REPORT

Opuha Water

Proposed Opuha Dam Downstream Weir Enhancement - LHS Option

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1 Introduction

Further to recent discussions this report overviews recent work about revisiting an Opuha Dam Downstream Weir (ODDW) enhancement left hand side (LHS) scheme. LHS options involve demolition of the crest of the existing ungated ogee weir and installation of flap gates on the crest of a new ogee weir at a lower level. Possible arrangements were described at a high level in February 2011[1]. It is important that this report is read in conjunction with the 2011 work as the earlier report provides a more comprehensive description of the proposal and outlines as-built details.

The assessment focusses on possible diversion arrangements because management of construction stage floods was a key consideration when Opuha Water Limited (OWL) elected to consider right hand side (RHS) scheme options. Appendix A includes some preliminary design sketches from February 2011 together with other recent sketches illustrating the diversion concept.

Also reported is an updated cost estimate for the LHS scheme to include provision for the described arrangement as well as a preliminary programme.

2 Construction diversion – LHS options

2.1 Background

Demolition of the existing ogee weir crest and training walls in the vicinity of the crest impacts on the ability of the ODDW structure to pass floods during the construction period. Because the overflow embankment earth fill is exposed at a low level, the overflow embankment is also at a risk of damage if a significant flood was to occur during critical construction activities. A simple coffer dam around the existing ogee weir is complicated by the very close proximity of the existing radial gate and ogee weir.

Consequently, the LHS arrangement described in February 2011 was based on advice from Contact Energy that a coffer dam was impractical and that the scheme could be operated for key periods with the operating range of the ODDW pond limited to 2.0 m above the top of the gate opening[2]. A 2.0 m operating range corresponds to a maximum pond level during construction of 337.75 m RL, 3 m lower than the existing maximum operating level (and existing weir crest) at 340.75 mRL. The capacity of the gate in the fully open position with the pond at 337.75 m RL is approximately 26 m^3/s which compares to an estimated Gooseberry Stream mean annual flood in the order of 17-18 m^3/s. A diversion capacity only a little greater than the mean annual flood is much less than the diversion capacity typically associated with dam construction. Also, while accepting that the pond can be kept artificially low outside of flood conditions, the level duration curve included in Appendix B indicates that about ninety percent of the time the pond level is greater than 337.75 mRL.

OPWL subsequently determined in 2011 that the risk of the pond level exceeding 337.75 m RL during critical construction activities as well as the operational inconvenience of limiting the pond to 337.75 mRL was too high. Risk associated with the diversion was a key factor influencing consideration of right hand side (RHS) scheme options as the RHS opportunities allowed a coffer dam crest level coincident with the existing enclosure embankment at 342.25 mRL. Thus for RHS options previously considered, there would not have been an impact on ability of the ODDW to pass floods during construction.

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1 Tonkin & Taylor; Opuha Dam, Downstream Weir Enhancement: Rough cost estimate; February 2011; T&T reference 51137.006

2 Ibid

2.2 LHS diversion option

Following recent discussions with OWL, set out below is consideration of a diversion arrangement to facilitate construction of a LHS scheme intended to:

i. Preserve the existing routine pond operating regime to 340.75 mRL during normal operating conditions (i.e. not during times of flood). The proposal will enable the pond to operate to 340.75 mRL during construction and will provide significantly more flexibility than limiting the pond level to 337.75 mRL as initially proposed by Contact Energy.
ii. Provide an increased ability to pass floods during construction (relative to the 2011 LHS scheme) to a level acceptable to OWL and ECan (Environment Canterbury as relates to the Building Consent Authority function as well as potential resource consent implications), albeit that the risk of a construction stage exceedance is greater than the RHS options previously considered.

2.2.1 Overview

The diversion arrangement now proposed to facilitate construction of a LHS scheme features a coffer dam to 340.75 mRL (now as agreed with OWL) consisting of a reinforced concrete wall and earth bund. The wall is necessary to allow the diversion bund to connect to the existing reinforced concrete weir structure given the limited space between the existing ogee weir and the existing radial gate. It is noted that other crest level options may also be available to provide different levels of flood protection. The level duration curve included in Appendix B indicates that over the relatively short period from 7 November 2011 to 15 May 2014 (when the overflow embankment did not operate) about ninety nine percent of the time the pond level is less than 340.75 mRL.

