Whiskey Creek Plan Change, Palmerston North

Stormwater Management Plan for Flygers Investment Group Limited

Mitch Hydro Limited | April 2021

Mitch Hydro

Whiskey Creek Plan Change, Palmerston North

Stormwater Management Plan for Flygers Investment Group Limited

Approved for release by	Paul Mitchell Director, Hydrologist CPEng	Date: 15 April 2021 Ref: 2017.03 Status: Issue 2
Email paul@mitchhydro.co.nz	Mob +64 27 655 4620	Mitch Hydro Limited 2 Ashleigh Way Waikanae Beach Waikanae 5036 New Zealand

Mitch Hydro

Contents

1 Introduction 1
2 Objectives 1
3 Scope 1
4 Methodology 2
4.1 Initial Discussions 2
4.2 Site Visit 2
4.3 Existing Drainage 2
4.4 Geology 4
5 Rainfall – Runoff Modelling 5
5.1 Introduction 5
5.2 Design Rainfalls 5
5.3 Existing Catchment Runoff 6
5.4 Fully Developed Catchment 7
5.4.1 Plan Layout 7
5.4.2 Land Use Assumptions 8
6 Stormwater Mitigation 10
6.1 Stormwater Quantity 10
6.1.1 Flood Scenarios 10
6.1.2 Secondary Flow Paths 10
6.1.3 Flood Detention Pond 10
6.1.4 Other Mitigation Options 17
6.2 Stormwater Quality 18
6.2.1 Constructed Wetland 18
6.2.2 Rain Gardens 18
6.3 Hydraulic Connectivity 18
7 Flygers Line Spillway Events 19
7.1 16 February 2004 Flood 19
7.2 20-21 June 2015 Flood 20
7.3 Design Considerations 21
8 Conclusions 22
9 Limitation 23
10 References 23

Appendix A Existing Layout
Appendix B Fully Developed Layout
Appendix C Stormwater Mitigation
Appendix D Flygers Line Spillway (Horizons)

1 Introduction

Mitch Hydro Limited (Mitch Hydro) has been engaged by Flygers Investment Group Limited to develop a Stormwater Management Plan (SMP) for the proposed Whiskey Creek Plan Change, Palmerston North.

2 Objectives

The main objectives are summarised below:

1. Research requirements with respect to stormwater mitigation for the proposed development;
2. Attend, via a video link, 1 or 2 workshops to discuss the site and assist in agreeing on a possible structure plan; and
3. Prepare a Stormwater Management Plan (SMP) that identifies, discusses and mitigates the stormwater effects of the land being rezoned.

The SMP will compliment and inform the Section 32 analysis report.

3 Scope

The scope will include the following key items:

1. Initial discussions with the project team;
2. Site visit to assess:
    a. Existing stormwater infrastructure constraints / performance and flood hazards:
    b. Site-specific options for stormwater mitigation (quantity and quality); and
    c. Any other relevant issues.
3. Develop methodology for SMP;
    a. Review existing land uses;
    b. Type and condition of existing pervious areas;
    c. Existing drainage infrastructure and condition; and
    d. Any other relevant issues.
4. Catchment hydrology;
    a. Rainfall;
    b. Geology;
    c. Climate change;
    d. Existing land use;
    e. Fully developed (unmitigated) land use.
5. Undertake mitigation assessment for the proposed increase in impervious areas (roofs, pavements and roads):
    a. Confirm design approach; and
    b. Assess / demonstrate effectiveness of proposed mitigation options.

6. The issue of a technical report, which outlines the above considerations, demonstrates 'Hydrologic Neutrality' and makes recommendations for the preferred stormwater concept designs.

4 Methodology

4.1 Initial Discussions

Paul Mitchell (Mitch Hydro) has been involved in the project since June 2017 including:

- Catchment walkover, survey and assessment of the site drainage, downstream Palmerston North City Council (PNCC) stormwater connection adjacent to No. 91 Benmore Avenue, and overland flow paths;
- Meeting with Jon Bell (Horizons) on 27 March 2018 to discuss the potential effects and preferred modelling approach;
- Discussions with project team, DHI and review of 2D modelling outputs; and
- Project meeting (5 November 2019) with Grant Higgins (Flygers Investment Group), Kevin Judd (Resonant CEO), Paul Thomas (Thomas Planning), Nuno Jeronimo (DHI), David Murphy (PNCC) and Veni Demado (PNCC), and Jon Bell (Horizons).

4.2 Site Visit

Paul Mitchell initially visited the site on 16 March 2018 to familiarise with the general layout. He revisited the site on 27 March 2018, with (then) KOA[1] survey staff, to walkover the catchment, and to assess / survey the network of open channel drains and their connection with the downstream PNCC stormwater main.

4.3 Existing Drainage

The approximately 39 ha site is bounded by Rangitikei Line to the north-east, Flygers Line to the north-west, and the floodway stop-bank north of Benmore Avenue properties to its south-east.

The site is located in the lower Whiskey Creek catchment. The site is currently being used for pastoral farming, with cattle herds observed in the paddocks. The ground surface is generally in good condition (Figure 1) with some erosion and pitting observed on the banks and slopes adjacent to the large, remnant open channels.

The area drains roughly east to west until it is intercepted by the remnant Whiskey Creek open channels draining to the south, which culminate at the floodway stop-bank adjacent to No. 91 Benmore Avenue, where the PNCC 900mm diameter stormwater main commences (Figure 2).

[1] Kevin O'Connor and Associates Limited

Figure 1: General condition of pasture (March 2018)

Figure 2: PNCC 900mm dia. stormwater connection adjacent to No. 91 Benmore Avenue

The entire site is affected by localised catchment flooding, but more significantly by Mangaone Stream spillway events, which spill from the Flygers Line spillway some 1.4 km upstream. The spillway was designed by the (then) Manawatū Catchment Board (now Horizons) in 1982 to reduce flooding through Palmerston North.

During Flygers Line spillway events there are multiple flow controls across site, including the two open channels (Whiskey Creek and tributary) plus sheet flow across driveways and roads etc. The February 2004 and June 2015 flood events both flooded across the Rangitikei Line / Flygers Line intersection. The spill flows drain to the Taonui Basin and downstream to the Oroua and Manawatū Rivers.

4.4 Geology

The surficial soils of the proposed site (Figure 3) are mostly Kairanga silt loam, with a small area of Te Arakura fine sandy loam, and the coarser Karapoti sandy loam (gravelly phase) in the Whiskey Creek remnant stream channel. These soils are typically poorly draining.

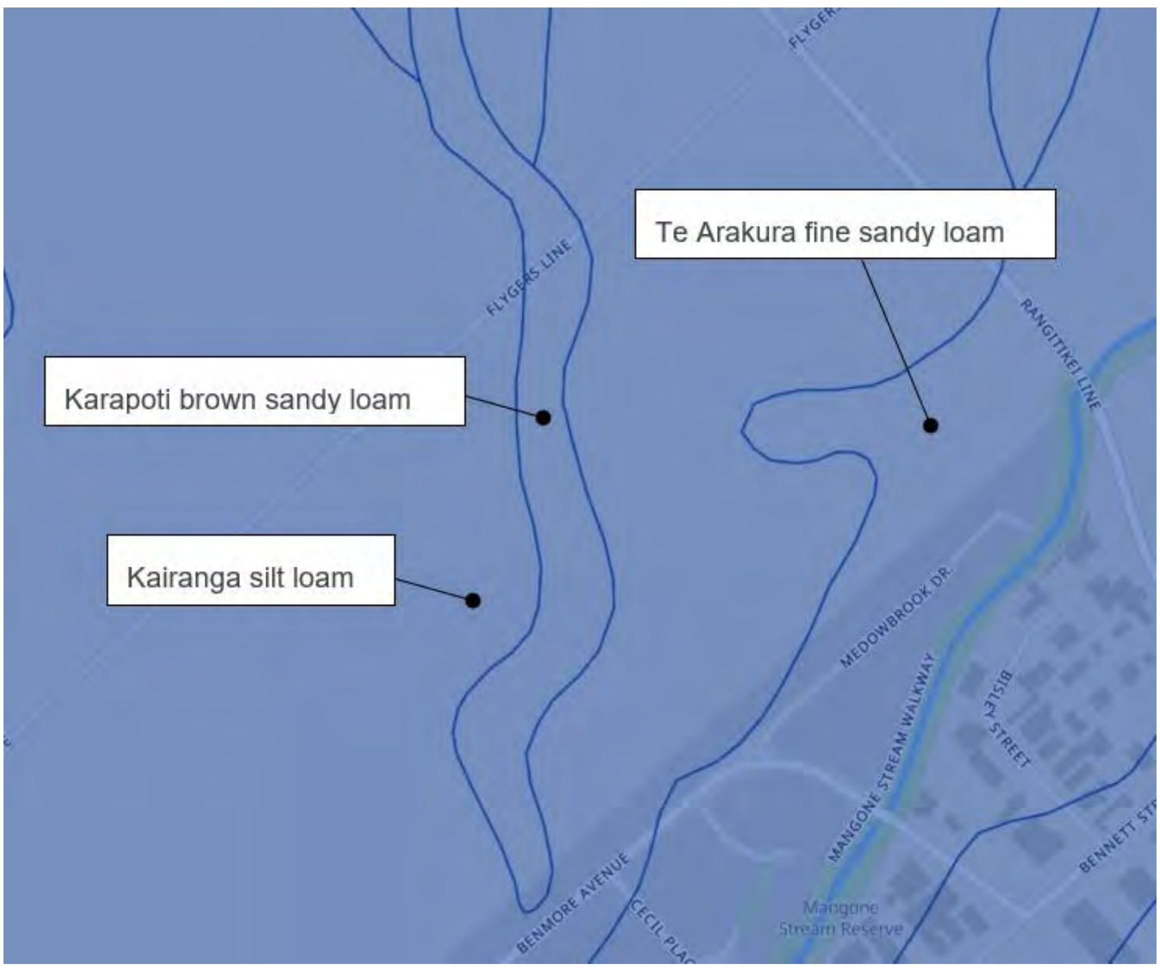


Figure 3: Surficial Soils

Applying the United States Soil Conservation Service (SCS) rainfall-runoff method, the surficial soils are categorised as ‘poorly draining’ Class C. During significant rainfalls events, the soils are high yielding in terms of runoff.

5 Rainfall – Runoff Modelling

5.1 Introduction

The United States Soil Conservation Service (SCS) method has been applied in this study. This method is commonly used in New Zealand to demonstrate the runoff characteristics of both greenfield and existing urbanised catchments. It is considered an industry standard method having been formally adopted in 1999 by the (then) Auckland Regional Council (TP 108).

The modelling applied in this study has considered the existing and fully developed scenarios as 'lumped' catchments. This is because of the preliminary nature of the design layouts and the further refinement envisaged during subsequent consenting stages. These assessments will provide a preliminary level of understanding of the effects of the proposed Plan Change on stormwater runoff and the recommended mitigation approach.

5.2 Design Rainfalls

The HIRDS V4 design rainfall depths have been applied in this study. HIRDS V4 is a generalised procedure to obtain spatially and temporally consistent depth-duration-frequency design rainfalls for any location in New Zealand, utilising data collected by NIWA and local territorial authorities.

These rainfalls have been applied in many flood assessments in the Manawatū and around New Zealand. We have also applied the RCP 6.0 (2081-2100) climate scenario to provide for climate change effects over the life of the infrastructure.

The events considered in this study are the 2-year, 5-year, 10-year, 20-year, 50-year, 100-year and 200-year Average Recurrence Interval (ARI) events. Climate adjusted design rainfalls are listed in Table 1.

