IN THE MATTER of the Resource Management Act 1991 ("RMA" or "the Act")

AND

IN THE MATTER the **PROPOSED WAIKATO DISTRICT PLAN**

STATEMENT OF EVIDENCE OF DR MURRAY GRANT WEBBY IN RESPECT OF FLOODING AND FLOODPLAIN MANAGEMENT

1. INTRODUCTION

1.1 My full name is Murray Grant Webby. I am a Principal Hydraulic Engineer with Damwatch Engineering Limited. I have worked for Damwatch Engineering since June 2016. Prior to my current position, I held the position of Principal Hydraulic Engineer with Opus International Consultants. I was previously employed by Opus International Consultants and its predecessor organisations, Works Consultancy Services, Works and Development Services Corporation and the Ministry of Works and Development for 35 years.

1.2 I hold a Bachelor of Engineering (1st Class Honours) degree in Civil Engineering, which I obtained in 1978. I also hold a Doctor of Philosophy degree in Civil Engineering, which I obtained in 1981. Both degrees were from the University of Canterbury. I have over 39 years' experience as a hydraulic engineer, working for power generation companies in New Zealand and overseas, New Zealand government departments and agencies, regional and district councils, and private companies.

1.3 I am a Chartered Professional Engineer. I am also a Fellow of Engineering New Zealand and a member of the NZ Society on Large Dams, the NZ Hydrological Society, the Engineering NZ / Water NZ Rivers Group and the International Association for Hydro-Environment Engineering and Research.

1.4 In my role as a technical specialist, I am often called upon to provide expert evidence on:

(a) The management and operation of natural lakes and lakes controlled for hydro-electricity generation purposes, and on the hydrological and climatological processes affecting such lakes; and

(b) The management of natural hazards on floodplains and the effects of those hazards on infrastructure.

1.5 In 2019, I advised Meridian Energy (Meridian) on the history of lake level changes for Lake Pukaki, the dynamic and natural processes affecting the lake, the current lake level management regime for the lake, extreme flood inflows and lake levels, lakeshore inundation due to high lake levels, wind effects and waves, and shoreline erosion.

1.6 From 2011-2016, I advised the New Zealand Transport Agency on flood hazards affecting four significant watercourse crossings of the proposed Peka Peka to North Otaki Expressway north of Wellington. I was the hydraulic designer for these watercourse crossings and presented evidence on natural flood hazards and the design of the watercourse crossings to the Board of Inquiry which considered the resource consent application for the proposed Expressway.

1.7 From 1998-2002, I advised Mercury NZ's predecessor organisations, Mighty River Power Limited and the ECNZ Northern Generation Group, on the impact of hydropower operations on the Lower Waikato River during investigations to support the renewal of resource consents for the Waikato Hydro System. This included the impact of hydropower operations on flood management.

1.8 I have been advising Mercury NZ Limited (Mercury), as the owner and operator of the Waikato Hydro System, on wider floodplain management issues in the Lower Waikato River, including the Proposed Waikato District Plan, and the proposed Ambury Properties Limited (APL) development and the rezoning of land at Ohinewai.

1.9 I provided evidence with respect to the Ohinewai PWDP hearing. I also participated in a pre-hearing expert witness conference on flooding matters in June 2020, and signed the joint witness statement of experts in relation to flooding which resulted from that conference.

Expert Witness Code of Conduct

1.10 I confirm I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note (2014) and agree to comply with it. I can confirm that the issues addressed in this statement are within my

area of expertise and that in preparing my statement I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Floodplain management

1.11 Floodplain management in the Lower Waikato River is of interest to Mercury, as it works closely with Waikato Regional Council (being the statutory flood manager) in relation to the operation of the Waikato Hydro System during times of flooding. The Waikato Hydro System can attenuate some, but not all, fluvial flooding, and so, the proper management of fluvial flooding risk in the Lower Waikato River is of interest to Mercury.

1.12 It is important to note that fluvial flooding, flooding of land caused by rivers streams and lakes overflowing their banks, is different from pluvial flooding although the effects may be similar. Pluvial flooding is associated with rain falling directly onto land and causing flooding to occur due to the inability of floodwaters to drain away, either naturally or with the aid of a stormwater drainage network.

Scope of evidence

1.13 This statement of evidence has been prepared in response to the Section 42A Report, Hearing 27C: Flood Hazards and Defended Areas (Section 42A Report).

1.14 My evidence covers the following:

(a) Reviews the Section 42A Report and critiques its recommendations on the 1% Annual Exceedance Probability (AEP) floodplain management overlay mapping (Section 2);

(b) Identifies key documents which contain information relevant to flood management in the Lower Waikato River, and the design and operation of the Lower Waikato-Waipa Flood Control Scheme (Section 3);

(c) Provides a summary of information related to Lake Waikare which is a key off-channel flood storage component of the Lower Waikato-Waipa Flood Control Scheme (Section 4);

(d) Explains the importance of the current Design Flood Level of RL 7.37 m for Lake Waikare, and why I consider the Section 42A Report's recommendation to omit it from the PWDP in the interim, until a

revised Design Flood Level taking account of future climate change effects is defined, is flawed (Section 5);

(e) Comments on the Section 42A Report's policy recommendations related to the management of flood risk generally (Section 6); and

(f) Sets out my conclusions (Section 7).

