Appendix A: Stage 3 design drawings (Bound separately)

Appendix B: Peer review letters

25 October 2011

Joseph Thomas
Project Manager WWAC
Tasman District Council
Private Bag 4
Richmond
Nelson 7050

6CWI04.00

Dear Joseph

Lee Valley Dam - Initial Peer Review Feedback on Stage 1 Design Report

It had been our intention to provide formal review feedback on the stage 1 design in a format similar to our previous review comments on the geotechnical investigation matters. However, the preliminary nature of much of the design information presented at this time is not particularly suited to this approach, as much of it is expected to be overtaken by the advancing state of knowledge as the design progresses. Furthermore, as reviewers we need to maintain a degree of independence from the design development process, in order to effectively carry out our review of the final design without being compromised by any earlier inputs to the process. On this basis we have chosen to table the following informal feedback with a view to:

- Identifying any ambiguity or lack of clarity in our understanding, and
- Initiating discussion on key aspects of the current design.

The following points are expected to dovetail into the current process of updating the risk register insofar as risk and uncertainty form the focus of our review.

We have addressed the matters in categories of hydrology, hydraulics, and structural / geotechnical design. Matters pertaining to water quality are not covered at this point, and we have not duplicated the geotechnical investigation matters covered in our previous formal review response as these are essentially still current. The items are presented in no particular ranking of significance. Some of the informal review points presented pertain in part to the adoption of final design or performance criteria, which the review team has already been asked to comment on prior to the production of the stage 1 design report. We are of the view that while the design standards applicable to a high PIC impoundment are broadly defined in the NZSOLD Dam Safety Guidelines, there is opportunity for detailed performance targets to be defined in their context of the design form adopted, its degree of resilience, and the degree of confidence established in the detailed loading conditions and response mechanisms at work. We therefore see this aspect as neatly linking in to the current risk assessment process, and will be pleased to support this process wherever we can add value.

Hydrology

1. On p2 a definition of ARI is provided. In fact this definition is incorrect. ARI is generally used as an abbreviation of Average Recurrence Interval and not Annual Recurrence Interval.

2. The assessment of the potential effects of climate change follows a very standard approach. Of particular concern, however, is that most of the 'methods' suggested relate almost solely to the potential effect of climate change on storm rainfall. No consideration is given to all the other consequential effects which may occur within the hydrological cycle, and in particular to the rainfall-runoff relationship.

3. Given the uncertainty and wide range of potential values for the predicted rise in average temperatures we would question the use of 'mid range values'. This is particularly the case for a major infrastructure development such as the Lee Valley dam, and where the potential consequences are significant should under-design result in failure. we would have thought that conservative design might require the use of 'high end temperature increases'; or at least the provision of a sensitivity analysis to show the potential range and variability of such effects. The latest temperature predictions and trends are that temperatures are actually rising faster than the mean predictions. Each revision of the predictions has resulted in an increase in expected temperatures. It would be useful therefore to see the difference of using perhaps 2.9°C (the mean of the A1FI high emission scenario) as opposed to 2°C used in the analysis presented. The use of a higher predicted temperature rise would also recognise the high level of uncertainty inherent in global warming predictions and their possible effect on storm rainfalls.

4. Given the significant changes in temperature used in the modelling of storm rainfall, we are concerned that these differences were then used in a rainfall-runoff model calibrated to the current climatic conditions and environment. While it might be impossible to model how the Lee Valley hydrological and rainfall-runoff system will operate in 80 years with a rise in temperature, it is overly simplistic to argue that the only change will be in storm rainfall.

5. If such a significant change is expected in rainfall, one would also expect changes in evapotranspiration, soil storage, vegetation cover, runoff coefficient, and a range of other factors. In addition, the formation of the dam is likely to significantly change the rainfall-runoff relationship by resulting in 100% runoff over the dam. This effect may be significant depending on the surface area of the reservoir and the runoff rates used for the rest of the catchment under the existing scenario.

6. Some discussion is therefore required as to the uncertainty of the future rainfall-runoff relationship, and how this uncertainty has been incorporated into the design.

7. The issue of uncertainty is critical given the residual error which still remains in the HEC-RAS rainfall-runoff model even after calibration. Although it is argued that the calibration is good, it would appear that the errors are still up to 20% with respect to the peak discharge. It is of particular concern that the modelled

flows are always (in the examples provided) less than the measured flows. As stated, this difference will be even greater once the dam is formed and the runoff coefficient for a significant proportion of the catchment becomes 100%.

8. The most recent calibration event also shows a modelled peak discharge of ~168m³/s compared to a measured discharge of 208m³/s. That is, the modelled peak discharge is only about 80% of that measured.

9. While the calibration of storm volumes is argued to be better, this is only after the recession constant and base flows have been adjusted. The recession in the model always appears too slow. Adjustment appears to be necessary for each event modelled. This raises questions regarding the validity and uncertainty of using the same model to predict future storm runoff given further changes to the rainfall-runoff relationship.

10. Given the uncertainty in the rainfall-runoff model for the existing situation, what are the implications of this when using the same model to predict the potential effects of climate change? It is important that the logic applied to rainfall-runoff modelling, and predicting the potential effects of climate change, is consistent. At present this does not appear to be the case. At the very least the assumptions and argument used must be explicitly stated.

11. Given the uncertainty in the results of the rainfall-runoff model it is important that the significance of this uncertainty in both peak discharge and storm volumes are assessed by routing a range of flood hydrographs through the dam. It is only following this routing that the significance of uncertainty in the model, and the predicted effects of climate change can be assessed.

In summary, we believe that there is considerably more uncertainty in the rainfall-runoff modelling and assessing the potential effects of climate change than argued. While much of this uncertainty cannot be quantified, it is critical that it is recognised. It is therefore essential that the potential effects of this uncertainty are assessed by using a range of more extreme values and by routing the different flood hydrographs through the dam. Where possible the potential effects of this uncertainty should be quantified and otherwise clearly stated.

Hydraulics

1. Flood Hydrology

Further to the above comments on the hydrology, the flood estimates for the dam site have been produced using a rainfall / runoff model calibrated against recorded flood discharges for three relatively modest flood events – 22 January 2008, 24 November 2008 and 19 January 2011. The measured hydrographs for these floods are from the Lee River above Waterfall Creek gauging station. It is unclear how accurate the "measured" peak flood discharges for these calibration events are. Nor is it clear what the accuracy of the flood estimates for much lower flood frequencies obtained from the rainfall / runoff routing model is. The following specific questions relate to these issues.

How good is the stage / discharge rating for this gauging station? What is the highest flow that has been gauged with a current meter at this site?

How good are the peak flood discharges estimated from the stage / discharge rating for the rainfall / runoff model calibration events? Have they been extrapolated above existing current meter gauging measurements? If so, by how much? What is the possible error in the stage / discharge rating curve when extrapolated to higher sages (river levels)?

What is the possible error in the predicted discharge estimates for lower frequency floods in Table 3-1?

2. Selection of Construction Design Flood

Flood Routing during construction - Tables 6-1 and 6-2

We have difficulty understanding the figures in the "Peak Outflow if Dam Does not Breach" Column. For any crest level of the partially completed dam presuming that the flood water reaches that level then the outflow will be the same for each occasion. The peak outflow will be at the maximum water level reached and thus the flow increases as the level rises.

Section 6 of the report is somewhat confusing and inconclusive. It concludes with the statement that "the risk to downstream areas over the period of construction for this diversion option is likely to be an order of magnitude lower than over the nominal service life of the dam". This statement requires community acceptance of the duration time consequence of the hazard exposure to be a simple function; some further debate as to the validity of this approach is needed when comparing risks during construction with risks during the service life of a structure.

It is not clear what the selection criteria are for the diversion culvert size. Nor is it explicitly stated what the recommended diversion culvert size is although a sample risk profile is given for a diversion culvert with a cross-sectional area of 24m2.

For this culvert size, what size (magnitude and frequency) floods would just be able to be passed without the partially constructed embankment dam being overtopped at the three intermediate construction levels – 165m, 175m and 185m?

What would be the incremental downstream Population at Risk if the partially constructed dam was to be overtopped and fail?

3. Height of Parapet Wall on Dam Crest

Table 11-4 in Section 8.1 (page 45) refers to10% and 1% AEP wave heights on the dam. These will be a significant factor in determining the height of the parapet wall on the dam crest. However there is no discussion of wind wave effects and how these affect the design of the dam crest.

What is the general philosophy that is being adopted with respect to design of the wave wall on the dam crest?

What is the critical wind direction that gives rise to the maximum wind speeds at the dam site? What is the critical wind direction that is aligned with the proposed reservoir? What wave heights are generated by the maximum wind speeds with the critical direction? What is the runup on the dam face from these wave heights? How does the proposed reservoir operation impact on reservoir levels and hence the height of wave runup on the dam?

4. Spillway Capacities

It is not clear from the report what the overall philosophy is with respect to proposed spillway capacities and operation.

When is the auxiliary spillway proposed to be first activated? What is the discharge capacity of the primary spillway at this time? What is the headwater level at the dam? What flood magnitude does this correspond to?

When is the second part of the auxiliary spillway proposed to be activated? What are the discharge capacities of both the primary and auxiliary spillways at this time? What is the headwater level at the dam? What flood magnitude does this correspond to?

What is the overall design capacity of both the primary and auxiliary spillways? What is the design headwater level at the dam? What flood magnitude does this correspond to?

5. Spillway Hydraulics

The sharp side-wall contractions shown in the spillway chute layout will give rise to the formation of cross-waves which will be reflected back and forth across the chute at they are conveyed downstream by the high velocity super-critical chute flow. The side-walls will need to be high enough to contain these cross-waves. The magnitude of the cross-waves will be exacerbated if the width of the ogee crest is increased.

Under PMF conditions, the flow velocities in the flip bucket (ski jump) at the bottom of the spillway chute are expected to approach ~27m/s. For flow velocities of this magnitude (> 20m/s), the potential for cavitation in the spillway flip bucket is significant and needs to be addressed. Cavitation mitigation measures may be required.

The jet projecting from the end of the flip bucket at the end of the spillway chute will spread laterally before impacting in the area of the plunge pool downstream, At the present time the plunge pool geometry shown on drawing no. 27425.100-100 does not show any divergence from the flip bucket structure to accommodate this spread of the spillway jet. Erosion of the left bank adjacent to plunge pool is therefore likely to be a significant issue.

The area of the plunge pool needs very careful attention to minimise the risk of bank erosion. This may require excavation of a wider plunge pool area and adjustments made to the spillway chute and flip bucket geometry to direct the spillway jet to fall more in the centre of the river.

The effects of river bed erosion by the falling spillway jet in the plunge pool area needs to be addressed.

Structural and Geotechnical Design

1. Much of the detail provide is labelled preliminary, or is essentially generic in nature. Our comments are therefore subject to design development decisions. Some figures in the report do not directly match the details on the attached drawings.
2. The scope of foundation improvement is the form of undercutting and concrete backfilling, grouting, dental concrete / shotcrete etc., is subject to quantification.
3. Construction River Diversion – Sec 6.2

    It is noted that the starter dam is preliminary at this stage and will be detailed in a subsequent design stage. This is potentially an important element in the design of several features of the project, and its scope needs to be determined to progress the other elements.

    Conduit velocities are critical and there needs to be quantitative consideration of erosion / abrasion factors and possible treatments regarding invert and wall damage.

    Further explanation would be helpful to our understanding on how the diversion is to be plugged and the inlet/outlet flow regulation managed (ref dwg 500)

    An indication of the structural design detail for the conduit is yet to be provided, especially the nature of any jointing.

4. Embankment Design

    The adopted upstream slope is critical in determining the location of the plinth. As the design and geotechnical investigation work progress there is less scope to vary the slope, despite the comment that final batter slope geometry is yet to be determined.

    it is not clear from the report if the use of kerb wall construction (Figure 7-4) is to be used over the whole dam or only particular areas. For instance the kerb option is not shown in Figures 7-1 or 7-2 or in the details in drawing sheet 530. The use of kerbs to retain the upstream face is considered to be a practical feature, but there are also means of compacting a 1.5:1 face slope.

    In Table 7-1 Zone 3A has not been included. If kerbs are to be used over the whole face the role of Zone 2A needs to be clarified.

5. Concrete Facing Membrane

    We agree that 300mm is an appropriate nominal thickness for the concrete face slab and in line with guidelines for concrete-faced rockfill dams. We presume this is the minimum tolerance; i.e 300mm -0/+xxmm?.

    The vertical construction joints in the slipformed panels are shown (dwg 250) with continuous horizontal reinforcement. This detail is inferred to apply to all such joints with no thermal contraction provision across the membrane. Supporting detail is needed to show that the in-service thermal stresses will be adequately accommodated by this approach, especially on a partially full reservoir condition.

    The perimetric joint detail at the starter dam (dwg 250) indicates that the supporting internal formed face slope is other than perpendicular to the membrane plane immediately below the joint. Supporting detail needs to be provided to show the performance of the joint under severe seismic loading will not be compromised by this design.

Evidence of consideration having been given to durability and / or maintenance of the perimetric joint needs to be provided.

The basis of the structural separation of the parapet wall from the concrete facing membrane needs to be provided.

6. Outlet Conduits and Associated Features

The nature of the structural interaction between the outlet risers and other elements and the sealing details needs to be provided, particularly under conditions where settlement or other deformation may occur.

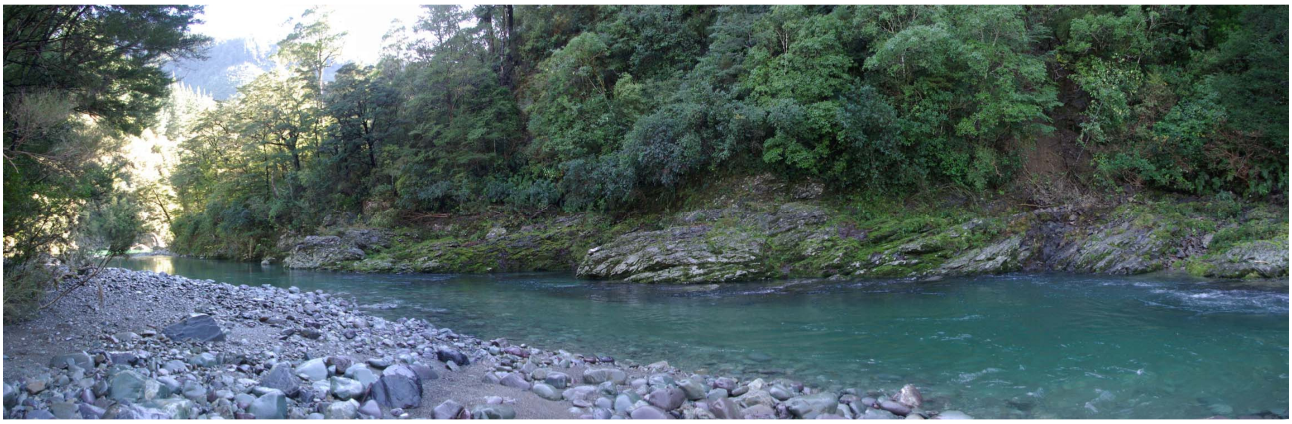
We are not clear as to the mode of operation of the gated inlet and the means of maintaining the functionality of this feature.

The need for and nature of venting the conduit under normal tail water conditions is unclear to us from the information shown on dwg 500.

Yours sincerely

Ian Walsh CPEng, Rec Eng (A), FIPENZ
Partner - Opus International Consultants Ltd
Lead Reviewer on behalf of the following review team members
Lambert Anderson
Dr Grant Webby
Dr Jack McConchie

Cc Mark Taylor
Tonkin & Taylor (Auckland by email)



Peer Review of Lee Valley Dam Design

Interim Report	Number 03	Date 27 January 2012
Purpose of Review Report To present review feedback on the adopted design criteria for structural behaviour aspects; Review of hydraulic design criteria is covered by separate communication.		

Review Team Contributors Ian Walsh		
Reviewed Documents	T&T Letter Keith Dickson "Lee River Dam – Detailed Design Criteria" and attached report.	T&T Ref 27425.100 13 April 2011, and report issue 1 of 12 April 2011
Relevant Communications		

Copied to:	**WWAC** **c/- Joseph Thomas** **Tasman District Council**	**T&T Nelson** **Attn M Foley**	**T&T Auckland** **Attn M Taylor**

Attachments	None

Ref ID	Description of the Risks	
010	Adopted design criteria do not satisfy structural performance or compliance obligations as represented by accepted industry good practice or the application of NZSOLD Dam Safety Guidelines as a means of establishing compliance with the Building (Dam Safety) Regulations or the NZ Building Code.	
	Peer Review Position General Design Criteria as listed in Table 4.1 and following sections of the report Review comments only by exception; all uncommented criteria are accepted in principle. Note that review of the GNS seismic advice is outside of the scope of this commission, but the seismic design approach and design standards are included. Functional outcomes not related to impoundment safety or "building" compliance are also not included within the scope of this review. **Operational basis earthquake: OBE.** I concur that site specific seismic assessment can be applied to establish the appropriate ground response for the chosen annual exceedence probability event(s). However, I am of the view that the NZSOLD OBE criteria can be non-conservative in some instances if it is applied without due consideration of the specific nature of the progressive failure mechanism(s) relevant to the structure and its critical elements. For example, for a CFRD structure of this nature, I would expect that the water retaining element including all joints should be designed to remain fully serviceable in an event with an AEP of say at least 500 years. I therefore consider the project would benefit from some development of the OBE design condition from a serviceability perspective. I anticipate that such development will not significantly change the physical nature of the final design, but it will give greater clarity to the important progressive failure mechanisms and improved confidence in understanding the failure risks. **Seismic loading for non-critical structural elements**. I presume this category is intended to apply to elements that do not have a primary or secondary function related to safe retention of the impoundment and that are not expected to be associated with response to an impoundment related incident. That is, by definition not "appurtenant works", and therefore requiring compliance within the "normal" building control provisions of the Building Act rather than the specific dam safety clauses. I concur that site specific seismic assessment can be applied, but actual design loading should be checked against the methodology and annual exceedence probability criteria of NZS1170.5, specifically the importance level rating and the design service life for such elements.	**Active**

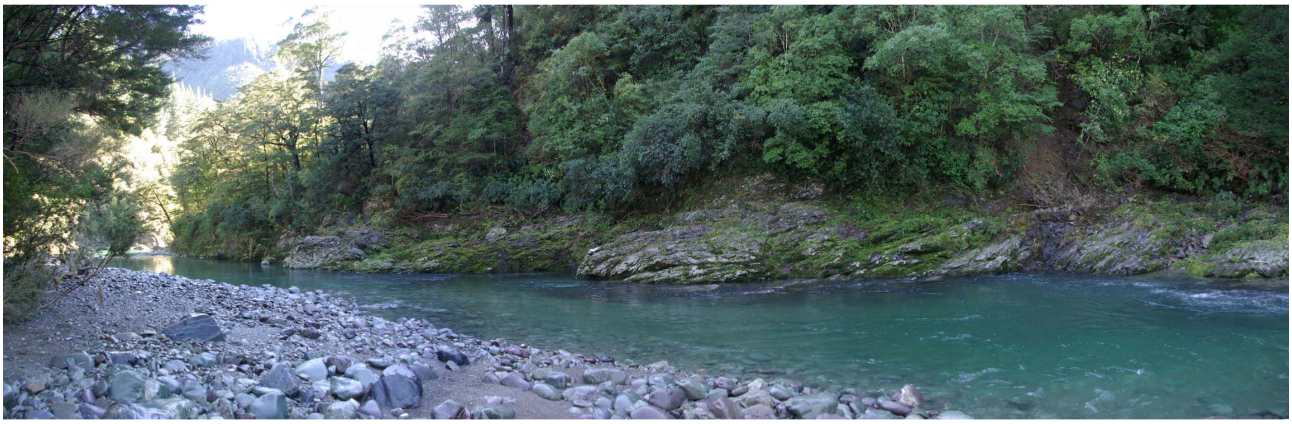
Loading combinations. The listing of load combinations presented in section 4.2 appears to be incomplete. For example, given the stated intention in section 4.13 to design the embankment to remain stable without the concrete facing being intact, the loading cases will need to include for various seepage conditions as identified elsewhere in the report, and the associated degree of stability / deformation that may be considered acceptable. Furthermore the manner of including transient hydraulic loadings onto the structural elements is not identified, nor the nature or degree of how of thermally induced stresses are to be considered. I support the intended use of Makdisi-Seed simplified embankment response analysis in this case, and suggest that the load combinations need to be extended to clarify the seepage conditions to which this analysis is to be applied. This rational analysis approach addressed in section 4.13 is supported, but no associated specific performance targets / criteria have been defined.

Seismic loading for appurtenant works. As appurtenant works by definition are elements that have a primary or secondary function related to safe retention of the impoundment and/or that are expected to be associated with safe response to an impoundment related incident, the applicable design standards may not be fully captured by the listing presented in section 4.3. There is potential for other criteria to apply to any such "critical" elements, subject to specific assessment of the specific potential failure mechanisms identified, and their influence on risk exposure.

Seepage rates: Section 4.5.4 presents several target seepage / drainage capacity parameters, but does not clarify where a facing "failure" involving say damage or deterioration of the perimeteric joint may fit within this listing, as it is inferred that this information may relate primarily to seepage paths that bypass the facing/plinth system.

Constructed and Natural Slopes: Sections 4.15 and 4.16 address management and analysis methods to be applied to slope instability risk, but do not present the target performance or design criteria as such. The adoption of a systematic risk based approach is supported, but the threshold levels of acceptable and tolerable risk will need to be established.

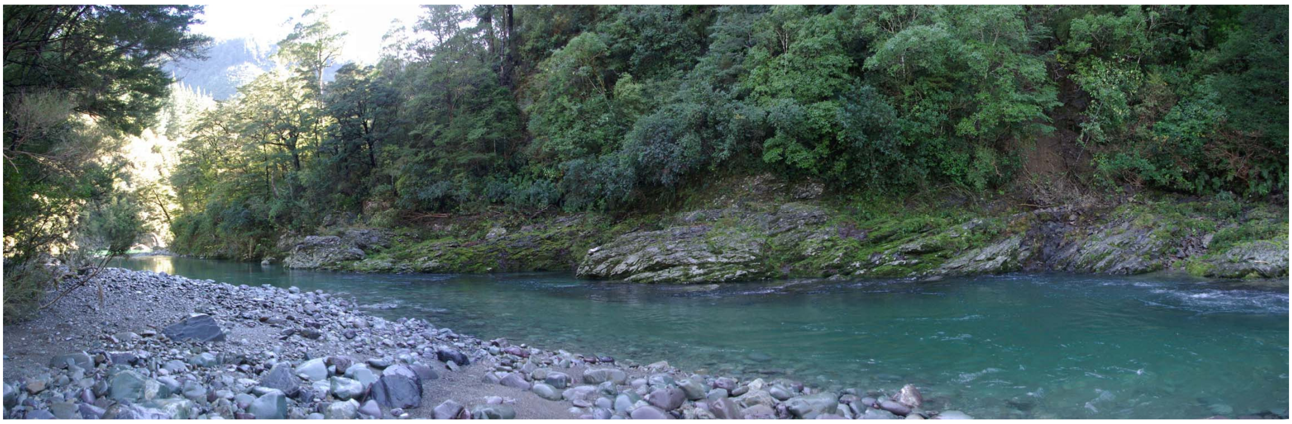
Other Considerations



Peer Review of Lee Valley Dam Design

Interim Report	**Number** 04	**Date** 31 January 2012	
Purpose of Review Report To present review feedback on further compliance aspects for building consent. Review of general structural and durability criteria, and review of hydraulic design criteria are covered by separate communication.			
Review Team Contributors Ian Walsh			
Reviewed Documents	T&T Letter Keith Dickson "Lee River Dam – Detailed Design Criteria" and attached report.	T&T Ref 27425.100 13 April 2011, and report issue 1 of 12 April 2011	
Relevant Communications			
Copied to:	**WWAC** **c/- Joseph Thomas** **Tasman District Council**	**T&T Nelson** **Attn M Foley**	**T&T Auckland** **Attn M Taylor**
Attachments	None		

Ref ID	Description of the Risks	
011	Adopted design criteria do not satisfy personnel safety compliance obligations related to sections of the NZ Building Code other than B1 – Structure, and B2 – Durability, or any other relevant standards pertaining to safety of personnel and the public.	
	Peer Review Position **Safety of O&M personnel and the public:** Design criteria for establishing compliance with relevant sections of the NZ Building Code covering such aspects as safety from falling (F4), are not specifically addressed in the design criteria report. Furthermore, the aspect of safe access into confined spaces for operational and maintenance activities is also not covered. These considerations may influence final design layouts and/or detailing of the works for such aspects as access ways, barrier systems, drainage, and ventilation of potential work spaces, etc., and may be relevant to the issue of the full building consent. I suggest that that a section covering these considerations be added to the report to give clarity to the intended compliance process being followed during detailed design.	
	Other Considerations	**Active**



Peer Review of Lee Valley Dam Design

Interim Report	**Number 05**	**Date 8 February 2012**

Purpose of Review Report

To present review feedback on matters arising in connection with the decision to progress design work on potential hydropower development.

Review Team Contributors Ian Walsh		
Reviewed Documents	T&T Letter Mark Taylor "Lee River Dam – Hydropower design and interfacing"	T&T Ref 27425.100 18 January 2012
Relevant Communications		

Copied to:	**WWAC** **c/- Joseph Thomas** **Tasman District Council**	**T&T Nelson** **Attn M Foley**	**T&T Auckland** **Attn M Taylor**

Attachments	None

Ref ID	Description of the Risks	
012	Commitment to develop the potential hydropower scheme may result in disruption of the current dam design programme, and lead to rework, delay, and cost exposure, arising from the lack of current design development of the hydropower scheme elements.	
	Peer Review Opinion 1. The detailed list of items and scope of work identified for clarification of final design purposes appears quite sound for its stated purpose of leading to detailed design and building consent application. 2. However, as I understand the current situation, the hydropower aspect of the development has not yet reached a point of establishing its technical feasibility nor its commercial viability, so there is still some way to go in terms of the usual project development cycle before one would be investing in detailed design. That is, there is a need for further development of the concept to identify a preferred arrangement and capacity, such that decisions on feasibility and viability can be reached first. Such decisions would normally need to be supported by some preliminary design and analysis, but this would be to a much lower level of detail than would be needed for construction purposes. A degree of judgement would need to be exercised as to those matters which are critical to feasibility and viability decisions, as many matters of detail (which may be important for construction), are not necessarily particularly relevant to a decision to progress beyond the feasibility stage. 3. Unfortunately the main dam design is now progressing well into the detailed design phase, and the different aspects of the development appear to have got “out of step”. There is now a risk of the hydropower aspect disrupting further progress on the dam detailed design, and/or leading to rework, delay and costs. 4. There is no simple answer to this challenge unless the hydropower preliminary design and subsequent detailed can be fast tracked to meet the T&T detailed design timeline. 5. On the assumption that this degree of fast track action is not practical, the challenge for the executive team may be to make a decision based upon the limited state of knowledge that has been already reached, or may be reached in the very near future. The choices available would appear to be: a. Cease any work on the hydropower facility in the meantime, and forego any current commitment to	**Active**

investing in this potential.

b. Commit to some interface works for possible future retrofitting of a hydropower facility, allowing the dam detailed design to progress in a manner that accommodates such an interface.

c. Commit to the “current” hydropower arrangement, locking in whatever interface issues this may create, and complete the hydropower scheme design and construction within this concept, hoping to fit within the dam construction programme.

6. I am not fully informed as to all the factors affecting this decision, but as a general observation I am attracted to option b). This approach appears to offer the least risk of significantly disrupting the main project, while not ruling out the potential benefits at some point. The down sides of this approach are that

a. Up front cost is incurred in designing and constructing the flexible interface works, which are likely to be less than optimal for the detailed final design due to the need for “flexibility’ in utilising the interface.

b. Generation benefits are deferred, possibly indefinitely

c. A future retrofit project is likely to incur higher costs than one integrated with the original dam design and construction process.

7. I suggest that these aspects be approximately quantified to assist your executive group in addressing this decision. If the costs of pursuing option b) are significant relative to the potential hydropower investment returns, or if the potential net benefits available from hydropower investment are not substantial, then there would appear to be little reason to depart from option a).

8. Please feel free to discuss this further if I can be of assistance in progressing these matters.

Other Considerations

Appendix C: Minutes of HAZOP workshop and Contract Procurement workshop

Tonkin & Taylor

Meeting notes

Meeting:	Lee river dam - M&E HAZOP (operation and safety) workshop		27425.500
Venue:	T&T Auckland Office. Level 3, Carlton Gore Rd. Hunua Room	**Date:**	16 April 2012
cc:	Charlotte Reed (CR) (T&T), Keith Dickson (T&T) Mark Taylor (T&T)		
Present:	Joseph Thomas (JT) (WWAC), Julian Raines (JR) (WWAC), Tim King (TK) (WWAC), Ian Walsh (IW) (Opus), Luke Gallagher (LG) (PB), Neville Laverack (NML) (T&T), Simon Croft (SFC) (T&T), Phil Carter (PC) (T&T)James Russell (JICR) (T&T)		
Apologies	Nil		

During the meeting, the following items and courses of action were discussed by the attendees.

Item	Description	Discussion	Action
1	Introductions	Attendees introduced themselves.	Nil
2	Workshop Objectives	Description of the objectives provided by NML. These objectives were: • Description of the operational requirements of each of the key components • Identification of potential health and safety issues associated with each of these items	Nil
3	Brief overview of the project elements	Noted that due to the very recent appointment of the mechanical sub consultant (LG) the mechanical design is only in very preliminary stages. SFC discussed, in brief, the elements identified by T&T that could create H&S hazards including: • Debris management – because it is a commercially forested catchment this represents a significant issue, both for the long term and during construction diversion. It could be mitigated by the installation of a debris boom, intake screens and catchment management • Use of divers – divers would be needed to carry out work on the intake screens • Confined space issues – related to the operations, maintenance and surveillance (OM&S) of the valves and pipework within the conduits through the dam • Access during spillway operation – because the bypass culverts are initially for diversion during construction (and as such are set as low as possible) downstream stoplogs will need to remain in place semi-permanently to prevent	Nil

Item	Description	Discussion	Action
		regular backflooding of the culverts • Access in general – the size of the penstocks (in the order of 1.2 m to 1.6 m diameter) used to convey the water to the turbine(s) will take up a significant amount of space in the culverts which will create a challenge for access for inspection and maintenance. • Landslide generated wave overtopping – presents a risk to the infrastructure in the powerhouse	

4	Debris management	SFC discussed the challenges with debris and the consequent risk of damage to the intakes and/or blocking of the spillway in the event of debris boom failure (these are known to occur – although infrequently).
		• Risk is from existing forestry debris as well as potential future forestry activities
		• If debris/log boom is not located across the reservoir log debris is likely to accumulate on the right abutment where access and removal is potentially more difficult.
		  o Boats or barges may be required to remove it
		  o Screens likely to be subject to increased debris loading
		• It is considered good practice to provide a landing area to provide access for removal of logs/debris trapped by the boom
		• OM&S procedures for the dam will need to cater for debris management and associated OSH issues.
		JR questioned the significance of the debris suggesting that by the time the dam is constructed the pine forest may have largely rotted out and that any remaining material can be removed with catchment management. NML noted that there are multiple methods for managing the catchment.
			T&T and PB to consider these issues in design **[Refer covering letter]**
			
			WWAC to investigate catchment management options with forestry operators including long term forestry operational plans.