Table 1: Whiskey Creek Design Rainfall (including climate to 2100)

ARI (Years)	Annual Exceedance Probability (AEP) %	HIRDS V4 (RCP 6.0) 24-hour rainfall depth (mm)
2	39	57
5	20	73
10	10	86
20	5	98
50	2	116
100	1	130
200	0.5	144

5.3 Existing Catchment Runoff

As noted above, the surficial soils are categorised as ‘poorly draining’ Class C (Table 2).

Table 2: SCS Curve numbers for Class C Soils

Land Use	Condition	Curve Number (CN)
Bush / Garden	Good	70
Pasture / Grass	Good	74
Gravel Roads	NA	82
Impervious	Roof / pavement	98

The area to be rezoned (refer plan in Appendix A) is limited to approximately 12.86 ha and comprises of Lot 1 DP 389924 (0.86 ha) with existing dwelling; and Lot 2 DP 389924 (12.0 ha) mainly in pasture. The existing scenario will address the runoff from the combined 12.86 ha site.

The 12.86 ha site drains approximately east to west until it intercepts with the Whiskey Creek open channels, which are outside of the proposed development area. The catchment is likely to be ephemeral, and is relatively flat with an approximate slope of 0.0043m/m (1 in 230) and a time of concentration of approximately 38 minutes.

The existing land use is summarised in Table 3, which indicates that the impervious and bush areas are equally small with almost the entire site in pasture and a weighted curve number of CN 74.0. A simplified HEC-HMS model for the existing catchment is shown in Figure 4.

Table 3: Existing Catchment Characteristics

Curve Number						Slope (m/m)	Tc (minutes)	Initial Losses
Area (ha)					Weighted CN			
Roof / paved (CN 98)	Metal Driveway (CN 82)	Pasture / Grass (CN 74)	Bush / Garden (CN 70)	Total Site				
0.063	0.096	12.101	0.600	12.86	74.0	0.0043	38	5.0

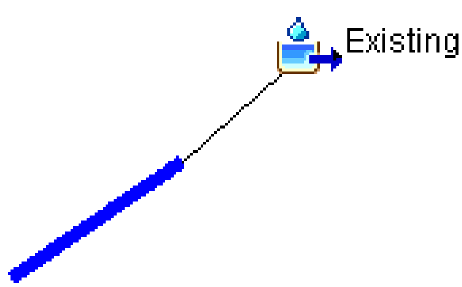


Figure 4: HEC-HMS Existing Model

5.4 Fully Developed Catchment

5.4.1 Plan Layout

The fully developed (Resonant) layout is included in Appendix B. There are some minor differences between the modelled layout in Appendix B and the McIndoe Urban 'Indicative Masterplan' layout (refer Figure 5 below).

Both layouts are indicative (only) and indicate similar land uses, number of lots and implied imperviousness. For the purposes of the modelling, we have assumed that the stormwater conveyance for the development would be by kerb and channel, and by reticulated stormwater pipe.

The location, sizing and hydraulic connectivity of the stormwater network will be confirmed during subsequent consenting stages.

Figure 5: McIndoe Urban Indicative Masterplan (Figure 21, 2021)

5.4.2 Land Use Assumptions

The indicative layout (Appendix B) includes approximately 170 lots ranging in size from 171m² to 1050m². The predominant lot size is at or about 450m², which also coincides as the average lot size. The following assumptions[2] with regard to site coverage have been applied in the stormwater modelling:

- Maximum impervious (building) area:
  - 40% for lot areas <500m²;
  - 200m² on sites 500-572m²;
  - 35% for lot areas >572m²; and
- Maximum total imperviousness per lot (average 65%):
  - Lot size 171m² to 366m² 75%
  - Lot size 367m² to 449m² 70%
  - Lot size 450m² to 561m² 65%
  - Lot size 562m² to 1050m² 60%
- Grass minimum 15%; and
- Garden / trees minimum 10%.

The south-western extent of the development site (approx. 7000m²) has been assessed as a reserve and suitable for stormwater flood detention. The remainder of the site, includes approximately 162 lots as indicated in Table 4. The land use for the fully developed catchment of 12.86 ha is detailed in Table 5, which indicates an increase in the weighted curve number as a result of the development from CN 74.0 to CN 87.1.

The time of concentration also reduces slightly from approximately 38 minutes (existing) to 33 minutes (fully developed). We have assumed a curve number of CN 90 for the detention area, which may also contain commercial areas, roads and other lots depending on the final area requirements of the flood detention pond.

Table 4: Lot Numbers and Sizes

Lot Size (m²)	Number	Area m²						Total impervious %
		Gross	Roof	Paving	Grass	Garden / Trees	Total / Weighted	
171-366	20	4023	1609	1408	603	402	4023	75%
450-491	117	52909	21164	13227	13227	5291	52909	65%
526-561	8	4366	1600	1238	1092	437	4366	65%
576-650	13	7955	2784	1989	2387	796	7955	60%
770-1050	4	3722	1303	931	1117	372	3722	60%
Total	**162**	**72975**	**28460**	**18792**	**18425**	**7298**	**72975**	**65%**
Curve Number			**98**	**98**	**74**	**70**	**89.1**	**NA**

[2] Refer PNCC District Plan Section 10 (May 2018), Residential Zone - Permitted Activities 10.6.1 (d) ii Site Coverage

Table 5: Fully Developed Catchment Characteristics

Land Use	Area m²	Area ha	CN
Road / footpath	21600	2.160	98.0
Lots	72975	7.298	89.1
Road berms	14025	1.403	74.0
Park / Reserve	13000	1.300	70.0
Flood detention area	7000	0.700	90.0
Total	**128600**	**12.86**	**87.1**

A simplified (lumped) HEC-HMS model for the fully developed catchment is shown in Figure 6.

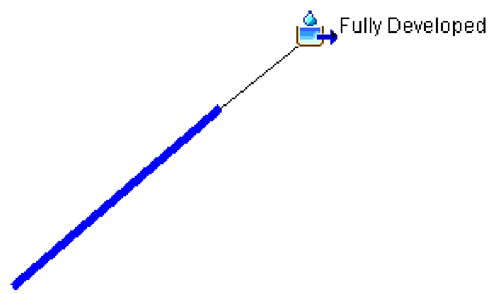


Figure 6: HEC-HMS Fully Developed Model

6 Stormwater Mitigation

6.1 Stormwater Quantity

6.1.1 Flood Scenarios

Runoff from the existing 12.86 ha site currently drains to the remnant Whiskey Creek catchment and downstream to the existing PNCC 900mm diameter stormwater connection adjacent to No. 91 Benmore Avenue. This situation will remain unchanged as a result of the proposed Plan Change. The two flood scenarios for assessment include:

1. Local storm events affecting the Palmerston North stormwater catchment; and
2. Mangaone Stream flooding when the Flygers Line spillway operates and spills water across Rangitikei Line / Flygers Line to Whiskey Creek and the downstream Taonui Basin.

Stormwater mitigation for the two scenarios is outlined in the following sections.

6.1.2 Secondary Flow Paths

The Stormwater Mitigation plan (Appendix C) provides an indicative pipe layout and probable secondary flow paths. It is proposed that any secondary flow would be contained within the roading corridor. The frequency and magnitude of secondary flow would be determined when the stormwater piped network is confirmed during subsequent consenting stages.

6.1.3 Flood Detention Pond

The performance of the proposed flood detention pond has been assessed within 'XPSTORM'. XPSTORM is a comprehensive 1D-2D modelling software package which includes both open channel and closed conduit systems. It is ideal for optimising the design of stormwater piped systems including flood detention storages. The XPSTORM model of the fully developed ‘mitigated’ catchment is shown in Figure 7.

The flood modelling assumes that all runoff from the development is routed through the pond. The pond is provisionally proposed as 1.5m deep[3], 90m long by 50m wide with minimum 3:1 embankment batters. The total area of the pond (including a 3m wide buffer zone) is estimated to be in the order of 5000m². Further details are included in Table 6. The provisional level-area curve for the pond is plotted in Figure 8 and listed in Table 9 of Appendix C.

[3] Subject to confirmation of local groundwater levels

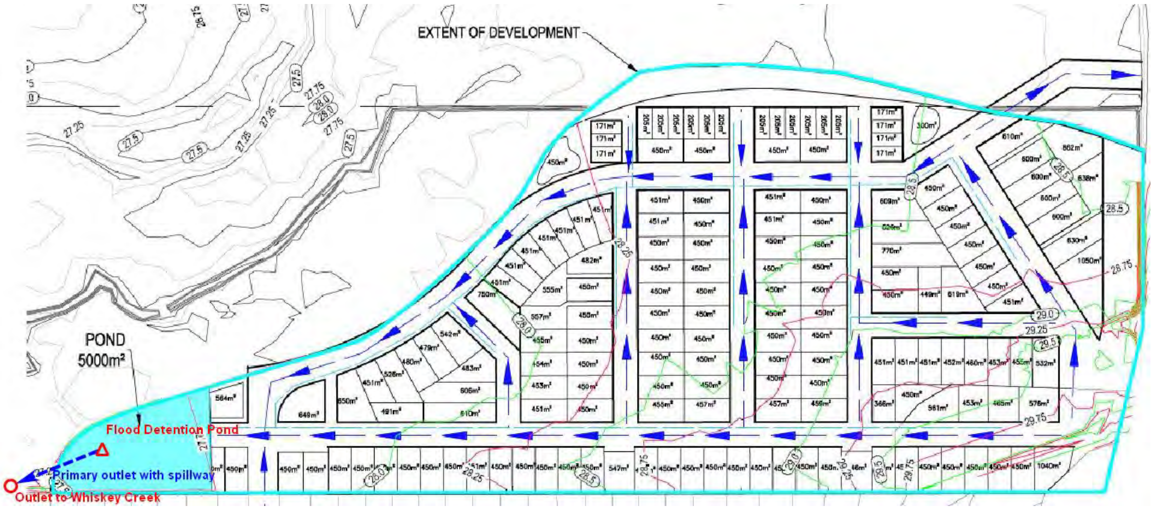


Figure 7: Fully Developed XPSTORM 'Mitigated' catchment model

Table 6: Whiskey Creek Flood Detention Pond (PROVISIONAL)

Variable	Dimension
Pond dimensions	90m long x 50m wide
Pond base level	RL 26.25m
Embankment crest level at outlet	RL 27.75m
Approximate storage volume at spillway crest level	3700m³
Embankment batters	Minimum 3:1
Culvert outlet diameter	300mm
Culvert outlet invert level	RL 26.25m
Culvert outlet invert to convey to Whiskey Creek	RL 26.20m
Whiskey Creek invert level at property boundary (approx. 100m downstream)	RL 25.0m
Spillway (2.5m wide broad-crested weir)	Crest Level 27.25m
	Operates in 50-year ARI and greater events
	Passes the 100-year ARI event at RL 27.45m (0.30m freeboard to embankment crest)
	Passes the 200-year ARI event with 0.23m freeboard to crest level

It is proposed that the outlet would discharge into the reserve and drain via an open channel swale, or similar, over a distance of approximately 100m downstream to the remnant Whiskey Creek channel (approx. invert RL 25.0m) immediately upstream of the south-western property boundary. The PNCC 900mm diameter stormwater connection is a further approximate 110m downstream with its invert at approx. RL 24.2m.

