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The Higher Lower Tongariro

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Executive Summary

This report is in response to public concern over the perceived high level of the Lower Tongariro. It describes the general state of the Tongariro River from Rangipo to the mouth, noting changes over the last 40 years and suggests what will happen in the future. It lists possible countermeasures to manage the river from Turangi to the mouth. A bibliography of known Tongariro River studies is also included.

The Tongariro is a volatile river which undergoes significant channel changes in response to floods and eruptions. The river transports vast amounts of sediment through its upper reaches and deposits the sediment on its delta from Turangi downstream.

Visual inspections of the lower delta show the river is close to breaking out of its present channel to find a new course to Lake Taupo. There is a significant amount of water being lost from the 'normal' river channel, even during moderate freshes. Floodwaters spill from the river upstream of De Latours Pool eastwards to Stump Bay and west towards the Tokaanu Tailrace via Deep Stream. The most likely future breakout route is from Downs Pool to Tokaanu Bay via Deep Stream.

The dominant factors influencing the growth of the lower delta have been the frequency and magnitude of floods and eruptions, the level of Lake Taupo during floods and willow tree growth on the delta. The effects these factors have had on the delta building process can be considered either beneficial or detrimental depending on whether one is considering wildlife habitat or human infrastructure on the delta.

1. Introduction

Recent flooding has raised public concern over the high level of the Lower Tongariro River. Environment Waikato has commissioned this study to provide:

- An explanation of the general state of the Tongariro River from Rangipo to the mouth, noting changes over the last 40 years,
- An assessment of likely scenarios for the future evolution of the river,
- A list of possible countermeasures to manage future evolution of the river from Turangi to the mouth, and
- Identification of any gaps in current knowledge requiring investigation before implementation of countermeasures listed above.
- A bibliography of studies undertaken on the Tongariro River.

This report aims to address these issues in a manner that can be readily interpreted by the general public.

2. The state of the Tongariro River

The Tongariro River carries thousands of tons of sediment per year. Some sediment comes from the Kaimanawa Range and large amounts of volcanic ash, pumice and lava fragments come from the Central North Island volcanoes. The term "sediment" refers to all alluvial material ranging in size from large boulders to fine clay. Although the Tongariro has a gravel bed to a point just downstream of Turangi, the volcanoes provide mainly sand and finer sediment to the river. Eruptions are not regularly spaced but occur in clusters with intervening quiescent periods. The last 40 years have seen a relatively quiet period and, if the previous 40 years are indicative of future volcanic activity, much higher sediment loads will be delivered to the river in future. On the basis of the past 100 years behaviour, eruptions can be expected, on average, around once every two years.

The 1995-96 eruptions deposited nearly 7 million tons of material in the Tongariro catchments. Two thirds of this was sand sized particles or smaller (Manville et al. 1996). Much of the readily available, fine volcanic sediment from these eruptions has already washed down to the Tongariro delta but subsequent floods release new "waves" of sediment into the river.

When sediment supply from upstream is reduced, floods can re-entrain old deposits resulting in bed or bank erosion. On the lower delta, floods during low lake levels may re-open silted river mouths and push sediment further out into the lake.

Rocks and gravel that are visible on the river bed are only a small part of the total sediment load that is carried by the river. The bulk of the sediment is fine material carried during floods.

For discussion, the river is separated into two segments, one where it mainly transports sediment and one where it deposits sediment. The dividing line is at Turangi where the delta region starts and shortly thereafter the bed material changes from gravel to sand. Location maps for the two segments are shown in Figures 1 and 2.

Upstream of Turangi (Fig. 1) the river acts like a conveyor belt bringing sediment to the delta. The conveyor operates in spurts (corresponding to floods) and the sediment load mainly depends on previous volcanic eruptions and flood history. While silt may be carried through to Lake Taupo, gravel may only move a few tens of metres downstream in each annual flood. This process can produce temporally "frozen" waves of gravel or sand, stored as deposits in bars on the river bed.

Over recent decades, on average about 11,700 tons of gravel and larger sized sediment has been carried past Turangi each year. For sand and finer sized material the rate of transport is at least ten times greater. The river-borne sediment is eventually deposited on the Tongariro delta (shown in Fig. 2). As the Tongariro River flows across the delta towards Lake Taupo the flatter channel slope means that floods do not have sufficient energy to carry the entire sediment load brought from upstream. Sediment that is dropped from the river raises the local river bed.

After a period of deposition, the channel slope becomes even flatter. Unless sediment is removed, the local river bed level rises and the river banks are less able to contain floods. The delta region then becomes more flood-prone and swampy. When this has happened in the past, the river has eventually broken out of its elevated channel to take a new course to Lake Taupo.

This happened many times in previous centuries. Each new river course usually followed the lowest lying land and this low lying reach then built up, over the years, until the river again changed course.

