Civil Engineering Assessment

Puke Kapo Hau Mahinerangi Wind Farm Stage 2, Otago

RILEY

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Civil Engineering Assessment
Puke Kapo Hau Mahinerangi Wind Farm Stage 2, Otago

1.0 Introduction

This report has been prepared by Riley Consultants Ltd (Riley) at the request of Tararua Wind Power (TWP). TWP, a fully owned subsidiary of Mercury NZ Limited, is progressing Stage 2 of the Mahinerangi Wind Farm which is to be known as "Puke Kapo Hau" ("the Project", "Puke Kapo Hau" or "MWF2")[1]. The report outlines our assessment of the civil engineering works proposed for the Project and has been prepared to support a Resource Consent application (by others) and in compliance with the Environment Court Practice Note 2023 (Code of Conduct for Expert Witnesses).

The Project involves the construction and operation of up to 44 turbines (providing up to an additional 189MW total capacity), with blade tip height of up to 165m, located within 54 potential turbine locations. Stage 2 of the Project require the movement of some of the consented turbine locations and will be authorised by way of a change/cancellation of conditions to Land Use Consent RM1409 (along with other changes to the consent conditions). For the purposes of assessing the civil engineering works for the Project, a 4.3MW turbine has been adopted.

The Project also involves applications for new activities including a new operations and maintenance building, substation, battery storage, and an overhead transmission line which will connect into the existing overhead power line located to the south of the Wind Farm Site. New Resource Consents for various regional council activities are also being sought.

Stage 1 of the Wind Farm is built and is currently operating, compromising 12 No. 3MW turbines.

The proposed removal of the area referred to as the Thomas Block has reduced the consented Project area from 1,723 ha to approximately 1,570 ha. The Project is located on the eastern foothills of the Lammermoor Range, situated approximately 5km north of Lake Mahinerangi and approximately 50km west of Dunedin (Figure 1). The west and north-western boundary of the Project is bounded by the Te Papanui Conservation Park and Black Rock Scientific Reserve.

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[1] These project references are interchangeable, but for the purposes of this report we have attempted to use "the Project" in the first instance.

Figure 1: Location of the Project (green line)

The Project generally lies between 600m and 730m elevation. This is characterised by mainly broader gently to moderately inclined ridge and plateaus - incised by relatively shallow (i.e. 10 to 20m deep) gullies with moderate to steeper sides. The ridges and plateaus are commonly developed into pastureland but can also have a mixed cover of grass and tussock. Wetland/watercourses are notable in gully inverts with tussock predominating on the side slopes. The Project's consented layout takes advantage of favourable terrain – following the broader ridges and plateaus and avoiding the gullies wherever practicable.

However, as outlined in the application documents, amendments to the existing Land Use Consent are now required to enable development of Stage 2 of the Project. Material changes required to deliver Stage 2 include:

- Increase to the turbine blade tip height from 145m to 165m,
- Increase the total wind farm capacity (Stage 1 and Stage 2) from 200MW to 226MW,
- Revised 'Proposed Turbine Location and Contingency Zones' (CZs)[2], which remain within the Wind Farm Development Area (with two identified and minor exceptions addressed in this report).
- Amend the consented roading and platform layout (and sizes) to suit the amended CZs, including encroachment into Wind Farm Development Buffer areas.

[2] CZs are defined as up to a 100m radius circle centred on the proposed turbine location and within which a turbine tower may locate. Contingency Zones feature cut outs of the 100m radius to avoid a feature for example wetlands (incl 10m buffer), gullies (where clearly defined), Eldorado Track Road reserve, QEII covenant area, Environment Court Exclusion Areas (BMP W07190/1), Site Boundary, Wind Farm Development Area (BMP W07190/1). Where there is an exception, this has been addressed in this report.

The original Mahinerangi Wind Farm consent applications were advanced in 2006 on the basis that the turbines were to be selected at the detailed design stage. Condition 11 limited the maximum installed capacity to 200MW which was within the then National Grid connection capacity, and Condition 12 set the maximum number of turbines at 100. The Resource Consent applications considered two realistic options - a 100 x 2MW turbine layout, or a 67 x 3MW turbine layout. However, the Land Use Consent does not limit the activities in that manner.

The consented wind farm layout is shown on Boffa Miskell plan BMP W07190/1 – included as Figure 2.

The 2MW turbines were realistic at the time the original consent was granted. However, wind turbine technology has significantly advanced since that time, and it is no longer realistic to advance an 82 No. x 2MW (164MW being the balance of 200MW consented limit following the construction of the 12 turbines as part of Stage 1) turbine layout for assessment purposes. This is because 2MW turbines are no longer readily available on the international market. TPW has therefore adopted a 'real-world' consented configuration for assessment purposes as follows:

- 47 turbines, 145m high, 9m ground clearance, 136m rotor diameter, 3.45MW within a possible 88 turbine locations and associated CZs.

In terms of what is proposed, a civil design has been undertaken for the Project based on the following:

- 44 turbines, 165m high, 20m min ground clearance[3], 136m rotor diameter within 54 possible turbine locations and associated 100m radius CZs.[4]

This civil design has also included the changes to the access track layout, new operations and maintenance building, substation, battery storage, and an overhead transmission line. All activities remain within the consented Wind Farm Site. The Project Site Development Plan is shown in Figure 3.

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[3] Noting this is for assessment purposes, a hub height has not been provided. TWP wish to retain a ground clearance of 20m and specifying a hub height obscures this assessment. No hub height is specified in the Land Use Consent.
[4] The proposed turbine locations have been renumbered from north to south and thus do not correlate with the consented turbine numbering shown on Boffa Miskell plan BMP W07190/1.

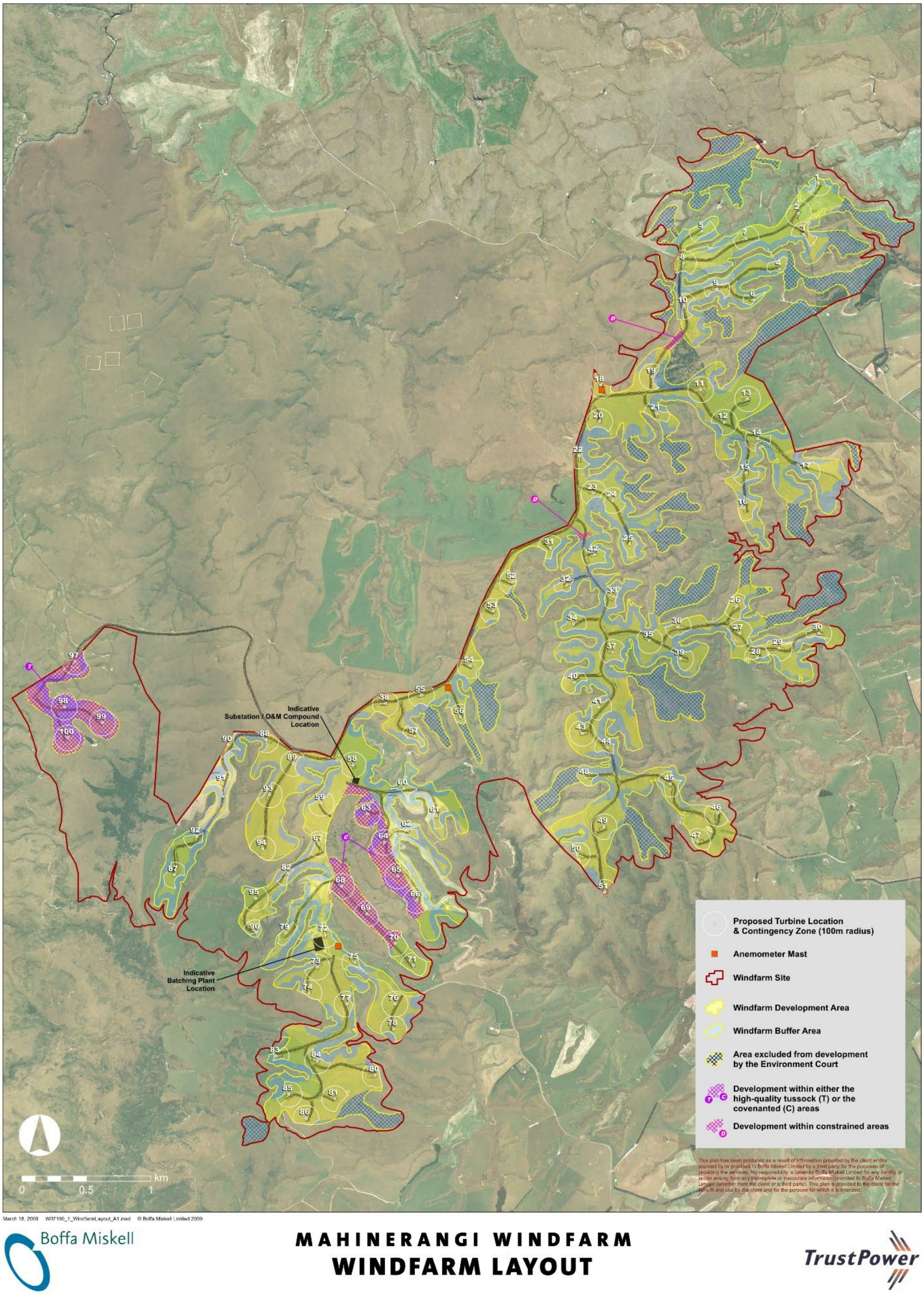
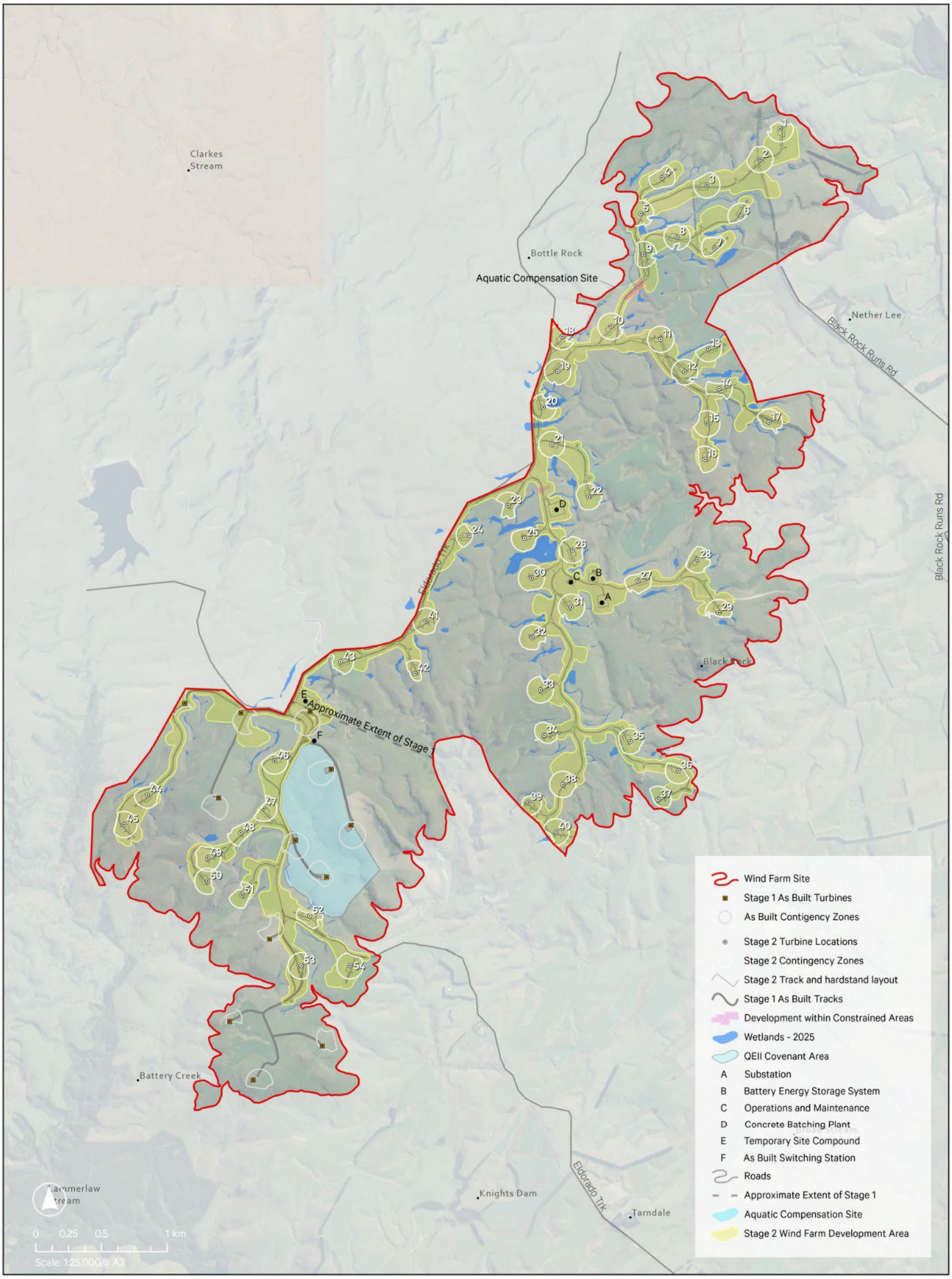


Figure 2: Consented Wind Farm Layout – BMP W07190/1 (Boffa Miskell, dated 18 March 2009)



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Map 1 - Puke Kapo Hau Stage 2 Layout Plan

Mercury

Figure 3: The Project Site Development Plan

The main differences between the existing Land Use Consent layout and the proposed layout for Stage 2 are summarised in Table 1.

Table 1: Main Differences Between the Consented and Proposed Layout.

Attribute	Consented Layout	Consented real-World Layout	Proposed Layout (the Project)
Turbine locations	100	88 (plus Stage 1)	54 (plus Stage 1)
Turbines (to be built)	100 (Stage 1 with 12 existing)	47 (plus Stage 1)	44 (plus Stage 1)
Maximum consented tip height	145	145	165
Indicative turbine capacity for assessments	2MW or 3MW	3.45 MW	4.3MW
Maximum installed generation capacity	200 MW	200MW	226 MW
Transmission line	Was a Permitted Activity at the time		New application
Thomas Block (identified in the Mahinerangi Wind Farm Layout Plan BMP W07190 as Development within 'high-quality' tussock)	Included	Included	Excluded

This assessment quantifies the scale of civil works required to construct the Project, compared with civil works required to construct a real-world layout within the consented constraints of the existing consent. The challenges of working within the existing constraints and proposed departures from them are outlined in the following section. From a civil engineering perspective, the revised Stage 2 layout and changes to engineering related conditions are material to the delivery of the Project. This is addressed in further detail in Table 2 and Section 2.3.

1.1 Review of Existing Consent Conditions

Riley have reviewed the Land Use Resource Consent conditions and Table 2 outlines the principal civil engineering conditions which require amendment for the delivery of the Project, along with reasons for this.

Table 2: Clutha District Council: RM1409, Land Use Consent Principal Civil Conditions Review

Condition Ref	Condition Description	The Project (Riley design – 44 Turbines)	Comment
Construction Conditions			
25i) Site Development Plan	All facilities and infrastructure shall be inside the Wind Farm Development Area depicted on BMP W01790.	There are five turbine locations where proposed earthworks associated with wind farm access tracks and hardstands will fall outside the consented Wind Farm Development Area. These turbine locations are: • WTG 7 • WTG 36 • WTG 39 • WTG 50 • WTG 52.	It is not practical to keep all works within the Wind Farm Development Area at these locations due to the increased hardstand layout for the modern turbines, access limitations and site constraints. This is discussed further in Section 2.3 below.
25i)a)	Turbines to be located within circles (i.e. CZs) as depicted on Wind Farm Layout Plan BMP W07190/1.	Potential turbine locations lie within the CZs except for turbines: • WTG 20 • WTG 39 • WTG 40 • WTG 47 • WTG 52.	These proposed five turbines cannot practically fit within the BMP W07190/1 CZs due to the increased hardstand and blade sizes, access limitations and site constraints. Modified CZs are proposed (as depicted in Figure 1) to reflect the Project layout – details of which are explained further in Section 2.3 below. The new positions of WTG 20, 39, 40, 52 avoid blade overhang of: • Wind Farm Development Area, • Paper Road, • Road Reserve, and • QEII areas.
25i)b)ii)	12m track width during construction narrowing to 5.0m post construction.	Track width during construction = 5.5m min plus allowance for widening (creating a total width of up to 9.5m) on bends. Reduced to 5.5m wide post-construction.	Tracks widths are dictated by oversized turbine component delivery vehicles. Corner widening will be narrowed to 5.5m width post construction, however it is not desirable to reduce further to the 5.0m, as this will be tight for two-way light vehicle traffic (i.e. maintenance vehicles).

Condition Ref	Condition Description	The Project (Riley design – 44 Turbines)	Comment
25i)d)	All hardstands to be located within the CZs as depicted on Wind Farm Layout Plan BMP W07190/1, maximum area of 1,400m^2, maximum fill depth of 12m.	Portions of the proposed turbines will be located outside the consented CZs. The new hardstands will have an area of approximately 1,855m^2. Max fill depth will not exceed 12m.	The hardstands for 4.3MW machines are larger than those which were originally consented (based on 2MW machines), and therefore they cannot not fit wholly within the CZs. Modified CZs have been proposed as shown in Figure 3 and detailed in Section 2.3 below. Each of the modified CZs overlap in part with the consented CZs.
25i)g)	Substation site to be located generally as shown on BMP W07190/1.	Refer updated Project layout (Figure 3) for new proposed location.	Stage 1 switchyard was positioned in general accordance with consented location. The Project requires a new substation which will be positioned to the north - located centrally within the Stage 2 area. The new substation, together with the BESS and transmission line require a new Land Use Consent.
25i)h)	Operations and Maintenance Building (O&M Building) to be located generally as shown on BMP W07190/1.	Refer updated Project layout (Figure 3) for new proposed location.	O&M Building to be positioned to the north - located centrally within the Stage 2 area and is subject to a new land use application.
25i)j)	The concrete batching plant to be located generally as shown on BMP W07190/1.	Refer updated Project layout (Figure 1) for new proposed location.	Batching Plant to be positioned to the north - located centrally within the Stage 2 area.

2.0 Proposed Wind Farm Details

As described above, the wind farm layout and design for assessment purposes has been based on an indicative turbine specification having a 4.3MW capacity and a rotor diameter of 136m and minimum ground clearance of 20m. TWP do not seek to specify the generation capacity (size) of the Stage 2 turbines to enable flexibility at the detailed design and procurement stages. The Project will include the following key features:

- Roading (access track – internal) network that will provide vehicular access to the turbine locations during and following construction, with various connections from Eldorado Track. Site tracks will be unsealed granular pavement with a minimum width of 5.5m and additional widening at bends to accommodate turbine component delivery vehicle swept paths.
- Turbine platform/hardstand areas are required for storage of components and placement and erection of the crane for installation. The main (hardstand) portion is retained as a gravel pad for future turbine maintenance activities.
- Electrical reticulation, consisting of underground cables between the turbines and the substation.
- A substation, occupying an area approximately 0.68ha, located within the site, to collect the power generated by the turbines.
- A Battery Energy Storage System (BESS), to temporarily store surplus power, occupying an area approximately 0.42ha.
- An overhead 110kV transmission line between the substation and existing overhead power lines located to the south of the site adjacent to Eldorado Track. The main section of overhead lines will feature up to 25 pole structures up to 45m in height. Consent is sought to locate the lines/poles within a 100m wide corridor, measured 50m either side of the indicative route, subject to any environmental constraints.
- Access tracks will be formed to provide maintenance access to each structure location. Both the transmission line corridor and access tracks consider wetlands and other noted ecologically sensitive areas (for example rocky outcrops or snow tussock grassland) and avoid such areas where practicable.
- Operations and maintenance (O&M) facility, approximately 2,200m^2 (including 700m^2 of buildings), indicative sizing is based on the Kaiwera Downs Wind Farm Stage 2 O&M.

2.1 Access Track Layout and Geometry

2.1.1 Wind Farm Tracks

An access track network will be formed within the Wind Farm Site and designed to:

- Provide vehicular access to each of the turbine sites.
- Align with the configuration of the turbine hardstands – geometry of which will be determined by the turbine supplier based on the turbine model chosen.
- Accommodate the oversized transport vehicles that will deliver the Turbine components to the respective turbine sites.

For the Project a total access track length of approximately 31km will be required, based on an indicative 44 No. turbine layout. The actual total access track length will depend on which of the 54 potential locations will be constructed. The internal (circulation) tracks within the site will have a normal (minimum) metalled carriageway width of 5.5m, with localised widening on corners (potentially up to 9.5m total width), to allow for the transportation of turbine components as well as general construction traffic. Where required, passing bays may be implemented to facilitate opposing oversized vehicle movements.

The guiding geometric requirements for access tracks are based on swept paths of the turbine transport vehicle and are outlined in Table 3.

Table 3: Preliminary Geometric Requirements for Wind Farm Access Tracks

Parameter	Max Longitudinal Gradient	Vertical Curve Radius	Minimum Horizontal Curve Radius	Minimum Carriageway Width
Wind Farm Access Tracks	15%(1)	500m	80m(2)	5.5m

(1) Steeper sections are permitted if tractor pulling units are utilised, and/or metalled access tracks are stabilised – generally up to maximum of 18% - excluding road to substation.

(2) Can revert to min R50m in constrained locations – track widening (up to 9.5m total width) will apply.

The preliminary alignment of the tracks has considered the following:

- Align along existing farm tracks where practicable and/or follow ridgelines.
- Avoid gullies and steeper terrain where practicable.
- Maintain a 10m setback from mapped wetlands, where practicable.

2.1.2 Transmission Line Tracks and Laydown Areas

Access tracks will be formed to the transmission line structures (poles) and temporary pads will be formed adjacent to the structures. The tracks will be designed for construction vehicles – including mobile crane and component deliveries. The design criteria for the tracks are presented in Table 4.

Table 4: Preliminary Geometric Requirements for Transmission Line Access Tracks

Parameter	Maximum Longitudinal Gradient	Vertical Curve Radius	Minimum Horizontal Curve Radius	Minimum Trafficked Width
Transmission Line Access Tracks	16%	200m	50m(1)	4.5m

(1) Absolute minimum of 20m radius in constrained areas – road widening would likely be required.

Where practicable the track alignment aims to:

- Access from adjacent (proposed) wind farm tracks.
- Utilise (follow) existing farm tracks and stay close to existing ground levels, to minimise earthworks.
- Aligned close to fence lines (edge of paddocks).
- Avoid gullies and steeper terrain.
- Maintain a 10m setback from mapped wetlands.

- The access tracks for the transmission line incorporate vehicle passing bays roughly every 500m.

A flat temporary construction/laydown pad/s (200m^2 area) has been provisioned at each pole location.

Following construction, the tracks will only be required to provide light 4WD vehicle access to the structures during the operational phase.

2.1.3 Turbine Hardstand Configuration

Turbine supplier specifications have been reviewed to determine indicative hardstand dimensions to enable assembly and erection for the tower, nacelle, and blade components. For assessment purposes Riley have considered a 4.3MW turbine featuring a 136m rotor diameter, and minimum 20m ground clearance. Based on this turbine size an indicative hardstand configuration is shown in Figure 4.

Each turbine permanent hardstand is approximately 1,855m^2 (60m long by up to 32m wide) located on one side of a central access track. The hardstand will comprise the turbine, main crane, and laydown areas for various turbine components. Identified as "Turbine Permanent Hardstand Area" in Figure 4, this area will remain as a permanent hardfill platform for ongoing maintenance activities for the life of the wind farm.

Temporary cleared areas and laydown areas of approximately 1,770m^2 make up the balance of the area and will be used for the blade laydown area, main crane boom assembly, and support crane pad. However, these additional laydown areas are temporary and will be recontoured and re-vegetated following construction and therefore are not considered part of the 'Turbine hardstand' that must be located within the CZs[5].

The turbine suppliers require a gently sloping hardstand, typically with maximum 1% transverse and 1% longitudinal gradient.

[5] Note – Both the permanent hardstand area and temporary hardstand/laydown areas are included in earthworks and pavement quantities outlined in the sections below.

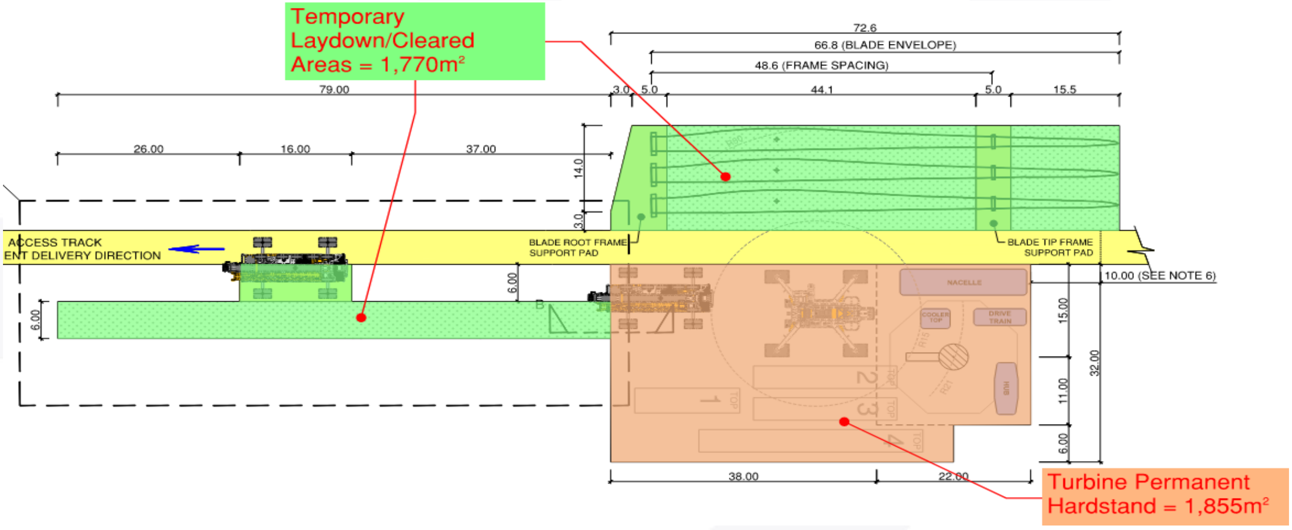


Figure 4: Indicative Turbine Hardstand (4.3MW, 136m Rotor Diameter)

The turbine hardstand will be typically arranged 'offline' from the main access track alignments where more than two platforms are located beyond, and where space allows. This allows access to the other platforms to be maintained during deliveries/construction. Vehicle turning areas will also be provided at selected platforms – to enable delivery vehicles to turn and exit the site (refer Figure 5).

Figure 5: Typical Turbine Platform Arrangement

2.2 Amendments to Contingency Zones and Wind Farm Development Area Boundary

It is proposed the Land Use Consent be varied with updated CZs for each proposed turbine locations. New CZs are proposed to accommodate the:

- Increased turbine hardstand areas.
- Access track geometric requirements of the oversized turbine component delivery vehicles – which are significantly larger than the components considered for the original consent. The alignment of the tracks influences the position of the turbines and hardstands.

The location and shape of the new CZs (as shown in Figure 3) have been defined based on the following criteria:

- Draw 100m radius from the proposed turbine coordinate (like for the consented CZs).
- Avoid wetland 10m buffers.
- Avoid gullies (identified based on ground contours and/or change in vegetation as observed from aerials).
- Avoid road reserve (Eldorado Track).
- Avoid the QEII covenant areas.
- Avoid the areas identified as Environment Court exclusion areas (Figure 2).
- Trim to the Wind Farm Site Boundary.
- Trimmed to the consented Windfarm Development Area – except where that is not practicable for Turbine 39 and 52.

For Turbine 39 and 52, it is not practicable to locate the hardstands within the consent Development Area boundary, because:

- The proposed position of the hardstand for Turbine 39 is restricted by the existing sloping terrain and the ability to achieve the necessary access track vertical and horizontal geometry. As a result, the access track (and associated earthworks batters) will also encroach beyond the consented Windfarm Development Area. For the avoidance of doubt all works will remain within the Windfarm Site boundary.
- The position of the hardstand for Turbine 52 needs to be repositioned to avoid blade overhang on the adjacent road reserve and QEII areas to the south and north. As a result, the access track and vehicle turnaround area (and associated earthwork batters) will also encroach beyond the consented Windfarm Development Area. For the avoidance of doubt all works will remain within the Windfarm Site boundary.

In addition to the above, a variation is being sought for a minor encroachment beyond the Windfarm Development Area boundary for the following instances (refer also Figure 6):

- Turbine 7 – the blade and crane boom assembly areas (and associated earthworks batters) extends slightly over the Windfarm Development Area boundary. This turbine is located on a narrow spur between two wetlands. There is insufficient space to locate all laydown areas and earthworks within the consented Windfarm Development Area based on the proposed turbine location and hardstand orientation - which is governed by the proximity to nearby Turbine 8 (given wind shadow considerations), and the minimisation of cut earthworks.
- Turbine 36 – the access track linking Turbine 36 and 37 extends beyond the Windfarm Development Area boundary. This is due to topographical constraints, and limitations of curve radii for component delivery vehicles.
- Turbine 50 – the access track approaching Turbine 50 extends beyond the Windfarm Development Area boundary. The existing terrain is too steep to accommodate an access track within the Development Area boundary, and still comply with the turbine component transport specifications.