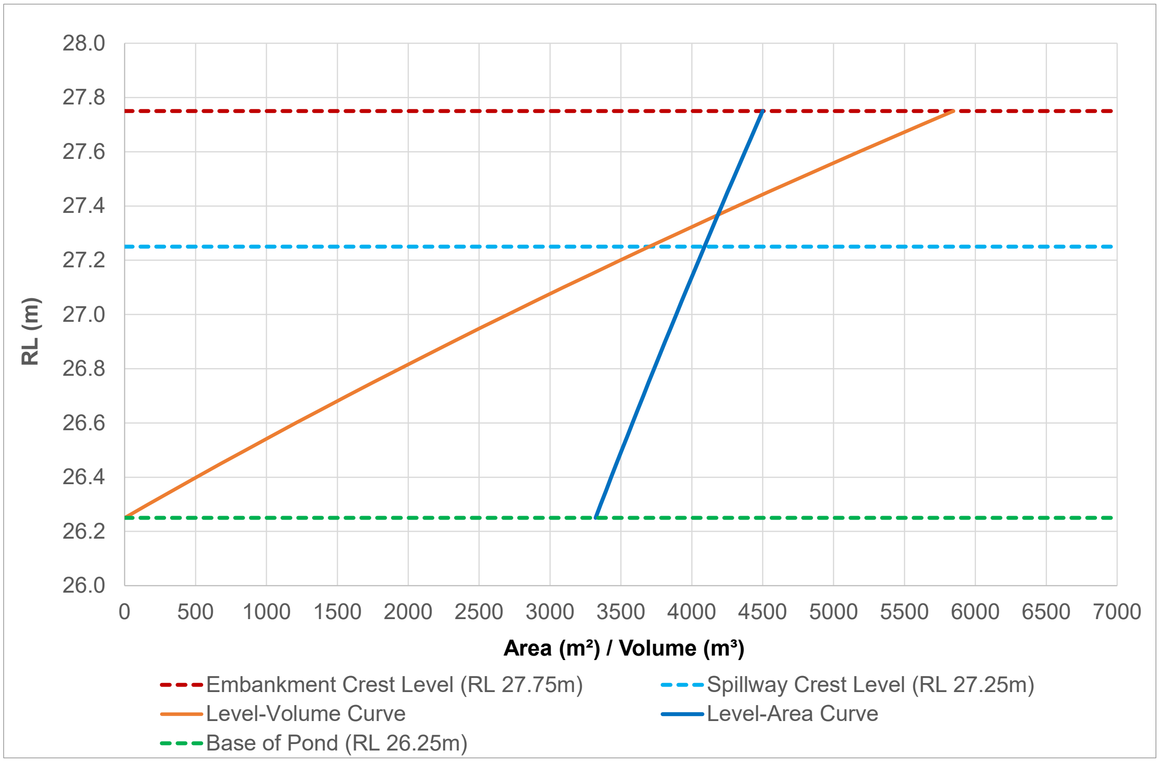


Figure 8: Whiskey Creek Flood Detention Pond – Level-Area-Volume Curve (PROVISIONAL)

Summary model outputs are included in Table 7, which indicate reductions in the peak discharges in all events up to the 100-year ARI event. Spill flow commences in the 50-year ARI event; and the dam does not overtop in the 200-year ARI event. Further refinement of the pond design and performance would be undertaken during the consenting stage. The flood runoff volumes are included in Table 8, which indicates an increased runoff volume of approximately 3400m³ in the 100-year ARI (1% AEP) event.

Flood hydrographs (2-yr ARI to 200-year ARI) are plotted in Figure 9 to Figure 15, and pond levels in Figure 16.

Table 7: XPSTORM Flood Mitigation Model Results

Event (ARI, years)	Peak Flow (m³/s)					Pond Level (RL, m)	Freeboard (m)
	Existing	Fully Developed (Unmitigated)	Pond Outflow				
			Culvert Flow	Spill Flow	Total Outflow		
2	0.15	0.37	0.13	0.00	0.13	26.67	1.08
5	0.24	0.54	0.16	0.00	0.16	26.89	0.86
10	0.31	0.66	0.18	0.00	0.18	27.06	0.69
20	0.39	0.80	0.20	0.00	0.20	27.24	0.51
50	0.51	0.99	0.21	0.19	0.40	27.37	0.38
100	0.61	1.1	0.22	0.38	0.60	27.45	0.30
200	0.71	1.3	0.23	0.61	0.84	27.52	0.23

Table 8: 24-hour Design Flood Runoff Volume

Event (ARI, years)	Runoff Volume (m³)		
	Existing	Fully Developed (Unmitigated)	Increase
2	2324	4033	1709
5	3663	5848	2185
10	4762	7270	2508
20	5934	8729	2795
50	7646	10793	3147
100	9107	12512	3406
200	10580	14210	3630

