REPORT

Plan Change 65 Dambreak Assessment

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Tasman District Council
Prepared by
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Executive Summary

The 2015 Wakefield Strategic Review identified an area of land (DA 17) that could be considered for rezoning to "Rural Residential". The rezoning would allow for approximately 20 new dwellings. Two existing dams are located in series on a single property immediately upstream of the DA 17 land. It was recognised that a potential failure of either of these dams could result in inundation hazard on the DA 17 land, and this study was commissioned to assess the extent and nature of this potential hazard.

A model was developed to estimate the drambreak outflow and likely downstream flood extents and depths. An earlier river flood mapping exercise commissioned by TDC that included Piture Stream was used as a context for dambreak modelling and discussion. The previous modelling identified the Pitfure Stream floodplain, the extents of which were used in 2015 as the basis for determining the boundary of DA 17. The earlier modelling showed that the DA 17 land was well above the Piture Stream floodplain, but that in the Q100 event, flows from the spillways of the existing dams were expected to break out of the channel and result in shallow inundation of DA 17 land. The peak flow in this event is expected to be in the order of 2-4 m^3/s. This compares to the modelled dambreak flows of up to 100 m^3/s.

Any breach of the dam is expected to form rapidly, with peak outflows occurring within 10-15 minutes of breach initiation. Flows are expected to spread across DA 17 land to the north (refer Figure 1003353-F1 in Appendix A for flood extents). The majority of the inundation is expected to be within the Brown property, with only minor inundation of Hodgkinson property.

This means that most of the Hodgkinson land can be developed without any mitigation and without any risk of dambreak inundation. It is also likely that with some bunding and/or overland flowpath works, dambreak inundation risk to the eastern edge of Hodgkinson land could be mitigated to allow development of the whole property. The assessment and design required to confirm this is outside the scope of this study.

It also means that in the absence of any mitigation, development within the Brown property is very likely to put population at risk in the event of a dam breach. While the determination of a Potential Impact Classification (PIC) is outside the scope of this study, it is highly likely that rezoning and subsequent development of the Brown property would increase the PIC for the dams (currently rated as "very low"). This may require an increase in the design standard of the dams as well as increased obligations on the dam owner in terms of monitoring and reporting.

While beyond the scope of this study, a number of observations on the condition of the dams has been included in Section 7. This section highlights a number of physical infrastructure and potential dam safety considerations that require attention.

1 Introduction

1.1 Background

As part of the 2015 Wakefield Strategic Review, Tasman District Council (TDC) identified an area of land (referred to as DA 17 – see Figure 1.1 below) that could be considered for rezoning to "Rural Residential". The rezoning is being considered under proposed Plan Change 65 (PC65). The rezoning would allow for approximately 20 new dwellings, in addition to the one existing dwelling. It has previously been identified as being largely outside the Pitfure Stream 1% Annnual Exceedance Probability (AEP) floodplain (sometimes referred to as the Q100 floodplain).

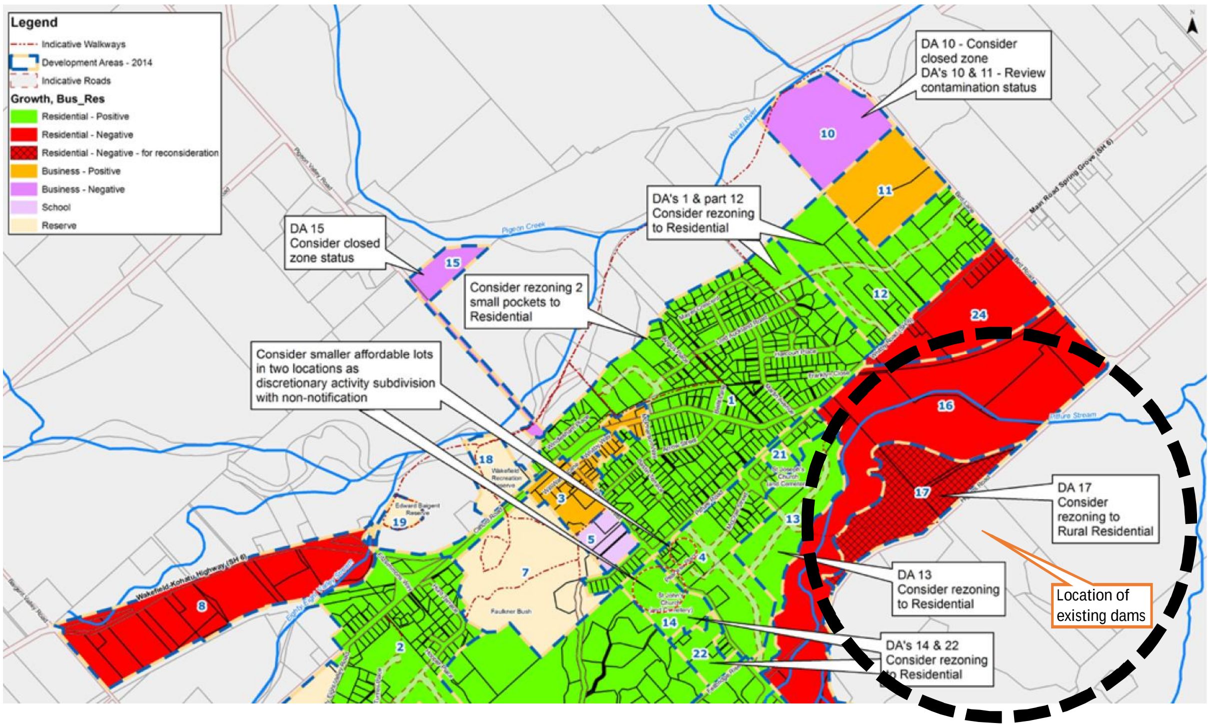

Figure 1.1: Location of DA 17 land and two existing dams located immediately upstream. Pitfure Stream runs south to north. Source: Wakefield Strategic Review – Draft Plan Change brochure, TDC, dated April 2015.

