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11/6/18

Mr G Starr
Ventus Energy

Cc
Mr M Denize
488 Rawhiti Rd
Te Aroha

Proposed Kaimai Windfarm

Culverts along Main Access Road

Background Information

This report supersedes an earlier report (dated 6/4/18) on the same subject but with the benefit of more detailed information, along with the benefit of having a 2 – 5 yr rainstorm event occur which allowed some back analysis of the assessed storm flows previously analysed. The report remains in the same format and the subsequent findings are commented on later in the report.

The wind farm proposal involves siting 24 wind turbines as detailed on plans previously supplied. Access to all the turbine sites is via the access road to the Denize property at 488 Rawhiti Rd. The road follows a steep sided gully and stream that opens into the larger portion of the catchment on the western side of the Northern Kaimai range. The catchment is largely short grazed moderate to steep grassland with the head of the catchment fed by 3 small streams.

These types of catchments tend to have short time of concentrations, meaning the type of storm that will provide the peak flow will be a short duration with intense rainfall, the type that often occurs with thunderstorms. The critical storm in this case has been calculated at around 1 hr duration. In practice this would usually require a rainstorm event of several hours to thoroughly saturate the catchment followed by a period of intense rainfall of 25 - 35 mm within an hour

While the corresponding flood events are short and sharp, the intense rainfall runoff can be damaging causing localised erosion, the high discharge volumes are then gone quickly. In this case high stream flows in the order of the peak flow volume would last less than half an hour with the stream returning to very much lower flows largely able to be confined to channels and spillways that are able to be traversed by heavy vehicles.

Based on HIRDs rainfall statistics, and our assessment of runoff coefficients and catchment characteristics calculations of rainfall runoff have been made.

Brief and Scope of Report

The purpose of this report is to report on the adequacy of the culvert capacity for the main culverts on the access road to the windfarm. The original culverts that were assessed were located at 100, 780, 1300 and 2060m from Rawhiti Rd. There are additional culverts totalling 18 in all, with most being less than 400 mm diameter. We consider the major culverts to be the larger ones that will need to be sized appropriately and/or possibly extended for the road access works.

In the absence of any specified standard, major culverts were looked at on the basis of their adequacy in terms of a 2 – 5 yr return period storm event. This was considered to be the largest storm event that needed to be designed for. Larger events (greater than 10 Yr return period) would be expected to create significant damage to the catchment and waterway and also overtop existing culverts.

It is worth noting that all existing culverts have been installed in such a way that overflow could occur without serious problems occurring.

Flood Assessment and Discharge Calculations

The time of concentration was estimated at around 1 hr and the Bransby Williams formula confirmed this. The Rational formula was used to obtain a rough order discharge using runoff factors of 0.5 to 0.6 which was considered appropriate for the total catchment.

HIRDs depth/duration tables provided rainfall intensity based on the location of the centre of the catchment. No global warming allowance was added as this was not for future predictions, nor was the design rainfall figures considered sufficiently accurate to apply multiplying factors to.

Despite the catchment area being on the small side for a TM61 assessment (322 ha), this was carried out and gave a remarkably close agreement to the Rational method with 0.55 runoff coefficient, so the Q5 value of 16.5 m3/sec and Q2 value of 12.8 m3/sec were adopted.

A reassessment of the portions of the catchment resulted in a slightly lesser overall catchment area of 311 ha, but the overall difference is considered negligible, although a major part of the upper catchment does not discharge through the culvert at 2060 m as previously shown.
Apportioning the percentage discharge in the same proportions as to the areas (which is not absolutely correct), but was considered appropriate for the purpose of assessing the flow at each culvert site.

Flow capacity of existing culverts was assessed by using Inlet control culvert nomographs with height to overflow to determine the headwater depth.

These were as follows:

Culvert Location (m)	Size, Type	Max Capacity m3/sec	Q2 Discharge m3/sec	Q5 Discharge m3/sec
100	2x2 Box	10	12.8	16.5
250	450 Conc	0.3	0.8	1.0
780	1050 Steel	2.2	10.8	14
1300	1800&1050	11	9.8	12.7
1740	450 Conc	0.3	0.3	0.4
2060	1650 Conc	4	5.1	6.6
2260	375 Conc	0.25	0.2	0.3
2420	900 Conc	2.0	3.0	4.0

From the above chart it can be seen that a two-year event will just pass through culverts at 1300, 1740 and 2260 m with culvert 100, 2060 and 2420 m requiring moderate overflow. Culvert 250 and 780 would have substantial overflow.

The rainfall event of 3/6/18 has confirmed this (refer to photos at 250 and 780m in appendix)

The 1650 mm ø culvert at 2060m remains undersized for a two-year rainstorm event despite the catchment area being smaller than initially assessed as does the 900mm ø culvert at 2420m

The remaining 10 culverts that are currently crossing the Access Road 1 are generally small diameter i.e. mostly 375 mm diameter, and the subsequent storm overflow that occurs, and will continue to occur but is not seen as a significant issue, as any repairs are able to be carried out within a short time frame.

