Memorandum

Boffa Miskell

☐ **Auckland Fax: 64 9 359 5300**
P O Box 91250
Level 3, IBM Centre
82 Wyndham Street
Tel: 64 9 358 2526

☐ **Tauranga Fax: 64 7 571 3333**
P O Box 13373
Level 2, 116 on Cameron
Cnr Cameron Road & Wharf Street
Tel: 64 7 571 5511

☑ **Wellington Fax: 64 4 384 3089**
P O Box 11340
Level 9, Hewlett Packard Building
186-190 Willis Street
Tel: 64 4 385 9315

☐ **Christchurch Fax: 64 3 365 7539**
P O Box 110
Ground Floor
4 Hazeldean Road
Tel: 64 3 366 8891

Attention:	Roger Burra
Company:	NZ Transport Agency
Date:	12 April 2013
From:	Stephen Fuller
Message Ref:	**SH 1 Paekakariki - Fly by Wire valley investigations**
Project No:	W13022

Dear Roger

Introduction

The following memo documents our site visit and assessment of the catchments, the recommendations for future actions and associated assumptions, and ball-park costs.

I would note that, depending on the option chosen, particularly if continued grazing of all or some of the property is sought then further advice from a qualified farm management advisor should be sought.

Site Visit

The site was visited over four hours on 6 April 2013. Both gullies, Fly-by-Wire Creek and Hill Road Gully catchments, were walked, several debris trails explored to their origins, ground conditions considered, native vegetation patches visited, erosion trails and freshwater springs mapped for those areas readily accessible or visible, and a large number of photographs taken

The focus of the site visit was on the erosion trails by which we hoped to determine the source and cause of downslope movement of debris, and the likelihood of recurrence of the events of the 2003.

General observations

Our main observations were:

- Despite large visible areas of debris flows on steep slopes, these appeared to be ancient and relatively stable. Overall, there was far less mass slope failure than expected (Photos 1 & 2).
- Almost all contributing erosion was gully erosion. This was highlighted in the two reports provided (Duffil Watts & Tse Ltd 2003, and Williams 2008). However, Williams noted in his report that there had been considerable healing. Our observations were that almost all of the gullies that contained major erosion scars had been recently active and there was virtually no revegetation of these gullies. There have been several significant rainfall

events in recent months which may have caused this movement (Photos 3, 4, 9, 11, 16, and 17).

- Almost all gully erosion had as its upper slope terminus an active spring (Photos 5 and 6). We assume that the contribution of the spring was that it kept the gullies moist, even during summer, and so ensured persistent weathering and weakening of the underlying greywacke throughout the year.

- The report of Williams suggested that erosion commenced in the head of each gully. However, from a number of gullies that we climbed our read of the process was that the erosion did not commence at the head of the gully but rather in the much steeper lower slope sections. Once the initial failure had occurred erosion then 'ate' its way upslope as the stream attempted to find grade, eventually reaching the headwater spring (Photos 6, to 9).

- There was far less obvious erosion of the main stream channels than expected and the lower sections of the Fly-by-wire Gully were relatively free of debris (Photo 19). There remains, however, a significant accumulation of material in the upper sections of these streams and the discharge points of the larger eroded side gullies (Photos 9 to 12).

- The areas of native forest that have not been cleared are dominated by kohekohe, mahoe and karaka, and use of these stands for stock shelter mean there is no understorey or ground cover. Generally native forest stabilised the slopes (Photos 13 and 14), however, where the native forest had an open canopy due to stocking and die back, the erosion was able to eat upslope into the forest (Photos 15 and 16).

- Regeneration within the catchments is dominated by gorse, broom, and two native pioneer species tauhinu and *Olearia solandri*. The types of rapid growing native species that would normally succeed these pioneers (pennantia, coprosma, fivefinger, *Pittosporum*, hoheria, kanuka, marbleleaf) are largely absent from this landscape.

- Our calculations from GIS mapping are that these catchments have the following characteristics:

Name	Area (ha)	Length of Gully Erosion (m)	Area of Native Bush and advanced regeneration (ha)	Length of Bush Margin (m)
Hill Road Gully	49.5	1,858	10.9	4,400
Fly-By-Wire Gully	88.9	2,445	1.2	750
TOTAL	138.4	4,303	12.1	5,150

- The area of native bush including regenerating native scrub is approximately 12.1 ha or 9% of the total catchment area which is 138 ha. The majority of this lies in the Hill Road catchment. The Fly-by-wire catchment has only a tiny fragment of native forest and where there is shrubby regeneration it is mostly gorse.