Despite the Windfarm Development Area trespasses, a minimum 10m buffer from the mapped wetlands is maintained in each instance listed above, as shown in Figure 6 and in all instances the works remain within the Windfarm Site.

2.3 Wetlands Encroachments

Wetlands located within 100m of the proposed Project earthworks have been mapped by ecologists from SLR Consulting. Locations where earthworks are proposed within, or within 10m, of a wetland, are shown in Figure 7 and Table 5.

With the exception of the locations detailed in Table 5, the Project layout - including turbine hardstands, CZs, access tracks, site infrastructure, and surplus fill disposal areas - has been designed to avoid encroachment on wetlands and provide a minimum buffer distance of 10m.

Table 5 describes why there is a functional need to locate works within a particular wetland, along with mitigation measures that have been factored into the civil design.

Refer to the SLR Ecology report for assessment of these specific areas and the proposed effects management hierarchy.

Section 4.2 provides for further information on stormwater culverts beneath access tracks and hardstands and assessment against NES-F Regulation 45 (maintaining surface flow to Wetlands within 100m of earthworks).

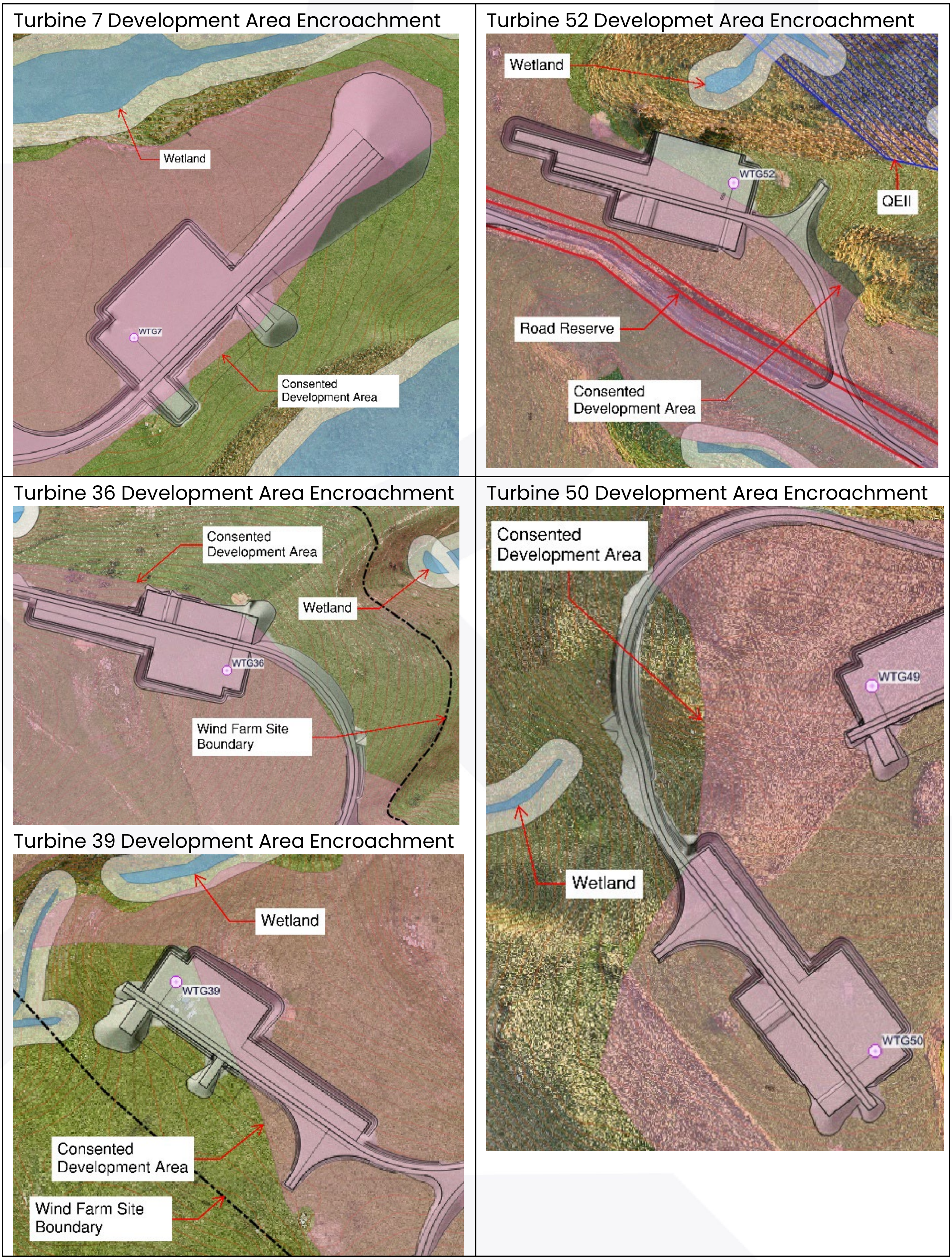


Figure 6: Turbine Hardstands and Access Tracks Outside Consented Development Area

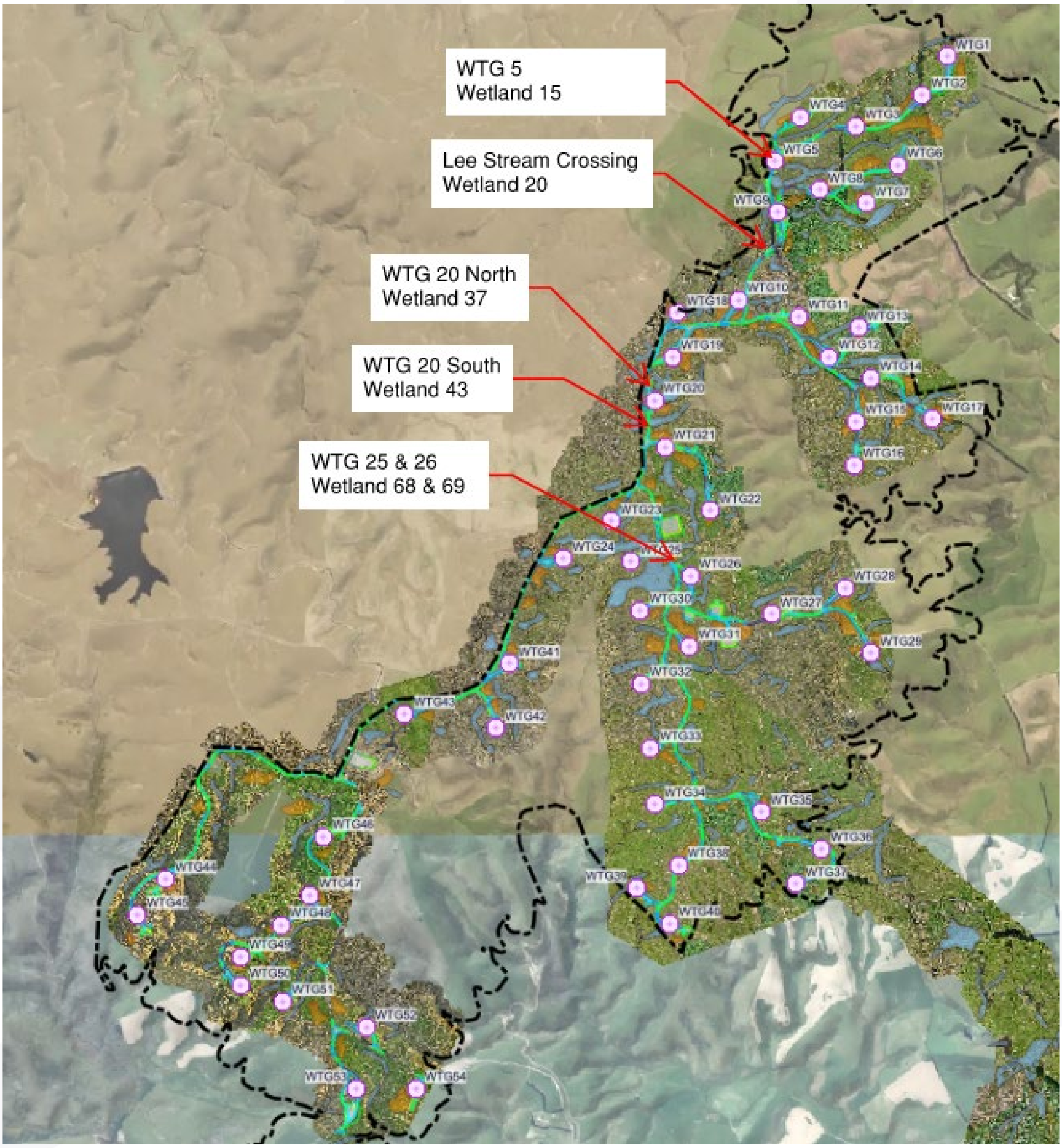
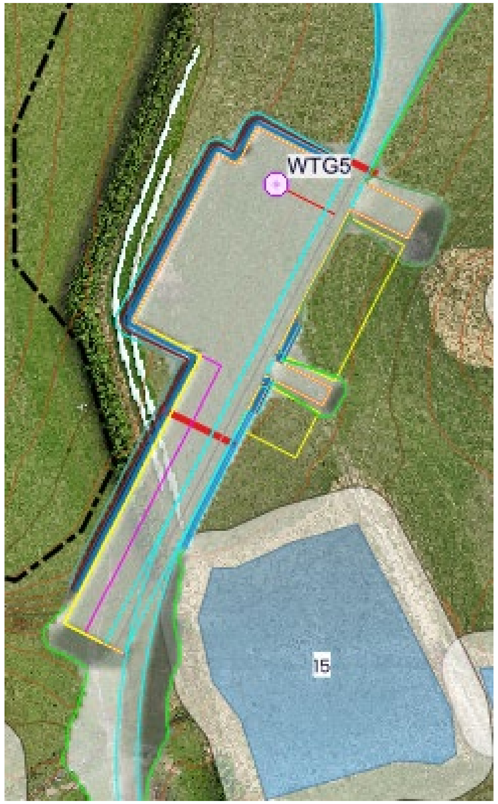
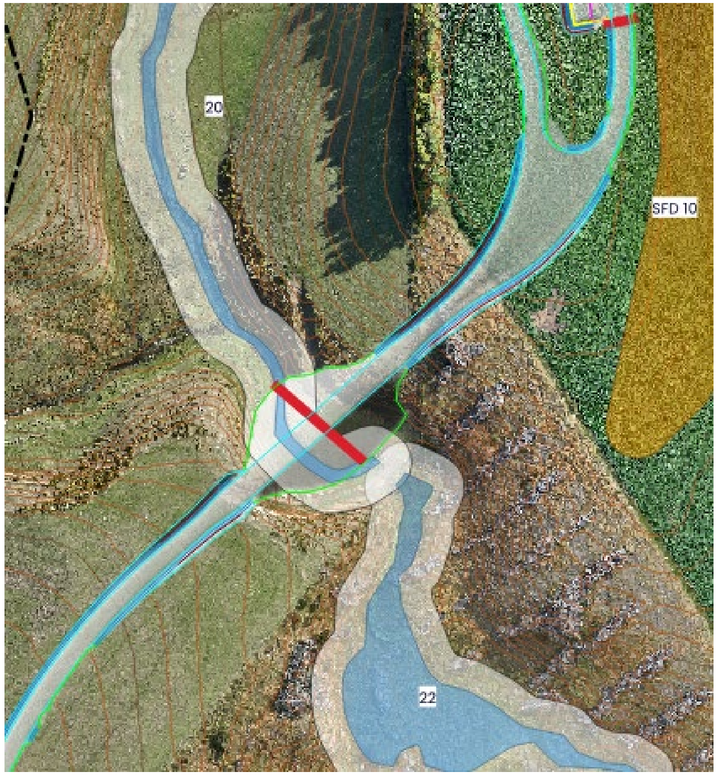


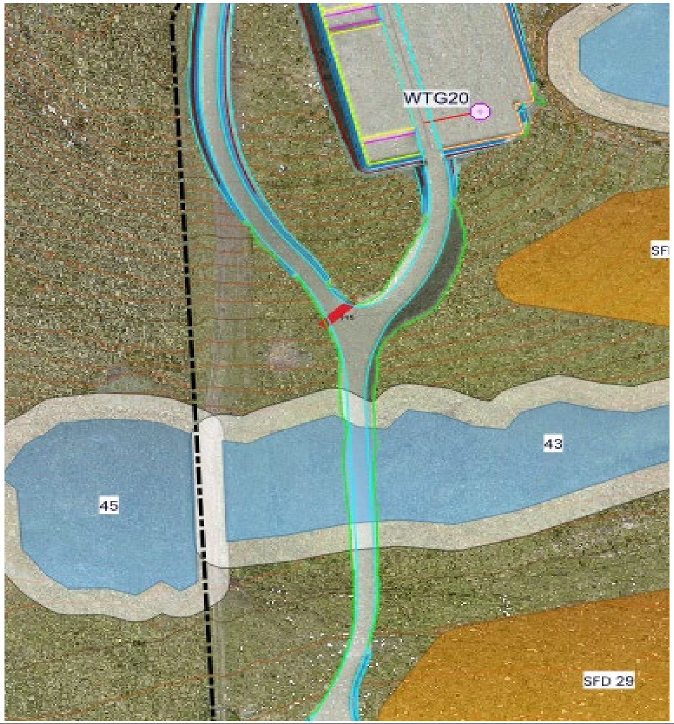
Figure 7: Wetland Encroachment Locations (excluding transmission line tracks)

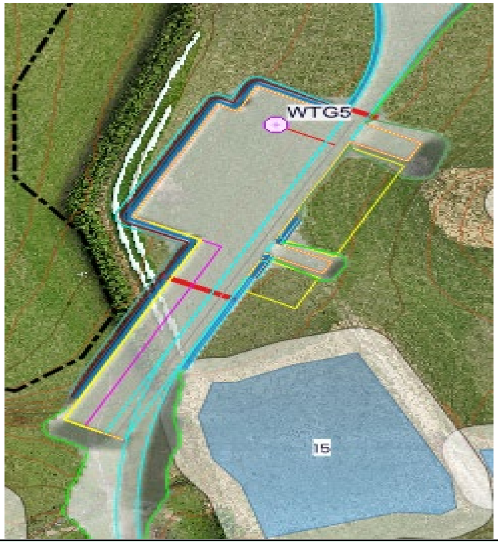
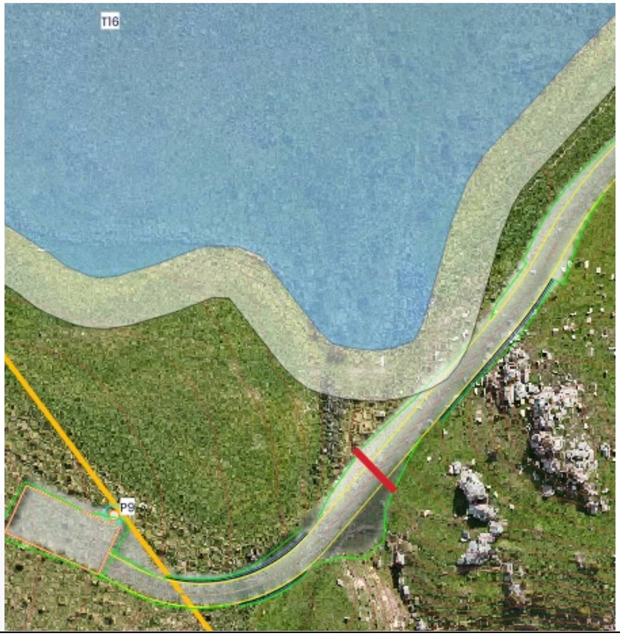
Table 5: Details of Access Tracks and Hardstands within Wetlands or Within 10m of a Wetland

Location	Description And Mitigation Factors	Site Map
Wind Farm Access Tracks and Hardstands		
Wetland 15, south of Turbine 5	Proposed Track will be located within 10m of wetland extent. Proposed track and temporary Turbine 5 hardstand area is threaded through narrow gap between Wind Farm Site Boundary and Wetland 15 – so not possible to maintain the 10m setback. Stormwater culverts will be installed to maintain wetland hydrology. Area of earthworks within the wetland = **0m²**. Area of earthworks within 10m of wetland = **103m²**	

Location	Description And Mitigation Factors	Site Map
Wetland 20 - Lee Stream Tributary Crossing	An existing culvert and farm track crossing will be replaced with a new culvert and track crossing located approximately 25m to the north-west. Works in this area was contemplated under the consent, and it is identified as “Development within constrained area D” on Site Development Layout Map BMP W07190/1. As identified on BMP W07190/1, the crossing of the Lee Stream tributary is unavoidable. The existing track crossing location is only suitable for light vehicles and does not provide a suitable vertical geometry for heavy vehicle construction traffic. The proposed new crossing location provides the required vertical alignment for the track route and optimal alignment of the proposed stream culvert. Refer report Section 5.0 for details on the proposed stream culvert. The existing farm track crossing will be removed and area rehabilitated once the new track crossing is completed. Area of earthworks within the wetland = **154m²**. Area of earthworks within 10m of wetland = **771m²**	

Location	Description And Mitigation Factors	Site Map
Wetland 37 - North of Turbine 20	Turbine 20 Auxiliary Crane platform fill batter located within Wetland 10m buffer. Due to the presence of wetlands to the north and south, no other suitable land is available to accommodate the required fill batter. Therefore Turbine 20 has been situated/orientated to make best use of the terrain and area between wetlands. Runoff will sheet flow across the platform – so wetland hydrology will be unaffected. Area of earthworks within the wetland = **0m²**. Area of earthworks within 10m of wetland = **112m²**	

Location	Description And Mitigation Factors	Site Map
Wetland 43 - South of Turbine 20	An existing farm track is to be replaced with a new track crossing through (and perpendicular) to the wetland (based on newly mapped extents – 2025). The wetland is already severed by an existing farm track. However, it is not practicable to utilise the track as it does not provide a suitable vertical geometry and is too narrow. The new crossing will be more centrally located on the ridgeline which will provide the required vertical alignment for the track route. Being centrally located on the ridgeline supports the overland flow path of the wetland as it naturally falls to the east and west – so there is no effect on wetland hydrology. Once the new track is constructed, the existing farm track crossing of wetland will be removed and area rehabilitated. Area of earthworks within the wetland = **322m²**. Additional area within 10m of wetland = **194m²**	
Wetland 68 and 69 - Access Track between Turbines 25 and 26	Proposed Track will be located within 10m of wetlands 68 and 69. The proposed track is threaded through a narrow gap between Wetlands 68 and 69 – so not possible to maintain the 10m setback. Stormwater culverts will be installed to maintain wetland hydrology. Area of earthworks within the wetlands = **0m²**. Area of earthworks within 10m of wetlands = **317m²**	

Location	Description And Mitigation Factors	Site Map
Wetland 15, south of Turbine 5	Proposed Track will be located within 10m of wetland 15. Proposed track and temporary Turbine 5 hardstand area is threaded through narrow gap between Wind Farm Site Boundary and Wetland 15 – so not possible to maintain the 10m setback. Stormwater culverts will be installed to maintain wetland hydrology. Area of earthworks within the wetland = **0m²**. Area of earthworks within 10m of wetland = **103m²**	
Transmission Line Access Tracks		
Wetland T16	Proposed access track has a very minor encroachment within 10m of wetland T16. The track cannot move any further to the south-east due to significant rock exposures Area of earthworks within the wetland = **0m²**. Area of earthworks within 10m of wetland = **15m²**	

Location	Description And Mitigation Factors	Site Map
Wetland T26, T27, T28	Proposed access track threaded through narrow gap between adjacent wetlands – follows existing farm track. Minimal earthworks required – minor trimming of subgrade and pavement construction only. Area of earthworks within the wetlands = **0m²**. Area of earthworks within 10m of wetlands = **220m²**	
Wetland T30	Proposed access track follows existing farm track which is located within 10m of wetland 30. Minimal earthworks required – minor trimming of subgrade and pavement construction only. Area of earthworks within the wetlands = **0m²**. Area of earthworks within 10m of wetland = **250m²**	

2.4 Pavement Design - Tracks and Hardstands

2.4.1 Summary

Pavement for the access tracks and turbine hardstands will be subject to detailed design. The pavements will primarily consist of engineered unsealed gravel (aggregate) layer/s (technically referred to as an unsealed flexible pavement). The access track pavements will be specifically designed for the development layout, anticipated subgrade and drainage conditions, and heavy construction vehicle volumes.

The pavement design will continue the key philosophies and objectives used to guide the rest of civil engineering and geometric design for the wind farm e.g.

- Environmentally sensitive.
- Fit-for-purpose.
- Cost-effective.

The design intent is for the access track pavements to perform adequately for the duration of the construction works (when the pavements are most heavily loaded). Some intra and post-construction maintenance of the tracks is possible depending on final design and construction.

The pavement layers will likely consist of:

- Basecourse layer (surface layer) – ideally a higher quality aggregate in direct contact with vehicle tyres. This material is generally strong (resists crushing), durable, and has good surface grip and resistance to wheel skidding characteristics e.g. All Passing 40mm aggregate (AP40).
- Sub-base layer – underlies the basecourse and is the key load-bearing layer of the pavement. This is engineered (placed and compacted in even layers with quality control measures). It aids drainage and protects the underlying subgrade (natural/in-situ, or fill). This layer is generally thicker with larger size aggregate (e.g. AP65 to AP100), and may be slightly lower quality and durability, compared to the overlying basecourse aggregate.

There are several potential project benefits if track and hardstand pavement aggregates can be manufactured from site-won material - e.g. reduced transport volumes on public roads, increased sustainability factors for potentially re-purposing bedrock to aggregate that may otherwise be cut to waste etc.

Weathered schist (refer Section 3.2) could provide suitable sub-base aggregate and can also be used as a capping layer to engineered fills, and as an engineered replacement of undercut (unsuitable) subgrade. The moderately weathered schist is expected to be regularly encountered, across the site, during road and WTG platform excavations.

Moderately weathered schist is not a preferred option for the basecourse (surfacing) aggregate. However, detailed design may confirm scenarios where this could be used for basecourse, with the understanding that additional monitoring and maintenance of the pavement may be required both during and after construction. For example, for lower category and/or easier-gradient access tracks, or where it is treated (strengthened) with the addition of lime or cement additives.

Site-won less/slightly weathered schist, encountered during the excavation of roads, hardstands, and turbine foundation, is expected to produce a basecourse aggregate that is suitable for the project. Alternatively, basecourse will need to be provided by importing higher-quality aggregate. This may be necessary if insufficient volumes of site-won basecourse aggregate are confirmed during detailed design. As discussed below, the assessment for this Resource Consent application assumes that all pavement aggregate are imported.

Key considerations for the availability and use of site-won slightly weathered schist bedrock as pavement aggregate include:

- The slightly weathered bedrock is expected to be very infrequently encountered during excavations for Stage 2 tracks, platforms, and foundations. Machine boreholes undertaken ca. 2025 typically encountered consistent slightly weathered schist below approximately 9m to +20m, and generally greater than approximately 15m below existing ground level. This is generally below the proposed earthworks cut depth. Notable areas where potentially better-quality bedrock was relatively close to the existing ground surface are in the south-west (Stage 1) end of the site e.g. MH201, TP251, and TP255. Additional investigations and assessment during detailed design are recommended to confirm volumes of available better-quality bedrock.
- Laboratory aggregate tests suggest the rock has satisfactory durability compared to the Transit New Zealand (TNZ) M/4 Specification - i.e. two tests returning 'CA' Weathering Resistance Index values - refer to Appendix F results included in the Riley MWF2[6] GFR. However, Crushing Resistance tests completed on the two samples returned a consistent 70 to 80kN. This is slightly below the NZTA M/4 Specification of +130kN.

In summary pavement aggregate tests on two samples suggests site-won schist will have satisfactory durability but could have reduced strength under repeated heavier axle loads. This could be managed but additional monitoring and maintenance during and after construction, particularly if there are substantiative benefits (including project economics) for using site-won aggregate and reducing (or negating) the need for imported pavement aggregates.

2.4.2 CBR Values for Preliminary Design

The design methods noted above principally require input of subgrade California Bearing Ratio (CBR) values, and frequency of equivalent standard axles (i.e. standard 80kN) (ESAs).

[6] Riley - MWF2 Geotechnical Factual Report (GFR), ref: 240034-F, Issue 0.1, dated 6 June 2025.

The CBR values for the anticipated in-situ cut-subgrade materials have been estimated based primarily on empirical correlations using in-situ strength tests (i.e. Scala penetrometer, hand Shear Vane, Clegg impact hammer) completed during the site investigations. Based on the site investigations and our experience with similar materials the inferred in-situ CBR's are summarised in Table 6.

Table 6: In-Situ Cut-Subgrade CBR Values – Recommended for Preliminary Design

In-Situ Material Type	Inferred CBR Value - *Typical Range* [*Adopted for Design*]	Comments
Soil-Like (Includes near-surface colluvium, local alluvium, and most-weathered schist)	*3 to 13* *[3]*	Recommend lower bound CBR as this material can weaken upon loading and is susceptible to softening with increased moisture content. Undercutting of this material may be an efficient risk mitigation during design/construction.
Highly weathered, very weak to weak schist	*8 to 25* *[9]*	Locally gradational contact with overlying and underlying soil and less-weathered rock may be present resulting in an apparently broader range of in-situ test results.
Moderately weathered, weak to moderately strong schist	*+20* *[25]*	-

Riley procured a limited programme of four 300mm diameter plate bearing tests (PBT) on selected in-situ subgrade. This included two PBT on soil-like material and two on the highly weathered schist material, with the details and results included in Appendix C-4, of the Riley MWF2 Geotechnical Factual Report (GFR). Empirical correlation of the PBT results support the inferred in-situ subgrade CBR outlined in Table 6.

CBR values for bulk fill, adopted for preliminary design are summarised in Table 7 (refer to Appendix F of the Riley GFR for laboratory test reports and results summary).

The soil-like materials are likely to be sensitive to moisture content. This will reduce the efficiency of using soil-like materials as an engineered fill – particularly around wetter weather periods. Accordingly, it is envisaged that weathered rock is the preferred material for structural fills.

Table 7: Bulk Fill Subgrade CBR Values - Recommended for Preliminary Design

Bulk Fill Material Type	Soaked CBR Value - *Typical Range* [*Adopted for Design*]	Comments
Soil-Like (Includes near-surface colluvium, local alluvium, and most-weathered schist)	5 to 25 *[5]*	The higher soaked laboratory CBR values (i.e. 25) are considered anomalous, and we consider it is appropriate to adopt a lower-bound value for preliminary design.
Highly weathered, very weak to weak schist	15 to 40 *[15]*	-
Moderately weathered, weak to moderately strong schist	16 to 40 *[25]*	-

2.4.3 Conceptual Design

The site traffic volumes have been estimated based on expected construction materials to be delivered to site plus internal vehicle movements relating to the construction of the wind farm. As post-construction traffic volumes will be relatively low, the estimated standard axles over the design life of the pavement are based primarily on construction traffic.

Based on the envisaged traffic requirements, subgrade conditions, and experience on other wind farm sites, a pavement thickness between approximately 150mm to 250mm is anticipated. For the purposes of this assessment, it has been assumed a 200mm average depth pavement, of either selected site-won schist, or high-quality imported aggregate for the pavement.

A lower confidence level for the pavement design may be chosen (i.e. thinner pavement), given that the tracks will not be used for public use, and post-construction traffic will be limited. This may further facilitate the use of site-won pavement aggregates.

The pavement design is sensitive to the value of the subgrade CBR. The pavement thickness can be optimised (during detailed design) by undertaking subgrade improvement works - to increase the bulk CBR for either cut-subgrade and fill-subgrade. Examples include; cut-subgrade - undercutting weaker/unsuitable materials and replacing with a suitable engineered site-won rock fill, and or use of strengthening and separating geogrid and geotextile layers; and placing a cap of moderately weathered schist in fill-subgrade situations.

As noted above, moderately weathered site-won schist encountered during excavations for the tracks, platforms, and turbine foundations is expected to be suitable as sub-base aggregate, although detailed design may confirm scenarios where this grade of aggregate is suitable for the (surfacing) basecourse aggregate too.

Slightly weathered site-won schist is expected to be suitable for both sub-base and basecourse (surfacing) aggregates. A key consideration is that slightly weathered schist appears to be relatively scarce across the site and is only expected to be encountered in limited volumes during excavations for tracks, platforms, and foundations (as noted above). Additional investigations, laboratory tests and assessment are recommended during detailed design to confirm the practicalities of extracting sufficient site-won pavement aggregate, including volumes of higher-quality slightly weathered schist.

Pavement aggregates, whether site-won or imported, will need to meet durability and strength requirements adopted during detailed design. Additional monitoring and maintenance of pavement may be appropriate, particularly if site-won aggregates are used, considering that durability and strength characteristics of these could be slightly below some aspects of national design and construction guidelines e.g. NZTA M/4 Specification.

Stormwater control, along the access tracks, hardstands, and other areas of civil works, is essential to ensuring adequate performance of any pavement placed. Stormwater controls will consist of 'v-drains' and 'u-drains' (table drains) where tracks and hardstands are in cut, along with numerous culverts which will convey flow beneath the tracks and hardstands, thus preventing surface water ponding and pavement becoming water-logged. Refer stormwater sections below for further details.

