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Transpower New Zealand Limited
Co No.: 372941N/A

AECOM

Flood Risk Assessment

25-Mar-2024
Far North Solar - The Point Solar Farm
Grid Injection Point – Solution Study
Report
Commercial-in-Confidence

Flood Risk Assessment

Client: Transpower New Zealand Limited

Co No.: 372941

DRAFT

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Professional Registration

This document includes professional services that require approval from a registered professional.

Registration Scheme	Discipline / Area of Practice	Name of Registered Professional*	Signature	Registration No.	Date
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* The registered professional must be the originator of this work or have provided direct supervision to the originator.

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Executive Summary

The Far North Solar (FNS) -The Point Solar Farm GIP SSR project was awarded to AECOM New Zealand by Transpower New Zealand Limited (Transpower) to complete a flood risk assessment study.

The project area is in the vicinity of the Waitaki hydroelectric project.

The published data on flood maps from the local authorities was used to form the basis of the study.

Attempts to locate data from Ecan, Canterbury District Council, and NIWA were completed. The available hydro-electric flood hazard maps have been studied.

However, it is observed that there is no evidence of availability of information from any source regarding the pluvial flood depth in the project area.

Rainfall depth and intensity data along with regional flood statistics were downloaded from NIWA's portal.

For the 450year Average Recurrence Interval (ARI) with climate change allowances associated with the most extreme representative concentration pathway (RCP) 8.5 the input data for this event had to be extrapolated from existing NIWA information.

For the model development, frameworks have been laid out before the model study. These frameworks are in terms of the modelling conventions and applications to be followed and used, and the modelling criteria for setting up essential parameters for the models to be developed. The modelling tools have been reasonably selected for the modelling works. The catchment area with the mouth of the catchment at the Benmore Lake entrance through various rivers have been delineated using the software, HEC-HMS and Arc GIS.

A rain-on-grid two-dimensional(2D) model have been developed for the FNS project area that also includes the substation area using the software, HEC-RAS 2D, and conclusions based on the model study. With the applied losses, the rainfall data have been set as one of the boundary conditions (BC). The established model has been simulated.

The following conclusions can be drawn from this study:

1) The rain-on-grid approach provides conservative results in terms of spatial flooding and will provide a good basis for understanding the implications of civil works for the proposed FNS substation.
2) The maximum flood level and flood depth corresponding to 450year ARI RCP8.5 event are 397.2m RL and 0.1m, respectively at the upstream end of the site.
3) Transpower needs to consider what freeboard is appropriate for the various components of the substation based on the risk of flood inundation. It is recommended that a 500mm freeboard is considered for critical infrastructure.
4) The substation platform area is outside the hydroelectric flood inundation hazard map due to dam and canal breaches defined by OPUS NZ for Genesis Energy and Meridian.

1.0 Introduction

1.1 Project area for flood risk assessment study

The Far North Solar (FNS) 300MW solar project area is located around 10km southeast of Twizel town near the confluence of Pukaki River and Tekapo River. The key features of the project area and the proposed location for substation for the flood risk assessment study have been displayed in Figure 1 below.