1.15 My evidence is accompanied by Angus McKenzie's planning evidence on Topic 27 on behalf of Mercury NZ Limited.

2. REVIEW OF SECTION 42A REPORT

2.1 The Section 42A Report generally concurs with the view of the Director-General of Conservation that a non-statutory map, e.g. a GIS flood hazard layer in a GID mapping system, does not 'provide the level of certainty to ensure the Flood Plain Management Area is given appropriate statutory weighting in decisions relating to flood hazard' (paragraph 463).

2.2 The Section 42A Report considers that 'robustly constructed and peer reviewed modelled flood extents placed on the planning maps gives the community the greatest certainty as to affected and non-affected areas. It considers that such information is more likely to be informed by evidence because of the rigour of the planning process (paragraphs 466 - 467).

2.3 The report acknowledges that not all High Risk Flood Areas in the District have been mapped. This includes the 1% AEP flood extent for the Rangiriri Spillway and Lake Waikare (paragraph 469), which as discussed later in Section 4, I consider to be critical components of the Lower Waikato-Waipa Flood Control Scheme.

2.4 The report rejects the submission of the Director-General of Conservation that 'High Flood Risk Areas at Lake Waikare should be based on the current design flood level (RL 7.37 m) and include provision for changes in flood areas in response to climate change and catchment management programmes' (paragraph 468).

2.5 The report states that work by Waikato Regional Council on revising the 1% AEP design flood level for Lake Waikare including the effects of climate change has yet to be commissioned, although it is understood to be scheduled for the next financial year. The report expresses the view that, "in time, the results of that modelling can be included in the 1% AEP flood extent mapping" (paragraph 470).

2.6 The omission from the planning maps of the 1% AEP flood extent for Lake Waikare, based on current knowledge, begs the question of how the PWDP is to manage flood risk until the 1% AEP design flood level accounting for future climate change effects is revised. I consider that not having some interim line drawn in the sand to define the flood hazard in an area where there is a known quantified flood hazard, is a flawed approach.

2.7 I consider that the question of how the PWDP manages flood risk in the interim applies equally to other areas where the 1% AEP flood extents have not yet been adequately defined.

2.8 As discussed further in Section 4 of my evidence, Lake Waikare forms a critical and integral component of the flood management system for the Lower Waikato / Waipa River System. It temporarily stores excess volumes of floodwater in the Lower Waikato River and releases the stored volume slowly over time to provide flood relief for people and property further down river.

2.9 I consider that the current 1% AEP design flood level for Lake Waikare must be a logical starting point for the defining the 1% AEP flood extent for the area around Lake Waikare. The lake and its surrounding area functions as a giant bathtub when the Lower Waikato-Waipa Flood Control Scheme operates, so the 1% AEP flood surface will have a constant level across the area (unlike along the Waikato River where the 1% AEP flood surface will have a gradient due to the movement of floodwaters downslope towards the sea). With future climate change effects such as more extreme precipitation over the country[1], the current 1% AEP design flood level for Lake Waikare is only likely to increase.

2.10 I consider it important to point out that the Section 42A Report's definition of High Risk Flood Areas (see paragraph 19) means that if included in the planning maps, some areas within the 1% AEP flood extent for Lake Waikare and the Rangiriri Spillway would be excluded from the mapped High Risk Flood Areas, as they would not satisfy the criteria specified in paragraph 19. I consider that some of those areas within the 1% AEP flood extents for Lake Waikare and the Rangiriri Spillway that do not satisfy the criteria for High Risk Flood Areas would still be areas of significant risk. I discuss this further in Section 6 of my evidence.

[1] Ministry for the Environment 2018. *Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from IPCC Fifth Amendment, 2nd Edition.* Wellington: Ministry for the Environment.

2.11 I consider it important that the current 1% AEP design flood extents for Lake Waikare and the Rangiriri Spillway, which are currently known, should be shown on the planning maps. I discuss this further in Section 5 of my evidence.

3. DOCUMENTS REVIEWED

3.1 I have reviewed the following documents, which are relevant to flooding and floodplain management issues affecting the Lower Waikato / Waipa River System.

(a) "Ambury Development Flood Assessment", letter from Tonkin and Taylor Limited to Waikato Regional Council dated 8 June 2020 (T&T, 2020a).

(b) "Lake Waikare Storage Volumes – Final report", letter from Discovery Marine Limited to Environment Waikato dated 11 June 2004 (DML, 2004).

(c) "The Waikato Regional Flood Event of 9-20 July 1998", paper prepared by A J Munro, Flood Duty Officer, Environment Waikato and published in the Australasian Journal of Disaster and Trauma Studies, Volume 1998-2 (Munro, 1998).

(d) "WRC Lower Waikato 2D Modelling: Huntly, Ohinewai and Horotiu Model Build", report prepared by DHI Water and Environment Limited for Waikato Regional Council, 25 February 2020 (DHI, 2020).

(e) "Lower Waikato River Model Review", letter report prepared by Tonkin and Taylor Limited for Waikato Regional Council, 18 May 2020 (T&T, 2020b).

(f) "Lower Waikato Waipa Flood Control Scheme Review, Part A – Hydraulic / Hydrological Evaluation", Waikato Valley Authority Technical Report No. 25, 1983 (WVA, 1983).

(g) "Proposed Waikato District Plan – Evidence for Defended Areas and 1D/2D Mapping used for Flood Plain Management Area", letter prepared by Waikato Regional Council (Rick Liefting) for Janice Carter on behalf of Waikato District Council, 24 March 2021 (Liefting, 2021).

(h) "Hearing 27c: Natural Hazards: Flood Hazards, Appendix 4: Flood Modelling – Evidence of Greg Whyte" (Whyte, 2021).