3.0 Earthworks

3.1 General

An indicative track and hardstand layout have been prepared to provide access for construction vehicles to the turbine locations. From this layout, Riley has carried out an assessment of the earthwork cut and fills and surplus volumes, disturbance areas, and sediment control measures.

Design work has been undertaken utilising 12D Model, a civil design software package, based on drone LiDAR topographical information, as provided by TWP.

3.2 Geology

The published regional geological map for the area[7] indicates the site is underlain by predominantly quartzofeldspathic schist bedrock, correlated to the Caples terrane (refer Appendix J – sketch sheets 240034-SK212 and -SK213 included in the Riley MWF2 GFR). The schist is classified as metamorphic "textural zone" TZIII (i.e. foliated schist with quartz-feldspar segregation laminae >10mm long and <2mm thick). The schist foliation is indicated to dip 15° to 30° toward the north-east to south-east quadrant at the site.

The geotechnical investigation has not identified any active faults within the Windfarm Development Area.

[7] GNS Science QMAP, 1:250,000 scale map, "*Geology of the Dunedin Area*", Map 21, dated 1996

The scope and results of the geotechnical investigations at the site are included in the Riley MWF2 GFR. The GFR primarily includes results from fieldwork undertaken ca. early-2025. Investigation results undertaken to support the original Resource Consent application (ca. 2007) are also appended to the GFR. The early-2025 investigation scope primarily includes, machine test pits and machine boreholes, and laboratory tests on selected soil and rock samples, and geophysics (Ground Penetrating Radar – GPR, and downhole shear wave profiles).

The general inferred ground profile, with increasing depth below ground level (bgl) consists of:

- Topsoil - forms a consistent thin surficial layer across the site – generally 0.2m and locally 0.3m thick where present.
- Near-surface soil-mantle – consists of predominantly cohesive soils, with variable geological origin. The mantle may consist of wind-blown loess (silt and fine sand deposited predominantly during the last glaciation), more/completely weathered schist zones and layers, locally alluvium, colluvium (i.e. soils deposited across a hillslope under the influence of gravity but without water confined to a stream or gully), and reworked derivatives of the above. The soil-mantle has variable thickness and distribution and is inferred to be effectively absent from large areas (where topsoil is underlain directly by variably weathered schist). Where present the soil-mantle thickness ranges from a few hundred millimetres to approximately four metres (e.g. TP291) and is generally less than 0.6m thick. Thicker soil-mantle deposits are generally less than 1m thick and are likely to be thickest near the head of gullies.
- Variably weathered schist:
  - Ranges from highly weathered to slightly weathered, but generally highly to moderately weathered is encountered within the range and limit of machine test pits.
  - Weathering profile is irregular vertically or laterally across the site – changing over short horizontal distances.
  - Is typically a 'normal' profile, i.e. reducing weathering with increasing depth below the ground-surface. However, 'inverted' weathering profiles are expected locally i.e. more weathered underlying less weathered rock layers (e.g. MH210 where repeated intervals of inverted weathering are noted, MH221, and MH222).
  - The schist ranges from very weak to strong but is generally less than the lower-end of moderately strong.
  - Where present the very weak to weak material is between a few hundred millimetres to many metres thick (e.g. approximately 6m and 10m in MH212 and MH216, respectively).
  - Moderately weathered schist is typically brown and grey, and weak to the lower-end of moderately strong (noted above).

- Slightly weathered schist is typically grey, and moderately strong to strong. As noted above (Section 2.3 - Pavement Aggregates) there are limited instances of this rock being encountered by ca. 2025 machine test pits (e.g. TP251, TP255, TP289, possible TP292, and MH201 and MH202). Machine boreholes undertaken ca. 2025 typically encountered consistent slightly weathered schist below approximately 9m to +20m, and generally greater than approximately 15m below existing ground level.
- Rock mass in the schist is dominated by foliation and foliation subparallel defects, with generally 2 or 3 moderately to subvertically inclined joint sets that are typically closely to moderately widely spaced. It can be difficult to observe joints and defects in the test pits. Sheared and crushed zones were very locally noted in test pits.

Notable geotechnical observations and results include:

i. As noted above the schist foliation dips gently to moderately to the east and north-east (i.e. striking approximately north-south). There are many areas were soil mantle and often topsoil too is effectively absent, and less weathered schist outcrops at the ground-surface. Notable schist exposures are indicated on sketch plans including in Appendix J of the MWF2 GFR. Schist exposures are particularly evident locally along the sides of the relatively shallow gullies that are eroded into the remnant regional-scale paleo erosion-surface that is exposed in the East and Central Otago ('Waipounamu Erosion Surface').

   The schist exposures are also locally evident across the broad ridges – where they may either just 'break' the ground-surface or may be lower elevation mounds. These exposures can individually, or in a chain, define approximately north-south lineaments. These are inferred to be strike ridges to the foliation – consisting of stronger and potentially more quartz-rich layers in the schist that are less susceptible to weathering and erosion, compared to the surrounding rock.

3.3 Hydrogeology and Effects of Earthworks on Wetlands

Generally, the proposed earthworks follow ridgelines and spurs, and is elevated above the wetlands, which are predominantly located in the gullies. Wetland and gully water is expected to be fed through a combination of surface water flows and groundwater seepage flows. Groundwater monitoring indicates the groundwater table is in the bedrock with depths varying significantly (i.e. 3m to 17m bgl, and median and mean values of approximately 7m and 8.5m bgl) (refer Appendix B-3 of Riley GFR). It is expected:

- The groundwater flow to be primarily along joints and fractures within the rock mass. Seepage flow rates through the rock mass will be very low.
- The localised groundwater and hydrogeology conditions may be complex including influence from irregular weathering profiles and lower permeability, and laterally persistent, defects such as foliation sub-parallel sheared/crushed zones (where present). Local perched water tables may be present above such sheared/crushed zones (if any).

- In general, the groundwater table will coincide with the gully invert/wetland and to progressively rise in elevation away from the gully and in the hillslopes surrounding gullies (refer annotated inferred earthworks sections - Riley Dwg ref: 240034-265 to -267).

As noted above, maximum cut depths of approximately -10m, and -7m are proposed for the turbine platforms and access tracks. However, most cuts are less than approximately -3m to -4m bgl.

The vast majority of track and platform cuts are expected to be many metres above the groundwater table. However, we cannot discount the possibility of groundwater being encountered – particularly where there is the combination of deeper cuts and/or shallower groundwater levels. With reference to the annotated inferred earthworks sections (Riley Dwg ref: 240034-265 to -267)[8], we do not expect this to impact the overall groundwater supply to the gullies/wetlands because:

- The proposed cuts are above the level of the adjacent wetlands/gullies and are therefore not expected to act as a 'drawdown' to the wetlands/gullies.
- The area of the tracks and platforms is a very small percentage of the total area adjacent to, and potentially supplying groundwater seepage flows to, a wetland/gully system. This will offset (mask) any local impact of the track and platform cuts on the groundwater recharge to the wetland/gully (if any).
- Seepage flows from track and platform cuts will be intercepted and conveyed via the table drain network and appropriately discharged onto nearby gully slopes (facilitating this water to reach the nearby gully) (if any).

3.3.1 Turbine Foundation Temporary Excavations

Temporary excavations for the construction of turbine foundations typically extend 3 – 4m below the WTG platform level (dependant on foundation design). Groundwater seepage flows may be encountered in a limited number of foundation excavations. It is unlikely that such temporary dewatering will have a negative impact on the gully/wetland flows (see discussion above).

Groundwater and/or stormwater flows should be readily managed by temporarily collecting the water in surface sumps and pumping this out to an appropriate discharge location on a nearby hillslope (downslope of the turbine). The works will be undertaken in accordance with erosion and sediment controls plans – particularly if the discharge water contains suspended sediment.

3.4 Earthworks Design

Preliminary cut and fill batter slopes are provided in Table 8, based on preliminary geotechnical investigations and assessment of the subsurface conditions.

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[8] The three platforms considered in Riley Dwg: 240034-265 to -267 are WTG13, WTG39, and WTG40. These are selected platforms and are considered to represent relatively 'worst case' examples – i.e. where cut earthworks are proposed close to wetlands.

Table 8: Preliminary Cut and Fill Batter Slopes (Subject to Detailed Design)

Batters	(V:H)	Inclination +/- horizontal (°)
Cut – Colluvium soils (includes Residual to Highly weathered rock)	1:1	45
Cut – Moderate to slightly weathered rock	2:1	63
Fill (engineered soil and rock fill)	1:3	18

The proposed turbine hardstands are generally designed with foundations excavated into natural ground and founded on bedrock. This design approach results in a typical maximum fill depth of approximately +2.0m for the permanent hardstand platform, and a maximum cut depths of -10m. In accordance with Land Use Consent Condition 25(i)(d), fill depths of up to +12m are permitted for turbine hardstands. The current design remains well within this allowance, ensuring compliance with consent conditions while maintaining geotechnical stability.

The preliminary design includes a maximum cut or fill batter height for access tracks of -7m and +8m, respectively. This is based on topographical constraints and the need to maintain safe and efficient access for construction vehicles. Land Use Consent Condition 25(i)(c) permits fill depths of up to +10m for access tracks. The proposed design is therefore compliant with the consented limits and reflects a conservative approach to earthworks.

Where filling is necessary, the stability of the fill material in relation to the overall slope will be considered including the removal of unsuitable material, (i.e. organics, or lower strength soil or rock), appropriately keying the base of fill into the slope, adequate compaction, and moisture conditioning of the fill. Drainage within the fill may also need to be considered to ensure suitable factors of safety are achieved for the fill.

A summary of the proposed max cut/fill depths across the site are presented in Table 9.

3.5 Earthwork Volumes and Areas

A 3D earthworks model has been developed for the access tracks and hardstands. Table 9 presents the estimated earthworks quantities modelled for the Project and the consented real-world Layout, for comparison purposes. The earthworks for the consented real-world layout have been estimated from the Project quantities on a pro-rata area basis, considering the reduced turbine platform and foundation sizes, and increased access track pavement width and lengths (refer table notes below).

Based on quantities from Table 9 - construction of the Project (including transmission line works), will result in less excess spoil compared with a consented real-world layout. The main reason for this reduction is the narrowing of tracks from the 12m width considered for the original consent, to the 5.5m now proposed. The Project surplus fill is estimated at approximately 365,000m^3. The civil contractor who constructed Stage 1 of the wind farm, has advised that the surplus fill generated was approximately 19,000m^3 for Stage 1, spread as blanket fills over an approximate total area of 18,000m^2. Therefore, the estimated Project surplus fill volume (when combined with the Stage 1 surplus) is approximately 384,000m^3, well below the Land Use Consent limit of 460,000m^3.

Table 9: Preliminary Earthwork Quantities and Track Lengths

Description	Quantities			
	The Project	Consented Real-World Layout(5)	Stage 1 Wind Farm (Constructed)	Land Use Consent Limits
Wind Farm (access tracks and platforms)				
Number of Turbines	44	47	12	100
Track Length (incl. length of tracks through Turbine platforms)	31km	31km	5.2km	37km
Cut Volume (incl Rock) (2)(3)(4)	-530,000m^3	-584,000m^3		
Rock Cut Volume (3)(4)(6)	-255,000m^3	-280,000m^3		
Fill Volume(2)(3)(4)	189,000m^3	208,000m^3		
Turbine Foundation Excavation Volume (Assumed 100% Rock)	-66,000m^3 (7)	-53,000m^3 (8)		
Turbine Foundation Backfill Volume	44,000m^3 (7)	35,000m^3 (8)		
Surplus Fill Volume (excl topsoil)	-363,000m^3	-394,000m^3	-19,000m^3	-460,000m^3(9)
Total Earthworks Area(1,4)	55.2ha	59.5ha		
Max fill depth – Permanent Turbine Hardstands	2m (WTG 25)			12m
Max fill depth – Temporary Turbine Laydown Areas	7m (WTG 53)			
Max cut depth – Permanent Turbine Hardstands	-10m (WTG 29 and 53)			
Max Fill Depth – Access Tracks	8m (exit from WTG 53)			10m
Max Cut Depth – Access Tracks	-7m (entry to WTG 13)			-10m

Description	Quantities			
	The Project	Consented Real-World Layout(5)	Stage 1 Wind Farm (Constructed)	Land Use Consent Limits
Transmission Line (access tracks and construction pads)				
Track length	8.8km			
Cut volume(2)	-9,900m^3			
Fill Volume(2)	-8,200m^3			
Surplus Fill Volume (excl topsoil)	-1,700m^3			
Total Earthworks Area	6.7ha			
Max Fill Depth	3.5m			
Max Cut Depth	-3.0m			

(1) All earthworks areas excluding surplus fill disposals.

(2) Volumes are calculated based on the difference between existing stripped ground surface (allowing 0.2m topsoil strip) and the finished subgrade surface (assuming average 0.2m new pavement thickness), i.e. excludes topsoil strip.

(3) Excludes excavations and backfill of turbine foundations, undercuts/subgrade improvement, surplus fill disposal sites.

(4) Includes turbine Access tracks and platforms, O&M facilities, substation, contractors site compound, concrete batching plant facility. BESS and substation areas excluded from Consented Real-World quantities.

(5) Calculate multiplier to be used for estimating Consented Real World earthworks quantities based on the Project quantities (based on earthworks area):

a. Access tracks 31 km @ 6.2m wide (average) for the Project, compared with 31 km (assumed) @ 12m wide for the consented real-world layout. For the Project, 67% of total access track earthworks area comprises the pavement, i.e. 33% is cut/fill batters (approx. 3.1m width per m track on average) – adopt same batter width for Consented Real World layout.

b. The Project – 44 (4.3MW) No. turbine hardstands @ 3,555m^2 per hardstand (1,855m^2 permanent + 1,770m^2 temporary), compared with 47 (3.45MW) No. @ 1,400m^2 for real-world consented. For the Project the permanent and temporary hardstands comprise (on average) 70% of the total turbine platform earthworks area (balance being earthworks batters) – assume same ratio for Consented Real World layout.

c. Therefore, based on a) and b), scale up Project earthworks (on pro rata area basis) by 1.1x to estimate the consented real-world quantities.

(6) Rock = MW Schist or harder. Assumed average depth to MW schist from existing ground surface = 1.2m

(7) Based on foundation designs developed for similar sized turbines on other wind farms – 1,500m^3 excavation volume per turbine (assumed in rock), 1,000m^3 backfill volume.

(8) Assume a 3.45MW machine foundation is 80% of the size of a 4.3MW machine foundation size.

(9) Consent Condition 25i)e)

The temporary hardstand platforms will be revegetated following completion of the turbine construction and track widening at bends and junctions will be reduced to 5.5m width and revegetated. The estimated disturbance areas associated with the Project during, and post-construction are shown in Table 10. This shows that the construction of the Project will result in less disturbance area during construction compared to the consented real-world layout, but results in a larger post-construction disturbance area. The area of surplus fill disposal is estimated as 42.7ha, compared with an area of 61.5ha permitted by the Land Use Consent.

Table 10: **Indicative Disturbance Areas Associated with the Wind Farm**

Disturbance Areas	Quantities			
	The Project	Consented Real-World Layout	Stage 1 Wind Farm (Constructed)	Land Use Consent Limits
Wind Farm				
During Construction (incl. cut and fill batters):				
• Turbine Hardstands (either side of access track)	21.9ha	9.2ha(9)		
• Access Tracks (incl. length of tracks dissecting each turbine platform)	29.0ha	47.2ha(7)		
• Substation, O&M, BESS and construction site facilities (batching plant, site compound.)(10)	4.2ha	3.1ha		
• Surplus Fill disposal sites(1)	41.9ha	45.3ha	1.8ha	61.5ha
Sub Total	97.0ha	104.8ha		
Post Construction (permanent hardfill and impervious surfaces):				
• Turbine Hardstands	8.2ha(2)	6.6ha(3)		
• Access Tracks	17.1ha(4)	15.5ha(5)		
• Substation, O&M, BESS (incl SW Basin)(6,10)	1.3ha	0.22ha		
Sub Total	26.6ha	22.3ha		
Transmission Line				
During Construction (incl. cut and fill batters):				
• Construction pads	0.6ha	-		
• Access Tracks	6.1ha	-		
Sub Total	6.7ha	-		
Post Construction (permanent hardfill and impervious surfaces)				
• Access Tracks and pads(8)	4.0ha	-		

(1) Based on the fill surplus from Table 9 (combined wind farm and transmission line earthworks), allowing for 15% bulking factor and an assumed 1.0m average fill depth (blanket fill type assumed).

(2) Based on 1,855m^2 permanent hardstand per turbine platform – support crane pad, blade support pads, cut and fill batters to be re-vegetated.

(3) 1,400m^2 consented hardstand area per turbine

(4) 31km total track length – reduced to 5.5m width post construction

(5) 31km total track length – reduced to 5.0m track width post construction

(6) platform cut and fill batters to be re-vegetated

(7) Access tracks 31km @ 6.2m wide (average) for the Project, compared with 31km (assumed) @12m wide for the consented real-world layout. For the Project, 65% of total access track earthworks area comprises the pavement, i.e. 37% is cut/fill batters (approx. 3.3m on average) – and use same batter width for Consented Real World layout. Therefore, apply a 1.63x multiplier to estimate consented real-world area.

(8) 8.8km total track length – 4.5m pavement width. Construction pads to be re-vegetated

(9) For the Project - 44 No. turbine hardstands @ 3,555m² per hardstand (1,855m² permanent + 1,770m² temporary), compared with 47 No. @ 1,400m² for real-world consented. For the Project the permanent and temporary hardstands comprise (on average) 70% of the total turbine platform earthworks area (balance being earthworks batters) – assume same ratio for Real World layout. Therefore, apply a 0.42x multiplier to estimate consented real-world area.

(10) Assume same site facilities areas for the Project and consented real-world layouts – except Substation and BESS excluded from real-world layout

The turbine hardstand geometry and orientation within the CZs, track alignment and platform levels, will be optimised at detailed design stage to minimise total earthwork volumes and disturbance areas.

3.6 Surplus Fill Disposal Sites

The earthworks required to form the access tracks, platforms, and turbine foundations, will result in a large fill surplus, as shown in Table 9. As explained in the section above, the estimated surplus volume for the Project is less than the volume permitted by Condition 25(e) of the Land Use Consent. Surplus fill will be deposited as blanket fills at locations within the Windfarm Development Area. The locations consider the original consented Surplus Fill Disposal (SFD) locations but redesigned to suit the Project layout. As such, the change in conditions extend to the movement within the Windfarm Development Area for these new SFD sizes and locations – noting that no single SFD is the same location/shape as the original SFDs.

A total of 84 SFD locations have been identified based on the potential 54 turbine locations – refer Riley Dwg 240034-203 in Appendix F for details. The number of SFDs will likely reduce based on the final layout of the 44 turbines to be built. As identified in Table 10, a total area of 41.9ha has been calculated for SFDs, based on earthworks surplus and assuming a 15% fill bulking factor and 1.0m average fill depth. This area (when combined with 1.8ha surplus fil area form Stage 1) is below the 61.5ha provided for in the Land Use Consent.

The design and location of the SFDs considers the following factors:

- No disposal shall take place within gullies/wetlands, SFD's to maintain a minimum 10m setback from wetland extents.
- Located on broad ridgeline features with gently to moderately sloping ground <15% gradient, with relatively easy access for construction vehicles.
- Located close to areas of cut with easy construction vehicle access.
- Situated in an area of stable ground (generally based on visual assessment).
- No disposal shall take place into any permanent or intermittent rivers or streams.
- Locate entirely within the consented Windfarm Development Area.
- SFD's will be contoured so they do not impound nor divert surface water, generally following the pre-existing ground profile beneath. Therefore, surface runoff will simply sheet flow across the SFD finished surface, thus conserving flows to wetlands downslope.

- The SFD's will be 'blanket fill' type – i.e. non-engineered fill spread over the grass paddocks – typically 1-2m thick, and up to 3m max – in accordance with condition 25i)d) of the Land Use Consent. The fill will be placed to uniform compaction, achieved by the general tracking of construction plant/vehicles.
- A typical SFD cross section is shown in Figure 8.

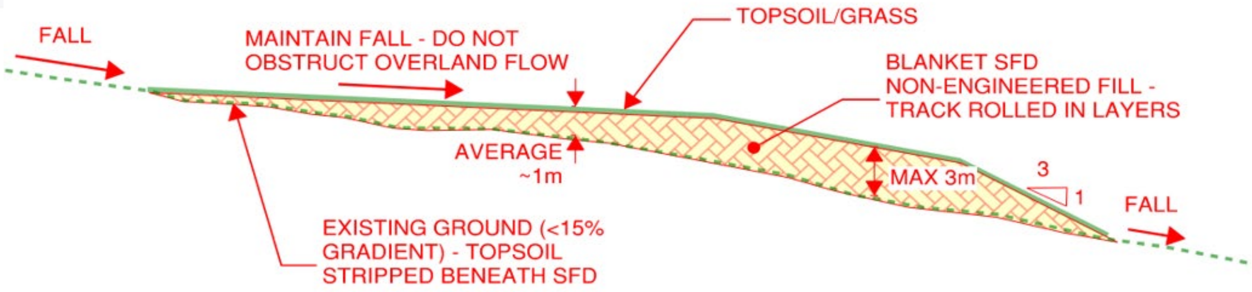

Figure 8: Surplus Fill Disposal Site – Typical Section

4.0 Stormwater Management

4.1 Introduction and Principles

This section covers sheet flow, overland flow paths, and ephemeral watercourses intercepted by tracks and hardstands. Section 5 covers the management of stream crossings.

The wind farm tracks and hardstands will intercept surface water runoff and thus without management have the potential to effect existing drainage patterns within the Wind Farm Site.

Riley have undertaken a site wide catchment assessment to determine the location and design of proposed stormwater culverts which will minimise the impacts on existing drainage patterns. The primary purpose of the stormwater culverts is to keep pavements free from surface water (culverts to be adequately sized to pass the design rainfall event) and ensure that the water level range and hydrological function of wetlands is maintained.

Key design principles employed in the stormwater management of the wind farm track and hardstands include:

- Tracks and hardstands to be located along ridgelines where practicable to avoid impact on natural flow paths.
- Preservation of natural flow paths and wetland catchments to prevent the alteration or reduction of wetland water levels, supporting their hydrological function and biodiversity. This will be achieved through the use of stormwater culverts where tracks and hardstands intercept the flow paths which eventually drain to the natural water bodies – thus conserving the existing catchments.

- Where practicable, design access tracks to allow stormwater to sheet flow naturally across the terrain, minimising the need for culverts.
- Where stormwater is collected, mitigation of potential erosion along drains and at outlets with energy dissipation. This will be achieved through rock lined channels along steep gradients and rock aprons at culvert and drain outlets.
- Protection of proposed infrastructure from erosion or overtopping with adequately sized culverts to convey flow beneath the fill embankments.

4.2 Culvert Types

The proposed stormwater culverts have been categorised into four main types (refer appended Riley Dwg: 240034-281 for details):

1. Type A culverts – to be located within gully features/ephemeral streams (where there is no fish habitat) beneath access track fill embankments.
2. Type B and C culverts – to be located at various locations along the access track and turbine platform table drains, to convey flow beneath the tracks and hardstands where they cross natural flow paths. Positions are determined relative to the location of the downstream watercourse/wetlands (i.e. to maintain surface flow to the wetlands). Type B culvert outlets terminate on earthwork fill embankment and thus incorporate a rock lined flume section to direct flows to a riprap apron at the toe of the embankment. Type C culvert outlets terminate directly to the embankment toe (with a riprap apron).
3. Type D culverts – to be located at locations along access track and turbine platforms, to connect flow from one U/V ditch drain to another, conveying flow beneath tracks and hardstands where they cross natural flow paths or where a sag point is located along the access track alignment

4.3 Culvert Design

A catchment analysis has been undertaken using the GRASS 8[9] module (v2.0) embedded within QGIS. The existing ground drone survey has been merged with existing LiDAR of the wider catchment to allow for flow path analysis and determination of the catchments. A 150m^2 min catchment size has been adopted to conservatively define the upstream extent of the flow paths. The survey was then merged with the design surface and flow paths recalculated. Flow paths from pre and post development assessments were then compared and culverts positioned to maintain original flow paths to the wetlands, where they otherwise would have been diverted by the proposed earthworks.

Culvert blockages are often caused by trees/branches. Because most catchments are grassed and free from wooded areas or dense vegetation, the likelihood of blockages occurring is low.

[9] GRASS 8 (Geographic Resources Analysis Support System) is an open-source GIS toolbox developed by academics across the world, embedded within QGIS, which is commonly used to undertake catchment analysis and flow path modelling.

A time of concentration for each culvert has been determined using the Ramser-Kirpich formula, designed for rural catchments. A run-off coefficient of 0.3 across the site, corresponding to medium soakage soil with pasture and grass cover has been assumed. The run-off coefficient has then been adjusted according to Table 2 in NZBC E1/VM1 according to the catchment slope. Rainfall data has been taken from the NIWA database (HIRDS), considering a climate change scenario of RCP 4.5 for the period 2081 – 2100.

Flow rates have been calculated using the Rational Method (NZBC E1/VM1). Culverts have been sized to pass flows from the 10% AEP rainfall event (in accordance with the original regional Land Use Consent - Condition 20), according to the event duration corresponding to the time of concentration of each unique catchment. In larger rainfall events the water will head up in the drains and culvert inlets and is permitted to overtop tracks and hardstands.

The permanent hardstands comprising the permanent buildings/structures (substation and O&M) will be specifically designed to consider overland flow paths for up to the 1% AEP event.

Flow rates have been correlated to the maximum flowrate capacity of the pipe, assuming inlet control, to give a required pipe size, which exceeds this capacity.

The culvert outlets will be specifically designed to provide energy dissipation to mitigate erosion effects. During detailed design, we anticipate this will be achieved through rock rip-rip aprons, designed in accordance with Auckland Council's *TR2013/080 - Hydraulic Energy Management: Inlet and Outlet Design for Treatment Devices.*

The culvert and rip rap apron details are presented in the Tables 11 and 12. Calculations are included within the Appendices.

Table 11: Design Culvert Sizes

Culvert Diameter (mm)	Max. Flow (L/s)	Max. Catchment Area (ha)
300	110	1.84
375	190	3.18
450	300	5.01
525	450	7.52
600	620	10.36

Table 12: Riprap Apron Details

Culvert Diameter (mm)	Riprap Apron Length (m)	Min. Rip Rap Apron Width (m)	Min. Stone Size d_{50} (m)	Min. Stone Layer Depth (m)
300	3.5	0.9	0.2	0.4
375	4.4	1.2	0.2	0.4
450	5.3	1.4	0.2	0.4
525	6.3	1.6	0.25	0.5
600	7.3	1.8	0.25	0.5

4.4 Table Drain Culvert Locations

The preliminary locations and sizing of each proposed stormwater culvert are presented within the drawings in Appendix B. A total of 96 total proposed culverts are required based on the track and hardstand layouts for the 54 potential turbine locations. Some of these culverts will not be required once the design is refined for the preferred 44 turbine layout.

Only one culvert has been identified for the transmission line access tracks, where the proposed track crosses a defined gully. Elsewhere, the transmission line access tracks are designed to enable runoff to head up/sheet flow across the pavement, meaning no other culverts are required (noting the temporary nature of these tracks).

5.0 Stream Management

5.1 Stream Identification

One of the objectives of the wind farm and access track design was to minimise the number of stream crossings required.

Streams within the site were identified using the New Zealand River Environment Classification (REC) 2010, which comprehensively maps New Zealand's river network. This data was accessed through the Ministry for the Environment Data Service.