Two existing irrigation dams are located in series on property immediately above the DA 17 area, as shown in Figure 1.1 above. TDC staff have identified inundation due to dambreak as a potential hazard for any new development downstream of the dam. A decision was made to investigate the likely extent of potential dambreak flooding as part of the information required to reach a decision on the proposed PC65 with respect to DA 17. This report sets out the details and findings of that investigation.

1.2 Scope

The scope of this report is described in the letter of engagement[1]. In particular the deliverable is described in detail in task 8, quoted below:

> *Task 8 - Prepare a brief summary report including flood maps as described in Task 5 above, implications of any proposed rezoning on the owner of the dams, and implications of potential dam break for any future development within the downstream floodplain.*

[1] *Proposal – Dambreak Assessment for 335 Higgins Road dams – Professional dam safety services*, T+T letter 1003353, 01 June 2017

We proposed to achieve this by undertaking the following tasks:

1. Meeting with you to obtain background reports and information, and review of this information;
2. Site visit with you and dams owner to view the dam and downstream floodplain (06 June 2017);
3. Liaise with Eric Verstappen and/or Glen Stevens (TDC staff) to obtain 1% AEP modelling results of the Pitfure Stream to confirm the downstream floodplain extents;
4. Development of a hypothetical dambreak outflow hydrograph, based on best practice approaches to estimation of dam failure modes and breach formation times. We will consider the combined effect of the two existing dams in series in determining the worst case hydrograph (i.e. the worst case may be failure of the upper dam first, leading to subsequent failure due to overtopping of the lower dam);
5. Development of a 1% AEP dam outflow hydrograph, in accordance with TDC Engineering Standards. This will be combined with the dambreak flooding to enable generation of model results that represent the inundation extents that might arise from either flooding due to extreme rainfall or flooding due to a dambreak event. The output (described below) will present two flood scenarios: normal rainfall-induced 1% AEP flooding, and a combined 1% AEP flood with dambreak;
6. Development of a hydraulic model to assess the dambreak floodplain. We propose to use LiDAR data supplied by TDC to create a ground surface model. It will be assumed that any culverts within the downstream floodplain are blocked during a dambreak flow event. The model will be a 2-d model with a resolution suitable for representing downstream features that might control flood levels and extents (embankments, stopbanks, terraces, etc.);
7. Simulation of the dambreak event over the model domain to assess the extents and depths of inundation within the downstream floodplain.

1.3 Report structure

This report covers the following:

- The NZSOLD requirements and processes in Section 2;
- The generation of peak flow and dambreak hydrograph as well as a description of the flood hazard model in Section 3;
- The flood hazard model results and analysis in Section 4;
- A summary of the approach to assessing consequences in Section 5;
- Discussion on the implications of the dambreak modelling in Section 6;
- Observations on the condition of the existing dams in Section 7.

2 Legal obligations and NZSOLD Guidelines

2.1 Legislative framework

The responsibilities of people and entities that store water behind dams are well established in both common law and case law. The New Zealand Government had attempted to codify these responsibilities by promulgating the Dam Safety Scheme. The Dam Safety Scheme was a draft risk management regulatory regime for dams in New Zealand, and was prescribed under the Building Act 2004 and draft Building (Dam Safety) Regulations 2008. It was scheduled to come into force on 1 July 2015.

The Ministry of Business, Innovation and Employment advised on 25 June 2015 that this would no longer go ahead. The Building (Dam Safety) Regulations 2008 were then revoked under the Building (Dam Safety) Revocation Order 2015 on 31 July 2015. Ministers are currently considering options to manage dam safety under the Resource Management Act (RMA) rather than the Building Act.

Legal obligations and liabilities for dam owners remain in relation to the following legislation:

- Civil law
- The Resource Management Act (1991)
- The Building Act (2004)
- The Civil Defence Emergency Management Act (2002)
- The Health and Safety at Work Act (2015)
- The Hazardous Substances and New Organisms Act (1996)
- The Local Government Act (2002).

A building consent is still required for construction or significant modification of a 'large dam', which is defined in the Building Act as a dam that has a height of 4 m or more and holds 20,000 m^3 of water or other fluid. Under the Building Act a building consent may also be required for modification to an existing large dam including appurtenant structures (i.e. spillways, intakes/outlets).

The New Zealand Society on Large Dams (NZSOLD) have recently updated the Dam Safety Guidelines (NZSOLD 2015). Guidelines typically consist of recommended, non-mandatory controls that help support standards or serve as a reference when no applicable standard is in place. In general, guidelines should be viewed as strongly recommended practice. NZSOLD (2015) represents the recommended practice for dam safety in New Zealand. The guidelines have been written by practitioners and have been subject to international and local peer review.

The NZSOLD guidelines also provide legal context:

> *In New Zealand the dam Owner also has a duty of care in common law to prevent harm befalling others from a release of the contents from their dam.*

This is reflected in Principle 4[2]:

> *The responsibility for the safety of the dam rests with the dam Owner. The dam Owner is directly responsible for the safety of a dam. This is both a moral and legal obligation*.

NZSOLD 2015 represents a substantial step change from the previous NZSOLD 2000 version. The revised version reflects changes in industry knowledge and practice over the last 15 years and provides an increased level of detail for some aspects.

2.2 Consequences assessment and process

Determination of the suitable Potential Impact Classification (PIC) for the two dams in this study is beyond the scope of this report. In terms of consequences of failure of either or both of the two dams, the scope of this report is limited to providing some qualitative remarks on likely consequences. If a decision is made to pursue rezoning of DA 17 as part of PC65, it is likely that the dams will require a PIC rating in order to identify the design standards and operation and maintenance obligations required to mitigate the dambreak hazard. A PIC assessment would need to consider whether development of the area downstream of the dam might change the PIC rating for the dams.

