T.A. Little et al.
Late Holocene surface ruptures on the southern Wairarapa fault, New Zealand: Link between earthquakes and the raising of beach ridges on a rocky coast

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## Figure Captions

**Figure A.** Active fault traces and folds along a southern part of the central section of the Wairarapa fault, near Lake Wairarapa (after Rodgers and Little, 2006).
**Figure B.** i) Photograph, looking SW along the southern of the two fault strands showing location of CC-1 and CC-4 trenches. Liz Schermer for scale. ii) Photograph, looking SW along the northern of the two fault strands showing location of CC-2 and CC-3 trenches. Liz Schermer is standing at the toe of a small alluvial fan that infills the NE corner of the swampy depression.
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**Appendix A: Methods**

Detailed maps of the trenches and surrounding topography were prepared at each site from point elevation data collected on foot using a Leica real-time kinematic (rtk) Global Positioning System (GPS) system employing a differential correction relative to a base station affixed to the geodetic benchmark LUCENA (NZMS270-S27A). Because of locally significant bush cover at the Pigeon Bush site, the topographic map of Fig. 3 (from Rodgers and Little, 2006) includes some points that were surveyed by 3D laser ranging from instrument stations (control points) that had already been located by G.P.S. (see Rodgers and Little, 2006, for further details). All positions are quoted relative to the New Zealand Geodetic Datum 1949 (precision <5 cm) and heights are relative to mean sea level with a vertical accuracy of ± 20 cm. For each map, the survey points were gridded (at 1 m node spacing and using a triangulation-with-smoothing algorithm) in the program Vertical Mapper 2.0, which is a module of the Mapinfo Professional (ver. 9.0) desktop G.I.S. program. The resultant Digital Elevation Model (DEM) was contoured by Vertical Mapper. Grid marks (in meters) on the Figures refer to the New Zealand Map Grid Coordinate System.

After excavation by back-hoe, the trench walls were cleaned by hand and then gridded horizontally and vertically at 1 m intervals using white string. Geological features were flagged using colored nails and logged “by hand” directly on graph paper at a scale of 1:20. Twenty-four samples of organic material from these trenches were submitted to Waikato Radiocarbon Laboratory for conventional radiocarbon dating, and a further sixteen samples were submitted to Rafter Radiocarbon Laboratory (GNS Science) for dating by Accelerated Mass Spectrometry (AMS).

## Appendix B.
## Unit descriptions for Pigeon Bush trenches (trenches PB-1, PB-2).

**NE Wall of Pigeon Bush 1 Trench (PB-1). The Younger Abandoned Channel**
Bearing 303. Logged by Little & Schermer in April, 2006. Log is Fig. 4a.

**Cfu:** Gravels & silts. Poorly sorted. Undifferentiated channel-infilling gravels and silts (mixture of fluvial and colluvial)

**Si:** Yellowish-grey silt with sparse (10%) subangular granules to fine pebbles. Unit is slightly coarser at the base. Well sorted.

**Sgr:** Brownish-grey, silty pebble gravel & pebbly silt (more gravel at the base). Very poorly-sorted.

**Tgr:** Cobble gravel with coarse sand matrix. Crudely bedded. Poorly sorted, clast supported, subrounded to subangular greywacke cobbles up to 25 cm in diameter. Matrix contains pebbles up to 5-10 cm in diameter. Interpreted as fluvial "Waiohine terrace gravels.

**SW Wall of Pigeon Bush 1 Trench (PB-1). The Younger Abandoned Channel**
Bearing 303. Logged by Little & Schermer in April, 2006. Log is Fig. 4b.

**Grs:** Dark medium greyish-brown**,** soil-modified gravelly silt. Contains <5% subangular strongly weathered pebbles up to 2 cm in diameter and charcoal. Mottled, with root casts.

**Ps:** Dark greyish-brown, silty to fine sandy, orange-mottled paleosol. Stiff, massive-textured. Abundant charcoal and uncommon pebbles up to 3 cm in diameter. Interpreted as "Burnt layer" intertonguing with fluvial channel gravel, and in part reworked.

**Fgr-1:** Orange-stained, granule-pebble gravel with silty matrix. Loose granular texture, crudely bedded. Clasts are subrounded to subangular up to 2 cm in diameter. Clast-supported and moderately sorted. Contains abundant detrital charcoal. Interpreted as fluvial channel-infilling gravel.

**Fgr-2:** Similar to above, but with greyish-brown matrix and more poorly sorted (clasts up to 5 cm diameter). Interpreted as fluvial channel-infilling gravel.

**Fgr-3:** Reddish-brown-stained, pebble gravel. Crudely bedded. Clasts are subrounded to subangular up to 3 cm in diameter. Clast-supported and moderately sorted. Interpreted as fluvial channel-infilling gravel.

**Fgr-4:** Reddish-brown-stained, fine pebble gravel with coarse sandy matrix. Crudely bedded. Clasts are subrounded. Clast-supported and moderately-well sorted. Includes several thin lenses of organic material equivalent to the ch unit. Interpreted as fluvial channel-infilling gravel.

**Fgr-5:** Reddish-brown-stained, pebble-cobble gravel with sandy matrix. Massive. Clast-supported and moderately-well sorted. Clasts are subrounded to subangular, up to ~10 cm in diameter. Interpreted as fluvial channel-infilling gravel.

**Cg1:** Medium greyish-brown, gravelly silt. Massive. Greywacke clasts are subangular and up to 4 cm in diameter. Very poorly-sorted and matrix-supported. Contains scattered charcoal. Interpreted as laterally derived colluvium.

**Cg2:** Similar to above, but lighter grey in color and with root mottles and Fe-staining. Clasts up to 5 cm diameter. Interpreted as laterally derived colluvium.

**Cg3:** Light greyish-brown, gravelly silt. Massive. Clasts are up to 5 cm in diameter and subangular to subrounded. Fe-stained, contains charcoal. Crumb structured with root casts. Interpreted as laterally derived colluvium.

**Cg4:** Medium greyish-brown or orangish-grey silt with rare subangular gravel clasts up to 4 cm in diameter. Interpreted as laterally derived colluvium.

**Cg5:** Light greyish-brown, gravel with matrix of silt and fine sand. Clasts up to 8 cm in diameter. Very poorly-sorted. Gravel clasts have an internal clast-arrangement fabric arranged parallel to edge of channel (dips 30-45° SE). Interpreted as laterally derived colluvium.

**Cg6:** Dark reddish-brown or grey, silty gravel. Loose-textured. Subangular clasts up to 6 cm in diameter. Fe-stained. Interpreted as laterally derived colluvium.

**Cg7:** Medium-brown, poorly-sorted silty gravel. Clasts are angular to subangular, up to 5 cm in diameter. Fe-stained, contains charcoal. Interpreted as laterally derived colluvium.

**Sgr:** Orange-brown stained pebble gravel with silty matrix. Clasts are subrounded, up to 5-8 cm in diameter. Clast-supported and moderately to poorly-sorted. Unit becomes more poorly sorted to SE. Interpreted as fluvial channel-infilling gravel.

**Si:** Light greyish-brown gravelly silt. Compact. Massive. Clasts up to 3 cm in diameter.

**Tgr-2: C**obbles in a silty matrix. Subrounded clasts, up to 12 cm in diameter (typically < 4 cm). Interpreted as fluvial terrace gravels.

**Tgr-1:** Boulders and cobbles in sandy matrix. Crudely bedded. Subrounded to subangular clasts, up to 25 cm in diameter. Interpreted as fluvial terrace gravels.

**SE Wall of Pigeon Bush 2 Trench (PB-2). The Older Abandoned Channel**
Bearing 046. Logged by Little & Schermer in April, 2006. Log is Fig. 4c.

**Tps:** Medium-dark-grey organic silty loam (Topsoil). Root-mottled, with abundant cobbles up to 9 cm in diameter.

**Cdf:** Yellowish-grey gravelly silt. Compact. Contains 20-40 % angular-subangular greywacke cobbles, up to 10 cm in diameter. Matrix-supported, very poorly-sorted. Channel-infilling debris flow unit.

**Si:** Yellowish-grey silt containing sparse subangular granules to fine pebbles. Well-sorted.

**Tgr:** Cobble gravel with coarse sand matrix. Crudely bedded. Poorly sorted, clast supported, subrounded to subangular greywacke cobbles up to 25 cm in diameter. Matrix contains pebbles up to 5-10 cm in diameter. Unit includes some coarse sandy interlayers that are Mn-stained. Interpreted as fluvial “Waiohine” terrace gravels.

## Appendix C.
## Unit descriptions for trenches at Riverslea Station (trenches RVL-1, RVL-2).

Excavated and logged on 13-14 April, 2006

**NW Wall of Riverslea 1 Trench (RV-1). The Main Scarp.**
Bearing 320. Logged by Van Dissen & Little on 4 April, 2006. Log is Fig. 6a.