Design Considerations

The adoption of an appropriate standard in terms of a waterway capacity to a certain return period would seem a reasonable design approach, particularly if there was a need to have public access or service personnel get to turbine sites in all weather situations.

As there is no such brief or specification a sensible and practical approach to adopting acceptable criteria can be discussed based on the following site details:

- The site is not for Public Access
- Service personnel are unlikely to have unplanned or urgent access needs
- The existing access has been in operation for many years without problems

- The access is used for heavy vehicles on a regular basis, however the much larger and longer vehicles under current construction proposals will clearly require some easing of horizontal and vertical curves to facilitate unimpeded access.

- With axle loadings not exceeding highway limits, the short spans of box culverts (and existing culverts with appropriate backfill) would appear not to need special design. However increased road design widths will require extensions to most current culverts. Any additional fill heights over culverts will require extensions to existing culvert lengths. This will include the many smaller diameter culverts.

- Design gradients for proposed internal roads beyond the existing access are, in places, moderately steep and (like the existing access) are of gravel surface and will be subject to potential storm damage.

Considering that these types of catchments respond to high intensity short duration rainfall events, the flood waters are also gone within a short period (but often leaving damage in the form of flood debris, fallen trees washouts and slips).

The rainstorm event of 3/6/18 provided 1hr duration rainfalls of 26 mm at Te Aroha and Queens Head (near Waikino), with day totals of 72 and 92 mm respectively. The day total at the site was 95 mm, so assuming similar rainfall pattern, the site is likely to have experienced in excess of 26 mm within an hour (This being a 2 – 5 yr event at the site). The site having higher altitude than both Te Aroha and Queens head adds weight to this assumption.

Back analysis of flows over various culverts supports earlier discharge asessments.

Also

- Disruption in terms of the length of time a flood event would prevent access is very small (probably < 1Hr)

- The hazard of flood overflow on the access road is limited, as it is not a public access and all personnel involved with the wind farm can be briefed regarding the potential flood hazard.

- Heavy vehicle access is unlikely to be seriously affected unless there are slips and washouts, which is still likely to occur even with culverting to a high standard

Therefore, infrastructure such as roading and culverts constructed to high design standards to cater for events of significant return periods is hence considered questionable.

The situation is quite different for public access as is demonstrated where the same waterway crosses Rawhiti Rd (a Council Public Road) less than 200 m downstream

of the 100 culvert, the waterway capacity beneath the bridge is estimated to be capable of passing the 100 yr event*

(* this estimate was by inspection and No specific measurements or calculations were carried as it was outside the scope of this report)

Discussion and Recommendations

We believe that the existing culverts and concreted overflow spillways serve the farm access and potentially the wind farm quite adequately barring the need to improve the geometric aspects of the road.

While the capacity of the 100 m crossing (Box) is almost adequate the width is well under the proposed 6.0m carriage way and being on a mild horizontal and vertical curve necessitates an extension to this crossing. Not being a standard box unit, replacement with a 2 x 2 box culvert with the ability to overflow would seem appropriate.

The extent of overflow that occurs at culvert 250 m and 780 m during even a moderate storm event could be reduced by having much larger culverts. A larger culvert at 250m would seem appropriate. The existing concrete spillway at 780 is shaped to provide good overflow (clearly because it happens more frequently than the other crossings), and in many ways this could likely continue to operate successfully. However, the culvert itself is an old steel structure that is well corroded, and its integrity clearly relies on the rock fill and concrete overlay.

Culverts beyond this location can in our opinion be retained provided concrete spillway measures are constructed. The 900mmØ culvert at 2420 m could be extended and the raising of the road to provide a more appropriate vertical curve would allow greater heading up of the culvert and hence a higher discharge capacity would be achieved. The need for flood overflow spillway work may be necessary, otherwise a larger culvert could be considered.

Recommendations for culvert upgrading on the basis of culverts being able to (or almost able to) discharge runoff from storm events up to a 2 yr event are summarised below:

Culvert Location (m)	Size, Type	Max Capacity (m3/sec)	Q2 Discharge (m3/sec)	Required works
100	2x2 Box	10	12.8	Replace with 2 x 2 Box
250	450 Conc	0.3	0.8	Replace with 900ø
780	1050 Steel	2.2	10.8	Replace with 2 x 2 Box
1300	1800&1050	11	9.8	Leave (& fit upgraded Road)
1740	450 Conc	0.3	0.3	Extend & Construct Spillway
2060	1650 Conc	4	5.1	Construct concrete Spillway

2260	375 Conc	0.25	0.2	Extend Culv (fit road)
2420	900 Conc	2.0	3.0	Extend Culv (raise road)

While the structural aspects of the culverts and crossings are outside the scope of this report, it is recommended that the structural integrity of the culverts are at least visually checked by a structural engineer prior to the passage of large loads for the Windfarm project.

