IAN R BROWN ASSOCIATES LTD
geological engineering consultants

Northern Ohariu Fault

Review of geomorphologic evidence for an active fault trace

March 2009

Report for
Kapiti Coast District Council

Project Number 996

Level 2, 86-96 Victoria Street P.O. Box 24 147 Wellington
Phone (04) 471 1464 Facsimile (04) 471 1745

1. Introduction

Ian R Brown Associates Ltd (IRBA) has been engaged by Kapiti Coast District Council (KCDC) to review evidence for the Northern Ohariu Fault within the KCDC jurisdiction. Part of this review is to address active fault issues relating to a site at 156 Ringawhati Road.

The fault trace was identified during regional fault mapping by the Institute of Geological and Nuclear Sciences Ltd (IGNS) (Van Dissen 1997), though previous studies in the area had variously identified possible fault traces.

Preliminary results were presented in conference proceedings (Van Dissen et al. 1998, 1999). A detailed study was commissioned by EQC in 1997, and results were presented by Palmer and Van Dissen (2002). A subsequent report (Van Dissen and Heron 2003) presented fault avoidance zonations for planning purposes within the KCDC area.

Further details about the fault, in particular in the vicinity of Ringawhati Rd were supplied by GNS Science to KCDC in 2007 (Heron & Van Dissen 2007).

The Northern Ohariu Fault within the KCDC area can be divided into two segments, from Te Horo to Otaki River, and north of Otaki River to Waitohu Stream (Figure 1).

2. Data sources

KCDC supplied digital shape files of fault avoidance zones as defined in the District Plan.

Vector data (derived from 1:50,000 scale mapping) comprising contours, streams, rivers, terraces and roads were obtained from the LINZ website. A black and white digital orthophotograph was also downloaded from LINZ.

Vertical aerial photograph stereo pairs were inspected at National Archives and copies ordered from NZ Aerial Mapping Ltd. The relevant survey is SN198, Run 306, images 7, 8 and 9 and SN198, Run 307, images 7, 8 and 9, photographed in April 1948. Additional photographs from Set 306A taken in April 1957 were also inspected. Low altitude vertical aerial photographs covering the area were borrowed from GNS Science.

LIDAR data were provided by Greater Wellington Regional Council as Access databases. These data constituted the ground strike points only, in New Zealand Map Grid coordinates, and were extracted into ASCII (XYZ) files. The points were then modelled using ER Mapper software into one metre grids and then converted to New Zealand Transverse Mercator projection. For ease of use the individual tiles were combined into one dataset. In order to generate cross sections the ER Mapper dataset was exported to Techbase and re-modelled into a 4 metre grid.

Quaternary geology of the area is discussed by Palmer et al. (1988). We have georeferenced their map (Figure 1).

All mapping data has been compiled using the NZTM2000 datum and grid.

3. Geomorphology – Te Horo to Otaki River

The area between Te Horo and the Otaki River comprises a generally featureless gravelly surface which is mapped as Ohakea II in age (Oxygen isotope Stage 2) by Palmer et al (1988). A Quaternary timescale is shown in Figure 2. This aggradation surface was deposited by the Otaki River during the last glacial period. Soil is thin and there is little loess development. The age of the surface is estimated to be between 22,590 yr BP and 10,000 yr BP, with the younger age limit defined by a covering of dune sand on the western part of the surface which was believed to have stabilised at around 10,000 yr BP (Hawke & McConchie 2005).

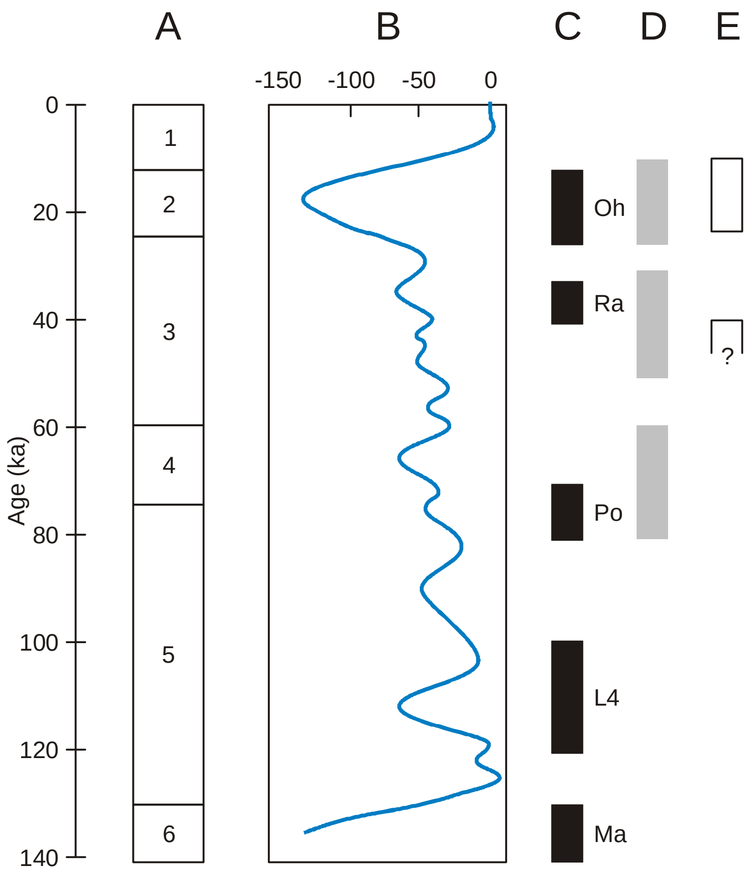


Figure 2. Quaternary stratigraphy, New Zealand. A = Oxygen Isotope stages, B = Relative Sea Level curve (metres relative to present day), C = Loess stratigraphy Oh = Ohakean, Ra = rattan, Po = Porewan, Ma = Marton. D = loess units from Palmer at al. (1998), E = Koputaroa Dune deposition. From Hawke & McConchie (2005).

Our interpretation of the LIDAR data clearly shows the fluvial channel pattern through the area, particularly on the more southwestern parts (Figure 3). The channels have a typical braided form, and are slightly sinuous. The orientation of the channels swings from SE-NW on the eastern parts of the surface to nearly E-W on the western parts, reflecting the fanning out of channels across the aggradational fan of the Otaki River. While a number of channels appear to bend across the fault trace, there are other instances where channels clearly extend across the trace without noticeable lateral offsets.

At the southern end of the mapped fault trace, the surface is mapped as Ohakea I, a slightly older surface at a slightly higher elevation (about 1.5–2.5 m above the main Ohakea II surface).

The LINZ vector data indicate there is limited drainage developed across this surface, probably because of the free-draining alluvial soils.

Adjacent to the current bed of the Otaki River, there is a steep scarp of 18–20 m height where the river has eroded down into the older deposits of the terrace. There is a low terrace at about 3m above the present river level described by Palmer et al. (1988) as “Older Recent Alluvium”.

4. Geomorphology – Otaki River to Waitohu Stream

In contrast to south of the Otaki River, most of the area north of the river and along Ringawhati Rd comprises an older terrace surface, the Marton Terrace. This was deposited during an older interglacial period, and is mantled with three loess units deposited in subsequent glacial events (Palmer et al. 1988). The age of the surface is 140–150 kA and the overlying loess units are approximately 15–25, 30–50 and 65–75 kA respectively (Palmer & Van Dissen 2002, see Figure 2).

Drainage across this surface is derived from streams arising on the hill country to the southeast of the area (Figure 4). There are some unusual patterns of stream direction across the area. On the east side of Ringawhati Rd, there is a stream which captures much of the drainage from the hill country and diverts this in a SW direction (approximately parallel to the road) towards the Otaki River. Slightly NE of this stream, another stream collects drainage from the hill country and crosses Ringawhati Rd, then turning SW and running subparallel to the road and reaching the Otaki River via a steeply incised gully. Both stream systems are incised or have eroded wide areas adjacent to the channels, which suggests they are well-established landform features.

At the north end of Ringawhati Rd, streams arising from the hill country drain towards Waitohu Stream.

Adjacent to the north side of the Otaki River is an early Holocene (6,500–10,000 yBP) erosion terrace cut down by c.30 m into the Marton surface which is 8.6m higher (max) than the adjacent river flats. Young recent alluvium is present along the modern Otaki River.

The bed of Waitohu Stream is also eroded into the Marton terrace deposits, and these deposits are described by Palmer et al. (1988) as “Older Recent Alluvium” (Figure 1).

