OPUHA WATER LTD
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Board Paper
June 2014

Title: Downstream Weir Upgrade – proposal to proceed

Purpose

This paper presents, for consideration of the Board, the proposal to upgrade the Downstream Weir to increase the flood handling capability of the structure.

The proposal represents a major capital expenditure for the company and the cost estimate is now significantly more than had previously been provided by the project engineers. The current estimate to complete the upgrade is $2.7m.

The project is currently on hold pending the Board's decision to proceed.

A comprehensive report from the project engineers, Tonkin & Taylor (T&T), accompanies this paper.

Background

The proposal to modify the downstream weir structure, to increase the flood handling capability, arose primarily as a result of the second operation of the fusible overflow embankment in May 2009. The fusible overflow embankment is a section of the main embankment that is designed to wash out in very high flow events and thus protect the main downstream weir embankment from being overtopped and damaged. It has operated (as designed) on two occasions – March 2002 and May 2009. The cost (~$250k), difficulties and disruption faced by Opuha in re-instating the weir prompted a consideration of an upgrade that would reduce the likelihood of the fusible section operating and thus requiring rebuild. At this time (2009), Contact Energy were managing the dam and power station for Opuha and Tonkin & Taylor were the incumbent engineers for civil aspects of the dam and associated structures.

By February 2011, Tonkin & Taylor (T&T) had prepared a proposal to increase the flood capacity of the existing spillway to allow a flood passing capacity of approximately 250 cumecs compared with the previous 115 cumecs. This increased capacity meant that the frequency of the fusible embankment operating could be expected to reduce from around once in five years to something like once in 30 years. The proposal was based on modifying the existing spillway and installing flap gates on the spillway that would be lowered in the event of a major flood.

Further work was undertaken to progress the proposal concept over the following year. While the proposal was reasonably simple in concept and considered to be a feasible option, there were some limitations and risks identified that prompted a review of the options available.

The principal risk identified was the construction risk associated with isolating the existing spillway for a period of up to four months to carry out the modifications. During this period there was considered to be a high risk that the construction works themselves could be damaged during a high flow event and the fusible embankment was at higher risk of operating because the spillway could not be relied on to operate properly. This proposal also required reasonably complex temporary works construction techniques to provide a dewatered construction area. An alternative upgrade option for a new separate structure had been identified in the initial study. This option did not have the same construction risks because the construction works could be conveniently isolated from the main operational works and did not require continuous dewatering facilities as part of the temporary works.

The alternative separate structure option also provided two other significant advantages over the initial proposal.

A separate structure with radial gates provided much better capability to control the releases during high flows and, in particular, provided confidence that 'flushing flows' would be able to be managed much more effectively. Flushing flows had been trialled as a method of controlling the proliferation of algae in the river downstream from the dam, and initial trial results were encouraging but suggested that higher flows than were able to be released from the existing structure were required.

The separate structure also would enable a mini hydro generation facility to be installed in the new structure if this additional feature was determined to be economic. Preliminary calculations indicated that a generator of around 300kW could produce up to 2000 GWh pa generating around $160k pa revenue.

A comparative study completed in November 2012 indicated that alternative, separate option was likely to be more expensive ($1.7m compared with $1.3m for the initial option) however the Board accepted a recommendation in January 2013 that the concept of a separate gated structure be developed and approved $280k to be spent on design development and consenting of the option for a separate structure and to assess the viability of incorporating a hydro generation facility.

The programme that was prepared following this approval projected consent approval prior to Xmas 2012. As it has turned out, the consent application process, including the consultation with potentially affected parties as well as local interest groups, has blown out considerably. We lodged the consent application in April 2014 and we are still to receive approval although we have been advised at least that the consent will be processed by both councils (MDC and ECan) on a non-notified basis.

This extended consent process has created a significant delay to the programme and also resulted in an increase in costs for this preliminary process. Expenditure to date is $330k so the original budget for this phase has been exceeded. This is a result of the direct costs of the consent process as well as the consequence of the whole programme to date being extended.

As part of the design development, site investigations have been carried out to address some of the uncertainties that existed around the concept proposal in 2012. These investigations related to ground conditions and levels. Unfortunately these have revealed conditions that have all tended to result in increases in the project requirements – deeper and bigger structures. These changes have contributed to a significant increase in the estimated costs to complete the project.

The attached report from T&T outlines the proposal for a separate spillway structure as the project currently stands. The estimated cost to complete presented in this report is $2.7m.

Revised Cost

The revised cost estimate is both surprising and disappointing. In assessing the difference between the Nov 2012 estimate of $1.7m and the revised cost now of $2.7m, the civil costs have all doubled and the engineering costs have nearly tripled.

T&T have identified some of the key reasons for the marked increase in costs in section 6.1 of their report. The main increases in civil costs appear to be due to the increase in size of the stilling basin as a result of the investigations into actual river bed levels and rock depths and an increase in gate size due to refinement of the hydraulic parameters of the proposed structure. Other reasons include additional drainage provisions, additional requirements that have arisen from the consenting process and an inflationary shift in rates for construction materials and personnel.

I would have expected that many of these cost increases would have been provided for through the contingencies provided in the initial estimate (35% civil contingency) but it is apparent that the potential impact of the uncertainties that existed in 2012 were not fully understood.

If the project is to proceed, it will be essential that a strong discipline of cost control is maintained to avoid any cost increases and to, as quickly as possible, address any remaining uncertainties and confirm that the contingency amounts provided for in the new estimate are adequate or not required.

I have discussed with T&T the possibility of reducing the likely costs through optimising the performance requirements and therefore the size of the structure. There would appear to be some potential here, and we would undertake that exercise anyway, but it is not possible at this stage to identify the likelihood or size of any potential savings.

Potential Project Benefits

This section addresses the potential benefits of the project.

In the January 2013 Board Paper, the anticipated benefits were discussed with a preliminary assessment of the overall economics. That preliminary view identified that there was a marginal economic case based on the quantifiable benefits but that there were also some genuine but less tangible benefits. It is obvious that the revised cost estimate has made the 'business case' for this project significantly less attractive and a review and closer look at the anticipated benefits is required.

The January 2013 Board Paper presented a preliminary economic evaluation and this evaluation is included with this report as Attachment 1.

The main benefits anticipated are:

- Reduced frequency of fusible embankment rebuilds
- More flexibility in the operation of the main dam storage
- Better flushing flow control
- Potential for hydro generation

Reduced frequency of fusible embankment operation and rebuilds.

This has been the primary driver for this project and is addressed in the attached T&T Report. As well as the future reconstruction cost, which is anticipated to increase as the material required to rebuild the embankment becomes increasingly more difficult to source locally and expensive to import from off site, there is also the less tangible aspect that ECan have indicated that they are not wanting to see the embankment continue to be washed out at the historical frequency and this sentiment has also been expressed by other river users and local groups. While we cannot quantify or allocate a cost/benefit to this 'expectation', I think it is reasonable to suggest that we do not have a 'do nothing' option as far as mitigating the likelihood or the effects of the fusible embankment operating. Completing the current project would be sufficient to address this expectation, but alternative options, such as the original proposal to modify the existing spillway, would probably suffice and cost less to implement.