**si:** Light grey-brown fine sandy silt (topsoil) with some fine gravel (clasts up to 5 cm in diameter, but typically <2 cm).

**ss4:** Gravelly silty sand.

**gvl-4:** Sand to medium gravel. Bedded. Clasts up to 8 cm diameter but typically <1cm. Locally cross-bedded in cm- decimeter-thick sets. The unit fines up-slope.

**gvl-1:** Fine to medium gravel, sandy at the base.

**gvl-2:** Fine to medium gravel.

**ss-1:** Coarse to fine sand with some thin layers of pebble gravel. Cross-bedded.

**css:** Coarse sand to fine gravel.

**ss-5:** Coarse to fine sand. Cm to decimeter-bedding.

**gss:** Fine gravel and sand. Poorly sorted.

**ss-2:** Fine-coarse sand. Unit fines upward.

**ss-3:** Sand and fine gravel. Cross-bedded on a cm-decimeter scale.

**gvl-3:** Cobbly coarse gravel with some thin beds of coarse sand and fine gravel.

**ss-6:** Fine sand. Massive.

**NE Wall of Riverslea 2 Trench (RV-2). Scarplet to NE and Above the Main Scarp.**
Bearing 335. Logged by Schermer, Moulopoulou, Van Dissen, and Little on 4-5 April, 2006. Log is Fig. 6b.

*Units to NW of fault strand 1:*
**gvl-17:** Dark greyish brown, fine-med gravelly silt. Somewhat more compact than unit cvgl-16.

**si-15a:** Light greyish-brown (mottled with orange) fine, sandy silt. Massive.

**gvl-5b:** Dark greyish-brown, coarse sand to fine gravel. Bedded with subrounded clasts.

**si-5:** Medium grey silty fine sand to sandy silt. Poorly bedded at cm-dm scale. Some med-coarse sand stringers (line pattern in log - Fig 6b).

**gvl-4:** Dark greyish brown, med-coarse gravel. Weakly bedded.

**ss-3:** Dark greyish-brown, coarse sand. Massive.

**ss-2:** Medium grey sand and light grey silt. Cm-bedded (sand in middle, silt at top and bottom).

**gvl-1:** Dark greyish-brown pebble to fine cobble gravel. Weakly bedded. Poorly sorted. Subrounded clasts up to 10 cm in diameter, but typically <5 cm.

*Units in fault zone:*
**cgvl-16:** Dark greyish-brown, silty, fine to medium gravel, somewhat less compact than unit 17. Gravel stringer with 2-3 cm clasts occurs at SE part of the unit's basal contact. Interpreted as fissure-fill following the most recent earthquake.

**si-10:** Light grey, fine sandy silt with lenses of fine gravel.

**gvl-10b:** Fine gravel with clast diameters of <1 cm.

**si-9a:** Light grey, fine sandy silt. Unit is mottled orange to brown at base, and contains rare gravel clasts up to to 2-3 cm in diameter.

**gvl-8:** Dark greyish-brown, pebble to fine cobble gravel. Weakly bedded. Poorly sorted. Subrounded clasts up to 10 cm in diameter but typically <5 cm.

**ss-7:** Medium grey, fine sand with some silt. Cm-bedding.

**gvl-6:** Dark greyish-brown fine gravel.

*Units to SE of fault zone:*
**gvl-18:** Dark grey, fine to medium cobble gravel with an open sandy matrix. Bedded. Poorly sorted. Some beds are stained purplish-red with Fe-oxide.

**si-15b:** Greyish brown, mottled, fine sandy silt with rare fine gravel clasts.

**si-14a:** Fine-medium silty sand, mostly massive in texture.

**ss-14b:** Fine to medium sand with a 2-cm silt bed in the middle.

**si-14c:** Silty, fine-medium sand, mostly massive in texture.

**ss-12:** Medium grey sand and light grey silt. Cm-bedding. The sand occurs in the middle, the silt at the top and bottom.

**gvl-11:** Sandy fine gravel with clasts up to 3 cm in diameter.

**si-9b:** Light grey, fine sandy silt. Unit is mottled orange to brown at base, and contains rare gravel clasts up to 2-3 cm in diameter.

**si:** Light grey-brown fine sandy silt (topsoil) with some fine gravel (maximum clast size 5 cm, but mostly no coarser than 2 cm).

**ss4:** Gravelly silty sand.

**gvl-4:** Bedded sand to medium gravel with clasts that are typically <1cm in diameter, and that reach a maximum diameter of 8cm. Locally cross-bedded in cm- decimeter-thick sets. The unit fines up-slope.

**gvl-1**: Fine to medium gravel, sandy at the base.

**gvl-2:** Fine to medium gravel.

**ss-1**: Cross-bedded, coarse to fine sand with some thin layers of pebble gravel.

**css**: Coarse sand to fine gravel.

**ss-5**: Cm to decimeter-bedded, finely parallel-laminated, coarse to fine sand.

**gss:** Poorly sorted fine gravel and sand

**ss-2:** Fine-coarse sand. Unit fines upward..

**ss-3:** Sands and fine gravel cross-bedded on a cm-dm scale.

**gvl-3:** Cobbly coarse gravel with some thin beds of coarse sand and fine gravel.

**ss-6**: Massive fine sand.

**<u>NE Wall of Riverslea 2 Trench (RV-2). Scarplet to NE and Above the Main Scarp.</u>**
Bearing 335. Logged by Schermer, Mouslopoulou, Van Dissen, and Little on 4-5 April, 2006. Log is Fig. 6b.

*Units to NW of fault Strand 1:*
**gvl-17:** Dark greyish brown fine-med gravelly silt, somewhat more compact than unit 16.

**si-15a:** Massive, light grayish-brown (mottled with orange) fine sandy silt.
**gvl-5b:** Dark grayish-brown, bedded coarse sand to fine gravel with subrounded clasts.

**si-5:** Medium grey silty fine sand to sandy silt with some med-coarse sand stringers (line pattern in log). Poorly bedded at cm-dm scale.

**gvl-4:** Dark greyish brown, weakly bedded med-coase gravel.

**ss-3:** Dark grayish-brown, massive coarse sand.

**ss-2:** Cm-bedded medium grey sand and light grey silt (sand in middle, silt at top and bottom).

**gvl-1:** Dark grayish-brown pebble to fine cobble gravel. Poorly sorted and weakly bedded, with subrounded clasts to 10 cm (typically <5 cm).

*Units in fault zone:*
**cgvl-16:** Dark grayish-brown, silty fine to medium gravel, somewhat less compact than unit 17. Gravel stringer with 2-3 cm clasts occurs at SE part of the unit's basal contact. Interpreted as fissure-fill following the most recent earthquake.

**si-10:** Light grey, fine sandy silt with lenses of fine gravel.

**gvl-10b:** Fine gravel with clast diameters of <1 cm.

**si-9a:** Light grey, fine sandy silt. Unit is mottled orange to brown at base, and contains rare gravel clasts to 2-3 cm.

**gvl-8:** Dark grayish-brown, pebble to fine cobble gravel. Unit is poorly sorted and weakly bedded with subrounded clasts to 10 cm (typically <5 cm).

**ss-7:** Medium grey, cm-bedded fine sand with some silt.

**gvl-6:** Dark grayish-brown fine gravel.

*Units to SE of fault zone:*
**gvl-18:** Dark grey, bedded medium gravel. The unit is poorly sorted with fine to medium cobbles and an open sandy matrix. Some beds are stained purplish-red with Fe-oxide.

**si-15b:** Greyish brown, mottled, fine sandy silt with rare fine gravel clasts.

**si-14a:** Fine-medium silty sand, mostly massive in texture.

**ss-14b:** Fine to medium sand with a 2-cm silt bed in the middle.

**si-14c:** Silty fine-medium sand, mostly massive in texture.

**ss-12:** Cm-bedded, medium grey sand and light grey silt. The sand occurs sand in the middle, the silt at the top and bottom.

**gvl-11:** Sandy fine gravel with clast diameters to 3 cm.

**si-9b:** Light grey, fine sandy silt. Unit is mottled orange to brown at base, and contains rare gravel clasts to 2-3 cm.

## Appendix D.
## Unit descriptions for Cross-Creek trenches CC-1 and CC-4 across the southern strand of the Cross-Creek pull-apart graben.

**NE Wall of Cross-Creek 1 Trench (CC-1).**
Bearing 320. Logged by Van Dissen, Little, Schermer on 10-12 April, 2006. Log is presented in Fig. 8a.

*Units NW of fault:*
**Peat, undifferentiated:** Brown woody peat, mainly NW of clastic units and tree roots.

**wl:** Organic silt with gravel clasts up to 5 cm in diameter. Metal fence wire at/near base of layer. "Wire layer" interpreted as surface deposits (swampy, gravelly soil) that were disturbed during fencing and agriculture.