The proposed wall would be founded at about 336.55 m RL adjacent to the existing concrete structure dropping slightly as the wall extends away from the existing concrete (TBC by survey). The average height would be approximately 4.2 m with a crest at 340.75 m RL. The wall would be designed as a cantilever with coffer dam fill placed over the footing with a shear connection to rock as is required. Photographs 1-3 below illustrate where the wall would be located and provide a perspective on the foundation conditions. The wall thickness may vary from about 250 mm at the top to around 450 – 500 mm at the base. Depending upon requirements for working room adjacent to the existing weir the wall could be approximately 16.5 m long at the base coincident with a crest at 340.75 m RL. The dimensions will vary for other wall crest levels.

While specific details of the temporary bund are best left to the constructor (for example the degree of initial construction relative to maintenance requirements during construction), the arrangements may comprise the following if an earth bund is selected:

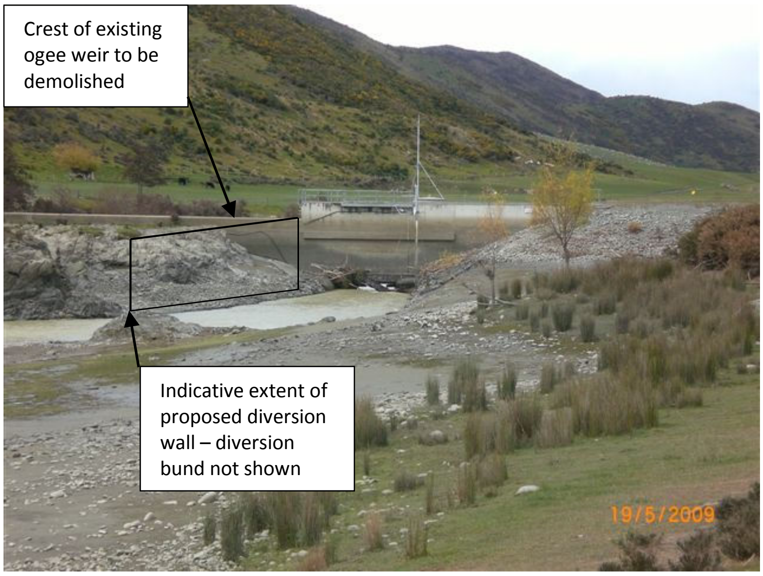
- 2 m wide crest.
- Upstream and downstream side slopes approximately 2H:1V.
- Height up to about 4.75 m adjacent to the diversion wall assuming that the base of the wall is locally at 336.0 m RL at this interface, reducing to 0.75 m high where existing rock level is at 340.0 m RL (topography to be confirmed by survey).

Appendix A includes some preliminary design sketches from February 2011 together with other recent sketches illustrating the diversion concept.

Estimated construction costs exclusive of GST for the diversion arrangement described are described in Section 8 and set out in Appendix E.

Other arrangements may be possible in lieu of an earth bund, for example arrangements such as proprietary systems, sand bags, mass blocks with membranes. Such arrangements would be at the discretion of the constructor to meet some form of performance specification. Specification requirements would need to address stability, flooding levels and increased flow velocities in the vicinity of the intake.

No specific consideration has been given as to potential implications on the efficiency of the gate flow during normal operation as a consequence of the proposed wall.



