upstream Culvert 2	Upstream Culvert 1	Upstream Culvert 2	Upstream Culvert 1	Upstream Culvert 2	Upstream Culvert 1	Upstream Culvert 2
Pre Dev	163.16	159.98	163.36	161.38	163.47	162.15	163.76	163.71
Post Dev	163.13	159.99	163.34	161.38	163.46	162.16	163.76	163.71
Increase due to Dev	**-0.02**	0.01	**-0.02**	0.00	**-0.01**	0.01	0.00	0.00
Crest Level	163.46	163.4	163.46	163.4	163.46	163.4	163.46	163.4
Pre Dev Freeboard	0.30	3.42	0.10	2.02	0.00	1.25	-0.30	-0.31
Post Dev Freeboard	0.33	3.41	0.12	2.02	0.00	1.24	-0.30	-0.31

* negative values indicate reduction in flood level in development case

** negative values indicate overtopping

As per existing conditions, both of the culverts included in the model are only expected to be overtopped in 100yr ARI storm event. Relatively small increases in both of the culverts are predicted due to the proposed development ranging from 10-14mm.

The proposed stormwater network in the development site is designed to capture and convey runoff at 10-yr ARI storm event to discharge towards the stream (upstream of Great South Road

Culvert). Due to the network , there is a reduction in flood level over the private access road versus the existing condition for 10yr ARI and smaller storm event.

5.4 Limitations and Assumptions of modelling

Key assumption and limitations of the model are summarised below:

- The model has been built with the purpose of assessing the 2-year, 5-year, 10-year and 100-year ARI flood results in the vicinity of the proposed Weigh Bridge Bombay development site. The level of detail included in the model has been set in line with this objective.
- The modelled topography is defined using a surface mesh, developed from Auckland councils 2016 LiDAR DEM. Detailed surface features such as retaining walls, kerbs, smaller surface drains are not expected to be represented in this model. Additionally, channel representation in the 2016 LiDAR DEM is assumed to suitably represent conveyance for the 100-year ARI event.
- Except as explicitly stated (i.e. key culverts), the underground stormwater network (public and private) is not included in the model.
- This model uses rainfall based on the TP108 synthetic temporal pattern, which combines multiple predicted intensity, frequency, duration profiles for a given ARI (Average Recurrence Interval).
- Rainfall/runoff losses were estimated using TP108 hydrological parameters. No validation of expected soil infiltration has been undertaken.
- Calibration and Validation of the model results has not been undertaken.
- Roughness values have been applied based on GIS information and available guidance. These may not be representative of specific site conditions everywhere in the catchment.
- The downstream model boundary has been extended past the site to account for potential backwater effects. Backwater effects beyond this boundary are assumed negligible.
- Modelling has been completed, and recommendations made using the existing topography. It is noted that if significant changes to the landform occur (especially in terms of culvert overtopping levels) then this may impact on the recommendations of this report.

6 Conclusion

Hydraulic modelling and a volumetric assessment have been carried out to determine the predicted flood extents adjacent to the proposed site and to quantify the potential effects of the proposed development on downstream predicted peak water levels and flows.

The following sections summarise the predicted impacts at 3 key locations.

Private Access Road Culvert (Culvert 1)

The following points summarise the findings of the predicted impact on peak water levels at Culvert 1:

- Culvert 1 is predicted to overtop during the 100y ARI events only (both ED and MPD scenarios) for the existing condition. The predicted maximum flood depth over the private road for 100yr ARI is 80mm (ED) and 300mm (MPD) in the existing case (undeveloped).

- The maximum predicted increase in peak water level due to development across this access way was **10mm** during the **100y ARI (ED)** event.
- Due to the proposed stormwater network for the site, there is a predicted **reduction** in peak water level upstream of Culvert 1 when compared to the existing case for more frequent storm events – i.e. **2yr, 5yr and 10yr ARI**.

Great South Road Culvert (Culvert 2)

The following points summarise the findings of the predicted impact on peak water levels at Culvert 2.

- The culvert is predicted to overtop during the 100y ARI events only (both ED and MPD scenarios) for the existing condition. The predicted maximum flood depth over the private road for 100yr ARI is up to 80mm (ED) and 300mm (MPD) in the existing case.
- The predicted **increase in peak water level** due to the proposed development is **14mm** for the **100yr ARI** (ED scenario) with no measurable increase predicted for the MPD scenario.
- While an increase in peak water level due to the development was **No overtopping** is expected for the more frequent rainfall event **10yr, 5yr and 2yr ARI.** The maximum relative increase was approximately 0.01m for the 10y MPD event, however this occurs with 1.24m of freeboard and is contained within the main channel.

Downstream Flood Zone (upstream of SH1)

The results of the volumetric analysis in the downstream floodplain are summarised below:

- The high-level analysis indicates that the maximum potential increase in peak water level due to development in the downstream flood plain (immediately upstream of SH1) is 25.8mm for 100y ED case and **27.6mm for 100y MPD case** – based on the extents of the currently published floodplain.
- It is considered that the predicted increase in flood risk due to the development will be lowered if modelled using a hydrodynamic modelling software which includes the downstream culverts.