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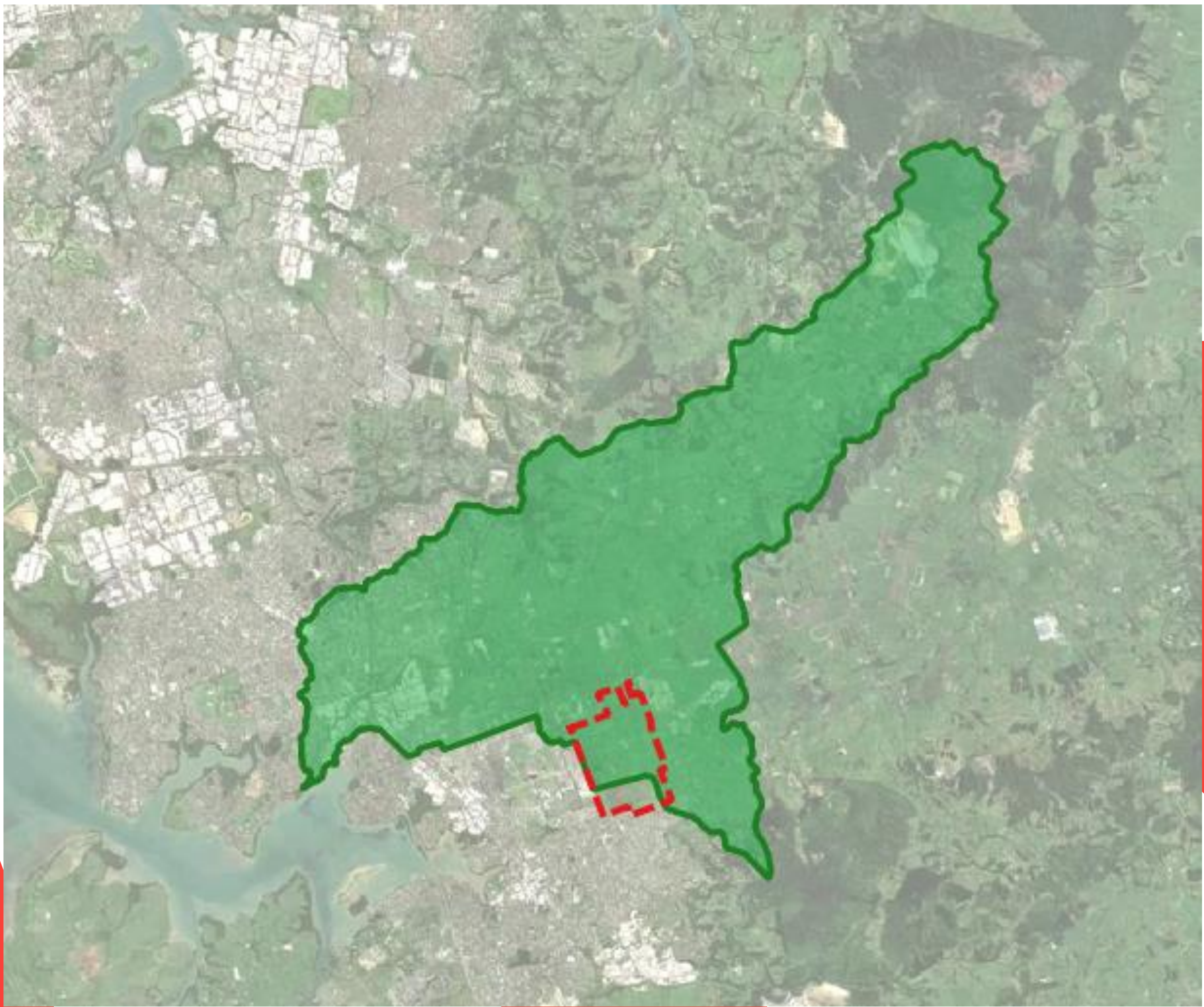
Auckland Council

Papakura Stream Flood Hazard Modelling – Sunfield Development

24 September 2025

3-AWD30.AP



Papakura Stream Plan Change Modelling Support

Sunfield Modelling

Auckland Council

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1	11 July 2025	Issued as Draft
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ABBREVIATIONS AND DEFINITIONS

3WSR	Three Waters Strategy Report
AC	Auckland Council
ARI	Average Recurrence Interval
AUK46	Auckland 1946 Vertical Datum
CC	Climate Change
CN	Curve Number
CoP	The Auckland Code of Practice for Land Development and Subdivision Chapter 4: Stormwater Version 4.0
ED	Existing Development
FUZ	Future Urban Zone
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System (hydrological modelling software)
ICM	InfoWorks ICM (hydraulic modelling software)
MPD	Maximum Probable Development
NZVD2016	New Zealand Vertical Datum 2016
PWL	Permanent Water Level
SWMP	Stormwater Management Plan
T+T	Tonkin + Taylor
ToC	Time of Concentration
TP108	Technical Publication 108: Guidelines for stormwater runoff modelling in the Auckland Region

EXECUTIVE SUMMARY

Purpose and Scope

This report was prepared for Auckland Council (**AC**) to analyse the changes in flood hazard due to the proposed Sunfield master planned community development (**Sunfield development**) within the Papakura Stream catchment. We have modelled the proposed land use changes and attenuation devices of the Sunfield development, as proposed by Sunfield Developments Limited (**the applicant**). We have not analysed the flood hazard within proposed Sunfield Development.

There are existing flood hazards downstream of the proposed development, including the predicted overtopping of key roads and flooding of private properties. Inundation of 130 habitable floors, and 65 commercial floors is predicted during the future climate 100-year ARI event. The predicted flooding downstream can occur in a variety of rainfall patterns, due to the complex interaction between the flood flows from rural and urban areas.

The purpose of this work is to analyse the potential impacts of the proposed development on the predicted downstream flood hazard to improve AC's confidence in the findings of the applicant's modelling report. As the applicant did not provide their model files, we have replicated the proposed attenuation devices from the provided reports and plans.

This study uses AC's latest available stormwater catchment model of the Papakura Stream catchment. This model is built in InfoWorks ICM. We updated the ICM model to improve representation around the proposed development, such as adding in existing open drains based on survey data provided by AC.

Modelling Approach

We modelled 56 scenarios by varying the following items.

- **Development scenarios**: The proposed Sunfield development was compared to a baseline of the existing development scenario as well as compared a baseline of maximum probable development within the catchment.
- **Rainfall events**: We analysed the 2,10 and 100 year ARI events, both with and without climate change. We also analysed spatially varying rainfall, in order to represent conditions when the attenuated flow from the development coincides with flows from upstream rural catchment.
- **Peat soil curve numbers**: We analysed four different curve numbers for peat soils. This comparison was done due to the uncertainty associated with perviousness of the peat soils.

The scenarios are summarised in the table below:

Scenario Categories	Development	Rainfall	Peat CN
Current Development	**E** – Existing development **E+SUN** – Existing development with Sunfield	Rainfall ARI: • 2 Year (No CC) • 10 Year (No CC) • 100 Year (No CC)	Lower Bound (CN 39) Group B Soil (CN 61) Group C Soil (CN 74) Upper Bound (CN 98)

Scenario Categories	Development	Rainfall	Peat CN
Maximum Probable Development	**M** – Maximum probable development, not including Sunfield. **M+SUN** – Maximum probable development including Sunfield.	Rainfall ARI: • 2 Year (2.1°C), • 10 Year (2.1°C) • 100 year (3.8°C)	Lower Bound (CN 39) Group B Soil (CN 61) Group C Soil (CN 74) Upper Bound (CN 98)
Spatially Varying Rainfall	**M** – as above **M+SUN** – as above	Spatial Rainfall ARI: • 10 Year (3.8°C) • 100 year (3.8°C)	Lower Bound (CN 39) Group C Soil (CN 74)

Conclusions

- **The applicant did not provide complete technical details** regarding their proposal, limiting the scope of our analysis:
    - The engineering plans that the applicant provided have missing information. We have had to assume some details based on engineering judgement (including dimensions and arrangement of stormwater pond outlet structures).
    - The applicant did not provide their model files, and therefore our analysis is based on the provided 3WSR report and attached engineering plans.
    - The previous peer reviews that are included in the lodged documents did not review the hydraulic models directly.
- **Peat Soils:** Our modelling shows that the change in flood hazard due to the development on the downstream properties varies depending on the amount of infiltration available within peat soil. With lower CN values (higher infiltration) the upstream catchment flows are lower, but the increase in downstream peak flood level due to the development is relatively greater. Overall, our results show greater peak flood level increases immediately downstream of the Sunfield development when considering a lower curve number for peat.
- **Local Flood Hazard Results (Within nearby open drains):** Our modelling predicts that the Sunfield development can result in an increased flood level on nearby downstream properties. An increase in flood hazard is predicted immediately downstream of pond 1 in the 2-year ARI event. In the 2-year ARI, peat CN61 scenario our modelling predicts that the flood depth downstream of pond 1 will increase by approximately 100mm on neighbouring properties due to the Sunfield development. This increase in flood hazard is likely in part due to the applicant's proposal to combine the existing overland flow paths into a single discharge location.
- **Downstream Flood Hazard Results (Within Papakura Stream main channel):** Our modelling does not predict an increase in flood depth within the main Papakura Stream channel (approximately 1.7km downstream) in any of the scenarios modelled. We believe that this is due to the applicant's proposal to divert part of the existing Papakura Stream catchment to the Awakeri basin.
- **Downstream open drains predicted capacity:** The downstream open drains have existing capacity constraints, and hence are sensitive to increased runoff, for example during relatively frequent events

(i.e. 2-year ARI). Due to the flat topography of the development site and adjacent downstream properties, the water level in these drains may influence the performance of the applicant's proposed attenuation devices. Our modelling predicts that in the 100-Year ARI events the downstream flood level causes water to flow back into pond 2.

- **Catchment Diversion**: The applicant's proposal to divert part of the current Papakura Stream catchment into the Pahurehure Inlet via the Awakeri Wetlands plays a key part in limiting the potential increases in existing flood hazard in the Papakura Stream.

Recommendations

- Regarding the peat soils;
    - The applicant's modelling uses a single curve number of 74 for all pre-development peat soils.
    - The peat soils are known to be highly variable, and are subject to seasonal variation.
    - Our modelling shows that the change in flood hazard due to the development can vary based on the assumed peat CN values.
    - Therefore further consideration of the perviousness of the peat soils is recommended. This could include assessing the likely range of possible CN values for the existing peat ground and incorporate that into their modelling. We consider this critical to determining the sizing of attenuation devices to avoid increasing flows above the pre-development condition.
- Our modelling indicates that the applicant's proposal to combine the existing overland flow paths into one discharge point could increase the flood hazard of properties immediately downstream of pond 1. We recommend that the applicant carries out more detailed hydraulic analysis of the existing conveyance channels downstream of pond. A more in-depth hydraulic analysis of the open drains will give AC greater confidence of the impacts of the applicant's proposal on the flood hazard within properties downstream of the development.

1 PROJECT BACKGROUND

This report was prepared for Auckland Council (**AC**) to analyse the changes in flood hazard due to the proposed Sunfield master planned community development (**Sunfield development**) within the Papakura Stream catchment. The Sunfield development consists of approximately 4,000 residential lots and 56.5 Ha of industrial land. We have analysed the proposed land use changes and attenuation devices of the Sunfield development, as proposed by Sunfield Developments Limited (**the applicant**). AC is working in parallel with GHD to analyse the impacts of the development on existing predicted flood hazard in the Pahurehure inlet catchment. In the applicant's proposal a ~55 Ha section of the development site is re-routed from discharging to the Papakura Stream, and is routed to the Pahurehure inlet catchment instead. We have worked collaboratively with GHD to ensure that both catchment models are in alignment and capture this proposed change.

This study uses AC's latest available model of the Papakura Stream catchment. This model is built in InfoWorks ICM. The model build is described in Papakura Stream Model Update, Model Build Report (WSP, 2021). This model has previously been updated based on high-level calibration of several historic events. This catchment model was built for AC in order to assist with catchment planning. Previous work has also included the running of historical rain events, analysis of the potential impacts on predicted flood risk of developing parts of the catchment, including the Takanini North Future Urban Zone (FUZ). We have also previously analysed potential impacts on predicted flood hazard using spatially varying rainfall events within the catchment.

The proposed Sunfield development spans across two catchments. The northern part of the site drains into the Papakura Stream catchment, and the southern part of the catchment drains into the Pahurehure inlet via the Awakeri basins. The Papakura stream catchment is known to have historical flooding issues. Previous modelling by WSP analysed the flood risk in a number of scenarios.

There are significant existing flood hazards downstream of the proposed development, including the predicted overtopping of key roads and flooding of a large number of private properties, including inundation of over 130 habitable floors, and 65 commercial floors during the future climate 100-year ARI event (WSP, December 2024). Additionally, the predicted flooding downstream can occur in a variety of storms types, due to the complex interaction between the flows from rural and urban areas for different events.

The lower parts of the catchment are flat with peat soils. The stream catchment has two distinct sections, with a rural upstream section and urbanized downstream section. The overall catchment and location of the Sunfield development is shown in Figure 1-1.

AC's ICM model was schematised for analysing the potential flooding associated with the stream (i.e. flooding associated with overland flow paths or surcharging stormwater network were not represented in this model). While this model has several limitations, which are detailed in the Model Build Report (WSP, 2021), it is considered suitable to complete this analysis with the updates described in this report.

The purpose of this work is to analyse the potential impact of the proposed development on the predicted downstream flood hazard to improve AC's confidence in the findings of the applicant's modelling report. As the applicant did not provide their model files, we have replicated the key proposed attenuation devices from the provided reports and plans.

The ICM model was updated to allow for the assessment of the Sunfield development. These updates consisted of refining the catchment boundaries around the Sunfield site and adding surveyed farm drains around the proposed Sunfield development site.

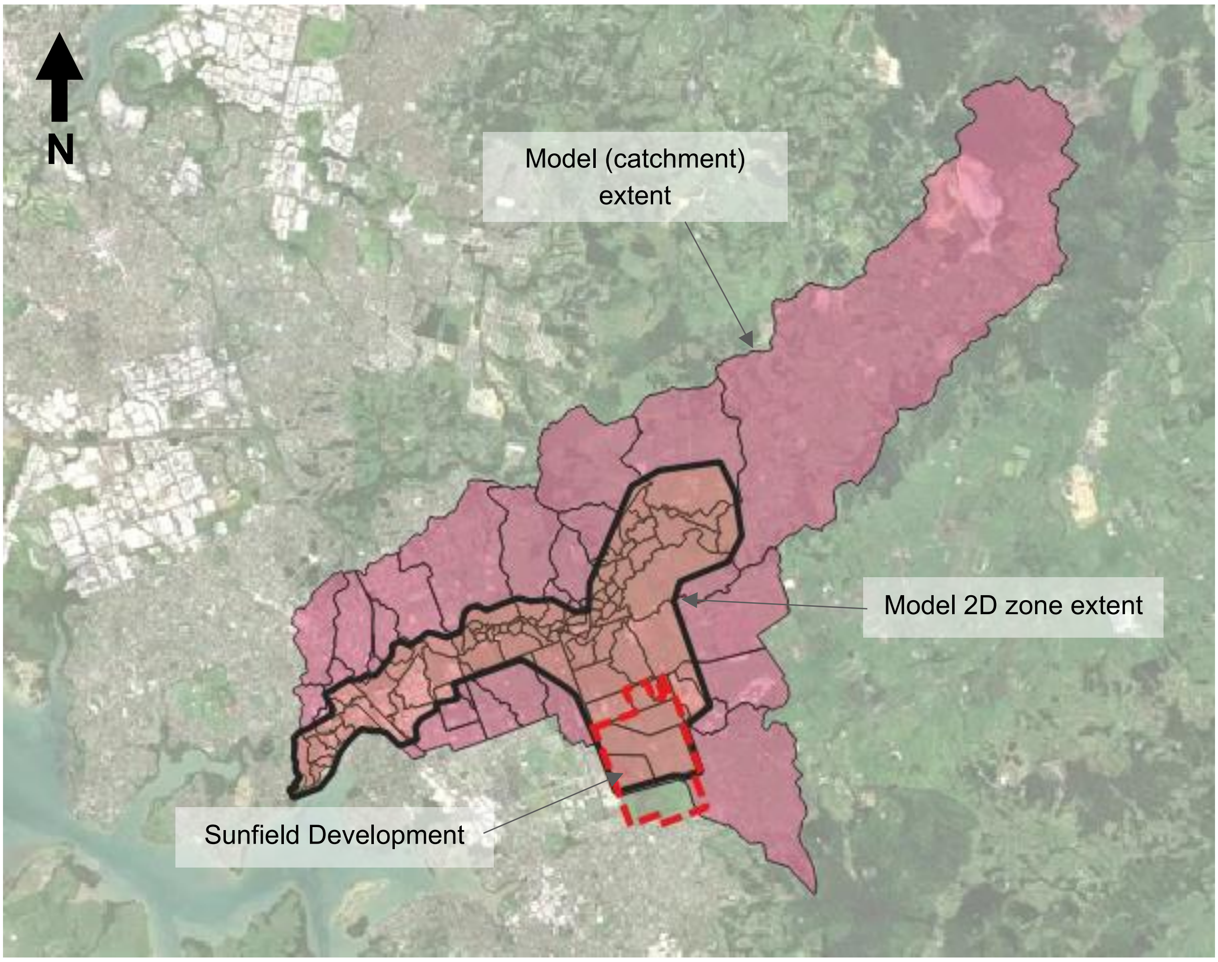

Figure 1-1: Overview of the Papakura Stream hydraulic model, showing location of Sunfield Development.

1.1 PROVIDED DATA

The following files were provided to WSP to carry out this analysis:

- Sunfield lodged documents. Provided by Weir Consulting on behalf of Auckland Council 15/04/2025.
- Farm drain survey data (.csv). Provided by Auckland Council on 02/04/2025.
- Tonkin + Taylor HEC-HMS Model for Alfriston / Randwick Rise proposed land use change (May 2025).

2 MODEL UPDATES

We updated the existing ICM model in order to enable appropriate representation of the proposed Sunfield development. Model updates were:

- Base model updates, as discussed in Section 2.1
- Model updates to represent Sunfield, as discussed in Section 2.2
- Model updates to represent other development areas, as discussed in Section 2.3

2.1 BASE MODEL UPDATES

The “base model” represents the existing development and underpins all scenarios; changes to the base model are reflected in each scenario unless a scenario overrides them (e.g. some surveyed open drains within the Sunfield development area are removed in scenarios that include the development).

2.1.1 SUBCATCHMENT DELINEATION

We revised the Papakura Stream subcatchments to match property boundaries as well as with:

- The extents of the proposed Sunfield development. This was done so that the proposed Sunfield land use changes could be readily implemented.
- The extent of the Pahurehure Inlet catchment model (email from Scott Wilkinson (GHD) on 4 April 2025). This was done so that both model boundaries did not have overlaps or gaps.

Figure 2-1 shows the subcatchments that we updated.

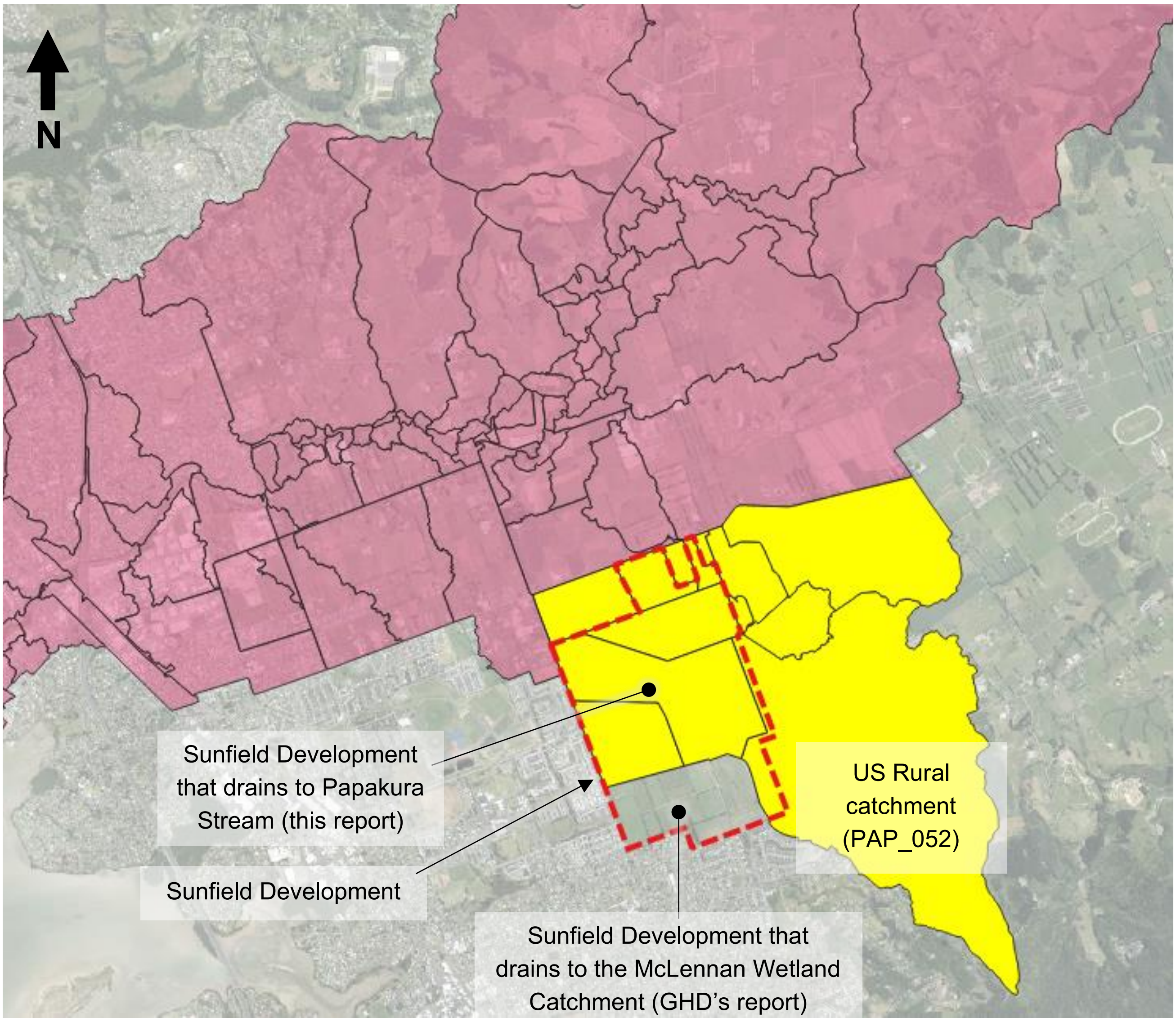

Figure 2-1: Base model subcatchments that were updated shown in yellow.

The following points summarise the subcatchment updates completed as part of this analysis:

- We set the impervious area of the subcatchments using the "Impervious Surfaces 2017" layer, downloaded from Auckland Council's Open Data portal in April 2025 (AC, 2025).
- We calculated the time of concentration (ToC) using Equation 4.3 from TP108 (ARC, 1999). For this we used:
  - Channelisation factor of 0.8 assumed. For the upstream rural catchment (PAP_052) we assumed a channelisation factor of 1.0, as this catchment has no fewer constructed drains.
  - Catchment length from Council's overland flow paths.
- Curve number assumed to be 74.
- Slope calculated using the equal area method and the 2016 LiDAR (i.e. the same LiDAR as the overland flow paths).
- All updated subcatchments except one were within the peat soil zone, as shown in Figure 2-2. For these subcatchments, all pervious areas in the existing development scenarios were set to peat.

- For subcatchment PAP_052 (called catchment C in the Sunfield 3WSR), we assumed the impervious area was evenly distributed, so the ratio of the pervious was the same as the soil coverage shown in Figure 2-2. We did not adjust the different soil areas based on the location of impervious surfaces.

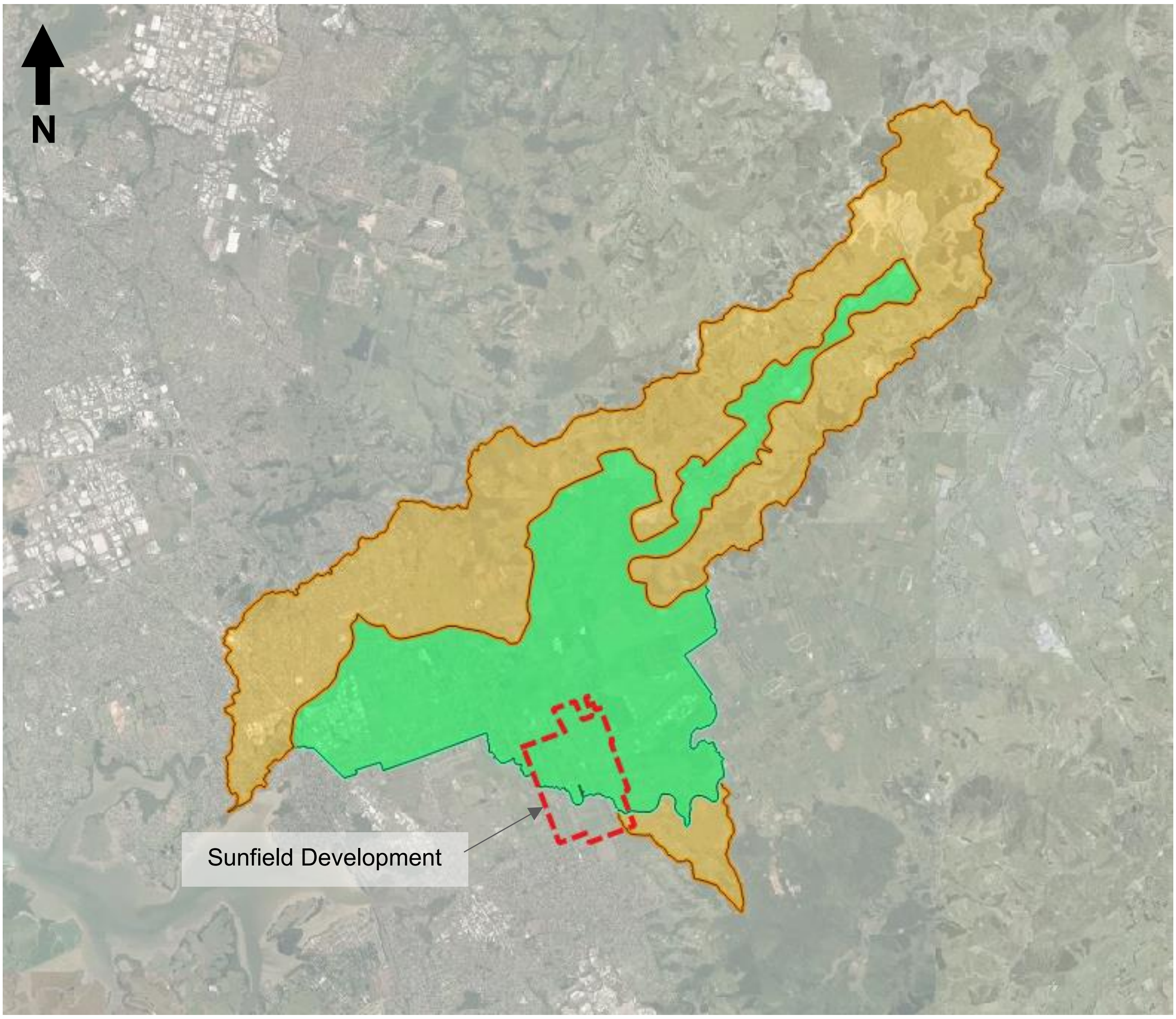

Figure 2-2: Soil types – Peat shown in green, Waitemata Mudstone shown in orange.