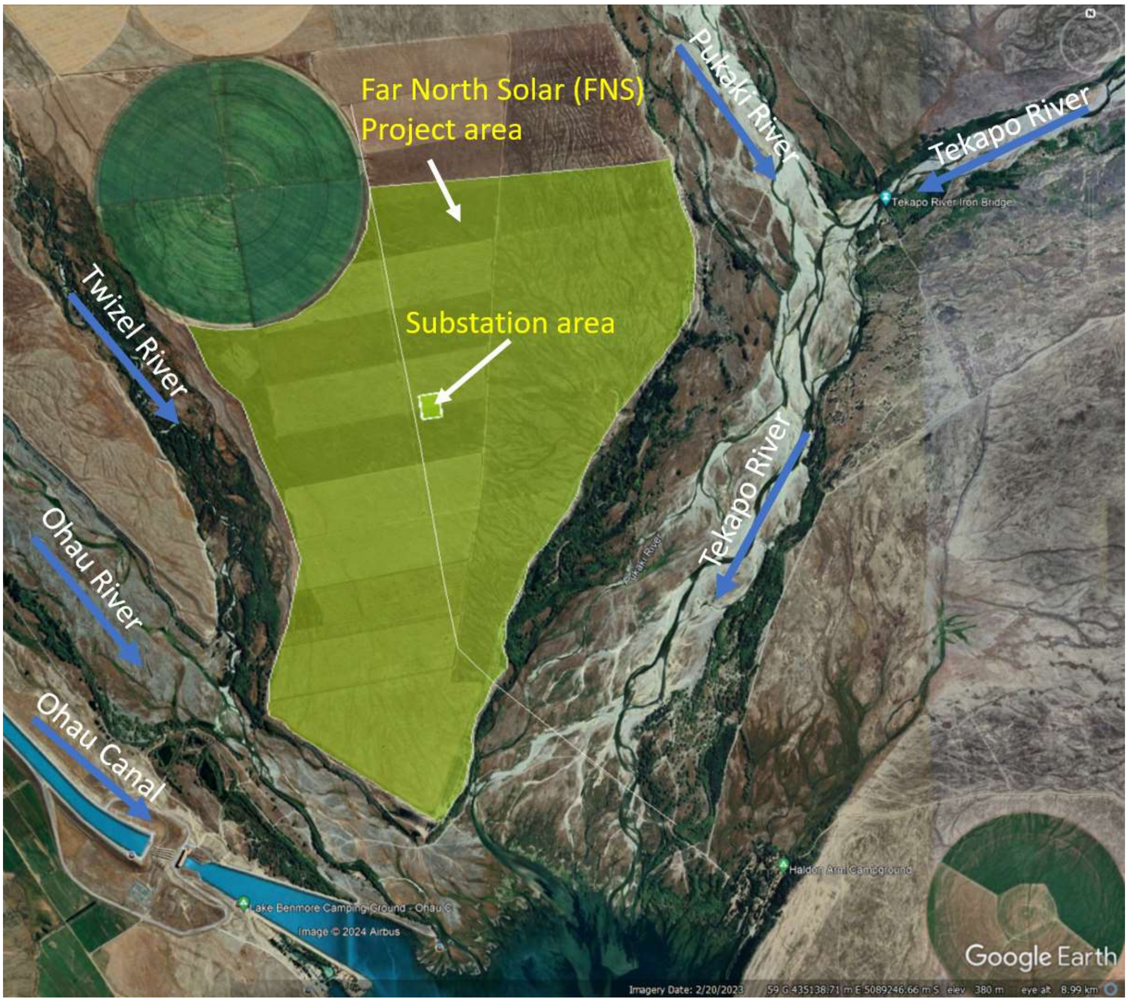

Figure 1 Project area indicating substation platform location.

In this report the land area displayed in the tender document -Scope of Services (SOS) Appendix A has been termed as the project area, whereas the location shown for substation has been termed the proposed substation platform area/ proposed substation area.

1.2 Previous study

The information from the drawing (Drawing no. 6/3434/1/6504, Sheet No 22, Revision R1) of the previous study for the project -Hydro-electricity inundation hazard area maps for Mackenzie District Council Plan Change 13 prepared in 2015 published by Opus, Genesis Energy, and Meridian indicate that map was developed displaying the possible area of hydro-electric hazard in the unlikely event of dam or canal breach. However, the hazard extent does not reflect natural flooding areas with the map displayed in Appendix A.

However, as the project area is downstream of the dams and in the proximity of hydroelectric stations, it is presumed that the basin might have already been studied thoroughly. Also, from the preliminary investigation it has been observed that the extent of hydroelectric flood hazard due to unlikely event of dam or canal breach forms a good basis for the present study. It may be noticed in Appendix A that about 12% of the proposed FNS project area encroaches the hydroelectric hazard extent towards the Tekapo River but the substation area is on non-hazard (hydroelectric) area.

