PEACOCK D H LIMITED

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WAIAPU RIVER MEAN BED LEVEL TRENDS; 1958 TO 2017

1.0 Introduction:

This is one of a series of reports on river 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. Trends have been assessed starting at the most upstream cross section, a short distance downstream of the SH35 bridge at Ruatoria. "*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. While long term trends in mean bed levels are reasonably reliable indicators of bed level change, shorter term trends (i.e. from surveys over ten years or less) are not reliable and it would be unwise to rely on these surveys alone.

2.0 The Waiapu River and catchment:

The Waiapu River catchment, Figure 2, covers some 1730 square kilometres, second only in area to the Waipaoa River catchment within the Gisborne District. The Waiapu River, Figure 3, extends some 25 kilometres from the sea to where it branches into its two main tributaries, the Mata and the Tapuaeroa rivers, 1.5 kilometres upstream of the SH35 bridge at Ruatoria.

The Waiapu River is a very powerful river with a relatively steep profile even in its lower reaches close to the sea. The author understands that in te reo maori "Waiapu" means to "gobble up", and it is known that this river has drowned a number of people who have tried to cross it by wading in pre-European days. It has also "gobbled up" land by erosion of the banks, a recent example being the loss of part of SH35 at Turitaka, near Tikitiki; see Figure 1.

Fig.1: *Erosion of SH35, Turitaka. Photo: D Peacock; 25th September 2013.*

3.0 Executive Summary:

The aggradation of the upper Waiapu River and tributaries is a recent phenomenon geologically speaking, and has only occurred since deforestation of much of the catchment in the late 19th and early 20th centuries. Surprisingly to the casual observer, the long-term trend (in a geological timeframe) has been degradation, which is in response to tectonic uplift. The Waiapu River has responded to this ongoing uplift of the land by downcutting, viz; degrading.

A plot of the present profile of the Waiapu River bed shows how very steep the gradient is in the lower reaches. The bed gradient only five kilometres from the river mouth is about 2.6 m/km, By comparison, the Waipaoa River bed does not reach this grade until some 65 to 70 kilometres from the mouth. This is because the uplift rate is higher in the north of the region that it is in the south of the region. The lower reaches of the Waipaoa River (Poverty Bay flats) are in fact subsiding.

The mean bed level data derived from the Waiapu River cross section surveys has relatively long temporal and spatial gaps as well as the effects of large scale shingle extraction works, which has made it difficult to obtain a comprehensive picture of the overall mean bed level trends.

Mean bed level plots for the two most upstream cross sections (EC538 and EC539) show “gradual” average aggradation rates over the 57 year period (1958 to 2015) of 17 to 18 mm/year. The great majority of the shingle excavated from the river is in the vicinity of EC539, which has had a localised influence on mean bed levels at these sites, but the natural fluctuations in mean bed levels has masked these effects.

The mean bed level data from EC536 effectively “integrates” the upstream effects of the shingle extraction and the input of bed load from the Mangaoporo River, and shows relatively steady mean bed levels over the past 40 years;

Mean bed level plots for the two most downstream cross sections (EC533 and EC534) also show a distinct similarity with both degrading at a gradual rate over the full 57 year period, but remaining steady or aggrading slightly over the past thirty years. This gradual degradation is more in keeping with the (geological) long term degradation of this river bed.

The volume of shingle excavated from the river over the past 15 years (2001 to 2015) averages 38,300 m^3/year. This is a large annual excavation rate, comparable to the rate of excavation for the lower Mata River.

Although the survey data is rather incomplete, this river is of such importance to local iwi and also for research purposes that continued monitoring (with some improvements) has been recommended.

Fig 2. Waiapu River Catchment

Land Information

Name: waiapu
Path: X:\Projects\waiapu.mxd
Date: 31/03/2017
User: mdc

Contains Crown Copyright Data -
Sourced from Land Information NZ.
Orthophotography - NZAM, Terralink & Aerial Surveys

Scale 1:225,000

4.0 Waiapu River bed profiles:

Figure 4 shows the Waiapu River bed profiles for 1958 and 2015. This curve is slightly convex near the downstream end, and then concave upwards upstream of EC535 (10,330m). Note that EC535 is not shown in Figure 3 having been destroyed, the last survey being in 1986.

