Table 5: Operation And Maintenance Of Stormwater Infrastructure

ITEM	MAINTENANCE REQUIREMENT	FREQUENCY A = Annual M = Monthly BM = Bi-monthly AMS = After Major Storm S = After Monthly Storm	RESPONSIBLE ENTITY WDC = Waipā District Council
Swales	Engineered channels should be inspected at least on an annual basis, but also after any major storm event. Maintenance requirements to follow Regional SW Guideline – Appendix C.	A and AMS	WDC
Road OLFP	Engineered OLFPs should be inspected at least on annual basis, but also after any major storm event.	A and AMS	WDC
Outlets	OLFP outlets should be inspected at least on annual basis, but also after any major storm event where failures appeared to occur during the storm event.	A and AMS	WDC
Wetland	Maintenance requirements to follow Regional SW Guideline – Appendix C.	A, every 3 Months, and S	WDC

4.0 HYDRAULIC MODELLING

4.1 MODELLED SCENARIOS

Stormwater models of the PC14 Structure Plan Area were built using Infoworks ICM utilising a coupled 1D/2D model with the primary purpose of assessing the impact of future development of the PC14 Structure Plan Area on the flood behaviour of the Mangaone Stream. A comparison of the parameters used in the models between the pre- and post-development scenarios is provided in **Table 6**.

Table 6: Catchment Hydrology Modelling Parameters

PARAMETERS	PRE-DEVELOPMENT	POST-DEVELOPMENT
CATCHMENT SURFACE AND STORMWATER STRUCTURES		
Ground topography	Lidar data 2007-2008 updated with more recent surface in Cambridge area, St. Kilda development, Appleby swale, and Waikato Expressway. Topographic survey within the PC14 Structure Plan Area is found to be consistent with the Lidar data for flood simulation purposes.	
Catchment	Part of 2D mesh	PC14 Structure Plan Area is modelled as lumped sub-catchment discharging into constructed wetlands. The wetlands within the PC14 Structure Plan Area, and the areas outside, are represented as part of the 2D mesh.

Table 7: Catchment Hydrology Modelling Parameters

PARAMETERS	PRE-DEVELOPMENT	POST-DEVELOPMENT
Stormwater infrastructure	Existing culverts along Mangaone Stream are represented as 1D links. Culverts without available size and elevation information are burned as part of the DEM and captured by the 2D mesh.	Existing culverts along Mangaone Stream are represented the same way with the pre-development. Constructed wetlands within the PC14 Structure Plan Area are represented as 1D storage areas with controlled outfall to the existing wetland.
HYDROLOGY		
Rainfall depth	Source: High Intensity Rainfall Design Systems (HIRDS) Version 4. No climate change adjustment applied for pre-development. 1%AEP = 155 mm 10%AEP = 100mm 50%AEP = 65.8 mm	For areas outside of the PC14 Structure Plan Area represented as 2D mesh, the same pre-development rainfall is applied. For areas within the PC14 Structure Plan Area, adjustments were applied following the climate change temperature increase of 2.1 °C scenario, with adjusted rainfall as follows: 1%AEP = 181.0 mm 10%AEP = 113.2mm 50%AEP = 71.7 mm
Rainfall pattern (design storm)	From Waikato Stormwater Runoff Modelling Guideline (Waikato Regional Council Technical Report 2018/02)	
Rainfall losses	Effective rainfall is calculated externally to account for rainfall losses prior to being loaded into the 2D mesh.	For areas outside of the PC14 Structure Plan Area represented as 2D mesh, the same pre-development rainfall is applied. For areas within the PC14 Structure Plan Area represented as lumped sub-catchment, the rainfall is applied directly into the sub-catchment polygons. Rainfall losses are calculated internally by ICM based on Initial Abstraction and % impervious.
Impervious percentage within the site	0%	The following catchment distribution is assumed: **Industrial lots and roads** = 80% of site catchment at 90% impervious **Stormwater reserve** = 20% of site catchment at 15% impervious **Weighted average** = 75% impervious.
Mean composite CN within the site	66.5	90-92
Mean initial abstraction (Ia) within the site	1.40 mm	7.55 mm
	Based on composite CN according to the Waikato stormwater runoff modelling guideline (Waikato Regional Council Technical Report 2018/02).	
Surface roughness (manning n)	0.05	0.05

4.2 OUTLET CONTROL

For each constructed wetland, two separate outlets have been designed to provide the following:

- Outlet 1 is an orifice located exactly at the permanent water level in the constructed wetland and has been sized to discharge the minimum extended detention volume over a course of 24 hours.
- Outlet 2 is also an orifice located at the extended detention level in the pond to discharge the rest of the live storage to Mangaone stream. The orifice has been sized to ensure that post-development peak flows do not exceed pre-development peak flows from the respective catchment areas of the proposed constructed wetlands.