5. Fault characteristics – Te Horo to Otaki River

South of the Otaki River, the Northern Ohariu Fault is expressed as a generally continuous low linear scarp which can be clearly seen on the ground, on aerial photographs and in the LIDAR data. We have generated a series of 15 cross sections across the fault scarp at a spacing of 250m to enable the vertical offset across the scarp to be measured (Figure 5A/B).

Vertical offset details are given in Table 1. In general, the scarp is down to the southeast. At the southwestern end, the scarp is curved and downthrown to the northwest.

Section line	Vertical fault offset (m)	Downthrown side
1	0.8	NW
2	1.4	NW
3	0.4	NW
4	0.8	SE
5	1.0	SE
6	1.8	SE
7	0.8	SE
8	1.7	SE
9	1.0	SE
10	1.6	SE
11	1.1	SE
12	1.0	SE
13	1.1	SE
14	2.0	SE
15	0.4	SE

Table 1. Vertical offset measured across the Northern Ohariu Fault south of the Otaki River. See Figure 3 for location of the section lines.

Through much of this area, the District Plan fault polygons accurately overly the position of the fault indicated in the LIDAR data. However, at the southwest end, the fault trace has a similar azimuth to fluvial channel features, resulting in uncertainty in the GNS mapped location (Figure 3). The LIDAR data indicates the fault curves towards the southwest and continues past the mapped extent, to a point at 1779276 mE / 5481216 mN. LIDAR data also indicate the fault is downthrown to the northwest through this area.

Adjacent to the Otaki River, the fault location can be clearly identified on the Ohakea II surface extending to its eroded edge. On the lower terrace, GNS indicate that the fault can be clearly seen on the 1948 aerial photographs, at a position slightly offset to the NW from the position on the high terrace, which is inferred to indicate dip on the fault plane. Due to orchard development in the area, the feature is not visible on current photographs. The LIDAR data also shows a subtle feature on the inboard (cliff) side of the low terrace, extending for a distance of c.85 m from the base of the cliff, though no lateral offset is evident (Figure 3). The vertical fault offset determined from our cross section through this area is 0.4m, which is similar to variation in elevation for adjacent parts of the low terrace surface (Figure 5B, Section 15). In contrast, the fault offset on the adjacent upper, older surface is 2.0m (Figure 5B, Section 14).

The LIDAR map of the surface shows that fluvial channel features extend across the fault scarp at numerous points (Figure 3). This indicates that through this area, fault movement appears to be generally vertical since deposition of the surface 10-22,000 yrs BP.

6. Fault characteristics, Otaki River to Waitohu Stream

In contrast to the southern section, the fault character across the area from the Otaki River to Waitohu Stream is complicated by extensive fluvial erosion of the Marton Terrace surface, and uplift or subsidence adjacent to parts of the fault trace (Figure 4). Drainage appears to be diverted around the areas of uplift and through the areas of subsidence. Measured vertical offsets determined from cross sections are listed in Table 2, and cross section locations are shown in Figure 4. Cross sections are shown in Figure 6A, B.

Section line	Vertical fault offset (m)	Adjacent subsidence (m)	Downthrown side
1	1.2		SE
2	2.7	5	SE
3	4.4	5	SE
4	3.5 (4.8)	8	SE
5	(4.3)	7	
6	(7.4)	10	
7	1.7	5	SE
8	±1.6		SE
9	2.4		SE
10	0.3		SE
11	–		
12	–		

Table 2. Measured vertical fault offsets and adjacent vertical movements, Otaki River to Waitohu Stream. Values in brackets are heights of mounds adjacent to the fault trace above the regional slope. No scarp is evident on Section 11 (across Waitohu Stream) or Section 12 (hillslopes to N of Waitohu Stream).

At the southern end, the fault is clearly present on an "Early Holocene" terrace adjacent to the Otaki River, which lies about 25 m below the Marton Terrace.

As the fault crosses onto the Marton Terrace, it appears to occupy an eroded trench between two deeply incised stream channels. Moving to the NE, there is a clear scarp present on Section 3 (Figure 6A), though the topography has been modified slightly by road formation. Further NE, along Sections 4–6, the fault appears to be expressed as a narrow zone of uplift which reaches elevations of up to 7.4 m above the regional slope. From Section 7 onwards, only limited offsets are present, and the LIDAR data indicate that the fault trace is discontinuous, as mapped by GNS.

On the "Older Recent Alluvium" surface adjacent to Waitohu Stream (Figure 6B, Section 10), there is a clear fault trace evident in aerial photographs and the LIDAR data, though the vertical offset appears to be less than 0.3m. A distinct change in vegetation across the fault trace indicates drainage from the western (upstream) side is impeded by the fault. GNS state there is clear evidence on the 1949 aerial photographs for right lateral offset at this locality. We were unable to detect such evidence on the photographs, or on the ground (Figure 7).

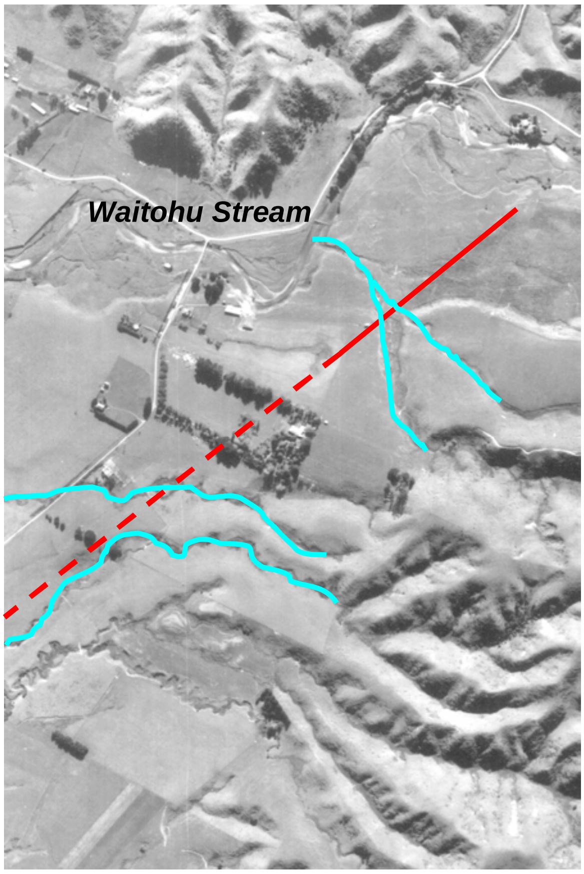


Figure 7. 1948 vertical aerial photograph (SN 198 Run 306/9) of northern Ringawhati Rd area.

On the lower image, the fault trace is marked in red and the stream channels in blue.

The GNS mapped fault polygons adequately capture the position and / or likely position of the fault trace. However, between Sections 5 and 9 (Figure 6A), deformation is "Distributed" (comprising multiple fault traces and/or folds) and not "Well Defined" as indicated (Ministry for the Environment 2003, Table 8.1).

There are no detailed fluvial channel patterns preserved on the Marton Terrace surface from which to determine whether lateral offset across the fault trace is present, due to loess cover. However, three stream channels cross the fault trace. One is located between Sections 6 and 7, and is diverted round the north side of the narrow zone of uplift discussed above. There appears to be an offset of about 55m to the south as this stream crosses the fault trace. However, this sense of lateral offset is opposite to that documented by GNS for other localities on the fault, and it is likely that the stream channel pattern is not due to offset across the fault trace. Two small streams adjacent to Waitohu Stream cross the fault trace, though little if any lateral offset of stream channels was observed.

7. Fault location at 156 Ringawhati Rd

The site at 156 Ringawhati Rd and adjacent areas was inspected on 12 December 2008 in the company of the landowner, Dr Fred Davey. The location of various landform features was recorded with a hand-held GPS.

The surface in this area was mapped as "Older Recent Alluvium" by Palmer et al. (1988) (Figure 1). However, exposure at the rear of the residence indicates that thick (3m+) loess is present on the site, indicating that the surface is older than c.15,000 yrs (the youngest age for loess deposition). An indistinct terrace c.100m N of the house, at approximately the N boundary of the property, represents the southern boundary of Waitohu Stream sediments. The surface has also been eroded by a small stream draining the springs on the property.