[2] Reference: NZSOLD Module 1

Principle 1 of the NZSOLD guidelines states:

> *The consequences of a dam failure should be understood so that appropriate design, construction and management actions can be applied to protect people, property and the environment.*
>
> *The potential consequences of dam failure may include loss of life, injury, damage to infrastructure and property, damage to environmental values, and economic and social impacts[3].*

The following steps are recommended for work to aid in assessing the potential consequences of a dam failure:

i Identify and consider the potential failure modes for the dam;

ii Estimate the resulting discharge characteristics;

iii Map the affected area(s);

iv Assess consequences.

This current investigation covers tasks (i) – (iii). The assessment of consequences (including identifying population at risk and potential loss of life) would need to be undertaken as a further work package in order to determine a PIC rating for the dam.

3 Dambreak flood hazard assessment

3.1 Dam characteristics

Table 3.1 and Table 3.2 show the key characteristics of the dam used in developing the dambreak hydrograph.

Table 3.1: Dambreak parameters – upper dam

Source	Reservoir volume (m3)	Dam height (m)	Crest width (m)	Crest length (m)
T&T 1980 report	3,400	6	4	75
1990 Nelson Catchment and Regional Water Board Report	8,000	6	4	75
2000 TDC Small Dam Inspection Report	3,500	6	4	75
Value adopted for dambreak modelling	3,500	6	4	75

Table 3.2: Dambreak parameters – lower dam

Source	Reservoir volume (m3)	Dam height (m)	Crest width (m)	Crest length (m)
1990 Nelson Catchment and Regional Water Board Report	50,000		4	120

[3] NZSOLD Module 1

Source	Reservoir volume (m3)	Dam height (m)	Crest width (m)	Crest length (m)
2000 TDC Small Dam Inspection Report	30,000	8	4	125
Value adopted for dambreak modelling	30,000	8	4	125

Figure 3.1 below shows the location of the dam and the approximate extents of the land under consideration for residential zoning under PC65.

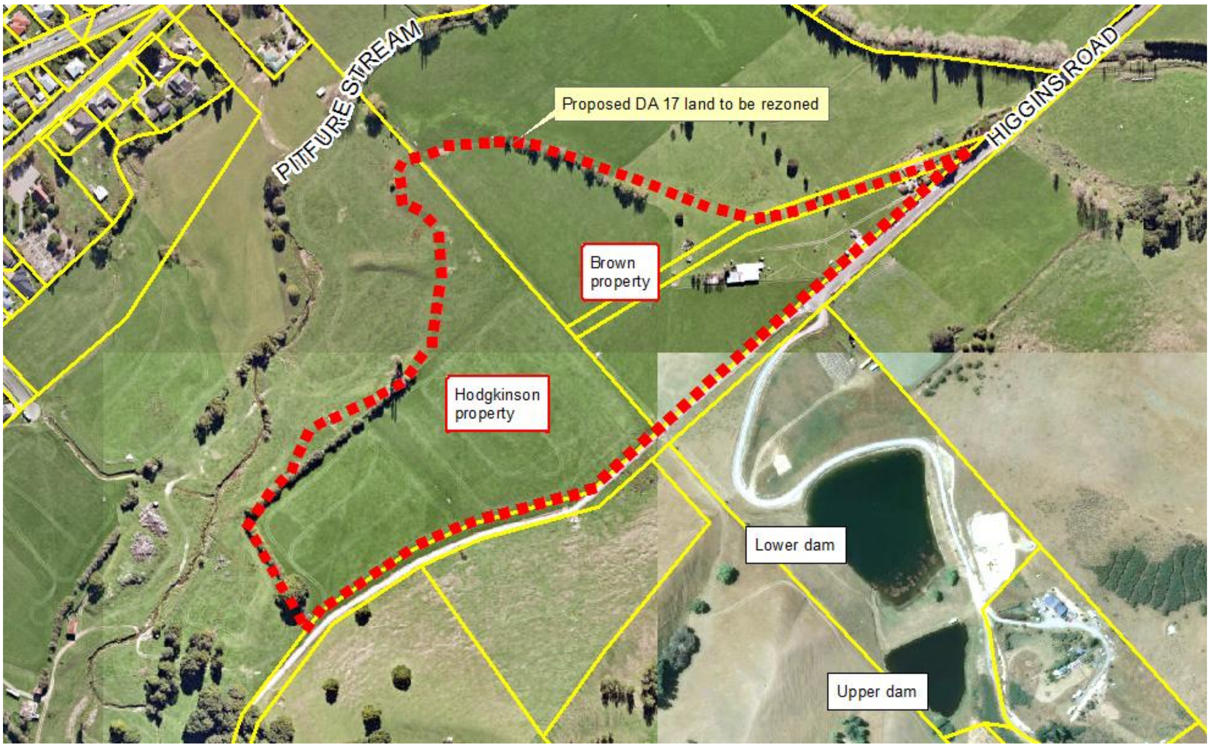

Figure 3.1: Location plan. Property ownership information supplied by TDC.

The site of the proposed land to be rezoned is located on an elevated river terrace. The site is bounded by the Pitfure Stream to the north and west. Two dams are located to the south east with a 29.3ha catchment.

3.2 Types of dambreak assessment

The purpose of this assessment is to provide advice on inundation risk to the DA 17 land parcel. Inundation of this land may arise from extreme rainfall, or from the failure of the existing dams. Potential dam failure modes that have been considered include those associated with extreme rainfall events (e.g. due to overtopping and subsequent erosion of the embankment or excessive seepage leading to a piping failure), or 'sunny day' failure modes (e.g. due to an earthquake, or internal erosion/piping). For the purposes of estimating the envelope of inundation hazard due to either sunny day or rainy day failure, it is assumed that the rainy day failure will generate the greatest flood extents, and therefore only the rainy day scenario has been modelled. As the 1% AEP flood flows are small compared with the peak dam breach flow (<5%), the difference between the extreme rainfall and sunny day scenarios are expected to be similar.

3.3 Dam breach hydrograph

The dam breach hydrograph was developed using HEC-HMS version 3.5. The dams are assumed to fail in series, i.e. the upper dam fails at the point of peak catchment runoff, releasing storage into the lower dam, which then fails. This is considered the worst case scenario.

