1 Fairway Drive, Avalon
Lower Hutt 5011
PO Box 30368
Lower Hutt 5040
New Zealand
T +64-4-570 1444
F +64-4-570 4600
www.gns.cri.nz

25 February 2022

Planning Policy Manager
Upper Hutt City Council
Private Bag 907
Upper Hutt 5140

Attention: Emily Thomson

Dear Emily,

**Revision of Fault Avoidance Zones for the Wellington Fault in Upper Hutt City**

## 1.0 INTRODUCTION

Active faults and Fault Avoidance Zones (FAZs) were previously mapped for Upper Hutt City by Van Dissen et al. (2005) using aerial photographs, prior to the collection of Wellington Region-wide Light Detecting and Ranging (LiDAR) data. These LiDAR data have recently been used to map active faults in the South Wairarapa, Carterton and Masterton districts (Litchfield et al., in press) and, as part of that exercise, some changes have been identified as to the location of the Wellington Fault at the South Wairarapa District / Upper Hutt City boundary. Subsequently, Upper Hutt City and James Beban of Urban Edge Ltd commissioned GNS Science to review recent findings on the Wellington Fault and to refine the FAZs within Upper Hutt City jurisdiction. Specifically, the tasks were to:

- Assess if the Wellington Fault FAZ can be revised in the area around Turksman Lane in Upper Hutt.
- Revise FAZs elsewhere along the Wellington Fault in Upper Hutt City where new findings and data exist, including possible re-definition of the geographic extent of the Distributed, Uncertain Poorly Constrained and the Well-Defined Extended FAZs.
- Write a letter report outlining the latest findings, the amendments to the FAZs and the reasons for the changes.
- Provide updated GIS files.

This report summarises the findings of this Wellington Fault FAZ revision and is accompanied by GIS files of the fault traces and FAZs.

# 2.0 REVIEW OF RECENT FINDINGS AND FAZ METHODOLOGY

## 2.1 Review of Recent Findings on the Wellington Fault

The previous Wellington Fault traces mapped in Upper Hutt City by Van Dissen et al. (2005) were compared with traces visible on the 1 m 2013 Wellington LiDAR data. The LiDAR-based traces were found to only significantly differ (more than a few metres) east of Te Marua Water Treatment Plant, so the new mapping in this study focused on this area (Figure 2.1).

The new fault mapping in the South Wairarapa District shows that the Wellington Fault in the Tararua Ranges is complex and is made up of multiple sub-parallel strands, each made up of multiple traces (Litchfield et al., in press). At the South Wairarapa District / Upper Hutt City boundary, these form two main strands, which we here call the Main strand and the Turksman Lane strand, purely for descriptive purposes (Figure 2.1a).

A brief review was also undertaken of recent geotechnical investigations for the Kaitoke Main Water Pipeline replacement at Silverstream Bridge close to the Upper Hutt / Lower Hutt City boundary (GHD 2021). The design report supplied to GNS Science shows that the Wellington Fault has been located in test pits and drillholes on the downstream (Lower Hutt) side of Silverstream Bridge. These datapoints may result in a small change in the FAZ in Upper Hutt City, which was previously constrained by a fault scarp now destroyed beneath the bridge foundations. However, the locations in the design report (GHD 2021) are not sufficiently accurate to warrant revising the FAZ at this stage, and requests for more detailed data have proved unfruitful. If Upper Hutt City Council wish to pursue this further, it could be undertaken at a later date.

Details of the changes to the Wellington Fault traces and FAZs east of Te Marua Water Treatment Plant are described in Section 3, from south to north.