The locations of a minor topographic bulge and the two springs on the property were recorded. These are located near the centre of the mapped fault position (Figure 8). On the adjacent land to the north, towards the water treatment plant on Waitohu Stream, the fault trace can be seen traversing river flats. The location of the fault trace at the fenceline south of the water plant also falls within the fault zone. Adjacent to the treatment plant, the fault trace appears to have been excavated to form a drainage ditch. LIDAR mapping suggests other parts of the fault trace on the river flats may have also been excavated. Two small streams draining the adjacent hills cross the fault trace with little apparent offset (Figure 8).

Fault offsets recorded through this area are lower than typical for the Marton Terrace (Sections 8 and 9, 1.9 and 2.4m respectively, Table 2). While it is likely that the surface on the property is underlain by Marton Terrace deposits, the limited offsets indicate there has been erosion at some time between Marton Terrace deposition and loess cover deposition.

We concur with GNS that fault location through the property at 156 Ringawhati Rd has been accurately mapped. However, as indicated above, the fault zone would be better marked as "distributed" rather than "well defined".

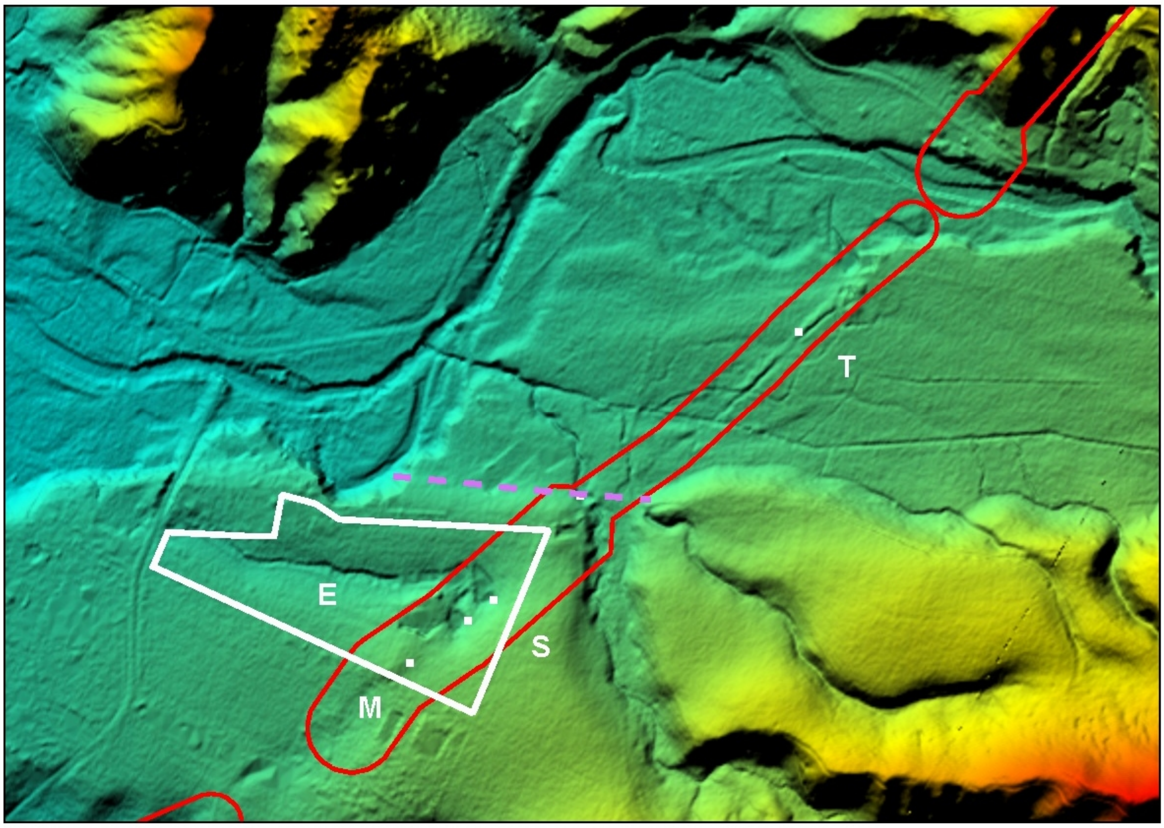


Figure 8. LIDAR plot, 156 Ringawhati Rd and surrounding area. Sites marked as follows: M = mound, S = springs (x2), E = eroded stream valley draining springs, T = trench along fault trace. Point locations recorded with hand-held GPS. Dashed purple line is terrace edge facing Waitohu Stream.

8. Fault motion and recurrence interval

The Northern Ohariu Fault in the study area has been mapped across a variety of surfaces of different ages. In general, greater vertical offsets (including uplift and subsidence) are recorded on the older (Marton Terrace) surfaces, whereas only very minor offsets are recorded on the younger (Holocene) surfaces.

Vertical offsets up to 2 m are present on the Ohakea II (OI2) surface, and up to 17.5 m on the Marton Terrace (OI6) surface which is 8 times older. A plot of age versus offset (Figure 9) indicates that the fault is characterised by an average vertical offset rate of 10m in about 120,000 yrs (0.08 mm per year). A maximum vertical offset rate for the fault (calculated from 17.5 m in 140,000 yrs, which includes all vertical movements) is about 0.12 mm per year. On the Ohakea II surface, the vertical offset rate is 0.09 mm per year (assuming the surface is c. 22000 yrs old), which is consistent with the rate seen on the older Marton surface. Rates of subsidence adjacent to the fault trace along Ringawhati Rd are 0.03–0.07 mm per year, and the rate of uplift is 0.03–0.05 mm per year.

As indicated above, there is no evidence for lateral offsets across the fault trace in the study area. Ancient stream channel patterns on the Ohakea II surface south of the Otaki River are not disrupted by fault movement, and modern streams along Ringawhati Rd cross the fault trace with no apparent right lateral offset.

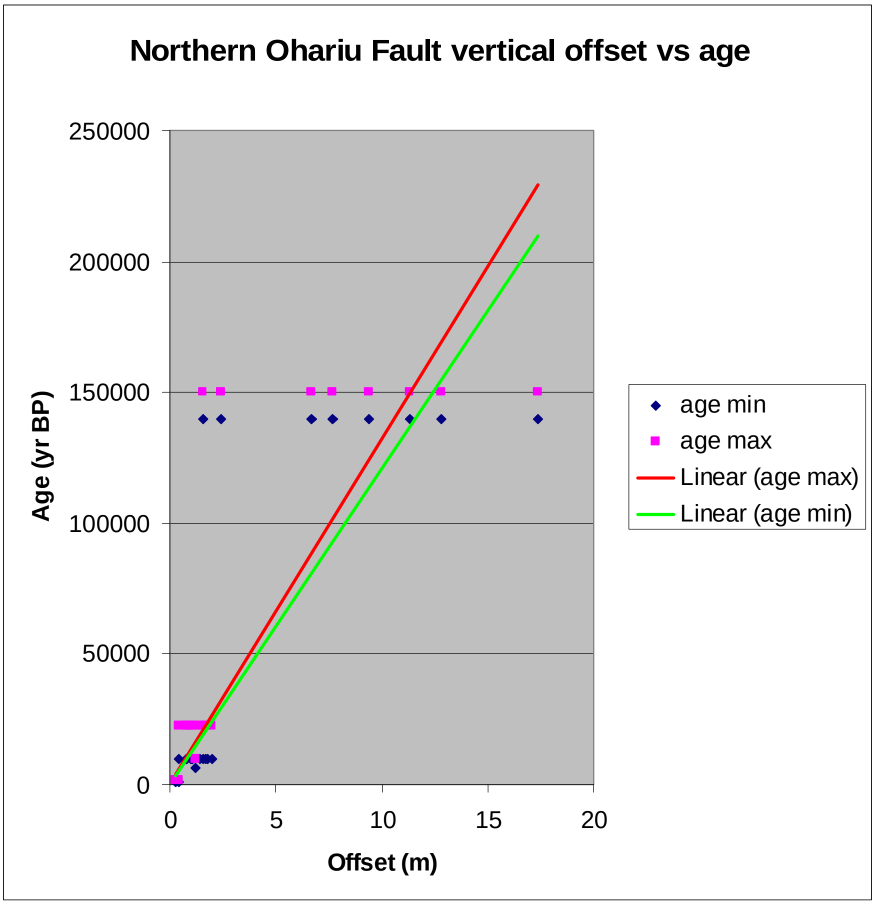


Figure 9. Plot of total vertical offset versus age, with linear best fits for minimum and maximum surface ages.