A range of methods exist for estimating dambreak parameters. The methods use the height of stored water, total storage volume at the time of breach and assumed breach side slopes to estimate the height, width and formation time of the breach.

3.3.1 Breach height and stored volume

The breach height and volume of stored water are based on the details shown in Table 3.1 and Table 3.2 above for a breach commencing at the dam spillway.

3.3.2 Breach width

Breach width was estimated using empirical formulae derived by Von Thun and Gillette, and Froehlich. The breach widths estimated using the formulae are summarised in Table 3.3 below. The Froelich (2008) estimate was selected for design because:

- the dataset that this estimate is based on considers 74 dams of comparable type to the dams under consideration in this study;
- the dataset of 74 dams is much larger and more up to date than other methods.

Table 3.3 Average breach width

Method	Average breach width (m)	
	Upper dam	Lower dam
Von Thun And Gillette 1990	21	26
Froehlich (1987)	8	15
Froehlich (1995b)	5	10
Froehlich (2008)	5	10
Selected	5	10

3.3.3 Breach formation time

Breach formation times calculated using empirical formulae by Macdonald and Langridge-Monopolis and Froelich are summarised in Table 3.4 below.

Table 3.4: Breach formation time

Method	Breach formation time (mins)	
	Upper dam	Lower dam
MacDonald and Langridge-Monopolis (1984)	4.8	9
Froelich (1995b)	2.4	5.4
Froelich (2008)	3.6	7.2
Selected	3.6	7.2

3.3.4 Breach side slopes

Breach side slopes of 0.5 horizontal to 1 vertical were adopted as appropriate for an earth-fill dam.

3.3.5 Breach discharge hydrograph

The dam breach hydrographs were computed using HEC-HMS and the above parameters as inputs. We note that the stored volume is critical to this assessment, and that we have assumed values from information provided to us by TDC. We do not have any sub-surface survey data, and there is therefore some uncertainty around the actual storage volumes. Figure 3.2 shows the lower dam dambreak hydrograph.

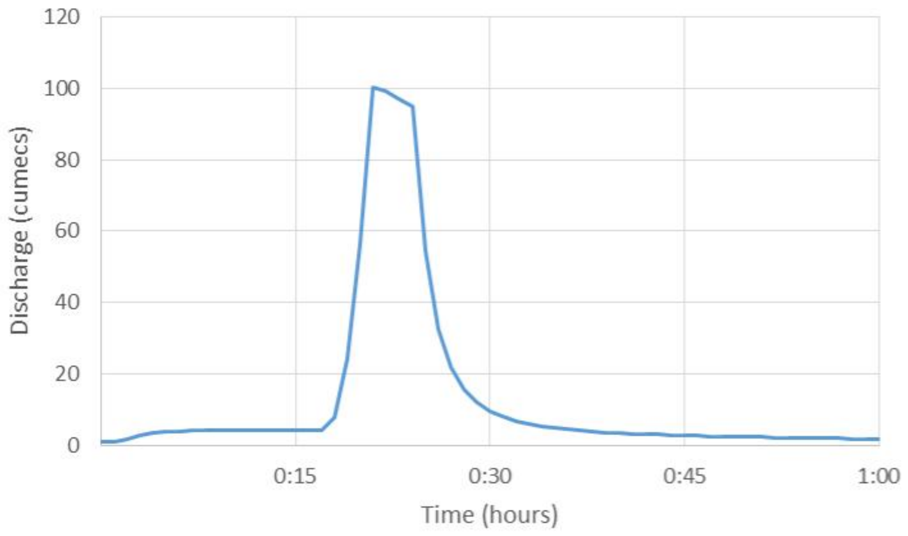

Figure 3.2 Breach discharge hydrograph

3.3.6 Sensitivity analysis

Sensitivity analysis on key breach parameters (e.g. breach formation time) was outside the scope of this study. If further work is to be carried out as part of any PIC assessment, we recommend undertaking a sensitivity analysis.

3.4 Hydrology

A 1% AEP storm hydrograph was developed, with the peak flow value checked using a range of flow estimation methods. The peak value used was also cross-checked with the value used by SKM for modelling of 1% AEP flooding in the Pitfure Stream.

3.4.1 Loss and transform method

The SCS curve was adopted as the loss method. A curve number of 68 was selected as appropriate for the catchment soils and cover characteristics.

The Clark unit hydrograph was adopted for the transform method. A time of concentration (Tc) was calculated using a range of methods, and a value of 20 minutes adopted. A storage coefficient equal to 2/3 of the ToC was adopted.

3.4.2 Catchment characteristics

Refer to Figure 3.3 for the catchment area draining to the dams.