Photograph 1: Streamflow through existing radial gate, existing ogee weir and proposed diversion wall

Photograph 2: Streamflow through existing radial gate and foundation area for proposed diversion wall

Photograph 3: Streamflow through existing radial gate and foundation area for proposed diversion wall

2.2.2 Construction sequencing

Construction of a LHS scheme featuring the described diversion arrangement is anticipated to be much as follows:

i. **Prior to construction lower the Opuha lake level**. It will be necessary to plan the works for a time of the year that enables the lake to be drawn down prior to construction commencing. A low lake level during construction will enable floods to be retained in the lake and as far as is achievable, limit releases from the reservoir during coincident floods in Gooseberry Stream. Ensuring an appropriate lake level prior to construction is a very important component of the proposal (refer to Table 2 following). Owl have recently indicated that 385 m RL is a suitable level/target lake level prior to construction that can be accommodated by OWL. No routing has been undertaken to confirm the

ii. **Lower the pond level and construct diversion wall**. It will be necessary to lower the pond below 336.55 m RL to enable construction of the diversion wall. The pond will more or less limited to stream flow through the existing radial gate when during this period i.e. there will be only be very limited ability to attenuate power station flows and power station releases will more or less be the flow released from the ODDW. While the constructors working area will be at risk from flood rise, in principle the ability of the ODDW to release flood flow will be unchanged during this phase.

iii. **Form diversion bund.** A diversion bund is required to isolate the existing ogee weir from the pond. The bund will link the existing overflow embankment to the proposed diversion wall. In principle the pond level will be able to raise above 336.55 during the latter stages of coffer dam construction

iv. **Demolish crest of existing weir and both training walls in the vicinity of the new weir crest.** This is the critical construction activity insofar as risk of damage to the structure is concerned.

v. **Construct new weir block and training walls.** Once reinforced concrete construction is complete then the risk of flood flow damaging the existing overflow embankment will be less than the present situation.

vi. **Works to protect the toe of the existing chute and sill**. Note that with regard to flood protection, there is some flexibility associated with the scheduling of subsequent work as the ODDW will have capacity to pass greater flow at this point with /or without the new gates. However, without the coffer dam the new gates will be required in order to provide the necessary degree of routine flow attenuation/operational flexibility for the remainder of the construction period (i.e. the pond won't be able to be raised to 340.75 m RL until the new gates are operational). There is merit in undertaking the toe protection work first.

vii. **Install new gates on reformed weir crest**.

viii. **Install foot bridge deck over the weir**.

ix. **Remove the coffer dam.** Subject to the final arrangements adopted, there may be little point in removing the diversion wall.

2.2.3 Design standards

At present, a five year or greater average recurrence interval (ARI) flood event may be expected to cause some damage to the overflow embankment. The overflow embankment has been designed for a five year ARI event. The probability of at least one five year ARI events occurring in a typical five year period is 67 %.

The NZSOLD Guidelines[3] state the following in regard to earth dams:

"If a <u>site-specific risk-based approach which considers exposure times and the downstream consequences of failure</u> is not completed, the Owner and Designer should give consideration to the following guidelines for diversion capacity:

- *If the incremental consequences of a dam failure during construction include no potential for the loss of life downstream of the dam, a return period of 50 years may be appropriate for the sizing of the diversion works.*
- *If the incremental consequences of a dam failure during construction include the likelihood of the loss of one or more lives downstream of the dam, a return period of 250 years or greater may be appropriate for the sizing of the diversion works."*

It is worth noting that the weir structure per se is not an earth dam. While the overflow embankment is (and is at risk for a short period when the LHS training wall is demolished) the unique nature of the works justify that a "site-specific risk-based approach which considers exposure times and the downstream consequences of failure" is undertaken to determine an appropriate standard.

Appendix D includes more information from the NZSOLD Guidelines and is included to provide some more background on the matter with regard to the NZSOLD perspective.

While the source document is now not operative, the following ANCOLD comments are of relevance[4]:

"Matters to consider, as appropriate for the limited construction period, site arrangements and consequences of the diversion capacity being exceeded, are:

- *For proposed dams, risk of failure during construction, as far as practicable, to be no greater than the risk of failure over the long-term life of the dam.*
- *For existing dams, as far as practicable, provisions so that existing risks from floods will not be increased during remedial works."*

The guidance referenced has been taken into account to provide a perspective on the arrangements considered.