2.1.2 OPEN DRAINS

The area surrounding the proposed Sunfield development is flat with seasonally high groundwater. A network of private and roadside table drains provide land drainage. We will refer to these as open drains. Anecdotally these drains have standing water in them during winter, and have limited capacity to convey surface water during extreme events (there is anecdotal evidence of flooding in less than 2-year ARI events).

These open drains were not specifically included in the original Papakura model, but were represented in the ground surface model, albeit at a low level of detail. As the development is proposing discharge into these drains we determined that direct representation of these drains was important for this analysis and that available survey data should be added to the model to improve the accuracy of modelling low ARI events (e.g. 2-year ARI).

We added the open drains based on the survey undertaken by Aurecon in 2012, which was provided by AC on 2 April 2025. This survey also included the culverts along these drains, and we added the culverts relevant to this analysis into the updated model. In total we added 49 culverts and approximately 5.8 km of open drains. Some of the open drains and culverts in the survey data were not downstream of the Sunfield development. We did not add these open drains and culverts, as they were not critical to this analysis. However, they could be added in future analyses if necessary. The extent of the modelled drains modelled is shown in Figure 2-3.

There were some gaps in the survey data, as circled in Figure 2-3. In this area we increased the resolution of the ground model mesh size. This was done to improve the representation of open drains that were only captured via LiDAR.

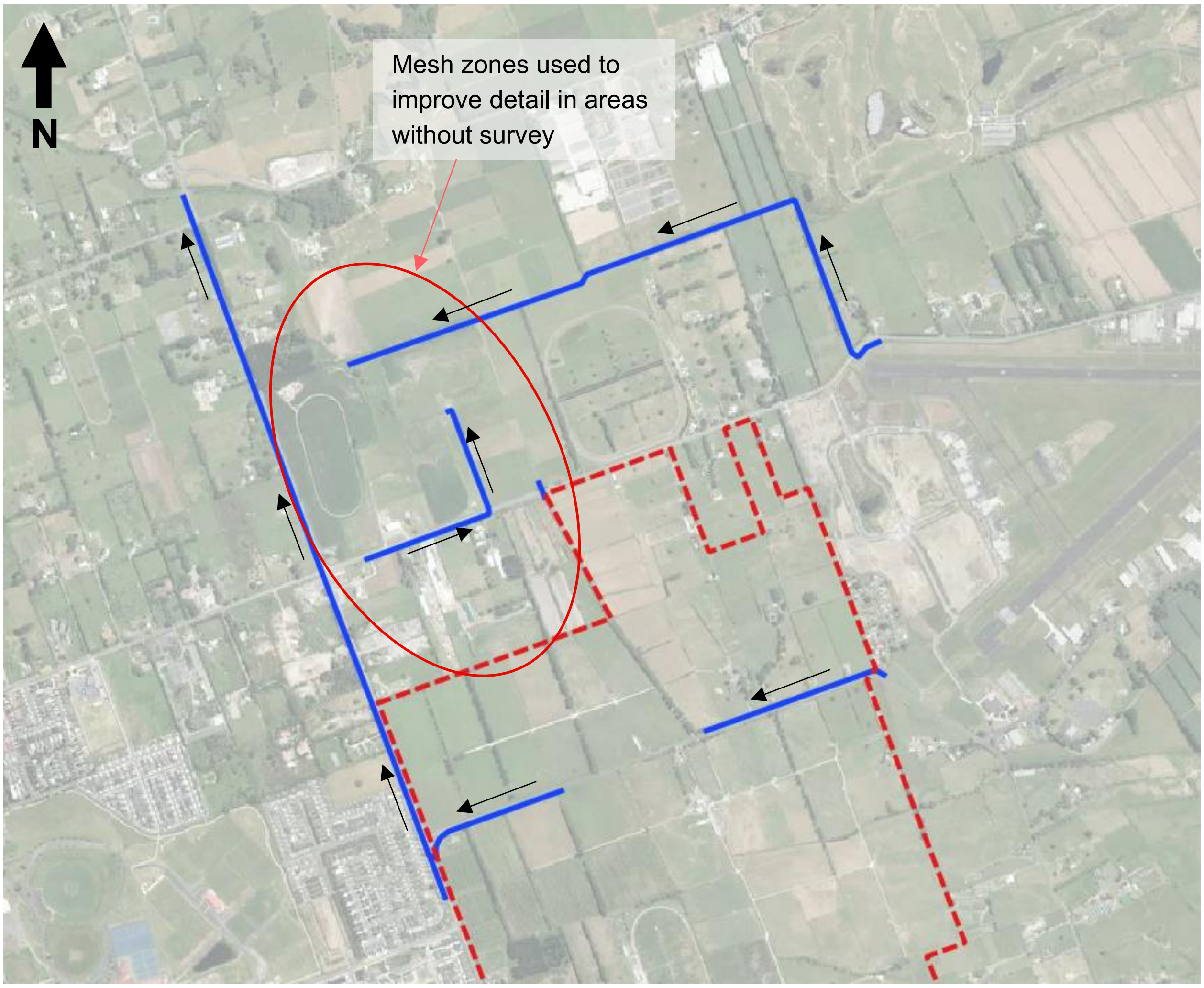

Figure 2-3: Extent of surveyed farm drains and culverts added to model.

We modelled the open drains in 2D by setting the invert to match the surveyed bottom of bank levels and assuming vertical walls. We also set the Mannings roughness coefficient to n=0.05 to reflect the increased drain conveyance resulting from channelising the flow.

Open drains in other areas are represented in the 2016 LiDAR surface, however their representation is limited by the accuracy of the 2016 LiDAR (for example interference from overgrown vegetation on the banks can reduce cross sectional area).

The open drains along Hamlin Road were included only in the scenarios without the Sunfield development, as this area is proposed to be re-developed in the scenarios with the proposed Sunfield development.

2.2 SUNFIELD DEVELOPMENT

As per the applicant's 3WSR, the proposed development consists of approximately 4,000 residential lots, as well as 56.5 Ha of industrial land. We have analysed the proposed Sunfield development within the Papakura Stream catchment based on the applicant's design. We have included representation of the key proposed attenuation devices from the provided reports and plans.

The following lodged files were used in this analysis:

- Infrastructure Report (Maven, 2025a)
  - Engineering drawings from Appendix B of the infrastructure report were used in replicating the proposed stormwater structures.
- Three Waters Strategy Report (Maven, 2025b).

Apart from the diversion channel, no internal flows within the Sunfield Development were modelled.

Pond 1 was modelled in 2D, with culverts and base linear structures representing the weirs. Ponds 2 and 3 were modelled in 1D. These structures are described in more detail below.

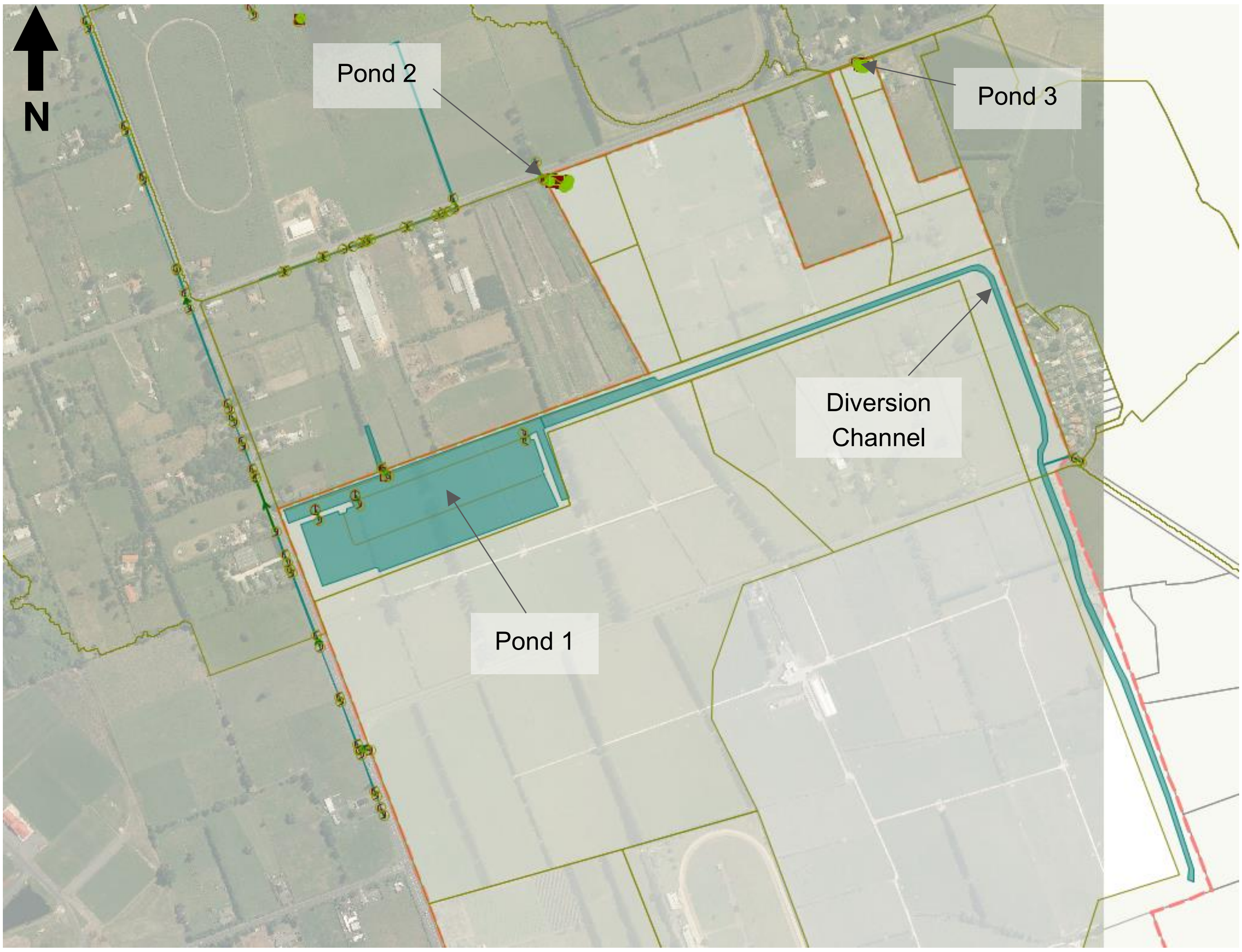

Figure 2-4: Overview of key modelled assets within Sunfield development

Datum Conversion:

The Sunfield drawings were provided in the NZVD2016 vertical datum. As the ICM model is in AUK1946 all vertical values had to be converted. Where vertical datums are discussed we have labelled them as either

AUK46 for Auckland Vertical datum 1946 or NZVD2016 for NZ Vertical Datum 2016. A single offset value of 0.288m was used across the Sunfield development site.

AUK46 = NZVD2016 + 0.288m

This single offset value has been sourced from the Land Information New Zealand (LINZ) Auckland 1946 to NZVD2016 Conversion Raster. There is some variation in offset value depending on location, however due to the size of the proposed development a single offset value provides an acceptable level of detail.

2.2.1 PROPOSED MODIFICATION TO CATCHMENT BOUNDARY

The applicant proposes to reroute part of the current Papakura Stream catchment into the Pahurehure inlet via the Awakeri Wetlands, as shown in Figure 2-5.

The 3WSR states that the yellow highlighted area (approx. 55 Ha) currently discharges to the Papakura Stream catchment, and the applicant proposes to modify the topography of the area in order to reroute this area to the Awakeri wetlands.

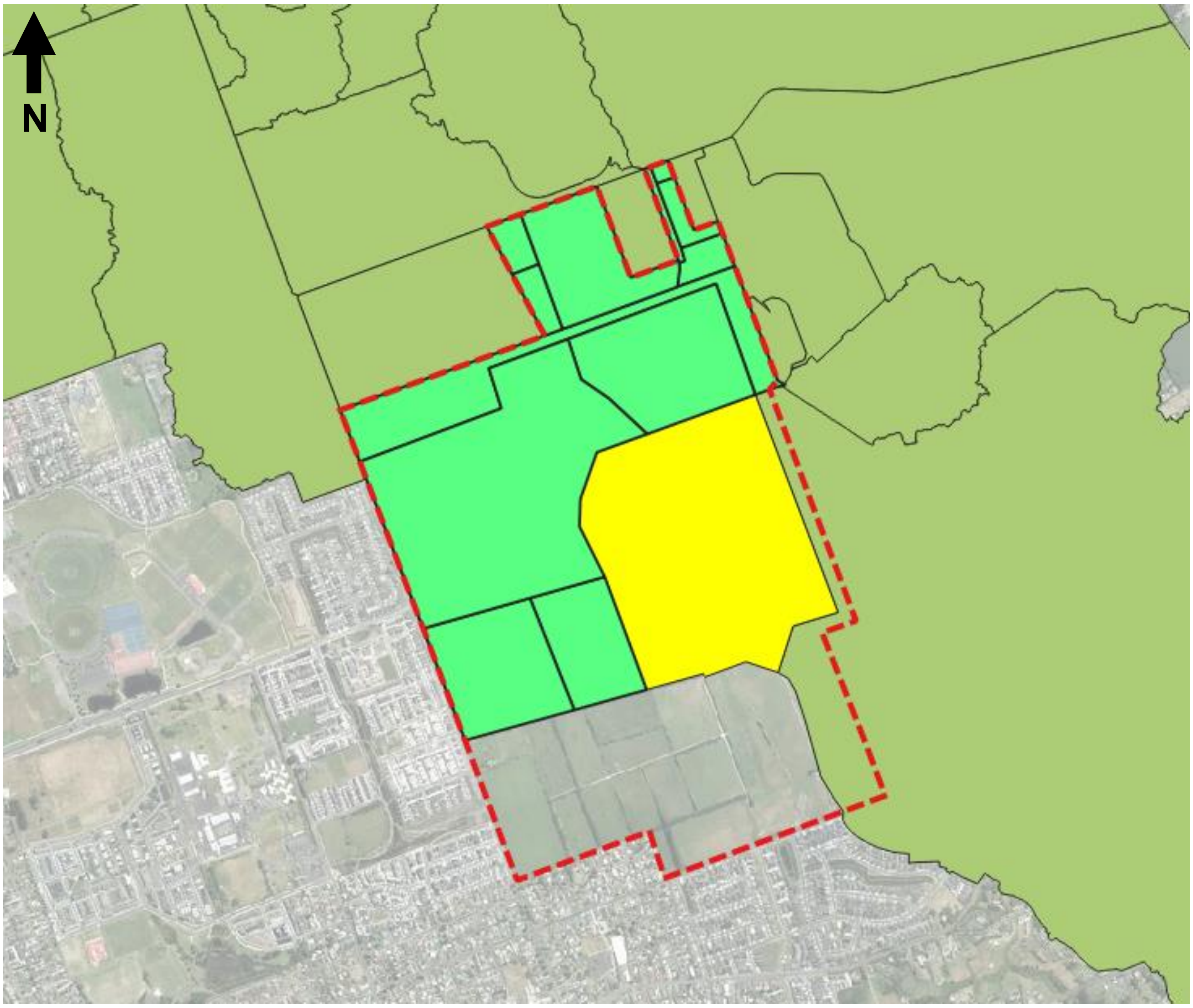

Figure 2-5: Catchment area within Sunfield Development that is diverted to Awakeri wetlands.

2.2.2 DIVERSION CHANNEL

The proposed development includes a diversion channel running around the eastern and northern boundaries of the development, to the proposed Pond 1 discharge point. We understand that the purpose of this channel is to allow connectivity for the upstream rural catchment, while avoiding the need to convey flows through the site

We modelled the diversion channel using invert levels from drawing M-C4511 and created a mesh level zone with vertical walls. We have not analysed the capacity of the channel itself, therefore accurately modelling the side slopes is not considered to be critical.

The downstream end of the channel (where it connects to pond 1) has an invert set to 21.010 (AUK46).

The upstream end of the channel in the ICM model was at chainage 2020m as shown on M-C4511, with an invert level of 30.128 (AUK46).

All intermediate points are interpolated, assuming a constant channel grade.

2.2.3 POND 1

Pond 1 was modelled in 2D, with the extents of each basin traced from the provided drawings.

Pond 1 outfalls pipe:

The applicant’s drawings only shows one outlet pipe, although the label on the drawing lists two inverts. We have therefore assumed that the intent is for two different outlet pipes at this location.

We have assumed a size of DN450 for the pipe downstream of the orifice, as this size is not given on the drawings.
Figure 2-6 shows how we have included these outlet pipes within our model.

Figure 2-6: Pond 1 outfall pipes configuration in model. Orange flagged values are from Sunfield SWMP (with datum conversion). Red flagged values are inferred/assumed.

Pond 1 internal pipes:

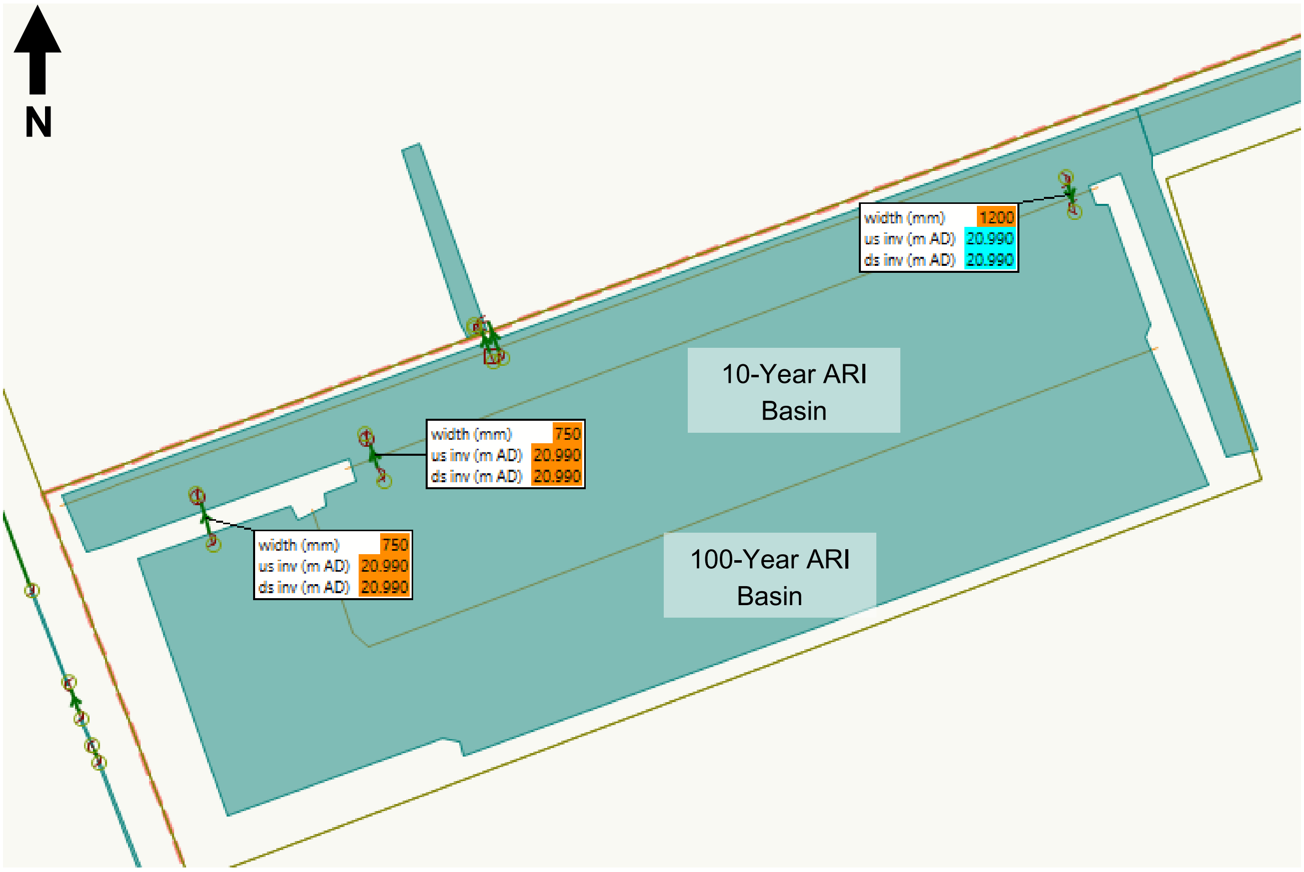

Figure 2-7: Pond 1 internal culverts configuration in model. Orange flagged values are from Sunfield SWMP (with datum conversion). Blue flagged values are based on engineering judgement (i.e. details not provided by applicant).

The two DN750 pipes connecting the 10-year and 100-year ARI basins to the diversion channel were modelled with a flap gate to only allow flows to drain down the basins following a storm event, as per the applicant's plan.

The drawing M-C4602 shows a box culvert connecting the diversion channel to the 10-year ARI basin of pond 1, as shown in Figure 2-8. The drawing does not show the invert of this box culvert, and no further information is provided. We have therefore assumed that this is an open culvert (no flap gates) at the invert level of the pond.

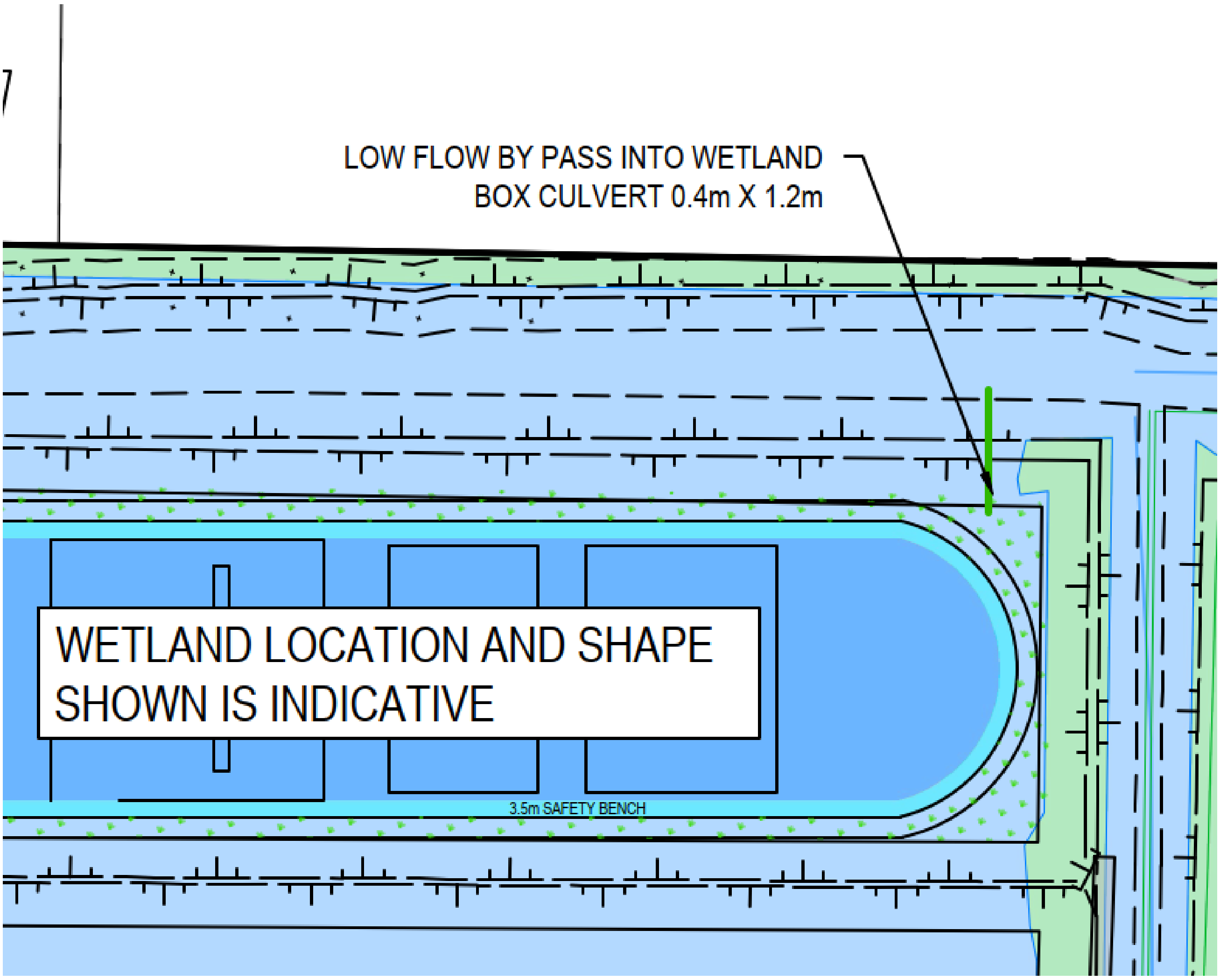

Figure 2-8: Snip from M-C4602, reproduced from applicant's lodged document. Box culvert location shown.

Pond 1 weirs:

There are three weirs within pond 1. The outflow weir allows the pond to discharge out from the site to the North. The 10-year ARI weir connects the diversion channel to the 10-year ARI pond basin, and the 100-year ARI weir connects the 10-year ARI pond basin to the 100-year ARI pond basin. The length and position of the weirs traced from the DWG REF. All three weirs were modelled using base linear 2D structures in ICM. The base linear structures were set as broad crested weirs, with the crest width set to 2m.

The 10-year ARI weir has a constant crest height of 22.808 (AUK46), and a length of 345m.

The 100-year ARI weir has a constant crest height of 22.858 (AUK46), and a length of 412m.

The outflow weir has a varying crest height, as shown in Figure 2-10.

Note a label on M-C4605 drawings states that the 22.47m AD (NZVD2016) section of bund is 20m long, however the geometry length is close to 60m long. This difference results in a significant change in the performance of the bund. We have assumed that the geometry is correct, and that the label is wrong. This is shown as the second section of 22.758m AD (AUK46) weir in Figure 2-10.