It should be noted that the outlet sizes are indicative at this stage, as well as the resulting peak outflows from the constructed wetlands. Opportunities to refine the outlet sizes and peak flows will be available once the numbers, locations, and layouts of the proposed constructed wetlands are finalised at resource consent stage.

4.3 MODEL RESULTS

4.3.1 PC14 STRUCTURE PLAN AREA RUNOFF

The peak flows of the northern and southern catchment are derived from the results of the pre-development scenario. The controlled outlets can reduce the post-development peak flows from the constructed wetlands to approximately 29-33% of the pre-development peak flows, as shown in **Figure 10**. It should be noted that previous iterations of the orifice sizes that achieved 80-100% of the pre-development peak flows increased the flood risk downstream of the PC14 Structure Plan Area, including the culverts in Victoria Road and those located in the Dairy Factory site. By further controlling the peak flows from the PC14 Structure Plan Area, the negative downstream impacts of the proposed development are fully mitigated and, in some areas, the flood levels are improved, as illustrated in **Figure 10** below.

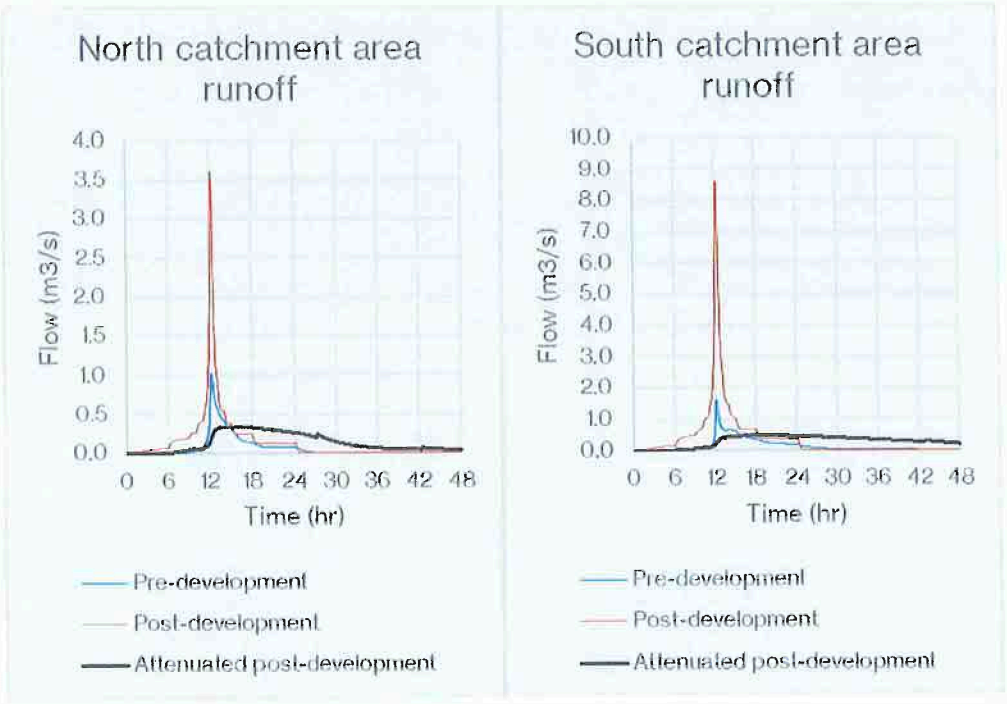

FIGURE 10: RUNOFF TIME SERIES FROM THE PC14 STRUCTURE PLAN AREA FOR 1% AEP STORM EVENT

4.3.2 DOWNSTREAM IMPACTS

Peak flows and flood levels were derived from the results of the hydraulic model in locations identified in **Figure 11**. A comparison of the peak flows and flood level between different storm event is summarised in **Table 8** and between pre- and post-development scenarios is summarised in **Table 7**. Positive values in the table mean higher discharge or flood levels in the post-development model compared to the pre-development; negative values mean lower discharge or flood levels in the post-development model compared to the pre-development. Zero values mean no observable change between the two scenarios.