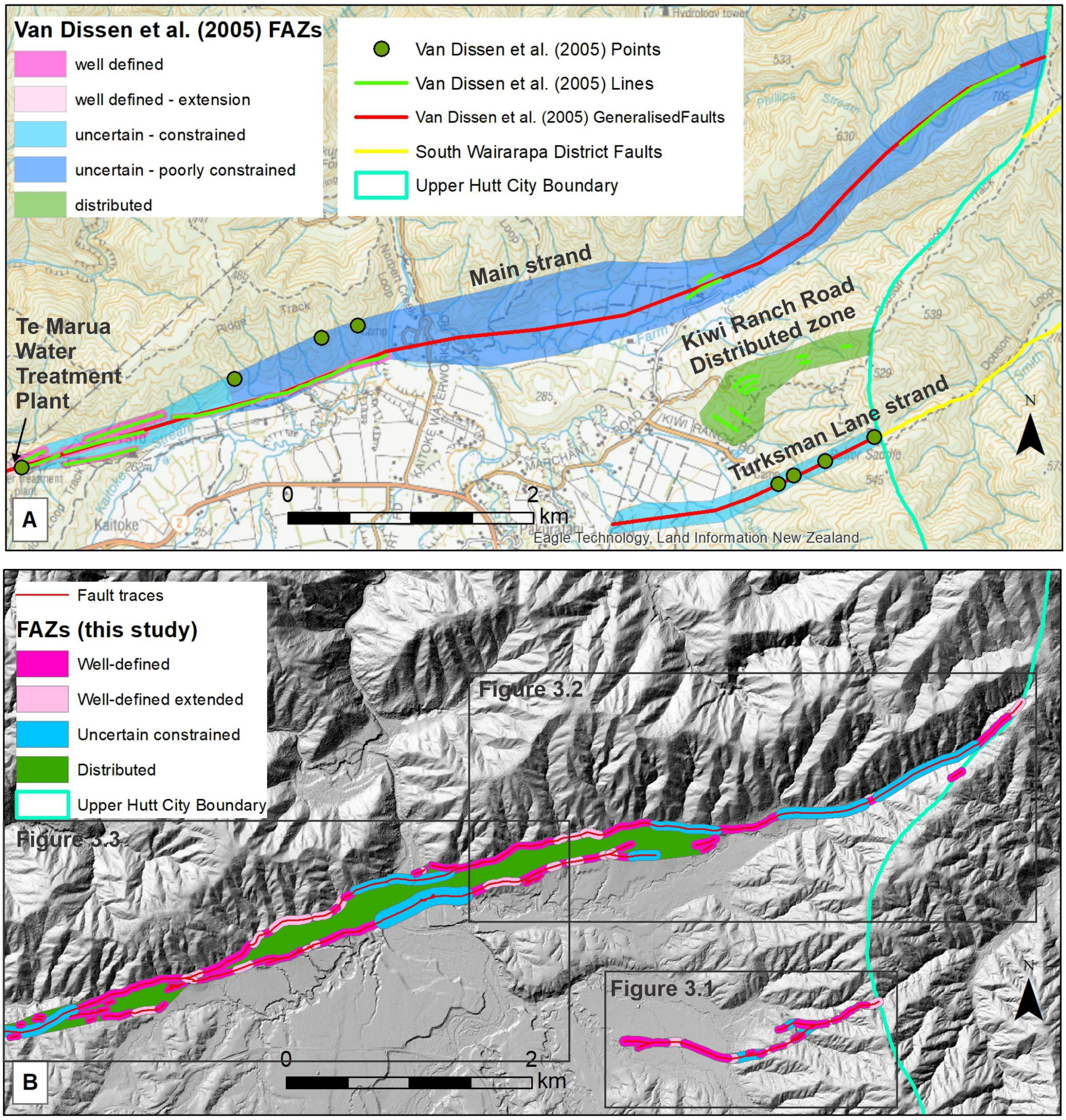



Figure 2.1 The Wellington Fault east of Te Marua Water Treatment Plant in Upper Hutt City. (A) Previous mapping in Upper Hutt City by Van Dissen et al. (2005) and in South Wairarapa District by Litchfield et al. (in press). (B) Active fault traces (red lines) and FAZs (shaded polygons of magenta, pink, light blue and green) mapped in this study. The background map in (B) is the 1 m LiDAR hillshade model.