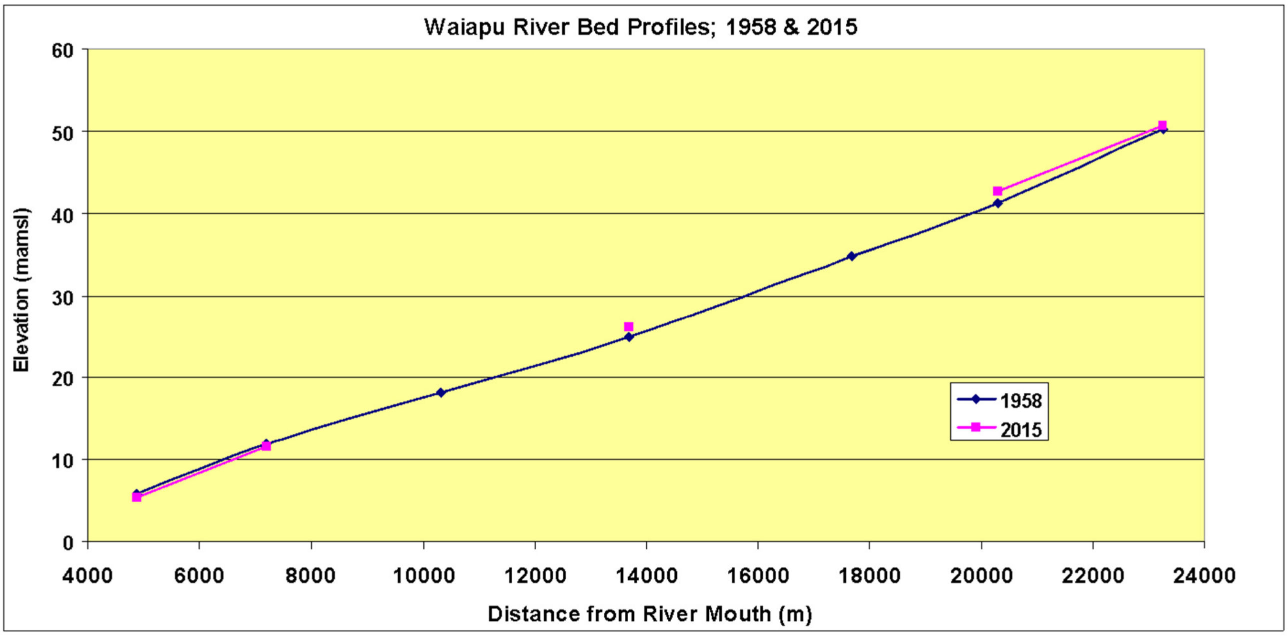

Fig. 4.

This anomaly in the bed gradient may be due to the lack of survey control between bench marks when they were originally established. However, even if the bed gradient between EC533 and 534 (2.61m/km as surveyed in 2015) is only approximately correct, it is unusually steep so close to the mouth. Bed gradients in the Waipaoa River, the other major river in the Gisborne district, are an order of magnitude less than this so close to the sea, and the Waipaoa River bed does not reach this grade until some 65 to 70 kilometres from the mouth.

In geological time scales the long term trend for the Waiapu River has been described by Dr M Marden as follows:
"The long-term trend (since before and including the period called the Last Glacial Maximum i.e. ~15000 years ago) has been degradation in response to tectonic uplift. The uplift rate near the crest of the Raukumara Range of about 4mm/year (Yoshikawa 1988, Litchfield and Berryman 2007) is higher. The lower reaches (Poverty Bay flats) of the Waipaoa are in fact subsiding so there has been greater capacity for storing sediment, whereas for the Waiapu much of the sediment is exiting the catchment".

The short term (approx. 10 year), and long term (up to 125,000 years), coastal uplift rates for the Waiapu River in the vicinity of Ruatoria are both 1.6 mm/year; (Beavan and Lichfield 2012). The river has responded to this ongoing uplift of the land by downcutting i.e. degrading. The aggradation of the upper Waiapu River and tributaries is a recent phenomenon geologically speaking, and has only occurred since deforestation of much of the catchment in the late 19th and early 20th centuries.