[3] New Zealand Society on Large Dams, New Zealand Dam Safety Guidelines, May 2015
[4] ANCOLD; DSC11 Acceptable Flood capacity for Dams; August 1992

To assisting the unique nature of the project, the 50 year ARI event mentioned by NZSOLD is greater than the magnitude of the flood that will cause the overflow embankment to operate with the new gates in place.

2.2.4 Diversion capacity

The design report[5] refers to work by PB Power that states that in the wide open positon (1,500 mm wide opening) the existing radial gate can accommodate the flows listed in Table 1 below.

Table 1: Existing radial gate capacity - 1,500 mm gate opening

Pond level (m RL)	Gate discharge (m^3/s)
334.25	0
334.75	8.88
335.25	12.76
336.25	18.60
337.25	23.48
338.25	27.91
339.25	32.09
340.25	36.13

To provide some insight into the pond levels listed in Table 1, included in Appendix B is a level duration curve for the ODDW pond based on the data from 7 November 2011 to 15 May 2014. The period is dominated by normal every day operating conditions and does not include significant floods (e.g. an event of sufficient magnitude to cause the overflow embankment to operate). The level duration curve indicates that during this period the pond level exceeded 340.75 m RL less than 1 % of the time. The curve also shows that the pond exceeded 340.75 m RL for 10% of the time over the very short period from 1 January to 28 March 2013. The periods are short and it is understood that there were no floods during this time that were close to causing the overflow embankment to operate. This appears to indicate that from the perspective of routine operation (i.e. excluding floods) 340.75 m RL is an appropriate level to adopt for the diversion.

Gooseberry Stream enters the ODDW pond below the main dam and has a catchment of some 1,500 ha. Table 2 below relates the magnitude of different average recurrence interval floods in Gooseberry Stream to pond levels on the basis that the radial gate is acting as a hydraulic control. Probabilities that a particular event is exceeded in typical one month and two week periods are also included. The adopted one month period relates to an assumed critical construction window and requires confirmation and as requested, a two week period is also reported to provide further perspective on the matter.

It is important to note that the scenarios outlined in Table 2 do not explicitly consider discharge from the Opuha Dam service spillway (aside from noting that a diversion arrangement set at 340.75 mRL may accommodate a combined flow from Gooseberry Stream and the dam of 38.6 m^3/s). The information presented in Table 2 has been revised from the earlier issue to include approximate long term average probability of exceedance during typical one month and two week long periods.

[5] Tonkin & Taylor; Opuha Dam Project Design Report For Civil Works Contract Undertaken By Doug Hood Ltd; May 1999; T&T reference 13909

Table 2: Probability of pond level exceedance based on estimated Gooseberry Stream flood flow with and without power station discharge

Approximate pond level[1] (m RL)	Estimated Gooseberry Stream flow (m^3/s)	Power station discharge (m^3/s)	Pond outflow (m^3/s)	Approximate frequency of Gooseberry stream event ARI (years)	Approximate long term average probability of exceedance during typical periods (%)	
					During one month	During two weeks
339.90	18.6	16.25	34.9	2.2	5.1%	2.4%
340.00	19.0	16.25	35.3	2.2	4.9%	2.3%
340.25	20.1	16.25	36.1	2.3	4.5%	2.1%
340.50	21.2	16.25	37.5	2.5	4.2%	2.0%
340.75	**22.3**	**16.25**	**38.6**	**2.6**	**3.9%**	**1.8%**
336.25	18.6	0	18.6	2.2	5.1%	2.4%
337.25	23.5	0	23.5	2.8	3.6%	1.7%
338.25	27.9	0	27.9	3.6	2.7%	1.2%
339.25	32.1	0	32.1	4.5	2.1%	1.0%
339.70	34.0	0	34.0	5.0	1.8%	0.9%
340.25	36.1	0	36.1	5.6	1.6%	0.7%
340.50	37. 5	0	37.5	6.1	1.5%	0.7%
340.75	**38.6**	**0**	**38.6**	**6.4**	**1.4%**	**0.6%**

Note 1: Approximate pond level based on gate in the fully open position acting as hydraulic control