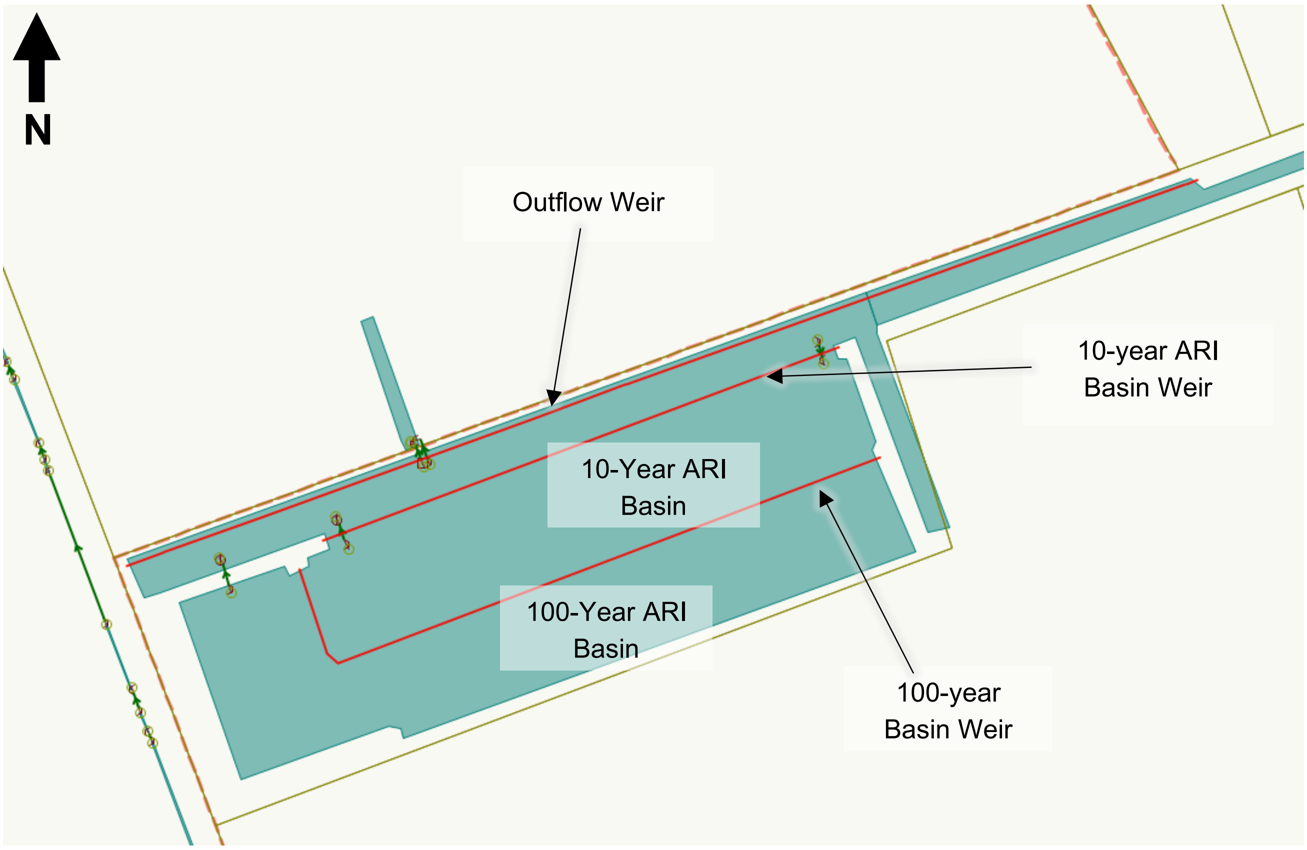

Figure 2-9: Location of weirs within pond 1.

Base linear structure (2D) : SUN_Pond1_BLS_OutflowWeir : Section data

	Offset (m)	X coordinate (m)	Y coordinate (m)	Crest level (m AD)	RTC Definition
1	0.000	1773404.779	5899233.847	23.000	
2	24.970	1773428.221	5899242.450	23.000	
3	25.945	1773429.153	5899242.737	22.758	
4	90.063	1773489.684	5899263.881	22.758	
5	90.248	1773489.858	5899263.943	22.708	
6	275.469	1773663.865	5899327.414	22.708	
7	275.749	1773664.128	5899327.508	22.758	
8	334.339	1773718.956	5899348.167	22.758	
9	334.493	1773719.102	5899348.217	22.888	
10	707.677	1774070.573	5899473.651	22.888	
11	708.350	1774071.212	5899473.864	23.000	
12	715.985	1774078.450	5899476.291	23.000	
*					

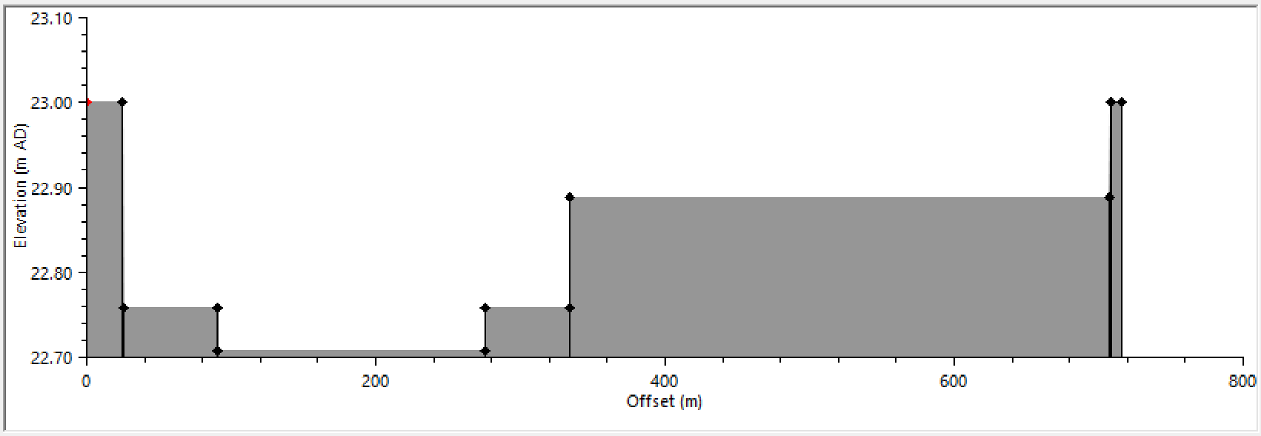

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Figure 2-10: Pond 1 Outfall weir profile.

2.2.4 POND 2

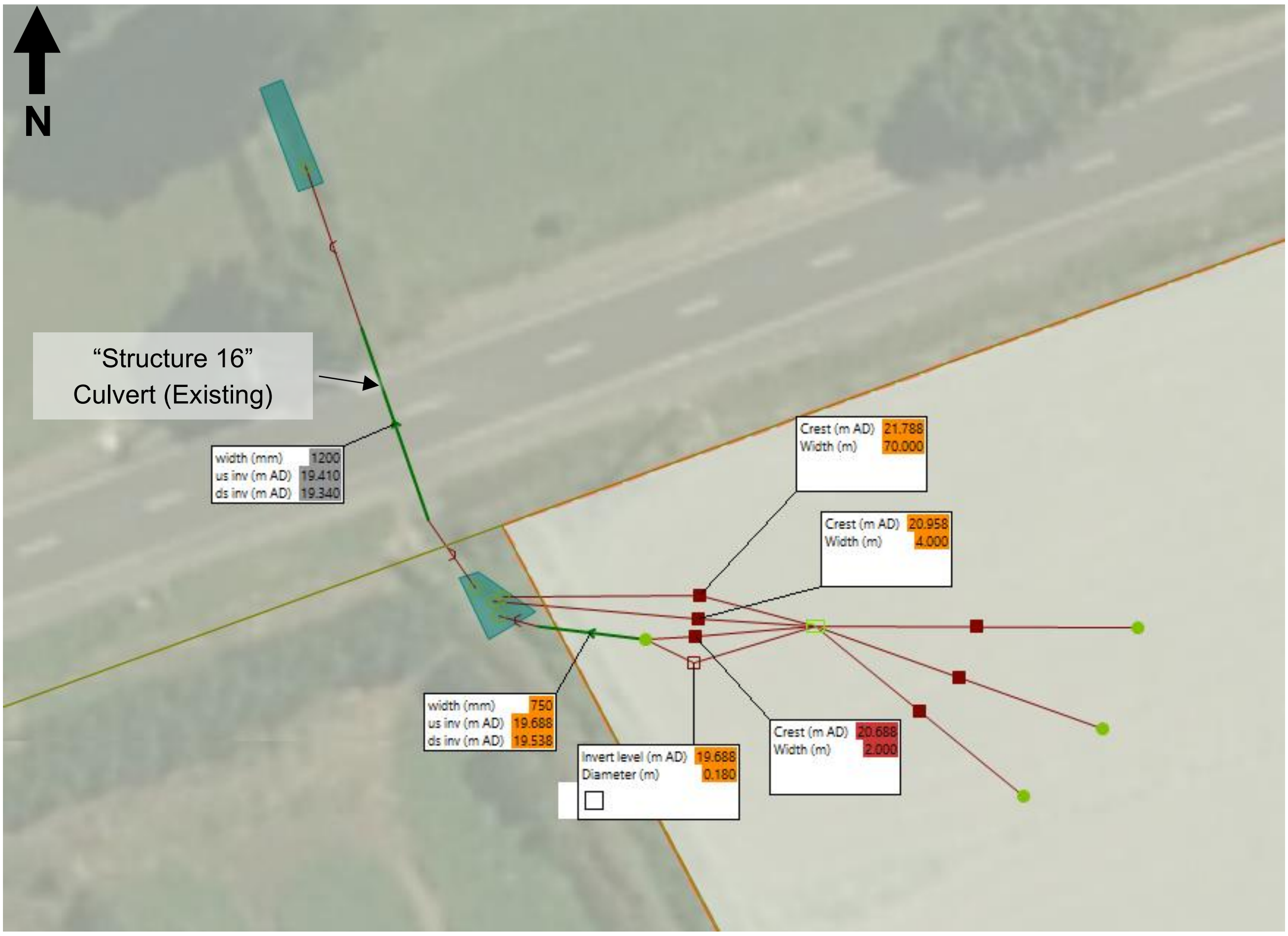

Figure 2-11: Pond 2 configuration in model. Orange flagged values are from Sunfield SWMP (with datum conversion). Red flagged values are inferred/assumed. Grey flagged values are from survey.

The pond 2 base width was digitized from the applicant's engineering plans (M-C4500). We have assumed that the extent shown on the plan is the PWL of the ponds, aka the invert of the pond. We have assumed a 1:4 side slope for this pond.

	Level (m AD)	Area (m2)
1	19.688	10984.60
2	21.788	14829.87
3	23.000	14829.87

Figure 2-12: Pond 2 stage table

The pond 2 lowest outlet is below the model grid level in the surrounding area. We have included the downstream existing culvert (known as the "structure 16" culvert in the provided open drain survey data), which is lower than the pond 2 outfall. However, the open drain in the model downstream of the existing culvert is based only on LiDAR. As the ground surface recorded in the ground model is higher than the pond 2 invert the pond is unable to drain fully after a rain event. Pond 2 does not drain below ~800mm depth (38% of the pond maximum depth). This limitation will likely result in a lower level of service for the proposed basins.

2.2.5 POND 3

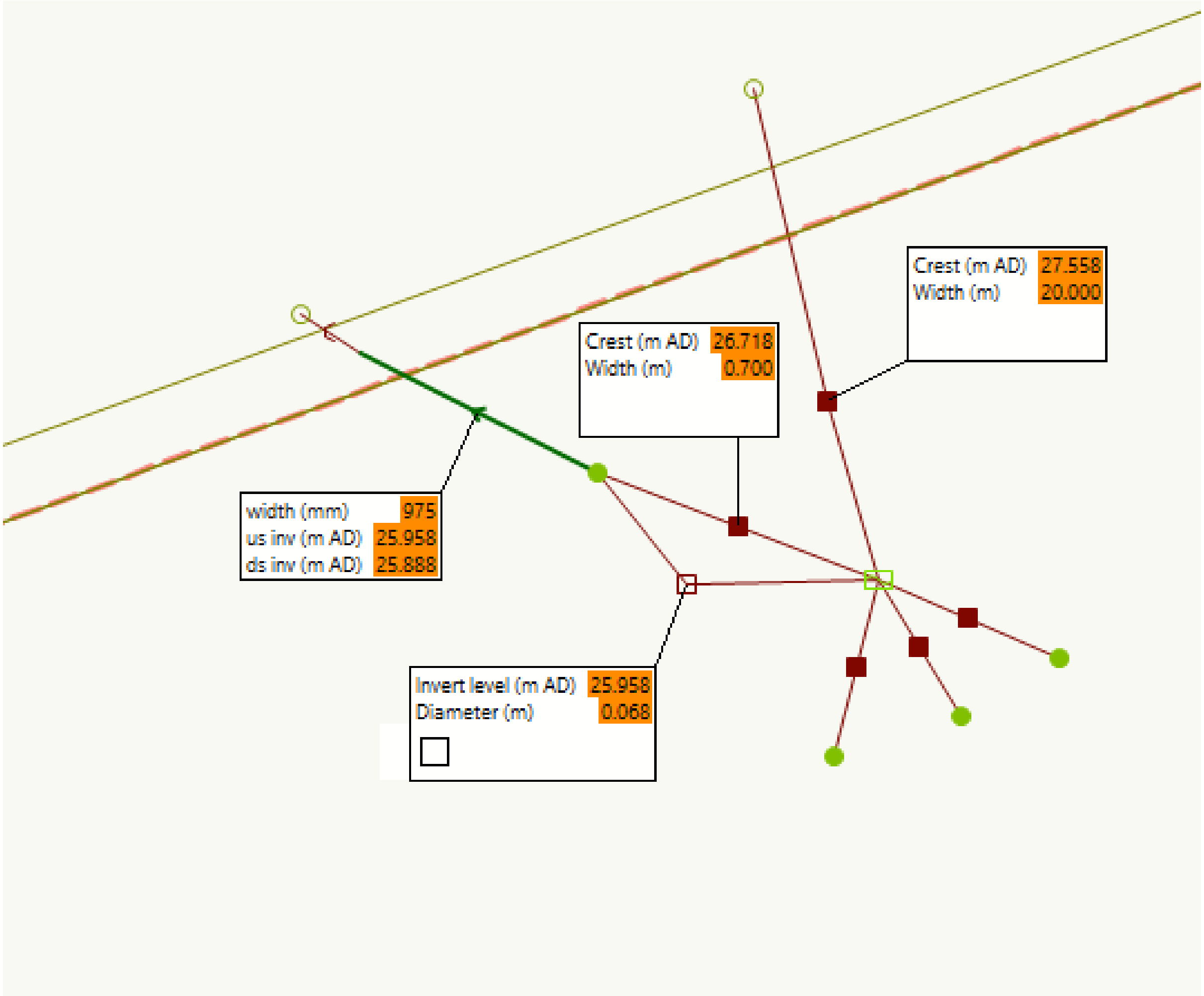

Figure 2-13: Pond 3 configuration in model. Orange flagged values are from Sunfield SWMP (with datum conversion). Red flagged values are inferred/assumed.

The pond 3 base width was digitized from the applicant's engineering plans (M-C4500). We have assumed that the extent shown on the plan is the PWL of the ponds, aka the invert of the pond. We have assumed a 1:4 side slope for this pond.

	Level (m AD)	Area (m2)
1	25.958	1415.70
2	27.558	2535.39
3	28.000	2535.39

Figure 2-14: Pond 3 stage table

The pond 3 lowest outlet is below the model grid level in the surrounding area. As the ground surface is higher than the pond 3 invert the pond is unable to drain fully after a rain event. Pond 3 does not drain below ~550mm depth (34% of the pond maximum depth). This limitation is unlikely to have a significant impact on the peak flow through the ponds, but it does mean that slightly too much volume will be detained in the model.

The applicant's plans shown an existing DN300 culvert under Airfield Road, however no data was available for this culvert so we could not add it to our model.

2.2.6 GENERAL POND ASSUMPTIONS

The following assumptions were applied to all 3 proposed ponds:

- We have used a discharge coefficient of 0.88 on all orifices.
- For the 1d weirs used on ponds 2 and 3, we have assumed a discharge coefficient of 0.85.
- Culvert pipe roughness: CW roughness of 1.5mm used.
- All outfalls from ponds had their 1D-2D linkage basis set to “elevation” in model.

2.2.7 POST DEVELOPMENT GROUND SURFACE

We have assumed there is no flooding within the Sunfield development, and no additional storage apart from ponds 1,2,3 and the diversion channel. This assumes that the internal design and proposed re-grading of land within Sunfield will be designed to convey flows to the detention ponds for all modelled scenarios.

In the model we have prevented any ponding from occurring within Sunfield development by setting all areas of Sunfield site to a nominal elevation of 50m. This was done to prevent any overland flow from outside the site from entering the site. The only location where outside overland flows are allowed into the development area is into the diversion channel along Hamlin Road.

2.2.8 POST DEVELOPMENT LAND USE

We have used a post development impervious areas and percentages as described in the 3WSR. The extents of each land use are shown in Figure 2-15, with the impervious cover shown in Figure 2-16.

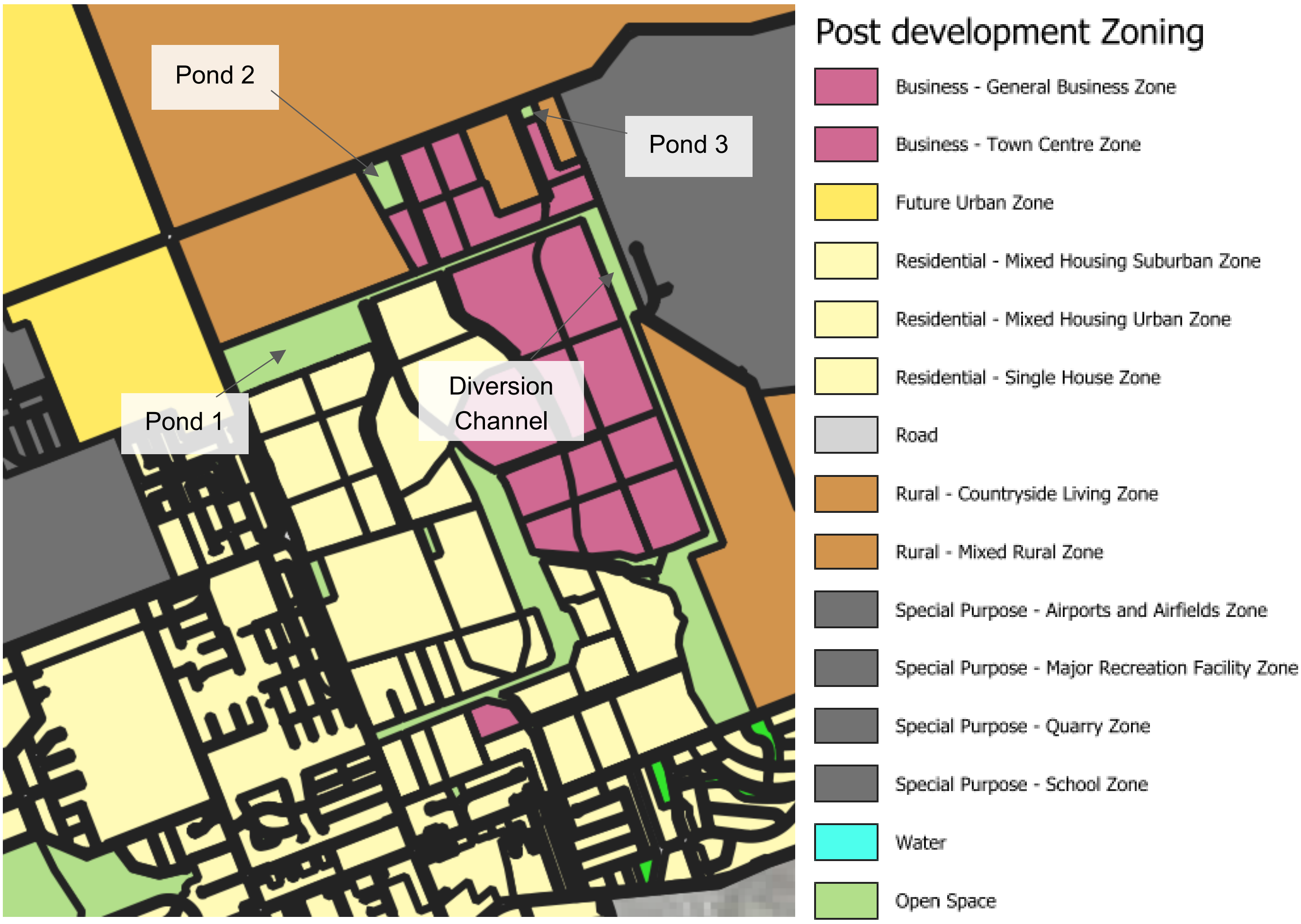

Figure 2-15: Post development proposed land uses reproduced form 3WSR, reproduced from page 225 of the 3WSR.

Zone	Impervious %
Commercial, Town Center	100
Industrial	90
Residential, retirement village	60
Road	85
Open space	10
SW channel (Awakeri Wetlands)	10

Figure 2-16: Post development proposed land uses impervious cover, reproduced from page 108 of the 3WSR.

2.3 MPD BASELINE SCENARIO

We created a maximum probable development (MPD) scenario to represent a potential future state of development incorporating the wider catchment area. Other development areas were included to create a baseline for comparison, so that the impact of the Sunfield development on existing flood hazard could be analysed relative to a plausible future scenario.

The MPD scenario follows the same approach used in previous Papakura Stream modelling, where imperviousness is set to the greater of either the existing imperviousness or that permitted by the Auckland Unitary Plan, with the exception of specific development areas where future urban areas are either consented, the subject of a current application, or planned (i.e. FUZ).

The following specific development areas were identified:

- Sunfield development modelled as per received documents (Section 2.2)
- Alfriston Structure Plan Area (Section 2.3.1)
- Ardmore Airport (Section 2.3.2)
- Future Urban Zone (FUZ) (Section 2.3.3)
    - FUZ between Alfriston and Randwick Rise and Popes Road assumed to not fully develop.
    - FUZ south of Popes Road assumed to fully develop.

Note: This modelling work does not analyse the impacts of these other development, and inclusion in this modelling work does not constitute any implied acceptance of any proposed elements of ongoing plan changes.

Figure 2-17 shows the different areas the MPD assumptions were applied to. Additionally for the Ardmore Airport and FUZ area south of Popes Road we assumed these areas would have detention ponds so that the post-development flow does not exceed the pre-development flow (refer to Section 2.3.4).

Future imperviousness was based on the recommended (rather than upper) values in *Appendix 4: Recommended Impervious Coverage for Auckland Unitary Plan Zones* from the *Stormwater Modelling Specifications (Final Issue 1)* (AC, December 2023).

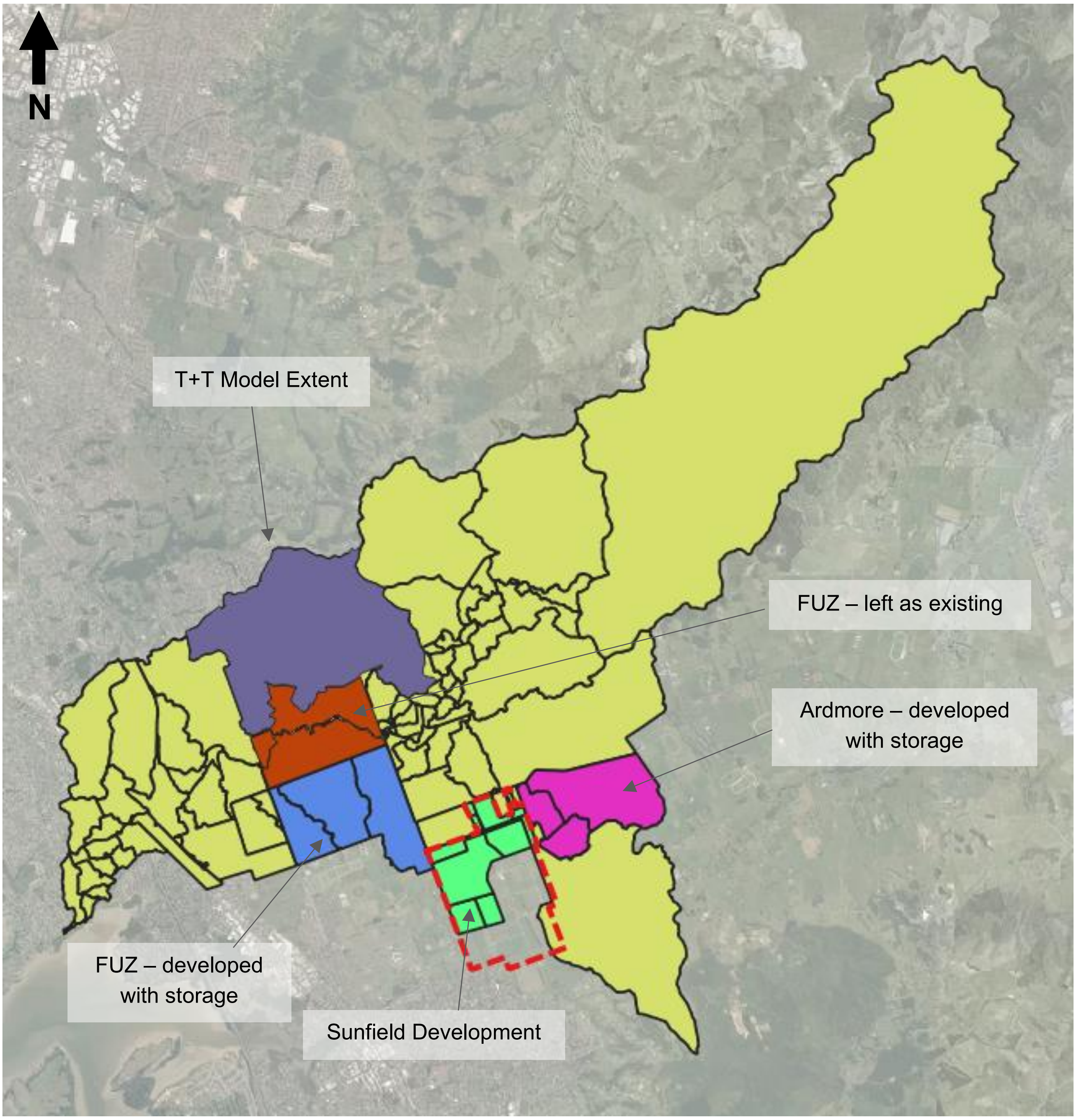

Figure 2-17: Overview of MPD land use changes modelled.

2.3.1 ALFRISTON STRUCTURE PLAN AREA

As part of two private plan changes within the FUZ (as well as some land to the east of Mill Road), a structure plan was submitted to council.

Tonkin + Taylor (T+T) previously developed storage and attenuation for the proposed developments at Alfriston and Randwick Rise. We replaced the subcatchments for this area in our Papakura Stream catchment model with the attenuated outflows from the T+T HEC-HMS model.

It is important to note that the incorporation of this structure plan modelling results is intended to allow for future development based on readily available information. It does not constitute acceptance by Council of the stormwater management strategies presented either the private plan change applications in this area, or the structure plan itself. This modelling work does not analyse the impacts of these other development on flood hazard.

With Councils permission, we re-ran the HEC-HMS model (using software version 4.12) for the same ARI and climate change events that the inflows would be applied to in our model. The scenarios were:

- TP108_2y_2p1_24h_TPD
- TP108_10y_2p1_24h_TPD
- TP108_100y_3p8_24h_TPD

The: “PostDevMinPondsTakaniniManagementAreaA” version of the model was used.