## 2.2 Revised FAZ Methodology

The revised FAZs presented in this study were developed following the general methodology outlined in the Ministry for the Environment (MfE) Active Fault Guidelines (Kerr et al. 2003), whereby a 'Likely Fault Rupture Zone' is buffered by an additional 'Setback Zone'. Effort was made to be as consistent as possible with both the previous Upper Hutt City (Van Dissen et al. 2005) and South Wairarapa District (Litchfield et al., in press) mapping, but the detailed methodology changed slightly between the two studies with use of LiDAR data. The methodology used in this study is the same as that used for the South Wairarapa District and is outlined in more detail in that report (Litchfield et al., in press). In brief, the methodology is shown in Figure 2.2 and consists of the following steps:

1. *Buffer the fault traces by the Deformation Width* (the horizontal width of the fault feature or, for concealed faults or faults with no surface trace, the maximum width of where the fault deformation could be located).
2. *Buffer the zones developed in step 1 by an additional 3 m* to account for the Capture Uncertainty, which accounts for the error involved with transferring the fault location to a map. In this investigation, this Capture Uncertainty is relatively small as all traces were mapped using high-resolution LiDAR data.
3. *Buffer the zones developed in step 2 by the 20 m setback zone*.
4. Where it is considered there will likely be ground surface deformation between traces, *manually define a Distributed zone* encompassing this area.

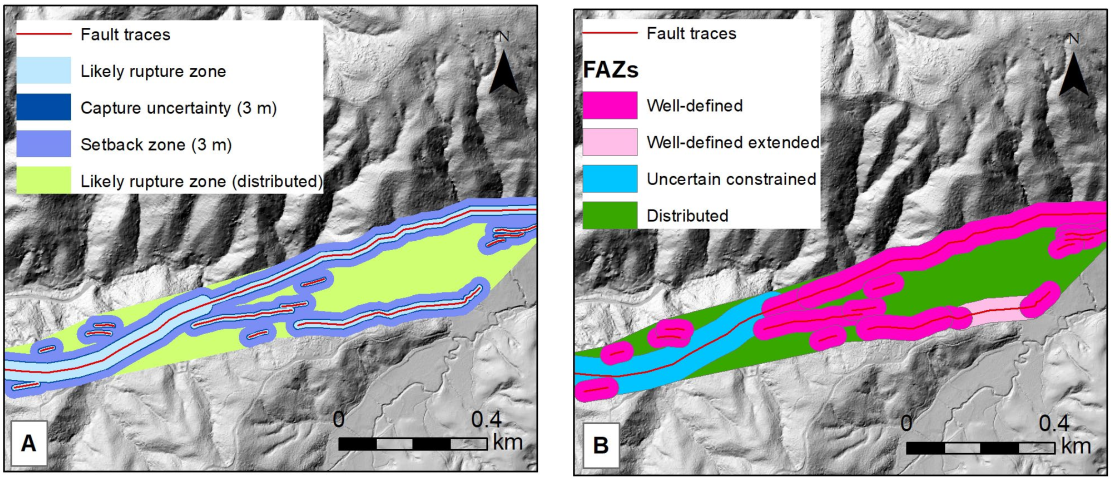



Figure 2.2 Revised FAZ methodology used in this study. (A) The components (buffers) used to develop the FAZs. (B) The final FAZs, coloured by fault complexity.

## 3.0 REVISED WELLINGTON FAULT MAPPING AND FAZS

### 3.1 Turksman Lane Strand

The Turksman Lane strand of the Wellington Fault mapped in this study extends from the South Wairarapa District / Upper Hutt City boundary (Puffer Saddle) across Turksman Lane to an unnamed stream near Pakuratahi (Figure 3.1). Within the hills to the east, the traces are generally sharp (fault complexity well-defined) and semi-continuous, with one branch in the centre (North branch). Most traces and FAZs are within the previous FAZ, except for the western end of the North branch. Connections have been inferred across small gullies, and the corresponding FAZs have a fault complexity of well-defined extended or uncertain constrained (refer to Kerr et al. [2003] or Van Dissen et al. [2005] for fault complexity definitions).