The benefit of extending the period between rebuilds is more tangible and quantifiable. T&T have provided an assessment of that in their report (Table 3, p11) but I feel that it is a little simplistic in comparing future costs/benefits with the upfront cost of the upgrade. If it is treated more as an investment decision, then a more traditional way to assess the project would be to compare the upfront cost with a future benefit/avoided cost stream and either convert the future benefit/avoided cost stream into an NPV or in this case an annualised cost may be appropriate.

The benefit of reducing the likelihood of the fusible weir operating is the avoided cost of multiple rebuilds. A conservative estimate of the rebuild cost is $300k. A reasonable assumption is that the frequency of operations and rebuilds of the embankment would move from approximately one in five years to one in thirty years. It could occur in any one of those thirty years so a reasonable evaluation would be to say that without the upgrade the potential annual cost is $300k/5 years ($60k per annum) and with the upgrade the comparable potential annual cost $300k/30 years ($10k per annum). This suggests a 'benefit' of around $50k per annum. As the potential cost of the rebuild is increased, so is this benefit – for example an assumed cost of $350k results in a benefit of $58k per annum.

These cost estimates do not account for the disruption to operations that occur when the embankment fuses including the loss of control of water release and therefore the very non-optimum operation mode of the power station during the rebuild. (The power station would need to be operated continuously to provide a continuous release of water during the period when there is no storage capability within the regulating pond. Being forced to run continuously is very likely to mean either more water is released than was intended or that the power station is operated at low load where turbine efficiency is reduced. In saying this, if there has just been a major flood event, it is also reasonable to presume that, in the short term at least, there will be plenty of water in the lake and a requirement to lower the lake anyway.

More flexibility in the operation of the main dam storage

This aspect is covered reasonably well in the January 2013 paper although there is an additional value aspect associated with a higher average lake operating level that was not considered.

The previous paper discusses the value from being able to have more flexibility to shift or hold water to take advantage of the seasonally variable electricity prices. The assessment includes some scenario analysis based on actual events in 2012 and suggests a $50k per annum benefit is probably conservative.

Another feature of the lake operating regime with the upgraded DSW is that we would expect, in general to maintain the average lake level higher since the risk to the DSW from spill from the lake is reduced. This aspect has been included in T&T's assessment. The benefit of a higher average lake level is realised through increased output from the generator for a given amount of water. Our assessment is that a one metre average level increase would realise $30k-$35k per annum through increased generator output.

Better Flushing Flow Control

The radial gate option was selected ahead of an overflow/flap gate option because radial gates offer the operational ability to control the release from the regulating pond at all pond water levels. This selection was made in the context that this operational capability would provide flexibility in releasing flushing flows to deal with downstream river and water quality issues.

Assessing the benefit of flushing flows and, in particular, determining what is the most effective flushing regime is, I suggest, still 'work in progress'. We have conducted two trials over the last two seasons with the assistance of NIWA and the trial this year has certainly added to our understanding of what is effective and reinforced our belief that having flexibility in the release of water both in magnitude of the flow and also duration is key to the effectiveness of a flushing flow. So while it is evident the proposed upgrade will enable better flushing flows, it is difficult to assign a value or benefit to this feature. It is not certain, for instance, whether having the capability to release water at a higher rate but possibly a shorter duration will result in less water being required overall. Similarly the fact that a flushing flow will not require the initial 'overfill' of the regulating pond that wastes water in the start-up period is difficult to assign any meaningful value to.

Potential for hydro generation

The selection of the option to construct a separate spillway structure was influenced by the fact that it provided the opportunity for a hydro generation facility to be incorporated into the new construction. A review of this option has been completed and indicates that the economics are quite marginal (IRR around 8%). If a hydro option is considered to be economic then it is reasonable to assign some of the value to the overall weir upgrade and thus bolster the business case for the upgrade. At this stage however I cannot confidently say that there is a material benefit that can be attributed from the hydro to the project. (Note that a subsequent paper will present the hydro option in more detail for consideration by the Board)

Other benefits

There are a number of other features of the proposed upgrade that are positive but not able to be easily quantified.

The upgrade includes a proposal to install an access bridge across the existing spillway. This feature will address an historical operational and personnel safety issue. At present the normal access to the gate and the control hut for the downstream weir requires personnel to walk across the ogee spillway (or alternatively walk across the bottom of the spillway structure and then walk up the slope of the concrete spillway face.) There are no handrails or guards in place (or able to be fitted) to provide slip/fall protection so a purpose designed access bridge will address what is currently an unacceptable situation.

Economic Assessment

An investment of $2.7m (current cost estimate) would typically require a minimum annual return of around $230,000 based on an 8% cost of capital.

The tangible, quantifiable benefits of the downstream weir upgrade identified above total approximately $140k per annum which would support a cost of approximately $1.6m.

There are some intangible benefits including meeting the expectation of ECan and key river users that we will reduce the likelihood of the overflow embankment operating and the potential to provide more effective flushing flows, but these are difficult to quantify as part of an economic assessment.

Discussion

The revised cost estimate provided by T&T in response to my request in May is considerably higher than expected based on the preliminary estimate presented in November 2012. .

Based on the revised cost, there does not appear to be a business case for the project on strictly economic grounds.

There is a strong expectation that Opuha will implement some measures to reduce the potential for the overflow embankment to operate at it's historical (and design) frequency. This expectation has arisen from the experience of the two historical events when the embankment has operated and also through our recent promotion of the upgrade project.

Except for the consenting process, I have stopped all development work on the project until we can decide whether we intend to proceed now with the project as it is currently proposed.

Conclusion and Recommendation

The revised cost estimate is considerably greater than anticipated and it is now necessary for Opuha to decide whether to proceed with the implementation of the project as currently proposed.

I am seeking some guidance from the Board whether the increased cost is acceptable given there is not a clear economic case for the project but there are other intangible benefits and a high degree of expectation from key stakeholders.

Tony McCormick
Chief Executive
20th June 2014

Attached

1. Economic Evaluation – section from January 2013 Board Paper
2. Report from Tonkin & Taylor on estimated construction cost – June 2014

Attachment 1

Section from January 2013 Board Paper

Economic Evaluation

The main basis for this project is the mitigation of the risk of repeated operation of the Overflow Embankment with the consequential repair cost (~$250k - $300k per rebuild) and the resultant environmental impact downstream from the embankment debris.

The design frequency of operation of the Overflow Embankment is approximately 1 in 5 years. It has operated twice in the 14 year history of the dam (and can possibly be assumed to have operated in Feb 1997 had the dam been completed and operational). So the historical record suggests that we could expect a rebuild approximately once every 5 years. Given that the cost of rebuild is expected to increase with time as materials become increasing more difficult to source locally, a reasonable assessment is that the present day cost of the upgrade of $1.7m balances the potential cost risk of five or six rebuilds over a 25 to 30 year period, i.e. annual average benefit/avoided cost of approximately $55k per annum.. On a standalone basis this is marginal at best as an economic justification.