**om:** Dark reddish brown organic mud with abundant rootlets, scattered granule to fine pebbles and charcoal. Friable.

**cw3:** Gravelly silt, and silt with gravel clasts up to 15cm in diameter but typically <5 cm. Interpreted as colluvial wedge.

**cw2:** Gravelly, silty, cobble gravel. Compact. Subangular clasts up to 12 cm in diameter. Poorly sorted. Between fault strands 1 and 2 consists of cobble gravel with sandy-silty matrix containing subangular clasts up to 16 cm in diameter. Friable, loose, poorly sorted, and clast-supported. Interpreted to be offset across fault strands 1 and 2, and to extend SE and across the upper part of the scarp on the footwall. Interpreted as colluvial wedge.

**cw1:** Peat matrix with discontinuous lenses of subangular gravel that include some clasts up to 10 cm in diameter.

**tree roots:** Wood in upright growth position. Tree penetrates units pt1, pt4, pt5 and lower part of undifferentiated peat.

**pt5:** Dark brown organic mud containing wood fragments and rootlets.

**pt4:** Brown (slightly lighter than p5) silty organic mud containing wood fragments and rootlets.

**pt3 :** Organic silt containing minor fine gravel clasts.

**pt2:** brown-grey, woody peat, and silt**.**

**pt1:** Rich brown peat containing sparse pebbles.

*Units within fault zone:*

sg: Greenish-grey mud matrix gravel. Sheared with fault aligned or random clasts. Very poorly sorted. Clasts up to 18 cm in diameter. Adjacent to fault strand 1, includes a 6 cm wide band of gouge.

*Units SE of fault:*
**tgr-4:** Cobble gravel in a sandy matrix. Massive to crudely bedded. Weakly compacted. Subrounded clasts up to 26 cm in diameter. Matrix supported. Poorly sorted. Interpreted as "Waiohine" Terrace.

**bss:** Brown-weathered gravel. Bedded. Also beded coarse sand and fine gravelly sand that is interbedded with decimetre thick beds of fine-medium gravel or sandy gravel. Interpreted as "Waiohine" Terrace.

**ss:** Silty sand with some coarse sandy laminae. Compact. Interpreted as "Waiohine" Terrace.

**tgr-3:** Orange stained fine to medium gravel. Overlaps sheared gravel, sg, and fault strand 3. Interpreted as "Waiohine" Terrace.

**tgr-2:** Bouldery gravel. Massive. Poorly sorted. Clasts up to 30 cm in diameter. Interpreted as "Waiohine" Terrace.

**pt6:** Woody peat and silt. At least 35 cm thick on SW wall. On NE wall the same unit consists of 2 layers of peat with a gravelly sand layer 5-9 cm thick in middle. Interpreted as "Waiohine" Terrace.

**tgr-1:** Fine gravel with subangular clasts up to 3 cm in diameter. Interpreted as "Waiohine" Terrace.

**SW wall of Cross Creek Trench 4 (CC-4)**
Bearing 315. Logged by Tim Little, Rachel Carne on 5-7 February, 2007. Log is presented in Fig. 8b.

*Units SE of Fault (Footwall):*
**tg:**: Cobble gravels with a granular sand matrix. Compact. Crudely bedded. Imbricated. Sub-rounded clasts. Clast-supported. Clasts up to 15 cm in diameter. Includes some lenses of sand. Interpreted as "Waiohine" Terrace.

**sd:** Grey to red-brown, medium sand. well sorted with scattered pebbles. Interpreted as "Waiohine" Terrace.

**gs:** Grey, iron-stained gravel with a grey matrix of medium sand. Compact and firm. 15-20 % pebble clasts. Clasts up to 5 cm in diameter). Interpreted as "Waiohine" Terrace.

**stg:** Variably iron-stained and mottled, pebble to cobble gravel. Weakly consolidated. Unit is dominated by granular coarse sand and pebbles. Bedding is defined by change in grain size between coarse sand and pebble gravels, on sub-10 cm scale. Cm-scale stratification defined by

layers of coarse sand granules, pebbles and cobble gravels. Clasts up to 7 cm in diameter. Interpreted as “Waiohine” Terrace.

**bg:** Boulder gravel. Subrounded clasts up to 28 cm in diameter. Interpreted as “Waiohine” Terrace.

*Units within fault zone:*
**sg:** Pebble-cobble gravel. Soft and sheared. Includes ~5 cm of peat gouge smeared and entrained in unit along fault 1. Also includes 5 cm thick zone of light grey clay gouge along fault 1.

*Units NW of fault (Hangingwall):*
**mo:** Dark brown organic mud, grades NW into peat.

**cwC:** Pale grey-brown, gravel with mud matrix. Pebbles mostly subangular in shape. Clasts up to 13 cm in diameter. Matrix-supported. Abundant roots. Interpreted as colluvial wedge.

**cs**: Light grey, clay and silt. Hard, plastic. Interpreted as ponded material.

**si:** Light-medium brown sand and gravel in silty matrix. Sparse clasts up to 3 cm in diamter. Contains roots. Grades NW into peat.

**cwB:**, Red- to medium-brown, gravelly mud-sand. Soft, friable. Subangular greywacke clasts up to 7 cm in diameter. Matrix-supported, very poorly sorted. Abundant roots and dispersed detrital wood fragments up to 4 cm. Grades NW over 10 cm into darker red-brown organic peat containing subangular pebbles up to 2.5 cm in diameter. Interpreted as colluvial wedge.

**cwA:** Soft, grey, gravel with mud matrix. Matrix supported, poorly sorted. Contains clasts up to 15 cm in diameter. Interpreted as colluvial wedge.

**Peat, undiff.:** Dark reddish-brown, organic clay-peat. Soft. Abundant wood and root fragments.

**dp:** Deformed lens of peat with entrained cobbles and pebbles up to 8 cm in diameter.

**Appendix E.**
**Radiocarbon dating of trenches CC-1 and CC-4 across the southern strand of the Cross-Creek pull-apart graben**

*Radiocarbon Dating of Trench CC-1*

Eleven samples were $^{14}C$ dated from the NE wall of trench CC-1 (Fig. 8a and Table 1). All but one of these yield ages that are in the correct stratigraphic order (at 95% confidence). The oldest samples were collected from the uplifted block of the fault zone from a peat layer that occurs interbedded with coarse fluvial gravels of the "Waiohine" terrace. A wood fragment (sample CC-1-1a-ii) from unit "pt6" yielded an age of 13,160-12,900 cal. yrs B. P.; whereas, the surrounding peat matrix to this wood (CC-1-1a-i) yielded an age of 12,700-12,100 cal. yrs B. P.

An apparent $^{14}C$ age reversal occurs in the lower part of trench CC-1. On the downthrown block of the Wairarapa fault zone, the lowest dated sample (sample CC-1-12, a peat) yielded a $^{14}C$ age of 3690-3460 cal yrs B.P (unit "pt1"). Nearby to the SE, on the opposite side of fault strand 4, peat sample CC-1-11 yielded a $^{14}C$ age of 2780-2409 cal. yrs B. P. This age is younger than that of the stratigraphically overlying sample CC-1-10 in the "pt4" unit (peat, 3320-2970 cal. yrs. B. P), but (just) overlaps with that of sample CC-1-9 (organic clay, 2870-2730 cal. yrs. B. P.) collected from higher parts of the "pt4" unit in the same trench. Our preferred interpretation is that that sample CC-1-11 yields a younger than its overlying host sediments, because it was post-depositionally contaminated by (unnoticed) root material. Alternatively, it is possible that sample CC-1-10 yielded a pre-depositional (i.e., "too old") age because its included some older detrital material derived from underlying units such as "pt1."

Stratigraphically higher in the trench, sample CC-1-8 (2350-2130 cal yrs. B.P) was collected from unit "pt5" where it stratigraphically overlies the small gravel-bearing (and organic-rich) lens referred to as "cw1," and where it underlies the large colluvial wedge, "cw2." Just to the NW of this sample, the outermost layer of wood in sample CC-1-6 from the "beheaded" tree that occurs embedded in the "pt5" unit yielded an age of 2340-2110 cal. yrs. B. P. Peat sample CC-1-7 was collected at the top of unit "pt5," immediately below the basal contact of the "cw2" wedge. At 2490-2150 cal yrs. B.P., this age is within error of the tree's age (sample CC-1-6), suggesting that

death of the tree and emplacement of the large colluvial wedge immediately above it were coeval events. The youngest samples in the trench (CC-1-13 and CC-1-14) are organic clays that were collected on either side (above and below) the uppermost (unfaulted) colluvial wedge, "cw3". These yielded ages that overlapped with one another across the interval 920-800 cal yrs. B. P.

