Meridian

In the matter of: the Resource Management Act 1991 (*Act*)

and

in the matter of: the hearing of submissions and further submissions by Meridian Energy Limited on Plan Change 13 (Mackenzie Basin) to the Operative Mackenzie District Plan

between **Meridian Energy Limited**
Submitter

and **Mackenzie District Council**
Territorial Authority

Statement of evidence of Nigel Connell on behalf of Meridian Energy Limited

Dated: 1 September 2008

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STATEMENT OF EVIDENCE OF NIGEL CONNELL ON BEHALF OF MERIDIAN ENERGY LIMITED

INTRODUCTION

1 My full name is Nigel Aldrich Connell.

2 I have the following qualifications: Bachelors Degree in Civil Engineering from the University of Canterbury graduating in 1964, and a Diploma of Hydraulic Engineering from Delft University, Holland, graduating in 1966.

3 I am a Member of the Institution of Professional Engineers New Zealand (IPENZ) and a Chartered Professional Engineer in New Zealand. I am a member of the New Zealand Society on Large Dams (NZSOLD); a technical group of IPENZ and the New Zealand Hydrological Society.

4 I am contracted to Damwatch Services Limited, a speciality dam engineering consulting company. I have had over 44 years experience in water resource development, dam engineering, and dam safety. This has involved experience in the fields of investigation, design, construction and commissioning of primarily water resource development projects including dams, canals, hydro development, river control, tropical irrigation, water supply, urban development and bridges. I have conducted twelve safety reviews on earthfill, rockfill and gravity dams in New Zealand and Indonesia.

5 I have been involved in the following work in relation to Meridian Energy Limited's (Meridian's) Waitaki Power Scheme:

5.1 I was project manager and team leader of the study which determined the Potential Impact Classifications (PIC) for the Tekapo, Pukaki and Ohau Canals.

5.2 I have assisted Meridian in developing seepage management programs for the Waitaki Power Scheme canals.

6 My evidence today addresses issues arising from the proposed future residential development nodes described in Plan Change 13 (Mackenzie Basin) to the Mackenzie District Plan (Plan Change 13). Some of these proposed nodes may be located within Landscape Sub-Areas (LSAs) that are in close proximity to important structures associated with the Waitaki Power Scheme. I am concerned in particular about new nodes being located within LSA's M6, M7 and M8. I note that the LSA references "M#" are as per the attachment to Meridian's original submission, a copy of which is **attached** as Annexure 1 for ease of

reference. LSA's M6, M7 and M8 are located wholly (in the case of M6 and M7) and partially (in the case M8) down slope from the Tekapo Canal.

7 As I discuss in more detail in my evidence below, the development of nodes within LSA's M6-M8 would impact on the PIC for key components of the Waitaki Power Scheme.

8 I am surprised that there is an absence of consideration of the impacts of these proposed nodes on the Waitaki Power Scheme, and on the appropriateness of the LSAs (and new nodes within them) given the natural and physical attributes of the basin (i.e. large floodplains, and the existence of hydro electricity infrastructure). While I am aware that the landscape and visual aspects have been considered in determining the location of the proposed LSAs (and within which new nodes may be developed), I have not seen any material that assesses the proposed nodes against criteria of this type either generally or specifically. I consider it appropriate that this assessment occur as part of making decisions on Plan Change 13.

9 In my professional opinion LSAs M6 and M8 require amendment as I describe in more detail below, and LSA M7 requires deletion in its entirety.

PIC (POTENTIAL IMPACT CLASSIFICATION)

10 PIC is an index defined in the NZSOLD Dam Safety Guidelines[1] (NZSOLD Guidelines) to indicate the consequences of a hypothetical dam or canal breach on the population, infrastructure and environment impacted by the consequent outflow of the dam or canal contents. Dam safety in New Zealand is regulated by the Building Act 2004, which refers to both the Building (Dam Safety) Regulations 2008 and the NZSOLD Guidelines. The NZSOLD Guidelines specifically address dams.

11 The Waitaki Power Scheme canals are large, impounding significant volumes of water. They are constructed both in cut and in other locations, depending on the topography traversed, on fill. The fill embankments vary from low, (where transitioning from cut to fill) to up to a maximum height of 46m. The canal embankments are zoned, engineered structures and the canal is lined with low permeability silty gravels (which forms one of the zones of the embankment). Zoned means the embankment section is constructed with up to 7 different earthfill material types in order to safely manage seepage within the canal embankments. Accordingly, and in accordance with NZSOLD

[1] New Zealand Society on Large Dams, November 2000, New Zealand Dam Safety Guidelines.

Guidelines, Section I-2, (which explains the special nature of dams and canals which retain very large volumes of water), the canals are treated as long dams for the purposes of determining their PIC.

12 Modern water retaining structures such as dams and large canals are very safe, with an extremely low likelihood of failure. This high level of safety is achieved by close attention to, and management of, the potential hazards and risks. An essential part of this process is the identification of the potential impacts or consequences of dam or canal failure. The principle is that a dam whose failure would cause excessive damage or the loss of many lives should be designed, commissioned and managed to a proportionately higher standard than a dam whose failure would result in less damage or fewer lives lost. Internationally, this is a well established standard practice for dams.

13 The Building Act 2004 requires the classification of dams according to the potential impact of failure of the dam on persons, property and the environment by applying prescribed criteria and standards for dam safety.

14 The potential impacts or consequences of a dam or canal breach are described in terms of life, socio-economic, financial and environmental effects. This classification system places dams and canals into "high", "medium", and "low" potential impact categories depending on the severity of the potential consequences of a hypothetical dam breach. This classification does not imply that the structure is more likely to fail, rather that the standards and actions to be applied by the owner in managing its safety should be more stringent to minimise the risk of a failure.