Soil Conservation Research

The Soil Conservation Technical Handbook (Anthony and Hicks, 2001) provides a comprehensive summary of practical soil erosion prevention and rehabilitation techniques for different types of erosion in New Zealand. In summary it identifies common soil conservation practices and benefits as follows:

- Spaced or close tree planting on hill slopes and stream banks
- Retiring erosion-prone land from pasture (scrub and indigenous forest reversion)
- Fencing gullies and waterways to prevent stock access, and fencing off erosion prone land for targeted management
- Pasture (e.g. over-sowing and species selection) and grazing management
- Earthworks and structures to slow runoff (e.g. terracing, debris dams, and suitable drainage)

This and other authors identify the benefits and costs of these options. Those that I consider here are poplar and native regeneration / revegetation.

Poplar

Poplar species are commonly used for controlling soil slip and gully erosion, and can be planted in the presence of livestock (typically using pole protectors during the initial years of growth) and on wetter soils.

For the type of gully erosion in permanent and ephemeral streams that needs to be managed here, pair-planting is a method often used. Willows or poplars are planted in one to two rows about 2–3 metres apart on each side of the gully floor and at 10 m to 15 m spacing down the gully. In time their roots create a damming effect which slows the water flow, stabilises the gully sides, and allows other plants to re-grow.

Poplars are fast growing and their root systems develop rapidly. Benefit begins at 5 or 6 years of age with straight line improvements from 10 years of age reaching erosion reductions of 75% at 20 years (Parminter et.al. 2001). McIvor et al 2011 notes the link between pole size (1m wand or stake, 1.5m sheep pole, 2.5 to 3m cattle pole) and plant spacing. His calculations were that poplar trees with a dbh of >30 cm will stabilise soil within 10m of the trunk. This size can be achieved in 9 to 13 years by sheep poles depending on site characteristics.

Poplar reduces the total area of productive pasture with implications for pasture productivity, plant spacing and tree management. Poplars also require timely management including thinning and pruning. However, poplar has additional potential uses such as supplementary stock fodder during periods of drought and the provision of shade and wind shelter for stock.

Natives

Native plants have relatively slow growth rates compared to exotic species, and thus have an initial disadvantage for stabilising eroded sub-soils. Despite this slow start, native species can be effective for erosion control, and in the long term have the same strengths as poplars and require no long term maintenance. For instance, Bergin et al. (1995) evaluated shallow landslide damage under regenerating scrub (i.e. manuka and kanuka) on East Coast hill country compared to pasture, and found a reduction in landslide damage of 65% under 10 year old stands increasing to 90% under 20 year old stands.

These figures suggest poplar begins showing benefit in half the time of native bush, but that at 20 years erosion reductions under native bush can match that of poplar (subject to site conditions). However, on the kind of landform we are considering here, natural regeneration is unlikely to provide these benefits in a reasonable timeframe due to the harshness of the environment and lack of seed sources of the types of species needed. Active revegetation would be needed to achieve rapid benefit and mass planting by natives is considerably more expensive than the planting of exotics.

Discussion

We suggest there are four options for this site in increasing order of cost and effectiveness.

1. **Planting of erosion prone gullies and headwaters with a species such as poplar.** We see this as the minimum requirement for managing gully erosion. It will not provide as much erosion control as full revegetation with natives in the long term, but it will provide considerable benefit and in half the time it would take for natives to establish the same level of protection and with much lower cost. This option allows the land to continue to be farmed, but it requires ongoing poplar management and stock protection of poles. There is unlikely to be a long term economic return from these trees for the landowner and there will be a loss of productive pasture. Some farmers see this as a loss; others see the other benefits making up for this loss. Either way, you will be reliant on the future landowner to continue to maintain the poplar plantings through thinning and pollarding. An option is to provide an annual grant to ensure this work is carried out. The attached map shows the locations of current active erosion where this would be applied.

2. **Plant erosion prone gullies and headwaters with poplar, and interplant with native species.** We believe this would provide additional long term benefit and would over time reduce the need to manage poplar. It would, however, require fencing and destocking of these gullies to provide a minimum 20 m wide planted corridor (10m either side of the erosion channel. In 20 years a native canopy would be established and the level of protection will increase to about 40 years. There would be a need for control of rabbits and hares for the initial years of plant establishment. This is factored into the per-hectare cost. Ongoing management could reduce after initial planting to annual possum control.