We had to make some minor changes to the T+T HEC-HMS model so that it would run. Elevation-storage tables “Pond1a_TP_Storage” and “Pond12_TP_Storage” had duplicated rows which prevented the model from running. We resolved this by deleting the duplicated rows in the elevation-storage tables as shown by the example in Figure 2-18.

ERROR 41557: Values in elevation-storage table "Pond1a_TP_Storage" are not ascending for reservoir "Pond 1a".
ERROR 41557: Values in elevation-storage table "Pond12_TP_Storage" are not ascending for reservoir "Pond 12".
ERROR 40052: Found "2" errors in basin model "Takanini".
WARNING 15303: Aborted run "TP108_100y_3p8_24h_TPD" at time 25Jun2025, 13:38:21.

HEC-HMS error message

Paired Data | Table | Graph

Elevation (M)	Storage (1000 M3)
18.78	0.0000
21.78	2.6000
30.00	15.0000
30.00	30.0000
30.00	30.0000
30.00	30.0000
30.00	30.0000
30.00	30.0000

Received model

Paired Data | Table | Graph

Elevation (M)	Storage (1000 M3)
18.78	0.0000
21.78	2.6000
30.00	15.0000
30.01	30.0000

Our change (duplicate rows deleted)

Figure 2-18: HEC-HMS error message and elevation-storage tables

Table 2-1 shows our comparison between the rainfall depths in the T+T HEC-HMS model to our values. The rainfall depths are slightly different (at most 6 mm difference for the 2-year event) but match well between the two models.

Table 2-1: Comparison of rainfall depths in the WSP ICM model and T+T HEC-HMS model

Rainfall Event	Rainfall Depth (mm)	
	ICM Model – Rural Profile	T+T HEC-HMS Model
2-year 2.1°C climate change	82	88
10-year 2.1°C climate change	164	166
100-year 3.8°C climate change	293	293

Figure 2-19 shows where we loaded the outflows from the T+T HEC-HMS model into our model.

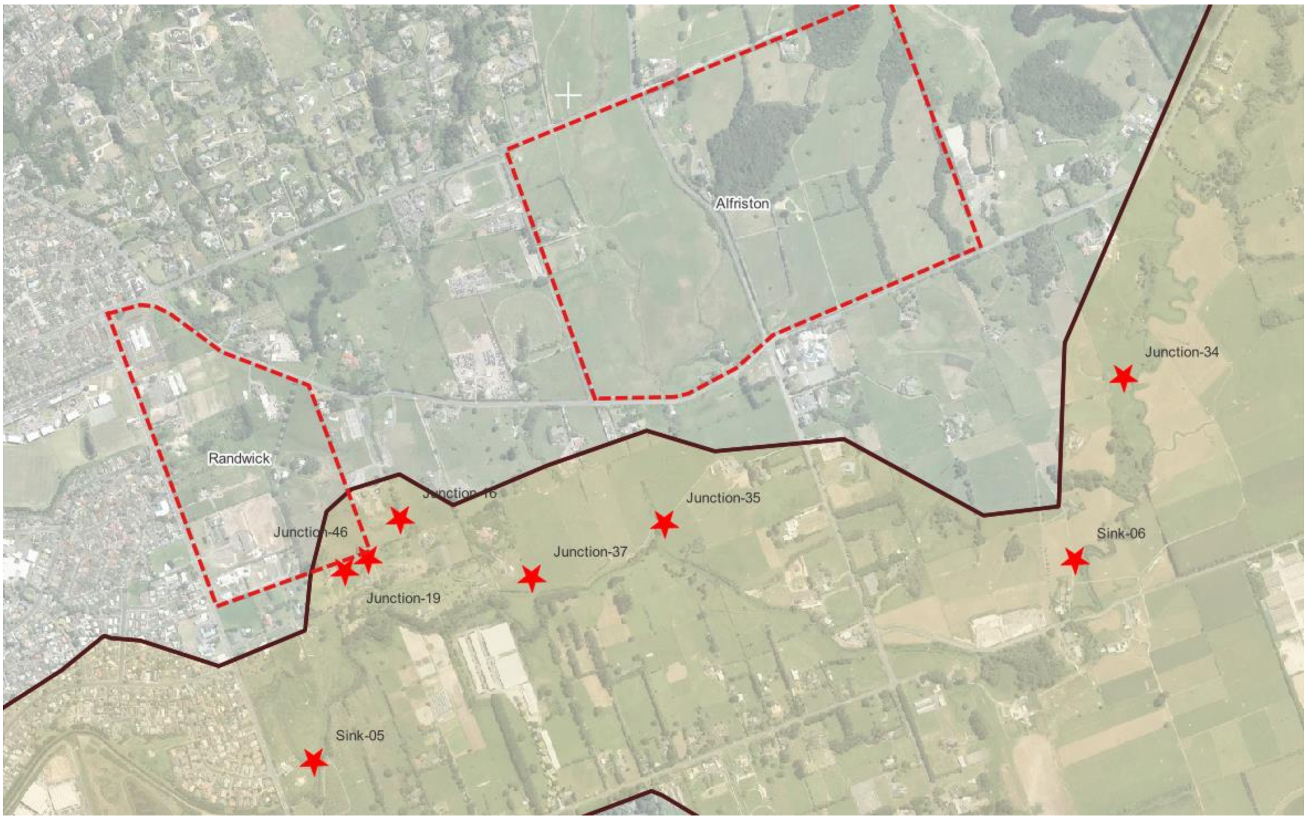

Figure 2-19: Loading points for T+T HEC-HMS model into the ICM model.

2.3.2 ARDMORE AIRPORT DEVELOPMENT

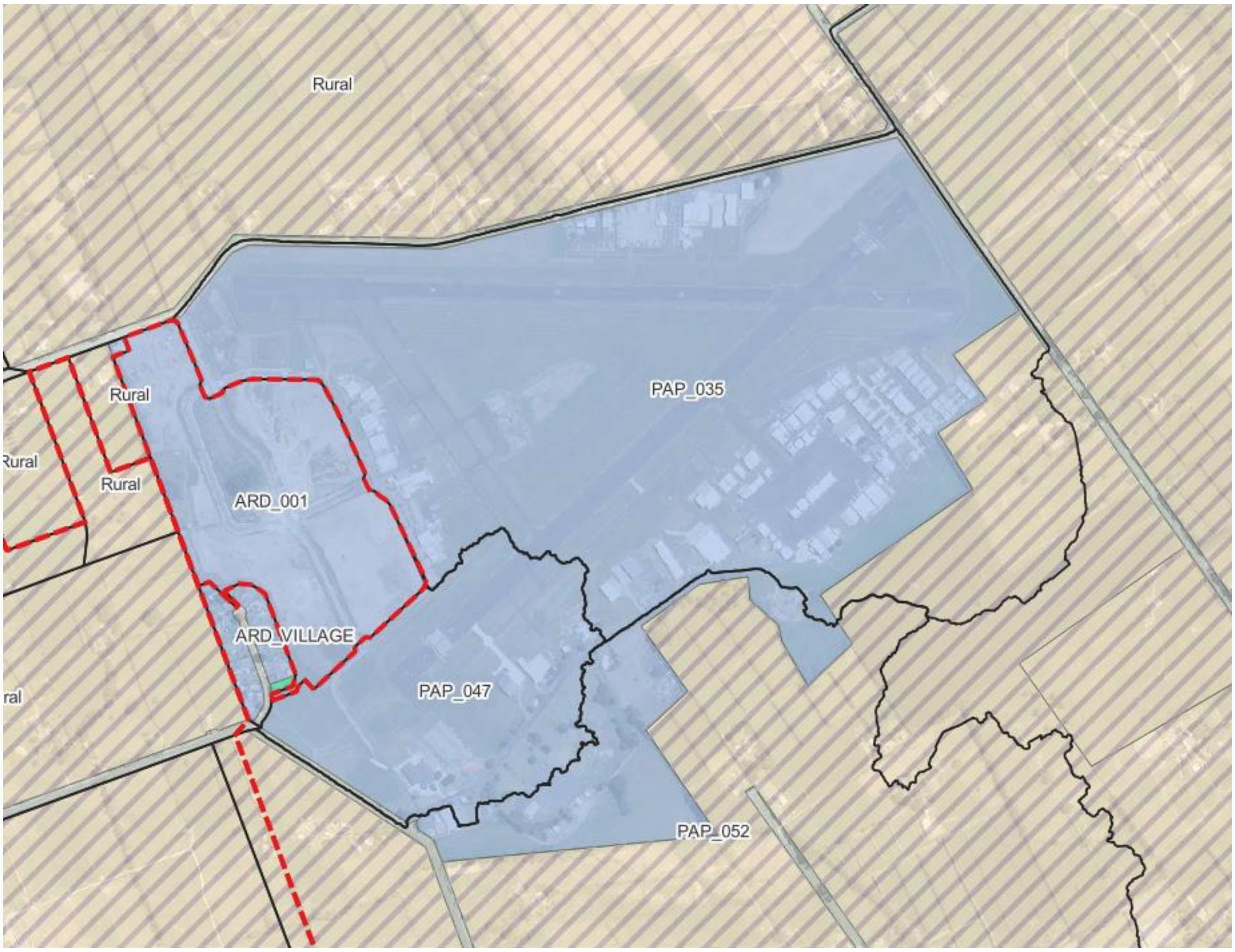

Figure 2-20: Zoning around Ardmore airport. Blue zone indicates Airport zone. Remaining areas are rural mixed zone.

The existing model subcatchments were updated with the airport zoned area set to 80% impervious, and rural areas set to 10% impervious. The affected subcatchments are those intersecting with the blue area shown in Figure 2-20. This resulted in the final impervious percentages shown in Table 2-2.

Table 2-2: MPD percentage impervious for subcatchments around Ardmore airport

Subcatchment	MPD - % Impervious	MPD - % Pervious
ARD_001	80.0	20.0
ARD_VILLAGE	68.0	32.0
PAP_035	70.0	30.0
PAP_047	79.0	21.1
PAP_052	12.8	87.2

2.3.3 FUTURE URBAN ZONE

Some areas between Porchester Road and Mil Road in the Papakura Stream catchment are zoned as Future Urban Zone (FUZ). For this analysis we have assumed that:

- The FUZ area between Alfriston/Randwick Rise and Popes Road will either maintain current impervious coverage or increase to a maximum of 10% as per Rural zoning, as this area is fully within the Papakura Stream floodplain.
- The FUZ area south of Popes Road (Figure 2-21) may feasibly develop to a maximum of 70% impervious.

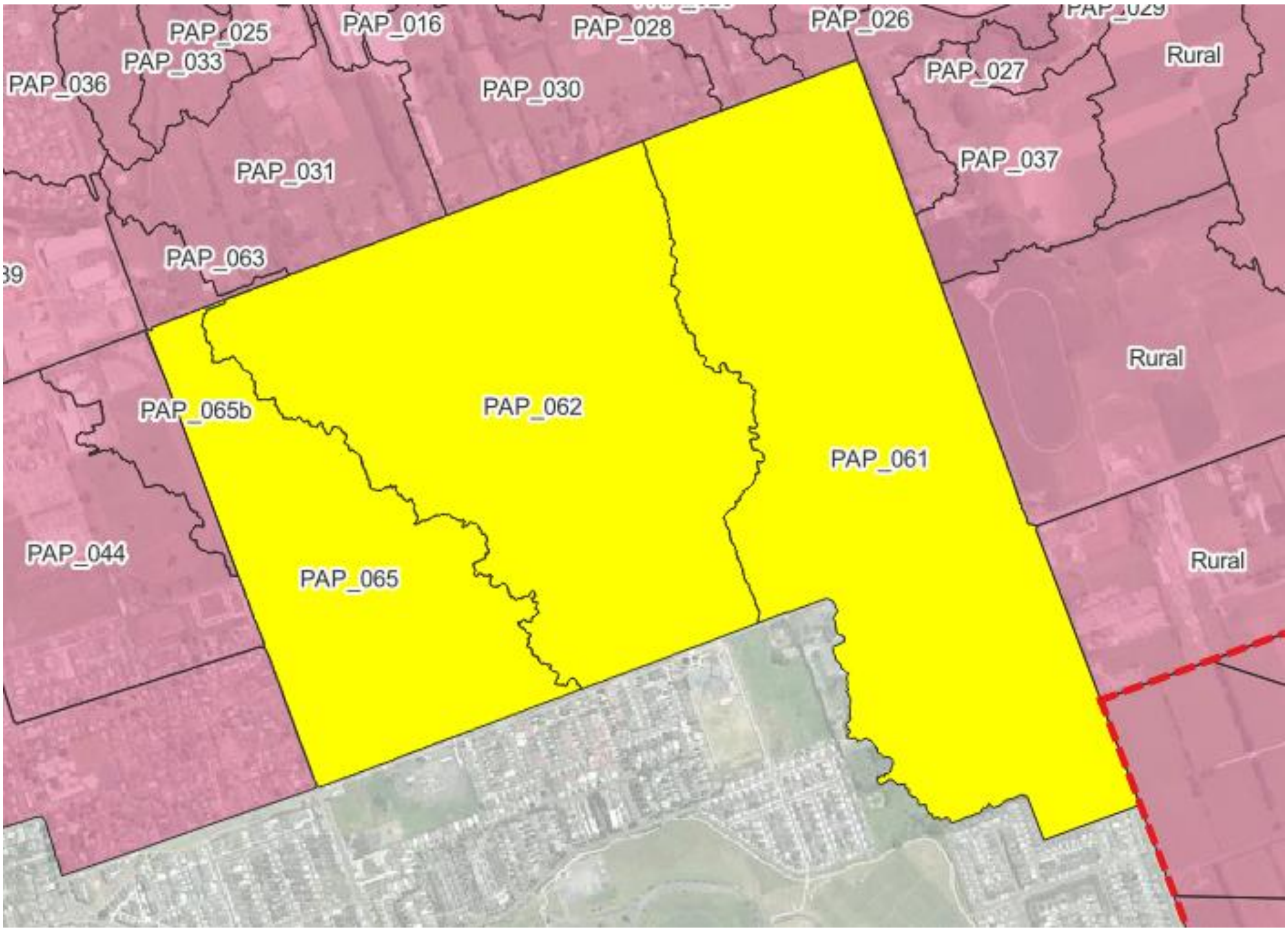

Figure 2-21: Future Urban Zone south of Popes Road in the Papakura Stream catchment model

2.3.4 ARDMORE AND FUZ PONDS SIZING

The three primary sub catchments of Ardmore and the three developed FUZ subcatchments were modelled with indicative ponds to restrict future runoff flows to a pre-development level.

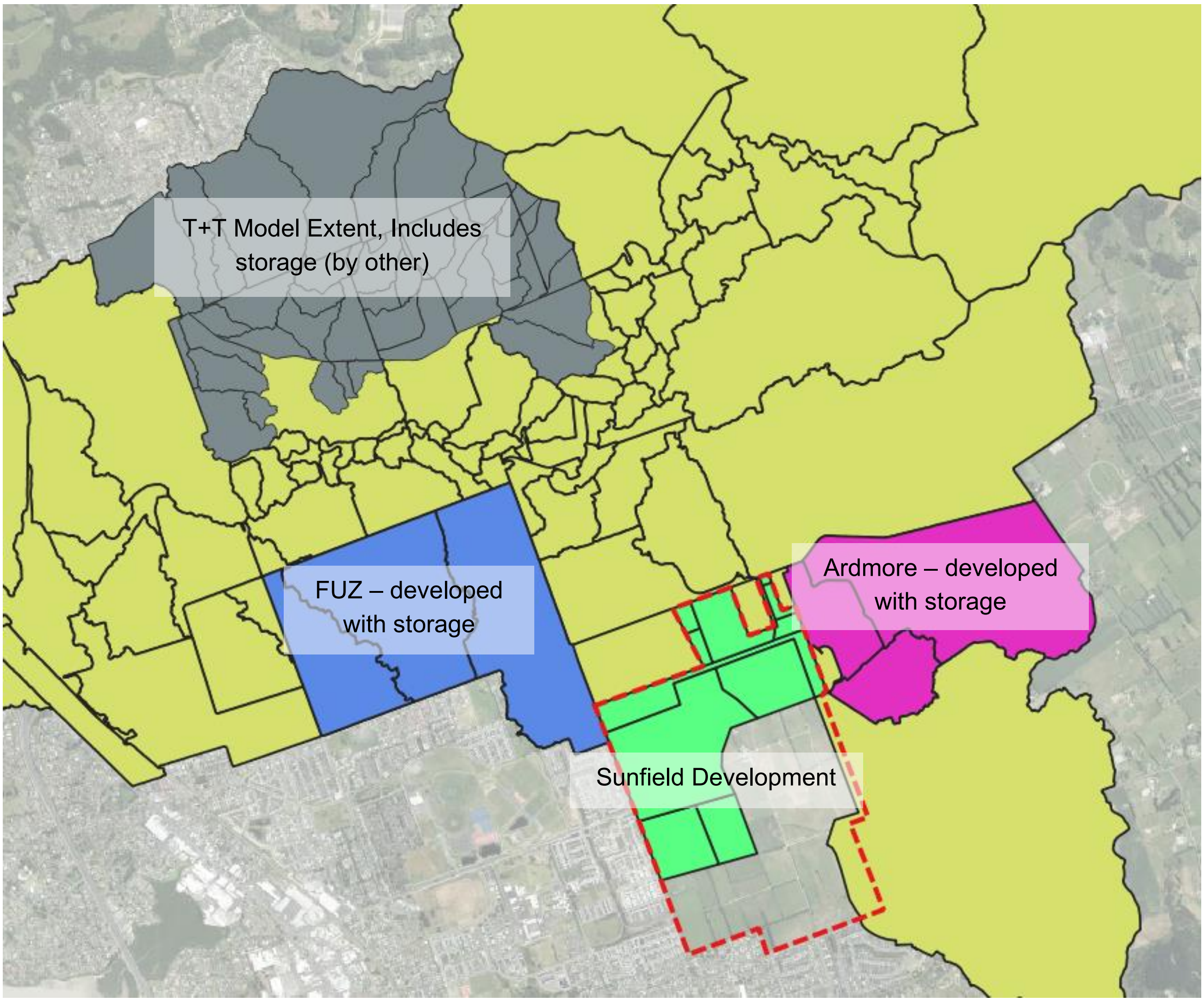

Figure 2-22: Subcatchments that had indicative storage added in the MPD scenario (FUZ and Ardmore).

Pond Sizing Method:

The following points summarise the criteria used to size ponds for the areas indicated in Figure 2-22:

- Size pond such that there is no increase in runoff in 10-year or 100-year ARI with CC TP108 rainfall event. Increase relative to the existing development
- Assumed CN61 for both pre and post development options.
- Only considered 10-year ARI 2.1CC and 100-year ARI 3.8CC (TP108 nested storms only)
- All ponds sized to limit depth to less than 1.5m.
- Ponds assumed to be square with 1:4 side slope.

Ponds were all sized from a standard template, with two orifices. The first at 0.0m elevation and the second at 0.9m elevation. An emergency spill weir was added at 1.5m elevation.

In the 10-year ARI event the lower orifice is sized to limit discharge to the greenfield peak flow, and set a maximum water level between 0.8 and 0.9 m.

In the 100-year ARI event the 2nd orifice is sized to limit discharge to the greenfield peak flow, and set a maximum water level below 1.5m

Ponds were sized using standard WSP pond staged sizing spreadsheet. Used ICM subcatchment hydrographs for as pre and post development flows.

Table 2-3: Indicative pond sizing applied to Ardmore and FUZ in MPD scenario

Location	Subcatchment	Orifice 1 Diameter (m) (at pond invert)	Orifice 2 Diameter (m) (at 0.9m depth)	Bottom Area (m^2)	Top Area (m^2) (At 1.5m elevation)
Admore	ARD_001	1.8	1.8	9,000	10,174
Admore	PAP_035	9	5	30,000	32,114
Admore	PAP_047	1.8	1	7,000	8,040
FUZ	PAP_065	2	2.2	14,000	15,456
FUZ	PAP_062	3.1	4	35,000	37,281
FUZ	PAP_061	2.7	2.7	40,000	42,436

Note these ponds and orifices are sized purely to limit flows. The orifice sizes are not feasible in practice and therefore further work is required to confirm the actual pond sizing required.

Implementation of ponds in MPD scenario:

To facilitate free flow discharge conditions all ponds were set at nominal 50m elevation (i.e. so downstream water levels do not influence pond sizing and discharge assumptions).

Orifices were modelled as screw pumps with specified head discharge curves. This was done to overcome model limitations. The head discharge table copied into ICM model from T-WED 109 Stormwater Routing Model for each pond/orifice configuration.

2.4 DESIGN RAINFALL

Two types of rainfall patterns were used in the analysis of potential changes to downstream flood hazard due to development.

- Homogenous; and
- Spatially Varying

Homogenous rainfall is in line with the current modelling specifications for flood hazard models, and is typically used to analyse maximum flows and hence flood hazard in this catchment.

Spatially varying rainfall scenarios are also included, with the intention of identifying rainfall distributions (which are considered equally likely to occur as a homogenous event) where the proposed development is expected to have a higher relative increase in predicted flood hazard.

These two rainfall approaches are presented in Sections 2.4.1 and 2.4.2.

2.4.1 HOMOGENEOUS RAINFALL

The homogenous rainfall (i.e. rainfall applied uniformly across the catchment) events were applied with two rain zones, as shown in Figure 2-23. This was done since due to the size of the catchment there is some variation in the rainfall depths between the upper and lower reaches.

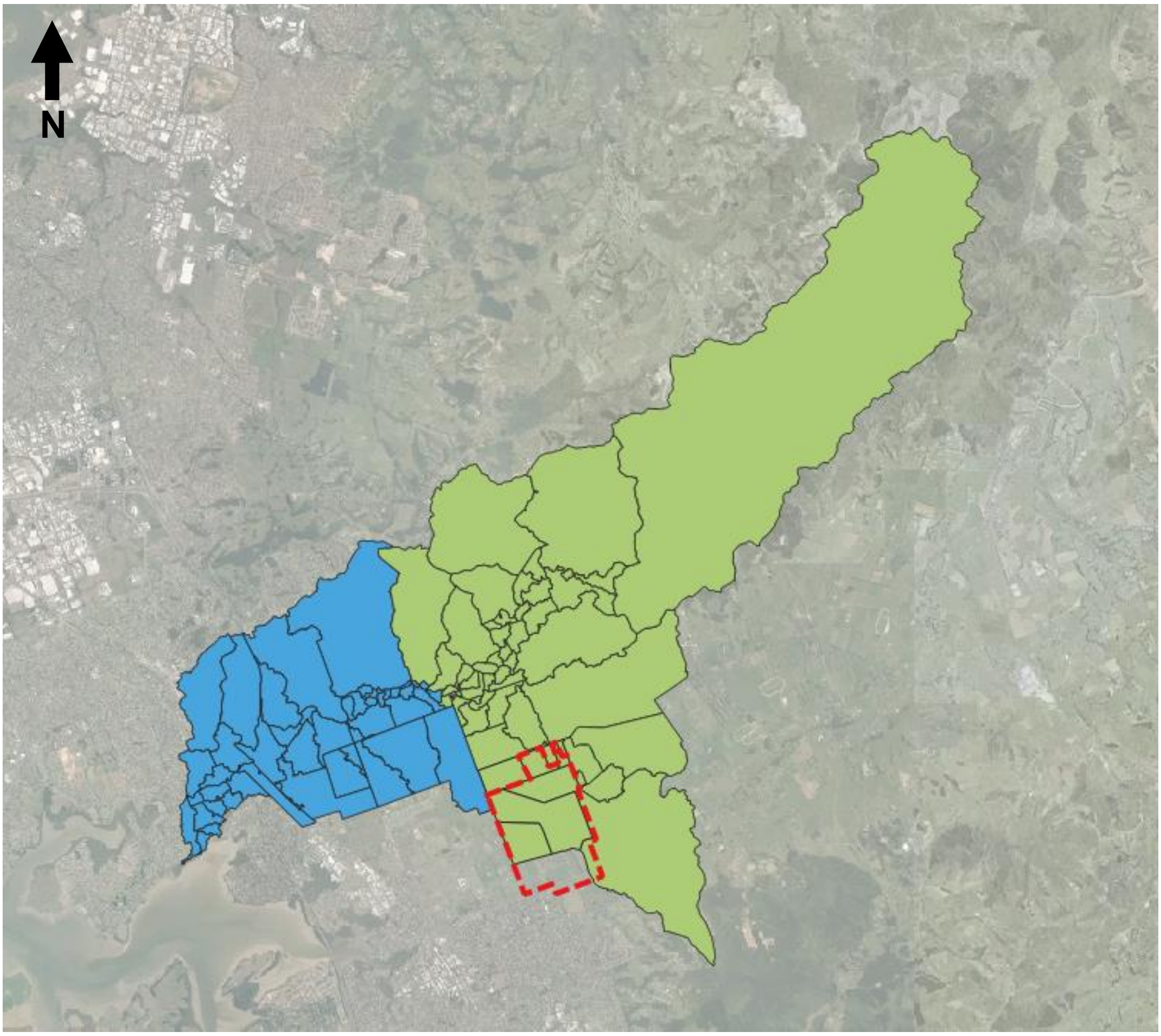

Figure 2-23: Urban vs Rural rainfall profile areas as applied in the Papakura ICM model (Blue = Urban, Green = Rural).

The climate change temperature increases we used were as per Section 4.2.11 of The Auckland Code of Practice for Land Development and Subdivision Chapter 4: Stormwater Version 4.0 (AC, July 2025) (hereafter referred to as the CoP):

- 2.1°C for the 2- and 10-year ARI events
- 3.8°C for the 100-year ARI event.

This corresponds to the percentage increases in rainfall depth shown in Figure 2-24.

Annual exceedance probability (AEP)	Percentage Increase in 24-hour design rainfall depth due to future climate change – 2.1°	Percentage Increase in 24-hour design rainfall depth due to future climate change – 3.8°
50%	15.1%	27.4%
20%	16.4%	29.6%
10%	17.0%	30.8%
5%	17.2%	31.2%
2%	17.6%	31.9%
1%	18.1%	32.7%

Figure 2-24: Percentage increase in TP108 24-hour design rainfall depth (Table 1 from the CoP)

We used the same historic rainfall depths as the previous modelling and adjusted these for climate change. Table 2-4 shows the design rainfall depths used for this analysis.

Table 2-4: Design rainfall depths

ARI	Historic Rainfall Depths		Climate Change Temperature Increase	Climate Change Rainfall Depths	
	Urban	Rural		Urban	Rural
2 Yr	71 mm	71 mm	2.1°C	82 mm	82 mm
10 Yr	135 mm	140 mm	2.1°C	158 mm	164 mm
100 Yr	213 mm	221 mm	3.8°C	282 mm	293 mm

We used the TP108 normalised 24-hour temporal rainfall intensity profile from Table 2 of the CoP, reproduced in Table 2-5.