15 A fundamental principle adopted for the Waitaki Power Scheme canals is that a PIC can be applied to discrete lengths of the canals, because the downstream consequences of a canal breach vary depending on the features of that length of canal and the adjacent topography over which a potential canal breach outflow would discharge.

16 The Waitaki Power Scheme canals traverse generally undulating topography and breach outflows generally enter areas defined by topographic features and natural waterways. In some situations flow from a potential breach travels significant distances overland before reaching a collection channel such as a river. Assessing the lateral extent of a breach flow over broadly flat land, and the parameters such as depth and velocity, is a complex hydraulics problem requiring detailed topography and computer modelling of the overland flow. The assessment of the PIC of separate reaches of the Waitaki Power Scheme canals utilises information from canal breach and breach outflow hazard studies conducted for discrete reaches of canal, as

appropriate to both the canal embankment and the landscape over which potential breach outflow would traverse.

Compliance, monitoring and surveillance requirements

17 The NZSOLD Guidelines recommend design, construction, commissioning and surveillance standards for dams relative to the assessed PIC. For the design stage these relate to standards for the design (particularly design loadings) of the dam, the experience level of the designer and comprehensiveness of investigation and analysis input to design. For example, a small low PIC dam design may utilise precedent or empirically based design, based on foundation investigation carried out using test pits excavated by an excavator achieved in several days. A large high PIC dam on the other hand may require geologic and foundation investigation requiring months of input by an investigative team utilising exploratory drilling and other methods, followed by further months of input by a design team.

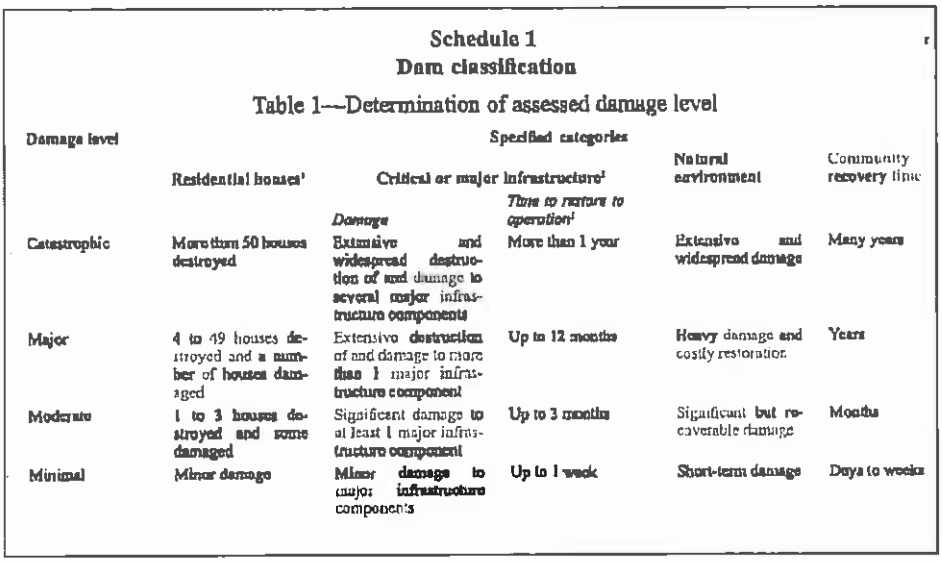
18 The Building Act 2004 requires that once established the PIC of all dams in New Zealand are reviewed 5 yearly, to identify any factors downstream of the structure which may adversely affect the current classification.

Assessment criteria

19 In order to assess the PIC of a dam or canal, in accordance with the Building (Dam Safety) Regulations 2008 (Regulations), the risk to public safety downstream of a dam or canal is first assessed by determining the damage level in accordance with Schedule 1 Table 1 of the Regulations; which are set out below as Figure 1. These include a matrix of residential structures, infrastructure and environmental components. Guidance is provided by notes to Table 1 (set out below as Figure 2).

20 The PIC is then determined from Table 2, copied from the Regulations and included below as Figure 3, using the Damage Level assessed from Table 1 and also the Population at Risk. The Population at Risk includes all those persons who would be directly exposed to flood waters within the canal breach outflow zone if they took no action to evacuate.

Figure 1: Schedule 1 From the Building (Dam Safety) Regulations 2008.

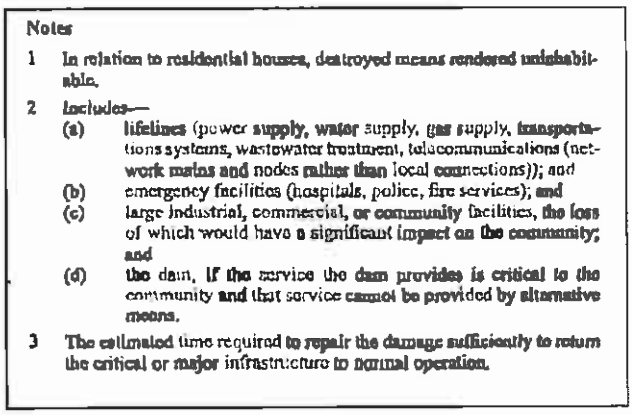


Schedule 1
Dam classification

Table 1—Determination of assessed damage level

Damage level	Specified categories				
	Residential houses[1]	Critical or major infrastructure[2]		Natural environment	Community recovery time
		Damage	*Time to return to operation*[3]		
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 to 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 to 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

Figure 2: Notes to Table 1.