No data have yet been obtained to constrain the recurrence interval of the Northern Ohariu Fault. Given that there are mappable fault traces on young surfaces (indicated by GNS to be <1000 yr), the last movement of the fault does appear to be within the last c.1000 yrs. There is very limited vertical offset on those young surfaces (0.3–0.4 m), suggesting that vertical displacement for a single offset event is c.0.3 m.

Assuming an average vertical displacement of 0.3 m for a single event, a recurrence interval of 4000 yrs would generate displacements 1.8–2.1 m for the Ohakea II surface and 11.4–11.7 m for the Marton surface. This latter value is less than the total vertical offset, but equivalent to the offset across the scarp and subsidence combined (i.e. uplift of folded area excluded). This analysis also indicates that the Ohakea II surface is more likely to be as old as >22000 yrs rather than the lower age of the possible range indicated above.

9. Conclusions and Recommendations

The mapping of the Northern Ohariu Fault within the KCDC area of jurisdiction is generally accurate, with the mapped fault avoidance zone overlying scarp positions or other surface features identified independently from analysis of LIDAR data. In general, our investigation confirms GNS observations. However, at the southwest end, the fault trace appears to curve to the south and the mapped extent appears to have included fluvial channel features as having a fault origin. The fault avoidance zone should be modified in this area.

Along Ringawhati Rd, the present fault avoidance zone is mapped in parts as having a greater width (90 m) through an area of discontinuous surface expression. In addition to fault rupture, there is uplift and subsidence through this area. This area should be mapped as a zone of "Distributed" deformation for greater consistency with the MFE Guidelines.

Where the fault crosses Waitohu Stream, GNS describe clear evidence (on the 1948 aerial photographs) for right lateral offset (though no details are given). We are unable to confirm these observations from our inspection of the same aerial photographs and the LIDAR data, or on the ground.

At present the Recurrence Interval class assigned by GNS to the Northern Ohariu Fault is Class II (>2000 – <=3500 yrs), as indicated by geomorphic features present along the fault in areas outside the present study area. A similar movement history to the Ohariu Fault, which has been extensively studied by trenching and dating analysis, is inferred. The recurrence interval for the Ohariu Fault is 2200 yr, with a last rupture event about 1000 yr BP, a mean horizontal slip rate of 1–2 mm/yr and a mean single event horizontal displacement of 3.7 m in a dextral direction (Litchfield et al . 2006).

We concur with GNS that the time of last rupture on the Northern Ohariu Fault was probably similar to the Ohariu Fault (about 1000 yr BP). However, in the study area, fault movement is predominantly vertical, with no evidence for horizontal slip. Approximately 20–40 m of dextral offset of fluvial channel patterns on the Ohakea II Surface would be expected if the lateral movement component was 1–2 mm per year, however numerous channel features can be traced across the fault scarp with no apparent offset. Likewise, expected offsets on the Marton Terrace surface would be c.300 m, though nothing of this magnitude is evident in the study area. GNS also present no evidence for lateral movement throughout the area between Te Horo and Ringawhati Rd.

Our analysis indicates a vertical movement rate along the Northern Ohariu Fault of c. 0.09 mm per year can be applied throughout the study area. In contrast, the horizontal slip rate for the Ohariu Fault is 1–2 mm per year. Our estimate of the recurrence interval is 4000 yrs (assuming a single vertical displacement of 0.3 m about 1000 yrs BP). However, some movement associated with the fault is compressive folding rather than faulting, and this appears to be occurring in addition to fault offsets and subsidence. The rates of uplift and subsidence are in the range 0.03–0.07 mm per year.

We consider that the Northern Ohariu Fault in the study area should be assigned to fault Recurrence Interval Class III, >3500 yrs to <= 5000 yrs. A revised fault zone polygon is presented in Figure 10.

10. Applicability

This report has been prepared for the benefit of Kapiti Coast District Council with respect to the brief given to Ian R Brown Associates Ltd. It may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Opinions and recommendations contained in this report have been derived from the information and data gathered during the course of our investigations.

No liability is accepted by Ian R Brown Associates Ltd nor by any Director, or any other servant or agent of the company, in respect of the use of this report (or any information contained therein) by any person for any purpose other than that specified in the brief.

11. References

Hawke, R.M.; McConchie, J.A. (2005): The source, age and stabilisation of Koputaroa dunes, Otaki-Te Horo. New Zealand Journal of Geology and Geophysics, 48, 517–522.

Heron, D. & R. Van Dissen (2007): Review of fault location at two sites on the Kapiti Coast. IGNS Letter Report 2006/158LR to Kapiti Coast District Council, 15pp.

Litchfield, N.J.; Van Dissen, R.J.; Langridge, R.M.; Heron, D.W.; Prentice, C. (2004): Timing of the most recent surface rupture event on the Ohariu Fault near Paraparaumu, New Zealand: short communication. New Zealand Journal of Geology and Geophysics, 47(1): 123–127.

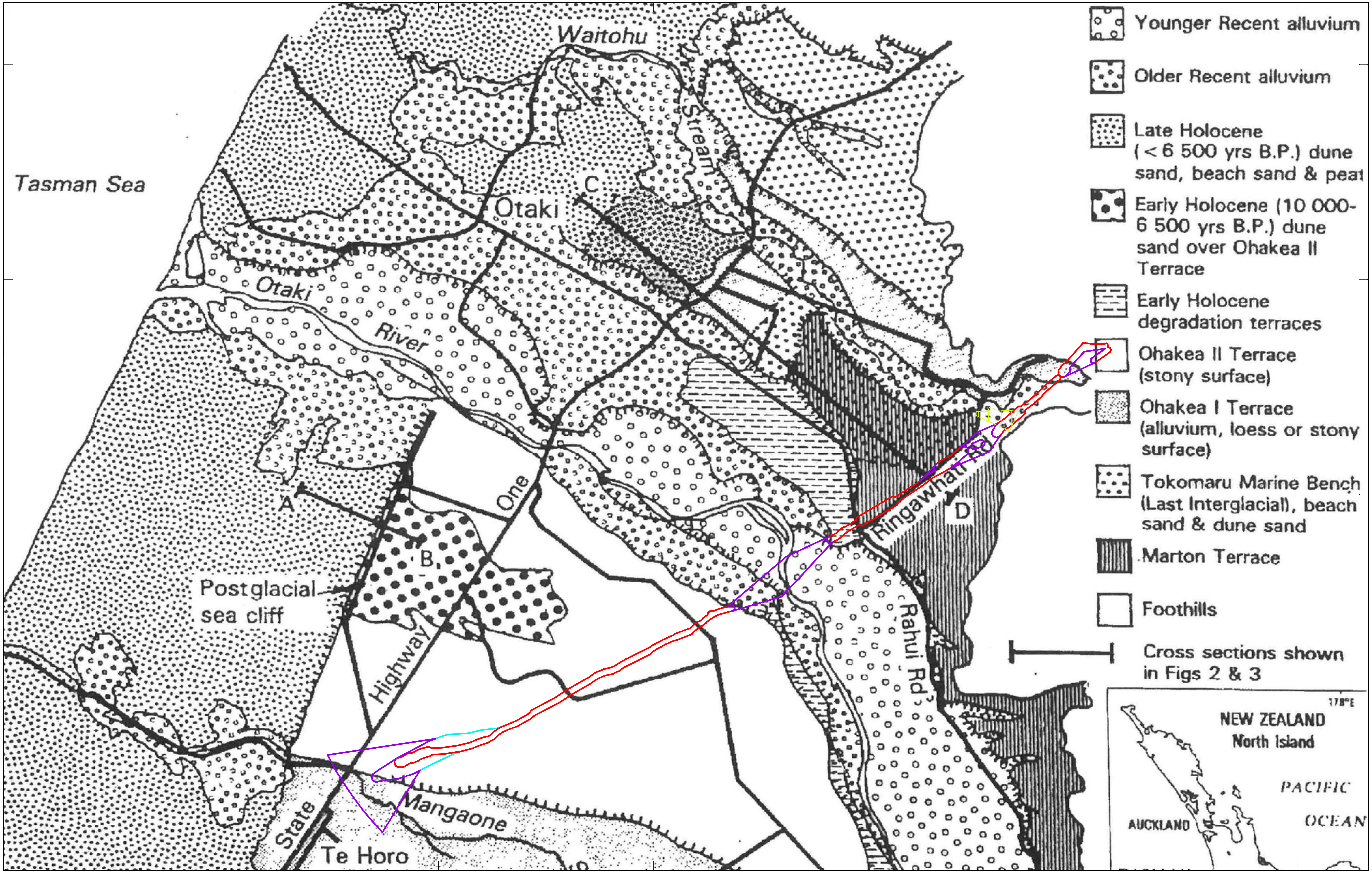
Litchfield, N.J.; Van Dissen, R.J.; Heron, D.W.; Rhoades, D.A. (2006): Constraints on the timing of the three most recent surface rupture events and recurrence interval for the Ohariu Fault: trenching results from MacKays Crossing, Wellington, New Zealand. New Zealand Journal of Geology and Geophysics, 49(1): 57–61.