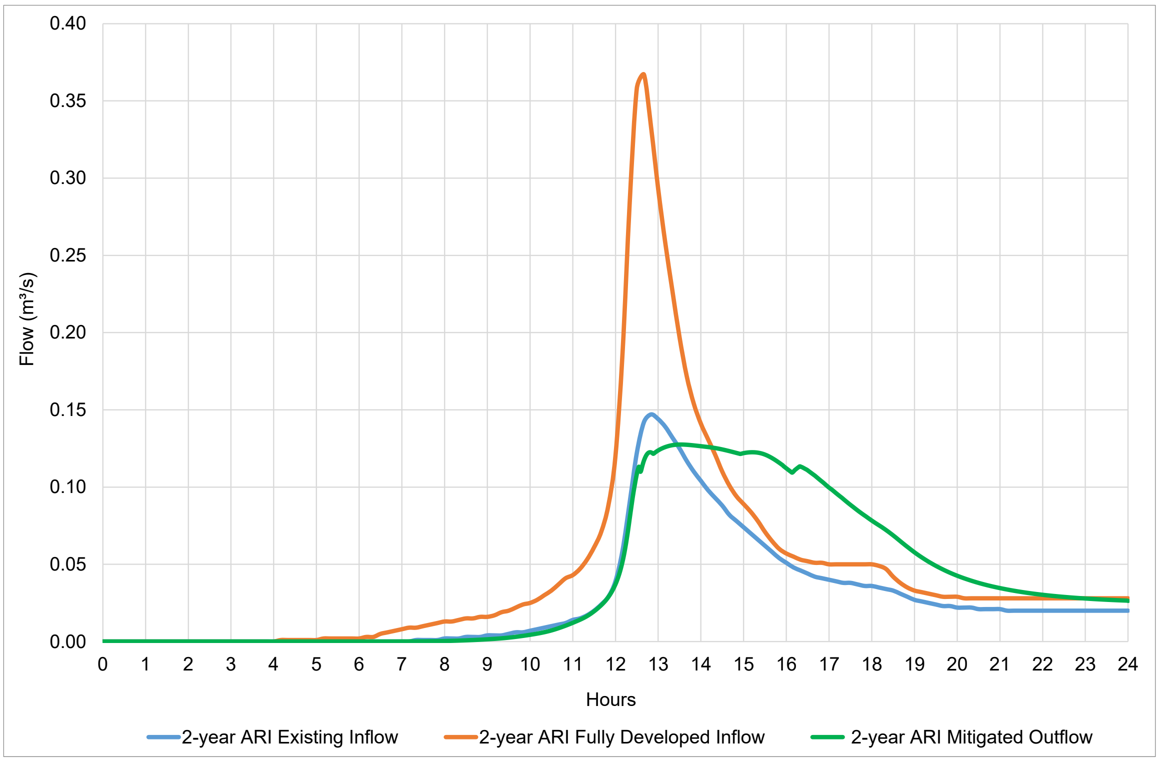


Figure 9: 2-year ARI Peak Discharges

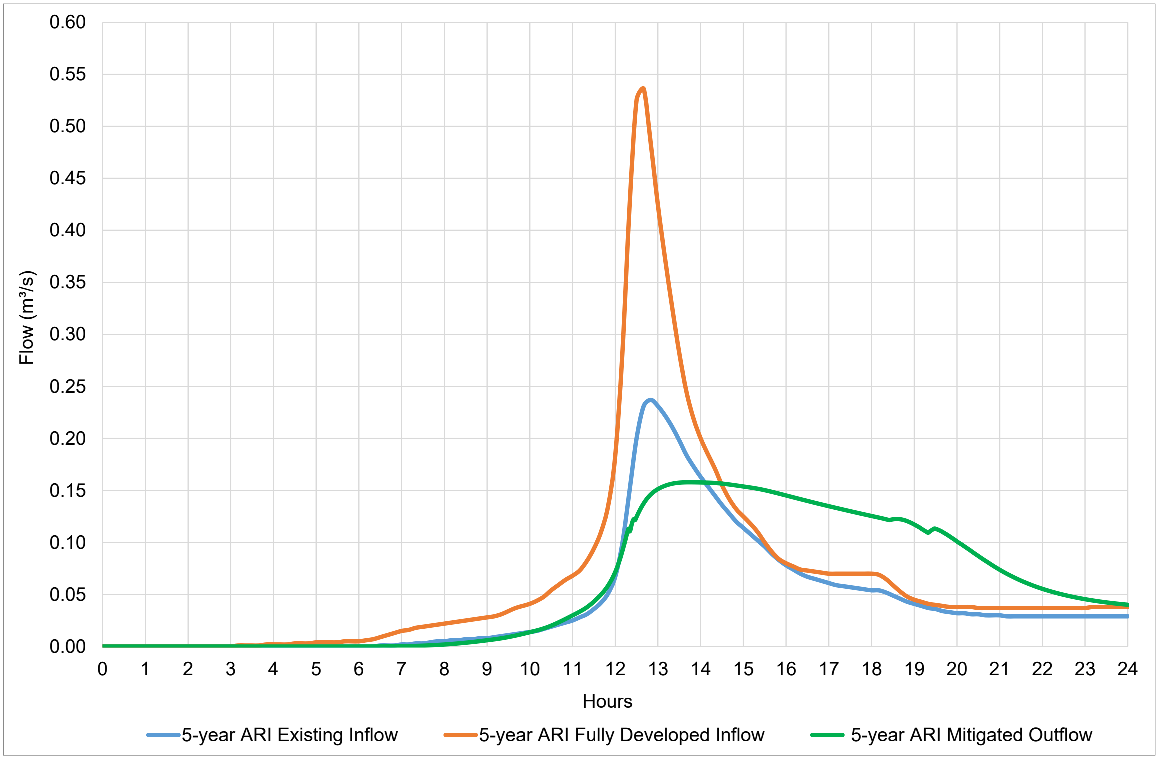


Figure 10: 5-year ARI Peak Discharges

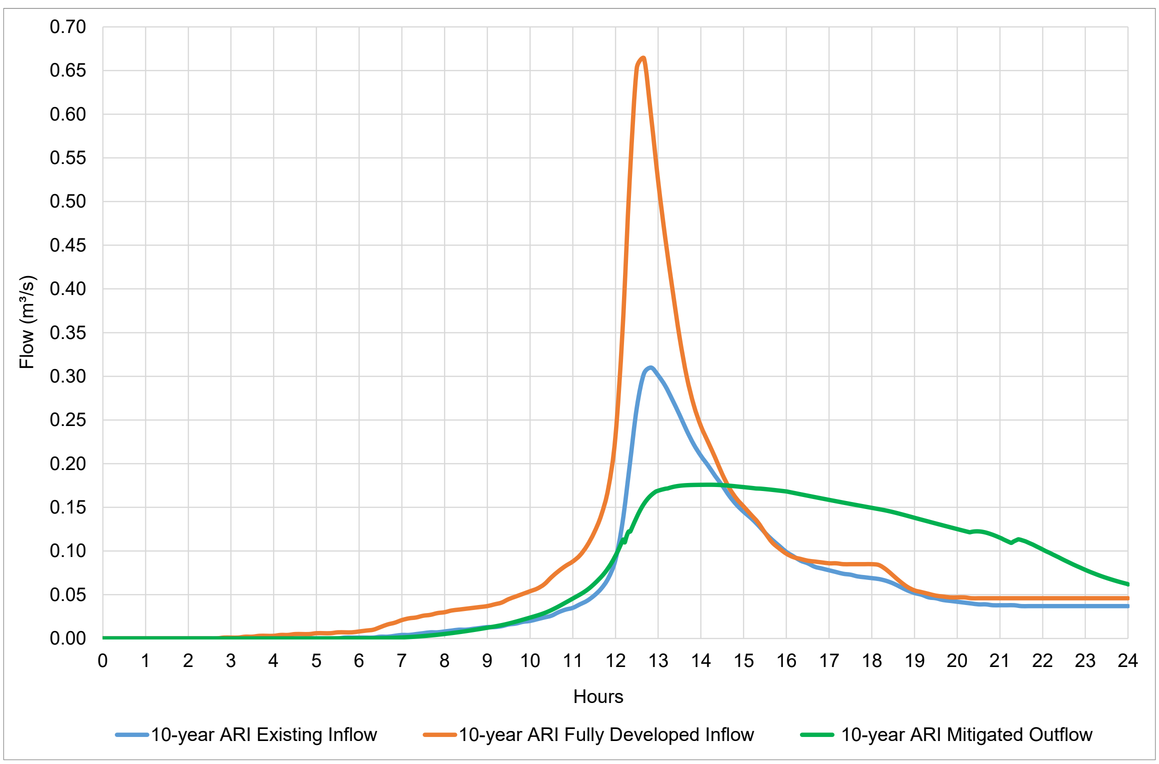


Figure 11: 10-year ARI Peak Discharges

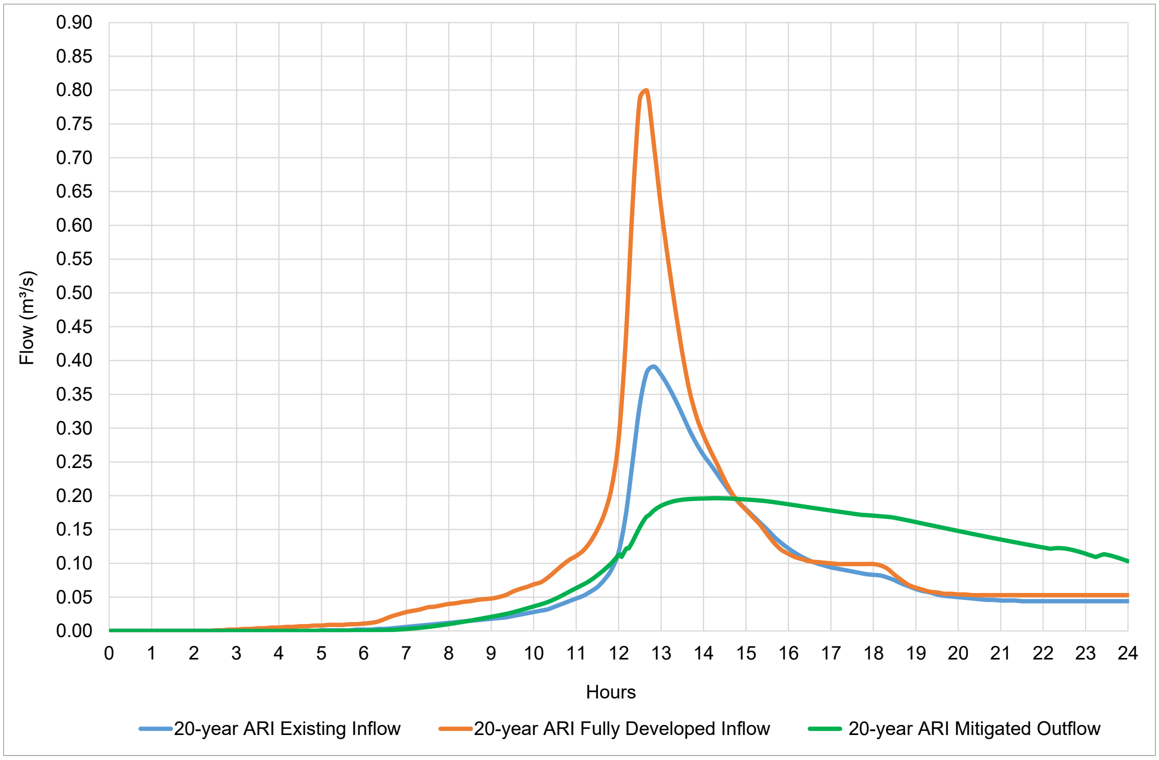


Figure 12: 20-year ARI Peak Discharges

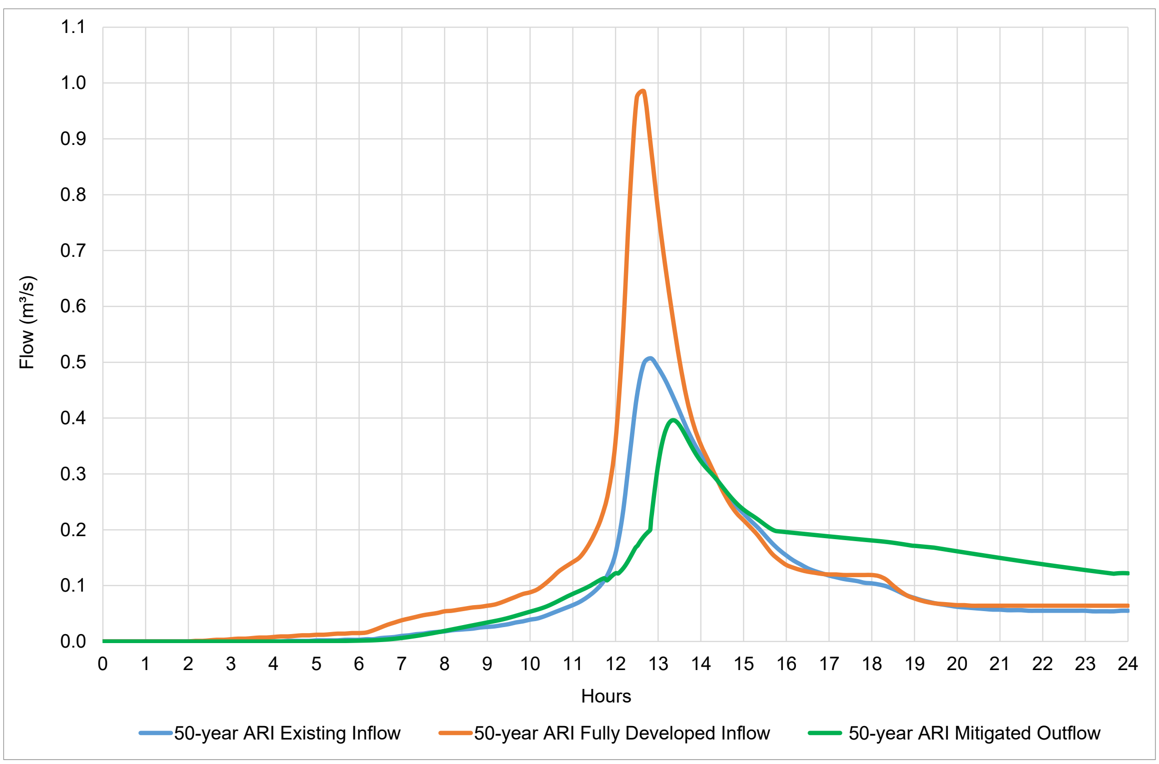


Figure 13: 50-year ARI Peak Discharges

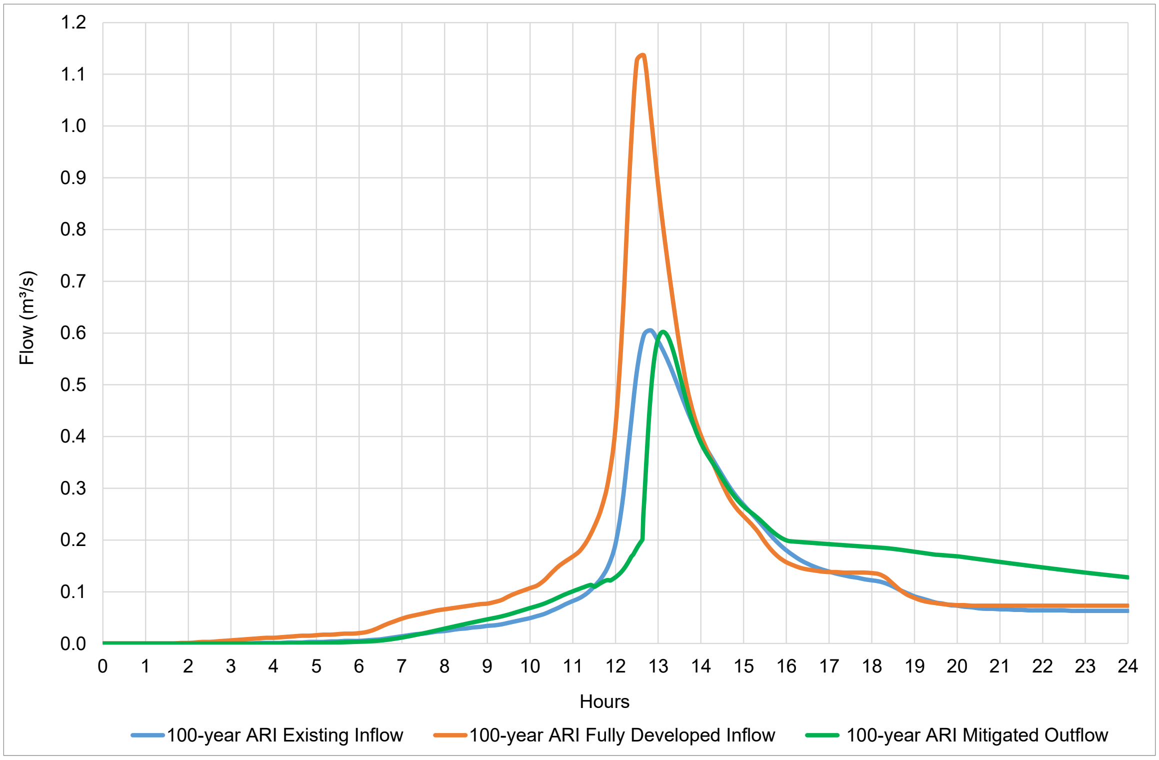


Figure 14: 100-year ARI Peak Discharges

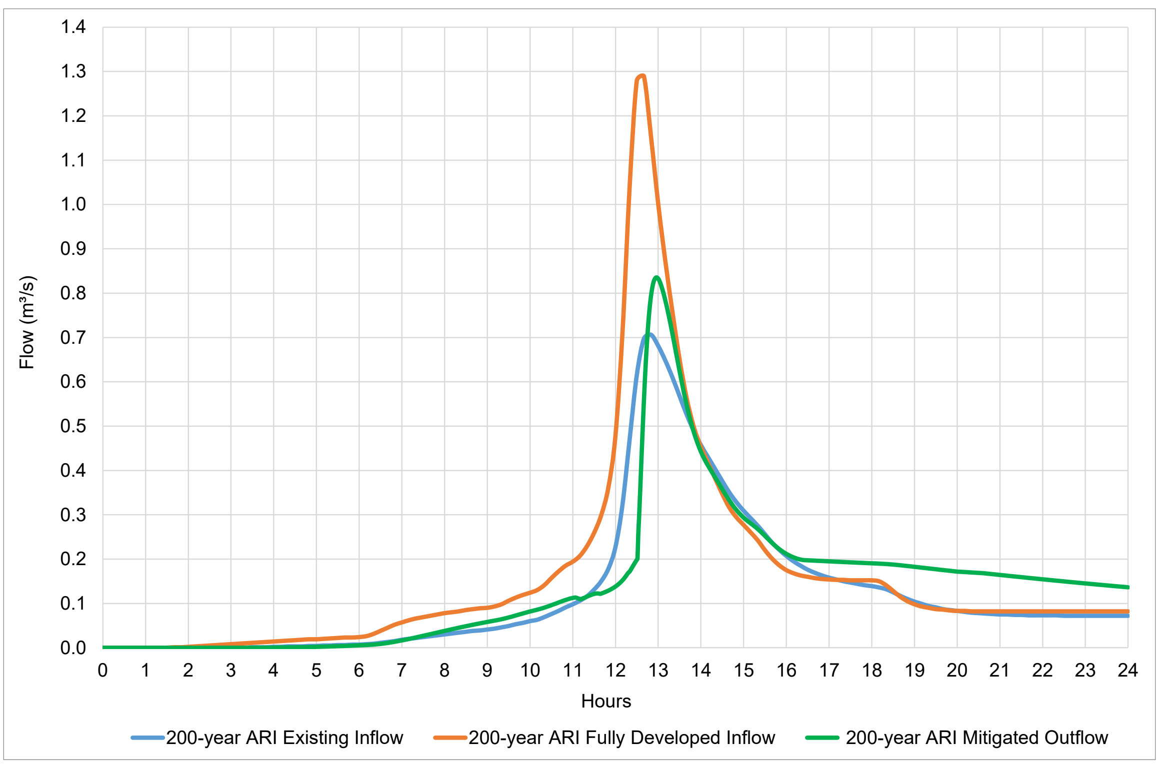


Figure 15: 200-year ARI Peak Discharges

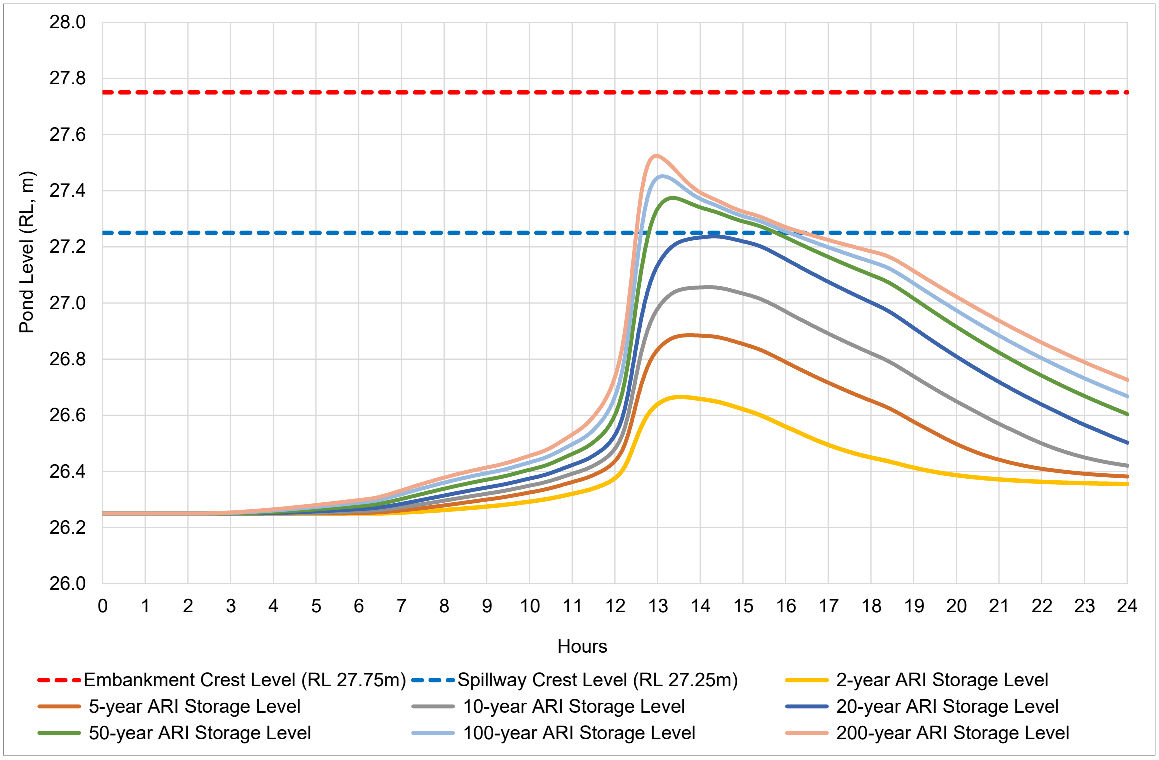


Figure 16: Flood Detention Pond – Design Flood Levels

6.1.4 Other Mitigation Options

Stormwater quantity mitigation options that would reduce the size of the proposed flood detention pond would include source controls, such as reduced imperviousness per lot, roof-water tanks and / or underground detention storages.

The average roof area for the development (refer Table 4) is approximately 176m². Allowing 1800 litres per 100m of roof area indicates a total storage of just over 500m³, which would reduce the required pond storage volume by approximately 14%.

Additional controls to reduce the total imperviousness (currently assessed as an average of 65% per lot) would also have a beneficial effect on reducing the detention pond footprint.

Underground flood detention storages (e.g. Cirtex or similar) could also be considered for discrete residential and / or commercial areas within the development.

These options will be considered in more detail at the subdivision consent stage with a view to introducing stormwater to the reserve at the northern end of the development to enhance stream revitalisation.

6.2 Stormwater Quality

Stormwater quality treatment could be achieved for the development by way of:

- A constructed wetland; or
- Rain gardens in the road berms.

We emphasise that the constructed wetland option is an alternative to, and not in addition to, the rain gardens.

The Structure Plan also identifies an additional location at the intersection of Roads 1 and 4 as back-up area for stormwater detention / treatment i.e. in the event that it is required.

6.2.1 Constructed Wetland

A constructed wetland[4] could be developed downstream of the proposed flood detention pond in the remnant Whiskey Creek channel prior to discharging to the PNCC stormwater connection at Benmore Avenue. The earthworks associated with the wetland would need to be sympathetic to the impact on flood levels in the floodway.

6.2.2 Rain Gardens

Rain gardens / bioretention devices in the road berms could be applied to provide stormwater quality treatment of discrete residential and / or commercial areas or as a catchment-wide solution for the entire development.

These 'source controls' would provide stormwater quality treatment of the runoff from the road and lot paved surface areas prior to discharging to the piped stormwater system. Direct connection of roof water from all lots to the stormwater mains in the road would reduce the size requirements of the rain gardens.

Auckland Council GD01 (2017) provides guidance on the sizing of bioretention devices for water quality ‘treatment only’. Applying this standard, the bioretention devices are typically sized at 2% of the impervious paved (road and driveway) catchment area. Individual device locations, size and media layers would be confirmed during the consenting phase when the stormwater network design is known.