*Radiocarbon Dating of Trench CC-4*

Six samples on the downthrown side of the fault were $^{14}C$ dated on the SW wall of trench CC-4 (Fig. 8b and Table 1). Despite their proximity along strike of the fault zone, and the similar maximum depth of each trench, the sediments in trench CC-4, are largely older than those exposed in trench CC-1. They are also more deformed (apparent dip of 20-25° to the NW) in proximity to the fault rather than subhorizontal, (as in CC-1). We infer this increase in stratal dip and sediment age between the two trenches to reflect a local up-bulging of the peat basin along the fault to the SW, so that deeper parts of that basin are exposed in trench CC-4 than they are in trench CC-1. The folding could have included a component of fault drag adjacent to the basin margin fault (strand 2 in Fig. 7a). This inferred NE structural plunge parallel to the fault probably explains why the intra-peat unconformity was observed in the SW wall of trench CC-1 and NE wall of trench CC-4, but not on the more distant (structurally deeper) SW wall of CC-4.

On the SW wall of CC-4 (Fig. 8b), the two lowest peat samples (CC-4-4 and CC-4-6) yielded statistically overlapping ages between 5290-5040 cal. yrs. B. P. An overlying wood sample (CC-4-11, part of wedge "cwA") yielded an older age of 5590-5310 cal. yrs. B. P. As outlined above, we interpret this latter wood sample to be one of six detrital wood samples yielding ages of ~5.5-5.2 ka that were recycled upward from a forest horizon near the base of the peat. Continuing up-section, samples CC-4-10 (peat, 4970-4620 cal. yrs B. P), CC-4-16 (organic clay, 4870-4610 cal. yrs. B. P.), and CC-4-13 (wood, 3340-3070 cal yrs. B. P.) yield dates in correct stratigraphic order. These bracket the ages of colluvial wedges, "cwA", "cwB", and "cwC."

Two samples (CC-4-2 and CC-4-3) were collected on the NE wall of trench CC-4 above and below the intra-peat unconformity prior to the collapse of that wall (Fig. 8c). Above the contact, a 5 cm-thick layer of finely laminated silt depositionally

drapes across a steep fault that, beneath the unconformity, juxtaposes soft peat against a block of firm and lighter-colored (organic-poor) clayey silt (Fig. 8c). This contact is inferred to be the "intra-peat unconformity" that also occurs draping faults 4 and 5 on the SW wall of trench CC-1 (the two exposures are located ~2 m away from one another). Peat sample CC-4-3 was collected 10 cm above the unconformity yielding a $^{14}C$ age of 4420-4140 cal. yrs. B. P. Sample CC-4-2 was collected in the faulted peat block at a depth of ~5 cm below the unconformity. Despite this sample being stratigraphically older than CC-4-3, it yielded a statistically younger age of 4090-3830 cal. yrs. B. P. Recall that in trench CC-1, another $^{14}C$ age reversal was encountered in proximity to the unconformity (see first section of this Appendix). Ignoring samples CC-1-11 and CC-4-3 for the moment, there are (in both trenches) four other $^{14}C$ peat samples collected in the vicinity of the intra-peat unconformity. These remaining samples yielded ages that are in the correct stratigraphic order to one another and to other surrounding samples. They are samples CC-1-9 and CC-1-10 (from above the unconformity and samples CC-1-12 and CC-4-2 (from below it).

Our preferred interpretation, therefore, is to regard the $^{14}C$ ages of samples CC-1-11 (in trench CC-1) and CC-4-3 (in trench CC-4) as being non-depositional. It is unclear to us why $^{14}C$ age inversions should occur in different trenches, in both cases on peat samples spanning the intra-peat unconformity. Although the causes of the age reversals are uncertain, they might include some combination of unrecognized root contamination and recycling of organic material. Why such processes would be localized to the proximity to the intra-peat unconformity is unknown.

Our interpretation, while not unique, is the only one that honors all the rest of the (surrounding) $^{14}C$ samples in both trenches on both sides of the intra-peat unconformity. It is important to point out that alternate interpretations of the data, while they would change the inferred (absolute) age of the intra-peat unconformity, would not affect the total number of surface rupturing events interpreted from the Cross Creek trenches (see main body of the text).

## Appendix F. Unit descriptions for Cross-Creek trenches CC-2, CC-3 across the northern strand of the Cross-Creek pull-apart graben

**NE Wall of Cross-Creek 2 Trench (CC-2).**
Bearing 320; Logged on 10-12 April, 2006 by Russ Van Dissen, Tim Little, Susanne Grigull, Kate Wilson, Liz Schermer. Log is presented in Fig. 9a.

*Overlapping and Unfaulted Units*
**topsoil:** dark brown, organic, silt-rich

**gsi:** Dark brown gravelly silt. Gravel clasts up to 10 cm in diameter. Very poorly sorted. Contains abundant roots. Interpreted as chiefly road-derived anthropogenic fill material, but may include some natural colluvium near base (above description). Correlative layers in trench CC-3 contain wire fragments.

*Units SE of Fault (Hangingwall)*
**Pt, undiff.:** Dark brown peat and organic rich silt with local embedded logs.

**pt:** Dark brown silt. Soft. Organic rich, with fibrous peat at base and including some gravel and fragments of charcoal and wood.

**osi-2:** Dark brown silt. Moderately developed crumb structure with charcoal fragments throughout.

**si:** Variably yellowish-grey to orange-brown to very dark grey silt and fine sand. Charcoal rich at base. (locally present at base of osi-2).

**osi-1:** Dark brown silt with well developed crumb structure. Contains rare gravel clasts.

**co-2:** Brownish grey, sandy gravel becoming increasingly silty to SE. Variably subangular to rounded clasts of greywacke up to 15 cm in diameter. Matrix-supported. Interpreted as colluvial wedge.

**co-1:** Cobbles. Up to 22 cm in diameter. Redeposited train (one clast-deep) of terrace-derived rounded cobbles just above the base of the peat (pt) layer. Interpreted as colluvial wedge.

**slt:** Light-medium- to blue-ish- grey, fine sandy silt. Stiff. Also includes silty fine sand and some pebbles up to 5 cm in diameter. Interpreted as terrace deposit.

**tg:** Fine to coarse gravel with sparse thin sand beds. Crudely bedded to massive. Rounded to subangular clasts up to 30 cm in diameter. Unit becomes siltier near the top, and sandier towards the NW. Interpreted as fluvial terrace gravel.

*Units in fault zone:*
**co-3:** Light brownish grey pebble-cobble gravel with a silty and sandy matrix. Gravel clasts range from fine pebbles to cobbles, 5cm ~20 cm in diameter. Poorly sorted. Interpreted as colluvial wedge.

**sg:** Terrace gravel (tg unit). Soft and friable. Sheared with tectonic alignment of clasts parallel to fault.

*Units NW of Fault (Footwall)*
**ss:** Greenish-grey, coarse sand. Friable. Moderately-well sorted. Lacks pebbles. Interpreted as fluvial deposit.

**tg:** As above. Unit becomes orange-stained near fault strand 1.

**NE Wall of Cross Creek Trench 3 (CC-3)**
Bearing 315º. Logged on 5-7 February, 2007 by Russ Van Dissen, Julia Bull, Dave Murphy. Log is presented in Fig. 9b.

*Overlapping and unfaulted units*
**u-col:** Dark yellow-brown, gravelly silt. Clasts up to 10 cm in diameter, but typically <5 cm. Pronounced crumb soil structure with common modern roots. Interpreted as anthropogenic fill.

**op:** Light-medium brown, silt-peat. Organic rich. Pronounced crumb soil structure and common modern roots. Basal contact marked between grids 9.5 and 13 by an intermittent stone line.

**s-col:** Greyish, light-medium brown, silt. Firm. Subrounded-subangular clasts up to 10 cm in diameter, but typically <4 cm. Some rare gravel to NW of fault zone. Grades SW above fault zone into grayish, light-medium brown, gravelly silt to silt with some gravel. Firm. Unit contains wire. Interpreted as anthropogenic fill.

**grs:** Greyish, light-medium brown, coarse gravelly silt to NW of fault zone. Firm. Clasts up to 15 cm in diameter, but typically <5 cm. Grades SW above fault zone into light brown, silty and sandy, fine to coarse gravel with similar clast sizes. Interpreted as anthropogenic fill or natural colluvium.

*Units NW of fault (footwall)*
**cpg:** Light grey, silty, fine to coarse gravel. Loose-slightly compact, poorly sorted. Clasts up to 20 cm in diameter, but typically fine pebbles. Fluvial marker unit.

**ss:** Grey-light brown, medium-coarse sand, with rare granules and pebbles. Slightly compact. Fluvial marker unit.

**tg**:: Yellow-brown, gravel with silty-sandy matrix. Compact. Massive to poorly bedded. Subrounded clasts up to 40 cm in diameter, but typically <10 cm. Poorly sorted. This unit to SE of fault is same but has grey-orange staining, and clasts up to 30 cm in diameter. Interpreted as “Waiohine” Terrace.

