Appendix J Stormwater Management and Flood Modelling Report

Fast-Track Approvals Act 2024 Substantive Application

Hinuera Solar Farm

Harmony Energy NZ #6 Limited

SLR Project No.: 880.016894.00001

19 August 2026

STORMWATER MANAGEMENT & FLOOD MODELLING REPORT

HINUERA SOLAR FARM
HARMONY ENERGY NZ #6 LIMITED
STATE HIGHWAY 27 & 29
HINUERA

PROJECT INFORMATION

CLIENT	Harmony Energy NZ #6 Limited
PROJECT	MM-0809 – Hinuera Solar Farm

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1. EXECUTIVE SUMMARY

A flood modelling assessment was undertaken for the site at the corner of State Highway 27 & 29, Hinuera, known as Hinuera Solar Farm. The purpose of this assessment was to evaluate potential flood risks associated with the utility-scale solar/ Battery Energy Storage System (BESS) installation, ensuring minimal risks to equipment during both construction and operation phases, while also mitigating any adverse environmental impacts.

The study involved the development of hydrological and hydraulic models to assess flood risks under pre-development for 10-, 20-, 50-, 100-, and 250-year storm events, as well as post-development scenarios the 100-year storm event, incorporating a 2.1°C climate change adjustment in line with regional standards.

The pre-development models identified areas of the site vulnerable to flooding, with flood depths exceeding design requirements identified in certain locations. The post-development model incorporated terrain modifications, including the raising of roads, construction of foundation pads for electrical infrastructure, and filling of a low-lying area in the north. These changes were designed to mitigate flood risks and ensure compliance with freeboard requirements for critical components such as the substation, O&M building, and PCUs.

Key findings from the assessment are presented below:

- The 100-year post-development scenario showed a minor increase in flood levels (approximately 30mm) in localised areas of the site, with localised changes due to terrain modifications.
- Floodwater hazards are typically confined to existing watercourses, namely the Mangawhero Stream, to the Northwest of the site.
- Critical infrastructure, including the substation, O&M building, PCU's and BESS, are advised to be elevated above the 100-year flood level freeboard requirements. However, some areas within the site still exceeded 300 mm flood depth during a 10-year event and should be considered for placing of the Photovoltaic (PV) panels. Alternatively, flood sensors may be used to restrict movement and ensure the modules are kept above the water level in a flood event.
- The post-development fill scenario in the northern corner results in minor increases in modelled flood levels both on-site and off-site (generally <120 mm off-site). At this stage, no detailed mitigation design has been developed; however, the magnitude and extent of these changes are considered localised and will be managed through final detailed design, with the intent of avoiding adverse effects on neighbouring properties. Floodwater mitigation may be introduced in the form of engineered measures, although this should be modelled at detailed design stage to ensure that flood risk is not moved to downstream areas.
- Three major culverts (one existing and two proposed) have been included in the models however, the minor culverts located in the farm drains have not been included in the post-development model. This will be provided later at the detailed design phase to convey additional flow and minimize ponding caused by the new roads.

A summary of the pre-development and post-development model results are shown in Section 4.4.3 Flood Model Comparison.

2. BACKGROUND

2.1. AUTHOR QUALIFICATIONS AND STATEMENT OF COMPLIANCE

Joshua Dempsey – Civil Engineer/Team Lead – Maven

I am a Civil Engineer and Team Leader at Maven. I have been employed at Maven since 2020. I hold the qualification of Bachelor of Engineering (Honours) from the University of Auckland. I am currently working towards Chartered Professional Engineer (CPEng) registration with Engineering New Zealand.

I have over 5 years of experience in stormwater design, three waters, roading, and earthworks across a diverse range of project types. I've previously lead the civil design for Tauhei solar Farm, where my primary role was to oversee the civil design and delivery including site access, internal roading networks, stormwater management, earthworks, and platform preparation for solar infrastructure.

I confirm that, in my capacity as author of this report, I have read and abide by the Environment Court of New Zealand Practice Note 2023, and in particular section 9 the Code of Conduct for Expert Witnesses.

Uriaan du Plessis – Graduate Engineer – Maven

I am a Graduate Engineer at Maven. Maven is a civil engineering consultancy specialising in land development, infrastructure design, stormwater management, and resource consenting. I have been employed at Maven New Zealand since 2025. I previously worked for Tauranga City Council in Tauranga from 2024 to 2025. I hold the qualification of Bachelor of Civil Engineering with Honours from The University of Waikato in Hamilton, New Zealand. I am an Emerging Professional Member with Engineering New Zealand.

I have experience in civil engineering design, stormwater management, hydrology, flood assessment, infrastructure planning, and land development engineering, including technical reporting to support resource consent and building compliance assessments.

I confirm that, in my capacity as author of this report, I have read and abide by the Environment Court of New Zealand Practice Note 2023, and in particular section 9 the Code of Conduct for Expert Witnesses.

2.2. INTRODUCTION

Maven Matamata Limited have been engaged by Harmony Energy NZ #6 Limited (Harmony) to undertake a hydrological and hydraulic assessment for a utility-scale solar/BESS installation known as Hinuera Solar Farm (HSF) at the corner of State Highway 27 & 29, Hinuera.

The solar farm is projected to generate approximately 70MW (AC) / 100MWp (DC) of nominal power. This assessment aims to evaluate compliance with the client's specifications, with a focus on identifying and minimising potential risks to equipment during both the construction and operation phases of the project, while also minimising potential impacts on equipment and the surrounding environment.

Note that because the project site is uninhabited, the criteria for assessing risk will differ from those applied in inhabited zones. Consequently, local flood risk standards, including freeboard requirements, are not applicable in this context. The specific events under consideration are outlined in the subsequent sections below.

This report outlines the methodology used for flood modelling and presents the findings from pre-development and post-development scenarios. It also provides recommendations to address identified risks and ensure the project's resilience to hydrological challenges.

2.3. SCOPE OF REPORT

The purpose of this work is to develop hydrologic and hydraulic models to assess current flood risk, inform earthworks and concept civil design, and determine the effects of this development on neighbouring properties. These objectives are achieved through pre-development models of the site based on the 10-, 20-, 50-, 100-, and 250-year storm events as well as the post-development model of the 100-year storm.

To fulfil the purpose of the study, the following tasks have been undertaken:

- Desktop study to establish the existing catchment extents and topography.
- Hydrologic and hydraulic analysis using the direct rainfall method to evaluate runoff and obtain pre-development model results for design.
- Location of fill areas to reduce local depressions and minimise depth of ponding.
- Post-development modelling to assess the effectiveness of proposed flood mitigation measures on flood risk and mitigate adverse impacts on neighbouring properties.

This report covers the results of the hydrologic and hydraulic modelling, including an assessment of the pre-development scenarios and recommended flood mitigation measures, for any future post-development model applications.

2.4. SITE DESCRIPTION

The site is situated on the corner of State Highway 27 and State Highway 29, Hinuera, approximately 8.0km South of Matamata and 8.5km North of Tīrau, in a direct line. The site is approximately 154.53ha in area. The topography is generally flat, though the site climbs towards the East, to a peak of approximately RL101m along the Eastern boundary of 8270 and 8302 State Highway 27, with existing gradients of up to 10% in localised areas, and an overall, undulating contour from East to West, about 0.5% grade.

The upstream catchment extends approximately 12km south. Flood modelling has been identified as one of the critical elements for assessing the feasibility of the proposed utility-scale solar/BESS installation at this site.

Figure 1, below, shows a site locality map with the site area identified in yellow.

The site occupies the following land parcels:

- Lots 1 & 2 DPS 83767
- Section 1 Block X Tapapa SD
- Part Lots 1, 2 & 3 DP 11891
- Lot 2 DP 473263
- Section 3 Block X Tapapa SD
- Section 9 Block X Tapapa SD
- Section 11 Block X Tapapa SD

The geodetic datums used for this site are NZGD2000 Mount Eden for horizontal and NZVD2016 for vertical.

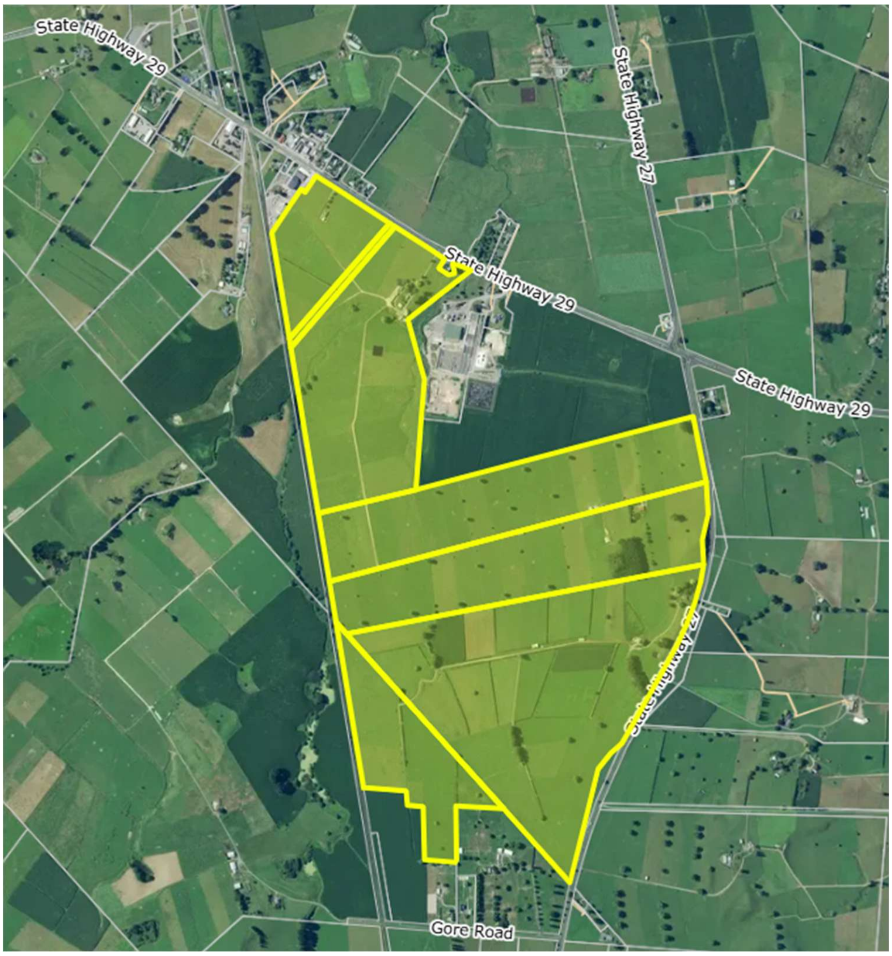


Figure 1: Site Locality Map – Source: Grip Map

2.5. STANDARDS AND RESOURCES

This development is within the jurisdiction of Matamata-Piako District Council (MPDC) and Waikato Regional Council (WRC). A list of the standards and guidelines, as well as publicly available resources that were used are shown below:

- WRC TR20/06 Waikato Stormwater Runoff Modelling Guideline
- NIWA HIRDS (High Intensity Rainfall Design System V4)
- ARC TP108 Guidelines for Stormwater Runoff Modelling in the Auckland Region
- Waikato Regional Hazards Portal (for river flooding and flood management)
- REC2 (River Environment Classification, v2.0)
- NEH 630 Chapter 9 Hydrologic Soil-Cover Complexes
- LCDB v5.0 – Land Cover Database version 5.0, Mainland, New Zealand, from LRIS Portal
- Public imagery (Google Maps, Bing Maps, New Zealand Imagery from Eagle Technology)

3. CATCHMENT CONTEXT

3.1. TERRAIN DATA

Terrain data contains a representation of the landform shape. Existing LiDAR data for the region was available from LINZ Data Service. Further information, such as site observation and photos, have been used to determine site conditions and establish reasonable hydrological assumptions.