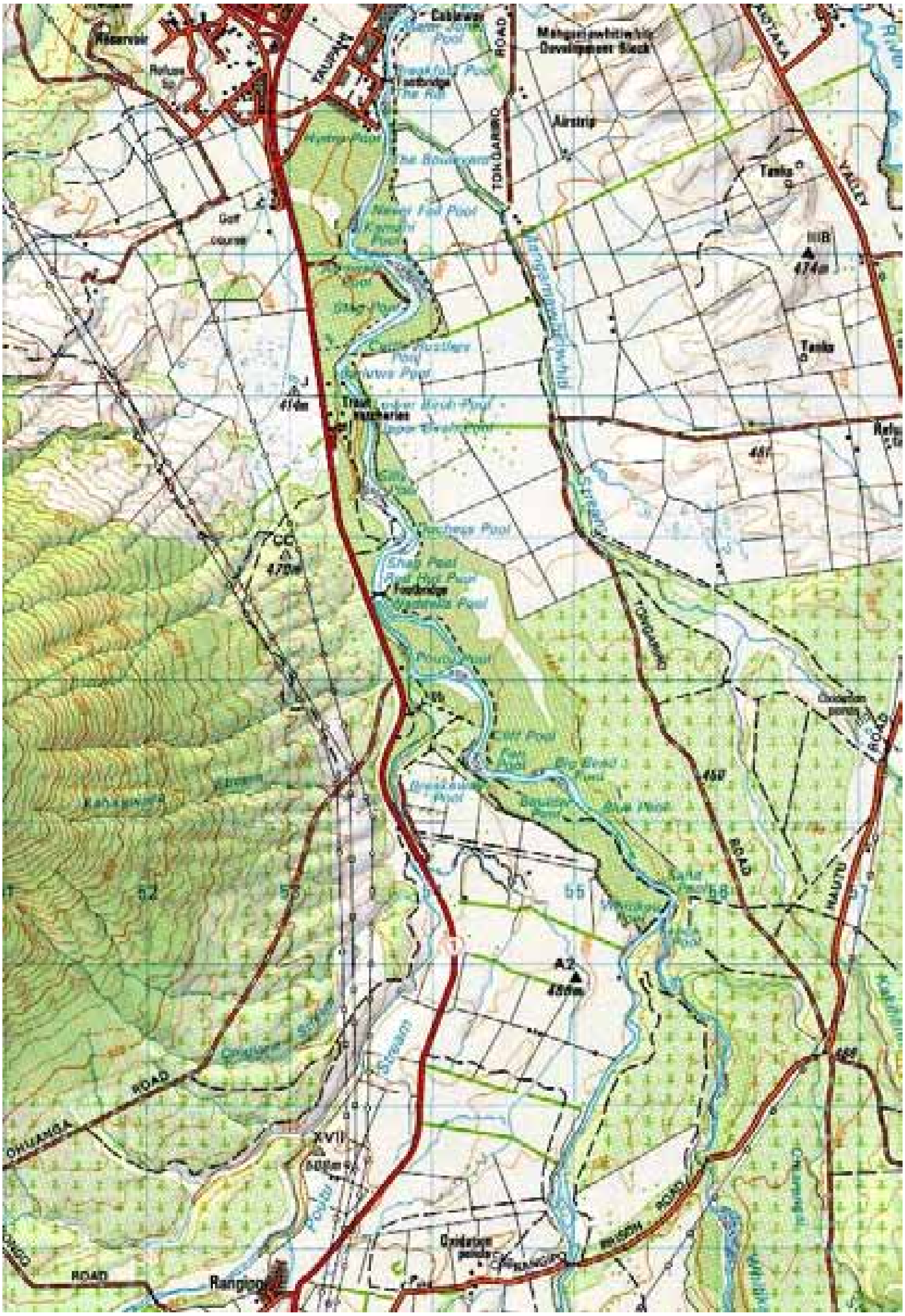

Figure 1: **Map showing Rangipo (bottom) to Turangi (top) section of the Tongariro River (prior to the February 2004 flood).**

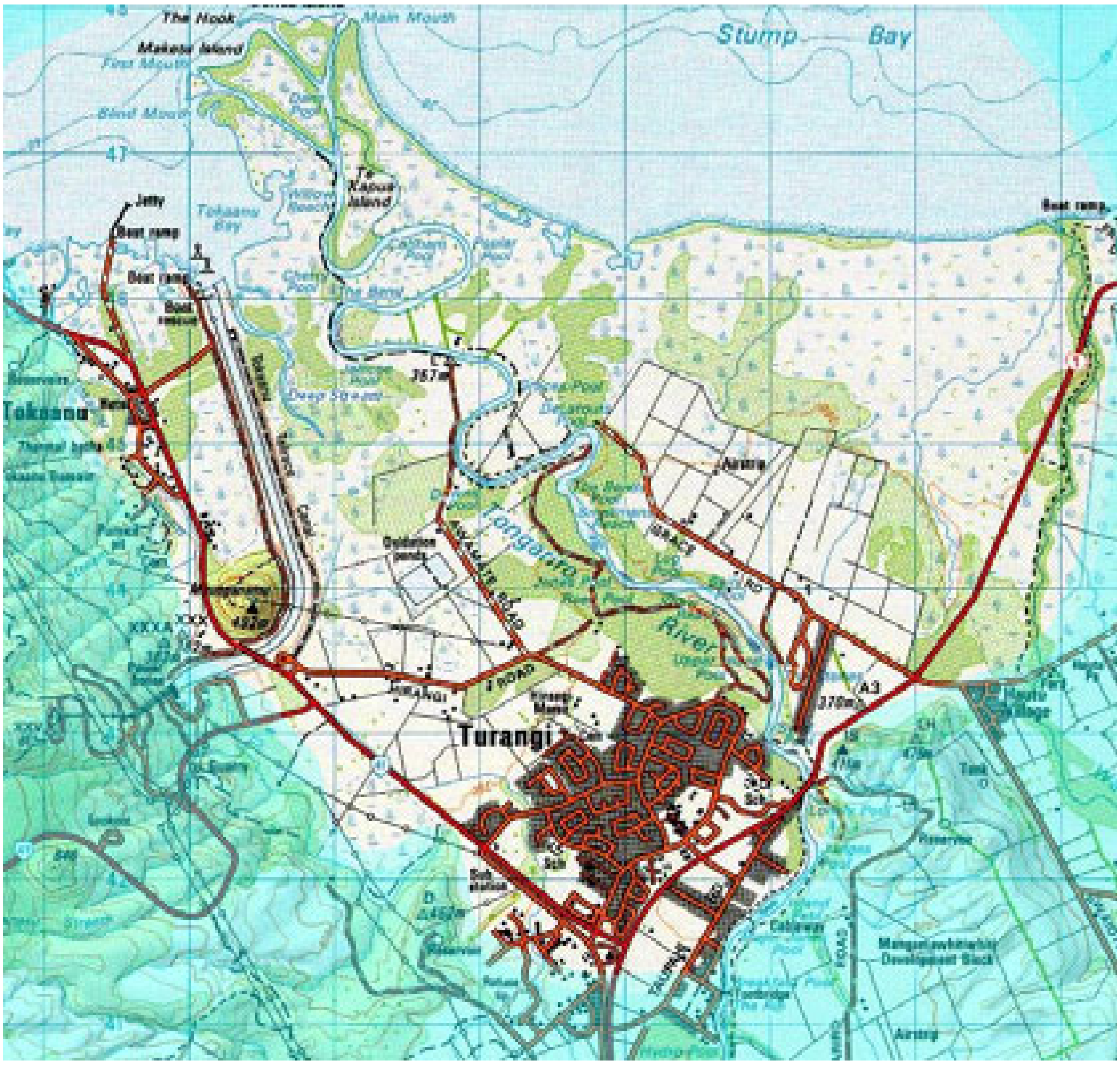

Figure 2: Map showing the Tongariro River Delta from Tokaanu in the east to Hautu in the west (situation shown prior to the February 2004 flood).

Prior to forming the present delta mouths, the river flowed between Turangi town and the position of the Turangi oxidation ponds and then entered Lake Taupo along the line of the present Tokaanu stream. Evidence of other earlier river mouths can be seen in underwater contours in Stump Bay of Lake Taupo (Fig. 2). Although the present position of the river mouth has been relatively stable since the 1900's, on a geologic timescale this location is temporary.