*Units in fault zone*

**pg:** Light grey, silty, fine-coarse gravel to NW of fault zone. Loose-slightly compact. Clasts up to 10 cm in diameter but typically fine. Poorly sorted. pg between faults similar, with clasts up to 15 cm in diameter, but typically <5 cm. Random clast orientation, with no indication of tectonic rotation. pg between faults interpreted to represent the fill of a fault fissure/wedge that was deposited at the same time as pg to the NW of the fault zone). Fluvial marker unit.

**stg:** Grey, silty, sandy gravel. Loose-compact. Many blade shaped cobbles with sub-vertical orientation. Interpreted as tectonically aligned and rotated alluvial gravel within fault zone.

**sp2:** Peat with some gravel. Tectonically mixed and sheared.

**sp1:** Peat and gravel. Tectonically mixed and sheared. Notable sub-vertical orientation of blade shaped clasts.

*Units SE of fault (hangingwall)*

**pt5:** Light-medium brown, organic rich silt. Firm. Rare clasts up to 4 cm in diameter.

**co-2:** Light grey-brown, gravel with organic-rich silt matrix. Firm.. Clasts are angular-subrounded, up to 15 cm in diameter, but typically <4 cm. Matrix-supported. Grades downward into similar organic rich silt, with only some gravel. Interpreted as colluvial wedge.

**pt4:** Medium brown, organic rich silt-peat. Soft-firm. Contains common modern roots to SE.

**os**: Medium brown gravelly organic rich silt to organic rich silt with some gravel. Firm. Subangulr-subrounded clasts up to 6 cm in diameter. Some roots. Mixed units near tree.

**cs:** Medium-grey, fine gravel-coarse sand. Compact. Clasts up to 4 cm in diameter, but typically <1cm. Mixed units near tree.

**ogs:** Medium brown, organic rich, gravelly silt. Soft. Subrounded-subangular clasts up to 7 cm in diameter. Mixed units near tree.

**pt3:** Dark brown-black, gravelly, organic rich silt/peat. Soft-firm. Some scattered subrounded-subangular gravel clasts, up to 10 cm in diameter, but typically <5 cm Unit contains abundant wood fragments.

**pt2:** Medium brown, fibrous peat to organic rich silt. Soft. Contains abundant wood and/or roots.

**pt1:** Medium-dark brown, organic rich silt. Soft. Some gravel clasts up to 10 cm in diameter, but typically <4 cm. Abundant roots and/or wood fragments.

**ssg:** Medium brown-light grey silty gravel. Compact. Clast up to 15 cm in diameter, but typically <5 cm. Moderately sorted. Interpreted as “Waiohine” Terrace.

**gs:** Medium grey, gravelly silt to silt with some gravel. Massive, stiff. Subrounded clasts up to 20 cm in diameter. Smaller clasts are subangular. Interpreted as "Waiohine" Terrace.

**SW Wall of Cross Creek Trench 3 (CC-3)**
Bearing 315º; Logged by Tim Little and Rachel Carne on 7-9 February, 2007. Log is presented in Fig. 9c.

*Overlapping and unfaulted units*
**u-col:** Light-grey sandy-silt. Friable. Scattered pebbles up to 8 cm in diameter. Crumbly texture apparently overprinted by soil forming processes. Abundant modern roots. Interpreted as anthropogenic fill.

**s-col:** Medium-brown, organic rich pebbly-silt. Firm. Scattered angular-subangular pebbles (~ 5 % of unit). Contains a piece of wire. Interpreted as anthropogenic fill.

**grs:** Medium-brown gravel, with a sandy-silt matrix. Friable. Abundant subangular cobbles with a gradation of clast sizes from up to 15 cm diameter, down to sand. Matrix supported, very poorly sorted. Interpreted as natural colluvium or anthropogenic fill.

*Units NW of fault (footwall)*
**cpg:** Pebble-gravel. Weakly compacted. Subrounded clasts mostly in 1-2 cm range, up to ~7 cm in diameter, and down to 5 mm. Well sorted. Variably iron stained. Strong clast fabric with imbrication that suggests flow to SE. Fluvial marker unit.

**ss:** Grey-yellow, coarse sand. Soft and unconsolidated. locally pebbly with pebbles up to 1 cm in diameter. Well sorted. Fluvial marker unit.

**tg:**: Yellow-brown weathered gravels with a pebbly-sand matrix. Compact. Crudely bedded (some alignment of clasts). Subrounded cobbles up to 20 cm in diameter. Clast supported. Interpreted as "Waiohine" fluvial terrace gravel.

*Units in fault zone*:
**pg:** Cobble-bearing fine pebble gravel. Loose and friable, but not clay rich or sheared looking. Dominated by coarse sands, granules and fine pebbles, (~15 % pebbles) with clasts up to 10 cm in diameter. Poorly sorted. Variably iron stained. Fluvial marker unit.

**fg:** boulder terrace gravels, with hard firm boulders up to 20 cm in diameter. Faulted. Depositionally overlain by co-2 and pt underlying co-2.

**stg:** Gravel with coarse, sandy matrix. Soft, sheared. Subrounded pebbles up to 7 cm in diameter. Loose and faulted on both sides of unit. Interpreted as terrace gravels.

*Units SE of fault (hangingwall)*
**pt:** Dark reddish-brown, mottled, organic clay-peat. Fibrous, with lots of wood fragments. Scattered pebbles up to 6 cm in diameter.

**co-2:** Pebble to cobble gravel with matrix of dark red-brown, sandy organic silt. Plastic. Subangular clasts up to 10 cm in diameter. Matrix supported. Strongly deformed. Interpreted as colluvial wedge.

**co-1:** Pebble to cobble gravel with muddy, clayey matrix with abundant sand. Soft and friable. Gravel clasts up to 9 cm in diameter. Matrix-supported, poorly sorted. Not very organic, but includes some streaks of organic mud. Faulted to the NW, deformed, dipping 60-70º with underlying peat. Interpreted as colluvial wedge.

**ssg:** Medium-grey gravelly fine sand and silt. Firm but friable. Subrounded-subangular clasts up to 10 cm in diameter, but typically <6 cm. Organic rich, gradational with overlying peat. Interpreted as “waiohine” Terrace.

**gs:** Light grey, gravel with silt-sand matrix. Firm. More friable (weathered) than underlying tg. Contains a variable percentage of subrounded greywacke clasts, up to 12 cm in diameter. Locally dominated by lenses of sandy-silt. Clast-supported. Near top of unit, matrix becomes quite organic over gradational boundary, with gravels mixed into a peaty material. Interpreted as “Waiohine” Terrace.

**Appendix G**.

**Radiocarbon dating of trenches CC-2 and CC-3 across the northern strand of the Cross-Creek pull-apart graben**

Seven samples from trench CC-2 and five from CC-3 were $^{14}C$ dated (Table 1). Of these, four are wood and the rest are peat, organic clay, or charcoal. All from trench CC-2, the wood samples (CC-2-33, CC-2-35, CC-2-37, CC-2-38) yield ages that are older than stratigraphically underlying non-wood samples (CC-2-30 and CC-2-34), but that are indistinguishable from one another (range, ~5.6-5.0 kyr B. P.). As explained above, these wood fragments are interpreted to be recycled from a near-basal forest layer in the peat basin that suffered a major event of forest disruption, soon after inception of the present graben. All the non-wood samples in trenches CCC-2 and CC-3 yield $^{14}C$ ages that are in the correct stratigraphic order. In trench CC-3, samples CC-3-L (5280-4850 cal. yrs. B. P., peat) and CC-3-E (4410-3990 cal. yrs. B.P., organic clay) provide a maximum bracketing age constraint for colluvial wedge "co-1"; whereas, samples CC-2-34 (4970-4620 cal. yrs B. P., organic clay) and CC-2-30 (4980-4640 cal. yrs. B. P., organic clay) in trench CC-3 provide minimum bracketing ages for the "co-1" wedge (there it is expressed as a line of coarse cobbles). In trench CC-2, the higher colluvial wedge "co-2" is underlain by samples CC-2-30 and CC-2-34 (4980 - 4620 cal. yrs. B. P, organic clay); and overlain by sample CC-2-31 (2294-1991 cal. yrs. B. P, charcoal). Moreover, in trench CC-3, the same wedge is also bracketed from below by samples CC-3-6 (4520-4180 cal. yrs. B.P., organic silt and charcoal) and CC-3-F (3080-2790 cal yrs. B. P., organic clay); and from above by sample CC-3-2 (2150-1940 cal. yrs. B. P., charcoal).