Terrain data is typically imported as a Digital Elevation Model (DEM) raster into the models. Topographic surveys (such as LiDAR) are processed into DEM formats, then exported. If required, these may undergo further processing through Geographic Information System (GIS) software before importing into the model. Design surfaces are created in engineering software such as Civil 3D or 12D Model, then converted to a DEM, which may undergo similar post-processing through GIS. Surfaces are merged chronologically, where appropriate, with older data being overwritten with newer data in each spatial cell. DEM grids of different resolutions are resampled during reprojection to align all data to the same resolution and coordinate system. Minor errors will occur due to limitations in the spatial resolution and alignment differences between the DEMs, especially in sloped and non-uniform areas.

3.1.1. PRE-DEVELOPMENT TERRAIN

The Waikato LIDAR DEM was used for the preliminary model (the first dataset in Table 1 below). Results from this analysis was used to refine the catchment boundaries and build the detailed pre-development model. Table 1 below shows construction of the pre-development terrain (in order of subservience):

Name	Description	Organisation	Data Capture Date	Horizontal Resolution	Horizontal Accuracy
lds-waikato-LiDAR-1m-dem-2021	Waikato LIDAR DEM from LINZ Data Service	LINZ	2021	1m	+/- 1m

Table 1: Pre-Development Terrain Information

The DEMs were reprojected and merged into a combined surface with 1m resolution. The resultant surface was used as the base terrain for the combined hydrologic/hydraulic models.

3.1.2. TERRAIN QUALITY

The accuracy of the topographic information was provided alongside the data, with the root mean square error (RMSE) and maximum error detailed as follows:

- Hardstand surfaces: Maximum vertical error of 200mm.
- Soft surfaces: Maximum vertical error of 200mm.
- Bathymetry data: Riverbed level data were unavailable and could not be incorporated into the terrain model.

3.1.3. CATCHMENT DELINEATION

The extent of the preliminary model was established using a high-level assessment through River Environment Classification (REC2), assisted by an initial model. The direct rainfall method was selected for hydrologic modelling due to the nature of the catchment. The plains have an average grade of approximately 0.3% and diffuse overland flow was observed across most of the modelled area.

Catchment delineation is relevant for capturing the catchment extents for direct rainfall models, but clear delineation is often not required. The catchment area for the pre-development model was based on the preliminary model, with catchment boundaries checked against HEC-HMS.

The pre-development model extent was taken further than the catchment boundary, with a boundary condition around the outside to remove flow from neighbouring catchments. Refer to Figures 2 & 3, below, for screenshots of the overall catchment overlaid on the DEM.

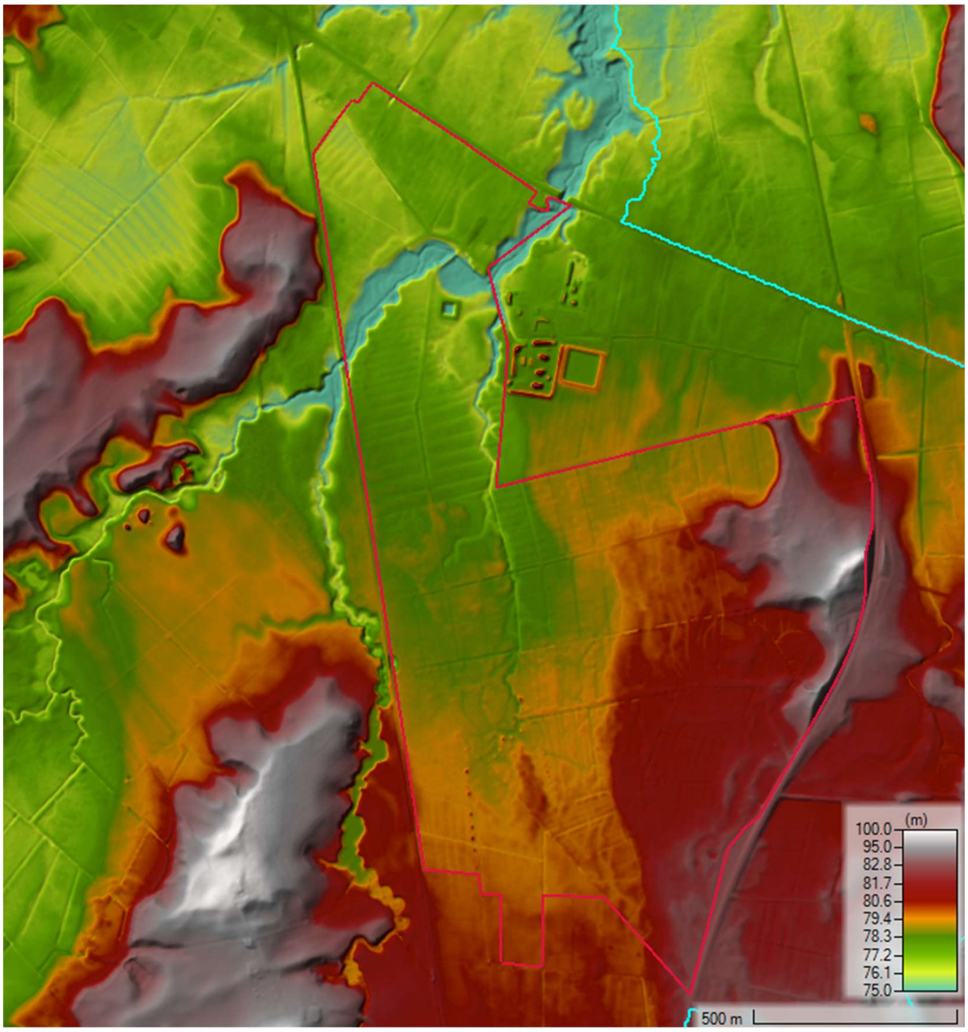


Figure 2: Pre-Development Basin Model Terrain – Source: HEC RAS

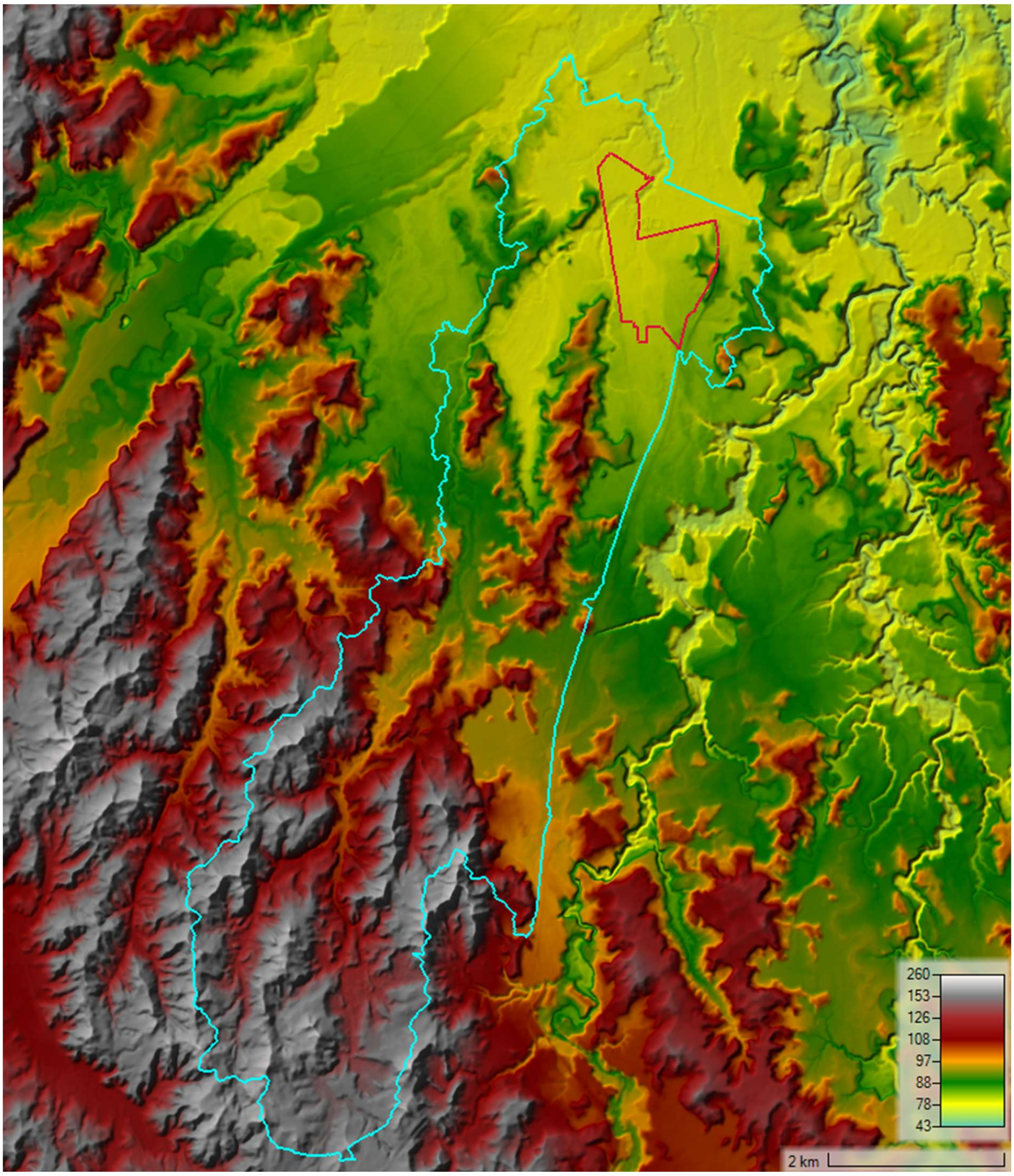


Figure 3: Pre-Development Basin Model – Full Boundary – Source: HEC RAS

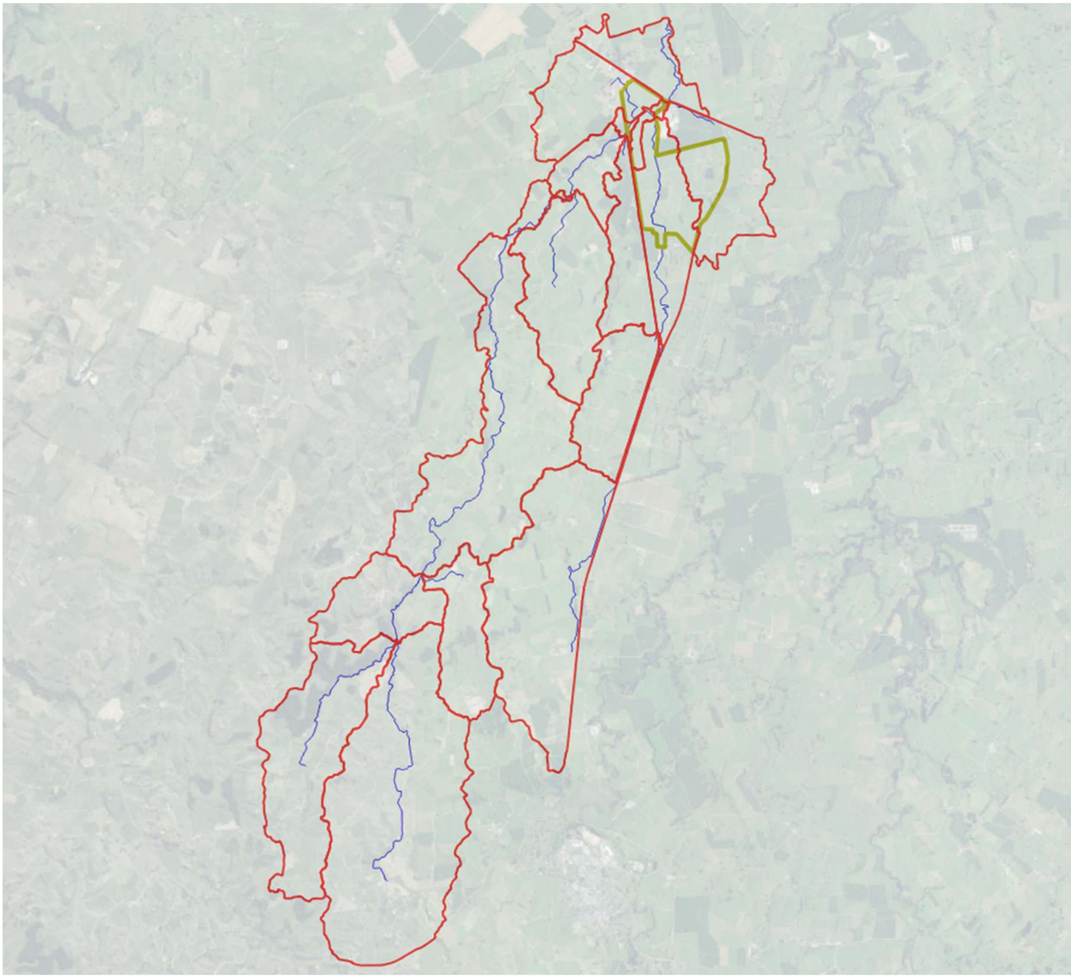


Figure 4: Catchment Area – Source: QGIS

3.2. CATCHMENT TOPOGRAPHY

The catchment generally falls towards the Northeast. The catchment boundary is bounded by State Highway 27 and the Ōraka Stream to the East and Mangawhero Stream (and tributaries) to the West.