Ministry for the Environment (2003): Planning for development of land on or close to active faults. Ministry for the Environment, Wellington, New Zealand, 67 pp.

Palmer, A.S.; Barnett, R.; Pillans, B.J. (1988): Loess, river aggradation terraces and marine benches at Otaki, southern North Island, New Zealand. In Loess, Eden & Furkett (eds), Balkema, Rotterdam, pp163–174.

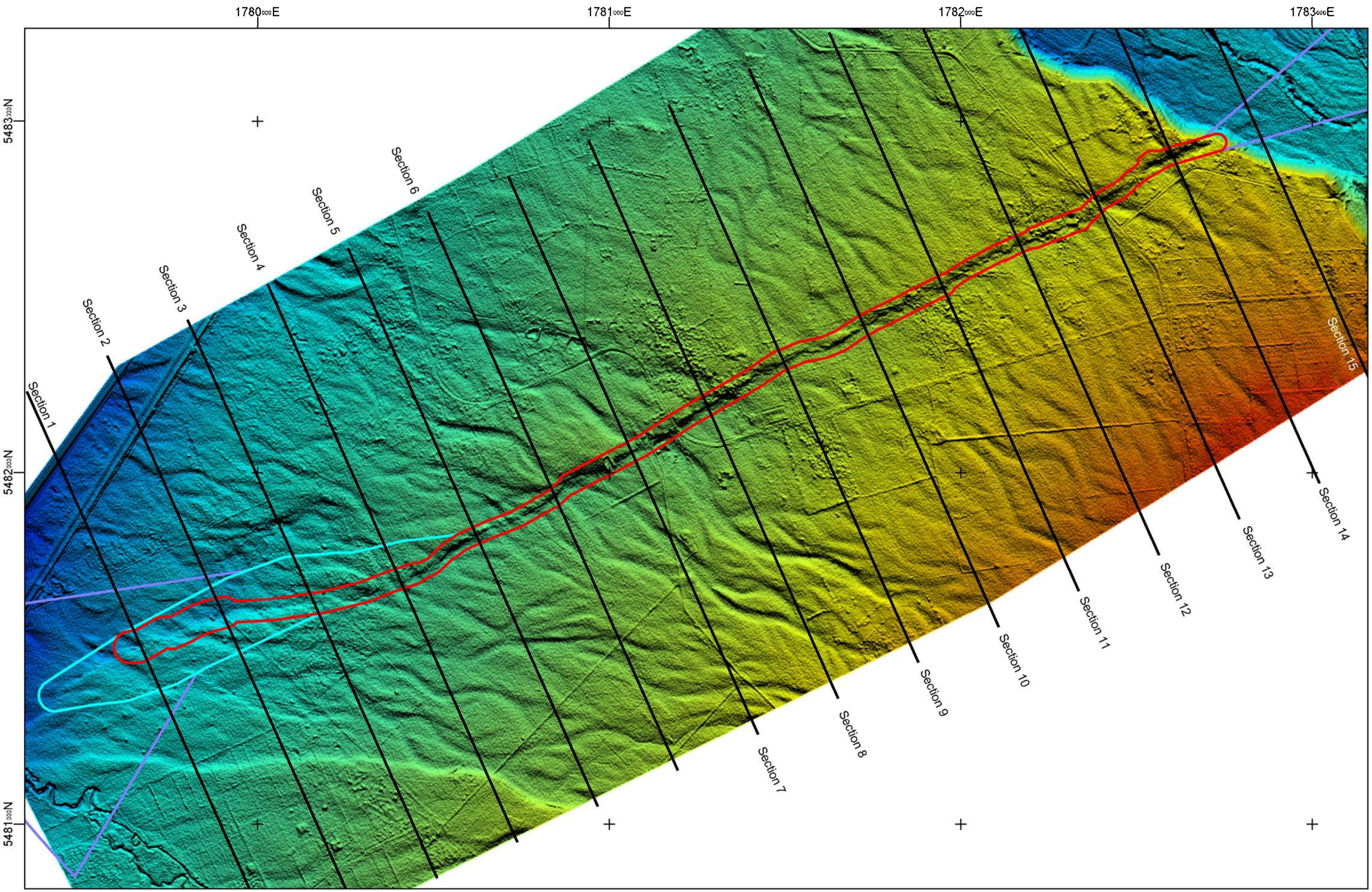
Van Dissen, R., & Heron, D. (2003): Earthquake Fault Trace Survey Kapiti Coast District, IGNS Client Report 2003/77, August 2003, 36pp plus figures.

FIGURES

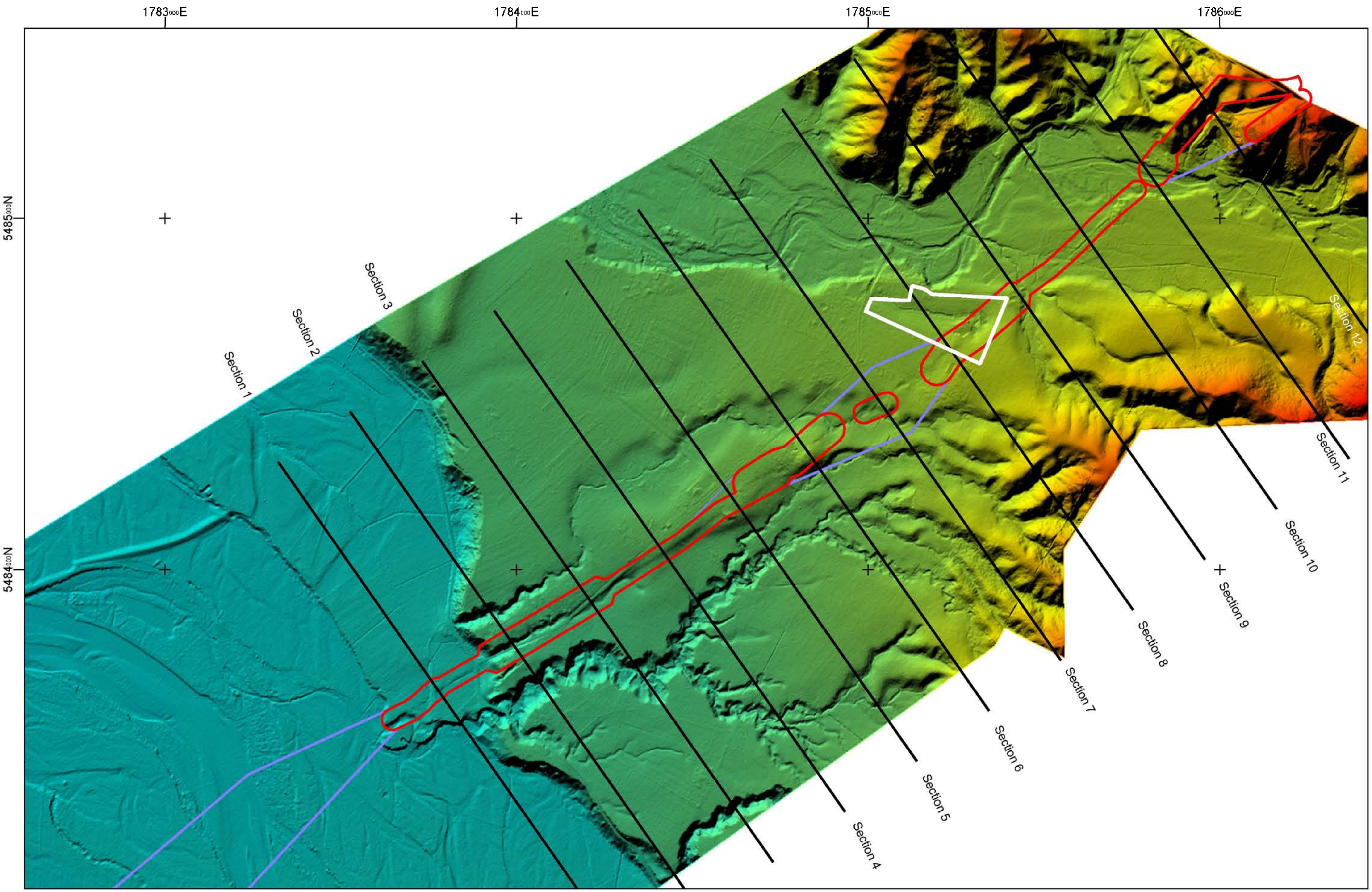


Palmer et al. (1988)