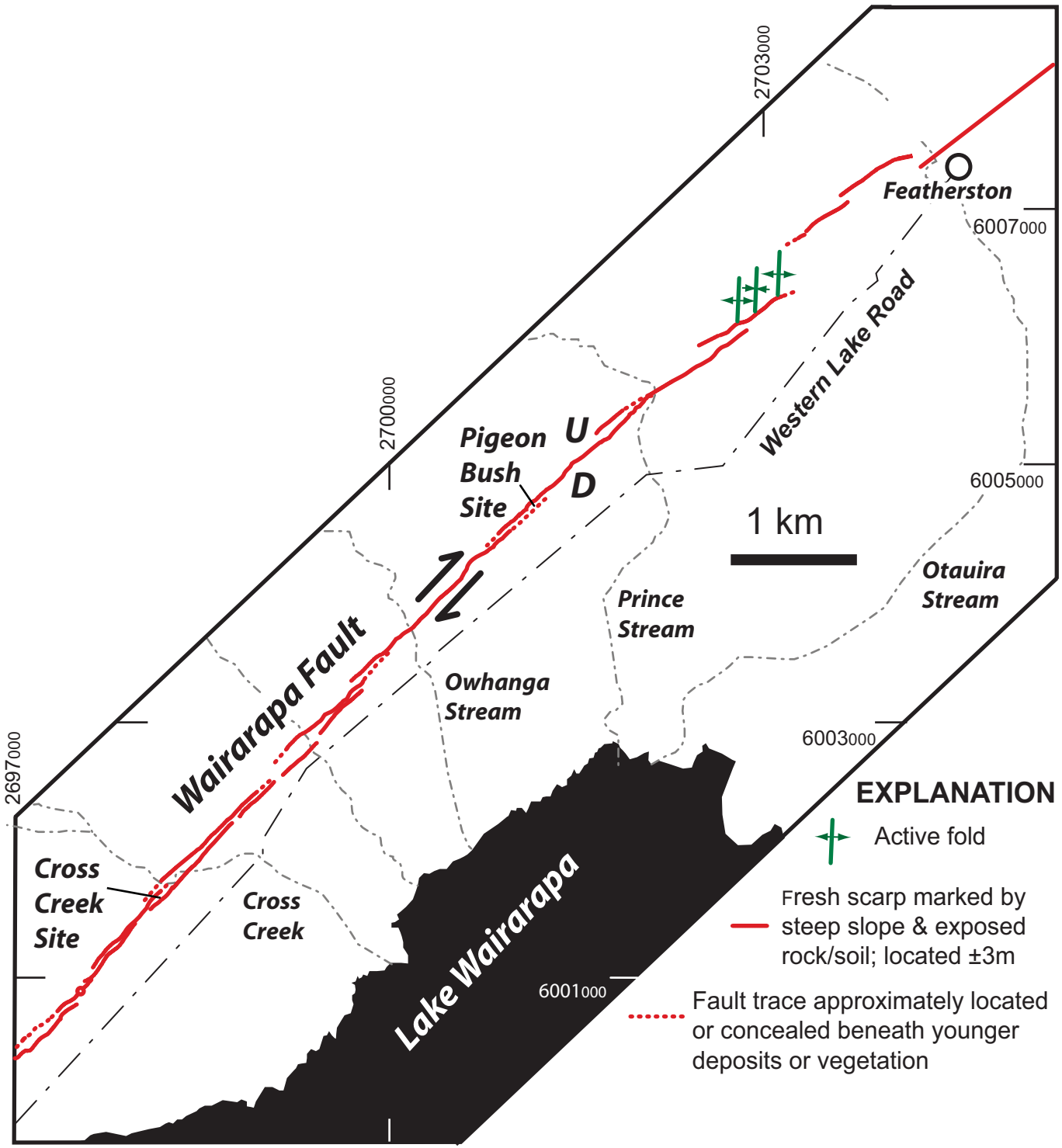
**Appendix H**

**Summary of Surface Rupturing Earthquakes on the Wairarapa Fault and Event Correlation Between the Trenches**

The oldest earthquake (Fifth Event in Table 3) occurred 5280-4640 cal. yrs. B. P. It produced colluvial wedges that were exposed in three of the four Cross-Creek trenches. Our preferred age for this earthquake, 5209-4842 cal yrs. B. P., is based on the interpretation that sample CC-2-38 is the youngest dated element of a fossil forest (one of six samples) that was destroyed by this earthquake in early stages of swamp development on the Cross Creek pull-apart graben. The second-oldest event (Fourth Event) was recorded by formation of the intra-peat unconformity that overlaps steeply dipping faults in both of the southern Cross-Creek trenches, and by a colluvial wedge found in one of them (trench CC-4, unit "cwB"). This event's age range of 3690-3070 cal. yrs. B.P. is based on $^{14}C$ ages that bracket the age of the unconformity. The next-youngest earthquake (Third Event) produced colluvial wedges in all four of the Cross-Creek trenches. The composite age constraints for the upper and lower contacts of these wedges yield an age range of 2340-1991 cal. yrs. B. P. for this earthquake. A preferred age of 2340-2110 cal. yrs. B. P. is based on our interpretation that a tree occurring immediately beneath a large wedge was toppled and killed as a result of this earthquake, and that this death is dated by sample CC-1-6. Evidence for a penultimate event taking place between ~1000 cal yrs. B.P. and ~500 cal yrs B. P. was found at Pigeon Bush (trench PB-1), Riverslea (trench RV-2), and the southeastern side of the Cross Creek graben (trenches CC-1 and CC-4). The northwestern side of that graben preserves evidence for two earthquakes younger than ~2 ka, but does not provide any minimum bracketing ages (trenches CC-2 and CC-3). The penultimate earthquake's timing is most narrowly constrained in trench CC-1, where a colluvial wedge is bracketed in time by overlying and underlying $^{14}C$ samples to the interval, 920-800 cal. yrs. B. P. The most recent surface rupture is attributed to 1855 A. D. on the basis of historical data (Grapes and Downes, 1999). Although geological evidence for this last earthquake was found at all trench sites, the state of preservation of this evidence was variable (and generally poor) at Cross-Creek, where a colluvial wedge attributable to this great earthquake could not be confidently identified. Given the evidence for human modification at this site (e.g., road fill bearing fragments of wire), our view is that one may once have been present, but that

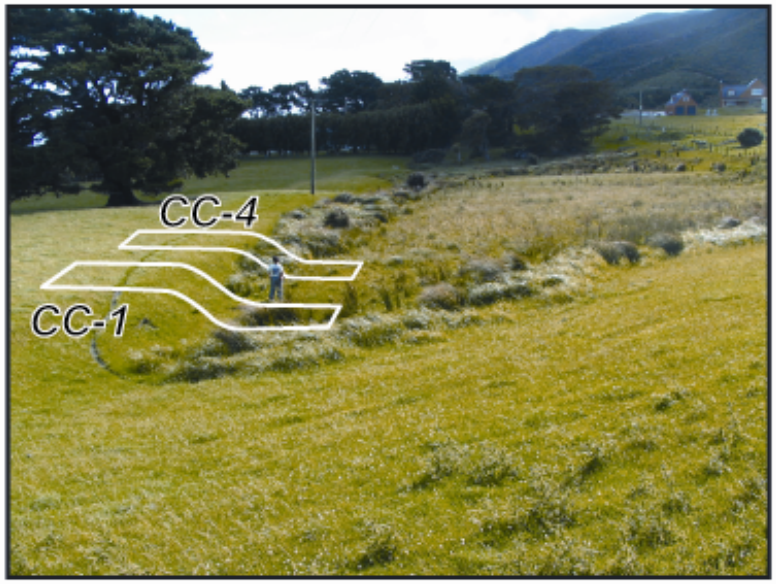
human activity associated with deforestation and agriculture has disturbed the uppermost layers in the graben.