Preliminary analysis showed that the volume of water flowing through the flow path marked by the Mangawhero Stream is around 29m³/s in the 100-year event. Refer to Figure 4, below, which shows the flood depths from the preliminary model.

The total catchment area modelled is approximately 30km². Flows from lesser events are primarily managed through channels and culverts. There are 3 major culverts (2 proposed and 1 existing) located within the tributary stream. The two proposed culverts both have catchments of greater than 100ha, but less than 500ha. The internal drainage will consist of approximately 26 additional internal culverts of varying sizes which will be confirmed at detailed design stage.

3.3. RECEIVING ENVIRONMENT

Flows through the site discharge into the Mangawhero Stream and its tributary. Stormwater in smaller events will primarily be discharged through hydraulic structures, which connect to the channels adjacent to the site. The accuracy of the information available for these hydraulic structures is more important in smaller events, as they are the primary method of flow conveyance and control.

The site appears to fall outside of any designated scheme, under the management of WRC. The level of service for the WRC-maintained stormwater infrastructure in the area is to drain water from the 10-year storm within three days, with the primary function being to prevent pasture damage. Since this level of service will have a negligible effect in a storm event, additional infrastructure specific to the scheme (such as flood pumps) was not included in the model.

WRC has not provided modelling results for the Mangawhero Stream, nor does the Mangawhero Stream appear in any recorded flood mapping.

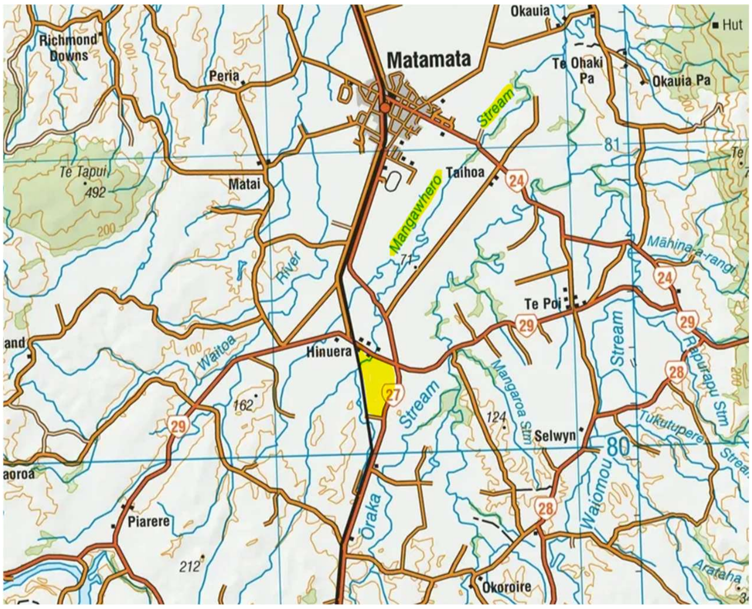


Figure 5: Mangawhero Stream – Source: NZ Topo Map

3.4. SITE GEOLOGY

The following soil types have been identified in the Geotechnical Investigation Report from CMW dated 06/11/2025:

- Topsoil
- Hinuera Formation – stiff to very stiff sandy silt
- Hinuera Formation – stiff to very stiff sandy silt interbedded with medium dense to dense sand
- Hinuera Formation – dense sand
- Walton Subgroup – very stiff and very dense sandy silt and sand

3.5. EXISTING FEATURES

Limited existing stormwater infrastructure has been shown on the topographic plans. Buildings on the site for development and neighbouring properties are shown in the aerials.

The site is located outside of any designated scheme, under the management of WRC, as detailed in the Receiving Environment section, above. The system is designed to manage and drain floodwaters from a 10-year storm event within three days. WRC-specific infrastructure related to this drainage scheme has not been specifically surveyed.

3.6. POST-DEVELOPMENT TERRAIN

The post-development HEC-RAS terrain was updated to reflect the proposed site layout and associated earthworks required. The modifications that were considered in the model's proposed ground surface include the addition of the proposed accessways and roads, inverter station pads, the site warehouse, switching station, and the O&M building platforms. These features were incorporated into the post-development terrain to represent changes in overland flow paths, local storage, and flood behaviour resulting from the proposed development.

Drainage infrastructure within the site was also updated to reflect the proposed design. No existing swales were removed or significantly modified as part of the proposed development. Aside from the inclusion of the two new culvert crossings, existing drainage conveyance paths were generally maintained across the site.

The two new culverts were incorporated within the existing north-south stream that feeds the Mangawhero Stream. These culverts sit beneath two of the proposed internal roads to maintain existing overland flow in this stream.

A culvert was incorporated beneath the existing farm track at the Mangawhero Stream crossing to represent conveyance, with sizing intentionally conservative due to limited existing information. The adopted dimensions may underrepresent true capacity and have resulted in simulated overtopping during severe events. This approach provides a conservative assessment of flood levels, with refinement recommended once detailed data becomes available.

Sizing and placement of other minor culverts haven't been incorporated into the model at this stage and will be confirmed at the detailed design stage. These culverts will convey additional flow and reduce ponding caused by the new roads.

Parts of the northern corner of the site shall be raised to reduce ponding depths. It is noted that filling within this area will displace some localised ponding, however, post-development modelling confirms that the impact of this displacement is negligible. This is discussed further in section 4.4.2.

4. FLOOD ASSESSMENT

4.1. MODELLING METHODOLOGY

The direct rainfall method was chosen because the initial model exhibited flow patterns which lack distinct and defined flow paths, known as diffuse overland flow. Direct rainfall is a newer hydrological method that is still gaining traction around the world. It generates a more accurate representation of how rainfall originates, disperses and infiltrates across the model area, particularly in regions with gentle slopes where water does not concentrate into specific channels. This approach combines the hydrologic and hydraulic components into an integrated model.

Hydrologic modelling is the process of creating a simplified representation of real-world hydrological systems. It uses inputs like rainfall, soil properties, and land cover to estimate the runoff generated in a rainfall event and resultant surface flows at predetermined points. Input parameters are abstracted from real-world processes and captures processes such as rainfall, evapotranspiration, and infiltration.

Hydraulic modelling simulates the behaviour of fluid flow and captures more localised effects, such as the flow behaviour around hydraulic structures. Effects such as fluid acceleration, wave propagation and tailwater conditions are considered. Results produced commonly include water level, velocity, and flow direction.

Catchment delineation is affected by the spatial resolution and construction of the computational grid to provide accurate runoff. Additionally, model run times are noticeably longer than a similar hydraulic model with direct inflows. However, this approach is required to capture the flow behaviour observed in this catchment and predict flood levels with more accuracy.

4.2. HYDROLOGICAL PARAMETERS

4.2.1. OVERVIEW

The storm event was simulated with a 24-hour nested storm profile using the data shown in TR20/06 Section 4.1 Temporal Pattern. The simulation was then extended for an additional 24 hours after the end of the rainfall event, with no additional water flowing into the system. The peak discharge occurred approximately 1 to 2 hours after the peak rainfall intensity. However, the recession limb of the hydrograph extended beyond the initial 24-hour period. Consequently, the extended simulation duration allows the model to capture the full hydraulic response of the catchment.

4.2.2. MODEL PARAMETERS

All models assume a climate change adjustment of 2.1°C, as is standard in the Waikato Region. See Item 2 of IM-M11 – Incorporating effects of climate change, Part 2 – Resource Consent Overview, WRC Regional Policy, consistent with TR20/06 Section 4.3 Climate Change.

The change in rainfall depth was calculated from Table 3 in the HIRDS Version 4 Technical Report Section 4.4 Augmentation factors for HIRDS. A screenshot of the table is shown in Figure 6 below. As there is no data available for events exceeding the 100-year storm, the climate change adjustment for the 250-year storm is based on the same change factor: an increase of 13.6%/°C of warming.

DURATION/ARI	2 YR	5 YR	10 YR	20 YR	30 YR	40 YR	50 YR	60 YR	80 YR	100 YR
1 HOUR	12.2	12.8	13.1	13.3	13.4	13.4	13.5	13.5	13.6	13.6
2 HOURS	11.7	12.3	12.6	12.8	12.9	12.9	13.0	13.0	13.1	13.1
6 HOURS	9.8	10.5	10.8	11.1	11.2	11.3	11.3	11.4	11.4	11.5
12 HOURS	8.5	9.2	9.5	9.7	9.8	9.9	9.9	10.0	10.0	10.1
24 HOURS	7.2	7.8	8.1	8.2	8.3	8.4	8.4	8.5	8.5	8.6
48 HOURS	6.1	6.7	7.0	7.2	7.3	7.3	7.4	7.4	7.5	7.5
72 HOURS	5.5	6.2	6.5	6.6	6.7	6.8	6.8	6.9	6.9	6.9
96 HOURS	5.1	5.7	6.0	6.2	6.3	6.3	6.4	6.4	6.4	6.5
120 HOURS	4.8	5.4	5.7	5.8	5.9	6.0	6.0	6.0	6.1	6.1

Figure 6: Percentage Change Factors to Project Rainfall Depths Derived from the Current Climate to a Future Climate That is 1 Degree Warmer

The models were built from the parameters listed in Table 2 below.

	Event			Rainfall				Model
Scenario	**ARI**	**Duration**	**Storm Profile**	**Data Source**	**Historic Depth**	**CC Adjustment**	**Adjusted Depth**	**Duration**
Pre-development	10-year	24 hours	TR20/06	NIWA HIRDS	143 mm	Historic + 2.1°C	182.3 mm	48 hours
Pre-development	20-year	24 hours	TR20/06	NIWA HIRDS	166 mm	Historic + 2.1°C	212.4 mm	48 hours
Pre-development	50-year	24 hours	TR20/06	NIWA HIRDS	199 mm	Historic + 2.1°C	255.4 mm	48 hours
Pre-development	100-year	24 hours	TR20/06	NIWA HIRDS	226 mm	Historic + 2.1°C	290.5 mm	48 hours
Pre-development	250-year	24 hours	TR20/06	NIWA HIRDS	261 mm	Historic + 2.1°C	335.5 mm	48 hours

Table 2: Parameters Used for Modelling Relevant Rainfall Events

The hydrologic models use the SCS Curve Number methodology for catchment runoff calculations. The land cover type was chosen as "Pasture, grassland, or range-continuous forage for grazing" of fair condition as described in Table 9-1 of NEH Part 630 Chapter 9. Hydrologic soil group (HSG) B was assumed over the entire catchment area based on site geology.

4.2.3. RAINFALL DATA

The rainfall events were based on the same hyetograph from WRC TR20/06. As stated in the Overview section, the duration has been extended to 48 hours. This is included in the graph in Figure 7 below showing the rainfall profile, where the last 24 hours have no rainfall. Note that the graph is unitless and has been scaled to the total 24h rainfall depths for each event in their respective models.

