PEACOCK D H LIMITED

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PAOARUKU STREAM MEAN BED LEVEL TRENDS; 1958 TO 2016.

1.0 Introduction:

This is the last of a series of reports on river/stream bed level trends in the Waiapu catchment, Ruatoria, commissioned by the Environmental section and the (former) Roading section of the Gisborne District Council.

The following trends in mean bed levels have been derived from cross section surveys by the former East Cape Catchment Board and the Gisborne District Council, commencing in 1958.
"*Mean bed levels*" has a specific meaning in relation to braided rivers on the east coast, and a full definition is provided in the Addendum.

Cross section surveys are only a "snapshot" of the river bed levels at a specific location on a particular day. Because of the movement of bed load material in "waves" during floods and freshes, there are frequent naturally occurring fluctuations in mean bed levels. There is available data from only one cross section on this stream, which limits the interpretation of bed level trends. While long term trends in mean bed levels are reasonably reliable indicators of bed level change, shorter term trends (ie; from surveys over ten years or less) are not reliable and it would be unwise to rely on these surveys alone.

2.0 The Paoaruku Stream catchment:

The Paoaruku Stream is in a very small catchment (7.5 square kilometres) situated between the Mangaoporo and Poroporo River catchments, and 2.9 kms north-east along SH35 from the Mangaoporo River bridge; see Figure 1.
The Paoaruku Stream, including its upper tributary the Totara Stream, is a total 5.2 kilometres in length. The Totara stream is very steeply graded, with the headwater ridge, including the peak Ouewheki at an elevation of 467m.