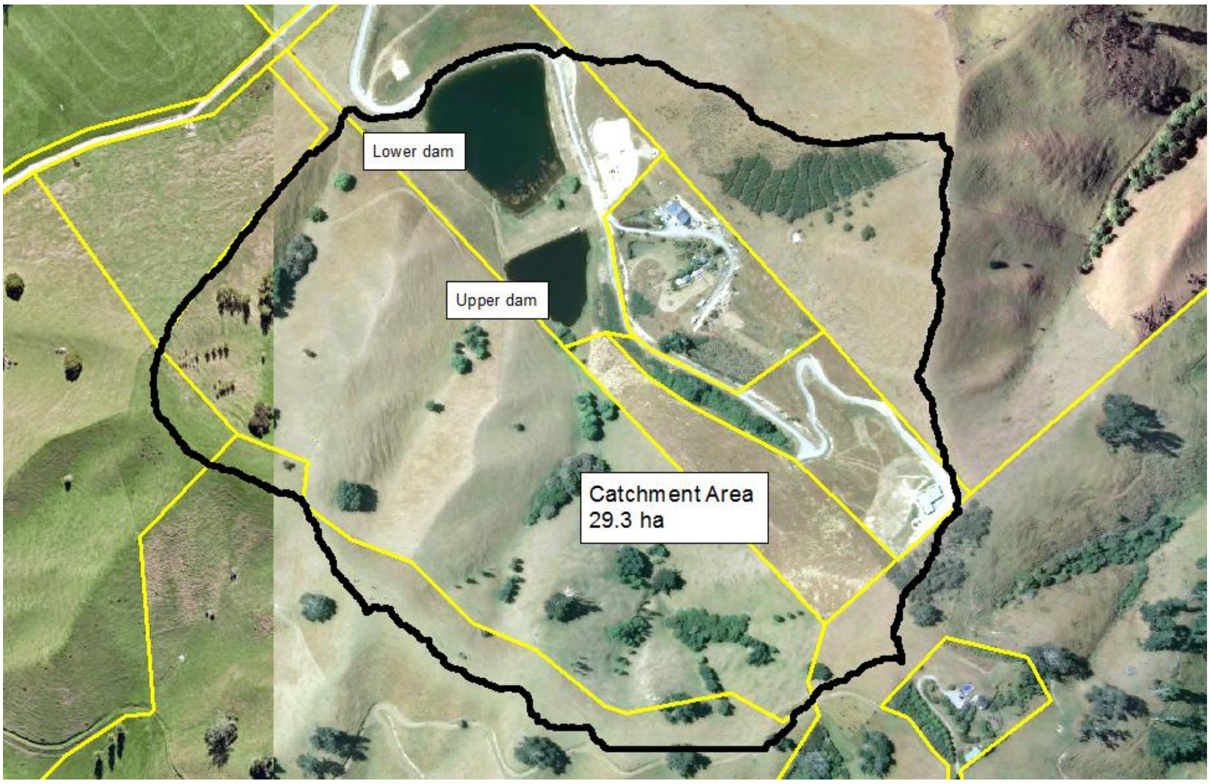

Figure 3.3: Catchment draining to the two dams

From GIS analysis the following geometric catchment characteristics were calculated:

- Area = 29.3ha
- Longest flow path = 710m
- Catchment slope by equal areas method = 0.063m/m

3.4.3 Peak discharges

A summary of the peak discharges are presented in Table 3.5 below. A design flow of 4.3 m^3/s was adopted for modelling purposes. While this is higher than previously assumed in the SKM assessment of the 1% AEP floodplain, we note that the peak runoff is two orders of magnitude less than the estimated dambreak peak flow and the difference is considered negligible in terms of the dambreak floodplain depths and extents.

Table 3.5: Comparison of estimates for 1% AEP peak catchment runoff

	Estimated 1% AEP peak catchment runoff (m^3/s)
HEC-HMS	4.3 (selected)
TP108	5.5
Rational method	2.2
SKM Flood Hazard modelling (Jeffries Catchment 7)	2.4

3.4.4 1% AEP storm hydrograph

The 1% AEP hydrograph for the dams' catchment was computed using HIRDS v3 data and the above parameters as inputs into a HEC-HMS v3.5 model. Figure 3.4 shows the hydrograph calculated from HEC-HMS for a 1% AEP storm draining to the two dams. As is standard practice, the hydrograph was developed for the simulation of a 24-hour event using a nested rainfall pattern. This means that design rainfall intensities for different durations (from rainfall statistics) up to 24 hour duration are embedded within the temporal rainfall distribution. The resulting hydrograph is then timed so that its peak coincides with the peak of the dambreak hydrograph.

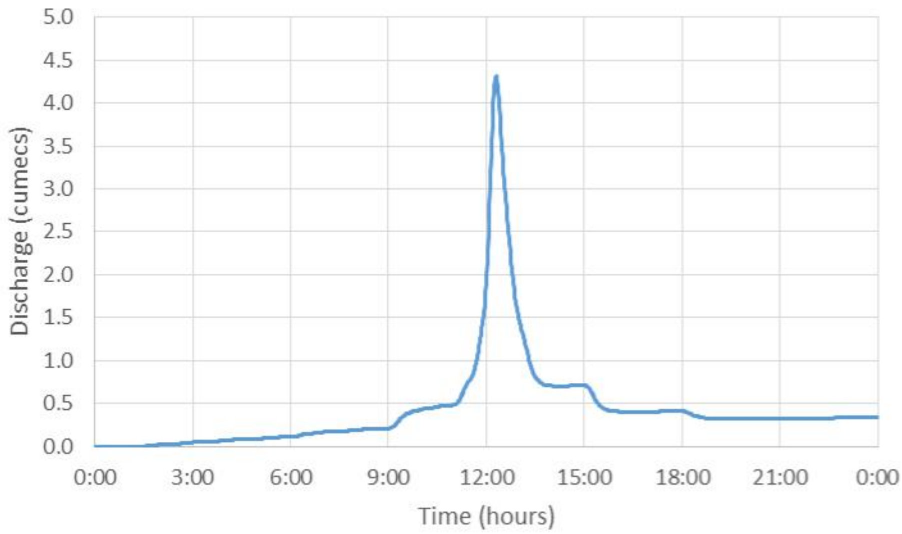

Figure 3.4: 1% AEP storm hydrograph for the catchment draining to the dams

3.5 Flood hazard model

For the dambreak routing a 2D hydraulic model was developed using TUFLOW software.

For flood hazard from the Pitfure Stream a flood hazard model has been developed historically for TDC by SKM for which we have been provided the results for a 1% AEP storm.

3.5.1 T+T dambreak routing hydraulic model

The model was developed using a TUFLOW fixed grid software package. A rectilinear grid was created from LiDAR to represent the ground surface. The LiDAR data used was provided by TDC and was captured in November of 2015. The grid uses a 2 m cell size.

3.5.1.1 Structures

No structures were explicitly modelled (i.e. culverts/bridges); however the dam itself (including auxiliary spillways and dambreak) were modelled separately in HEC-HMS. For the purposes of this study, the Higgins Road bridge crossing was represented as an open channel as per the LiDAR data. This simplification has no effect on modelled depths within DA 17 land.