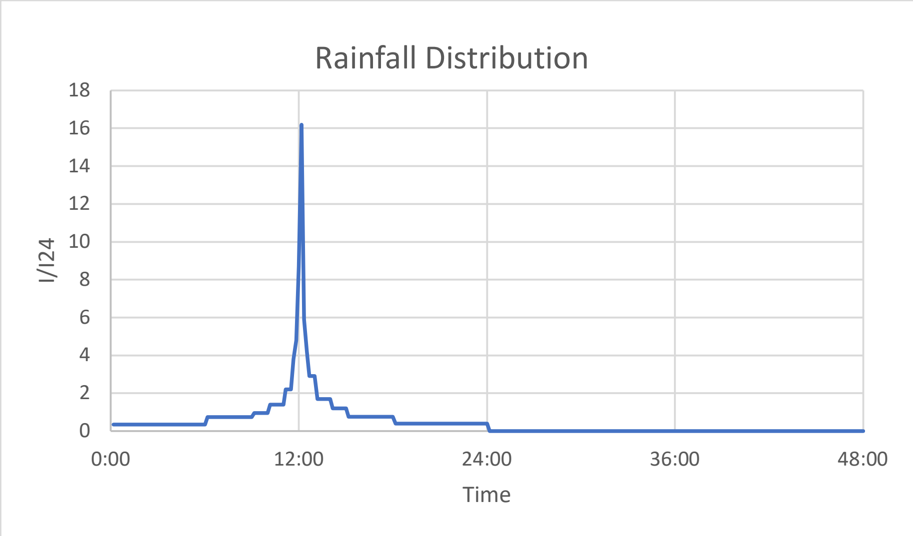


Figure 7: Rainfall Distribution Hyetograph Used to Represent Each Rainfall Event

4.2.4. ASSUMPTIONS

Curve numbers, storage, and initial abstraction are based on observed soil properties and available information at the time of study. The values chosen for the model represents the general hydrological response predicted for each land cover type and subbasin, but more spatial variability is expected, compared to the model inputs used.

4.3. HYDRAULIC MODELLING

4.3.1. OVERVIEW

All models used the same inputs to maintain consistency, except for hyetographs, which were changed based on the total rainfall depth. Due to the flatness of the site, some areas may have changes in flood extents between different storm frequencies.

4.3.2. MODELLING SOFTWARE

The hydraulic models for the site have been developed using HEC-RAS (River Analysis System) version 6.3.1 developed by Hydraulic Engineering Center (HEC) of the United States Army of Corps of Engineers (USACE).

4.3.3. MODEL PARAMETERS

In addition to the hydrological parameters discussed in the section above, the main parameters used to build the hydraulic models are described below, in sequential order of inputs into the model:

Terrain data contains a representation of the landform shape and is processed using the method outlined in the Terrain Data section under Catchment Context above. This data was imported into the model as a DEM. Buildings were not added to the model because the building density is sufficiently sparce to have a negligible effect on flood behaviour overall.

Geometry files store the spatial and GIS information relating to the model. It includes definitions for storage areas, flow areas, 1D hydraulic elements (such as culverts), and boundary condition lines. Each geometry has an associated projection. A grid size of 20m was used across the 2D flow area. Break lines were added at ridgelines and areas where refinement was required to modify the positions of local computation points. All break lines were set at a resolution of 10m. The computational mesh immediately around the site is shown in Figure 8, below.

The three culverts that were added in the models have diameters range from 450mm for the two tributary culverts to 1050 mm for the Mangawhero Stream culvert as shown on the ESC Plans (C200). These culverts appear to be critical in large storm events, but this effect was not significant enough to have a noteworthy effect on flood levels. No flow control structures (such as flap gates) were observed on site.

Flow data contains the data linked to the boundary conditions in the geometry files. Inflow boundary conditions used hydrographs obtained through the process outlined in the Model Parameters and Rainfall Data sections under Catchment Context, above. This assessment uses unsteady models with varying flow rates through time.

Plan data determines how the simulation is computed. Models are based on the Shallow Water Equations with time steps based on the Courant number, which accounts for more hydraulic factors than the Diffusion Wave equations and gives a more accurate output in most situations. 1D/2D iterations have been enabled to potentially increase the stability and accuracy of the model.

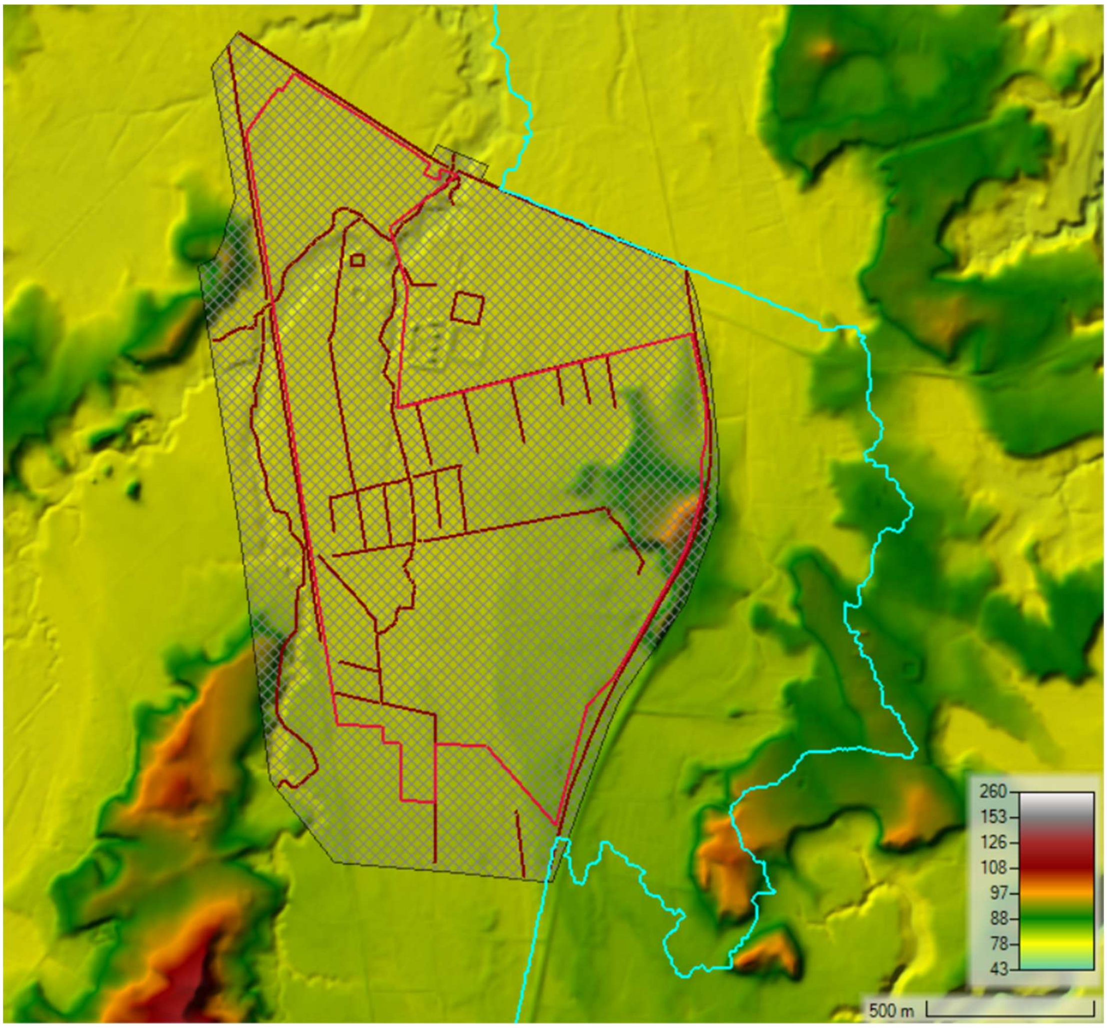


Figure 8: Pre-Development Terrain and Computational Mesh – Source HEC RAS

4.3.4. BOUNDARY CONDITIONS

Four normal depth boundary conditions were used as the boundary conditions for the North Inflow, West Inflow, South-West Inflow and South Inflow. Another auxiliary boundary condition was placed around the remaining perimeter of the model boundary to remove excess flows from outside the catchment boundary.

The same boundary conditions were used for all models.

4.3.5. ASSUMPTIONS

Publicly available information has been used for the areas both within and outside of the site. Generally, public data is lower resolution, less recent, not specific to the area of study, and not as easily verified against the raw data. However, tolerances and comparisons between different sources in multiple formats (such as aerial imagery, LiDAR and REC2 catchment delineation) are consistent with each other, which increases confidence in this data.

Attenuation of the catchment within the modelled area was included through terrain storage. However, the accuracy of topographic data is affected by vegetated cover and may affect flow direction, terrain flood storage, stop-bank overtopping levels and times. To account for the presence of roads in the model, a uniform width was assigned to all roads as part of the terrain modification process. The chosen road width had a negligible impact on the model's storage capacity and flow characteristics.

Infrastructure upstream of the site may impact results. Flows that may be redirected away from the catchment by underground infrastructure are not captured in the model. This is less of a risk for rural catchments, as flows are less likely to be rerouted through pipes or other conveyance systems. This was not investigated and may affect model results.

The differences in behaviour between sheet flow, concentrated flow and stream flow has been simulated by applying a nominal depth to obtain differences in infiltration and conveyance behaviour. Assumptions could be conservative and may not correspond to actual flood behaviour.

Culvert inverts in the post-development models were determined based on the surrounding terrain heights. Since flow rates are predominantly influenced by the head difference across the culvert, variations in invert levels have a minimal impact on the model results.

4.4. MODELLING RESULTS

4.4.1. NUMERICAL ACCURACY AND MODEL STABILITY

A larger cell size was used for this project because of the uniformity of the terrain. Additionally, smaller cell sizes would increase model run times and reduce model stability. Numerical accuracy was controlled using a range of time steps based on maximum Courant numbers.

All the models showed instability at the start and end of the simulation but were relatively stable at the peak. Since critical flood values occur near peak flow, initial errors dissipate before reaching this stage. The instability is likely due to the direct rainfall method, which involves shallow flow over a large area and is more error prone. Results were evaluated for numerical convergence (represented by WSE error) and volume difference. While volume differences are within acceptable limits across most scenarios, numerical convergence was weaker than expected, aligning with the observations mentioned above.

4.4.2. FLOOD MODEL COMPARISON

A summary of the model results is shown in Tables 3 and 4 below:

Table 3: Comparison of Pre-Development Model Results for 10-, 20-, 50-, 100-, & 250-Year Storm Events

	Pre-Development					
	10-year	20-year	50-year	100-year	250-year	
Peak Site Flow	13.46	17.53	22.64	29.28	37.14	m^3/s
Time of Peak	23:53	22:29	22:25	21:58	21:49	hh:mm
Peak Site Flood Level	88.14	88.14	88.14	88.15	88.16	m (NZVD2016)
Peak Outlet Flood Level (Stream)	73.96	74.10	74.28	74.42	74.60	m (NZVD2016)
Peak Flood Depth (Stream)	3.04	3.04	3.09	3.11	3.15	m
Peak Flood Depth (Site)	0.45	0.53	0.62	0.66	0.73	m
Total Volume at Outlet	912.96	1191.19	1622.22	2010.27	2546.04	m^3

Table 4: Comparison of Pre-Development and Post-Development Model Results for 100-Year Storm Events

	Pre-Development vs Post-Development			
	Pre-Development 100-year	Post-Development 100-year	Difference	
Peak Site Flow	29.28	29.20	-0.08	m^3/s
Time of Peak	21:58	22:00	+00:42	hh:mm
Peak Site Flood Level	88.15	88.17	+0.02	m (NZVD2016)
Peak Outlet Flood Level (Stream)	74.42	74.61	+0.19	m (NZVD2016)
Peak Flood Depth (Stream)	3.11	3.22	+0.11	m
Peak Flood Depth (Site)	0.66	0.69	+0.03	m
Total Volume at Outlet	2010.27	1990.30	-19.97	m^3

The results indicate a general increase in the range of flood levels across the site for all storm frequencies when comparing pre-development and post-development scenarios. However, some areas show reduced flood levels in the post-development model. Pre-development conditions showed minimal diffusion due to the absence of terrain storage within the site. In contrast, post-development scenarios showed increased diffusion, particularly for higher-frequency storm events, which results in smoother peak flows.