GRAPHIC SCALE		ORIGINAL SCALE 1:35000	Kapiti Coast District Council
EXPLANATION	GNS fault zone polygons: Well defined; Distributed; Uncertain - constrained; 156 Ringawhati Rd. Source: Palmer et al. (1988) Figure 1. Grid = NZTM	JOB NO. 996	Northern Ohariu Fault study Quaternary geological map
		Ian R Brown Associates Ltd *Geological Engineering Consultants* PO Box 24-147 Wellington New Zealand Tel (04) 471-1464 Fax (04) 471-1745	DRAWN SDW — FIGURE 1 APPROVED IRB — DATE 9-Mar-2009



GRAPHIC SCALE 0 0.500 1.000 1.500 Kilometre	ORIGINAL SCALE 1 : 10,000		Kapiti Coast District Council
EXPLANATION GNS fault zone polygons: Well defined; Distributed; Uncertain constrained. Section lines. LIDAR data was provided by Greater Wellington Regional Council. Grid = NZTM	JOB NO. 996		Northern Ohariu Fault Study LIDAR map, Te Horo to Otaki River
	Ian R Brown Associates Ltd *Geological Engineering Consultants* PO Box 24-147 Wellington New Zealand Tel (04) 471-1464 Fax (04) 471-1745	DRAWN JPC	FIGURE 3
		APPROVED IRB	DATE 9-Mar-2009



GRAPHIC SCALE 0 0.500 1.000 1.500 Kilometre

EXPLANATION

GNS fault zone polygons
- Well defined
- Distributed
- Uncertain constrained

Section lines

156 Ringawhati Road

LIDAR data was provided by Greater Wellington Regional Council.

Grid = NZTM

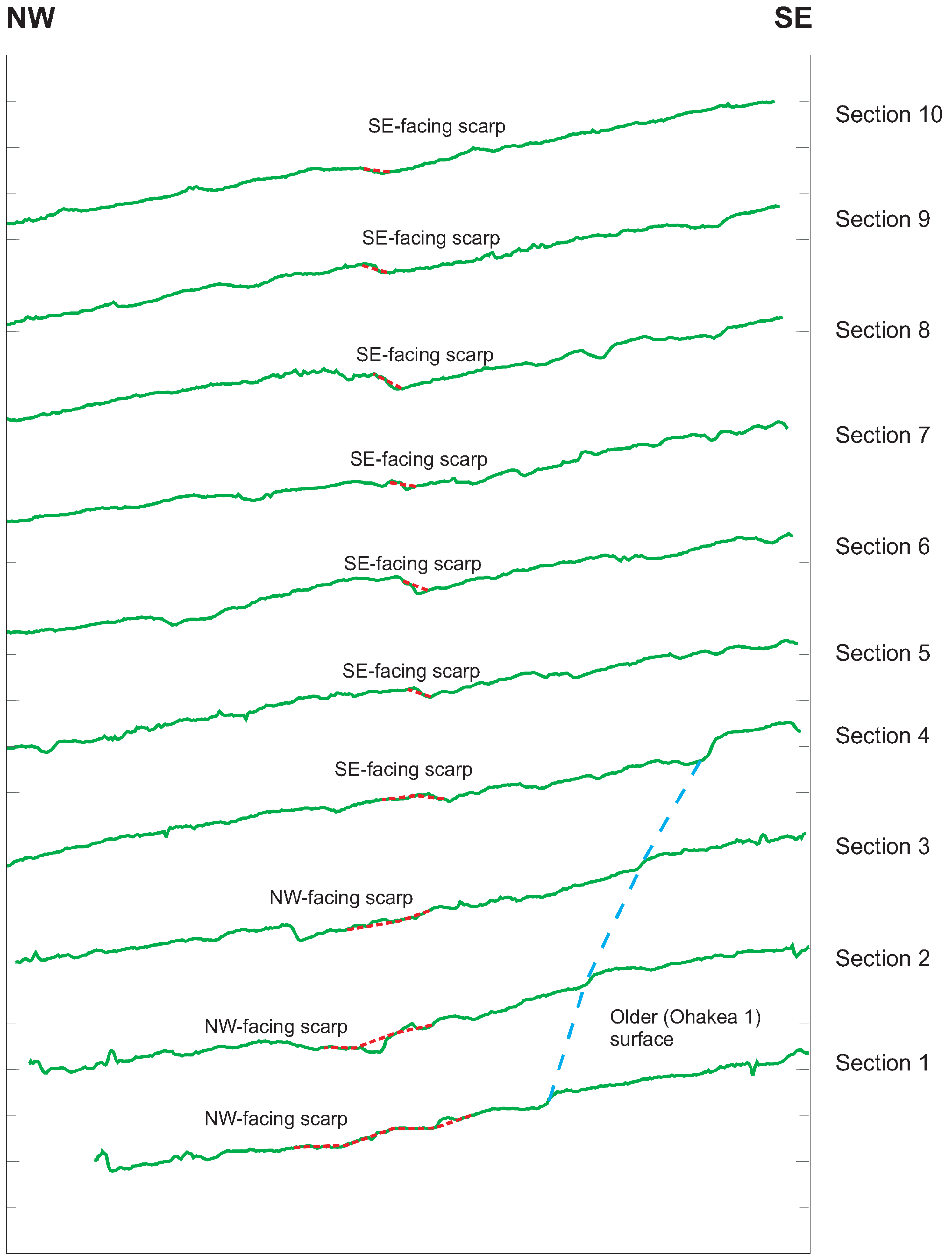
ORIGINAL SCALE	1 : 10,000
JOB NO.	996

Ian R Brown Associates Ltd
Geological Engineering Consultants
PO Box 24-147 Wellington New Zealand
Tel (04) 471-1464 Fax (04) 471-1745

Kapiti Coast District Council

Northern Ohariu Fault Study
LIDAR map, Otaki River to Waitohu Stream

DRAWN	JPC	FIGURE	4
APPROVED	IRB	DATE	9-Mar-2009



GRAPHIC SCALE Vertical tick = 5m, Vertical exaggeration = 20:1.