6.3 Hydraulic Connectivity

The hydraulic connectivity of the rain gardens with the stormwater network, flood detention pond and possible constructed wetland would be proven during subsequent consenting stages.

[4] Consistent with Wellington Water (2019)

7 Flygers Line Spillway Events

The Mangaone Stream 'Flygers Line' spillway (refer Horizons extract in Appendix D) has been designed to commence operation when flow at the Milson Line flow gauge reaches 124m³/s (4.4m). Horizons has categorised this flow as a 10% AEP (10-year ARI) event.

The spillway was originally (1982) designed to spill up to 68m³/s in the 1% AEP (100-year ARI) event, however, following the significant February 2004 flood event this was revised upwards to 113m³/s.

The spillway has operated four times since it was constructed in 1984/1985 (~35 years):

1. 25 August 1986 (operated prematurely due to lupin growth in the downstream channel artificially raising water levels at the weir);
2. 24 July 1988;
3. 16 February 2004; and
4. 20-21 June 2015.

Discounting the August 1986 event, the spillway would normally have operated three times in approximately 35 years i.e. slightly less frequently than the intended '1 in 10 year' design criteria.

To consider the relative timing of the Mangaone Stream at Milson Line (Site 32557, 154 km²) catchment and Flygers Line spillway operation i.e. relative to the much smaller Plan Change catchment (0.13 km²), we have assessed the most recent i.e. February 2004 and June 2015 spillway events. Rainfall and flow data are provided by Horizons.

7.1 16 February 2004 Flood

The 16 February 2004 flood event (Figure 17) was a long-duration storm in the Mangaone Stream catchment. Approximately 20mm of (antecedent) rainfall fell between late afternoon on 11 February and the morning of 14 February. The most intense rainfall commenced around 9.00pm on 14 February; and ended shortly after 3.30am on 16 February. A total of approximately 135mm of rainfall was recorded at the Valley Road gauge over the approximate 31-hour storm duration.

While the magnitude of rainfall varies between the Valley Road and Milson Line rain gauges, the temporal pattern appears to be very similar.

The Mangaone Stream started to rise from a low flow of approximately 0.5m³/s at 11am on 15 February; and peaked nearly 20 hours later at around 190m³/s just prior to 7am on 16 February.

The data indicate that the Flygers Line spillway would have operated over an approximate 10-hour period i.e. commencing around 2.45am on 16 February (flow exceeded 124m³/s at the Milson Line gauge) and ceasing about 1pm later that day (flow reduced below 100m³/s).

The total spilled volume during this approximate 1% AEP flood event is estimated at approximately 1.5 Mm³ i.e. assuming that the spillway commenced spilling at 124m³/s (at the Milson Line gauge), the downstream Mangaone Stream channel passed approximately 140m³/s at the peak (as noted in Appendix D), and the spillway ceased to spill at approximately 100m³/s (at the Milson Line gauge).

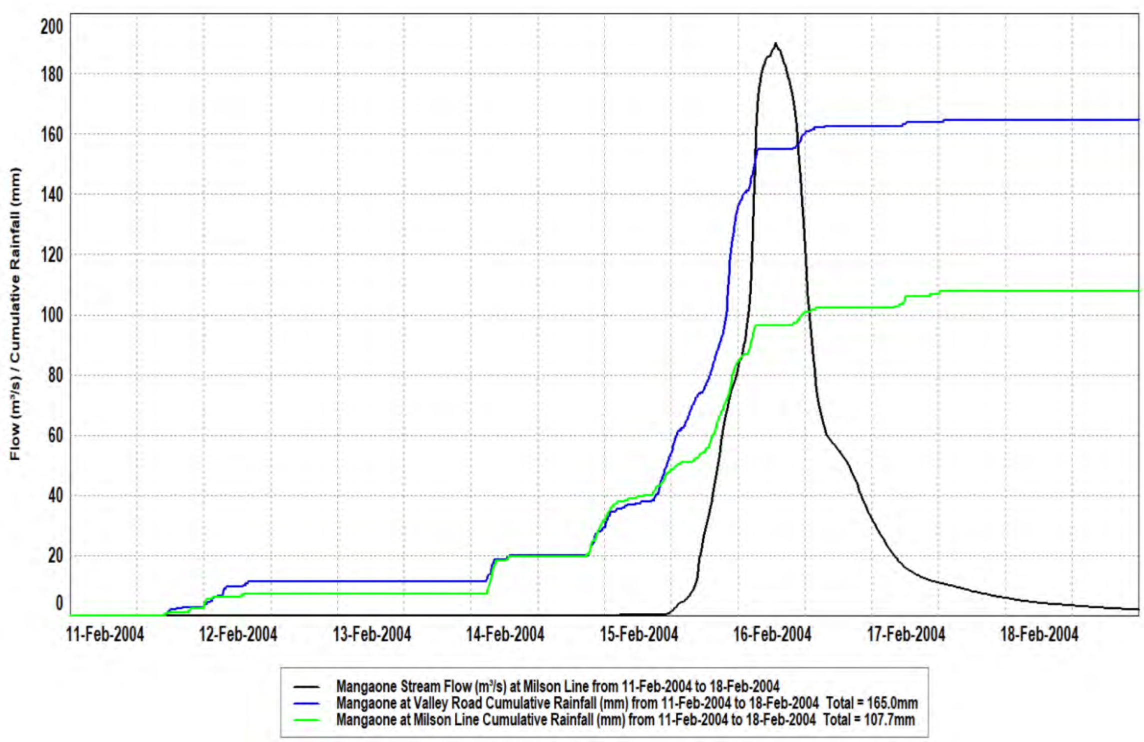


Figure 17: Mangaone Stream Flood (16 February 2004)

7.2 20-21 June 2015 Flood

The 20-21 June 2015 flood event (Figure 18) was also a long-duration storm in the Mangaone Stream catchment. The rainfall event commenced shortly before 9.00am on 19 June and ended shortly before midnight on 20 June. A total of approximately 138mm of rainfall was recorded at the Valley Road gauge over the approximate 39-hour storm duration.