*Little et al., Fig. A*

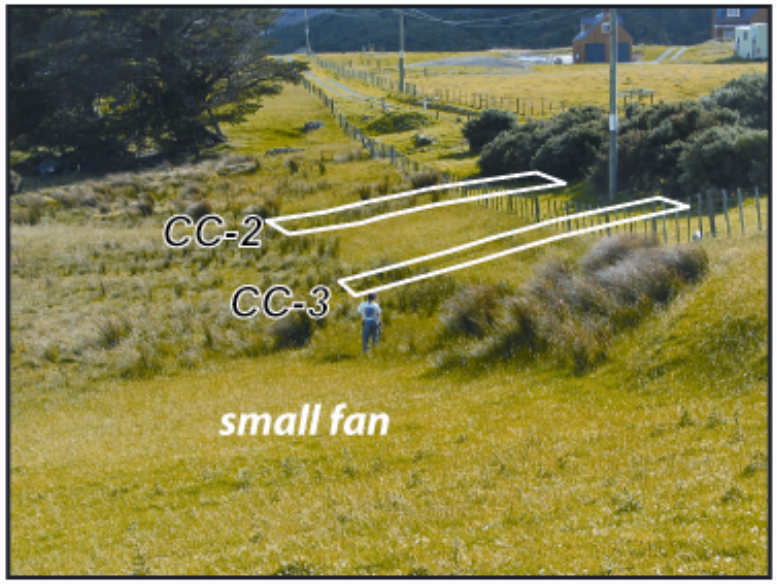


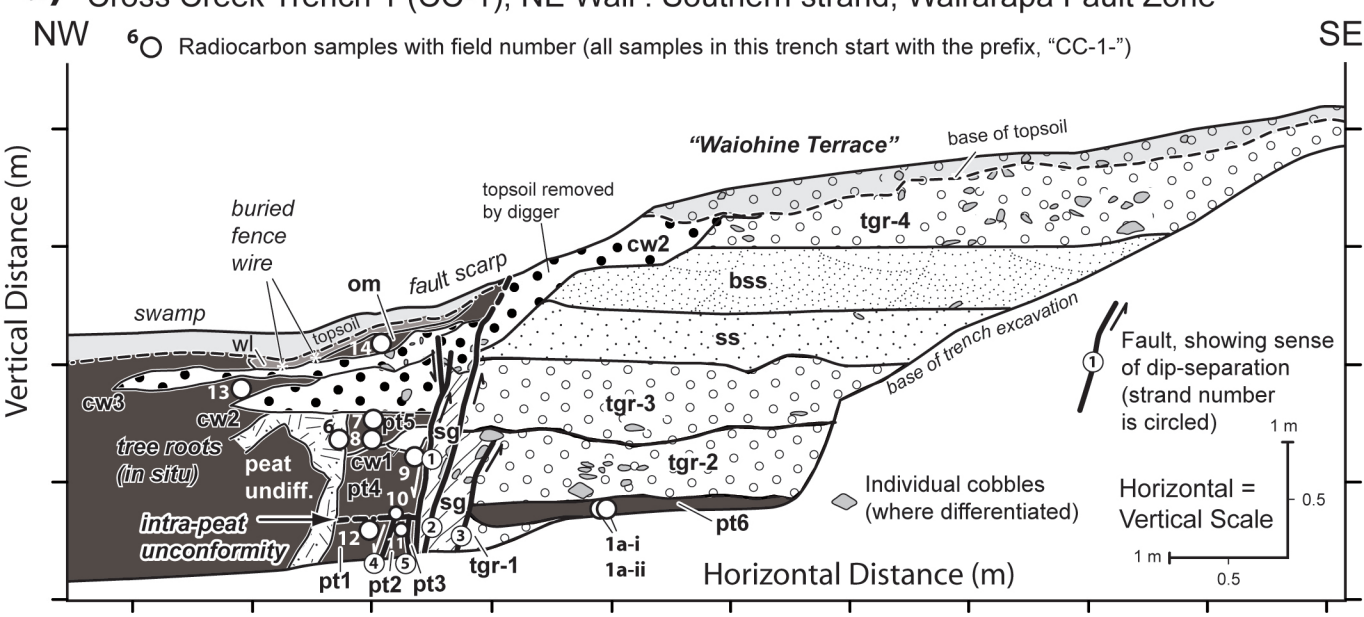
*Little et al., Fig. B*

**i)**




**ii)**






**sg** Sheared silt-matrix gravel with subangular clasts that are locally aligned parallel to fault (includes 6 cm of plastic clay gouge along strand no. 1)

**wl** Organic silt with gravel clasts. Unit includes embedded metal wire and is informally termed the "wire layer"

**cw1, cw2, cw3** Angular- subangular gravel in silty and sandy matrix. Interpreted as colluvium. cw-1 has organic-rich matrix.

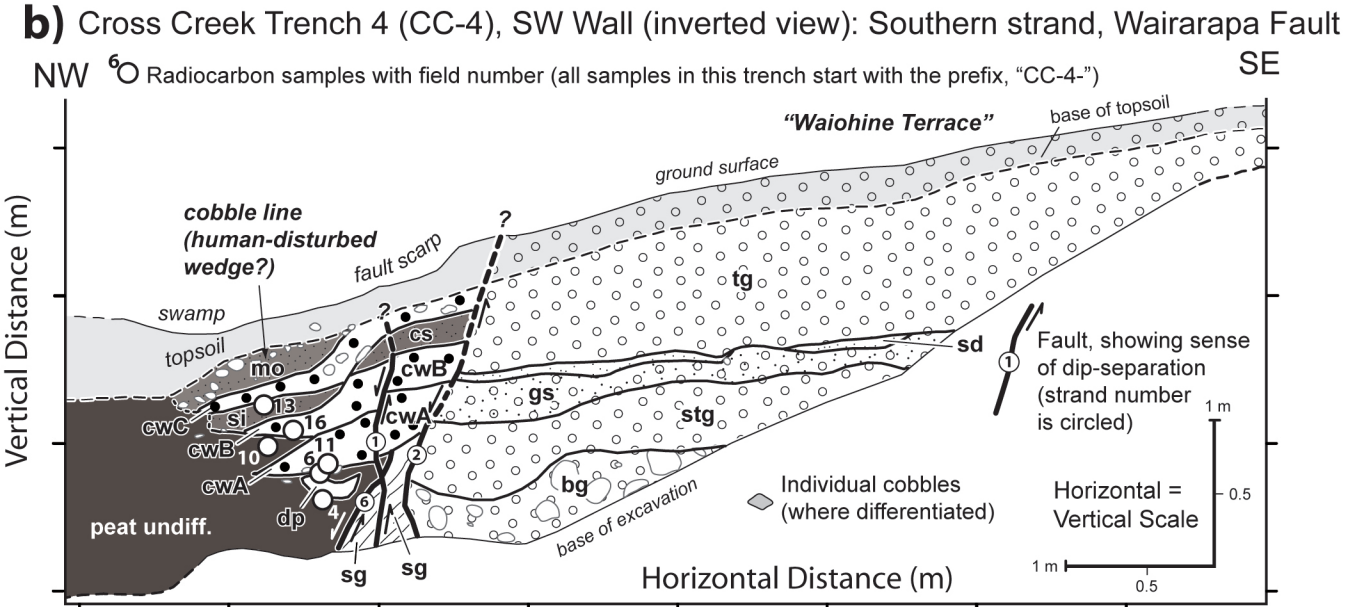
**bss** Coarse sand, fine pebbly sand, and sandy pebble gravel (bedded at dm scale). Interpreted as fluvial.

**ss** Silty fine-medium sand with coarse sandy laminae. Interpreted as fluvial.

**ptn** Units (n = 1,2,3,4,5,6) of variably silty, organic clay and peat with abundant plant fibres, wood fragments

**om** dark organic clay with scattered granules to fine pebbles and charcoal.

**tgr-n** Units (n = 1, 2, 3, 4) of massive to crudely bedded, pebble-cobble gravel with sandy matrix. Interpreted as fluvial.




**mo** Dark brown organic clay-silt (grades NW into peat). Includes line of cobbles.

**si, cs** **si** is medium grey, fine pebbly silt, grading NW into peat. **cs** is light-gray clay-silt

**cwA, cwB, cwC** Wedge-shaped units (n = A, B, C) of subangular pebble gravel supported by clay-sand matrix (interpreted as colluvium).

**dp** Deformed lens of peat that includes entrained cobbles and pebbles

**peat, undiff.** Organic clay and peat with abundant wood fragments and roots

**sg** Soft, sheared pebble-cobble gravel (includes 5 cm of clay gouge and 5 cm of smeared peat along fault strand no. 1)

**tg** Terrace gravel: crudely bedded, cobble gravel with granular sandy matrix (fluvial)

**sd** Medium sand with scattered pebbles (well-sorted, fluvial)

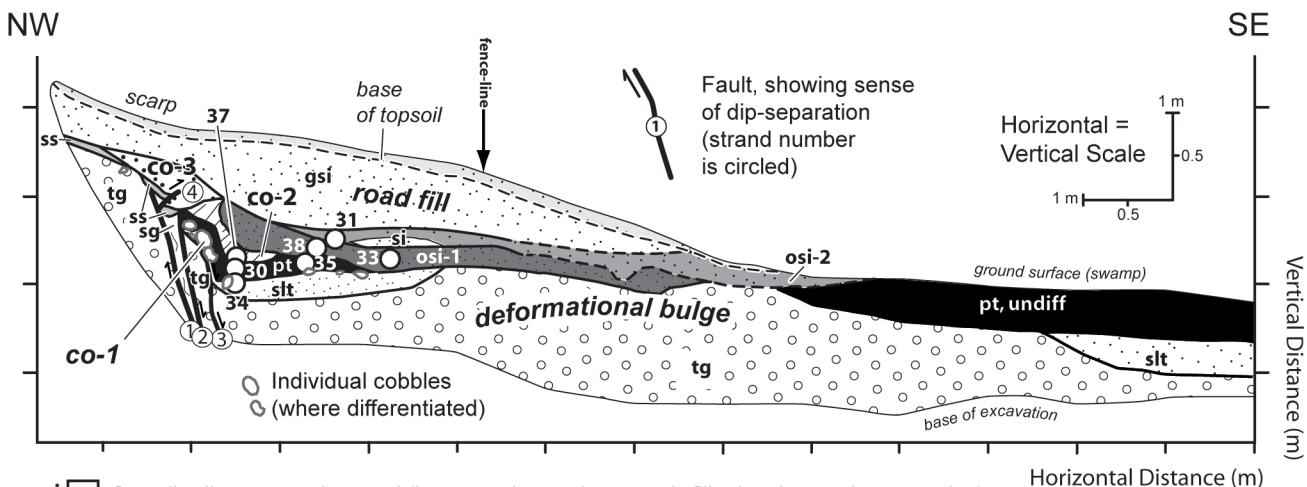
**gs** Gravelly (pebbles, cobbles) medium sand