The process of a river changing course to form a delta is not specific to the Tongariro, however, the Tongariro delta is changing rapidly because of the huge volumes of volcanic material brought from upstream. In addition, from March to December 1983 there was a swarm of small earthquakes that raised the Acacia Bay end of Lake Taupo by 55 millimetres relative to the Tokaanu end of the lake (Hancox et al, 1999). This made the southern shores of the lake more flood-prone.

Over the last 1850 years the Tongariro delta has grown at an average rate that could approach 2.6 million tons per year (see Figure 3). This is around twenty times the present annual rate of growth. The delta grew more rapidly following periods with heavy volcanic activity and slowly at other times. Turangi town is located on the head of the delta. A cross-section cut through the Tongariro delta is shown in Figure 3.

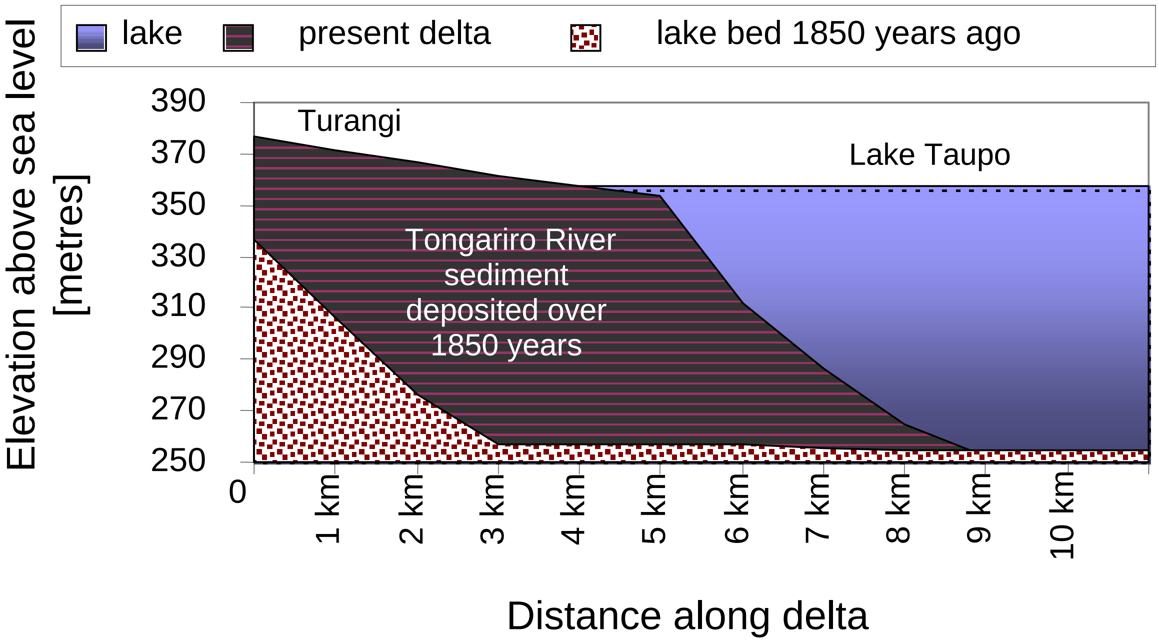

Figure 3: Cross-section cut through the Tongariro delta showing alluvial deposition that may have occurred during the last 1850 years.

2.1. Flood History

River flows have been measured at Turangi since January 1957. The largest recorded flood peak had 1,470 tons of water per second in February 1958. The second largest had 1,440 tons per second at 3.50am on 29 February 2004. A peak of 1,040 tons per second occurred in March 1964 and there were two floods in early July 1998, the highest peaking at 920 tons per second. For the remainder of this report river flows are given in cumecs (meaning cubic metres of water per second). One ton of water per second is equivalent to one cumec.

Prior to the recent February 2004 flood, the expected frequency for a flood of this size was approximately 1 in a 100 years. However, since there have now been two such floods within 50 years it is necessary to revise flood return period estimates and the February 2004 event is now considered closer to a 1 in 60 year event.

Moderate floods also can cause changes in the river morphology. In the 11 years from 1957-1967 there were 5 significant floods (i.e. 5 floods bigger than the 5-year flood level). For the 18 years from 1968 -1985 there were no significant floods. In the 19 years from 1986 – 2004 there were 13 significant floods. Major changes in the Tongariro River can be expected during periods with frequent floods.

2.2. Changes between Rangipo and Turangi

In this section of the river, bank erosion occurs mainly by bank undermining during floods and by slips from high banks during local rainstorms. Sudden channel changes can occur when floodwaters find a more direct downstream course.

In 1967-72 the Poutu barrage was constructed 8 km upstream of this section. The barrage temporarily cut off gravel supply from upstream until its reservoir filled with gravel. From 1973 the intake at Poutu began operating and low flows in the river were managed to ensure at least 11.3 cumecs were flowing downstream of Poutu and at least 27 cumecs at Turangi. From 1994 the rates were revised to ensure at least 16 cumecs flowed below Poutu Intake and at least 22 cumecs flowed at Turangi. From 2003 the rule on flows at Turangi was removed.

2.2.1. Changes in position of river channels

A comparison of aerial photos taken in June 1958 (after the large flood) and December 1984 allows identification of changes in the river position over that period. The last 17 years of the period was relatively placid with no significant floods so the dominant changes noted below are likely to have occurred prior to 1968 (the third largest flood on record occurred in March 1964).

From Sand Pool (just downstream of the Whitikau River confluence) to Breakaway Pool, 1.5 km downstream, the river scoured its left bank and moved some 20 – 30 metres in a South-west direction towards State Highway 1. For the next 1.5 km from Breakaway Pool to Red Hut Pool the river eroded its right bank and moved a similar distance to the North-east. It re-formed an old 800 metre long shortcut from Poutu Pool to the footbridge upstream of Red Hut Pool, creating a 300m wide island. This "new" shortcut was the main channel of the river back in the 1920s. Further downstream, the photographs indicate the river moved Duchess Pool some 60 metres eastwards by eroding its outer bank. The river channel moved a similar distance towards its west bank at the next pool downstream (Silly Pool) and then towards its east bank opposite the present trout hatcheries. The channel position did not change from the hatcheries to Stag Pool. Below Stag Pool the channel position shifted some

150 metres, from the west side of the large braided gravel area to the east side of the area. The channel position was stable from here down to just upstream of the Koura St footbridge where it moved some 40 metres towards the east. Further downstream there were minimal changes until the reach above the SH1 Bridge which is discussed in the next section.

The next aerial photographs cover an interval from December 1984 to January 1993. There were several moderately sized floods in this shorter period. The main changes in river position were at Barlows Pool (downstream of the hatcheries) where the river cut some 60 metres off the sharp corner that previously existed and consequently moved the main channel to the east. From Stag Pool to Admirals Pool the river shifted back to the west side of the large braided area mentioned above and eroded the outside (east) bank. The channel position was relatively stable until upstream of the SH1 Bridge which is discussed in the next section.