A benefit of the proposed upgrade will be the potential to operate the main dam storage more flexibly. The current practice has been to consistently maintain a buffer within the lake to reduce the likelihood of excessive spill that could threaten the Overflow Embankment in the event of a very high inflow event. While there will always be an incentive to minimise the spill from the dam (which represents lost generation opportunity) there is potential advantage in being able to hold back water on a seasonal basis and generate at higher value times. A graphic example of this occurred in 2012 when the lake level was consciously lowered in March to provide a buffer of at least two metres as has been common practice in recent years. The generation was a record high for March as a result of the pursuit of the target buffer level In April, inflows dropped significantly and generation was reduced. Our contract price for April is 11% higher than March. So we effectively forewent the better April prices in order to create a buffer. A very simplistic analysis of swapping the generation amounts between these two months results in a $48k improvement. The situation was further highlighted when Spot Prices went very high in May but we restricted generation because of very low inflows and a lake level already at our target buffer level. A similar simplistic analysis of swapping the generation amounts between May and March results in a $270k potential difference in revenue. May was an extreme month but the March/April assessment is a very valid assessment of what could typically be achieved through improved flexibility in lake storage operating and a reduction in the average lake level buffer being set each month. A $50k per annum improvement in generation revenue from improved lake storage flexibility would reduce the payback period for the $1.7m project to approximately 16 years, a $150k per annum improvement results in an 8 year payback. (simplistic analysis based on present day values). This range of 8 to 16 years is considered to be a realistic assessment based on these two benefits.

The improved flushing flow ability that is potentially presented by the upgrade option is a tangible benefit but difficult to quantify. In the same context, the reduced environmental impact from reducing the operation of the Overflow Embankment is a tangible benefit (ECan have expressed their concern over continued operation and downstream damage) but difficult to quantify in economic terms.

A more comprehensive economic assessment could be carried out by attempting to quantify the non-economic benefits and do a probabilistic assessment of the lake storage level benefits, however this level of assessment is not proposed in this case.

Instead, the Board is requested to consider the estimated cost in the context of the overall benefits and risk reduction offered by the proposed upgrade and approve the next stage of project development – the completion of a detailed design and consenting phase.

Attachment 2

Report: Opuha Downstream Weir: Project Overview and estimated construction cost update

Tonkin & Taylor – June 2014

REPORT

Opuha Water Ltd

Opuha Downstream Weir Project Overview and estimated construction cost update

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

Opuha Water Ltd

Opuha Downstream Weir
Project Overview and estimated construction cost update

Report prepared for:

Opuha Water Ltd

Report prepared by:

Tonkin & Taylor Ltd

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June 2014

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Executive summary

This report presents a developed design (partly complete detailed design) and associated updated construction cost estimate for the proposed Opuha Dam Downstream Weir (ODDW) enhancement scheme. The proposed works comprise the construction of two radial gates with a stilling basin on the true right hand side (RHS), viewing downstream, of the existing ODDW radial gate and ogee weir structure. An optional hydropower add-on is also being considered and reported separately. The new structure will be located within the existing closure embankment.

The enhancement will increase the flow that will cause the overflow embankment to fuse (wash out) from 99 m^3/s to 250 m^3/s. The 250 m^3/s flow capacity is greater than the flood magnitudes of 137 m^3/s (2002) and 180 m^3/s (2009) that previously caused the overflow embankment to operate.

The enhancement will provide the following benefits, all of which are considered to be significant:

- Reduced likelihood of the overflow embankment operating (fusing) – on long term average this may be by a factor of six or seven and mitigate risks such as limited supply of overflow embankment upstream face liner material (as was experienced in 2009).
- Provide enhanced ability to release flushing flows to the Opuha River Downstream of the weir.
- Allow for increased generation at the main Opuha Dam power station by enabling the lake to be held at higher levels.
- Facilitate construction of a small hydroelectric power station coincident with the enhancement project.

A suite of resource consents are required and applications have been lodged with both McKenzie District Council and Environment Canterbury (ECan). The applications are comprehensive and consequently in both instances the councils are processing the applications on a Non-notified basis. This is considered to be a very good outcome and avoids costs and time delays associated with a hearing. However, several late queries from ECan in relation to river engineering matters have arisen, which we are in the process of resolving.

A project programme has previously been prepared to demonstrate how construction of key civil works aspects may be undertaken during the summer of 2014-15. The programme relies on final resource consents being available by 25 July 2015 coinciding with completion of detailed design. Detailed design is now a little behind programme as a consequence of OWL requesting a pause on 23 May 2014. Detailed design work is still on hold until OWL restart the design work.

The updated estimate to construct the works is $2.68 M NZD as at June 2014. Particular costs included and excluded from this sum are set out in section 6 of this report.

A comparison is provided to outline potential expenditure with the enhancement ($2.0 M NZD including allowance for additional hydroelectric generation) and without the enhancement ($2.1 M NZD), albeit that the latter is spread over a long time period. Based on raw costs the totals are very similar. However, it is noted that this assessment does not quantify intangible benefits such as ability to release flushing flow. The additional benefits are considered to be very significant.

Construction costs are now considered to be much more than when rough estimates were developed in 2012. The basis for the amendments relate to amendments to base information

(for example new information indicates that the river has lowered, potentially related to the 2002 and 2009 events and rock level has been clarified) and more comprehensive design analyses now undertaken.

There are a range of risks and opportunities associated with the proposal and these are outlined in detail in section 7 and subject to OWL's view some opportunities for savings are presented. Examples where savings may be realised include review of the design threshold flood, extent of stilling basin/energy dissipation provided and level of certainty around hydraulic performance. A number of risks relate to continuation of the existing situation whereby, based on long term average, the probability of the overflow embankment operating is becoming significant as it is some five years since the last event in 2009.

1 Overview

This report presents a developed design (partly complete detailed design) and associated updated construction cost estimate for the proposed Opuha Dam Downstream Weir (ODDW) enhancement scheme. The proposed works comprise the construction of two radial gates with a stilling basin on the true right hand side (RHS), viewing downstream, of the existing ODDW radial gate and ogee weir structure. An optional hydropower add-on is also being is considered and reported separately. The new structure will be located within the existing closure embankment.

Rough order cost estimates for concept options to locate a gate structure on the RHS were presented by Tonkin & Taylor (T&T) to Opuha Water Ltd (OWL) in November 2012[1]. Recent work has progressed the RHS radial gate option preferred by OWL (previously described as 'RHS with new radial gates and stilling basin') towards detailed design. Opuha Water Ltd now require a revised construction cost estimate prior to completion of detailed design. This has been prepared based on detailed design work completed to date in order to inform OWL of current project cost expectations. T&T consider that the civil works design is approximately a little less than 50 % complete (analyses are much more than 50 % complete but documentation of the design is less complete)

[1]Tonkin & Taylor; Opuha Dam, Downstream Weir Enhancement: Right hand Side Scheme Rough Cost Estimate, Reference 51137.006; November 2012.

2 Requirement for the enhancement

The requirement for the enhancement and purpose of the works is discussed in this section.