4. BACKGROUND INFORMATION

4.1 In this section, I explain the importance of Lake Waikare to the operation of the Lower Waikato-Waipa Flood Control Scheme.

Lake Waikare

4.2 Lake Waikare forms an integral component of the Lower Waikato-Waipa Flood Control Scheme which was originally developed in the early 1960's T&T, 2020a). The lake functions as an off-channel storage facility for significant flood events in the Lower Waikato River.

4.3 In 1965, the level of Lake Waikare was lowered. Since then, the lake has been controlled within a range of RL 5.4-5.75 m (Moturiki Vertical Datum 1953) (T&T, 2020a) to provide flood storage for a 1% annual exceedance probability (AEP) flood in the Lower Waikato River. The storage capacity of the lake includes a 600 mm freeboard allowance on top of the assessed 1% AEP design flood level of RL 7.37 m.

4.4 The flood storage function of the lake was achieved by constructing stopbanks to isolate the lake from the Waikato River to the west and the Whangamarino River to the north (T&T, 2020a). The stopbank along the Waikato River is designed to contain a 1% AEP flood in the river with 600 mm freeboard above the design flood level profile for the river. The stopbank along the northern foreshore of the lake is also designed to contain an assessed 1% AEP flood level plus 600 mm freeboard. It was constructed with a crest level of RL 8.0 m above the designated design flood level for the lake.

4.5 The flood storage volume required to be contained in Lake Waikare due to all sources of inflow was assessed to be 77 million cubic metres (WVA, 1983; T&T, 2020a). This was calculated to raise the level of Lake Waikare from an initial starting level of RL 5.65 m up to a level of RL 7.37m, designated as the design flood level for the lake. The actual flood storage volume between these levels has since been estimated to be approximately 82 million cubic metres (DML, 2004).

Lake Inflows and Outflows

4.6 Inflows to Lake Waikare from the Waikato River occur via the Te Onetea Control Gate and the Rangiriri Spillway (T&T, 2020a – refer Attachment 1):

(a) The Te Onetea Stream incorporates a culvert fitted with a control gate to throttle stream flows. The control gate is closed off to prevent

lake outflows to the Waikato River when river levels are lower than lake level. The control is also closed off to prevent Waikato River flow from entering the lake when river levels exceed RL 7 .0 m.

(b) The 1.2 km long Rangiriri Spillway forms part of the right bank stopbank along the Waikato River. The crest of the spillway is also formed by State Highway 1. When river levels exceed the crest level of RL 8.8-9.2 m, flow is diverted from the river into Lake Waikare.

4.7 Natural inflows to Lake Waikare include direct rainfall on the lake surface and inflows from the surrounding catchment (T&T, 2020a):

(a) The surface area of Lake Waikare is approximately 35 km^2 at a level of RL 5.6 m (DML, 2004). This increases to approximately 57 km^2 at the assessed 1% AEP design flood level of RL 7.37 m. Rainfall falling on the lake surface contributes directly to an increase in lake level.

(b) The area of the natural catchment is approximately 210.5 km^2 from NIWA's WRENZ website. A significant proportion of the natural catchment inflow is sourced from the Matahuru Stream which has a catchment area of approximately 106.3 km^2 from the same website.

4.8 Outflows from Lake Waikare occur via the Waikare Northern Outlet Control Gate (Waikare Gate) and the Northern Foreshore Spillway (T&T, 2020a – refer Attachment 1):

(a) The Waikare Gate is a control structure outlet within the Northern Foreshore Stopbank which discharges lake outflows via the Pungarehu Stream into Lake Whangamarino and the Whangamarino Wetland. It is used to control the level of Lake Waikare between RL 5.4 and 5.75 m under non-flood conditions. The control gate is required to be closed during a Waikato River flood event which is defined as being when the river level at the Te Onetea Gate exceeds RL 7.0 m and the river level at the Whangamarino River Outlet exceeds RL 4.0 m.

(b) The Northern Foreshore Spillway is located at the western end of the Northern Foreshore Stopbank on Lake Waikare. The spillway has a crest length of 73 m and the crest level is set at RL 7.36 m (T&T, 2020a). It allows floodwaters stored in Lake Waikare above the assessed 1% AEP design flood level of RL 7.37 m to spill out of the lake across farmland to the north and eventually into the Whangamarino Wetland. The spillway discharge capacity is limited

so that, if flow diversion from the Waikato River over the Rangirri Spillway continued to occur in an extreme flood while the Waikare Gate remained closed, lake levels could continue to rise to a level of RL 8.0 m. At this lake level, the Northern Foreshore Stopbank would be overtopped. There would also be widespread flooding in the Lower Waikato Valley.

Key Lake Levels

4.9 Lake Waikare is normally controlled between levels of RL 5.4-5.75 m (T&T, 2020a).

4.10 The July 1998 sequence of storm events resulted in high inflows from the local catchment including the Matahuru Stream (Munro, 1998). Floodwaters were diverted into the lake from the Waikato River via the Rangiriri Spillway which operated for the first time in 28 years. The lake level increased steadily from RL 5.60 m on 11 July to a peak of RL 6.29 m on 20 July[2].

4.11 The assessed design flood level for Lake Waikare is RL 7.37 m (T&T, 2020a) which coincides approximately with the crest level of the Northern Foreshore Spillway.

4.12 The highest lake level on record is RL 8.38 m which occurred during the February 1958 flood event (Munro, 1998). This occurrence was before the Lower Waikato-Waipa Flood Control Scheme had been constructed.