The Mangaone Stream started to rise from a low flow of approximately 0.5m³/s around 11am on 19 June; with an initial peak of approximately 152.8m³/s occurring at 2.45pm on 20 June (approx. 28 hours later), and a subsequent, slightly greater peak of 153.4m³/s occurring at 2.45am on 21 June i.e. some 40 hours after the storm commenced.

The data indicate that the Flygers Line spillway would have operated over an approximate 20-hour period i.e. commencing around 11am on 20 June (flow exceeded 124m³/s at the Milson Line gauge) and ceasing about 7am on 21 June (flow reduced below 100m³/s).

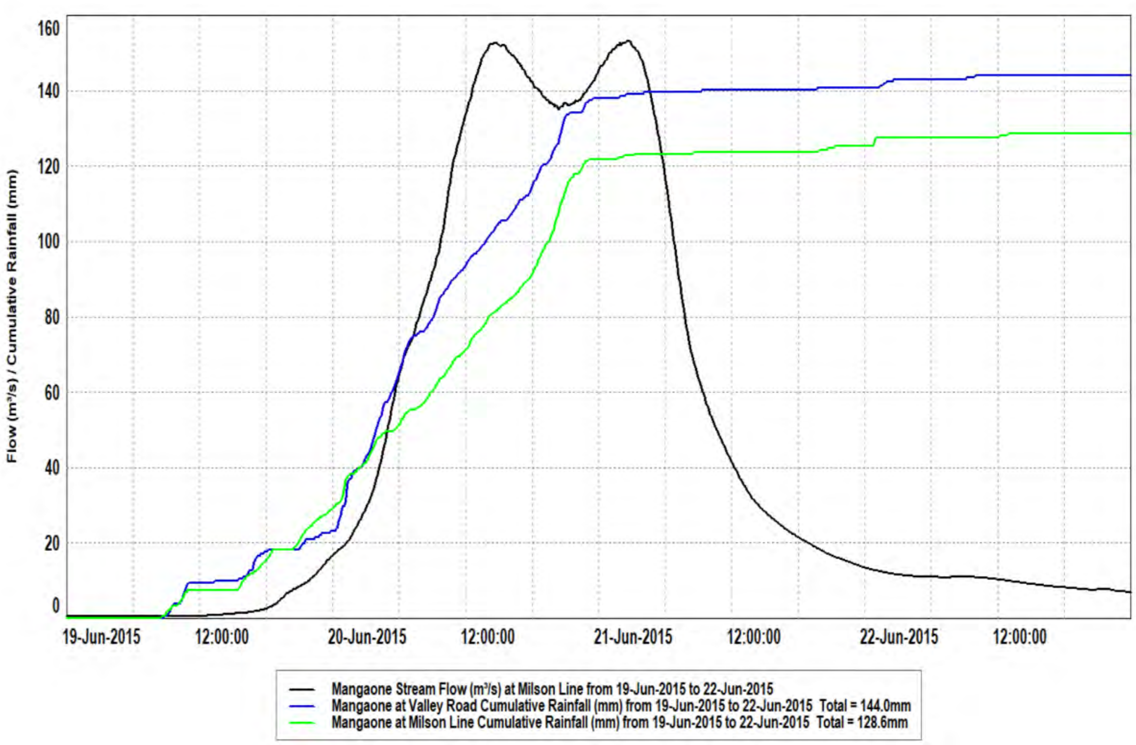


Figure 18: Mangaone Stream Flood (20-21 June 2015)

7.3 Design Considerations

The above data confirm that:

- The Flygers Line spillway has:
  - A 10% probability of operating every year; and has
  - Operated three times over the last 35 years.
- There are no major differences in the timing of rainfall as observed in the upper Mangaone catchment (at Valley Road) and in the lower Palmerston North city catchment (at Milson Line).
- During a 10% AEP (or lesser probability) flood event the:
  - Mangaone Stream catchment[5] (154 km²) has a time of concentration in the order of 30-40 hours.
  - Much smaller fully developed Plan Change catchment (0.13 km²) has a time of concentration of approximately 33 minutes.
- The total increased runoff volume in the 1% AEP event (as a result of the proposed Plan Change) of approximately 3400m³ (refer Table 8) is in the order of 0.2% of the total spilled volume down the Flygers Line spillway (1.5 Mm³) during the February 2004 event.
- The mitigated peak outflows from the proposed Flygers flood detention pond

[5] Measured at Milson Line (Site 32557)

would be very unlikely to coincide with the peak discharge from the Flygers Line spillway.

- The design of the proposed flood detention pond should consider the probable tailwater effect of flood levels in Whiskey Creek during Flygers Line (10% AEP and lesser probability) spillway events.

8 Conclusions

We conclude that:

1. The relatively small 0.13 km² fully developed catchment:
   a. Is likely to be ephemeral and would not provide a permanent flow.
   b. Would provide intermittent, limited duration, discharges during most rainfall events.
2. Stormwater effects as a result of the proposed 12.86 ha, mainly residential, development could be mitigated as follows:
   a. Stormwater Quantity:
      i. An approximate 1.5m deep, 90m long by 50m wide flood detention pond with 3:1 battered slopes, with a 300mm diameter primary outlet providing approximately 3700m³ of storage at the spillway crest level;
      ii. Source controls including roof-water tanks, underground storages and / or reduced imperviousness to reduce the size of the flood detention pond.
   b. Stormwater Quality:
      i. A constructed wetland downstream of the flood detention pond in the remnant Whiskey Creek channel; or
      ii. Rain gardens in the road berms.
3. The proposed flood detention pond provides hydraulic neutrality with reductions in the peak discharges (relative to the existing) in all events up to the 100-year ARI (1% AEP) event.
4. The Flygers Line spillway has:
   a. A 10% probability of operating every year; and has
   b. Operated three times over the last 35 years.
5. During a 10% AEP (or lesser probability) flood event the:
   a. Mangaone Stream catchment[6] (154 km²) has a time of concentration in the order of 30-40 hours.
   b. Much smaller, fully developed Whiskey Creek Plan Change catchment (0.13 km²) has a time of concentration of approximately 30-40 minutes.

[6] Measured at Milson Line (Site 32557)

6. The mitigated peak outflows from the proposed flood detention pond would be unlikely to coincide with the peak discharge from the Flygers Line spillway to the Taonui Basin.
7. The increased runoff volume in the 1% AEP event as a result of the Plan Change is also minimal i.e. in the order of 0.2% of the total spilled volume down the Flygers Line spillway during the February 2004 (approx. 1% AEP) event.
8. The design of the proposed flood detention pond should consider the probable tailwater effect of flood levels in Whiskey Creek during Flygers Line (10% AEP and lesser probability) spillway events.
9. Further refinement of the stormwater network including the rain gardens, flow conveyance, secondary flow paths, flood detention pond and possible constructed wetland is recommended during subsequent consenting stages.

9 Limitation

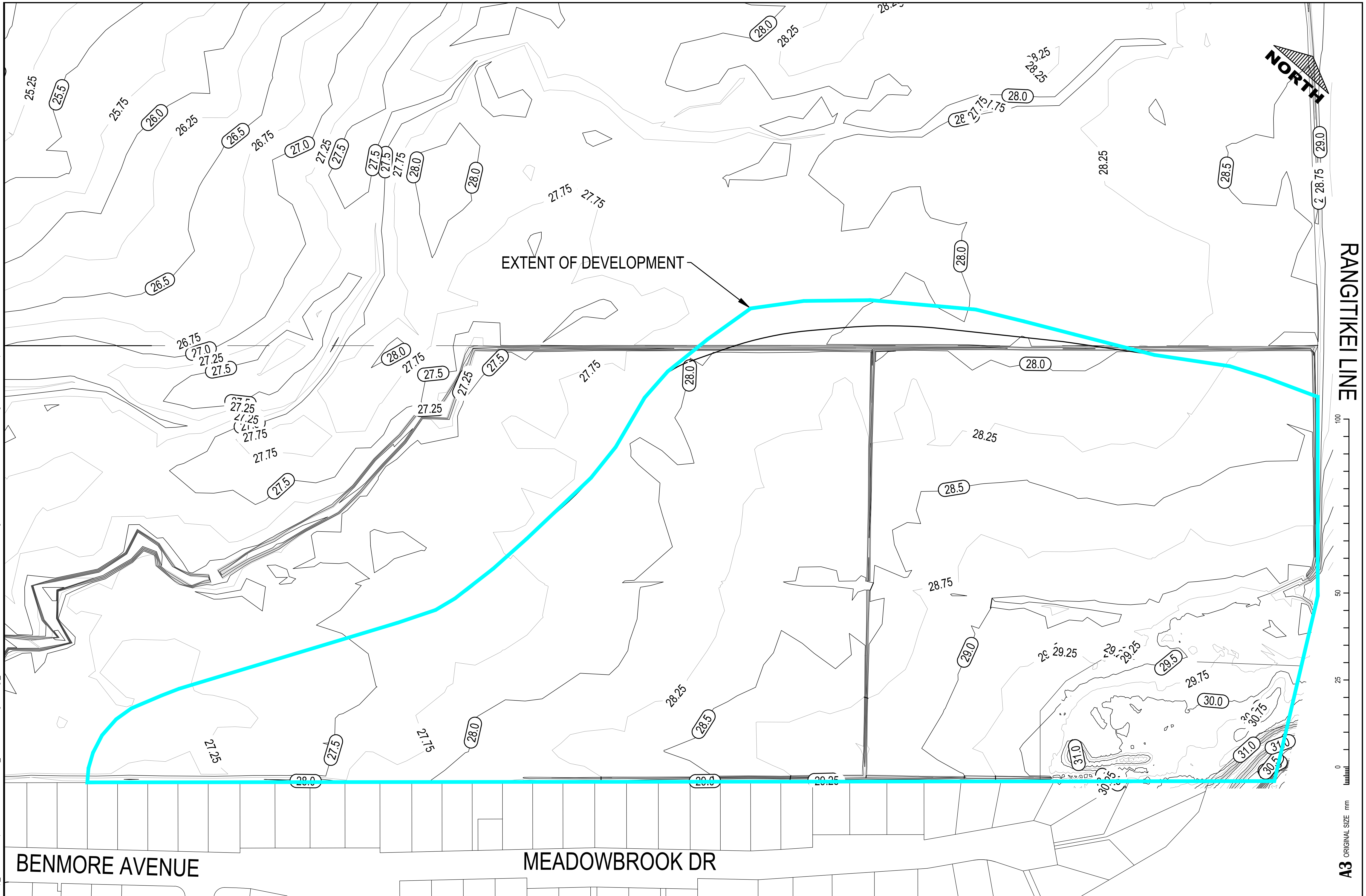
This report has been prepared solely for the benefit of Flygers Investment Group Limited as our client with respect to the brief. The reliance by other parties on the information or opinions contained in this report shall, without our prior review and agreement in writing, be at such parties' sole risk.