3.5.1.2 Floodplain resistance

A uniform floodplain resistance of Manning's n = 0.045 was adopted, as suitable for a grassed floodplain.

3.5.2 1% AEP flood hazard model

In 2015, TDC commissioned SKM to undertake mapping of the 1% AEP floodplain through Wakefield and Brightwater. TDC have supplied the modelled 1% AEP flood extents to provide context and a downstream boundary condition for dambreak modelling in this study. For details of the 1% AEP floodplain mapping, refer to the SKM report "Brightwater – Wakefield Flood Hazard Mapping" Rev B dated 12 December 2013.

4 Modelling results

The modelled dambreak flooding is presented in T+T Figure 1003353-F1 in Appendix A. The inundation modelling shows that for a dam breach near the left abutment of the dam, the flooding is predominantly within the Brown property, with some flooding along the eastern boundary of the Hodgkinson property. This means that most of the Hodgkinson land can be developed without any mitigation and without any risk of dambreak inundation. It is also likely that with some bunding and/or overland flowpath works, dambreak inundation risk to the eastern edge of Hodgkinson land could be mitigated to allow development of the whole property. The assessment and design required to confirm this is outside the scope of this study.

Modelled flood depths and velocities within the two properties are generally in the order of up to 0.9 m and 1.8 m/s respectively. This compares with modelled 1% AEP flood depths (provided by TDC) in the order of 0.2 m through the Brown property.

In the existing situation, most of the dambreak flows would travel across the terrace within the Brown property before flowing down the bank into the Pitfure floodplain. The 1% AEP flood levels in the Pitfure Stream (provided by TDC) are approximately 5 m lower than the level of the terrace. The modelling indicates only minor flows along Higgins Road and back into the Pitfure Stream below the Higgins Road bridge.

Overlaying the results of the 1% AEP modelling and the dambreak modelling (as in Figure 1003353-F1) shows that that there is no 1% AEP flooding of the DA 17 land outside of the modelled dambreak flood extents; i.e. that the dambreak inundation is the worst case right across the DA 17 area.

5 Potential impact classification assessment

The determination of a PIC rating for the dam is beyond the scope of this study. However, information is provided in this section to give TDC information on the how any future PIC rating would be determined.

Under the 2015 NZSOLD Guidelines, the consequences of failure, specifically the downstream harm and damage potential, are the main determinants for assessing the potential impact classification (PIC) of the dam.

Table 5.1 below is a reproduction of the interpretation of "catastrophic, major, moderate and minimal damages" from the guidelines.

Table 5.1: Determination of assessed damage level (NZSOLD May 2015)

Damage level	Residential houses[1]	Critical or major infrastructure[2] damage	Time to restore to operation[3]	Natural environment	Community recovery time
Catastrophic	More than 50 houses destroyed	Extensive and widespread destruction of and damage to several major infrastructure components	More than 1 year	Extensive and widespread damage	Many years
Major	4-49 houses destroyed and a number of houses damaged	Extensive destruction of and damage to more than 1 major infrastructure component	Up to 12 months	Heavy damage and costly restoration	Years
Moderate	1-3 houses destroyed and some damaged	Significant damage to at least 1 major infrastructure component	Up to 3 months	Significant but recoverable damage	Months
Minimal	Minor damage	Minor damage to major infrastructure components	Up to 1 week	Short-term damage	Days to weeks

Notes:

1. In relation to residential houses, 'destroyed' means rendered uninhabitable.
2. Critical or major infrastructure includes:
   i) lifelines (power supply, water supply, gas supply, transportations systems, wastewater treatment, telecommunications (network mains and nodes rather than local connections));
   ii) emergency facilities e.g. hospitals, police, fire services;
   iii) large industrial, commercial, or community facilities, the loss of which would have a significant impact on the community; and
   iv) the dam, if the service the dam provides is critical to the community and that service cannot be provided by alternative means.
3. The estimated time required to repair the damage sufficiently to return the critical or major infrastructure to normal operation.

Table 5.2 shows the potential impact classification system adopted by the guidelines which takes into account both the assessed damage level (as per table above) and the estimated population-at-risk (PAR) with the assessed category highlighted.

Table 5.2: Determination of Potential Impact Classification (PIC)

Assessed damage level	Population-at-risk (PAR)			
	0	1-10	11-100	100+
Catastrophic	High PIC	High PIC	High PIC	High PIC

Assessed damage level	Population-at-risk (PAR)			
	0	1-10	11-100	100+
Major	Medium PIC	Med/High PIC (see note 4)	High PIC	High PIC
Moderate	Low PIC	Low/Med/High PIC (see notes 3 and 4)	Med/High PIC (see note 4)	Med/High PIC (see notes 2 and 4)
Minimal	Low PIC	Low/Med/High PIC (see notes 1, 3 and 4)	Low/Med/High PIC (see notes 1, 3 and 4)	Low/Med/High PIC (see notes 1, 3 and 4)

Notes:

1. With a PAR of 5 or more people, it is unlikely that the potential impact will be low
2. With a PAR of more than 100 people, it is unlikely that the potential impact will be medium
3. Use a medium classification if it is highly likely that a life will be lost
4. Use a high classification if it is highly likely that 2 or more lives will be lost.

6 Implications

The results from the modelling to date have implications for any proposed development within DA 17 land, and implications for the current owner of the dams.

6.1 Implications for proposed PC65

The DA 17 land is located within two separate titles, as shown in Figure 6.1 below. TDC has advised that:

- the western half is owned by the Hodgkinsons, and the eastern half is owned by the Browns;
- there is one existing house on the Brown property, at the north-eastern extent of the DA 17 area, as well as an existing shed, more centrally located;
- assuming 5000 m² alotments, the Hodgkinson portion of DA 17 could accommodate eleven new lots/dwellings, and the Brown property 9 lots/dwellings in addition to the existing dwelling;
- there are other issues (e.g. sewer and water supply servicing) still to be resolved that may affect final lot sizes and numbers of dwellings.