**stg** Pebble-cobble terrace gravel, stratified

**bg** Bouldery terrace gravel

# Cross Creek Trench 2 (CC-2), NE Wall: Northern strand, Wairarapa Fault Zone

**a)** $^{31}$○ Radiocarbon samples with field number (all samples in this trench start with the prefix, "CC-2")




**gsi** Gravelly silt, very poorly sorted (interpreted as anthropogenic fill related to road construction)

**ss** Coarse sand (moderately sorted, fluvial)

**osi-2** Dark brown organic silt with crumb structure and abundant charcoal fragments throughout

**si** Yellowish-grey to orangish-brown or v. dark grey silt and fine sand, charcoal-rich at base

**osi-1** Organic silt with crumb structure and rare pebbles

**pt** **pt undiff.** Peat: dark-brown fibrous, locally silty, some pebbles. Abundant detrital wood, charcoal; includes whole logs in swamp

**sg** Sheared terrace gravel with alignment of clasts parallel to fault

**co-3** Gravelly silt: gravel clasts (subangular-subrounded) in silt matrix. Interpreted as colluvial wedge

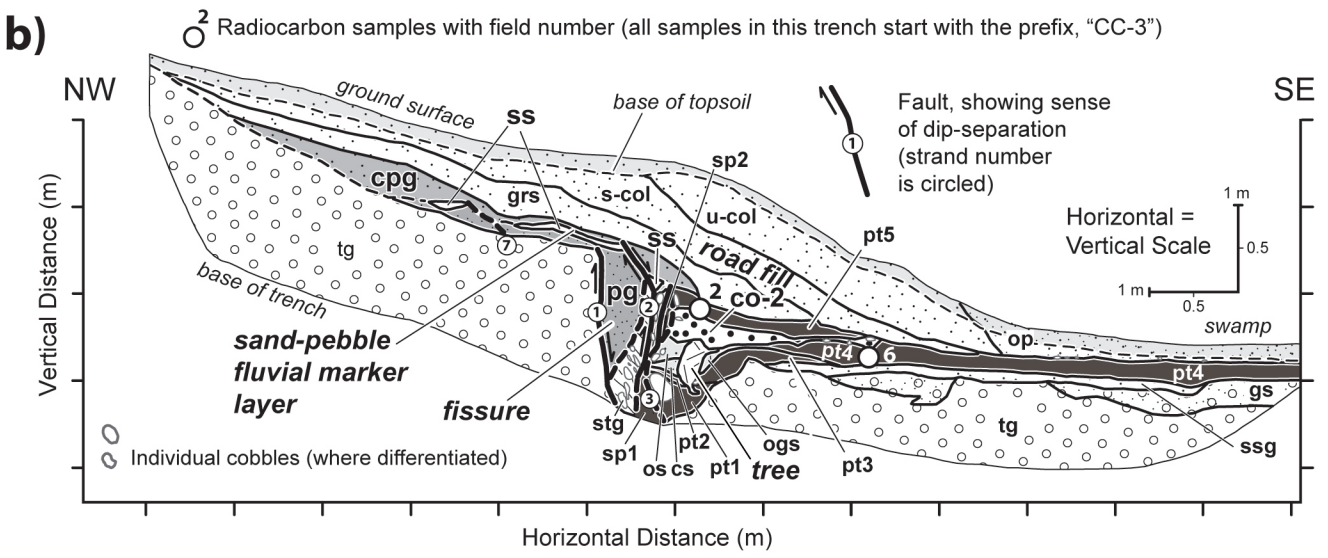
**co-2** Gravelly sand: gravel clasts (subangular-subrounded) in sandy silt matrix. Interpreted as colluvial wedge

**co-1** Layer of rounded cobbles. Interpreted as terrace-derived gravel (redeposited colluvium)

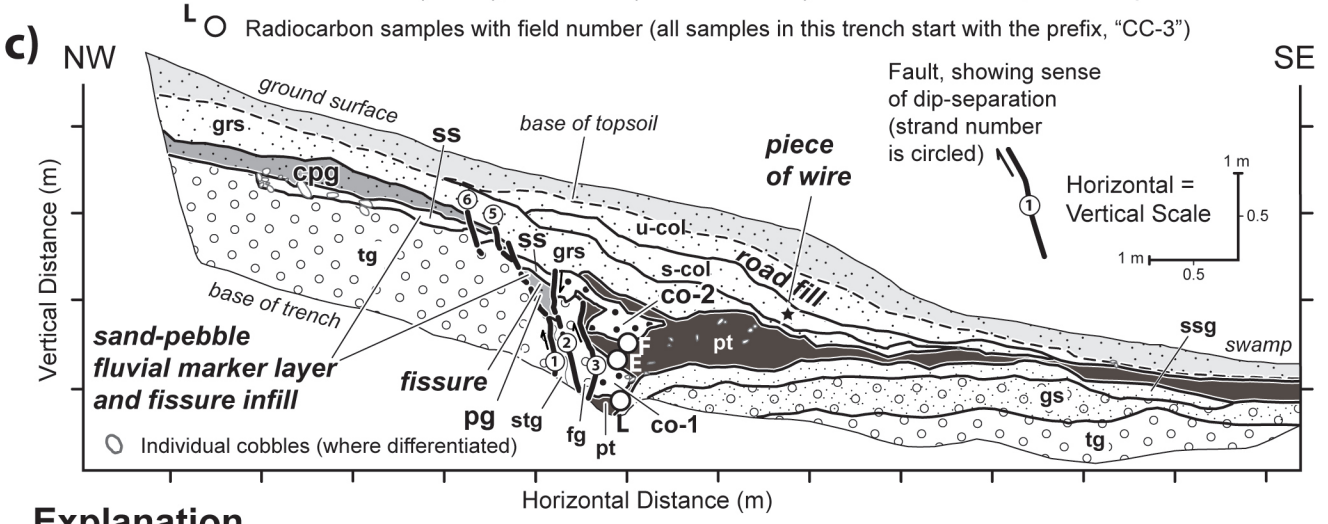
**slt** Fine sandy silt and silty fine sand with subangular pebbles (interpreted as overbank deposits)

**tg** Pebble-cobble terrace gravel, with some lenses of coarse sand, crudely bedded to massive (fluvial)

Cross Creek Trench 3 (CC-3), NEWall: Northern strand, Wairarapa Fault Zone




Cross Creek Trench 3 (CC-3), SW Wall (inverted view): Northern strand, Wairarapa Fault Zone




## Explanation

**u-col, s-col** — Pebble-cobble gravel in a sand-silt matrix (v. poorly sorted).Clasts are angular-subangular. s-col contains wire and both units are interpreted as anthropogenic fill

**grs** — Coarse gravelly silt to NW of fault zone, grading SW into fine to coarse gravel that contains increasing sand-silt component.

**op** — Organic rich silt and peat. Pronounced crumb soil structure. Abundant modern roots

**cpg** — Pebble gravel (compact). Clasts are well-sorted, subrounded, and imbricated (interpreted as fluvial deposit)

**ss** — Coarse sand (well-sorted) with sparse fine pebbles (fluvial)

**pg** — Coarse sand to fine pebble gravel, locally including cobbles. Interpreted as fissure-infilling fluvial deposit

**co-2, co-1** — Pebble-cobble gravel supported by matrix of silty or clayey sand (poorly sorted). Clasts are subangular-subrounded. Interpreted as colluvial wedges

**ogs** — Mixed unit near tree: Gravelly organic rich silt. Subrounded-subangular clasts

**cs** — Mixed unit near tree: Gravelly coarse sand

**os** — Mixed unit near tree: Organic rich silt with varying gravel component. Subrounded-subangular clasts

**pt1,pt2, pt3,pt4** — Fibrous, organic-rich clay or peat with abundant wood fragments and some scattered pebbles

**sp1, sp2** — Tectonically mixed and sheared peats and gravels (sub-vertical orientation of blade shaped clasts in sp1)

**gs** — Gravelly sand in matrix of sandy silt, clast supported (fluvial terrace)

**ssg** — Organic rich, fine sandy and silty gravel, subrounded-subangular clasts (fluvial terrace deposit)

**stg** — Sheared terrace gravel with alignment of clasts parallel to fault (coarse sandy matrix)

**fg** — Faulted cobble terrace gravels

**tg** — Terrace gravel: boulders and cobbles (subrounded) in a pebble-sand matrix. Clast supported and crudely bedded.