From 1993 to the present there were frequent floods including the February 2004 flood which caused significant changes. The island just downstream of the Rangipo Prison Road Bridge (at bottom of Fig. 1) was split in two by a new channel which the 2004 flood cut through the island's centre. At Breakaway Pool the river created a shortcut (similar to the one it had formed 1 km further downstream, some 40 years earlier). This enlarged a minor channel through a heavily vegetated island into a new main channel lying 200 metres away from the previous main channel (Fig. 4). Downstream of this "cutoff" the river eroded 50 metres from its west bank over a distance of 300 metres towards Poutu Pool. The river abandoned the previous shortcut from Poutu Pool to Red Hut Pool and scoured 60 metres from the western side of the island that previously existed at this location. From here to Barlows Pool the channel eroded large stretches by around 50 metres into the west bank. The flood increased the large braided area in an upstream direction towards Stag Pool. From Kamahi Pool to Major Jones Pool the left bank was severely eroded and the main channel moved up to 40 metres westwards.

2.2.2. Changes in level of the river bed

Long-term changes in river bed level can be inferred from data collected at flow gauging stations. Puketarata recorder is sited just downstream of the Rangipo Prison Road Bridge (at the bottom of Fig. 1) and Turangi gauging station is located at the cableway at Major Jones Pool (at the top of Fig. 1). Changes in recorded water levels at these stations are shown in Figures 5 and 6.

