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OCEANA GOLD (NEW ZEALAND) LIMITED
WAIHI OPERATION, NEW ZEALAND
STORAGE 3 - TAILING STORAGE FACILITY - RL155
DAM BREACH AND POTENTIAL IMPACT CLASSIFICATION ASSESSMENT

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EXECUTIVE SUMMARY

1. The purposes of this dam breach assessment are to:

    a. Assess consequences of a hypothetical breach of the Storage 3 TSF to determine the Potential Impact Classification (PIC). The PIC sets the standards for design, construction, and operation of the dam. Dams with higher potential impacts are designed to be resilient to extreme load conditions associated with natural hazards or unlikely scenarios which may occur in operation.
    b. Develop maps for the Emergency Action Plan (EAP). The maps are used for planning and managing the unlikely event of a breach.

2. Tailings Storage Facility (TSF) - Storage 3 RL155 will be designed, constructed and operated in accordance with modern standards which are set out in the New Zealand Dam Safety Guidelines (NZDSG). OGNZL is also committed to the recommendations in the recently published Global Industry Standard for Tailing Management (GISTM). Dams that are designed and operated to these standards have a low and acceptable risk of potential failure, and a breach would be highly unlikely to occur.

3. Under the NZDSG there are three Potential Impact Categories (PIC), Low, Medium, and High PIC. Tailings Storage Facility (TSF) - Storage 3 RL155 has been assessed to have a **HIGH Potential Impact Classification (PIC)**. The PIC is based on assessing the incremental consequences of a **hypothetical** breach of a dam under normal (i.e., sunny day) and rainy day conditions. For Storage 3 RL155 the rainy day condition is the more critical case for the assessment of PIC because a breach under normal sunny day conditions would be largely confined to within the Ohinemuri River channel. The PIC for the rainy day condition is based on the scenario which causes the maximum incremental consequences on top of flood conditions in the receiving rivers and streams. For Storage 3 the receiving watercourse is the Ohinemuri River and its tributaries. Four baseline flood events (1 in 100 year, 1 in 1,000 year, 1 in 10,000 year, and Probable Maximum Flood) were considered to assess which flood scenario has the maximum incremental consequence. A breach of Storage 3 associated with a 1 in 1,000 year return period flood into the Ohinemuri River was found to give the maximum incremental consequences and the associated inundation maps are provided to show the basis of assessment for the PIC.

4. The modelled 1 in 1,000 year flood was found to result in near full stopbank flows in the Ohinemuri River passing Paeroa. The additional flow from the modelled dam breach causes the stopbanks to overtop in Paeroa. The risk of a breach into Paeroa is extremely low as a 1 in 1,000 year flood is unlikely and a breach of the TSFs is highly unlikely. If a flood higher than a 1 in 1,000 year flow occurred then the areas behind the stopbanks would be at risk from overtopping, even without a dam breach. In a 1 in 100 year flood the modelling shows no overtopping of the stopbanks in Paeroa occurs with a dam breach. Maps with the rainy day breach with a 1 in 100 year flood are also provided along with the 1 in 1,000 year maps for emergency planning purposes.

5. The modelling undertaken for this dam breach assessment uses source data and assumptions that will have differences from modelling by others that may have been undertaken for the management of the flood hazard in the area. Any comparison of maps must consider the differences. The purposes of the Storage 3 dam breach assessment are specific for the assessment of PIC and emergency action planning. This is different to the purposes of flood hazard modelling. Specifically, the dam breach assessment uses Lidar ground level information which may differ from actual levels of the ground and stopbanks. This means that in an actual stopbank full scenario in Paeroa, the overtopping locations may differ from those shown on dam breach maps and these should not be relied on for any other purpose other than assessing the dam's PIC and developing an EAP. It is normal to review and update the PIC of a dam, including revising inundation maps to account for new information, every five years or whenever modifications to dams or their operational procedures could result in any change to downstream consequences of a potential dam failure.

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Terminology Abbreviations

AADT	Annual Average Daily Traffic
AEP	Annual Exceedance Probability
CDA	Canadian Dam Association
CPT	Cone Penetration Test
DOC	Department of Conservation
DV	Severity of the Flood Flow Which is the Product of Flood Depth and Velocity
EAP	Emergency Action Plan
FEMA	Federal Emergency Management Agency
GISTM	Global Industry Standard on Tailings Management
IDF	Inflow Design Flood
NIWA	National Institute of Water and Atmospheric Research
NZDSG	New Zealand Dam Safety Guidelines
PAR	Population at Risk
PIC	Potential Impact Classification
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SCPT	Seismic Cone Penetration Test
SDMT	Seismic Dilatometer Test
TDBA	Tailings Dam Breach Analyses
TSF	Tailings Storage Facility

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23 January 2025

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WAIHI OPERATION
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DAM BREACH AND POTENTIAL IMPACT CLASSIFICATION ASSESSMENT

1.0 INTRODUCTION

The tailings at the Waihi Operation are currently stored in two Tailings Storage Facilities (TSFs) known as Storage 1A and Storage 2. Oceana Gold (New Zealand) Limited (OGNZL) proposes to construct another TSF, Storage 3, with the embankment crest at RL155 (in Mine Datum minus 1000 m). Storage 3 is to be formed by a zoned downstream embankment that is constructed predominantly from mine overburden material that is excavated as part of the process of obtaining ore from the Gladstone and Martha Open Pits. The embankment forming Storage 3 is generally referred to as a tailings dam. Engineering Geology Limited (EGL) has been engaged by OGNZL to undertake a dam breach assessment for Storage 3 with the embankment crest at RL155. This report presents the results of the dam breach assessment and an assessment of the Potential Impact Classification (PIC) of Storage 3 in accordance with the most recent version of the New Zealand Dam Safety Guidelines (NZDSG) published in 2024 (Ref. 1).

The purpose of this dam breach study is to determine the PIC of the proposed Storage 3 dam and to provide maps showing likely areas of inundation to be included in the Emergency Action Plan (EAP) required by the NZDSG for emergency response planning purposes. There are three possible PIC categories in the NZDSG (Low, Medium, or High). Dam design criteria as well as construction and operational requirements are dependent on the PIC.

The hypothetical dam breach scenarios assessed in a dam breach study are not scenarios that are expected to occur and no assessment of probability of occurrence is undertaken for the hypothetical failure modes assumed in this study. Storage 3 RL155 will be designed, constructed and operated in accordance with modern standards which are set out in the New Zealand Dam Safety Guidelines (NZDSG). OGNZL is also committed to the recommendations in the recently published Global Industry Standard for Tailing Management (GISTM). Dams that are designed and operated to these standards have a low and acceptable risk of potential failure, and a breach would be highly unlikely to occur.

1.1. Dam Breach Guidance

The methodology used in this dam breach assessment is in accordance with the NZDSG (Ref. 1) and adopts the recommendations in the Canadian Dam Association (CDA) draft Technical Bulletin on Tailings Dam Breach Analyses (TDBA) published in 2020 (Ref. 2). The dam breach assessment and its results are also required to meet requirements 2.3 and 2.4 of the Global Industry Standard on Tailings Management (GISTM, Ref. 3) that was published in August 2020.

The NZDSG (Ref. 1) identifies three levels of assessment for undertaking dam break assessments (initial, intermediate, and comprehensive). A comprehensive assessment is typically required for dams that have high failure consequences which is the case for Storage 3. A comprehensive tailings dam breach study usually requires the identification and consideration of potential failure modes, assessment of tailings characteristics, estimation of outflow volume, dam breach flood routing, mapping of the extent of flood inundation and evaluation of the peak flood depth, flow velocity, time of flood arrival, time of flood peak, and inundation duration at key locations.

The CDA Technical Bulletin on TDBA (Ref. 2) is a guidance document prepared by the CDA for tailings dam breach analyses. It is considered to represent the current best practice and is a referenced document in the GISTM.

The GISTM was published in August 2020 (Ref. 3). It provides a framework for safe TSF management while affording operators flexibility as to how best to achieve this goal. Requirements 2.3 and 2.4 in the GISTM cover dam breach analyses. A comprehensive dam breach analysis undertaken in accordance with the NZDSG (Ref. 1) and the CDA Technical Bulletin on TDBA (Ref. 2) will satisfy the GISTM requirements.

1.2. Limitations

The modelling undertaken for this dam breach assessment uses source data and assumptions that will have differences from modelling undertaken for the management of the flood hazard in the area. Any comparison of maps must consider the differences. The purposes of the Storage 3 dam breach assessment are specific for the assessment of PIC and emergency action planning. This is different to the purposes of flood hazard modelling. Specifically, the dam breach assessment uses Lidar ground level information which may differ from actual levels of the ground and stopbanks. This means that in an actual stopbank full scenario in Paeroa, the actual overtopping locations may differ from those shown on dam breach maps and these should not be relied on for any other purpose other than assessing the dams PIC and developing an EAP. It is normal to review and update the PIC of a dam, including revising inundation maps to account for new information, every five years or whenever modifications to dams or their operational procedures could result in change to downstream consequences of a potential dam failure.

1.3. Report Updates

The assessment and findings provided in this report were completed early in the Waihi North Project application development process in 2021/2022. Despite the time that has elapsed since their completion, the assessment and findings remain applicable to the Waihi North Project being applied for under the Fast-track Approvals Act 2024. The geometric parameters of the dam breach remain the same and applicable. Only minor update to the PIC assessment tables to align with the 2024 version of the New Zealand Dam Safety Guidelines has been made.

2.0 WAIHI TAILINGS STORAGE FACILITIES

At the Waihi Operation, there are two existing TSFs, Storage 1A and Storage 2. As part of the Life of Mine, Storage 1A is proposed to be raised to RL182, and Storage 2 to RL160.7. Both TSFs are downstream construction, except for the proposed 4.7 m centreline construction raise on Storage 2. As of June, 2021, Storage 1A has a minimum crest level of RL173.6 and Storage 2 has a minimum crest level of RL156.4.

The location of Storage 3 relative to other site facilities is shown in Figure 1. A site plan of Storage 1A, Storage 2, and Storage 3 is shown in Figure 2. A breach of Storage 3 could result in discharges of tailings and water into the downstream area. The receiving catchment is the Ohinemuri River and its tributaries (including the Ruahorehore Stream). The Ohinemuri River flows along the southern side of Waihi township and along State Highway 2 (SH2) to the west through the Karangahake Gorge, past Paeroa township and into the Waihou River which flows into the Firth of Thames.

3.0 OBJECTIVES AND SCOPE

The results from the dam breach assessments are used to assess the consequences of dam breach events, including the Population at Risk (PAR), Potential Loss of Life, and damage to the infrastructure, environment, and community. They are the basis for assessing the PIC which sets:

1) the dam design criteria.
2) requirements for construction and operation; and
3) dam safety management including emergency planning.

Storage 3 is in a rural area, approximately 3.0 km southeast of Waihi township. The area downstream of Storage 3 comprises rural, residential, recreational, and commercial land, e.g. the Waihi and Paeroa townships and the Karangahake Gorge Historical Walkway. Therefore, the assessment requires a level of detail that is appropriate to determine which assets and stakeholders could be impacted by a breach. Detailed and quantitative TDBAs are required for the Waihi Operation site.

4.0 INFORMATION REQUIREMENTS

Information that is required for a comprehensive dam breach assessment for Storage 3 includes:

- Identification of downstream receptors, including population, infrastructure at risk, environmental and cultural values.
- Latest survey and design information for Storage 3 and the adjacent Storage 1A and Storage 2.
- Water balance modelling and water management requirements to estimate the future stored water volumes in Storage 3.
- Hydrologic information on the catchments of Storage 3 and the Ohinemuri River and its tributaries.
- Information on the tailings properties.
- Liquefaction assessments of the tailings.
- Lidar survey of the project site and the area along the dam breach flow path.

5.0 POTENTIAL FAILURE MODES AND DAM FAILURE SCENARIOS

A potential failure mode is a hypothetical failure mechanism which is developed considering the physical characteristics of the dam structure and its foundation, subsurface drainage conditions, surface water management, operation, maintenance, and surveillance. Potential failure modes can and do vary during the lifecycle of the TSF. A TSF that is appropriately designed and operated considers all potential failure modes and includes measures in design, construction, operation and closure which provide resilience and robustness against each, meaning that failure is highly unlikely. Different failure modes each have different scenarios which lead to failure and different scenarios that may occur during breach.

The term 'potential failure mode' is not associated with a probability of this event occurring and having potential failure modes is not a reflection of facility safety deficiency (Ref. 3).

The potential failure modes and their effects will be considered in the detailed design of proposed Storage 3. A Failure Modes and Effects Analysis (FMEA) for Storage 1A and Storage 2 to their current consented crest heights was conducted at the OGNZL office at Waihi on 15 August 2018 (Ref. 4). The proposed Storage 3 is of similar design as the existing Storage 1A and Storage 2 (i.e., downstream construction). The potential failure modes identified in the FMEA for the existing Storage 1A and Storage 2 are like those associated with the proposed raised Storage 3 and have been adopted in the TDBAs.

In the TDBAs, the failure scenarios are selected based on potential failure modes. The failure modes in conjunction with applicable hydrologic conditions in the receiving watercourse constitute the dam failure scenarios selected for a TDBA. For Storage 3, two failure scenarios were considered, each with different initial hydrologic conditions:

- **Sunny Day breach scenario** – This Sunny Day scenario assumes a sudden dam failure occurring during normal hydrologic conditions in the receiving watercourse (i.e., not due to a storm event). There is no triggering storm or flood event and potentially no advanced warning of failure to the downstream areas. The breach scenario is assumed to develop during normal operations from either collapse or overtopping failure modes due to instability of the embankment triggered by strong earthquake shaking, elevated pore pressures in the embankment fill, internal erosion, and/or foundation instability.

- **Rainy Day breach scenario –** This Rainy Day scenario assumes a failure that is triggered by extreme rainfall with a dam breach initiated by overtopping. The downstream incremental impacts are analysed for a range of flood events by comparing the consequences with and without failure of the dam.

For the purposes of this study a breach of Storage 3 is assumed to result in the release of both tailings and water. Some tailings are eroded and entrained within the water and flow downstream and some are deposited close to the TSF as a mud type flow.

6.0 POTENTIAL CASCADE FAILURE SCENARIOS

Potential cascade failures of dams are commonly considered where dams are in sequence down a watercourse. This is because the failure of one dam can cause extreme loading on the next dam and result in both failing. This can increase the potential damage assessment and result in a higher PIC to be selected for design and greater areas of potential inundation for emergency planning. A breach of Storage 1A into Storage 3 is a potential failure mode, however, the Rainy Day scenario selected already considers a highly improbable scenario of a crest full impoundment volume within Storage 3 (i.e., a volume well above the PMP 72 hour volume) and applies this breach flow at the worst time during peak flood flow in the Ohinemuri River. The assumptions made in the Rainy Day scenario already consider an extreme case. In detailed design further assessment and management of potential cascade failures is recommended. This could involve scenarios where Storage 3 could contain the volume of water released from Storage 1A and situations where emergency spillways are excavated to control outflows from Storage 1A and 3 together.

7.0 TAILINGS CHARACTERISATION

In-situ tests, including Cone Penetration Tests (CPTs), Seismic Cone Penetration Tests (SCPTs) and Seismic Dilatometer Tests (SDMTs) have been undertaken on the tailings in Storage 2. The results indicate that the tailings have contractive behaviour (Ref. 5). Tailings stored in Storage 3 are expected to have similar characteristics. Consequently, the tailings are assumed to be liquefiable in the TDBAs.

The runout analysis of the tailings slurry is based on the residual strength inferred from in-situ tests and empirical models considering a continuum approach reported in the literature, such as Lucia et al. (1981, Ref. 6) and Olson and Stark (2002, 2003, Refs. 7 & 8).

8.0 HYDROLOGIC ANALYSIS

Two different events have been considered for a breach of Storage 3. They are Sunny Day and Rainy Day breach scenarios.

In a Sunny Day breach scenario, the supernatant decant pond water is assumed to be at a normal operational level. A volume of 0.240 Mm^3 is adopted as the normal decant pond water volume.