2.1 Reduction in fusing of the existing overflow embankment

The project will reduce the likelihood and long term average frequency of the existing overflow embankment fusing and washing out. The enhancement will provide the ODDW with additional capacity to pass floods greater than the present 1 in 5 annual exceedance probability (AEP) flood prior to the overflow embankment fusing and washing out. Currently the fusible overflow embankment may be expected to operate and wash out in flows greater than a 99 m^3/s magnitude or 1 in 5 AEP flood. Following completion of the enhancement works, the design event that will trigger fusing of the overflow embankment will be in the order of 250 m^3/s. This would be enabled through a combination of passing the flood flows via the existing ogee weir, existing radial gate and new radial gate and weir structure. It is important to appreciate that the overflow embankment will still operate/fuse following completion of the proposed enhancement, albeit that the occurrences will be much less on long term average.

Table 1 below overviews significant flood flows associated with the ODDW.

Table 1: ODDW - major flood flows

Flood event	Flood peak
Original design event to cause the overflow embankment to operate and wash out (present situation).	99 m^3/s equivalent to a 1 in 5 annual exceedance probability event (effectively about 119 m^3/s may be passed by fully opening the radial gate at high pond levels for short period of time).
January 2002 flood that caused the overflow embankment to overtop and wash out	137 m^3/s reported by Contact Energy in 2009.
15 May 2009 flood that caused the overflow embankment to overtop and wash out	Approximately 180 m^3/s reported by Contact Energy in 2009 associated with peak Opuha Dam reservoir level of 393.2 m RL (reservoir peak understood to have occurred subsequent to the overflow embankment fusing).
Revised design event to cause the overflow embankment to operate and wash out	Adopt design flow of 250 m^3/s based on prior consultation with OWL. Initial work estimated that the a flow of 250 m^3/s was very roughly equivalent to a 1 in 30 annual exceedance probability event at the ODDW including routed outflows from the main dam and contributing flow from Gooseberry Stream.

Particular problems associated with the overflow embankment fusing (and thus reasons to extend the time between fusing events) include:

- The reinstatement cost is significant and likely to rise in the future. The 2009 reinstatement was reported to have cost in the order of $250,000[2]. Reinstatement is likely to exceed this figure based on 2014 cost data. In particular, significant additional reinstatement costs will be incurred if OWL require filter protection to the overflow embankment upstream face liner (not presently provided) and/or it is necessary to import upstream face liner material.
- There is a finite amount of suitable fine grained material suitable for use as the upstream face liner available in close proximity to the site. This is mostly on land not owned by OWL

[2] Pers. com. Contact Energy

and thus there is no certainty of material availability. There were challenges and delays in 2009 reconstruction in securing sufficient quantities of suitable material. Future costs will escalate as material becomes more difficult to source and has to be carted further.

It is now considered important to manage the quantity of available material for future works, insofar as is possible, prolonging the supply of locally available material;

- There is a perception that fusing of the overflow embankment in accordance with expectations is somehow a dam failure scenario particularly in the public arena. ECan have informally expressed a view that overflow embankment operation should be minimised and possibly prevented.
- Concerns have been raised associated with downstream sediment discharge resulting from operation of the overflow embankment.

2.2 Release of flushing flows

Sustained low flow releases from the ODDW, arising as a consequence of flow attenuation by the dam without natural flood peaks, is seen by many as a significant contributing factor to poor water quality within the reach of the Opuha River downstream of the ODDW.

The project will enable OWL to release more effective flushing flows from the ODDW to the Opuha River for the purpose of providing greater flow variability and assisting in the removal of nuisance periphyton growth, which is currently a problem in the Opuha River. Whilst intangible, this benefit is seen as significant. Trials will be required post construction in order to establish the optimum flushing arrangement.

2.3 Improved operation of Opuha Dam

The enhancement will enable the operating regime of the dam to be improved by holding the lake higher with reduced flood buffer storage and thus potentially increase the effectiveness of the dam storage facility and increase the efficiency of the existing power station at the dam.

2.4 Hydro-power add-on

There is potential for a small hydro-power add-on to be completed in conjunction with the ODDW enhancement. An assessment of this enhancement including a cost estimate is reported separately. The gate structure may be constructed with or without the additional hydroelectric power station.

3 Proposed general arrangement

3.1 Overview of proposed works

The proposed works are briefly summarised below. Design assumptions and parameters upon which the developed design has been based are summarised in Appendix A. Three developed design drawings are provided in Appendix B of this report.

The proposed ODDW enhancement scheme comprises of the following key structures, primarily within the closure embankment:

- A substantial reinforced concrete structure within the existing closure embankment incorporating two new radial gates closing on a new ogee weir block. Each gate is anticipated to be 4.25 m high in accordance with Mechanical Technology Limited (MTL) advice by 5.7 m wide.
- The new reinforced concrete structure features an approach channel, weir block, central pier, chute and stilling basin within the existing closure embankment.
- A trapezoidal tailrace channel predominantly formed within river gravels below the proposed gate structure to convey flows back to the Opuha River.

Other works included as part of the upgrade include:

- Vehicle bridge over the proposed weir.
- Foot bridge over the existing weir.
- Additional miscellaneous works.

3.2 Radial gates and ogee weir

The proposed radial gates will be located within the closure embankment and will serve two functions:

i. Passage of flood flows up to the design event of 250 m^3/s without the overflow embankment fusing by releasing flow via the proposed structure, existing ogee weir and existing radial gate.
ii. Conveyance of flushing flows to create artificial freshes downstream as part of a river management regime, advised by NIWA to comprise 40 m^3/s sustained for 2 hours and subject to operational trials.

An approach channel and training wall will be created, which will encourage uniform flow through the gate structure. The proposal provides for two 4.25m high radial gates, each 5.7 m wide, to be installed on a new ogee weir with an 800 mm wide central pier. The crest of the ogee weir is at 337.9 m RL and the radial gates would lift clear of the flow during the design flood event.

3.3 Chute and stilling basin and tailrace

A concrete-lined chute immediately downstream of the proposed radial gates will pass flood and flushing flows to a stilling basin to dissipate energy. The tailrace will comprise an unlined trapezoidal channel excavated into in-situ materials.

Some armour has been allowed for in key areas to reduce scour. The tail race area will be formed in a braided river environment where fine and coarse sediment transport is a fundamental natural process associated with this setting and some movement is likely during flood flows. That notwithstanding, it is not expected that erosion will occur during routine operation of the scheme at times of low flow once equilibrium conditions are established.

3.4 Foot bridge over existing ogee weir

A foot bridge is proposed to provide foot access across the existing ogee weir as currently access across the existing weir when it is spilling is not possible. This will enable pedestrian access from the left hand side to the existing radial gate and plant room as well as the proposed new gate structure and power station when the existing ogee weir is spilling. This proposed foot bridge will not be accessible during the very rare times that the overflow embankment is, or is at imminent risk of, fusing.

The proposed foot bridge comprises three equal clear spans with two intermediate supports. The bridge deck width is in the order of 1 m and with 30 m overall clear distance between abutments. The main deck structural members and intermediate supports will be fabricated from structural steel with a proprietary steel deck and handrail arrangement.

3.5 Vehicle bridge over proposed gate structure

There is currently vehicle access from the RHS access track across the closure embankment to the existing radial gate. Construction of the proposed radial gates and power station will cut into this existing access track. A bridge is therefore proposed to enable vehicle access over these structures. The proposed bridge included in the scheme will be capable of taking a Class 1 heavy vehicle load as defined by the New Zealand Transport Agency Bridge Manual. If necessary, heavy equipment not able to use the bridge may cross over the tail race when there is no flow through proposed structures and flow is released via the existing gate.