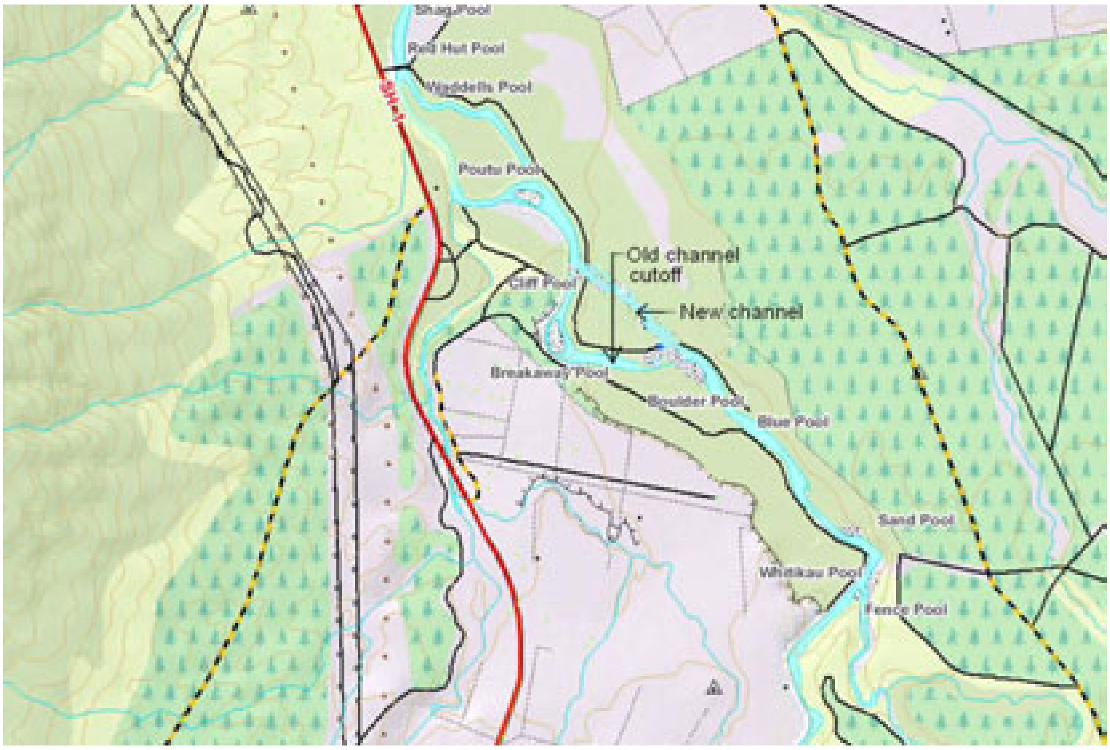

Figure 4: **Breakaway Pool before and after the Feb. 2004 flood.**

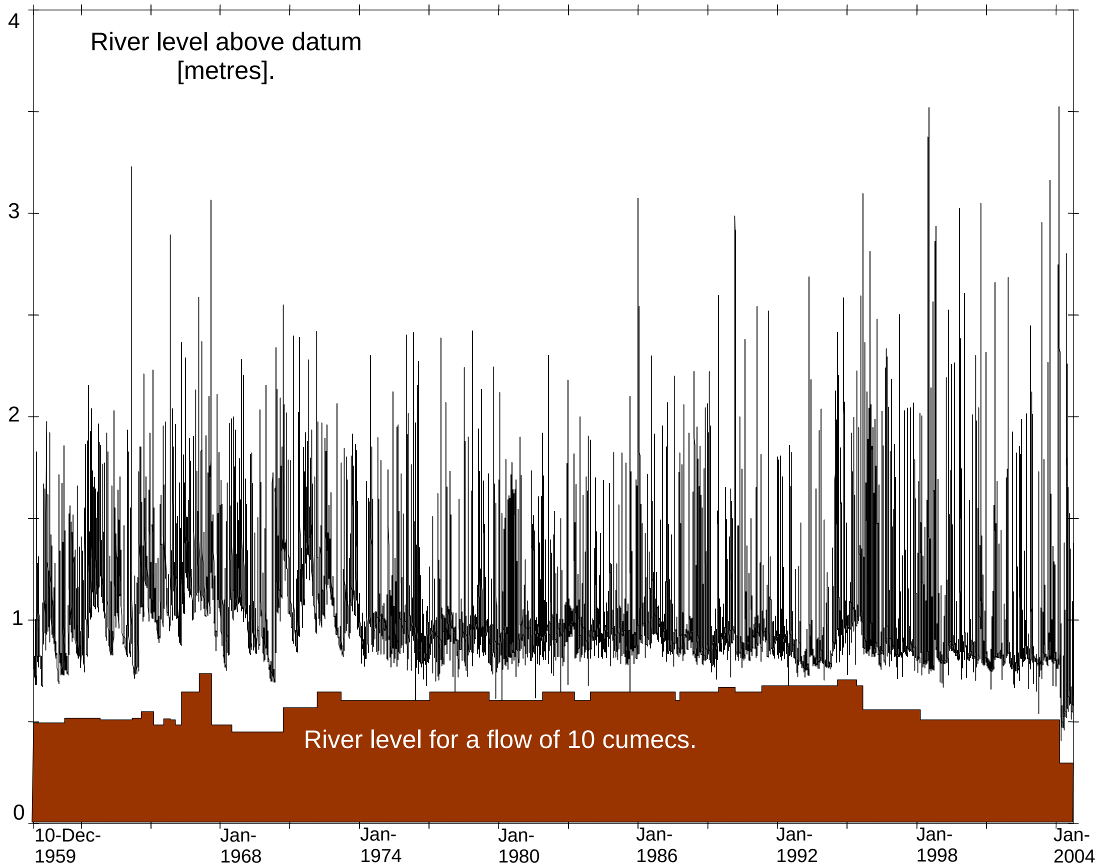

Figure 5: **Changes in water level at Puketarata gauging station.**

The upper trace in Fig. 5 shows water levels at Puketarata over the past 45 years. Changes in the level of the 10 cumec flow give a good indication of changes in the average level of the river bed (shown as the shaded area at the bottom of the figure). Figure 5 shows that there are often step changes in bed level occurring when there are high water levels (i.e. floods). Up until 1994 the bed level at Puketarata was fluctuating but slowly rising. Since 1995 the bed level has fallen by 40 centimetres, half of this fall occurring during the February 2004 flood. This situation illustrates how floods can change bed levels and how bed levels affect the water level. The figure shows that water levels at Puketarata were higher in the January 1998 flood than in the February 2004 flood, even though the 2004 flood was a larger flood.

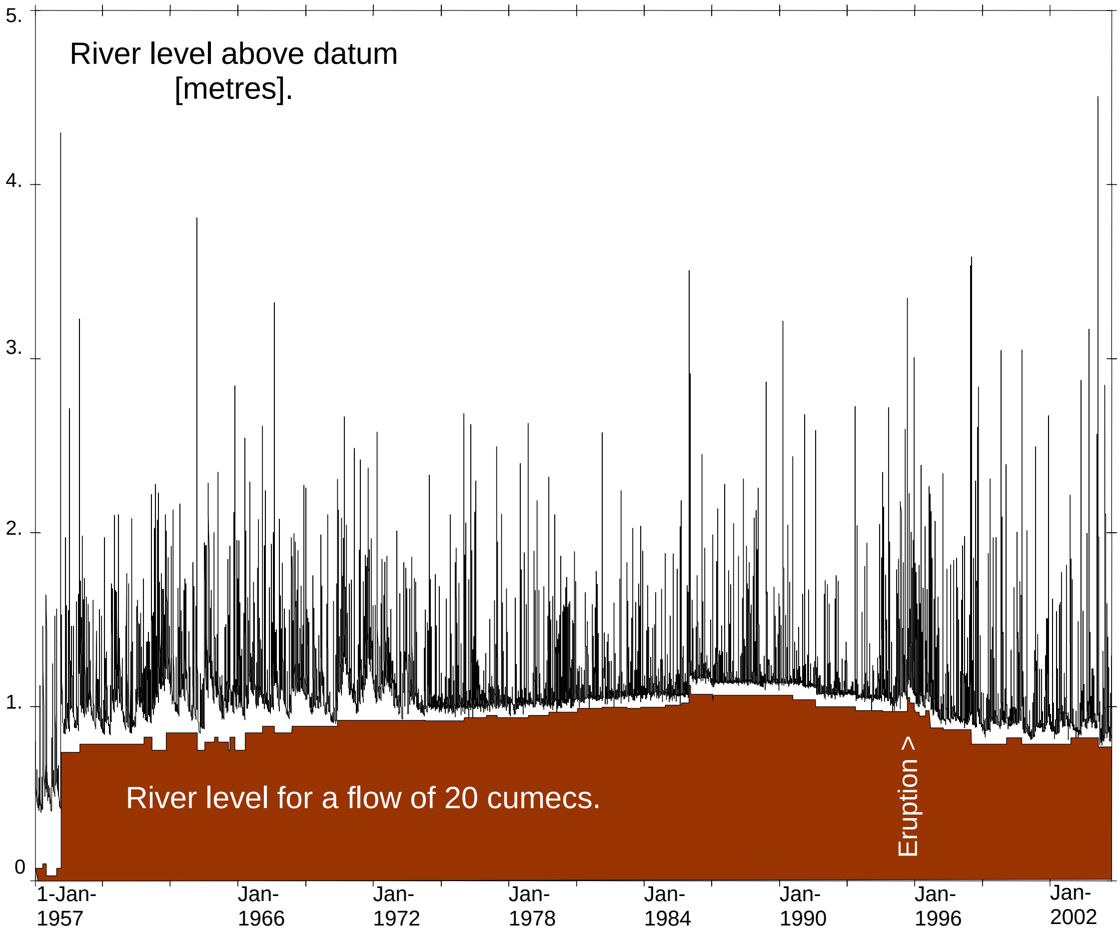

Figure 6: Changes in water level at Turangi gauging station.

Figure 6 shows a similar graph for the Turangi gauging site near Major Jones Pool at the downstream end of this section of river. Changes in the level of the 20 cumec flow give a good indication of changes in the average level of the river bed. The graph covers 46 years of record and includes the February 1958 flood, the largest flood on record. The 1958 flood is shown to have caused a sudden increase in bed level and the bed then continued to rise slowly until the late 1980's. The period of rising bed levels corresponds to the lull in floods from 1968 to 1985. Since the 1990's the bed level at the Turangi gauging site has been falling with the exception of minor rises caused by sand deposits from the 1995-96 eruptions. The fall in bed level of the gauging site indicates that gravel has been moved downstream. The fall in bed level corresponds to the period characterised by the return of frequent floods. The February 2004 flood caused little change in level at the gauging site but transported a large amount of gravel through this site and deposited it further downstream on the head of the delta.

2.3. Changes between Turangi and the Delta Mouth

A plan of the delta region in 1900 (shown in Fig. 7) indicates that there were extensive swamps on the delta but also drier areas, suitable for cultivations, along the river borders. In the 1920s the river near Turangi was braided. This means the river had many channels which frequently changed position. Gravel extraction since the 1960s helped stabilise this reach and the river became confined to a much narrower channel. At least one million tons of gravel were extracted from the Tongariro downstream of the SH1 bridge during the 1960's. During the 1970's and early 1980's, more gravel was extracted for construction of the hydro projects. In recent times there has been no significant gravel extraction. In the absence of gravel extraction, the alluvial fan at the head of the delta has grown at a more natural rate and the associated river bed rise has contributed to increased bank erosion and flooding. In recent years a braided channel has again developed and the banks have come under attack from the widening river. These changes are discussed in more detail below. To protect the town, stopbanks were constructed from Kutai St to Koura St at the south end of Turangi, from Te Aho Rd to the SH1 Bridge, from the SH1 Bridge to Herekiekie St. and off the end of Tautahanga Rd. The February 2004 flood caused the bed level to rise further (as much as 1.2 m in places on some shoals). Following the flood, the Herekiekie St stopbank was extended downstream to Tongariro Lodge.