The modelled results around to the Mangawhero Stream crossing indicate that upstream flooding occurs during larger storm events under both pre- and post-development scenarios due to the conservative size selected for the modelling of this culvert. However, the post-development model shows only minor changes relative to existing conditions, with peak flows reducing slightly by 0.08 m^3/s during the 100-year event and upstream flood levels increasing by a maximum of 0.02 m. These changes are considered negligible and confirm that the proposed development does not materially exacerbate flooding associated with the existing culvert constraint.

The total discharge from the site across the northern discharge boundary shown in Figure 9 was plotted to illustrate the difference in flow rates for each of the storm scenarios (Figure 10). All events show an overall time of concentration of approximately 10 hours, although discharge timing at individual points varies by up to 2 hours.

Due to the post-development terrain modifications outlined in Section 3.6, several changes in flood behaviour were observed within the site:

- The proposed roading has elevated ground levels within the road corridors. In places this obstructs minor overland flows/sheet flow, resulting in small increases in ponding and flood depths. This will be reviewed during detailed design and, if required, addressed through the inclusion of minor culverts and drainage provisions.
- The installation of inverter station pads, as well as the site warehouse, switching station, and O&M building platforms, displaces minor ponding, causing water to shift to adjacent ponding areas.
- In the northwest corner of the site, raised ground levels were modelled with the intention of mitigate ponding. This was effective in reducing flood depths within the modified area, but has led to a marginal increase in surrounding flood depths. This includes up to approximately 120mm just beyond the northwestern boundary. This was modelled in order to understand what impact this would have on flooding, however the increase in flooding will be mitigated at the detailed design. It is also noted that the detailed design to deal with on-site ponding may differ from the fill area shown on the plans at this stage.

Generally, the increases in ponding depths due to displacement are considered negligible, with an increase in post development ponding depth within the site of no greater than 30mm. This excludes stream areas and subsequently has little to no impact on the overall design.

If necessary due to discrete areas of filling, any increase in flood depth at the Northern boundary (120mm) will be mitigated at the detailed design stage through the use of overland flow paths to drain this area into the Mangawhero Stream, preventing negative effects on the neighbouring property.

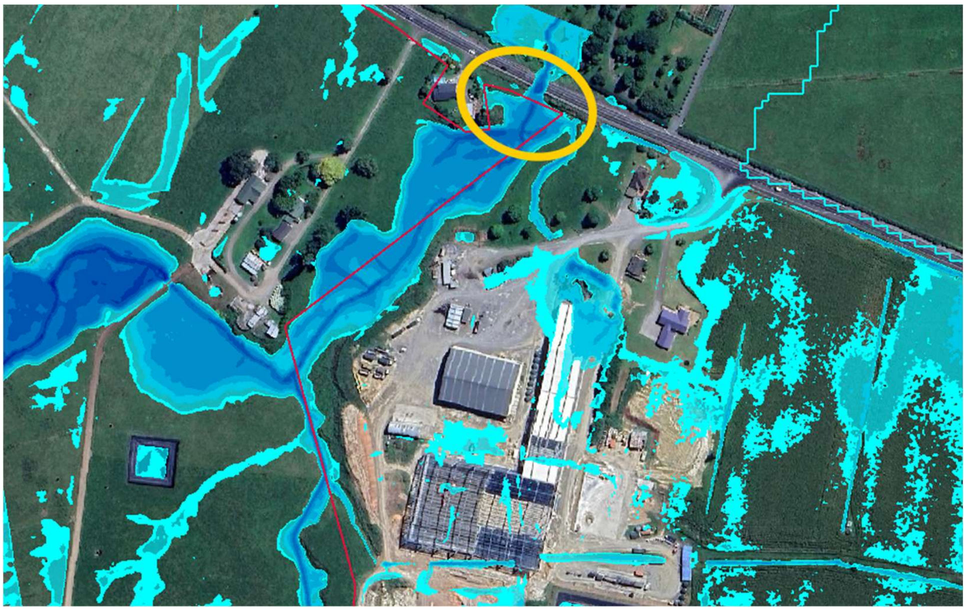


Figure 9: Location of Northern Discharge Boundary

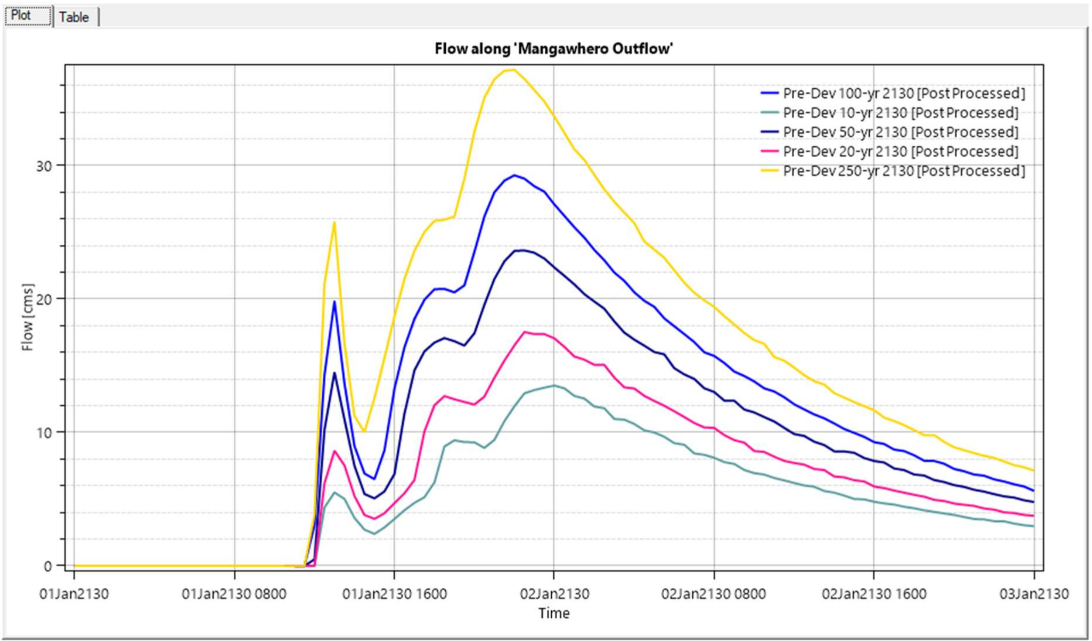


Figure 10: Overall Discharge Flow Rate via Northern Discharge Point

4.4.3. FLOOD LEVELS

Figure 11 below shows the modelled flows for pre- and post- development at the northern discharge boundary. This boundary exhibits similar flow behaviours for both the pre- and post-development simulations, as reflected in the shape of both respective stage hydrographs. There is, however, an inherent uncertainty in the time of peak due to multiple peaks that occur and common model instabilities.

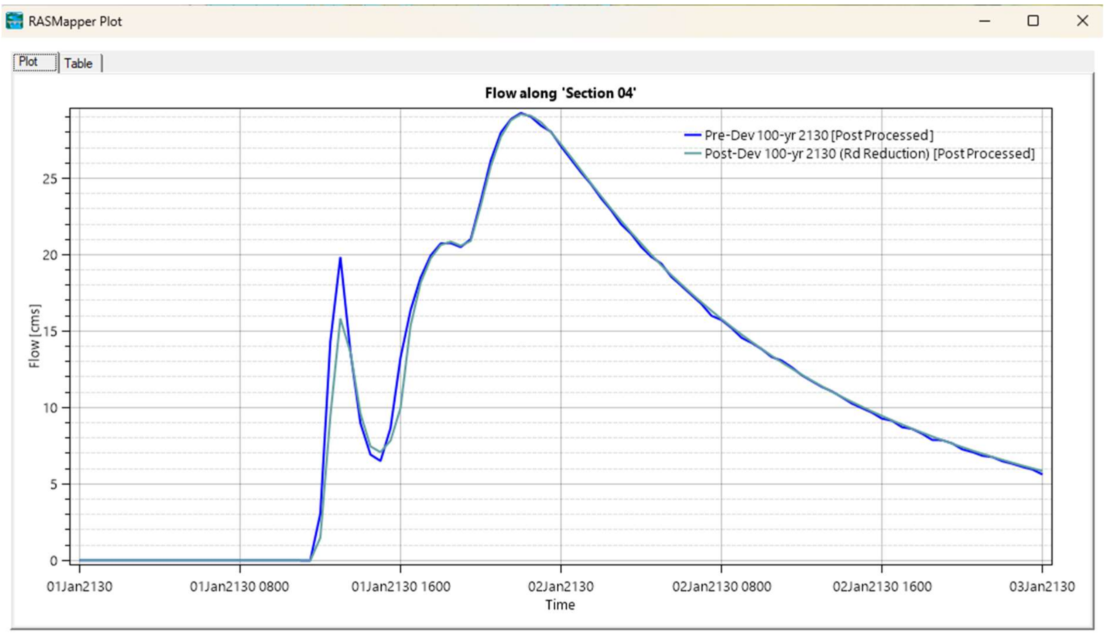
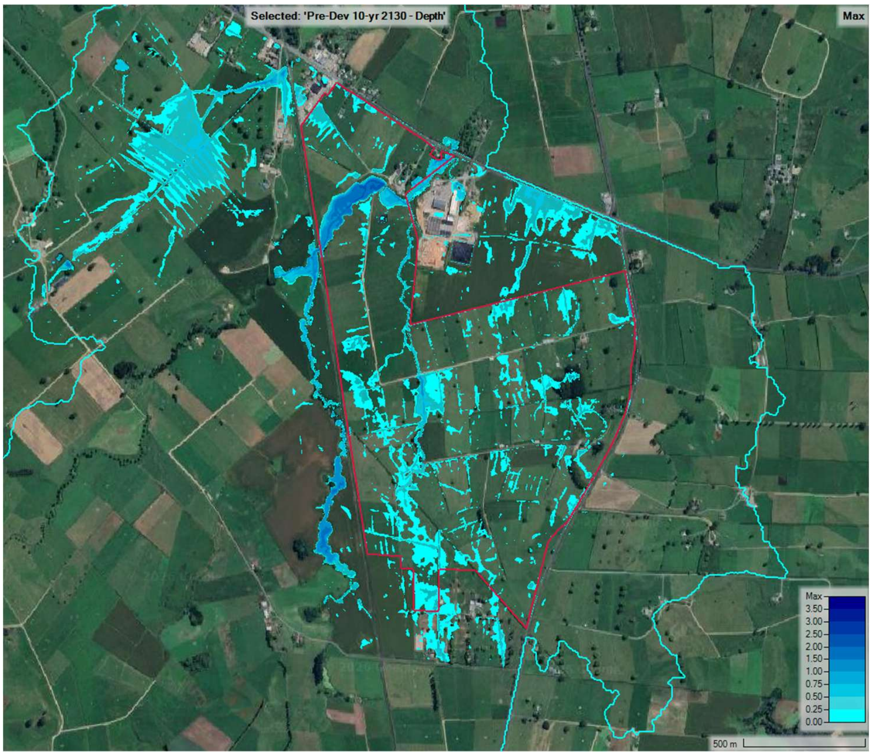
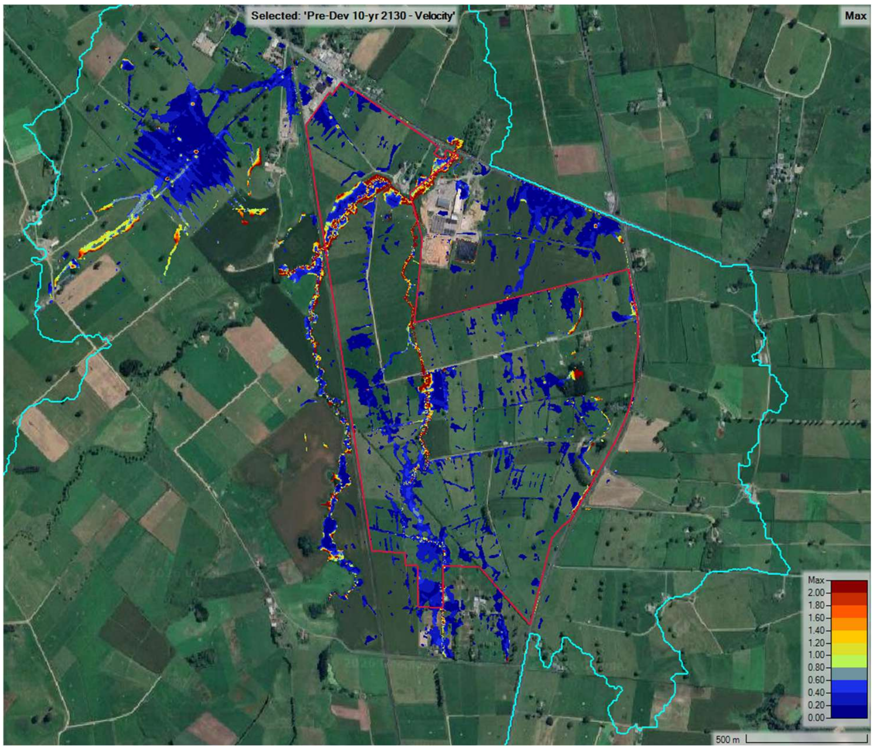