5.2 Stream Crossings

The proposed turbine layout and geometric road design requires one stream crossing over a tributary of Lee Stream (the Lee Stream tributary). This stream crossing is provided for within the existing Resource Consent and will provide access to nine turbine sites at the northern end of the site. Without a steam crossing access to these turbine sites would not be possible. The location of the Lee Stream tributary and the proposed crossing (45°44'5.00"S, 169°54'53.71"E) is shown in Figure 9

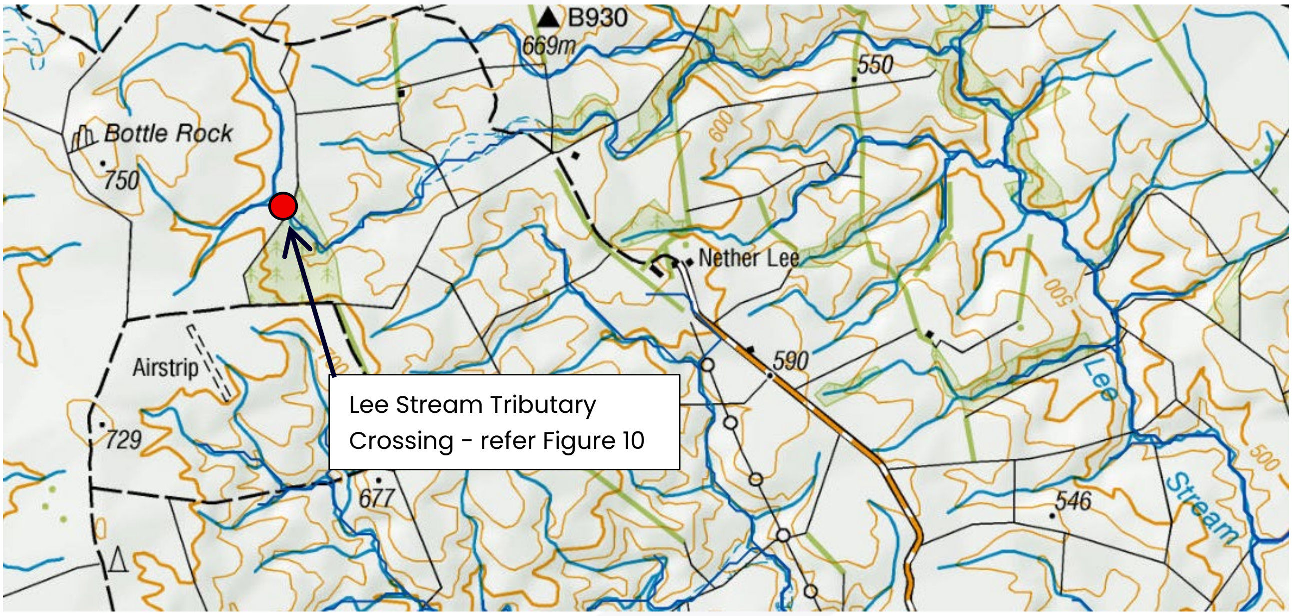

Figure 9: Lee Stream Tributary Crossing Location Near the North End of the Site.

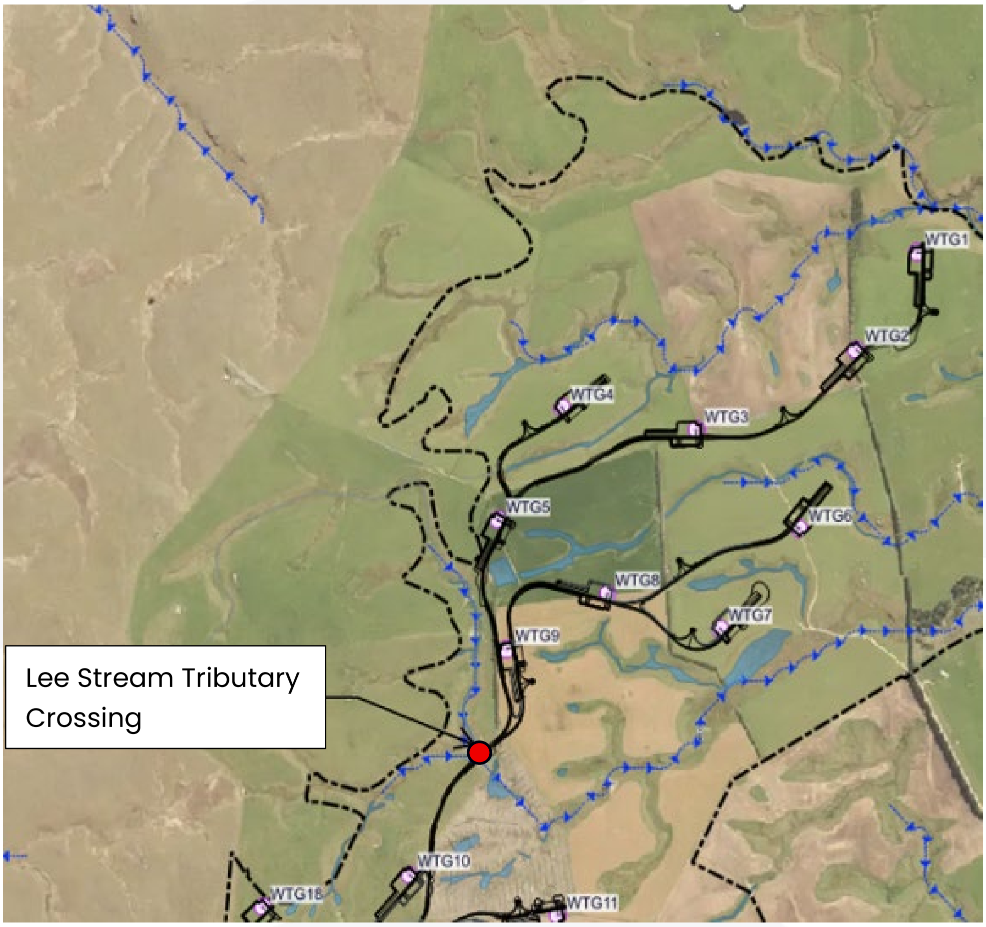

Figure 10: Lee Stream Tributary Crossing Location, showing MfE Classifiable Rivers.

All other potential stream crossings have been avoided in favour of longer track routes to proposed WTG locations. An example is a potential stream crossing at between WTG 44 and WTG 45. The crossing was avoided by taking a longer track route to the north as shown in Figure 11.

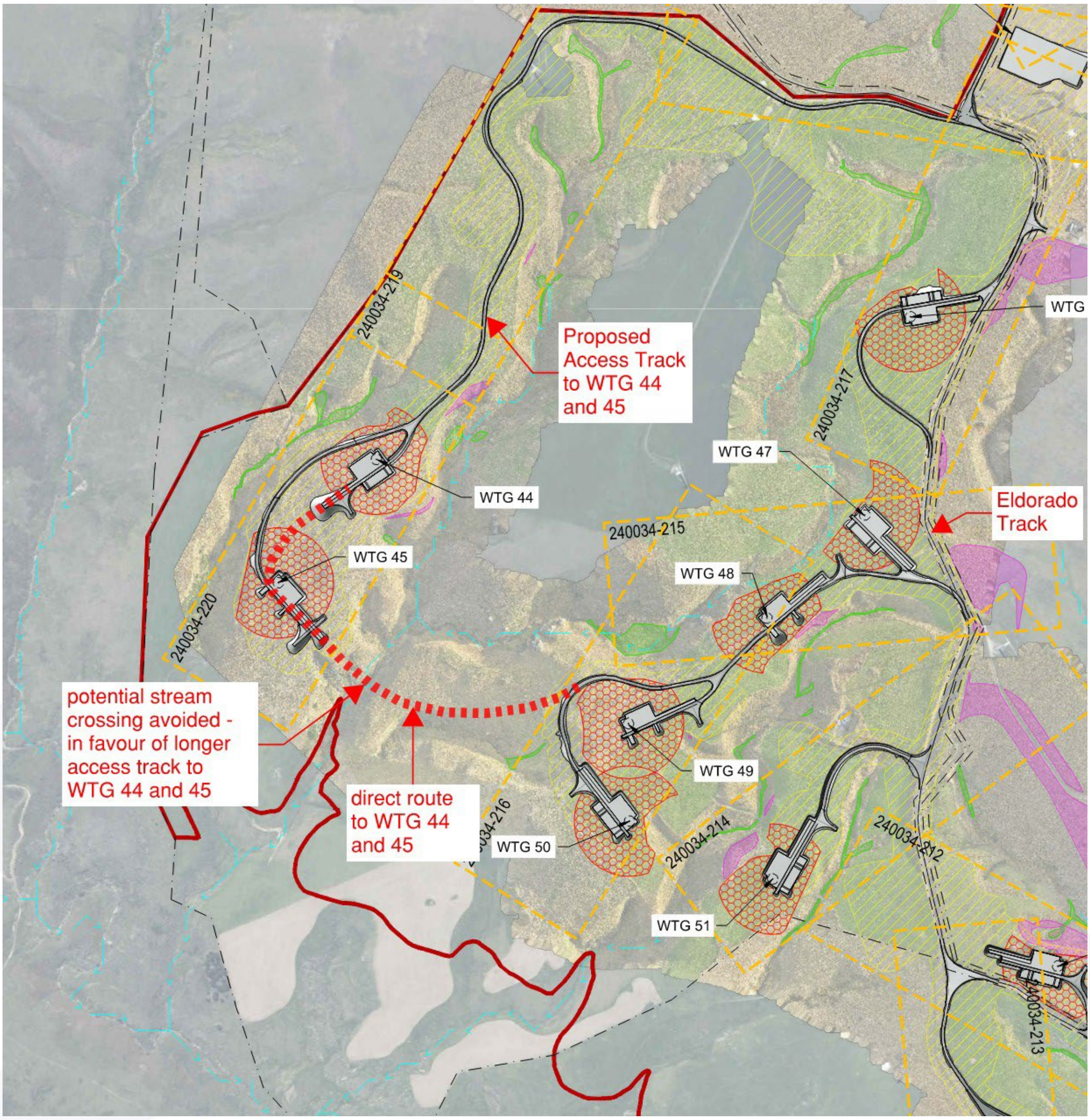

Figure 11: Potential Stream Crossing Avoided by Using Longer Track Route

5.3 Lee Stream Tributary Description

The upstream and downstream reaches of the stream are incised within a wide floodplain (Figure 12) that contains tussock and other vegetation. The downstream reach and floodplains are overgrown with dense vegetation, along with logging debris. Survey data indicate the stream bed has a gradient of 0.6-1.2% in the vicinity of the proposed crossing.

An existing farm track crossing is located downstream of the proposed crossing location. The crossing consists of a low embankment and a concrete culvert (approximate diameter of 750mm). The hydraulic capacity of the culvert is restricted by sedimentation.

Figure 12: Confluence Immediately Upstream of Proposed Culvert Inlet (May 2025)

Figure 13: View upstream from existing crossing (April 2024).

Figure 14: Existing farm track crossing. Stream flow direction is right to left (March 2025).

5.4 Design Options

The existing farm track crossing is likely a barrier to fish passage and is also not suitable for wind farm construction traffic due to:

- The hydraulic capacity of the existing culvert.
- The steep vertical gradients on the approaches to the crossing.

Therefore, a new stream crossing was preferred.

A bridge option was reviewed, however an approximately 60m long bridge would be required. Such a bridge would be very expensive to construct, especially considering oversized construction vehicle loadings.

An open based culvert was also considered to maintain the existing stream bed. However, due to the earth loads imposed by the embankment, this option was not feasible.

A culvert option was therefore selected.

The preferred stream crossing is located approximately 25m upstream of the existing farm track. The location was selected as it provides sufficient area to construct the culvert offline from the existing stream.

5.5 Flood Passage Design Criteria

Table 13 summaries the developed design criteria for the proposed culvert. The surcharge design criteria were developed to limit the flood level effects upstream of the culvert.

Table 13: Flood Passage Design Criteria

ARI (Year)	Design Criteria
10 (+CC)	No culvert surcharge (above culvert obvert)
100 (+CC)	Less than 1m surcharge (above culvert obvert)

1. Climate Change (+CC) = RCP4.5 for the period 2081-2100.

No flood passage design criteria were developed for flow velocities.

5.6 Fish Passage Design Criteria

The Resource Management (National Environmental Standards for Freshwater) 2020 (Regulations) states that the placement of a culvert in, on, over, or under the bed of any river or connected area is a Permitted Activity if it complies with Regulation 70(2)(a)-(g) conditions. These are as follows:

(a) The culvert must provide for the same passage of fish upstream and downstream as would exist without the culvert, except as required to carry out the works to place, alter, extend, or reconstruct the culvert; and

(b) The culvert must be laid parallel to the slope of the bed of the river or connected area; and

(c) The mean cross-sectional water velocity in the culvert must be no greater than that in all immediately adjoining river reaches; and

(d) The culvert's width where it intersects with the bed of the river or connected area (s) and the width of the bed at that location (w), both measured in metres, must compare as follows:

i. where $w \leq 3$, $s \geq 1.3 \times w$ and,

ii. where $w > 3$, $s \geq (1.2 \times w) + 0.6$;

(e) The culvert must be open-bottomed, or its invert must be placed so that at least 25% of the culvert's diameter is below the level of the bed; and

(f) The bed substrate must be present over the full length of the culvert and stable at the flow rate at or below which the water flows for 80% of the time; and

(g) The culvert provides for continuity of geomorphic processes (such as the movement of sediment and debris).

Sections 5.7 to 5.10 below sets out how the proposed stream culvert complies with Regulation 70(2) rules.

Both of the following versions of the New Zealand Fish Passage Guidelines have also been referenced to determine the fish passage design criteria for the culvert:

- New Zealand Fish Passage Guidelines, Version 1.0, April 2018.
- New Zealand Fish Passage Guidelines, Version 2.0, June 2024.

Table 14 summaries the fish passage flow design criteria from the guidelines.

Table 14: Quantifiable Fish Passage Design Criteria

Element	Version 1	Version 2
Low Fish Passage Design Flow (Q_L)[1.]	$\leq$ 95% exceedance flow	Baseflow or; One third of bank-full flow[2.] or; 0.5-year ARI flow One tenth of 2-year ARI flow
High Fish Passage Design Flow (Q_H)[1.]	$\geq$ 20% exceedance flow	Bank-full flow[2.] or; 1.5-year ARI flow or; One half of 2-year ARI flow
Culvert Embedment	25-50% of culvert height (circular or box)	For circular culverts: between 1/3 and 1/2 of the culvert diameter. For box culverts: 300mm or 2 × D_{50} (where D_{50} is the median substrate size), whichever is greater.
Culvert Span	1.3 x bankfull width	n/a
Minimum Water Depth at Low Flow	150mm	150mm
Substrate Stability	At high fish passage design flow.	At 100-year ARI flow.
Fish Swimming Distance	n/a	Greater than culvert length at Q_H.
Minimum Fish Passage Width on Each Side of Culvert	n/a	150mm

Notes: [1]. Version 2 has slightly different naming but the same symbols.
[2]. Bank-full flow is defined as the maximum flow that a channel can convey without overflowing onto the floodplain.

Project specific design criteria include:

- Match the existing stream bed material as closely as possible within the culvert.
- Permanent access for inspection and/or maintenance staff to enter the culvert.
- Provision of a low flow channel meander.
- Removal of any existing fish passage barriers near the new crossing.

5.7 Hydrological Assessment

The rational method as specified in NZBC E1/VM1 was used to estimate the design flows, as no flow monitoring has been undertaken at the site. Catchment characteristics were extracted from the QGIS culvert assessment to determine the relevant inputs for the rational method. Table 15 presents the catchment characterises.

Table 15: Catchment Characteristics

Parameter	Value	Note
Area (ha)	81.09	LiDAR and site specific survey.
Catchment Slope (%)	3	Measured in QGIS from LiDAR.
Run-off Coefficient	0.30	NZBC E1/VM1 Table 1: Medium soakage – pasture
Slope Correction Factor	-0.05	NZBC E1/VM1 Table 2
Slope Corrected Runoff Coefficient	0.25	
Time of Concentration (minutes)	21	Ramser-Kirpich Formula

Design rainfall intensities were sourced from HIRDs V4 considering climate change RCP 4.5 for 2081-2100 as presented in Table 16.

Table 16: 20-Minute Design Rainfall

ARI (Year)	Depth (mm)	Intensity (mm/hr)
2	7	22
2 (+CC)	8	25
10 (+CC)	16	47
100 (+CC)	32	96

Resulting design flows are presented within Table 17.

Table 17: Peak Design Flows

ARI (Year)	Flow (m^3/s)
2	1.22
2 (+CC)	1.40
10 (+CC)	2.65
100 (+CC)	5.40

Table 18 presents the fish passage design flows.

Table 18: Fish Passage Design Flows

Fish Passage Design Flow	Flow (m^3/s)	Definition
Low (Q_L)	0.12	One tenth of 2-year ARI flow as per Table 13
High (Q_H)	0.70	One half of 2-year ARI flow (+CC) as per Table 13

5.8 Existing Channel Hydraulics

A two-dimensional HEC-RAS hydraulic model was developed to simulate the design floods within the existing channel. The general properties of the model are presented in Table 19.

Table 19: Model General Properties

Property	Description/Value	Comment
Model Upstream Extent	~ 60m upstream of crossing	Considered far enough away so the boundary condition will not influence results at the crossing
Model Downstream Extent	~ 50m downstream of crossing	
Downstream Control	Normal Depth/0.01	Typical slope at boundary
Manning's n	0.035	Representative of stream
Ground Surface	Site Specific Survey	
Grid Size (m)	0.2, with a 0.15 refinement within culvert	Small grid size to represent culvert details.
Time Step (s)	Time step based on Courant condition (default of 0.1)	
Equation Set	Shallow water equation set	

Results are presented later within this section.

5.9 Flood Passage Hydraulic Design

5.9.1 Culvert Dimensions

A 2.5m wide, 2.5m high, box culvert was selected to provide:

- sufficient height for inspection/maintenance access.
- at least 1.3 x stream bed width, the bed width is estimated to be approximately 1.0m.
- sufficient width for the low flow channel meander.

- A minimum 300mm embedment, In accordance with the New Zealand Fish Passage Guidelines for box culverts. The Regulations requirement for a minimum 25% diameter embedment depth is specific to circular culverts only.

5.9.2 Culvert Infill Material

The culvert infill material will be sourced from local and/or imported material. Table 20 presents a preliminary grading specification.

Table 20: Culvert Infill Material Preliminary Grading Specification

Particle Diameter (mm)	Weight Passing (%)
5	5
10	16
75	50
100	84
350	100

5.9.3 Hydraulic Model

A two-dimensional HEC-RAS hydraulic model was developed to simulate the design floods with the proposed culvert and embankment in place. The general properties of the model are the same as those presented in Table 20.

Table 21 summarises the culvert specific properties. For the purposes of the flood design event, the capacity of the low flow channel has been ignored (with a blocked depth of 1.0m measured from the invert of the culvert) and a conservative Manning's n of 0.035 has been applied for the culvert (to match the existing stream channel).

Table 21: Culvert Specific Properties

Culvert Properties	Value
Span (m)	2.5
Height (m)	2.5
Barrels	1
Manning's n	0.035
Culvert Inlet Invert Level	682.3
Blocked Depth (m)	1.0
Culvert Outlet Invert Level	682.0
Length (m)	34
Grade (%)	1.0

Table 22 demonstrates that the proposed culvert meets the flood passage design criteria. It is noted that the flood level increases upstream of the culvert do not extend beyond the property boundary.

Table 22: Model Results

ARI Flood Event (Years)	Peak Flood Level (m RL)	Peak Flood Level Relative to Culvert Obvert[1.] (m)	
		Criteria	Design
10 (+CC)	684.0	<0.0	-0.8
100 (+CC)	684.8	<1.0	0.0

Note: Culvert Obvert = RL 684.8 m.

5.10 Fish Passage Hydraulic Design

5.10.1 Design Alignment and Profile

Figure 15 presents a plan view schematic of the design including the:

- track embankment
- box culvert
- low flow channel meander.

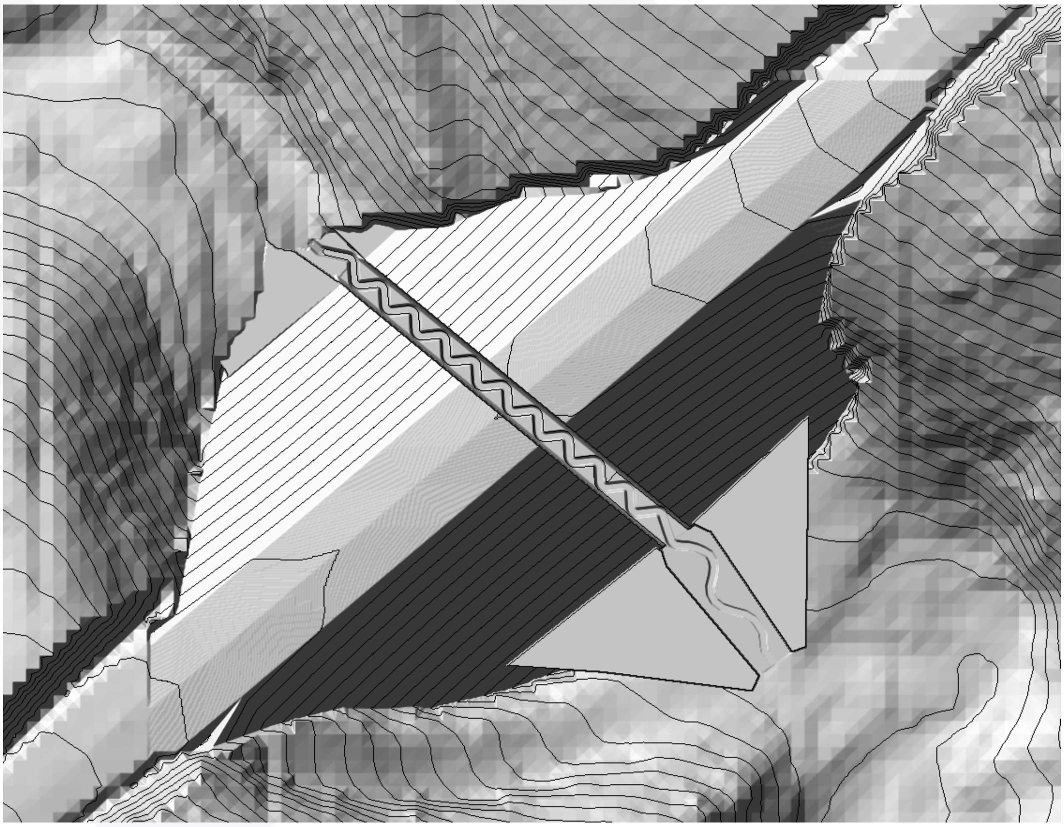

Figure 15: Design Schematic

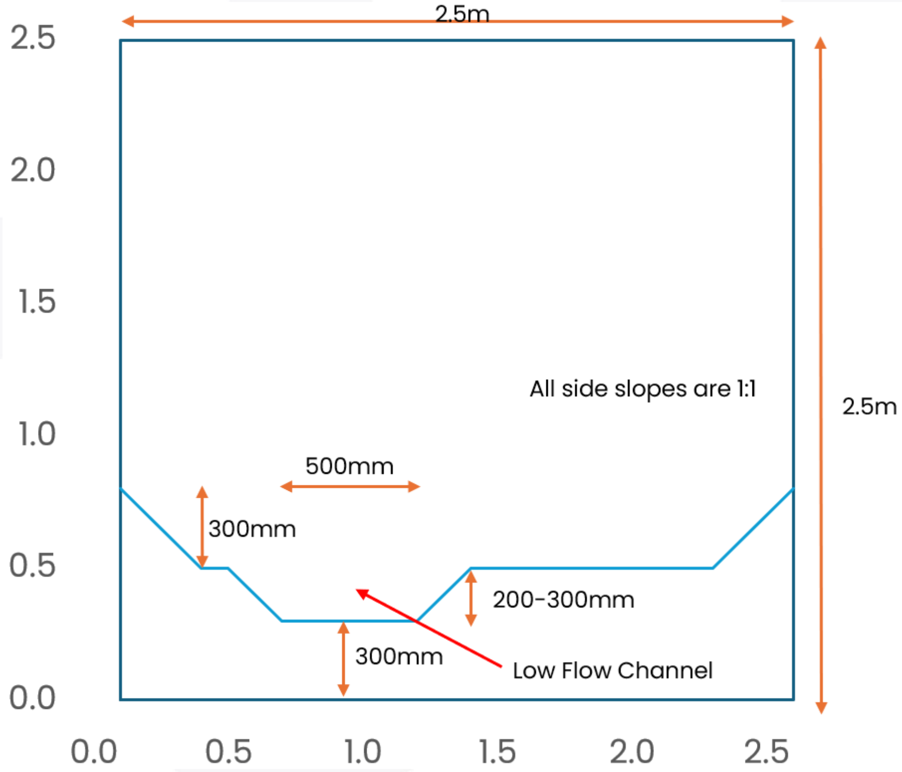

Figure 16: Design Profile Schematic

5.10.2 Hydraulic Model

A two-dimensional HEC-RAS hydraulic model was developed to simulate the fish passage design flows through the culvert. Again, a Manning's n of 0.035 was applied for the culvert (to match the existing stream channel).

5.10.3 Low Fish Passage Design Flow Hydraulic Model Results

Figure 17 presents a map of the low fish passage design flow depths. The map clearly shows that the flow depths are greater than 150mm within the culvert, and transition to shallower depths where tying into the existing stream. It is therefore considered that the low fish passage design flow criterion has been met.

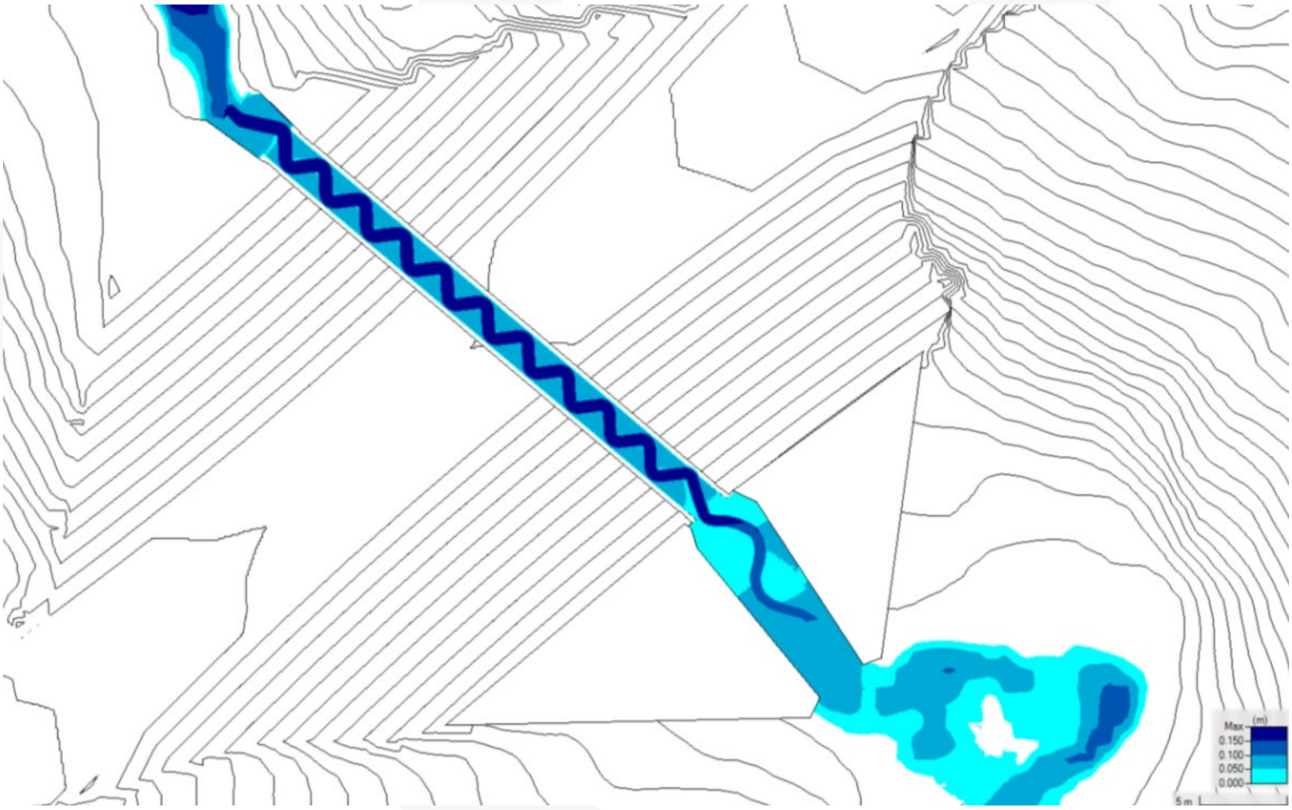

Figure 17: Low Fish Passage Design Flow Depths

5.10.4 High Fish Passage Design Flow Hydraulic Model Results

Figures 18 and 19 present maps of the high fish passage flow velocities with the proposed works in place and the existing scenario respectively.