By way of comparison and to provide a general perspective on the probabilities outlined above the following comments are provided:

i. The overflow embankment has been designed for a five year ARI event. The probability of at least one five year ARI event occurring in a typical five year period is 67 % with or without the proposed works. More than one event may occur during the period.

ii. Gooseberry Stream flood flows in the order of 22.3 and 38.6 m^3/s are estimated to correspond to 2.6 and 6.4 ARI events respectively. The 2.6 ARI event would also equate to a pond level of 340.75 m RL if the dam is discharging 16.25 m^3/s (16.25 m^3/s being the maximum power station discharge). The 2.6 ARI flood level would be much less than 340.75 m RL if the dam is not discharging.

iii. The probability that a pond level of 340.75 mRL may be exceeded by inflow from Gooseberry Stream during a typical one month period is 1.4% without any discharge from the dam, increasing to 3.9 % if the dam/power station has a coincident discharge of 16.25 m^3/s.

iv. If dam discharges can be avoided during the critical construction window (by way of drawing the reservoir down prior to construction) then the 1.4 % probability that the pond level will exceed 340.75 mRL is low and less than the 1.84 % probability of a five year ARI discharge from the dam during a typical month without reservoir drawdown prior to construction.

v. The NZSOLD Guidelines make reference to a 50 year ARI event as the basis for the design of the diversion for an earth embankment without consideration of a specific risk assessment. The probability of at least one fifty year ARI event occurring in a typical two year period is 4.0 % (2 years corresponding to an assumed construction period for a significant project). So long as the Opuha Dam reservoir is drawn down prior to construction then the risk of overtopping during construction, as far as practicable, is no greater than the risk of overtopping over the long-term life of the ODDW structure.

vi. Based on the iv. above, so long as the reservoir is drawn down to an appropriate level prior to construction, the older ANCOLD criteria ("existing risks from floods will not be increased during remedial works") is met.

The comments outlined above form a risk assessment as suggested by the NZSOLD Guidelines. It is apparent from the above that the lake level at the start of construction is a key parameter that determining the suitability of a diversion set at 340.75 mRL. OWL have suggested a target lake level at the start of construction of 385 m RL, 6.2 m below the crest of the service spillway weir at 394.2 mRL. It is recommended that detailed design include routing (based on existing models) to assess risks associated with this initial lake level.

3 Gate options and M&E requirements

The 2011 assessment assumed that the proprietary Obermeyer flap gate system would be adopted. A primary consideration at that time was that the existing Obermeyer gates on the crest of the service spillway were also provided by Obermeyer. It is noted that other proprietary systems exist (e.g. AWMA and Yooil) and a bespoke design is also an option.

Set out below is a brief description of option some options and detailed design includes work to confirm the preferred system and establish how the gates will be procured.

3.1 Obermeyer

Included in Appendix C is updated information recently received from Obermeyer. The following points are understood to be relevant at this time:

i Obermeyer have indicated that they may require 12 weeks to design and manufacture their gates following receipt of an instruction to proceed. This appears problematic – refer to the subsequent section on programme for further discussion.

ii It is noted that OWL have reported some ongoing issues with the control system associated with the present gates. Work will be needed to ensure that similar issues to not arise at the ODDW installation if Obermeyer gates are selected.

iii The proposed ODDW gates will most likely be raised most of the time. Some thought is needed to ensure that potential risks associated with the sudden loss of air pressure in the supporting air bags can be accommodated by OWL.

iv It is noted that the information included in Appendix C excludes certain necessary work. For example power supply, gate installation and reticulation of the air supply. Arrangements will be necessary to resolve these matters e.g. including provision for a sub-contractor than can design and install the air supply pipework.

v Present arrangements including weir crest level is based on weir coefficient information advised by Obermeyer and it is necessary that this parameter is confirmed.

vi Obermeyer advise that their gates can sustain a 300 mm overtopping flow. Whilst flushing has not been assessed quantitatively at this time, this may be of benefit for flushing releases insofar as maximising the volume of the flush is concerned.