On the plains to the west, the trace locations are significantly different to the previous mapping, with an overall swing to the west-northwest (parallel to Kiwi Ranch Road) and up to 340 m north of the centre of the previous FAZ (Figure 3.1). The traces are sharp (well-defined) on the LiDAR data, with well-defined–extended connections inferred across small streams. While we do consider these traces to be active fault traces, it cannot be ruled out that these are either partly or wholly the result of erosion by small streams, which also swing to the west-northwest after they emerge from the hills. That is, the steps in the LiDAR data could have been formed by riverbank erosion rather than ground-surface fault rupture. These traces on the plains have therefore been classified as ‘possible’ active faults, and further work is recommended to determine whether they are active fault traces.

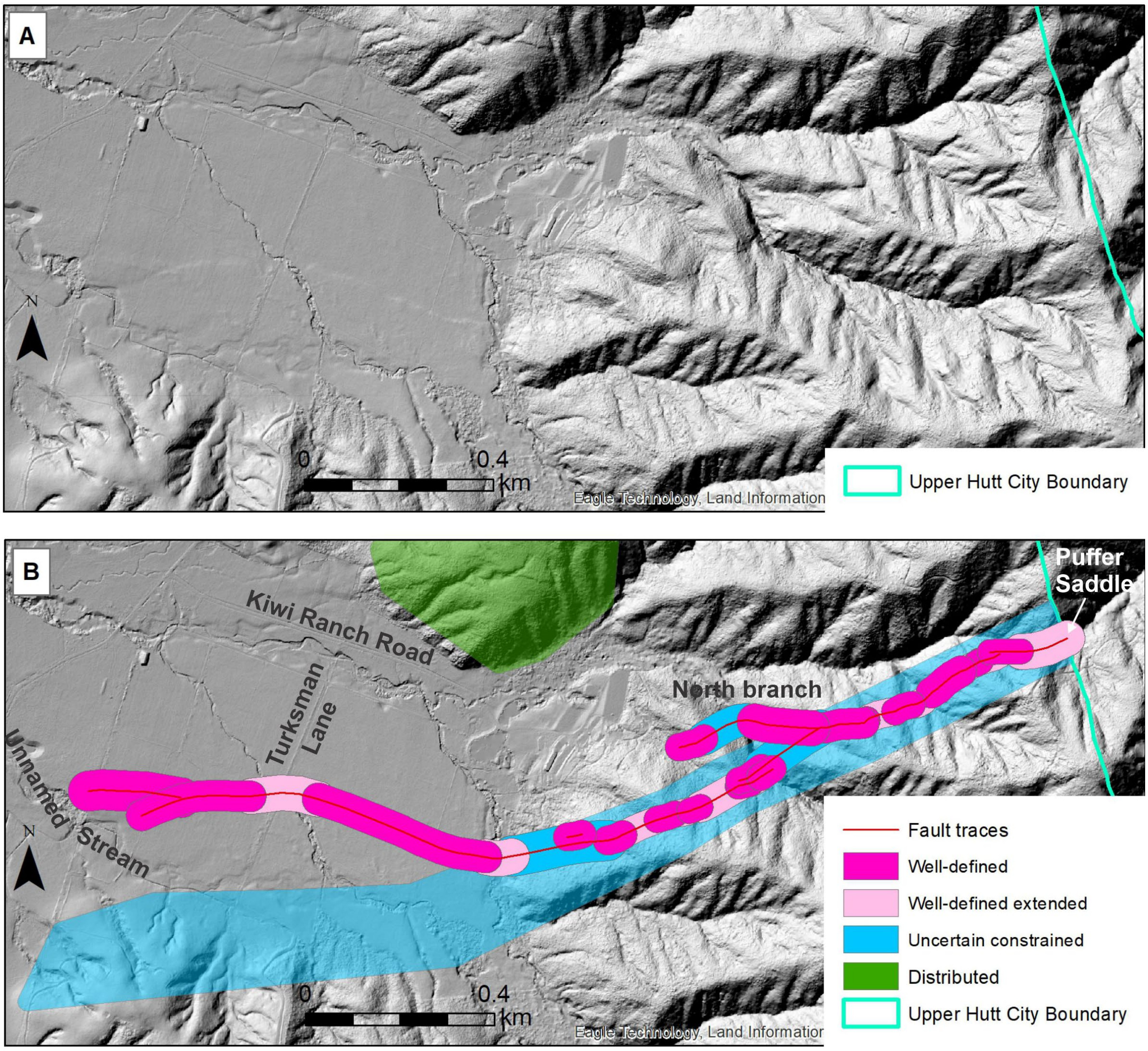



Figure 3.1 Turksman Lane strand of the Wellington Fault. (A) LiDAR hillshade map. (B) Active faults (red lines) and revised FAZs (solid coloured polygons of magenta, pink and blue) overlain on the previous (Van Dissen et al. 2005) FAZs (transparent coloured polygons of green and light blue).

## 3.2 Kiwi Ranch Road Distributed Zone

A series of ‘fault controlled’ and ‘possibly fault controlled’ lines were mapped by Van Dissen et al. (2005) in the hills northeast of Kiwi Ranch Road (light green lines on Figure 2.1a). These were considered to either be fault scarps or ridge rents (gravitational hillslope collapse features formed during earthquakes) and were encompassed in a Distributed FAZ (dark green zone on Figure 2.1a).

Only two of these features are visible in the LiDAR data, and one appears to be the side of a gully. Their isolated nature and lack of continuity suggests that they are not active fault scarps. The Distributed FAZ has therefore been removed from the revised dataset (Figure 2.1b).

However, this is not to suggest that there couldn’t be ground deformation in this area during an earthquake. It is likely that there will be lots of landslides and some isolated, secondary, fault ruptures in the hills surrounding the Wellington Fault during an earthquake.

## 3.3 Main Strand

The eastern end of the Main strand of the Wellington Fault at the South Wairarapa District / Upper Hutt City boundary was previously mapped in the headwaters of Phillips Stream, but the mapping in this and the South Wairarapa District study (Litchfield et al., in press) shows it to instead be situated in the headwaters of Farm Creek (Figure 3.2), up to 600 m south of the centre of the previous FAZ. A sharp (well-defined) trace occurs along the district boundary and in Farm Creek valley, and traces are inferred along the rest of the valley floor, with uncertain constrained fault complexity. Another isolated, short, trace has also been mapped at the district boundary but does not appear to connect with the Main strand.