5 (a)	Intake and Intake screens	Feasibility design incorporated removable screens to enable removal for maintenance along with specifically designed bulkheads for intake isolation. Detailed design considerations favour a more robust intake and screen design, with double isolation within the concrete conduit. The screens will be locked in position on the dam face but are able to be removed or repositioned using divers. The requirement to isolate the intake pipelines will be significantly less frequent and manufacture of temporary bulkheads if required will be more cost effective than a permanent solution.	

Item	Description	Discussion	Action
		The purpose of the intake screens and whether or not they prevent fish entering the turbine was discussed. SFC noted the design criteria report does not require fish protection (for the no hydro option). JT suggested T&T and Cawthron should discuss whether or not Cawthron are happy with the proposed intake arrangement. The intake screens will need to be cleaned and adjusted periodically using divers. The screens will need to be locked down to the dam face to ensure they are not dislodged or damaged by debris or wave action. Debris that gets past the debris boom will have the potential to lodge between the screens and the dam face. It is proposed that winches / cables / crane to lift screens out or adjust position would be brought on site as and when needed and not left in place. Operational procedures and dam instrumentation need to prevent air entrainment into intakes.	<u>Clarification</u>: For hydro option, screens to provide a clear mesh opening size of 20 mm and a 0.3 m/s approach velocity. T&T to confirm with Cawthron the suitability of proposed fish screening
5 (b)	Intake and Intake screens	TK discussed the purpose of the dual intake arrangement being for the required environmental mixing as outlined in the Cawthron report. SFC noted that the Cawthron report doesn't address mixing of the water in any detail and mixing is not possible once the water level is drawn down below the top intake. Also noted that the revised intake design provides facility to adjust the intake levels. TK / JT - How does this affect compliance with potential consent conditions?	T&T to seek further clarification from Cawthron on flow mixing requirements to meet likely consent conditions **[Refer covering letter]**
6	Inclined intake pipework	Feasibility design included rectangular concrete intakes inclined on the dam face. Detailed design considerations favour twin pipes supported on pedestals. Advantages of this solution include: • Tolerance to dam face deformations due to flexibility at joints • Ease and increased speed of construction • Enables adjustable intake levels • Several construction materials to choose from Options of using either Glass Reinforced Plastic (GRP) or corrosion protected steel were discussed. GRP presents potential advantages over steel with respect to maintenance and handling. JT questioned the ability to source GRP material. SFC confirmed that it is widely used and manufactured in Australia thus availability should not be an issue.	PB to perform options assessment for material types used for the intake pipes and penstocks. Possible options include: • Only GRP • Only Steel • Combined GRP and Steel Post workshop note; JT has suggested consideration of HDPE

Item	Description	Discussion	Action
		The pipe arrangement will use standard joint systems that allow some movement at joint locations. Joints need not be 100% watertight as some minor leakage can be tolerated. Pipes need to be secured to pedestals to prevent dislodgement (waves / debris impact) or flotation if isolation bulkheads are used. Pipe thermal expansion / contraction movement needs to be catered for in design. Divers will be required to: • Inspect intake pipework and supports as part of ongoing OM&S • Facilitate pipe removal and adjust intake level and screens	
7 (a)	Valves and bifurcations	Significant discussion by all around the type and quality of the valves that should be used. The conduit and any internal valve chamber are likely to be considered a confined space and designers of such structures are obliged to minimise the associated risks. The valves need to ensure that health and safety requirements are met and adequate protection is provided to operations and maintenance staff working in the conduit under a wide range of operational scenarios. It was generally agreed that: • The isolating valves closest to the two intakes should be of high quality as these are critical components for preventing uncontrolled release • Specifying the type and manufacturer of these valves is appropriate (e.g. Glenfield valves) due to their critical nature • The remaining valves should be chosen based on a quality versus cost assessment since they are not as critical for dam and operator safety. IW noted that uncontrolled release is a serious issue to be avoided but it won't necessarily result in catastrophic failure of the dam. Ultimately, for all the valves downstream of the two main isolation valves, the committee can decide to stay with higher quality valves should they wish.	PB to specify high quality valves for those critical for preventing uncontrolled release, and lower quality valves for the others. Contract will need to consider required quality control procedures including factory inspections to ensure critical valves are manufactured and tested to meet the specification and who is purchasing the valves.
7 (b)	Valves and bifurcations	IW noted that if comprehensive control of flow mixing is required then designing for both mixing and hydro may prove challenging. IW has not seen this type of application before though it may be possible to achieve. Valves required for varying mix ratios are likely to cause more head loss, which is contrary to the driver for hydro which is to minimise head loss.	PB to address the technical feasibility of providing sufficient head to satisfy the turbine requirements whilst meeting Cawthron flow mixing recommendations **[Refer covering letter]**

Item	Description	Discussion	Action
		JT noted that T&T was made aware of the mixing requirement previously. TK noted that T&T to review the discussion with Cawthron about the mixing and other environmental issues. If the two are mutually exclusive, i.e. the ability to provide irrigation and the hydro add on, it is clear that the hydro is no longer feasible. A free discharge valve (FDV) is likely to be required. These do not operate well if partly submerged so locating them within the conduit is unlikely to be feasible. It was agreed that the preferred location for the FDV is at the downstream end of the conduits - this also provides better access for inspection and maintenance. IW commented that it was not necessary for the FCDV to operate at high downstream flood levels so a lower level installation may be possible.	
7 (c)	Valves and bifurcations	There was discussion around using two valves to provide double isolation for a safe working area inside the conduits (related to standards for safe working in a confined space). TK commented that it may be possible to apply for resource consent with the option to stop the environmental flows for brief periods during major maintenance, which may simplify some of the valving requirements.	T&T will proceed with design on the basis that stopping the environmental flows for brief periods for maintenance will be acceptable.
8	Penstock	There was significant discussion around the most suitable arrangement of the penstocks and the location of the bifurcation. Two options were discussed namely: • Locating the bifurcation close to the upstream face of the dam to minimise the amount of pipe required or; • Installing twin penstocks and shifting the connection to the downstream face to improve both constructability and ease of access to the valve work. It was agreed that, from construction, OM&S and safety perspectives, the latter would be preferable. Cost and design implications have yet to be assessed.	T&T and PB to assess both options and recommend the preferred solution **[Refer covering letter]**
9 (a)	Hydro Powerhouse	SFC noted that landslide generated wave overtopping may pose a risk to the hydro powerhouse infrastructure. Assessment of this risk is currently underway.	T&T and PB to consider this risk in design
9 (b)	Hydro Powerhouse	SFC discussed the scale of the excavation required to incorporate the powerhouse into the design. It was generally agreed that relative to the size of the conduits it is not a significant excavation.	Nil
9 (c)	Hydro Powerhouse	The relative merits of the Turgo vs. the Francis turbine were discussed. In general the advantages of the Turgo	PB to consider both options in design

Item	Description	Discussion	Action
		are its ability to operate over a wider range of flows and lower cost of installation. The advantages of the Francis turbine are that it can utilise more of the available head due to the draft tube being submerged and it is typically slightly more efficient. IW noted that in design terms the Francis is a better option but with respect to price and simplicity the Turgo is worthy of consideration. LG noted that the Francis is much more widely used within New Zealand and therefore operators are familiar with it and there is a wider range of potential suppliers. LG also noted it may be possible to use just one Turgo where the Francis design may require two.	
9 (d)	Hydro Powerhouse	There was discussion around whether the hydro turbines could pass the all of the environmental flushing flows. LG commented that this is unlikely as the flushing flows are significantly higher than typical turbine rated flows. The FDV is likely to be required to pass the full 5 m^3/s flushing flow at minimum operating level. This is because the turbines are likely to be out of their operational range at such low reservoir levels.	PB to consider maximum flow capacity of the turbines when evaluating
10 (a)	General	JT asked whether or not there would be significant rework on the design if the hydro option was not taken up. IW noted that the there would be some rework because the two scenarios are aiming to achieve different outcomes. In the hydro case the objective is minimising head loss whereas for irrigation release the objective is to achieve the required release flow rate with no need to conserve head.	Nil
10 (b)	General	IW raised the point that he is not convinced that the business case for hydro has been proven. As such WWAC run the risk of investing too much in technical design without having first proven the economic viability of the scheme.	No specific action
10 (c)	General	TK asked whether or not the cost difference between the Hydro and non-Hydro components will be presented. PC responded that this requires additional design work and costing. TK stated that by the end of the current phase of hydro design WWAC should be in a position to make a final decision on whether to incorporate the hydro components.	Nil

16 April 2012
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Tonkin & Taylor

T&T Ref: 27425.500
16 April 2012

Waimea Water Augmentation Committee
C/O Tasman District Council
Private Bag 4
Richmond

Attention: Mr Joseph Thomas

Dear Joseph

Post Meeting Notes

March 2012 Lee Valley Dam HAZOP Workshop Minutes

This letter provides additional information on several of the topics raised during the Lee Valley Dam HAZOP (operation and safety) workshop held in our Auckland office on 27 March 2012.

WWAC approved variations to the Tonkin & Taylor Ltd (T&T) scope of work for the Lee Valley Dam on 20 March 2012. These variations were to undertake:

- Hydropower preliminary design to a sufficient level of detail to enable the progression of the main dam design; and
- A half day HAZOP (operation and safety) workshop in Auckland on 27 March 2012.

It was noted at the start of the HAZOP, due to the timing of instructing the hydropower variation (less than a week before the workshop) there was insufficient time to undertake any significant level of design work for the mechanical components of the dam prior to the workshop. Thus the workshop covered the salient issues at a higher level than originally intended. We believe that considerable benefits were realised, notably raising WWAC and the design team's awareness of the likely operational issues.

Flow Mixing

One of the more significant issues that arose at the HAZOP workshop was the degree of flow mixing required to ensure flows of acceptable water quality. During the meeting, the degree of mixing required by Cawthron was compared to that provided by the preliminary valving arrangement and there was some debate in relation to this.

Clearly, the issue of mixing is limited to the periods when water can be abstracted from both inlets.

T&T undertook to follow up with Cawthron to seek further clarification on flow mixing requirements to meet likely consent conditions, which we have subsequently done and we summarise the outcomes of this dialogue below.

The Cawthron report[1] executive summary states:

> *"We recommend that two outlets are incorporated into the scheme design. One outlet should be near the bottom of the reservoir to be used during dry years and during floods to flush any poor quality bottom water from the reservoir. A second outlet should be at approximately 185 m Relative Level (RL) to be used under most conditions to release good quality surface water from the reservoir during most years."*

Further details are provided in Section 3 of the same report, reproduced below for ease of reference:

> *"The level selected for the outlet is predicted to have a large influence on where the stratification layer will form in the reservoir (Figures 3, 4 and 5). A low level release outlet near the base of the dam (155 m RL, Figure 5) would result in a fully mixed water column during summer in dry years (e.g. 2000/2001). However, during normal or wet years an outlet at this level would potentially be releasing any poor quality bottom water. An outlet approximately 10 m below the reservoir surface (185 m RL) would ensure that it was possible to release good quality surface water from the reservoir during most years, although in dry periods the reservoir may drop below 185 m RL making this higher level outlet redundant. Hydrological modelling for the period from 1957 to 2007 indicates that the reservoir would drop below 185 m RL around 1% of the time. Given these results we recommend that two outlet levels are incorporated into the scheme design. One outlet should be near the bottom of the reservoir to be used during dry years and during floods to flush any poor quality bottom water from the reservoir. A second outlet should be provided at approximately 185 m RL to be used under most conditions unless reservoir levels were too low. Given that water temperatures near the surface of the reservoir will be relatively high at times, it may also be possible to manage outlet use to limit thermal effects on the river downstream. This strategy is currently used at the Maitai Reservoir to limit changes in water temperature as a result of discharges from the dam."*

This indicates that the design of the intake arrangements does not need to enable the water to be mixed at varying ratios from each intake level. It also reiterates that mixing will not be possible once the water drops below the minimum draw-off level of the top intake.

Dr. Roger Young of Cawthron has provided further clarification subsequent to the HAZOP workshop. He confirms the above understanding of the report content - that in general mixing is unlikely to be required, although the ability to provide some mixing may be advantageous to vary downstream water temperatures in the hotter months.

> *"The only circumstances I see where mixing of upper and lower water would be required is during relatively short periods in the warmest months of summer. In those conditions you potentially have very warm surface waters (with low nutrients/iron/Mn) that could cause problems downstream if released, and bottom waters with relatively high concentrations of nutrients/iron/Mn (but cool), which could also cause problems downstream. However, if you*

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[1] Hay J, Young R, Strickland R, 2009 "Aquatic Ecology: Mitigation and Management Options Associated with Water Storage in the Proposed Lee Reservoir", Cawthron Report No. 1701, December 2009

mix the two it might be possible to manage the high temperature problem and the high nutrient problem and release relatively cool water that has only slightly elevated nutrient concentrations."[2]

Based on this feedback from Cawthron we believe that the proposed preliminary intake and valving arrangement (Drawing 153987-PID-001) meets the design requirements when reservoir levels are high enough to abstract from both intake levels.

The preliminary design enables water from the two intake levels to be mixed, but not in a controlled manner. The proposed butterfly valves (V3 and V4) are not suitable for throttling flows and should either operate fully open or fully closed. In the event that both valves are fully open it is estimated that 50% to 60% would be drawn in through the bottom intake and 40% to 50% through the top intake (the exact proportions depend on the final configuration of the intakes, pipework and valves). If more control on mix proportions and variability is required (e.g. by the resource consent) a different and more expensive type of valve would be required for valves V3 and V4.

The preliminary design also includes a Free Discharge Valve (FDV) which will aerate and cool flow. Further, it would be technically feasible to manually alter the intake levels if required by removing some of the modular pipe components. For example, this could be desirable during long warm periods or if the reservoir is drawn down for long periods.

T&T asked Dr. Young to provide some commentary on possible consent conditions considering the work Cawthron has done to date. Dr. Young advises that the consent conditions <u>might</u> conceivably be something like the following:

WATER TEMPERATURE

The temperature of water released from the reservoir shall not be altered by more than 2 °C compared to the temperature of the inflowing water and shall never be greater than 23 °C, or greater than a daily average of 21 °C.

NUTRIENTS/IRON/MANGANESE

When outflows from the reservoir are less than 5 m^3/s, the concentrations of dissolved inorganic nitrogen, dissolved reactive phosphorus, dissolved iron and dissolved manganese shall be less than 0.10 g/m^3, 0.01 g/m^3, 0.5 g/m^3 and 0.5 g/m^3, respectively.

When outflows from the reservoir are greater than 5 m^3/s, the concentrations of dissolved inorganic nitrogen, dissolved reactive phosphorus, dissolved iron and dissolved manganese shall be less than 0.44 g/m^3, 0.015 g/m^3, 1.0 g/m^3 and 1.2 g/m^3, respectively.

These conditions do not apply when outflows from the reservoir are greater than 20 m^3/s.

A detailed review of the impact of any conditions should be carried out before they are accepted. Conditions such as those above could require the installation of a telemetered flow monitoring site with temperature logging in the Lee River upstream of the reservoir.

Environmental flow releases

At the workshop it was postulated that the resource consent conditions may enable the environmental flow release to cease for short periods of time for major maintenance. The design will

[2] Email communication from Dr. Roger Young 2 April 2012

proceed on the basis that this will be possible as there are precedents for this philosophy around New Zealand.

Confined Space

Another significant issue raised in the HAZOP is that the conduits and valve chamber most likely present a confined space risk. As designers of a potential confined space structure requiring regular access by personnel, we are obligated to design the space to eliminate or minimize the risks associated with work in a confined space. The Department of Labour Health and Safety website gives guidance on confined space requirements and states:

> *"The Department of Labour accepts Australian Standard AS 2865:2009 Confined Spaces as the current state of knowledge on confined space entry work."*

We understand that, despite this statement, AS/NZS 2865:2001 is still the current applicable New Zealand standard. AS/NZS2865:2001 forms the basis of our design at present and the discussion below relates to this document.

Section 10.1 states that, if a risk assessment identifies a risk to health or safety arising from work in a confined space, the risk shall be eliminated or, if this is not possible, minimised by the implementation of appropriate risk control measures. A hierarchy of control measures to eliminate or, if this is not possible, minimise the risk should be followed, prioritised as follows:

i. Elimination

ii. Substitution

iii. Isolation

Section 6 states:

> *6 DESIGN, MANUFACTURE, SUPPLY AND MODIFICATION*
>
> *6.1 The confined space shall be designed, manufactured and supplied so as to minimize the need to enter the confined space*
>
> *6.2 The confined space shall be designed, manufactured and supplied so as to minimize the risks associated with work in a confined space*

During the HAZOP workshop there was considerable discussion, for the hydro arrangement, on the risks and mitigation measures required to safely construct, operate, maintain and inspect valves located at the upstream end of the conduits. Two general configuration options were discussed:

a) Locating the bifurcation close to the upstream face of the dam to minimise the amount of pipe required; or

b) Installing twin penstocks and shifting the bifurcation to the downstream face to improve both constructability and ease of access to the valve work.

During the HAZOP it was agreed that from construction, OM&S and safety perspectives the latter option would be preferable. Cost and design implications have yet to be assessed. However, at first glance, although Option a) has lower pipework costs this is offset to some extent by the need to provide ventilation fans, ventilation ducting, more lighting, longer communication systems, permanent access walkways, culvert roof strengthening, culvert internal wall removal to accommodate bifurcation and valves etc.

Though not discussed in detail at the workshop, the same confined space issues arise for a non-hydro configuration. In that case flow would be released into both concrete conduits making the design to ensure safe access for personnel without a third barrel more challenging. Without penstocks to convey high velocity flow to the outlet energy dissipation occurs within the concrete structure under the dam. Valves used to provide the energy dissipation and control the flow will, for OM&S reasons, need to be observed in operation from time to time. For reasons of dam safety, access to the valves whilst in operation will also need to be provided. Thus, the valve configuration for the non-hydro design case would also require double isolation, permanent elevated access walkways, lighting and communication systems. Ventilation fans and ducting would also probably be needed.

Given the wording of AS/NZS 2865:2001 that in design the *"risk shall be eliminated or, if this is not possible minimized..."* there is a clear health and safety bias towards Option b). Additionally, most of the duties in the Act are qualified by the phrase 'all practicable steps'.

Safe Work Australia provides guidance[3] on the interpretation and application of the term 'reasonably practicable' in considering the standard of health and safety that is expected in the Australian context:

> *"Although the cost of eliminating or minimising risk is relevant in determining what is reasonably practicable, there is a clear presumption in favour of safety ahead of cost........choosing a low cost option that provides less protection simply because it is cheaper is unlikely to be considered a reasonably practicable means of eliminating or minimising risk."*

It should be noted that many dam owners/operators, both in New Zealand and other countries, are now having to implement expensive programmes to improve the confined space safety and access on their existing facilities. Whilst it is not conceivable to completely future proof the design for all possible future legislative changes, there are lower long term health and safety risks with Option b).

Cognisant of the above discussion, Option b) is favoured by T&T and will be the primary option pursued for the hydro arrangement unless:

- Directed otherwise by WWAC prior to 24 April 2012; or
- A design or constructability issue becomes apparent during design development resulting in the need to revert to an alternative solution.

Debris Barrier

T&T considers that forestry debris in the upstream catchment is a significant long term issue and hence the matter was raised in the HAZOP workshop.

This debris poses a hazard to the dam during construction when the diversion culverts are susceptible to debris blockage. This would be associated with heavy rainfall events causing localised or widespread mobilisation of forestry debris.

During, and soon after, first filling of the reservoir it is anticipated that significant volumes of floating debris (wood and brush) will migrate towards the dam and will need to be managed and removed progressively from the reservoir. Some discussion of the debris management strategy proposed for

[3] http://www.safeworkaustralia.gov.au/AboutSafeWorkAustralia/WhatWeDo/Publications/Pages/interpretive-Guideline-reasonably-practicable.aspx

the Mokihinui scheme is provided in Section 12 of the Damwatch (2007) Mokihinui Hydro Proposal Project Engineering Description[4].

In the long term, localised or widespread mobilisation of forestry debris, associated with heavy rainfall events, will need to be managed. It is likely that large debris rafts will form on the Lee reservoir at some stage and the risk of spillway choking and/or blockage needs to be appropriately mitigated.

By way of example, Photos 1 and 2 show debris rafts on two New Zealand schemes, Matahina and Patea. Advice from operators of schemes with similar debris issues is that extracting the debris can be time consuming, difficult and hazardous if boats are required.

T&T will include a debris boom in the Stage 3 design to provide adequate protection from this hazard and to facilitate safe maintenance of debris in the long term.

Photo 1 - Matahina

[4] Damwatch (2007) Mokihinui Hydro Proposal Project Engineering Description. Publicly available at: http://www.wcrc.govt.nz/mokihinui/application/2.1%20Project%20Engineering%20Description.pdf

Photo 2 - Patea

Finally, we understand that at some stage WWAC will require a cost estimate for the hydro and non-hydro options to finalise its decision about whether to proceed with the hydropower option. Our current scope of work includes cost estimates that are sufficient to compare between hydropower design options but excludes a full construction cost estimate at this time. We recommend WWAC commissions the development of this cost estimate, which could constitute a variation to the existing scope of work.

In summary:

a) We have revisited our understanding of the mixing requirements for water quality as set out in Cawthron's report and consider our proposed preliminary design meets these requirements;

b) We are proceeding with a design that assumes that the resource consent conditions will allow the environmental flows to cease for short periods of time during major maintenance;

c) We recommend proceeding with the twin penstocks for health and safety reasons;

d) We consider forestry debris is and will remain a hazard at the Lee dam site and will include a debris boom in the Stage 3 design to provide a degree of protection to the dam from this hazard and to facilitate safe maintenance of debris in the long term; and

e) WWAC should consider commissioning a study to compare the costs of the hydropower and non-hydropower options.

Please advise by 24 April should WWAC require a different or particular approach.

Yours sincerely

K. J. Dickson

Keith Dickson
Project Director

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Tonkin & Taylor

Minutes

Meeting:	Lee River Dam - Contractual procurement workshop		27425.100
Venue:	T&T Auckland Office. Level 2, 105 Carlton Gore Rd, Newmarket. Hunua Room	**Date:**	27 March 2012
cc:	Mark Foley (T&T Geologist), Keith Dickson (T&T Project Director), Simon Croft (T&T Designer), Phil Carter (T&T Designer), Charlotte Reed (T&T Designer),		
Present:	Joseph Thomas (WWAC/TDC) Julian Raine (Deputy Chairman WWAC) Tim King (WWAC, TDC Councillor) Stuart Ritchie (Fletcher Vautier Moore, TDC Lawyers), Murray Staite (TDC) Ian Walsh (Opus - Peer reviewer) (arrived at 10:45am) Mark Taylor (T&T - Project Manager) Graham Wallace (T&T)		
Apologies			

Item	Description
1.0	Morning tea and Introductions
2.0	Workshop objectives **Origins:** • The workshop follows from the MWH review in late 2010 • Discussion paper was produced in June 2011 • The Workshop now takes place during the Stage 3 design phase **Purpose:** • MT ran through the agenda
3.0	**WWAC objectives** JR noted that cost is paramount for the committee and the funders have indicated that they have no appetite for cost increases above the feasibility estimates. JT noted that the MWH peer review concluded that in their opinion the feasibility estimate contingency (at 20%) was conservative. MT responded that the MWH review actually says that it was conservative for the *scheduled items,* and that it also noted there are that items that are not scheduled that could be above and beyond the existing contingency.

4.0	Brief overview of the project, design stage and programme (MT and JT)
	
	• MT presented a brief overview of the arrangements and noted possible design alterations:
	    o The spillway may be altered to a single spillway (rather than an additional auxiliary spillway with a fuseplug). This is to eliminate risks associated with large plugs of flow when the fuseplug breaches.
	    o Mentioned inclined intakes and possible amendment to GRP (Fibreglass) or steel to avoid issues of cracking, but also to mitigate potential constructability issues. With GRP or steel pipes there might be the future opportunity to remove or add sections to amend the intake levels if required.
	• JT outlined where WWAC are with their contract with the Crown (CIF funding) which lasts through to June 2013.
	• JT asked if an organisation other than the designer could undertake the construction supervision
	• MT explained that some clients elect to have a local works supervisor as a cost saving measure, but recent T&T experience is that this role ends up being replicated This is because they have to go back to the designer regularly for queries. i.e. it does not necessarily result in a cost saving.
	• Current procurement model (Design Bid Build)
	• Discussed that there are possible additional 'boxes' that can be added to the organisation charts to represent:
	    o an Engineer to the Contract and/or works supervisor who is a person other than the Designer.
	    o a Project Manager,
	    o an independent surveyor etc.

5.0	JT asked who the likely Contractors are that would be able to construct the dam: MT responded that the likely candidates (with an NZ presence) are: • Downer • Fletcher • Leighton • MacDow • Hawkins are also possible as they have large construction experience, but limited dam experience • IW suggested that the main contractor should be NZ based, but that they may need some overseas experience for selected items.

6.0	Procurement options
	• Alliances:
	    o They encourage Innovations
	    o Provide transparency of cost
	    o Working as team (rather than confrontational as with a traditional approach)
	    o Possible construction savings
	    o IW experience and published papers suggest that they are advantageous in shortening construction programme, but not necessarily cost savings
	    o JT asked who funds the Alliance. MT responded that the client pays, not the consultant or contractor.
	
	• Design Bid Build (Traditional)
	• Design and Build
	    o Advantage is that the Contractor is motivated to look for savings, but note that this is to

	maximise the Contractor's profit, not reduce the client's costs. o JT asked about Fletchers involvement as constructability advisor and is their role to look for savings. o MT replied that Fletchers are engaged to look at specific aspects where requested by T&T to look for advantages in various options, but that they are not sitting alongside T&T as in a true Design/Build contractual arrangement. • Early contractor Involvement • Briefly discussed PPP or PFI models and BOOT (Build Own Operate Transfer) - where an external party funds design and operates the dam (for a profit). • Widely used in UK, limited use in NZ (for school construction). • Generally unpopular with the public • WWAC attendees acknowledged that they are unlikely to change from the traditional approach because the design has already progressed so far.
7.0	**Cost estimates** • MT explained that the current feasibility estimates are median or average estimates. The actual cost may be above or below these estimates. • IW explained that many local authority/public bodies adopt a P70 or P85 estimate for budgeting. NZTA adopt a P50 [50th percentile] because they have a whole portfolio of projects, but that they also have the requirement that they still have funding available to meet the P95 for any single project should it be required. • IW suggested that WWAC needs to consider what risk profile they have and therefore what level of risk they are comfortable adopting. Based on discussions in the workshop WWAC should probable adopt (for budgeting) an estimate that is greater than the P50 estimate. i.e. greater than the feasibility estimate. The feasibility estimate did not explicitly define the probability associated with it. • MT explained that the current design was for the 2 culvert option with meshing of the downstream face of the dam. The meshing is considered necessary because of the large volumes of forestry debris in the catchment that could block the culverts during a storm. • TK pointed out that there has been a 1 in 500 year event in the area before Christmas. JT clarified that that was in respect of rainfall intensity, but the flows in the Lee were not unusually high. • IW suggested that WWAC should be very careful in what they communicate to the public e.g. that the cost estimate is the estimate only valid at the time it is undertaken [the feasibility estimate is currently 3 years old, and it may be 2-3 years before construction commences]. • IW also suggested that committee no longer think about the cost estimate as a single cost, but instead as a range, that could be above or below the median. • JR asked, if the committee were to spend more money on investigations, would that reduce the construction cost. • MT responded that it would not necessarily reduce cost, it may increase, but it would give the committee greater certainty • IW added that as peer reviewer that the investigations and information he has been provided is appropriate for the project. IW did not think that WWAC had under or over invested in the investigations
8.0	**Insurances** • TK asked what can be insured during the works. IW replied that natural hazards such as flood events and earthquakes can be insured, but that insurance has an effect on the contract cost • GW added that construction cost blowouts cannot be insured • IW recommended that WWAC seek the advice of an insurance specialist because engineers are

	not specialists in this area

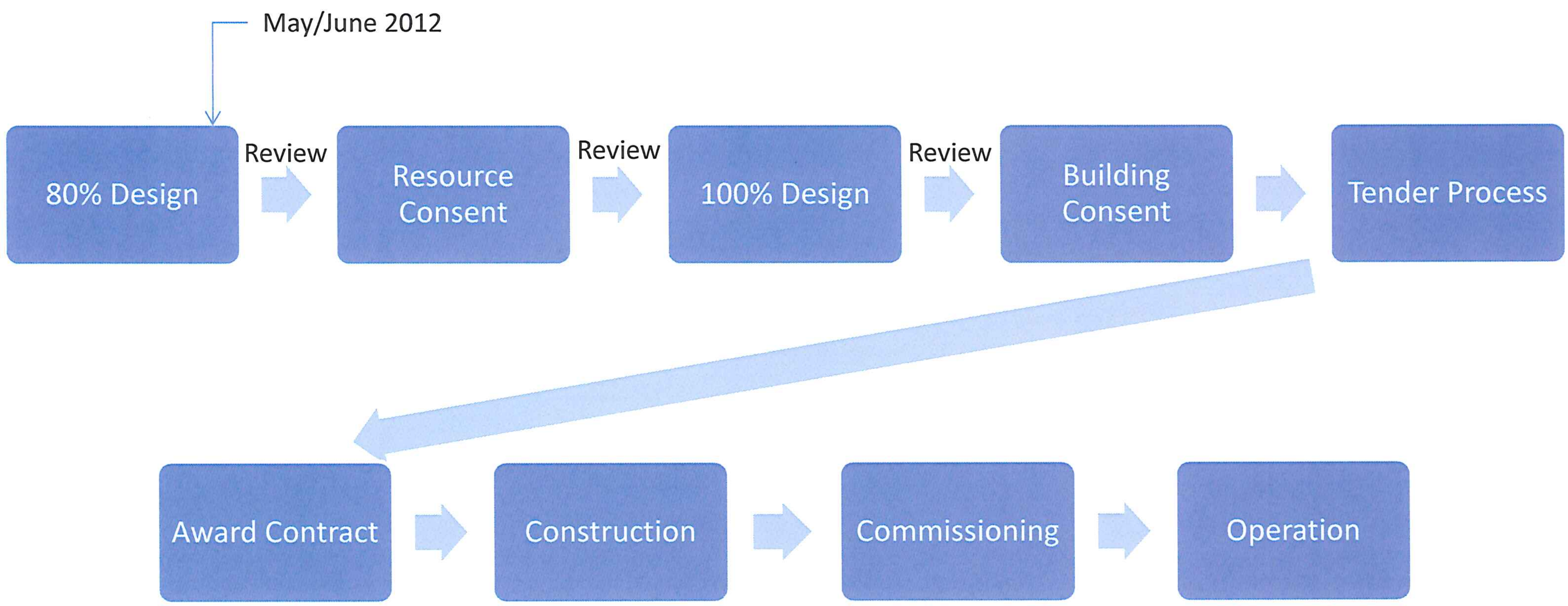
9.0	Basis of payment
	• Measure and value
	  ○ GW explained that the quantities are scheduled by the Engineer
	  ○ This is their estimate of the quantities, but not the final which will only be known once the construction is complete
	  ○ The Contractor is paid for the actual works completed (rather than what is estimated at Tender).
	  ○ A disadvantage is that there is little incentive for the Contractor to minimise their works
	  ○ The responsibility for measuring is the Engineer's under NZS3910, but is often a collaborative effort with the Contractor in practice.
	• Lump sum - This is still subject to variations if the Contractor believes the works to be beyond the scope of the provided information of if anything changes (so not a GMP).
	• Discussions were had around what options there were for cost certainty for the project e.g. Guaranteed Maximum Price (GMP). IW explained that there can be a GMP for the project based only on the information provided to the Contractor. If the actual conditions e.g. additional grout or rock excavation is required, then the Contractor is likely to treat it as a variation over and above the GMP.
	• Negotiated - This is where the client negotiates directly with one or more Contractors to agree a price for the works.
	  ○ MS considered that this model is unlikely to be adopted because of Council backing of the project. Could would probably require a transparent tender process.
	• Cost plus – as for negotiated
	• Excepted risks - There are standard excepted risks under NZS3910. WWAC need to review these and make sure they understand them. They can be transferred to the Contractor, but this will attract additional costs.
	• JR asked T&T to provide some information on what items are likely be scheduled as lump sums if Measure & Value (M&V) is adopted.