Unlike water storage dams, passing a flood through an active TSF during operation is not a common practice due to the requirement to manage, reuse or treat supernatant water on top of the tailings. Direct rainfall and runoff from the catchments above the TSFs will be fully stored. Water collected on the TSFs at the Waihi Operation is pumped to the Processing Plant or to the Water Treatment Plant for treatment before being discharged into the Ohinemuri River, until the impounded water reaches an acceptable quality to be discharged without treatment. The Waihi TSFs do not have permanent spillways that allow direct discharges to natural watercourses until closure. However, designs and defined emergency spillway locations for controlled release of water are included in the EAP. The inflow design flood (IDF) for the Waihi TSFs is the runoff arising from a Probable Maximum Precipitation (PMP) storm event. This is generally viewed as the Probable Maximum Flood (PMF). It is the theoretical maximum flood that could plausibly occur at a particular time of year in a design watershed (WMO, 2009, Ref. 10). The TSFs are designed to contain the runoff from a 72hr-PMP (i.e., PMF) with 1 m freeboard. The Rainy Day breach scenario further assumes that water has filled up the 1m freeboard as well and is at the dam crest level, i.e., a water volume of 1.2 Mm^3. This crest full water level is assumed to occur when the TSF is at its maximum height and the tailings are at their maximum level.

The NZDSG (Ref. 1) requires that reservoir inflows and levels, and downstream watercourse flows, should be those most likely to occur coincident with an assumed potential dam failure mode. For the Rainy Day PMP event at Storage 3, the concurrent downstream river flows across the catchment can easily vary. As it is the incremental change in effects which determines PIC, sensitivity analyses have been undertaken for downstream watercourse flows with different return period intervals, including 1 in 100, 1 in 1,000, and 1 in 10,000 Annual Exceedance Probabilities (AEPs), and for the PMF. The 1 in 1,000 scenario resulting in the greatest incremental effect from a dam was adopted for PIC assessment. This approach is consistent with the methodology in the CDA Technical Bulletin (Ref. 2).

9.0 TAILINGS DAM BREACH ASSESSMENT CASES

The CDA Technical Bulletin (Ref. 2) recommends that there are two main factors that are expected to have an important impact on the character and volume of the outflow from a TSF during a breach event:

- The presence of fluids on the surface of the impoundment near the dam; and
- The potential of liquefaction induced flowability of the tailings material, which may be due to various trigger mechanisms, including the breach itself.

CDA Technical Bulletin (Ref. 2) uses these factors to define four types of tailings dam breaches. It is assumed that the tailings are liquefiable in Storage 3 and that there will be supernatant water present during operation and post closure. Therefore, it is assumed for this study that a breach of Storage 3 will result in release and flow of fluids and eroded and liquefied flowable tailings. On this basis, Storage 3 is classified as a Case 1A type of breach according to the CDA Technical Bulletin (Ref. 2). This case is characterised further in Section 10.0.

10.0 BREACH ANALYSIS

10.1. Physical Processes for Tailings Dam Breaches

For Case 1A defined by the CDA Technical Bulletin (Ref. 2), a breach can be assumed to consist of two processes:

- **Process I**: discharge of supernatant pond water eroding part of the dam, and carrying eroded tailings and dam fill materials entrained in the water flow, and
- **Process II**: the tailings mass undergoing flow liquefaction resulting in a discharge of liquefied tailings, including part of the failed section of the embankment, together as a mud.

10.2. Type of Breach Outflows

The breach outflow from Process I results in a water flood wave that includes entrained tailings that can propagate far downstream causing erosion and inundation of the downstream environment. Process I is modelled as a water breach using the HEC-RAS software (Refs. 11 & 12).

In Process II, the liquefied tailings create a mud flood, which is less fluid compared to flows discharging during Process I. The tailings consequently deposit closer to the breach location when the slope of the downstream surface is less than 4 degrees. In this dam breach assessment, the extent of deposition associated with Process II is estimated using 3D volumetric modelling as the downstream slope is less than 4 degrees.

10.3. Dam Breach Locations

Assessment of various dam breach locations for Storage 3 has been undertaken. The location that causes highest consequence was used in the detailed breach analysis. This location is shown in Figure 2 and was determined from review of different breach locations.

10.4. Volume of Breach Outflow

Discharge of the supernatant pond water in a breach event would mobilise tailings through erosion (i.e., the tailings would be entrained). For the Sunny Day scenario the outflow volume associated with Process I is assumed to be 0.480 Mm^3. This includes 0.240 Mm^3 of supernatant pond water and 0.240 Mm^3 of eroded and entrained tailings. A volume of 0.937 Mm^3 of tails and embankment is assumed to be deposited as part of Process II. For the Rainy Day scenario the outflow volume from Process I is 1.976 Mm^3. This includes 0.786 Mm^3 of supernatant pond water and 1.194 Mm^3 of eroded and entrained tailings. A volume of 0.391 Mm^3 of tails and embankment is assumed to be deposited as part of Process II. The assumed volumes released in Sunny Day and Rainy Day breach scenarios are summarised in Table 1.

10.5. Breach Modelling

10.5.1. Breach Parameters

Several models for estimating the ultimate breach dimensions (width, side slopes, volume eroded, etc.), as well as the breach formation time, have been developed (Refs. 2 & 12). They are empirical models derived from breaches of water storage embankments, which are either homogeneous or zoned earthfill, or rockfill dams. Ideally, models developed from tailings dams that are representative of the embankments at the Waihi Operation Site would be preferred. However, there are no comparative models available that simulate the formation of the breach of tailings dams. Therefore, the models used for water storage dams to estimate the breach dimensions and formation times have been used. This is considered acceptable by the CDA Technical Bulletin (Ref. 2). The different models give different estimates, which have been used to model a range of possibilities.

Five models have been used to estimate breach parameters. They are:

- Froehlich (1995) – Ref. 13
- Froehlich (2008) – Ref. 14
- MacDonald and Langridge-Monopolis (1984) – Ref. 15
- Von Thun and Gillette (1990) – Ref. 16
- Xu and Zhang (2009) – Ref. 17.

The breach parameters leading to the worst case scenario, i.e., that give greatest maximum flood depth and shortest time of arrival, are adopted for this assessment of the breach consequences.

10.5.2. Breach Outflow Hydrograph

10.5.2.1. Sunny Day Breach Scenario

The Sunny Day breach scenario is assumed to be a collapse type failure caused by instability associated with weak embankment foundations under strong earthquake shaking. Breach parameters were determined by using the regression models in Section 10.5.1 and are summarised in Table 2. The volume of released material in Process I was estimated to be the total volume of supernatant water (i.e., 0.24 Mm^3) and an equal volume of eroded tailings (i.e., 0.24 Mm^3). The breach bottom elevation on the upstream face of the embankment for TDBA Process I, was taken to be the same as the Process II breach geometry shown in Figure B1. An elevation-storage relationship was derived to represent the volume change from the breach bottom elevation to the normal operation decant level. It is shown in Figure 3. The dam breach outflow hydrographs were derived by using HEC-RAS.

10.5.2.2. Rainy Day Breach Scenario

For the Rainy Day breach scenario, the potential failure mode is assumed to be overtopping and progressive erosion. The dam breach outflow hydrograph is governed by the erodibility of the dam. Breach parameters were determined by using the regression models in Section 10.5.1 and are summarised in Table 3. Only the Von Thun and Gillete (Ref. 16) and Xu and Zhang (Ref. 17) regressions were considered, as these two regression models account for the effects of embankment erodibility. The volume of release material in Process I was estimated to be the total volume of supernatant water (i.e., 1.194 Mm^3) and eroded tailings for Process I (i.e., 0.786 Mm^3). The breach bottom elevation on the upstream face of the embankment for TDBA Process I, was taken to be the same as the Process II breach geometry shown in Figure B1. The elevation-storage relationship for the cone of depression shown in Figure 3 was adopted to represent the volume change from the breach bottom elevation to the crest level of the embankment. The dam breach outflow hydrographs were derived by using HEC-RAS.

10.5.2.3. Adopted Outflow Hydrograph

A suite of breach outflow hydrographs for the Sunny Day and Rainy Day breach scenarios are shown in Figures 4 and 5, respectively. The maximum breach outflows are associated with the model of Von Thun and Gillete (Ref. 16) for both of the Sunny Day and Rainy Day conditions. The maximum associated outflow hydrographs have been used in the runout analysis to assess the extent of inundation.

11.0 RUNOUT ANALYSIS

A two-phase approach was adopted in the TDBAs of Storage 3 for the runout analysis. The runout analysis of Process I water flood including entrained tailings was modelled as a water breach and the runout analysis of Process II of deposited materials was estimated using 3D volumetric modelling. The analyses are discussed in the following sections.

11.1. Process I

11.1.1. Flood Routing Tool

The downstream inundation due to the TDBA Process I was modelled by the computer program HEC-RAS 2D (Ref. 11). This 2D flood modelling program was developed to model the hydraulics of water and debris/mudflow over alluvial fans, in channels and flood plains. The model uses the full dynamic wave momentum equation and a central finite difference routing scheme to predict the flood wave over a computational domain. In the runout analysis, the slurry from TDBA Process I was analysed as water, i.e., Newtonian flow.

11.1.2. Terrain Model

The terrain model used for flood routing was developed using the 2007/2008 0.5m contours (Ref. 30) developed from LiDAR survey.

11.1.3. Downstream Flood Extent

The CDA Technical Bulletin on TDBAs recommends that the downstream flood routing should extend to the point where the incremental effects of a failure would no longer represent a threat to life, properties and the environment, or where sufficient warning time would exist. The Federal Emergency Management Agency (FEMA, Ref. 18) recommends that the dam breach flood routing for the Rainy Day breach scenario needs to be modelled as far downstream as required for the incremental increase in depth to be within 0.3 m to 0.6 m, or the distance travelled by the peak of the flood wave in 24 hours. Similarly, for fair weather scenarios, FEMA (Ref. 18) recommends the study extends until the flows decrease to be within the river channel (i.e., a bank full flood), or until a large water body such as a lake, reservoir, or an ocean is intercepted.

For Storage 3 the flood routing model was terminated immediately upstream of the confluence of the Ohinemuri River and Waihou River. The Sunny Day breach flow is fully attenuated before reaching the boundary of the model. The Rainy Day breach flow incremental depth is less than 0.6 m at the confluence of the Ohinemuri River and the Waihou River. The incremental increase in depth is considered sufficiently low to set this point as the model boundary based on the recommendations in FEMA (Ref. 18).

11.1.4. Roughness Coefficients

The roughness coefficient of the flow path was assumed to be a Manning's n value of 0.04. This was selected according to the recommendations in the HEC-RAS manuals (Refs. 11 & 12). The Manning's n value considers base surface roughness, obstructions, irregularities, channel alignment, vegetation, and distance to the breach location.

11.1.5. Natural Flows

No baseflow was modelled in the Sunny Day breach scenario. This is because the dam breach flow is more than two times greater than the mean annual flow in the downstream watercourse, and thus the baseflows in the downstream watercourse can be ignored according to FEMA (Ref. 18).

The Rainy Day breach scenario assumes a breach of the embankment occurs during a flood event. The natural flows from watersheds for downstream watercourses that are tributaries of the Ohinemuri River were modelled as multiple sources of inflows, i.e., Sources 1 to 16 as shown in Figure A1 in Appendix A. The inflow hydrographs of the natural flows are summarised in Figure A2 in Appendix A. The temporal pattern from Tomlinson and Thompson (1992, Ref. 19) for short duration rainfall events was considered in the routing of natural flows. The model was calibrated against the Flood Frequency Tool (Ref. 20) of National Institute of Water and Atmospheric Research (NIWA), which provides a comprehensive assessment of flood hazard across New Zealand rivers and streams. The peak natural flows of downstream watercourses from the modelling are consistent with the best estimates as given in the NIWA's Flood Frequency Tool.

Analyses were undertaken to determine the incremental consequences of a dam breach with different downstream watercourse flood flows i.e., 1 in 100, 1 in 1,000, 1 in 10,000 AEPs, and the PMF. The greatest incremental consequences were with the 1 in 1,000 AEP flood event. This was adopted as the Rainy Day breach scenario for the PIC assessment. Flood inundation map for the 1 in 1,000 AEP flood event has been prepared for the assessment of incremental effects (refer to Figure A1 in Appendix A).

11.2. Process II

11.2.1. Volume Balance Analysis

The volume of tailings and embankment materials eroded and deposited immediately downstream of the Storage 3 embankment in Process II depends on the breach elevation, the profile of the displaced tailings and the topography of the ground downstream of the breach. The volume of deposited materials immediately downstream of the TSF embankment was estimated by comparing the volume balance according to the equation below:

$$V_{T\_MOB} + V_{EMB} = V_{DEP} + V_{T\_EROD}$$

where:

- V_{T_MOB} is the volume of mobilised tailings, which is the sum of eroded tailings in Process I water flood and the liquefied tailings in the Process II mud flood;
- V_{EMB} is the embankment fill eroded;
- V_{T_EROD} is the volume of eroded tailings in Process I as calculated in Section 10.4; and
- V_{DEP} is the volume of materials deposited downstream.

The deposition maps for Process II are determined using 3D volumetric modelling with the assumed angle of repose and dam breach parameters as discussed below.

11.2.2. Angle of Repose for Deposited Tailings Materials

Historic breaches of TSFs indicate that only a portion of the tailings is released. This is attributed to the fact that unlike water, tailings have shear strength. The released tailings will usually come to rest at an angle which is dependent on the residual strength of the tailings. In addition, observations indicate that the slope of the tailings remaining within the TSF is much steeper than the angle of repose of the breached tailings (Ref. 21).

Released saturated tailings have been documented to come to rest at slopes of between 1º to 4º (1V:57H to 1V:14H) measured from the toe of the mobilised tailings back into the impoundment (Refs. 6 & 22). These slope angles depend on the residual shear strength of the tailings after mobilisation and the topography of the downstream area of the dam. Most of the documented breaches of TSFs are on relatively flat ground. For Storage 3 an angle of 1V:30H (i.e., 1.9º) was applied downstream of the dam based on the model of Lucia et al. (1981, Ref. 6).

The eroded surfaces of breached embankments, sloping from the upstream shoulder to the downstream shoulder, have been reported to be 1V:7H to 1V:35H (Ref. 6). The slope is dependent on the material used to construct the embankment. Given that material used for the construction of the Storage 3 embankment within a 1V:3H slope of the crest is likely to be mainly rockfill, a 1V:10H grade has been adopted for this study within this extent. Further downstream a flat surface has been assumed. See Figure B1 and C1.

12.0 TDBA RESULTS AND DISCUSSION

12.1. Sunny Day Breach Scenario

12.1.1. Inundated Area

The inundation map associated with the Process I water flood and the deposition map associated with the Process II mud flow for the Sunny Day breach scenario are shown in Figures B2 and B3 in Appendix B. The volume of mobilised tailings estimated to be discharged is 0.786 Mm^3. Of this 0.240 Mm^3 of tailings is estimated to be released as eroded tailings as part of Process I. The volume of Process II material deposited adjacent to the embankment is estimated at 0.937 Mm^3 and includes the remaining mobilised tailings and the volume of the eroded embankment. The Process I water flood in the Sunny Day breach scenario will initially discharge into the Ruahorehore Stream then to the Ohinemuri River. Flow will extend up the banks of the Ruahorehore Stream in places however does not affect any houses. Only Baxter Road and the Baxter Road Bridge which is about 3.6 km downstream of Storage 3 are inundated by the flow. Further downstream, the flow will be contained and attenuated within the Ohinemuri River Channel before reaching the Waihi and Paeroa townships. Deposited mud flow (Process II) from the embankment is estimated to spread approximately 300 m from the downstream toe of Storage 3 and will not affect any houses, roads, and bridges. The volumes of tailings and eroded embankment material discharged are summarised in Table 1. The incremental effects are due to the inundation of Baxter Road and the Baxter Road Bridge and are caused by the Process I water flood.