4.13 Lake levels of RL 6.29 m (July 1998 peak level), RL 7.37 m (assessed 1% AEP design flood level for the lake) and RL 8.00 m (crest level of the Northern Foreshore Stopbank) are shown on the topographic map of Lake Waikare attached as Attachment 2. The map has been produced using LiDAR sourced topographic data obtained in 2010-11 and provided by the Waikato Regional Council.

5. IMPORTANCE OF RL 7.37 M DESIGN FLOOD LEVEL FOR LAKE WAIKARE AND NEED FOR ITS INCLUSION ON PLANNING MAPS

5.1 As noted in paragraph 4.4 above, the required flood storage capacity for Lake Waikare was estimated to be approximately 77 million cubic metres to contain direct rainfall on the lake surface, local catchment runoff into the lake, overflow from the Lower Waikato River and baseflow from local

[2] The July 1998 event in the Waikato River had a peak flow of 1,490 m^3/s at Huntly which was only marginally lower than the estimated peak of the February 1958 flood event (1,540 m^3/s). The peak flood flows in the river between Ngaruawahia and Mercer hovered between a 2% AEP and a 1% AEP (Munro, 1998). In some locations, flood levels were higher than in the February 1958 flood event.

groundwater and tributaries (T&T, 2020a). This was calculated to raise the level of Lake Waikare from an average initial level of RL 5.65 m up to RL 7.37 m, designated as the 1% annual exceedance probability flood level for the lake.

5.2 The 600 mm freeboard allowance on the crest of the northern foreshore containment stopbank provides an additional flood storage buffer of 42 million cubic metres for the lake for events exceeding the 1% annual exceedance probability flood (T&T, 2020a).

5.3 The design flood level of RL 7.37 m for Lake Waikare was last defined in 1983 (WVA, 1983). This level was lower than the design flood level of RL 7.71 m determined in 1959 for the original design of the Lower Waikato-Waipa Flood Control Scheme (WVA, 1959)[3]. It was also much lower than the peak flood level of RL 8.38 m which occurred in the February 1958 flood. I understand that the design flood level has not been reviewed since 1983.

5.4 Storms that give rise to severe floods in the Waikato / Waipa Catchment are generally, but not always, ex-tropical cyclones. The latest climate change projections for New Zealand indicate that ex-tropical cyclones affecting New Zealand are likely to be "stronger and cause more damage as a result of heavy rain and strong winds" (MfE, 2016)[4]. The July 1998 flood event resulted from a series of depressions from the Tasman Sea with active rain bands moving across the country (Munro, 1998) dropping a progressively increasing volume of rainfall over the Waikato / Waipa Catchment (these frontal systems filled up Lake Taupo near the head of the catchment). The latest climate change projections also indicate that "intense rainfall is likely to increase in most areas, except for parts of Northland and Hawke's Bay" with the increases likely to be "small for the remainder of the North Island and larger for the South Island…".

5.5 Based on these projections, I consider it more likely that the 1% AEP design flood level for Lake Waikare will increase when it is revised to take account of the effects of future climate change. I expect that the revised 1% AEP design flood level would lie between the current level of RL 7.37 m and an upper limit of RL 8.00 m (the crest level of the Northern Foreshore Stopbank).

5.6 The RL 7.37 m and RL 8.00 m contour lines around Lake Waikare are marked by the red and green lines respectively on the map in **Attachment 2**. At

[3] Waikato Valley Authority. "Lower Waikato-Waipa Control Scheme", Unpublished Report, 1959.
[4] Ministry for the Environment. Climate Change Projections for New Zealand. Snapshot June 2016, Info 765.

the scale of the map, the green line (RL 8.00 m contour) lies over the top of the red line (RL 7.37 m contour) around much of the lake indicating ground levels are much steeper in these areas. There is a larger area along the southwest side of the lake around Ohinewai (including the recently proposed Ambury Properties Limited (APL) development marked by the red hatched area) and another smaller area along the south-east side of the lake where the land adjacent to the lake is flatter and the RL 7.37 m and RL 8.00 m contour lines are more widely spaced.

5.7 I consider it imperative that the current design flood level for Lake Waikare (RL 7.37 m) is retained as an interim base standard against which the effects of any future development within the local catchment are assessed, pending further review of the design flood level.

5.8 The Section 42A Report states that, while the 1% AEP flood profile (allowing for future climate change effects) has been established for the main channel of the Waikato River "*using a consistent and best practice methodology*", this has not been done for Lake Waikare and the Rangiriri Spillway as this "*is a separate and complex exercise which has not yet been commissioned*" (paragraph 470).

5.9 I consider this to be an indefensible excuse not to include the flood hazard extents for Lake Waikare on the planning maps when there already exists an accepted and quantified 1% AEP design flood level for the Lake (the red contour line in **Attachment 2** to my evidence, at RL 7.37 m), albeit based on a 1983 review (WVA, 1983) without consideration of the effects of future climate change.

5.10 The Section 42A Report comments on the RL 8 m contour line around Lake Waikare (marked as the green line in Attachment 2) and states it is unclear what it actually represents (paragraph 473). The Report further describes the line as "*a 'psuedo level' that corresponds with the stopbank level (scheme design) at the northern end of Lake Waikare, if the lake were to fill up and spill over into the Whangamarino Catchment*". Paragraph 4.4 of my evidence confirms the RL 8.0 m is the crest level of the northern foreshore stopbank on Lake Waikare. However, I disagree with the description of the RL 8.0 m contour line as a "psuedo level".