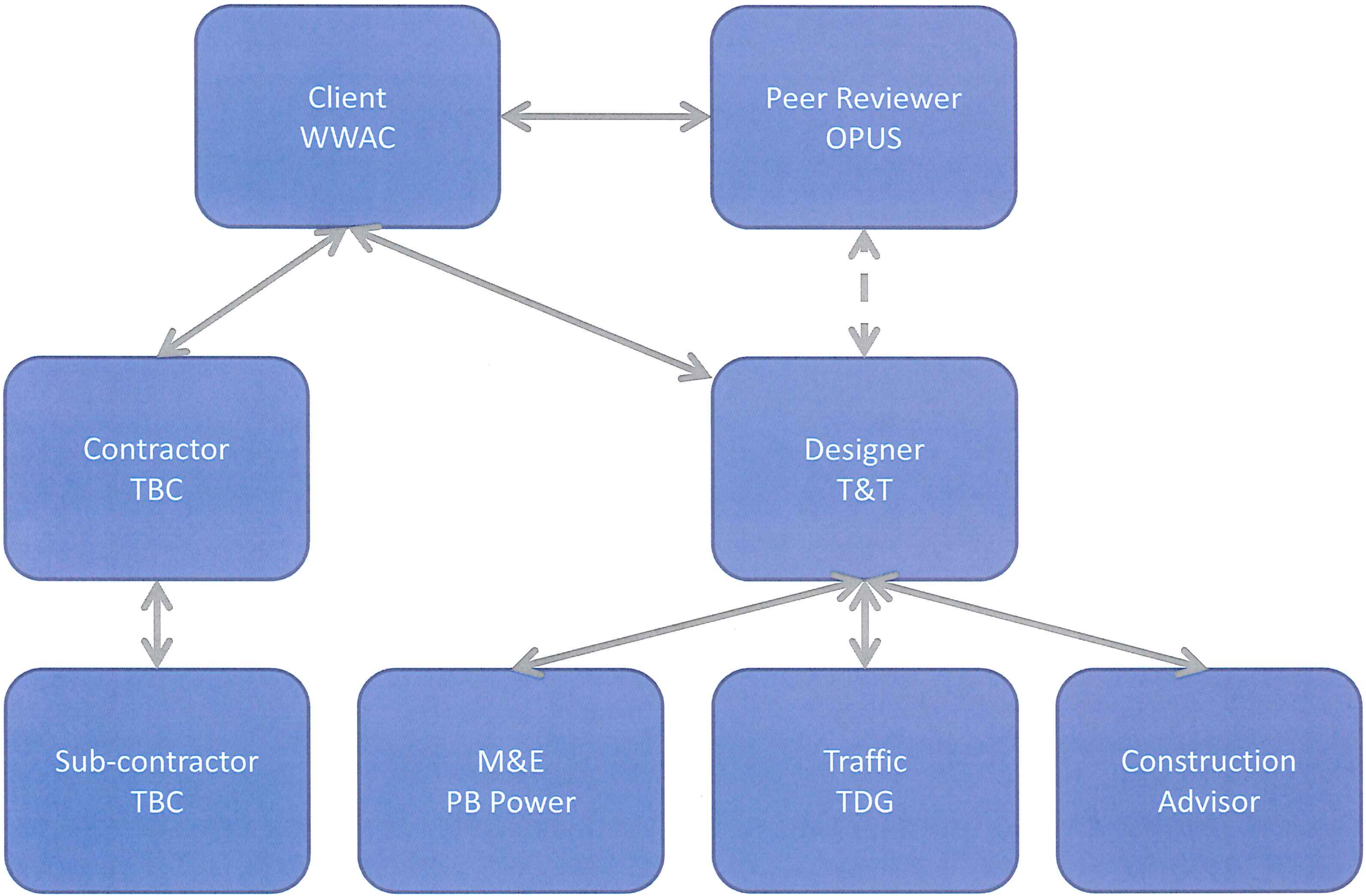
10.0	Tendering/Procurement (not applicable to all procurement methods) • TK commented that given it has TDC involvement; it is likely that tendering of some form will be required. • The use of Weighted attributes in evaluation was discussed. Methodology, track record and Resources having particular importance. • MT explained that there can be a client emphasis of having the price as the majority of the weighting, but that there is a risk that only the lowest tender price wins, rather than the overall best tender. • IW commented that the tender conditions need to be carefully written so that there is flexibility in the evaluation. • Discussion around how tenderers put their A team into the document, but they do not actually carry through into construction. Consideration should be given to wording the documents to encourage the same team as evaluated are the ones who build it. • Intellectual property of tenderers - IW advised some tenderers offer alternatives, but if they are not selected as the Contractor, this idea cannot be used. Some client organisations will pay the unsuccessful tenderers for that intellectual property rights so they can use it. • WWAC is keen on alternatives if they stack up and the contract should provide this opportunity • Following a discussion on possible tendering and prequalification processes, the committee attendees responded that they are attracted to a tender process with some form of pre-qualification. Various pre-qualification options are available - for example:

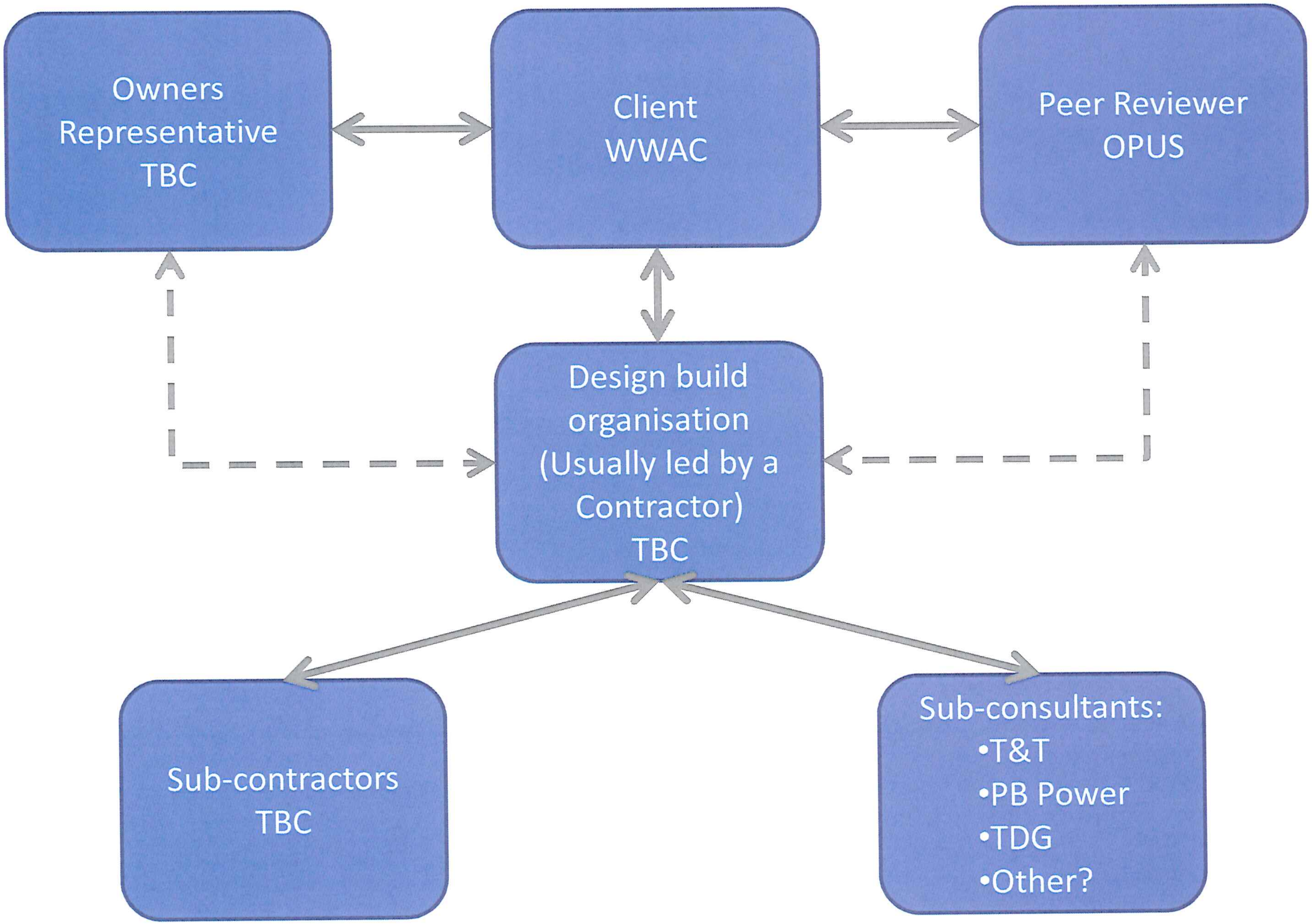
	○ A Registration of Interest (ROI) where a sample set of drawings, a description of the works and a draft schedule of quantities are sent to tenderers. Tenders then notify to the client their 'interest' in the project. The tenderers are evaluated and often shortlisted on attributives such as track record, resources etc. When the full tender documents are ready they are issued only to the successful shortlisted tenderers. This process has the advantages: ▪ that the tenderers do not have to spend as much effort in preparing a full tender when they are in a competitive market (i.e. before shortlisting) ▪ the process gives the market a 'heads up' that the project is coming, so that tenderers have some time to speak to suppliers and sub-contractors ▪ the pre-qualification process can be prepared in parallel before the final design is complete
11.0	Project programme • Tender period - Assuming no prequalification then 2 months as a minimum. 3 months would be a preferred basis: ○ This period may be greater if a prequalification process is included. ○ In general the longer tenderers are given, the more accurate the tender price. • Review and Contract Award (6 weeks minimum - 2 months preferred) - This will depend on tags, negotiations required and WWAC's own approval procedure • Contractor Mobilisation • Construction - Fletchers during the Stage 1 review had considered that approximately 3 years would be more appropriate than the feasibility estimate of 2 years. IW agreed that because it is a constrained site, the works may not be able to be accelerated by adding additional plant. • The Stage 1 report identified that there are preferred times of the year to undertake the diversion works. Therefore WWAC should take that timing into consideration when putting the works out to tender.
12.0	Methods for potential cost savings (within the scope of procurement) • Provide adequate tender period • Encourage alternative tenders. This should be balanced with any resulting changes to building and resource consents and possible programme delays as result. • Tenderers could be asked to nominate a construction time (and associated savings) as an alternative. • MT explained that the forestry road realignments are outside the scope of the dam construction estimates and should remain outside the main contract. This is best for WWAC to negotiate directly with the forestry operator and or land owner. • IW expressed that in his experience, due to the minimal time effort that the tenderers have in preparing alternatives, these are unlikely to result in real savings once evaluated

Attached:

Simplified charts of Traditional and Design- Build Contractual arrangements presented and discussed in workshop.


May/June 2012
80% Design
Review
Resource Consent
Review
100% Design
Review
Building Consent
Tender Process
Award Contract
Construction
Commissioning
Operation


Client
WWAC
Peer Reviewer
OPUS
Contractor
TBC
Designer
T&T
Sub-contractor
TBC
M&E
PB Power
Traffic
TDG
Construction
Advisor


Owners Representative TBC
Client WWAC
Peer Reviewer OPUS
Design build organisation (Usually led by a Contractor) TBC
Sub-contractors TBC
Sub-consultants:
•T&T
•PB Power
•TDG
•Other?

Appendix D: Draft Emergency Action Plan (EAP)

EMERGENCY ACTION PLAN

Waimea Water Augmentation Committee

Emergency Action Plan
Lee Valley Dam

EAP prepared for:

Waimea Water Augmentation Committee

EAP prepared by:

Tonkin & Taylor Ltd

Distribution:

Waimea Water Augmentation Committee	**1 copy**
Tonkin & Taylor Ltd (FILE)	**1 copy**

October 2012

T&T Ref: 27425.100

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Pages	Date	Issue No	Description	Initials
All	28/05/2012	1	Draft preparation	SGB
All	23/07/2012	1	Draft preparation	JICR
ALL	09/2012	1	Draft issue	MCNT
All	17/9/12	1	Draft	SZM
All	26/9/2012	1	Draft	SFC
ALL	20/10/12	1	Draft with Stage 3 Report	MCNT

Controlled Copy Distribution List

ORGANISATION	Copy number
Dam Owner	1
Designer (Tonkin & Taylor Ltd - Auckland)	2
NZ Police	3
Civil Defence	4
St John Ambulance Service	5
NZ Fire Service	6

Summary

This document provides a draft of a possible Emergency Action Plan (EAP) for the operational phase (as distinct from construction phase) of a proposed dam on the Lee River, a tributary of the Waimea River in Tasman District. It is intended to provide an indication of the envisaged content for the operative EAP for the completed dam. Details will need to be completed and particular descriptions in this document will need to be modified and sections added or deleted to match the final physical and organisational arrangements following detailed design and construction. This draft EAP has been prepared under the assumption that the dam does not have a hydropower component.

This EAP provides a systematic means of:

a) Defining and identifying a Crisis, Emergency Situation or Unusual Occurrence which may threaten the integrity of the dam and require immediate action;

b) Documenting the procedure for declaring a Crisis or Emergency Situation;

c) Ensuring effective actions are taken to prevent dam failure;

d) Avoiding loss of life and minimising property damage in the event of a failure by providing timely warnings in a systematic way to the appropriate emergency management organisations for their implementation.

The responsibilities and actions of each organisation are outlined in the EAP. It is intended that each organisation will keep this EAP readily available to assist staff in rapid decision making.

Preliminary warnings to Civil Defence and the NZ Police are to be utilised wherever possible.

The priority of the EAP is identified as being that, if a Crisis or any Emergency Situation endangers the integrity of the dam and/or downstream property or life, the Dam Owner or its Agent must immediately notify:

Organisation	Name	Contact Numbers		DAM OWNER TO COMPLETE AND MAINTAIN LIST
		Work	Home	
NZ Police				
Civil Defence				
Dam Owner				
Dam Operator				

<u>Special Note</u>

If a Crisis or Emergency Situation is declared and the NZ Police and Civil Defence cannot be contacted immediately on the above numbers, ring 111 and report the incident to the NZ Police.

SITUATION HIERARCHY

SITUATION LEVEL DESCRIPTION	NOTES	ACTION REQUIRED
Unusual Occurrence Section 3.4	Incident does not represent an immediate danger but must be evaluated. Incident generally managed by routine procedures. May require preliminary warning to be issued to Civil Defence and NZ Police.	ACTION 1 Section 4.5
Emergency Situation Section 3.3	Warning to be issued to Civil Defence and NZ Police. Requires a coordinated response together with overview, advice and action from Technical Experts. May or may not result in a Civil Defence Emergency or escalation to a Crisis Situation.	ACTION 2 Section 4.4
Crisis Situation Section 3.2	Imminent dam failure with catastrophic consequences. Civil Defence Emergency requiring a coordinated multi-agency response.	ACTION 3 Section 4.3

EMERGENCY EVALUATION PROCEDURE

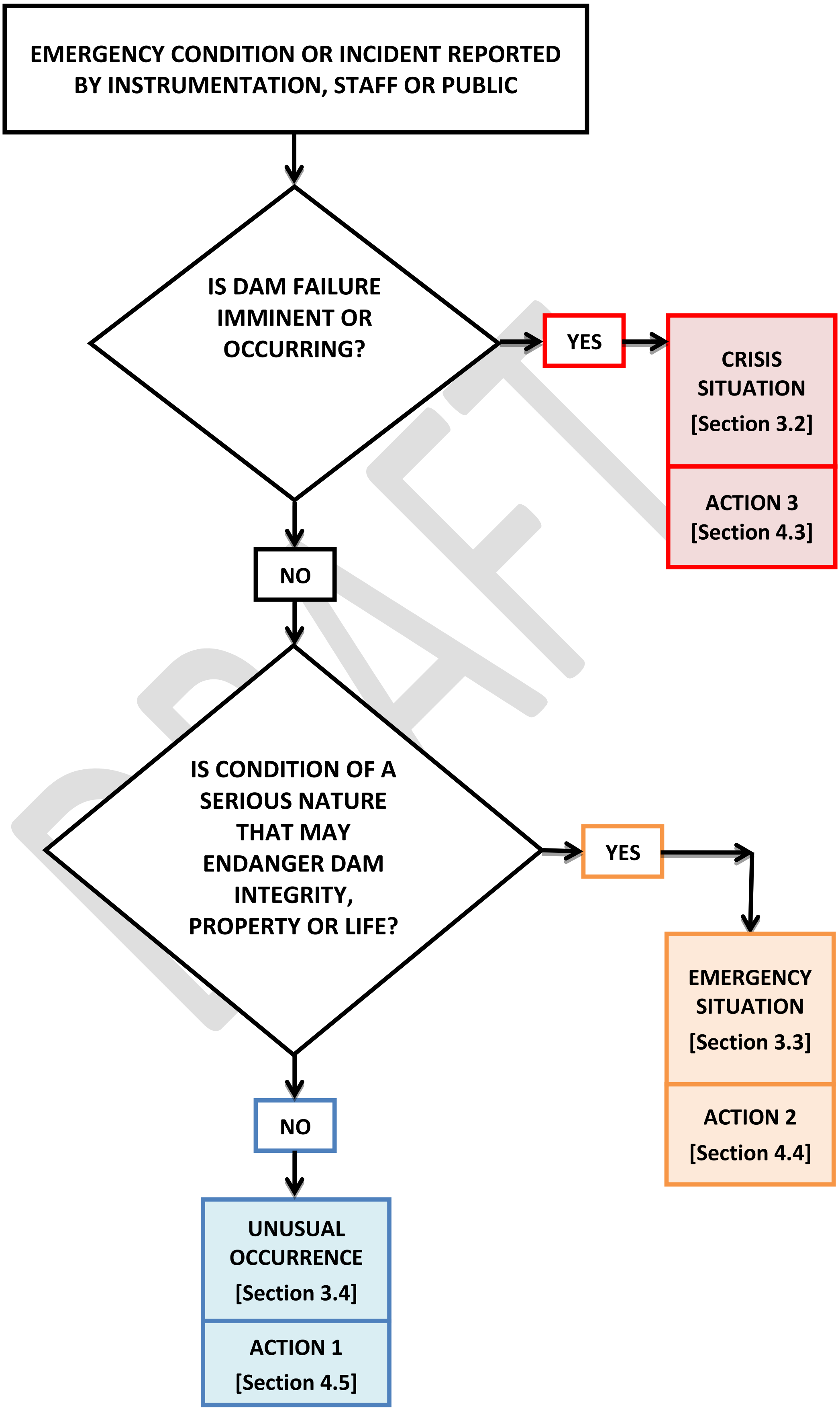


Table of contents

Contents

1 Purpose of the EAP

1.1 Introduction

This document provides a draft of a possible Emergency Action Plan (EAP) for the operational phase (as distinct from construction phase) of the proposed Lee Valley Dam. It is intended to provide an indication of the envisaged content for the operative EAP for the completed dam. Details will need to be completed and particular descriptions in this document will need to be modified and, sections added or deleted, to match the final physical and organisational arrangements following detailed design and construction. This draft EAP has been prepared under the assumption that the hydropower add on is not a component of the final dam arrangement. If a hydropower component is constructed then the EAP will require updating as appropriate.

The Contractor (when appointed) will be required to prepare an EAP for the construction of the dam.

This EAP has been prepared to assist the Dam Owner, the NZ Police and the Civil Defence authorities in responding swiftly and effectively in the event of an emergency at the Lee Valley Dam, including the potential effects of a hypothetical breach of the dam. The EAP facilitates efficient mobilisation of manpower and equipment to deal with any incipient undesirable condition at the dam and allows for identifying areas at risk and the timely warning and evacuation procedures for the protection and security of communities downstream.

The EAP has been prepared generally in accordance with the New Zealand Society on Large Dam (NZSOLD) Dam Safety Guidelines.

The procedures are designed to prevent or minimise the loss of life and/or property damage resulting from an emergency at the dam. In case of an emergency affecting the integrity of the dam, procedures for initiating warning of endangered downstream populations are specified, consisting essentially of notification of local emergency services.

The EAP does not cover communications with insurers, news media or its customers. Further, it does not cover emergencies external to the dam site area or sabotage, bomb threat, riot, severe storms, fires (including forest fire), oil and hazardous substance spills, drowning and major accidents, fish and wildlife losses, criminal actions or power supply emergencies.

1.2 Lee Valley Dam location and access

The Lee Valley Dam is located on the Lee River, a tributary of the Waimea River in the Tasman District as shown in Figure 1-1. The dam site is located on the Lee Valley Road, approximately 16.5 km from the State Highway 6 junction with River Terrace Road in Brightwater. An alternative road route to the site, approximately 30km long, is via the Edward Street / State Highway 6 junction in Wakefield. Figure 1-1 shows both main routes to the dam with the River Terrace Road Route in Blue and the longer Edward Street Route in Green. There are other, more difficult, forestry access routes to the dam site in the event that the main roads are not passable but these may require four wheel drives / farm bikes and portions on foot. However, these may not be passable in severe storm conditions or after a major earthquake.

Air access to the dam by helicopter is also an option; however landing of a float plane on the reservoir could be dangerous due to the risk of floating forestry debris.

The nearest airstrip is Nelson Airport approximately 33 km from the dam by road.

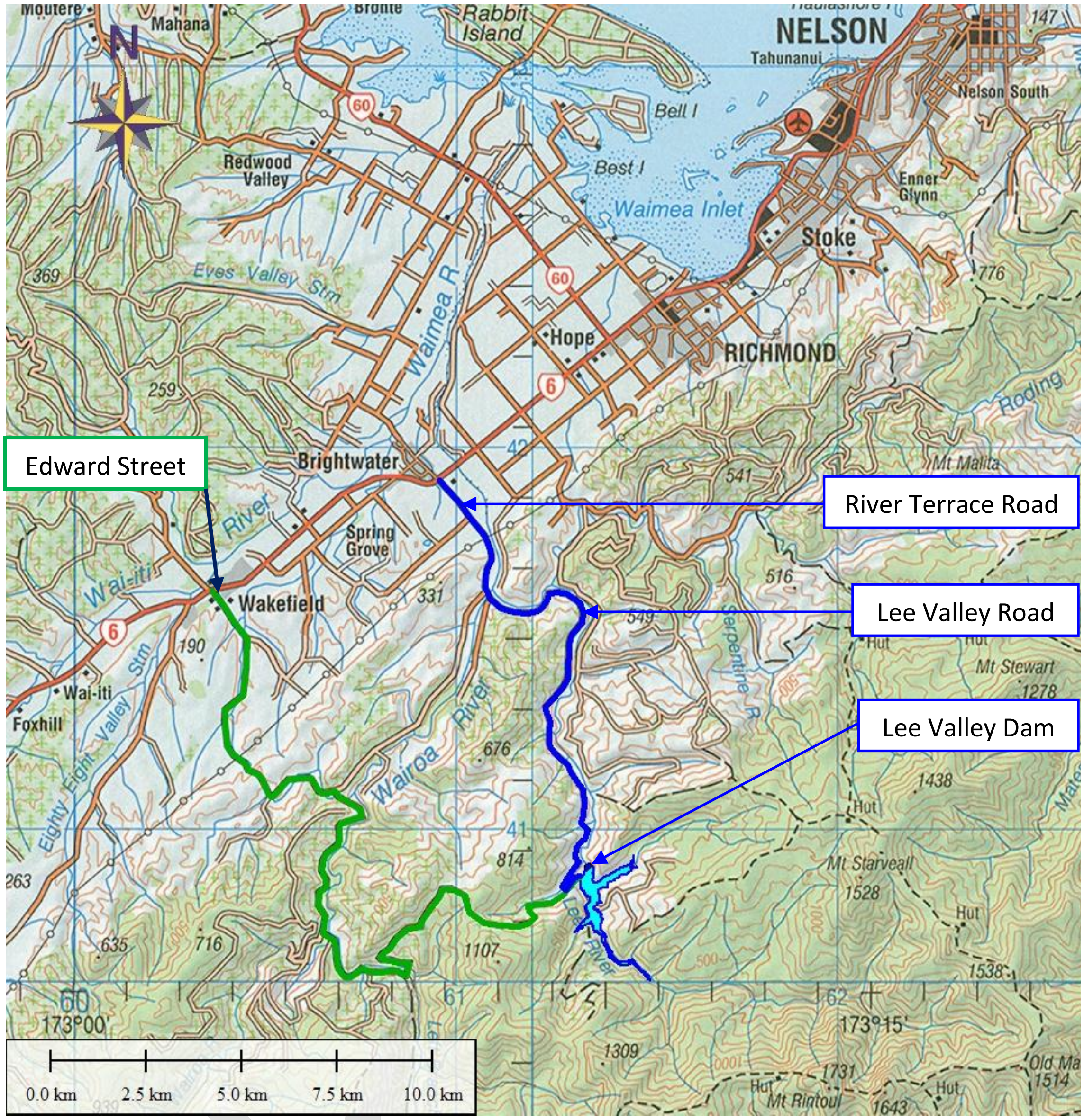


Figure 1-1 Dam Location Map

Table 1-1 provides coordinates for the Lee Valley Dam site to three common coordinate systems.

Table 1-1 Lee Valley Dam coordinates

Coordinate System	Latitude or Northing	Longitude or Easting
Latitude and Longitude (WGS84)	41° 28' 13.2" S	173° 09' 40.9" E
New Zealand Transverse Mercator (NZTM2000)	5409017 mN	1613473 mE
New Zealand Map Grid (NZMG49)	5970712 mN	2523466 mE

Further discussion about site access in conjunction with flood inundation mapping is contained in Section 8.4.2.

1.3 Lee Valley Dam technical data

Table 1-2, taken from the Lee Valley Dam Stage 3 design report[1] summaries the key technical information for the dam.