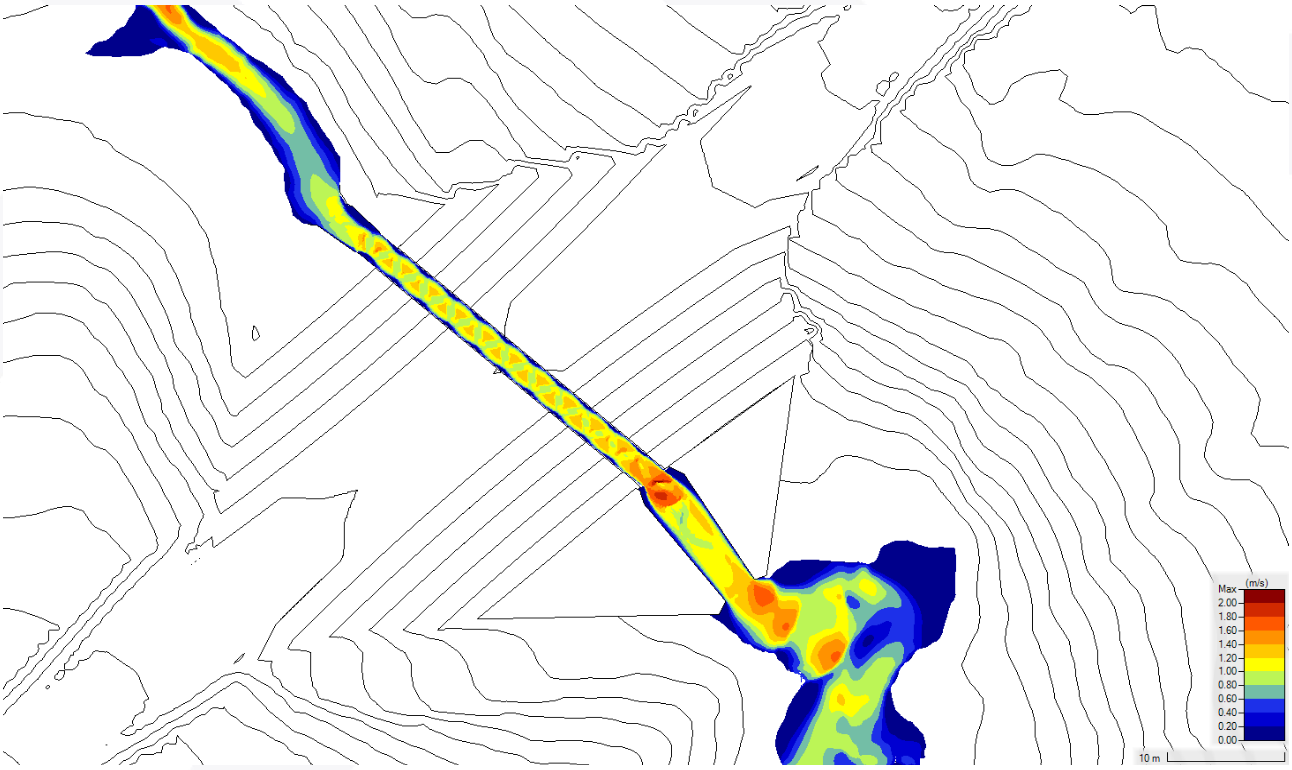

Figure 18 High Fish Passage Design Flow Velocities – Proposed

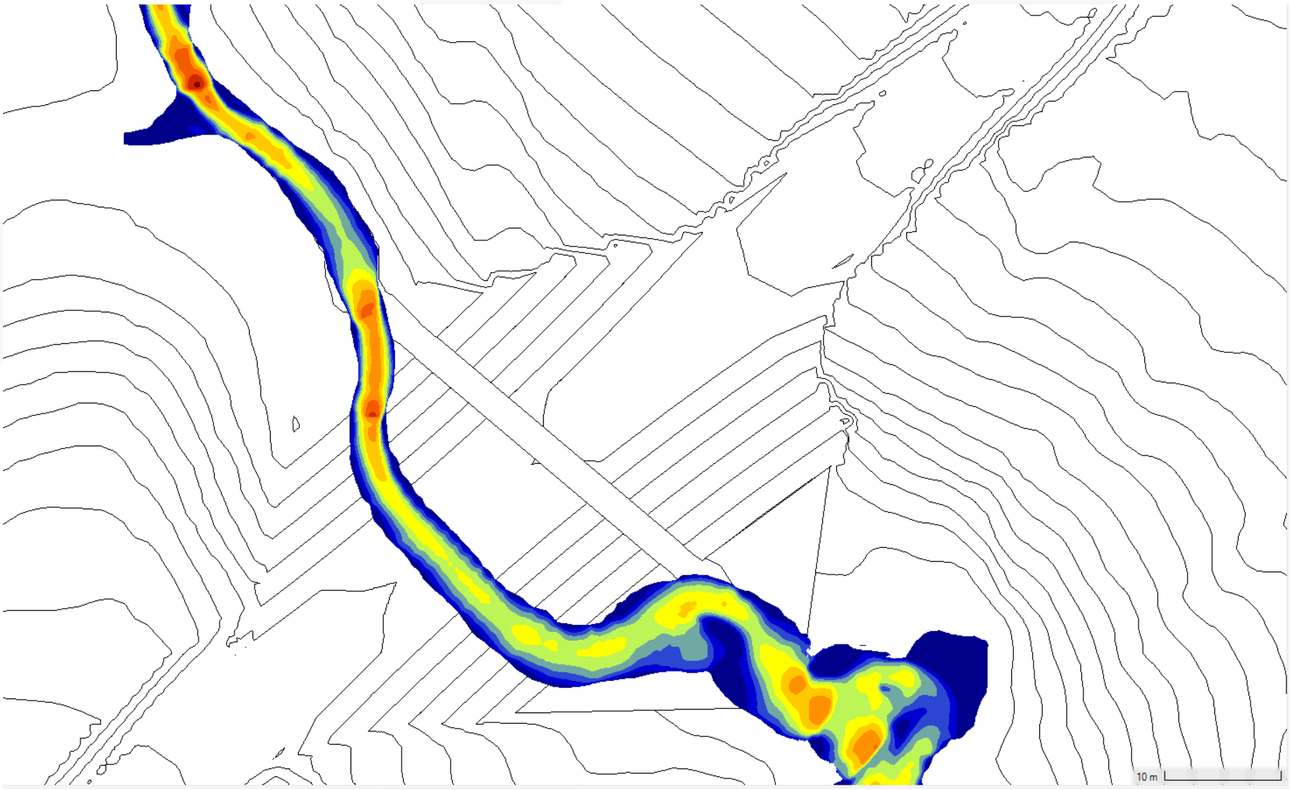

Figure 19: High Fish Passage Design Flow Velocities - Existing

Table 23 presents the Regulations fish passage design criteria for a Permitted Activity. The mean cross-section velocity within the culvert is no greater than existing upstream and downstream reaches – thus complying with Regulation 70(2) rule (a) (c).

Table 23: High Fish Passage Design Velocity Criteria - Regulations

Criteria	Modelled Within Culvert	Modelled Upstream Existing Watercourse	Modelled Downstream Existing Watercourse	Criteria Met?
Mean Cross-Sectional Velocity (m/s)	0.99	0.99	1.29	Yes

Figure 20 demonstrates how the Guidelines high flow fish passage design criteria for a 150mm wide (minimum) by 150mm deep (minimum) fish passage path along both sides of the culvert is met.

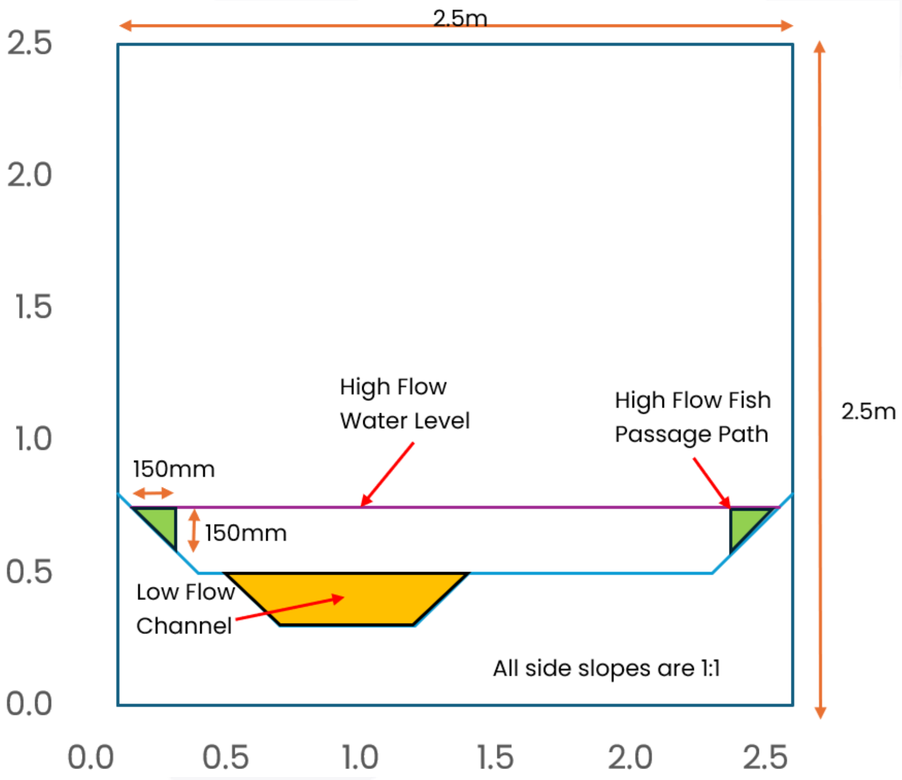

Figure 20: High Flow Fish Passage Path

5.11 Structural Design

Structural design of the culvert and headwalls will be determined at detailed design stage.

5.12 Construction

The culvert will be constructed offline from the existing stream.

The existing farm track will be maintained during construction of the new stream crossing to enable light vehicle access. Following construction of the new stream crossing, the existing farm track crossing and culvert will be removed and that section of stream rehabilitated.

Refer Section 8.5 for further details.

5.13 Commissioning

The stream flow will be diverted into the culvert during a period of low flow and inspected by the designers to ensure the flow depths and velocities are suitable for fish passage. If any improvements are necessary, the bed within the culvert will be modified.

6.0 Battery Energy Storage System Fire Water and Stormwater Disposal

6.1 Fire Water Management

Emergency storage of fire water runoff from the BESS will be provided to prevent contaminated fire water from entering the environment. The BESS platform will comprise an impervious (paved) surface and contoured such that if a fire were to occur, the contaminated runoff (generated during a firefighting operation) will be directed to a stormwater collection manhole located at the corner of the platform. The manhole will feature a submerged outlet with pipe connection to a downstream high-density polyethylene lined detention basin - sized to store the fire water volume referenced below. The outlet from the basin will have a readily accessible isolation valve which will be manually shut off in the event of a fire to prevent the contaminated water from discharging to the environment. The stored contaminated water will then be removed from site in a timely manner.

6.2 Fire Water Volumes

New Zealand Firefighting Water Supplies Standards do not provide commentary on fire water design specific to BESS. As a result, the Renewable Energy Facilities v4 Design Guidelines and Model Requirements has been used to supplement the SNZ PAS 4509-2008 Firefighting Water Supplies Code of Practice, ensuring the fire water design is sufficient for the unique fire risks present at the BESS and complies with New Zealand regulations.

SNZ PAS 4509-2008 Firefighting Water Supplies Code of Practice

The design of the fire water system has been undertaken assuming a Fire Hazard Category (FHC) of FHC 3, defined as "working/business/storage activities with medium fire load such as manufacturing, processing, bulk storage up to 3 metres" in Table 1 – Method for determining required water supply calculations (SNZ PAS 4509-2008).

Based on a largest firecell floor area of <199m^2, (i.e. footprint of each battery unit) and an FHC of 3, Table 1 of SNZ PAS 45094509 prescribes a Fire Water classification (FW) of FW 3. Table 2 – Method for determining firefighting water supply specifies a minimum of 180m^3 water within a 90m distance but no closer than 6m from the hazard.

CFA Design Guidelines and Model Requirements: Renewable Energy Facilities & AS 2419.1:2021 Fire hydrant installations, Part 1: System design, installation and commissioning

The CFA guideline specifies the requirements where no reticulated water is available in Appendix A: Guideline Checklist – Additional Requirements for Battery Energy Storage Systems - Centralised BESS. A minimum fire water supply volume of 288m^3 (equivalent of 1 x hydrant flowing at 20L/s for four hours) is required or sufficient volume to provide for the number of hydrants triggered from Table 2.2.5(D) in AS 2419.1:2021 for four hours at 10L/s. For an open yard area of approximately 4060m^2, two hydrant outlets are required to size the water supply volume (see Table below). As a result, a stored volume of 288m^3 is required by this method.

Requirements from both approaches are summarised below (Table 24). As the CFA is more specific to BESS fire safety design and provides a volume in excess of the relevant NZ standard, the volume of 288m³ of fire water will be adopted. This will be stored in permanent above ground tank/s at the BESS platform.

Table 24: Comparison of Categories and Fire Water Volumes

Item	SNZ PAS 4509-2008	CFA Design Guideline/ AS 2419.1:2021
Category	FHC 3	Open yard
Minimum Fire Water Volume (m^3)	180	288

6.3 Stormwater Management

Stormwater/snow melt runoff from the BESS impervious platform will be directed to the detention basin as described above. In addition to its primary purpose of providing emergency storage of contaminated fire water, the stormwater basin will also provide attenuation of stormwater runoff from the BESS. Outflow from the basin will be controlled via a t-bar decant (150mm above the basin floor) and overflow manhole and will discharge overland via a pipe and a rock lined swale/outlet apron. The decant will be designed to limit discharge from the basin to pre-development levels for the 10yr ARI 24hr rainfall event. The floor of the basin will be graded towards the outlet as shown in Figure 21 to reduce the potential for standing water. The fire water storage requirement (288m³) is the determining factor in sizing the basin, and this volume is significantly larger than the volume require to provide the stormwater attenuation. For larger storms/snow dumps or in case of blockages to the decant, the stormwater/snow melt will overtop the scruffy dome manhole. The outlet pipe to wetland has been conservatively sized as a 300dia pipe to convey the Q100 year post development flow.

Refer to appended Riley drawing 240034-289 for BESS site plan and stormwater management details.

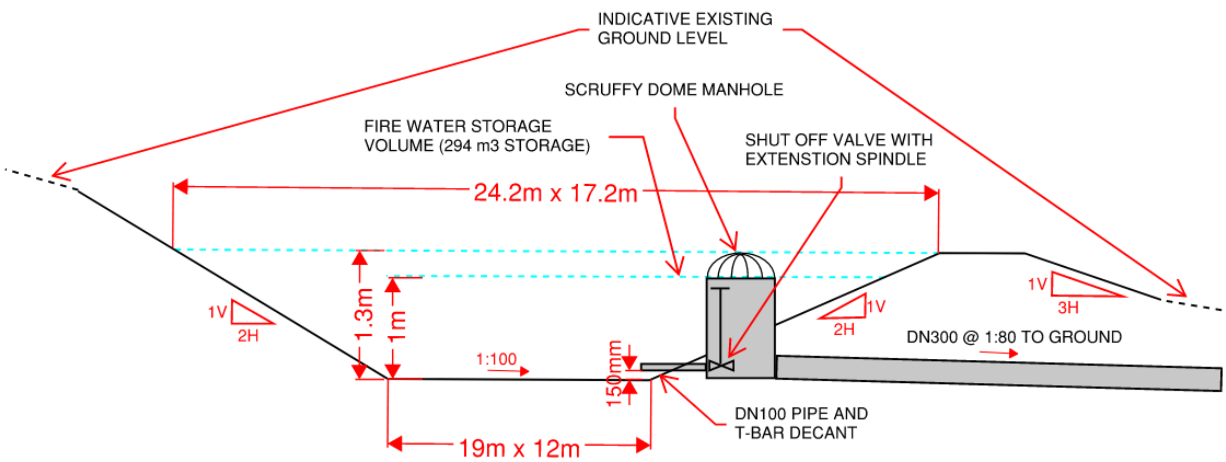

Figure 21: Detention basin typical cross section

7.0 Stormwater Systems Commissioning and Monitoring

Requirements for the commissioning, and monitoring of the performance of the stormwater systems shall be set out in the Environmental Construction Management Plan (ECMP) and is summarised as follows.

Following the installation of the stormwater systems (open drains, culverts, headwalls, manholes, basin, rip rap outlets, etc), as-built plans shall be prepared detailing the size/alignment/location/and specification of the stormwater system. The as-built plans shall be checked and certified by the project engineer or surveyor as being an accurate record of the constructed systems, and as confirmation that they have been constructed in accordance with the approved design drawings. Copies of the as-built plans shall be provided to ORC on request.

Monitoring of the wind farm stormwater systems shall be undertaken during the initial operation phase, to confirm the systems are operating correctly and effectively.

Once the respective earthwork catchments have been fully stabilised and ESC measures removed, the following monitoring of the stormwater systems shall be arranged by the consent holder.

- On commissioning – inspect the condition of the stormwater systems, e.g. - culverts correct size and free from debris, rock riprap correct grade and coverage, low flow channel within stream culvert complete and operating correctly, detention basin liner complete and certified by installer. Undertake quarterly and post-storm inspections (where > 20mm rainfall accumulates over 24hr period) – inspect the condition of the stormwater system, check for any signs of erosion within channels or downstream of outlets. Undertake remedial/maintenance measures as required, such as placement of additional rock protection if signs of significant erosion, removing debris from culverts, etc.
- After one year of operation, formal monitoring of the stormwater system can cease provided inspection records show the system is operating effectively. However, it is expected that ad-hoc monitoring and maintenance of the stormwater system will continue as part of the general wind farm operation. Ongoing monitoring of wetlands shall be covered under the Wetland Monitoring and Management Plan.

Details of the inspections and any follow up actions taken shall be recorded and made available to ORC on request.

8.0 Construction Aspects

8.1 Temporary and Permanent Site Facilities

The proposed temporary and permanent site facilities listed below form part of the earthworks design and aggregates volume estimates. The indicative sizes are based on other similarly sized wind farms. The proposed facility locations have been determined based on the turbine layout and maximising the efficiency of traffic movements and power reticulation through the site. Locations are shown on the layout plans in Appendix D:

- 10,600m^2 platform for the temporary concrete batching plant.
- 10,350m^2 platform for the temporary Site Compound - located near the site entrance off Eldorado Track. The site compound will be used for the contractor site offices, parking area, and storage yard.
- 2,200m^2 platform for the permanent O&M Facilities, including 700m^2 of building footprint comprising a site office and workshop.
- 6,750m^2 platform for the permanent wind farm substation.
- 4,200m^2 platform for the permanent BESS, which enables energy from wind, to be stored and then released.

As discussed above, the temporary platform areas will be returned to pasture, following construction.

8.2 Aggregate Sources and Quantities

Aggregates will be required to form access tracks and platform pavements, as well as for batching concrete for the turbine foundations.

Concrete aggregate (coarse aggregate and sand) will all need to be imported from suitable offsite quarries – likely commercial quarries located near Dunedin.

Based on the observed level of weathering of the schist encountered during geotechnical investigations, it is unlikely that site-won rock will be suitable for access track and platform pavements. Therefore, like for the concrete aggregates, imported aggregates will be used for pavement construction.

A preliminary assessment of imported aggregate volumes has been undertaken for the Project and consented real-world layout. The aggregate volumes are presented in the tables below. The traffic movements generated by the transportation of the aggregates have been estimated and included in the tables. This information has been used by Beca in the Transport Effects Assessment and Construction Traffic Management Plan. The transmission line, substation and BESS is a new scope of works to be consented; therefore, those quantities have been excluded from the real-world consented layout table.

The traffic movements generated by the transport of water for construction activities are also presented in the tables below.

Table 25: The Project - Estimated Aggregate and Water Volumes and Off-Site Traffic Movements

Item	Sand/Aggregate Volume Per Turbine		Total Sand/Aggregate Volume (44 Turbine)		Loose Cement Volume (Turbine Foundations)		Sand/Aggregate Transportation[4]	Water Volume	Cement Delivery[6]
	Loose Volume (m^3)	Solid Volume (m^3)	Loose Volume (m^3)	Solid Volume (m^3)	Per Turbine (m^3)	Total	Truck and Trailer Return Journeys	Truck and Trailer Tanker (30,000L capacity)	Cement Delivery Truck (16T payload)
Turbine Foundations[1] [4] [6]	462		20,330		154	6,776	1,020	147	510
Wind Farm Tracks[2][4]			59,800	39,000			2,990		
Transmission Line Tracks and pads[4][7]			11,040	7,200			550		
Turbine platforms[5][4]	660	430	29,040	18,920			1,455		
Site Facility Platforms[3][4]			10,460	6,820			520		
Dust Suppression and Earthworks Conditioning[8]								1,565	
TOTAL:	-	-	130,670	-	154	6,776	6,535	1,712	510

1. Based on foundation volume of 350m3 + 50m3 blinding concrete (levelling course) - based on concept 4.3MW turbine foundation design and the following calculation:
    a. Wet volume = 350+50 = 400m3. Dry volume = 400*1.54 = 616m3. Assume 1:1:2 cement/sand/aggregate volume ratio (dry volume) for 40mPa concrete. Treat sand/aggregate as having the equivalent vehicle movement per m3 - for simplicity.
    b. Water volume = up to 100m3 per turbine (contractor provided)
2. Assume 200mm pavement depth for wind farm tracks. 19.5ha pavement area. Includes length of access tracks dissecting each turbine platform, includes turning bays and junctions
3. Assume 200mm pavement depth, and based on following platform areas:
    a. 10,600m2 for concrete batching plant facility
    b. 2,200m2 O&M,
    c. 10,350m2 Site Compound
    d. 6,750m2 substation
    e. 4,200m2 BESS
4. Assuming 2,300kg/m3 solid density for compacted aggregates (access tracks and platforms), and 1500kg/m3 loose density, and following assumed truck payloads/delivery options:
    a. Truck and Trailer = 30T (20m3 loose)
5. 2,150m2 platform (hardfill) area (1,855m2 main hardstand plus blade fingers and assist crane pad), assume 200mm pavement depth.
6. Loose cement density = 1200kg/m3, assume 16T payload per cement delivery vehicle (32T gross weight).
7. Assume 150mm hardfill depth for transmission line access tracks and pads, 4.8ha pavement area
8. Assume 200m3 of water per day required during peak summer period (3 months), and 100m3 per day during shoulder months (3 Months) for dust suppression and earthworks/pavement compaction. Assume 6-day working week and construction period extends over two earthwork seasons

Table 26: Consented Real-world Layout - Estimated Aggregate and Water Volumes and Off-Site Traffic Movements

Item	Sand/Aggregate Volume Per Turbine		Total Sand/Aggregate Volume (47 Turbine)		Loose Cement Volume (Turbine Foundations)		Sand/Aggregate Transportation	Water Volume	Cement Delivery
	Loose Volume (m^3)	Solid Volume (m^3)	Loose Volume (m^3)	Solid Volume (m^3)	Per Turbine (m^3)	Total	Truck and Trailer Return Journeys	Truck and Trailer Tanker (30,000L capacity)	Cement Delivery Truck (16T payload)
Turbine Foundations[1]	370		17,390		123	5,780	870	125	430
Wind Farm Tracks[2]			114,080	74,400			5,707		
Turbine platforms[3]	430	280	20,210	13,160			1,010		
Site Facility Platforms[4, 5]			6,790	4,630			340		
Dust Suppression and Compaction								1,565	
TOTAL:	**-**	**-**	**158,470**	**-**	**123**	**5,780**	**7,930**	**1,690**	**430**

(1) 80% of proposed 4.3MW turbine foundation size assumed for 3.45MW 'real-world layout' turbines.
(2) 12m wide tracks – 31 km estimated for 47No. turbine layout, 200mm pavement thickness
(3) 1,400m² hardstand, 200mm pavement thickness
(4) Same quantities as the Project assumed, less BESS and Substation
(5) Assume same areas and pavement thickness as Proposed Wind Farm – except no Substation or BESS

The original consent considered water takes from Lake Mahinerangi and the local Deep Stream Reservoir, which are no longer proposed (refer Section 8.4.1 below). Therefore, water for the Project will be transported over larger distances compared with the Real-World example. Refer to the Beca Transport Effects Assessment for further details on traffic generation and assessment of effects.

8.3 Concrete Works

Due to the large volumes of concrete required to construct each turbine foundation, a concrete batching plant facility will be set up on-site during construction. The facility will likely comprise dual batching plants to supply the volume of concrete at the rates needed.

The batching plant will be located centrally within the Wind Farm Development Area, refer to Figure 3. This will provide a concrete supply source close to the construction work, thus optimising the efficiency of construction traffic and concrete delivery.

Furthermore, materials such as cement and aggregate will be delivered to the site by vehicles typically larger than standard concrete trucks, therefore, reducing the number of vehicle movements on the public road network.

It is proposed to vary the requirement in Land Use Condition 33 that restricts concrete manufacturing to the hours of 6.30am to 8.00pm from Monday to Friday, and 7.30am to 6.00pm on Saturdays. The existing consented noise limits relating to concrete manufacturing will be retained.

8.4 Construction Water Supply

Water will be required for construction activities, including conditioning of earth fill, pavement construction, dust suppression during earthworks operations, and concrete production for turbine foundations.

8.4.1 Water Source

There are no on-site water sources suitable to supply the water needed during construction activities, therefore construction water will be imported to site via water tankers, and stored in temporary above ground water tanks.

The water reservoirs associated with the Deep Stream Hydro Project (one of which is located close to the site entrance) are owned and operated by Manawa Energy (now 100% owned by Contact Energy) and therefore are not available to take water from.

8.4.2 Water Demand

The Project peak daily water demand has been conservatively estimated at up to 350m^3 per day at peak times (summer months) based on feedback from the contractor who constructed Stage 1, and assuming some overlap between water take for concrete batching and other construction activities. The 350m^3 per day is made up of the below elements, and rounded up:

- Up to 50m^3 per day for pavement and earthworks conditioning
- Up to 200m^3 per day for dust suppression
- Up to 100m^3 per day for concrete production.

Water may be stored in temporary above ground tanks adjacent to the batching plant and/or the lined BESS detention basin. Watercarts used for dust suppression will be filled from the on-site tanks/basin.

8.4.3 Water Conservation

Water conservation is of increasing importance due to increasing instances of regional drought and the general scarcity of water. To conserve water during construction, the following measures will be undertaken:

- Setup a roof rainwater collection system from the site offices. This will provide potable water to the site offices/amenity block. The tank/s may need to be topped up with imported potable water during extended dry periods. The tank/s may be repurposed for the permanent Operations and Maintenance building roof water collection system, post-construction.

- Use/import non-potable water sources for dust suppression activities, where practicable.
- Have trigger controls on all hoses.

8.5 Lee Stream Crossing Construction Methodology

The envisaged construction methodology/sequence for the stream culvert works is outlined below. The alignment of the proposed stream culvert is offline from the existing stream; thus the temporary stream diversion works during culvert installation will be relatively straight forward and low impact. Refer appended stream diversion works drawings 240034-287 and -288 for more details. The expected duration of Phase 1 works (works within the stream) is approximately two weeks.

Phase 1:

1. As far as is practical undertake works during dry/low flow periods where no significant rain is forecasted.
2. Construct diversion bunds to divert cleanwater runoff away from the working area.
3. Construct non-erodible dams (using sand-bags or similar) at the upstream and downstream end of the culvert. Form temporary/isolated stream diversions to direct stream flow around bunded areas. Downstream dam to feature a T-bar decant to drain the works area if required to keep the area dry from groundwater/water leakage.
4. Offline from stream - install precast culverts and wingwalls, pour in-situ concrete baffles and aprons, place culvert infill material and form low flow channel as per design.
5. Place and compact backfill material around the culvert to half height (minimum).
6. Remove diversion bunds, and upstream and downstream dams - allowing flows to pass through the new culvert.

Phase 2:

1. Install silt fences around the base of the fill embankment.
2. Continue with backfill over the culvert and forming of the fill embankment.
3. Form sediment control measures for approach tracks (e.g. drop out pits) and commence earthworks to form the tracks.
4. Existing farm track crossing and culvert to be removed and stream channel extended (undertake works during low-flow dry period)
5. Stabilize the earthworks area and remove sediment controls

8.6 Erosion and Sediment Control

The general principles for erosion and sediment control (ESC) will be the implementation of measures reducing the potential for erosion of exposed soils during land disturbing activities (erosion control), and to adopt treatment devices that collect and retain sediment prior to discharge to the downstream receiving environment.

The ESC Practices outlined in the below sections and shown on the example plans in Appendix D, follow the principles of Auckland Council's *GD05 Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region (2016)* which Otago Regional Council has adopted.

Riley have prepared a Draft Earthworks Management Plan (EMP), inclusive of a Draft Erosion and Sediment Control Plan (ESCP), and is included separately with the application. The EMP outlines the proposed measures to control sediment runoff and to mitigate erosion and dust arising from earthworks. The final version of the EMP will detail the ESC measures to be implemented at each stage of earthworks.

The general principles of the EMP are as follows:

- Regular liaison between the Contractor(s), Engineer to Contract and the Regulatory Authorities' Representatives.
- Diversion of clean water away from the work site, where practicable.
- Minimise disturbance to the areas necessary to complete the construction activities.
- Avoid/control dust emissions with appropriate dust mitigation measures.
- Where practicable, intercept and treat all sediment laden water from the work area prior to discharging into the downstream environment, particularly earthwork areas upslope of sensitive receiving environments such as wetlands and reservoirs.
- Implement measures to prevent construction traffic exiting the construction areas onto public roads/tracks with sediment and other materials attached to the undercarriage and tyres (i.e. wheel wash).
- Inspect the erosion and sediment control measures regularly and undertake any maintenance necessary to maximise the potential to retain sediment on the site.
- Undertake regular inspection and testing of discharges from sediment control devices, to verify minimum standards of discharge are being met in accordance with the consent conditions.
- In the event of forecast for heavy rain, stabilise the site as far as practicable and close the works down.
- Ongoing assessment of the erosion and sediment control measures and, if required, adjust as the work progresses.

The following report sections provide an overview of the EMP, example ESC drawings are included in the appended Civil Drawings for reference (Appendix D).