3. **Plant erosion prone gullies and headwaters with poplar and, retire surrounding sub-catchments to encourage allow natural regeneration.** Retirement of the wider catchments is not required for erosion control; however, it may be that areas of the farm are not considered economically viable or it may be decided that fencing the individual gullies in some locations is too difficult and retiring and fencing some sub-catchments is more cost effective. In either of these scenarios natural regeneration will occur rapidly but would need to be supported by some enrichment planting to return key species to the successions. Logically this supplementary planting would occur in moist gully headwaters and on the valley floors where good growth would be guaranteed.

4. **Fence Native Forest.** The few fragments of native forests are currently used as shelter for stock. In areas intense grazing of the understorey has resulted in die back and allowed erosion into and through the stands. If under Option 1 and 2 above, the valley were to continue to be farmed, fencing of these forests would allow them to thicken, margins and understorey to form, and would ensure ongoing erosion control. These forests will also provide a seed source for any native regeneration that is allowed or encouraged. The loss of this bush as stock shelter would be compensated by the planting of poplars. The area we recommend be fenced and retired under this option is shown on the attached Map, and is in the order of 12 ha.

Cost

The likely ball park costs associated with the recommended reforestation strategies are:

Option 1: Poplar poles only

Pricing for this varies widely depending on source. Recent pricing we have sourced gives a combined in-the-ground price for a pole of $17.25 (including the 1.7 m high pole, pole protector, and labour). However, a recent Taranaki Regional Council brochure suggests it could be as low as $9.25 per stem planted. Other documents provide a per hectare rate assume different levels of cover. For example $175/ha at 20% cover (Parminter et al 2001).

We assume a targeted planning scenario where only the erosion-prone gullies are pair planted, two rows of trees are planted either side of each gully at a spacing of 5 metres across the gully and 10m down the gully, and the total length of gully requiring planting we estimate at 4,300 m.

- At the higher price of $17.25 per pole the total cost for targeted planting would be in the order of $30k

  ($12.8k for Hill Road Gully, and $16.8k for Fly-by-Wire Gully).

- Using the cheaper rate of $9.25 we get a total cost in the order of $16k

  ($7k for Hill Road Gully, and $9k for Fly-by-Wire Gully).

- For this option no fencing is required. There will be a small reduction in productive pasture, perhaps in the order of 10% but no land needs to be retired.

Option 2: Poplar poles and native planting

Native revegetation is considerably more expensive than poplar poles, depending on species and spacing mass planting we estimate the cost of mass planting natives will be in the order of $30 to $50 k per ha (we note mass planting for some projects around Wellington can reach as high as $120k per hectare but this tends to be planting of a different scale and purpose).

For this option fencing costs are quite high as narrow strips up gullies would need to be fenced and we estimate 8.6 km would be needed. Fencing costs are generally in the order of $10 to $15 per metre.

We assume a targeted planning scenario where only the erosion-prone gullies are planted, native plants are placed at 1 metre spacing's, 10 m to either side of each gully scar over an area of 8.6 ha (4,300 m x 20m).

- At the rates above the cost of native plants would be in the order of $258k to $430k.

  (@ $30k/ha this equates to $112k for Hill Road Gully; $146k for Fly-by-Wire Gully).
  (@ $50k/ha this equates to $186k for Hill Road Gully; $244k for Fly-by-Wire Gully).

- Poplar planting would still be required at between $16k and $30k as for Option 1.

- Fencing costs would be in the order of $86k (@$10/m) to $130k (@$15/m).

  (@ $10/m this equates to $37k for Hill Road Gully; $49k for Fly-by-Wire Gully)
  (@ $15/m this equates to $56k for Hill Road Gully; $73k for Fly-by-Wire Gully).

- The area of retired farmland will be in the order of 8.6 ha

  (3.7ha for Hill Road Gully; 4.9ha for Fly-by-Wire Gully)

Option 3: Poplar poles with land retirement and regeneration

Assuming poplars are planting in each erosion-prone gully and the surrounding hillsides are retired this option only requires supplementary planting of a standard selection of hardy natives in key locations to provide seed sources for regeneration. We estimate a total area of approximately 4.5 ha or roughly half the area of Option 2.