Notes

1 In relation to residential houses, destroyed means rendered uninhabitable.

2 Includes—
- (a) lifelines (power supply, water supply, gas supply, transportations systems, wastewater treatment, telecommunications (network mains and nodes rather than local connections)); and
- (b) emergency facilities (hospitals, police, fire services); and
- (c) large industrial, commercial, or community facilities, the loss of which would have a significant impact on the community; and
- (d) 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.

Figure 3: Table 2 From Building (Dam Safety) Regulations 2008

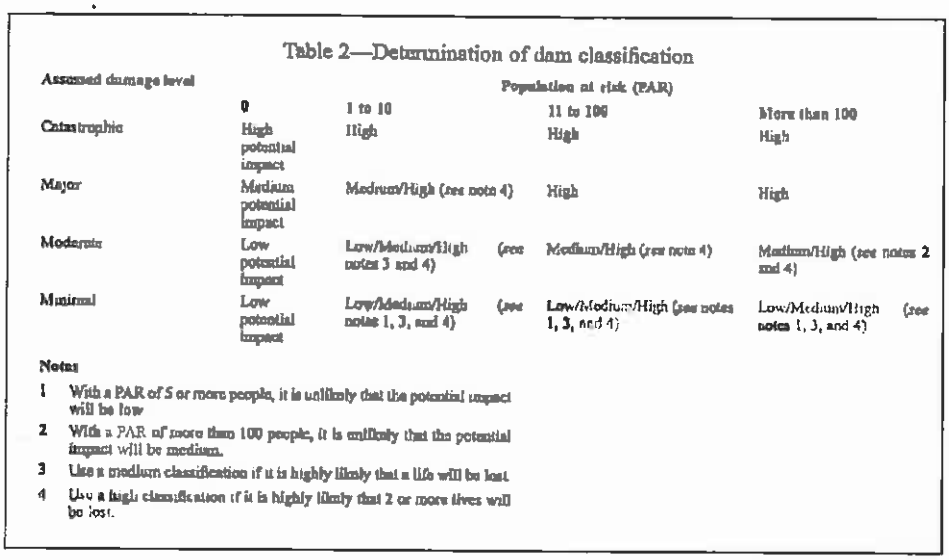


Table 2—Determination of dam classification

Assessed damage level	Population at risk (PAR)			
	0	1 to 10	11 to 100	More than 100
Catastrophic	High potential impact	High	High	High
Major	Medium potential impact	Medium/High (see note 4)	High	High
Moderate	Low potential impact	Low/Medium/High (see notes 3 and 4)	Medium/High (see note 4)	Medium/High (see notes 2 and 4)
Minimal	Low potential impact	Low/Medium/High (see notes 1, 3, and 4)	Low/Medium/High (see notes 1, 3, and 4)	Low/Medium/High (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.

21 An assessment of the PIC for an embankment reach of the Tekapo Canal is **attached** as Annexure 2 to illustrate the procedure used to assess the PIC for a dam or canal.

22 The consequences of a hypothetical dam or canal breach can be evaluated at varying levels of detail. For the purposes of this evidence the level of detail is explained in terms of the guidelines given by the Australian National Committee on Large Dams (ANCOLD) in their 'Guidelines on Assessment of Consequences of Dam Failure – May 2000' (ANCOLD Guidelines). The ANCOLD Guidelines describe Initial, Intermediate and Comprehensive Levels of Assessment as described below:

22.1 An Initial Assessment would be based on readily available data and general impressions, and is likely to be conservative and raise uncertainties;

22.2 An Intermediate Assessment requires a more quantitative assessment in terms of damages or losses and population at risk;

22.3 A Comprehensive Assessment is only required if there are unresolved uncertainties about the importance of the dam (or canal) or a lack of confidence in the assessment of consequence impacts. This level of assessment requires detailed data gathering and numerical modelling.

23 The approach taken in assessing the PIC for the Waitaki Power Scheme canals follows that adopted for assessing the impact of dams. There

are well established precedents in assessing the PIC for dam reservoirs. However, the same cannot be said for canal based systems. As explained previously, the fundamental principle used with the Waitaki Power Scheme canals is that different PIC values are applied to discrete lengths of canal, because the downstream consequences of any potential canal breach vary depending on the features of that length of canal and the adjacent topography in the area of the breach outflow.

24 For example, where a canal is entirely cut into the ground surface, it is not possible for a local collapse of the canal side to release significant amounts of water from within the canal. Thus, this type of canal section will have a PIC of low. However, a canal formed in a fill section, can release the water in the canal, if it were to fail. The PIC for this section of canal will depend on the potential consequences of such a release.

25 The approach taken to determine the PIC for the Waitaki Power Scheme canals is as follows:

22.1 Discrete locations are selected in the fill sections of each bank of each canal for evaluating the potential consequences of a canal embankment failure in that section;

22.2 At each selected location, the outflow from a hypothetical embankment failure is modelled;

22.3 The outflow across the ground surface is estimated (to the level of detail required as described above) based on the breach outflow and the topography over which the outflow traverses;

22.4 For assessing the effects on public safety, inundation at each individual residence and public facility in the inundation area is considered;

22.5 For assessing the socio-economic, financial and environmental consequences, information on the area of inundation, depth and velocity of flow is used to estimate the extent of damage;

22.6 The public safety and socio-economic and environmental consequences are input to Table 1 to determine the Damage Level which is input to Table 2 along with Population at Risk determined from residences and public facilities that are inundated, in order to determine the PIC; and

22.7 The PIC results assessed at each selected location are then assumed to apply along the adjacent canal length on each side

to the halfway point between that selected location and the next adjacent selected location or, in some cases, to the location where the canal passes from fill into cut.