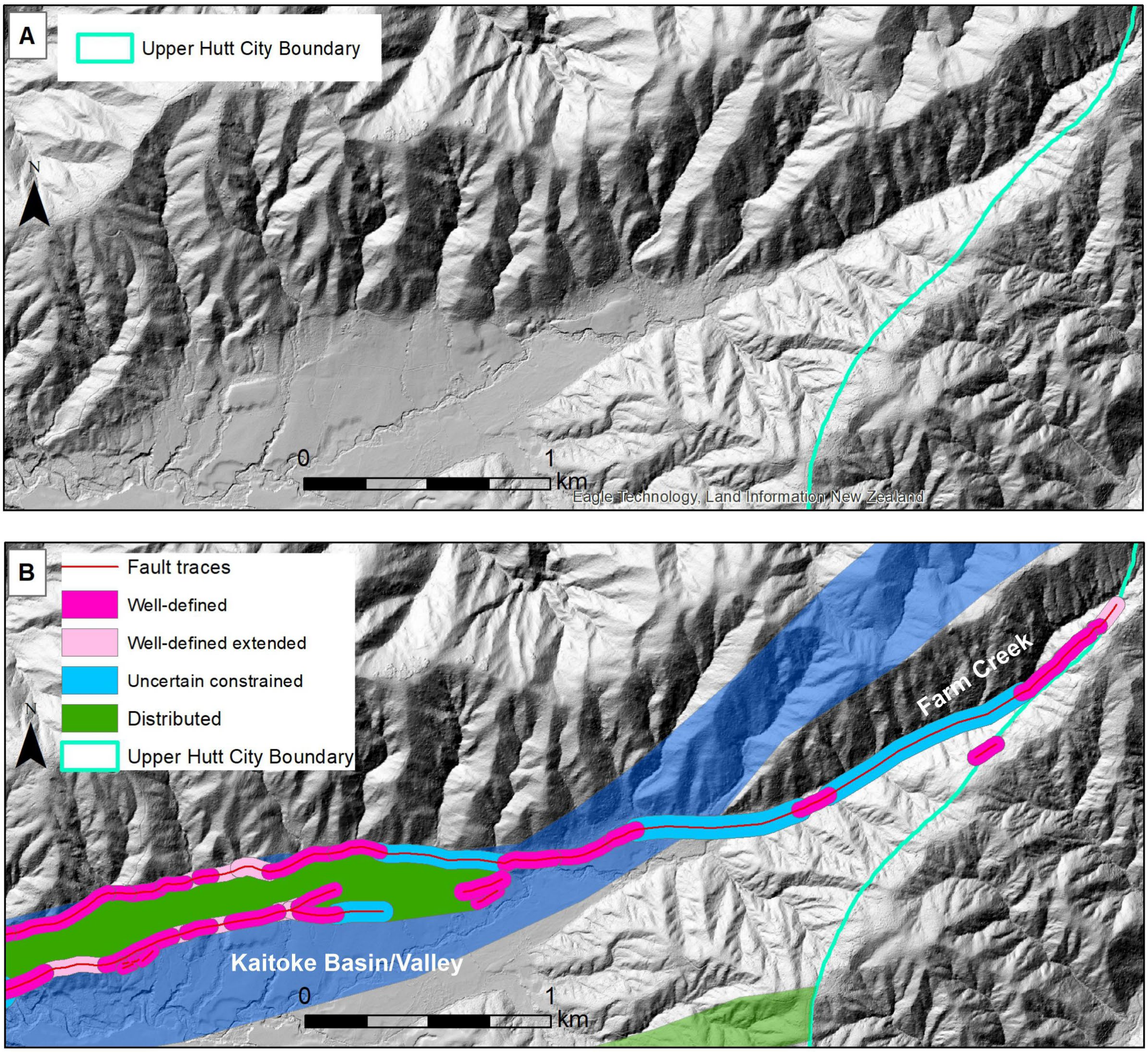



Figure 3.2 Eastern half of the Main strand of the Wellington Fault. (A) LiDAR hillshade map. (B) Active faults (red lines) and revised FAZ (solid coloured polygons of magenta, pink and light blue) overlain on the previous (Van Dissen et al. 2005) FAZs (transparent coloured polygons of green and dark blue).

Within the Kaitoke Basin/Valley, the Main strand is mapped in this study as two parallel sub-strands within the previous uncertain – poorly constrained FAZ (Figure 3.2, Figure 3.3). It is considered likely that there could be future ruptures and ground deformation between these sub-strands, so a distributed FAZ has been developed between them. All of these revised FAZs are within the previous uncertain – poorly constrained FAZ of Van Dissen et al. (2005), but, east of the Hutt River, they are on the northern side, resulting in a significant reduction in FAZ width. Both sub-strands are comprised of sharp (well-defined) traces joined with inferred traces across small streams (well-defined–extended) and larger rivers (uncertain constrained), but, in general, the southern sub-strand appears to be the most active. Trenches have been excavated across the southern sub-strand by Langridge et al. (2009) (yellow dots on Figure 3.3b). One of the trenches revealed a record of multiple earthquakes in the last 11,000 years, from which a maximum recurrence interval of about 1000 years was derived.