5.11 When an engineered structure such as a stopbank is designed to contain a flood of specified magnitude (such as a 1% AEP flood), a freeboard allowance is always provided to allow for uncertainty in the estimation of the design flood magnitude (the estimation of flood magnitudes is usually based on the analysis of historical records, of flood discharge. When the length of

historical record is as short is 20-30 years, the uncertainty in the estimate of the 1% AEP is much larger than when the record is much longer). Freeboard also provides a safety buffer against turbulence-induced waves in a river and wind-generated waves in a lake which could overtop a stopbank, causing erosion of the stopbank and leading to a possible failure.

5.12 In the case of the northern foreshore stopbank on Lake Waikare, the design freeboard allowance is 600 mm which, when added to the 1% AEP design flood level of RL 7.37 m, equates in round terms to the design crest level of RL 8.0 m for the northern foreshore stopbank.

5.13 The key design parameter for flood storage in Lake Waikare is the flood inflow volume. As stated in paragraph 4.5 of my evidence, this was estimated to be 77 million cubic metres (WVA, 1983; T&T, 2020a). The design inflow volume was calculated to raise the level of Lake Waikare from an initial level of RL 5.65 m up to a level of RL 7.37 m (designated as the design flood level for the lake).

5.14 The additional flood storage volume available in Lake Waikare between the design flood level (RL 7.37 m) and the crest level of the northern foreshore stopbank (RL 8.0 m) was estimated to be approximately 37 million cubic metres (DML, 2004). At the time of design of the Lower Waikato / Waipa Flood Control Scheme, this additional flood storage capacity would have represented an additional safety buffer to allow for the uncertainty in the estimation of the design flood inflow volume. As Lake Waikare was developed as a managed lake, the additional flood storage capacity would also have represented a safety buffer against a malfunction or mis-operation of the control gate at the Onetea Culvert (refer to **Attachment 1** to my evidence) which is normally shut off to stop inflows into the lake from the Waikato River when the river level exceed RL 7 0 m.

5.15 At the current time, the additional flood storage volume available in Lake Waikare between the design flood level (RL 7.37 m) and the crest level of the northern foreshore stopbank (RL 8.0 m) can also be regarded as a 'partial buffer' for the effects of future climate change. I use the description 'partial buffer' here, as the effects of future climate change on the lake have not yet been estimated and the buffer requirements for uncertainties in the design inflow volume and against a malfunction or mis-operation of the control gate at the Onetea Culvert remain valid.

5.16 The Section 42A Report notes that the RL 8.0 m level was agreed with the developers of the APL development "*who could choose to adopt this level or undertake its own 1% AEP flood modelling including an allowance for climate*

change ahead of the Waikato Regional Council completing its work" (para. 473). I concur with this approach.

5.17 Due to the importance of Lake Waikare as a primary flood storage facility for the Flood Scheme and the likely effects of future climate change projections for New Zealand, the appropriate resource management response to how the PWDP addresses flood hazards in this area generally (including future cumulative effects), needs to be determined. I am not a planning expert but, contrary to the recommendations in the Section 42A Report, it is my view that the PWDP provisions should:

(a) reference the current assessed 1% AEP design flood level of RL 7.37 m for Lake Waikare as an interim measure by appropriately depicting this on the planning maps (as per the submission of the Director General of Conservation (2108.16));

(b) require that the effects, including cumulative effects, of any future developments within the above area (including that area covered by the Ohinewai Structure Plan) on the flood storage capacity of Lake Waikare be considered (as discussed in the evidence of Mr McKenzie);

(c) include a policy response to manage development below the RL 7.37 m contour line around Lake Waikare on **Attachment 2** (red line); and

(d) incorporate some provision for the revised 1% AEP design flood level for Lake Waikare accounting for the effects of future climate change to be incorporated when it becomes available (as per the submission of the Director General of Conservation (2108.16)).

6. SECTION 42A REPORT POLICY RECOMMENDATIONS RELATED TO MANAGEMENT OF FLOOD RISK

6.1 The Section 42A Report defines High Risk Flood Areas as those areas contained within the 1% AEP floodplain where, in a 1% AEP flood event (paragraph 19):

(a) the depth of water exceeds one metre; or

(b) the speed of water exceeds one metre per second; or

(c) the flood depth multiplied by the flood speed exceeds one

6.2 It is important to note that the use of the word 'or' in this definition implies that, if any one of these criteria is satisfied in a floodable area, then that area is deemed to be High Risk.

6.3 The definition in paragraph 6.1 of the Section 42A Report is consistent with the definition given in the Waikato Regional Policy Statement. It also matches part of the flood hazard curve separating the H4 hazard category (unsafe for people and vehicles) and the H5 hazard category (unsafe for vehicles and people; all buildings vulnerable to structural damage; some less robust buildings vulnerable to failure) in **Attachment 3** to my evidence.

6.4 **Attachment 3** is sourced from Book 6 – Flood Hydraulics of the 2019 Australian Federal Government publication "Australian Rainfall and Runoff: A Guide to Flood Estimation", which is widely recognised in Australia and New Zealand as an industry standard guideline publication.

6.5 Policy 15.2.1.1 of the PWDP deals with new development in areas at significant risk from natural hazards and requires avoidance of "*new subdivision, use and development where they will increase the risk to people's safety, well-being and property in the following areas identified as being at significant risk from natural areas*" (paragraph 101 of the Section 42A Report). The policy identifies High Risk Flood Areas as being covered by this requirement.