26 This approach accounts for the effects of canal failure at specific locations due to the water released from that particular section of canal. There is a need to also determine the effect of water from one potential canal failure entering the next canal downstream and to assess the risk that this effect could lead to a cascade failure.

Consequence of an increase of PIC

27 While new structures can be designed and constructed to withstand the loads associated with the current or potential PIC for their location. The situation is more difficult for the existing canal structures which were designed and built decades ago, and which did not anticipate the land use changes currently proposed for the Mackenzie basin. It is considerably more difficult and expensive to upgrade existing infrastructure to meet a change in evaluation criteria, where this becomes necessary as a consequence of significant change in the downstream environment.

28 Should a change of land use or other change in the downstream environment result in an increase to the potential impact classification of a dam or canal, there are a number of consequences arising from that increase. These mainly affect the dam safety management activities of the dam or canal owner.

29 One set of consequences is the required frequency of surveillance inspection, the detail of assessment of monitored data, and the extent and frequency of safety reviews. If the PIC increases from low, to medium or high, then emergency planning also becomes necessary. This necessitates preparation by the dam or canal owner of an Emergency Action Plan (EAP) which is integrated with the Operations and Surveillance procedures, considers all the potential hazards, and puts in place actions to isolate, prevent, protect life, or, mitigate losses dependant on the circumstances of the emergency. The EAP will:

29.1 Identify emergency conditions which could endanger the integrity of the dam or canal which would require immediate action;

29.2 Document procedures to be followed by the dam owner and operating personnel in an emergency; and

29.3 Provide timely warning to police and civil defence for their implementation of measures for downstream communities such as evacuation.

30 For the Waitaki Power Scheme canals an increase in PIC will have relatively little effect with respect to surveillance and safety plans as there are sections of the canals that presently have a high PIC. The present surveillance and safety planning are generally in accordance with this high classification, but would require review and potentially additional activities if the PIC of sections of the canals were to increase.

31 A second set of consequences is the required assessment of canal embankments for earthquake loading.

32 The earthquake and flood loads for which a dam or canal has to be assessed increase significantly as the PIC increases from Low to Medium and to High. A safety review, particularly the comprehensive safety review of a dam or canal with a PIC which has increased from low to medium or high, would raise the need for an assessment of the performance of the dam or canal under increased earthquake shaking and also the ability to withstand more extreme floods. With respect to the Waitaki Power Scheme canals it is ensuring the capability to withstand the most extreme earthquake shaking loads that could be a significant impact on the owner, if new nodes of residential development are established in LSAs M6-M8.

33 For the Waitaki Power Scheme canals an increase in the PIC (by example, as a result of an increased residential development downstream of the structure) would increase the earthquake shaking loads which the canal embankment must withstand. Dam industry practice for earthquake loading is determined by reference to the publication by Mejia et al 2001[2]. For assessing dam safety Mejia et al consider the following:

33.1 For a high PIC dam, the Safety Evaluation Earthquake (SEE) is a 1 in 10,000 annual exceedence probability (AEP) earthquake event.

33.2 For a medium PIC dam, the SEE magnitude is that associated with a 1 in 2,500 AEP earthquake event.

33.3 For a low PIC dam, the SEE magnitude is that for a 1 in 500 AEP event.

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[2] Mejia, L., Gillon M., Walker J., Newson T. (2001) Seismic Load Evaluation Criteria for Dams of Two New Zealand Owners

34 Earthquake loading of a 1 in 500 AEP (low PIC) is the same as that required for general buildings in New Zealand. The building earthquake loading standard NZS1170 requires earthquake loading with an AEP of 1 in 2,500 for buildings of importance; including power stations. This equates to the requirements for a medium PIC dam. The effect of NZS1170 is that the SEE for low and medium PIC dams both need to be for a 1 in 2,500 AEP earthquake, and a 1 in 500 AEP event is not in fact ever used for low PIC dams. Accordingly, there is incremental earthquake loading (from 1 in 2,500 to 1 in 10,000 AEP) only if the PIC moves to high, and there is no real change from moving from a low PIC to a medium PIC.

35 If the PIC of a section of existing canal changes to high, the assessment of the canal embankment may reveal the need for strengthening to maintain the safety of the embankment for the high PIC earthquake loading criteria (i.e. the difference between 1 in 2,500 AEP and 1 in 10,000 AEP shaking loads). As mentioned earlier such upgrades of existing infrastructure are complex and expensive undertakings. The evaluations themselves are significant engineering undertakings, requiring specialist engineering input and costing hundreds of thousands of dollars. Should strengthening be necessary it could require, land purchase and construction of earthfill buttressing of canal embankment requiring expenditure by Meridian in the order of many hundreds of thousands of dollars per kilometre of canal affected. The actual expenditure would depend on the length and height of canal embankment that required upgrading. .

36 I have significant concerns with three of the LSAs shown in Plan Change 13 as being suitable for, and intended to provide for, further or new nodes of residential subdivision and development. Those LSAs are M6, M7 and M8 located wholly (in the case of M6 and M7) and partially (in the case of M8) down slope from the Tekapo Canal. LSAs M6 and M7 are both shown as suitable for three further nodes of residential development, and LSA M8 is shown as suitable for one such additional node.

37 I am concerned that these LSAs have been included in Plan Change 13 without apparent consideration of their location in relation to the existing hydro electric power canals in the Mackenzie Basin due to their potential impacts on that infrastructure. Surprisingly, it further appears that account has not been taken of natural flood plains of the Pukaki and Tekapo Rivers that pass through LSAs M5 and M8.

