Before the Hearings Panel
At Wellington City Council

Under Schedule 1 of the Resource Management Act 1991

In the matter of the Proposed Wellington City District Plan

Statement of evidence of David Ross Burbidge behalf of Wellington City Council (Tsunami)

Date: 18 May 2023

INTRODUCTION:

1 My full name is David Ross Burbidge. I am employed as Tsunami Team Leader at GNS Science.

2 I have prepared this statement of evidence on behalf of the Wellington City Council (the **Council**) in respect of technical related matters arising from the submissions and further submissions on the Proposed Wellington City District Plan (the **PDP**).

3 Specifically, this statement of evidence relates to tsunami inundation that has informed the relevant Coastal Hazards provisions and mapping in the PDP.

4 I am authorised to provide this evidence on behalf of the Council.

QUALIFICATIONS AND EXPERIENCE

5 I hold the academic qualifications of a Doctor of Philosophy (Earth Sciences – 2000) from the Australian National University (ANU) and a Bachelor of Science (First Class Honours in Physics - 1996) also from the ANU.

6 I am currently the Tsunami Team Leader at the Institute of Geological and Nuclear Sciences Limited (GNS Science). I have worked at GNS Science since 2014, including four years as the Head of Department for Tectonophysics (which included the Tsunami Team) before moving into my current role.

7 My previous work experience prior to coming the GNS Science comprises of one year working as a Research Scientist at the Defence Science and Technology Organisation (DSTO) in Australia and then 12 years working at Geoscience Australia (GA). At GA I was the Earthquake Hazard Section Leader for four years and for the rest of that a period I was a Research Geophysicist within that Section. During that time, I worked on a range

of projects covering the fields of earthquake and tsunami hazard and risk assessment and tsunami monitoring and forecasting.

8 During my time at GNS Science, I have led, or contributed to, a range of tsunami inundation hazard modelling projects including projects for Hutt City Council, Wellington City Council, Hawkes Bay Regional Council, West Coast Regional Council, Bay of Plenty Regional Council and Environment Canterbury.

9 I contributed to the 2021 update to the National Tsunami Hazard Model (NTHM). The NTHM estimates the maximum tsunami height off the coast which has a particular probability of being exceeded each year. The NTHM underpins the tsunami inundation hazard assessments listed above. I was second author on the final report for the update.

10 I am currently a member of the Tsunami Expert Panel for New Zealand and sit on the DART (Deep-Ocean Assessment and Reporting of Tsunamis) Project Board and Technical Advisory Group. I have provided tsunami advice through to emergency managers during numerous tsunami responses during my time at GNS Science. I am also on the Event Controller Panel for GNS Science and was recently the GNS Science Controller for GNS Science's Auckland Flooding response earlier this year.

11 I lead a research project within GNS Science that aims to assess the hazard and risk posed by earthquakes on the Hikurangi Subduction Zone and all their cascading effects. This includes tsunami, but also includes other cascading effects from earthquakes such as earthquake induced landslides. The project aims to look not only on the direct effect of earthquakes on infrastructure, but also the cascading effect of that damage on lifeline network effectiveness and the economy.

12 I lead the Tsunami Strategy Development Sub-Theme within GNS Science. This project aims to put together a coordinated strategy for all the tsunami research within GNS Science. It covers all the tsunami

related work that we do, all the way from tsunami monitoring, hazard and risk assessment and through to advice and response

13 I am a member of American Geophysical Union and the Geoscience Society of New Zealand.

Code of conduct

10 I have read the Code of Conduct for Expert Witnesses set out in the Environment Court's Practice Note 2023. I have complied with the Code of Conduct in preparing my evidence and will continue to comply with it while giving oral evidence before the Environment Court. My qualifications as an expert are set out above. Except where I state I rely on the evidence of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

SUMMARY

11 My name is David Ross Burbidge.

12 I have been asked by the Council to provide Tsunami evidence in relation to the appeal on Chapter Natural Hazards and Risk.

13 My statement of evidence addresses

a. The tsunami inundation hazard mapping available to and used by WCC during the preparation of this Proposed Plan Change; and

b. My advice I provided to WCC in response to submissions received on this proposed Plan Change.

INVOLVEMENT WITH THE PROPOSED PLAN

14 I have been involved in the PDP since 2020 when WCC contracted GNS Science to provide probabilistic tsunami maps to inform their Urban Growth Plan review.

SCOPE OF EVIDENCE

15 My statement of evidence addresses the following matters:

Tsunami

16 I prepared one report entitled: *Burbidge DR, Gusman AR, Power WL, Wang X, Lukovic B. 2021. Wellington City probabilistic tsunami hazard maps. Lower Hutt (NZ) GNS Science. 24p. Consultancy Report 2021/91.*

17 In the report we provide a range of probabilistic tsunami inundation hazard maps for three annual probabilities of exceedance (APoEs) and at two different sea level values, the present value and one with an additional 1.0 metres of sea level rise included. I led the project, AR Gusman did the tsunami inundation modelling, WL Power helped to determine which scenarios to use from the NTHM and X Wang set up the models used in the assessment. All authors contributed to the final report.