Table 2-5: TP108 Normalised 24-hour temporal rainfall intensity profile (Reproduced from CoP v4 table 2)

Time (hrs:mins)	Time Interval (min)	TP108 Normalised Rainfall Intensity (I/I24)		
		Historic Climate	**Future Climate change – 2.1°C**	**Future Climate change – 3.8°C**
0:00 – 6:00	360	0.34	0.29	0.27
6:00 – 9:00	180	0.74	0.69	0.66
9:00 – 10:00	60	0.96	0.89	0.85
10:00 – 11:00	60	1.40	1.40	1.40
11:00 – 11:30	30	2.20	2.30	2.36
11:30 – 11:40	10	3.80	4.14	4.35
11:40 – 11:50	10	4.80	5.23	5.50
11:50 – 12:00	10	8.70	9.49	9.97
12:00 – 12:10	10	16.20	17.66	18.56
12:10 – 12:20	10	5.90	6.43	6.76
12:20 – 12:30	10	4.20	4.58	4.81
12:30 – 13:00	30	2.90	3.08	3.20
13:00 – 14:00	60	1.70	1.75	1.77

Time (hrs:mins)	Time Interval (min)	TP108 Normalised Rainfall Intensity (I/I24)		
		Historic Climate	**Future Climate change – 2.1°C**	**Future Climate change – 3.8°C**
14:00 – 15:00	60	1.20	1.16	1.14
15:00 – 18:00	180	0.75	0.72	0.7
18:00 – 24:00	360	0.40	0.36	0.34

Comparison with rainfall used in Sunfield 3W strategy report:

Sunfield falls within "rural" section of catchment in our model, so comparing the "rural" rainfall depths with the values used in the Sunfield 3WSR:

ARI	Historic Rainfall Depths		Climate Change Rainfall Depths	
	WSP – Rural Profile	**Sunfield 3WSR**	**WSP – Rural Profile**	**Sunfield 3WSR**
2 Yr	71 mm	75 mm	82 mm	86 mm
10 Yr	140 mm	145 mm	164 mm	170 mm
100 Yr	221 mm	225 mm	293 mm	298 mm

The rainfall depths used are all within 5mm, and based on rounding + variance of location selected, these rainfall depths are in alignment, so there we find no issue with the rain depths used in the Sunfield 3WSR.

2.4.2 SPATIALLY VARYING RAINFALL

We considered a variety of spatially varying rainfall events. The rainfall spatially varying rainfall events consists of the full rainfall depth applied in the downstream part of the catchment, with 50% of the event rainfall depth being applied in the upper part of the catchment. The boundary between these two zones was varied, as shown in Figure 2-25.

The intention of this is to analyse potential conditions where the attenuated flow from the development coincides with flows from upstream (specifically areas which will have a similar time of concentration to the attenuated peak flows).

Not all these rainfall options result in useful comparisons for the analysis of the changes in flood hazard due to the Sunfield development. Results are only presented for the spatially varying rainfall where the split is at the Alfriston-Ardmore Rd line shown in Figure 2-25. In this scenario the Sunfield development, as well as the upstream rural catchment flowing through the Sunfield diversion channel, receive 100% of the rainfall depth. The area to the north of Alfriston-Ardmore Rd receives 50% of the rainfall depth. In this scenario peak flow from the rural area is more aligned with the attenuated peak discharge from the basins, which is expected to highlight potential changes in flood hazard due to the Sunfield development.

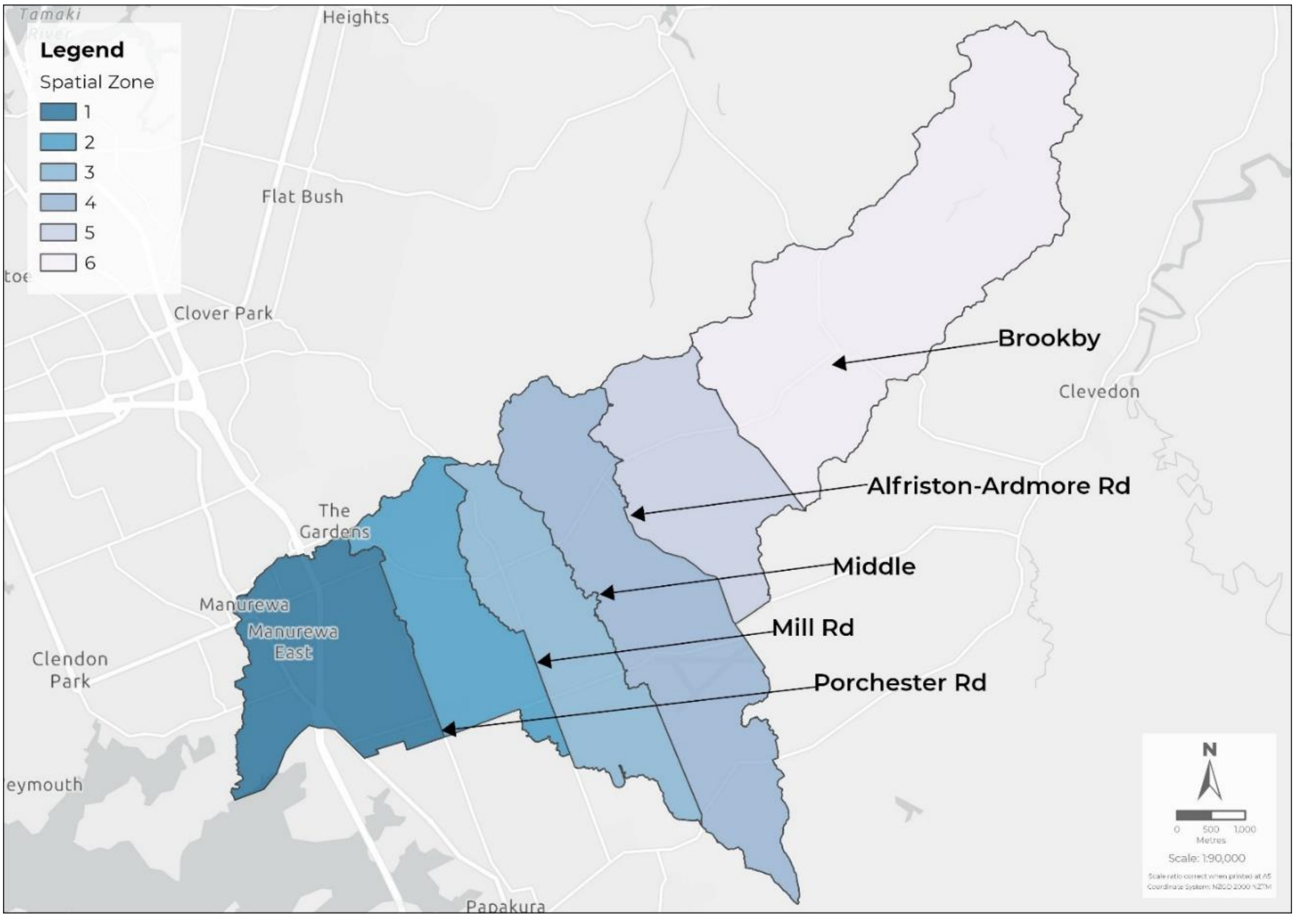

Figure 2-25. Locations where spatial split between 50% and 100% rainfall was considered.

3 MODELLED SCENARIOS

We modelled scenarios based on the combination of three parts: development, ARI, and peat CN. The values for each part are listed in Table 3-1.

Table 3-1: Scenario parts and values

Scenario Categories	Development	Rainfall	Peat CN
Current Development	**E** – Existing development **E+SUN** – Existing development with Sunfield	Rainfall ARI: • 2 Year (No CC) • 10 Year (No CC) • 100 Year (No CC) Homogenous rainfall	Lower Bound (CN 39) Group B Soil (CN 61) Group C Soil (CN 74) Upper Bound (CN 98)
Maximum Probable Development	**M** – Maximum probable development, not including Sunfield. **M+SUN** – Maximum probable development including Sunfield.	Rainfall ARI: • 2 Year (2.1°C), • 10 Year (2.1°C) • 100 year (3.8°C) homogenous rainfall	Lower Bound (CN 39) Group B Soil (CN 61) Group C Soil (CN 74) Upper Bound (CN 98)
Spatially Varying Rainfall	**M** – Maximum probable development, not including Sunfield. **M+SUN** – Maximum probable development including Sunfield.	Spatial Rainfall ARI: • 10 Year (3.8°C) • 100 year (3.8°C) Spatial variation: • 100% rainfall depth to Alfriston-Ardmore Rd	Lower Bound (CN 39) Group C Soil (CN 74)

This gave a total of 56 scenarios, as shown in Table 3-2.

Table 3-2: Total number of scenario runs done.

Scenario Categories	Development	Rainfall	Peat CN	Number of runs
Current Development	2	x3	x4	= 24
Maximum Probable Development	2	x3	x4	= 24
Spatially Varying Rainfall	2	x2	x2	= 8
			Total	= 56

3.1.1 DEVELOPMENT SCENARIOS

Four development scenarios were analysed:

E: Existing development, incudes base model updates (open drains and subcatchment updates). Refer to Section 2.1.2 for further details.

E+SUN: Sunfield development with no other proposed development included. Connectivity and attenuation devices reproduced from provided reports and engineering plans. Refer to Section 2.2 for further details.

M: Maximum probable development, not including Sunfield development. Refer to Section 2.3 for further details.

M+SUN: Maximum probable development including Sunfield development. The Sunfield development connectivity and attenuation devices are the same as in the "E+SUN" scenario.

Table 3-3: Changes in options compared to the Existing Development scenario

Scenario	Sunfield	Alfriston and Randwick Rise	Ardmore Development and Assumed Ponds	FUZ South of Popes Road and Assumed Ponds	FUZ North of Popes Road
ED Baseline	✗	✗	✗	✗	✗
ED+SUN	✓	✗	✗	✗	✗
MPD Baseline	✗	✓	✓	✓	✗
MPD+SUN	✓	✓	✓	✓	✗

3.1.2 TIME OF CONCENTRATION

Time of concentration (ToC) is recommended to be amended for very large events (i.e. greater than 1 in 10-year ARI) to represent the faster catchment response associated with larger events. This means for this study the ToC is reduced in the 100-year ARI event.

The ToC for catchments in 100-year ARI events was reduced by 33%. Note this reduction was only applied to the larger catchments in the model. The pre and post development subcatchments within the Sunfield development area did not have their ToC modified from the TP108 value.

3.1.3 PERVIOUS SURFACE CURVE NUMBERS

Based on a previous desktop analysis, there are two main classes of soil types within the Papakura Stream catchment:

- Soils over of Waitemata Group (sandstone / mudstone) geological formation
- Alluvial sediments over large areas of peat. For the purpose of this study, it is assumed that all of the alluvial type soils within the valley floor are over peat.

Waitemata Group:

For simplicity, A CN of 74 is applied to the non-peat areas of the catchment to represent typical antecedent moisture conditions, as per Auckland Councils latest modelling specification (for running design events).

Peat Soils:

While clayey soils associated with the Waitemata group sandstones / mudstones are reasonably typical across much of the Auckland Region, the Peat soils represent a significant source of uncertainty.

Available information on this area, indicates that the infiltration capacity being subject to seasonal variation based on the ground water levels. The following excerpts are provided:

- Auckland Council Technical Report 2013/040 (2013) identifies the Papakura Peat areas as having “Good” soakage potential.
- The Central Papakura Area ICMP (2016) states that “The groundwater level is reported to rise to the surface in winter in parts of the area (to be confirmed by monitoring) causing localised ponding”
- Plan change documents for the nearby Takanini area state that:
    - “Soakage test results indicate some of the highest soakage rates were found within peat areas”, but goes on to add “However, sample testing indicated the peat also had low permeability.”
    - Section 6.1: “Groundwater is seen to fluctuate throughout the year, with only minor seasonal variation. The reason for the small variance between summer and winter could be due to the anticipated high porosity of the peat (where water level fluctuations are within the peat) and/or low recharge rates, and needs to be further explored. For the most part the entire thickness of peat is saturated with the water table lying close to the upper boundary as stated in the PDP report3”

Due to the uncertainty associated with this soil type, a sensitivity approach was taken, using four different CN values. The CN for “Pasture” for Group B and Group C soils were tested, as well as upper and lower bound values for fully saturated and unsaturated soils. The Group B and Group C CN values taken from Table 3.3 of TP108 were 61 and 74 respectively. We adopted upper and lower bound values of 98 and 39 respectively. This effectively assumes that during wetter months that the water table is at or near the surface resulting in no infiltration in the peat. During the drier months, when the water table is typically lower, the infiltration potential is assumed to be very high. The curve numbers for peat areas are summarised in Table 3-4.

Table 3-4: Peat CN scenarios and corresponding curve number

Peat CN	Curve Number
Lower	39
Group B	61
Group C	74
Upper	98

It is acknowledged that this is a sensitivity-based approach only: it is not intended to be an accurate description of the peat soils seasonal infiltration capacity. Additional information may be sought to decrease this uncertainty including site survey of peat extents, infiltration testing, or review of soil moisture / water table variation.

The Peat soils represent a significant source of uncertainty, with several sources indicating the infiltration capacity being subject to seasonal variation based on the ground water levels. While not a comprehensive hydrological review, this variation appears to be confirmed by the validation / calibration results presented in Appendix A

4 ASSUMPTIONS AND LIMITATIONS

4.1 GENERAL

The following assumptions and limitations relate to all scenarios modelled as part of this analysis:

- The model simulations were run assuming all areas started dry. Consecutive events could result in greater flooding than predicted in this report if the network's storage retains water from previous rainfall.
- The following assumptions are for the open drains and culverts added to the model as part of this analysis (see Section 2.1.2):
  1. Only the open drains and culverts near the Sunfield development were added to the model. Drains and culverts considered to be non-critical for this analysis (primarily due to their distance from the Sunfield site) were not added to the model. This is unlikely to significantly change the pre/post development flood hazard results.
  2. Culverts were assumed to be in good condition without sediment or blockage. Actual maintenance conditions may differ, potentially reducing flow capacity compared to the model assumptions.
  3. Open drains were modelled in 2D with a rectangular cross section, with the invert set to match surveyed bottom-of-bank levels and with vertical walls.
  4. Due to the number of culverts and their limited influence during more extreme events, the 2D mesh ground levels were not set to match the 1D culvert invert levels; instead, the 2D mesh ground levels were as per the 2D rectangular representation of the open drains. This approach may lead to differences in the head applied to the culvert. The primary objective was to incorporate the culverts for conveyance during more frequent, less intense events (e.g. 2-year ARI). Other culvert assumptions, such as the absence of sediment or blockage, are considered to have a more substantial impact on model results.
  5. No baseflow was added to the open drains in the model. It was assumed that baseflow in these drains is small compared to stormwater runoff. For less frequent, high-intensity rainfall events (10-year ARI or higher), this is likely a reasonable assumption. However, for more frequent, low-intensity rainfall events (e.g. 2-year ARI), the baseflow in the drains may be comparable to stormwater runoff, and this assumption could lead to under-estimation of ponding for these events.
  6. When calculating ToC we have used the TP108 method, and assumed a CN of 74. The ToC is not adjusted based on the different peat CN values.

4.2 SUNFIELD DEVELOPMENT

Infrastructure

1. All proposed assets relating to the Sunfield development were digitised from PDF plans or 3WSR report. The applicant did not provide their model files or proposed ground model. Therefore we had to digitize the location and extents of proposed attenuation devices from the provided PDF plans.
2. Our model is built in the AUK46 vertical datum. We have assumed that the provided engineering plans are in NZVD2016. There is conflicting info shown on the applicant's engineering drawings, with most stating to be in NZVD2016, but some drawings labelled as AUK46. Given the flatness of the site, even the small differences between these datums can significantly affect hydraulic performance.

3. We have not included any storage within the Sunfield development site apart from the ponds and diversion channel.
4. Pond 1 and the diversion channel are modelled with vertical walls. The diversion channel does not include the side slope as we do not have the applicant’s proposed ground model.
5. Assumed no overland flow paths through site – notable towards pond 2 and 3 where existing overland flow from rural lots goes through Sunfield site.
6. Pond 1 we have assumed two separate outlets, being the SMAF orifice and Post Storm Drain down pipe.
7. Pond 1 box culvert – The box culvert inlet to the 10-year ARI basin of pond 1. This is a critical structure which controls how the pond will operate, whether it can perform as described and therefore whether the development is feasible from a stormwater perspective. The applicant did not provide details for this structure. We have assumed this is a box culvert at the invert of pond, with no flow controls (i.e. flap gates or similar).
8. Pond 1 weirs modelled as broad crested weirs, with 2m crest width in ICM hydraulic model.
9. Pond 1 outflow weir: Drawn as scaled from drawing M-C4605. A label on the drawings states that the 22.47m AD (NZVD2016) section of bund is 20m long, however the geometry length is close to 60m long. This difference results in a significant change in the performance of the bund. We have assumed that the geometry is correct, and that the label is wrong.
10. Ponds 2 and 3 base areas scaled from applicant’s drawings, with an assumed side slope of 1:4.
11. Ponds 2 and 3 lowest outlets are below the model grid level. This means that these ponds are unable to drain fully after the rain event. Pond 2 does not drain below ~800mm, and pond 3 does not drain below ~550mm. This limitation is unlikely to have a significant impact on the peak flow through the ponds, but it does mean that too much volume is being detained.
12. Ponds 5 and 6 areas not developed. The applicant does not include any details for proposed attenuation for these two ponds. Imperviousness for the Ponds 5 and 6 catchment set to match applicants modelling. Although these areas are shown as residential, these have been modelled as open space due to property acquisition issues so set to 10% impervious. See page 118 of the 3WSR. For these areas we are assuming peat soil as undeveloped.

Hydrology

13. A Post development pervious CN of 74 was adopted within the Sunfield development site. This was done regardless of pre-development peat CN used in each scenario to account for the impact of development on flood hazard (i.e. site fill and compaction).
14. We were unable to review the applicant’s model. We are therefore unable to fully review all of their proposed hydraulic and hydrological assumptions.
15. We have inferred the extents of the proposed land zoning has from images within the 3WSR report (page 225 of the 3WSR). The image within the 3WSR does not show much detail. We have not included any Commercial, Town Centre or Road zones within our model.
16. We have used the same impervious percentage values given in the 3WSR report for each zone.
17. We have assumed 10% impervious cover in the stormwater diversion channel, which may be a slight underestimate as water surfaces could have a higher runoff.

4.3 MPD SCENARIO

1. We have assumed 10% impervious cover in rural zoned areas (Mixed rural zone).
2. Assumed development of FUZ south of Papakura Stream is only south of Popes Road. The area between T+Ts Randwick/Alfriston HEC-HMS model and Popes Road is not developed. This area is fully within a flood zone, so we have assumed will be unlikely to be developed.
3. The T+T HEC HMS model results for Randwick/Alfriston only cover 24 hrs duration. This captures the peak rainfall (which occurs at 12:00 hrs), however does not fully represent drain down flows post rain event. In practice this is a minor issue we are mainly concerned with the peak depth in stream, and this occurs within the first 24 hrs.
4. We have included indicative storage devices for the MPD growth for Ardmore and the Southern FUZ area. These ponds were sized to restrict post development peak flows to the pre-development rate. These ponds are indicative only, and do not consider site conditions or any potential changes to subcatchment boundaries.
5. Ponds outflow orifices are set using screw pumps in model, with head discharge curves specified based on the orifices.
6. No future sea level rise has been included at downstream boundary of the model. The Sunfield development is elevated above sea level (~20+ m RL) so the impacts of sea level rise on the model results presented in this report are expected to be negligible.

4.4 LEGACY ASSUMPTIONS AND LIMITATIONS

Assumptions and limitations from previous modelling of the Papakura Stream catchment apply to this work. These legacy assumptions and limitations are included in Appendix A.

The most relevant legacy assumptions/limitations are:

1. 2D floodplain element levels are derived from the Auckland Council 2016 LiDAR dataset. Detailed topographic features such as kerb and channel, retaining walls, narrow channels are not expected to be represented in this model. This may result in different flow directions (especially for lower flow) than observed during actual flooding events.
2. The 1D stream channel cross sections are derived from the 2016 LiDAR. The representation of the low flow channel may result in reduced conveyance especially for low flow events, which would normally be contained within the low flow channel.
3. Subcatchment sizes are typically much larger than the range recommended by Auckland Councils' modelling specification. In some cases the peak flows may be sensitive to upstream attenuation, network connectivity etc, particularly for smaller events.
4. This model has been schematised to analyse flooding associated with the Papakura Stream, and has undergone high level calibration to improve the modelled response compared to gauged flow for selected historic events.
5. The runoff surface proportions within each subcatchment were based on the estimated proportion of peat and the impervious and pervious proportion based on current development and the Auckland Unitary Plan.

5 RESULTS

The results for all modelled scenarios are discussed below. Flood depth and flood depth difference maps for the peat CN61 scenarios modelled are provided in Appendix B.

5.1 CHECK OF UNMITIGATED SUNFIELD DISCHARGE

We tested the impact of the Sunfield development on flood hazard without the proposed attenuation devices. These runs were completed to confirm whether the development was predicted to increase flood hazard if the attenuation devices were not included. These results showed that without mitigation, the Sunfield development will increase peak flow and water level downstream of the development site. This confirms the need for the development to include attenuation of stormwater runoff.

5.2 IMPACT ON LOCAL FLOOD HAZARD

The local changes in flood hazard due to the Sunfield development are discussed here. The changes in flood hazard due to the Sunfield development in the Papakura Stream are discussed in section 5.3.

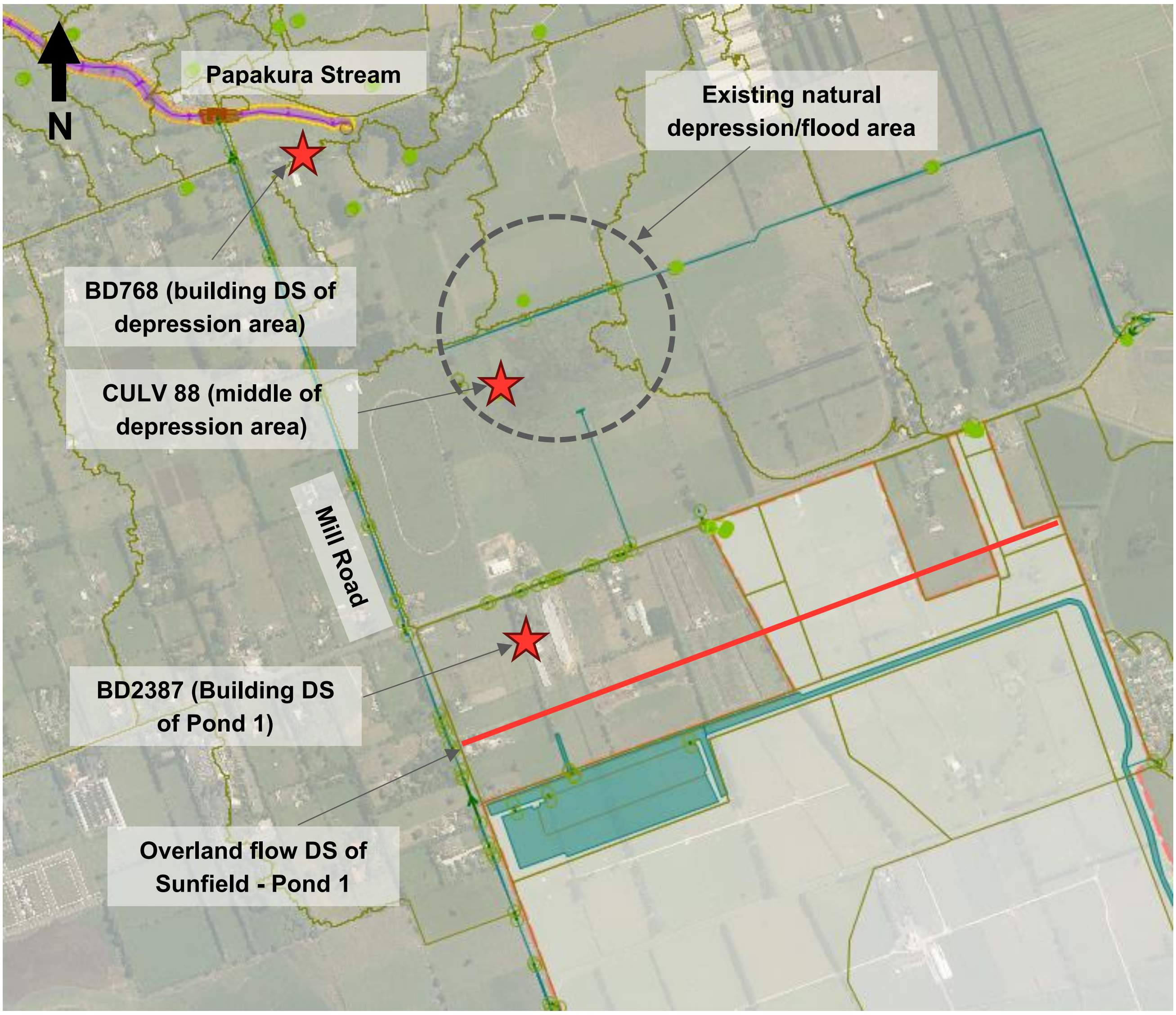

Figure 5-1: 1D Results locations immediately downstream of the Sunfield development site. Stars indicate location with depth results. Red line indicates location with flow results.

5.2.1 EXISTING DEVELOPMENT

Table 5-1 shows the flow results through the “Overland flow DS of Sunfield - Pond 1” line. These results show an increase in flow due to the Sunfield development in the 2 year ARI events, as well as increases in the 10 year and 100 year events when a peat CN of 39 is used.

Table 5-2 shows the depth results at the three locations indicated in Figure 5-1. These results show an increase in predicted peak flood depth at BD2387, which is a building structure immediately downstream of the Sunfield pond 1. The other two results locations do not predict any increase in flood depth in any of the events modelled.