Table 1-2 Key Lee Valley Dam Technical Data

Embankment characteristics	
Embankment type	Concrete Face Rockfill Dam (CFRD)
Embankment volume (approximate)	435,000 m^3
Nominal crest elevation (excluding camber)	201.23 mRL
Top of parapet wall (excluding camber)	202.83 mRL
Design Camber	0.3 m
Maximum dam height (from riverbed to dam crest on CL)	53 m
Crest length (approximately)	220 m
Crest width	6 m
Hydrology, reservoir and flood routing characteristics	
Catchment area	77.5 km^2
Normal top water level (NTWL)	197.2 mRL
Reservoir storage at NTWL	13,000,000 m^3
Reservoir area at NTWL	630,000 m^2
Mean Annual Flood level (MAFL)	199.09 mRL
Reservoir storage at MAFL	14,250,000 m^3
Operational basis flood level (OBFL)	200.48 mRL
Reservoir storage at OBFL	15,150,000 m^3
Maximum design flood level (MDFL)	202.53 mRL
Reservoir storage at MDFL	16,600,000 m^3
Reservoir storage at top of parapet wall (202.83 mRL)	16,800,000 m^3
Spillway characteristics	
Primary spillway type	Ogee Weir
Ogee weir effective length (on arc)	41.89 m
Peak outflow – Mean Annual Flow (MAF)	179 m^3/s
Peak outflow – Operational Basis Flow (OBF)	472 m^3/s
Peak outflow – Maximum Design Flood (MDF)	1060 m^3/s
Capacity outflow – Reservoir level at top of parapet wall	1152 m^3/s

[1] Tonkin & Taylor Ltd (2012) Lee Valley Dam Detailed Design Report Stage 3, Ref: 27425.100

Spillway and Energy dissipation characteristics	
Chute length (plan – ogee crest to start of flip bucket)	124 m
Chute width, narrow section	20 m
Chute horizontal transition length	71 m
Chute vertical curve length	21 m
Chute minimum height of concrete lining	2.8 m
Dissipation type	Flip Bucket
Flip bucket radius	20 m
Bucket lip level	156.6 mRL
Outlet characteristics	
Outlet type	Sloping outlet conduits on upstream face with removable screens and valve control.
Number of outlets	2
Outlet level – Upper (elevation of top of bellmouth)	181.5 mRL
Outlet level – Lower (elevation of top of bellmouth)	163.0 mRL
Control type	Twin 800mm Free Discharge Valves
Maximum design discharge capacity (Valve manufacturer velocity limits applied)	15.1 m³/s
Concrete conduit size under embankment (internal dimensions)	Twin 2.5 m Wide x 4.0 m High
River tailwater characteristics	
Tailwater level MAF	150.85 mRL
Tailwater level OBF	153.46 mRL
Tailwater level PMF	156.54 mRL
Irrigation and environmental flow release[1]	
Irrigation release at dam toe (at minimum operating level and from either intake)	2.23 m³/s
Environmental residual flow (7 day MALF at minimum operating level and from either intake)	0.51 m³/s
Environmental flushing flow (at minimum operating level and from either intake)	5.0 m³/s
Note 1: The criterion design capacity of the outlet is the largest of the requirements of 5.0 cumecs and is not additive (i.e. It is not 2.23 + 5 + 0.51)	

1.4 The Emergency Action Plan

The EAP provides a systematic plan to:

a) Define and identify a Crisis, Emergency Situation and Unusual Occurrences which may threaten the integrity of the dam and require immediate action

b) Document the procedure for declaring a Crisis or Emergency Situation

c) Ensure effective actions are taken to prevent dam failure

d) Avoid loss of life and minimise property damage in the event of a failure by providing timely warnings in a systematic way to the appropriate emergency management agencies for their implementation.

Detailed public warning and evacuation procedures are the responsibility of the NZ Police. If their resources are insufficient, they may call upon the Civil Defence authorities for aid. Information is included in the EAP, including inundation maps, to permit these agencies to develop effective warning and evacuation procedures.

Emergencies not specifically identified in this EAP shall be handled by the Dam Owner using procedures outlined in the EAP which are appropriate to the potential damage to the dam and to the threat to life, property and water supply posed by the emergency.

This EAP applies to the Operational Phase of the dam, post commissioning. It will be updated by the Dam Owner regularly, with formal written notification of any amendments being circulated to each holder of a controlled copy.

2 Responsibilities

2.1 Introduction

This section sets out the organisations responsible for the surveillance, maintenance and operation of the dam. It also specifies the organisations responsible for implementing the preventative and emergency actions detailed in Section 3.

The organisations or individuals with responsibility for this dam are as follows:

- Dam Owner
- NZ Police
- Civil Defence
- St John Ambulance Service
- NZ Fire Service
- Dam Designer (Tonkin & Taylor Ltd).

2.2 Dam Owner

The Dam Owner has a responsibility to operate the dam in a manner that is considered to meet sound engineering and professional standards, to meet all relevant legislative guidelines and in accordance with the Lee Valley Dam Operating Procedures. These procedures are based on the New Zealand Society on Large Dams (NZSOLD) Guidelines and the Lee Valley Dam Resource Consent conditions. [NOTE: At the time of writing this draft of the EAP a Resource Consent for the dam has not yet been applied for.]

From an emergency planning perspective the Dam Owner is responsible for:

a) Providing advice in the preparation of this EAP

b) Complying with the detail of this EAP

c) Ensuring that all the staff involved in the operation of the Lee Valley Dam are familiar with this EAP, and the company obligations in it

d) Ensuring that suitably trained and authorised staff are available to competently assess potential emergency situations and/or unusual occurrences. If, in accordance with the guidelines contained in Section 3 and their professional judgement, they identify a Crisis, Emergency Situation or Unusual Occurrence they must discharge the responsibilities of the Dam Owner throughout the period of the Crisis, Emergency Situation or Unusual Occurrence.

e) Having facilities and procedures in place to receive alarm signals from monitoring equipment at the dam and its early warning systems

f) Having facilities and procedures in place to give warnings to Civil Defence and the NZ Police in the event of a Crisis, Emergency Situation or Unusual Occurrence that may arise at the dam site

g) Maintaining a schedule of the expertise, staff, materials and equipment to counter threats to the integrity of the dam

h) Testing and maintaining the effectiveness of this EAP.

2.2.1 Suitably trained staff

Suitably trained staff are deemed to be those who can:

a) Recognise a Crisis, Emergency Situation or Unusual Occurrence as listed in this EAP, and understand their possible effects on the integrity and safety of the dam

b) Understand that the Emergency Situations or Unusual Occurrences identified in Section 3 are not an exhaustive list of every possible condition that could arise, and that judgement is required when assessing situations

c) Understand the importance of providing early warning to the NZ Police and Civil Defence of a Crisis, Emergency Situation or Unusual Occurrence that may develop at the dam site

d) Accurately monitor, record and report on reservoir levels and freeboard to the top of the parapet wall

e) Accurately complete the Notification Form as shown in Appendix A

f) Readily access the emergency service numbers required to notify the NZ Police and Civil Defence (see contact list Appendix C)

g) Operate communication equipment used to convey emergency messages (e.g. telephone, fax and mobile phone)

h) Correctly interpret and manage the implementation of the preventative actions set out in Section 4 of this plan

i) Liaise with Tonkin and Taylor Ltd (T&T) or other suitably experienced dam design organisations where specialist advice is required. The acquisition of such advice must not delay the notification of a Crisis, Emergency Situation or Unusual Occurrence

j) Safely supervise any of the operational tasks that may be necessary to remedy conditions which may be hazardous to the dam and/or downstream residents and properties.

2.3 Civil Defence

The Tasman District Council (TDC) Civil Defence Organisation has jurisdiction over any emergency that involves the Lee Valley Dam.

Civil Defence responsibilities, in relation to planning for emergencies at the dam, are those which pertain to local situations that could give rise to the need to declare an Emergency under the Civil Defence and Emergency Act (CDEM) or require a coordinated multi-agency response to an emergency not declared under the CDEM Act.

The most important requirement of this plan is that it dovetails into the current TDC Civil Defence plan.

Civil Defence planning responsibilities can be summarised as:

a) Providing advice in the preparation of this plan
[Not yet provided at the time of writing this draft of the EAP]

b) Notifying the Dam Owner of any external event of which they have knowledge that may affect the safety of the Lee Valley Dam

c) Ensuring that this EAP is compatible with TDC's Civil Defence plan

d) Maintaining an easily accessed contact system to ensure they can receive early warnings, and keeping the Dam Owner informed of any external events and/or information which may assist in assessing a Crisis, Emergency Situation or Unusual Occurrence at the dam site

e) Maintaining their own plan for the handling of emergencies that may arise out of a sudden release of water from the Lee Valley Dam.

2.4 NZ Police

The NZ Police have responsibility for protecting the life and property of residents of this country. This responsibility extends across the spectrum of emergencies, from those that may affect only one individual, to major emergencies.

The NZ Police responsibilities in relation to planning for a Crisis, Emergency Situation or Unusual Occurrence affecting the Lee Valley Dam are as follows:

a) Providing advice in the preparation of this plan
[Not yet provided at the time of writing this draft of the EAP]

b) Notifying the Dam Owner of any external event of which they have knowledge that may affect the safety of the Lee Valley Dam

c) Ensuring this plan is compatible with other NZ Police plans and procedures in the Tasman District

d) Having systems in place to allow receipt of reports of a Crisis, Emergency Situation or Unusual Occurrence, thus allowing the early implementation of NZ Police procedures

e) Liaising with Civil Defence on plans for the district relating to the handling of emergencies involving the Lee Valley Dam, in particular warning and/or evacuation procedures

f) Maintaining a current contact list of all residents downstream from the Lee Valley Dam that may be immediately affected by a sudden release of water from the dam

g) Establishing and maintaining a notification system for warning downstream residents, as well as Fire and Ambulance Services, in the event of a Crisis, Emergency Situation or Unusual Occurrence developing at the Lee Valley Dam site.

2.5 St John Ambulance Service and NZ Fire Service

Both services will be informed by the NZ Police of a Crisis, Emergency Situation or Unusual Occurrence at the earliest opportunity. Both services will in turn keep the Dam Owner informed of any external event of which they have knowledge, which may affect the safety of the Lee Valley Dam.

The NZ Fire Service and St John will develop and maintain their own specific procedures relating to a Crisis, Emergency Situation or Unusual Occurrence which may result in sudden release of water from the Lee Valley Dam. Such plans and procedures will be known to, and be compatible with, all other agencies involved with emergencies pertaining to the Lee Valley Dam.

2.6 Tonkin & Taylor Ltd

As designer of the dam, Tonkin & Taylor is best placed to provide advice to the Dam Owner in a Crisis, Emergency Situation or Unusual Occurrence. Tonkin & Taylor will endeavour to provide advice regarding preventative actions that may need to be undertaken. If such advice is not available, then other suitably qualified dam design organisations will be utilised.

3 Emergency identification, evaluation and actions

3.1 Emergency identification and evaluation

The Lee Valley Dam does not require permanent staff to be located at the dam site, however regular inspections are required as part of the Dam Safety Assurance Programme.

Warnings of a potential Crisis, Emergency Situation or Unusual Occurrence may be derived from automatic sensors and control equipment at the dam. In addition, warnings could be reported by staff, local residents or members of the public. Warnings from monitoring equipment will go to the Dam Owner. Warnings or reports from the public may be received by the Dam Owner, Civil Defence or the NZ Police. It is most important that any organisation receiving a report carries out its duties as set out in the Section 5 of this EAP.

The Dam Owner or staff, on receipt of a message indicating a potential problem with the dam will, without delay, investigate the cause, instigate the necessary actions and provide preliminary warning to Civil Defence and the NZ Police as per the notification requirements in Section 5 of this EAP. It is the responsibility of the Dam Owner to identify any incident as a Crisis, Emergency Situation or Unusual Occurrence. In the event that the Dam Owner cannot be contacted, Civil Defence will decide whether the emergency is likely to lead to the declaration of a Civil Defence Emergency and declare a Crisis/Emergency Situation or not.

Crisis, Emergency Situations and Unusual Occurrences at the dam are defined below.

3.2 Definition of Crisis Situation

Crisis Situation

A **Crisis Situation** is when the dam shows evidence of an imminent dam failure with catastrophic consequences, such as:

- Water flowing through a breach in the dam
- Spillway flow scouring and undermining the downstream face of the dam
- Water overtopping the dam causing large scale scouring of the downstream face of the dam

This is the most serious emergency for the dam and **requires immediate notification of the NZ Police and Civil Defence**. Declaration of a Civil Defence Emergency is likely.

Refer Section 4.3.1 on page 14.

3.3 Definitions of Emergency Situations

Emergency Situation

An **Emergency Situation** is a condition of a serious nature developing suddenly or unexpectedly that may endanger the integrity of the dam or downstream property and/or life. If preventative action is not taken this situation can worsen to become a Crisis Situation.

An Emergency Situation requires immediate action.

Possible Emergency Situations include, but are not limited to those described in Table 3-1.

Table 3-1 Emergency Situation Descriptions

Description	Section	Page
Reservoir water level at or above maximum design flood level (202.53mRL)	4.4.1	15
Excessive seepage likely to result in unravelling of the downstream face of the dam	4.4.2	15
Failure or impending failure of the dam spillway	4.4.3	15
Spillway blockage with lake level rising	4.4.4	16
Earthquake causing major damage and a risk of uncontrolled reservoir release	4.4.5	16

3.4 Definitions of Unusual Occurrences

Unusual Occurrence

An **Unusual Occurrence** is an event which takes place, or a condition which develops, that is not normally encountered in the routine operation of the dam and may have the potential to endanger its structure.

Unusual Occurrences must be evaluated to determine whether there has been any damage requiring correction, special safety measures needing to be implemented, and to assess if performance is in accordance with the design expectations.

Possible Unusual Occurrences include, but are not limited to those described in Table 3-2.

Table 3-2 Unusual Occurrence Descriptions

Description	Section	Page
Lake level at or above 199.13 mRL (1.93m above NTWL)	4.5.1	17
Earthquake felt in the area of the dam	4.5.2	17
Slumping, cracking or erosion of the dam or its abutments	4.5.3	18
New seepage, sudden increase in seepage rates or a murky appearance to the seepage from the dam	4.5.4	19
Damage to concrete face or parapet wall or loss of freeboard	4.5.5	19
Failure of dam instrumentation, early warning or communications systems	4.5.6	19
Spillway blockage or rockfall into spillway	4.5.7	19
Landslides into the reservoir	4.5.8	20

4 Actions during a Crisis, Emergency Situation or Unusual Occurrence

4.1 Introduction

Each organisation involved in the Lee Valley Dam emergency planning will have their own internal policies and procedures. These will determine their own actions in the event of an emergency.

The intent of this EAP is to outline the actions to be taken by the Dam Owner when dealing with a Crisis, Emergency Situation or Unusual Occurrence at the dam site.

The EAP cannot cover every possible condition, and judgements by the Dam Owner and design advice from Tonkin & Taylor or other suitably qualified organisations will be necessary in other situations.

4.2 Preventative action

Preventative actions need to be taken prior to and during the emergency situation. The important factor in the effectiveness of the EAP is the prompt detection and evaluation of information obtained from instrumentation and/or physical inspection and surveillance procedures.

The time factor for the onset of an emergency to awareness of imminent danger and its effect on the workability of the EAP is critical. Timely implementation of the EAP is a crucial element in its effectiveness and appropriate effective warning systems are imperative for emergency authorities to eliminate or minimise downstream effects or endeavour to avert substantial damage to the dam.

The primary action is to notify the NZ Police and Civil Defence if there is the potential for an uncontrolled release of water from the dam.

4.3 Crisis Situation actions

ACTION 3

4.3.1 Imminent dam failure

- Immediately warn Civil Defence and the NZ Police of the Crisis Situation in accordance with the Priority Notification Plan in Section 5 of this plan
  - Declaration of a Civil Defence Emergency is likely
- Fully open the outlet valves to assist in lowering the water level in the reservoir
- Vacate the immediate vicinity downstream of the dam
- Contact Tonkin & Taylor for advice on possible further remedial action
- Monitor, document and photograph dam status if safe to do so
- Continue to liaise with, and provide information to, Civil Defence and the NZ Police as necessary.

4.4 Emergency Situation actions

ACTION 2

In preparation for possible remedial action the Dam Owner will at all times operate the dam in accordance with approved operating procedures and this EAP.

Suitably trained staff will also be available on a 24-hour basis to respond quickly in the event of any Emergency Situation being reported and to supervise necessary responses and/or remedial works.

In response to the Emergency Situations listed below, the following actions shall be carried out by the Dam Owner as a minimum:

- Immediately warn Civil Defence and the NZ Police of the Emergency Situation in accordance with the Priority Notification Plan in Section 5 of this plan
- Immediately inspect dam to assess the situation, with a Technical Advisor if available
- Fully open the outlet valves to assist in lowering the water level in the reservoir, if safe to do so
- Monitor, record and report reservoir levels at least hourly
- Contact Tonkin & Taylor for advice on possible further remedial action
- Continue to liaise with, and provide information to, Civil Defence and the NZ Police as required.

If the Emergency Situations requires other specific actions these are described below:

4.4.1 Reservoir water level at or above maximum design flood level (202.53mRL)

- Continuously monitor and record meteorological forecasts and rainfall
- Monitor and record all seepage flows at least hourly if safe to do so
- No other emergency specific actions listed.

4.4.2 Excessive seepage likely to result in unravelling of the downstream face of the dam

- Lower the water level within the embankment by removing the weir plates within the v-notch weirs
- Monitor and record all seepage flows at least hourly if safe to do so
- No other emergency specific actions listed.

4.4.3 Failure or impending failure of the dam spillway

- No other emergency specific actions listed.

4.4.4 Spillway blockage with lake level rising

- Investigate and implement methods to remove the blockage if safe to do so
- No other emergency specific actions listed.

4.4.5 Earthquake causing major damage and a risk of uncontrolled reservoir release

- Major damage and a risk of uncontrolled release is considered to exist if:
  - Significant loss of freeboard with the potential for the dam to be overtopped
  - Spillway blockage has occurred and the spillway is likely to operate prior to removal of blockage
  - Significant damage to spillway concrete lining has occurred and the spillway is likely to operate prior to repairs being carried out
- Monitor embankment seepage and other instrumentation for indications of a potential dam breach
- If conditions indicate a dam breach is likely then immediately implement the Crisis Situation actions.

ACTION 3

4.5 Unusual Occurrence actions

ACTION 1

The situations below do not represent an immediate danger to the dam and therefore will not in themselves endanger property or lives downstream of the dam. All Unusual Occurrence events shall be recorded in the appropriate Dam Safety Assurance Program documentation.

Nevertheless, wherever possible or necessary, a preliminary warning should be issued to the Civil Defence and the NZ Police in accordance with the notification requirements shown in Section 5 of this EAP. The timely provision of early warnings can avert Emergency Situations.

4.5.1 Lake level at or above 199.13 mRL (1.93m above NTWL)

This is the level that base of the parapet wall joins the concrete face slab and is just above the design MAFL (199.09 mRL).

- Provide a suitably trained observer at the dam site who can accurately monitor and report on the situation
- Test and confirm operability of communication systems and dam instrumentation
- Monitor and record meteorological forecasts, rainfall, all dam instrumentation and seepage flows
- Alert operations staff to the situation.

4.5.2 Earthquake felt in the area of the dam

An inspection of the dam and appurtenant structures should be undertaken if an earthquake is felt or reported in the dam area. The response will differ depending if the intensity of the earthquake is more or less than a MM5 in the Modified Mercalli Intensity scale. Table 4-1 provides a guide for gauging the earthquake intensity. Refer Appendix H for the full intensity range.

Table 4-1 Key Modified Mercalli Intensity Scales for earthquake response

Category (MM)	Description
MM 4: Largely observed	Generally noticed indoors, but not outside, as a moderate vibration or jolt. Light sleepers may be awakened. Walls may creak, and glassware, crockery, doors or windows rattle.
MM 5: Strong	Generally felt outside and by almost everyone indoors. Most sleepers are awakened and a few people alarmed. Small objects are shifted or overturned, and pictures knock against the wall. Some glassware and crockery may break, and loosely secured doors may swing open and shut.
MM 6: Slightly damaging	Felt by all. People and animals are alarmed, and many run outside. Walking steadily is difficult. Furniture and appliances may move on smooth surfaces, and objects fall from walls and shelves. Glassware and crockery break. Slight non-structural damage to buildings may occur.
Note: Table adapted from GNS Science New Zealand website, September 2012.	

- Inspect the dam
  - Immediately if earthquake intensity equal to or greater than MM 5
  - As soon as reasonably practical if earthquake intensity less than MM 5
- Inspect and report on the embankment, abutments, spillway and appurtenant structures. Check for springs, change in seepage rates, deformation, erosion and concrete damage. Record location, extent and severity of any damage
  - Repeat the inspection and monitoring rounds every 12 hours as deemed necessary if earthquake intensity equal to or greater than MM 5
- If major damage has occurred at the dam and there is a risk of uncontrolled release of the stored water, this should be treated as an Emergency Situation as defined in Section 4.4.5

  ACTION 2

  Major damage and a risk of uncontrolled release is considered to exist if:
  - Significant loss of freeboard with the potential for the dam to be overtopped
  - Spillway blockage has occurred and the spillway is likely to operate prior to removal of blockage
  - Significant damage to spillway concrete lining has occurred and the spillway is likely to operate prior to repairs being carried out
- Advise Civil Defence and the NZ Police of the situation at the dam site if significant changes from normal conditions are observed
- Alert operations staff of the situation
- Test and confirm operability of communication systems and dam instrumentation
- Undertake deformation survey of the dam, spillway and appurtenant structures
- Monitor seepage flows for indications of possible damage to the concrete face or its joints. If seepage flows increase, contact Tonkin & Taylor to determine possible remedial actions
- If visible damage has occurred, evaluate and determine whether special safety measures or corrective action is required.

4.5.3 Slumping, cracking or erosion of the dam or its abutments

- Record and photograph location, extent and severity of the damage
- Evaluate the damage and determine whether special safety measures or corrective action is required
- If the damage is evaluated as severe enough to jeopardise the safety of the dam this should be treated as an Emergency Situation as defined in Section 4.4.5

  ACTION 2
- Contact Tonkin & Taylor to determine possible remedial actions.

4.5.4 New seepage, sudden increase in seepage rates or a murky appearance to the seepage from the dam

- Record and photograph location, extents and estimate rate of any new seepage
- Monitor and record seepage rates, take samples of murky seepage
- Evaluate the situation and determine whether special safety measures or corrective action is required
- If the seepage issue is evaluated as severe enough to jeopardise the safety of the dam this should be treated as an Emergency Situation as defined in Section 4.4.5

  ACTION 2

- Contact Tonkin & Taylor to determine possible remedial actions.

4.5.5 Damage to concrete face or parapet wall or loss of freeboard

- Record and photograph location, extent and severity of the damage
- If a loss of freeboard, conduct a deformation survey
- If a loss of freeboard, lower the water level as deemed necessary by increasing the discharge from the outlet valves.
- Evaluate the damage and determine whether special safety measures or corrective action is required
- If the damage is evaluated as severe enough to jeopardise the safety of the dam this should be treated as an Emergency Situation as defined in Section 4.4.5

  ACTION 2

- Contact Tonkin & Taylor to determine possible remedial actions.

4.5.6 Failure of dam instrumentation, early warning or communications systems

- As soon as reasonably practical mobilise experienced Staff to the dam site with suitable monitoring and communications equipment to remedy the situation or monitor the dam until the failed equipment can be restored
  - Immediate mobilisation required if early warning system is involved
  - Immediate mobilisation required if inclement weather is forecast and the dam spillway is likely to become operational.

4.5.7 Spillway blockage or rockfall into spillway with reservoir below NTWL

If such an event has occurred and forecast inflows into the reservoir are likely to result in the reservoir level exceeding the NTWL before the blockage can be cleared, this should be treated as an Emergency Situation as defined in Section 4.4.4

ACTION 2

Otherwise:

- Provide preliminary warning to Civil Defence and the NZ Police in accordance with the Notification requirements shown in Section 5

- Mobilise suitably experienced staff, machinery/equipment and remove the blockage from the spillway
- Monitor reservoir level closely and if the water level is rising, increase discharge from the outlet valves as required to limit the rise in water level
- If unable to clear the blockage, this should be treated as an Emergency Situation as defined in Section 4.4.4

  ACTION 2
- Contact Tonkin & Taylor for advice on possible further remedial action.

4.5.8 Landslides into the reservoir

The dam has 5.63m of freeboard with the reservoir at NTWL. It is expected to be capable of accommodating waves that may be generated by the identified landslides as described in the design report. However should it become apparent that a landslide around the reservoir rim may be mobilising:

- Provide preliminary warning to Civil Defence and the NZ Police in accordance with the Notification requirements shown in Section 5
- Landslide to be investigated by a suitably experienced geologist
- Deformation monitoring of the landslide should be carried out
- Contact Tonkin & Taylor for advice on possible further remedial action.

5 Communication plans and procedures

5.1 Communications responsibilities

5.1.1 The Dam Owner or operator

The Dam Owner or operator has primary responsibility for the following communications requirements:

a) As a priority, to immediately warn Civil Defence and the NZ Police of a Crisis, Emergency Situation or Unusual Occurrence that develops at the dam site in line with the Priority Notification requirements of this plan

b) Such advice to be given verbally, then confirmed by emailing/faxing the completed Notification Form as shown in Appendix A

c) To assist this communication requirement, the Dam Owner will maintain effective 24-hour telephone, mobile phone, email, and fax contact capability as shown in the Contact List in Appendix C

d) The Dam Owner will also need to consult with Tonkin & Taylor as designers of the dam, in the event of a Crisis, Emergency Situation or Unusual Occurrence

e) In the event of any incident at the dam site the Dam Owner are responsible for advising the insurers of incident details

f) The Dam Owner will maintain an arrangement with the Meteorological Service to be provided with heavy rainfall warnings.

5.1.2 Civil Defence

24-hour Civil Defence contacts are maintained by the Tasman District Council.

Civil Defence staff from the Council will advise the Dam Owner of any external event known to them, and considered to pose a possible threat to the Lee Valley Dam (e.g. information from the Meteorological Service, is a prime example of data made available to Civil Defence, that could assist the Dam Owner in planning and decision-making).

The Civil Defence Organisation will have systems in place to allow easy contact from the Dam Owner, or any other agency or individual wishing to advise of emergency situations or unusual occurrences relating to the Lee Valley Dam.

5.1.3 NZ Police

The NZ Police are an essential service who will quickly become involved in any emergency, which threatens life or property. The Dam Owner will therefore keep the NZ Police informed of a Crisis, Emergency Situation or Unusual Occurrence relating to the Lee Valley Dam.

The NZ Police will keep the Dam Owner informed of any external events known to them, which may create an emergency situation at the dam site. Contact details for the Dam Owner are shown in Appendix C of this plan.

On receipt of notification of a Crisis, Emergency Situation or Unusual Occurrence the NZ Police will immediately inform the NZ Fire Service and St John Ambulance Service of the details of the incident and ensure that Civil Defence have been notified. Contact details for these organisations are shown in the Contact List in Appendix C.

The NZ Police will maintain their own up-to-date contact list of all properties/persons downstream of the Lee Valley Dam and liable to be immediately affected by any sudden release of water from the dam. This list is shown in Appendix D.

It is the responsibility of the NZ Police to advise all such persons of any danger resulting from a Crisis, Emergency Situation or Unusual Occurrence at the Lee Valley Dam site.

5.1.4 NZ Fire Service and St John Ambulance Service

NZ Fire Service and St John Ambulance organisations will maintain easily accessible contact systems to allow receipt of warnings from the NZ Police.

Contact details for these organisations are shown in Appendix C.

5.1.5 Tonkin & Taylor Ltd

Tonkin & Taylor Ltd (as Dam Designer) will need to be available for consultation, or to give advice to the Dam Owner in relation to a Crisis, Emergency Situation or Unusual Occurrence involving the dam.

They must therefore maintain a contact list of persons capable of giving such advice. Details of these contacts are shown in Appendix C.

5.2 Communications systems

This section briefly describes the communications systems available at Lee Valley Dam which may be used in to a Crisis, Emergency Situation or Unusual Occurrence.

[To be completed once communications systems at the dam site have been confirmed.]

A possible arrangement may include:

- Landline
- Mobile phone
- Satellite Phone
- Radio
- Telemetry system.

The Dam Owner will ensure that these communication systems are maintained and remain operable as far as is reasonably possible.

The relevant voice and fax communication telephone numbers and email addresses are detailed in Appendix C.

5.3 Notification procedures

5.3.1 Priority notification

In the event of an Emergency Situation and/or Unusual Occurrence the Dam Owner will, as a priority, give warnings to the following 2 agencies:

NZ Police		DAM OWNER TO COMPLETE AND MAINTAIN LIST
Duty Supervisor	Ph ………………………	
Tasman Civil Defence		
…………………………………………	Ph ………………………. (24 hrs)	
(Civil Defence Manager) Office		
Office Fax	Fax ………………………	
Home Ph.	Ph ………………………	
OR		
…………………………………		

Special Notes

If dam collapse is imminent, or an Emergency Situation occurs, and the NZ Police and Civil Defence cannot immediately be contacted on the above numbers, ring 111 and report the incident to the NZ Police.

The key information that needs to be supplied is given in the Notification Format below. Contacts will be made in accordance with the Notification Flow Chart in Appendix D. An Emergency Contact List is provided in Appendix C.

5.3.2 Notification format

When reporting to other services (e.g. Civil Defence, NZ Police, etc.) the Dam Owner will convey the following information (Appendix A provides a form):

a) Name of person making report and organisation they represent;

b) Name of dam (Lee Valley Dam) and location details;

c) Description of problem;

d) Location of problem:

- in relation to embankment (i.e. halfway up from toe);
- in relation to the outlet;
- in relation to dam crest;
- in terms of what part of the dam is affected (i.e. upstream slope, downstream slope or crest).

e) An estimate of the quantity of any unusual flow, as well as a description of flow quality (i.e. clear, cloudy, muddy, etc.);

f) A reading of the reservoir level;

g) An indication of whether the reservoir water level is rising, stable or falling;

h) The current weather conditions at the site;

i) An indication of whether the situation appears to be worsening, remaining stable, or improving;

j) An indication of whether the situation appears to be containable or not;

k) Anything else that the caller considers to be important.

This information must be passed immediately to the Regional Authority. The message must be confirmed by faxing and emailing a completed copy of the Notification Form shown in Appendix A. A copy is also to be faxed and emailed to the NZ Police and Civil Defence as well as the Control Room.

5.4 Priorities

a) Alert and evacuate residents of the Lee Valley and lower Wairoa Valley by telephone if possible (refer to the attached list). NOTE: After an earthquake or a severe flooding event, telephone may not be viable means of communication;

b) Evacuate all the low lying areas along the Waimea River Flood Plain including residents of Brightwater, Hope, Spring Grove, Richmond and Redwood Valley;

c) Have trucks and staff on hand to assist residents with problems caused by flood waters;

d) Advise residents to stay away from the Lee, Lower Wairoa and the Waimea Rivers.

6 Response during darkness or adverse weather

Planning for emergency access should work on the premise that it is dark and raining, and/or that Lee Valley Road will be impassable due to storm or earthquake induced slips and/or flooding. Hence, access for emergency action or repairs may be difficult and/or dependent on the availability of earthmoving equipment to clear slips and debris. It is also likely that helicopter availability may be compromised by other perceived priorities e.g. Civil Defence.

6.1 Access

The location of the dam makes it possible that access to the site will be unavailable in the event of extreme weather or major earthquake.

However, in the event that access cannot be gained in a timely manner then it may be possible to contact and utilise the assistance of residents local to the dam. If possible, provision should be made to provide some degree of training to enable these residents to assist should such an eventuality occur.

6.2 Work at the site

The location of all staff involved in investigating or monitoring potential or actual Emergency Situations or Unusual Occurrences at the dam should wherever possible be known to another responsible person at all times.