18 To produce these maps, we used the latest version to New Zealand's National Tsunami Hazard Model (NTHM) to select scenarios appropriate at each APoE for the zone offshore the Wellington region. The NTHM estimates the maximum offshore tsunami amplitude across a range of APoEs across for all of New Zealand, including Wellington. We then used a high-resolution digital elevation model combining the bathymetry and topography of the region, and the scenarios described above, to hydrodynamically model the inundation expected from each of them in the region covered by WCC. Inundation models were run twice for each scenario, once at each of the sea-level values requested by WCC. These

scenarios then combined using a weighted median approach to create probabilistic tsunami inundation maps for each APoE and sea-level rise combination across the area of interest giving a total of six maps. The map data then provided to WCC in digital form along with an accompanying methodology report.

19 The level of modelling provided to WCC is consistent with the preferred approach for Level 3 tsunami inundation hazard modelling as outlined in the "Tsunami Evacuation Zones - Director's Guideline for Civil Defence Emergency Management Groups [DGL 08/16]" (https://www.civildefence.govt.nz/assets/Uploads/publications/dgl-08-16-TsunamiEvacuation-Zones.pdf). The models are all physics-based computer simulations and are based on "multiple scenarios 'de-aggregated' from an appropriate an appropriate probabilistic model and modelled from source" (page 15, DGL 08/16). In addition to being used to inform Tsunami Evacuation Maps design, Level 3 and above tsunami modelling is the preferred modelling level in DGL 08/16 to inform risk-based Resource Management Act (1991) "planning measures to avoid or mitigate tsunami risk. They could also be used in pre-event recovery planning, such as establishing options for set-back, retreat or redesign." (Section 4.3.1, page 19 of DGL 08/16).

20 I understand the Coastal Hazard Overlay (Tsunami) layers shown in Proposed Plan Change are based on the maps in the figures listed in the table below. If this is the case, I have visually inspected the models on the website (Map - Wellington City Proposed District Plan) and the maps in our report (Figure 4.2, 4.4 and 4.6).

21 The Overlays are clearly based on the data we produced for WCC. The "High Hazard" zone appears to cover the same area as that shown in our Figure 4.2. The "Medium Hazard" zone appears to be the area shown in our Figure 4.4 which is not covered by their "High Hazard" area. Similarly, the "Low Hazard" zone covers the areas in the map shown in our Figure 4.6 that were not already covered by their "High" or "Medium" hazard areas.

22 The WCC s.42a reporting planner has also sought advice on tsunami inundation depths in response to general submissions on tsunami hazard and to ensure consistency, where appropriate, with the coastal inundation layer. In particular, I was asked if removing the areas with flow depths below 5cm may be appropriate as inundation depths at this level may not produce a sufficient risk that would need a land use planning response. For our tsunami inundation models, these sort of small flow depths typically occur right at the edges of the areas shown in the maps. In my opinion, the risk posed by tsunamis with flow depths of around 5cm is very low. Tsunamis with flows depths this small are very unlikely to cause any structural damage. At this level the tsunami is very likely to be controlled by small scale topographic features that are too small to be resolved in the digital elevation model used in our simulations (e.g., raised beds, gutters etc). The typical accuracy of the Lidar on which the digital elevation model is based is of order 10cm. The numerical accuracy of the model itself and the conversion of the numerical model into the GIS layers could also introduce errors of about this magnitude. Therefore, removing areas with flow depths less than 5cm would be reasonable in my opinion if the council chooses to do so. However, that would still leave the possibility of some minor inundation with flow depths of about 5cm in the removed areas at the given annual probability of exceedance.

GNS Report Map	**Proposed Plan Change 56 Map Layer**
Figure 4.2: 1-in-100 years at current MHWS plus 1.0m sea level rise	Coastal Hazard Overlay (Tsunami): High Coastal Hazard Area
Figure 4.4: 1-in-500 years at current MHWS plus 1.0m sea level rise	Coastal Hazard Overlay (Tsunami): Medium Coastal Hazard Area
Figure 4.6: 1-in-1000 years at current MHWS plus 1.0m sea level rise	Coastal Hazard Overlay (Tsunami): Low Coastal Hazard Area

Response to Submissions

23. Council officers have sought advice as to whether the below requested changes are appropriate from a technical perspective, particularly in terms of the location of fault rupture.

Submitter Name	Submission Point No.	Submission Point Text
David Karl	309.4	Considers that according to presentations from WCC staff and technical experts at a community climate adaptation meeting, modelling underpinning the current maps reflects some of the available, appropriate possible modelling, but does not account for wave dynamics. It is understood from these experts comments wave dynamics may have a significant bearing on the island. Seeks that the tsunami inundation overlay be amended to account for wave dynamics that include consideration of Tapu Te Ranga (the island in Island Bay).

24 I was not at the meeting in question so I cannot comment on what was said in the presentation. However, the tsunami modelling we did for this project did take the wave dynamics of tsunamis into account. For each of the scenarios listed in our report we hydrodynamically modelled the tsunami propagation and inundation all the way from the earthquake's source location and onto shore. The Digital Elevation Model we used for the modelling included Tapu Te Ranga and thus the effect of the island on the inundation extents of each scenario, and thus on the resulting hazard maps, is already included. No amendments are therefore required.

Date: 18/05/2023

David R. Burbidge

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David Ross Burbidge