2.0 Objective and scope

2.1 Flood risk assessment

The objective of the study is to complete the flood risk assessment of the project area, particularly, the proposed area of substation platform.

Following are the scope of flood risk assessment for the project area:

i. to study and analyse the suitability of the substation site flooding to be based on the 450year return period flood level (which might be extrapolated from the 100year and 250year events).

ii. to recommend a freeboard above the estimated 450year return period flood level with RCP8.5 considering climate change, wave action, and uncertainties in the assessment.

iii. To determine the required platform level based on the results of flood risk assessment.

3.0 Data availability

3.1 Rainfall data

The rainfall data in terms of rainfall depth and intensity were sourced from National Institute of Water and Atmosphere Research Limited - High Intensity Rainfall Design System (NIWA-HIRDS V4).

The data was spatially presented, and data reports could be generated for any location. The data has been categorized as follows:

- historical rainfall statistics data, and
- future rainfall statistics for various climate change scenarios (from RCP2.6, 4.5, 6.0, and 8.5).

The NIWA HIRDS rainfall data for the project area was collated for the present study.

The rainfall data (RCP 8.5 scenario) has been displayed in Appendix B.

3.2 Regional flood frequency data

The New Zealand peak flood river data was also available from NIWA New Zealand River Flood Statistics (NIWA-NZRFS).

Many of the rivers and streams are displayed on the New Zealand River map and these data are spatially presented on the map in the aforesaid weblink of NIWA and the data reports could be generated for any of the digitized river or stream by clicking over it.

The nearest river in the proximity of the project area is the Tekapo River on the downstream of the confluence of the Pukaki River and Tekapo River. Although a range of peak flood data for various ARIs is available for this location, the present study focuses on the impact of the flood, which is available in the form of hydro-electric hazard map. It is assumed that any adverse effect due to river fluvial flooding in terms of flood extent on the downstream area of the dams within the catchment would not be as severe as the extent shown in the hydro-electric hazard map. Considering this, the impact of pluvial flood has only been assessed for the FNS project area.

3.3 Geographical information system (GIS) data

3.3.1 Digital elevation model (DEM) data

The NZ 8m Digital Elevation Model (2012) data has been downloaded from the Land Information New Zealand (LINZ).

The projection used in the data is New Zealand Transverse Mercator 2000 (NZTM2000) and the vertical datum is New Zealand Vertical Datum 2016 (NZVD2016).

It has been used as a base ground model for the flood model.

4.0 Desktop assessment for flood risk

4.1 Preliminary observations and study

For the project, RCP8.5 (2081-2100) has been considered.

NIWA-HIRDS and RFS data covers all design rainfall events from 1.58yr ARI to 250yr ARI as shown in Table 1 below.

Table 1 ARIs exhibited by NIWA-HIRDS and NIWA-NZRFS

ARI (Year) for depth and intensity NIWA-HIRDS at project area	ARI (Year) for depth and intensity NIWA-HIRDS at project area
1.58	40
2	50
5	60
10	80
20	100
30	250

The corresponding values of rainfall depth and intensity, and the flood values have been displayed in Appendix B. The rainfall hyetograph from NIWA has been used to establish the nested rainfall intensity. The hyetograph has been displayed in Appendix C.

To extrapolate the data for the 450year ARI, the Gumbel method has been applied to the available data above with the results shown below.

Table 2 Extrapolated rainfall and flood data for 450-year ARI event from HIRDS V4 and NZRFS

450yr ARI RCP8.5 results	
24-hour Rainfall depth (mm)	Rainfall intensity (mm/hr)
181.0	7.5

5.0 Model development

5.1 Modelling background

In the present study, one of the prominent factors is the location of the project area, which is nearest to the Tekapo River indicating that at a basin or catchment scale, the project area is encapsulated in the catchment itself. However, as explained above, the hydroelectric hazard map is already available. It may be used as reference for understanding the impact for pluvial flood on FNS project area including the substation area.