3.2 AWMA

Whilst AWMA have expressed a strong desire to be involved, at the time of writing details about the AWMA proposal are yet to be received. The following points are understood to be relevant at this time:

i It is noted that AWMA have not yet been able to confirm the capacity of their system to pass the design flow in the lowered position.

ii AWMA have indicated that their system will require a reinforced crest shape more complicated than that indicated by Obermeyer.

iii It is noted that, based on the recent information from Obermeyer, there will most likely be programme issues with the time necessary to supply the Obermeyer system. Equivalent/comparable information about the AWMA system is not yet available.

iv It is understood that AWMA are presently providing flap gates of a similar size to those anticipated for a project in Auckland.

v It is understood that AWMA may prefer to supply and install the gates although this is to be confirmed.

vi AWMA have indicated that their gates are designed to operate in either closed or open positons only and that the gates will lock in the raised position. AWMA advise that this is of benefit in the unlikely event of a sudden loss of air pressure necessary to keep the gates raised.

A relatively high level email is included in Appendix C outlining the AWMA advice as at 21 July 2015.

3.3 Other options and miscellaneous mechanical and electrical requirements

Proprietary systems other than Obermeyer and AWMA also exist. For example Yooil who have also been approached albeit that no response has been received from this organisation. It is not proposed to follow this any further. Indications are that that it is desirable that the gate supplier has specific New Zealand experience and both Obermeyer and AWMA have this track record.

It is recognised that a bespoke flap gate design may also be adopted albeit that it is understood that the recently completed CPWL Stage 1 project identified that propriety design and build gate systems were cost effective. Consideration of a bespoke design is not considered at this point further albeit that this may be revisited if required by OWL.

A range of miscellaneous mechanical and electrical (M&E) will be necessary if a proprietary system is adopted. For example confirmation of the power supply (and potential backup) to suit the adopted system is also required.

4 Energy dissipation

A LHS option will increase the flow in the existing chute by a significant amount. The flow will be much greater than was originally contemplated when the structure was designed. Present measures to dissipate energy include mass concrete at the base of the existing chute as well as an end sill.

Recent review of construction stage photographs indicates that the extent of the mass concrete relative to rock level, as well as rock mass integrity under the mass concrete, is a little uncertain. Resolution of this matter is important as inadequate protection of the toe of the chute during increased design flows could result in undermining and instability of the structure.

Subject to assessment, additional mass concrete and/or reinforcement may be required to increase stability of the toe. Prior to or during the initial stages of detailed design it will be necessary to remove some of the existing mass concrete and confirm the location of the rock head and the quality of the rock mass at this location.

A very nominal sum of $75,000 (base estimate excluding contingency) is included to allow for this work. The investigation is needed to confirm the scope.

5 Hydroelectric generation

It is not simple to include the proposed hydroelectric scheme within the LHS scheme now contemplated. However, it may be possible to consider this as a separate project that would utilise the existing closure embankment as the coffer dam (i.e. the new structures would be built below the existing closure bund).

6 Resource consent matters

It will be necessary to review the resource consent conditions against the proposed LHS scheme. Based on prior discussions we understand that OWL are presently completing this assessment. One matter that this work will need to address is the different diversion arrangement now proposed.

7 Programme

A programme for the new LHS option is included in Appendix F. As of 22 July the programme is draft. As discussed, the purpose of developing a programme at this point is to provide a perspective as to how the proposed LHS scheme may relate to a construction period commencing about April 2016 when OWL anticipate having the lake at least at 385.0 m RL. The following comments are made in regard to the draft programme:

i The programme assumes that the detailed design process starts on 10 August 2015, approximately two and a half weeks from 22 July (date of first issue of draft programme). A later start date will impact on programme. The programme highlights the importance of a timely start. The programme has very little float and whilst achievable is considered tight.

ii The draft programme assumes that Obermeyer gates will be used. It is recognised that other proprietary systems (e.g. AWMA) as well as a bespoke design could be selected. At the time of writing programme information from AWMA is not available. The programme relies on a decision in early September regarding gate supply. This is necessary so that civil design can suit the selected gate system. The programme is also reliant on conformation of information from the gate supplier in early September necessary to progress the civil design.