The opinions, conclusions and recommendations in this report are based on our interpretation of the available data. Should further information become available then these should be reviewed.

10 References

ARC TP108, 1999	'Guidelines for stormwater runoff modelling in the Auckland Region, Technical Publication 108. Prepared for Auckland Regional Council by Beca Carter Hollings and Ferner Limited, April 1999.'
Auckland Council (GD01), 2017	'Stormwater Management Devices in the Auckland Region, Guideline Document 2017/001 Version 1, December 2017.'
Wellington Water, 2019	'Water Sensitive Design for Stormwater: Treatment Device Design Guideline, Wellington Water, Version 1.1, December 2019.'

Appendix A Existing Layout



J:\200\214\214115 Higgins Group_Urban Development-Palmerston North_CJF\04 Civil Engineering_214115 FLYGERS PROJECT\Production Drawings\SWMP\214115 SW Catchments.dwg 8/17/2020 4:58 p.m.

Rev	Details	Drawn	Date
1	ISSUED FOR DISCUSSION		17/08/20

resonant
MULTI-DISCIPLINARY ENGINEERING & SURVEYING SERVICES
Bringing places & spaces to life

The Contractor shall check all dimensions on site.

71 Pitt Street, PO Box 600 Palmerston North
06 356 7000 info@resonant.co.nz
www.resonant.co.nz

STORMWATER CATCHMENTS
RANGITIKEI LINE - FLYGERS LINE
PALMERSTON NORTH
EXISTING CONTOURS

HIGGINS GROUP

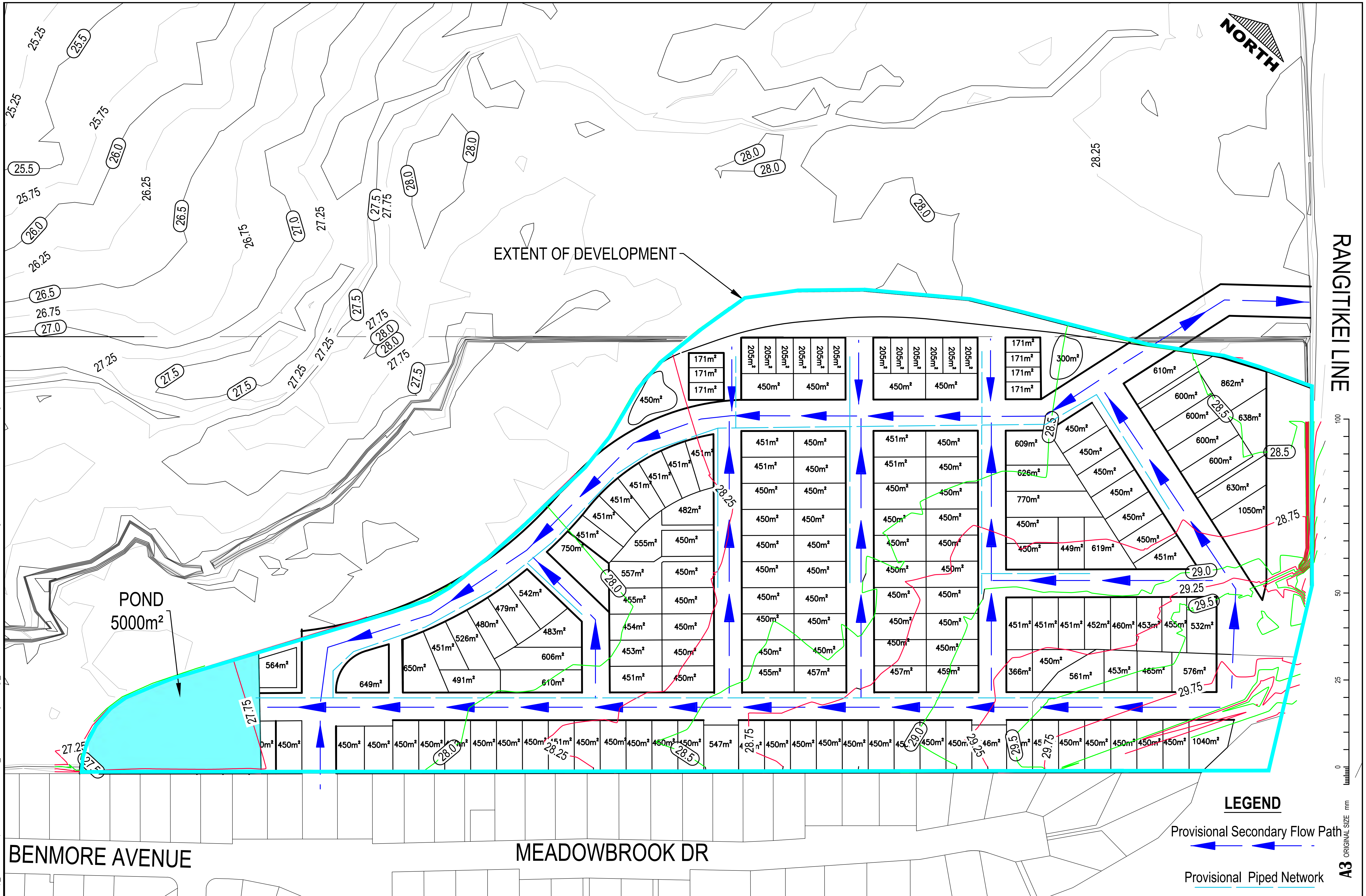
	Initials	Date
Surveyed	RSJP	04/19
Designed	KBJ	08/20
Drawn	JGR	08/20
Checked		
Approved		

DO NOT SCALE, If in doubt ask for dimensions

Scales A3	Job No.
1:2000	214115

CAD Path/File	Sheet	of	Sheets	Rev.
214115 SW Catchments	1		2	1

Appendix B Fully Developed Layout



J:\200\214\214115 Higgins Group_Urban Development-Palmerston North_CJF\04 Civil Engineering_214115 FLYGERS PROJECT\Production Drawings\SWMP\214115 SW Catchments.dwg 9/24/2020 1:44 p.m.

Rev	Details	Drawn	Date
1	ISSUED FOR DISCUSSION		24/9/20

Mitch Hydro

resonant — MULTI-DISCIPLINARY ENGINEERING & SURVEYING SERVICES — Bringing places & spaces to life

The Contractor shall check all dimensions on site.

71 Pitt Street, PO Box 600 Palmerston North
06 356 7000 info@resonant.co.nz
www.resonant.co.nz

STORMWATER CATCHMENTS
RANGITIKEI LINE - FLYGERS LINE
PALMERSTON NORTH
STORMWATER MITIGATION

HIGGINS GROUP

	Initials	Date
Surveyed	RSJP	04/19
Designed	KBJ	08/20
Drawn	JGR	08/20
Checked		
Approved		

DO NOT SCALE, If in doubt ask for dimensions

Scales A3	Job No.
1:2000	214115

CAD Path/File	Sheet	of	Sheets	Rev.
214115 SW Catchments	2		2	1

Appendix C Stormwater Mitigation

Table 9: Flood Detention Pond Level-Area-Volume Curve (PROVISIONAL)

RL	Length (m)	Width (m)	Area (m²)	Volume (m³)	Comment
26.25	81.00	41.00	3321	0	Pond base
26.30	81.30	41.30	3358	167	
26.35	81.60	41.60	3395	336	
26.40	81.90	41.90	3432	506	
26.45	82.20	42.20	3469	679	
26.50	82.50	42.50	3506	853	
26.55	82.80	42.80	3544	1030	
26.60	83.10	43.10	3582	1208	
26.65	83.40	43.40	3620	1388	
26.70	83.70	43.70	3658	1570	
26.75	84.00	44.00	3696	1754	
26.80	84.30	44.30	3734	1939	
26.85	84.60	44.60	3773	2127	
26.90	84.90	44.90	3812	2317	
26.95	85.20	45.20	3851	2508	
27.00	85.50	45.50	3890	2702	
27.05	85.80	45.80	3930	2897	
27.10	86.10	46.10	3969	3095	
27.15	86.40	46.40	4009	3294	
27.20	86.70	46.70	4049	3496	
27.25	87.00	47.00	4089	3699	Spillway Crest
27.30	87.30	47.30	4129	3904	
27.35	87.60	47.60	4170	4112	
27.40	87.90	47.90	4210	4321	
27.45	88.20	48.20	4251	4533	
27.50	88.50	48.50	4292	4747	
27.55	88.80	48.80	4333	4962	
27.60	89.10	49.10	4375	5180	
27.65	89.40	49.40	4416	5400	
27.70	89.70	49.70	4458	5622	
27.75	90.00	50.00	4500	5846	Embankment Crest

Appendix D Flygers Line Spillway (Horizons)

The Mangaone Stream has a 180 square kilometre catchment, originating in hill country to the north east of Palmerston North. The 10 kilometre reach at the downstream end is located within Palmerston North. This reach is stop banked, with extensive development on the protected area.

Even although the Mangaone stream is much smaller than the Manawatu River, damage costs resulting from a stopbank breach would be large. The LMS Special Project report shows a map (Figure 5) of three flooding scenarios. The scenarios correspond to three compartments, separated by the stream stopbanks and by the railway embankment. It is unlikely that all three compartments would flood in the same event, because three independent failures would be needed for that. The compartment with the highest potential damage cost is to the north of the railway embankment, and includes the Bennett Street industrial area. In 1994 the damage costs were estimated at $62 million. That is direct damage costs only, and does not include indirect and intangible damages.

The capacity of the Palmerston North reach of the Mangaone Stream is very limited, even though it is stopbanked. The largest flood that can be conveyed is much smaller than the 1% AEP, let alone the 0.2% AEP. The proximity of development means that the cost of upgrading to either of these standards would be prohibitive. Up to 13 bridges would have to be raised and lengthened, and stopbanks would have to be set back, necessitating the purchase of many houses and industrial buildings adjacent to the stopbank.

However the Mangaone stopbanks at Palmerston North are probably the most secure stopbanks in the Lower Manawatu Scheme, with an annual probability of failure less than for any other LMS stopbanks. This is despite the limited channel capacity. It is because two spillways are incorporated into the Mangaone stopbanks upstream of Palmerston North. During major floods they spill enough water to ensure that the stopbanks protecting the city are never overtaxed.

1.1.1 The spillways

The spillway referred to as the "Roberts Line spillway" is located on the Derby Creek stopbank, which is a return bank from the Mangaone. It is a simple spillway, formed by a 250 metre length of stopbank that is lower than adjacent stopbanks. It operates during any flood that exceeds 140 cumecs at Milson Line. This is a 7% AEP (15 year) flood.

The spilled water flows approximately towards the south west. For the first 2.5 kilometres it flows parallel to the Mangaone Stream, and only a short distance away. The Mangaone Stream then turns left towards the airport, but the overland flow path continues straight ahead, eventually reaching the Taonui Basin pond. On the way it is joined by water from the Flygers Line spillway.

The right stopbank downstream of the spillway is not up to the height needed to contain a 1% AEP flood, although it would probably have a reasonable chance of containing a 2% AEP. There is no proposal to upgrade this stopbank, because any overtopping or breach water is not expected to do much damage. It would travel only a very short distance before joining the main overland flow from the spillway.