Wherever possible two people should attend to a Crisis, Emergency Situation or Unusual Occurrence at the site. Contact must be established and regularly maintained with an external party at no more than one hourly intervals.

The Dam Owner will ensure that suitably trained staff will be available to cope with all reasonable activities required under this EAP and the Operating Procedures under foreseeable weather and post-earthquake conditions.

The Dam Owner will ensure that appropriate safety equipment and information (including a copy of this Emergency Action Plan) and the routine test and inspection records are kept at the site.

Site lighting may not be working at the dam, especially during or following a natural hazard event. Therefore, for action during periods of darkness staff should use vehicle headlights and take battery and vehicle operated spotlights to site.

Communications from the site could be significantly more difficult during periods of adverse weather or in post-earthquake conditions. It is therefore important that all the systems are regularly checked throughout a Crisis, Emergency Situation or Unusual Occurrence and that care is taken to ensure all messages are correctly received.

7 Sources of equipment and materials

7.1 Special equipment

Special equipment in the form of earthmoving plant may be required under certain Emergency Situations or Unusual Occurrences. This plant is large, slow to move and therefore due allowance must be made for the time it will take to reach the site. Wherever possible equipment located in the vicinity of the dam should be utilised. Civil Defence has the right to commandeer equipment in the event of a civil emergency and therefore, close cooperation should be maintained with the Civil Defence.

Special equipment sources are noted in Appendix E.

7.2 Supplies and materials

Riprap, sandbags and other construction materials can be sourced from the local suppliers noted in Appendix E.

7.3 Emergency power supplies

The power supply to the dam may be interrupted following a natural hazard event. For this reason a backup power supply is located at the dam. However, if required additional emergency power supply can be obtained from the sources noted in Appendix E.

8 Supporting information

8.1 Storage elevation curve

Figure 8-1 presents the reservoir water storage versus water elevation relationship.

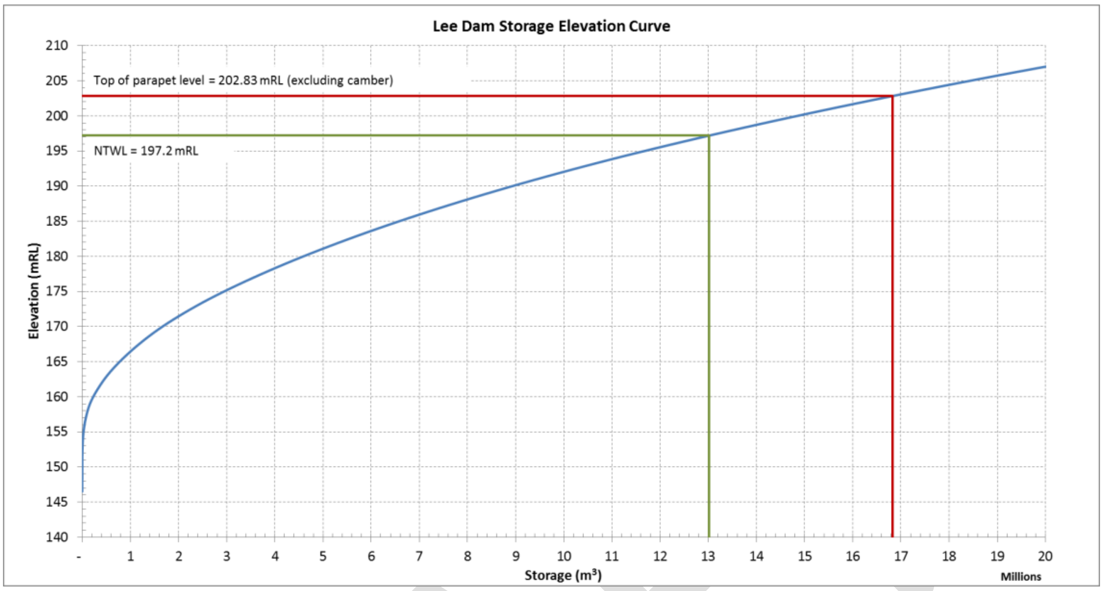


Figure 8-1 Storage elevation curve for the Lee Valley Dam indicating NTWL

8.2 Spillway rating curve

Figure 8-2 shows the rating curve (flow rate versus reservoir level) for the ogee weir.

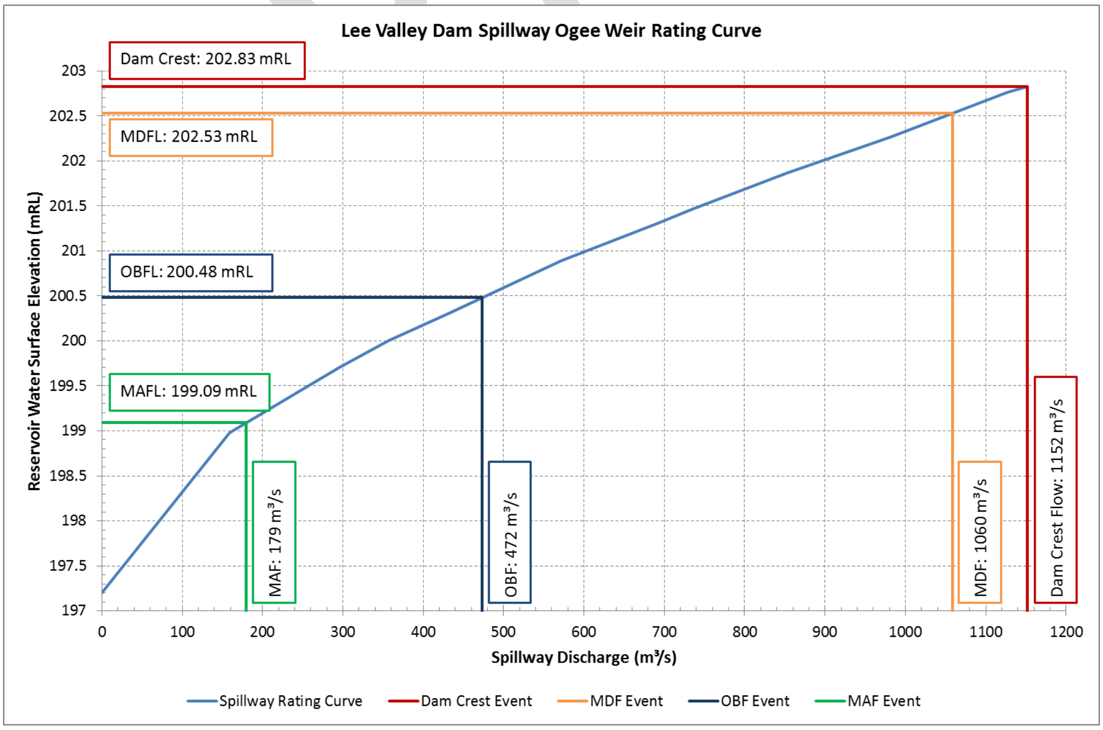


Figure 8-2 Ogee weir rating curve

8.3 Monitoring instrumentation

Figure 8-3 shows the location of the monitoring instrumentation for the dam. The instrumentation comprises:

[List to be developed and figure to be inserted when the details become available.]

Figure 8-3 Monitoring instrumentation for the dam (to be completed)

8.4 Dam break analysis

8.4.1 Flood inundation mapping

A dam break analysis has been undertaken to map the potential inundation area in the event of a dam break event. Such studies are hypothetical in nature, and entirely divorced from the remote chances of a dam failure ever occurring. The results are used to review downstream hazard potential and provide information for emergency management planning purposes.

In the Dam Break Analysis and Hazard Assessment report (Tonkin & Taylor 2009) a "sunny day" failure case was investigated. In that study it was considered unnecessary to also model a flood-induced failure as a decision was taken in the feasibility design to provide sufficient spillway capacity at the dam to cope with the PMF. The results of the simulated dam break scenarios and assumptions made in the analysis are detailed in the associated report (Tonkin & Taylor 2009).

For the purposes of the EAP it was considered necessary to model a "rainy day" failure case because this represents the worst possible case in an emergency situation. The dam break scenario chosen was the Probable Maximum Flood event, this event is assumed to be coinciding with the 100 year event in the tributaries.

The elapsed time from dam breach initiation until the first wave arrives (warning time) and the elapsed time to the peak water depth is given at specific locations downstream from the Lee Valley Dam in A paper presented at the 2004 ANCOLD/NZSOLD conference (Amos, Nicholson, Webby, & Gillon, 2004) discussed the application of depth and velocity dam break parameters in assessing the "danger to life" due to a dam failure. It refers to a parameter known as "*dv*" (depth multiplied by velocity).

This parameter is used to assess the risk to life according to following:

$dv < 0.5$	No danger to life
$0.5 < dv < 1.0$	Some danger to life exists
$dv > 1.0$	Danger to life significant

Table 8-1.

Two figures below represent the inundation area. Figure 8-4 shows the estimated depth of flooding (m) from the confluence of the Wairoa and Lee Rivers to the delta of the Waimea River. Figure 8-5 is a plot of the "dv" parameter.

A paper presented at the 2004 ANCOLD/NZSOLD conference (Amos, Nicholson, Webby, & Gillon, 2004) discussed the application of depth and velocity dam break parameters in assessing the "danger to life" due to a dam failure. It refers to a parameter known as "*dv*" (depth multiplied by velocity).

This parameter is used to assess the risk to life according to following:

$dv < 0.5$	No danger to life
$0.5 < dv < 1.0$	Some danger to life exists
$dv > 1.0$	Danger to life significant

Table 8-1 Time to peak flow during "rainy day" failure case

River Chainage (m)	Location	Time for flood- wave to first arrive (min)	Time for peak water depth to occur (min)
0	Lee Dam	**T=0**	-
2910	Lucy Creek confluence	3	38
8220	Fairdale	11	42
12720	Wairoa River confluence	15	48
16470	State Highway 6 bridge at Brightwater	20	61
20330	Wai-iti River confluence	27	76
24220	State Highway 60 bridge	64	98

The inundation area and the distribution of *dv* is shown in Figure 8-5. The highest risk to life and buildings in the unlikely event of a failure of the Lee Valley Dam is the area to the east and north of Brightwater.

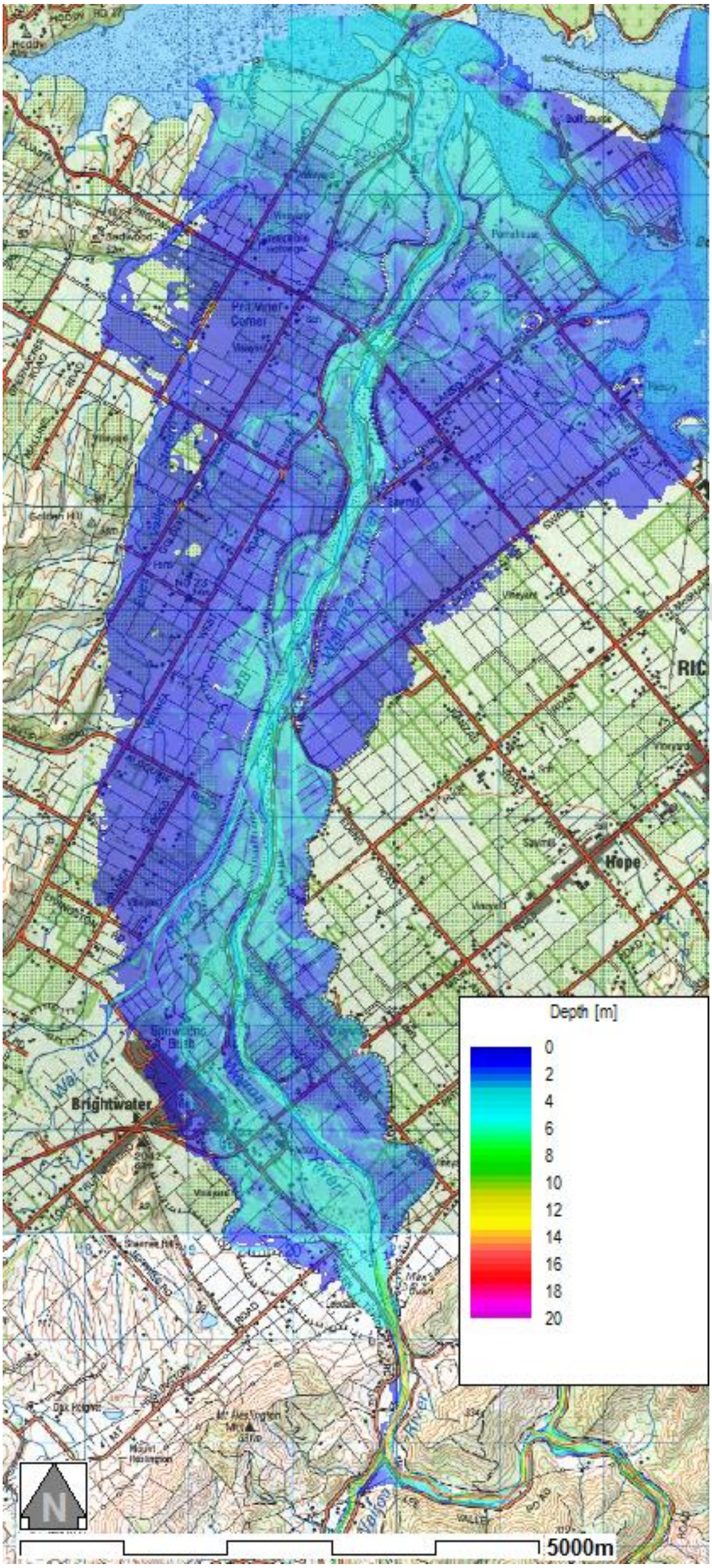


Figure 8-4 Inundation map showing the depth of flooding from the junction of the Wairoa and Lee Rivers to the mouth of the Waimea River.

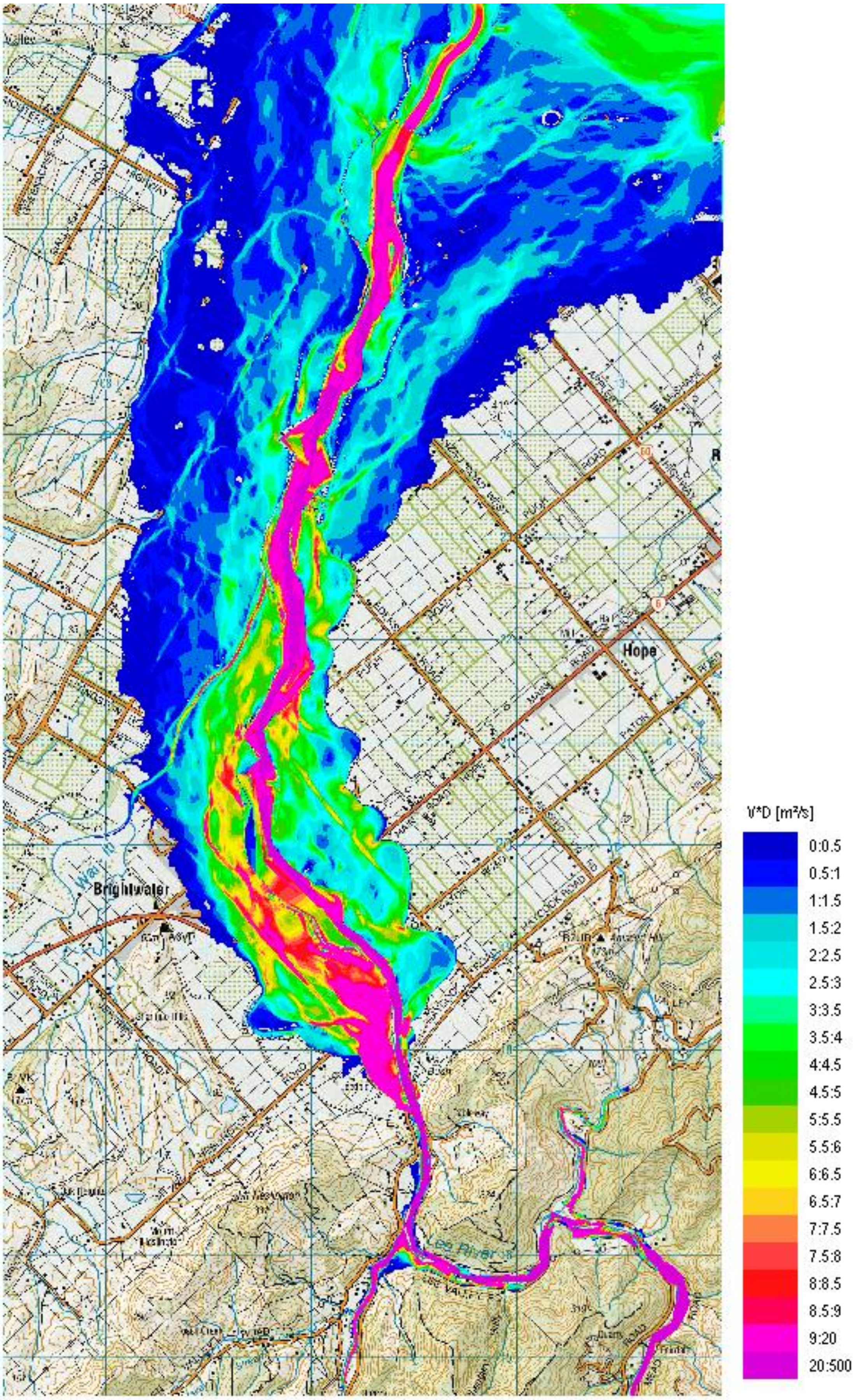


Figure 8-5 Assessment of inundation area based on dv (depth multiplied by velocity)

8.4.2 Site access

Lee Valley Road will be significantly inundated and consequently impassable in the dam break scenario. If coinciding flood events in adjacent creeks are occurring, it is also likely that access to Anslow Road (through Wairoa Gorge Road or Pig Valley Road) will also be cut.

If all access by road is inundated, access by helicopter should be considered.

8.4.3 Towns and properties affected

A significant number of properties downstream of the dam between the dam site and the mouth of the Wairoa River are likely to be affected by either inundation or the inability to access the main roads during a dam break scenario.

In the Lee Valley, flow depths are likely to be high and any residences within low lying areas of the valley will be severely impacted.

Once the flood emerges onto the Wairoa River plain the flow spreads out and consequently water depth decreases. At the peak of the flooding approximately half of the town of Brightwater would be inundated to depths ranging from 0.5 to 3 m (see Figure 8-7).

Downstream of Brightwater the Wairoa terraces are largely used for agricultural purposes with some residential use. The water depth in this region is shallower ranging from 1 to 2 m with deeper inundation confined to the river channel (see Figure 8-4).

8.4.4 Temporal variability

Figure 8-6 and Figure 8-7 are focussed on the area around Brightwater to illustrate the speed at which the flood wave would increase the danger and consequently the limited time available for emergency services to react.

Figure 8-6 shows the dv plot prior to the arrival of the flood wave. This plot shows the dv ratings along Terrace Road ranging from 0 – 0.95; i.e. falling into the category of “some danger to life exists” as defined above. Figure 8-7 shows the situation approximately 20 minutes later at the peak of the dam break flow. Along Terrace Road the dv levels have now increased to 3.78 – 8.95 well in excess of the 1.0 threshold where “danger to life is significant”.

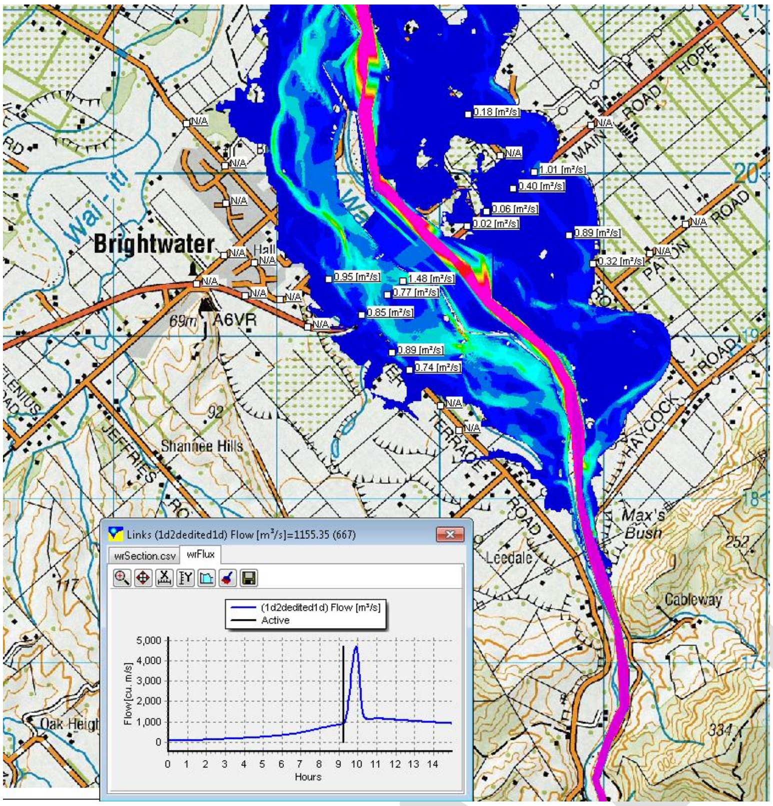


Figure 8-6 dv (depth multiplied by velocity) prior to arrival of dam break wave

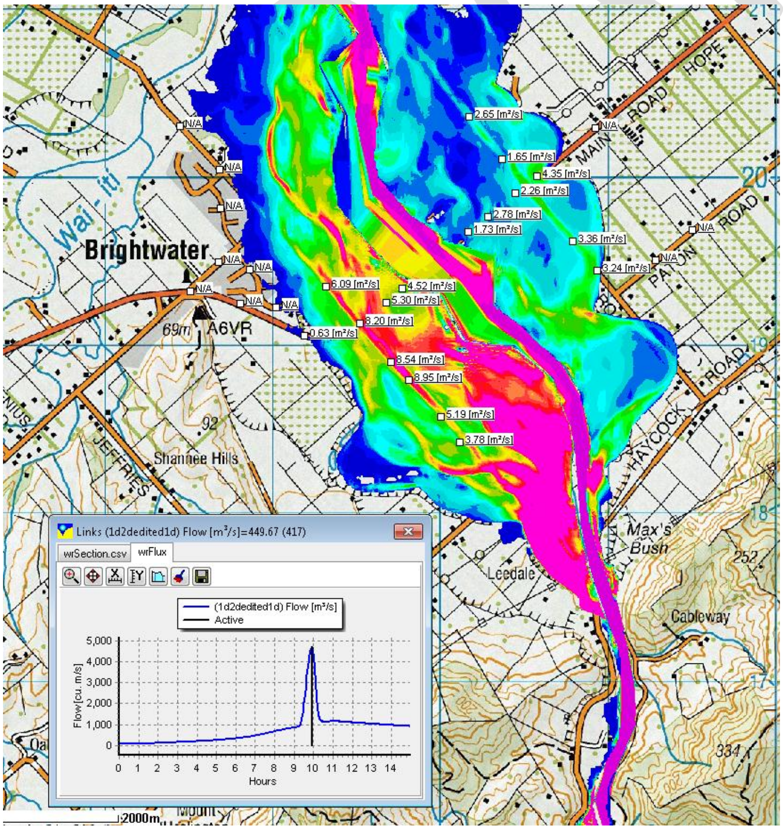


Figure 8-7 dv (depth multiplied by velocity) at time of peak dam break flow

9 Warning system

The Dam Owner should establish an early warning system as an integral part of the EAP. Possible early warnings system could comprise some or all of the following:

- Rainfall gauges (upstream of the dam and at the dam site, existing rainfall gauge: Lee at Trig F)
- Backup power supply
- Telemetry transmission of monitoring data
- River flow gauges on the Lee River immediately downstream of the dam and on the Lee River upstream of the confluence with the Wairoa River
- A monitoring station should be set up at the dam site which receives automatic rainfall readings, real time reservoir levels, spillway discharge and seepage flows. The monitoring station should include landline, satellite telephone, mobile telephone, radio, and facsimile facilities.

10 Testing of the EAP

Where a test of the EAP is proposed, ensure that the communication messages commence with the words “This is a limited communications test (or full communications, or operational test, as appropriate), of the dam-breach notification procedure for the Lee Valley Dam”, or similar, so that there is no doubt that it is a test, and not an emergency.

a) Limited tests within the Dam Owner’s organisation

It is the responsibility of the Dam Owner to initiate and coordinate a limited communication test (dam breach condition) involving only the Dam Owner at least once every year. Additional tests shall be conducted at the discretion of the Dam Owner whenever justified by staff changes or for other reasons.

b) Full communication tests

It is the responsibility of the Dam Owner to initiate and coordinate a full communications test involving the entire notification procedures for a dam breach.

c) Operational tests

It is the responsibility of the Dam Owner, in consultation with the local civil defence officer, to initiate an operational test of the dam breach emergency warning and evacuation procedures. The timing of the operational tests shall be determined in cooperation with the NZ Police and the civil defence agencies.

Coordination of the civil emergency response procedures is the responsibility of the Regional Civil Defence Officer, and the local civil defence response authorities.

The Dam Owner will participate in planning and execution of the operational tests including development of the form or scenario for each test, providing information as required and sending out notification of the simulated breach.

d) Reporting

The Dam Owner shall maintain a record of each test on the “Record” form which follows, noting the date and time of the test and the person initiating it.

Test reports shall be sent by each participant to the Dam Owner using the “Test Report” form which follows.

The Dam Owner shall prepare and keep a brief summary of each test, noting the problems encountered and steps taken to eliminate similar problems in the future.

11 Construction Emergency Action Plan

The constructor (or an appropriate person appointed by the Dam Owner) will provide an EAP to cover the period whilst the dam is being built. That EAP will be attached to this report as an addendum.

12 Review and revision procedure of this plan

12.1 Dam Owner

a) On receipt of the EAP

The Dam Owner shall arrange for all local and Civil Defence staff to receive a thorough briefing on the EAP. The Dam Owner shall ensure that they are familiar with the procedures for emergency reporting, notification, and action.

b) Periodic review

The Dam Owner shall ensure that local and Civil Defence staff maintain familiarity with the regularly updated EAP by scheduling periodic reviews and briefings at a frequency to be agreed between the Dam Owner, Civil Defence and any other appropriate outside agency.

Review by outside agencies should be recorded in the revision form found in Appendix G.

c) Revisions

The Dam Owner is responsible for ensuring the currency of this EAP and for arranging for the preparation of revisions and the distribution of copies thereof to all EAP recipients.

Proposed revisions should be addressed to the Dam Owner using the standard revision form. A complete list of all revisions shall be maintained at the front of the EAP.

12.2 Outside agencies

Copies of the EAP will need to be sent to all relevant agencies. Each agency involved in the emergency procedures will be asked to enter into an agreement to support the EAP by sending the Dam Owner a "letter of understanding" similar to the form letter attached.

The objectives of the agreement are:

a) To secure each agency's commitment to fulfil its designated responsibility under the EAP

b) To encourage active involvement in reviewing, updating and testing the EAP

c) To reduce misunderstanding of any of the procedures detailed in the EAP.

Agencies who are parties to the agreement are expected to participate in the EAP by reviewing the EAP for adequacy and forwarding any comment or suggested improvements to the Dam Owner.

Agencies involved in the notification procedure for dam-breach are expected to participate in the full communications and operational tests of the procedures, complete Test Report forms (see Appendix F), and mail them to the Dam Owner for evaluation.

The Dam Owner will arrange for the revision of the EAP as necessary. A record of review by outside agencies shall be maintained.

12.3 Public facilities

The Dam Owner to advise what public access and facilities will be provided at the dam site.

13 Applicability

This report has been prepared for the benefit of the Waimea Water Augmentation Committee with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor by:
....	....
Simon Croft	Keith Dickson
Senior Water Resources Engineer	Project Director

JICR

Lee EAP.docx

Appendix A – Emergency Notification Form

1. **NAME/Organisation …………………………..2. DATE………… 3. TIME ……….**
4. **DAM NAME ………………………………………………………………………………..**
5. **PROBLEM**
   5.1 Description ………………………………………………………………………

   ……………………………………………………………………………………………..

   5.2 Specific Area of Problem at Site……………………………………………………

   ……………………………………………………………………………………………..

6. **UNUSUAL FLOW**
   6.1 Quantity ………………………………………………………………………………..
   6.2 Quality ………………………………………………………………………………..

7. **WATER LEVEL**
   7.1 Reservoir level ………………………………………………………………………..
   7.2 Rising/Stable/falling
   ……………………………………………………………………………………………
8. **SITUATION**
   8.1 Improving/stable/worsening/containable……………………………………………
   8.2 Other Comments ……………………………………………………………………..

9. **GENERAL COMMENTS**
   9.1 Weather conditions …………………………………………………………………..
   ……………………………………………………………………………………………..