12.1.2. Population at Risk

The Population at Risk (PAR) defined in the NZDSG (Ref. 1) is the number of people who would be directly exposed to inundation greater than 0.5 m in depth if they took no action to evacuate. The PAR includes permanent populations (people in houses and buildings) and temporary populations (mine workers, farm workers, people in commercial and retail areas, recreational users, and road and bridge users). The assessment of PAR for the Sunny Day breach scenario is summarised in Appendix B. Baxter Road and the Baxter Road Bridge are likely to be affected by the Process I water flood. The Campbell method (Ref. 27) was used to estimate the PAR due to flooding of roads and bridges. The total PAR is assessed to be one for the Sunny Day breach scenario.

12.1.3. Potential Loss of Life

The Potential Loss of Life is dependent on many factors, a number of which are related to human behaviour and response under adverse conditions, such as the dam breach scenarios. The Campbell method (Ref. 27) was adopted to assess the Potential Loss of Life for roads and bridges. The estimation of Potential Loss of Life for the Sunny Day breach scenario is summarised in Appendix B. People driving across Baxter Road Bridge are at higher risk due to the limited time of warning in the event of a dam breach. The Potential Loss of Life for the Sunny Day breach scenario is assessed to be zero.

12.1.4. Potential Impact on Residential Dwellings

In the Sunny Day breach scenario, no downstream residential dwellings are expected to be affected by the breach flood as their floor levels are above the flood level associated with a Sunny Day breach.

The impact of a Sunny Day breach on the residential dwellings is assessed to be minimal, with no inundation predicted.

12.1.5. Potential Impact on Major Infrastructure

No critical or major public infrastructure would be affected by the Sunny Day breach flood except for Storage 3 itself. Damage to the Baxter Road Bridge would affect the access to the Waihi Processing Plant and Water Treatment Plant from SH2. However, there are alternative routes of access. Some damage to the road surface and erosion of the shoulder of Baxter Road is anticipated. Significant damage to Storage 3 would occur and it would take more than a year to repair Storage 3. The remediation works would need to ensure the long-term stability and security of the tailings.

The impact of a Sunny Day breach on the critical or major infrastructure is assessed to be catastrophic, due to the damage to Storage 3.

12.1.6. Potential Impact on Natural Environment

A Sunny Day breach of Storage 3 would result in the release of tailings and pond water carrying sediments into the Ruahorehore Stream and Ohinemuri River. Damage to the natural environment includes introduction of sediment and other contaminants into watercourses and onto the surrounding ground surface and erosion and instability along rivers and streams. Some mobilised tailings and eroded embankment would settle out in the Ruahorehore Stream and would require removal. Some mobilised tailings would deposit in the Ohinemuri River. The damage to the natural environment would be significant but recoverable. Clean up would take up to 12 months. Some people could be affected due to potential contamination of water in the river (e.g., people undertaking recreational activities in the river or taking water from the river to irrigate farmland, gardens or crops).

The economic impact of a Sunny Day breach on the natural environment is moderate.

12.1.7. Potential Social, Cultural, and Economic Impact

For the Sunny Day breach scenario, no damage to the Karangahake Gorge Historical Walkway is estimated, including the trail and bridges. The riverbed would be impacted which would have an effect on its users for recreation.

Impact on water quality and the environment has significance for Maori. Water is a taonga for Maori and contamination of water would significantly impact on its mana and spiritual qualities (Mauri and Wairua).

As Storage 3 is not the only operating TSF at the Waihi Operation, a breach of Storage 3 would not necessarily result in the closure of the mine. However, it could be expected to result in a cessation or significant reduction in mining and ore processing for a period. This would have a major economic impact for OGNZL and their employees, for the Waihi community, and contractors employed by OGNZL. Water is taken from the Ohinemuri River for irrigating farmland and crops, and so contamination of the river is likely to have some economic effects for affected businesses.

12.1.8. Community Recovery Time

A Sunny Day breach of Storage 3 would not be expected to result in consequences that would have a significant impact on the community and its recovery time. Sectors of the community would suffer economically as noted in 12.1.7. There would be significant damage to land immediately adjacent to Storage 3. There would be a minimal impact on travel as only Baxter Road would be expected to be affected.

The assessed community recovery time is months, and the impact is moderate.

12.1.9. Potential Impact Classification

The PIC has been assessed in accordance with Module 2 of the NZDSG (Ref. 1). The assessed damage levels for the various categories of damage have been based on the criteria given in the NZDSG which are presented in Table 5. The PIC is dependent on PAR and the damage assessed for different categories. The criteria for PIC assessment in the NZDSG are presented in Table 6.

A summary of the assessed PAR, Potential Loss of Life, and damage levels for different categories that need consideration is provided in Table 7. The PIC of the Storage 3 embankment under a Sunny Day breach scenario is assessed to be **High**.

12.2. Rainy Day Breach Scenario

12.2.1. Inundated Area

The inundation map associated with a 1 in 1,000 year flood in the Ohinemuri River and Ruahorehore Stream and Process I dam breach flow, and the deposition map associated the Process II mud flow for the Rainy Day scenario are shown in Figures C2 and C3 in Appendix C. The extent of the 1 in 1,000 year flood without the dam breach flow is shown as a red line for comparison and to assist judgement of the incremental effects of a breach. The volume of mobilised tailings discharged in Process I is about 0.786 Mm^3. The scenario which results in the greatest incremental consequences for the Rainy Day scenario is a breach into a 1 in 1,000 AEP flood event in the Ohinemuri River. A notable contribution to the PIC is the estimated incremental effects on the Paeroa township. Stopbanks along the Ohinemuri River are constructed around Paeroa to provide flood protection (Ref. 25). A sensitivity analysis shows that the 1 in 1,000 AEP flood would be close to the crest of the stopbanks and the Rainy Day breach flow modelled for Storage 3 indicates overtopping of the stopbanks and some shallow flooding of a part of Paeroa township. However, it is reinforced that a 1 in 1,000 year flood and a breach is very unlikely. Some incremental flooding effects could also along the Ruahorehore Stream and Ohinemuri River flood channel including along the southern edge of Waihi township, River Road and SH2 in the Karangahake Gorge, and farmland adjacent to Storage 3.

12.2.2. Population at Risk

The assessment of PAR for the Rainy Day breach scenario is summarised in Appendix C. Most of the incremental PAR associated with breach are due to flooding of residential houses and SH2. Residential houses with the greatest incremental effects are located:

1. Along the southern edge of the Waihi township; and
2. Around the northern bank of the Ohinemuri River in the Paeroa township.

The incremental PAR due to breach related flooding of residential houses is estimated to be 196.

The section of SH2 from Waihi to Tauranga would be flooded over a section of 0.4 km in length by the natural flood, and therefore also the breach flow. The monitored annual average daily traffic (AADT) for this road in 2019 is 11,770 (Ref. 26). SH2 from Waihi to Paeroa would be flooded over a length of 9.3 km by the natural flood, and therefore also the breach flow. However in a major flood, this road would be closed to traffic. The section of SH2 passing Paeroa would be flooded over a section of 0.4 km in length, along withThorp Street and Willoughby Street by the breach flow (>0.5m depth). Several rural roads, i.e., Baxter Road, Clarke Street, Gilmour Street, Frankton Road, are flooded and five bridges are overtopped in the assessment. The Campbell method (Ref. 27) was employed to estimate the PAR due to flooding of roads and bridges. The incremental PAR due to flooding of roads and bridges is estimated to be 4.

The combined total incremental PAR (houses, roads, and bridges) assessed for the Rainy Day breach scenario is 200.

12.2.3. Potential Loss of Life

The assessment of Potential Loss of Life for the Rainy Day breach scenario is summarised in Appendix C. The assessment of Potential Loss of Life for residential houses in this study is based on Graham (1999, Ref. 23), which considers two fundamental factors:

1. Severity of flood; and
2. Warning times.

The fatality rates for different conditions are listed in Table 4. The fatality rates for Rainy Day failure are in accordance with those due to dam breach flood as summarised in Table 4. The fatality rates for flood events without dam failure are in accordance with ANCOLD Guidelines (Ref. 24). The incremental Potential Loss of Life due to incremental flooding of residential houses is estimated to be one. Based on the Campbell method (Ref. 27), the incremental Potential Loss of Life due to flooding of bridges and roads is estimated to be one. As a result, the total incremental Potential Loss of Life for the Rainy Day breach scenario is estimated to be two.

12.2.4. Potential Impact on Residential Dwellings

In the Rainy Day breach scenario, released pond water and eroded tailings (Process I breach water flood) inundates seven residential dwellings to depths greater than 1.5 m and according to fragility curves produced by NIWA (Ref. 28). These seven houses are in the lower lying areas near to the TSFs and south of the Waihi township, the lower area through the Karangahake Gorge, and lower lying areas adjacent to the stopbanks in the Paeroa township. Of these seven houses only one would have exceed 1.5 m in the natural 1 in 1,000 year flood. 47 residential dwellings are identified as being inundated to depths of between 0.5 m to 1.5 m and these houses would have between moderate to severe degrees of damage. In a natural 1 in 1,000 year flood only six houses are estimated to be inundated with depths between 0.5 m to 1.5 m.

The impact of a Rainy Day breach on residential dwellings is assessed to be major.

12.2.5. Potential Impact on Major Infrastructure

The critical infrastructure affected by the Rainy Day breach scenario modelling include Storage 3, SH2, and the Ohinemuri River stopbanks around Paeroa township. Significant damage of Storage 3 can be anticipated. If the dam failed, it could take more than a year to repair Storage 3. However, Storage 3 may not be the only operating TSF at the Waihi operation. The remediation works would need to ensure the long-term stability and security of the remaining tailings.

The SH2 Tauranga Road Bridge in Waihi and Criterion Bridge (on the road from Paeroa to Te Aroha) in Paeroa are indicated to be overtopped by a 1 in 1,000 year flood, and therefore also the same flood with a breach, but damage is estimated to be limited. The Baxter Road Bridge, Waikino Railway Bridge, and Waitawheta Road Bridge are indicated to be overtopped by a 1 in 1,000 year flood, and therefore also the same flood with a breach, and could be destroyed. A significant section of SH2 from Waihi to Paeroa townships would be flooded in 1 in 1,000 year flood and therefore also from a breach. The maximum flood depth and flood velocity varies along SH2. Significant damage would be expected at some locations with large flood depths and velocities (e.g., damage to the road surface, shoulder, and culverts), however, this damage is likely in 1 in 1,000 year flood also and is only expected to be marginally worse with a breach. Flooding damage is likely to result in short-term road closure and restrictions on traffic while repairs are undertaken. However, most of SH2 is anticipated to have low damage and minor erosion.

Localised overtopping of the Ohinemuri River stopbanks near Paeroa are anticipated under the Rainy Day breach scenario with a 1 in 1,000 AEP flood. The overtopping could erode the stopbanks. Repair of the damaged section is likely to be localised and is likely to take months.

There are also non-critical or minor infrastructure assets that are susceptible to damage, including several roads in Waihi and Paeroa townships.

Considering the extent of damage on SH2 and the number of roads and bridges affected by the incremental effect of the dam breach flood and deposited sediments, we anticipate the restoration of major infrastructure to normal operation would take more than a year, which is primarily associated with the repair of Storage 3.

The impact of Rainy Day breach on critical or major infrastructures is assessed to be catastrophic.

12.2.6. Potential Impact on Natural Environment

The potential incremental impact of a Rainy Day breach scenario of Storage 3 on the natural environment would be major and restoration of the Ohinemuri River and farmland adjacent to the river and Ruahorehore Stream would be costly and time consuming. The extent of area impacted by a Rainy Day breach scenario is significantly wider than that of a Sunny Day breach scenario, as it includes the Gilmour Reserve and flood plain of the Ohinemuri River and confluences with tributaries and approximately 20 hectares land in the Paeroa township.

The incremental impact of a Rainy Day breach on the natural environment is assessed to be catastrophic.

12.2.7. Potential Social, Cultural, and Economic Impact

Damage on the Karangahake Gorge Historical Walkway, including the historical railway trail and several bridges, is considered. Department of Conservation (DOC) estimates that the site attracts about 80,000 visitors annually (Ref. 29). The site is one of DOC’s 50 Historic Icons, where the stories of the site are told and protected. The incremental effects over a flood are likely to be mostly related to the effect of tailings deposition clean up on tourism.

Impact on water quality and the environment has significance for Maori. Water is a taonga for Maori and contamination of water would significantly impact on its mana and spiritual qualities (Mauri and Wairua). A breach would have an incremental impact for Maori over a natural flood because it would temporarily impact water quality.

The economic impact associated with a Rainy Day breach would be not much more significant than natural flood. In a 1 in 1,000 year flood SH2 would likely be closed temporarily and then there would be restrictions on traffic while repairs were undertaken. This would impact on many businesses in the area, however, this would be primarily because of the natural flood.

Some farms located close to the Ohinemuri River would be affected by deposition of sediment, some of which may be tailings which would need to be cleaned up. The Waikino Hotel could be destroyed and the Waikino Station Café could be significantly damaged by a natural flood, and a breach could cause some increase in damage. Several businesses located close to the Ohinemuri River in Paeroa township could also experience some increase in damage over a natural flood due to a breach.

As Storage 3 is not the only operating TSF at the Waihi Operation Site, a breach of Storage 3 would not necessarily result in the closure of the mine. However, it could be expected to result in a cessation or significant reduction in mining and ore processing for a period. This may have major economic impact for OGNZL and their employees, for the Waihi community, and contractors employed by OGNZL. Water is taken from the Ohinemuri River for irrigating farmland and crops, and so contamination of the river may have some economic effects for affected businesses.

12.2.8. Community Recovery Time

It could take several months to remove tailings and debris in the Ruahorehore Stream and Ohinemuri River, the surrounding farmland, townships, and recreational area. It would likely take more than a year to repair Storage 3. Incremental damage to the Ohinemuri River stopbanks could take months to repair. Rebuilding the severely damaged or destroyed residential buildings would also take over a year. Therefore, the community recovery time is assessed to be years and the impact to be major.

12.2.9. Potential Impact Classification

The PIC of the Storage 3 embankment has been assessed in accordance with guidance provided by Module 2 of the NZDSG. A summary of the assessed PAR, Potential Loss of Life, and damage levels for different categories that need consideration is provided in Table 8. The PIC of the Storage 3 embankment under a Rainy Day breach scenario is assessed to be **High**.

13.0 ASSESSMENT OF POTENTIAL IMPACT CLASSIFICATION

The PIC of the Storage 3 embankment is assessed to be **High.** This is based on the Rainy Day breach scenario which is more critical than the Sunny Day breach scenario. The PAR in the Rainy Day breach scenario is significantly greater than for the Sunny Day breach scenario.

14.0 EMERGENCY PLANNING

The dam breach inundation map for the Rainy Day scenario with the modelled 1 in 100 year Ohinemuri River Flood is provided in Appendix D. The 1 in 100 year flood is a more likely flood scenario than the 1 in 1,000 year flood. The 1 in 100 year map and the 1 in 1,000 year map (Appendix C) can be adapted for the EAP for Storage 3.

15.0 CONCLUSIONS

The proposed Storage 3 is to be constructed with the embankment crest at RL155. A dam breach study has been undertaken, the consequences of the breach assessed and the Potential Impact Classification (PIC) of the embankment determined in accordance with the guidance in Module 2 of the New Zealand Dam Safety Guidelines. The Storage 3 embankment is assessed to be **High PIC.**

The breach study is based on hypothetical scenarios which are not connected to the probability of occurrence. A TSF that is appropriately designed, constructed, operated, and maintained in accordance with modern standards (e.g., NZDSG and GISTM, Refs. 1 & 3) would have a low and acceptable risk of failure.

The dam breach maps developed as part of this assessment are to inform the Emergency Action Plan prepared to manage the response in the unlikely event of a breach.