Table 5-1: Existing development flow results (homogeneous rainfall, local change in predicted peak flow)

Event ARI	Peat CN	Overland flow DS of Sunfield - Pond 1		
		ED [m^3/s]	ED + SUN [m^3/s]	Difference [m^3/s]
2	39	3.1	3.5	+0.5
	61	4.0	4.7	+0.7
	74	5.3	5.8	+0.5
	98	11.4	10.4	-1.1
10	39	13.2	14.1	+0.9
	61	17.3	16.3	-1.1
	74	20.5	17.9	-2.6
	98	27.1	25.7	-1.4
100	39	32.6	33.8	+1.1
	61	43.1	39.3	-3.7
	74	49.6	42.6	-7.0
	98	58.9	47.1	-11.8

Table 5-2: Existing development depth results (homogeneous rainfall, local change in predicted peak water depth)

Event ARI	Peat CN	BD768 (Building DS of depression area)			CULV 88 (middle of depression area)			BD2387 (Building DS of pond 1)		
		ED [m]	ED + SUN [m]	Difference [m]	ED [m]	ED + SUN [m]	Difference [m]	ED [m]	ED + SUN [m]	Difference [m]
2	39	0.00	0.00	0.00	1.67	1.64	-0.03	0.00	0.08	+0.07
	61	0.00	0.00	0.00	1.82	1.77	-0.05	0.04	0.12	+0.07
	74	0.00	0.00	0.00	1.94	1.88	-0.06	0.10	0.15	+0.05
	98	0.00	0.00	0.00	2.34	2.25	-0.09	0.21	0.24	+0.02
10	39	0.24	0.24	0.00	2.51	2.50	-0.01	0.24	0.29	+0.05
	61	0.34	0.33	-0.02	2.66	2.64	-0.02	0.29	0.31	+0.02
	74	0.42	0.40	-0.02	2.76	2.73	-0.03	0.31	0.33	+0.01
	98	0.56	0.54	-0.03	2.96	2.90	-0.05	0.36	0.38	+0.02
100	39	0.72	0.72	-0.01	3.11	3.10	-0.01	0.40	0.43	+0.04
	61	0.79	0.78	-0.02	3.22	3.19	-0.03	0.45	0.46	+0.01
	74	0.83	0.81	-0.02	3.27	3.24	-0.04	0.48	0.47	+0.00
	98	0.89	0.86	-0.03	3.38	3.33	-0.05	0.52	0.49	-0.02

5.2.2 MAXIMUM PROBABLE DEVELOPMENT

Table 5-3 shows the flow results through the “Overland flow DS of Sunfield - Pond 1” line in the homogenous rainfall events. These results show an increase in flow due to the Sunfield development in the 2 year ARI events, as well as increases in the 10 year and 100 year events when a peat CN of 39 is used.

Table 5-4 shows the flows through the “Overland flow DS of Sunfield - Pond 1” line in the spatially varying rainfall events. These results only show an increase in flow during the 10 year ARI event events when a peat CN of 39 is used.

Table 5-5 shows the depth results during the homogeneous rainfall events at the three locations indicated in Figure 5-1. As in the existing development scenario these results show an increase in predicted peak flood depth at BD2387 in the 2 year and 10 year events. BD2387 is a building structure immediately downstream of the Sunfield pond 1. The other two results locations do not predict any increase in flood depth in any of the events modelled.

Table 5-6 shows the depth results during the spatially varying rainfall events. As in Table 5-5 the model predicts and increase in peak flood depth at BD2387 in the 10 year ARI event.

Table 5-3: Maximum probable development flow results (homogeneous rainfall, local change in predicted peak flow)

Event ARI	Peat CN	Overland flow DS of Sunfield - Pond 1		
		MPD [m³/s]	MPD + SUN [m³/s]	Difference [m³/s]
2	39	4.8	6.5	+1.7
	61	6.9	7.9	+1.0
	74	8.8	9.2	+0.3
	98	14.8	13.4	-1.4
10	39	19.4	18.6	-0.8
	61	24.4	22.8	-1.6
	74	28.1	26.9	-1.2
	98	35.1	31.9	-3.2
100	39	60.7	53.2	-7.5
	61	75.1	59.2	-15.9
	74	83.0	62.3	-20.8
	98	92.7	66.0	-26.7

Table 5-4: Maximum probable development flow results (Spatially varying rainfall, local change in predicted peak flow)

Event	Peat CN	Overland flow DS of Sunfield - Pond 1		
		MPD [m³/s]	MPD + SUN [m³/s]	Difference [m³/s]
10	39	25.4	26.3	+1.0
	74	36.4	33.3	-3.1
100	39	63.6	55.0	-8.6
	74	86.5	64.0	-22.5

Table 5-5: Maximum probable development depth results (homogeneous rainfall, local change in predicted peak depth)

Event ARI	Peat CN	BD768 (building DS of depression area)			CULV 88 (middle of depression area)			BD2387 (DS of pond 1)		
		MPD [m]	MPD + SUN [m]	Difference [m]	MPD [m]	MPD + SUN [m]	Difference [m]	MPD [m]	MPD + SUN [m]	Difference [m]
2	39	0.00	0.00	0.00	1.98	1.94	-0.04	0.08	0.16	+0.09
	61	0.00	0.00	0.00	2.10	2.05	-0.05	0.13	0.19	+0.06
	74	0.00	0.00	0.00	2.20	2.14	-0.06	0.17	0.22	+0.05
	98	0.20	0.15	-0.04	2.50	2.42	-0.08	0.26	0.28	+0.02
10	39	0.48	0.47	-0.01	2.81	2.80	-0.01	0.30	0.33	+0.03
	61	0.57	0.55	-0.02	2.92	2.90	-0.02	0.34	0.36	+0.02
	74	0.61	0.59	-0.02	2.98	2.95	-0.03	0.37	0.39	+0.02
	98	0.68	0.66	-0.02	3.11	3.07	-0.04	0.41	0.42	+0.01
100	39	0.98	0.96	-0.02	3.50	3.47	-0.03	0.52	0.52	0.00
	61	1.04	1.01	-0.03	3.58	3.55	-0.04	0.57	0.54	-0.03
	74	1.07	1.04	-0.03	3.63	3.58	-0.04	0.60	0.55	-0.05
	98	1.13	1.09	-0.04	3.72	3.67	-0.04	0.66	0.60	-0.05

Table 5-6: Maximum probable development depth results (Spatially varying rainfall, local change in predicted peak depth)

Event ARI	Peat CN	BD768 (building DS of depression area)			CULV 88 (middle of depression area)			BD2387 (DS of pond 1)		
		MPD [m]	MPD + SUN [m]	Difference [m]	MPD [m]	MPD + SUN [m]	Difference [m]	MPD [m]	MPD + SUN [m]	Difference [m]
10	39	0.33	0.33	0.00	2.72	2.73	+0.01	0.35	0.39	+0.04
	74	0.52	0.50	-0.01	3.00	2.97	-0.03	0.42	0.43	+0.01
100	39	0.76	0.74	-0.02	3.23	3.22	-0.02	0.53	0.52	-0.01
	74	0.90	0.88	-0.02	3.46	3.43	-0.04	0.61	0.56	-0.05

5.3 IMPACT ON FLOOD HAZARD IN PAPAKURA STREAM

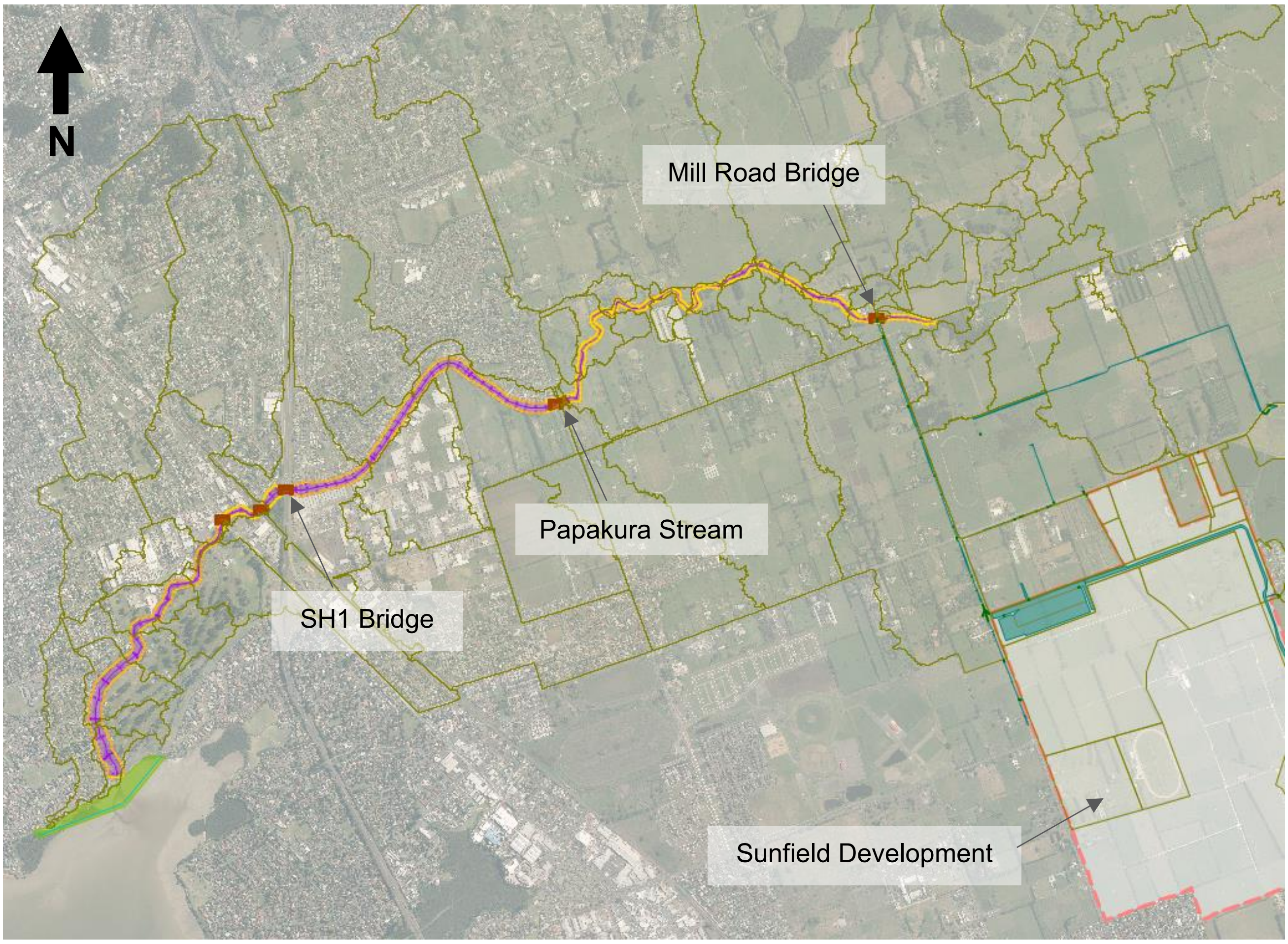

Figure 5-2: 1D Results locations within Papakura Stream.

5.3.1 EXISTING DEVELOPMENT

Table 5-7 shows the flow results in Papakura Stream at Mill Road and SH1. These results show a small increase in flow at Mill Road due to the Sunfield development in the 10-year and 100-year ARI events. The depth results shown in Table 5-8 indicate that although a small increase in flow is predicted, the Sunfield development does not results in an increase in the maximum depth in the stream at either location.

Table 5-7: Existing development flow results (homogeneous rainfall, Papakura Stream change in predicted peak flow)

Event ARI	Peat CN	Papakura Stream at SH1			Papakura Stream at Mill Road		
		ED [m^3/s]	ED + SUN [m^3/s]	Difference [m^3/s]	ED [m^3/s]	ED + SUN [m^3/s]	Difference [m^3/s]
2	39	14.8	14.0	-0.7	12.5	12.3	-0.2
	61	17.3	16.4	-1.0	14.7	14.3	-0.4
	74	19.7	18.6	-1.2	16.8	16.2	-0.6
	98	29.6	27.3	-2.3	23.0	22.3	-0.7
10	39	47.2	46.8	-0.4	27.8	27.9	+0.1
	61	57.2	55.8	-1.4	28.3	28.3	-0.1
	74	64.3	62.3	-2.0	28.2	28.2	0.0
	98	84.4	79.1	-5.3	29.1	29.3	+0.1
100	39	122.7	122.1	-0.6	30.0	30.6	+0.6
	61	148.3	143.8	-4.4	30.3	30.8	+0.4
	74	165.6	158.7	-6.9	30.4	30.7	+0.3
	98	188.8	179.5	-9.2	29.9	30.0	+0.2

Table 5-8: Existing development depth results (homogeneous rainfall, Papakura Stream change in predicted peak water levels)

Event ARI	Peat CN	Papakura Stream at SH1			Papakura Stream at Mill Road		
		ED [m]	ED + SUN [m]	Difference [m]	ED [m]	ED + SUN [m]	Difference [m]
2	39	1.28	1.25	-0.03	2.26	2.23	-0.03
	61	1.37	1.34	-0.03	2.39	2.35	-0.04
	74	1.45	1.41	-0.04	2.51	2.46	-0.05
	98	1.73	1.67	-0.06	2.91	2.83	-0.08
10	39	2.11	2.10	-0.01	3.37	3.36	-0.01
	61	2.30	2.28	-0.02	3.54	3.52	-0.02
	74	2.43	2.39	-0.03	3.64	3.61	-0.03
	98	2.75	2.67	-0.08	3.82	3.79	-0.03
100	39	3.33	3.33	-0.01	4.08	4.07	-0.01
	61	3.69	3.63	-0.06	4.17	4.13	-0.04
	74	3.91	3.82	-0.08	4.19	4.17	-0.02
	98	4.22	4.11	-0.11	4.27	4.23	-0.05

5.3.2 MAXIMUM PROBABLE DEVELOPMENT

Table 5-9 shows the flow results in Papakura Stream at Mill Road and SH1 in the homogenous rain events. Table 5-10 shows the flow results in Papakura Stream at Mill Road and SH1 in the spatially varying rainfall events. These results show a small increase in flow at Mill Road due to the Sunfield development in the 10 year and 100 year ARI events.

The depth results shown in Table 5-11 and Table 5-12 indicate that although a small increase in flow is predicted in some scenarios, the Sunfield development does not result in an increase on the depth in the stream at either location.

Table 5-9: Maximum probable development flow results (homogeneous rainfall, Papakura Stream change in predicted peak flow)

Event ARI	Peat CN	Papakura Stream at SH1			Papakura Stream at Mill Road		
		MPD [m^3/s]	MPD + SUN [m^3/s]	Difference [m^3/s]	MPD [m^3/s]	MPD + SUN [m^3/s]	Difference [m^3/s]
2	39	24.3	23.5	-0.8	19.8	19.6	-0.2
	61	27.4	26.1	-1.3	21.8	21.4	-0.4
	74	30.2	28.7	-1.5	23.3	22.8	-0.5
	98	40.9	38.3	-2.7	26.6	26.3	-0.3
10	39	75.9	75.4	-0.4	28.2	28.3	+0.1
	61	89.2	86.5	-2.7	28.9	29.2	+0.3
	74	98.3	94.7	-3.7	29.4	29.6	+0.2
	98	121.4	115.0	-6.3	29.8	29.9	+0.2
100	39	226.3	219.0	-7.3	29.9	30.4	+0.4
	61	248.1	238.2	-9.9	32.5	29.7	-2.8
	74	261.1	250.4	-10.7	35.2	29.1	-6.0
	98	286.3	273.2	-13.1	32.0	29.0	-3.1

Table 5-10: Maximum probable development flow results (Spatially varying rainfall, Papakura Stream change in predicted peak flow)

Event	Peat CN	Papakura Stream at SH1			Papakura Stream at Mill Road		
		MPD [m^3/s]	MPD + SUN [m^3/s]	Difference [m^3/s]	MPD [m^3/s]	MPD + SUN [m^3/s]	Difference [m^3/s]
10	39	59.1	61.3	+2.2	27.5	27.8	+0.3
	74	83.8	82.7	-1.0	29.2	29.3	+0.2
100	39	160.3	159.3	-1.0	29.6	30.1	+0.5
	74	210.1	204.6	-5.6	29.0	29.3	+0.3

Table 5-11: Maximum probable development depth results (homogeneous rainfall, Papakura Stream change in predicted peak depth)

Event ARI	Peat CN	Papakura Stream at SH1			Papakura Stream at Mill Road		
		MPD [m]	MPD + SUN [m]	Difference [m]	MPD [m]	MPD + SUN [m]	Difference [m]
2	39	1.59	1.57	-0.02	2.68	2.65	-0.03
	61	1.67	1.64	-0.03	2.79	2.75	-0.04
	74	1.74	1.71	-0.04	2.89	2.84	-0.05
	98	1.99	1.93	-0.06	3.21	3.13	-0.08
10	39	2.62	2.61	-0.01	3.74	3.73	-0.01
	61	2.83	2.79	-0.04	3.86	3.83	-0.02
	74	2.97	2.92	-0.05	3.92	3.89	-0.03
	98	3.32	3.23	-0.09	4.01	3.97	-0.04
100	39	4.72	4.65	-0.08	4.38	4.34	-0.03
	61	4.95	4.88	-0.07	4.47	4.40	-0.07
	74	5.07	4.99	-0.08	4.50	4.43	-0.07
	98	5.26	5.14	-0.12	4.53	4.49	-0.04

Table 5-12: Maximum probable development depth results (Spatially varying rainfall, Papakura Stream change in predicted peak dpeth)

Event ARI	Peat CN	Papakura Stream at SH1			Papakura Stream at Mill Road		
		ED [m]	ED + SUN [m]	Difference [m]	ED [m]	ED + SUN [m]	Difference [m]
10	39	2.35	2.39	+0.03	3.45	3.44	-0.01
	74	2.75	2.74	-0.02	3.70	3.68	-0.02
100	39	3.86	3.85	-0.01	4.10	4.06	-0.04
	74	4.47	4.41	-0.06	4.25	4.22	-0.03

6 DISCUSSION

6.1 PEAT CN SENSITIVITY

As seen in the results tables in section 5, there are different changes in flood hazard due to the development depending on what curve number is used for the peat soils. Infiltration in Peat soils is expected to vary significantly depending on the ground water level. Refer to Section 3.1.3 for further discussion.

The main conclusions are:

- A lower CN means that the relative predicted increase in flood hazard due to the development is higher. With a lower CN the upstream catchment flows are lower, but the increase in flood water depth of the development is relatively greater. Overall, our results show greater increase on predicted depths immediately downstream of the Sunfield development when considering a lower curve number.
- As the applicant has only assessed CN of 74, their pre-development flows will not represent a case where the peat is relatively dry and has low runoff. This means that the sizing of the attenuation devices may not attenuate to pre-development flow rates in some cases.

6.2 CONCENTRATION OF FLOWS DOWNSTREAM OF POND 1

The Sunfield development (as per the provided drawings) will remove existing overland flow paths that currently flow through the site. The existing flow path shown in Figure 6-2.

Currently flows are predicted to cross Hamlin Road mainly at two locations:

- Main flow path under a bridge near 51 Hamlin Road (Blue circle in Figure 6-1).
- Hamlin Road retains some runoff, with flows eventually spilling over at the western end of Hamlin Road (Green circle in Figure 6-1)

Current flows out of the Sunfield site are spread across multiple properties, as shown with red arrows.

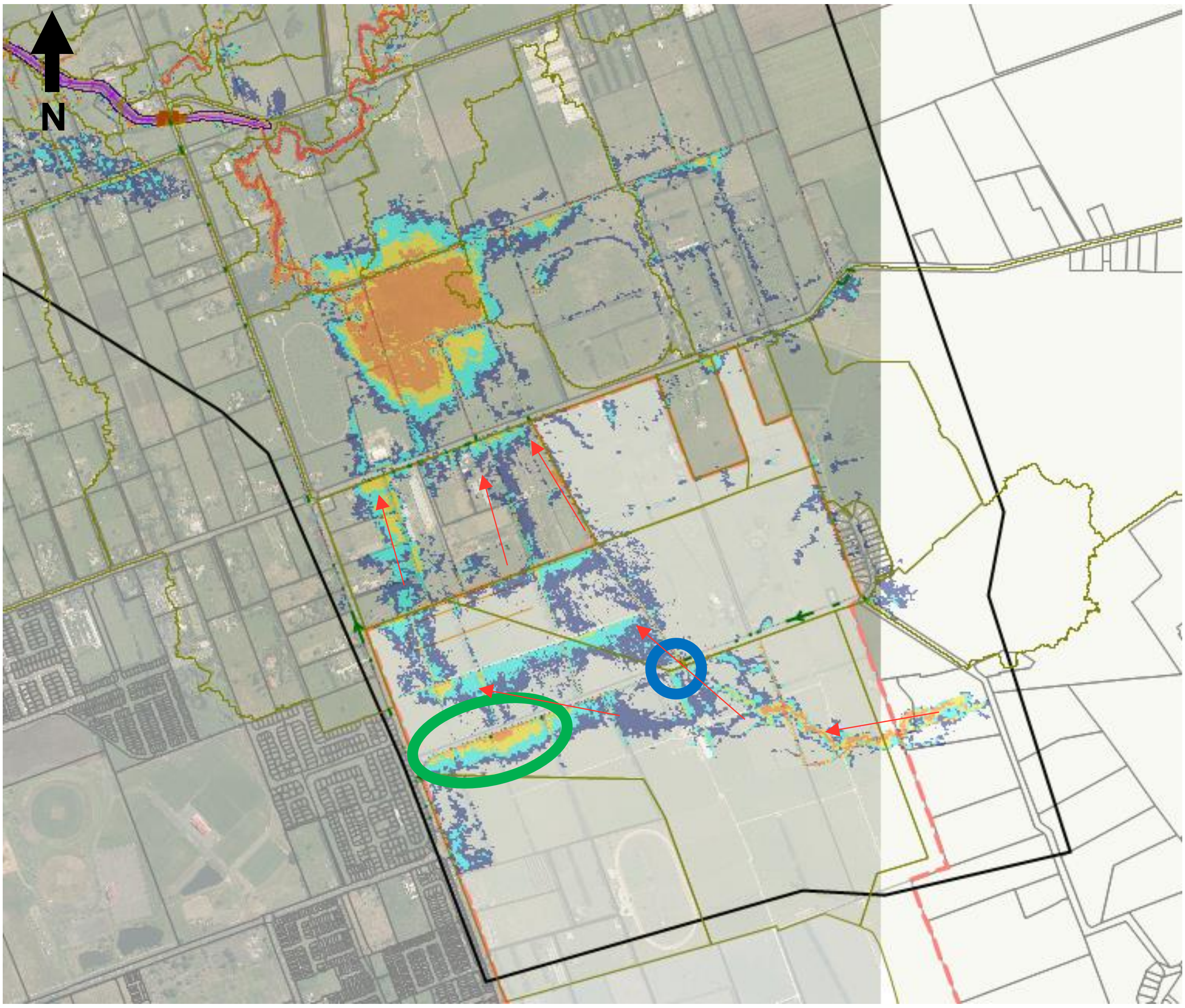

Figure 6-1: Example of existing overland flow paths through the Sunfield development site – 2-year ARI CN61 E.

Proposed flow path:

The applicant proposes to collect and discharge all the upstream rural flows through the diversion channel into pond 1. This will concentrate the current overland flow paths and discharge them all into private property at one location.

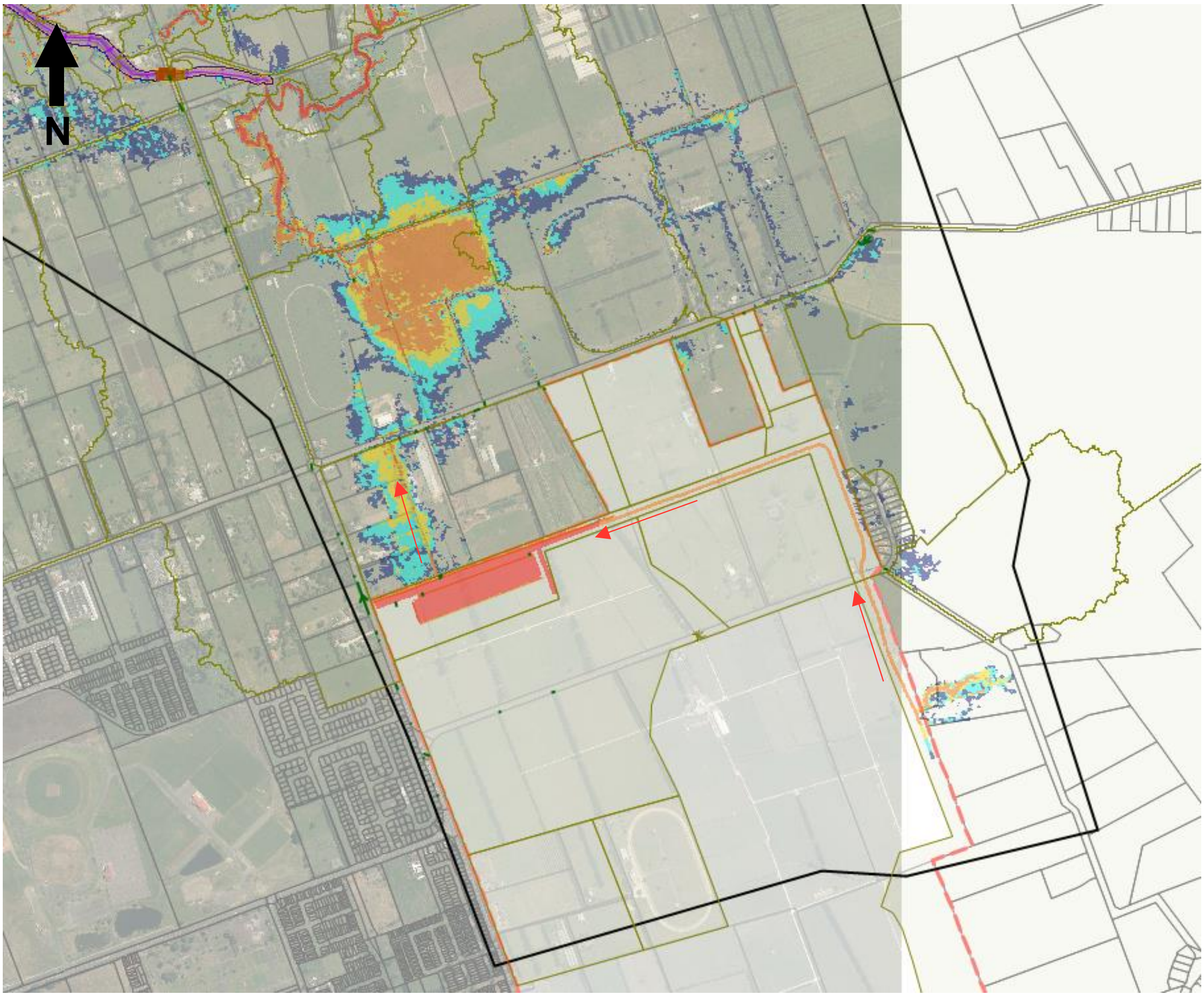

Figure 6-2: Proposed overland flow path through Sunfield development site – 2-year CN61 E+SUN.

Since the proposal involves concentrating the overland flow paths into a single location, it is not sufficient to analyse the overall flows and to maintain the total pre-development flow rate. Loading all the flow into one location requires a more in-depth analysis of the current capacity of the open drains immediately downstream of pond 1.

Compounding the concentration of the overland flow paths, our results indicate that in some events the overall pre-development flow rate is exceeded when including the Sunfield development. Based on our modelling the pond 1 outfalls do not always attenuate outflows to the pre-development flow rate, as shown in Table 5-1. In particular, the post-development flows exceed the pre-development flows in all modelled 2-year ARI events, except when a CN value of 98 is used.

The combination of increasing the total flow rate in some events, as well as concentrating the existing flow paths means that properties immediately downstream of Sunfield pond 1 are predicted to have an increase in flood depth, as seen in Table 5-2.