10. **NOTIFICATION CHECKLIST (tick when done, record time and name)**

Waimea Water Augmentation Authority	Time ……………..	Person Contacted ……………	
NZ Police	Time ……………..	Person Contacted ……………	
Civil Defence	Time ……………..	Person Contacted ……………	
Ambulance	Time ……………..	Person Contacted ……………	
NZ Fire Service	Time ……………..	Person Contacted ……………	
Tonkin & Taylor Ltd	Time ……………..	Person Contacted ……………	

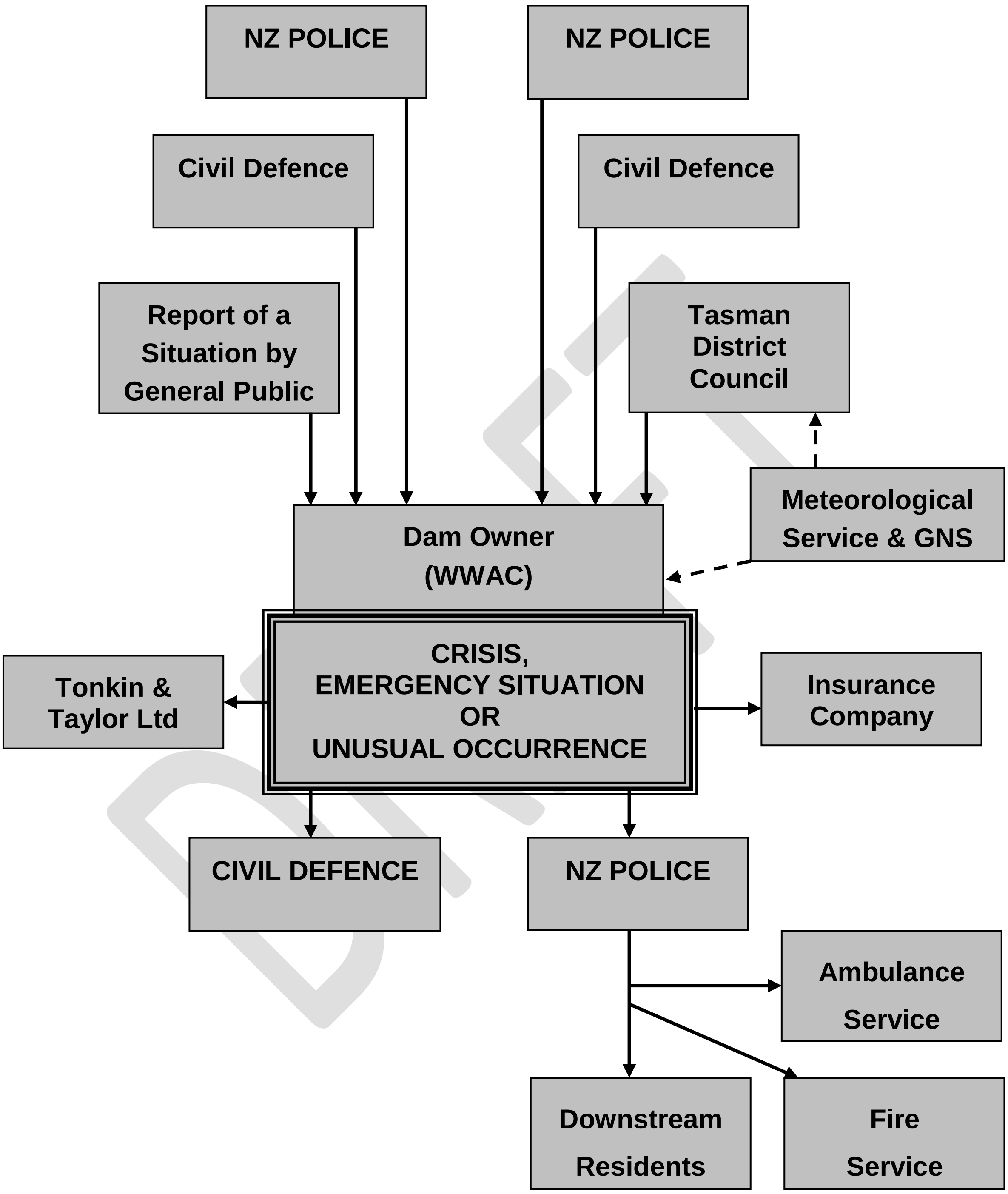
SIGNATURE ………………………………………………………………………………….

Distribution: Dam Owner, NZ Police, Civil Defence

Appendix B - Notification Flow Chart

Dam Site Emergency

External Emergency



Appendix C - Contact list

Organisation	Name/ Position	Office Phone	Home Phone	Other Contact Details (e.g. Mobile phone)
Waimea Water Augmentation Committee (Dam Owner)				
NZ Police	Emergency	111	-	-
	Central Control Room			
	Local Police Office			
Civil Defence	Regional (…………)			
Ambulance	Emergency	111		
	St John's Ambulance			
Fire Services	Emergency	111		
	NZ Metropolitan			
	Rural			
Tonkin & Taylor Ltd (Designer)				

Appendix D - Downstream residents contact details

Name	Address	Office Phone	Home Phone	Other Contact Details (e.g. Mobile phone)	DAM OWNER TO COORDINATE WITH NZ POLICE TO COMPLETE AND MAINTAIN LIST

Appendix E – Sources of equipment and materials

Earthmoving equipment

Earthmoving equipment required can be sourced from these suppliers:-

Company:		DAM OWNER TO COMPLETE AND MAINTAIN LIST
Address:		
Telephone:		
Company:		
Address:		
Telephone:		

Supplies and materials

Riprap, sandbags and other construction materials can be sourced from the following local suppliers.

Company:		DAM OWNER TO COMPLETE AND MAINTAIN LIST
Address:		
Telephone:		
Company:		
Address:		
Telephone:		

Generator

If required, a generator can be sourced from:-

Company:		DAM OWNER TO COMPLETE AND MAINTAIN LIST
Address:		
Telephone:		
Company:		
Address:		
Telephone:		

Dewatering pumps

Dewatering pumps can be sourced from:

Company:		DAM OWNER TO COMPLETE AND MAINTAIN LIST
Address:		
Telephone:		
Company:		
Address:		
Telephone:		

Appendix F - Test report

LEE VALLEY DAM EMERGENCY PREPAREDNESS PLAN:
TEST REPORT

TO:	Operations & Maintenance Coordinator Tasman District Council Private Bag NELSON	DATE: FILE:
FROM:	______________	TYPE OF TEST: ☐
	______________	Limited Communications Test ☐
	______________	Full Communications Test ☐
	______________	Operational Test ☐
	______________	*(Please tick type of test)*

TIME AND DATE FIRST NOTIFIED: ______________

NOTIFIED BY: ______________

NOTIFICATIONS MADE:

NAME	AGENCY(IES)	TIME OF CALL

MESSAGE RECEIVED/PASSED ON

____

____

____

____

COMMENTS ON TEST:

____

____

____

____

(If space is insufficient use additional sheet(s)

____

Signature

Appendix G – Revision Record Form

LEE VALLEY DAM

EMERGENCY PREPAREDNESS PLAN

REVIEW BY OUTSIDE AGENCIES

Agency	Date Reviewed	Remarks

LEE VALLEY DAM

EMERGENCY PREPAREDNESS PLAN

RECORD OF BRIEFING SESSIONS,
AND FULL COMMUNICATIONS AND OPERATIONAL TESTS

Date	Time	Initiated by	Description	Remarks

LEE VALLEY DAM
EMERGENCY PREPAREDNESS PLAN

REVISION FORM

To: Dam Owner .... Date:
Dam Operator …………………

From: ____________________________ File:
Name Signature

Proposed Revision:

Other EAPs affected:

(cc as applicable)

For Office Use Only:

Approved/Not Approved: Date:

Operations Manager

Actioned: Date:

Appendix H – The Modified Mercalli Intensity Scale

The Modified Mercalli Intensity Scale*	
Category	**Definition**
MM 1: Imperceptible	Barely sensed only by a very few people.
MM 2: Scarcely felt	Felt only by a few people at rest in houses or on upper floors.
MM 3: Weak	Felt indoors as a light vibration. Hanging objects may swing slightly.
MM 4: Largely observed	Generally noticed indoors, but not outside, as a moderate vibration or jolt. Light sleepers may be awakened. Walls may creak, and glassware, crockery, doors or windows rattle.
MM 5: Strong	Generally felt outside and by almost everyone indoors. Most sleepers are awakened and a few people alarmed. Small objects are shifted or overturned, and pictures knock against the wall. Some glassware and crockery may break, and loosely secured doors may swing open and shut.
MM 6: Slightly damaging	Felt by all. People and animals are alarmed, and many run outside. Walking steadily is difficult. Furniture and appliances may move on smooth surfaces, and objects fall from walls and shelves. Glassware and crockery break. Slight non-structural damage to buildings may occur.
MM 7: Damaging	General alarm. People experience difficulty standing. Furniture and appliances are shifted. Substantial damage to fragile or unsecured objects. A few weak buildings are damaged.
MM 8: Heavily damaging	Alarm may approach panic. A few buildings are damaged and some weak buildings are destroyed
MM 9: Destructive	Some buildings are damaged and many weak buildings are destroyed.
MM 10: Very destructive	Many buildings are damaged and most weak buildings are destroyed.
MM 11: Devastating	Most buildings are damaged and many buildings are destroyed.
MM 12: Completely devastating	All buildings are damaged and most buildings are destroyed.
*Adapted from GNS Science New Zealand website, September 2012	

Appendix E: Draft Operational Maintenance and Surveillance Manual (O M & S)

REPORT

Waimea Water Augmentation Committee

Lee Valley Dam
DRAFT Operation, Maintenance and Surveillance Manual

Report prepared for:

Waimea Water Augmentation Committee

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

Waimea Water Augmentation Committee	1 copy
Tonkin & Taylor Ltd (FILE)	1 copy

October 2012

T&T Ref: 27425.100

Table of contents

Document control

DOCUMENT CONTROL		Prepared By: T&T
Title: Lee Valley Dam – Operation, Maintenance and Surveillance Report	Waimea Water Augmentation Committee	Initial: JICR File name: 20120524 Operation, Maintenance & Surveillance Report DRAFTV1.docx

Pages	Date	Issue No	Description	Initials
All	06/12	Draft	Initial Draft	JICR
All	30/07	Draft	Draft review and conduit items	NML
All	17/10	Draft	Draft review	SFC

1 Introduction

This manual was prepared in general accordance with:

- NZSOLD NZ Dam Safety Guidelines 2000
- Building (Dam Safety) Regulations 2008
- International practice for a dam of this size, risk and condition.

At the time of writing the Building (Dam Safety) Regulations had been referred to the Local Government and Environment Select Committee. It is anticipated that the proposed bill will not be promulgated until before July 2014.

The following text describes various aspects of the 2008 Regulation requirements relevant to Lee Valley Dam (that may be subject to revision by anticipated Regulation amendments). Insofar as the 2008 Regulations are concerned, the High Potential Impact Category assigned to Lee Valley Dam requires that a Dam Safety Assurance Programme (DSAP) is developed for Lee Valley Dam. The manual addresses a number of the DSAP requirements. Regulation 8 of the Building (Dam Safety) Regulations lists the criteria and standards that a DSAP must address as set out in 8 (1). This Operation, Maintenance and Surveillance (OM&S) Manual addresses the following aspects of Regulation 8:

8 (2) A dam safety assurance programme must—

(a) be consistent with the dam safety management principles related to operation, maintenance, surveillance, and emergency action planning as provided in the New Zealand Dam Safety Guidelines (published by the New Zealand Society on Large Dams, November 2000); and

(b) be appropriate to the type and size of the dam and the dam classification given to the dam under Regulation 4.

8 (3) Every dam safety assurance programme must contain the following:

(a) requirements for and frequency of surveillance, routine visual inspections, instrument monitoring, data evaluation, and reporting to the dam owner;

(b) requirements for annual dam safety reviews;

(c) requirements for comprehensive dam safety reviews; and

(e) requirements for inspection of appurtenant structures, including testing of gates and valves that contribute to reservoir safety.

This Surveillance and Monitoring Plan does not address the following aspects of Regulation 8:

8 (3) (d) details of an emergency action plan; and

(f) procedures for the investigation, assessment, and resolution of dam safety deficiencies.

2 Scope and purpose

This document provides an outline of an OM&S Manual for the proposed Lee Valley Dam. It is intended to provide an indication of the envisaged content for the OM&S Manual for the completed dam. Details will need to be completed and particular descriptions in this document will need to be modified, and sections added or deleted, to match the final physical and organisational arrangements following construction and commissioning.

This document sets out basic procedures related to surveillance and dam safety for the Lee Valley Dam. It covers procedures for correct operation according to design parameters, routine maintenance requirements for prudent asset management and procedures related to surveillance and dam safety. This particular document does not cover the hydro generation and irrigation release equipment. Separate companion documents must be developed and referred to for these parts of the facility.

This manual is intended to provide guidance to the staff who operate, maintain and carry out regular inspections of the Lee Valley Dam as well as Council Engineers and Consulting Engineers who may be involved in the evaluation of surveillance records and carrying out annual inspections of the dam.

Careful regular surveillance in accordance with this manual is of prime importance to safeguard the integrity of the works as well as to highlight any specific maintenance and operational problems. Effective surveillance is reliant upon the rigorous collection of observation and monitoring data followed by prompt evaluation and any necessary action.

3 Background information

3.1 Dam description

The Lee Valley Dam is located south of Nelson City on the Lee River, a tributary of the Waimea River in the Tasman District as shown in Figure 3-1. The dam site is located on the Lee Valley Road, approximately 16.5km from the State Highway 6 junction with River Terrace Road in Brightwater. An alternative road route to the site, approximately 30km long, is via the Edward Street / State Highway 6 junction in Wakefield. Figure 3-1 shows both main routes to the dam with the River Terrace Road Route in blue and the longer Edward Street Route in green.

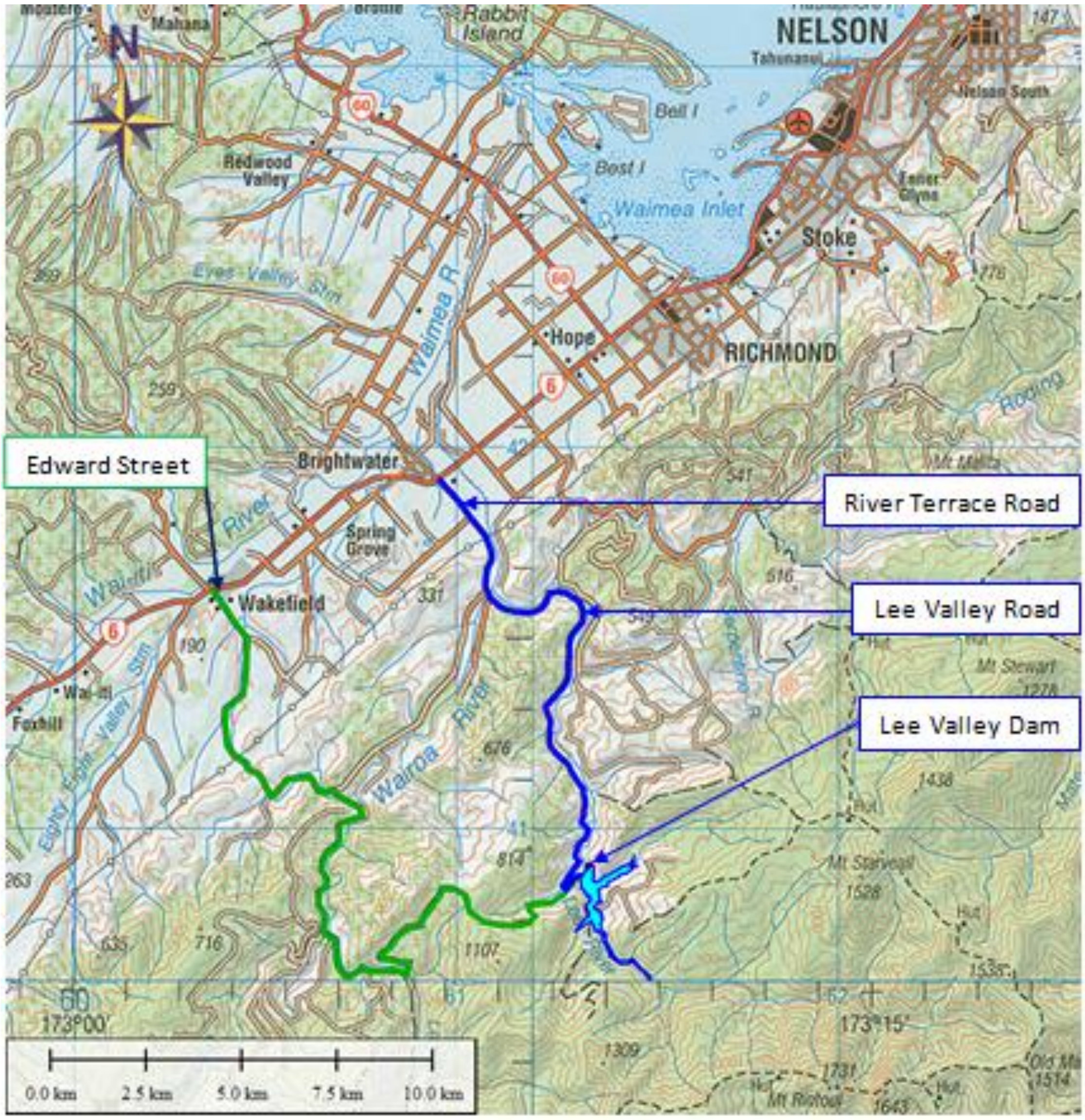


Figure 3 – 1: Lee Valley irrigation dam location plan.

The dam is a Concrete Face Rockfill Dam (CFRD) approximately 220 m long and 53 m high. The purpose of the dam is to provide a supply of irrigation water. Water is to be drawn from the reservoir via low and high level intakes that are inclined on the upstream face of the dam before being discharged back into the Lee River through an outlet pipe and free discharge (cone) valve. Water is abstracted for irrigation from the Lee River further downstream.

The general arrangement and details of the dam and appurtenant structures are provided in the appended drawings. Key characteristics of the dam and appurtenant structures are summarised in Table 3-1.

Table 3-1: Key dam characteristics

Embankment characteristics	
Embankment type	Concrete Face Rockfill Dam (CFRD)
Embankment volume (approximate)	435,000 m^3
Nominal crest elevation (excluding camber)	201.23 mRL
Top of parapet wall (excluding camber)	202.83 mRL
Design Camber	0.3 m
Maximum dam height (from riverbed to dam crest on CL)	53 m
Crest length (approximately)	220 m
Crest width	6 m
Hydrology, reservoir and flood routing characteristics	
Catchment area	77.5 km^2
Normal top water level (NTWL)	197.2 mRL
Reservoir storage at NTWL	13,000,000 m^3
Reservoir area at NTWL	630,000 m^2
Mean Annual Flood level (MAFL)	199.09 mRL
Reservoir storage at MAFL	14,250,000 m^3
Operational basis flood level (OBFL)	200.48 mRL
Reservoir storage at OBFL	15,150,000 m^3
Maximum design flood level (MDFL)	202.53 mRL
Reservoir storage at MDFL	16,600,000 m^3
Reservoir storage at top of parapet wall (202.83 mRL)	16,800,000 m^3
Spillway characteristics	
Primary spillway type	Ogee Weir
Ogee weir effective length (on arc)	41.89 m
Peak outflow – Mean Annual Flow (MAF)	179 m^3/s
Peak outflow – Operational Basis Flow (OBF)	472 m^3/s
Peak outflow – Maximum Design Flood (MDF)	1060 m^3/s
Capacity outflow – Reservoir level at top of parapet wall	1152 m^3/s

Spillway and Energy dissipation characteristics	
Chute length (plan – ogee crest to start of flip bucket)	124 m
Chute width, narrow section	20 m
Chute horizontal transition length	71 m
Chute vertical curve length	21 m
Chute minimum height of concrete lining	2.8 m
Dissipation type	Flip Bucket
Flip bucket radius	20 m
Bucket lip level	156.6 mRL

Outlet characteristics	
Outlet type	Sloping outlet conduits on upstream face with removable screens and valve control.
Number of outlets	2
Outlet level – Upper (elevation of top of bellmouth)	181.5 mRL
Outlet level – Lower (elevation of top of bellmouth)	163.0 mRL
Control type	Twin 800mm Fee Discharge Valves
Maximum design discharge capacity (Valve manufacturer velocity limits applied)	15.1 m^3/s
Concrete conduit size under embankment (internal dimensions)	Twin 2.5 m Wide x 4.0 m High

River tailwater characteristics	
Tailwater level MAF	150.85 mRL
Tailwater level OBF	153.46 mRL
Tailwater level PMF	156.54 mRL

Irrigation and environmental flow release[1]	
Irrigation release at dam toe (at minimum operating level and from either intake)	2.23 m^3/s
Environmental residual flow (7 day MALF at minimum operating level and from either intake)	0.51 m^3/s
Environmental flushing flow (at minimum operating level and from either intake)	5.0 m^3/s
Note 1: The criterion design capacity of the outlet is the largest of the requirements of 5.0 cumecs and is not additive (i.e. It is not 2.23 + 5 + 0.51)	

3.2 Roles and responsibilities

Table 3-2 shows the key parties involved in the design, construction and operation of the dam and their roles and contact details.

Table 3-2: Key parties, roles and responsibilities

Party	Contact Details	Role / Responsibilities
Owner	Waimea Water Augmentation Committee	Ongoing operation and maintenance To act on the advice of their advisors in respect to dam safety. Implementation of commissioning procedures
Designer	Tonkin & Taylor Ltd Office Phone: (09) 355 6000	Scoping study report Geotechnical investigations and reporting Detailed design and design report Operation and maintenance manual DRAFT Emergency action plan DRAFT
Peer reviewer	Opus International	Peer review of the detail design
Constructor	To Be Confirmed	To Be Confirmed
Engineer to the Contract	To Be Confirmed	To Be Confirmed
Regulatory Agency	Tasman District Council	Resource consent Building consent

4 Key aspects relating to safety

The Lee Valley Dam structure, with its appurtenant works, is a High Potential Impact Category (PIC) structure and is required, to be operated and maintained in accordance with the NZSOLD Dam Safety Guidelines (2000) and the Building Act 2004 with the attendant regulations. The Regulations require a Dam Safety Assurance Programme is prepared for this High PIC Dam including submission of Form 2 – Dam Safety Assurance Programme, and Form 3 Annual Dam Compliance Certificate, to the Tasman District Council in the manner set out in the Regulations. These requirements may be amended when the recently advised Regulation revisions are produced.

The main embankment of this dam is constructed from locally sourced rock and gravels. The upstream concrete face prevents excessive seepage resulting in loss of storage and the potential for unravelling of the downstream face of the dam. The spillway is founded on rock at the left abutment.

Key aspects relating to safety are:

- Safe passage of floodwaters, which puts emphasis on spillway operation and the avoidance of spillway blockage from accumulated debris and damage to the concrete lining;
- Performance in a large earthquake, which is essentially dealt with under emergency action procedures;
- The management structure and level of training of those involved in operating, observing and maintaining the facility, and the specialist advice available.

5 Management structure and personnel

Overall management of the facility should be by a senior person who meets the proficiency requirements recommended by the NZSOLD NZ Dam Safety Guidelines (2000) (refer Table E.1), who is fully familiar with the details of the facility and the contents of this and all related documents.

Management should have access to specialist consultants who can give appropriate advice on any proposed changes or repairs to structures, equipment or systems as well as advice in emergency situations or when equipment alerts occur. One or more appropriately qualified engineers experienced with High PIC dams (such as a Category A Recognised Engineer) should be readily available to provide advice in a timely manner in the event of an unusual occurrence or emergency situation.

Personnel undertaking routine operations and surveillance require a suitable level of education and background training in their areas of input. Staff undertaking routine operations and surveillance activities should meet the proficiency requirements recommended by the NZSOLD Dam Safety Guidelines (2000) Table E.1.

External contractors would normally be employed for routine maintenance and repairs with their specific instructions being based on this document and other relevant supporting documents, with an appropriate level of management overview.

The management structure of the Lee Valley Dam is to comprise a Dam Operator, Dam Safety Consultant and Dam Owner. The Dam Operator and Dam Safety Consultants are to operate the dam in the following ways:

The **Dam Operator** is responsible for the day to day management of the structure and will give all operational directives. All instrumentation readings and surveillance reports will be forwarded to them for reporting to the Dam Owner and to the Tasman District Council. Any reading falling into the Alert Level or Trigger Level zone, or observation of any unusual or unsatisfactory behaviour is to be immediately forwarded to the Dam Operator or, in their absence, the Dam Safety Consultant. The Dam Operator will ensure that a suitable replacement is available at any time during which their individual representative is unavailable.

The **Dam Safety Consultant** is responsible for the examination of the instrumentation readings and consideration of any unusual or unsatisfactory behaviour. They will prepare the monthly reports, complete the annual inspection and prepare summary reports as required. The Dam Safety Consultant will ensure that a suitable replacement is available at any time during which their individual representative is unavailable.

6 Operations and maintenance requirements

6.1 Introduction

This section describes how the dam and its appurtenant structures are to be operated, what items need to be maintained, and the standards of maintenance to retain functional safety. The requirements are subdivided into the various structures, with a brief description of the item and then operational requirements described before maintenance.

6.2 Reservoir

6.2.1 Description

At the Normal Top Water Level (NTWL) of 197.2 mRL the reservoir has a storage capacity of approximately 13 million m3. Further details on the Reservoir can be found in the Stage 3 Design Report (T&T, 2012).

Figure 6-1 presents the reservoir water storage versus water elevation relationship for the dam.

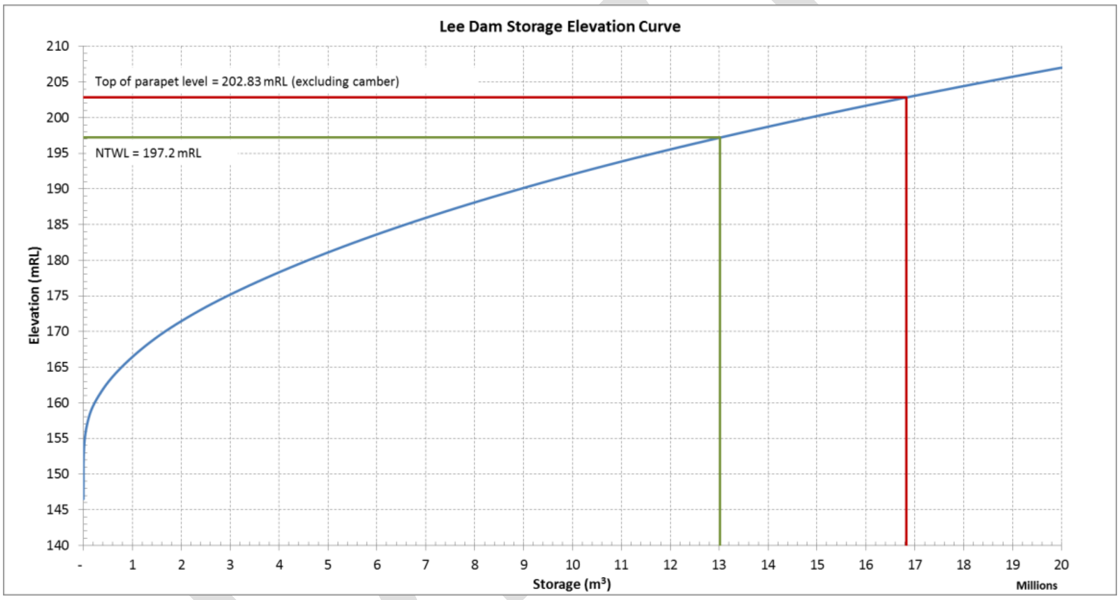


Figure 6 1 Storage elevation curve for the Lee Valley Dam indicating NTWL and top of parapet wall

6.2.2 Operation

6.2.3 Maintenance

Reservoir maintenance substantially comprises regular removal of debris and remedying any significant abutment instability adjacent to the embankment. All debris that impairs free discharge at the spillway should be removed as soon as evident.

Any sign of abutment instability arising from wave action undercutting slopes, intense local rainfall, or earthquake, which might lead to blockage of any dam component, should immediately be assessed and remedial action taken as necessary. Any other instability or erosion of the reservoir rim not directly affecting the abutments should be noted, photographed and then discussed with an experienced dam engineer. Pegging out the extents of such features is useful to help monitor whether the features are changing over time.

6.3 Debris boom

6.3.1 Description

The Lee Valley Dam design includes a debris boom to provide protection from accumulated debris compromising spillway capacity. At the time of writing, the debris boom recommended for the dam is a Worthington Products Incorporated TUFFBOOM waterway barrier and includes debris screens and a mooring buoy to alleviate load and maintain stability. The boom also requires shoreline anchors, anchor blocks and anchor connection chains. Further details on the Debris Boom can be found in the Stage 3 Design Report (T&T, 2012).

6.3.2 Operation

The debris boom requires surveillance and periodic clearance, which is discussed in Section 8. Operation shall be in accordance with manufacturer and supplier requirements and these should be incorporated into this OM&S manual.

6.3.3 Maintenance

Maintenance shall be in accordance with manufacturer and supplier requirements and these should be incorporated into this OM&S manual.

At times, especially during periods of significant rainfall or high winds, debris (in particular logs and other forestry debris) may mobilise and float down the reservoir. The debris boom is expected to trap the majority of this debris which should be removed to prevent excessive build up and undue boom loading.

The anchor locations, boom linkages and the individual booms will need to be inspected for signs of damage or corrosion. Any components that are damaged sufficiently to impair the performance or structural integrity of the boom shall be repaired or replaced as soon as possible.

6.4 Embankment dam

6.4.1 Description

The embankment dam is a Concrete Face Rockfill Dam (CFRD) with a maximum dam height of 53 m and a crest length of 220 m. Further details on the embankment dam can be found in the Stage 3 Design Report (T&T, 2012).

6.4.2 Operation

The embankment is a static structure and has no specific operational requirements other than maintenance and surveillance, which are discussed below and in Section 8.

6.4.3 Maintenance

Components which may require maintenance from time to time include exposed upstream faces of the embankment, the crest and other access roads, the downstream face of the dam, and the drainage outlet structures.

Maintaining the condition of the upstream concrete face of the dam is important to the proper performance of the dam and the prevention of undue seepage. During periods of draw down the concrete face should be inspected for cracks due to shrinkage of the concrete and uneven settlement of the underlying embankment. Any major cracking or spalling which causes significant seepage should be repaired in accordance to approved methods as soon as it is practical to do so.

The sealed dam crest access road should be maintained by patching, edge-break and pothole repairs. Trafficking of the crest should be minimised in order to minimise damage.

The downstream face of the dam should be regularly inspected for any signs of seepage, movement or other disturbance. Vegetation should be prevented from growing on the face of the dam.

Seepage from the dam is collected and measured in two v-notch weir structures at the toe of the dam. Over time these may accumulate sediment or become partially blocked due to debris accumulation. These structures shall be regularly monitored and cleared and any damage remedied to ensure correct operation.

6.5 Spillway

6.5.1 Description

The spillway comprises a 40 m long ogee weir contracting to a 20 m wide chute and terminating in a 20 m radius flip-bucket. The spillway incorporates an underdrainage system to relieve pressure water pressures that may build up under the slab and enable monitoring of same. Two bridges cross the spillway, these are covered separately in Section 6.6.

Spillway details can be found in the Stage 3 Design Report (T&T, 2012) and construction drawings.

Figure 6-2 shows the design rating curve (flow rate versus reservoir level) for the spillway ogee weir.