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TABLES

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Table 1. Summary of Breach Outflow Volumes During Processes I and II

Scenario	**Volume of Supernatant Pond, V_w (Mm^3)**	**V_w : V_{T_EROD}**	**Volume of Eroded Tailings, V_{T_EROD} (Mm^3)**	**Volume of Process I Breach Outflow, V_{OUT_I} (Mm^3)**	**Volume of Eroded Embankment, V_{EMB} (Mm^3)**	**Volume of Liquefied Tailings, V_{T_LIQ} (Mm^3)**	**Volume of Mobilised Tailings, V_{T_MOB} (Mm^3)**	**Volume of Deposition, V_{DEP} (Mm^3)**
Sunny Day	0.240	1:1	0.240	0.480	0.391	0.546	0.786	0.937
Rainy Day	1.194	1:0.66	0.786	1.976	0.391	0.000	0.786	0.391

Notes:

1. $V_{T\_MOB} + V_{EMB} = V_{DEP} + V_{T\_EROD}$.
2. The volume of mobilised tailings, V_{T_MOB}, is the sum of eroded tailings in Process I water flood and the liquefied tailings in the Process II mud flood.

Table 2. Breach Parameter Estimation by using HEC-RAS (Sunny Day)

Required inputs in HEC-RAS[1]	Values	Note
Top of dam elevation (RL)	155.00	
Breach bottom elevation (RL)	137.14	Base of cone of depression
Impoundment elevation at failure (RL)	152.09	Initial water elevation
Impoundment volume at failure (m^3)	480,000	Volume of cone of depression
Dam crest width (m)	20	Based on design
Slope of US dam face Z1 (H:V)	2.3:1	Average slope based on design
Slope of DS dam face Z2 (H:V)	4.8:1	Average slope based on design
Earth fill type	Non-homogeneous or Rockfill	
Dam type	Homogeneous/zoned-fill dam	
Dam erodibility	Medium	

Range of breach parameters[2]

Method	Bottom width (m)	Side slopes (H:V)	Development time (hrs)
MacDonald and Langridge-Monopolis (1984)	0	0.5	0.32
Froehlich (1995)	4	1.4	0.19
Froehlich (2008)	8	1	0.22
Von Thun and Gillete (1990)	42	0.5	0.61
Xu and Zhang (2009)	13	0.95	0.56

Notes:

1 Parameters are for a tailings storage dam for Process I (i.e., initial discharge of pond and eroded tailings).

2 Breach parameters for a full breach of a water storage dam with a bottom elevation at RL137.14.

Table 3. Breach Parameter Estimation by using HEC-RAS (Rainy Day)

Required inputs in HEC-RAS[1]	Values	Note
Top of dam elevation (RL)	155.00	
Breach bottom elevation (RL)	137.14	Base of cone of depression
Impoundment elevation at failure (RL)	155.00	Initial water elevation
Impoundment volume at failure (m^3)	1,976,000	Volume of cone of depression
Dam crest width (m)	20	Based on design
Slope of US dam face Z1 (H:V)	2.3:1	Average slope based on design
Slope of DS dam face Z2 (H:V)	4.8:1	Average slope based on design
Earth fill type	Non-homogeneous or Rockfill	
Dam type	Homogeneous/zoned-fill dam	
Dam erodibility	Medium	

Range of breach parameters[2]

Method	Bottom width (m)	Side slopes (H:V)	Development time (hrs)
Von Thun and Gillete (1990)	54	0.5	0.61
Xu and Zhang (2009)	24	1.06	0.99

Notes:

1 Parameters are for a tailings storage dam for Process I (i.e., initial discharge of pond and eroded tailings).

2 Breach parameters for a full breach of a water storage dam with a bottom elevation at RL137.14.

Table 4. Flood Severity and Incremental Fatality Rate Based on Graham Method

Severity	Warning/Travel Time (min)	Fatality Rate Dam Failure[1]	Fatality Rate Flood Only[2]	Incremental Fatality Rate	Description
Low	< 15 (no warning)	0.01	0.0002	0.0098	Appropriate where no buildings are washed off the foundations (Water depths less than 3.0 m; DV values less than 4.6 m^2/s)
	15-60	0.007	0.0002	0.0068	
	> 60	0.003	0.0002	0.0028	
Medium	< 15 (no warning)	0.15	0.03	0.12	Applied to locations where homes are destroyed but trees or mangled homes remain for people to seek refuge on (Water depths larger than 3.0 m; DV values larger than 4.6 m^2/s)
	15-60	0.04	0.005	0.035	
	> 60	0.03	0.005	0.025	
High	Instantaneously arrived in seconds	0.75	N/A[3]	0.75	For locations flooded by the near instantaneous failure of a concrete or earthfill dam (where the dam fails in seconds rather than minutes or hours)

Notes:

1. The fatality rate for dam failure is based on the suggested rate in DSO 1999 (Ref. 23).
2. The fatality rate for flood events without dam failure is according to the guidance in Section A5 of Appendix A of ANCOLD Guidelines (Ref. 24).
3. The scenario is generally not applicable for natural flood.

Table 5. Categories of Damage for Assessing PIC (Table 2.2, NZDSG, Ref. 1)

Damage level	Specified categories				
	Community[1]	Cultural	Critical or major infrastructure[1]		Natural environment
			Damage	Time to restore to operation[2]	
Catastrophic	One or more of the following apply: • 50 or more household units rendered uninhabitable. • 20 or more commercial or industrial facilities rendered inoperable • 2 or more community facilities rendered inoperable or uninhabitable.	Irreparable loss to 2 or more historical or cultural sites.	Two or more critical or major infrastructure facilities rendered inoperable.	One year or more.	Extensive and widespread damage, with permanent, irreparable effects on the natural environment.
Major	One or more of the following apply: • 4 or more but less than 50 household units rendered uninhabitable. • 5 or more but less than 20 commercial or industrial facilities rendered inoperable. • 1 community facility rendered inoperable or uninhabitable.	One or both of the following apply: • irreparable loss to 1 historical or cultural site. • loss to 1 or more historical or cultural sites where it is possible, but impracticable, to fully restore the site.	One critical or major infrastructure facility is rendered inoperable.	Three months or more but less than 1 year.	Extensive and widespread damage where it is possible, but impracticable to fully restore or repair the damage.
Moderate	One or more of the following apply: 1 or more but less than 4 household units rendered uninhabitable. 1 or more but less than 5 commercial or industrial facilities rendered inoperable. loss of some functionality of one or more community facilities.	Significant loss to 1 or more historical or cultural sites where it is practicable to restore the site.	One or more critical or major infrastructure facilities are affected by the loss of some functionality.	Less than 3 months.	Significant damage that is practicable to restore or repair.
Minimal	Minor damage that does not materially affect the functionality of any household unit, commercial or industrial facility, or community facility (or no damage).	Loss to 1 or more historical or cultural sites that will require minor restoration only (or no loss to any historical or cultural site).	Minor damage to 1 or more critical or major infrastructure facilities (or no damage).	One week or less.	Only minor rehabilitation or restoration may be required or recovery is possible without intervention (or no damage).

Notes:

1. 'Rendered uninhabitable' in respect of the community damage category and 'rendered inoperable' in respect of the critical and major infrastructure damage category should be interpreted as meaning 'damaged beyond repair or destroyed'.
2. The estimated time required to repair the damage sufficiently to return the critical or major infrastructure to the normal operation that the infrastructure had immediately before the failure of the dam.

Table 6. Determination of Potential Impact Classification (PIC) (Table 2.6, NZDSG, Ref. 1)

Assessed damage level	Population at Risk (PAR)				Potential loss of Life
	0	**1 to 10**	**11 to 100**	**100+**	
Catastrophic	High	High	High	High	No persons
	N/A[1]	High	High	High	One person
	N/A[1]	High	High	High	Two or more persons
Major	Medium	Medium	High	High	No persons
	N/A[1]	Medium	High	High	One person
	N/A[1]	High	High	High	Two or more persons
Moderate	Low	Low	Medium	Medium	No persons
	N/A[1]	Medium	Medium	Medium	One person
	N/A[1]	High	High	High	Two or more persons
Minimal	Low	Low	Low	Low	No persons
	N/A[1]	Medium	Medium	Medium	One person
	N/A[1]	High	High	High	Two or more persons

Notes:

1. Not applicable. Population at risk is zero therefore no Potential Loss of Life.

Table 7. Assessment of Damage for Sunny Day Breach Scenario

Damage Category	Assessment of Damage	Damage level
Residential Buildings	No houses destroyed or damaged	Minimal
Critical or major infrastructure		
• Damage	Storage 3, Baxter Road, and Baxter Road Bridge	Moderate
• Time to restore to operation	One year or more	Catastrophic
Natural environment	Significant but recoverable damage	Moderate
Cultural	-	Minimal
	PAR	1
	Potential Loss of Life	0
	Damage Level	Catastrophic
	PIC	High

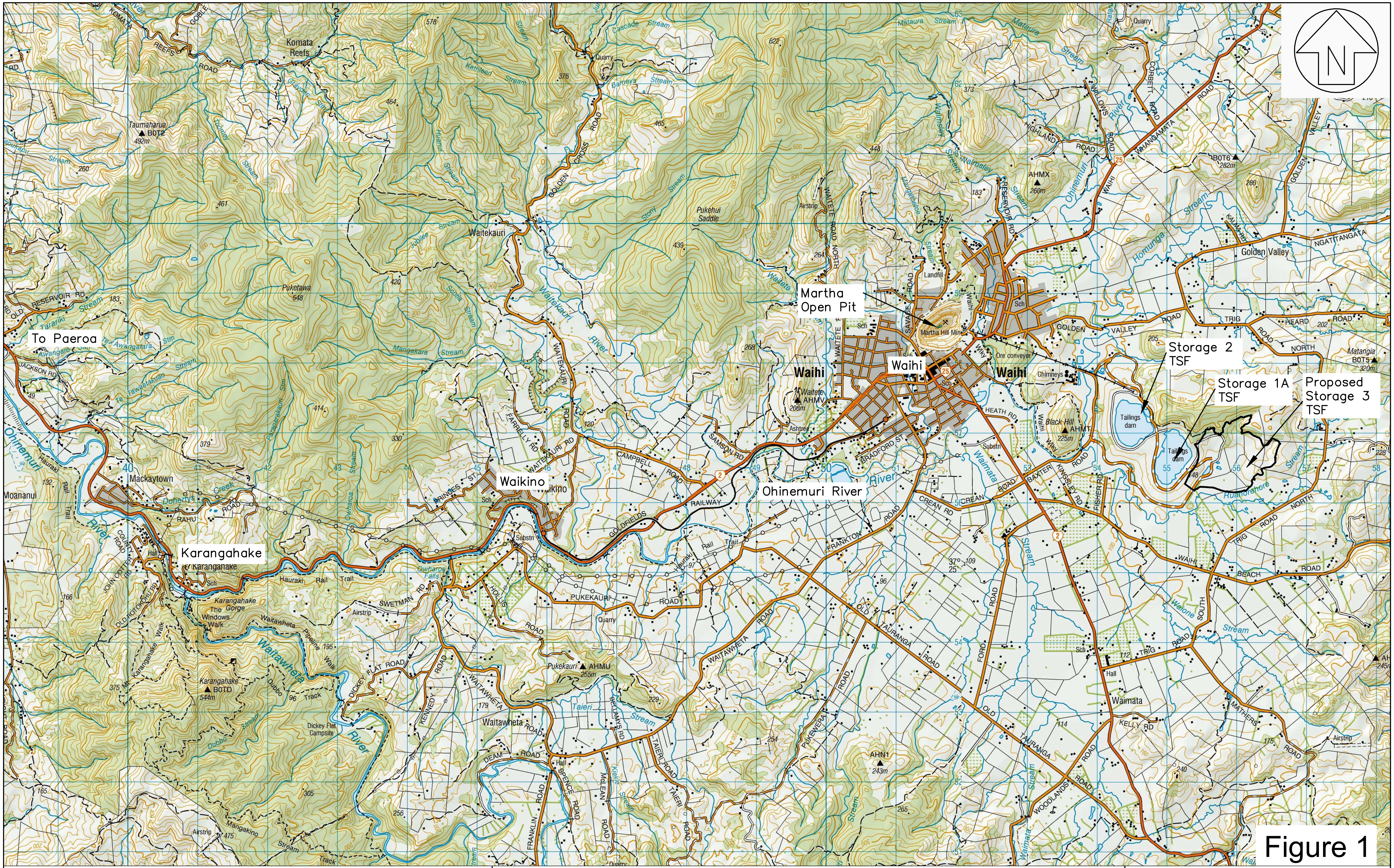
Table 8. Assessment of Damage for Rainy Day Breach Scenario

Damage Category	Assessment of Damage	Damage level
Residential Buildings	Seven houses destroyed and 47 houses damaged	Major
Critical or major infrastructure		
• Damage	Storage 3, SH2, and several minor roads and bridges	Major
• Time to restore to operation	More than 1 year	Catastrophic
Natural environment	Extensive and widespread damage	Catastrophic
Cultural	-	Minimal
	Incremental PAR	200
	Incremental Potential Loss of Life	2
	Damage Level	Catastrophic
	PIC	High

FIGURES

1 TO 5

List of Figures



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OCEANA GOLD (NEW ZEALAND) LIMITED - WAIHI
Storage 3 Tailings Storage Facility, RL155, Dam Breach
Locality Plan

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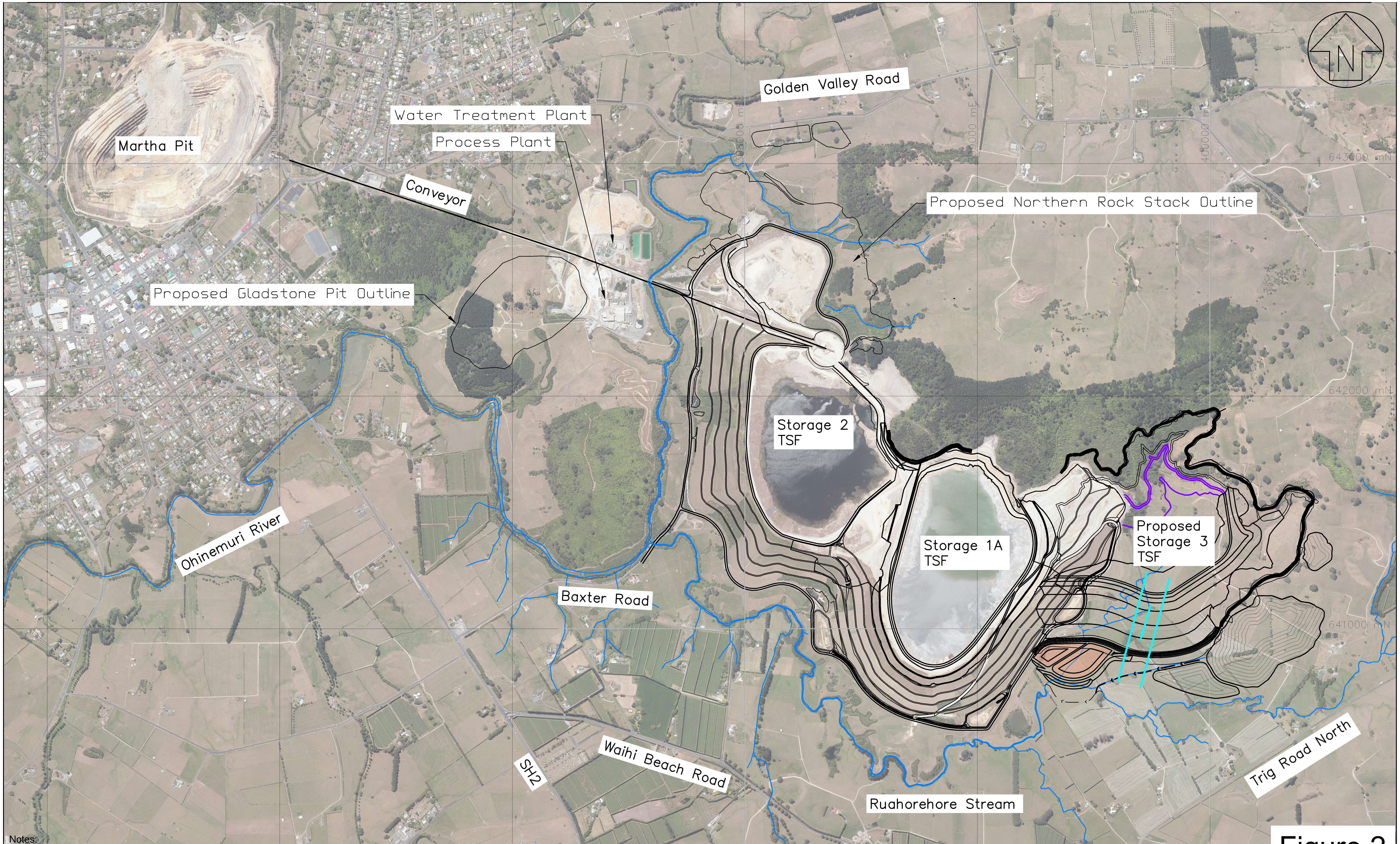