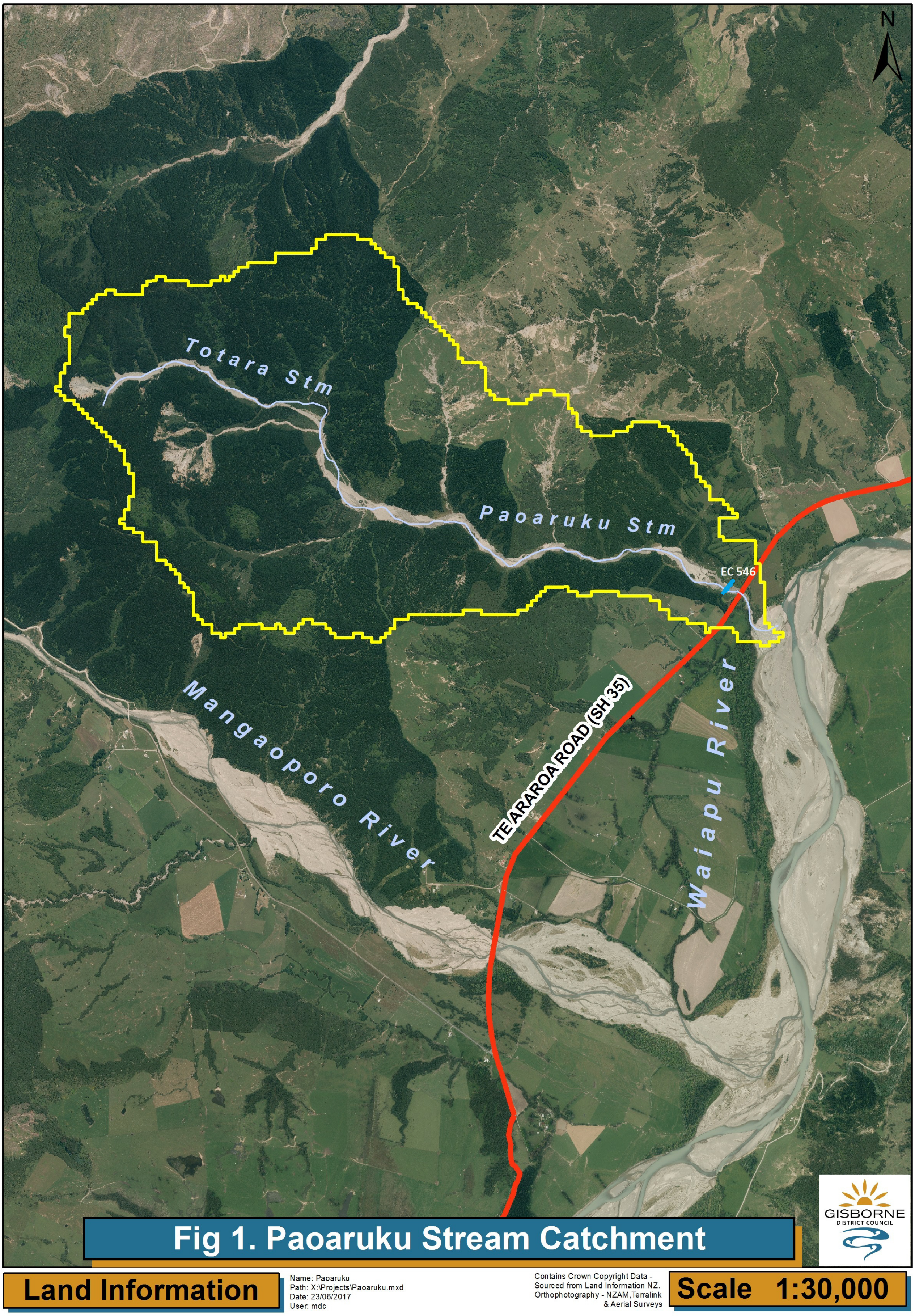

Fig 1. Paoaruku Stream Catchment

3.0 Executive Summary:

For its size this small catchment contains one of the highest concentration of gullies mapped anywhere in this region.

Unfortunately there is available data from only one cross section, which limits the interpretation of bed level trends. What has been established however, for the only cross section (just upstream of the SH35 bridge), is that between 1958 and 1970 the stream has been degrading at, an average rate of 69 mm/year, followed by an 18 year period of aggradation from 1970 to 1988, averaging a rapid 150 mm/year. Since then mean bed levels have fluctuated, but with the 2016 mean bed level virtually the same as in 1988. Since 1988 mean bed levels at EC546 have been at least 2.5 metres above the mean bed level in 1970.

Although reforestation has yet to make a significant difference in reducing the rate of sediment generation, the post-2003 lowering of the mean bed level can be attributed to reforestation and the recolonising of gully heads by indigenous reversion which has progressively 'shut-down' the gullies and reduced the sediment supply from the many smaller gullies.

However there are still several major gullies in the headwater reaches that have remained active plus developing gullies within two un-forested pastured sub-catchments in the lower reaches. Reforestation of these sub-catchments would prevent these gullies from enlarging further and would in time reduce the amount of sediment entering the main channel.

4.0 River bed load material grading:

The river bed visible in Figure 2 is upstream of the SH35 bridge, and in the vicinity of EC546. The stream traverses lithologies comprising the Whakai Formation, producing fine-grained sediments with high attrition rates.
Dr M Marden has provided a full description of the lithology that the stream transverses in item 5 of the Addendum.

Fig. 2: Paoaruku River bed upstream of SH35 Bridge.
Photo: D Peacock, 17th October 2017.

Fig. 3: Upstream side of SH35 Bridge; Sandy Gorringe in front of pier.
Photo: D Peacock, 17th October 2017.

It is likely that mean bed levels at EC546, which is only 106 metres upstream of the SH35 bridge, have been raised by the confining effect of this bridge; see Fig. 3.

5.0 Paoaruku Stream Mean Bed Levels:

Figure 4 below, shows mean bed levels for the Paoaruku Steam at the only cross section, EC546, 106 metres upstream of the SH35 bridge; see also Fig 1.