3.6 Other miscellaneous works

A range of minor works are also required and are provided for. Examples include:

- Recontouring finished ground in the vicinity of the closure embankment downstream toe and adjacent stream.
- Subsoil drainage at the base of embankment walls is proposed to assist with management of seepage.
- Geosynthetic clay liner is proposed for all disturbed areas of the upstream embankment face and upstream of the approach apron to assist with management of seepage.
- Enhancement of the existing elver pass if the power station does no proceed or alternatively construction of a new elver pass if the new power station does proceed.
- Modifications to the existing radial gate so that it may close.

3.7 Hydro-electric power station add-on

An optional mini hydro-electric power station is also proposed as part of the ODDW enhancement works in order to improve the efficiency of the scheme's water use. This option is considered and reported separately to the main gated works and is not discussed further in this report.

4 Consent requirements

The project (proposed gate structure and hydro add on) require a suite of resource consents from Environment Canterbury (ECan) and McKenzie District Council.

Comprehensive resource consent applications have been submitted to both councils and in each instance the applications are being processed on a Non-notified basis. This is a very positive outcome. Both councils have adopted this approach as a consequence of:

- The detailed nature of the applications that considered a wide range of potential effects on the environment.
- Documentation verifying extensive consultation with a wide range of parties ECan considered to be potentially affected by the project.

This approach has avoided the significant time delays and cost associated with the hearing process that would have arisen if the councils had notified the application. Affected party signoffs are complete with the exception of ECan river engineering. Resolution of some points raised late in the process by ECan river engineering section is anticipated soon.

This report does not consider matters arising from trap and transfer of adult eels arising from OWL consultation with Arowhenua that is outside of the resource consent process associated with this project.

In addition to Resource Management Act requirements, building consent from ECan arising from the Building Act is required for the works. An application for building consent may be made when detailed design is complete. It is very important to note that assessment of building consent is in no way related to third parties and ECan are obliged to issue building consent provided that the application demonstrates on reasonable grounds that the proposed works are consistent with the Building Act and comply with the Building Code.

5 Project programme

The programme revised in March 2014 required detailed design and resource consents to be issued by 25 July 2014 in order to allow construction of key aspects of the civil works to occur over the summer of 2014 and 2015.

At this stage indications are that final resource consent conditions will be available by 25 July.

There will be an impact on programme arising from OWL placing detailed design on hold on 23 May. This will impact project delivery and may compromise the extent of construction able to be completed this summer.

The March 2014 programme allowed 110 working days for construction of civil works and 140 days for Mechanical and Electrical design, manufacture and installation, the later assuming that the generation opportunity is included (based on the . Based on revised arrangements arising from increased construction quantities described separately, it is considered prudent to extend civil construction to 125 working days (equivalent to 25 weeks).

It is anticipated that a tender analysis report will be prepared to enable OWL to take an informed decision about acceptance of an offer following the tender period.

The March 2014 Programme anticipated a tender analysis report delivery date of 17 October 2014, with a three week window to 7 November 2014 for OWL to approve letting of construction contracts. The 17 October date to deliver the tender analysis report to OWL will be influenced by the 23 May hold. .

6 Cost Estimate

Estimates of the capital cost for construction of the ODDW enhancement scheme have been carried out based on the developed concept design presented in this report. The design has to date, been progressing towards completion of final detailed design. At this time we consider detailed design of civil works components to be approximately 50 % complete as previously noted. The design is still subject to the requested final approval of design parameters from OWL, further design work, design review, and resource consent conditions. These matters could result in amendments to the work described in this report. The estimate may need to be updated to reflect revisions as they emerge. The purpose of this report is to update OWL with project progress, including revised cost estimates, and inform OWL of various risks and opportunities associated with the project. It is intended that the estimates will assist with review of the project business case by OWL.

Rough order cost estimates for options to locate a gate structure on the RHS were presented in November 2012. The estimate provided here uses a similar methodology adopted in 2012 albeit that base information and engineering analyses are more comprehensive (not complete at the time of writing). The cost estimate previously reported was based on preliminary design and assumptions that have now been progressed and defined. This provides more certainty on quantities and therefore costs. This increased confidence is taken into account through a reduction in contingency percentages.

MTL have provided a cost estimate in November 2012 for the mechanical and electrical components for the radial gate system. MTL revised this estimate in May 2014 to reflect the changes.

Quantities for civil works have been calculated for all major items and a schedule of quantities developed based on the arrangements described in the previous sections. Estimated construction rates have been selected based on industry knowledge and reviewed against recent tender prices. The rates have also been reviewed by Breen Construction Ltd, who provided assistance in the 2012 estimate and have knowledge of the site. It was highlighted in the 2012 that the Breen Construction Company is a small specialised company that may have quite a different cost structure to a large company and that may result in higher costs than those reported below.

The schedule of quantities provides the base cost upon which contingencies and marks ups are applied to allow for uncertainties and other associated costs.

A summary of the cost estimate is provided in Table 2 following.

Table 2: Summary of cost estimates as at April 2014

Item description	Estimated cost
Earthworks including tailrace and cofferdam.	$197,000
Reinforced concrete work including approach channel, walls, weir, pier and chute.	$575,000
Stilling basin.	$289,000
Vehicle bridge.	$24,000
Steelwork including foot bridge and handrails.	$55,000
Miscellaneous items including geosynthetic clay liner (GCL) and drainage.	$56,000
Base civil cost	**$1,196,000**
Civil contingency – 20 %	**$240,000**
Base mechanical and electrical cost, including power supply, gates, software, diesel pump, installation and commissioning. MTL advise there are some exclusions.	$477,000
M&E contingency - 10 %	**$48,000**
Engineering – T&T per letter dated 10 April 2014	**$299,700**
Engineering - MTL	$123,000
Preliminary and general – 15 %	$295,000
Total estimated capital cost	$2,678,800

It is noted that the estimated costs presented do not include the hydro-power add-on option that is reported separately.

6.1 Basis for amendments

The significant increase in cost estimates from 2012 is primarily due to the revised size of the main gated structure arising from resolution of hydraulic uncertainties set out in the November 2012 report that was primarily focused on an Obermeyer flap gate option. Factors that have contributed to the increase in cost include:

- As noted in the November 2012 report, base information available at that time regarding river levels was limited. It has since been established that river bed is now at lower level than indicted by the historical information available for the 2012 assessment, potentially as a consequence of the 2002 and 2009 floods and subsequent overflow embankment reinstatement works. As speculated in the 2012 report, it has been necessary to lower the structure so that the hydraulic jump remains stable and the revised levels have been a significant contributor to revised stilling basin depth and length and thus greater cost.
- The focus of the 2012 report was the Obermeyer gate option. As noted in the 2012 report, at that time there were uncertainties associated with the performance of the relatively narrow stilling basin during extreme flood events related to the radial gate option that and this uncertainty has contributed to the deeper structure.
- The width of the proposed weir has been increased from 5 m to 5.7 m as a consequence of detailed design stage sensitivity analyses. The 5 m width was based on typical values. It is worth noting that performance associated with typical values and the greater width will enable a margin on top of the 250 m^3/s flow rate adopted as the base case for design. A consequence of this amendment is:

  - Increased M&E costs for the radial gate structures;
  - Increased quantities of reinforced concrete components including approach apron, weir block, vehicle bridge, chute and stilling basin;
  - Increased earthwork volumes.
- The November 2012 report did not include cost estimates to prepare resource consent applications as consent requirements had not been identified at that time.
- Incorporation of further drainage provisions, arising from site investigations being carried out post November 2012 including GCL, subsoil drainage and additional filling.
- Incorporation of additional components such as more refined elver pass, diesel generator and the like.
- Inflation and changing market forces from 2012 to 2014 including revisions to contractor advice relating to appropriate construction rates from 2012 to 2014.