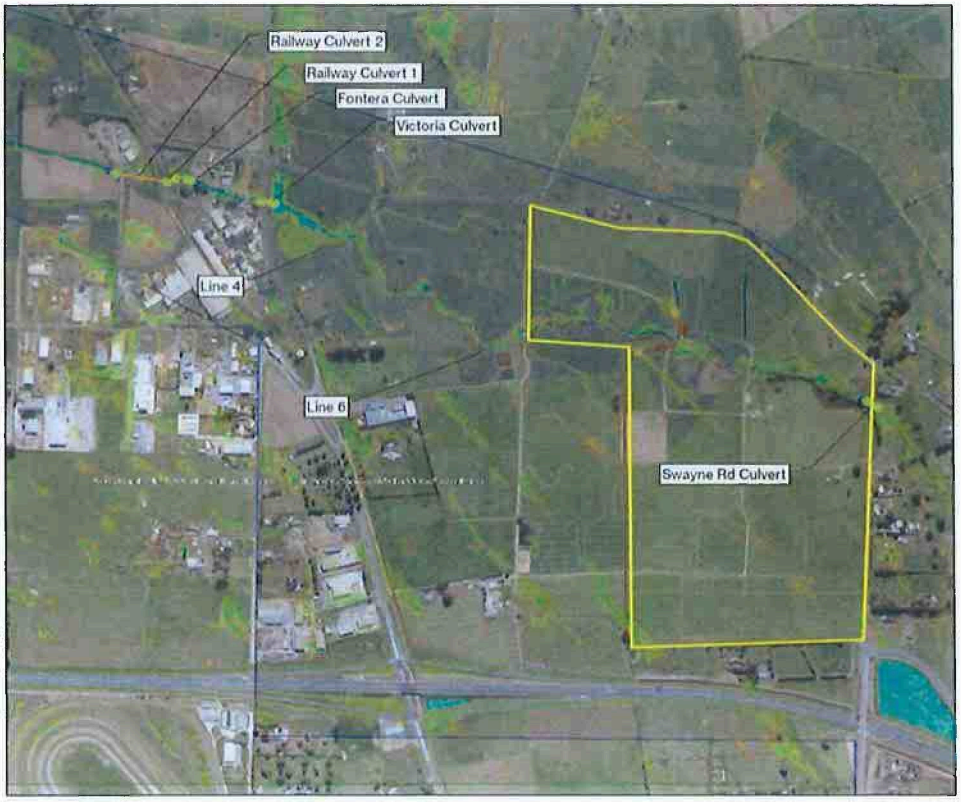

FIGURE 11: OBSERVATION POINTS WITHIN THE HYDRAULIC MODEL

Table 8: Summary of changes in peak flows and flood levels

LOCATION	50% AEP		10% AEP		1% AEP	
	Peak flow (m/s)	Flood level (m RL)	Peak flow (m/s)	Flood level (m RL)	Peak flow (m/s)	Flood level (m RL)
Swayne Rd Culvert	0.00	-0.01	0.00	0.00	0.00	-0.00
Line 6	-0.03	0.00	-0.22	0.00	0.00	0.00
Line 4	-0.10	0.00	-0.46	0.00	-0.59	0.00
*Victoria Road Culvert	-0.07	-0.03	-0.18	-0.09	0.08	0.02
*Fonterra Culvert	-0.07	-0.02	-0.19	-0.06	0.00	-0.01
*Railway Culvert 1	-0.07	-0.06	-0.20	-0.07	-0.01	-0.02
*Railway Culvert 2	-0.06	-0.26	-0.21	-0.16	-0.02	-0.03

*Flood levels are taken from the upstream end of the culverts except Swayne Rd

There is no observed significant change in the flood level and peak flow at the culvert along Swayne Road. This means that the proposed stormwater management solution for the PC14 Structure Plan Area will not change the water levels in the constructed wetland and will not cause backflow towards the upstream of the culvert.

Reduction of peak flow is observed for the two observation points (Lines 4 and 6), although the flood levels are maintained. This is related to the natural capability of the stream to partially detain water along the stream/wetland corridor.

Small increases in both discharge and flood level are observed to the culvert beneath Victoria Road, but this is limited to the extreme storm event only (1% AEP). Further investigation of the hydraulic model results show that the timing of the peak flow and flood level has changed in the post-development scenario (**Figure 12**) because of the flow attenuation applied to the PC14 Structure Plan Area. However, while the change in timing is also observable further downstream, the increase in peak flow and flood level is localised and does not propagate further downstream. Moreover, the increased flood level is very small (within the range 2cm-2.5cm) and flood extent which will be confined to the existing flood plain area.