2.3.1. Changes in position of river channels

A comparison of aerial photographs shows that between 1958 and 1984 the river, from 0.6 km upstream of SH1 bridge to just upstream of DeLatours Bend, changed from being a braided channel to a single thread. The single channel crossed from hugging

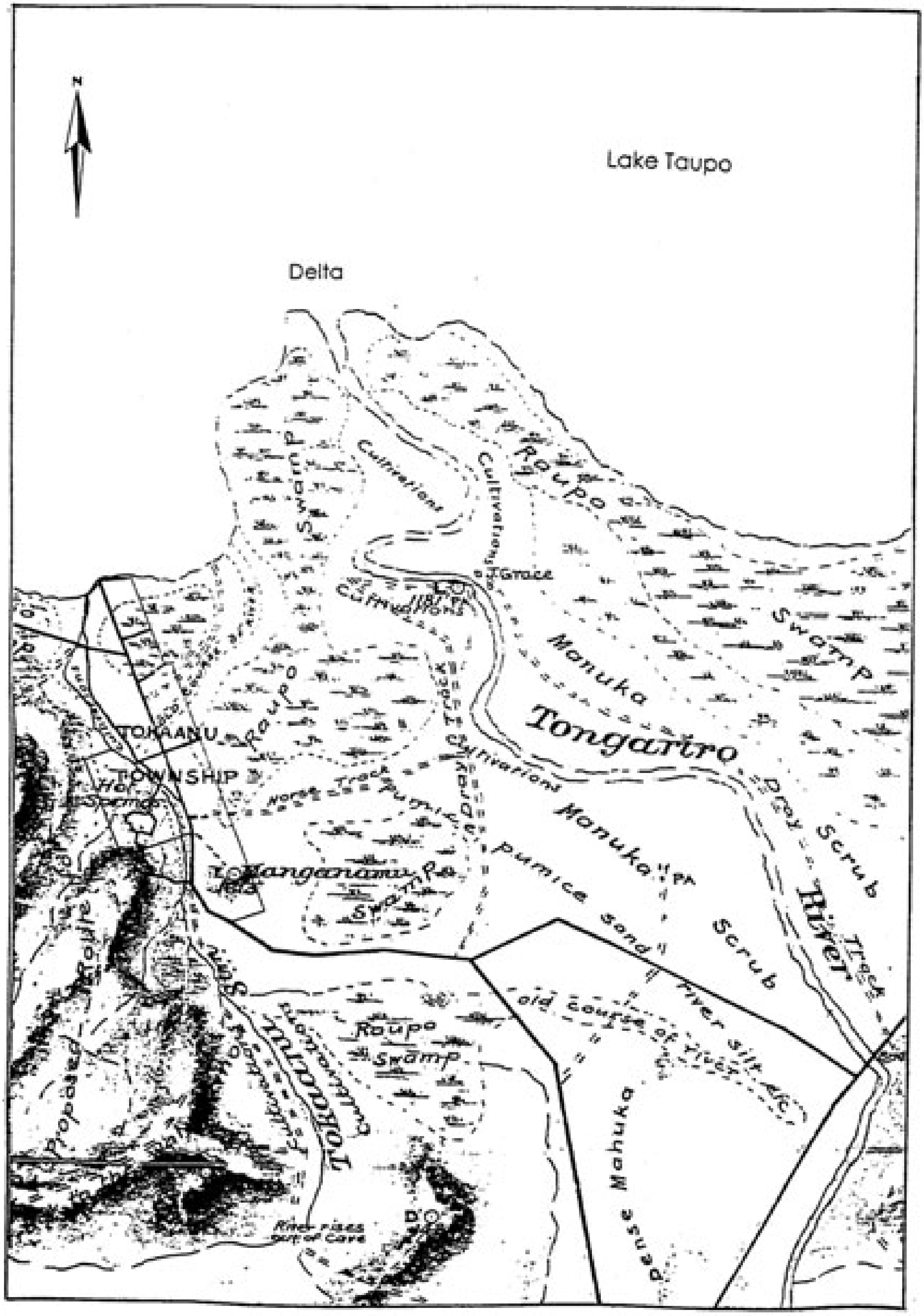

Figure 7: **Plan of Pukawa and Tokaanu Survey Districts made in 1900.**

the west bank just upstream of the bridge to the east bank at Herekiekie St, crossed briefly to the west then hugged the east bank for 2 km down to DeLatours Bend. These changes were brought about by the gravel extraction described above. From DeLatours Bend to the mouth there were no major changes in river position other than the apparent silting up of the small channel to the east of Te Kapua Island.

From 1984 to 1993 the photographs indicate that the channel split into two branches just upstream of the SH1 Bridge and several small islands developed in the channel for a distance of 1 km downstream from the bridge. At DeLatours Bend the channel had moved some 30 m towards the outer (eastern) side of the meander. The island between the Hook Mouth and Main Mouth eroded some 70 m shorewards.

Morphological changes since 1993 occurred mainly as a result of the 2004 flood. Trees removed and transported during the flood became stuck on the SH1 Bridge piers, forming a debris dam on the upstream side of the bridge. Following the flood, just upstream of the SH1 Bridge, the main channel returned to the east side of the river and then crossed to the west bank at the bridge as shown in Fig. 8. From the bridge the channel now crosses to the east bank and 0.5 km downstream of the bridge it presently lies some 100 m further east than prior to the 2004 flood. From this point a large meander has formed that takes the channel 200 m west towards Tautahanga Rd.

Downstream from this point the nature of the river changes to a sandbed channel with very low banks. A low stopbank has been built to protect the sewage ponds which lie half a kilometre away from the main river.

Figure 8: Aerial view of the Tongariro River and SH1 at Turangi taken on 5/5/2004.