Figure 11: Flows – Northern Discharge Point

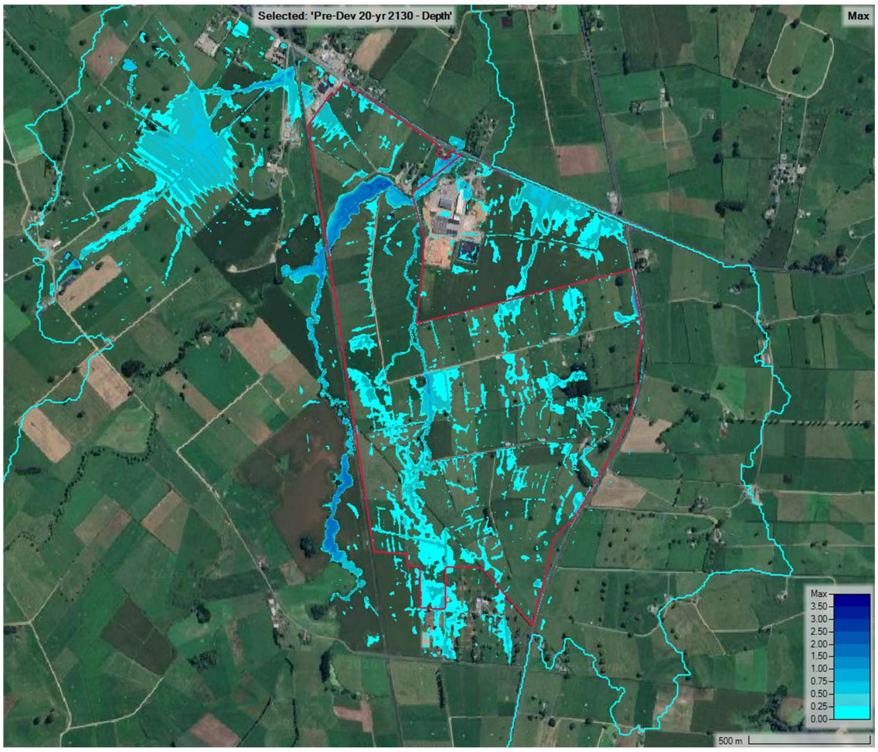
The following screenshots show the depths and velocities for each event. Due to the model using the direct rainfall method, a cutoff depth has been chosen to reduce the area of flooding shown. This is standard practice for direct rainfall models, and the cutoff depth is chosen such that sheet flow is ignored while critical areas are still displayed. A cutoff depth of 100mm has been chosen in this instance. Depths are shown as discrete shades at 250mm increments up to 1.0m and then 500mm intervals, up to a maximum 3.5m. Velocities are shown as continuous shades up to 2 m/s. Refer to the enlarged scales immediately below, which is consistent with all the results maps.

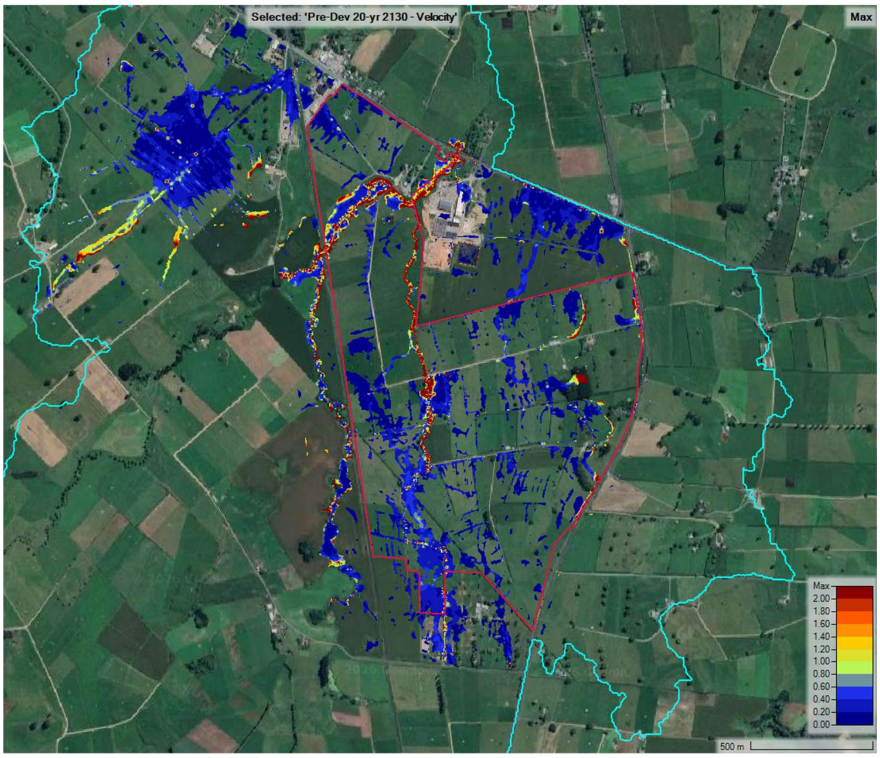
For more flood depth information, refer to C410 drawing set.



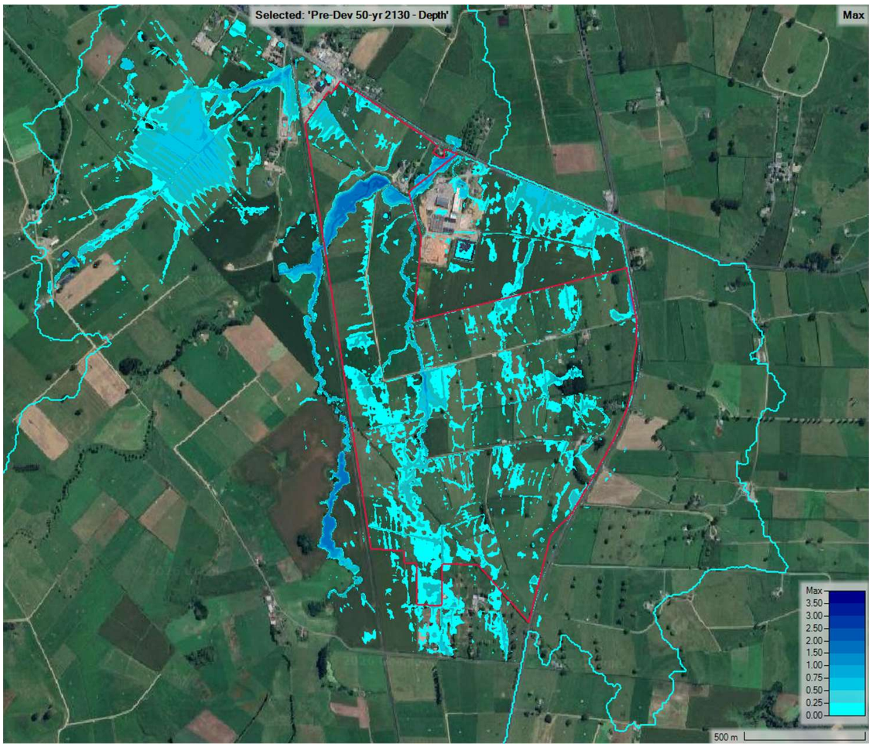


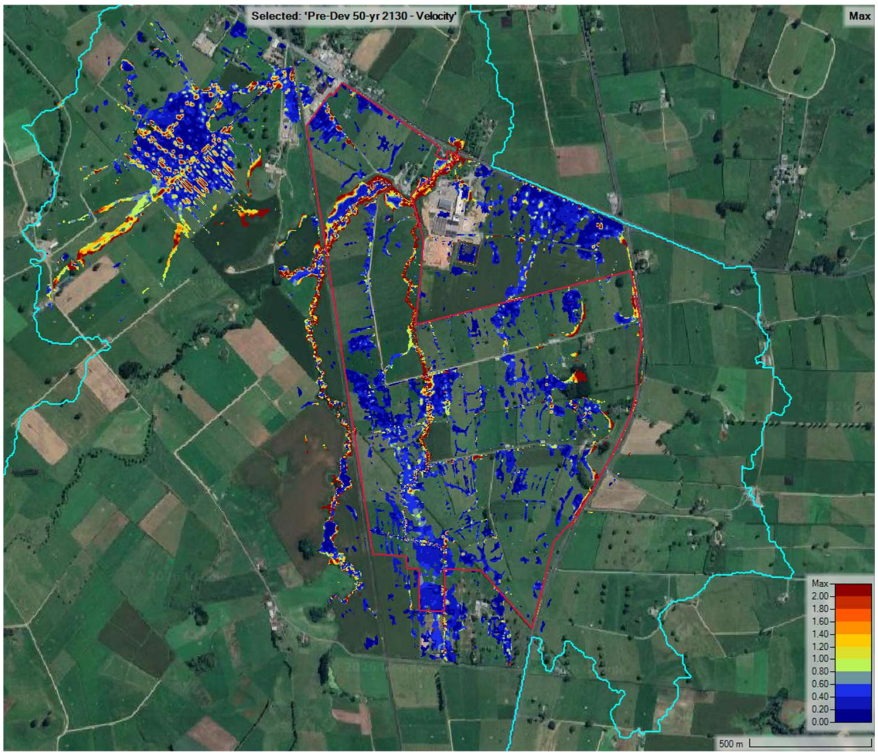
Figures 12-13: Flood Depth and Velocity – 10-Year Pre-Development Event with 2.1°C Climate Change Adjustment – Source: HEC RAS