5.0 Mean bed level plots:

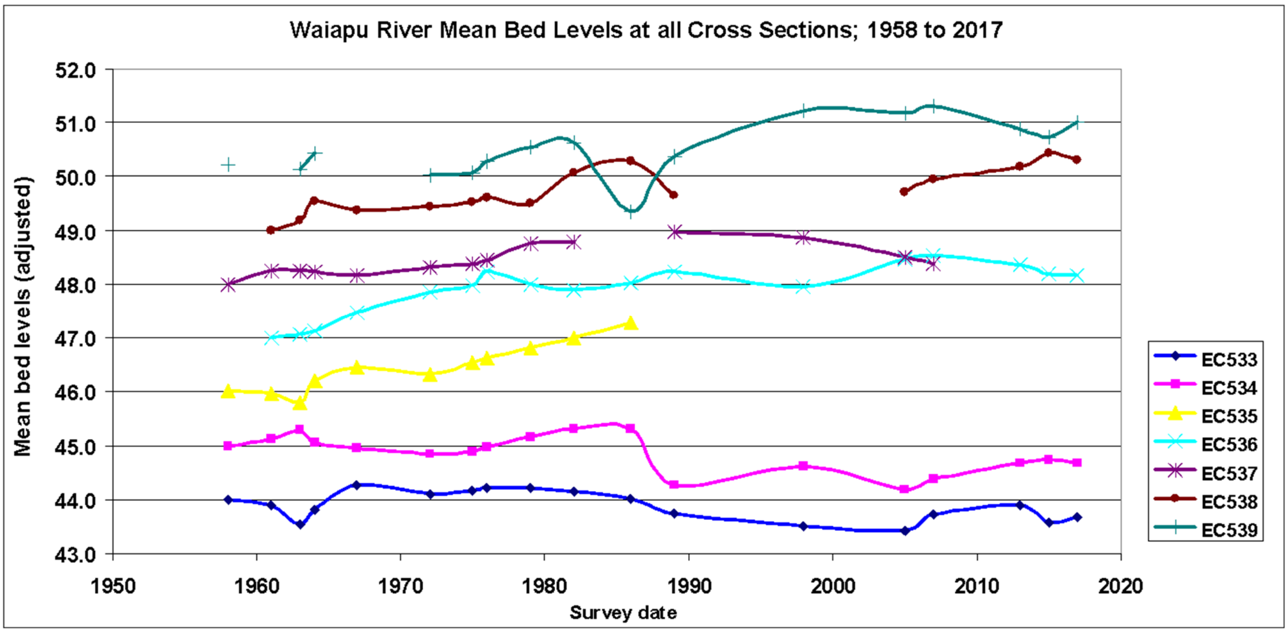

Fig. 5

Figure 5 above shows mean bed levels for all the cross sections plotted together. The plot for EC539 is at the correct elevation, but the other six plots have been adjusted upwards so that the curves can be conveniently compared.

Mean bed level plots for the two most upstream cross sections (EC538 and EC539) show a distinct similarity, with "gradual" average aggradation rates over the 57 year period (1958 to 2015) of 17.7 and 17.5 mm/year respectively. These two cross section plots are most likely to have been influenced by large scale shingle extraction over the years, see Chapt. 6; however the overall bed elevation today remains higher than when these cross sections were originally surveyed.

The mean bed level plot for the cross section at EC537 shows a moderate rate of aggradation until 1989, followed by a decreasing rate of aggradation since then, however the plot is considered to be unreliable after 1989 because of the influence of the Mangaoporo River fan.

The cross section at EC536 has had a moderate rise in mean bed level (81 mm/year) between 1961 and 1976, followed by 41 years remaining almost steady. EC535 follows the same trend until 1986, but unfortunately the bench mark at this site has since been destroyed.

Mean bed level plots for the two most downstream cross sections (EC533 and EC534) also show a distinct similarity with both degrading at a gradual rate over the full 59 year period, but remaining steady or aggrading slightly over the past thirty years. This gradual degradation is more in keeping with the (geological) long term degradation of this river bed.

6.0 Impact of Shingle Extraction Works:

In the reach 300 metres upstream and 500 metres downstream of the SH35 bridge at Ruatoria, there has historically been large scale shingle excavation works for supply of metal for roading and other uses. Shingle excavation quantities in this area have been recorded by the Gisborne District Council. The volume of shingle excavated from the river over the past 15 years (2001 to 2015) has varied between 10,100 and 71,900 m^3/year, with an average of 38,300m^3/year. This is a large annual excavation rate, comparable to the rate of excavation for the lower Mata River, (18, 500 m^3/year at Makarika bridge, and 35,700 m^3/year from the Kimberley operation, although part of this comes from terraces rather than the active river bed).

The figures since 2001 have been compared to the mean bed level changes, but unfortunately there is a gap in the cross section surveys between 1989 and 2005 at EC538, and between 1998 and 2005 at EC539. This leaves only the ten year period from 2005 to 2015 with figures for both mean bed level surveys and excavated shingle volumes available.

Figure 6 is a plot comparing the volume of bed load material deposited or eroded in the reach between EC538 and EC539 since 2005, with the cumulative volume of shingle excavated over the same period.