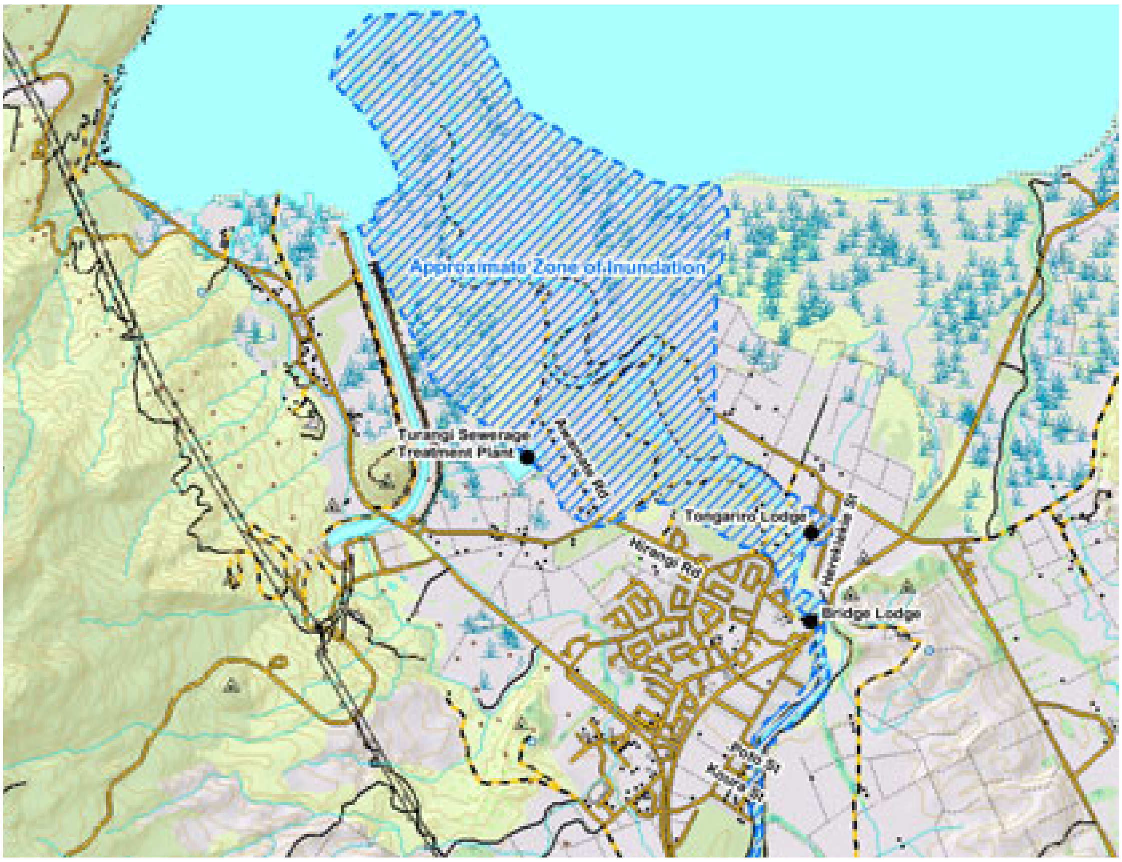

Figure 9: **Approximate zone of inundation from Feb. 2004 flood (Bowler, 2004)**

Figure 10: **Tongariro Delta following Feb. 2004 flood (photo J. Bowler, 1/3/2004).**

Much of the 2004 floodwater spilled from the main channel (see Figures 9 and 10) and there is little evidence of changes in channel position on the lower delta. Willow trees constrict river channels that would naturally migrate by lateral erosion.

The west side of the Hook Mouth extended some 150 metres lakewards. The head of Deep Stream (Fig.2) extended some 250 m towards Downs Pool.

2.3.2. Changes in level of the river bed

No gauging stations exist downstream of the bridge but river bed levels can be inferred from photographs and field inspections. Since 1900 the bed level of the river has risen in the delta region and most of the lower delta is now frequently flooded.

The Feb. 2004 flood was the largest since the 1995-96 eruptions and it is estimated (EW document 922125) that around 95,000 tons of gravel (50,000 cubic metres) was deposited by the Tongariro River between SH1 Bridge and DeLatours pool. The volume of sand and finer sediment brought to the delta is unknown but it could have been ten times greater than the volume of gravel. Because Lake Taupo was high at the time of the flood, less sediment would have flushed into the lake. The lake level increased by about 200mm as a result of the storm.

A large underwater tongue of gravel formed just downstream of the SH1 Bridge as shown in Figure 8. This “slug” of gravel near the State Highway bridge is exacerbating bank erosion and will increase future flood levels in this part of the river. Stopbank protection has been improved following the flood as shown in Fig. 11.

Figure 11: Rock to protect Herekiekie St Stopbank from river attack.

The increase in bed level is also evident at Swirl Pool where water spills out of the main channel during everyday flows as shown in Fig. 12.

Figure 12: Water spills from the main river channel towards the west from Swirl Pool.

Below this point the river channel is constrained by willows (Fig. 13). These decrease bank erosion and increase out-of-channel sedimentation during floods.

Figure 13: Willows confine the main channel over much of the delta.

Even minor freshes overtop the low riverbanks and deposit suspended sediment adjacent to the river. An area at the end of Grace's Road is almost permanently under water as shown in Fig. 14.

Figure 14: The lower end of Grace's Rd is overgrown and underwater when there is a flow of 60 cumecs in the river.

The high level of the river bed is evident in Figures 15 and 16 which show that land beside the river is lower than the level of water in the river. Here, water that seeps from the river during everyday flows or spills during freshes, flows into Deep Stream. There is a strong likelihood that the main river channel will divert towards Deep Stream in a future flood.

Figure 15: A low stopbank contains the Tongariro on the West side of Downs Pool. The river level is higher than ground level at the end of Awamate Rd.

Figure 16: **The extension of Awamate Rd is submerged with seepage from the Tongariro River when there is around 60 cumecs in the river.**

Downstream of this point much of the delta that was previously dry is now semi-permanently under water, as shown by the situation at Church's house in Fig. 17.

Figure 17: **Church's old house has water to near floor level with a 60 cumecs flow in the river.**

3. Future evolution of the Tongariro River

The river channel position has undergone many changes in the past and this can be expected to continue into the future. The timing of these changes will depend on the occurrence of future floods and eruptions.

Upstream of Turangi the bed level appears to be entering a falling phase and, as a mildly degrading river is relatively stable, no severe changes are forseen in this section of the river unless a major eruption occurs. The position of the main channel will continue to change, as it has done in the past, and variations in bed level can be expected, especially where the river is adjusting to new channel locations such as have occurred with the split in the island downstream of Puketarata and the cutoff of Breakaway Pool.

Downstream of Turangi the situation is more serious and major changes in the river's position on the delta are likely to occur in the future.

Overflow channels across Grace Road to Stump Bay and across Awamate Rd towards Deep Steam have become more established following the February 2004 flood and it is only a matter of time before the river will break out of its present course and take a new route to Lake Taupo. Possible breakout routes are shown in Figure 18.

An inspection of the situation in November 2004 showed that the water level in Deep Stream is over a metre lower than the water level in the nearest part of the Tongariro River and Deep Stream is "head-cutting" towards the river as shown in Figure 19.