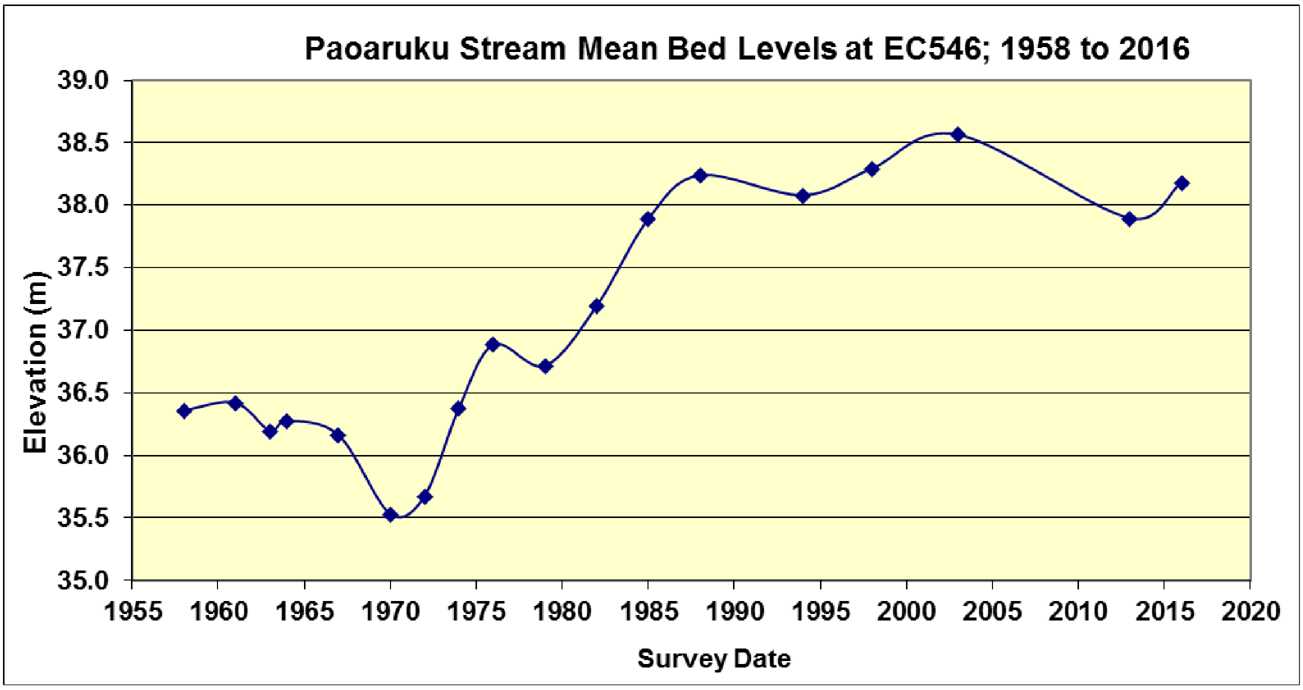

Fig. 4.

Between 1958 and 1970 the stream has been degrading at an average rate of 69 mm/year, followed by an 18 year period of aggradation from 1970 to 1988, averaging a rapid 150 mm/year. During this 18 year period there has been a short period of degradation between 1976 and 1979.

Dr M Marden has commented as follows; *"As reforestation of these gullies didn't occur until late into the 1990s-early 2000s (exact planting date unknown) the gullies enlarged considerably prior to being planted and were the principle source of sediment throughout the period 1970-2003";* see Fig. 5…… *"During this time the ongoing excessive amounts of sediment generated by these gullies eventually exceeded the storage capacity of the upper channel reaches and thus more sediment was transported to the lower reaches resulting in the rapid rise in mean bed level at the measured cross-section".*

From 1988 (post-Bola), mean bed levels have moved up and down up to 500 mm, with the 2016 mean bed level virtually the same as the 1988 level. Dr M Marden has commented as follows; *"Although reforestation has yet to make a significant difference in reducing the rate of sediment generation, the post-2003 lowering of the mean bed level can be attributed to reforestation and the recolonising of gully heads by indigenous reversion which has progressively 'shut-down' the gullies and reduced the sediment supply from the many smaller gullies. With increasing tree age there will likely be a change in the hydrology of the catchment as a whole. As the forest ages, interception of rainfall by the tree canopy will increase and as a consequence runoff, and ultimately streamflow will decrease. With a reduction in stream flow, the sediment carrying capacity of the stream also decreases thus less sediment is likely to be transported as bedload to the lower reaches. Thus, long term, and barring any major storm events, the trend in mean bed level should be one of degradation. However there are still several major gullies in the headwater reaches that have remained active plus developing gullies within two un-forested pastured sub-catchments in the lower reaches.*

The gullies in the pastured sub-catchments have increased in size and are currently generating sediment that feeds into the main channel upstream of the measured section thus accounting for the increase in mean bed level since 2013. Reforestation of these sub-catchments would prevent these gullies from enlarging further and would in time reduce the amount of sediment entering the main channel".

Fig. 5: *Headwater gullies and Totara Stream; Oct. 2014.*

6.0 Conclusions:

- There are still several major gullies in the headwater reaches that have remained active plus developing gullies within two un-forested pastured sub-catchments in the lower reaches.
- Reforestation of these sub-catchments would prevent these gullies from enlarging further and would in time reduce the amount of sediment entering the main channel.
- Because of the fine grain size and poor quality of the bed load material, no shingle has been extracted here for commercial purposes in the past (according to GDC records since 2001);
- While it is most unlikely that shingle will be extracted from this stream in the future, the cross section surveys will provide a useful record of the impact of future storms or changes to the catchment land use;
- Whilst the long term mean bed level trends are reasonably accurate, shorter term trends ie; over 10 years or less, are not considered as reliable.