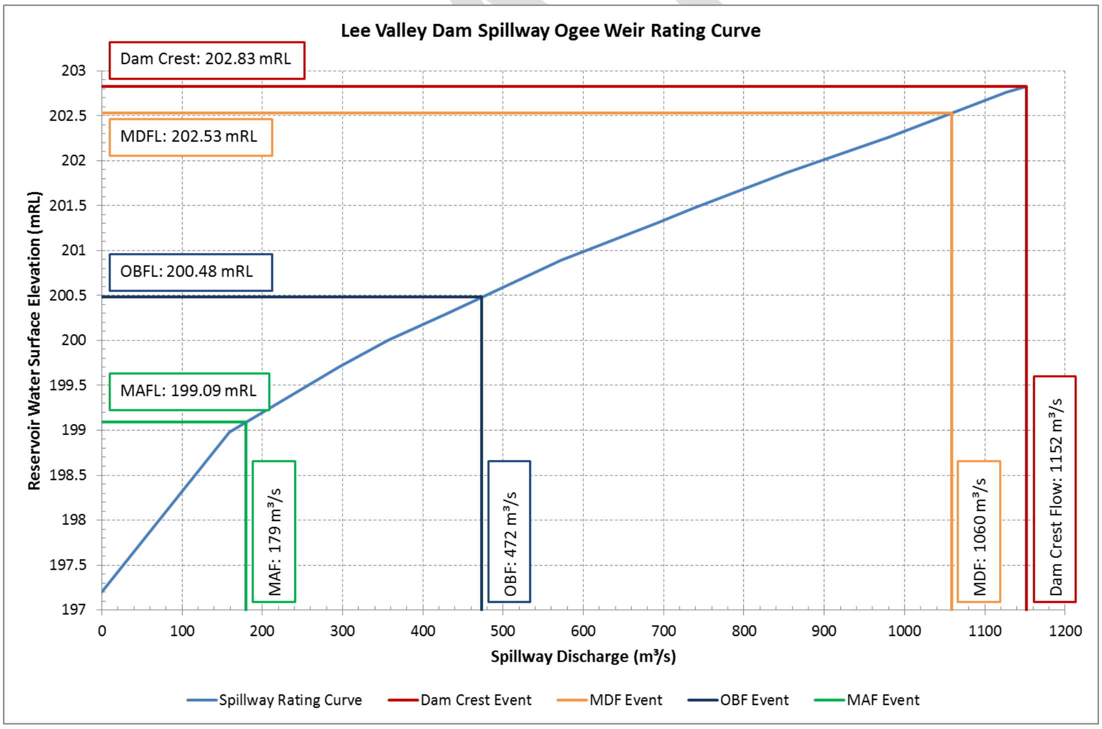


Figure 6 2 Ogee weir design rating curve

6.5.2 Operation

Operation of the spillway is automatic when the reservoir rises above the NTWL, provided that the spillway system is in operating order. No manual or mechanical intervention is required for operation of the spillway weir, chute or flip bucket.

6.5.3 Maintenance

The concrete structures of the spillway weir, chute and flip bucket shall be regularly inspected for cracking, spalling or other deterioration such as cavitation damage. Any such deterioration that may affect performance shall be repaired as soon as possible.

The drainage system under the spillway needs regular inspection and periodic clearance and/or jetting/flushing of any accumulated sediment. The transverse drains under the spillway daylight above the concrete lining of the chute walls to enable flushing. End caps on these drains should be properly secured and maintained to prevent ingress of debris from the surface.

The downstream toe of the flip bucket should be inspected for damage and any sign of erosion or undercutting. Any significant damage to the concrete liner protecting the downstream toe of the flip bucket should be repaired to prevent erosion or undercutting of the flip bucket foundations.

The flip bucket should be regularly inspected and cleared of any accumulated debris or rocks. Under low flow conditions rocks in the bottom of the flip bucket may circulate in the flow and abrade and erode the concrete lining. Further, the flip bucket incorporates a low level drain to allow water to drain from the bucket in times of low or no flow. This drain should be kept clear of any blockages and flushed if necessary.

All exposed structural steel should be inspected for corrosion. Areas of corrosion or damaged paint should be repaired to prevent failure and shortened service life.

6.6 Bridges

6.6.1 Description

Two bridges cross the spillway, one at the ogee weir and the other at the flipbucket. Table 6-1, taken from the design report for the dam, presents summary data for both bridges.

Table 6-1 Bridge summary

Description	Upper Bridge (Dam crest road)	Lower Bridge (Dam toe road)
Deck width - overall (between kerbs)	4.4 m (4.0 m)	4.4 m (4.0 m)
Design vehicle	6 wheel, 11 m long truck with 8.2 tonne axles	6 wheel, 11 m long truck with 8.2 tonne axles
Bridge length	Single 25 m clear span (26.2 m bearing to bearing	Two 25 m clear spans (26.2 m bearing to bearing)
Bridge type	Steel beam sub structure with composite concrete deck	Steel beam sub structure with composite concrete deck

Refer to the Lee Valley Dam Stage 3 Design Report (T&T, 2012) for further details.

6.6.2 Operation

The bridges over the spillways have no specific operational requirements, other than limits on their load carrying capacity.

The design vehicle for the bridges is a 6 wheel, 3 axle, 11 m long truck with an 8.2 tonne design axle. The bridges are also considered to have adequate capacity to carry a single HN (maximum legal weight limit vehicle) vehicle on any given span of the bridge.

6.6.3 Maintenance

Maintenance of the bridges should generally be in accordance with the Transit New Zealand 2001 Bridge Inspection and Maintenance Manual SP/M/016.

The bridges are comprised of a steel beam sub structure with composite concrete deck. Attention should be paid to:

- Any cracking or damage to the concrete deck
- Ensuring the expansion joint cover plates remain in place and in good condition
- Failure of protective coatings and corrosion damage, including at cross brace and fastener locations
- Bearings are maintained in good condition and free of accumulation of debris
- Loose or defective fastenings.

6.7 Outlet Facility

The design of the outlet facility is preliminary at the time of writing and to be completed during Stage 4. This section of the OM&S manual will, therefore, require updating once the detailed design of the outlet is complete.

Further details of the preliminary outlet facility as well as the envisaged operation and maintenance can be found in the Lee Valley Dam Mechanical Design Report Preliminary (Parsons Brickenhoff, 2012) which is appended to the Stage 3 Design Report (T&T, 2012).

6.7.1 Intake

6.7.1.1 Description

The proposed intake includes an intake screen, a tapered entry, a screen outlet bend and associated supporting structures. There are two intakes; an upper intake and a lower intake.

6.7.1.2 Operation

The intakes are designed so that the level they are set at can be lowered if necessary by removal of sections of the inclined intake pipework. It is envisaged that this will rarely be required.

Each of the intakes is to have a pressure transducer on the conduit pipeline to monitor the maximum pressure differential across the intake screens. This is to ensure a blocked screen does not expose the screen to the risk of collapse.

A programmable logic controller is to be used to compare the pressure transducer measurement to a transmitter monitoring the reservoir level, in order to calculate the pressure across each screen at the prevailing pipe discharge. If the pressure differential exceeds a set differential at that pipe discharge an alarm is to activate and the flow through that intake stopped until the cause of the screen blockage is rectified.

6.7.1.3 Maintenance

Regular screen cleaning is required for correct operation of the intake. Screen cleaning is to be a manual process and should only be undertaken in accordance with an approved safety management plan. For operator safety and to allow for easier removal of debris off the screen, the flow through the screen shall be stopped by closing the downstream valves while the screen is being cleaned. If the screen is in an accessible depth of water minor debris may be removed by an appropriately trained diver. If the screen is significantly blocked the screen may be unbolted and removed by winching it to the dam crest and then it can be cleaned in a readily accessible area.

6.7.2 Inclined intake pipework

6.7.2.1 Description

The inclined intake pipework on the upstream face of the dam transfers the water from the intake screens to the large radius bends at the upstream end of the conduits through the dam.

The arrangement consists of two pipe supports welded to each length of pipework. Each pipe support has two guides attached to the underside of the supports which run on rails that are anchored to the face of the dam. The guides provide alignment when the pipework is being installed or removed and also provide pipework restraint. A minimum of every second length of pipework is to be anchored into position using the lower saddle support, to prevent the axial loads being transferred onto to the pipework below. The anchoring is to be equivalent to that used for the intake screen: anchoring onto the guide rails. The anchoring details are to be confirmed during detailed design.

To accommodate movement of the concrete face as a result of deformation of the dam, the inclined intake pipework incorporates non thrust type dismantling joint couplings between each length of pipe. These couplings accommodate regular expansion and contraction pipework movement, and angular deflection between the two adjoining pipe lengths. The guide rail tracks are to be installed with gaps between each length of rail, to allow for thermal expansion and contraction, and any movement of the concrete face as a result of deformation of the dam face. The gap size is to be confirmed during detailed design.

6.7.2.2 Operation

The intake pipework is designed so that sections can be removed, by use of divers and winching from the dam crest, to adjust the level the intakes are set at but it is envisaged that this will rarely be required.

6.7.2.3 Maintenance

The intake pipework should be periodically inspected for damage and corrosion and repaired as necessary. This exercise may require divers and could be carried out at the same time as screen cleaning activities. Should the reservoir level be drawn down and expose sections of the pipework, these should be inspected at such times. Alternatively, pipes could be removed

The rail system and fixings on the dam face should be periodically inspected and maintained to ensure:

- Fasteners have not loosened
- Rails are at the correct alignment

- Galvanic separation elements are in place
- Any corrosion is maintained to acceptably low levels.

6.7.3 Conduit pipework

6.7.3.1 Description

The inclined intake pipework terminates at a thrust block located on top of the concrete conduits at the upstream base of the dam. There are then two long radius mitre bends, one per pipeline, between the inclined intake pipework on the face of the dam and the pipework running through dam's concrete conduits. Downstream of the bend there is a short straight section of pipeline leading to the primary isolating valve. Downstream of the valve the pipe diameter is reduced to the penstock size. At the downstream toe of the dam the penstocks are again reduced to discharges through the fixed cone valves. Air valves are also provided to release air and prevent vacuums during operation.

The length of the pipe sections will be determined in the Stage 4 detail design phase. It is anticipated that for the penstock, the number of couplings will be minimised to reduce the number of sources of potential future leaks, with other joints welded to provide added robustness. However, the penstock will still require several couplings for thermal expansion and dismantling purposes.

Valving is addressed in more detail in Section 6.7.4.

6.7.3.2 Operation

Operation is generally covered by the valve operation, Section 6.7.4.2.

Notwithstanding manufacturer/supplier specific requirements, the most significant operational consideration is restricting the flow rate in each penstock to a maximum value of 5m³/s. This is to ensure that velocities in the pipes are kept at acceptable levels to limit damage to the epoxy lined spirally welded steel pipework.

6.7.3.3 Maintenance

The pipework should be periodically inspected for damage to epoxy coatings and evidence of corrosion and remedied in accordance with manufacturer/supplier requirements. Particular attention should be paid to corrosion occurring around contacts with pedestals.

Couplings should be inspected for leaks and remedied in accordance with manufacturer/supplier requirements.

Low friction pads on each of the concrete pedestals should be positioned and maintained in accordance with manufacturer/supplier requirements.

It is proposed that a mobile lifting frame is to be used to for maintenance purposes, refer to Section 6.7.5. Pipework may be transported to the downstream end of the concrete conduits using this lifting frame and removed from the conduits using an external mobile crane.

6.7.4 Valves

6.7.4.1 Description

Details of the proposed valves for outlet facility as well as the envisaged operation and maintenance can be found in the Lee Valley Dam Mechanical Design Report Preliminary (Parsons Brickenhoff, 2012) which is appended to the Stage 3 Design Report (T&T, 2012).

A summary of the valves on each pipeline of the outlet facility, generally listed in downstream order, is provided below:

- DN1200 penstock primary isolation wedge type gate valve – electric actuation
- DN80 bypass pipe isolating gate valve – manual actuation
- DN80 primary bypass gate valve – electric actuation
- DN150 anti-vacuum air valve downstream of primary isolation valve – automatic actuation
- DN50 air release valve upstream of the fixed cone valve – automatic actuation
- ND800 fixed cone valve (FCV) – electric actuation.

6.7.4.2 Operation

All valves shall be operated in accordance with manufacturer/supplier recommendations.

The penstock isolation valves at the upstream end are electrically actuated and will be remotely operated from the control room or from the downstream toe of the dam (To be confirmed). Normally the penstock gate valves will be fully open and will only be closed to isolate the conduit pipework for maintenance or emergency purposes. A small diameter bypass pipe and valves are also provided to assist with the operation and maintenance of the penstock isolation valve.

The FCVs are electrically actuated (as well as manually) and will be remotely operated from the control room for the dam (To be confirmed). These FCVs will be operated on a daily basis to regulate and mix the flows released into the Lee River. The upper intake is expected to be used more frequently than the lower intake. The fixed cone valves are set at an elevation such that they can freely discharge and operate during Mean Annual Flood Flows. The FCVs should not be operated when partially submerged, to avoid damage, unless an emergency situation exists.

The FCVs shall be operated to maintain velocities in accordance with manufacturer/supplier recommendations and to maintain the velocities in the upstream pipework to the limits specified above.

Access to the fixed cone valves is via ladder/platforms at the toe of the dam. Access to the primary isolation valves is along the length of the concrete conduit under the dam. Procedures for manual operation of the valves will need to account for confined spaces requirements.

6.7.4.3 Maintenance

All valves shall be maintained in accordance with manufacturer/supplier recommendations.

Notwithstanding manufacturer/supplier recommendations, all valves should be regularly “exercised” to ensure that they remain in good working order.

Removable joints and flanges are provided so that valves can be removed if required for maintenance or replacement. A removable spool piece is provided in the rare event that the primary isolation valve needs to be removed.

It is proposed that a mobile lifting frame is to be used to for maintenance purposes, refer to Section 6.7.5. Valves may be transported to the downstream end of the concrete conduits using this lifting frame and removed from the conduits using an external mobile crane.

6.7.5 Moveable lifting frame

It is proposed that a mobile lifting frame is to be used to for maintenance purposes, to lift and move sections of pipework, primary isolation valves and other miscellaneous equipment to the downstream end of the conduits. At the downstream end of the conduits the equipment can be lifted up and out of the conduit utilising a mobile crane. The mobile lifting frame wheels would run on the invert of the conduit, either side of the pipework support saddles and the overhead manual lifting hoist would be located close to the ceiling of the conduit to maximise the lifting height. The mobile lifting frame would normally not be kept in the conduit, as it would restrict access down the conduit and the damp environment will increase the potential for corrosion. The frame will need to be kept in a suitable covered storage area, and when required, it would need to be lowered into the downstream end of the conduits using a mobile crane.

The proposed mobile lifting frame will be addressed in more detail in the Stage 4 detailed design phase.

7 Inspections

7.1 General

Routine inspection and surveillance requirements are set out in Section 8. Further to these requirements, three other levels of inspection should be carried out in accordance with the NZSOLD Dam Safety Guidelines:

- Annual inspections;
- Comprehensive Safety Review (in accordance with the Dam Safety Assurance Programme); and
- Inspections after unusual events.

7.2 Annual inspections

Annual inspections of the dam are required to confirm satisfactory behaviour or identify deficiencies by a thorough visual examination of the dam and review of monitoring data. Annual inspections should be undertaken by an experienced dams engineer in conjunction with an annual deformation survey. If possible, the inspections should be carried out when the reservoir is at a high level and the water clarity is good.

The annual inspection would include:

- A review of the year's surveillance data trends including deformation survey
- A visual check on the components of the facility including the spillway, bridges and the reservoir in the vicinity of the dam
- Discussion with operators on operation and maintenance of the dam and any issues of potential significance
- Preparation of a report discussing;
  - Condition and performance
  - Recommendations on any aspects related to dam safety
  - Recommendations on asset management, to the owner's requirements.

After a maximum of two years of operation, an inspection of the condition of upstream face of the dam and spillway weir should be carried out. This may require qualified divers if the reservoir level remains high up to this time. If a diver inspection is required, it should be carried out when the lake water temperature is moderate and the water clarity is good.

7.3 Comprehensive Safety Review

The Comprehensive Safety Review (CSR) is more comprehensive and targeted at confirming the safety of the main dam, including confirmation of design and construction standards in the light of current technical knowledge. Otherwise, it would embody the elements of the annual inspection.

The frequency of CSR is determined in the Dam Safety Assurance Programme. Under The Building (Act 2004), Parts 140 – 148, the Dam Owner must submit a Dam Safety Assurance Programme (of which this manual forms a part) for acceptance by the Regional Authority. Tasman District Council would act as a recipient of this Assurance Programme. Amendments to this OM&S manual may need to be included in a revised Assurance Programme and re-submitted for review and acceptance by the Regional Authority.

The bulk of the inspection work and reporting would be by a senior dams engineer experienced in CFRD/hydraulic structures design and construction, and knowledgeable of current technology. A senior engineering geologist would be desirable to have on the inspection team to provide advice on updated geological knowledge and any changes in seismic hazard.

The CSR should include an inspection of the condition of the upstream face of the dam and spillway weir. This may necessitate the use of qualified divers if the reservoir level is high at this time. If a diver inspection is required, it should be carried out when the lake water temperature is moderate and the water clarity is good.

In addition to making physical inspections and reviewing all surveillance data, the team would also examine all relevant records related to design and construction. On completion of all review work the team would produce a combined report focussing on safety of the main embankment dam. If any area of uncertainty is identified or the team identifies any aspect possibly needing upgrading because of changed knowledge (e.g. hydrology and floods), recommendations for resolving the issues would be made.

7.4 Inspections after Unusual Events

These inspections are on an as-needs basis. They might occur as a result of a sudden and significant change in seepage or deformation or some other unusual behaviour. As an indication, inspections should be made after significant earthquakes and during and following significant floods in accordance with the Emergency Action Plan. In the early years of operation in particular, the spillway performance should be inspected and monitored during floods. We recommend an inspection be carried out if:

- There are landslides into the dam reservoir
- Floods larger than the mean annual flood
- Seismic events are reported in the Richmond/Nelson region.

Occasional inspections of the upstream embankment face should be made when reservoir levels are low.

8 Surveillance

8.1 General

The following sections detail the monitoring for the operational phase and are subject to review on an ad hoc basis and as required under the regulatory requirements for the Dam Safety Assurance Programme reviews.

The objective of the routine surveillance is to maintain a complete record of the dam's behaviour and detect, as early as possible, any signs of potentially adverse behaviour so that causes can be assessed, corrective action taken, or in the extreme, emergency action procedures can be implemented. The observers or management must maintain a continuous plot of data and ready availability of records so that trends can be detected and evaluated. They must also react promptly and in accordance with instructions where an alert level reading is obtained. The alert levels assigned have a margin of comfort applied and do not, in themselves, represent a dangerous condition if the alert level is just exceeded. They do, however, require evaluation if the alert reading is verified as not being an incorrect reading. A copy of the alert criteria levels is provided in Appendix D (To be confirmed).

The remainder of this section sets out detailed requirements for routine monitoring. The frequency and scope of this monitoring may be subject to change following annual and/or five yearly inspections and occurrence of large flood events and as a longer duration performance database is obtained. Any changes should preferably be approved by the original designers, or by a suitably experienced dam engineer.

Forms which may be used for surveillance and monitoring records are provided in Appendix B & C (To be confirmed).

8.2 Visual inspections

Visual inspections should be made on a routine basis, normally in conjunction with reading monitoring points. However, personnel visiting the facility at any time should be made familiar with monitoring requirements and be required to check in passing for any signs of potential adverse behaviour. Special inspections are required after unusual events as discussed in Section 8.5.

Visual inspections should be based on a regular defined "route march" and recorded on a suitable form or electronically with backing up within 24 hours.

Generally all exposed surfaces in the close vicinity of the dam, particularly those below reservoir level, should be inspected to check for any signs of cracking, slumping, new wet patches, springs, settlement and the like, or basically any significant change from the normal condition. Any obvious deterioration of any structure must also be noted.

The visual inspections should as a minimum include the following:

- Condition of access roads and tracks
- Condition of the dam embankment (for erosion damage or signs of seepage)
- Parapet wall
- Seepage weirs
- Spillway weir
- Spillway and flip bucket drains
- Spillway bridges

- Debris boom
- Flipbucket and downstream plunge pool
- Outlet facility and area downstream of FCV
- Fish pass facility.

Floating debris accumulating on the debris boom should be noted, so that it may be removed before it becomes a potential threat to spillway operation. It is possible for water logged debris to pass underneath the debris boom and it should be removed as soon possible.

The minimum frequency of visual inspection should be fortnightly.

In addition, inspections of the upstream embankment face and inclined pipework should be made when reservoir levels are low.

8.3 Routine recording of instruments and seepage

The installations and seepage monitoring points are shown on the design drawings. Instruments are to be monitored and processed on a routine basis. Additionally, reservoir levels and daily site rainfalls are to be maintained and recorded as part of the dam monitoring dataset.

We recommend that the monitoring frequencies set out below be reviewed as part of the dam's first CSR.

Procedures for taking readings shall be as follows:

i. **Rainfall and reservoir level**

Rainfall and lake level readings shall be recorded on an hourly basis from instrumentation installed on site.

ii. **Spillway drains**

To be confirmed following Stage 4 design

iii. **V-notch Weir**

To be confirmed following Stage 4 design

8.4 Deformation surveys

Deformation surveys of the embankment dam should be undertaken annually, preceding or in conjunction with annual inspections, except as may be appropriate after an unusual event. It is preferable to undertake the surveys at a consistent time of year with a high reservoir level.

8.5 Inspections after Unusual Events

Unusual events are specified in the Emergency Action Plan.

As soon as possible after a felt earthquake, local observers should undertake a close visual inspection of the whole dam facility, including reservoir slopes, and monitor all instrumentation.

Where there are signs of significant wind or rain damage, any alert levels are exceeded or there are signs of possible adverse behaviour from earthquake, the Engineering Advisor should be informed and requested to advise on the matter. The Engineering Advisor may need to visit the site to provide suitable advice.

8.6 Alert criteria

The following alert criteria have been assessed based on the results of the initial monitoring. These alert values should be reviewed annually as part of the annual inspection process (see Section 6.2).

Alert levels to be confirmed following Stage 4 design.

Table 8.1 – Dam Alert Levels

Instrument	Data Limit Alert	Design Limit Alert
TBC	TBC	TBC

9 Applicability

This report has been prepared for the benefit of Waimea Water Augmentation Committee with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Simon Croft	Keith Dickson
Senior Water Resources Engineer	Project Director

SFC

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10 References

Department of Building and Housing. (2008, July 7). Buidling (Dam Safety) Regulations. Wellington.

Department of Housing and Building. (2004, August 24). Building Act. Wellington.

NZSOLD. (2000). *New Zealand Dam Safety Guidelines.* Wellington: New Zealand Socitey on Large Dams.

Parsons Brickenhoff. (2012). *Lee Valley Dam Mechanical Design Report Preliminary.*

T&T. (2012). *Lee River Dam - Detailed Design Report Stage 3.*

Appendix A: Drawings

- **To be provided following Stage 4 design**

Appendix B: Inspection Check Lists

- **To be provided following Stage 4 design**

Appendix C: Monitoring Data Sheets

- **To be provided following Stage 4 design**

Appendix D: Alert criteria

- To be provided following Stage 4 design

Appendix E: Staff proficiency requirements

- **To be provided following Stage 4 design**

Appendix F: Geological Interpretive Report (Bound separately)

Appendix G: M&E Design Report

Lee Valley Dam
Mechanical Design Report
Preliminary

July 2012

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Revision	Details	Date	Amended By
0	Preliminary for client comment	5 July 2012	
1	Amended to reflect client's comments	18 July 2012	DK, LG

Author: Luke Gallagher...

Signed: ....

Reviewer: David King, John Fredericksen, ...

Signed: ....

Approved by: David King...

Signed: ....

Date: ....

Distribution: Neville Laverack (Tonkin and Taylor) ....

Contents

1. Overview

Parsons Brinckerhoff has been contracted by Tonkin & Taylor Limited (T&T) to provide the mechanical detailed design for the Lee Valley Dam irrigation scheme outlet works, covering the intake screens, inclined intake pipework and valving arrangement for the bottom outlet releases.

This document is issued as a draft report based on the current preliminary design status. The content of the report will be incorporated in a T&T report covering other aspects of the scheme. The current design phase is termed “Stage 3 design”, and its intention is to be sufficient for a reasonable level of pricing. More detail design will follow in “Stage 4”, at which time this report will be comprehensively revised.

The preliminary design described in this report is shown in the following preliminary general arrangement drawings:

153987-ME-001	Preliminary intake screen general arrangement
153987-ME-008	Preliminary inclined intake pipework, pipework and support arrangement
153987-ME-016	Preliminary downstream bottom outlet pipework and valving arrangement

Revision 1 of this document includes comments received from T&T on 12/7/12, and subsequent discussions.

2. Intake structure

2.1 Description

The intake incorporates an intake screen, a bellmouth entry piece, screen outlet bend and supporting structure. There are two sets of intakes.

The intake screens consist of a rectangular bird cage type screen, with vertical screen bars and a fabricated support structure. The intake structure incorporates a bellmouth intake piece and an outlet bend, which connect, through a dismantling joint, to the inclined intake pipework on the face of the dam. The screen support structure incorporates guide channels for positioning the screens on the face of the dam. Each of the columns from the main support structure are to be securely anchored to the face of the by bolting and/or pinning the support structure to the guide rails (refer to section 2.6 for details on the screen support structure anchoring).

The screen and support structure are to be made from Grade 250 or 350 mild steel, with a suitable corrosion protection coating of hot zinc spray or an approved equivalent. The steel grade and protection will be confirmed as part of Stage 4 design.

Refer to drawing 153987-ME-001 for the preliminary intake screen general arrangement.

Parameter	Value	Comment
Number of pipelines	2	
Design flow rate for consideration of vortex formation	5.0 m³/s	flushing flow (occasional releases)
Design flow rate for screen approach velocity	2.23 m³/s	T&T forecasted maximum downstream release during 50 years of data
Maximum screen approach velocity	0.3 m/s	Cawthron report No. 1701, Dec 2009
Spacing between screen bars	20 mm	Cawthron report No. 1701, Dec 2009
Maximum pressure difference across screens, for design stress	3.0 m	Lewin, J 1995, *Hydraulic gates and valves,* Thomas Telford, London
Preliminary wave sizing	4 m/s	estimate used for basic inertia calculation
Earthquake loading	Stage 4 design	to be used in detailed design calculation
Minimum operating water level, upper intake	185.0 m	advised by T&T
Minimum operating water level, lower intake	166.5 m	advised by T&T

Table 1. Key design parameters, preliminary

2.2 Flow velocities and screen size

The intake screens are required to protect the downstream pipework and valving by preventing debris from entering the pipework. The intake screens are also to provide protection to aquatic life by limiting the bar spacing and approach velocity. The intake structure, including the screens and pipework, are to withstand loads from earthquakes, waves and minor impact from debris. The screen approach velocity is calculated based on no debris accumulation.

The preliminary sizing of the screen arrangement assumes a loading from a blockage that gives the pressure differential across the screens stated in Table 1.

At the preliminary stage the earthquake loading has not been considered in the design. Based on the preliminary wave action inertia analysis, the earthquake loading is not the critical load case. The earthquake loadings will be considered in the detailed design. The preliminary screen arrangement is tabulated below.

Parameter	**Value**
Estimated screen area required	14.0 m²
Screen sides, nominal overall size	2 m × 2 m
Screen side panel height	1.4 m
Screen bar material	8 × 60 mild steel flat bar
Unrestrained span of screen bar	470 mm
Mass of screen	Stage 4 design
Intake bellmouth diameter	1650 mm
Number of anchor bolts	Stage 4 design
Anchor bolt size	Stage 4 design

Table 2. Preliminary screen arrangement

2.3 Intake screen elevations

The minimum submergence depth of the bellmouth intake below the minimum operating level has been determined using the *ASCE Guidelines for design of intakes for hydroelectric plants, 1996.* The preliminary elevations of the top of the bellmouth intakes, to minimise the occurrence of vortex formation with the flushing flow stated in Table 1 are tabulated below. The flushing flow operating condition is identified in the figure below taken from the ASCE reference.

Vortices can be associated with vibrations, structural damage and flow reductions. In addition vortices can cause serious hydraulic problems with turbines.

Although the figure below indicates that there is the potential for the occurrence of vortex formation during flushing flows, a typical method to prevent vortex formation is to provide a submerged raft over the inlet. The screens over the Lee Valley intakes will serve this function. It is also noted that the operation with the irrigation releases, compared to the flushing releases, significantly reduce the likelihood of vortex formation.

It is likely that lowering the elevation of the intake will lower the risk of vortex formation, however it is noted from Figure 1 that there is no safe submergence. Furthermore lowering the elevation will lead to a deeper dive and deeper extraction of water, which may not be desirable for the environmental advisor.

Parameter	Value
Upper intake	
elevation of top of bellmouth intake	181.5 m
elevation of top of screen structure	184.2 m
Lower intake	
elevation of top of bellmouth intake	163.0 m
elevation of top of screen structure	165.7 m

Table 3. Preliminary screen elevations

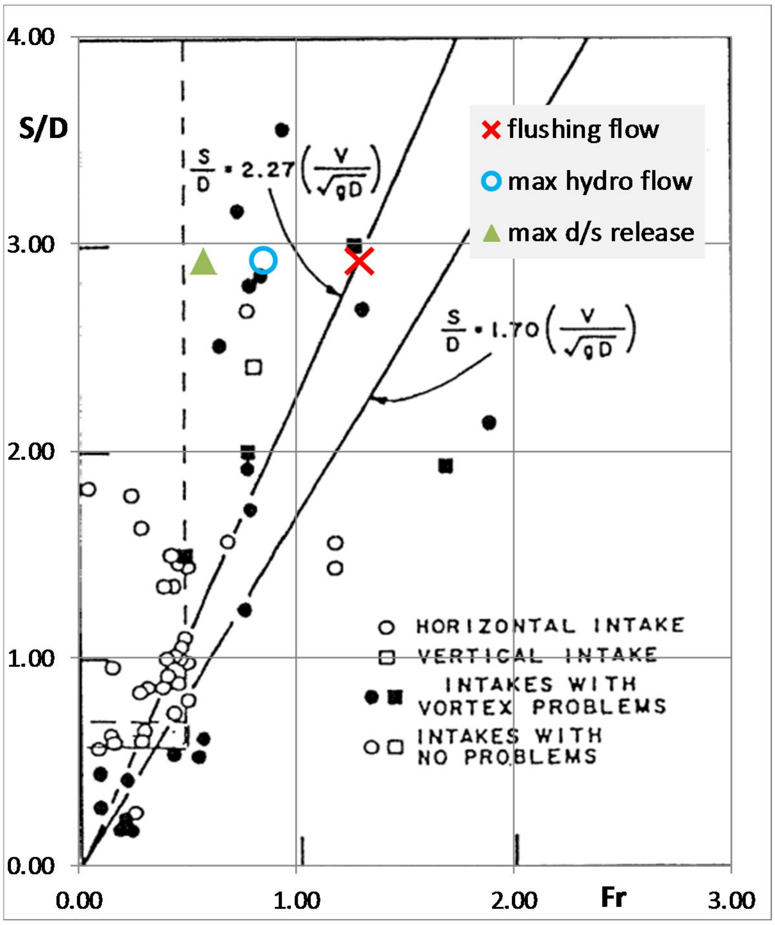

Figure 1. Submergence depth (S) of intakes to minimise the occurrence of vortices

2.4 Intake screen removal

The intake screens may need to be removed for maintenance, repairs or to adjust the installed elevation of the intake screens.