For the present study, the following modelling conventions have been followed:

1) For catchment delineation, it is reasonable to consider the mouth of the catchment at Benmore Lake (Ref. Figure 2). The GIS module of hydrological model, such as HEC-HMS and ArcGIS (ArcMap 10.8.2) shall be used. The catchment is mainly snowfed, which features the rivers, Tekapo River, Pukaki River, and Ohau River. The downstream flow is controlled at dam locations for the Waitaki hydro scheme. For a better understanding of the system, the integrated catchment modelling with applicable snowmelt models in New Zealand may be attempted, but it is beyond the scope of work. Also, the FNS area falls on the downstream end of the control structures in the said catchment. The FNS area is too small within the mighty catchment. As hydro-electric (dam-break) hazard is one of the unlikely events, the impact of it on the FNS area and its relative pluvial flood extent would be the key model study. Therefore, existing available information shall be used for references to carry out the model study.
2) The model used a two-dimensional rain-on-grid model representing the FNS project area (mesh size 10m x10m) and the substation area (mesh size 1m x 1m) using HEC-RAS 2D.

5.2 Modelling criteria

5.2.1 HEC-RAS 2D

While developing the model the following modelling criteria have been followed:

1) Boundary conditions (BCs):
    - Rainfall shall be one of the boundary conditions filled in with nested rainfall intensities with applied losses.
    - The boundary condition around the perimeter of the generated mesh shall be normal depth.
    - Manning's Roughness (n): Manning's (n) value for the overland flow of the gridded catchment shall vary from 0.06 to 0.07 dependent on land cover.

5.3 Model Setup

5.3.1 Catchment area delineation

The digital elevation model (DEM) data from LINZ has been processed following the routines of the GIS based software, HEC-HMS for catchment area delineation. The catchment area with the mouth of the catchment at the Benmore Lake entrance through various rivers have been delineated and the total catchment area is 6097 km^2. It has been observed that the area is highly snow fed.

In the processed output of catchment area, HEC-HMS also delineates the sub-catchments within the catchment area which in this case were six sub-catchments as shown in Figure 2 below.