9.0 Recommendations:
It is recommended that:

1. Cross section surveys are carried out in the future at the same sites at two yearly intervals**;**

NB: *This recommendation should be subject to further review when survey methods using the latest available technology; ie drone surveys and DEM's, have been appraised for use on all of the Waiapu catchment rivers.*

Acknowledgements:

- Ian Hughes and Brian Currie; for providing a continuous high quality survey record for the past 59 years;
- Mark Cockburn for the preparation of Figure 1;
- Dr. M Marden, for comments on the effect of reforestation, and for item 5 in the addendum.
- Paul Murphy for checking and commenting on the draft reports;
- Dr. J Tunnicliffe, Environmental Science Dept; University of Auckland; for preparation of items 1 to 3 in the addendum;

Prepared by:
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30th June 2017**;**
Updated 4th December 2017.

ADDENDUM

The following definitions and explanations have been provided to clarify the terms used in this report. Items 1 & 2 have been kindly provided by Dr Jon Tunicliffe; while item 5 has been prepared by Dr Mike Marden.

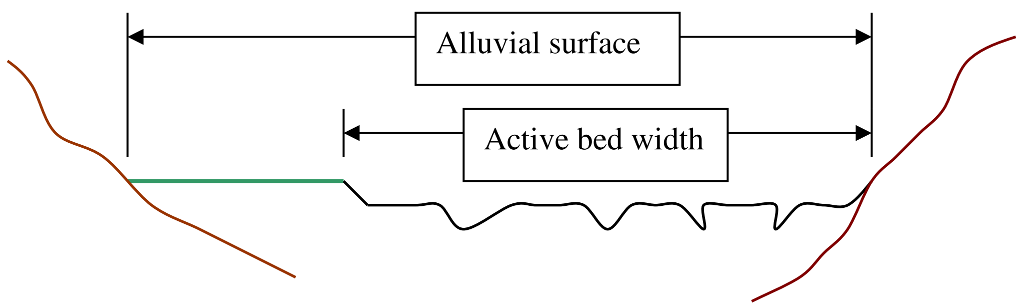
1. Mean river bed level:

"In the context of actively braiding or anabranching rivers found in the East Cape, ***mean river bed level*** refers to the average topographic elevation across multiple channels (including bed and banks) and the actively reworked (non-vegetated) alluvial surfaces, such as bars and braidplains. Changes to the mean bed elevation across this active transport corridor reflects adjustments to reach-wide sediment storage over time.

2. Reach:

A ***reach*** is length of river, typically constituting several meander wavelengths, with relatively homogenous governing conditions, e.g. discharge, channel geometry and floodplain extent."

3. Alluvial surface and active bed width:



The above diagram (not to scale), shows the ***alluvial surface*** for a braided river bed and the ***active bed width*** as measured by the cross section surveys. The green coloured terrace on the left of the diagram represents a terrace with vegetation at least one year old which is no longer considered to be part of the active river bed. ***Mean bed levels*** are computed for each cross section from the mean of all the levels taken within the active bed width.

4. Aggradation rates chart:

The following chart applies only to rivers/streams in the Waiapu catchment or the upper Waipaoa catchment.

Aggradation Rate mm/yr	**Descriptive term**
0 to 9	Negligible
10 to 29	Gradual
30 to 99	Moderate
100 to 199	Rapid
200 to 499	Very rapid
>500	Extreme

5. Paoaruku catchment lithologies:

The following explanation has been kindly prepared by Dr M Marden, Landcare Research, Gisborne:

In its lower reaches this approximately eastwards-draining stream traverses lithologies comprising the Whakai Formation. These consist of mainly massive mudstone and tuff and well-bedded tuffaceous sandstone and mudstone. Minor lithologies include oyster-rich limestone, muddy limestones, breccia conglomerate and metre-thick beds of igneous pebble conglomerate. At the point where the channel is aligned approximately NW-SE it is aligned along a thin belt of mélange which is fault-bounded with the Whakai Formation to the east and the Whangai and Tapuaeroa Formations to the west. The upper catchment drains these two latter formations which are mudstone-dominated with minor amounts of sandstone, breccia and conglomerate.

For its size this small catchment contains one of the highest concentration of gullies mapped anywhere in this region. Early photography shows that substantial volumes of sediment have been generated from these gullies with much of the material being stored as bedload within the upper reaches to form extensive areas of alluvial terrace and fan infill within the valley floor, particularly at the confluences of each sub-catchment. As with other catchments draining similarly fine-grained sediment with a high attrition rate, most of the sediment generated early in the piece was stored close to source and that which exited the catchment was as suspended sediment. With little storage occurring in the lower reaches it is possible that sediment starvation at times caused this stream to temporarily degrade at the measured section. Although unproven, these periods of degradation may coincide with, but be a delayed response to times between storm events when low flows are unable to mobilise material from the upper to the lower reaches. A review of the history of rainfall/storm events would confirm or refute this interpretation.