- Poplar planting would still be required at between $16k and $30k as for option 1.
- At the rates above the cost of native plants would be in the order of $120k to $200k, 40% of which would be in Hill Road Gully, 60% in Fly-by-Wire Gully
- We assume existing ridgeline fencing would be sufficient for this option, though some maintenance is required to bring these fences up to standard.
- Decisions over the area of land potentially affected would need some advice from a fencing contractor and farm management consultant.

Option 4: Fence native forest

If, under options 1 & 2 above, the land continues to be farmed we recommend fencing the small remaining stands native forest. We estimate approximately 5 km of fencing will be required.

- The total cost of fencing would be in the order of $52k at $10 per linear metre, up to $77k at $15 per linear metre.

  (@ $10/m this equates to $44k for Hill Road Gully; $7.5k for Fly-by-Wire Gully)
  (@ $15/m this equates to $66k for Hill Road Gully; $11.2k for Fly-by-Wire Gully).

- The total area of retired farmland will be in the order of 12 ha.

  (10.9 ha for Hill Road Gully; 1.2ha for Fly-by-Wire Gully)

Affect on Land Value

In providing the above options for your consideration we have not considered the effect of each on the value of the land for potential purchasers as this is outside our area of expertise. If NZTA requires this information we recommend that the advice of a qualified farm management consultant be sought to determine the impact of these options on land productivity and potential future price of the farms.

Boffa Miskell Ltd

Stephen Fuller

Director / Ecologist, BOFFA MISKELL
Telephone: 04 385 5798 (ddi) or 0272 225 741 (mobile)
or email stephen.fuller@boffamiskell.co.nz

References

NZ Ministry of Works (MOW). Water and Soil Conservation Centre. (1986): "Plant materials handbook for soil conservation : volume 2, introduced plants." Water & soil miscellaneous publication, no. 94. Wellington : Water and Soil Conservation Authority. W 11.0 PLA (2 copies) A 11.0 PLA ; C 11.0 PLA (2 copies, 1 in Ivan Jamieson).

I. Parminter, M.B. Dodd, and A.D. Mackay. 2001: Economic analysis of poplar planting on steep hill country. Proceedings of the New Zealand Grassland Association 63: 127–130 (2001).

I. R. McIvor, G. B. Douglas, J. Dymond, G. Eyles, and M. Marden: 2011: Pastoral hill slope erosion in New Zealand and the role of poplar and willow trees in its reduction. In "Soil Erosion Issues in Agriculture", edited by D. Godone and S. Stanchi, ISBN 978-953-307-435-1.

Taranaki Regional Council Sustainable Lands Management Programme Brochures.

“Pole planting what are the benefits?”

“Pole planting - general principles and practices”

“Pole planting – maintenance.”

Photos

Photo 1: Debris flows on steep slopes. These appeared to be ancient and relatively stable.

Photo 2: Small midslope failures like this are relatively uncommon.

Photo 3: Active and gully erosion in Fly-by-wire gully.

Photo 4: Stabilising gully erosion in Hill Road Gully.

Photo 5: Freshwater spring and rushland at the top of a major zone of gully erosion.

Photo 6: Freshwater spring in a gully head. Gully erosion creeping upslope toward the spring from bottom right.

Photo 7: One of the larger erosion scars in Hill Road Gully. There has been some stabilisation by native shrubs but areas of continuing failure are also present.

Photo 8: The upper extent of gully erosion shown in the previous photo.

Photo 9: Significant accumulation of mobile material in the upper sections of Hill Road Gully with continuing gully erosion occurring.

Photo 10: Significant accumulation of mobile material in the upper sections of Fly-by-wire Gully.

Photo 11: Accumulation of mobile material in the upper sections of Fly-by-wire Gully.

Photo 12: Gravel fan at the bottom of an eroding gully in the upper sections of Fly-by-wire Gully.

Photo 13: Some minor erosion of a gully in native forest in Hill Road Gully.

Photo 14: Looking upslope as for above photo

Photo 15: Unstable gully erosion that has extended upslope into heavily grazed native forest.

Photo 16: Looking upslope into forest in previous photo.

Photo 17: Looking downslope from previous photo.

Photo 18: Debris collector at the bottom of Hill Road Gully

Photo 19: The forested gorge in Fly-By-Wire Gully.