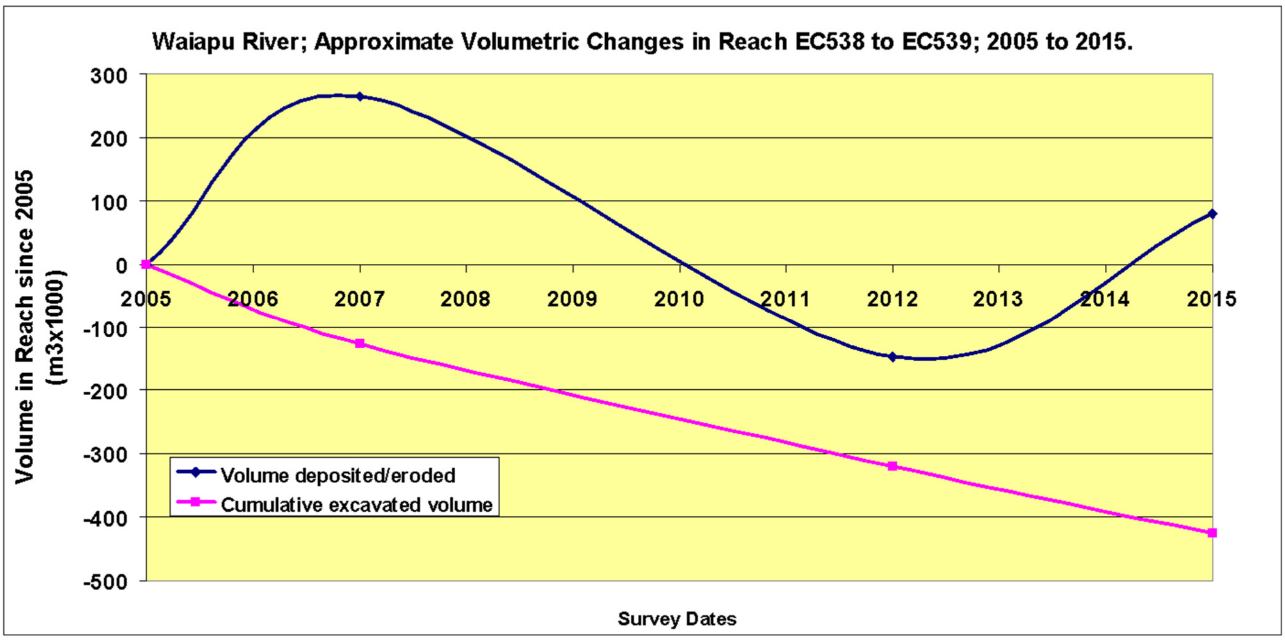

Fig. 6

The figure shows that despite a total excavated volume of 126,000 m^3 of shingle between surveys in

2005 and 2007, this reach of the river still deposited a net 264,000 m^3 of bed load material predominantly from the Tapuaeroa River.

While some of the shingle excavation works (particularly by Fulton Hogan Ltd.), were upstream of EC539, it could be expected that this would impact on the net volumes deposited in the reach itself.

Over the five year period between the 2007 and 2012 surveys the net volume eroded trends at a slightly faster rate than the rate of shingle extraction, but from 2012 to 2015 this reach gained bed load material despite the volume of shingle excavated over this period.

It is likely that the shingle extraction works are having an impact on the mean bed levels but not enough to outweigh the natural fluctuations of mean bed levels over this reach.

7.0 Mean bed level changes at individual cross sections:
For ease of comparison the following mean bed level plots have been charted to the same vertical and horizontal scale.

EC539; 23,250m:

This cross section is only a short distance downstream of the SH35 bridge at Ruatoria and is unfortunately in the area of large scale shingle extraction operations, so that mean bed levels at this site could be expected to be influenced by this.

The average aggradation rate from 1958 to 2017, illustrated by the linear trend line (Fig. 7) is 17.5 mm/year, however there is a major drop in mean bed level of 1.26m from 1982 to 1986, followed by a recovery. This may have been due to shingle extraction in the vicinity of the cross section shortly before the 1986 survey, or possibly due to the scouring effect of a flood. It may be tempting to attribute the "recovery" between 1986 and 1989 to a sudden input of bed load material from the Cyclone Bola flood, but this is unlikely as the most downstream cross section in the Tapuaeroa River only registered a significant rise in mean bed level from 1998. Also, there was a drop in mean bed level of 0.64m over the period 1986 to 1989 at EC538, some 3km downstream of EC539.