8.6.1 Proposed Earthworks Design Philosophy

Earthworks will be associated with a range of construction activities, including the construction of the turbine platforms, internal access tracks, site facility platforms, installation of culverts including within stream beds, fill disposal sites and stockpile sites. The effects of weather (i.e. wind and rain) and the use of equipment such as heavy excavators, scrapers, compactors, and trucks to carry out the earthwork activities may generate dust and sediment runoff until the site has been stabilised.

To mitigate the effects of earthwork activities on the surrounding topography, existing waterbodies and established vegetation, a low impact design approach has been adopted. This design approach will reduce the volume of sediment and dust leaving the site. The strategy adopted to achieve this design approach will be as follows:

a) *Access tracks and Turbine platforms* – align the access tracks along existing established accessways/tracks where possible, follow ridge line features and maintain a vertical alignment close to the existing contours (where practicable), to reduce the extent of earthworks. Position the turbine hardstands within the contingency zones (CZs) as per the approved Site Development Plan.

b) *Fill disposal* – the fill disposal sites have been identified during the design process and are shown on the Riley Civil Drawings in Appendix D. The SFDs have the following characteristics:

   - Located on broad ridgeline features or gently sloping ground with limited surface water catchment above.
   - Relatively easy access for construction vehicles and close to areas of cut
   - Situated in an area of stable ground (generally on the basis of visual assessment).
   - Locate wholly within the Windfarm Development Area depicted on the Site Development Plan.

8.6.2 Earthworks Construction Methodology

As is common for projects that have an extensive earthworks footprint (such as wind farms of this scale), the earthworks will be constructed in a staged manner to reduce the area and length of time the soils remain exposed. A staged approach was followed for the Kaiwera Downs Stage 2 Wind Farm for instance – which is currently under construction. The earthworks staging arrangement will form part of the EMP. Due to the scale of the earthwork activities, earthworks are likely to be carried out simultaneously in adjacent sub-catchments by separate teams, this will accelerate the works and reduce length of time that the earthworks are exposed to the weather. The earthwork areas will be stabilised to prevent erosion of exposed surfaces following the completion of each sub-catchment stage.

For each stage of earthworks, sediment and erosion control measures will be implemented to:

- divert clean water runoff away from earthwork areas, and
- intercept sediment laden runoff from earthworks areas and direct to sediment devices for treatment before controlled release to the downstream receiving environment;

The construction sequence for the implementation of sediment control measures will follow these general guidelines:

1) *General earthworks along access track alignments and Turbine and site facility platforms*

   a) Sediment control measures may not be required for earthworks where earthwork activities will not adversely affect the downstream environment and/or where the earthworks are minor and can be rapidly completed and stabilised during dry weather windows (cut and cover technique).

b) Construct diversion bunds to direct clean stormwater runoff away from earthwork areas as works progress. Where practicable, the diversion bunds will follow close to the existing contours to minimise gradients and prevent significant channel erosion. Stormwater collected will be directed to safe discharge points and may require staggered silt fences at the outlets to dissipate flow rates.

c) Place silt fences with returns around the extents of fill areas where the natural slopes exceed 18° and/or immediately adjacent to a wetland or water body where there is insufficient space to construct earth bunds.

d) Strip topsoil locally and form temporary diversion bunds to intercept sediment laden runoff (within fill areas). If the gradient of the diversion bunds used to intercept sediment laden runoff exceeds 2%, the channel should be stabilised with suitable materials to provide erosion protection (i.e. lined with geotextile fabric). Construct decant earth bunds to retain sediment from the temporary diversion bunds where specified.

e) Strip topsoil from the remaining earthworks area. Remove excess topsoil to fill disposal sites.

f) Water shall be used to spread across exposed trafficked surfaces to reduce dust migration.

g) Commence earthworks for the designated stage. At the end of each construction day, open drains and/or diversions bunds shall be formed within the exposed areas to reduce runoff lengths and divert sediment laden runoff to control devices.

h) Install culverts servicing an open drain adjacent to a track. Excavate around the inlets of the culverts to allow storage capacity where suspended materials can settle out, (i.e. a small drop-out pit).

i) Install drop-out pits at open drain termination points, include silt fence surround in locations within 50m of wetlands.

j) As earthworks reach the designed vertical alignment, the pavement surface and shoulders should be lined with the basecourse and rock fill to stabilise the exposed surfaces.

k) Topsoil and grass seed fill batters, hydro seed cut batters (in soils) on completion of the earthworks within each stage. Rock cut batters will be left in their natural state.

2) *Fill disposal/stockpile sites*

a) Construct diversion bunds to direct clean stormwater runoff away from the fill disposal/stockpile sites as works progress. Where practicable, the diversion bunds will follow close to the existing contours to minimise gradients and prevent significant channel erosion. Stormwater collected will be directed to safe discharge points.

b) Construct sediment retention ponds/earth decant bunds that will provide adequate retention of sediment laden runoff from the fill disposal/stockpile sites (including access tracks into the sites). The pond/earth decants shall be positioned to ensure the diversion bunds intercepting sediment laden runoff can be adequately graded into the structures. The sediment retention ponds/earth decants will be designed in accordance with GD05. Where catchments less than 0.5ha, earth decants are preferred over sediment retention ponds.

c) Construct diversion bunds to intercept sediment laden runoff and divert flows to the sediment retention pond. If the gradient of the diversion bunds exceeds 2%, the channel should be stabilised with suitable materials to provide erosion protection (i.e. lined with geotextile fabric).

d) At the entry/exit point of the fill disposal/stockpile sites, construct a rock lined stabilised construction entrance.

e) Undertake vegetation clearance, strip topsoil and organic material from the footprint of the SFD and place in stockpiles adjacent to the SFD. Install silt fences downslope of stockpiles.

f) Once the SFD design level and finished surface profile is achieved, respread stockpiled topsoil and organic material, and grass seed (seed selection to be in accordance with the rehabilitation management plan). This shall occur within 12 months of the SFD site strip, to make the use of the next planting season (in accordance with the rehabilitation management plan).

3) *Works within water bodies – Lee stream culvert crossing*

Refer to stream culvert construction Section 8.5 of this report for typical construction sequence to mitigate the effects of working within the stream.

4) *Concrete Batching Plant Facility*

a) Specific perimeter controls will be implemented at the concrete batching plant facility to capture surface water and sediment/contaminant runoff during the operational life of the facility.

b) The batching plant shall have a stabilised earth bund constructed around its perimeter to divert sediment laden runoff to the sediment retention device.

c) A containment area (sediment pond) shall be constructed to capture runoff and provide sufficient settlement of sediments prior to discharge to the downstream environment. The containment area shall be lined to prevent any water seepage into the natural ground.

d) The outlet from the pond shall be controlled by a manually operated valve; if there is spilling of cement in the concrete batching plant area, the valve will be temporarily shut until the spillage is removed.

e) Operation and monitoring of the pond and discharges are to be carried out in accordance with the approved EMP.

8.6.3 Description of Proposed Sediment Control Devices

The management and design of the sediment, erosion, and dust control measures at the site will be based on the area of the earthworks associated with the civil works for various phases of construction. The following techniques shall be used by the contractor to control sediment laden runoff and to prevent erosion of exposed ground. The techniques outlined below generally follow GD05 guidelines.

8.6.3.1 Cut and Cover

For sections of access track that follow close to existing grade, are in cut, and located >10m from a wetland; a cut and cover technique will be employed as follows:

- As the track is formed, the excavated material will be loaded directly onto a dumper and transported to the nearest SFD as indicated on the drawings.
- The trackside v-drains and cut batter will be rapidly stabilised with hydro seed or rock lined (for v-drain with gradient >5%)
- The v-drain will then convey clean water runoff to culverts or discharge points.

The length of access track that is left exposed will depend on dry weather window and the timeframes for earthworks and stabilisation. Cuts shall be stabilised prior to significant wet weather.

8.6.3.2 Surface Roughening of Fill Batters

Surface roughening is a temporary erosion control method involving the deliberate disturbance of bare soil surfaces, typically by creating grooves or using construction equipment to track the surface. Its main purpose is to increase surface roughness, promote water infiltration, reduce sediment runoff, and aid vegetation establishment by trapping seeds and moisture in the soil.

While effective as a short-term measure on slopes prone to sediment discharge, surface roughening is not a substitute for permanent stabilization and should be used alongside other erosion control methods during the stabilisation period. Proper implementation includes diverting water away from the area, filling existing rills, and ensuring cleat marks are left parallel to the contour to create micro sediment traps without over-compacting the soil

Figure 22: Surface Roughening of a Slope (Figure 39 from GD05)

8.6.3.3 Stabilised Construction Entrance

A stabilised pad of aggregate on a filter cloth base will be located at the site entrance/s (and entrances to the SFD's - dependent on construction staging) where construction traffic will be entering and leaving. This will prevent the entrance from becoming a sediment source and minimise dust generation and tracking of soil onto the adjacent environments. Specifications outlined in Table 27 will be used for the site entrance and entrances to fil disposal sites (where accessed from stabilised access tracks).

Table 27: Stabilised Construction Entrance Aggregate Specifications

Aggregate Size	50mm to 75mm washed aggregate
Thickness	150mm minimum
Length	10m minimum
Width	3m minimum

8.6.3.4 Wheel Wash

A wheel wash adjacent to the stabilised site entrance may be provided if required (dependent on cleanliness of vehicles exiting the wind farm Site). The wheel wash will consist of a temporary mobile chamber or a shallow pit (stabilised with roading aggregates or hotmix) and will be filled/maintained with water from an adjacent water tank or water cart. The purpose of the wash is to clean the earthmoving truck tyres, and therefore, reduce the amount of sediment being tracked onto public roads. The wheel wash will maintain a pool depth of 400mm to 500mm, and water will be replenished regularly (dirty water to be pumped and removed from site or overflow directed to sediment pond/decanting structures).

8.6.3.5 Runoff Diversion Channels and Cleanwater Diversion Bunds

Runoff diversion channels or bunds will be used to intercept and detain silt laden runoff and divert into drop-out pits, earth decant structures, or sediment ponds where specified. The channels shall be sized for the 5% AEP rainfall storm event (in accordance with GD05). Dewatering may also be required at times for runoff not draining away in low gradient dirty water diversion bunds, particularly around turbine hardstands. In this instance, a mobile turkey's nest can be constructed and used for dewatering if 100mm of clarity cannot be achieved. For an example of a mobile 'turkeys nest' used for dewatering, see Figure 107 from GD05.

Cleanwater diversion bunds are to be constructed to intercept overland flow from upper catchments and divert around the earthwork sites. The bunds shall be sized for the 5% AEP rainfall storm event (in accordance with GD05).

The channels and bunds, generally, have longitudinal gradients less than 2%. Where the grade exceeds this, or flow velocities are high, the channels may need to be lined with either rocks or geotextile fabric to prevent erosion of the underlying soils. The collected and diverted clean stormwater runoff will be disposed at safe locations to prevent erosion of the receiving environment.

8.6.3.6 Drop Out Pits and Sumps

Drop out pits may be used on steep sections of access tracks to ensure sediment laden water is slowed down and silt is deposited out at regular intervals. Drop out pits may also be installed within dirty water diversion channels to allow heavier sediment particles to drop out before they enter the sediment retention device, reducing the load on the device; or at termination points of roadside open drains - prior to discharge across grass fields. Drop out pits are approximately 500mm to 1,000mm deep and 1000m wide. The pits will be maintained regularly with contained sediment being removed and disposed of appropriately.

Where the drop out pit is located near to a wetland, a silt fence should also be installed as a secondary measure to filter overflow from the drop out pits.

Drop out pits may be used at the gently sloping turbine platforms in areas of cut. Runoff will be directed to and collected in the pit/sump where the heavier sediment to settle out before water is pumped (via floating offtake) to a turkeys nest and/or grassed area, which will provide further filtration.

8.6.3.7 Stormwater Inlet Protection

It is proposed to excavate around the inlet of the culverts in the track side open drains to form a sump (small drop-out pit) to allow settlement of suspended material. During construction, geotextile fabric may also be wrapped around the inlet of the culvert to intercept sediment laden runoff collected by the drain.

8.6.3.8 Temporary Culverts

Temporary culverts are to be installed across tracks, haul roads, and platforms, where required to maintain hydrological connectivity between segregated sections of wetlands, and/or to direct runoff to sediment control devices; until such time that the permanent culverts can be installed (generally relates to cut earthworks).

These culverts will be sized for the 5% AEP rainfall event in accordance with GD05 – refer Table 28 SEQ Table *ARABIC Table 28: Temporary Culvert Sizing – Earthworks Phase for the respective pipe sizes. Rainfall data has been taken from the NIWA database (HIRDS), and flow rates calculated using the Rational Method (NZBC E1/VM1) assuming bare soils (earthwork) ground cover. Flow rates have then been correlated to the maximum pipe capacities, assuming inlet control, to give a required pipe size, which exceeds this capacity.

The temporary culverts will be removed once the permanent culverts are in place. The temporary culverts will likely be HDPE pipes which have the advantage of being lightweight and high strength. It is intended the temporary culverts will be reused across the site as the earthworks progress.

Table 28: Temporary Culvert Sizing – Earthworks Phase

Culvert Diameter (mm)	Max Flow (L/s)	Max Catchment Area (ha)
300	50	0.33
375	120	0.79
450	190	1.25
525	280	1.84
600	400	2.63

8.6.3.9 Silt Fences

Silt fences may be used at various areas and times during construction. The silt fences will detain flows from the construction area so deposition of transported silt can occur through settlement. Silt fences may be utilised at confined areas where the contributing catchment is small, such as downslope of temporary stockpiles. 2m returns will require to be constructed on steeper slopes where the silt fence cannot follow the existing contours. Silt fences may, generally, be utilised for slope lengths up to 40m (for slopes less than 10%), or up to 15m for steeper fill batter slopes. Due to the high wind conditions at the site, silt fences will not be suitable for exposed areas and therefore will only be considered in spatially constrained areas where other controls are not practical to construct (e.g. stream crossings and adjacent to wetlands). Super silt fences may be required to withstand high winds in exposed areas.

Figure 23: Example Silt Fence – Isolated Earthworks Area Adjacent to a Watercourse

8.6.3.10 Decanting Earth Bund

Decanting Earth Bunds (DEBs) will be used to intercept sediment laden runoff and minimise the amount of sediment leaving the site through settlement. The DEBs will include forebays and be fitted with a floating T-bar decant structure, similar to that used in a sediment pond, to increase settlement time and improve sediment removal efficiency of the device.

The bund will be sized to have a volume of approximately 2% to 3% of the contributing catchment area and provide an adequately sized spillway to pass a 1% AEP storm event. The decant inlet will be positioned to provide 50% live storage volume with a minimum distance of 5m from the inlet. The maximum catchment area contributing to the earth bund structures is typically 0.3ha in accordance with GD05 recommendations, however, decants can be enlarged to cater to a larger catchment size on a case-by-case basis. Catchments of up to 0.5ha have been used on other wind farm projects.

DEBs may incorporate a rain activated chemical treatment system if/where specified (refer Section 8.6.3.12 below).

Figure 24: Example Decanting Earth Bund – Adjacent to a Construction Platform

8.6.3.11 Sediment Retention Ponds

Sediment retention ponds (SRPs) will be used to treat sediment laden runoff and reduce the volume of sediment leaving the site. SRPs may be used at the fill disposal sites or platforms, where large areas of earthworks will remain exposed to erosion during the construction period, i.e. where catchment sizes exceed the capacity of a DEB.

SRPs should be positioned at a convenient collection point for the sediment laden runoff. This position should also allow for easy access to carry out routine maintenance of the structure. SRPs shall be excavated into natural ground and embankments formed with engineered fill. The sediment retention ponds require specifically designed spillway arrangements to ensure overtopping of embankments does not occur during storm events.

The contributing catchment area for the sediment retention pond should be restricted to less than 3ha per pond. The minimum capacity of the pond should be 300m^3 for each hectare of contributing catchment (3% of the contributing catchment) where an additional 10% of this volume is used as a sediment forebay.

However, the minimum capacity may be reduced to 200m³ for each hectare of contributing catchment where the earthwork slopes are less than 10%. Sediment retention ponds will be constructed and maintained in general accordance with GD05 guidelines.

SRP's may incorporate rain activated chemical treatment system if/where specified (refer Section 8.6.3.12 below).

Figure 25: Example Sediment Retention Pond on a Hilly Site

8.6.3.12 Chemical Treatment

Water treatment chemicals (such as flocculants) can be applied to increase the rate of sediment settling out of the water column and is commonly used in conjunction with sediment retention devices (DEBs and SRPs). In practice, the chemicals are applied to the sediment laden inflows to the SRP's and DEB's, using a rain activated dosing system. This helps to achieve the permitted levels of Total Suspended Solids (TSS) prior to discharge from the device.

A Draft Chemical Treatment Management Plan has been prepared by Enviroco Ltd and is appended to the draft ECMP, included separately with the application. Bench testing of representative soil samples (collected from three locations around the site) was undertaken using a range of flocculant products. Findings from the bench testing concluded that there was not one stand out product, with each sample reacting differently to the chemicals. It was also observed that for each sample, the sediment settled out of the water within 24hrs without any chemical treatment. Therefore, it was concluded that rain activated treatment may not be necessary for this site, subject to the monitoring of turbidity and total suspended sediment of the water column in the devices during the early stages of earthworks.

The Enviroco recommendation is to have chemical products on-site during earthworks as a back-up (contingency measure) to facilitate flocculant dosed treatment, for example, products that can be implemented into sediment laden discharges via passive or controlled dosing systems. In general, chemical treatment will be considered for sediment control devices located within 50m of a wetland, or if the sediment control device is servicing a catchment > 1.5ha.

Coagulants (e.g. Alum/PAC) and Cationic PAM's (flocculants) will not be considered for the project, due to their toxic properties and risk of changes to pH levels in the receiving streams and wetlands. On the other hand, Anionic PAM's are widely used in New Zealand and are generally considered safe and non-toxic to aquatic life at approved doses.

Refer to the draft Chemical Treatment Management Plan for further details.

8.6.4 Sediment Control Device Selection Criteria

Refer to the draft EMP for the proposed application criteria of the control measures described above.

8.6.5 Sediment Yield Assessment

Representative sediment yield calculations have been carried out for sample earthworks operations – i.e. turbine platforms, stream crossings, access tracks, and surplus fill disposal sites. The assessment utilises the Universal Soil Loss Equation (USLE) to demonstrate the effectiveness of various Erosion & Sediment Controls proposed above. Refer to Appendix C for USLE calcs.

8.6.6 Dust Control

If not managed appropriately, dust created during the construction phase can affect vegetation, be a nuisance to personnel, and can contribute to sediment loads. Dust can be made airborne by wind or vehicular movement or a mixture of both. Due to the nature of the works, dust will need to be controlled and managed during the construction phase. Activities considered likely to generate dust include the following:

- Vehicle movements.
- Removal and replacement of topsoil.
- Excavation of material.
- Stockpiles, especially uplifting of material from stockpiles.

- Loading of vehicles.
- Site clearance.
- Track construction.
- Foundation construction.

In the event of dust generation becoming obvious through earthwork activities, appropriate measures to reduce the dust release to acceptable levels shall be undertaken. Methods that will be adopted for the dust control measures are as follows:

- Ensure the track surface remains in a damp condition utilising water trucks as necessary until exposed earthworks are stabilised.
- Limit site traffic speed to a level to reduce the production of dust into the atmosphere.
- Stage earthworks during construction to isolate and reduce the area of exposed earthworks and re-vegetate exposed surfaces as soon as practical.
- Stabilised entrance at the entry/exit points of the wind farm site and fill disposal sites and provide a wheel wash at the main entrance.
- If necessary, earthwork activities may be limited in specific areas during periods of high wind.

Stockpiled material has the potential to create dust. Dust can be generated when material is added to or excavated from a stockpile. The following methods are proposed to control dust from stockpiles.

- Wet suppression via water trucks.
- Covered storage in more sensitive locations.
- Reduced/controlling stockpile height and slopes (reduce wind entrainment).
- In the extreme event that remedial measures are found to be ineffective for the control of dust, works may be suspended as a precautionary measure until conditions are suitable for resumption.

Water for dust suppression will be sourced from one of two potential water sources as outlined in Section 8.4 of this report.

8.6.7 Stabilisation of Earthworks Surfaces

Following earthworks, general disturbance areas and fill batters will be stabilised by respreading locally stockpiled topsoil (stockpiled for a duration < 12 months) to a minimum depth of 300mm and applying grass seed (or hydro seed) - using non-invasive grass species such as brown top or rye grass. Hydro mulch may be required for highly exposed areas where wind and heavy rain may otherwise wash away the grass seed.

The steeper cut batters (in soils) will be stabilised with hydro seed (no topsoil), including polymer additives for erosion control where required. Rock cut batters will be left in their natural state – i.e. no stabilisation measures are required.

Hydroseed or hydro mulch will also be considered for areas requiring rapid stabilisation such as adjacent to watercourses – e.g. Lee Stream Tributary crossing.

Once 80% grass strike has been achieved (in accordance with GD05), erosion and sediment control measures can be decommissioned, ensure that the areas affected by the decommissioning of the sediment control measures are rehabilitated as appropriate.

Refer to the Vegetation Management Plan (included separately with the application) for details of remedial planting to be undertaken following the earthworks stabilisation works.

8.6.8 Monitoring and Maintenance of Control Measures

Regular monitoring and maintenance will be carried out on the sediment, dust, and erosion control devices during the construction phase in accordance with the EMP. Refer to the draft EMP for further details (included separately with the application).

9.0 Limitation

This report has been prepared for Tararua Wind Power, to inform the Expert Consenting Panel's consideration of Contact's application for approvals under the Fast-track Approvals Act 2024 and any subsequent regulatory processes.

The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties’ sole risk.

Appendix A

Authors' Qualifications and Experience

Appendix A: Authors Qualifications and Experience:

The primary author of this civil assessment is Luke Gordon. Edwyn Ladley has contributed to the pavement design and geology sections. Ed has also authored the Geotechnical Factual Report. Vaughan Martin has led the stormwater design and authored the stormwater and stream culvert sections. Our qualifications and experience are set out below.

Luke David Gordon

a) Principal Civil Engineer and Director at Riley Consultants Ltd.

b) Academic qualifications and professional memberships:

   i. Bachelor of Engineering (Civil, Hons) Auckland University 2005.

   ii. Chartered Member of Engineering New Zealand since 2013.

c) Work Experience:

   Luke has over 20 years' experience in civil engineering, including extensive design and project management experience in the renewable energy sector.

   Over the past decade, he has played a key role in more than six large-scale wind farm projects, as part of the resource consent delivery and design-build teams. Luke has authored the civil engineering technical assessments in support of resource consent for several of those wind farms.

   Luke is the lead civil engineer and design manager for the wind farm civil balance of plant (CBoP) works. Luke leads a team of civil engineers and designers at Riley.

Edwyn Ladley

a) Senior Geotechnical Engineer at Riley

b) Academic qualifications and professional memberships:

   i. Bachelor of Science (Geology), University of Canterbury, 1995

   ii. Master of Science (Geology), Otago University, 1999

   iii. Master of Engineering Science (Geotechnical and Engineering Geology), University of New South Wales, 2014

   iv. Member of Engineering New Zealand

   v. Member of the New Zealand Geotechnical Society

c) Work experience:

   Edwyn has over 25 years of broad engineering geology and geotechnical engineering practice including: tunnels, earthquake engineering, forensic engineering, slope stabilisation, dam safety, earthworks design and specifications. Edwyn has previously acted as an expert witness for forensic engineering and Resource Consent projects.

   Edwyn's wind farm experience spans the development cycle including pre-feasibility and resource consent assessments, design, and construction monitoring.

He leads teams focused on provide clients with targeted and fit-for-purpose site investigations and geotechnical designs to de-risk and manage geotechnical considerations and constraints.

Vaughan Martin

a) Principal Water Resource Engineer at Riley

b) Academic qualifications and professional memberships:

   i. Bachelor of Engineering (Civil, Hons) Auckland University 2000.

   ii. Chartered Member of Engineering New Zealand.

c) Work experience:

Vaughan has over 25 years' experience in civil, geotechnical and water resources engineering. His skills range from investigation and design through to contract documentation and construction supervision, including construction of one windfarm, and the construction of the Deep Steam Hydro-Electric Power Scheme adjacent to the proposed wind farm.

In more recent years, Vaughan's focus has turned to the more specific field of flood hydrology and hydraulic assessments.

Vaughan has served as the lead hydraulic engineer and designer of the wind farm stormwater system, including fish passage design.

Appendix B

Stormwater Calculations

Stormwater
Design Calculations

Prepared for:	Tararua Wind Power
Prepared by:	Madi Millar, Civil Engineer
Checked by:	Vaughan Martin, Principal Water Resources Engineer
Reviewed and approved for issue by:	Don Tate, **Project Director, CPEng**
Report reference:	240034-D
Date:	15 October 2025

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Aim:

Size the culverts and associated riprap aprons crossing access roads/platforms, determine max upstream catchment areas for a range of culvert sizes.

Method of Calculations:

The culverts have been sized based on the following assumptions:

1. The pipe culverts have been sized using Rational Formula for a 10-year ARI Flow considering climate change.
2. The time of concentration determined using the Ramser-Kiripich Formula, applicable for rural catchments.
3. The runoff coefficient has been adopted from New Zealand Building Code, assuming a medium soakage soil type for pasture/grass cover and unsealed pavements. Slope correction factors were applied based on the average catchment grade over the longest catchment flowpath.
4. Site rainfall intensities have been determined from HIRDS V4 using the RCP4.5 risk category for the period 2081-2100 (Table 1).
5. Nomograph (Chart 1A) and inlet control has been used to size culverts, with the exception of any locations where fish passage was required (Culvert 75 – Lee Stream Tributary), which was assessed separately.
6. Minimum 300dia culvert size to be specified to minimise risk of culvert blockage.
7. Assume acceptable for headwater to build-up to max 500mm above pipe soffit for 10yr event (i.e. no overtop of road) or 1.5 times pipe diameter (i.e. no orifice flow), whichever is less ($H_w < 1.5d$ rule will govern for culvert sizes < 1050dia).
8. Assume acceptable for flood waters to overtop road in larger storm events.
9. Design Culvert sizes are shown in below (Table 2) and a list of the culverts with their associated catchment parameters are shown below (Table 4).

Riprap Apron design has been determined based on the following principles:

1. Determine generic apron sizes (Table 3) for the range of culvert sizes required.
2. Assume culverts have a nominal gradient of 1:50.
3. Use pipe flow information from the culvert design calculations (10-year ARI Flow).
4. Use equations 20, 21, 22, 223 of the Auckland Design Manual TR2013/018 as basis of design.

Table 1. Rainfall intensities output (mm/hr) RCP4.5 for the period 2081-2100 for Mahinerangi Wind Farm

ARI	AEP	Duration							
		10m	20m	30m	1h	2h	6h	12h	24h
1.58	0.633	32.2	21.8	17.4	12	8.15	4.35	2.88	1.87
2	0.5	37	24.9	19.8	13.5	9.21	4.88	3.21	2.07

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Project No:	240034	**Page**	2	of	7
Project:	Mahinerangi Wind Farm				
Calc:	MM	**Date:**	07/10/2025		
Check:	VM	**Date:**	14/10/2025		
Description:	Culvert and Riprap Apron Design				

5	0.2	55.5	36.8	29.1	19.6	13.1	6.78	4.39	2.79
10	0.1	71.8	47.1	37	24.7	16.3	8.33	5.34	3.36
20	0.05	91.1	59.2	46.3	30.5	20	10.1	6.39	3.97
30	0.033	104	67.3	52.4	34.3	22.4	11.2	7.05	4.36
40	0.025	114	73.4	57.1	37.3	24.2	12	7.55	4.65
50	0.02	122	78.6	61	39.7	25.7	12.7	7.95	4.88
60	0.017	129	82.9	64.2	41.7	27	13.3	8.29	5.08
80	0.013	141	90.3	69.8	45.1	29.1	14.2	8.84	5.4
100	0.01	151	96.2	74.3	47.9	30.8	15	9.29	5.66
250	0.004	197	124	95.1	60.6	38.4	18.3	11.2	6.76

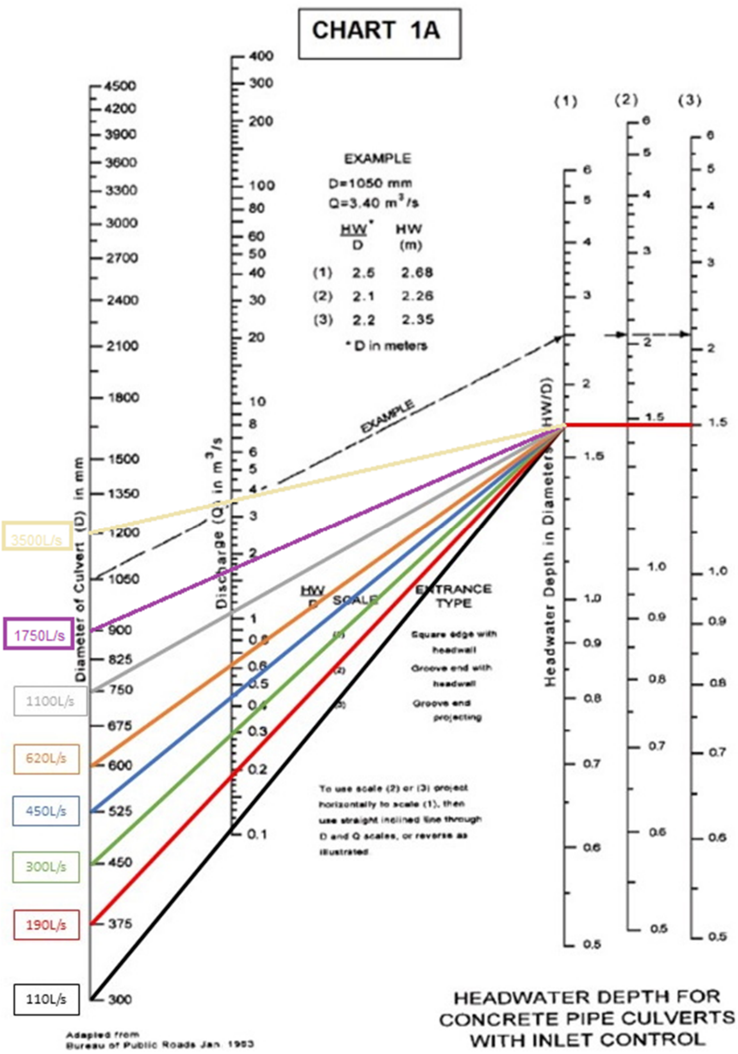


Table 2: Design Culvert Sizes

Culvert Diameter (mm)	Max. Flow (L/s)	Max. Catchment Area (ha)
300	110	1.84
375	190	3.18
450	300	5.01
525	450	7.52
600	620	10.36

Table 3: Riprap Apron Details

Culvert Diameter (mm)	Riprap Apron Length (m)	Min. Rip Rap Apron Width (m)	Min. Stone Size d_{50} (m)	Min. Stone Layer Depth (m)
300	3.50	0.90	0.20	0.40
375	4.40	1.20	0.20	0.40
450	5.30	1.40	0.20	0.40
525	6.30	1.60	0.25	0.50
600	7.30	1.80	0.25	0.50

Table 4. Culvert and associated catchment parameters for Mahinerangi Wind Farm.