Notes:
1. Map grid shown is Mine Grid: Mount Eden Old Cadastral

Figure 2

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Site Plan

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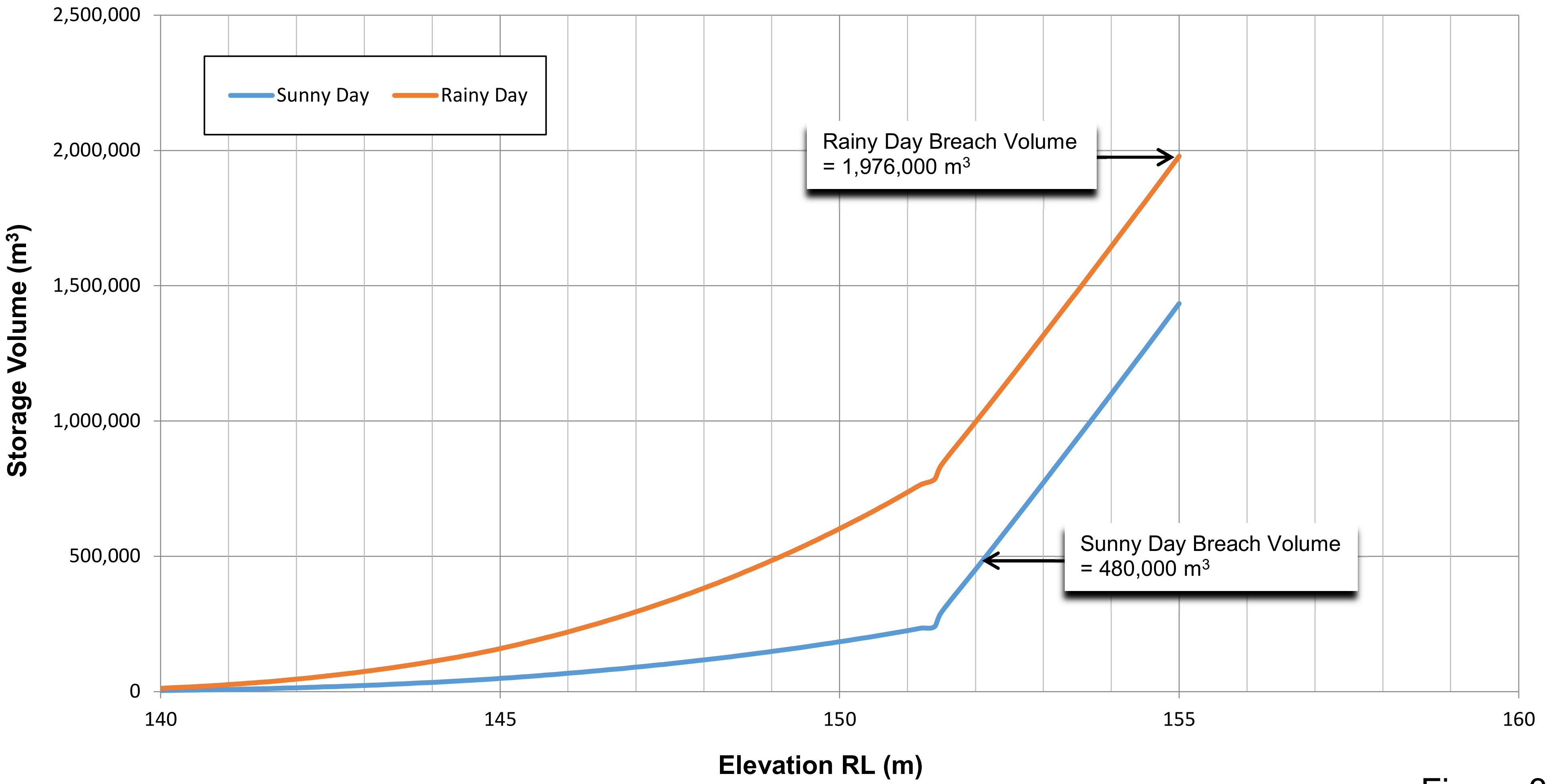

Figure 3

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Storage 3 Tailings Storage Facility, RL155, Dam Breach
Elevation - Storage Curves

Ref. No: 9216
Date: Jun 2022
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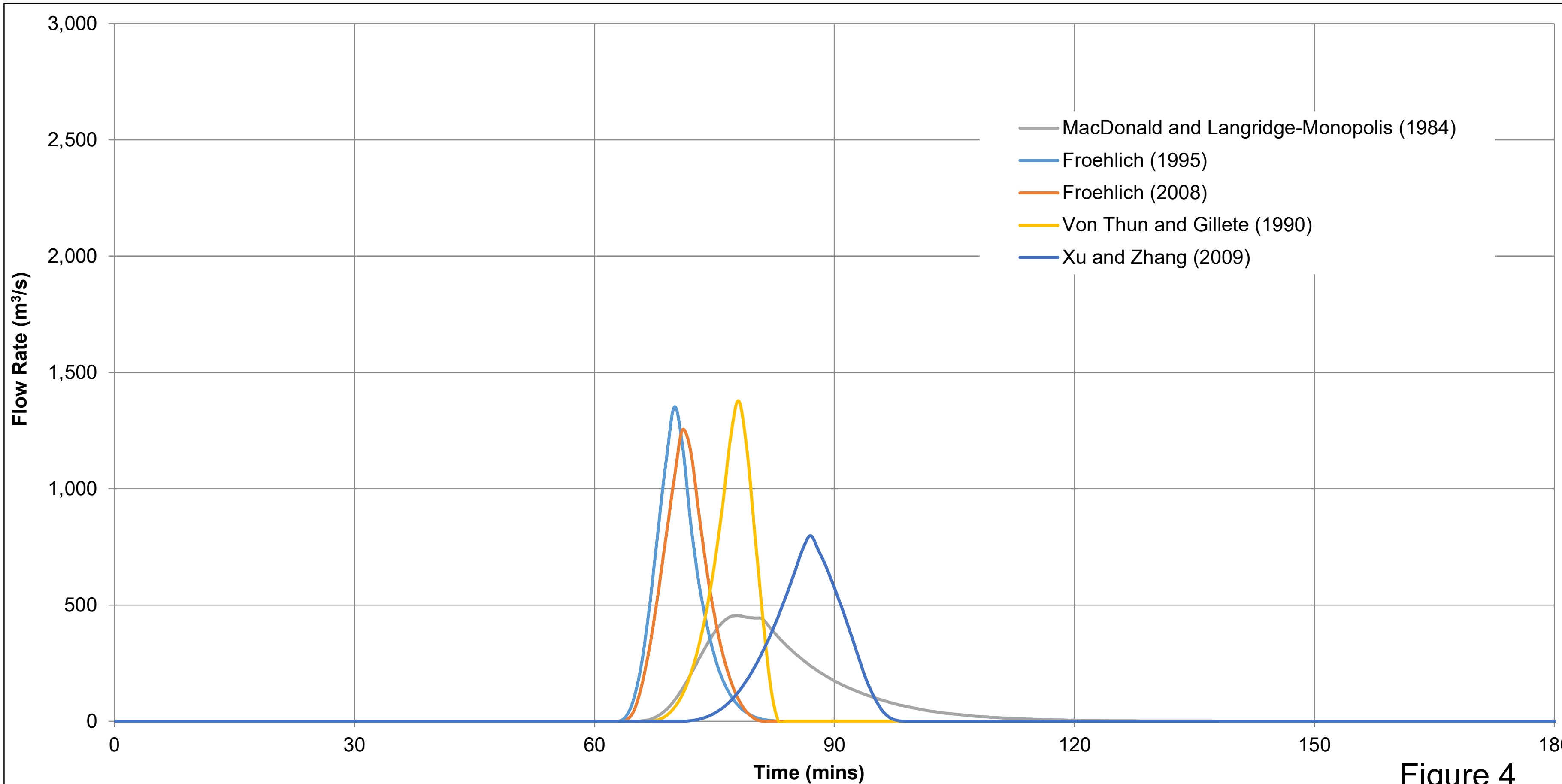

Figure 4

EGL Geotechnical, Earthquake and Dam Engineers **Engineering Geology Ltd** +64 9 486 2546 info@egl.co.nz Unit 7C, 331 Rosedale Road, Albany, Auckland PO Box 301054, Albany, Auckland 0752 www.egl.co.nz	**OCEANA GOLD (NZ) LTD - WAIHI** Storage 3 Tailings Storage Facility, RL155, Dam Breach *Breach Outflow Hydrographs for Sunny Day Breach Scenario*	Ref. No: 9216 Date: Nov 2021 Drawn: YW

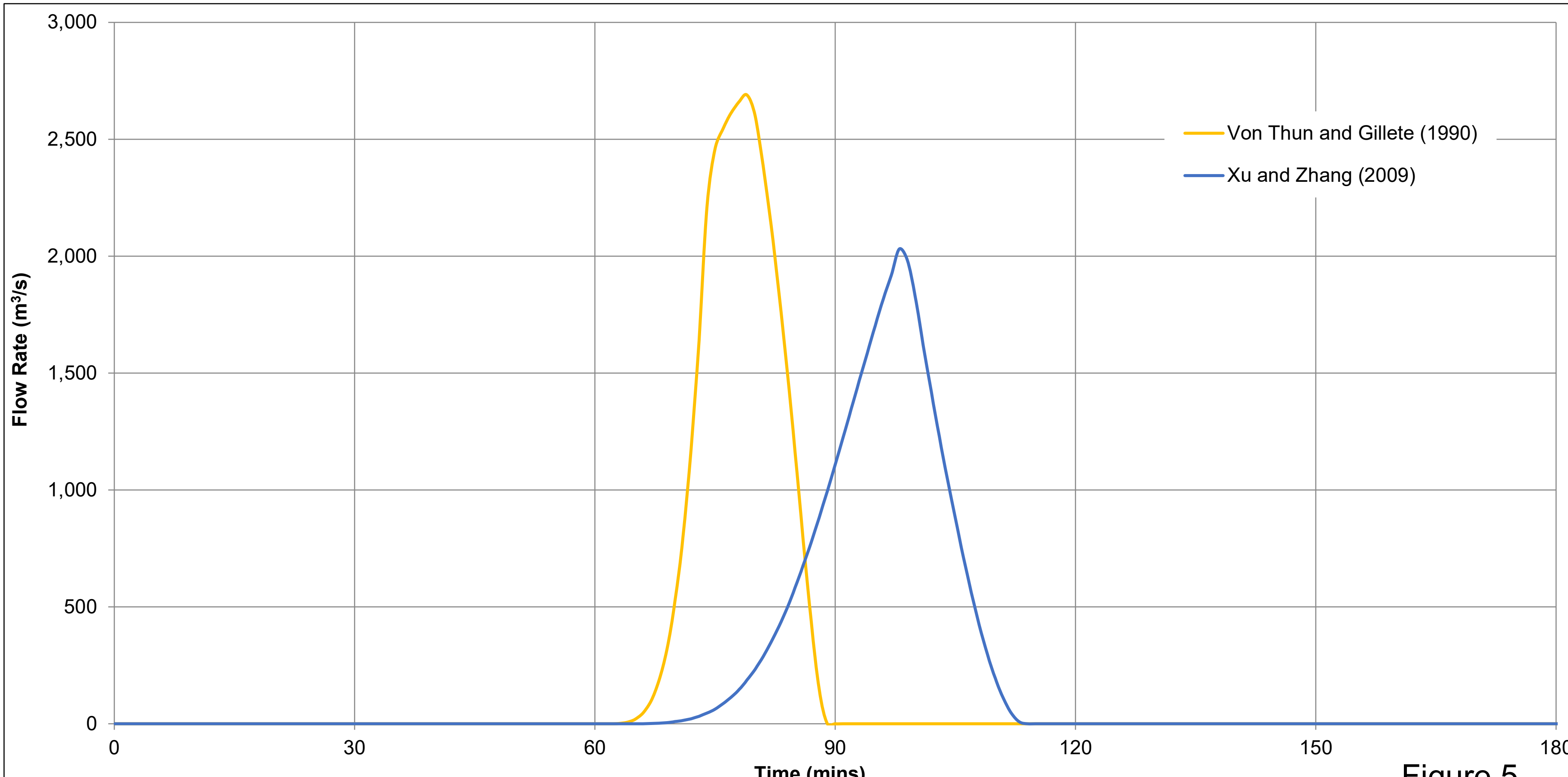

Figure 5

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Breach Outflow Hydrographs for Rainy Day Breach Scenario

Ref. No: 9216
Date: Nov 2021
Drawn: YW

APPENDIX A

NATURAL FLOW HYDROGRAPH AND 1 IN 1,000 YEAR FLOOD

Appendix A: List of Tables

Table A1. Summary of Consequences for 1 in 1,000 AEP Flood Event without Breach (Buildings)

Address	Distance Downstream (km)	No. of Buildings affected	Time of Arrival[1] (hr&min)	Time to Flood Peak[1] (hr&min)	PAR	Potential Loss of Life
Buildings along Ruahorehore Stream[2]	0.0 – 3.0	-	-	-	-	-
Buildings along Ohinemuri River passing Waihi Township	3.5 – 7.5	1	1 hr 35 min	2 hr 30 min	4	0.0008
Buildings along Ohinemuri River passing Karangahake Gorge	11.5 – 23.5	3[3]	1 hr 35 min	3 hr 10 min	16	0.0032
Buildings along Ohinemuri River passing Paeroa Township[2]	31.0 – 32.0	-	-	-	-	-
				Total	**20**	**0.004**

Notes:

(1) Time of arrival and time to flood peak are relevant to the beginning of the storm event.

(2) Locations are outside of flood extents.

(3) Some businesses are expected to be closed before a severe storm event and thus excluded in the estimation of PAR and Potential Loss of Life.

Table A2. Summary of Consequences for 1 in 1,000 AEP Flood Event without Breach (Bridges)

Bridge	Distance Downstream (km)	Time of Arrival[(1)] (hr&min)	Time to Flood Peak[(1)] (hr&min)	PAR[(4)]	Potential Loss of Life[(4)]
Baxter Road Bridge[(3)]	3.6	20 min	2 hr 15 min	-	-
SH2 Tauranga Road Bridge[(2)]	6.0	-	-	-	-
Frankton Road Bridge[(2)]	7.7	-	-	-	-
Waikino Railway Bridge	16.0	15 min	3 hr 25 min	0	0
Waitawheta Road Bridge	17.6	5 min	3 hr 35 min	0.58	0.44
Ohinemuri River Bridge[(2)]	21.0	-	-	-	-
Karangahake Gorge Walkway[(2)]	22.1	-	-	-	-
Crown Hill Road Bridge[(2)]	22.8	-	-	-	-
Criterion Bridge	31.7	1 hr 15 min	4 hr 10 min	0	0
			Total	**0.58**	**0.44**

Notes:

(1) Time of arrival and time to flood peak are relevant to the beginning of the storm event.
(2) The bridge is not overtopped by the flood.
(3) The bridge is overtopped by the flood and the detailed information is summarised in the corresponding road damage in Table A3.
(4) Estimations of PAR and Potential Loss of Life are based on the Campbell method (Ref. 27). Waikino Railway Bridge and Criterion Bridge are expected to be closed before a severe storm event and thus excluded in the estimation of PAR and Potential Loss of Life.

