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Memorandum

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Subject	**Addendum to the Pinehaven Stream Improvement Works, Pinehaven Road Culvert and Sunbrae Drive Culvert Flood Hazard Assessment Reports - DRAFT**	**Project Name**	Pinehaven Stream Improvements
Attention	Josie Burrows (GWRC); James Beban (UHCC), Mike Law (BECA)	**Project No.**	IZ089000
From	Peter Kinley		
Date	November 14, 2019		
Copies to	Tristan Reynard, Angela Penfold – Wellington Water		

Introduction

Following the issue of the Pinehaven Stream Improvements Flood Hazard Assessment Report (FHA) in September 2019, Pinehaven Stream Improvements Sunbrae Drive Culvert – Flood Hazard Assessment Report in October 2019 and the Pinehaven Stream Improvements – Pinehaven Road Culvert – Flood Hazard Assessment Report in October 2019 Jacobs have used the hydraulic model for the Pinehaven catchment to:

- Reassess the effect of climate change on rainfall depths in accordance with the IPCC Fifth Assessment (AR5) and to a projected 2120 timeframe; and
- Investigate the effects of interim scenarios where the upgraded culverts (at Pinehaven Road and Sunbrae Drive) are installed before the main stream channel upgrades. The three interim scenarios are:
    - Pinehaven Road culvert only;
    - Sunbrae Drive culvert only; and
    - Pinehaven Road culvert and Sunbrae Drive culvert only.

Background

The updated assessment of climate change was driven by new guidance from the Ministry for the Environment (MfE, September 2018). We have assumed the Representative Concentration Pathway 4.5 (RCP4.5) emissions curve from AR5 is appropriate and a horizon of 2120 to determine that the allowance for climate change required by the new MfE guidelines is a 20% increase in extreme event rainfall depth, compared to the 16% allowance used in the FHAs. We determined this in two ways:

1. We confirmed the requirements of Wellington Water Ltd's Regional Specification for Water Services (which are for a 20% increase in extreme rainfall).
2. We used rainfall data from HIRDS version 4 to calculate/extrapolate the allowance.

The values we calculated from HIRDS version 4 were lower than the Wellington Water requirements. Therefore, we chose the more conservative value.

The updated assessment of climate change to 2120 is in response to a request for further information under section 92 of the Resource Management Act to the Pinehaven Stream Improvements consent applications.

The interim scenarios have been re-modelled in response to a request for further information under section 92 of the Resource Management Act with respect to the Pinehaven Road and Sunbrae Drive culvert resource consent applications.

Results from updated modelling: 2120 climate change

The hydraulic model of the design scenario (i.e. with the proposed stream improvement works in place) has been re-run with the 25-year flood event (4% AEP) and the 100-year flood event (1% AEP), both with a 20% allowance for the effect of climate change and compared the water levels for the "20% increase" against the "16% increase". An assessment of the reaches where works are proposed has been undertaken and the remodelling shows:

- For the 25-year flood event (4% AEP) the maximum increase in water level is 31mm and the median increase is 18mm. The highest increases in peak water level occur immediately upstream of Pinehaven Road. The maximum increase in velocity is 0.07m/s and the median increase is 0.02m/s.
- For the 100-year flood event (1% AEP) the maximum increase in water level is 110mm and the median increase is 27mm. The highest increases in peak water level occur at the lower end of the works, from about 20m upstream of the Bypass Inlet and downstream in the Lower Pinehaven Stream reach. The maximum increase in water level occurs at the inlet to the main Pinehaven Stream culvert in Whitemans Road. The maximum increase in velocity is 0.07m/s and the median increase is 0.03m/s.

The number of habitable floor polygons within the extent of the 100-year flood event (1% AEP) for the two climate change scenarios for the base network and the proposed stream and culvert improvements are shown in **Table 1**.

Table 1: Effect of Updated Climate Change Guidelines on Floor Flooding

Scenario		Floors within the 100-year flood event (1% AEP) floodplain		
Network	Climate Change	Habitable	Non-habitable	Total
Base	16%	64	16	80
Stream and Culvert Improvements	16%	16	7	23
Base	20%	78	31	109
Stream and Culvert Improvements	20%	16	7	23

The numbers above differ from the numbers reported in the FHA. The change results from buildings on the eastern side of Blue Mountains Road being excluded, which was done because it was found that the proposed works do not have a significant effect in this area. As demonstrated in Table 1, the number of habitable floor polygons for 16% and 20% climate change factors remains unchanged for the stream and culvert improvement scenario, therefore it is demonstrated that for the proposed design the increase in climate change factor to 20% does not increase the number of impacted habitable floor polygons for the 100 year event (1%AEP).