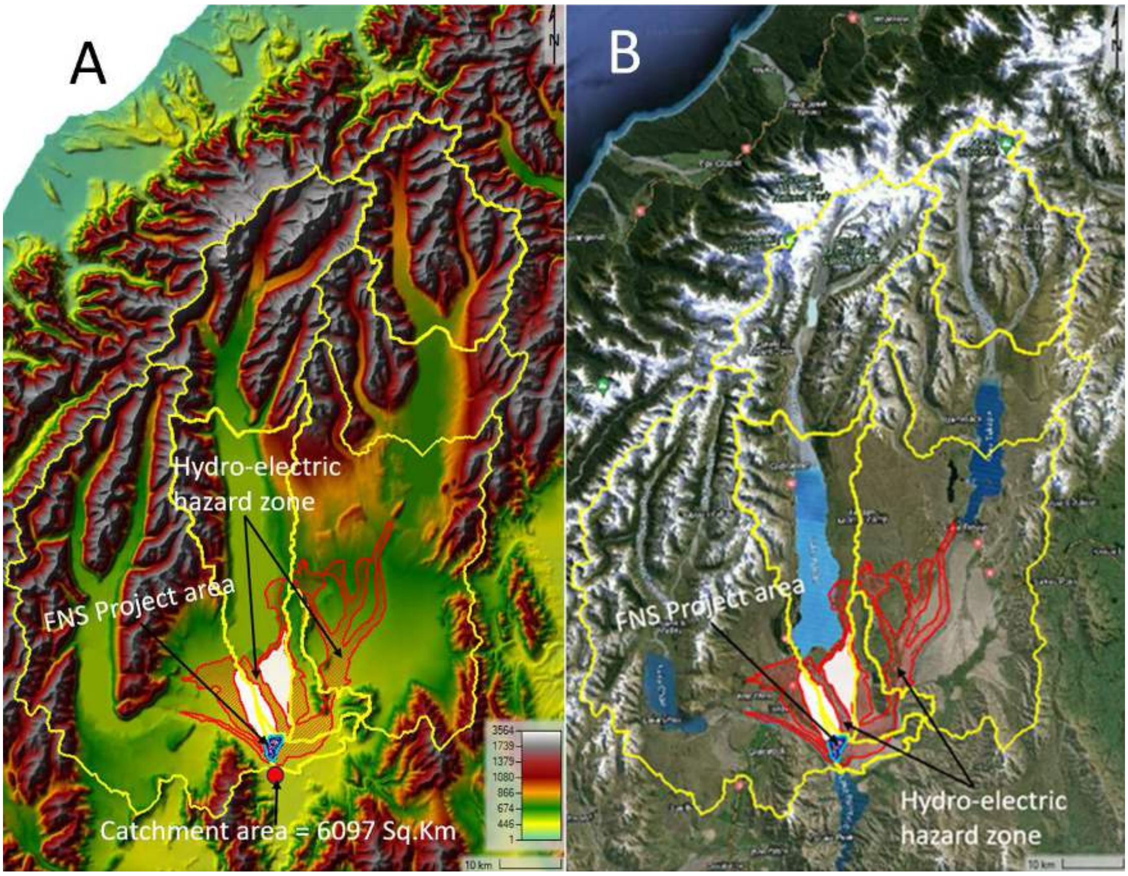

Figure 2 Catchment area of Benmore Lake at northern intakes from various rivers (inclusive of the project area); Picture A image source – LINZ Terrain, Picture B image source – Google Hybrid

In Figure 2, the white shades are the areas of non-hazardous (hydro-electric) zones, whereas the red shades with markup lines are hydro-electric hazard zones as discussed above. The details of hazard map are furbished in Appendix A.

6.0 Results and discussions

The results from the model study and their impact on the project area and substation platform locations have been discussed below.

6.1 HEC-RAS 2D results

The results from the HEC-RAS 2D model have been displayed and discussed in this section. The resulting flow hydrograph at the profile section representing the catchment outlet section has been displayed in the figure below and the flood values have been tabulated in Appendix D.

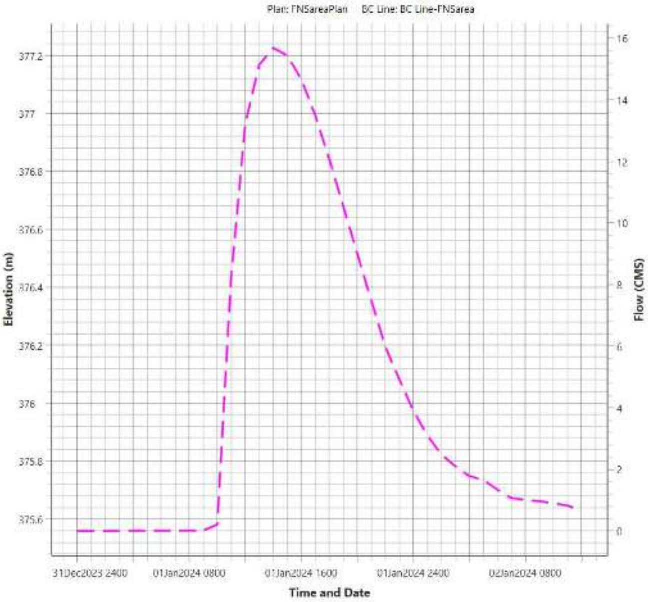

Figure 3 HEC-RAS 2D results: Peak flow hydrograph at the 2D boundary lines

In Figure 3, the peak flood hydrograph is resulted from the input 450yr 24hour design rainfall intensity (nested). The peak flood value resulting from HEC-RAS 2D model is 15.7m^3/s. The other results from HEC-RAS 2D, such as maximum water surface elevation (WSE) and flood depth for the catchment and for the project works have been displayed below.