Culvert ID	Catchment Area (ha)	Time of Concentration (min)	Slope Adjusted C	Design Flow (l/s)	Culvert dia. (mm)
1	2.0	10.0	0.25	98.6	300
2	0.4	10.0	0.25	18.9	300
3	1.2	10.0	0.25	61.5	300
4	0.3	10.0	0.30	15.7	300
5	0.4	10.0	0.35	30.1	300
6	1.0	10.0	0.30	57.8	300
7	2.8	10.0	0.25	140.3	375
8	0.6	10.0	0.25	29.4	300
9	1.3	10.0	0.30	23.3	300
10	0.2	10.0	0.25	11.8	300
11	0.1	10.0	0.25	7.2	300
12	0.3	10.0	0.30	16.7	300
13	1.3	10.8	0.25	66.1	300
14	1.1	10.0	0.30	62.6	300
15	0.2	10.0	0.25	7.5	300
16	1.1	10.0	0.30	65.0	300
17	1.5	10.0	0.35	101.0	300
18	0.5	10.0	0.30	29.4	300
19	1.1	10.0	0.30	66.3	300
20	0.4	10.0	0.25	17.7	300
21	1.2	10.0	0.25	57.4	300
22	0.2	10.0	0.25	11.3	300
23	2.1	10.0	0.25	104.5	300
24	0.7	10.0	0.30	40.8	300
25	0.9	10.0	0.25	46.3	300
26	0.2	10.0	0.25	9.0	300
27	1.7	10.0	0.25	84.9	300
28	0.3	10.0	0.25	16.6	300
29	1.5	10.0	0.25	72.3	300

Culvert ID	Catchment Area (ha)	Time of Concentration (min)	Slope Adjusted C	Design Flow (l/s)	Culvert dia. (mm)
30	2.0	10.0	0.25	97.9	300
31	0.2	10.0	0.25	9.3	300
32	0.9	10.0	0.25	44.3	300
33	1.8	10.0	0.35	128.1	375
34	0.9	10.0	0.25	42.5	300
35	0.9	10.0	0.25	45.6	300
36	0.9	10.0	0.25	42.7	300
37	0.1	10.0	0.25	4.5	300
38	0.2	10.0	0.30	10.2	300
39	0.2	10.0	0.30	10.1	300
40	0.1	10.0	0.25	4.0	300
41	0.1	10.0	0.30	6.5	300
42	0.7	10.0	0.25	36.9	300
43	1.0	10.0	0.25	48.9	300
44	0.2	10.0	0.25	10.8	300
45	0.3	10.0	0.30	15.0	300
46	0.6	10.0	0.30	37.2	300
47	0.9	10.0	0.25	42.9	300
48	0.1	10.0	0.30	8.0	300
49	1.8	10.0	0.25	91.7	300
50	0.5	10.0	0.30	30.8	300
51	0.9	10.0	0.35	61.4	300
52	1.2	10.0	0.30	72.8	300
53	0.4	10.0	0.25	18.6	300
54	1.6	10.0	0.25	81.0	300
55	0.7	10.0	0.25	33.7	300
56	0.5	10.0	0.25	23.7	300
57	0.8	10.0	0.25	39.5	300
58	0.4	10.0	0.30	24.0	300

Culvert ID	Catchment Area (ha)	Time of Concentration (min)	Slope Adjusted C	Design Flow (l/s)	Culvert dia. (mm)
59	0.3	10.0	0.25	13.8	300
60	1.4	10.0	0.30	81.0	300
61	0.8	10.0	0.25	39.1	300
62	0.8	10.0	0.25	41.1	300
63	0.5	10.0	0.25	22.5	300
64	0.2	10.0	0.30	14.0	300
65	0.8	10.0	0.25	38.4	300
66	0.2	10.0	0.35	10.5	300
67	0.1	10.0	0.25	4.9	300
68	1.7	12.6	0.25	86.9	300
69	2.7	10.0	0.25	133.1	375
70	0.3	10.0	0.30	17.4	300
71	0.2	10.0	0.25	10.6	300
72	0.3	10.0	0.25	16.9	300
73	2.7	18.5	0.25	132.7	375
74	0.2	10.0	0.25	8.8	300
75 – Lee Stream Tributary	79.1	22.6	0.25	2586.7	Box Culvert
76	2.9	10.0	0.25	144.4	375
77	0.6	10.0	0.30	36.9	300
78	1.1	14.7	0.30	66.7	300
79	1.7	13.6	0.30	101.4	300
80	1.9	10.0	0.25	94.4	300
81	2.5	19.2	0.25	122.5	375
82	0.3	12.8	0.25	17.1	300
83	1.0	10.0	0.35	69.4	300
84	0.7	10.0	0.25	34.2	300

Culvert ID	Catchment Area (ha)	Time of Concentration (min)	Slope Adjusted C	Design Flow (l/s)	Culvert dia. (mm)
85	0.5	19.5	0.25	26.4	300
86	1.5	10.0	0.30	90.0	300
87	0.2	10.0	0.25	8.4	300
88	0.7	10.0	0.25	33.3	300
89	0.5	10.0	0.25	22.6	300
90	0.8	10.0	0.30	47.7	300
91	3.1	10.0	0.30	182.9	375
92	0.3	10.0	0.30	14.8	300
93	0.6	10.0	0.25	27.9	300
94	0.8	10.0	0.25	38.9	300
95	1.8	10.0	0.30	105.7	300
96	0.1	10.0	0.25	3.7	300
97	0.4	10.0	0.25	22.0	300
98	0.8	10.0	0.25	42.0	300

USER TO ENTER DETAILS IN HIGHLIGHTED CELLS
GRADIENT SET TO CALCULATED OR SPECIFIED VALUE

RILEY

Pipe No

Roughness	1.5	mm	CALCULATE GRADIENT		SPECIFY GRADIENT	
Diam(mm)	300	mm	U/S level	m	1 in	50
Gradient	0.02	m/m	D/S level	m		
Mahinerangi Windfarm Culverts			Length	m		
Resource Consent - Design			Gradient		Gradient	0.020

PROPOR'N DEPTH	WETTED PERIMETER	AREA OF FLOW	HYDRAULIC MEAN DEPTH	VELOCITY (m/s)	DISCHARGE (l/s)	DEPTH (mm)	SURFACE WIDTH (mm)
0.01	0.06010045	0.00011964	0.0019907	0.138	0.02	3	60
0.02	0.08513823	0.00033737	0.0039626	0.244	0.08	6	84
0.03	0.10444981	0.0006179	0.0059157	0.333	0.21	9	102
0.04	0.12081475	0.0009484	0.0078500	0.412	0.39	12	118
0.05	0.13530804	0.00132133	0.0097654	0.484	0.64	15	131
0.1	0.19305033	0.00367877	0.0190560	0.779	2.87	30	180
0.15	0.23861965	0.00664872	0.0278633	1.013	6.74	45	214
0.2	0.27818857	0.01006414	0.0361774	1.209	12.17	60	240
0.25	0.31415927	0.01381916	0.0439877	1.379	19.06	75	260
0.3	0.34778384	0.01783515	0.0512823	1.527	27.23	90	275
0.35	0.3798311	0.02204824	0.0580475	1.658	36.56	105	286
0.4	0.41083152	0.02640328	0.0642679	1.773	46.81	120	294
0.45	0.44118867	0.03085043	0.0699257	1.873	57.78	135	298
0.5	0.4712389	0.03534292	0.0750000	1.961	69.31	150	300
0.55	0.50128912	0.03983541	0.0794659	2.037	81.14	165	298
0.6	0.53164627	0.04428255	0.0832933	2.100	92.99	180	294
0.65	0.56264669	0.04863759	0.0864443	2.152	**104.67**	195	286
0.7	0.59469395	0.05285068	0.0888704	2.191	115.80	210	275
0.75	0.62831853	0.05686668	0.0905061	2.217	126.07	225	260
0.8	0.66428923	0.06062169	0.0912580	2.229	135.13	240	240
0.85	0.70385815	0.06403711	0.0909801	2.224	142.42	255	214
0.9	0.74942746	0.06700706	0.0894110	2.199	147.35	270	180
0.95	0.80716975	0.0693645	0.0859355	2.143	148.65	285	131
1	**0.9424778**	**0.07068583**	**0.0750000**	**1.961**	**138.61**	**300**	**0**

USER TO ENTER DETAILS IN HIGHLIGHTED CELLS
GRADIENT SET TO CALCULATED OR SPECIFIED VALUE

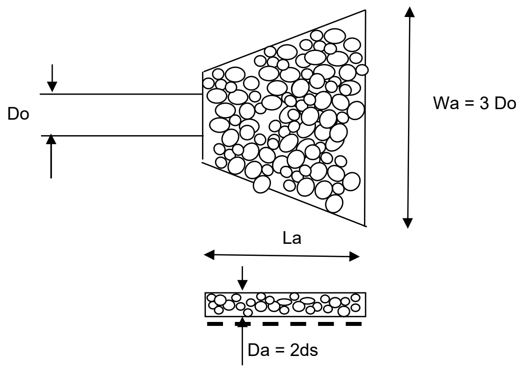
RILEY

Pipe No

Roughness	1.5	mm	CALCULATE GRADIENT			SPECIFY GRADIENT	
Diam(mm)	375	mm	U/S level		m	1 in	50
Gradient	0.02	m/m	D/S level		m		
Mahinerangi Windfarm Culverts			Length		m		
Resource Consent - Design			Gradient			Gradient	0.020

PROPOR'N DEPTH	WETTED PERIMETER	AREA OF FLOW	HYDRAULIC MEAN DEPTH	VELOCITY (m/s)	DISCHARGE (l/s)	DEPTH (mm)	SURFACE WIDTH (mm)
0.01	0.07512557	0.00018694	0.0024883	0.167	0.03	4	75
0.02	0.10642279	0.00052714	0.0049532	0.291	0.15	8	105
0.03	0.13056226	0.00096546	0.0073947	0.394	0.38	11	128
0.04	0.15101844	0.00148187	0.0098125	0.486	0.72	15	147
0.05	0.16913505	0.00206458	0.0122067	0.569	1.17	19	163
0.1	0.24131292	0.00574809	0.0238201	0.910	5.23	38	225
0.15	0.29827456	0.01038863	0.0348291	1.179	12.25	56	268
0.2	0.34773571	0.01572522	0.0452218	1.404	22.08	75	300
0.25	0.39269908	0.02159244	0.0549847	1.599	34.53	94	325
0.3	0.43472981	0.02786743	0.0641029	1.770	49.33	113	344
0.35	0.47478888	0.03445038	0.0725594	1.919	66.11	131	358
0.4	0.5135394	0.04125513	0.0803349	2.051	84.61	150	367
0.45	0.55148584	0.04820379	0.0874071	2.167	104.46	169	373
0.5	0.58904862	0.05522331	0.0937500	2.268	125.25	188	375
0.55	0.62661141	0.06224282	0.0993324	2.355	146.58	206	373
0.6	0.66455784	0.06919149	0.1041166	2.427	167.93	225	367
0.65	0.70330837	0.07599624	0.1080554	2.486	**188.93**	244	358
0.7	0.74336744	0.08257919	0.1110880	2.531	209.01	263	344
0.75	0.78539816	0.08885418	0.1131327	2.561	227.56	281	325
0.8	0.83036154	0.09472139	0.1140725	2.575	243.91	300	300
0.85	0.87982268	0.10005799	0.1137252	2.570	257.15	319	268
0.9	0.93678433	0.10469853	0.1117638	2.541	266.04	338	225
0.95	1.00896219	0.10838203	0.1074193	2.477	268.46	356	163
1	**1.17809725**	**0.11044662**	**0.0937500**	**2.268**	**250.49**	**375**	**0**

RIPRAP DESIGN (TR2013-018)



Job No.		240034
Project	Mahinerangi Wind Farm	
Date		13/10/2025
By	MM	

Diameter of stone

d_s = 0.25 x D_0 x F_0

where

d_s =	riprap diameter (m)	=	**0.12**
D_0 =	pipe diameter (m)	=	0.3
d_p =	depth of flow in pipe (m)	=	0.195
V =	velocity of flow in pipe (m/s)	=	2.152
F_0 =	Froude number = $V/(g \times d_p)^{0.5}$	=	**1.56**

Results

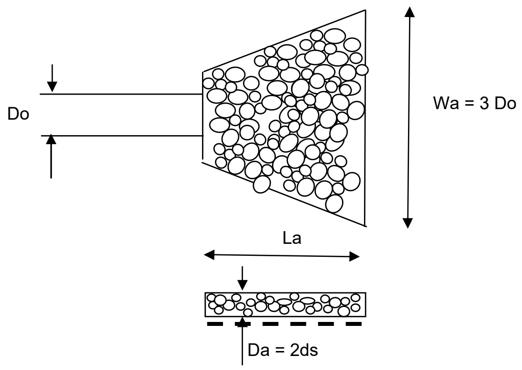
Thickness of stone layer , $D_a = 2d_s$	=	**0.23**	m
Width of area protected is 3 times the diameter of pipe. $W_a = 3D_0$	=	**0.90**	m

Height of stone is the crown of pipe + 300mm

Length of outfall protection (Apron length, m), $L_a = D_0 (8 + 17 \times \text{Log}F_0)$ = **3.38** m

RIPRAP DESIGN (TR2013-018)

Job No.	240034
Project	Mahinerangi Wind Farm
Date	13/10/2025
By	MM



Diameter of stone

d_s = 0.25 x D_0 x F_0

where

d_s =	riprap diameter (m)	=	**0.15**
D_0 =	pipe diameter (m)	=	0.375
d_p =	depth of flow in pipe (m)	=	0.244
V =	velocity of flow in pipe (m/s)	=	2.486
F_0 =	Froude number = $V/(g \times d_p)^{0.5}$	=	**1.61**

Results

Thickness of stone layer , $D_a = 2d_s$	=	**0.30**	m
Width of area protected is 3 times the diameter of pipe. $W_a = 3D_0$	=	**1.13**	m
Height of stone is the crown of pipe + 300mm			

Length of outfall protection (Apron length, m), $L_a = D_0\,(8 + 17 x Log F_0)$ = **4.31** m

REV	DATE	ISSUE	BY
A		ISSUED FOR RESOURCE CONSENT	FY

PREP. BY: MCM
REVD. BY: LG
APPROVED FOR ISSUE: DRAFT

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SHEET TITLE: PROPOSED CULVERT CATCHMENT PLAN - SHEET 1

CADFILE: 240034-FIG21-25.dwg
SCALE (A1): 1:5000
ORIG. SHEET SIZE: A1
DRAWING No.: 240034-FIG 21
REV.: A

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CADFILE: 240034-FIG21-25.dwg
SCALE (A1): 1:5000
ORIG. SHEET SIZE: A1
DRAWING No.: 240034-FIG 22
REV.: A

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SHEET TITLE: PROPOSED CULVERT CATCHMENT PLAN - SHEET 3

CADFILE: 240034-FIG21-25.dwg
SCALE (A1): 1:5000
ORIG. SHEET SIZE: A1
DRAWING No.: 240034-FIG 23
REV.: A

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SHEET TITLE	PROPOSED CULVERT CATCHMENT PLAN - SHEET 4

CADFILE	
240034-FIG21-25.dwg	
SCALE (A1)	ORIG. SHEET SIZE
1:5000	A1
DRAWING No.	REV.
240034-FIG 24	A

Appendix C

Erosion and Sediment Calculations

Erosion and Sediment Design Calculations

Prepared for:	Tararua Wind Power
Prepared by:	Aditya Raamkumar, Civil Engineer
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Checked by:	Luke Gordon, Principal Civil Engineer
Reviewed and approved for issue by:	Don Tate, **Project Director, CPEng**
Report reference:	240034-D
Date:	17 October 2025

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Objective

To estimate sediment yield from typical land disturbing activities included within the scope of the Mahinerangi Stage 2 Wind Farm development. The typical scenarios/catchments assessed were:

- Formation of wind turbine platforms.
- Formation of new access tracks/stream crossing
- Surplus fill disposal site – blanket fill.
- Concrete Batching Plant

Methodology

The Universal Soil Loss Equation (USLE) has been adopted to assess the 'pre-development', 'unmitigated', and 'mitigated' sediment yield.

USLE Equation: A = R x K x LS x C x P

A = Estimate of Sediment Generation (tonnes/ha/yr)

Where:

R = Rainfall Erosion Index (J/ha)
K = Soil Erodibility Factor (tonnes/unit of R)
LS = Slope Length and Steepness Factor
C = Ground Cover Factor
P = Roughness Factor

Design calculations and parameters are generally based on the Auckland Regional Council landfacts S-05: Estimating Sediment Yield Using the Universal Soil Loss Equation.

Rainfall Erosion Index (R)

R is calculated based on the 50% AEP 6-hour rainfall depth.

$$R = 0.00828 \times p^{2.2} \times 1.7$$

Where:
p = 25 mm (Hirds)
Therefore R = 16.74 J/ha

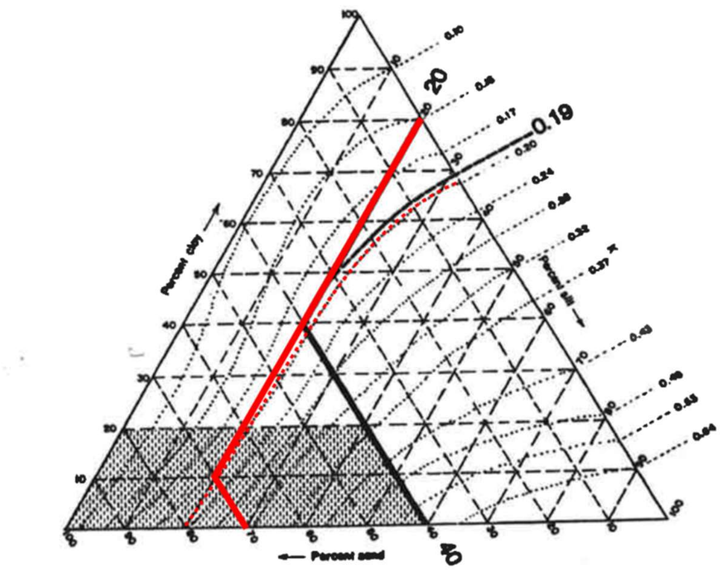
Rainfall depths have been obtained for the Historical data.

Soil Erodibility Factor (K)

K is based on a typical soil composition which has been assumed as uniform across the site. Test pit logs from site indicate an estimated 10% clay, 20% silt, and 70% sand. The nomograph shown in Figure 1 is used to determine the K value which is then multiplied by 1.32 to convert units. 4% and 0% organic content is assumed for pre-development and earthworks, respectively.

$K_{pre\text{-}dev}$ = (0.20 - 0.10) x 1.32 = 0.13 (adjusted for 4% organic matter)
$K_{earthworks}$ = (0.20 + 0.10) x 1.32 = 0.40 (0% organic matter)

Figure 1: Triangular Nomograph for Estimating K Values (red mark-up)



Goldman et al. 1986

Slope Length and Steepness Factor (LS)

LS has been assessed based site topography and corresponding values presented in S-05 Appendix 1 – LS Values. For the earthwork's construction phase, the average slope of the pre and post earthworks landform has been calculated. For the re-establishment phase the post earthworks slope has been calculated.

Figure 2: LS Values

APPENDIX 1: LS VALUES

Slope Ratio s,%	Slope Length, m 10.00	25.00	50.00	75.00	100.00	125.00	150.00	175.00	200.00	225.00	250.00	275.00	300.00
0.50	0.08	0.09	0.11	0.11	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15
1.00	0.09	0.12	0.15	0.17	0.18	0.20	0.21	0.22	0.23	0.23	0.24	0.25	0.26
2.00	0.14	0.19	0.23	0.26	0.29	0.31	0.32	0.34	0.35	0.37	0.38	0.39	0.40
3.00	0.21	0.27	0.33	0.38	0.41	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.57
4.00	0.26	0.37	0.49	0.57	0.64	0.70	0.76	0.80	0.85	0.89	0.93	0.96	1.00
5.00	0.31	0.48	0.69	0.84	0.97	1.08	1.19	1.28	1.37	1.45	1.53	1.61	1.68
6.00	0.39	0.61	0.86	1.06	1.22	1.36	1.49	1.61	1.72	1.83	1.93	2.02	2.11
7.00	0.47	0.75	1.06	1.29	1.49	1.67	1.83	1.98	2.11	2.24	2.36	2.48	2.59
8.00	0.57	0.90	1.27	1.56	1.80	2.01	2.20	2.38	2.54	2.70	2.84	2.98	3.11
9.00	0.67	1.06	1.50	1.84	2.13	2.38	2.60	2.81	3.01	3.19	3.36	3.53	3.68
10.00	0.78	1.24	1.75	2.15	2.48	2.77	3.04	3.28	3.51	3.72	3.92	4.11	4.30
11.00	0.91	1.43	2.02	2.48	2.86	3.20	3.51	3.79	4.05	4.29	4.53	4.75	4.96
12.50	1.10	1.74	2.46	3.02	3.48	3.89	4.26	4.61	4.92	5.22	5.51	5.77	6.03
15.00	1.47	2.32	3.28	4.02	4.64	5.19	5.68	6.14	6.56	6.96	7.34	7.69	8.04
16.70	1.74	2.76	3.90	4.77	5.51	6.16	6.75	7.29	7.79	8.27	8.71	9.14	9.55
20.00	2.34	3.70	5.23	6.40	7.39	8.26	9.05	9.78	10.45	11.09	11.69	12.26	12.80
22.00	2.73	4.32	6.11	7.49	8.65	9.67	10.59	11.44	12.23	12.97	13.67	14.34	14.98
25.00	3.38	5.34	7.55	9.25	10.68	11.94	13.08	14.12	15.10	16.01	16.88	17.70	18.49
30.00	4.56	7.21	10.19	12.48	14.41	16.12	17.65	19.07	20.39	21.62	22.79	23.90	24.97
33.30	5.41	8.55	12.09	14.80	17.09	19.11	20.93	22.61	24.17	25.64	27.03	28.34	29.61
35.00	5.86	9.26	13.10	16.05	18.53	20.71	22.69	24.51	26.20	27.79	29.30	30.73	32.09
40.00	7.25	11.47	16.22	19.86	22.93	25.64	28.09	30.34	32.43	34.40	36.26	38.03	39.72
45.00	8.71	13.78	19.48	23.86	27.55	30.80	33.74	36.45	38.96	41.33	43.56	45.69	47.72
50.00	10.22	16.15	22.84	27.98	32.31	36.12	39.57	42.74	45.69	48.46	51.08	53.57	55.95
55.00	11.74	18.56	26.25	32.15	37.13	41.51	45.47	49.12	52.51	55.69	58.71	61.57	64.31
57.00	12.35	19.53	27.62	33.83	39.06	43.67	47.84	51.68	55.24	58.60	61.77	64.78	67.66
60.00	13.27	20.98	29.67	36.34	41.96	46.91	51.39	55.51	59.34	62.94	66.35	69.59	72.68
66.70	15.29	24.18	34.20	41.88	48.36	54.07	59.23	63.98	68.40	72.55	76.47	80.20	83.77
70.00	16.27	25.73	36.39	44.57	51.46	57.53	63.03	68.08	72.78	77.19	81.37	85.34	89.13
75.00	17.72	28.03	39.63	48.54	56.05	62.67	68.65	74.15	79.27	84.08	88.62	92.95	97.08
80.00	19.13	30.25	42.78	52.39	60.50	67.64	74.10	80.03	85.56	90.75	95.66	100.33	104.79
85.00	20.49	32.39	45.81	56.11	64.78	72.43	79.34	85.70	91.62	97.18	102.43	107.43	112.21
90.00	21.79	34.45	48.72	59.67	68.90	77.03	84.38	91.14	97.43	103.35	108.94	114.25	119.33
95.00	23.03	36.41	51.50	63.07	72.83	81.42	89.19	96.34	102.99	109.24	115.15	120.77	126.14
100.00	24.21	38.28	54.14	66.31	76.57	85.61	93.78	101.29	108.29	114.85	121.07	126.98	132.62

Calculated From:

$$LS = \left(\frac{65.41 \times s^2}{s^2 + 10{,}000} + \frac{4.56 \times s}{\sqrt{s^2 + 10{,}000}} + 0.065\right) \times \left(\frac{l}{72.5}\right)^m$$

22.1

LS= topographic factor
l = Slope length, m
s = Slope steepness
m = Exponent dependent on slope steepness 0.2 for slopes<1%, 0.3 for slopes 1-3%. 0.4 for slopes 3.5-4.5%, and 0.5 for slopes > 5%)

Ground Cover (C) and Roughness (P)

C and P Factors have been adopted from S-05 based on the surface type.

Figure 3: C & P Values

Treatment	C factor	P factor
Bare Soil		
- compacted and smooth	1.0	1.32
- track walked on contour	1.0	1.2
- rough irregular surface	1.0	0.9
- disked to 250 mm depth	1.0	0.8
Native vegetation (undisturbed)	0.01	1.0
Pasture (undisturbed)	0.02	1.0
Establishing grass	0.1	1.0
Mulch – on subsoil[2]	0.15 (3 month period only)	1.0
Mulch – on topsoil[3]	0.05 (3 month period only)	1.0

Ground cover for re-establishment phase (mulch on topsoil) only relates to surplus fill disposals, plus platform/road earthworks batters/berms. Platforms and roads will be stabilised with hardfill – so those areas are excluded from the re-establishment areas.

E&SC Measures

E&SC factors will be incorporated into the USLE calculation to determine mitigation effectiveness before entering the receiving environment. These factors include:

Sediment Delivery Ratio (%)

Regarding the sediment delivery ratio, S-05 identifies 50% as generally accepted. However, this should be increased for steep sites (e.g., 70% where site slopes exceed 10°).

Sediment Control Measure Efficiency (%)

The effectiveness of E&SC devices. S-05 identifies 50% as a conservative value for most devices, except for Sediment Retention Pond (SRP) – where typically a min 75% efficiency is used. However, for coarse grained soils a higher efficiency can be assumed. In the case of MWF geology, the silts/sand and weathered rock matrix would constitute a coarse grained soil, therefore we have adopted the following assumptions for treatment efficiencies:

- Decanting Earth Bund (DEB) = 70%
- SRP = 85%
- Other Devices = 60%

Higher treatment efficiencies would apply for chemically treated SRPs and DEBs installed in accordance with Auckland Regional Council GD05.

Time (estimate only – to be confirmed by Contractor)

The USLE equation calculates annual sediment yield whereas, we have broken this down to months and estimated construction periods for land disturbing activities. We have assumed:

- Turbine and ancillary platforms will require up to 3-months each to form.
- New access tracks will likely be progressively constructed and covered but assume sections could be exposed for up to 3-months at a time.
- Fill disposal sites may remain active (i.e., exposed) up to 6-months.
- Stabilisation of backfilled disposal sites and/or slopes will take 3-months.

Calculations

Calculations and catchments plans have been appended for each case study.

Commentary on Proposed Sediment Controls

For access tracks in cut or minor fill (and not directly adjacent to wetlands), it is envisaged that a cut and cover technique can be applied. I.e. the trimmed subgrades will be stabilised progressively and prior to rain events, such that no specific sediment control devices will be required for those areas. Therefore, the cut and cover scenario has not been assessed further in terms of sediment yield calculations.