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1:6,000 @ A3

Data Sources:

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

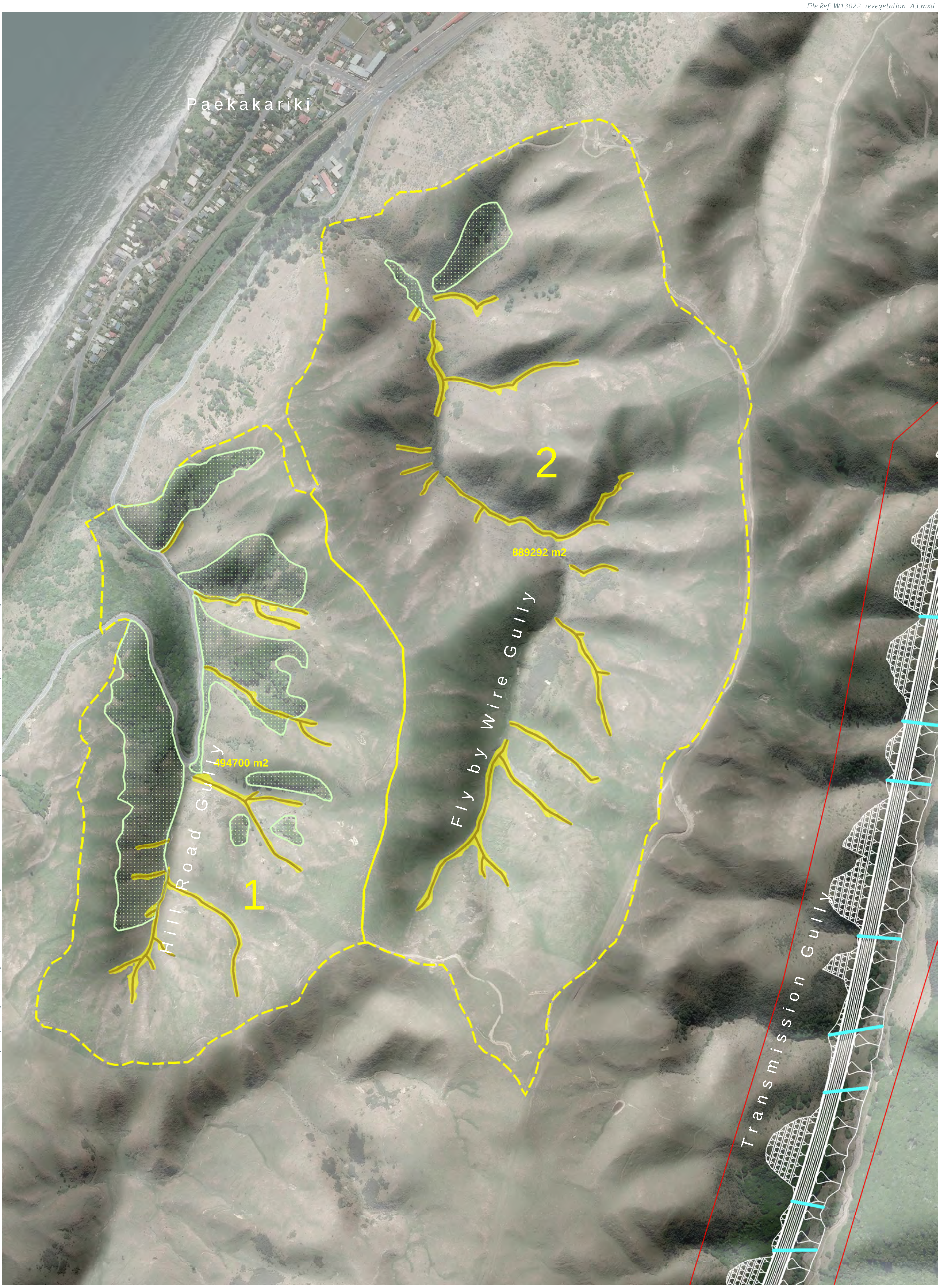
- Carriageway/Earthworks
- Designation
- Culverts
- Catchment Boundary

NZTA Paekakariki Streams

Locality Map

Date: 15 April 2013 | Revision: 0

Plan Prepared for NZTA by Boffa Miskell Limited



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0 200 m
1:6,000 @ A3

Data Sources:

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

- Catchment Boundary
- Gully Erosion Scars to Plant
- Native Bush to Retire
- Carriageway/Earthworks
- Designation
- Culverts

NZTA Paekakariki Streams

Revegetation and Retirement

Date: 15 April 2013 | Revision: 0

Plan Prepared for NZTA by Boffa Miskell Limited