Due to the long distance between the access road along the crest of the dam and the installed location of the intake screens, the screens have been designed to be removed without the need to bring in a high span crane. The removal of the screens can be achieved by winching the intake structure up the face of the dam. This would be achieved using the following steps:

1. A winch cable from a mobile crane would need to be connected to the screen support frame. This would be carried out by a diver if the screen is submerged, or if not, then an operator may be lowered down the face of the dam using appropriate safety procedures. The cable will pass through a pulley block attached to anchor points on the parapet wall; this will keep the cable at the same angle during lifting.

2. Once the crane has taken the weight of the intake structure, the screen hold down anchor bolts between the support structure and guide rails can be removed, and the dismantling joint coupling between the screen outlet pipework and the mating inclined intake pipework can be loosened.

3. The crane can then winch the intake structure up the face of the dam, with the structure being guided up the dam face by the guide rails. This operation is to be carried out only during calm conditions where significant wave action will not act on the moving structure.

4. Once at the top of the dam, the intake structure can be lifted off the guide rails and onto a suitable laydown area.

The uppermost lengths of the guide rails, at the top of the dam face, are to have the top of the rail partially removed so it does not inhibit lifting of the screen off the guide rails. This results in the lateral guiding and bearing surface of the top rail being reduced, which may require an additional local alignment and bearing surface at this upper length of track. This is to be considered in the detailed design.

2.5 Intake screen adjustment

To adjust the elevation and corresponding location of the intake screens, one or more sections of the inclined intake pipework need to be removed or added. This would be achieved using the following steps:

1. The intake screen would need to be removed and placed in a suitable laydown area, as described above in section 2.4.

2. One or more sections of the inclined intake pipework would then need to be removed or added, as described in section 4.3.

3. Once the changes to the inclined intake pipework have been made and the inclined intake pipework is in the final installed location, the new installed location of the intake screens can be confirmed to establish if any modifications to the screen anchoring hole locations in the guide rails are required (refer to the details below on the screen support structure anchoring). Confirming the new screen installation location may require the screen to be lowered into position to confirm the positions of the new anchoring points and that screen outlet and mating pipework align correctly in the new location.

2.6 Screen support structure anchoring

The intake screens are to be securely anchored to the face of the dam, to ensure the screens remain stable and do not transfer loads to the downstream pipework during seismic events and impact loads from waves and debris.

Each of the columns from the main support structure are to be securely anchored to the face of the dam by bolting and/or pinning the support structure to the guide rails. The guide rails are to have stiffener ribs to provide sufficient guide rail lateral strength, and additional sets holes are to be provided in the guide rail for future adjustment of the screen installation position.

2.7 Intake sealing for pipework dewatering

The ability to fit an inlet sealing system, to dewater the pipework upstream of the primary isolation valves, will be provided to enable future maintenance.

The intake screen design includes the ability to attach a sealing plate on the top of the bellmouth inlet piece, to enable the pipework to be dewatered. The requirement for the timing the design and supply of the sealing plate is to be confirmed with T&T, as the sealing plate is unlikely to be required until the primary isolation gate valves and/or the long radius bends undergo major maintenance.

The screen bottom plate is to have 20 mm holes around the bellmouth inlet, to enable the sealing plate to be bolted into position over the inlet. The sealing plate will require a vent pipe or hose, connected to a location above the maximum water level. The vent is to be appropriately sized to admit air and prevent a vacuum being created when the downstream pipework is dewatered at a controlled rate.

To install the sealing plate, the screen above the pipework inlet would first need to be removed. This would be achieved using the following steps:

1. The flow through the intake is to be stopped, with the primary isolation gate valve and bypass closed.

2. Installing the blanking plate is anticipated to be most easily done by removing the screen and support structure and locating it in a suitable work area, as describe in section 2.4.

3. At work area, each of the side screen bar panels are to be removed to access the support column mating flanges. The support column mating flanges can then be unbolted and the screen upper structure can be removed, exposing the top of the bellmouth inlet.

4. The sealing plate and vent can then be lowered over the pipework inlet and bolted into position, with a synthetic rubber gasket between the blanking plate and screen bottom plate.

5. The intake support structure, with attached sealing plate and vent, can then be lowered down the face of the dam, whilst ensuring the vent is kept open to prevent air being trapped in the inlet pipework.

6. Once the inlet pipework and support structure is re-installed back into position with the dismantling joint coupling reconnected, the pipework can then be drained in a controlled manner. This would most easily be achieved using the fixed cone discharge valve to drain the bulk of the water, with the balance of water being drained via a pipework drain valve.

2.8 Measurement of screen blockage

Each of the intakes will have a pressure transducer on the conduit pipeline, preferably at the downstream end to aid access. The pressure transducer is required to monitor the maximum pressure differential across the intake screens, to ensure a blocked screen does not expose the screen to the risk of collapse.

A programmable logic controller (PLC) is to be used to compare the pressure transducer measurement to a transmitter monitoring the reservoir level, in order to calculate the pressure across each screen at the prevailing pipe discharge. If the pressure differential exceeds a set differential at that pipe discharge an emergency alarm is activated, the flow through that intake is stopped and shall not be restarted until the cause of the screen blockage is rectified.

The most accurate method of obtaining a measurement of flow in the pipeline is to use a dedicated flow meter. Many types are available and these vary with cost and measurement uncertainty. The level of uncertainty may be important depending on how downstream users pay for the flow releases.

For an arrangement which includes a hydro powerhouse the performance characteristic of the turbine, or turbines, may be used to estimate the flow. This is typical for a hydro scheme and the level of uncertainty, although higher than using a dedicated flow meter, will likely be acceptable. A similar relationship can be made between the opening of the fixed cone valve and flow but the level of uncertainty will be greater than for the turbine.

2.9 Screen cleaning

When operating, the screens will be covered in water, thereby reducing the potential for floating debris to build up on the screen. The screens also have a slow approach velocity which assists to minimise debris build-up on the screen. The screens are designed with vertical sides and an angled top to reduce the build-up of debris on the screen.

During the detailed design, consideration is to be given to minimise the potential for the debris accumulation around the screen support structure.

The screen cleaning is to be a manual process, and should only be undertaken with a safety management plan and when it is safe to do so. For operator safety and to allow for easier removal of debris off the screen, the flow through the screen shall be stopped while the screen is being cleaned. The alternative intake should be used in these circumstances to provide downstream releases.

If the screen is close to the water surface, an operator may go out in a barge or boat and manually rake the sides of the screen.

If the screen is submerged to a depth accessible by diver, the driver may be able to dislodge minor debris. Alternatively if the screen is significantly blocked and the diver cannot clear the screen, the screen may be unbolted and removed so that it can be cleaned in an accessible area (refer to section 2.4 for the screen removal description).

3. General pipework design

3.1 Description

This section of the report applies to the all the large diameter pipework covered in this report, from the intake screens to the fixed cone discharge valves.

Parameter	**Value**	**Comment**
Pipe material		epoxy coated spirally welded steel pipework
Design flow rate	5.0 m^3/s	flushing flow
Primary isolation valve type	wedge type gate	
Maximum velocity through gate valve	5 m/s	recommendation from a reputable Australian supplier
Maximum probable flood level to consider for static pressure, PMF	202.53 m	
Maximum transient pressure	56.6 m	this value supersedes the preliminary calculation in Lee Valley *Dam, Hydro optimisation report*

Table 4. Key design parameters, preliminary

3.2 Pipework material

The pipework design is based on epoxy coated and lined spirally welded steel pipework, bends and fittings.

The choice of pipework material was made as a result of correspondence with T&T, and Parsons Brinckerhoff's May 2012 report *Lee Valley Dam, Review of intake pipework material options* with report identifier *153987-REPT-001*. The document provides a comparison of the steel pipework to glass reinforced plastic pipework and HDPE pipework.

Steel pipework has been selected as it has less specialised manufacturing processes, and also provides additional flexibility of being able to weld components together, either on-site or in the factory using routine techniques.

Steel pipework is also the traditional material of choice for most applications like the Lee Valley Dam project, and as such, the design of steel pipework, fittings and support systems has well established design codes and practices, which have been refined from many years of historical information. These design codes are used as part of normal steel pipework design practice. Steel pipework has the benefits of having a wide range of suppliers and it is commonly used throughout the world.

Corrosion protection coating systems for steel pipework, such as epoxy coatings, have been used extensively for many decades. The coating systems are well developed and are expected to provide long-term protection to the steel pipework.

3.3 Pipeline internal diameter optimisation

The minimum diameter of pipeline was determined, by consideration of the maximum velocity through the primary isolation valve at the design flow stated in Table 4. A recommended maximum velocity, see Table 4, had been advised by a reputable valve supplier, AVK. Parsons Brinckerhoff also recommends this limit to minimise erosion in the long radius bends. The internal diameter of the inclined intake pipework has been sized to be the same as the long radius bends. This is for simplicity and to keep the velocities down in the pipework upstream of the primary isolation gate valves, in order to reduce the long term internal erosion of the difficult to access pipework.

To minimise the downstream valving and pipework costs, a smaller internal diameter pipework is proposed downstream of the primary isolation gate valves, in the section commonly referred to as the penstock. The recommended internal diameter pipework is from the analysis in Parsons Brinckerhoff's June 2012 report *Lee Valley Dam, Hydro optimisation report* with report identifier *153987-REPT-002*. The detailed design of this pipework is not currently part of Parsons Brinckerhoff's scope.

Parameter	Value
Inclined intake pipework diameter	1200 mm
Bend diameter	1200 mm
Primary isolating valve diameter	1200 mm
Penstock diameter	1000 mm
Diameter of pipework at fixed cone valve	800 mm

Table 5. Preliminary pipework diameters

Parameter	Value
With downstream release flushing flow	5.0 m³/s
velocity with 1200 mm diameter	4.42 m/s
velocity with 1000 mm diameter	6.37 m/s
velocity with 800 mm diameter	9.95 m/s
With preliminary maximum hydro flow	3.3 m³/s
velocity with 1200 mm diameter	2.92 m/s
velocity with 1000 mm diameter	4.20 m/s
velocity with 800 mm diameter	n/a
With maximum irrigation flow	2.23 m³/s
velocity with 1200 mm diameter	1.97 m/s
velocity with 1000 mm diameter	2.84 m/s
velocity with 800 mm diameter	4.44 m/s

Table 6. Preliminary pipework water velocities

3.4 Pipeline thickness

The minimum pipework wall thickness has been determined after making the following considerations:

1. The minimum thickness required due to hoop stresses from internal pressure, including the transient pressure rise due to a downstream hydro station.

2. The minimum thickness required for shipping and handling, based on the greater of two estimation techniques, as provided in section 4.1.2.1 of the ASCE Manuals and reports on engineering practice No.79. The resultant value is given in Table 7.

3. A preliminary check was also carried out for the point load stress on a flat surface from self-weight and the estimated stress due to beam action. Note the estimated stress due to beam action was a basic preliminary check, rather than a detailed analysis. This will need to be carried out in the detailed design, with the spacing of the pipework supports determining the level of stress caused by the beam action.

4. The minimum thickness of the inclined intake pipework to prevent buckling from external pressure when dewatered at maximum reservoir level. This is based on the Stewart formula in AWWA Steel water pipe – A guide for design and installation, M-11.

5. The inclined intake pipework shall take account of robustness for wave action and impact loads from logs.

6. Any repairs to the exposed section of pipework either end of the bend would be extremely challenging to undertake as the adjacent pipework is encased in concrete and the upstream end of the bend will be submerged. These two sections of pipework have been specified as a heavier wall thickness; refer to drawing 153987-ME-016.

7. The thrust flanges are best located on the thicker sections of pipework.

Based on the analysis above, the preliminary minimum wall thicknesses recommended are stated in Table 7. Pipework not exposed to the external buckling pressures and impact loads may utilise a different minimum wall thickness. Pipework wall thicknesses will be confirmed as part of the detailed design analysis. The pipework contractor may reduce the number of pipe thicknesses if it is advantageous for cost or supply purposes.

Parameter	**Value**
Minimum for handling and installation	6 mm
Minimum to prevent external pressure buckling in inclined intake pipework	8 mm
Inclined intake pipework	10 mm
Bend, encased in concrete	8 mm
Straight pipe either end of bend, encased and exposed	16 mm
Penstock	6 mm
Pipework at fixed cone valve	8 mm

Table 7. Preliminary pipework thicknesses

3.5 Pipe section lengths

The length of the pipe sections will be examined in the detail design phase. The cost benefit of the number of couplings and support spacing will be considered. It is anticipated that for the penstock, the number of couplings will be minimised to reduce the number of sources of potential future leaks, with other joints preferably welded to provide added robustness. However, the penstock will still require several couplings for thermal expansion and dismantling purposes.

The data used so far in the analysis is tabulated below.

Parameter	Value
Inclined intake pipework	9 m
Penstock	Stage 4 design

Table 8. Preliminary pipework lengths

3.6 Transient surge analysis

A preliminary transient surge analysis has been carried out, as part of the Parsons Brinckerhoff's June 2012 report *Lee Valley Dam, Hydro optimisation report*. The maximum transient pressure from the emergency shutdown of the powerhouse at the turbine inlet under the worst credible operating conditions is stated in Table 4.

The pipework wall thickness required to accommodate the hoop stress in all sections of the pipework from the internal pressure, including the maximum transient pressure, is lower than that required for the pipework handling.

A transient analysis has not been conducted for the emergency closure of the primary isolation valves, but this is anticipated to be lower than for the hydro powerhouse, as the valve closure time will be significantly greater than that assumed for the hydro turbine in the transient analysis, despite the valve's discharge characteristic being less favourable.

4. Inclined intake pipework

4.1 Description

The inclined intake pipework on the upstream face of the dam transfers the water from the intake screens to the large radius bends at the upstream end of the through dam conduits.

The arrangement consists of two pipe supports welded to each length of pipework. Each pipe support has two guides attached to the underside of the supports which run on rails that are anchored to the face of the dam. The guides provide alignment when the pipework is being installed or removed and also provide pipework restraint. A minimum of every second length of pipework is to be anchored into position using the lower saddle support, to prevent the axial loads being transferred onto to the pipework below. The anchoring is to be equivalent to that used for the intake screen: anchoring onto the guide rails (refer to section 2.6). The anchoring details are to be confirmed during detailed design.

Parameter	Value	Comment
Dam face settlement, maximum, parabolic shape	100 mm	T&T feasibility report drawing A-01; to be used in Stage 4 design calculation
Maximum pipework temperature	°C	to be used in Stage 4 design calculation
Minimum pipework temperature	°C	to be used in Stage 4 design calculation

Table 9. Key design parameters, preliminary

4.2 Pipework alignment

The inclined intake pipework is to have jacking bolts and shims between the rail alignment guides and the pipework saddle supports. The jacking bolts are to be used to provide adjustment to the end position of the pipework, to aid in the pipework alignment for connection the non-thrust type couplings. These jacking bolts are to only be on the upper end of the pipework, aside from the section of pipework adjacent to the large radius bends, where both ends require adjustment.

The pipework saddle supports incorporate adjustable ends stops, so that when the pipework is lowered into position, the end clearance required between adjacent pipes can be maintained. The ends stops can be used to pre-set the gap clearance prior to lowering the pipework down the face of the dam, and can be used to provide final alignment in the installation location.

4.3 Pipework removal

The inclined intake pipework may need to be removed for maintenance, repairs or to adjust the installed elevation of the intake screens.

As with the intake structure, the inclined intake pipework is designed to utilise the same guide rail system to remove the pipework without the need to bring in a high span crane. The removal of the pipework can be achieved by winching the pipework up the face of the dam. This would be achieved using the following steps:

1. The intake structure would first need to be removed (refer to section 2.4).

2. To remove the pipework, a winch cable from a mobile crane would need to be connected to the pipework saddle support frame. This would be carried out by a diver if the screen is submerged, or if not, then an operator may be lowered down the face of the dam using appropriate safety procedures.

3. Once the crane has taken the weight of the pipework, the pipework saddle support hold down anchor bolts can be removed and the dismantling joint coupling between sections of pipework can be loosened.

4. The crane can then winch the pipework up the face of the dam, with the pipework being guided up the dam face by the guide rails. This operation is to be carried out only during calm conditions where significant wave action will not act on the moving pipework.

5. Once at the top of the dam, the pipework can be lifted off the guide rails and onto a suitable laydown area.

4.4 Dam settlement

To accommodate settlement of the dam face, the inclined intake pipework incorporates non thrust type dismantling joint couplings between each length of pipe. These couplings accommodate regular expansion and contraction pipework movement, and angular deflection between the two adjoining pipe lengths.

The guide rail tracks are to be installed with gaps between each length of rail, to allow for thermal expansion and contraction, and the settlement of the dam face. The gap size is to be confirmed during detailed design.

5. Conduit upstream valving and pipework arrangement

5.1 Description

There are two long radius mitre bends, one per pipeline, between the inclined intake pipework on the face of the dam and the pipework running through dam conduits. Downstream of the bend there is a short straight section of pipeline leading to the primary isolating valve. Downstream of the valve the pipe diameter is reduced to the penstock size.

A temporary flow diversion pipeline will connect, during construction, into the lower intake pipeline immediately downstream of the primary isolating valve. When the diversion pipeline is retired the connection stub will house a manhole and an air valve.

The primary isolation valves are to provide the primary means of isolation of the downstream pipework and valving, for maintenance access and for the emergency shutdown of one of the intakes.

Removable valve access platforms are provided local to the primary isolation valves, and also to enable easy access to the bypass valve, refer to section 7.2. The conduit is anticipated to require a limited amount of local enlargement above the actuator to facilitate installation and removal.

5.2 Bend design considerations

The long radius, mitre bends are to be encased in concrete to take the thrust loads from the change in flow direction, and to provide physical protection to the pipework. The physical protection is important as once installed and the dam is flooded, the bends will be very difficult to access.

At each end of the bends, the pipework protrudes out of the concrete for connection to the upstream inclined intake pipework and downstream primary isolation valves. Any repairs to this exposed section of pipework would be extremely challenging to undertake as the adjacent pipework is encased in concrete and the upstream end of the bend will be submerged. These two sections of pipework have been specified as a heavier wall thickness, refer to Table 7, and the corrosion protection coating shall be thicker than the standard coating utilised on the rest of the pipework. The inclined intake pipework upstream of the bends is also to be anchored to the guide rails to minimise loads being transferred to the exposed bend inlet pipework.

5.3 Primary isolation valve selection

A wedge type gate valve provides added security against flood inundation, as the gate valve has two separate sealing faces, compared to one seal on a typical butterfly valve. If a failure of a seal occurs, the second seal is still able to prevent substantial quantities of water from being released. A gate valve also provides added security as the physical arrangement of a gate valve does not allow the gate to be dislodged and release bulk quantities of water, whereas a butterfly valve shaft failure may result in the butterfly disc being dislodged.

Alternative highly reliable double sealing isolation valves, such as ball valves, are not typically cost effective for the selected sized valve.

These valves should be sited as closes to the upstream end of the conduit as possible to provide protection for the maximum length of pipework.

The gate valves are to be sourced from a reputable supplier, for example AVK, with a rigorous inspection and test plan to ensure the valves used are of a high quality.

Parameter	Value
Primary isolation valve size	DN1200
Pressure rating	PN16
Valve actuation	electrically
Actuator ingress protection rating	IP 68
Primary isolation valve bypass size	DN80
Bypass valve type	electrically actuated gate
Bypass pipeline isolating valve type	manual gate
Flow diversion connecting pipeline size	DN600

Table 10. Preliminary valve and associated parts selection

5.4 Valve operation

The primary isolation gate valves are recommended to be electrically actuated. This is to allow for the valves to be remotely opened and closed without the need to access the upstream end of the conduit. The electric actuators will also provide a method of shutting the primary isolation valves in an emergency, should a major leak downstream of the valve prevent safe access to the valve actuator. The valves will also be capable of manual operation.

The actuator should be capable of closing the valve in an emergency against the maximum flushing flow. Parsons Brinckerhoff's investigations indicate that an AVK valve is suitable for emergency closure.

The valve electric actuator requires ingress protection rating is specified in Table 10. It shall be suitable for submergence of greater than 6 m (to be confirmed in detailed design) for a period not less than 24 hours.

5.5 Primary isolation valve bypass

Each primary isolation gate valve is to incorporate a small bypass valve, of the preliminary size stated in Table 10. During normal operation, a bypass is required to balance the upstream and downstream pressures on the gate valve before the valve is operated. Due to the narrowness of the conduits the layout of the bypass pipeline should be relatively tight to the primary isolation valve, and hence if the primary isolation valve is normally supplied with a bypass then the dimensions of its design should be checked.

If the primary isolation valve and its bypass are closed, and the fixed cone valve or other downstream equipment is leaking, the downstream pipework may gradually drain. In this situation, prior to the primary isolation gate valve re-opening, the bypass should first be opened to re-fill the pipework and balance the pressure across the primary isolation valve. This would be most safely achieved remotely using the bypass electric actuator.

If the bypass was to be left open, full isolation would not be achieved with the primary isolation valve closed, and if there is a downstream leak it may result in potentially high velocities in the bypass pipework, which could go undetected for a period of time and lead to the internal erosion of the valve and pipework. An electric actuator provides the ability to open and close the bypass to suit the operation of the primary isolation valve, without the need to go up to the upstream end of the conduit.

It is recommended that the bypass also incorporates an electric actuator to the same ingress protection rating as the primary isolation valve.

The bypass pipeline incorporates a manual isolating valve upstream of the actuated bypass valve to allow maintenance of the bypass valve.

5.6 Air valves

An air valve is required downstream of the primary isolation valve to minimise cavitating conditions at the valve, and prevent the formation of a vacuum during closure against flow. Preliminary sizing has been carried out using a typical discharge coefficient covering a range of valve operating conditions.

A second air valve will be located immediately upstream of the fixed cone valve. This valve will act as an air release valve during priming. Preliminary sizing is based on common practice. Specific calculations will be addressed during the Stage 4 design.

Parameter	Value
Air valve type downstream of primary isolation valve	anti-vacuum
preliminary diameter	150 mm
Air valve type upstream of fixed cone valve	air release
preliminary diameter	50 mm

Table 11. Preliminary air valves selection

5.7 Valve maintenance and removal

The removal of the primary isolation gate valves is to be carried out using the following suggested steps:

1. The inclined intake pipework is to be sealed with a specially designed sealing plate and air vent, and de-watered (refer to section 2.7). It is recommended that this work is carried out when the reservoir level is low.

2. Once the intake has been sealed, the fixed cone valve can be utilised to control the dewatering of the pipework, with the primary isolation valve open.

3. Once it is confirmed that the pipework is dewatered and there is no significant leakage through the plugged intake, and it is safe to disassemble the pipework, the bypass pipework can be disassembled and removed.

4. The section of pipework downstream of the primary isolation valve can then be removed, by disconnecting the downstream non-thrust type coupling joint and unbolting the pipework from the primary isolation valve. The pipe section can then be lifted over the top of the pipework to the downstream end of the conduit, where it can then be lifted

out of the conduit using a mobile crane. Refer to section 6.7 for details on the mobile lifting frame.

5. The mobile lifting frame can then be used to remove the primary isolation gate valve, by first laying the valve over, so that the valve shaft is parallel to the downstream pipework. It can then be lifted over the top of the pipework to the downstream end of the conduit, where it can then be lifted out of the conduit using a mobile crane.

6. Conduit downstream valving and pipework arrangement

6.1 Description

Energy dissipation valves are required to release the water out of the outlet works at a controlled rate, without vibration or cavitation damage to the valve or surrounding structures. Fixed cone valves, also known as Howell Bunger valves, are recommended for this application. Fixed cone valves (FCVs), are typically more cost effective than alternative energy dissipating valves, such as submerged discharge valves or needle-plunger type valves.

At the downstream end of the penstock the pipeline size is reduced and the pipe is inclined to the fixed cone valves which are located at the end of the conduits. The valves are positioned above the conduit invert to keep the valves above minor flood events. A thrust block doubles as the support for the valve.

The electrically actuated primary isolation gate valves are also to act as the guard valves for the fixed cone valves.

An access platform will be provided for each valve; refer to section 7.3.The facility to vent air from the pipeline will be required adjacent to the fixed cone valve, during priming of the penstock.

Parameter	**Value**	**Comment**
Design flood level, MAF	150.85 m	valve to operate with this water level
FCV discharge required at minimum gross head	5.0 m³/s	

Table 12. Key design parameters, preliminary

6.2 Fixed cone valve sizing

The size of the fixed cone valve is such that it should pass the flushing flow under the minimum gross head, i.e. at the minimum operating level. T&T has expressed a preference for both fixed cone valves to be the same size. It is noted that theoretically the valve connected to the upper intake can never see the lowest reservoir levels and therefore would not need to be such a large diameter. The minimum gross head is the difference between the lowest reservoir level, see Table 1 and the selected fixed cone valve centreline elevation, see Table 13.

The valve discharge capacity is dependent on the head loss in the pipeline. Final valve sizing will be by the valve manufacturer to suit the specific valve flow characteristics.

The upper and lower intake fixed cone valves are to be the same size, so that in the event one valve is unavailable for an extended period due to repairs or maintenance, the other valve can be utilised to provide the maximum discharge flow rate. If necessary, the alternative fixed cone valve could be relocated onto the other intake, to utilise the preferred intake screen for water quality reasons.

Parameter	Value
Upper intake FCV size	DN800
Upper intake valve centreline elevation	166.5 m
Lower intake FCV size	DN800
Lower intake valve centreline elevation	166.5 m
Valve actuation	electrically

Table 13. Preliminary FCV arrangement

6.3 Actuation

Access around the fixed cone valves is hazardous when the valve is in operation, due to the high energy large volume of water being released, and personnel must not enter the conduit while the valve is operating.

The fixed cone valves are recommended to be electrically actuated, to enable the valve discharge to be adjusted remotely, without the need to enter the conduits.

It is recommended that a walkway platform is provided over the fixed cone valves, with the electric actuator mounted an accessible location on the side of the platform. This allows for convenient access to the electric actuator for maintenance purposes, and if an emergency manual override of the valve operation is required (utilising the electric actuator manual hand-wheel), safe access can be obtained without the need to enter the conduits.

6.4 Valve hood

It is recommended that a valve hood is provided on the fixed cone valve, to control the size and angle of the discharge footprint. Calculation of footprint is complex; it has yet to be carried out.

6.5 Water mixing

With a fixed cone valve on each of the intakes, both fixed cone valves can be opened to provide mixing of water for the downstream release.

If a flow meter is not installed on each intake, the discharge flow rate out of each valve will need to be estimated to adjust the water mixing. To determine an approximate discharge flow rate, the reservoir level, pipeline head loss characteristics and discharge characteristics of the valve are required to estimate the flow rate. Refer to section 2.8 for further comments on flow meters.

6.6 Valve removal

The fixed cone valve removal is only to be done once the primary isolation valve, and its bypass, have been confirmed closed. The pipework should be drained. Water releases out of an open drain valve should be monitored to ensure the primary isolation valve is providing sufficient isolation. The fixed cone valve can then be removed by a mobile crane.

6.7 Moveable lifting frame

It is proposed that a mobile lifting frame is to be used to for maintenance purposes, to lift and move sections of pipework, primary isolation valves and other miscellaneous equipment to the downstream end of the conduits. At the downstream end of the conduits the equipment can be lifted up and out of the conduit utilising a mobile crane.

The mobile lifting frame wheels would run on the invert of the conduit, either side of the pipework support saddles and the overhead manual lifting hoist would be located close to the ceiling of the conduit to maximise the lifting height.

The mobile lifting frame would normally not be kept in the conduit, as it would restrict access down the conduit and the damp environment will increase the potential for corrosion. The frame will need to be kept in a suitable covered storage area, and when required, it would need to be lowered into the downstream end of the conduits using a mobile crane.

The proposed mobile lifting frame has not yet been looked at in detail.

7. Conduit access

7.1 Confined space

Personnel access up the conduits is to be kept to an absolute minimum, as the conduits are considered to be potential confined spaces. This is because there is a potential risk of the atmosphere being compromised or a flood occurring from a major leak.

The *T&T Post meeting notes, March 2012 Lee Valley Dam Hazop workshop minutes*, dated 16/4/2012 provide background information on the conduits as confined spaces.

The risk of flooding is greatly reduced by providing the electrically actuated primary isolation gate valves. The fixed cone valves, primary isolation gate valves (and bypasses) are all to be closed before entry is obtained into the conduit.

Prior to proceeding to the upstream end of the conduits, the isolation of the primary isolation gate valves shall be confirmed by opening a small test/vent valve at the top of the pipework adjacent to the fixed cone valve.

Access to the upstream end of the conduits is not anticipated to be frequent with the electrically primary isolation valves and bypasses. The maintenance intervals are still to be confirmed with the valve and actuator suppliers, but the inspection intervals are likely to be yearly in accordance with NZSOLD Dam Safety Guidelines.

7.2 Primary isolation valve access platform

There is to be a local access platform adjacent to the primary isolation gate valves, to provide maintenance access to the valve and electric actuator, including operator access to the actuator control panel and manual override hand wheel. The platform also provides access to the bypass valve, which is to be located in an area also accessible from the platform.

The platforms will be removable, to provide clearance for when the valve is to be removed in the long term future.

7.3 Fixed cone valve access platform

The fixed cone valves will have local access platforms either side of the valves, to provide maintenance access to the valve and electric actuator, including operator access to the actuator control panel and manual override hand wheel.

The platforms will be removable, to provide clearance for when the valve is to be removed in the long term future.