Table A3. Summary of Consequences for 1 in 1,000 AEP Flood Event without Breach (Roads)

Road	Flood length (km)	Max. Flood Depth (m)	Time of Arrival[1] (hr&min)	Time to Flood Peak[1] (hr&min)	PAR[3]	Potential Loss of Life[3]
Baxter Road	0.7	3.2	25 min	2 hr 15 min	1.06	0.79
Clarke Street	0.4	1.6	1 hr 10 min	2 hr 30 min	0.32	0.05
Gilmour Street[2]	-	-	-	-	-	-
SH2 Tauranga Road[2]	-	-	-	-	-	-
Frankton Road	0.5	0.9	30 min	2 hr 50 min	1.06	0.01
SH2 Normanby Road	-	-	-	-	-	-
Thorp Street and Willoughby Street[2]	-	-	-	-	-	-
				Total	**2.44**	**0.85**

Notes:

(1) Time of arrival and time to flood peak are relevant to the beginning of the storm event.

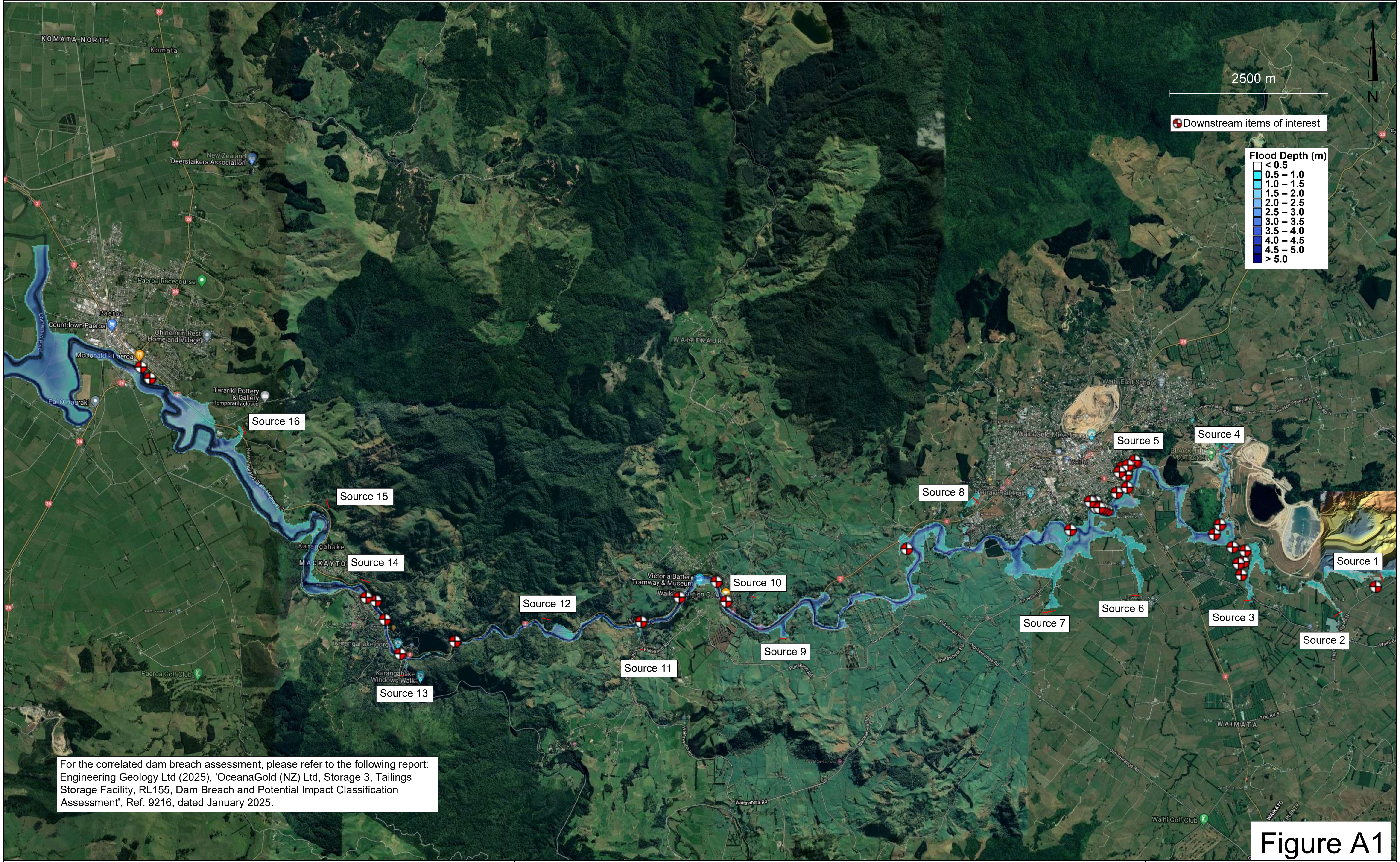
(2) The road is outside the flood extents.

(3) Estimations of PAR and Potential Loss of Life for roads are based on the Campbell method (Ref. 27).

Table A4. Summary of Incremental Consequences for 1 in 1,000 AEP Flood Event without Breach

Item		PAR	Potential Loss of Life
1 in 1,000 AEP Flood	Building	20	0.004
	Bridge & Road	3.02	1.29
	Summary	**23.02**	**1.294**

Appendix A: List of Figures



For the correlated dam breach assessment, please refer to the following report: Engineering Geology Ltd (2025), 'OceanaGold (NZ) Ltd, Storage 3, Tailings Storage Facility, RL155, Dam Breach and Potential Impact Classification Assessment', Ref. 9216, dated January 2025.

Figure A1

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Base Flood Inundation Areas
1 in 1,000 AEP - Overview

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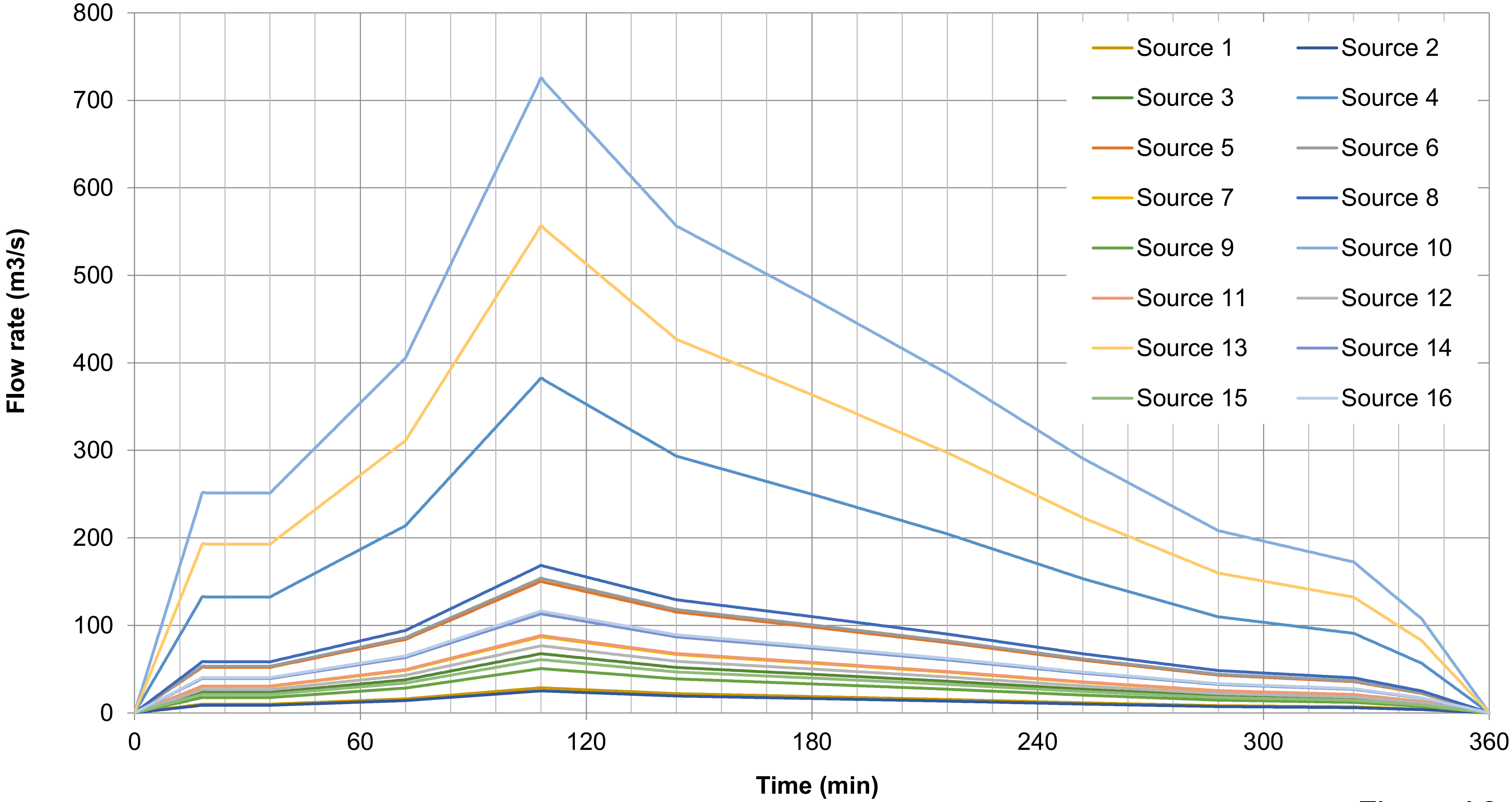

Figure A2

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Hydrographs of Natural Flows (1 in 1,000 AEP)

Ref. No: 9216
Date: Jun 2022
Drawn: YW

APPENDIX B

INUNDATION RESULTS OF SUNNY DAY BREACH SCENARIO

Appendix B: List of Tables

Table B1. Summary of Consequences for Sunny Day Breach Scenario (Bridges)

Bridge	Distance Downstream (km)	Time of Arrival[1] (hr&min)	Time to Flood Peak[1] (hr&min)	PAR[4]	Potential Loss of Life[4]
Baxter Road Bridge[2]	3.6	25 min	35 min	-	-
			Total	**0**	**0**

Notes:

(1) Time of arrival and time to flood peak are relevant to the dam breach initiation.

(2) The bridge is overtopped by the flood and the detailed information is summarised in the corresponding road damage in Table B2.

Table B2. Summary of Consequences for Sunny Day Breach Scenario (Roads)

Road	Flood length (km)	Max. Flood Depth (m)	Time of Arrival[1] (hr&min)	Time to Flood Peak[1] (hr&min)	PAR[2]	Potential Loss of Life[2]
Baxter Road	0.5	1.8	30 min	40 min	0.60	0.42
				Total	**0.60**	**0.42**

Notes:

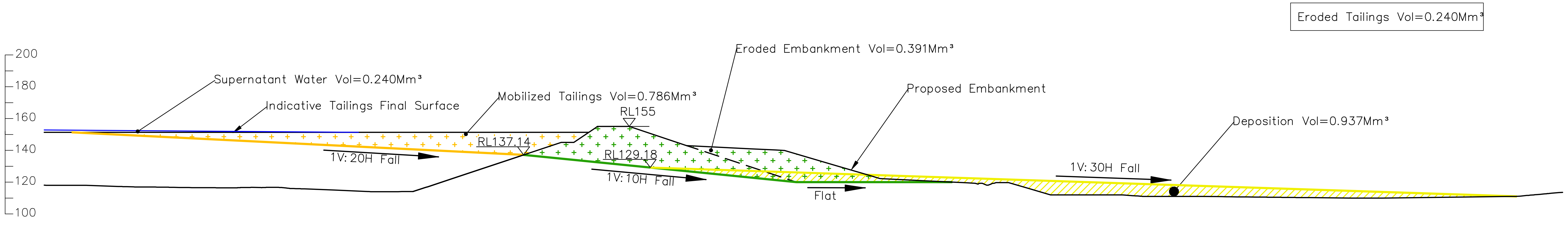
(1) Time of arrival and time to flood peak are relevant to the dam breach initiation.

(2) Estimations of PAR and Potential Loss of Life for roads are based on the Campbell method (Ref. 27).

Table B3. Summary of Incremental Consequences for Sunny Day Breach Scenario

Item		PAR	Potential Loss of Life
Sunny Day Breach Scenario	Building	0	0
	Bridge & Road	0.60	0.42
	Summary	**0.60**	**0.42**

Appendix B: List of Figures



DAM BREACH STUDY – SUNNY DAY BREACH STORAGE 3 CROSS SECTION

Scale 1:2,500 (@A3)

Figure B1

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Storage 3 Tailings Storage Facility RL155, Dam Breach
Dam Breach Cross Section
Sunny Day Breach Scenario

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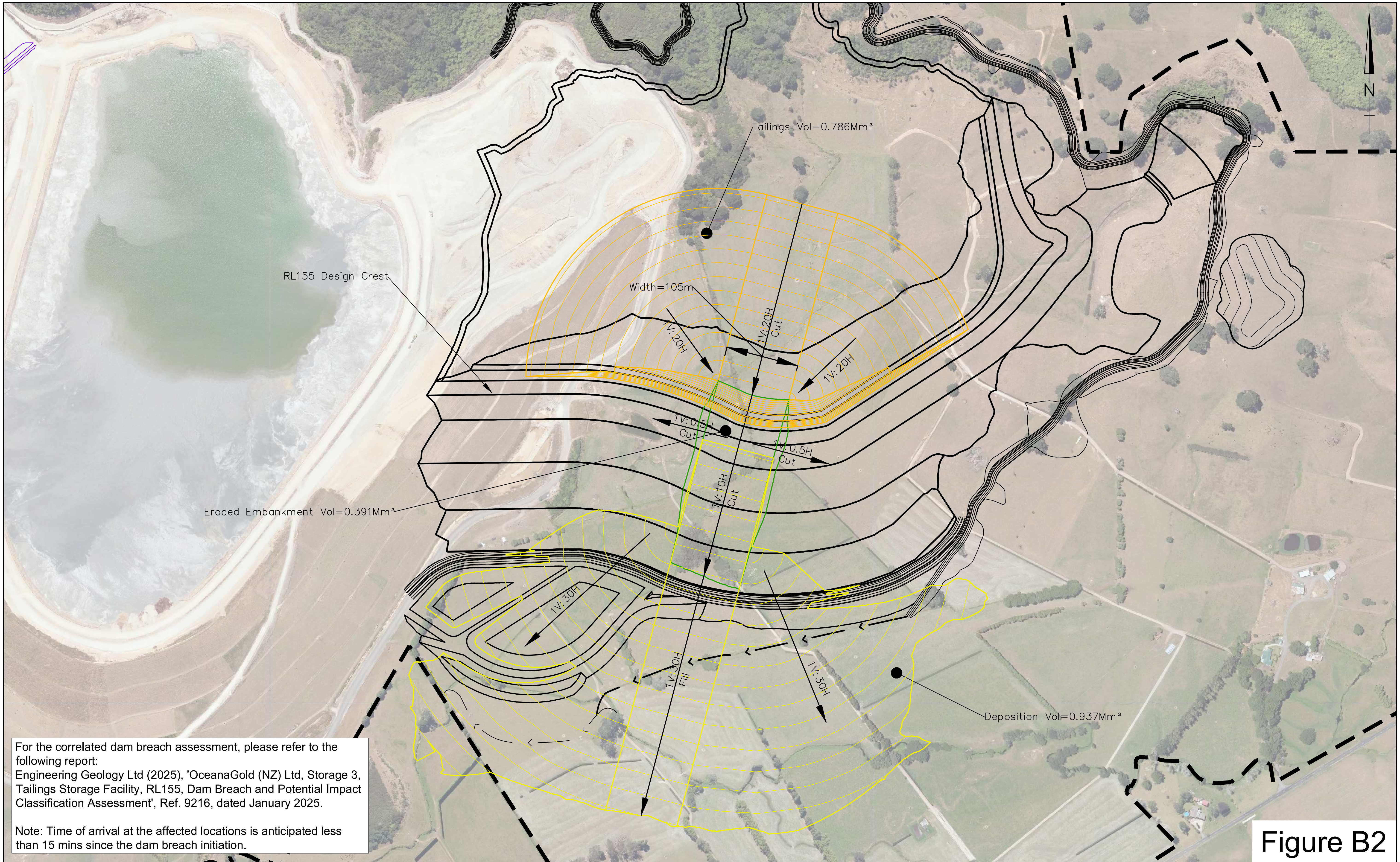

For the correlated dam breach assessment, please refer to the following report:
Engineering Geology Ltd (2025), 'OceanaGold (NZ) Ltd, Storage 3, Tailings Storage Facility, RL155, Dam Breach and Potential Impact Classification Assessment', Ref. 9216, dated January 2025.