6.2 Comparison of construction cost estimate to overflow embankment operation

Set out below is a simplistic comparison of potential overflow embankment operation over a nominal 30 year period for scenarios with and without the proposed gate enhancement works.

Whilst the specific occurrences of overflow operation will from time to time vary, the overflow embankment may be expected to operate approximately once every five years on long term average. The overflow embankment last operated in 2009. If the gate enhancement is not constructed soon then it is reasonable to expect a need to replace the overflow embankment in the near future and that six further occurrences will be required over a thirty year period (total of seven overflow embankment reinstatement activities). It is also reasonable to assume that if the gate and weir structure is constructed the overflow embankment may not need to be reinstated until near the end of the thirty year period considered.

Contact Energy report that the 2009 overflow reinstatement cost approximately $250,000. This cost is expected to rise in the future. One driver influencing cost increases is the limited availability of material to line the upstream face. The cost estimates are based on an arrangement broadly similar to the existing structure that has was built without filter protection to the underside of the overflow embankment liner. Provision of filter protection may be expected to add a significant amount to the cost of the overflow embankment reinstatement works if this is now OWL’s preference. For the purposes of the comparison, a figure of $300,000 per overflow embankment reinstatement has been adopted. It should be appreciated that this figure may indeed be light, particularly as lining material becomes harder to source and gravel is progressively washed down the river below from the overflow embankment location.

The reason for including a filter would be to limit the formation of sink hole within the upstream face of the overflow embankment. Sinkholes occur from time to time at the current time.

Table 3 below compares potential requirements in simple terms for overflow embankment reinstatement with and without the ODDW enhancement.

Table 3: Comparison of potential overflow embankment reinstatement requirements with and without the enhancement

	With the ODDW enhancement	Without the ODDW enhancement
Cost to construct the ODDW enhancement (excluding hydroelectric generation opportunity considered elsewhere and assuming prior costs are sunk cost equivalent to both options)	\$2.68 M	Nil
Reinstate the overflow embankment	1 occurrence @ \$300,000 or \$300,000 over 30 years	7 occurrences @ \$300,000 or \$2,100,000 over 30 years
Benefit of additional hydroelectric generation – in discussion with OWL very approximate estimate is \$30,000 – \$35,000 per annum per 1m head over a nominal 30 year period.	\$0.98 M/m	Nil
Indicative cost of the ODDW enhancement and overflow embankment reinstatement over a nominal 30 year period with benefit of additional.	\$2.68 M +\$0.30 - \$0.98 = 2.0 M	\$2.1 M

Table 3 indicates that in terms of total cost that options are cost neutral for the extent of costs considered. The significant intangible benefit resulting from an improved ability to release flushing flow is not reflected in this comparison.

It is important to note the following in relation to this comparison:

i. Cost are in terms of prices as at 2014.

ii. From time to time overflow embankment maintenance will be required. The comparison presented above assumes that this is cost neutral between options.

iii. Overflow embankment reinstatement costs will be greater than those presented if a higher performance standard (inclusion of filter protection) is required.

iv. Based on NIWA advice, considerable intangible benefits associated with improved ability to release flushing flow at the ODDW are also expected and this benefit is not included in the above assessment.

v. The above assessment does not quantify risks associated with the limited availability of liner material in the vicinity of the overflow embankment. Based on the 2009 this risk is considered significant and it is expected that this risk will become more of an issue with each subsequent reinstatement;

vi. The above assessment does not quantify loss of generation associated with lowering the lake to permit the overflow embankment reinstatement works. In addition it does not quantify other interruptions to OWL's business arising as a consequence of lost time. Such interruptions include those associated with reinstatement works and time/effort associated with managing the lake to protect the overflow embankment on an ongoing basis if it is at a higher risk of fusing without the enhancement.

6.3 Clarifications

It should be noted that the estimate for construction costs is for the cofferdam, gate works, tailrace, existing weir foot bridge and associated structures only.

Cost estimates include a provisional sum to upgrade the existing elver pass at the ODDW to be used in the event that the new power station does not proceed. In the event that the power station proceeds, it is assumed that this sum will contribute towards a new elver pass located adjacent to the new power station and the existing elver pass will remain as is.

Estimates do not allow for any of the following costs which would be additional to the reported estimates (this list is not comprehensive):

- Enhancement or modification of the existing overflow embankment in the event that this is necessary.
- Work outside the scope of the T&T fee proposal of 10 April.
- Modification or any works associated with the existing overflow embankment, i.e. minor filling meet design level of 341.95 m RL if considered necessary by OWL.
- Hydropower scheme add-on costs (reported separately).
- Additional work required to gain resource consents beyond the scope of work already provided to OWL.
- Environmental mitigation and compliance, for example NIWA input to certify the proposed elver pass as anticipated by resource consent conditions.
- Lost hydropower production from the main dam during construction or additional power able to be generated from maintaining the lake at a higher level.
- Financing.
- Costs charged by ECan in order to obtain the required resource consents as well as building consents and code compliance certificates.
- Taxes including GST.
- Insurance.
- Developer related costs including OWL internal costs.
- Commissioning and operation and maintenance beyond that.
- Construction cost variations due to market forces.
- Increases in costs of steel, fuel, or any other construction related materials.
- Other and/or revised items not specifically described in the engineering assessment reports.

7 Project risks, opportunities and benefits

Key project risks and opportunities identified at this time are set out below. A number of the risks are present because detailed design is incomplete. It is expected that a number of the risks will be addressed to a large extent by the as yet incomplete detailed design process. Some opportunities are presented that may provide savings – these matters relate to the level of energy dissipation required at high but infrequent flow, and the degree of certainty relating to flows routed through the weir in the vicinity of design threshold events.