The Flygers Line spillway is located 250 metres upstream of Flygers Line. It is a few hundred metres to the south west of the western end of the airport runway, and is the zig-zag shaped feature that can be seen from the air when taking off towards or approaching from the west. It was constructed during the summer of 1984 – 85.

It is not a simple spillway, it is a flow regulating structure. Compared to a simple spillway, the structure will release water less often, and in any flood smaller than the 1% AEP flood it will release a smaller quantity of water. It commences operation when the Milson Line flow reaches 124 cumecs, which is a 10% AEP (10 year) flood. This corresponds to 4.4 metres at the Milson Line recorder. The 1% AEP was taken (conservatively) as 192 cumecs, which means that 68 cumecs had to be spilled in the design event.

The spillway consists of a concrete sill 262 metres long, and zig-zag shaped in plan view (to minimize land occupied by overflows). Figure 10.3.1 below shows the spillway viewed from the downstream end. It carries 45 horizontally hinged gates of varying length, and 320 millimetres high. They are shaped so that rising water holds the gate shut by acting as a counterweight until it reaches the top of the gate, when the horizontal water pressure exerted on the vertical section of the gate becomes sufficient to tip it over. The design is found on Drawing 2496, Sheets 1 to 10.

Figure 10.3.1 Flygers Line spillway from downstream end

The intentions of the 1982 design were twofold:

- The structure should spill nothing for all flows less than 124 cumecs at Milson Line, and it should spill all water in excess of the 124 cumecs. i.e. upstream of the spillway, the flow can increase to more than 124 cumecs. Downstream, the flow can increase up to 124 cumecs, but must not increase thereafter; and

- The spillway should operate no more often than necessary. Without the gates mounted on the concrete sill, spilling would occur as soon as the stream flow exceeded 100 cumecs. The purpose of the horizontally hinged gates was to contain the water until the 124 cumec flow is exceeded.

Without the gates, overflows would occur three times as often as is actually the case. For every flood that exceeds 124 cumecs, there are two floods between 100 and 124 cumecs. Those two floods rise above the concrete sill, but do not release water because they do not rise high enough to tip gates.

Figures 10.3.2 and 10.3.3 below show how the gate action works. The flow increases until the water level rises to the top of some of the gates. The first gate tips, and as stream flow increases more gates tip one at a time until the flood peak is reached, after which no more gates tip. As the stream flow reduces, the flow over the spillway reduces and finally stops. The gates can then be stood up again, which has to be done manually. There is no machinery that does this. However the gates are light enough that one person can do the job manually.

Figure 10.3.1 Schematic cross section showing Flygers spillway gate operation

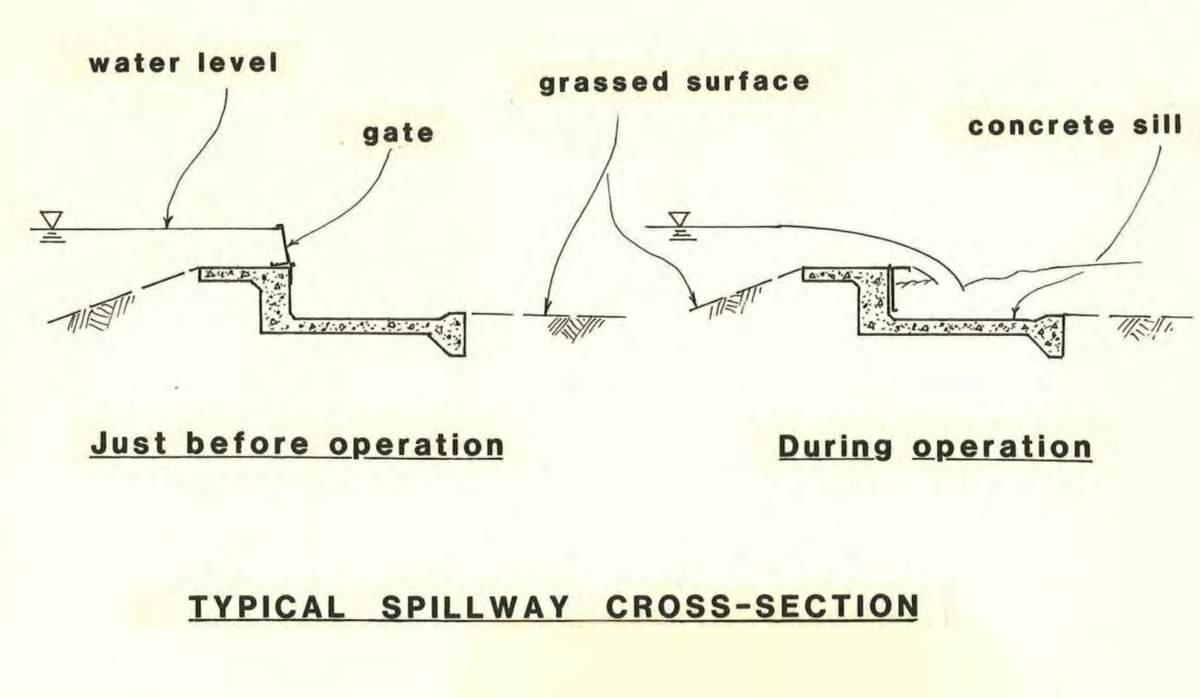
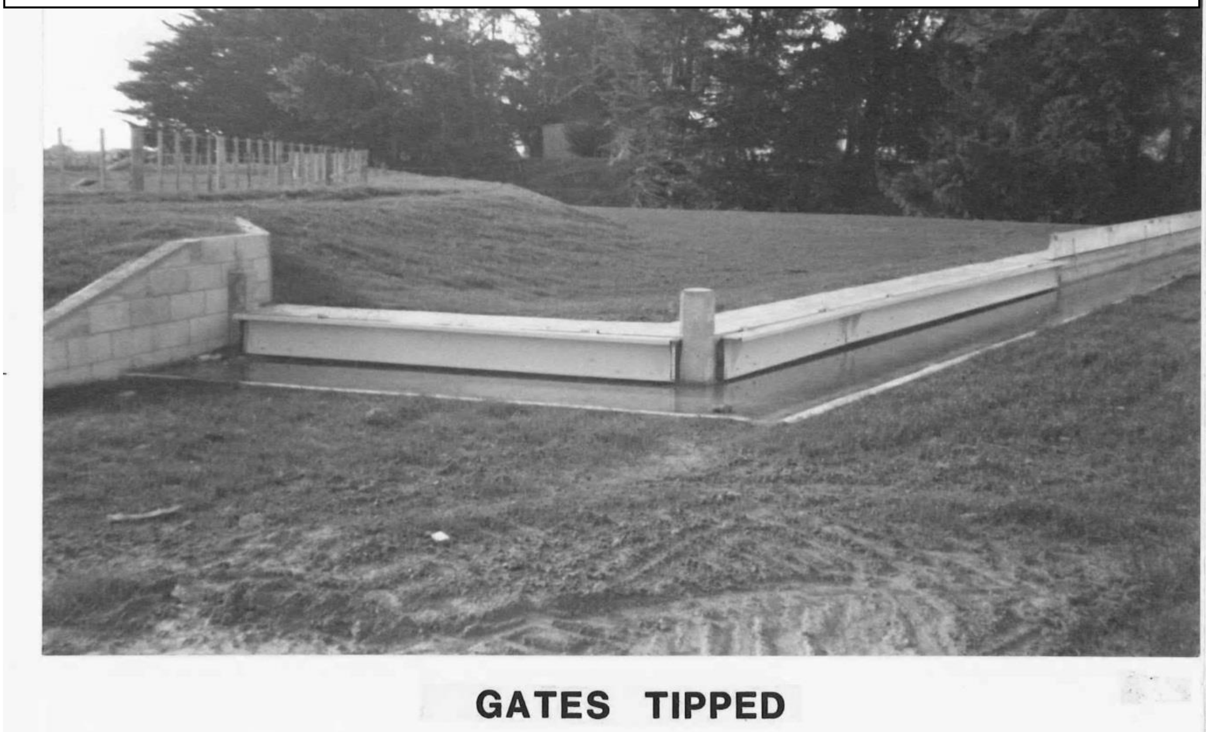


Figure 10.3.3 Flygers spillway gates – Upstream gates open, others closed



The original design flow over the spillway was 68 cumecs, but after February 2004 that had to be revised up to 113 cumecs. As discussed in section 4.5, the flow of a 0.2% AEP flood is larger than the 1% AEP at Bunnythorpe, but is exactly the same at Milson Line, because the right stopbanks near Roberts Line are certain to fail and release the extra water, so the 113 cumec spillway flow applies to any flood larger than a 1% AEP.

After the spillway flow exceeds 68 cumecs, the flow in the channel through the city will increase a little, up to about 133 cumecs. The new design flood level at the spillway will then be 100 millimetres higher than the old level. Fortunately the elevated water level does not persist very far downstream, because the channel roughness is less than assumed in the 1982 design. The 1982 roughness was based on flood levels from several floods in the years before 1982. Maintenance in recent years has been to a standard higher than that of 1982.

1.1.2 Performance of the Flygers Line Spillway and Mangaone Stream in the February 2004 flood

Flows over the spillway were partially obstructed by a maize crop planted in the floodway immediately downstream of the structure. The crop had been permitted on the basis that in over thirty years of record no significant flood had ever occurred during the months December to May inclusive. Clearly floods may be less likely at some times than others, but they are never impossible, and it is now clear that no crops should be permitted where they can obstruct outflows from the Flygers Line Spillway.

At the peak of the February 2004 flood, the channel through the city probably carried close to 140 cumecs. However, because of the good maintenance and hence low roughness, there was plenty of freeboard. Even with the extra flow, the water level was lower than the design level everywhere between the Rangitikei Line Bridge and the Pioneer Highway Bridge. The smallest observed freeboard was 290 millimetres, on the right bank just upstream of the Flygers Line Bridge.

1.1.3 The Mangaone Floodway

When the water leaves the structure, the spread of floodwaters is limited to a physically defined floodway for the first 800 metres. See Drawing 2496 Sheet 1. This was a condition of the water right obtained for the works under the 1968 Act. On the left bank this is achieved with a stopbank. On the right bank it is achieved partly by stopbanking and partly by the high ground of Whiskey Creek’s natural levee.

The land protected by the right stopbank is agricultural land, much of which is floodable when the Roberts Line spillway operates. Thus this stopbank is only useful for the few flood that are larger than a 10% AEP but smaller than a 7% AEP. The downstream end of this stopbank was left low so that it did not excessively impede overland flows from the Roberts Line spillway.

The left floodway stopbank protects two houses. During the February 2004 flood the stopbank experienced a little overtopping, although there was no significant damage. This stopbank is programmed for upgrading.

There are two fences crossing the floodway. The first is 50–100 metres from the structure. It is designed so that the wires can be quickly and easily detached from the posts, and lifted and fastened above the flow. The next fence is about 300 metres downstream in the floodway. It is a boundary fence, and the landowners wanted a fence more robust than the detachable wire system. Each time the spillway operated, the boundary fence collected debris, part of the fence was pushed over by the force of the flowing water, and was reinstated after the flood.

1.1.4 Spillway operations

The spillway has operated three times, on 25 August 1986, 24 July 1988 and 16 February 2004. The 1986 flow should not have been sufficient to trigger spillway operation, but a lupin infestation had developed adjacent to the stream a few hundred metres downstream of the Flygers Line Bridge. The water level in the stream was elevated by over a metre at the upstream end of the lupin, and the backwater effect was still present at the spillway 500 to 600 metres upstream, enough to operate the gates.

The lupin remained undetected until too late, because it was located downstream of a bend, and was not visible from the road. The land was purchased by the Manawatu Catchment Board, and has been kept clear of lupin since then.