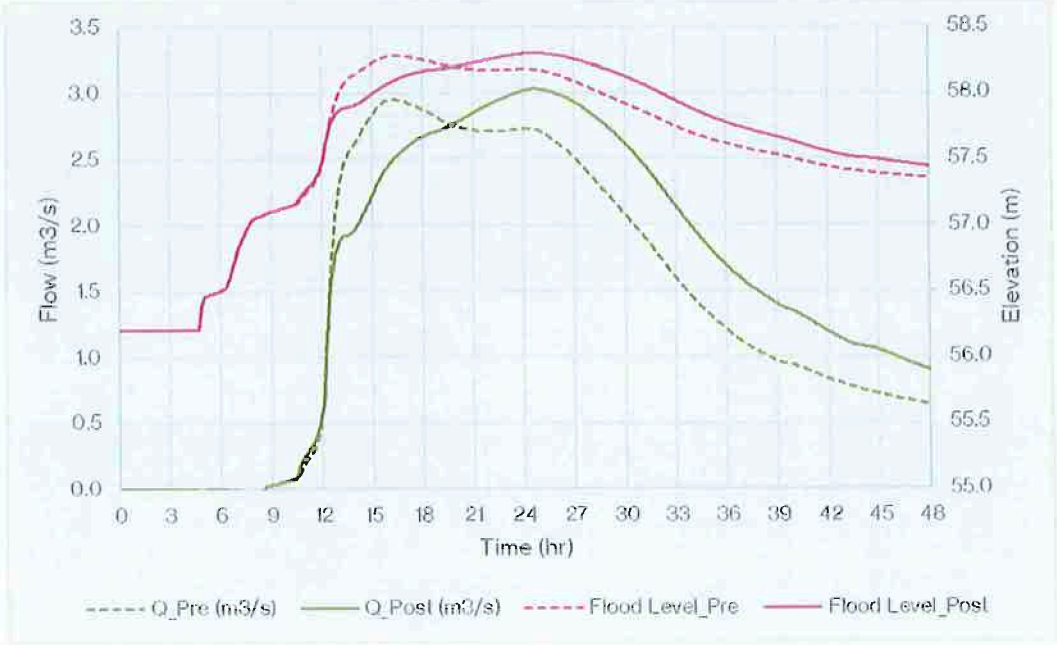

FIGURE 12: FLOW AND FLOOD LEVEL TIME SERIES IN VICTORIA CULVERT (1% AEP)

Aside from the culvert along Victoria Road, all other culverts further downstream are observed to experience a decrease in flood levels. In these locations, the decrease in flood levels is more pronounced in the more frequent storm events (10% and 50% AEP).

As previously discussed, red values indicate a small increase in flood depth at the upstream end of Victoria Road culvert and does not propagate to the downstream floodplain. The slight increase in flood depth is also mitigated by the lower flood level further downstream near the culverts along the railway.

Table 9: Peak flows and flood levels

LOCATION	PRE-DEVELOPMENT		POST-DEVELOPMENT	
	Peak flow (m/s)	Flood level (m RL)	Peak flow (m/s)	Flood level (m RL)
50%AEP				
Swayne Rd Culvert	0.08	61.85	0.09	61.84
Line 6	0.36	60.77	0.34	60.77
Line 4	0.47	59.71	0.37	59.71
*Victoria Culvert	0.45	57.42	0.38	57.39
*Fonterra Culvert	1.12	57.18	1.05	57.15
*Railway1 Culvert	1.12	56.30	1.05	56.24
*Railway 2 Culvert	1.12	56.04	1.06	55.77
10% AEP				
Swayne Rd Culvert	0.48	62.06	0.48	62.06
Line 6	1.21	60.77	0.99	60.77
Line 4	1.59	59.71	1.13	59.71
*Victoria Culvert	1.28	57.67	1.10	57.58
*Fonterra Culvert	2.00	57.31	1.80	57.25
*Railway1 Culvert	2.01	56.50	1.81	56.43
*Railway 2 Culvert	2.02	56.20	1.82	56.04
1% AEP				
Swayne Rd Culvert	2.10	62.51	2.10	62.51
Line 6	2.93	60.77	2.93	60.77
Line 4	3.65	59.71	3.06	59.71
*Victoria Culvert	2.96	58.28	3.03	58.30
*Fonterra Culvert	3.71	57.60	3.70	57.60
*Railway1 Culvert	3.72	57.08	3.71	57.05
*Railway 2 Culvert	3.73	56.71	3.72	56.68