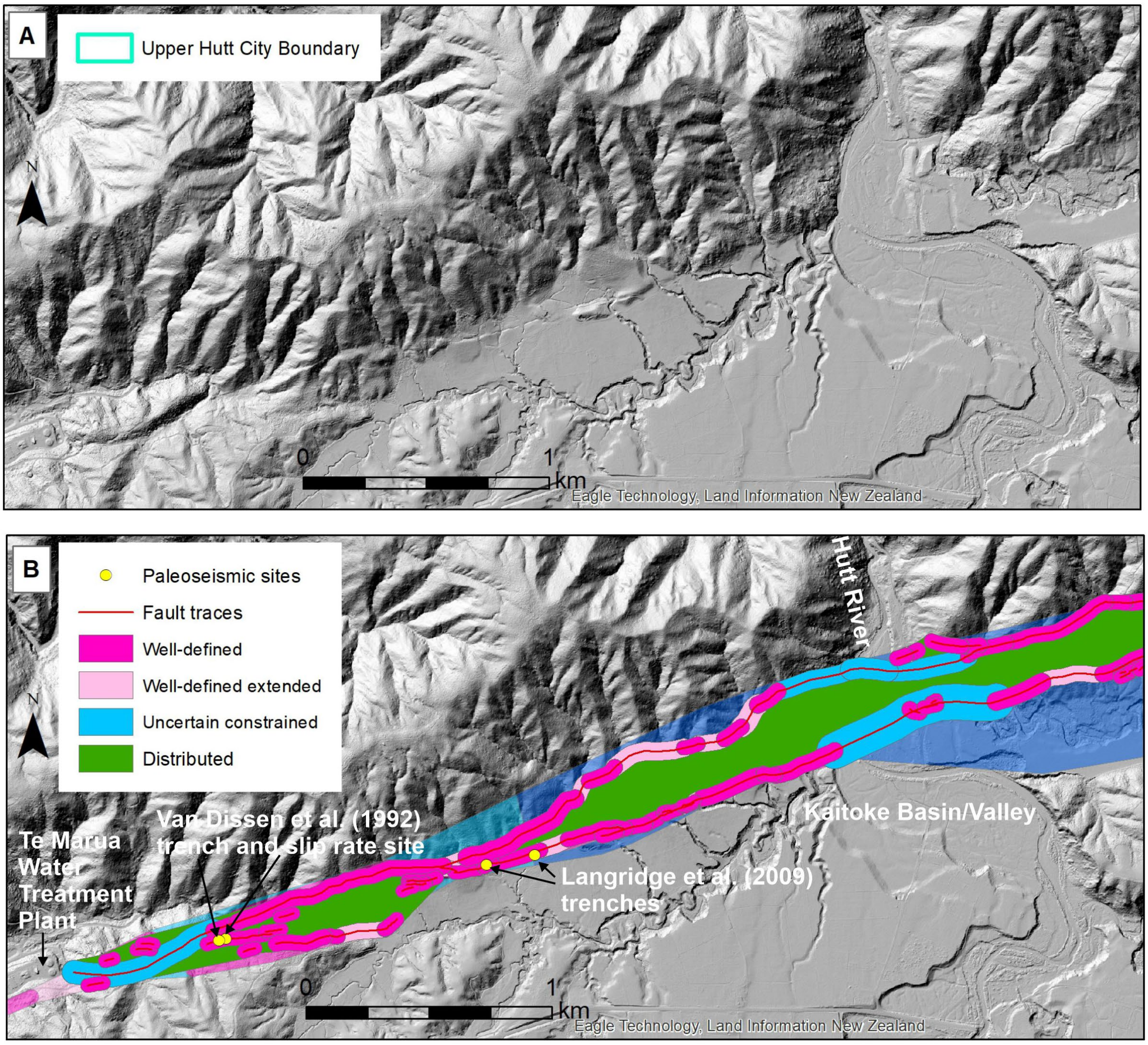



Figure 3.3 Western half of the Main strand of the Wellington Fault. (A) LiDAR hillshade map. (B) Active faults (red lines) and revised FAZ (solid coloured polygons of magenta, pink and light blue) shown overlain on the previous (Van Dissen et al. 2005) FAZs (transparent coloured polygons of green and dark blue).