In some scenarios the increase in flood depth is greater than 100mm, and increases the predicted flood hazard to properties downstream. In the 2-year ARI CN61 scenario there is an increase in flood depth of greater than 100 mm downstream of the pond 1 outfall, as shown in Figure 6-3.

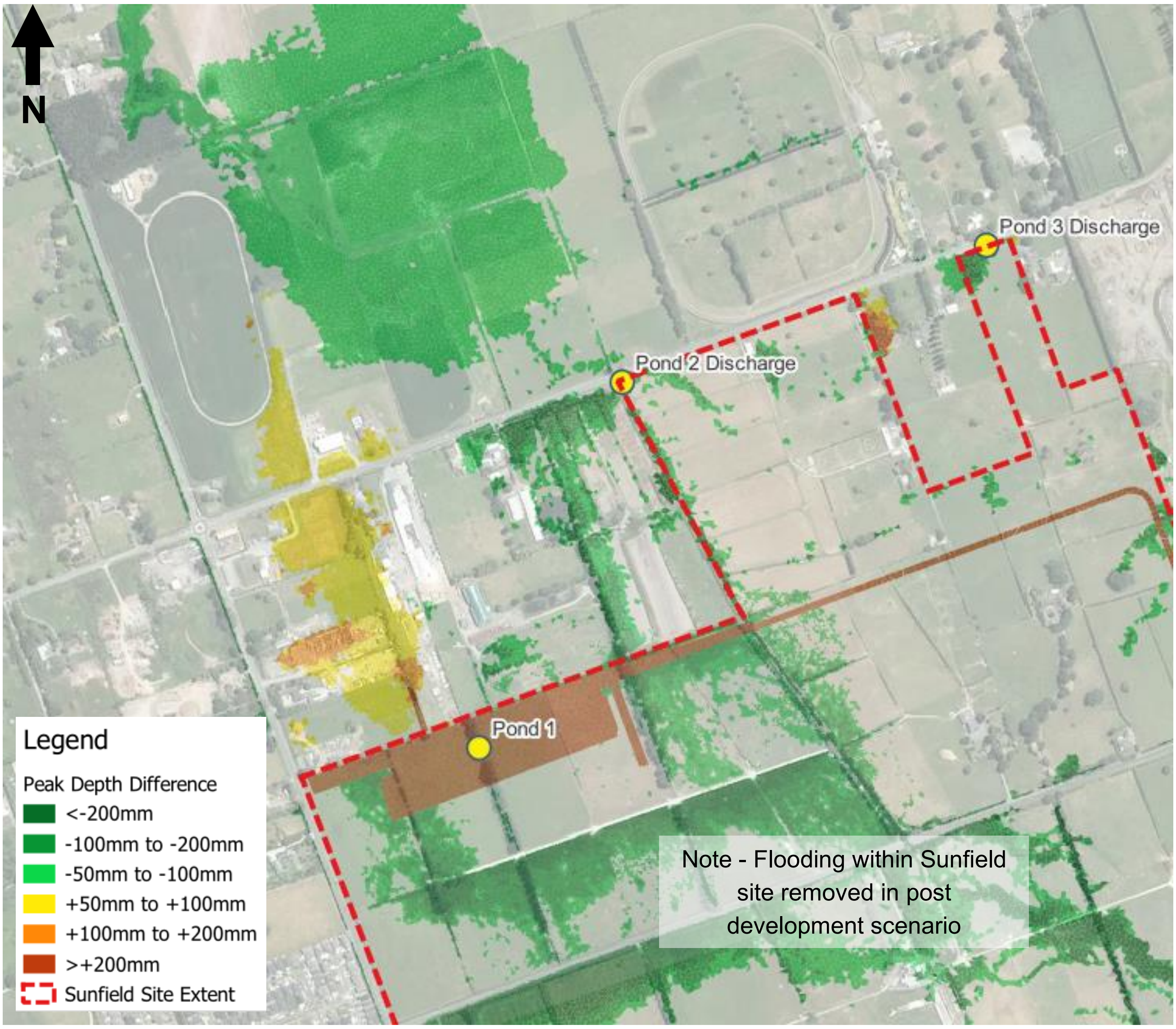

Figure 6-3: Change in predicted peak flood depth in the 2-year ARI, CN61 scenario, showing increase in predicted flood depth downstream of Pond 1.

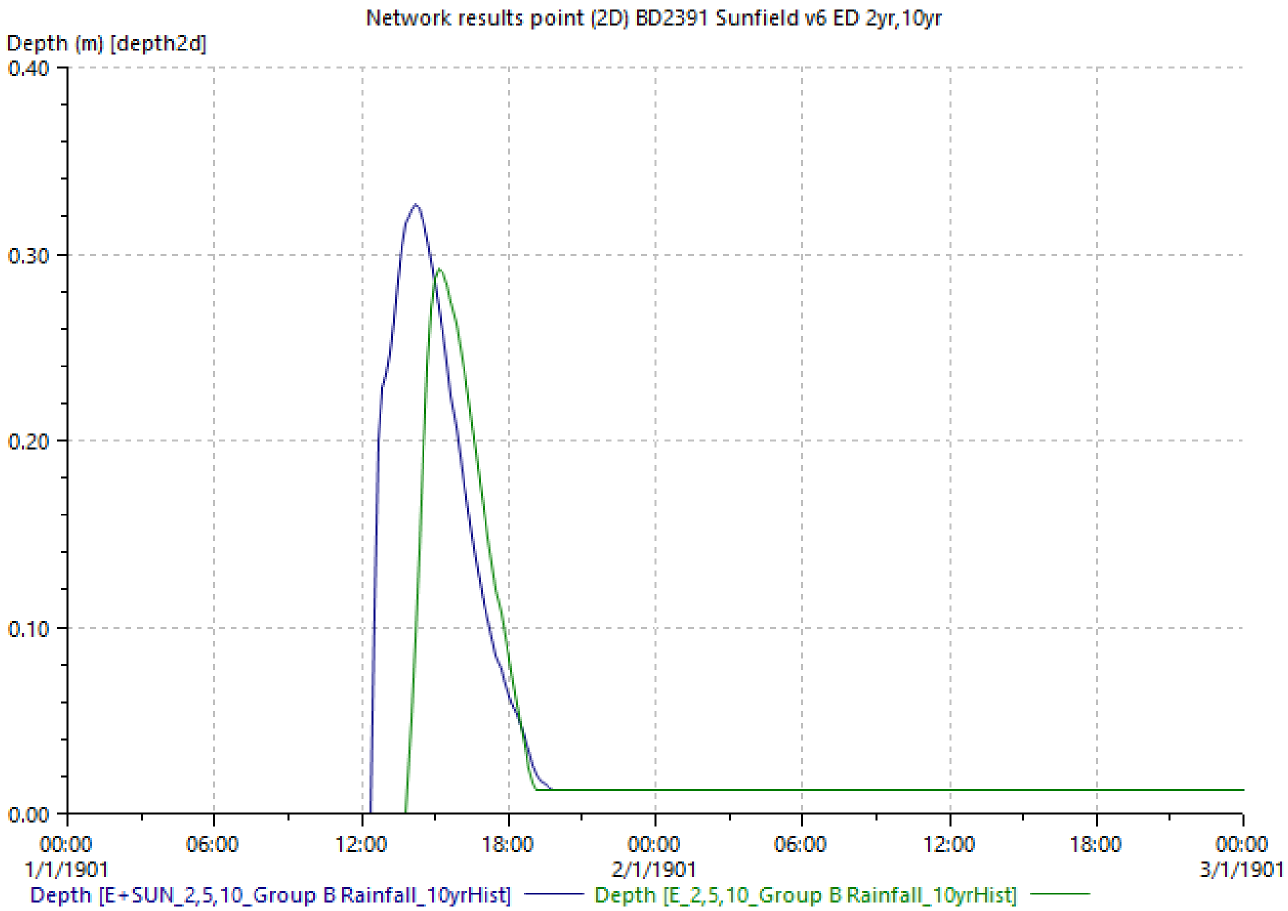

Figure 6-4: CN61 10-year ARI historical rainfall – showing predicted flood depth increase at building footprint.

Figure 6-4 shows the increase in predicted flood depth at a building downstream of pond 1 in the 10-year ARI CN61 scenario. The location of this building is shown in Figure 6-5. Note that this result is not apparent on the flood depth difference maps as the increase is less than 50 mm.

Figure 6-5: Location of BD2391 building, downstream of pond 1.

6.3 EXISTING DRAINS

The applicant's proposal is to discharge into the existing farm and roadside drains. As we have not received their model, we cannot confirm if the open drains and culverts were explicitly modelled by the applicant. However, it appears that the applicant has only relied on unmodified terrain to represent conveyance downstream of their development.

As discussed in section 6.2 areas immediately downstream of pond 1 will have an increase in flows due to the concentration of existing overland flow paths. These properties have small private drains, with likely very limited capacity for any additional flows. The applicant has not assessed the capacity of these drains to see if there will be any increase in predicted flood hazard due to the increased runoff from the development.

We have modelled some of the downstream roadside drains and culverts, as discussed in section 2.1.2. The available survey does not include the privately owned farm drains. Based on anecdotal information, the survey data, as well as photos during storm events, we believe that the existing farm drains and roadside drains have limited capacity for event relatively small events. Therefore, these open drains are likely unable to convey additional flows from the Sunfield development without increasing flood hazard on the surrounding properties.

During a recent rain event, which was assessed to have an ARI of less than 2 years, the open drains around the Sunfield development site were observed to overflow into the road, as seen in the photographs below.

Figure 6-6: Flooding near 115 Hamlin Road on 27 June 2025. Photo credit Andrew Chin (AC).

Figure 6-6 shows flooding is at upstream end of the Sunfield development, where the large rural upstream catchment is proposed to enter the diversion channel.

Figure 6-7: Flooding near 269 Airfield Road on 27 June 2025. Photo credit Andrew Chin (AC).

This flooding in Figure 6-7 shows the area immediately downstream of the Sunfield pond 2. This flooding extended into the roadway, and indicates an existing capacity issues of the open drains downstream of the Sunfield development area

6.4 PONDS 2 AND 3 BACKWATER

Our modelling indicates some backwater issues at pond 2 and 3. Figure 6-8 shows the flows through the different outlets from Pond 2, as well as the pond level on the secondary Y axis. Due to the high downstream water level the model predicts backflow into the pond via the 2m wider “10 year ARI” weir.

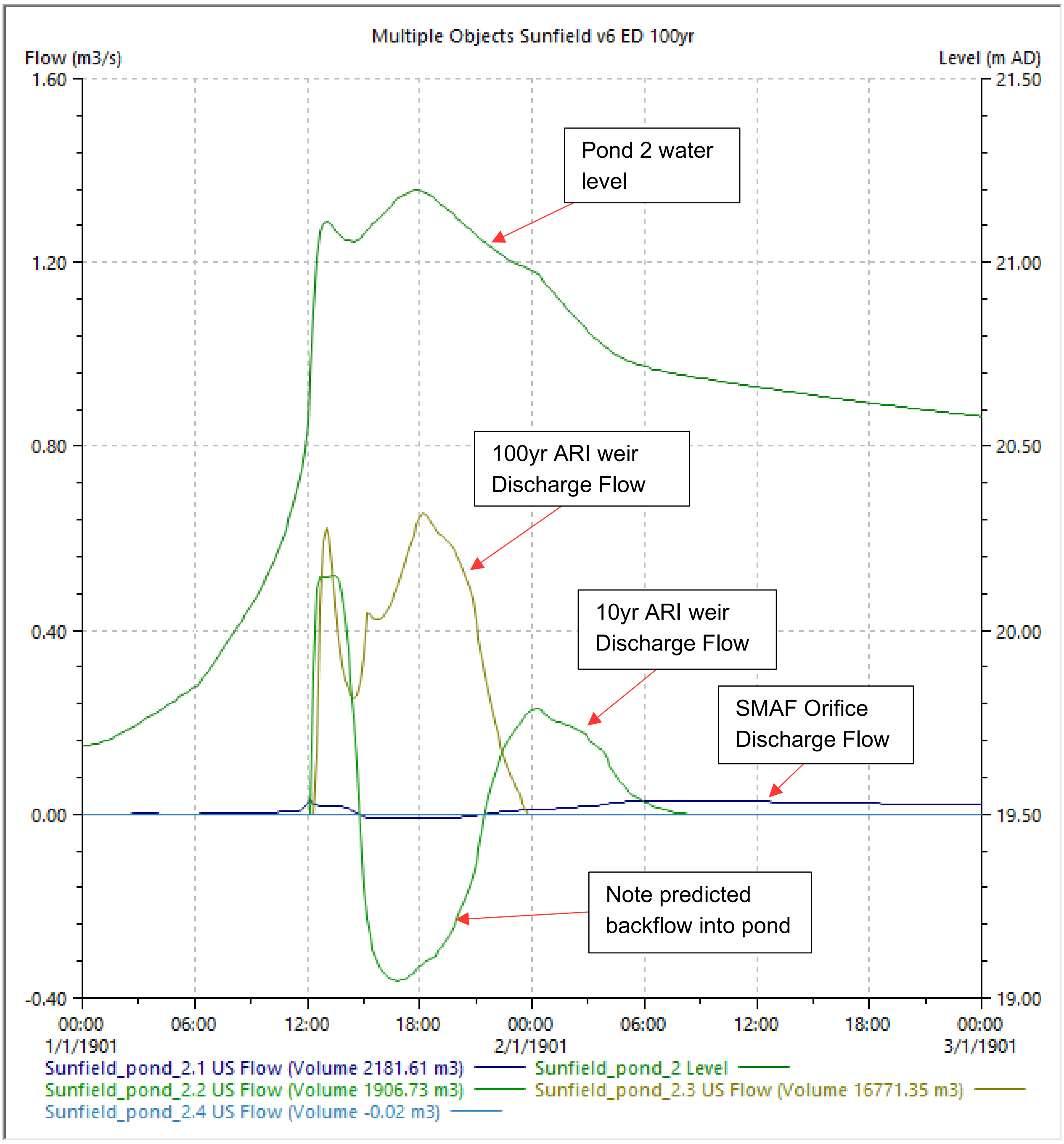

Figure 6-8: Predicted operation of pond 2 in 100 year ARI E+SUN scenario, CN 61.

The culvert “Structure 16” is immediately downstream of the proposed pond 2. This culvert was added into the ICM model based on the farm drain survey provided by AC. This structure does not appear to be restricting flows, as the model predicts very similar peak depths on both sides of the culvert. Figure 6-9 shows the water level in pond 2 compared to the water level downstream of the “structure 16” culvert on the north side of Airfield Road.

We note that high water levels in this location are a known issue, as is demonstrated by photos during a recent rain event shown in Figure 6-7.

Due to the model not including survey of the open drains downstream of pond 2, we have lower confidence in the model results in smaller rain events (i.e. 2 year ARI). However, in larger (10 and 100 year ARI) rain events, the downstream area floods and therefore the drains become less critical to the result.

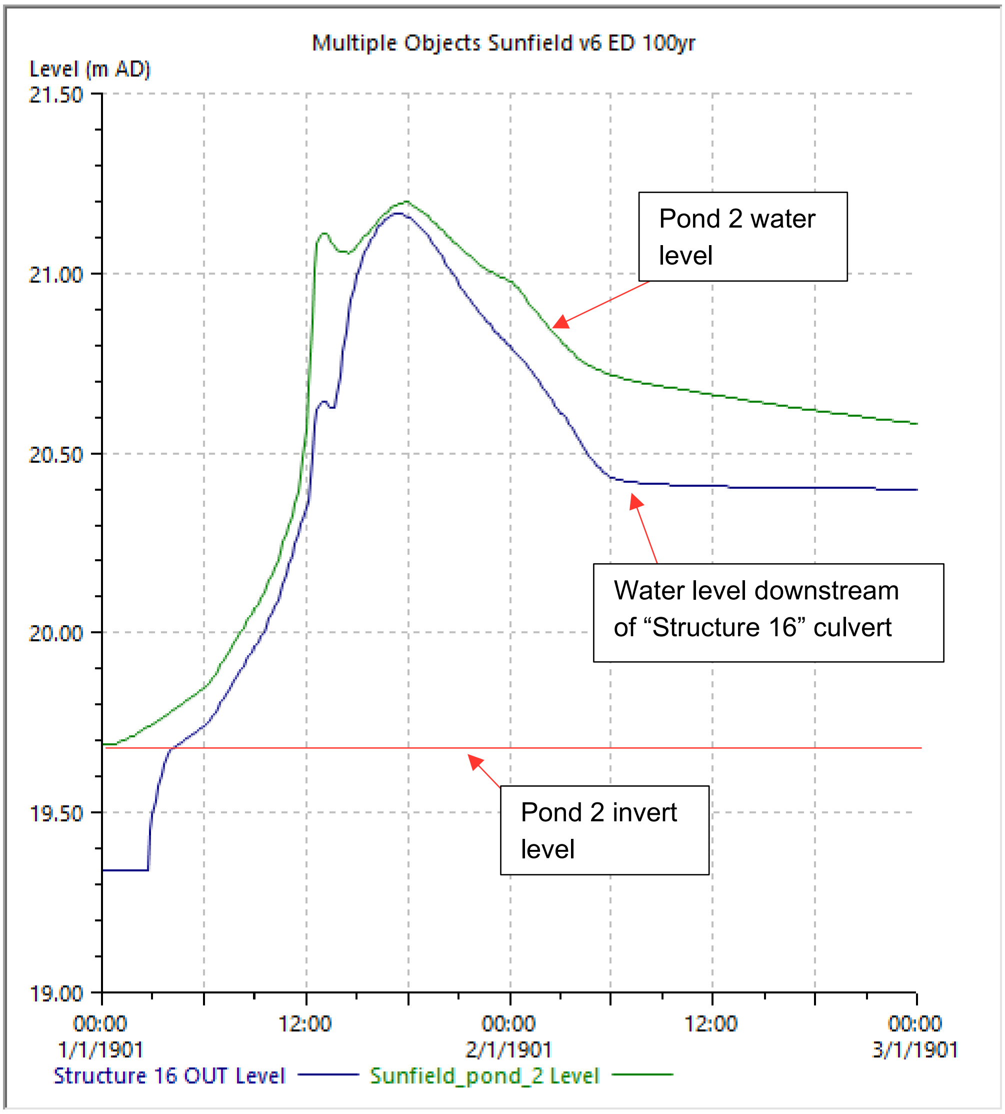

Figure 6-9: Predicted water level within Pond 2 and downstream north of Airfield Road. 100 year ARI E+SUN CN 61.

The applicant’s hydraulic model for ponds 2 and 3 does not appear to consider backwater effects from the downstream flood area. The applicant’s report does not discuss this backwater issue. The 3WSR states that the applicant has modelled these ponds in HEC-HMS, and loaded the discharge flows into their HEC-RAS model to assess downstream flood depths. As we have not received their models, we cannot confirm how the interaction between these models was implemented in the applicant’s models, and whether backwater effects were considered.

6.5 IMPACT OF MODIFYING CATCHMENT BOUNDARY

A key part of the applicant’s plan is the proposal to reroute part of the current Papakura Stream catchment into the Pahurehure inlet via the Awakeri Wetlands, as discussed in section 2.2.1. The reduction in catchment area flowing to Papakura Stream acts to offset the increased runoff from impervious area of the Sunfield Development. Table 6-1 summarises the total runoff volume in Papakura Stream with and without the Sunfield Development in the 10-year ARI existing development scenarios and quantifies the change in volume.

We believe that the diversion of this large portion of the catchment is a key factor in mitigation of potential downstream flood hazard impacts. If the proposed rerouted subcatchment were to discharge into the

Papakura Stream instead (even if un-developed) it is likely that this will result in an increase in downstream flood hazard.

The volume discharging to the Papakura stream catchment increases in scenarios with peat CN values of 61 and 39. With the proposed diversion, the volume draining to Papakura stream reduces in the scenarios where the peat is assumed to CN74 or CN98.

Without the diversion to Awakeri, the volume draining to Papakura stream would increase in all peat CN scenarios except when the peat is fully saturated (CN of 98).

Table 6-1: Comparison of runoff volume in from the Sunfield development subcatchments in the 10-year ARI homogenous rainfall (No climate change).

Peat CN	Pre-Development (E) Runoff Volume to Papakura Stream Catchment (m^3)	Post-Development (E+SUN) Runoff Volume (m^3)		Difference in Volume to Papakura Stream (m^3)	Percentage Difference Volume to Papakura Stream (%)
		To Papakura Stream	Diverted to Awakeri		
39 (Lower)	68,041	126,074	60,289	58,033	+85.3%
61 (Group B)	114,268	131,943	60,289	17,675	+15.5%
74 (Group C)	148,372	136,273	60,289	-12,099	-8.2%
98 (Upper)	240,141	147,924	60,289	-92,217	-38.4%

6.6 PEER REVIEW OF APPLICANT'S MODEL

Based on the documents provided by the applicant, it appears that a complete independent peer review of their models has not been carried out. The lodged documents include:

- the McKenzie & Co "Sunfield Fast Track Application – 3 Waters Review memorandum (Lodged document #14, dated 24/01/2025), and
- the CKL "Stormwater Management - Proof of Concept Review" memorandum (Lodged document #13, dated 10/02/2025).

The McKenzie & Co memorandum states that their review is "subject to an independent flood model peer review". The CKL memorandum states that they reviewed inputs into the model based on the Stormwater Modelling Report, but they did not review the models directly. CKL's memorandum recommends that a formal peer review of the hydraulic models be undertaken. The applicant has not provided any evidence of an independent peer review of the hydraulic models. Given the complexity of the proposed attenuation devices, as well as the existing flood hazards downstream of the development we recommend that an independent peer review of the applicant's models is carried out.

7 CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

- **The applicant did not provide complete technical details** regarding their proposal, limiting some aspects of our analysis:
  - The engineering plans that the applicant provided have some gaps with missing information. We have had to assume some details based on engineering judgement (including dimensions and arrangement of outlet structures).
  - The applicant did not provide their model files, and therefore our analysis is based on the provided 3WSR report and attached engineering plans.
  - The previous peer reviews that are included in the lodged documents did not review the hydraulic models directly.
- **Peat Soils:** Our modelling shows that the change in flood hazard on the downstream properties due to the development varies depending on the amount of infiltration available within peat soil. With lower CN values (higher infiltration) the upstream catchment flows are lower, but the increase in downstream flood level due to the development is relatively greater. Overall, our results show greater flood level increases immediately downstream of the Sunfield development when considering a lower curve number for peat.
- **Impacts on local flood hazard (Within nearby open drains):** Our modelling predicts that the Sunfield development can result in an increased flood level on nearby downstream properties. An increase in flood hazard is predicted immediately downstream of pond 1 in the 2-year ARI event. In the 2-year ARI, peat CN61 scenario our modelling predicts that the flood depth downstream of pond 1 will increase by approximately 100mm on neighbouring properties due to the Sunfield development. This increase in flood hazard is likely in part due to the applicant's proposal to combine the existing overland flow paths into a single discharge location.
- **Impacts on Papakura Stream flood hazard (Within Papakura Stream main channel):** Our modelling does not predict an increase in flood depth within the Papakura Stream in any of the scenarios modelled. We believe that this is due to the applicant's proposal to divert part of the existing Papakura Stream catchment to the Awakeri basin.
- **Downstream open drains:** The downstream open drains have existing capacity constraints, and hence are sensitive to increased runoff, for example during relatively frequent events (i.e. 2-year ARI). Due to the flat topography of the development site and adjacent downstream properties, the water level in these drains may influence the performance of the applicant's proposed attenuation devices. Our modelling predicts that in the 100-Year ARI events the downstream flood level causes water to flow back into pond 2.
- **Catchment Diversion**: The applicant's proposal to divert part of the current Papakura Stream catchment into the Pahurehure Inlet via the Awakeri Wetlands plays a key part in limiting the increases in existing flood hazard in the Papakura Stream.

Recommendations:

- Regarding the peat soils;
    - The applicant's modelling uses a single curve number of 74 for all pre-development peat soils.
    - The peat soils are known to be highly variable, and subject to seasonal variation.
    - Our modelling shows that the change in flood hazard due to the development can vary based on the assumed peat CN values.
    - Therefore further consideration of the perviousness of the peat soils is recommended. This could include assessing the likely range of possible CN values for the existing peat ground and incorporate that into their modelling. We consider this critical to determining the sizing of attenuation devices to avoid increasing flows above the pre-development condition.
- Our modelling indicates that the applicant's proposal to combine the existing overland flow paths into one discharge point could increase the flood hazard of properties immediately downstream of pond 1. We recommend that the applicant carries out more detailed hydraulic analysis of the existing conveyance channels downstream of pond. A more in-depth hydraulic analysis of the open drains will give AC greater confidence of the impacts of the applicant's proposal on the flood hazard within properties downstream of the development.

8 LIMITATIONS

This report (‘Report’) has been prepared by WSP exclusively for Auckland Council (‘Client’) in relation to the assessment of the proposed Sunfield development (‘Purpose’) and in accordance with the “Papakura Stream Plan Change Modelling Support” Statement of Works dated 28 February 2025. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party

In preparing this Report, WSP has relied upon data, surveys, analyses, designs, plans and other information (‘Client Data’) provided by or on behalf of the Client. Except as otherwise stated in this Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable for any incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

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WSP. (September 2021). *Papakura Stream Model Update: Model Build Report.* WSP reference: 3-AWD30.41.

APPENDIX A – LEGACY ASSUMPTIONS AND LIMITATIONS

Papakura Stream Model Update: Model Build Report (WSP, September 2021)

2D floodplain element levels are derived from the Auckland Council 2016 LiDAR dataset. Detailed topographic features such as kerb and channel, retaining walls, narrow channels are not expected to be represented in this model. This may result in different flow directions (especially for lower flow) than observed during actual flooding events.

The 1D stream channel cross sections are derived from the 2016 LiDAR. The representation of the low flow channel may result in reduced conveyance especially for low flow events, which would normally be contained within the low flow channel.

1D roughness values were estimated using available photographs and aerial photography, applying the CES methodology.

The use of single roughness values may impact on the conveyance during low flows especially flows that would typically be confined to the low flow channel (i.e. less than 2-year ARI).

River Reach Lateral linking uses lower than the typical values in some select locations to improve the overall stability of the model. The impact of this is that the overbank flow is expected to apply the submerged weir equation for a longer proportion of the time, which may result in higher hydraulic losses across these boundaries under certain flow conditions.

Hydrological parameters for soils were selected using TP108, based on the underlying geological layers (GNS online maps). These were determined to provide a reasonable representation of known soil types (i.e. approximate extent of peat). However, it is noted that in some locations the selected curve numbers may not be representative of the actual soil characteristics.

Bridge contraction and expansion coefficients have been determined using recommended typical values. While a sensitivity test was undertaken to confirm that the predicted water levels were not sensitive to these parameters, it is noted that these loss coefficients may not be appropriate for all events.

Bridge opening geometry is based on previous modelling data. This has not been validated against previous survey data.