Note: Green figures indicate reduced value, red figures indicate increased value

The results of the 2D flood models have been extracted to generate the flood maps in **Appendix 1**. From these flood depths, the flood level differences for each storm event have been post-processed in GIS. For 1% AEP storm event in **Figure 13**, localized increase in flood level can be observed along the stream/wetland corridor within the PC14 Structure Plan Area boundary. The mitigation of this effect along the stream/wetland corridor immediately downstream of the PC14 Structure Plan Area is associated with the utilisation of the stream/wetland corridor's natural retention capacity. Further refinement of the number of constructed wetlands and the location of the outfalls during the resource consent stage can optimise the utilisation of the wetland within the PC14 Structure Plan Area. More outfalls distributed in different locations along the stream/wetland corridor will change the peak flow timing for each pond/wetland and potentially reduce the negative impact on flood depth.

The impact upstream of Victoria Road culvert has also been investigated and found to be consistently within 2cm-2.5 cm range of increased flood levels and does not affect the downstream areas. The rest of the flooded areas do not change from the pre-development flood condition.

For the 10% and 50% AEP storm events in **Figure 14** and **Figure 15**, localised impact can be observed along the stream/wetland corridor within the PC14 Structure Plan Area which is also mitigated immediately downstream. For these more frequent storm events, flood levels are observed to be reduced by 2cm-6cm along Victoria Road culvert and into the downstream Dairy Factory site. This positive impact is associated mainly with the large attenuation proposed to be provided within the PC14 Structure Plan Area.