iii Obermeyer advise that a 12 week period is required from the time that the order is placed to the point that the gates are ready to dispatch from Obermeyer (TBC). Shipping is understood to be in excess of this period and could take around six to seven weeks (to be confirmed). At this stage is seems unlikely that OWL will be in a position to place a confirmed order for the gates until tenders for civil works have been reviewed. This indicates that there will be a delay (either before, during or after civil works) unless the time to supply the gates can be reduced.

iv The draft programme allows a two week period for Christmas 2015-16.

v Provision is included for OWL to approve tenders in mid-February 2016.

vi A number of updates will be required to the draft programme including, for example to consider the likes of the selected gate system (including the method of procurement) as well as the approach to the building consent (provided draft programme does not provided for a staged approach – a staged approach may be necessary depending upon ECan requirements regarding the level of detail needed by ECan to issue building consent for the gates).

vii The programme does not include provision for amendments to resource consents and assumes that if needed this work may occur in parallel with design (i.e. if required that this is not a critical path activity).

viii The programme does not include provision for development of hydroelectric generation.

8 Cost estimate information

The February 2011 rough order cost estimate of the capital cost for construction of the ODDW LHS enhancement has been updated and is set out below. The estimate is based on the outline proportions and arrangements described in the February 2011 report together with updates to rates from recent work and inclusion of the diversion scheme to 340.75 m RL described in Section 2. Aside from most key levels, arrangements are typically based on assumed sizes. A notable exception is the work associated with energy dissipation as describe above (very nominal base estimate sum of $75,000 included at this point). The outline bill of quantities included has been prepared on this basis (Appendix E). It should be appreciated that the arrangements and cost estimates may be revised during detailed design.

The methodology adopted for cost estimation is appropriate for this very preliminary stage given the nature of the assessment and available base data. Consequently, the anticipated margin of error around the cost estimate is ±40 % (as reported in 2011).

Obermeyer has provided a cost estimate to design, fabricate and supply gate components on a CIF basis to a major New Zealand port. Details of the OHI cost estimate are provided in Appendix C and USD prices advised by OHI are converted to NZD on an assumed rate of $1 NZD equals $0.65 USD (0.70 used in 2011). OHI were requested to price 1.55 m high gates. Lump sum costs for services (predominantly power and air supply) associated with the gates were assumed and are more uncertain than costs for civil works.

Other than prices provided by OHI, suitable 2014 construction rates for civil works were selected for items, based on previous tender and construction experience, and a base cost estimate built up. Rates were bench marked against recent rate information from Breen and Downer relating to RRHS schemes. Costs for rock excavation assume that rock is highly jointed and easily ripped and that the work face is not congested. Estimates assume concrete demolition material may be locally stockpiled for future use as rip rap material. Most rates have been reviewed and endorsed by Tim Anderson.

Percentages were allowed for contingency (civil 25 % & gate supply 15 %), contractor's preliminary and general (15 %), and constructors margin (12 %).

The estimate was arrived at with the following procedure:

i. The 'base estimate' (BE) is estimated from estimated quantities and rates. This is the estimated amount that would be on the bill of quantities for physical construction items based on the preliminary level assessments described.

ii. A 25 % contingency is added to the base civil estimate. A 15 % contingency is added to the base Obermeyer gate supply cost. This allows for unknowns that may be encountered during construction and uncertainties in preliminary level assessments. Application of this brings the cost to 1.25 x BE (civil) + 1.15 x BE (M&E).

iii. The contractor for the works needs to allow for preliminary and general items covering management and overhead related costs (both on-site and off-site) and these are estimated at 15 % of the base cost and contingency, i.e. P&G = (1.25 x BE (civil) + 1.15 x BE (M&E)) x 0.15.

iv. Contractors margin is advised to be 10 – 15 % of the base cost and contingency, i.e. (1.25 x BE (civil) + 1.15 x BE (M&E) + P&G) x 0.12. – included as advised by Tim Anderson but recognising that Breen have advised that the rate information they provided included provision for all their margins whereas Downer advise that their information did not include this provision i.e. it could well be conservative to include this allowance based on the rates adopted.