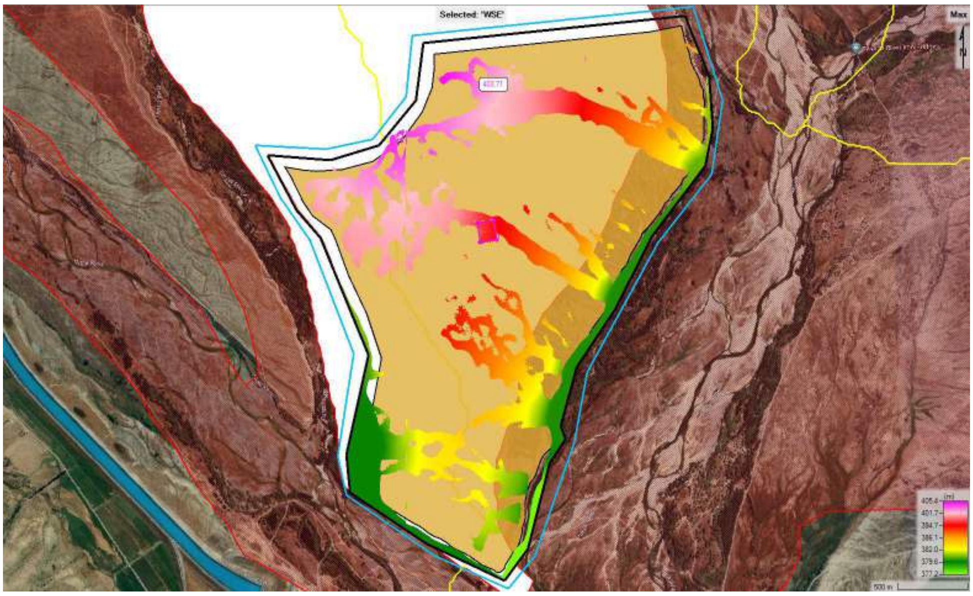

Figure 4 HEC-RAS 2D results: Maximum water surface elevation (masl; NZVD2016) on the FNS project area

In Figure 4, the water surface elevation (WSE) above the FNS project area and the substation platform location falls in the red to pink transition zone corresponding to the legend.