Table 4: Risks and opportunities

Risk/Opportunity/Benefit	Consequence/comment
Opportunity to achieve cost savings from current estimates if uncertainties with stilling basin performance can be accepted at high flows (similar in some regard to the situation at the existing radial gate). Risk of uncertainties with tail water conditions in the Opuha River.	Direction from OWL is sought regarding the level of certainty required relating to tail water level and ability to accept some scour in the tail race area during infrequent but significant flows. This matter is mitigated to some extent by the expected presence of rock immediately under the stilling basin and rock in close proximity to the tailrace channel invert. Modelling of the tail water levels within the Opuha River at high floods coincident with the maximum discharge is inherently uncertain. The water level in the vicinity of the tail race and river confluence is of particular note. The tail water level may be lower than assumed from the limited information available to utilise for design purposes. If the tail water level is lower than expected, the hydraulic jump within the stilling basin may not be stable and may extend beyond the stilling basin thus causing some erosion within the tailrace, in particular during times of high flow.
Benefit arises to generate additional electricity at the main power station by maintaining the lake at a higher level and thus increasing generation head.	In the past the lake level has been kept low to provide buffer storage to attenuate flood flows and reduce the risk of the overflow embankment operating. A lower lake level means that there is reduced head to generate electricity at the main dam. In very broad terms one metre of head could correspond to additional generation income of about $30,000 to $35,000 per annum.
Benefit created to construct a small hydroelectric power station at the ODDW coincident with the coffer dam and closure embankment excavations	Ability to earn additional income (albeit minor) and demonstrate efficient use of the existing resource.
Risk that the project resource consents are not available when required.	Both ECan and MDC have indicated that the applications for resource consent will be processed on a non-notified basis. At this time outstanding queries are limited to late questions from ECan river engineering staff. It is understood that the previously protracted issues related to aquatic ecology and eel passage have been resolved to the satisfaction of the consent authorities.

Risk/Opportunity/Benefit	Consequence/comment
Benefit arises to mitigate the risk associated with a shortage of overflow embankment upstream face liner material.	If the project does not proceed there is a risk that shortages of upstream face liner material for future overflow embankment reinstatement works will manifest themselves much sooner than if the enhancement works are undertaken. This is due to less frequent fusing events as a consequence of the new gates. Sourcing of suitable material was an issue when the 2009 works were undertaken.
Benefit created to assist with mitigation of water quality matters.	The proposed structure has the ability to enable the release of flushing flows to the Opuha River from the ODDW. It is expected that this opportunity may provide significant intangible results.
Opportunity to realise savings if the works are designed for a lesser flow. Magnitude and frequency of design flood – risk of frequent large floods	Savings may be achieved if the project is redesigned for a lesser flow. Based on early direction, a nominal flow rate has been developed for design purposes that is not based on a comprehensive frequency analysis. For example, the design flow rate is not directly tied to a specific return period event. There is a low probability that several large floods may occur within a short time causing fusing of the overflow embankment more frequently than say once in a thirty year period. This risk remains, albeit to a lesser extent, irrespective of the design flow rate adopted.
Risk associated with weir approach channel uncertainties Opportunity to achieve some savings if uncertainty in design performance may be accepted.	Flow entering the proposed gate structure has to turn close to ninety degrees in plan. Unfavourable hydraulic conditions arising due to a range of reasons could occur in the vicinity of the approach channel, particularly at high flows. Performance could be impacted. If favourable performance occurs the flood flow able to be passed via the ODDW prior to the overflow operating may be up to 273 m^3/s. This provides a margin of about 10 % on top of the relatively adverse parameters adopted to quantify the 250 m^3/s design case.
Risk that the proposed flushing regime does not deliver the expected benefits.	Water quality issues associated with Opuha Dam are not completely understood. Flushing trails to date have had variable outcomes. There is uncertainty about the effectiveness of flushing releases and trial and error will be required in order to establish exactly what flushing can and cannot achieve. There may be a risk that third party expectations may not be met
Risk that a significant flood may occur during construction	The upstream coffer dam crest will be set at the same level as the adjacent closure embankment. The penetration through the closure embankment will not be excavated until the upstream coffer dam is complete. The upstream coffer dam will not be removed until the new gate structure is complete. The constructor will be responsible for maintaining the coffer dam during construction in order to mitigate any seepage or dam safety matters associated with the coffer dam. Whilst there is a risk of flood damage to the upstream coffer dam during construction, coffer dam construction will occur for a relatively short period and this may be scheduled during favourable weather conditions with dam outflows managed

Risk/Opportunity/Benefit	Consequence/comment
	accordingly (note that the coffer dam will be formed in late spring/early summer during a period when OWL will require the lake to be relatively full).
Risk of a major flood may occurring within a short time following completion of construction.	A very large flood, for example an event much greater than the 2009 flood may cause the overflow embankment to operate irrespective of whether the new gates are constructed. It is not possible to design for all eventualities and to some extent this risk must be accepted by OWL irrespective of flow the gates are designed for.
Risk of uncertainty associated with weir coefficients. Coefficients adopted for design of the new ogee weir are based on empirical relationships and bear some uncertainty. The magnitude of the flow able to be passed may vary from design assessments	The length of the new weir is relatively short. Consequently end contraction coefficients are important. Empirical contraction coefficients and overall weir coefficients bear some uncertainty. If favourable performance occurs the flood flow able to be passed via the ODDW may be close to 273 m^3/s. This provides a margin of about 10 % on top of the relatively adverse parameters adopted to quantify the 250 m^3/s design case.
Risk associated with rock head level. There is inherent uncertainty in the location of the rock head level underlying the site. Rock is assumed to be highly jointed and able to be excavated to the shallow depths required by large machinery without blasting.	Rock head location has been investigated by limited test pits and some geophysical investigations. Ground water inflow from the full pond has complicated assessments. Rock head contours are considered to be accurate to within +/- 0.5 m and may not account for localised high or low irregularities within the profile. Rock head higher than anticipated or a rock mass stronger than anticipated will result in additional cost. Rock head lower than anticipated in the tailrace area will present increased tail race scour risk. Present assessments assume that rock may be readily excavated by conventional earthmoving equipment (eg 30 t excavator or similar with appropriate bucket and rock breaking equipment) and that the rock is well jointed and has favourable bedding to enable this approach consistent with adjacent exposures. Blasting may be required if this assumption is unconservative and such allowance is not provided for at this time.
Risk of closure embankment seepage	Since commissioning the closure embankment has leaked from time to time, particularly at high pond levels. Significant seepage into test pits downstream of the overflow embankment was also observed. The proposal therefore includes a GCL liner over the upstream face of the closure embankment in the vicinity of the slot cut through the closure embankment. Drainage provisions are also proposed to manage potential seepage within backfill in the vicinity of the closure embankment downstream shoulder.
Risk of stilling basin seepage from the Opuha River during construction	Costings assume that the inflow of water hydraulically connected to the river during stilling basin construction is minor. This issue may be more problematic.
Risk of overflow embankment maintenance	The present overflow embankment was originally intended to last for a period of time consistent with the 1 in 5 AEP flood event current at the time of construction. The upstream face liner does not contain filter protection. Whilst some overflow embankment leakage is acceptable, a risk remains regarding the future amount of overflow embankment maintenance.

Risk/Opportunity/Benefit	Consequence/comment
Risk associated with quantities used to develop the estimate. The developed design stage construction cost estimate is based on a developed concept design/partially complete detailed design that is not the final detailed design	Revisions to current arrangements may arise as a consequence of revisions to layouts or uncertainties associated with quantities adopted for the current cost estimate. In this regard, reinforcement quantities are of particular note because of amount of work completed when the estimate was requested.
Risk associated with rates used to develop the estimate. The developed design stage construction cost estimate is primarily based on rates adopted in consultation with an experienced constructor	Tender rates may vary due to different cost structures and changes in construction cost (materials and labour). The cost structure assumes that the work would be undertaken by a small specialist contractor and a large contractor may have a quite different cost structure that may result in costs greater than those reported at this time.