The reported estimate is therefore made up from:

Base estimate	BE
Contingency	1.25 x BE (civil) + 1.15 x BE (M&E)
P&G	0.15 x (1.25 x BE (civil) + 1.15 x BE (M&E))
Margin	0.12 x (P&G + (1.25 x BE (civil) + 1.15 x BE (M&E))

The cost estimate for the works as of July 2015 is as summarised in Table 3.

Table 3 Summary of cost estimate as at July 2015

Description	Cost (NZD)
Excavation and earthworks	$140,000
Demolition	$25,000
Reinforced Concrete	$95,000
Diversion	$65,000
Foot access bridge	$35,000
Mechanical and Electrical Services and Plant	$480,000
Miscellaneous non-scheduled Items	$20,000
Base case sub-total	$860,000
Contingency - 25%	$103,000
Gate supply contingency - 15%	$67,000
Preliminary and general - 12%	$124,000
Profit margin - 12%	$139,000
Engineering - TBC%	TBC
Total	$1,293,000

It should be noted that the rough cost estimate does not include any of the following costs which are extra to the reported cost:

- Engineering fees - to be updated by a revised proposal to supersede earlier advice for a different scope.
- Exchange rate fluctuations, primarily of significance in relation to gate components supplied from offshore. It is noted that the New Zealand dollar has recently dropped in value relative to the US dollar.
- Cost associated with resource consenting and consultation relating do amendments to consents if required but aside from usual allowances for consent compliance included within the P&G provision.
- Costs associated with miscellaneous M&E work extra over items included in the Obermeyer estimate (e.g. power supply from the existing plant shed). Miscellaneous M&E work e.g. compressed air reticulation, gate installation and the like, whilst included, are based on very high level lump sum estimates and contain more uncertainty than other items.

- Hydroelectric generation is excluded from the July 2015 estimate.
- Environmental mitigation during construction aside from a nominal inclusion within the contractors P&G allowance.
- Costs related to damage from a construction stage flood or other event resulting in a pond level in excess of 340.75 m RL.
- Lost production (e.g. from managing lake level prior to and during construction).
- Financing.
- Taxes including GST.
- Insurance.
- Developer related costs.
- Commissioning and operation and maintenance.
- Construction cost variations due to high demand including as a consequence of the Canterbury earthquake and related aftershocks.
- Increases in costs of steel, fuel, or any other construction related material.
- Other and/or revised items not specifically described within the cost estimate.

9 Recommendations and further work

For OWL to progress the LHS option described the following further work is proposed (refer also to the attached programme):

i. Based on information provided, OWL to confirm what level of flood protection during construction is acceptable to OWL e.g. 340.75 mRL (and thus the height of the diversion wall that is appropriate). As of 22 July 2015 understood that in principle this level is approved.

ii. OWL consider what Opuha Dam target lake level may be accommodated during construction in order to assist with management of floods during construction including:

   – The time of year that the proposed lake levels may be accommodated.

   – Contingency/course of action in the event that the proposed levels may not be achieved when construction is planned to commence.

   As of 22 July 2015 understood that OWL have suggested a target lake level of 385 mRL and it is recommended that the performance of this initial level be confirmed as an early stage detailed design activity. This work may identify a requirement to review this target.

iii. An as-built topographical survey is necessary to confirm the ground and rock head profile in the vicinity of the proposed works. The survey will need to include the proposed diversion wall area foundation and this will require the pond to be lowered to below 336.55 mRL.

iv. Review rock mass integrity, in particular the areas in the vicinity of the diversion wall foundation and at the toe of the chute.

v. It is necessary to confirm if there are any implications arising from the resource consent conditions.

vi. Confirm approach to address gate supply and miscellaneous M&E work e.g. power supply.

Detailed design may then proceed as programmed.

10 Applicability

This report has been prepared for the benefit of Opuha Water 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

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