In addition, TDC has advised that the exsiting two dams are owned by Barry McIntosh, but that Michael Mokhtar is the owner of the consents (including consents related to use of the water).

The dambreak modelling shows that without any mitigation, the Brown property could potentially be subjected to significant inundation, while dambreak inundation is confined to a relatively small area within Hodgkinson property (refer T+T Figure 1003353-F1 in Appendix A).

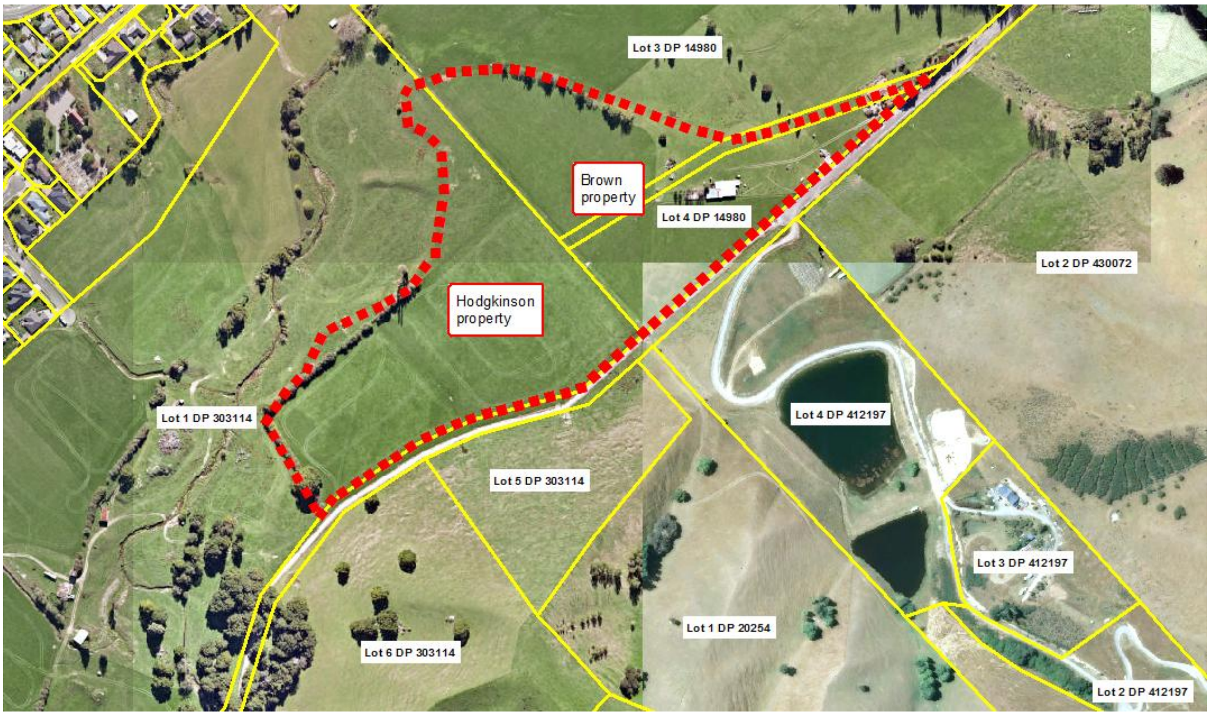

Figure 6.1: Ownership of land affected by DA 17. Approximate DA 17 boundary shown in red. Land ownership information provided by TDC.

Mitigation options may include one or a combination of the following:

- Excluding land shown as likely to be subject to dambreak inundation from the area to be rezoned;
- Bunding to reduce flooding on Hodgkinson and Brown properties. Some land on the southern boundary of either or both properties could be used to limit flood extents. An assessment would be required as to the impact of any such bunding on flooding and flowpaths in adjacent properties;
- Lowering the normal top water level (NTWL) of the dam, and/or infilling the lower contours of the reservoir to reduce stored volume available for release in a dambreak event. This would require temporary dewatering of the dam;
- Increasing the PIC rating of the dam based on the proposed development areas (considering population at risk and potential loss of life), and upgrading the dam structure and monitoring regime accordingly.

6.2 Implications for owners of existing dams and consents

Any development of downstream land may have implications for the owner and operator of the dams. The main implication is the possibility that the PIC rating for the dam may substantially increase. TDC documentation currently indicates that the dam has a PIC rating of “Very Low”.

Development within most of the Hodgkinson property (except a small margin along the eastern boundary) is possible without any impact on the PIC rating of the dam. However, any development within the Brown property is highly likely to substantially increase the PIC rating of the dam.

An increase in the PIC rating may require an increase in the design standard of the dam as well as increased obligations on the dam owner in terms of monitoring and reporting.

The lower dam is over 4 m in height and greater than 20,000 m³ in storage volume, and thus meets the criteria for classification as a Large Dam. Consequently, any significant change to the dam will need to be carried out in accordance with the 2015 NZSOLD guidelines, and a Building Consent would probably be required.

TDC have advised that records indicate that the dam may have last been inspected in 2000 by Doug Nottage for TDC. There are no records of any later inspection or maintenance work.

7 Observations of the existing dams

T+T staff visited the dams on 06 June 2017. The purpose of this visit was to obtain an understanding as to the catchments, flowpaths and drainage features in the downstream floodplain, rather than to inspect the dams. However, in the course of this inspection, the following observations were made with respect to dam safety and physical infrastructure that we include here for completeness:

1. Significant seepage was observed on the downstream faces of both dams, evidenced by the presence of reeds and soggy surface conditions at the time of inspection.
2. The rock-lined spillways of both dams showed evidence of scour. The spillway of the lower dam has significant scour of over a metre depth in places. The current dam owner reports occasionally throwing cobbles into the spillway. Some of this was still in place at the time of inspection, though some had also been washed to the culvert at the lower end.
3. Spillway flows are routed through two small culvert pipes under a cycleway at the lower end. TDC advise that these culverts were not specifically sized for a particular flow. At the time of inspection, the culvert inlets were partially blocked with gravel.
4. The normal top water level is approximately 0.4 m below the dam crest level. The owner reports water "sloshing onto the road" in storm conditions, and during the Kaikoura earthquake on 14 November 2016.
5. There is currently no facility to draw down water levels within either of the two dams if required for emergency purposes.
6. The downstream embankment of the lower dam appeared very steep between the middle of the dam and the left abutment. TDC LiDAR data indicates the embankment is at 1.5H:1V, which matches estimates made on site.
7. There has been some planting on the downstream face of the upper dam. Such planting can make observations of seepage and slumping difficult, and is generally not recommended.
8. Discussions with the dam owner and TDC indicate that there is no regularity to inspections of the dam, and that the most recent inspection appears to have been undertaken 17 years ago in 2000 (according to TDC records).