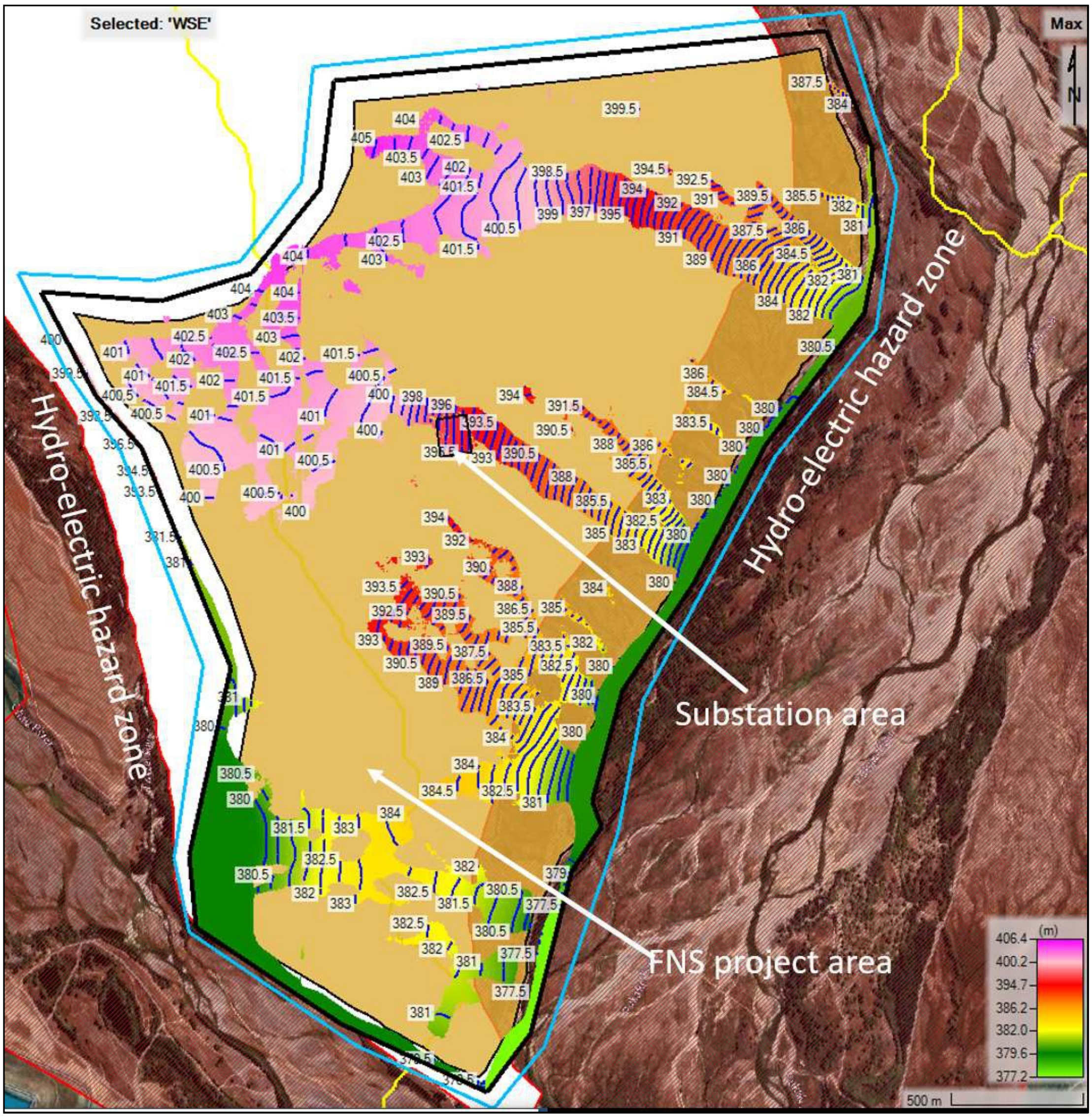

Figure 5 **HEC-RAS 2D results: Maximum water surface elevation (masl; NZVD2016) on the project area and the proposed location of substation platform**

In the Figure 5, the blue contours represent the water surface elevation ((WSE) measured in metres above sea level (masl) using the NZVD2016 vertical datum).

The areas with red hatched lines are the hydroelectric inundation hazard extent. It is to be noted that the FNS substation area shown above is located outside the hydroelectric inundation hazard map.