38 In the time available to prepare this brief I have not been able to delineate precisely the areas of the nodes that would be flooded by potential breach outflow from the Tekapo Canal. The topography of the landscape over which potential breach outflow would traverse before

entering a natural waterway varies significantly. Detailed evaluation of the extent of flooding by the potential breach outflow therefore requires detailed topography and numerical computer modelling of the breach outflow. In order to determine the inundation areas precisely it is necessary to survey the areas of inundation in order to get 1m contours (or better) and this is usually done with aerial survey of the areas. It is then necessary to numerically model potential breach outflows in order to determine both the area of inundation, and also the depth and velocity of flow.

39 Despite not having done a full assessment (i.e. involving actual survey and computer modelling work), it is possible for me, based on my expertise and experience with modelling breach outflow elsewhere, to assess the LSAs.

40 The proposed "Tekapo" LSAs M6, M7 and M8 located all, or in part, down slope of the Tekapo Canal, will impact on the PIC of reaches of the Tekapo Canal where the impact of potential canal embankment breach outflow is increased by development in the path of the breach outflow.

41 Potential breach outflow traverses:

41.1 the western area of LSA M6,

41.2 through the central area of LSA M7, and

41.3 through the central portion of the southern area of LSA M8 located down slope from the Tekapo Canal.

Approximate areas of LSAs M6, 7 and 8 that would be inundated by a potential canal breach are shown in Annexure 3, **attached** to my evidence.

42 In my opinion it is likely that the PIC for sections of the Tekapo Canal will change to high, if nodes of residential development were located in the areas of LSAs M6, M7 and M8 affected by inundation. My initial estimate of the lengths of canal embankment where the PIC would increase are summarised in Table 1, below.

Table.1: Initial Estimate - Tekapo Canal Embankment where PIC would increase.

Kilometre		Present PIC	Estimated PIC with Residential Development	Comment
From	To			
2	6.6	Low	High	Left bank
8.1	9	Low	High	Left and Right bank
17.7	21	Medium	High	Left bank
25.8	26.4	Medium	High	Left bank

Thus over 9km of canal are potentially impacted by the proposed LSA's. As noted in section 35 above this could result in a cost to Meridian of many hundreds of thousands of dollars per kilometre if upgrade to meet High PIC seismic criteria were found necessary.

43 As explained previously, it has not been possible to properly assess the precise extent of inundation of potential breach outflow in the LSAs. Proper assessment would involve topographic survey and computer numerical modelling of the potential breach outflows.

Summary

44 In my opinion, LSAs M6, M7 and M8 should be adjusted or deleted as follows:

44.1 LSA M6 should be reduced or moved in order to stay outside the area in the western portion of this node indicated approximately in Annexure 3;

44.2 LSA M7 should be deleted, as a major portion of this LSA is in the potential breach outflow area from the Tekapo Canal. The area of inundation in this LSA is also shown approximately in Annexure 3. While there are areas of LSA either side of the approximate area of inundation, I consider that the need to exclude infrastructure from the area of inundation makes development of the areas either side impracticable; and

44.3 LSA M8 should be reduced or moved in order to stay outside the area of potential breach inundation down slope from the Tekapo

Canal shown, and to also stay out of the area adjacent to and in the flood plain of the Tekapo River which is inundated by natural floods. For reasons similar to that given for LSA M7, I consider that the area west of the potential inundation area shown in Annexure 3 should be deleted.

RESPONSE TO PLANNER'S REPORT

45 I note that Meridian's submissions on the LSAs of concern addressed above are responded to in the Technical Report by Mr Densem. Mr Densem notes that the issues of concern to Meridian should be provided for in deciding the location of any particular node within the LSAs, but that "these matters are best dealt with on a case by case basis when an application for a new node is made" (page 18). Reference is also made to a policy in Plan Change 13 which requires that consideration be given to reverse sensitivity effects on power generation activities.

46 While I am not a planner and this matter is covered more specifically in the planning evidence and legal submissions for Meridian, I do not consider that this approach is sufficient given the importance of the issues raised and the importance of the Waitaki Power Scheme to the region and nation.

CONCLUSION AND RECOMMENDATIONS

47 In summary I conclude that it is not sound or sensible to provide for nodes of residential development in areas which will potentially require Meridian to undertake major remedial works to its canal structures in order to meet the standards of practice set out in the NZSOLD Guidelines.