The large amount of floodwater that is escaping from the main Tongariro channel into Deep Stream is evidenced by erosion of its left bank (which adjoins the Tokaanu tailrace) as shown in Figure 20. The small catchment of Deep Stream could not produce sufficient flows to cause such erosion. The erosion of the western bank of Deep Stream is caused by floodwaters from the Tongariro River.

At the exit of Deep Stream there is a large quantity of flood debris deposited into Lake Taupo (Figure 21). This debris has been moved by floodwaters that have escaped from the Tongariro into Deep Stream.

In light of this evidence, unless some form of intervention is engineered, it is considered that the Tongariro will breakout of its present channel during a future flood. The most probable location of the new Tongariro River mouth will be alongside the exit of the Tokaanu tailrace (shown as a dark blue trace on Fig. 18).

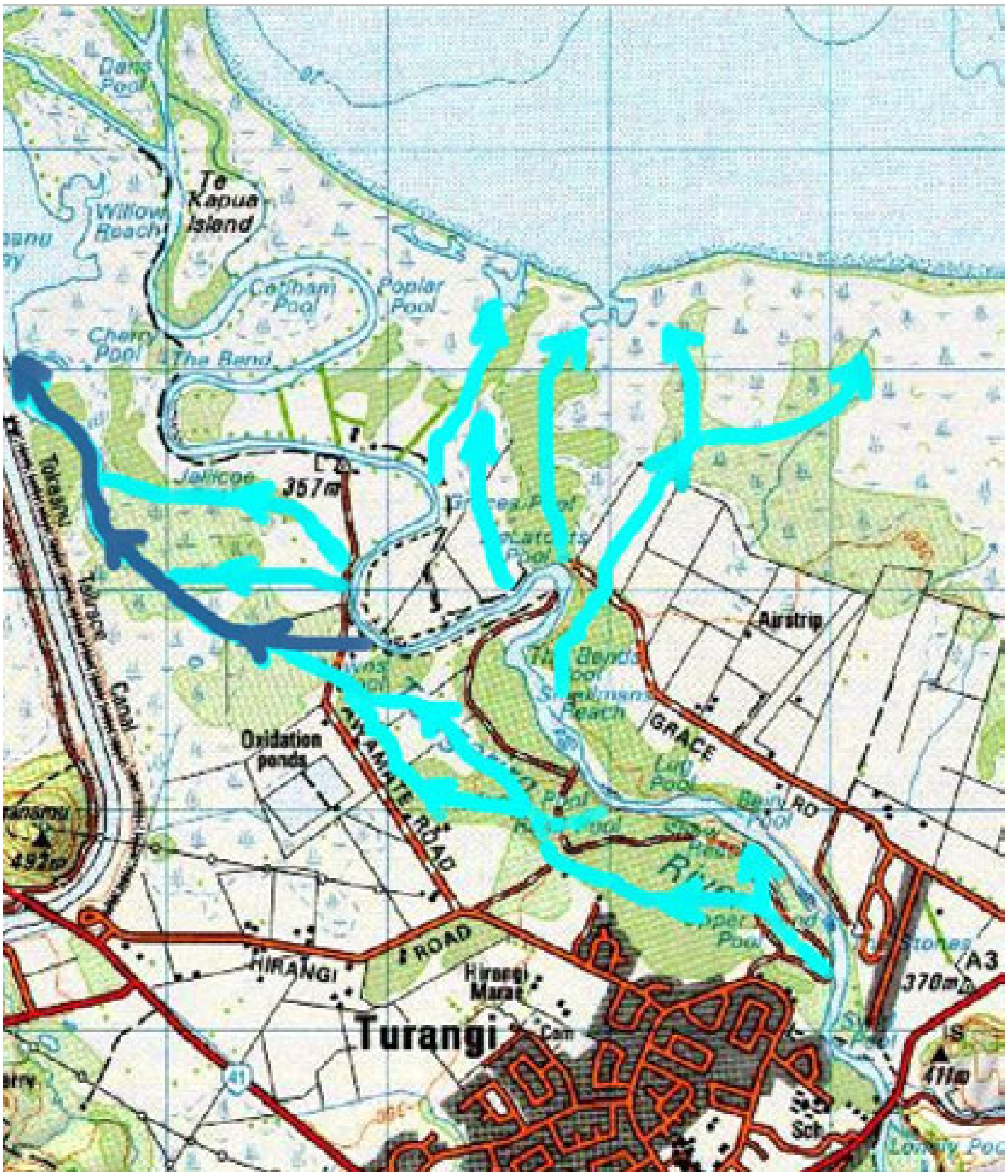

Figure 18: **Possible breakout routes and locations for the future mouth of the Tongariro River.**

Figure 19: Floodwater spilling into Deep Stream is causing "head-cut" erosion which brings Deep Stream closer to the Tongariro River

Figure 20: An indication of the volume of floodwaters exiting via Deep Stream is shown by the erosion caused to its left bank before it enters Lake Taupo (near the mouth of the Tokaanu tailrace).

Figure 21: Vegetation and debris entered Tokaanu Bay via Deep Stream in the Feb. 2004 flood.

4. List of management options

While it is not possible to control a river on a geologic timescale, it is possible to control relatively large floods, direct river evolution and pre-empt dramatic changes in river position as long as natural processes are guided and respected. A number of options are available for management of the Tongariro River depending on the vision that the stakeholders have for the river. Each option will have advantages and disadvantages and hence a combination of options might be appropriate within an overall management plan context. These options include:

- Implementing pre-emptive land use plans and controls so that the future evolution of the river will not adversely affect stakeholders.

- Doing nothing and managing the impacts of future changes, when they occur, through planning and control works. The impacts of future changes should not be underestimated as once the river changes position it may be extremely difficult to modify the new river course.

- Attempting to rejuvenate the current channel through dredging, vegetation control and river training works.

- Helping the river develop a new channel to Stump Bay through excavations and training works.

- Increasing the channel capacity in the vicinity of Turangi by extracting gravel from the river bed.

- Other control options such as meander cutoffs, guide walls and lake level management.

Because this river is subject to natural hazards such as volcanic eruptions, seismic activity and tectonic movements there is no guarantee that implementation of any management options will achieve a desired outcome. In formulating future management plans for the Lower Tongariro River these hazards need to be highlighted and considered.

5. Future Investigations

To guide the planning process for management of the river, a more accurate picture of flood breakout and future channel changes on the lower delta could be obtained with a numerical hydraulic model of the lower delta. It would be necessary to carry out an airborne laser altimetry (LiDAR) scan of the delta to measure the local topography in sufficient detail for high resolution hydraulic modelling.

If engineering works such as dredging, stopbanking or pre-emptive channel re-routing are to be considered, feasibility studies will be necessary to investigate the costs and benefits of such works.

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