It is envisaged that Sediment Retention Ponds (SRP's) will be the primary treatment device for the Surplus Fill Disposal sites (SFD's), given the longer earthworks duration associated with the SFD's, and sloping nature of the SFD sites (particularly in the case of gully fills).

It is envisaged that the decanting earth bunds (DEB's) will be suitable as primary treatment devices for wind turbine platforms and access track earthworks. The turbine platforms will be formed as gently sloping/ near flat platforms, therefore these favours splitting the platforms catchment into smaller sub-catchments draining to multiple DEB's.

The ancillary platforms (site compound/ batching plant/substation etc) may utilise SRP's or DEB's, dependant on site constraints and catchment properties.

Other sediment control measures may be utilised where appropriate within the site e.g.:

- silt fences in constrained areas where these is limited space for diversion channels/DEB's, subject to wind loading conditions.
- turkeys' nests - for dewatering (pump discharge) from bunded/low lying areas. Silt fences and turkeys nests are recognised treatment devices in GD05.

As per GD05, the DEB volumes must be min 2% of the catchment area, with recommended maximum catchment area of 3,000m^2. However, given large extent of the proposed earthworks, some flexibility can be applied to allow increased catchment area for each DEB (and proportionally increase the DEB volume – up to 5,000m^2) and thus reduce the total number of DEB's.

The use of rain-activated chemical treatment will be considered to increase the sediment yield efficiency of sediment control devices which are in proximity (nominally within 50m) of downstream water bodies – such as bogs/wetlands, and streams. Preliminary bench testing has been carried out on site soils and a draft Chemical Treatment Management Plan (CTP) has been prepared. However, for the purposes of this USLE assessment, chemical treatment has not been applied in terms of the sediment control efficiencies used.

Universal Soil Loss Equation (USLE)

Project No: 240034 **Design:** AR **Date:** 6/10/2025

Project: Mahinerangi Wind Farm Stage 2 **Check:** LG **Date:** 6/10/2025

RILEY

Catchment: **Stream works (Lee Stream Tributary crossing)**

Rainfall Depth: 25.00 mm

R = 16.75 J/ha

USLE: A = R*K*LS*C*P

A = Annual Estimated Sediment Generation, T/ha/yr
R = Rainfall Erosion Index, J/ha
K = Soil Erodability Factor, T/Unit of R
LS = Slope Length and Steepness Factor
C = Ground Cover Factor
P = Roughness Factor

Typ. Soil Composition:

Clay = 10%
Silt = 20%
Sand = 70%
$K_{pre-dev}$ = 0.13 4% organic
$K_{earthworks}$ = 0.40 0% organic

Typ. E&SC Devices:

		Efficiency
N/A	Unmitigated	0%
1	Chemically Treated Sediment Retention Pond	95%
2	Standard Sediment Retention Pond	85%
3	Chemically Treated T-bar Decanting Earth Bunds	85%
4	Standard T-bar Decanting Earth Bunds	70%
5	Other (e.g., silt fencing, mulch etc.)	60%

Area/Activity	R	K	Slope Length (m)	Slope Grade (%)	LS	Surface Type	C	P	Exposed Area (ha)	Duration (months)	A (T)	Sediment Delivery Ratio (%)	E&SC Device	Sediment Control Efficiency (%)	Estimated Sediment Yield (T)
Pre-development															
Existing Site	16.75	0.13	38	19.0%	4.61	Native vegetation (undisburbed)	0.01	1.00	0.15	6	0.008	50%	N/A	0%	0.0039
														Subtotal =	**0.0039**
Unmitigated Earthworks (Construction Period)															
Track Construction	16.75	0.40	38	5.0%	0.58	Bare Soil - compacted and smooth	1.00	1.32	0.04	3	0.055	50%	N/A	0%	0.0273
Batter construction	16.75	0.40	15.33	20.0%	2.79	Bare Soil -rough irregular surface	1.00	0.90	0.11	3	0.458	50%	N/A	0%	0.2290
Batter stabilisation	16.75	0.13	15.33	50.0%	12.19	Mulch on topsoil	0.05	1.00	0.11	3	0.036	70%	N/A	0%	0.0255
														Subtotal =	**0.282**
Mitigated Earthworks (Construction Period)															
Track Construction	16.75	0.40	38	5.0%	0.58	Bare Soil - compacted and smooth	1.00	1.32	0.04	3	0.055	50%	5	60%	0.0109
Batter construction	16.75	0.40	15.33	20.0%	2.79	Bare Soil -rough irregular surface	1.00	0.90	0.11	3	0.458	50%	5	60%	0.0916
Batter stabilisation	16.75	0.13	15.33	50.0%	12.19	Mulch on topsoil	0.05	1.00	0.11	3	0.036	70%	5	60%	0.0102
														Subtotal =	**0.113**

Notes:

1) Rainfall Erosion Index is calculated based on HIRDS V4 50% AEP 6-hour rainfall depth.
2) Soil Erodability Factor determined based on observed soil composition and Triangular Nomograph for Estimating K values (refer to Auckland Regional Council S-05 - Figure 1).
3) Slope Length and Steepness Factor based on site topography and corresponding values presented in Auckland Regional Council S-05 - Appendix 1.
4) Ground Cover and Roughness Factors based on surface cover type and corresponding values presented in Auckland Regional Council S-05 - Table 2.
5) 50% Sediment Delivery Ratio is generally acceptable except where sites are steep (i.e., 70% for sites where slopes exceed 10-degrees (or 17.5%)).

Universal Soil Loss Equation (USLE)

Project No: 240034 **Design:** AR **Date:** 6/10/2025
Project: Mahinerangi Wind Farm Stage 2 **Check:** LG **Date:** 6/10/2025

RILEY

Catchment: **Exemplar Catchment - Turbine Platform (WTG 7)**

USLE: A = R*K*LS*C*P

A = Annual Estimated Sediment Generation, T/ha/yr
R = Rainfall Erosion Index, J/ha
K = Soil Erodability Factor, T/Unit of R
LS = Slope Length and Steepness Factor
C = Ground Cover Factor
P = Roughness Factor

Rainfall Depth: 25.00 mm
R = 16.75 J/ha

Typ. Soil Composition:
Clay = 10%
Silt = 20%
Sand = 70%
$K_{pre\text{-}dev}$ = 0.13 4% organic
$K_{earthworks}$ = 0.40 0% organic

Typ. E&SC Devices:

		Efficiency
N/A	Unmitigated	0%
1	Chemically Treated Sediment Retention Pond	95%
2	Standard Sediment Retention Pond	85%
3	Chemically Treated T-bar Decanting Earth Bunds	85%
4	Standard T-bar Decanting Earth Bunds	70%
5	Other (e.g., silt fencing, mulch etc.)	60%

Area/Activity	R	K	Slope Length (m)	Slope Grade (%)	LS	Surface Type	C	P	Exposed Area (ha)	Duration (months)	A (T)	Sediment Delivery Ratio (%)	E&SC Device	Sediment Control Efficiency (%)	Estimated Sediment Yield (T)
Pre-development															
Existing Site	16.75	0.13	85	7.0%	1.37	Native vegetation (undisburbed)	0.01	1.00	0.85	6	0.013	50%	N/A	0%	0.006
														Subtotal =	**0.006**
Unmitigated Earthworks (Construction Period)															
Platform construction	16.75	0.40	78	4.0%	0.57	Bare Soil - compacted and smooth	1.00	1.32	0.60	3	0.748	50%	N/A	0%	0.374
Slope construction	16.75	0.40	27	20.0%	3.71	Bare Soil -rough irregular surface	1.00	0.90	0.25	3	1.384	50%	N/A	0%	0.692
Slope stabilisation	16.75	0.13	27	33.0%	8.58	Mulch on topsoil	0.05	1.00	0.25	3	0.058	70%	N/A	0%	0.041
														Subtotal =	**1.107**
Mitigated Earthworks (Construction Period)															
Platform construction	16.75	0.40	78	4.0%	0.57	Bare Soil - compacted and smooth	1.00	1.32	0.60	3	0.748	50%	4	70%	0.112
Slope construction	16.75	0.40	27	20.0%	3.71	Bare Soil -rough irregular surface	1.00	0.90	0.25	3	1.384	70%	4	70%	0.291
Slope stabilisation	16.75	0.13	27	33.0%	8.58	Mulch on topsoil	0.05	1.00	0.25	3	0.058	70%	4	70%	0.012
														Subtotal =	**0.415**

Notes:
1) Rainfall Erosion Index is calculated based on HIRDS V4 50% AEP 6-hour rainfall depth.
2) Soil Erodability Factor determined based on observed soil composition and Triangular Nomograph for Estimating K values (refer to Auckland Regional Council S-05 - Figure 1).
3) Slope Length and Steepness Factor based on site topography and corresponding values presented in Auckland Regional Council S-05 - Appendix 1.
4) Ground Cover and Roughness Factors based on surface cover type and corresponding values presented in Auckland Regional Council S-05 - Table 2.
5) 50% Sediment Delivery Ratio is generally acceptable except where sites are steep (i.e., 70% for sites where slopes exceed 10-degrees (or 17.5%)).

Universal Soil Loss Equation (USLE)

Project No: 240034 **Design:** AR **Date:** 6/10/2025

Project: Mahinerangi Wind Farm Stage 2 **Check:** LG **Date:** 6/10/2025

RILEY

Catchment: **Exemplar Catchment - Blanket Fill Disposal (SFD-04)**

USLE: **A = R*K*LS*C*P**

A = Annual Estimated Sediment Generation, T/ha/yr
R = Rainfall Erosion Index, J/ha
K = Soil Erodability Factor, T/Unit of R
LS = Slope Length and Steepness Factor
C = Ground Cover Factor
P = Roughness Factor

Rainfall Depth: 25.00 mm
R = 16.75 J/ha

Typ. Soil Composition:
Clay = 10%
Silt = 20%
Sand = 70%
$K_{pre\text{-}dev}$ = 0.13 4% organic
$K_{earthworks}$ = 0.40 0% organic

Typ. E&SC Devices:

		Efficiency
N/A	Unmitigated	0%
1	Chemically Treated Sediment Retention Pond	95%
2	Standard Sediment Retention Pond	85%
3	Chemically Treated T-bar Decanting Earth Bunds	85%
4	Standard T-bar Decanting Earth Bunds	70%
5	Other (e.g., silt fencing, mulch etc.)	60%

Area/Activity	R	K	Slope Length (m)	Slope Grade (%)	LS	Surface Type	C	P	Exposed Area (ha)	Duration (months)	A (T)	Sediment Delivery Ratio (%)	E&SC Device	Sediment Control Efficiency (%)	Estimated Sediment Yield (T)
Pre-development															
Existing Site	16.75	0.13	208.5	3.0%	0.50	Native vegetation (undisburbed)	0.01	1.00	2.07	9	0.017	50%	N/A	0%	0.009
														Subtotal =	**0.009**
Unmitigated Earthworks (Construction Period)															
Blanket filling	16.75	0.40	208.5	3.0%	0.50	Bare Soil - compacted and smooth	1.00	1.32	2.07	6	4.530	50%	N/A	0%	2.265
Blanket stabilisation	16.75	0.13	208.5	3.0%	0.50	Mulch on topsoil	0.05	1.00	2.07	3	0.028	50%	N/A	0%	0.014
														Subtotal =	**2.279**
Mitigated Earthworks (Construction Period)															
Blanket filling	16.75	0.40	208.5	3.0%	0.50	Bare Soil - compacted and smooth	1.00	1.32	2.07	6	4.530	50%	2	85%	0.340
Blanket stabilisation	16.75	0.13	208.5	3.0%	0.50	Mulch on topsoil	0.05	1.00	2.07	3	0.028	50%	2	85%	0.002
														Subtotal =	**0.342**

Notes:
1) Rainfall Erosion Index is calculated based on HIRDS V4 50% AEP 6-hour rainfall depth.
2) Soil Erodability Factor determined based on observed soil composition and Triangular Nomograph for Estimating K values (refer to Auckland Regional Council S-05 - Figure 1).
3) Slope Length and Steepness Factor based on site topography and corresponding values presented in Auckland Regional Council S-05 - Appendix 1.
4) Ground Cover and Roughness Factors based on surface cover type and corresponding values presented in Auckland Regional Council S-05 - Table 2.
5) 50% Sediment Delivery Ratio is generally acceptable except where sites are steep (i.e., 70% for sites where slopes exceed 10-degrees (or 17.5%)).

Universal Soil Loss Equation (USLE)

Project No: 240034 **Design:** AR **Date:** 6/10/2025

Project: Mahinerangi Wind Farm Stage 2 **Check:** LG **Date:** 6/10/2025

Catchment: **Exemplar Catchment - Concrete Batching Plant**

USLE: A = R*K*LS*C*P

A = Annual Estimated Sediment Generation, T/ha/yr
R = Rainfall Erosion Index, J/ha
K = Soil Erodability Factor, T/Unit of R
LS = Slope Length and Steepness Factor
C = Ground Cover Factor
P = Roughness Factor

Rainfall Depth: 25.00 mm
R = 16.75 J/ha

Typ. Soil Composition:
Clay = 10%
Silt = 20%
Sand = 70%
$K_{pre-dev}$ = 0.13 4% organic
$K_{earthworks}$ = 0.40 0% organic

Typ. E&SC Devices:

		Efficiency
N/A	Unmitigated	0%
1	Chemically Treated Sediment Retention Pond	95%
2	Standard Sediment Retention Pond	85%
3	Chemically Treated T-bar Decanting Earth Bunds	85%
4	Standard T-bar Decanting Earth Bunds	70%
5	Other (e.g., silt fencing, mulch etc.)	60%

Area/Activity	R	K	Slope Length (m)	Slope Grade (%)	LS	Surface Type	C	P	Exposed Area (ha)	Duration (months)	A (T)	Sediment Delivery Ratio (%)	E&SC Device	Sediment Control Efficiency (%)	Estimated Sediment Yield (T)
Pre-development															
Existing Site	16.75	0.13	160	2.5%	0.40	Native vegetation (undisburbed)	0.01	1.00	1.31	6	0.006	50%	N/A	0%	0.003
														Subtotal =	**0.003**
Unmitigated Earthworks (Construction Period)															
Batching plant filling	16.75	0.40	160	2.5%	0.40	Bare Soil - compacted and smooth	1.00	1.32	1.31	3	1.147	50%	N/A	0%	0.573
Batching plant stabilisation	16.75	0.13	160	2.5%	0.40	Mulch on topsoil	0.05	1.00	1.31	3	0.014	50%	N/A	0%	0.007
														Subtotal =	**0.581**
Mitigated Earthworks (Construction Period)															
Batching plant filling	16.75	0.40	160	2.5%	0.40	Bare Soil - compacted and smooth	1.00	1.32	1.31	3	1.147	50%	2	85%	0.086
Batching plant stabilisation	16.75	0.13	160	2.5%	0.40	Mulch on topsoil	0.05	1.00	1.31	3	0.014	50%	2	85%	0.001
														Subtotal =	**0.087**

Notes:

1) Rainfall Erosion Index is calculated based on HIRDS V4 50% AEP 6-hour rainfall depth.
2) Soil Erodability Factor determined based on observed soil composition and Triangular Nomograph for Estimating K values (refer to Auckland Regional Council S-05 - Figure 1).
3) Slope Length and Steepness Factor based on site topography and corresponding values presented in Auckland Regional Council S-05 - Appendix 1.
4) Ground Cover and Roughness Factors based on surface cover type and corresponding values presented in Auckland Regional Council S-05 - Table 2.
5) 50% Sediment Delivery Ratio is generally acceptable except where sites are steep (i.e., 70% for sites where slopes exceed 10-degrees (or 17.5%)).

Sediment Pond Design: (in general accordance with Council GD05)

RILEY

Job Name:	Mahinerangi WF					
Job Number:	240034					
Prepared by:	AR					
Reviewed by:						
Date:	21.08.2025					
Location	SFD-04					
Catchment Area	2.07	ha				
Slope of earthworks	3	%	Slope < 10% minimum volume of	2	%	of the contributing catchment
			Slope > 10% minimum volume of	3	%	of the contributing catchment
Minimum Volume of Pond	414	m^3				
Dead Storage Volume	124.2	m^3	30% of minimum volume of pond			
Live Storage Volume	289.8	m^3	70% of minimum volume of pond			

Shape of pond

Inlet side slope (Spreader)	3 : 1			
General side slopes	2 : 1	2:1 typically		
Length to Width ratio	3 : 1	Should range between 3:1 and 5:1		
Depth of Pond	2 m	Should range between 1 to 2m depth		
Depth of Dead Storage	1 m	min 0.4m		
Depth of Live Storage	1 m			
Width (top)	12 m	Width (@ top of dead storage)	8	m
Length (top)	36 m	Length (@ top of dead storage)	30	m
Width (bottom)	4 m			
Length (bottom)	26 m			

Freeboard dimensions

Freeboard depth	0.3 m
Width (top)	13.2 m
Length (top)	37.5 m

Calculated Storage

Dead Storage Volume	172 m^3	PASS
Live Storage Volume	336 m^3	PASS
Total Storage Volume	508 m^3	PASS

Forebay Design

Width	12 m	= width in accordance with GD05
Depth	1 m	in accordance with GD05
Length	2 m	in accordance with GD05

Decants

Max outflow rate	3 l/sec/ha	
Max flow for each decant	4.5 l/sec	(200 holes per decant)
Number of decants required	1.38	276 holes

Emergency Spillway

Base width	3 m	3m min
Depth	0.3 m	0.3m minimum
Side slopes	3 : 1	gradient
Flow Capacity (Qw)	1.03 m^3/sec	PASS

$\mathbf{Q}_{(100)}$ Design Flows

$Q_{(100)}$ 0.376 m^3/sec

Sediment Pond Design: (in general accordance with Council GD05)

Job Name:	Mahinerangi WF		
Job Number:	240034		
Prepared by:	AR		
Reviewed by:			
Date:	04.10.2025		
Location	Conc Batch Pant		
Catchment Area	1.31	ha	
Slope of earthworks	2.5	%	Slope < 10% minimum volume of 2 % of the contributing catchment
			Slope > 10% minimum volume of 3 % of the contributing catchment
Minimum Volume of Pond	262	m^3	
Dead Storage Volume	78.6	m^3	30% of minimum volume of pond
Live Storage Volume	183.4	m^3	70% of minimum volume of pond
Shape of pond			
Inlet side slope (Spreader)	3	: 1	
General side slopes	2	: 1	2:1 typically
Length to Width ratio	3	: 1	Should range between 3:1 and 5:1
Depth of Pond	2	m	Should range between 1 to 2m depth
Depth of Dead Storage	1	m	min 0.4m
Depth of Live Storage	1	m	
Width (top)	10	m	Width (@ top of dead storage) 6 m
Length (top)	30	m	Length (@ top of dead storage) 24 m
Width (bottom)	2	m	
Length (bottom)	20	m	
Freeboard dimensions			
Freeboard depth	0.3	m	
Width (top)	11.2	m	
Length (top)	31.5	m	
Calculated Storage			
Dead Storage Volume	92	m^3	**PASS**
Live Storage Volume	222	m^3	**PASS**
Total Storage Volume	314	m^3	**PASS**
Forebay Design			
Width	10	m	= width in accordance with GD05
Depth	1	m	in accordance with GD05
Length	2	m	in accordance with GD05
Decants			
Max outflow rate	3	l/sec/ha	
Max flow for each decant	4.5	l/sec	(200 holes per decant)
Number of decants required	0.87		175 holes
Emergency Spillway			
Base width	3	m	3m min
Depth	0.3	m	0.3m minimum
Side slopes	3	: 1	gradient
Flow Capacity (Qw)	1.03	m^3/sec	**PASS**

$Q_{(100)}$ Design Flows

$Q_{(100)}$	0.238	m^3/sec

REV	DATE	ISSUE	BY
A	4.07.25	ISSUED FOR RESOURCE CONSENT	FY

PREP. BY	REVD. BY
AT	LG

APPROVED FOR ISSUE: DRAFT

RILEY www.riley.co.nz

Mercury

CLIENT	TARARUA WIND POWER LTD
ADDRESS	453 ELDORADO TRACK, WAIPORI
PROJECT	MAHINERANGI WIND FARM STAGE 2
SHEET TITLE	LEE STREAM CULVERT DIVERSION WORKS - PHASE 2

CADFILE		
240034-287-288.dwg		
SCALE (A1)	ORIG. SHEET SIZE	
1:250	A1	
DRAWING No.		REV.
240034-288		A

LEGEND

- SF — SILT FENCE
- >> — CLEAN WATER DIVERSION
- DIRTY WATER DIVERSION
- DECANTING EARTH BUND (DEB)
- DROP-OUT PIT
- U-DRAIN (PLATFORMS)
- V-DRAIN (TRACKS)
- WETLANDS
- BLANKET TYPE FILL DISPOSAL SITES

NOTES:

1. RAIN-ACTIVATED CHEMICAL TREATMENT TO BE CONSIDERED FOR SRPS AND DEB'S WHEN LOCATED WITHIN 50m OF WATER BODIES OR EARTHWORKS CATCHMENT > 1.5ha. REFER TO THE CHEMICAL TREATMENT MANAGEMENT PLAN.
2. SILT FENCES MAY BE UTILISED IN CONSTRAINED AREAS IN LIEU OF DEB AND DIVERSION BUNDS (SUBJECT TO WIND EXPOSURE).
3. FILL DISPOSAL AREAS AND GENERAL FILL BATTERS TO BE STABILISED WITH TOPSOIL AND GRASS SEED FOLLOWING FILL COMPLETION. STEEP CUT SLOPES TO BE STABILISED WITH HYDROSEED.
4. ALL E&SC DEVICES TO BE INSTALLED IN ACCORDANCE WITH GD05.

EXEMPLAR CATCHMENT - TURBINE PLATFORM

EXISTING:

AREA = 0.85ha
LENGTH = 85m
GRADIENT = 7%

PROPOSED:

AREA = 0.40ha (PLATFORM) & 0.25ha (BATTERS)
LENGTH = 78m (PLATFORM) & 27m (BATTERS)
GRADIENT = 4% (PLATFORM) & 33% (BATTERS)

*2x DEB'S INSTALLED IN ACCORDANCE WITH GD05

NOTE: ASSUME 4% AND 20% GRADE ON PLATFORM AND BATTERS DURING CONSTRUCTION FOR CALCULATIONS.

RESOURCE CONSENT

REV	DATE	ISSUE	BY
A	4.07.25	ISSUED FOR RESOURCE CONSENT	FY

PREP. BY: AT | REVD. BY: LG
APPROVED FOR ISSUE: DRAFT

RILEY www.riley.co.nz | Mercury

CLIENT	TARARUA WIND POWER LTD
ADDRESS	453 ELDORADO TRACK, WAIPORI
PROJECT	MAHINERANGI WIND FARM STAGE 2
SHEET TITLE	TYPICAL EROSION AND SEDMENT CONTROL PLAN - ACCESS TRACK AND PLATFORMS

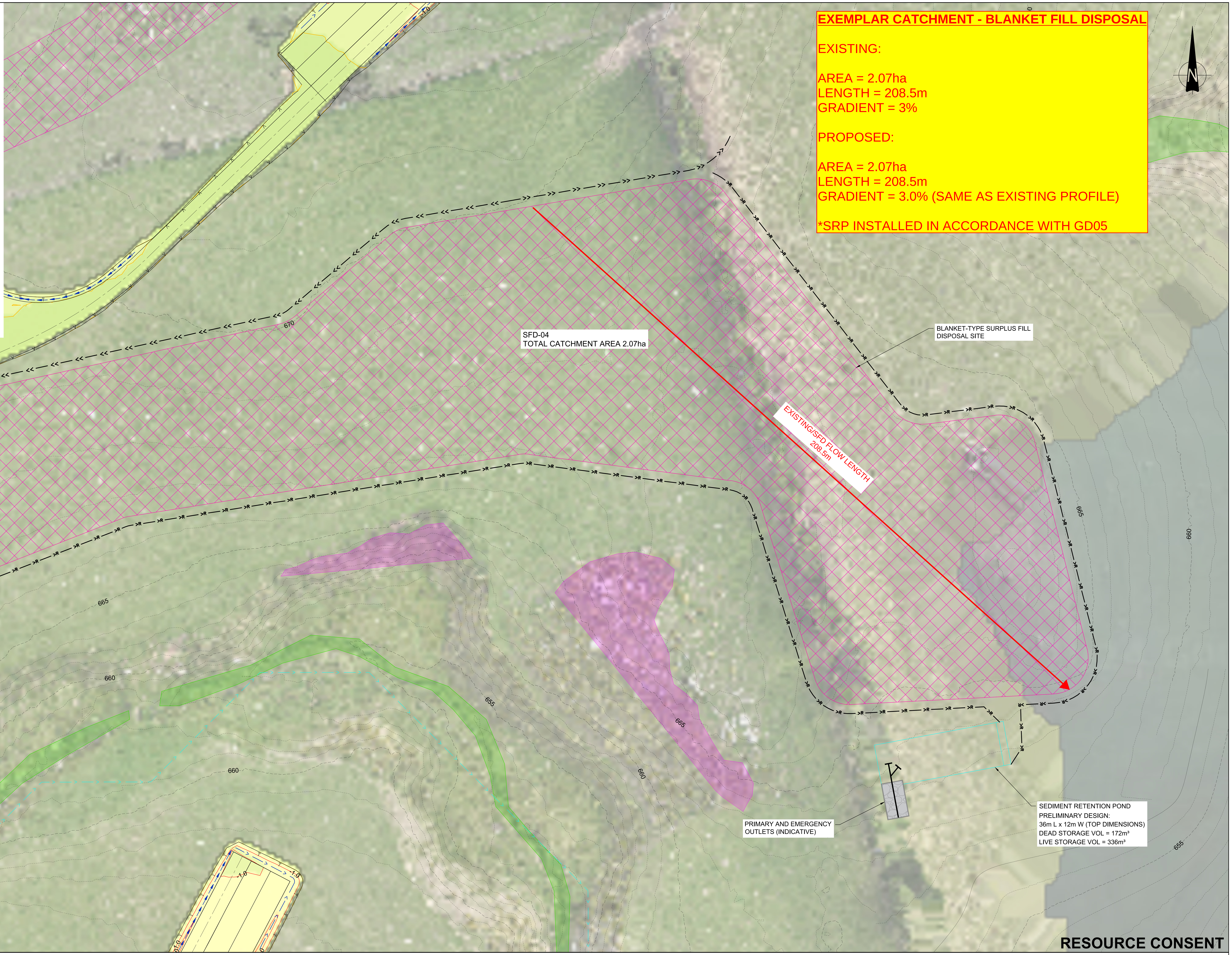
CADFILE: 240034-291-294.dwg
SCALE (A1): 1:500 | ORIG. SHEET SIZE: A1
DRAWING No.: 240034-291 | REV.: A

LEGEND

- SILT FENCE
- CLEAN WATER DIVERSION
- DIRTY WATER DIVERSION
- DECANTING EARTH BUND (DEB)
- DROP-OUT PIT
- U-DRAIN (PLATFORMS)
- V-DRAIN (TRACKS)
- WETLANDS
- BLANKET TYPE FILL DISPOSAL SITES

NOTES:

1. RAIN-ACTIVATED CHEMICAL TREATMENT TO BE CONSIDERED FOR SRPS AND DEB'S WHEN LOCATED WITHIN 50m OF WATER BODIES OR EARTHWORKS CATCHMENT > 1.5ha. REFER TO THE CHEMICAL TREATMENT MANAGEMENT PLAN.
2. SILT FENCES MAY BE UTILISED IN CONSTRAINED AREAS IN LIEU OF DEB AND DIVERSION BUNDS (SUBJECT TO WIND EXPOSURE).
3. FILL DISPOSAL AREAS AND GENERAL FILL BATTERS TO BE STABILISED WITH TOPSOIL AND GRASS SEED FOLLOWING FILL COMPLETION. STEEP CUT SLOPES TO BE STABILISED WITH HYDROSEED.
4. ALL E&SC DEVICES TO BE INSTALLED IN ACCORDANCE WITH GD05.
5. SURPLUS FILL DISPOSAL AREA SHAPES AND SIZES SHALL BE REFINED AT THE DETAILED DESIGN STAGE, WITH CONSIDERATION GIVEN TO APPROPRIATE LOCATIONS FOR SEDIMENT RETENTION PONDS OR DECANT EARTH BUNDS.



RESOURCE CONSENT

REV	DATE	ISSUE	BY
A	4.07.25	ISSUED FOR RESOURCE CONSENT	FY

PREP. BY	REVD. BY
AT	LG
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DRAFT	

RILEY www.riley.co.nz

Mercury

CLIENT	TARARUA WIND POWER LTD
ADDRESS	453 ELDORADO TRACK, WAIPORI
PROJECT	MAHINERANGI WIND FARM STAGE 2
SHEET TITLE	TYPICAL EROSION AND SEDMENT CONTROL PLAN - SURPLUS FILL DISPOSAL SITE

CADFILE	
240034-291-294.dwg	
SCALE (A1)	ORIG. SHEET SIZE
1:500	A1
DRAWING No.	REV.
240034-292	A