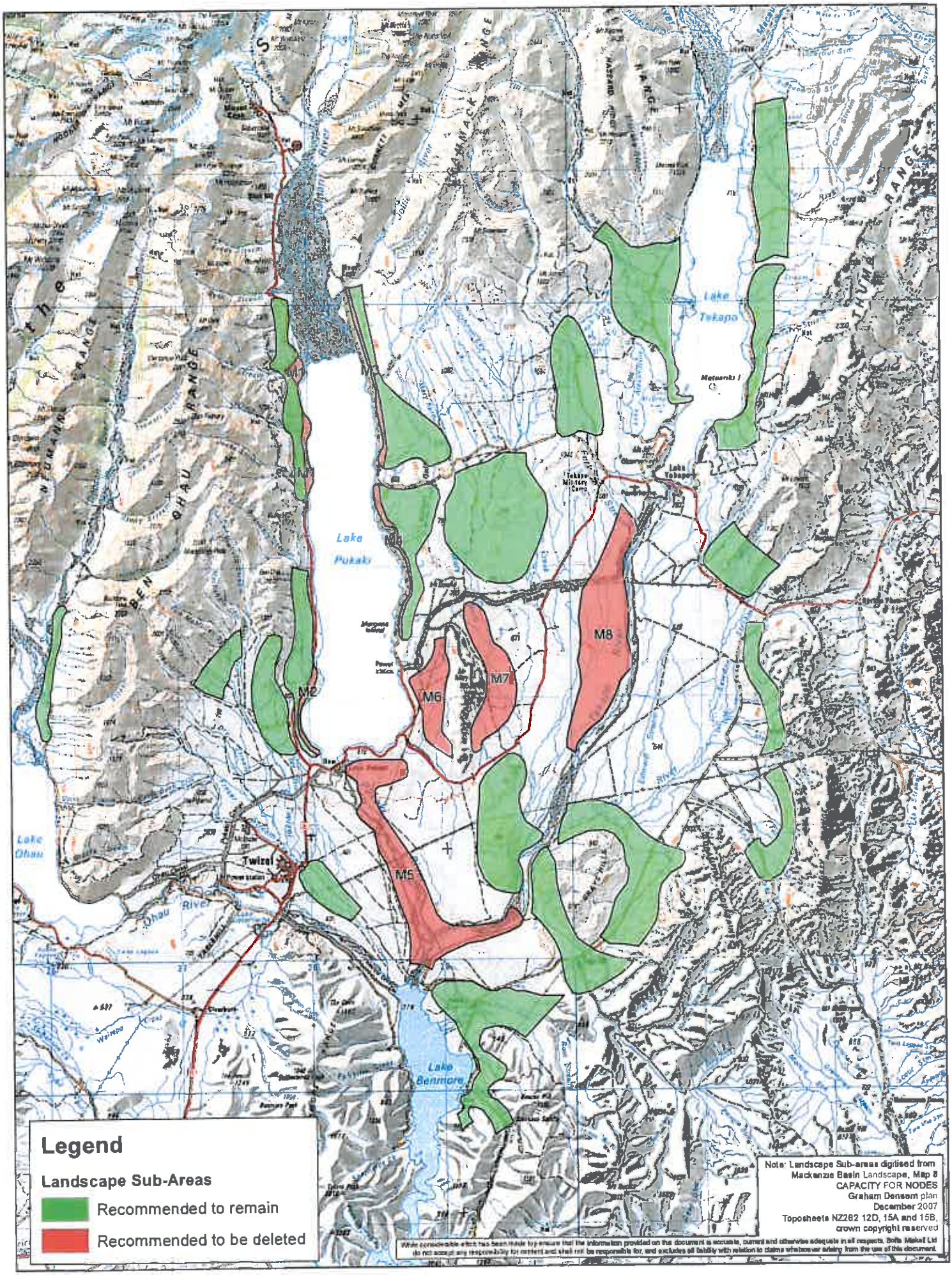
48 I therefore recommend that the LSAs M6, M7 and M8 be amended or deleted as set out in Annexure 3.

49 In order to move forward I consider it would be beneficial for the Council to meet with Meridian and its experts in PIC assessment, breach outflow and flood plain inundation modelling, so that the necessary amendments can be made to Plan Change 13 to provide appropriate areas for further or new residential nodes in the Mackenzie Basin.

Nigel Connell

Annexure 1

LSA references as per attachment to Meridian's submission.



Boffa Miskell

N

0 5 km

Scale - 1:250,000 (A3)

CAPACITY FOR NEW NODES
Meridian Recommendations

26 March 2008

ref. C06005_nodes.mxd

contact: gary.white@boffamiskell.co.nz

Annexure 2

Assessment of PIC for the reach km 11 to 12 of the Tekapo Canal.

This assessment of the embankment reach of the Tekapo Canal km 11 to 12 is provided to illustrate the procedure to assess the PIC for a section of the Tekapo Canal.

The broad approach taken is as follows:

- PIC determination is based on Building (Dam Safety) Regulations 2008, Schedule 1,
- Breach outflow assessment is used to determine the damage level based on damage to houses, infrastructure and the environment,
- The damage level is then determined from the Building (Dam Safety) Regulations 2008, Schedule 1, Table 1,
- The population at risk is estimated from the number of houses damaged and the average population per household from the most recent census,
- The PIC is determined from Schedule 1, Table 2 of the Building (Dam Safety) Regulations 2008

Breach outflow is determined by modelling a hypothetical breach in the canal embankment.

Hand calculations are undertaken initially to evaluate total storage volumes in each canal and to estimate for each hypothetical failure scenario, possible breach sizes, development times and peak breach outflows based on data from historical embankment dam failures. Selected failure scenarios are then simulated using a computational hydraulic model such as MIKE11. It is normal practice to adopt the worst breach outflow hydrograph from the scenarios modelled for assessment of the inundation downstream of the breach.

The canal details at 11.7 km are summarised in the Table Annexure 2-1 below:

Table Annexure 2-1: Canal Details

Locat -ion	Chain-age (m)	Embankment slope		Crest Width (m)	RL Crest	RL Invert	Max water level	Max water depth (m)	Embank -ment height (m)	Canal volume (million m^3)
		Mu:1	Md:1							
11.7 km	11765	2	2	6.10	678.5	671.2	676.82	5.58	7.32	421

The breach outflow down slope from the canal is then assessed dependant on the precision needed for assessment of the PIC.