6.6 The wording of Policy 15.2.1.1 equates significant risk with high risk. This is also stated in paragraph 142 of the Section 42A Report.

6.7 I consider that all High Risk Flood Areas are areas of significant risk, but that there are other floodable areas outside of High Risk Flood Areas which are also of significant risk. This is recognised by the H4 and H3 hazard categories defined in **Attachment 3**. These categories identify combinations of flood depth and flood velocity (speed), which are considered unsafe for people and vehicles and (H4) and unsafe for vehicles, children and the elderly (H3).

6.8 Mercury NZ Limited submitted on Policy 15.2.1.1 and requested that it be amended to split the objective into two parts with one objective for managing areas of significant flood risk and one objective for managing areas of high flood risk (Submission 2053.21). I support this request as I consider it to be:

(a) consistent with the continuum of flood hazard categories defined in **Attachment 3** which cover both life safety risk and building safety risk; and

(b) consistent with the requirement of a risk-based approach to natural flood hazards by Policy 13.2, Implementation Method 13.2.6 of the Waikato Regional Policy Statement that "*regional and district plans shall ensure that:*

(a) subdivision, use and development can only occur in a floodplain with an annual exceedance probability if 1% (where the floodplain does not match the definition of being a High Risk Flood Zone) or in an identified potential costal hazard areas (not being a High Risk Coastal Hazard Area) where:

i) appropriate assessment of the risks has been undertaken and these risks will not exceed acceptable levels."

6.9 Paragraph 143 of the Section 42A Report describes the approach used to develop Policy 15.2.1.12 Reduce Potential for Flood Damage as being a risk-based approach as it distinguishes between intolerable risk and significant risk, the latter being equated to high risk. Paragraph 144 further states that floodable areas within the 1% AEP floodplain falling outside those areas which meet the test for a High Flood Risk Area are areas of tolerable risk.

6.10 I disagree with this approach as it fails to recognise the continuum of hazard categories shown in Attachment 3. Policies 15.2.1.1 and 15.2.1.12 as they are currently drafted would imply that the hazard categories H4 and H3 are 'tolerable'. I do not consider hazard categories H4 and H3 to be tolerable as their definitions clearly imply a life safety risk to people.

6.11 I agree with paragraph 144 of the Section 42A Report where it states that all High Risk Flood Areas, are areas of significant risk, and also intolerable risk without mitigation. However, this does nothing to help with a risk-based approach when considering areas within a 1% AEP flood extent that do not meet any of the criteria for being classified as High Risk Flood Areas. As discussed in paragraphs 6.9 and 6.10 above, I consider the treatment of these non-High Risk Flood Areas within a 1% AEP flood extent as being areas of tolerable risk is incorrect as it is inconsistent with the hazard categories defined in **Attachment 3**. My conclusion is that the Section 42A Report has failed to recognise the risk management based points made in Mercury NZ Limited's submission.

7. CONCLUSIONS

7.1 Lake Waikare and the surrounding catchment below RL 8 m is an integral component of the Lower Waikato-Waipa Flood Control Scheme and provides

off-channel flood storage capacity for significant floods in the Lower Waikato River. (RL 8.0 m is the crest level of the Northern Foreshore Stopbank.)

7.2 The current assessed 1% AEP design flood level for Lake Waikare is RL 7.37 m. The RL 7.37 m contour is marked on the topographic map attached as Attachment 2 along with the RL 8.00 m contour.

7.3 The PWDP needs to:

(a) reference the current assessed 1% AEP design flood level of RL 7.37 m for Lake Waikare;

(b) require that the effects, including cumulative effects, of development on the flood storage capacity of Lake Waikare be considered;

(c) require a policy response to manage development below the RL 7.37 m line around Lake Waikare on Attachment 2; and

(d) incorporate a provision for the revised 1% AEP design flood level for Lake Waikare to be referenced when it becomes available.

7.4 I consider Policies 15.2.1.1 and 15.2.1.12 in the PWDP should be amended to recognise the continuum of flood hazards defined in my **Attachment 3** and cover floodable areas within 1% AEP flood extents that do meet any of the criteria for High Risk Flood Areas.

Murray Grant Webby
16 April 2021

Attachment 1: Lower Waikato – Waipa Flood Control Scheme at Lake Waikare (sourced from T&T, 2020)