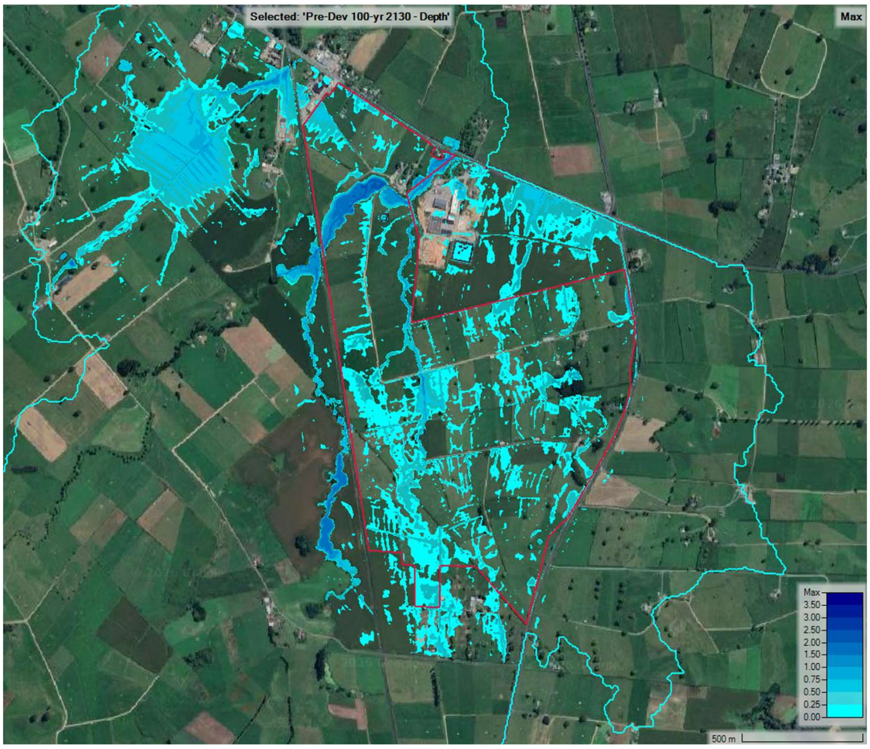


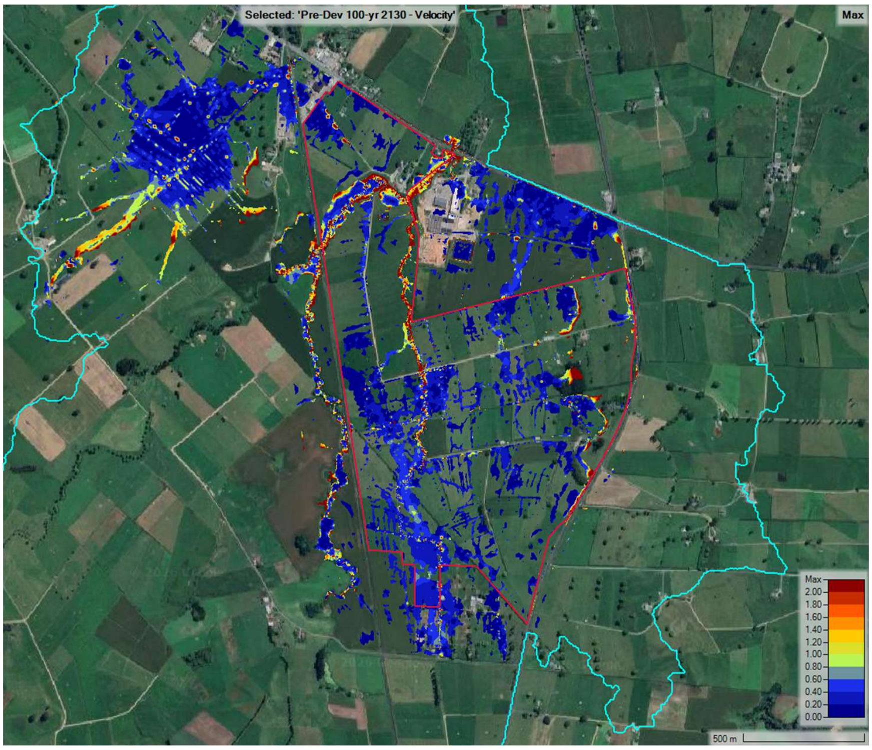
Figures 14-15: Flood Depth and Velocity – 20-Year Pre-Development Event with 2.1°C Climate Change Adjustment – Source: HEC RAS



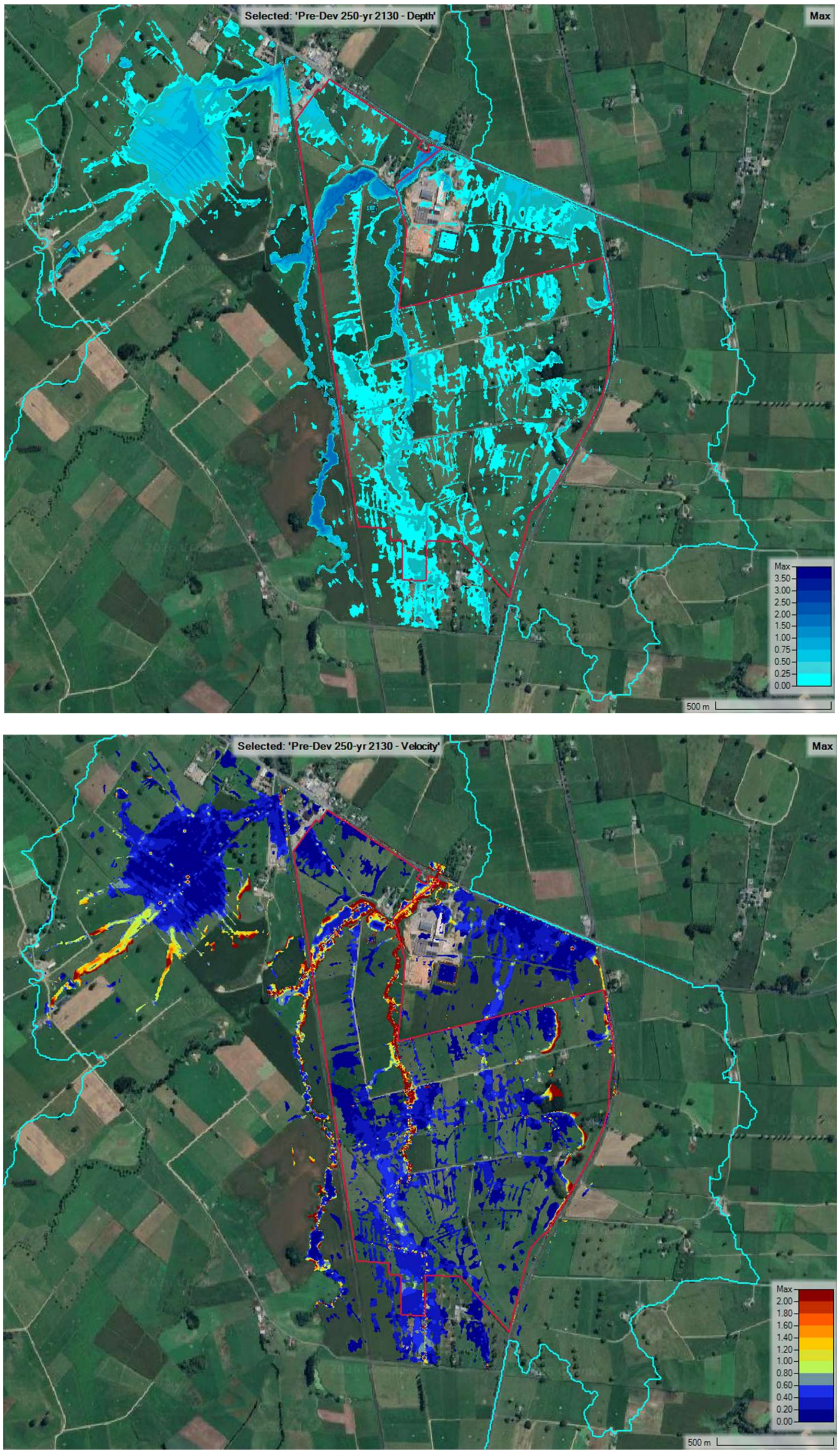


Figures 16-17: Flood Depth and Velocity – 50-Year Pre-Development Event with 2.1°C Climate Change Adjustment – Source: HEC RAS

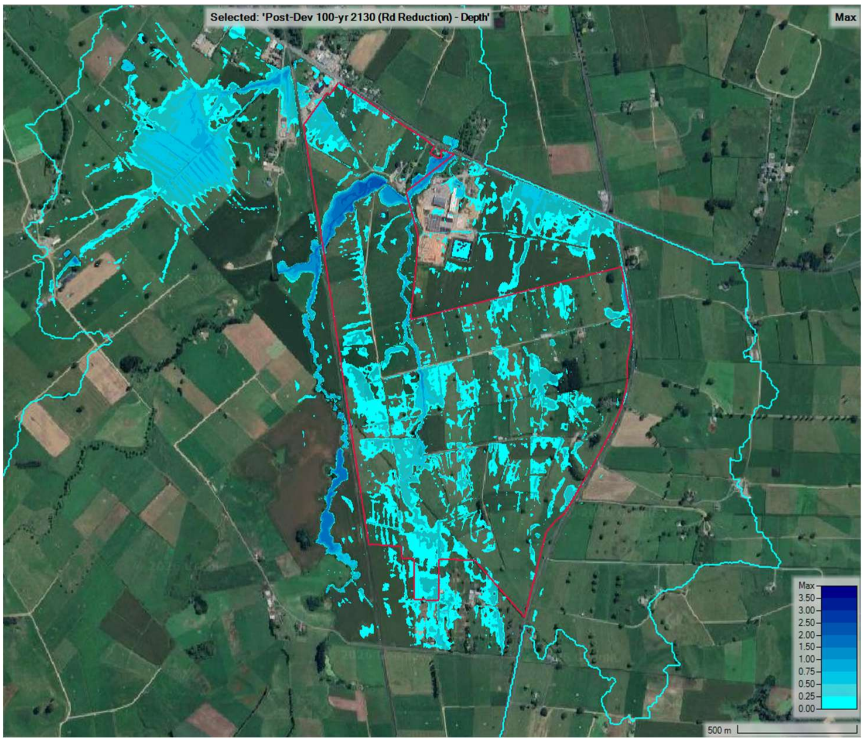


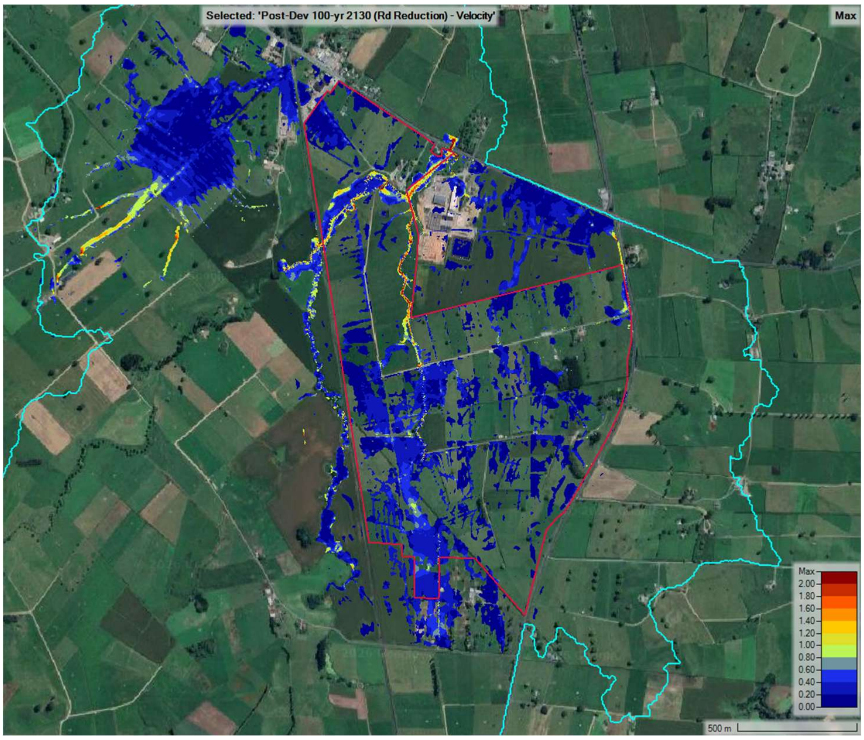


Figures 18-19: Flood Depth and Velocity – 100-Year Pre-Development Event with 2.1°C Climate Change Adjustment – Source: HEC RAS



Figures 20-21: Flood Depth and Velocity – 250-Year Pre-Development Event with 2.1°C Climate Change Adjustment – Source: HEC RAS





Figures 22-23: Flood Depth and Velocity – 100-Year Post-Development Event with 2.1°C Climate Change Adjustment – Source: HEC RAS

4.4.4. FLOOD LEVEL COMPARISON

Flood displacement volume has not been assessed, as the environmental effects of the proposed development have been evaluated using a flood model. The flood model provides a more accurate and comprehensive assessment of the changes in flood behaviour, including variations in flood levels, flow paths, and potential impacts on adjacent properties. This approach ensures a detailed understanding of how floodwaters are redistributed and how the development may influence flood risk both on-site and in the surrounding area.

Comparisons between pre-development and post-development conditions were conducted for the 100-year ARI flood event. The results reveal significant variations in flood levels within the site:

- In the 100-year event, flood levels range from -400 mm to +400 mm.

Outside the site boundary, the maximum increase in flood levels is less than 120mm in the 100-year event as shown in Figure 24. This occurs on the northwesternmost point and at the southern border of the site. These flows will be addressed in the detailed design stage through a mix of swales and culverts to allow water egress away from these areas.