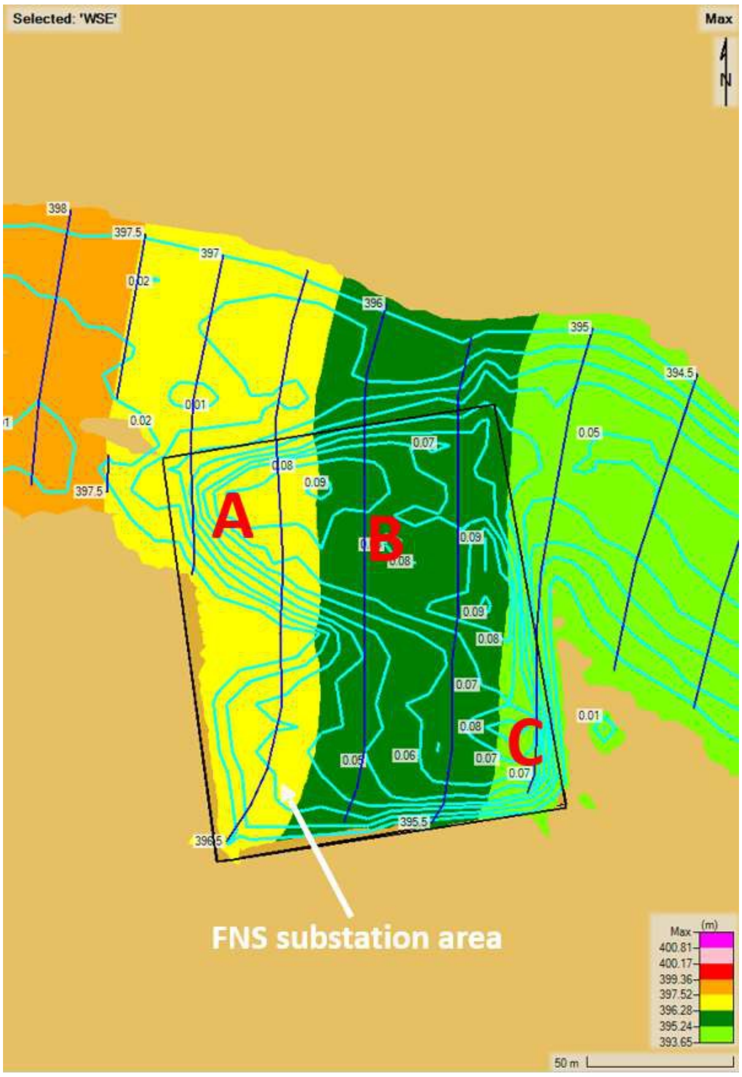

Figure 6 HEC-RAS 2D results: Maximum water surface elevation (m) on the proposed location of substation platform

In the Figure 6, the blue contour lines represent the maximum WSE, whereas the cyan contour lines represent the maximum flood depth (m). It may be noted in the above figure that the flood depth (0.1m) defines the maximum flood depth around zone A, zone B and zone C. The flood depths and flood levels have been classified into different zones as listed in the table below.

Table 3 Zonal classification of the flood levels and flood depth in the substation platform area

Zone	Flood depth (m)	Flood levels (masl) NZVD2016
A	0.1	397.2
B	0.1	396.5
C	0.1	395.5

The terrain data based on which the model is developed hints that the substation area lies in an overland sloping down from Zone A to Zone C of the substation area.

7.0 Model limitations

The limitations of the model have been pointed out below.

- The rainfall-runoff process in the HEC-RAS 2D model is rain-on-grid model and it does not involve the rainfall excess computation. Therefore, the pre-processing of data has been done applying losses that are applicable to the project area.
- The extents of flooding areas have been mapped based on the available DEM data from LINZ as mentioned in the previous sections. No specific survey was conducted for flood extent mapping. Therefore, the accuracy of the flood extent maps depends on the compound effects of uncertainties in the hydraulic model parameters, and the accuracy of the applied DEM model.

8.0 Conclusions

Following are the conclusions based on the above analysis:

1) The rain-on-grid approach provides more representative results in terms of spatial flooding and will provide a good basis for understanding the implications of civil works for the proposed substation of FNS project.
2) The maximum flood level and flood depth corresponding to 450year ARI RCP8.5 event are 397.2m RL and 0.1m, respectively at the upstream end of the site.
3) Transpower needs to consider what freeboard is appropriate for the various components of the substation based on the risk of flood inundation. It is recommended that a 500mm freeboard is considered for critical infrastructure.
4) The substation platform area is outside the hydroelectric flood inundation hazard map due to dam and canal breaches defined by OPUS NZ for Genesis Energy and Meridian.

9.0 References

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