For an Intermediate Assessment as defined by ANCOLD and described previously in paragraph 22 of my evidence, available topographic data and photographs obtained from a site reconnaissance are used. A judgment is made with respect to the amount of flood peak attenuation and flood spread anticipated downstream to where the canal or dam break flood would impact on either people or infrastructure. Based on the results of this assessment, flood hazard zones can be sketched and transformed to a composite flood hazard map. However, for the reach km 11 to 12 in this example one farm homestead and SH8 are in the outflow path and sketching of flood zones is not necessary.. It should be emphasised that in this case using 1 to 50,000 topographic maps with 20 m contours, these hazard maps are being prepared with only very limited topographic data. The outflow across the ground surface is estimated from assessment of the topography and outflow based on experience modelling such flows elsewhere.

A conservative approach is therefore necessary in defining the hazard zones of the inundation hazard maps based on this intermediate level of assessment.

Determination of the Damage Level is summarised in Table Annexure 2-2, below.

Table Annexure 2-2: Determination of Assessed Damage Level

Location	Scenario No	Breach Outflow Summary	Assessment of Damage to Houses	Socio Economic Financial and Environmental	Damage Level
11.7 km	TIL	4.21 M m^3 released with peak outflow 220 – 280 m^3/s.	Outflow passes through the Wolds Homestead, 2 habited houses with 1 to 2 m depth water with d x v > 1.	Significant but recoverable environmental damage. Large farm operation plant and equipment damaged, hence major financial loss ($1 to 10 million).	Moderate

The resulting Damage Level (in this example Moderate) is then input to Schedule 1 Table 2 of the Building (Dam Safety) Regulations 2008 as summarised in Table Annexure 2-3 below.

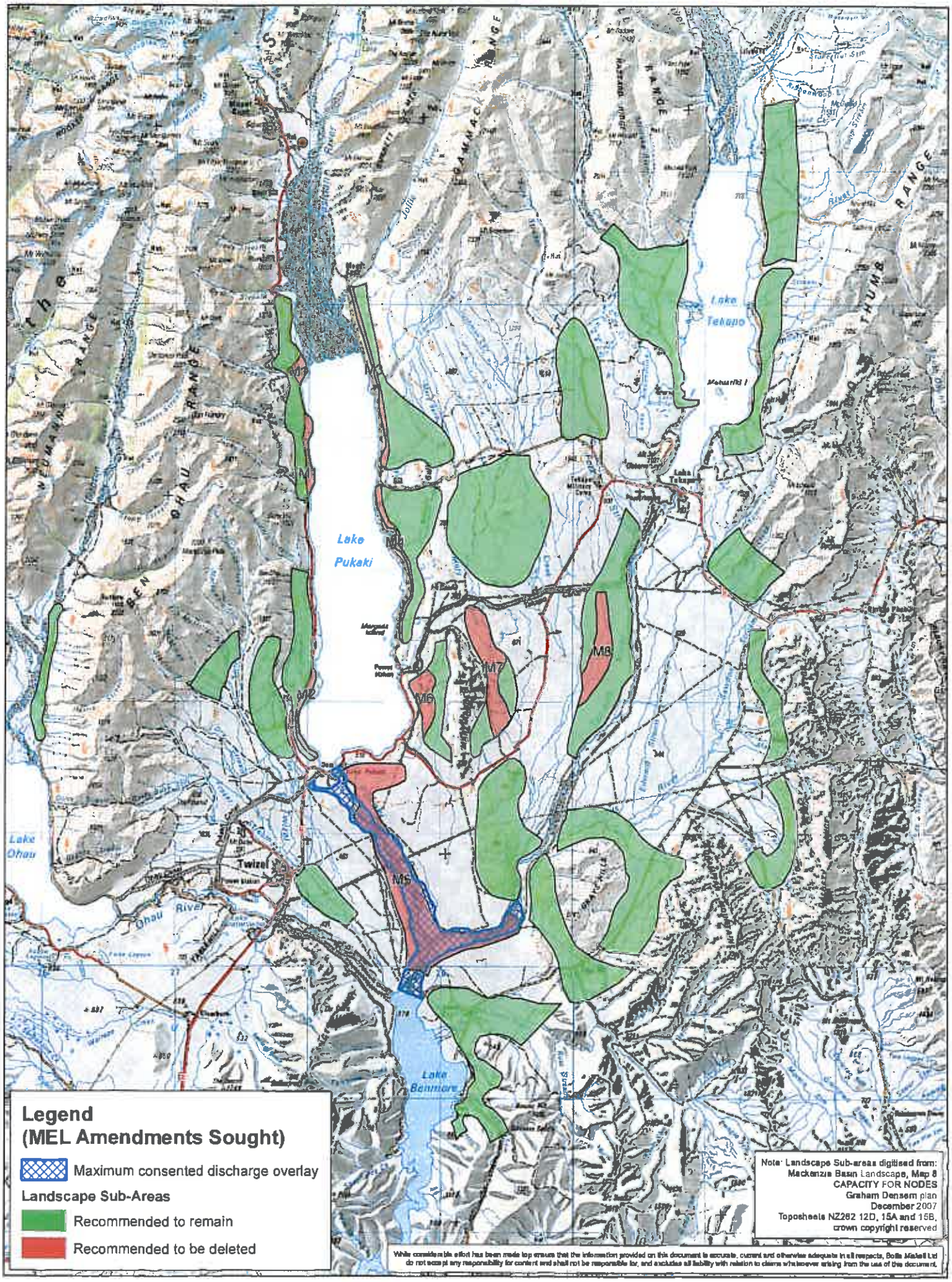
Table Annexure 2-3: Determination of Dam Classification

Assessed Damage Level	Population at Risk	Fatalities	PIC
Moderate	1 to 10	Highly likely 2 or more lives would be lost	High (based on Note 4)

Should there be need for a Comprehensive Assessment, topographic mapping would need to be obtained which requires site survey or more usually controlled aerial photography from which topographic contours at 1 m interval would be produced. This topography would input to a breach outflow computational hydraulic model such as MIKE 21 capable of modelling the relatively shallow spreading overland flow from a hypothetical breach. Output from this computational hydraulic model would then be used to produce precise inundation hazard maps for such a comprehensive level of assessment. Assessment of the PIC is then done as summarised in Tables Annexure 2-2 and 3 above.