FIGURE 13: FLOOD LEVEL DIFFERENCE FOR 1% AEP STORM EVENTS

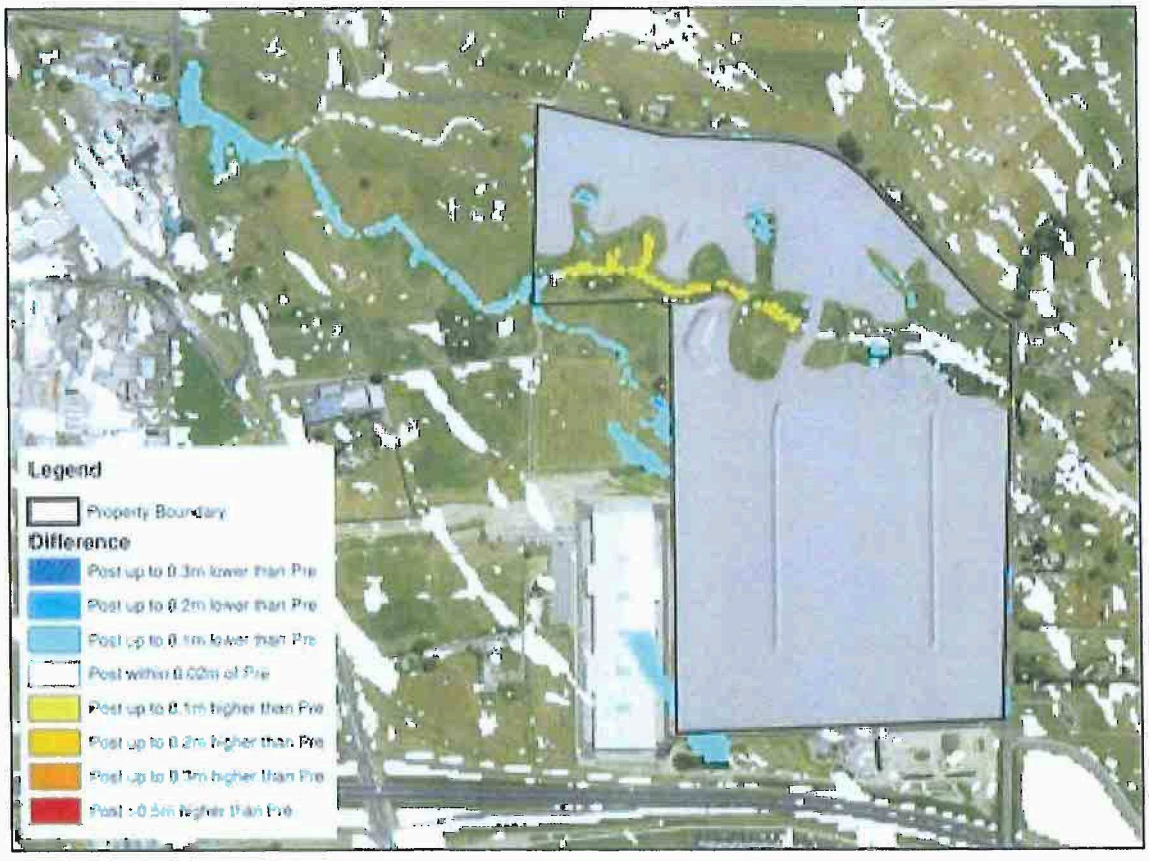

FIGURE 14: FLOOD LEVEL DIFFERENCE FOR 10% AEP STORM EVENTS

FIGURE 15: FLOOD LEVEL DIFFERENCE FOR 50% AEP STORM EVENTS

5.0 CONCLUSION AND RECOMMENDATIONS

The recommended stormwater management solution for the PC14 Structure Plan Area as discussed in this SMP report can be summarised as follows:

- The proposed PC14 Structure Plan Area is to be serviced by the primary stormwater network system with a level of service equivalent to the 10% AEP 24hr design storm event. Due to the topographical limitations of the PC14 Structure Plan Area, the primary network is proposed to be composed of planted swales along the road reserve.
- The secondary stormwater system along road reserves shall be designed to service runoff from the PC14 Structure Plan Area up to 1% AEP 24hr design storm event.
- Both primary and secondary networks shall convey runoff towards the proposed constructed wetlands.
- Water quality pre-treatment shall be provided via treatment train approach by the following:
    - At-source controls such use of inert building (roofing) materials shall be implemented via conditions of consent and/or consent notices to those developing and/or owning new buildings within the PC14 Structure Plan Area.

  - Appropriate water sensitive design applications such as proprietary devices shall be installed to provide pre-treatment of runoff from high-risk facilities as classified in the Waikato Regional Plan, prior to discharge to stormwater network.
  - Planted swales shall also provide pre-treatment of runoff from public roads where applicable.

- The first-flush runoff will be provided with water quality treatment and extended detention via proposed constructed wetlands to be accommodated adjacent to the Mangaone Stream within the existing stream/wetland corridor. The number and layout of constructed wetlands is indicative and will be subject to refinement at resource consent stage. The design of the constructed wetlands shall follow the requirements of the regional stormwater guidelines.

- Due to the shallow groundwater levels prevalent across the majority of the PC14 Structure Plan Area, and the limited hydraulic conductivity of underlying soil, disposal of stormwater via soakage is unlikely to be feasible for both the swales and the constructed wetlands. Therefore, the peak flow rate in the post-development scenario is proposed to be reduced via attenuation within the constructed wetlands.

- The stormwater management solution for the PC14 Structure Plan Area assumes that the full runoff volume up to 1% AEP will be attenuated within the constructed wetlands. Refinement of swale sizing to distribute the required detention volume to optimise the swale land take shall be undertaken at resource consent stage.

- The outlets of the constructed wetlands shall be designed to control the peak flows and to minimise any increase in flood risk downstream of the PC14 Structure Plan Area. The post-development hydraulic model indicates that this can be achieved by reducing the peak flow to approximately 50% of the pre-development peak flow of the 1% AEP storm event. By doing so, the flood risks downstream are also not increased for 10% and 50% AEP storm events.

- Erosion protection for the proposed stormwater infrastructure shall be provided as follows:

  - Appropriate planting media and stabilised walls are to be provided to the swales and constructed wetland embankments and spillways.
  - Constructed wetland inlets and outlets shall be provided with protection where applicable
  - Swales shall be provided with appropriate cover (riprap) along bends to protect channel banks.

- Flood models illustrate that for the 50% and 10% AEP storm events, the impact on the flood levels along the existing Mangaone Stream/natural wetland corridor is localised within the PC14 Structure Plan Area boundary and is fully mitigated by lower flood levels downstream. For the 1% AEP storm event, there is a 2cm-2.5 cm increase in flood level just upstream of Victoria Road, but there is no additional flood effect to the west of the Victoria Road culvert. Potential downstream flood effects are also mitigated by lower flood levels further downstream near the culverts along the railway.