EXPLANATION

Topography modelled from LIDAR

GNS fault polygon

ORIGINAL SCALE 1:1k V /1:20k H

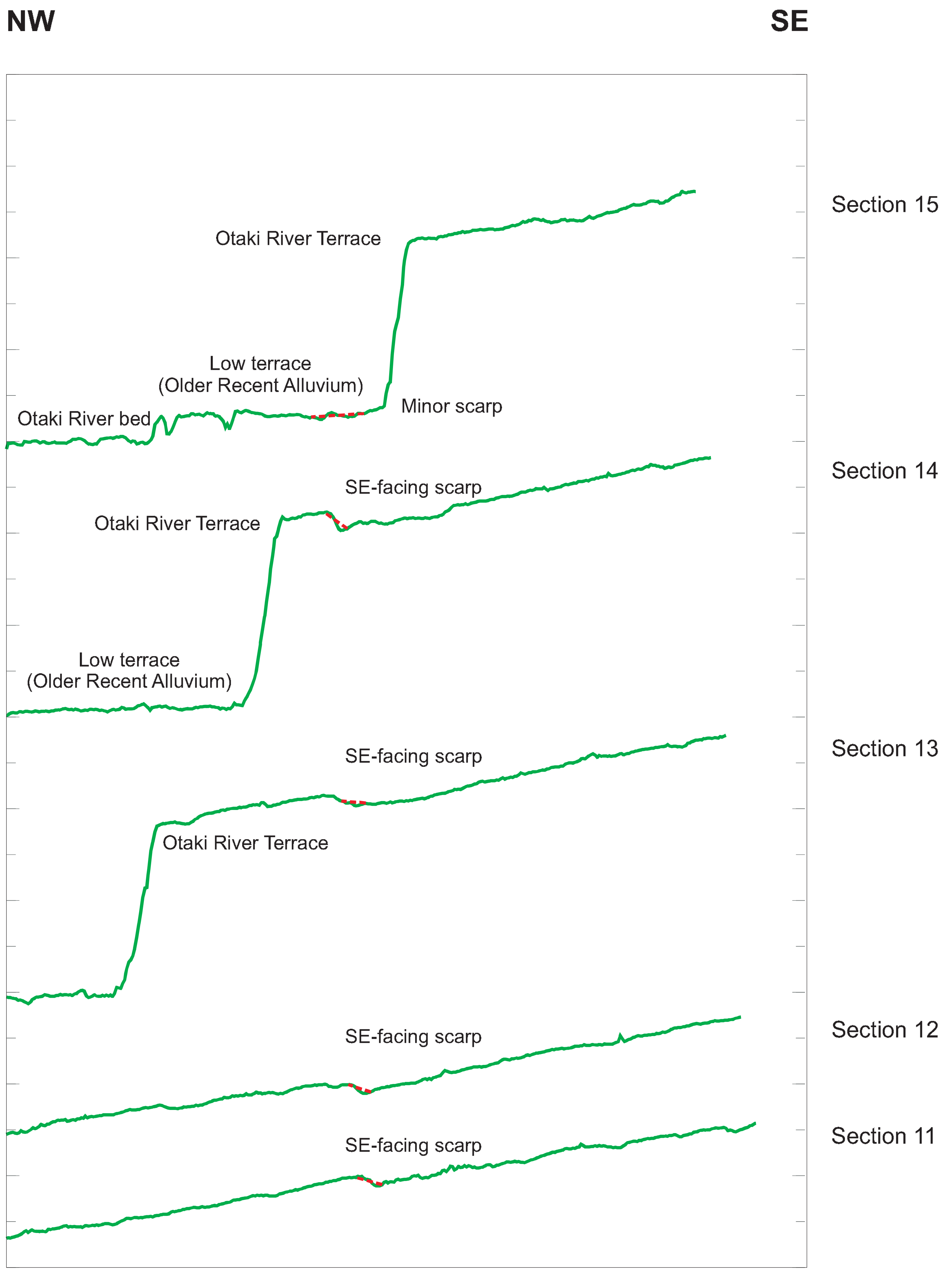
JOB NO. 996

Ian R Brown Associates Ltd
Geological Engineering Consultants
PO Box 24-147 Wellington New Zealand
Tel (04) 4711464 Fax (04) 4711745

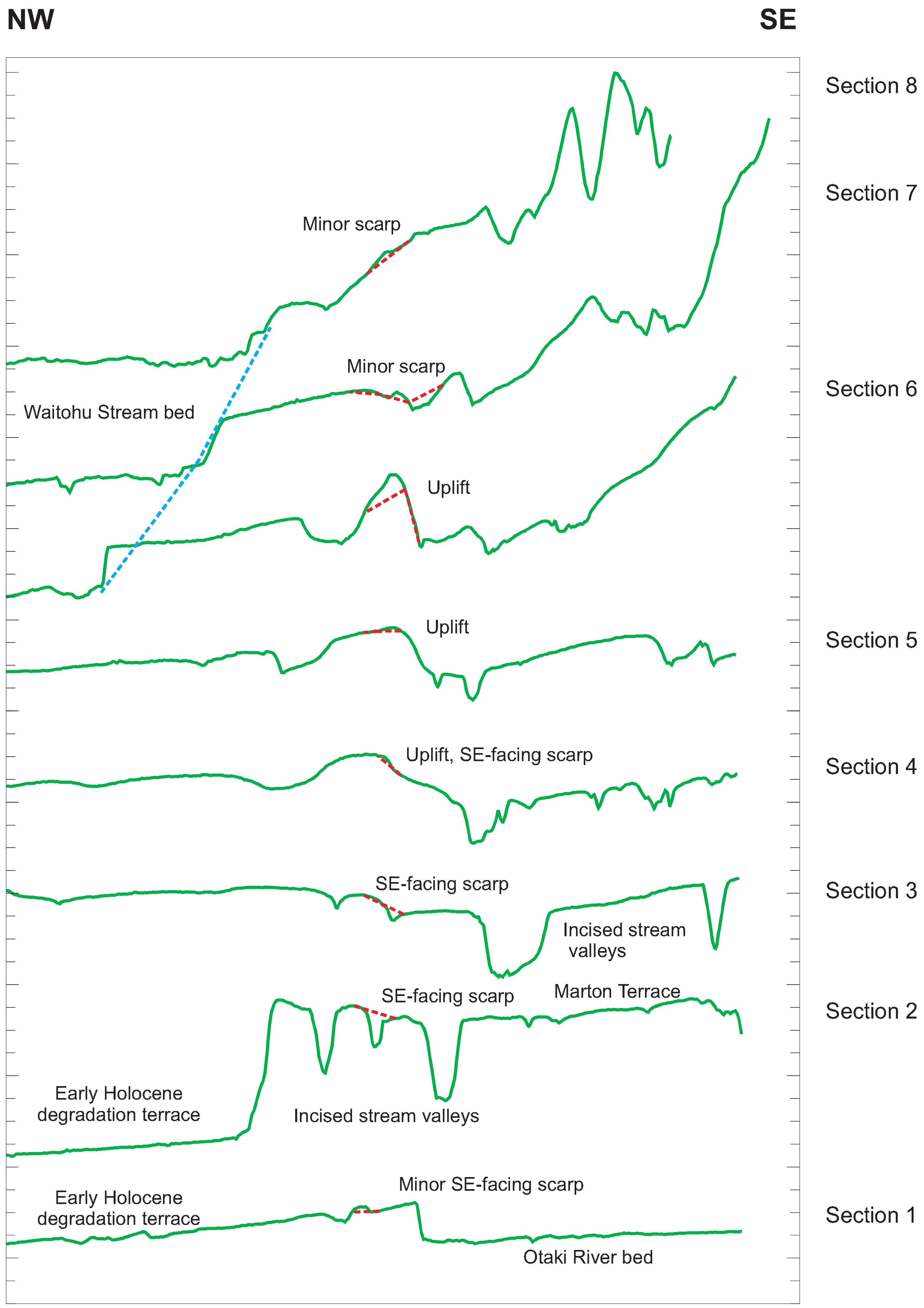
Kapiti Coast District Council

Cross sections 1-10 South of Otaki River

DRAWN	SDW	**FIGURE**	5A
APPROVED	IRB	**DATE**	11-Dec-2008



GRAPHIC SCALE Vertical tick = 20m, Vertical exaggeration = 20:1.	**ORIGINAL SCALE**	1:2k V /1:40k H	**Kapiti Coast District Council**		
EXPLANATION	**JOB NO.**	996	Cross sections 11-15 South of Otaki River		
Topography modelled from LIDAR GNS fault polygon	Ian R Brown Associates Ltd *Geological Engineering Consultants* PO Box 24-147 Wellington New Zealand Tel (04) 4711464 Fax (04) 4711745		**DRAWN** SDW	**FIGURE**	5B
			APPROVED IRB	**DATE**	11-Dec-2008



GRAPHIC SCALE Vertical tick = 5m, Vertical exaggeration = 10:1.