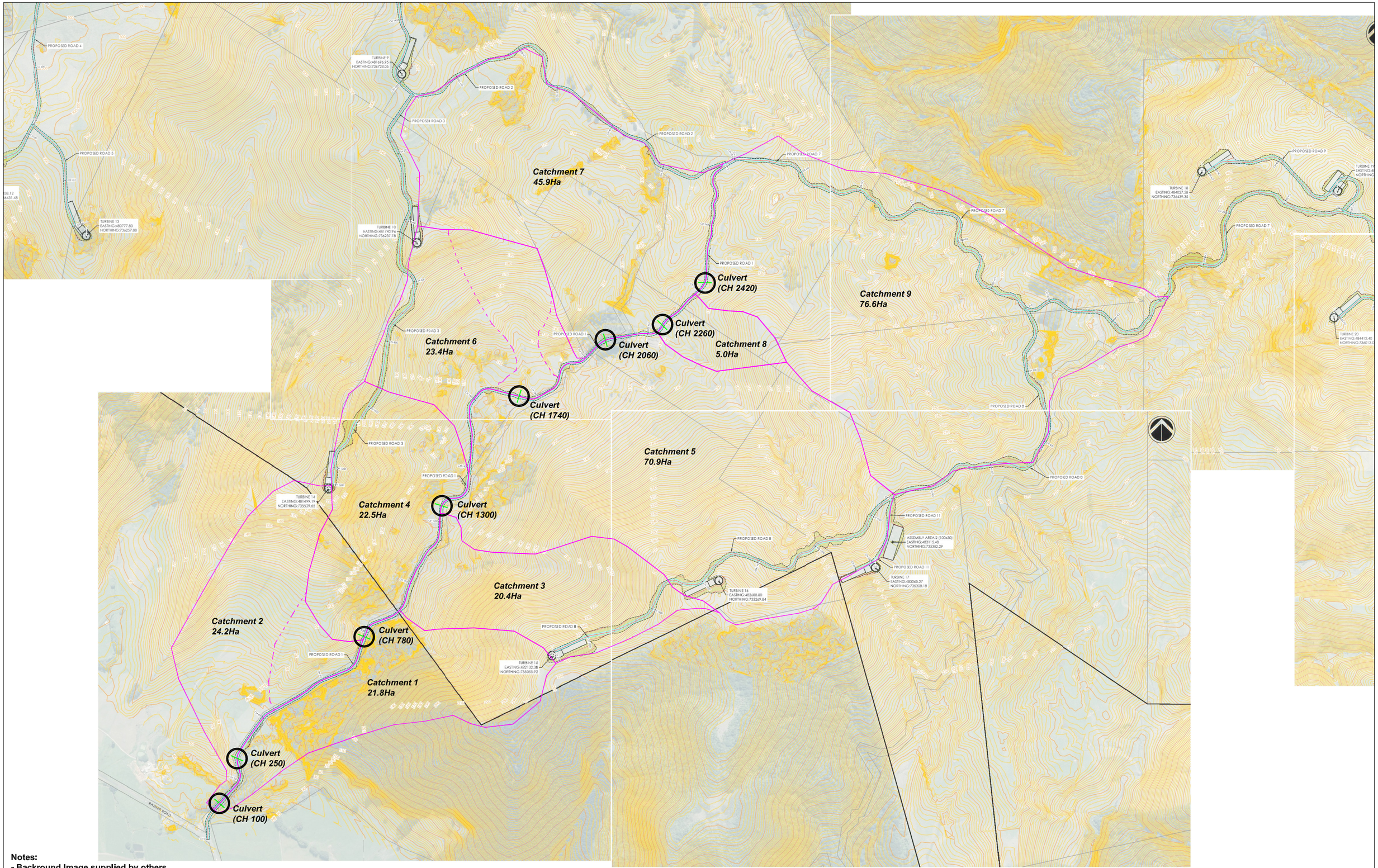
This report may be used to support resource consent application for the project.

Yours faithfully

M J Preston
Civil Engineering Services

Attachments: Photos
Calculation Summary
Culvert opening sketches
Culvert Nomographs

Footnote: An alternative access via Rotokohu Rd (Paeroa) is available should the access from Rawhiti Rd be deemed impassable.



Notes:
- Backround Image supplied by others

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	Draughted / CAD	S. LALA	06/2018	Cuvlert Catchement Details for Ventus Energy at Kaimai Wind Farm, Rotokohu Rd			Scale: 1:10000 (A3) / Drawing No. 18/1250/1/01
	Design / Proposal	M J PRESTON	06/2018				Sheet No. 01
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