Results from updated modelling: 2120 climate change for interim culvert scenarios

The base model has been updated to create scenarios representing the effect of:

- The upgraded Pinehaven Road culvert only;
- The upgraded Sunbrae Drive culvert only; and
- The upgraded Pinehaven Road culvert and Sunbrae Drive culvert only.

The base model has been re-run with the 25-year (4% AEP) and 100-year (1% AEP) flood events, both with 20% allowance for climate change. The three interim culvert scenarios with the 25-year and 100-year storm event, with a 20% allowance for climate change have been re-run and a comparison the effects has been undertaken. The remodelling shows there are increases in peak water levels for all three interim culvert scenarios downstream of both culverts compared to the base case. The results are summarised in **Table 2**.

Table 2: Culvert Scenario Water Level Results

Location where increases are measured	Scenario					
	25-year			100-year		
	Pinehaven Road culvert only	Sunbrae Drive culvert only	Pinehaven Road and Sunbrae Drive culverts only	Pinehaven Road culvert only	Sunbrae Drive culvert only	Pinehaven Road and Sunbrae Drive culverts only
Downstream of the Pinehaven Road culvert	+50mm	-10mm	+35mm	+20mm[1]	-10mm	+35mm
Downstream of the Sunbrae Drive culvert	0mm	+135mm	+135mm	+20mm[1]	+150mm	+150mm

1. The model run for the 100-year rainfall event and the Pinehaven Road culvert only did not complete in time for the addendum to be written, so values have been estimated based on interpolation of other model results. The table will be updated when results are available.

The culverts do not change the median velocity in the reaches where works are proposed. The effect of the interim culverts on velocities is shown in **Table 3**.

Constructing only the Pinehaven Road culvert increases velocities in the culvert barrel by up to 0.88m/s for the 25-year event and by up to 1.27m/s for the 100-year event. Installation of scour protection at the downstream end of the culvert reduces the maximum velocities in the channel by up -0.40m/s. The effects elsewhere in the area of the works are minor.

Constructing only the Sunbrae Drive culvert decreases velocities in the culvert barrel by up to -1.96m/s for the 25-year event and by up to -1.55m/s for the 100-year event. Increases in maximum velocity of up to +0.32m/s occur upstream and downstream of the culvert due to the smoother flow through the culvert. The effects elsewhere in the area of the works are minor.

Construction of both culverts has a similar effect on the change in maximum velocities at the affected areas as construction of individual culverts: for the interim scenario where both culverts are installed, the effects at Pinehaven Road are similar to when only the Pinehaven Road culvert is installed, and the effects at Sunbrae Drive are similar to when only the Sunbrae Drive culvert is installed, for both the 25-year and 100-year event.

Table 3: Culvert Scenario Velocity Results

Output Assessed	Scenario					
	25-year			100-year		
	Pinehaven Road culvert only	Sunbrae Drive culvert only	Pinehaven Road and Sunbrae Drive culverts only	Pinehaven Road culvert only	Sunbrae Drive culvert only	Pinehaven Road and Sunbrae Drive culverts only
Change in Maximum Velocity	+0.88m/s	+0.31m/s	+0.88m/s	+1.27m/s	+0.32m/s	+1.30m/s
Change in Median Velocity	0.00m/s					

The number of floors (floor polygons) within the extent of the 100-year flood event (1% AEP) for the two climate change scenarios for the base network and the proposed culvert and channel improvements) are shown in **Table 4**.

Table 4:Effect of Culvert Upgrades on Floor Flooding

Scenario		Floor polygons within the 100-year flood event (1% AEP) floodplain				
Network	**Climate Change**	**Habitable**	**Non-habitable**	**Total**	**New[2] Habitable**	**New[2] Non-habitable**
Base	20%	78	31	109	N/A	N/A
Pinehaven Road Culvert only[1]	20%	≤77	≤31	≤108	Could not be assessed	
Sunbrae Drive Culvert only	20%	71	27	98	2[3]	1[3]
Pinehaven Road culvert and Sunbrae Drive culvert	20%	70	27	97	2[3]	1[3]
Culvert and channel improvements	20%	16	7	23	0	0

1. The model run for the 100-year rainfall event and the Pinehaven Road culvert only did not complete in time for the addendum to be written.