Subcatchment sizes are typically much larger than the range recommended by Auckland Councils' modelling specification. In some cases the peak flows may be sensitive to upstream attenuation, network connectivity etc, particularly for smaller events.

Takanini Future Urban Zone Flood Effects Testing: Testing of Effects for Storms of Varying Duration and Spatial Distribution (WSP, December 2024)

This model has been schematised to assess flooding associated with the Papakura Stream, and has undergone high level calibration to improve the modelled response compared to gauged flow for selected historic events.

The runoff surface proportions within each subcatchment were based on the estimated proportion of peat and the impervious and pervious proportion based on current development and the Auckland Unitary Plan.

Modelled rainfall events use homogenous timing (i.e., all the different duration and spatial distribution runs assume the same timing for rainfall across the catchment). Actual events are expected to have some variation, which may impact the results; especially storms that track across the catchment from west to east or vice versa.

Analysis of historic rainfall events showed a different proportion of rainfall in the upper catchment is varies from 60% lower and 30% higher than the lower portion of the catchment, which were typically storms of relatively small ARI (i.e. 1 in 10 year and less). Review of the January 2023 Auckland Anniversary storm event rain radar showed the rainfall depth in the Manukau Harbour vs. the bottom of the Papakura catchment was approximately double (i.e. the depth of rainfall across the lower reaches of the Papakura stream was approximately 50% of the rainfall depth in the Manukau Harbour. Therefore for the design runs tested in this scenario, a 50% factor for reducing upstream rainfall depths was adopted as a plausible value.

The boundaries used for testing higher rainfall in the lower catchment vs. lower rainfall in the upper catchment were selected to limit the number of zones while providing a reasonable understanding of the potential areas where a demarcation between higher and lower rainfall zones may lead to a potential increase in downstream effects on flood hazard due to development within the FUZ.

The spatially varying rainfall zones are demarcated perpendicular to the stream flow direction. Boundaries between areas of higher and lower rainfall could occur from any direction or distribution. The boundaries tested were chosen as they would be allowed for reasonable assessment of this development location, as well as reasonable precedent for being possible based on reviewed rainfall events.

The approach taken for this analysis was to assume higher rainfall depths / intensities in the lower reaches compared to the upper reaches. This is considered to represent a scenario where effects from development in the lower portion of the catchment will be more apparent. It is noted that testing of effects of mitigation strategies (i.e. attenuation) may require the reverse scenarios; i.e. higher rainfall in the upper catchment.

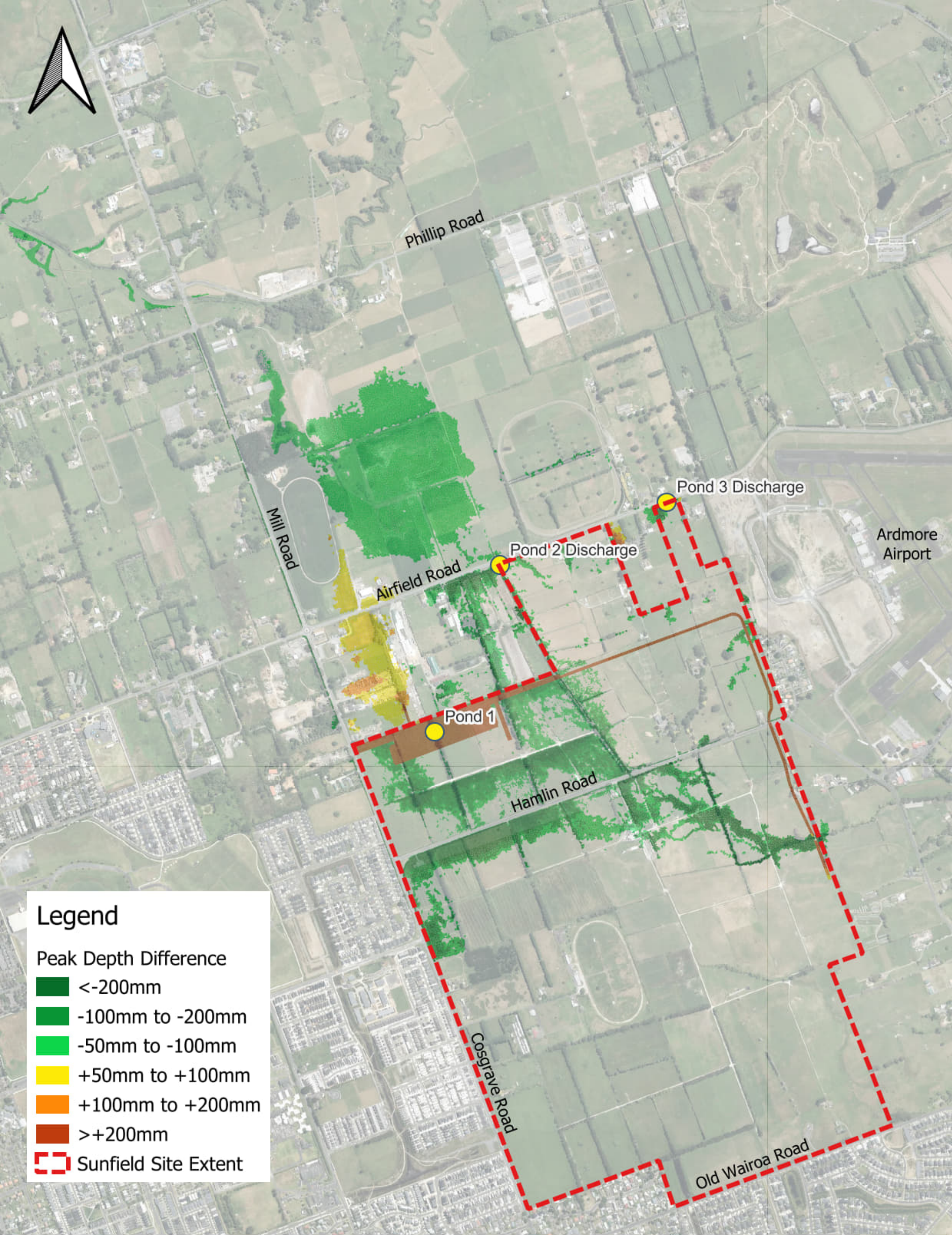
The peat extents used in the model are based on high level data provided by Auckland Council. The actual peat extent will create a different subcatchment runoff and may impact the potential flood hazard predicted in the downstream reaches of the stream.

For a given subcatchment, the distribution of impervious and pervious land cover on top of the peat was assumed to be equal as the distribution of future development (FUZ and infill) is unknown.

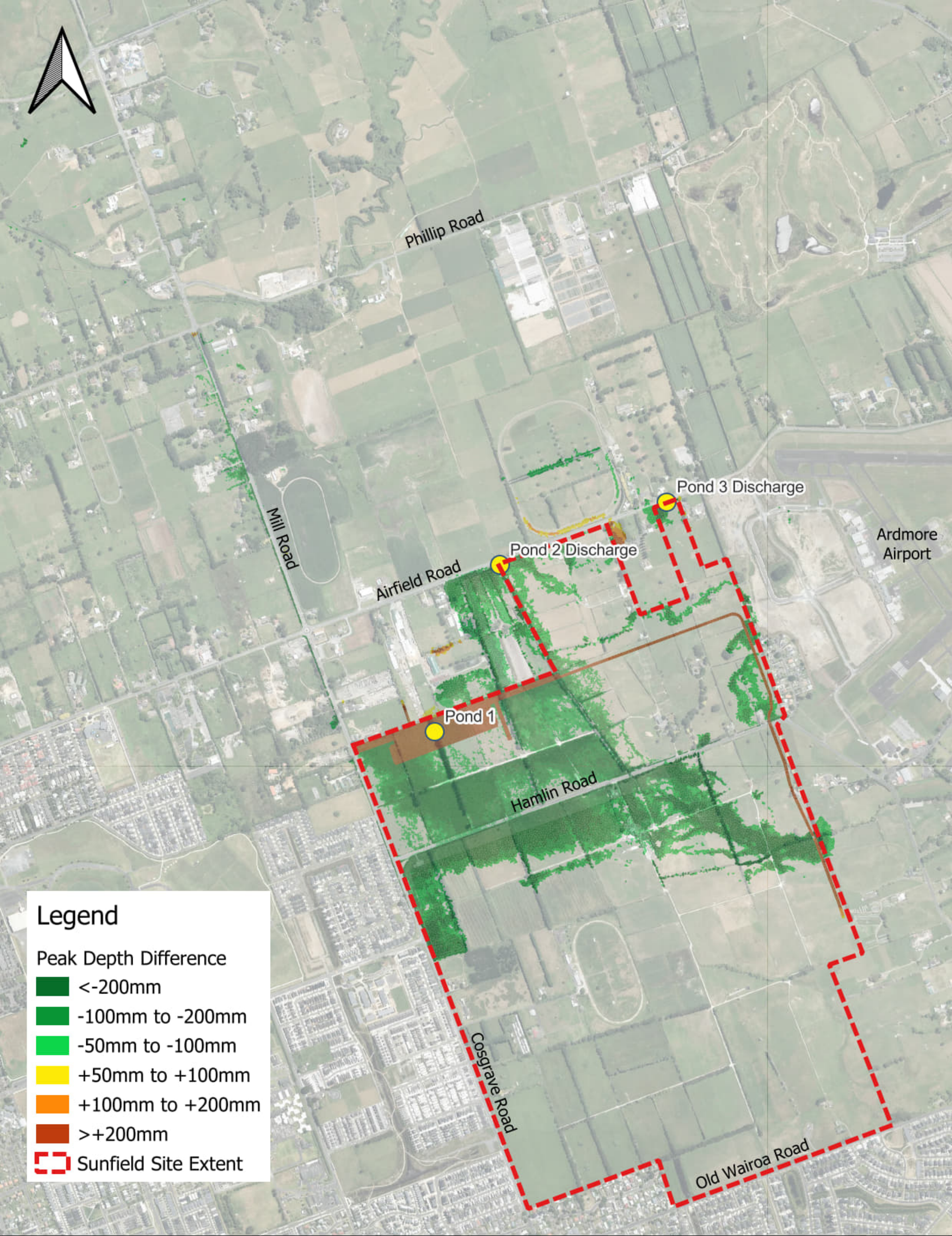
The CN39 (Lower) and CN98 (Upper) peat SCS depths selected are considered to be a sensitivity approach only. The selected values are intended to represent reasonable upper and low bounds for the peaty portion based of the catchment on limited validation events; additional testing would reduce the uncertainty of this assumption.

Baseflow or secondary contribution from subsurface flow has not been represented directly in this model.

APPENDIX B – RESULTS MAPS



wsp / Auckland Council Te Kaunihera o Tāmaki Makaurau	Sunfield Proposed Development Assessment - Papakura Stream Catchment	Peak Depth Difference Sunfield E vs E+SUN Peat CN: 61, Rainfall ARI: 2yr	
		R0	09/07/2025



wsp | Auckland Council Te Kaunihera o Tāmaki Makaurau

Sunfield Proposed Development Assessment - Papakura Stream Catchment	Peak Depth Difference Sunfield E vs E+SUN Peat CN: 61, Rainfall ARI: 10yr	
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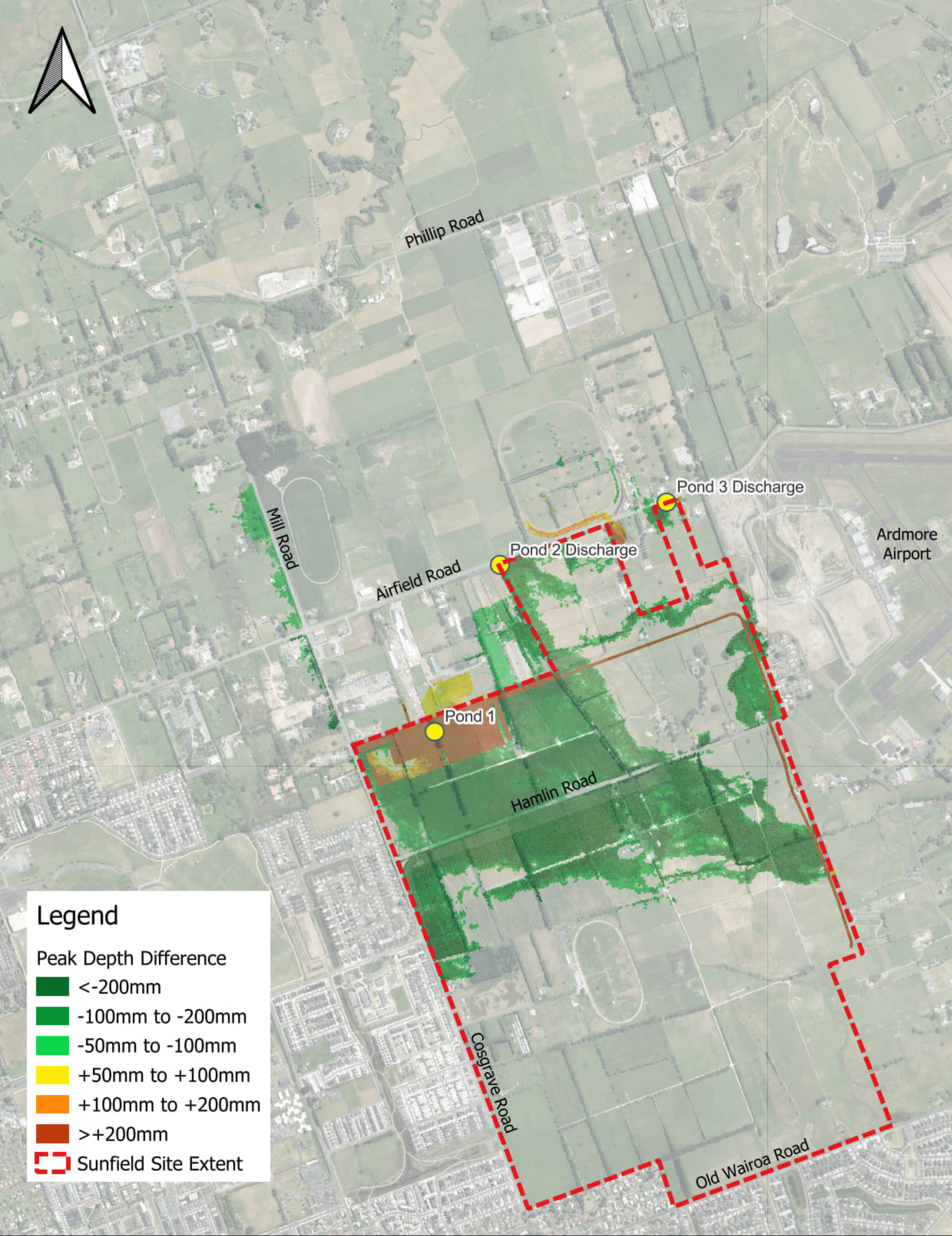
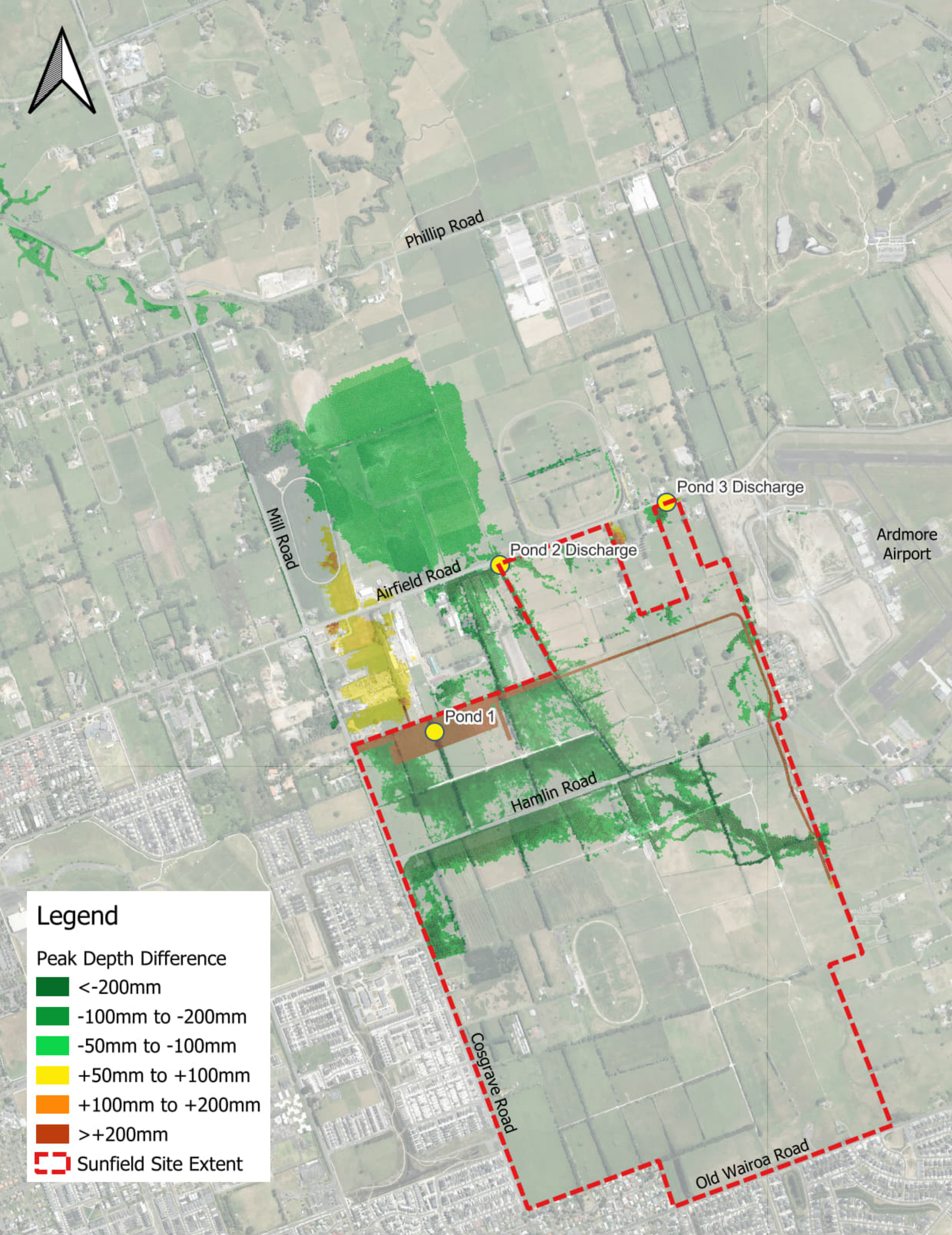
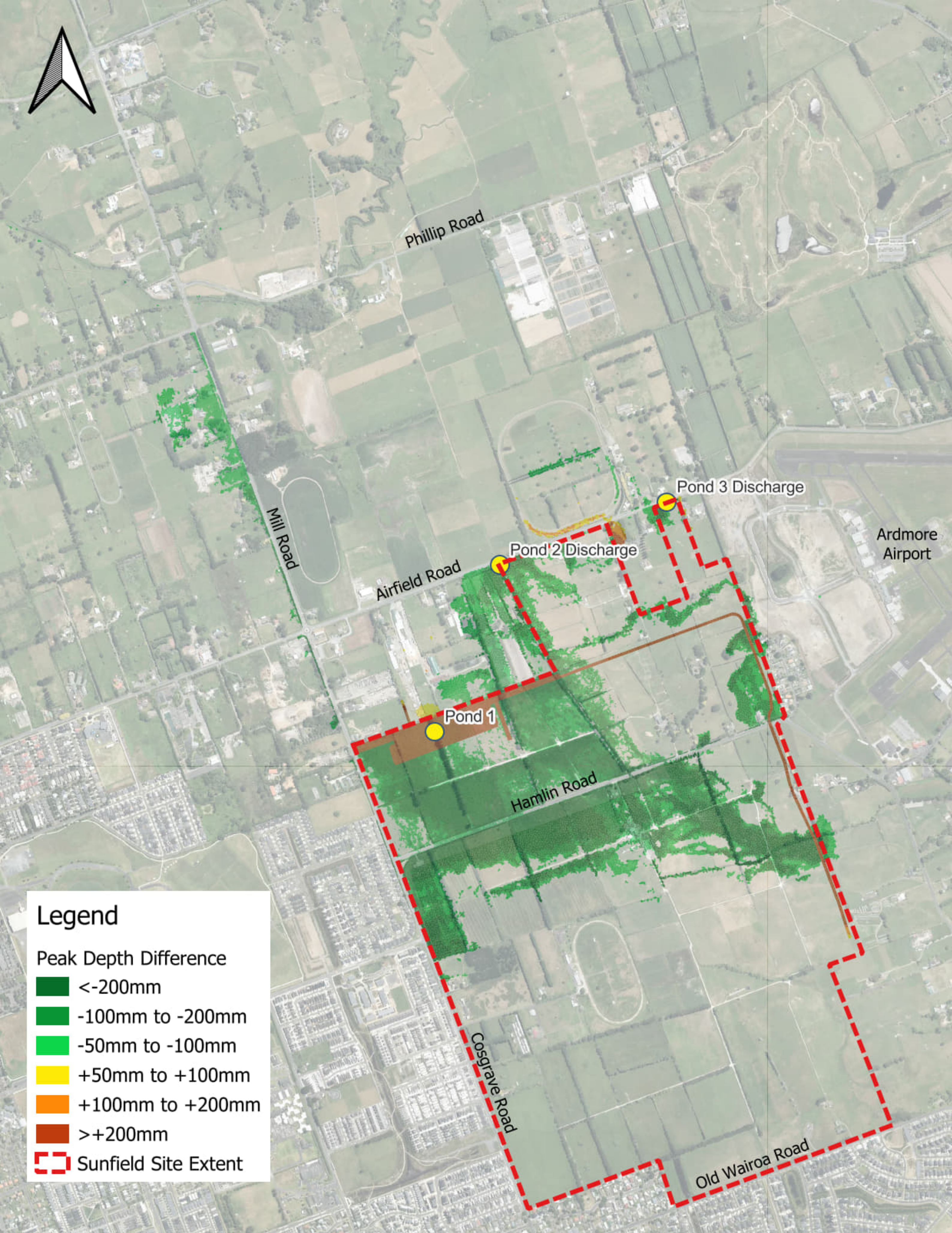


wsp / Auckland Council Te Kaunihera o Tāmaki Makaurau	Sunfield Proposed Development Assessment - Papakura Stream Catchment	Peak Depth Difference Sunfield E vs E+SUN Peat CN: 61, Rainfall ARI: 100yr	0 250 500 m
		R0	09/07/2025



WSP / Auckland Council Te Kaunihera o Tāmaki Makaurau	Sunfield Proposed Development Assessment - Papakura Stream Catchment	Peak Depth Difference Sunfield M vs M+SUN Peat CN: 61, Rainfall ARI: 2yr	0 250 500 m
		R0	09/07/2025



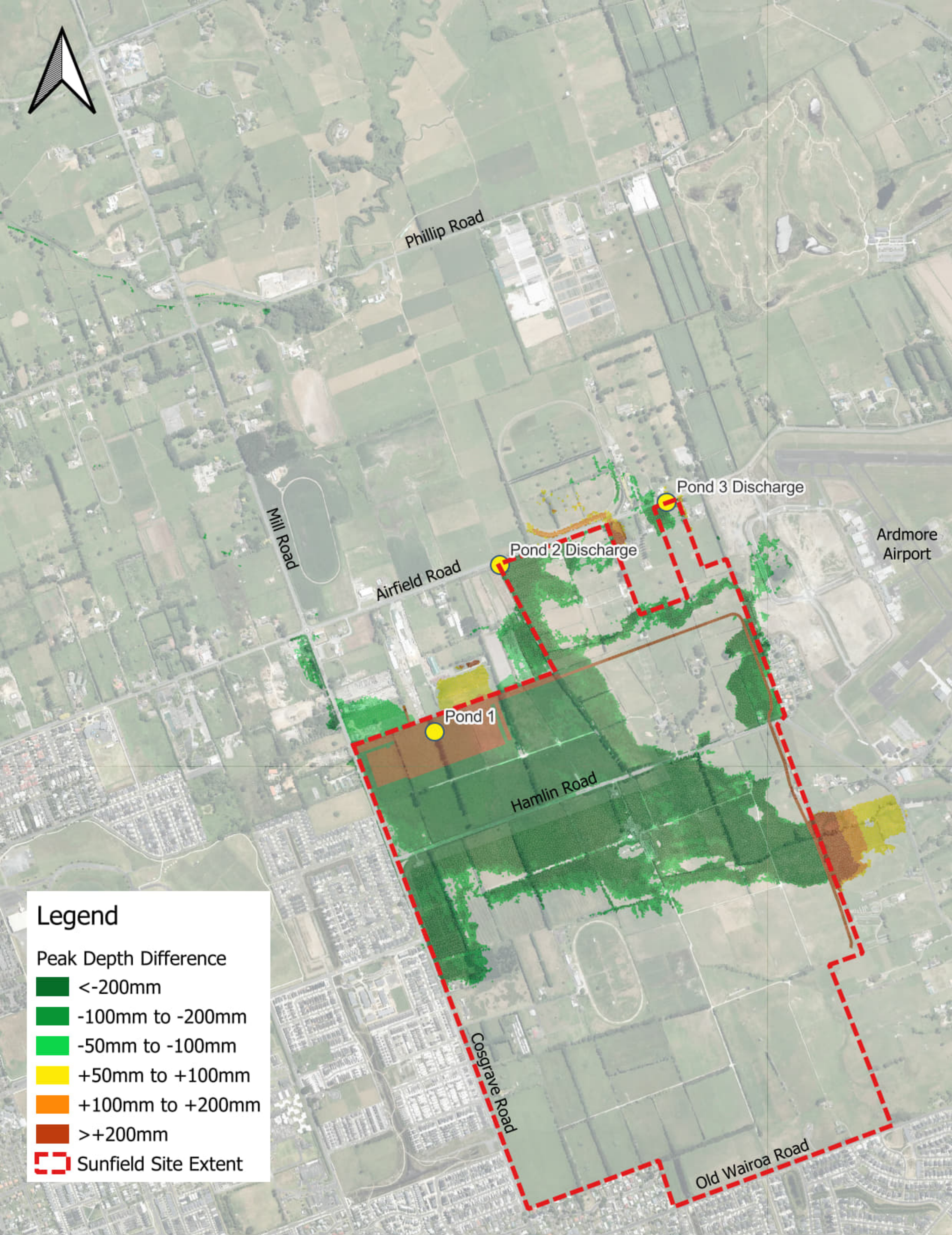
wsp | Auckland Council Te Kaunihera o Tāmaki Makaurau

Sunfield Proposed Development Assessment - Papakura Stream Catchment

Peak Depth Difference
Sunfield M vs M+SUN
Peat CN: 61, Rainfall ARI: 10yr

R0 | 09/07/2025

0 250 500 m



wsp / Auckland Council Te Kaunihera o Tāmaki Makaurau	Sunfield Proposed Development Assessment - Papakura Stream Catchment	Peak Depth Difference Sunfield M vs M+SUN Peat CN: 61, Rainfall ARI: 100yr	0 250 500 m
		R0 09/07/2025	