Note: Time of arrival at the affected locations is anticipated less than 15 mins since the dam breach initiation.

Figure B2

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Storage 3 Tailings Storage Facility, RL155, Dam Breach
Breach Geometry and Mud Deposition (Process II) for
Sunny Day Breach Scenario

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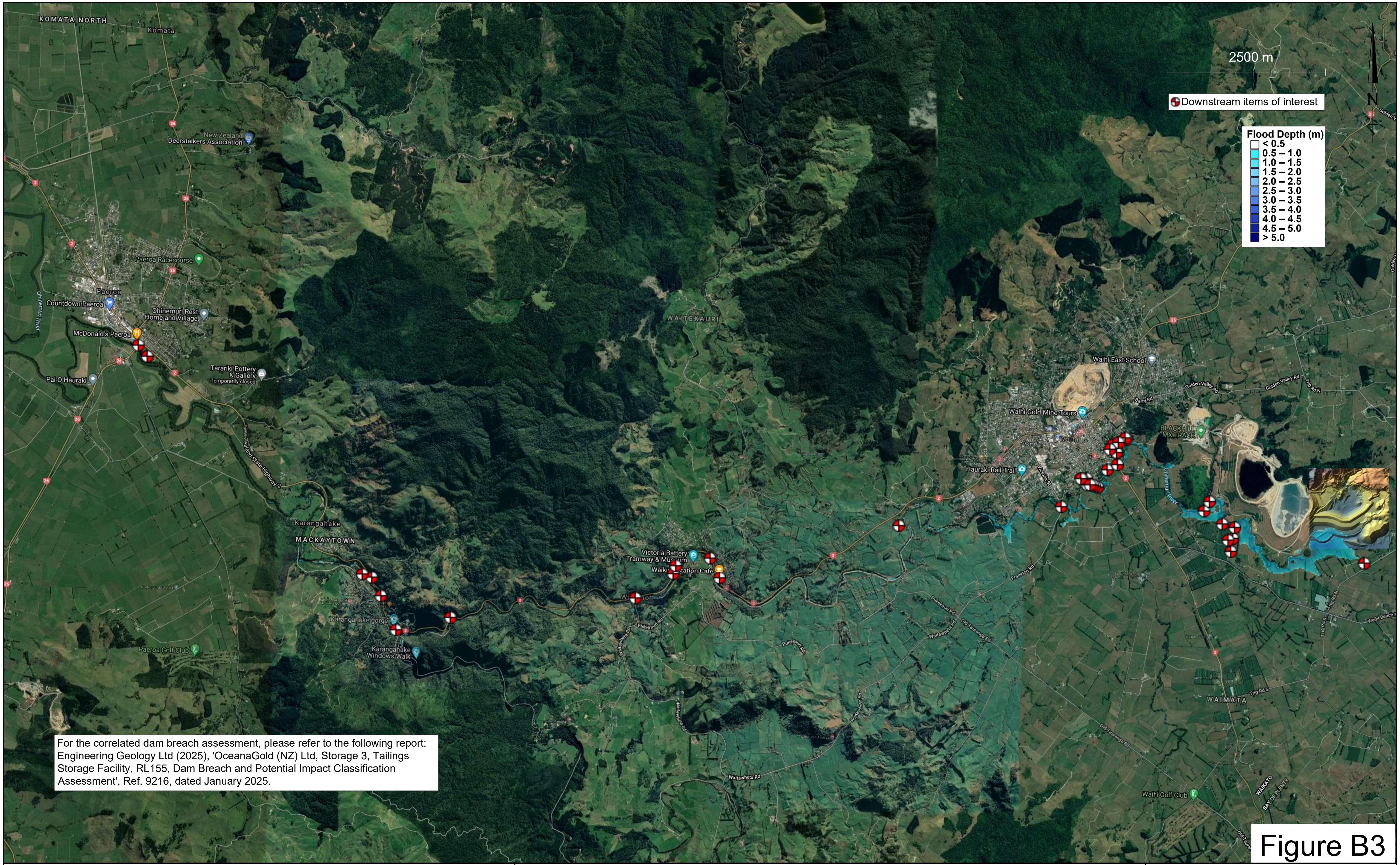

For the correlated dam breach assessment, please refer to the following report: Engineering Geology Ltd (2025), 'OceanaGold (NZ) Ltd, Storage 3, Tailings Storage Facility, RL155, Dam Breach and Potential Impact Classification Assessment', Ref. 9216, dated January 2025.

Figure B3

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Storage 3 Tailings Storage Facility, RL155, Dam Breach
Dam Breach Process I - Flood Inundation Areas
Sunny Day Failure - Overview

Drawing No.	9216–FigB3
Date:	Jan 2025
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Filename:	9216–Figs.dwg

APPENDIX C

INUNDATION RESULTS OF RAINY DAY BREACH SCENARIO WITH 1 IN 1,000 YEAR FLOOD

Appendix C: List of Tables

Table C1. Summary of Consequences for 1 in 1,000 AEP Flood-Induced Rainy Day Breach Scenario (Buildings)

Address	Distance Downstream (km)	No. of Buildings affected	Time of Arrival[1] (hr&min)	Time to Flood Peak[1] (hr&min)	PAR	Potential Loss of Life
Buildings along Ruahorehore Stream	0.0 – 3.0	1	20 min	30 min	4	0.028
Buildings along Ohinemuri River passing Waihi Township	3.5 – 7.5	12	20 min	35 min	48	0.336
Buildings along Ohinemuri River passing Karangahake Gorge	11.5 – 23.5	4[2]	1 hr	1 hr 35 min	16	0.064
Buildings along Ohinemuri River passing Paeroa Township	31.0 – 32.0	37	2 hr 30 min	3 hr 20 min	148	0.444
				Total	**216**	**0.872**

Notes:

(1) Time of arrival and time to flood peak are relevant to the dam breach initiation.

(2) Some businesses are expected to be closed before a severe storm event and thus excluded in the estimation of PAR and Potential Loss of Life.

Table C2. Summary of Consequences for 1 in 1,000 AEP Flood-Induced Rainy Day Breach Scenario (Bridges)

Bridge	Distance Downstream (km)	Time of Arrival[1] (hr&min)	Time to Flood Peak[1] (hr&min)	PAR[4]	Potential Loss of Life[4]
Baxter Road Bridge[3]	3.6	25 min	35 min	-	-
SH2 Tauranga Road Bridge[3]	6.0	35 min	55 min	-	-
Frankton Road Bridge[2]	7.7	-	-	-	-
Waikino Railway Bridge	16.0	1 hr 25 min	2 hr	0	0
Waitawheta Road Bridge	17.6	1 hr 30 min	2 hr 5 min	0.58	0.44
Ohinemuri River Bridge[2]	21.0	-	-	-	-
Karangahake Gorge Walkway[2]	22.1	-	-	-	-
Crown Hill Road Bridge[2]	22.8	-	-	-	-
Criterion Bridge	31.7	2 hr 20 min	2 hr 45 min	0	0
			Total	**0.58**	**0.44**

Notes:

(1) Time of arrival and time to flood peak are relevant to the dam breach initiation.

(2) The bridge is not overtopped by the flood.

(3) The bridge is overtopped by the flood or deposition and the detailed information is summarised in the corresponding road damage in Table C3.

(4) Estimations of PAR and Potential Loss of Life are based on the Campbell method (Ref. 27). Waikino Railway Bridge and Criterion Bridge are expected to be closed before a severe storm event.

Table C3. Summary of Consequences for 1 in 1,000 AEP Flood-Induced Rainy Day Breach Scenario (Roads)

Road	Flood length (km)	Max. Flood Depth (m)	Time of Arrival[1] (hr&min)	Time to Flood Peak[1] (hr&min)	PAR[3]	Potential Loss of Life[2]
Baxter Road	1.0	4.9	25 min	35 min	1.08	0.87
Clarke Street	0.4	3.2	30 min	45 min	0.32	0.23
Gilmour Street	0.1	1.1	40 min	50 min	0.19	0.01
SH2 Tauranga Road	0.4	1.9	35 min	55 min	1.71	0.51
Frankton Road	0.7	1.6	45 min	1 hr 15 min	1.10	0.01
SH2 Normanby Road	0.4	0.8	2 hr 10 min	2 hr 45 min	1.79	0.05
Thorp Street and Willoughby Street	0.3	0.8	2 hr 10 min	2 hr 45 min	0.21	0.00
				Total	**6.40**	**1.68**

Notes:

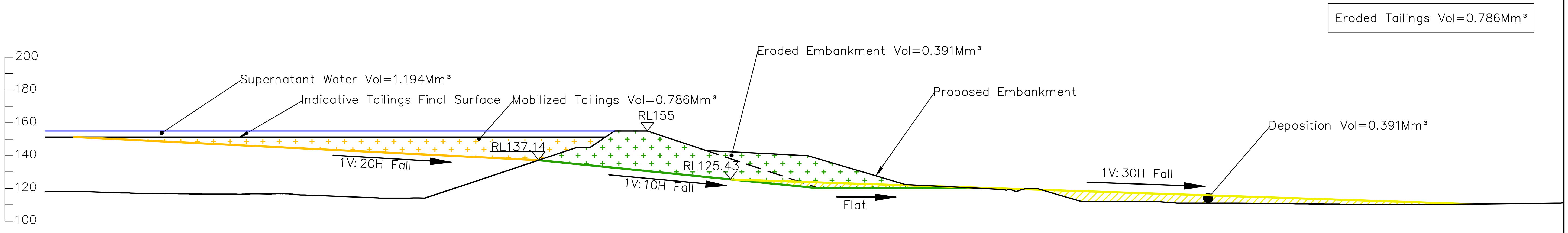
(1) Time of arrival and time to flood peak are relevant to the dam breach initiation.

(2) Estimations of PAR and Potential Loss of Life for roads are based on the Campbell method (Ref. 27).

Table C4. Summary of Incremental Consequences for 1 in 1,000 AEP Flood-Induced Rainy Day Breach Scenario

Item		PAR	Potential Loss of Life	Incremental PAR	Incremental Potential Loss of Life
1 in 1,000 AEP Flood	Building	20	0.004	-	-
	Bridge & Road	3.02	1.290	-	-
	Summary	**23.02**	**1.294**	**-**	**-**
Rainy Day Breach Scenario	Building	216.00	0.872	196.00	0.868
	Bridge & Road	6.98	2.120	3.960	0.830
	Summary	**222.98**	**2.992**	**199.96**	**1.698**

Appendix C: List of Figures



DAM BREACH STUDY – RAINY DAY BREACH STORAGE 3 CROSS SECTION

Scale 1:2,500 (@A3)

Figure C1

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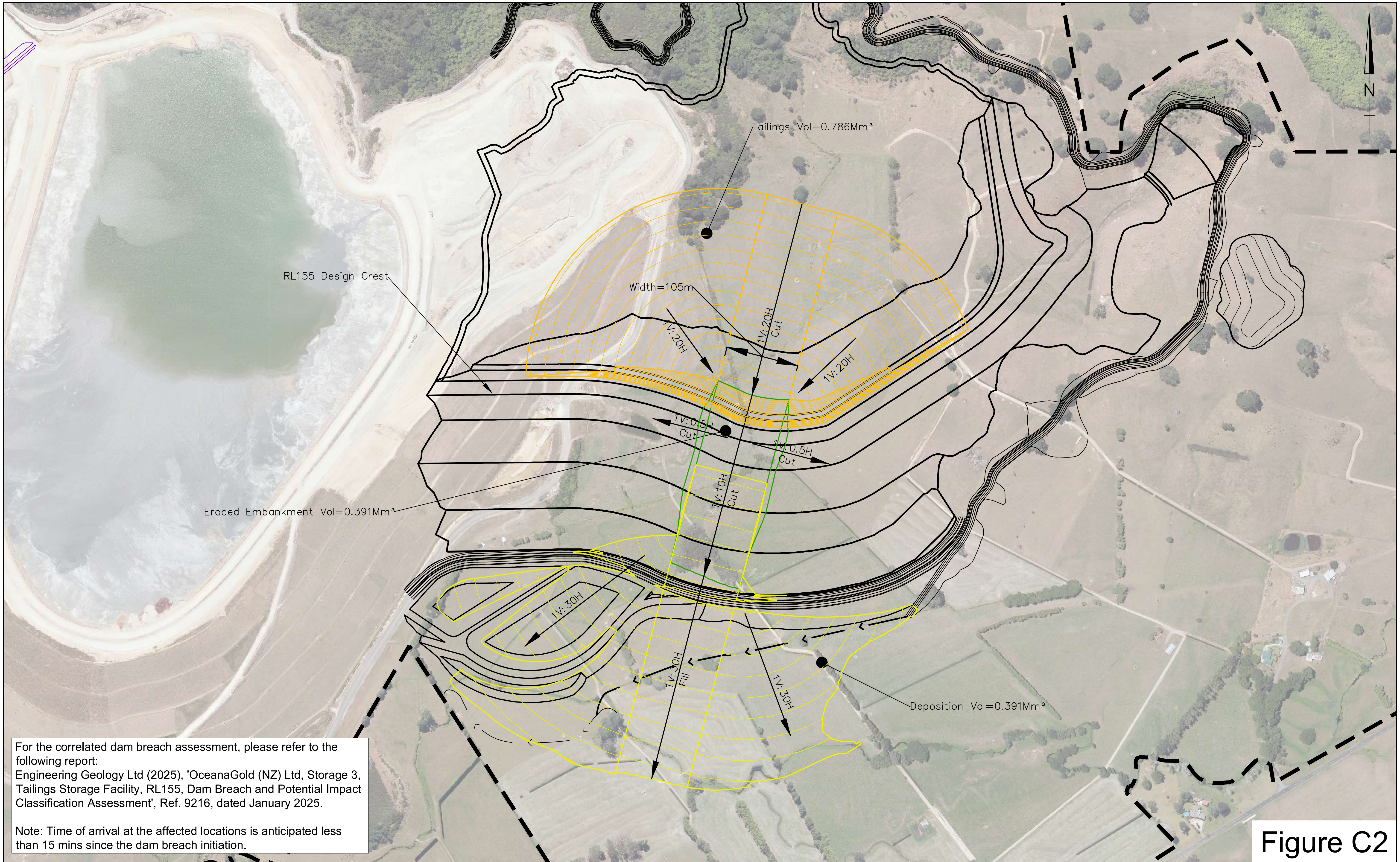
Storage 3 Tailings Storage Facility RL155, Dam Breach
Dam Breach Cross Section
Rainy Day Breach Scenario

Drawing No.	9216–Fig C1
Date:	Jun 2022
Drawn:	MC
Scale:	1:2,500 (@A3)
Filename:	9216–Figs.dwg



For the correlated dam breach assessment, please refer to the following report:
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Note: Time of arrival at the affected locations is anticipated less than 15 mins since the dam breach initiation.