8 Applicability

This report has been prepared for the exclusive use of our client Tasman District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by: Authorised for Tonkin & Taylor Ltd by:

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William Dufour David Bouma

Water Resources Engineer Project Director

Report reviewed by Damian Velluppillai, Senior Water Engineer

DNV
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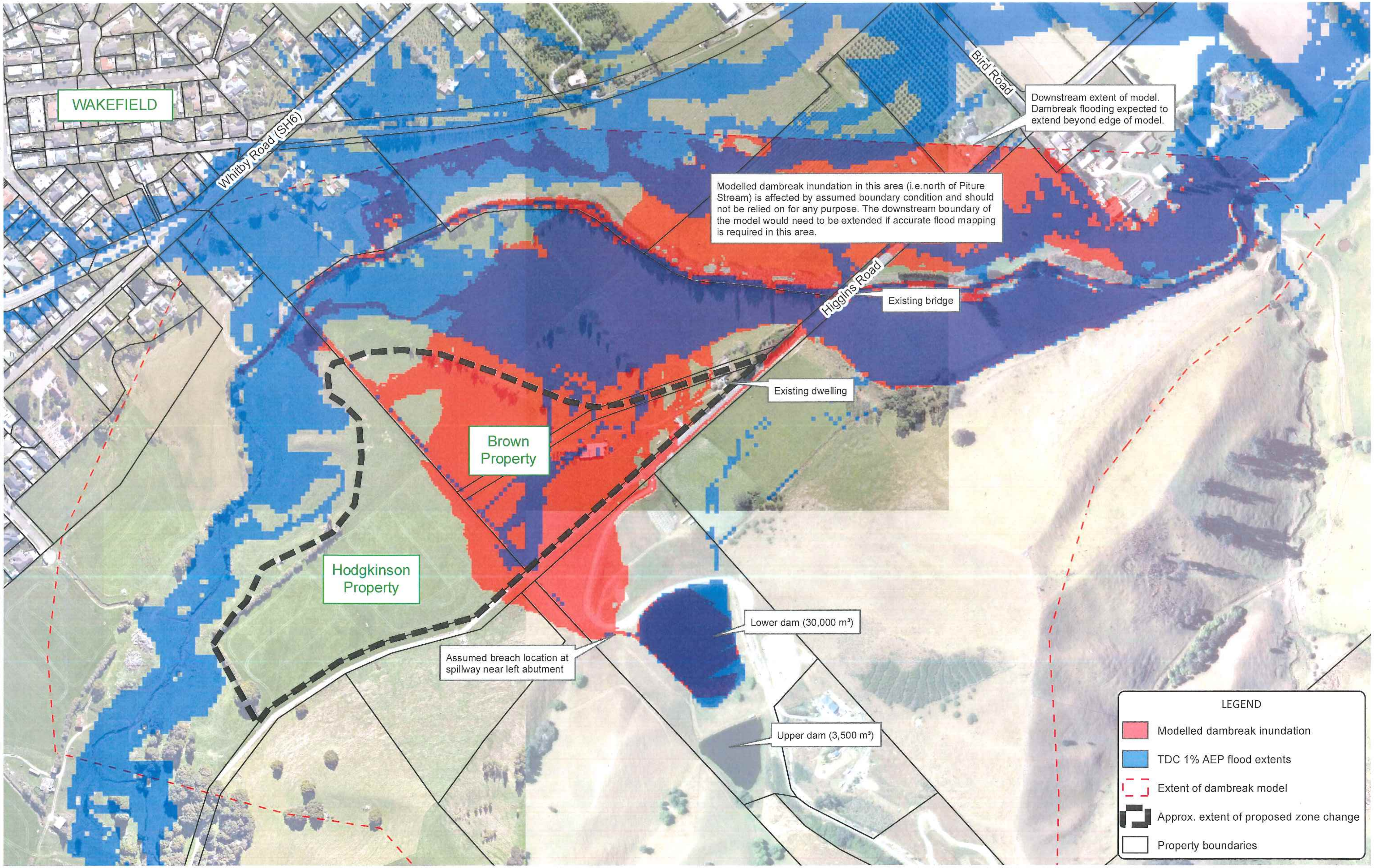
Appendix A: Flood inundation mapping

T+T Figure 1003353-F1: Modelled dambreak inundation extents



Notes: Aerial photograph, property boundaries and 1% AEP floodplain extents provided by Tasman District Council

A3 SCALE 1:4,000

0 50 100 150 200 250 Meters

Location Plan

Tonkin+Taylor

Lucas House, 51 Halifax Street, Nelson
www.tonkintaylor.co.nz

DRAWN	EMCF	Jul.17
CHECKED	DNV	Jul 17
APPROVED	pp DW	Jul 17
ARCFILE	1003353-F1.mxd	
SCALE (AT A3 SIZE)	1:4,000	
PROJECT No.	1003353	

TASMAN DISTRICT COUNCIL

PLAN CHANGE 65 DAMBREAK ASSESSMENT

Modelled dambreak inundation extents

FIGURE No. 1003353-F1 | Rev. 0

Path: P:\1003353\WorkingMaterial\GIS\FIGS\1003353-F1.mxd Date: 3/07/2017 Time: 12:03:05 p.m.

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