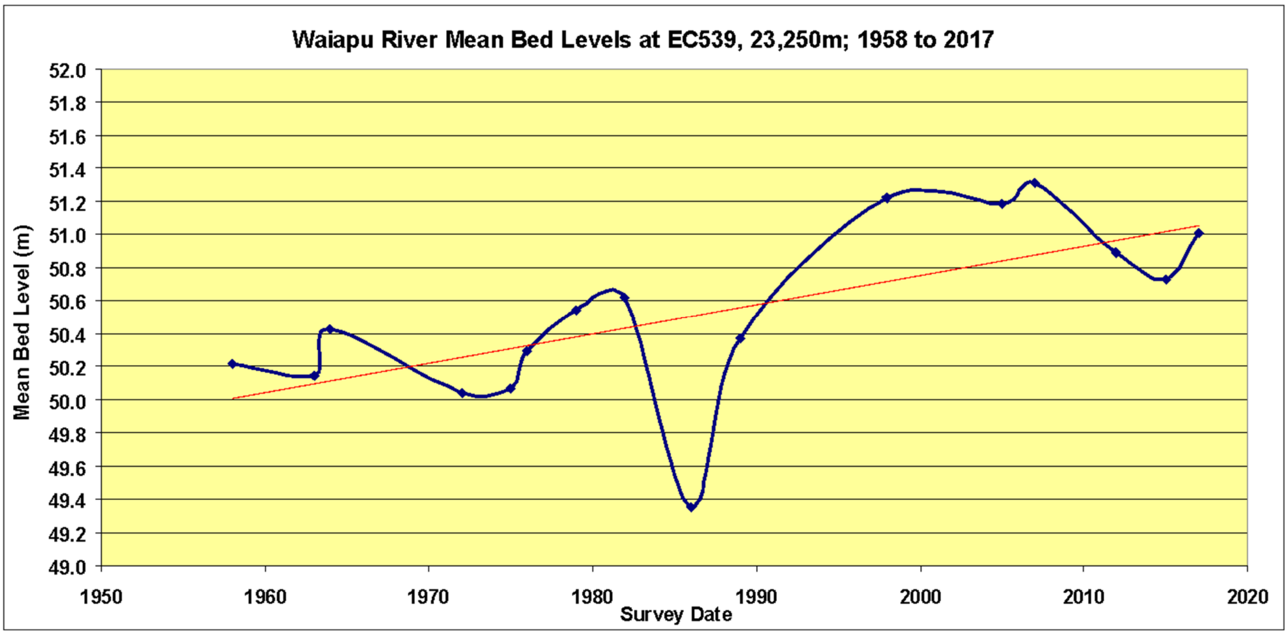

Fig. 7

EC538; 20,300m:

This cross section is near the Ruatoria radio mast. The mean bed level at this site rises at an average rate of 17.7mm/year (virtually the same average rate as at EC539), but in contrast to EC539 there is a sudden rise from 1979 to 1986 followed by a sudden drop to 1989; see Fig 8. There are no major tributaries between EC 538 and EC539, however the author understands that the Mangakinonui stream on the right bank "blew out" in the 1980's, and would have deposited its bed load in the vicinity of EC539. However this material is very fine grained and would have been easily washed away by the Waiapu River.

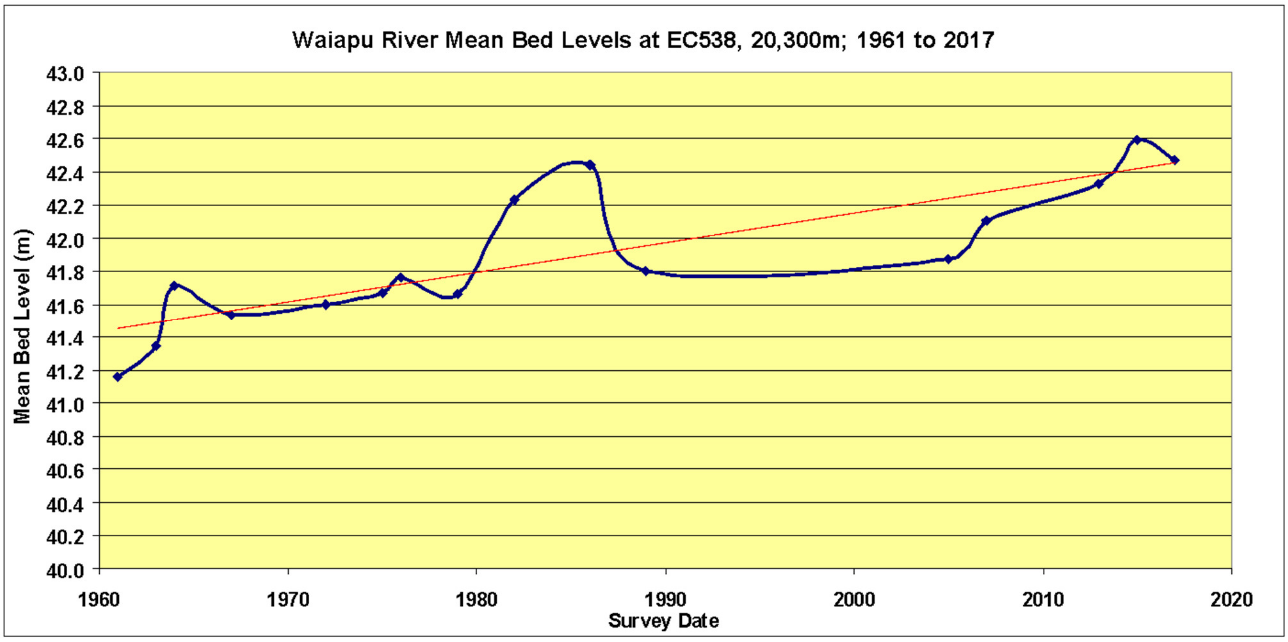

Fig. 8

EC537; 17,680m:

This cross section is a short distance downstream of the Mangaoporo River fan. It was noticed that the edge of the fan was intruding into the line of the cross section from about 1989, so the site was eventually abandoned, the last survey being in 2007. Between 1958 and 1989 mean bed levels rose at an average of 32 mm/year, with the input from the perched fan of the Mangaoporo no doubt influencing this rise. Post 1998 the mean bed levels are considered to be unreliable and misleading, so this plot is not shown here.