In the low hills between the Kaitoke Basin/Valley and the Te Marua Water Treatment Plant, several traces have been mapped in this study (Figure 3.3). These broadly correlate to lines mapped by Van Dissen et al. (2005) (Figure 2.1a), and they generally appear to be discontinuous and to comprise part of a broader zone, so a distributed zone has been developed between the individual trace FAZs. This is slightly narrower than the uncertain constrained FAZ of Van Dissen et al. (2005). A trench was excavated across one of these traces by Van Dissen et al. (1992), which constrained the timing of the second-to-most-recent event to approximately 700–800 years ago. A minimum dextral slip rate of about 3 mm/yr was also obtained for this trace.

## 4.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Recent findings on the Wellington Fault in Upper Hutt City have been reviewed and high-resolution LiDAR data interrogated, which has resulted in revised mapping of the fault and FAZs east of Te Marua Water Treatment Plant. The key changes are:

- The Kiwi Ranch Road Distributed zone has been removed.
- The western end of the Turksman Lane strand has been shifted up to 200 m to the north, from within the hills to the plains.
- The eastern end of the Main strand has been shifted south by one valley, up to 600 m south of the previous FAZ.

With the above exceptions, the remainder of the revised traces and FAZs are within the previous FAZs, but the revised FAZs are generally narrower. Previous wide uncertain constrained and uncertain – poorly constrained FAZs have been replaced with well-defined, well-defined extended and narrow uncertain constrained FAZs, with a distributed FAZ joining traces of the Main strand.

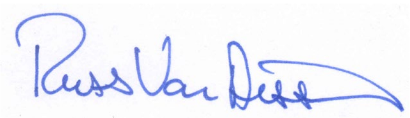
There has been one paleoseismology study (Langridge et al. 2009) on the revised Main strand since the Van Dissen et al. (2005) study, but the results do not change the Recurrence Interval Class of I (≤2000 years) (refer to Kerr et al. [2003] or Van Dissen et al. [2005] for definitions).

GNS Science recommends that Upper Hutt City:

- Replace any active fault datasets for the Wellington Fault east of Te Marua Water Treatment Plant in Upper Hutt City with the results of this study.
- Develop planning provisions using the information provided in this report and Van Dissen et al. (2005), including adoption of the guiding principles and risk-based decision-making tools of the MfE Active Fault Guidelines (Kerr et al. 2003).
- Investigate the tectonic origin of the possible western end of the Turksman Lane strand.

Yours sincerely,

Nicola Litchfield
Senior Earthquake Geologist



Russ Van Dissen (reviewer)
Senior Earthquake Geologist

## 5.0 REFERENCES

GHD. 2021. Silverstream Pipeline Replacement Project: design report. Wellington (NZ): Wellington Water Ltd. OPC 100394. 143 p. Prepared for Wellington Water Ltd.

Kerr J, Nathan S, Van Dissen RJ, Webb P, Brunsdon D, King AB. 2003. Planning for development of land on or close to active faults: a guideline to assist resource management planners in New Zealand. Lower Hutt (NZ): Institute of Geological & Nuclear Sciences. 71 p. Client Report 2002/124. Prepared for Ministry for the Environment.

Langridge RM, Van Dissen RJ, Villamor P, Little TA. 2009. It's Our Fault: Wellington Fault paleo-earthquake investigations: final report. Lower Hutt (NZ): GNS Science. 45 p. Consultancy Report 2008/344. Prepared for EQC, ACC and Wellington City Council.

Litchfield NJ, Coffey GL, Morgenstern R. In press. Active fault mapping for the South Wairarapa, Carterton and Masterton districts. Lower Hutt (NZ): GNS Science. Consultancy Report 2021/117. Prepared for Greater Wellington Regional Council.

Van Dissen RJ, Berryman KR, Pettinga JR, Hill NL. 1992. Paleoseismicity of the Wellington – Hutt Valley segment of the Wellington Fault, North Island, New Zealand. *New Zealand Journal of Geology and Geophysics*. 35(2):165–176. doi:10.1080/00288306.1992.9514511.

Van Dissen RJ, Litchfield NJ, Begg JG. 2005. Upper Hutt City fault trace project. Lower Hutt (NZ): Institute of Geological & Nuclear Sciences. 28 p. Client Report 2005/151. Prepared for Greater Wellington Regional Council, Upper Hutt City Council.