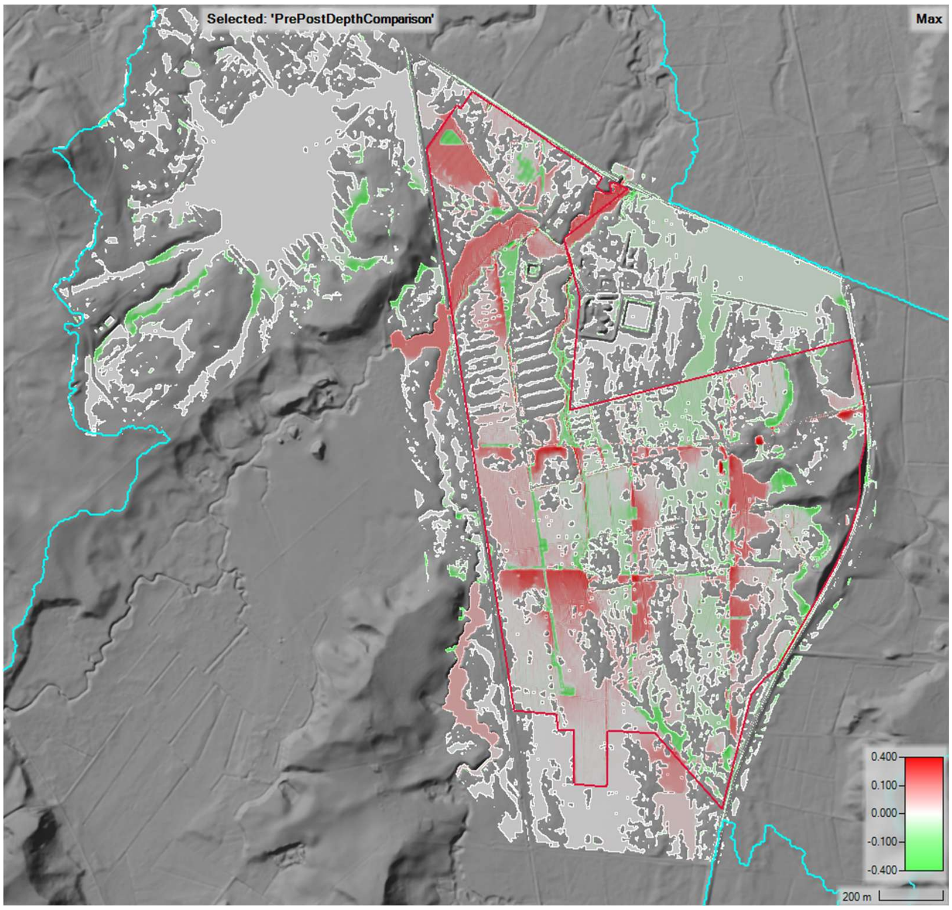


Figure 24: Difference in Flood Depth Between 100-Year Post-Development Event with 2.1°C Climate Change Adjustment and the 100-Year Pre-Development Event – Source: HEC RAS

4.4.5. HAZARDS

4.4.5.1. OVERLAND FLOW HAZARD

The hydraulic hazard associated with overland flow paths have been identified in line with NZTA P46 Stormwater management and minor stream diversion design specification (February 2025), Section 6.6(b), which requires hazards in public areas to be evaluated using depth and velocity, in accordance with Australian Rainfall and Runoff (AR&R), Book 6 - Flood Hydraulics, Figure 6.7.9. The site is privately owned with no public access, however, aligning with the NZTA P46 public area thresholds provides a conservative and well-established basis for flood hazard management.

Solar infrastructure is confined to areas where dv is less than or equal to 0.6 m^2/s under the 100-year ARI event. The stream corridor, where dv exceeds 1.0 m^2/s, is excluded from development and retained as a natural flow path with an appropriate setback buffer. Per AR&R, dv exceeding 1.0 m^2/s presents a risk of damage to structures, and dv exceeding 0.6 m^2/s is not considered safe for vehicle access and worker safety. Confining infrastructure to areas subject to less than 0.6 m^2/s protects both the integrity of structures and site personnel safety.

Management of high-risk zones (greater than 1.0 m^2/s) will be assessed as part of detailed design.

4.4.5.2. DESIGN FREEBOARD

There is no freeboard requirement from a regulatory compliance perspective. The targets currently set for concept civil design are:

- 10-year maximum flood depths to be under 300 mm across the site during construction.
- PCU and BESS base levels to have 300mm freeboard above the 100-year level.
- The substation earth pad level is set at RL=82.6m, providing approximately 450mm freeboard above the 100-year flood level. The O&M building pad is set at RL=82.6m, also.
- PV panels to have 300mm freeboard above the 100-year flood level.
- 250-year maximum flood level to be checked against design levels but not used for design.

It is envisioned that the general arrangement of the solar farm will be refined during the detailed design process, including potential minor adjustments to road alignments and minor adjustments to PV panel layouts to optimise panel layouts in ponding areas (refer to C410 and C418 drawings). Any such modifications are expected to mitigate ponding that exceed 300 mm during a 10-year flood event or prevent the placement of panels in these areas (refer to Figure 25 for areas where concept panel placement overlaps with >300mm deep post development 10-year flood depths). Alternatively, flood sensors may be used to restrict movement and ensure the modules are kept above the water level in a flood event

Apart from the northwestern corner, the post-development model does not include any future localised filling associated with panel refinement in the highlighted areas; however, any such filling is not expected to result in significant changes to on-site or neighbouring flood levels.

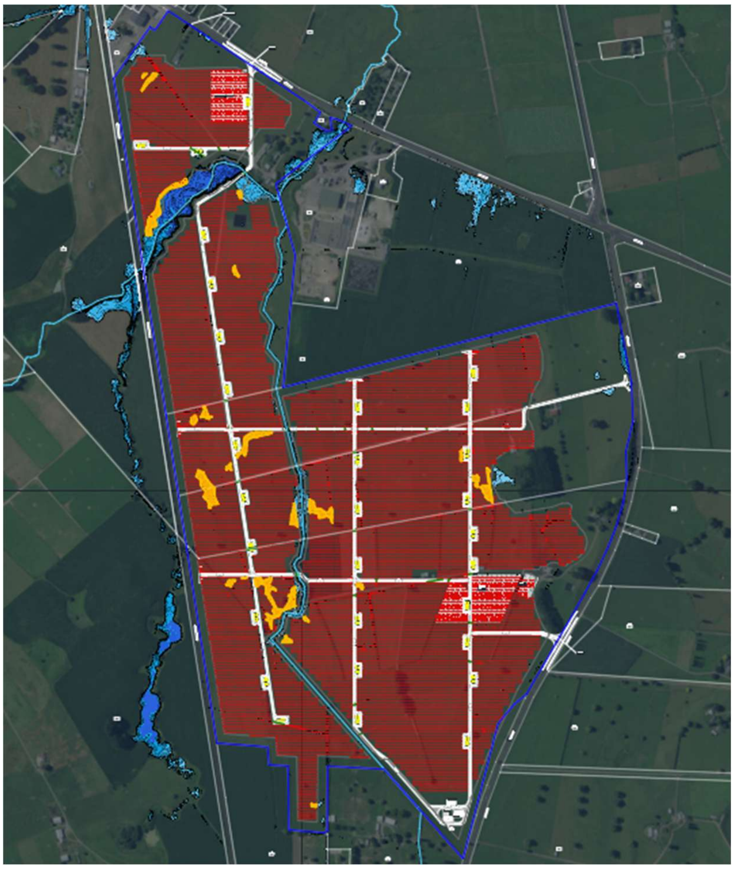


Figure 25: Flood Depths of >300mm from 10-Year Post-Development Event Highlighted in Yellow – Source: HEC RAS

Flow velocities beneath the PV panels are generally below 0.40 m/s in the 100-year event, increasing to 0.45 m/s in the 250-year event. While localised areas show higher velocities, these occurrences are brief and limited in duration.

The potential impact of these velocities on the PV modules and supporting structures should be assessed during detailed design. This should include evaluation of hydraulic forces acting on panel supports. Where required, mitigation measures such as increased panel clearance, optimisation of panel layout, and localised scour protection should be incorporated to ensure the integrity of the panel support structures under flood conditions.

4.4.6. SUMMARY

The results obtained from the hydrologic and hydraulic work completed to date show that:

- Pre-development models demonstrated reliable results at peak flow. The results are within the acceptable margin of error for the modelled scenarios. Further commentary is provided in Section 4.4.1 Numerical Accuracy and Model Stability.
- A summary of the model results has been provided in Section 4.4 Modelling Results. The results remain relatively consistent across different storm frequencies, showing a similar hydrological response for total site discharge and individual stage hydrographs at each discharge point.
- Two additional culvert installations, and one culvert upgrade (upgrade to be confirmed during detailed design) are required where proposed road crossings intersect the existing streams through the site. These are intended to prevent disruption to primary overland flow paths. Minor culverts will be identified and designed during detailed design to address localised ponding caused by road alignments intersecting minor overland flow paths. Several areas within the site exceed the 300mm flood depth in the 10-year storm specified by the client. To address this, it is recommended for the highlighted areas from Figure 25 to be filled with up to 300mm of topsoil to ensure flood depth remains below 300mm for construction.
- To improve drainage and reduce standing water, it is recommended to install roadside swales alongside all proposed roads. This measure will also improve pavement durability by ensuring proper drainage, preventing the migration of fines from repeated traffic loads. Alternative solutions to swales can be considered at detailed design, such as utilising existing drains.
- Model outputs for flood depths, water surface elevations and velocities will be provided digitally along with this report.

5. SUMMARY, LIMITATIONS AND CONCLUSION

5.1. REPORT SUMMARY

An evaluation of flood risk was completed to guide concept civil design of the proposed solar farm development project. Pre-development flood modelling identified existing conditions, which were used to inform the concept civil design and a post-development flood model. Minor terrain modifications, including further raising roads, constructing additional platforms for electrical infrastructure, designing/modifying minor culverts, and optimising minor overland flow paths, are expected to be incorporated into the post-development model during detailed design stage to reflect optimisation of the proposed design.

Critical infrastructure, including the substation, buildings, and PCUs, to be elevated to meet 100-year flood level freeboard requirements outlined in the Civil Infrastructure Report.

Some areas which exceeded 300mm flood depth for construction, can be mitigated by filling with additional topsoil with mitigations in place to prevent increasing effects on other properties.

5.2. LIMITATIONS

This assessment has limitations and constraints that may impact the accuracy and applicability of the results presented. These limitations arise from both challenges related to information availability, methodological choices, and inherent uncertainties in the modelling process.

Results shown are subject to the information available at the time of the assessment. A primary constraint was the limited availability of historical flood data or regional models specific to the catchment. Dependency on public topographical data introduces additional uncertainty in the model inputs. The accuracy of the results depends on the accuracy of these input data sources.

Assumptions made in the hydrological and hydraulic modelling also contribute to uncertainties. Smaller culverts (less than 400 mm diameter) were either modelled as open channels or excluded from the model, which may affect flow capacity, particularly in smaller events. Differences in characteristics between sheet flow, concentrated flow, and stream flow were approximated using a nominal depth as the boundary. Additionally, certain infrastructure details, such as pipes and culverts outside the immediate study area or widths of proposed roads, were not fully captured in the model.

Methodological limitations include numerical instabilities observed during model simulations, which may affect model accuracy. Minor errors were also introduced due to differences in spatial resolution and alignment between DEMs, particularly in steep or uneven terrain.

The analysis was conducted based on the design requirements provided by the client. While no specific regulatory requirements needed to be met, the methodology follows standard practices outlined in local and national guidelines.

5.3. CONCLUSION

Hydrologic and hydraulic modelling were undertaken for the subject site at the corner of State Highway 27 & 29, Hinuera, to support the proposed utility-scale solar installation known as Hinuera Solar Farm. The assessment evaluated flood risks under pre-development scenarios for 10-, 20-, 50-, 100-, and 250-year storm events, as well as post-development scenario for the 100- year storm event, incorporating a 2.1°C climate change adjustment, in line with regional standards.

This assessment confirms that flood risks have been considered, and appropriate mitigation measures have been considered and are to be applied to design to address potential impacts.