EC536; 13,680m:

This site known as "Peperes", has had a rise in mean bed level averaging 81 mm/year between 1961 and 1976, (Fig. 9), followed by 41 years remaining almost steady. The average aggradation rate from1961 to 2017 is 21.8 mm/year. Given the effects of large scale shingle extraction and the input of the Mangaoporo River bed load, this is the first cross section to "integrate" the effects of these two (opposing) major bed load influences.

There may have also been a more immediate (but lesser) bed load input from the Paoruku stream, only one kilometre upstream of this cross section.

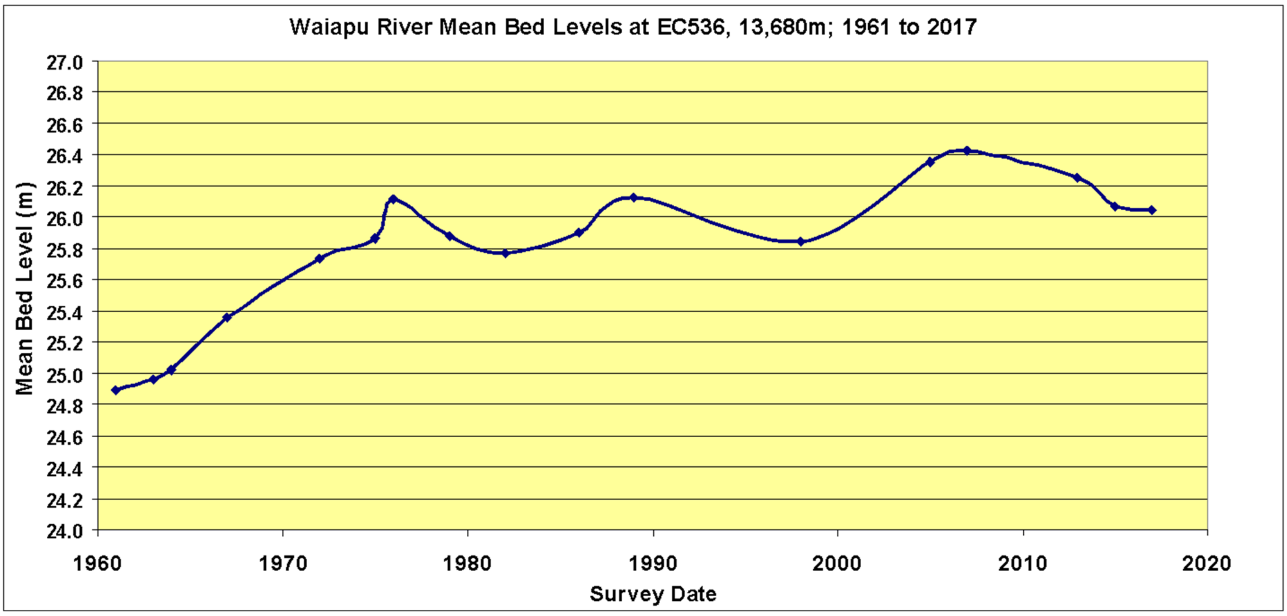

Fig. 9

EC535; 10,330m:
The plot at this cross section (not shown), shows an average aggradation rate over the 28 year period (1958 to 1986) of 45.4 mm/year, with an almost linear upward trend between 1975 and 1986 of 66.5 mm/year. However the bench mark at this site was unfortunately destroyed so that there have been no surveys since 1986. The plot for EC535 is available in Appendix 1.

EC534; 7210m:
This site is near Tikitiki, some three kilometres downstream of EC535. There are no significant tributaries and therefore no further bed load inputs between EC536 and EC534, and whereas at EC536 the mean bed level trend is upward at EC534 the (linear) trend line (Fig. 10), shows gradual river bed degradation averaging 12 mm/year at this site, however the plot fluctuates considerably about the trend line. From 1989 there appears to be gradual aggradation taking place.