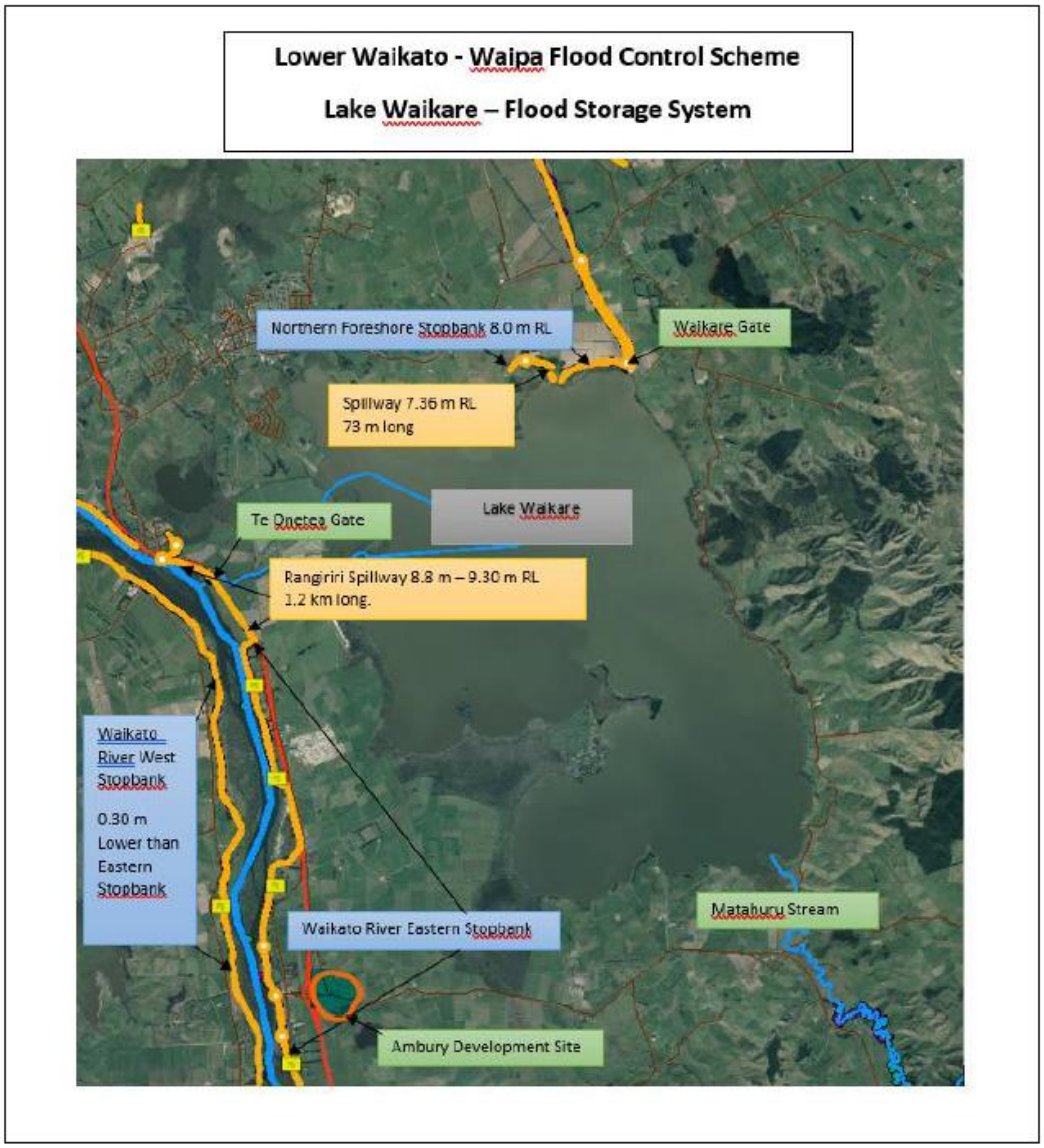

Figure 2.2: Lower Waikato – Waipa Flood Control Scheme at Lake Waikare (source: WRC 2020)

Attachment 2: Topographical Map of Land Around Perimeter of Lake Waikare showing lake levels of

- **RL 6.29 m (July 1998 peak level),**
- **RL 7.37 m (assessed 1% AEP design flood level for the lake)**
- **RL 8.00 m (crest level of the Northern Foreshore Stopbank on Lake Waikare)**