EXPLANATION

Topography modelled from LIDAR

GNS fault polygon

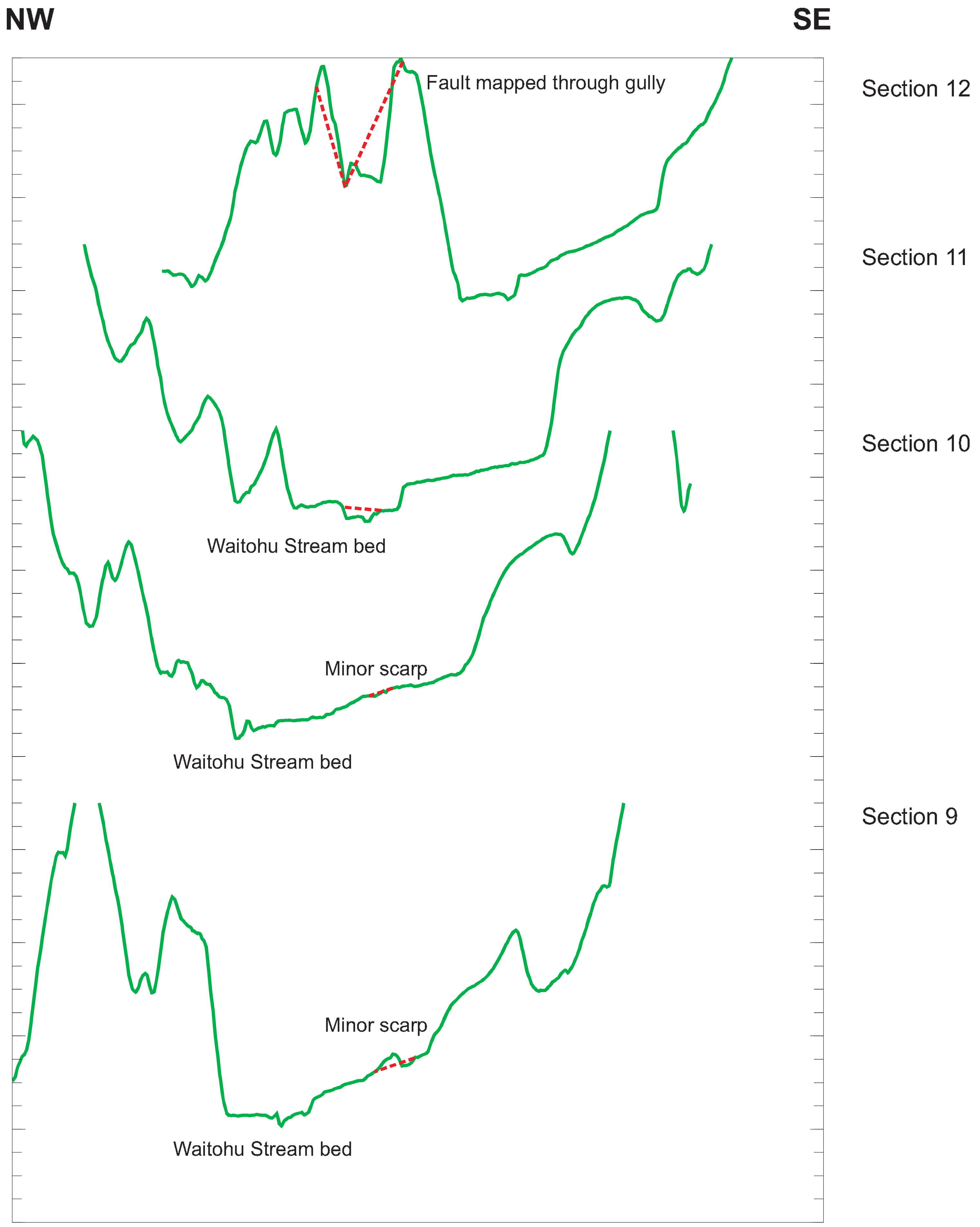
ORIGINAL SCALE	1:1k V /1:10k H
JOB NO.	996

Ian R Brown Associates Ltd
Geological Engineering Consultants
PO Box 24-147 Wellington New Zealand
Tel (04) 4711464 Fax (04) 4711745

Kapiti Coast District Council

Cross sections 1-8
North of Otaki River

DRAWN	SDW	**FIGURE**	6A
APPROVED	IRB	**DATE**	11-Dec-2008

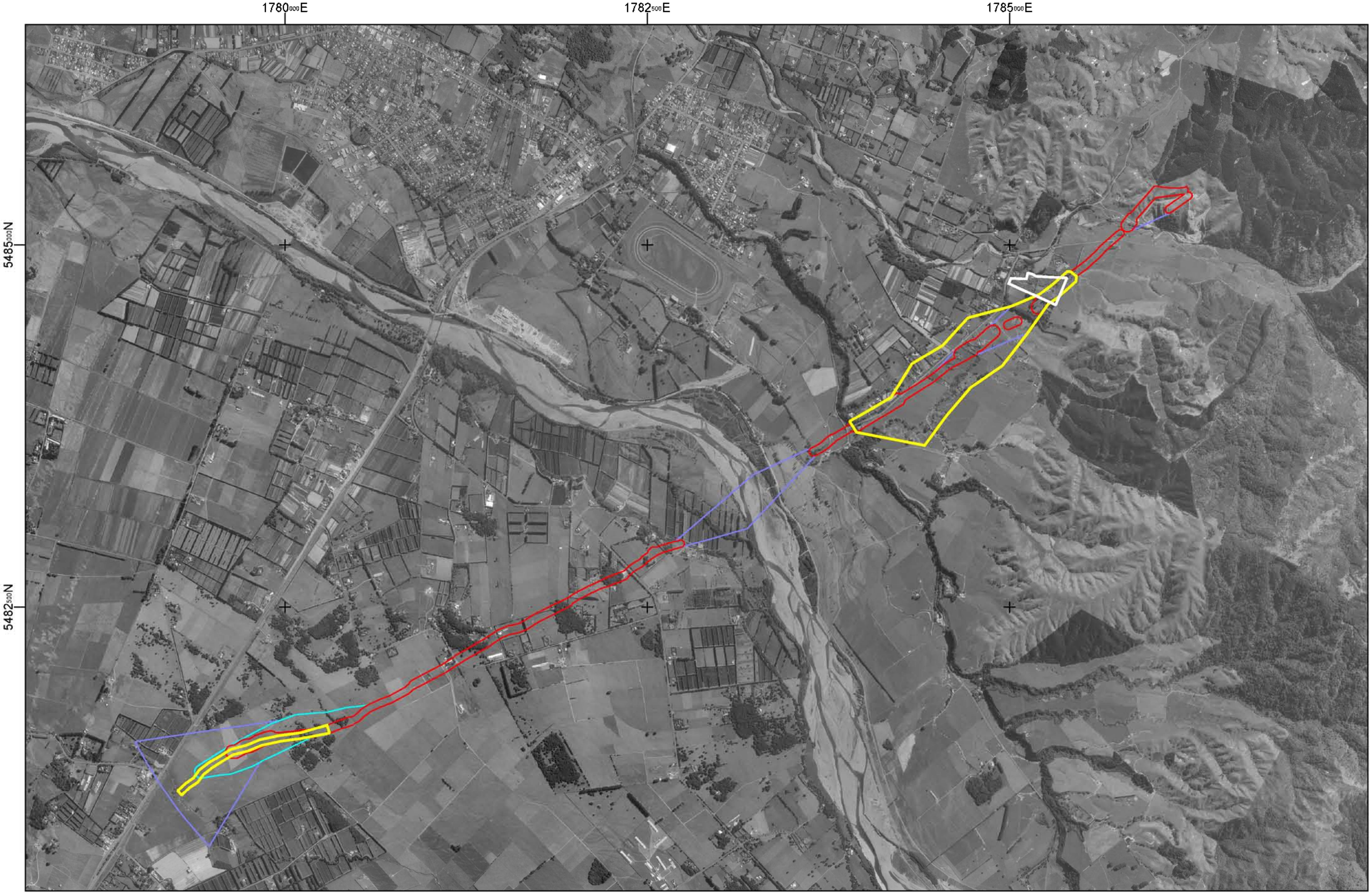


GRAPHIC SCALE Vertical tick = 5m, Vertical exaggeration = 10:1.

EXPLANATION

- Topography modelled from LIDAR
- GNS fault polygon

ORIGINAL SCALE	1:1k V /1:10k H	**Kapiti Coast District Council**	
JOB NO.	996	**Cross sections 9 -12 South of Otaki River**	
Ian R Brown Associates Ltd *Geological Engineering Consultants* PO Box 24-147 Wellington New Zealand Tel (04) 4711464 Fax (04) 4711745		**DRAWN** SDW	**FIGURE** 6B
		APPROVED IRB	**DATE** 11-Dec-2008



GRAPHIC SCALE 0 1 2 3 Kilometre

ORIGINAL SCALE 1 : 25,000

JOB NO. 996

Kapiti Coast District Council

North Ohariu Fault Study
Revised fault polygons

EXPLANATION

GNS fault zone polygons
- Well defined
- Distributed
- Uncertain constrained

IRBA proposed fault zones

156 Ringawhati Road

Background Orthophotos: LINZ R25d_fy_99_00.tif & S25c_fy_99_00.tif

Grid = NZTM

Ian R Brown Associates Ltd
Geological Engineering Consultants
PO Box 24-147 Wellington New Zealand
Tel (04) 471-1464 Fax (04) 471-1745

DRAWN	JPC	FIGURE	10
APPROVED	IRB	DATE	9-Mar-2009