Figure C2

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Breach Geometry and Mud Deposition (Process II) for
Rainy Day Breach Scenario

Drawing No.	9216-Fig C2
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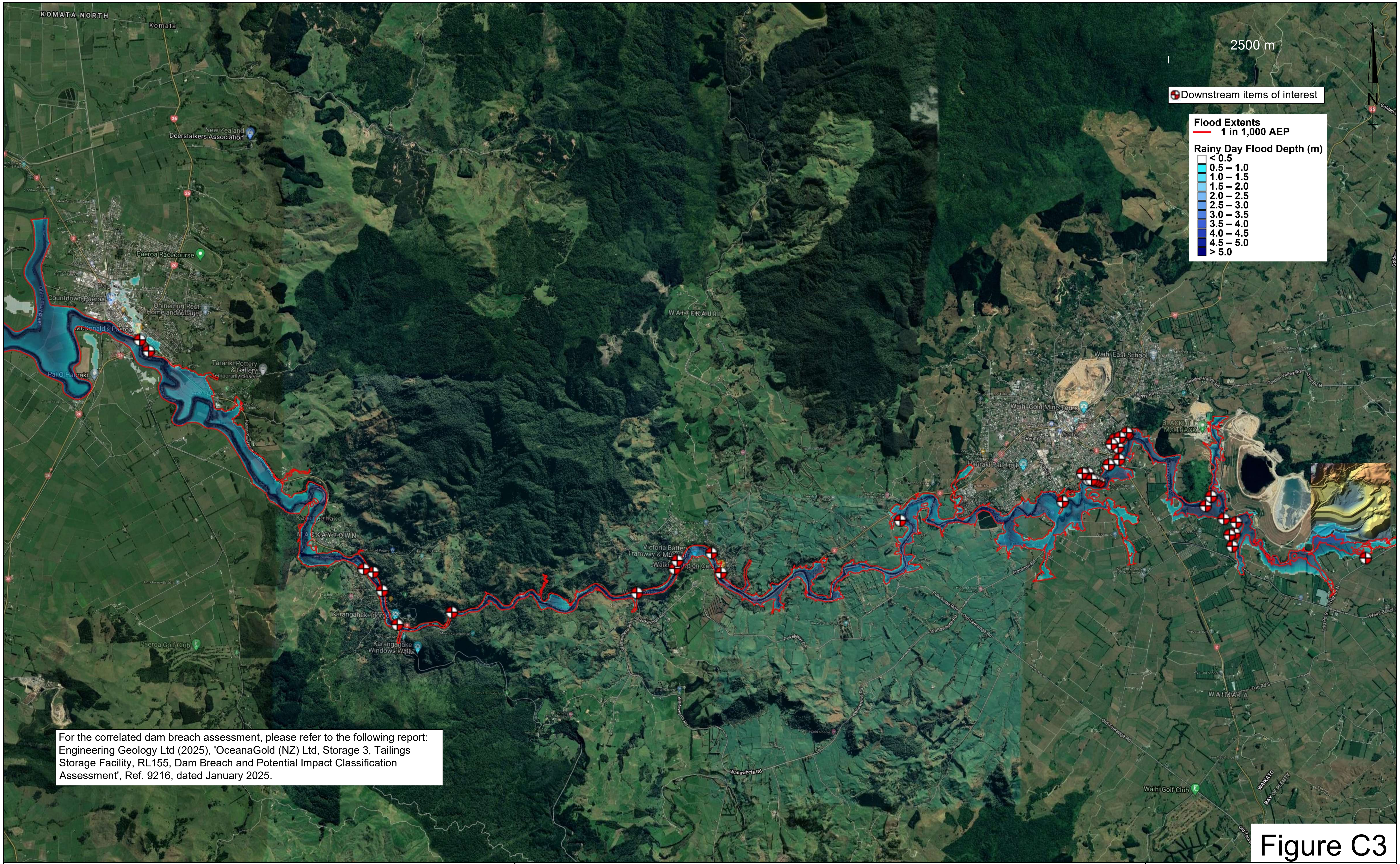

Figure C3

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Rainy Day Failure (1 in 1,000 AEP) - Overview

Drawing No.	9216–FigC3
Date:	Jan 2025
Drawn:	YW
Scale:	1:55,000 (@A3)
Filename:	9216–Figs.dwg

APPENDIX D

INUNDATION RESULTS OF RAINY DAY BREACH SCENARIO WITH 1 IN 100 YEAR FLOOD

Appendix D: List of Tables

Table D1. Summary of Consequences for 1 in 100 AEP Flood-Induced Rainy Day Breach Scenario (Buildings)

Address	Distance Downstream (km)	No. of Buildings affected	Time of Arrival[(1)] (hr&min)	Time to Flood Peak[(1)] (hr&min)
Buildings along Ruahorehore Stream	0.0 – 3.0	1	25 min	35 min
Buildings along Ohinemuri River passing Waihi Township	3.5 – 7.5	8	25 min	35 min
Buildings along Ohinemuri River passing Karangahake Gorge	11.5 – 23.5	4	1 hr 5 min	1 hr 35 min
Buildings along Ohinemuri River passing Paeroa Township[(2)]	31.0 – 32.0	0	-	-

Notes:

(1) Time of arrival and time to flood peak are relevant to the dam breach initiation.

(2) Locations are outside of flood extents.

Table D2. Summary of Consequences for 1 in 100 AEP Flood-Induced Rainy Day Breach Scenario (Bridges)

Bridge	Distance Downstream (km)	Time of Arrival[1] (hr&min)	Time to Flood Peak[1] (hr&min)
Baxter Road Bridge[3]	3.6	25 min	35 min
SH2 Tauranga Road Bridge[3]	6.0	35 min	55 min
Frankton Road Bridge[2]	7.7	-	-
Waikino Railway Bridge	16.0	1 hr 25 min	2 hr
Waitawheta Road Bridge	17.6	1 hr 35 min	2 hr 10 min
Ohinemuri River Bridge[2]	21.0	-	-
Karangahake Gorge Walkway[2]	22.1	-	-
Crown Hill Road Bridge[2]	22.8	-	-
Criterion Bridge	31.7	2 hr 25 min	2 hr 50 min

Notes:

(1) Time of arrival and time to flood peak are relevant to the dam breach initiation.

(2) The bridge is not overtopped by the flood.

(3) The bridge is overtopped by the flood and the detailed information is summarised in the corresponding road damage in Table D3.

Table D3. Summary of Consequences for 1 in 100 AEP Flood-Induced Rainy Day Breach Scenario (Roads)

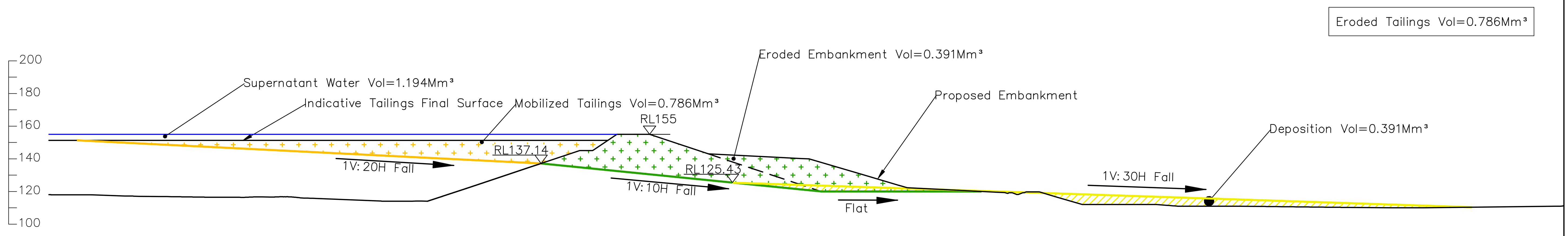
Road	Flood length (km)	Max. Flood Depth (m)	Time of Arrival[1] (hr&min)	Time to Flood Peak[1] (hr&min)
Baxter Road	0.9	4.6	25 min	35 min
Clarke Street	0.3	2.9	30 min	45 min
Gilmour Street	0.1	0.9	40 min	50 min
SH2 Tauranga Road	0.3	1.6	35 min	55 min
Frankton Road	0.6	1.3	50 min	1 hr 20 min
SH2 Normanby Road[2]	-	-	-	-
Thorp Street and Willoughby Street[2]	-	-	-	-

Note:

(1) Time of arrival and time to flood peak are relevant to the dam breach initiation.

(2) The road is outside the flood extents.

Appendix D: List of Figures



DAM BREACH STUDY – RAINY DAY BREACH STORAGE 3 CROSS SECTION

Scale 1:2,500 (@A3)

Figure D1

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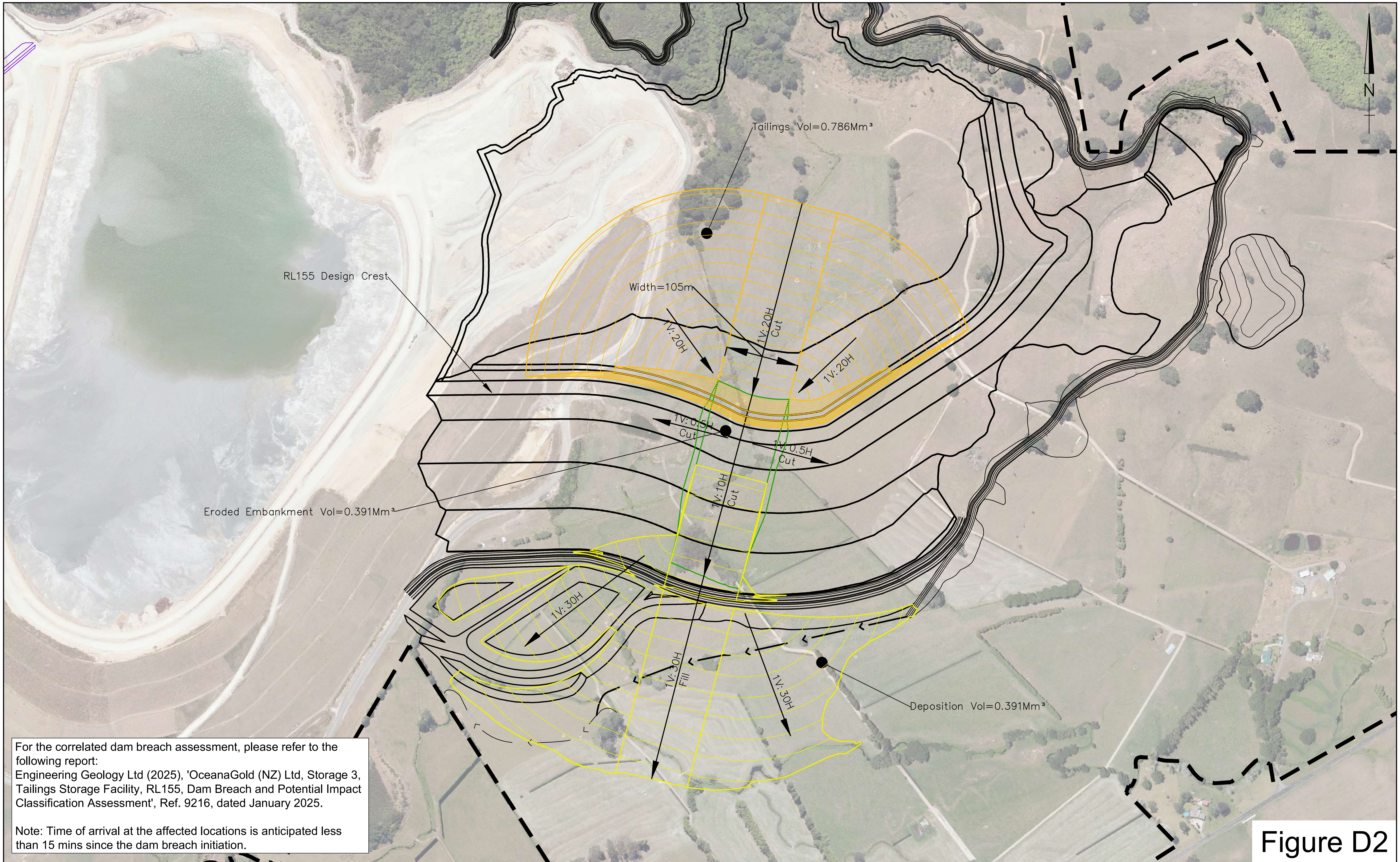

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Note: Time of arrival at the affected locations is anticipated less than 15 mins since the dam breach initiation.

Figure D2

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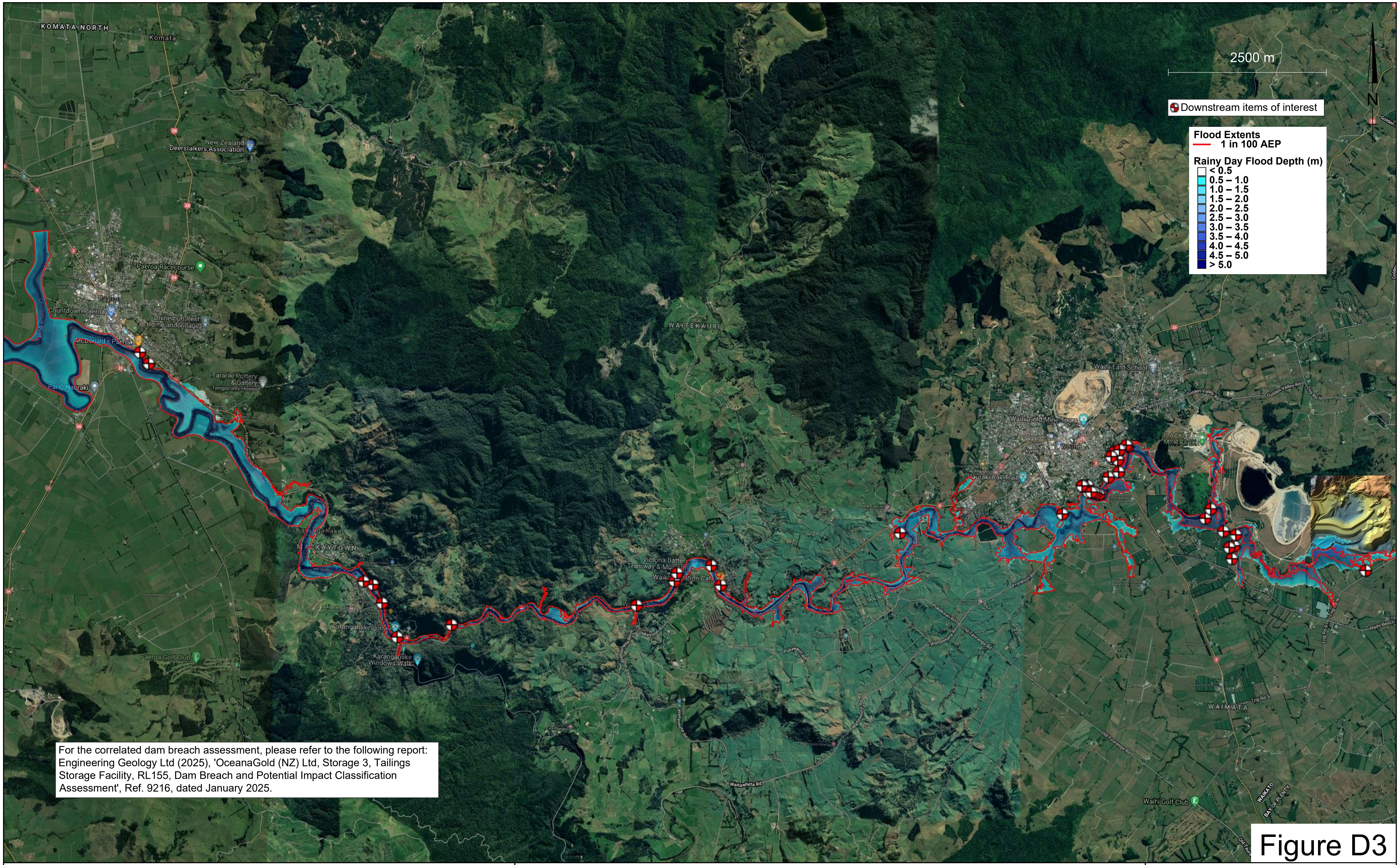

For the correlated dam breach assessment, please refer to the following report: Engineering Geology Ltd (2025), 'OceanaGold (NZ) Ltd, Storage 3, Tailings Storage Facility, RL155, Dam Breach and Potential Impact Classification Assessment', Ref. 9216, dated January 2025.

Figure D3

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