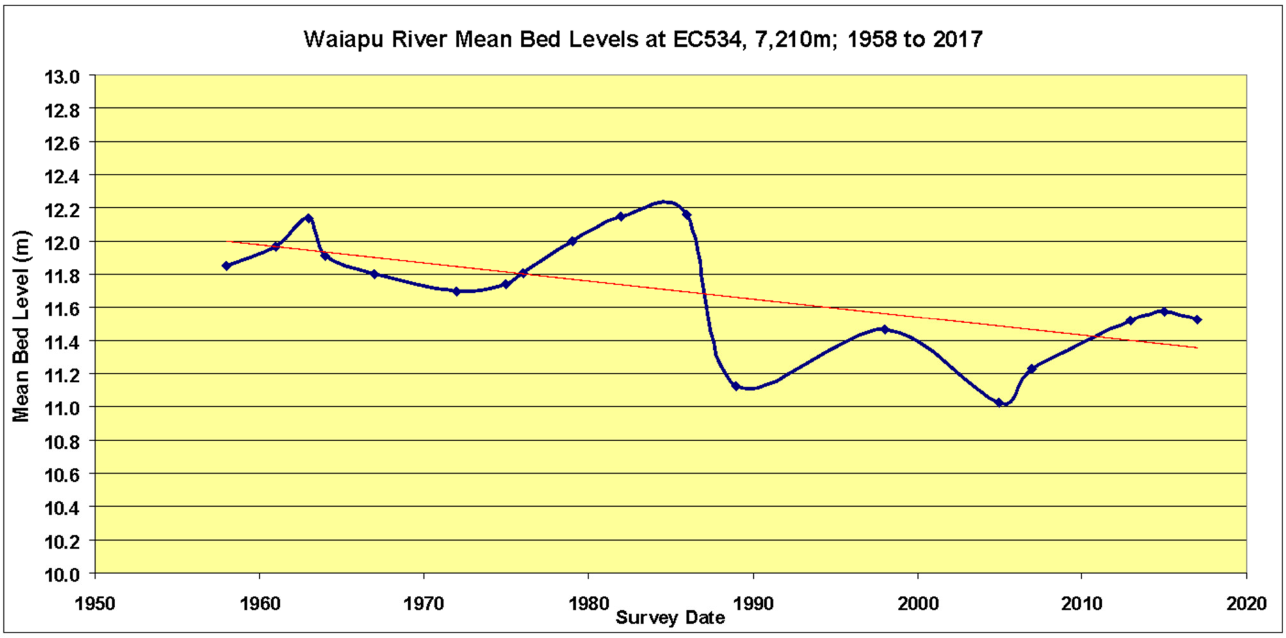

Fig. 10

EC533; 4870m:

EC533 is a short distance upstream of the Poroporo River confluence. The Poroporo is unlikely to contribute much if any bed load to the lower Waiapu river, as its bed load is very fine grained and likely to become wash load or suspended sediment by the time it reaches the Waiapu.

The mean bed level plot for EC533, (Fig. 11), shows degradation at a gradual rate of 7mm/year over the full 59 year period, similar to that for EC534.