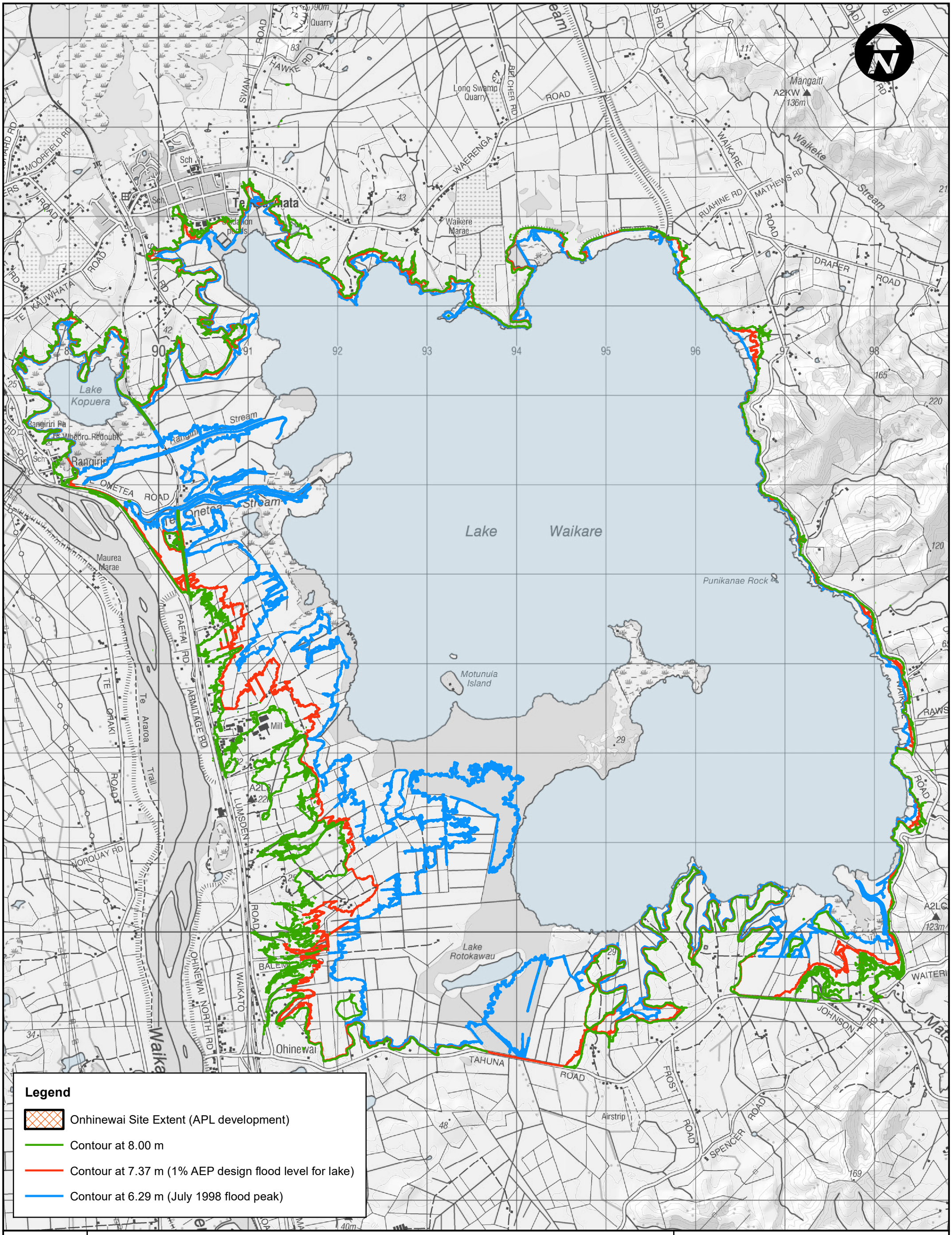

FIGURE 1 — **Topographic Plan of Land Around Perimeter of Lake Waikare**

DAMWATCH ENGINEERING BEYOND THE SURFACE

NOTES:

1. Background mapping (Topo50 and Ohinewai land parcel boundary) sourced from Land Information New Zealand (LINZ) and licensed by LINZ for re-use under the Creative Commons Attribution 4.0 New Zealand licence: *https://creativecommons.org/licenses/by/4.0/*

2. Contour lines sourced from 2010-2011 LiDAR survey data flown by NZ Aerial Mapping, provided by Waikato Regional Council and licensed by LINZ for re-use under the Creative Commons Attribution 4.0 New Zealand licence.

DATE:	15/04/2021
PREPARED BY:	BV
CHECKED BY:	GW
APPROVED BY:	SM
REVISION NUMBER:	02
REFERENCE:	E2042

SCALE:

REFER SCALE BAR

0 500 1,000 1,500 2,000 2,500 Meters

Attachment 3: Figure 6.7.9 from Book 6 – Flood Hydraulics

of 2019 Australian Federal Government publication

"Australian Rainfall and Runoff: A Guide to Flood Estimation"

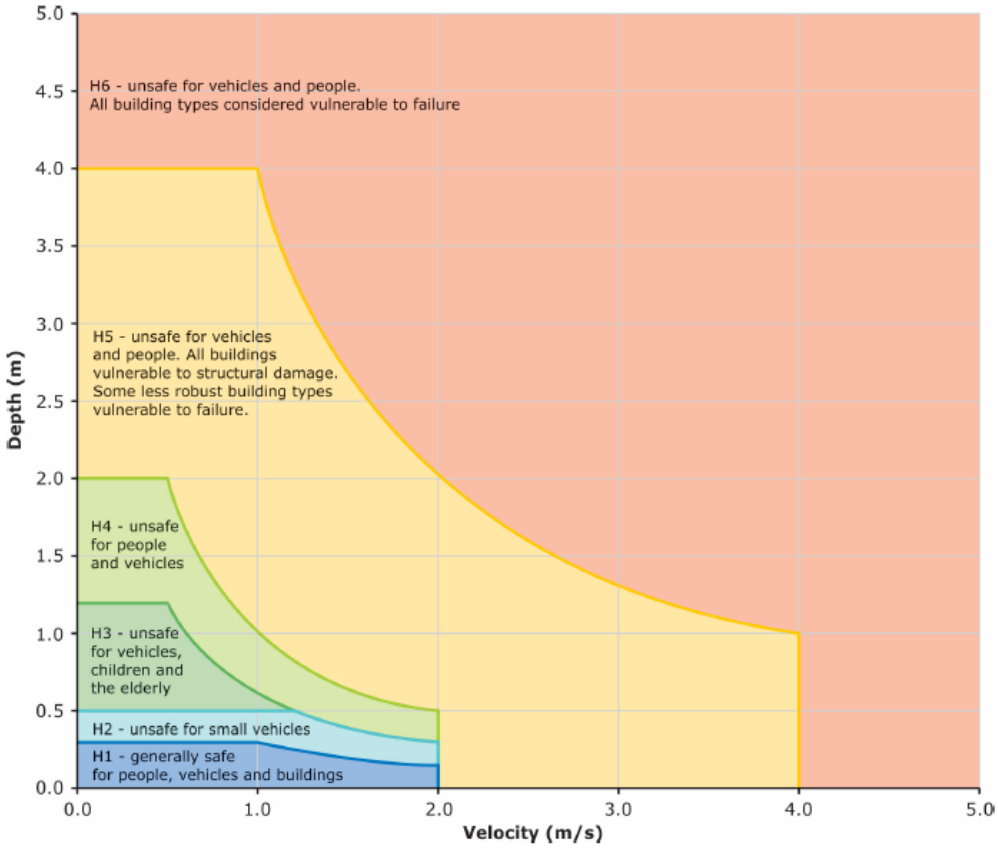

Figure 6.7.9. Combined Flood Hazard Curves (Smith et al., 2014)