Annexure 3

Approximate areas of LSAs M6, 7 and 8 that would be inundated by a breach of the Tekapo Canal



Legend
(MEL Amendments Sought)

- Maximum consented discharge overlay

Landscape Sub-Areas

- Recommended to remain
- Recommended to be deleted

Note: Landscape Sub-areas digitised from:
Mackenzie Basin Landscape, Map 8
CAPACITY FOR NODES
Graham Densem plan
December 2007
Toposheets NZ262 12D, 15A and 15B,

Boffa Miskell

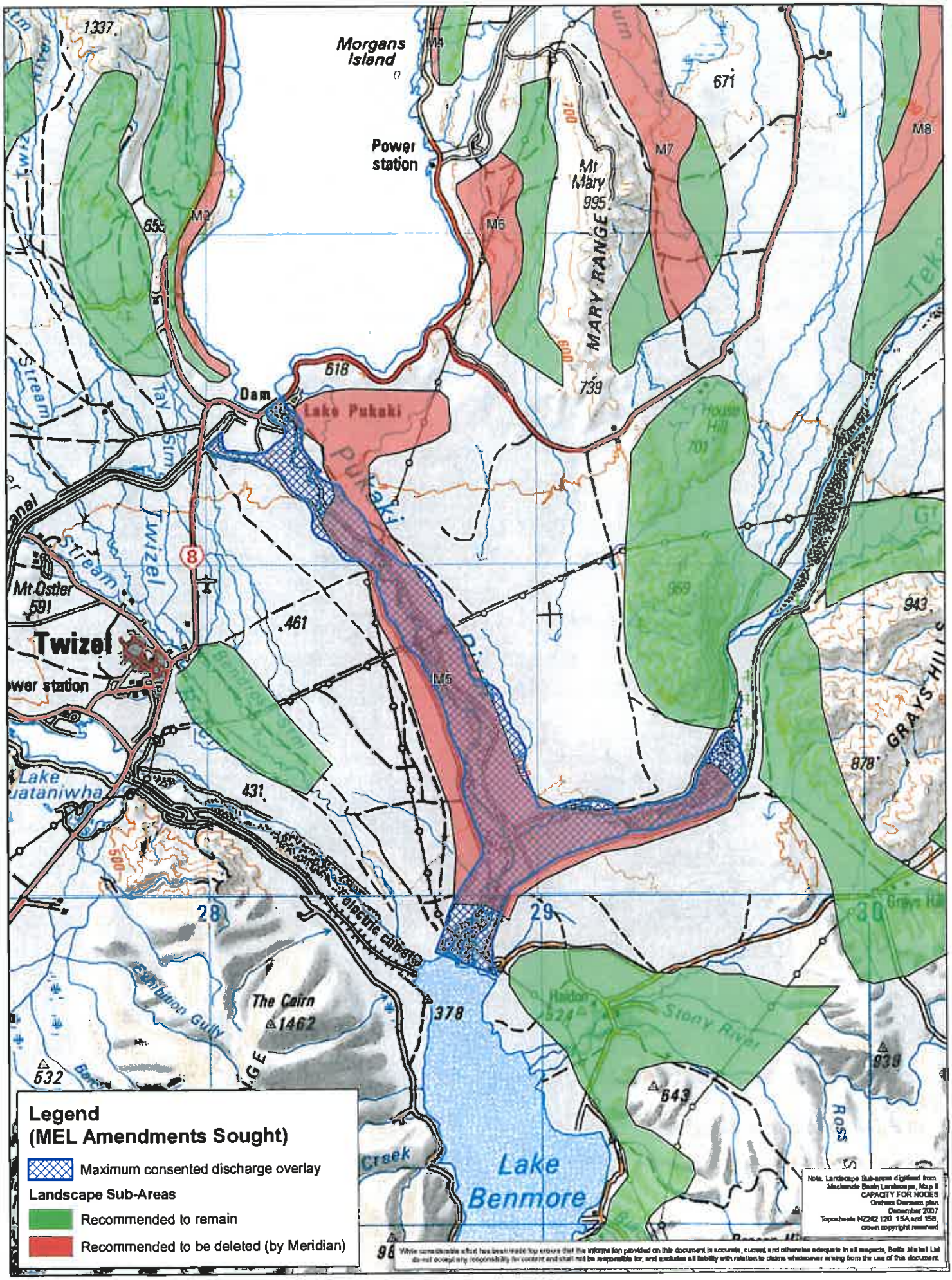
0 N 5 km

Scale - 1:250,000 (A3)

PROPOSED NEW NODES WITH AMENDMENTS SOUGHT BY MERIDIAN

29th August 2008

ref: C08005_001_nodes_r1.mxd
contact: gary.white@boffamiskell.co.nz



Boffa Miskell

0 N 2 km

Scale - 1 :100,000 (A3)

PROPOSED NEW NODES WITH AMENDMENTS SOUGHT BY MERIDIAN

29th August 2008

ref: C08005_002_FloodFailure_r1.mxd

contact: gary.white@boffamiskell.co.nz