2. New Habitable Floors and New Non-Habitable Floors are floors that are affected by the culvert upgrades. These are floors that are not within the 100-year flood event (1% AEP) floodplain in the Base scenario and are within it for the culvert scenario. i.e. the culvert upgrade brings the floodplain polygon into the building polygon. Ground and finished floor elevations should be verified to confirm if habitable floor flooding is predicted and if required mitigation measures should be implemented, eg. bunding or temporary choking of the upstream inlet of the Sunbrae culvert.
3. The New Habitable floors are both on the Silverstream Reform Church property. The New Non-habitable floor is a garage at 1 Tapestry Grove.

The effect of the interim culvert scenarios on water levels for the 25-year (4% AEP) flood event and the 100-year (1% AEP) flood event at the inlet of each culvert is shown in **Table 5** and **Table 6**, respectively.

Table 5: Culvert Inlet Peak Water Levels for the 4% AEP flood event

Culvert Location		Pinehaven Road	Sunbrae Drive
Culvert Soffit Level (design) (m RL)		55.16	51.23
Headwall Level (design) (m RL)		56.90	51.94
Network	Parameter		
Baseline	Water Level	55.83	52.70
	Freeboard	Not assessed	Not assessed
Pinehaven Road culvert only	Water Level	55.17	52.70
	Freeboard	1.73	Not assessed
Sunbrae Drive culvert only	Water Level	55.83	51.53
	Freeboard	Not assessed	0.41
Pinehaven Road culvert and Sunbrae Drive culvert only	Water Level	55.21	51.53
	Freeboard	1.69	0.41
Channel and Stream Improvements	Water Level	55.17	51.29
	Freeboard	1.73	0.65

Table 6: Culvert Inlet Peak Water Levels for the 1% AEP flood event

Culvert Location		Pinehaven Road	Sunbrae Drive
Culvert Soffit Level (design) (m RL)		55.16	51.23
Headwall Level (design) (m RL)		56.90	51.94
Network	Parameter		
Baseline	Water Level	56.02	52.79
	Freeboard	Not assessed	Not assessed
Pinehaven Road culvert only	Water Level	55.34-55.37	56.02
	Freeboard	1.53	Not assessed
Sunbrae Drive culvert only	Water Level	56.02	51.76
	Freeboard	Not assessed	0.18
Pinehaven Road culvert and Sunbrae Drive culvert only	Water Level	55.37	51.77
	Freeboard	1.53	0.17
Channel and Stream Improvements	Water Level	55.34	51.39
	Freeboard	1.56	0.55

The Pinehaven Road culvert is surcharged by between 10mm and 50mm in the 4% AEP flood event. It meets the requirement of at least 500mm of freeboard from the peak water surface elevation to the top of the headwall for all the relevant interim culvert scenarios and for the channel and stream improvements scenario. In the 1% AEP event the culvert is surcharged by 210mm, which is reduced to 180mm with the design in place. The freeboard requirements of at least 500mm is met for all relevant interim culvert scenarios for the 1% AEP flood event.

The Sunbrae Drive culvert is surcharged by between 40mm and 300mm in the 4% AEP flood event. It does not meet the requirement of at least 500mm of freeboard from the peak water surface elevation to the top of the headwall for the relevant interim culvert scenarios; 650mm of freeboard is achieved for the design (channel and stream improvements) scenario, which meets the requirement. In the 1% AEP event the culvert is surcharged by 530mm, which is reduced to 160mm with the channel and stream improvements in place. The freeboard requirements of at least 500mm is not met for any of the

relevant interim culvert scenarios for the 1% AEP flood event; 550mm of freeboard is achieved for the channel and stream improvements scenario, which meets the requirement.

As a result of the projected increase downstream of the Sunbrae Culvert for the interim condition before the stream works are completed, it is recommended to temporarily choke the inlet so the upgraded culvert discharge remains consistent with the base scenario. This will prevent an increase in water surface elevation for the interim condition compared to the base scenario.