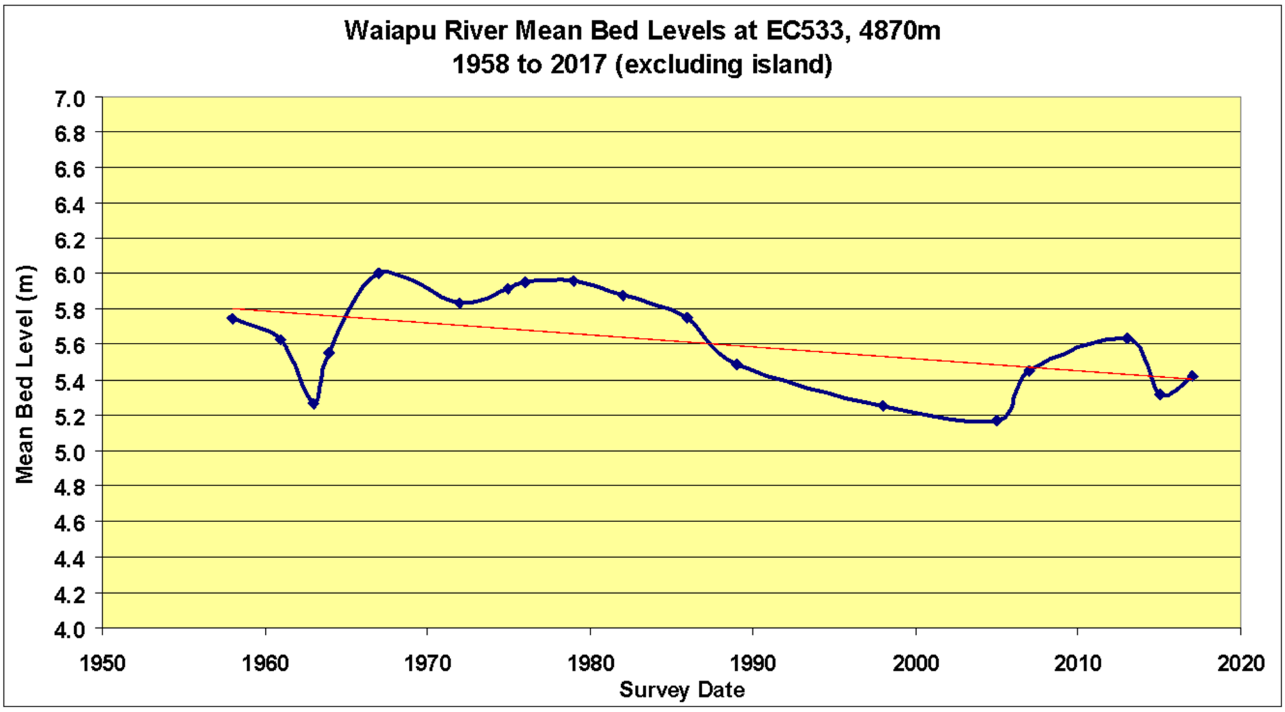

Fig. 11

7.0 Conclusions:

- The mean bed level data derived from the Waiapu River cross section surveys has relatively long temporal and spatial gaps as well as the effects of large scale shingle extraction works, which has made it difficult to obtain a comprehensive picture of the overall mean bed level trends;
- Although the survey data is rather incomplete, this river is of such importance to local iwi and also for research purposes, that monitoring should continue;
- The great majority of the shingle excavated from the river is in the vicinity of EC539, which has had an influence on mean bed levels at this site and at EC538, but the natural fluctuations in mean bed levels has masked these effects;
- While the two most upstream cross sections show a gradual rise in mean bed levels despite large scale shingle extraction, it is not likely that “peak bed level rise” from Cyclone “Bola” derived bed load material has reached these two sites yet;
- The Mangaoporo River would appear to be the major contributor of bed load material to the lower Waiapu River, however mean bed levels derived from surveys at this site (EC537) are considered to be misleading due to the encroachment of the Mangaoporo fan into the cross section;
- The mean bed level data from EC536 effectively “integrates” the upstream effects of the shingle extraction and the input of bed load from the Mangaoporo River, and shows relatively steady mean bed levels over the past 40 years;

- The net effect of shingle extraction in the Waiapu River main stem does not appear to be detrimental but more likely beneficial in moderating the attendant problems that excessive aggradation can cause.

10.0 Recommendations:
It is recommended that:

1. Cross section surveys are carried out in the future at the same sites at two to three yearly intervals; and to reinstate a bench mark at EC535 or nearby if practical to do so.
2. Conditions should be added to shingle permits to ensure that no shingle extraction is allowed within at least 50 metres either side of the cross section at EC539; and this condition is enforced rigorously;
3. Shingle extraction quantities should be clearly separated for sites upstream and downstream of cross section EC539;
4. Consideration be given to drone/DEM technology to assess the relative bed load inputs from the Mata and Tapuaeroa rivers at the confluence with the Waiapu river to the SH35 bridge;
5. A complete analysis of changes in river bed movement over time using aerial photography be undertaken to see how the river's position has changed and how much land has been lost.

NB: *Recommendation 1 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 35 years;
- Dr. M Marden, for editing the draft reports and for comments on the long term geological trends for the Waiapu;
- Mark Cockburn for the preparation of Figures 2 and 3;
- Paul Murphy for checking and commenting on the draft reports.

References:

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31st March 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.

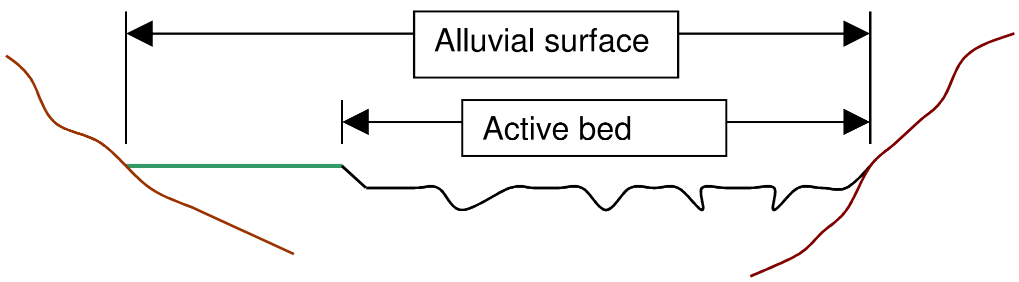
1. Mean river bed level:

"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 covered with vegetation which is no longer considered to be part of the active river bed. To be considered to be outside the active bed, a terrace (or island) has to be covered with established vegetation at least two years old, and which may be covered in water during floods but not be subject to scour or deposition of bed load material.

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

APPENDIX 1

This appendix, which is available on request from the environmental section of the GDC, comprises all mean bed level and profile plots prepared for this report in electronic form.