8 Summary and conclusions

This report presents a developed design (partly complete detailed design) and associated updated construction cost estimate for the proposed Opuha Dam Downstream Weir (ODDW) enhancement scheme. The scheme comprises radial gate structures and stilling basin, located within the existing closure embankment. The cost estimate also provides for other associated and miscellaneous works. The main conclusion drawn from this report are summarised as follows:

- The total estimated capital costs for the enhancement are $2.68 M NZD as at June 2014. The cost estimate has increased in relation to the rough cost estimate provided in 2012 due to changes in base information and a more comprehensive analysis. The estimate provided here is based on a partly completed detailed design (approx. 50%) and contains contingencies that reflect this.
- The potential expenditure without the enhancement is estimated to be in the order of $2.1 M over a 30 year period. This is compared to $2.0 M with the proposed enhancement. This comparison is based on a number of broad assumptions and does not consider significant intangible or uncertain benefits, nor does it allow for the limited supply of lining material for overflow embankment construction (this was an issue in the 2009 overflow embankment construction).
- The key benefits of the ODDW scheme are considered to be:
  - Increased flow capacity (99 m^3/s to 250 m^3/s) which reduces the likelihood of the overflow embankment operating. On a long term average this may be by a factor of six to seven occurrences. This also mitigates risks such as limited supply of overflow embankment material;
  - Less OWL management and operational staff time during high flows and reconstruction;
  - Provide enhanced ability to release flushing flows to the Opuha River Downstream of the weir;
  - Allow for increased generation at the main Opuha Dam power station by enabling the lake to be held at higher levels;
  - Facilitate construction of a small hydroelectric power station coincident with the enhancement project.
- The project programme provided in March 2014 prepared with an anticipated construction period in summer 2014-2015, relays on final resource consents being available in July 2015. At this stage indications are that consents will be Non-notified and available by this date. However, late queries have arisen in relation to river engineering matters and we are in the process of resolving these with ECan. There will be an impact to the programme due to a hold being placed on detailed design by OWL on 23 May. This may compromise the extent of construction that can be completed this summer.
- There are a range of risks and opportunities associated with the proposal and subject to OWL's view some opportunities for savings are presented. A number of risks relate to continuation of the existing situation. Based on long term average, the probability of the overflow embankment operating is becoming significant, as it is some five years since the last event in 2009. Other risks and opportunities relate to the partly complete nature of the detailed design.

9 Applicability

This report has been prepared for the benefit of Opuha Water Limited 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.

Mechanical Technology (MTL) have been engaged separately by OWL and have assessed mechanical and electrical components of the project.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
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Senior Civil Engineer	Project Director

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Appendix A: Design parameters adopted for developed design analyses and arrangements presented

Table A1 following summarises key parameters adopted for the developed design of the proposed ODDW enhancement described in the accompanying report.

Table A1: Design parameters

<table>
<tr><th>Parameter</th><th colspan="3">Adopted criterion</th></tr>
<tr><td colspan="4">Design flood flow rate</td></tr>
<tr><td>ODDW – Target design flood flow via existing ogee weir, existing radial gate and proposed new radial gate structure prior to overflow embankment operating.</td><td colspan="3">Target 250 m^3/s with ODDW pond level at 341.95 m RL</td></tr>
<tr><td rowspan="6">ODDW enhancement flow prior to overflow embankment operating – design flow via existing ogee weir, existing radial gate and proposed radial gate structure following ODDW enhancement with pond level at 341.95 m RL</td><td></td><td>Base case (m^3/s)</td><td>Adverse case (m^3/s)</td></tr>
<tr><td>Existing radial gate</td><td>16</td><td>45</td></tr>
<tr><td>Existing ogee weir</td><td>84</td><td>78</td></tr>
<tr><td>New ogee weir</td><td>173</td><td>127</td></tr>
<tr><td>Total</td><td>273</td><td>250</td></tr>
<tr><td colspan="3">Existing radial gate contribution limited to 16.25 m^3/s (rounded to 16 m^3/s) for the base case in accordance with original design recommendations (existing energy dissipation structure is the limiting factor). Existing radial gate flow contribution increasing for more adverse estimates of ogee weir capacity. Allowance for reduced capacity of the existing ogee weir crest as a consequence of the proposed foot bridge piers is included.</td></tr>
<tr><td colspan="4">Design flushing flow</td></tr>
<tr><td>Proposed flushing flow rate and duration</td><td colspan="3">40 m^3/s sustained for 2 hours as advised by NIWA</td></tr>
<tr><td>Design pond level prior to onset of flushing</td><td colspan="3">340.75 m RL proposed</td></tr>
<tr><td colspan="4">Design levels</td></tr>
<tr><td>Crest of Overflow Embankment</td><td colspan="3">341.95 m RL proposed</td></tr>
<tr><td>Crest of Closure Embankment</td><td colspan="3">342.25 m RL proposed</td></tr>
<tr><td>Crest of existing ogee weir & normal top water level of the ODDW pond</td><td colspan="3">340.75 m RL existing</td></tr>
<tr><td>Invert of proposed reinforce concrete approach channel</td><td colspan="3">336.4 m RL proposed</td></tr>
<tr><td>Crest of proposed ogee weir</td><td colspan="3">337.9 m RL proposed</td></tr>
<tr><td>ODDW pond level to permit construction and removal of the coffer dam</td><td colspan="3">335.25 m RL, 1 m above the invert of the existing radial gate at 334.25 m RL</td></tr>
<tr><td>Crest of the proposed coffer dam during construction of the proposed radial gate structure.</td><td colspan="3">342.25 m RL</td></tr>
</table>

<table>
<tr><th>Parameter</th><th colspan="2">Adopted criterion</th></tr>
<tr><td>Under side of proposed radial gate structure access bridge</td><td colspan="2">342.33 m RL at upstream edge reducing to 342.25 m RL at downstream edge (80 mm or 2 % fall over 4.0 m)</td></tr>
<tr><td>Top of approach wall</td><td colspan="2">Varies from 340.75 m RL to 342.25 m RL adjacent to bridge.</td></tr>
<tr><td>Invert of stilling basin</td><td colspan="2">330.0 m RL</td></tr>
<tr><td>Invert of tailrace</td><td colspan="2">331.2 m RL at downstream extent of stilling basin falling to the confluence with the Opuha River</td></tr>
<tr><td>Assumed ground water level for structural design (pond dewatered)</td><td colspan="2">337.5 m RL.</td></tr>
<tr><td rowspan="7">Anticipated tail water conditions at downstream extent of the stilling basin</td><td>Flow rate (m^3/s)</td><td>Anticipated tail water level</td></tr>
<tr><td>5</td><td>332.09 m RL</td></tr>
<tr><td>7</td><td>322.23 m RL</td></tr>
<tr><td>10</td><td>332.45 m RL</td></tr>
<tr><td>20</td><td>332.94 m RL</td></tr>
<tr><td>30</td><td>333.32 m RL</td></tr>
<tr><td>40</td><td>333.62 m RL</td></tr>
<tr><td colspan="3">Radial gate structure - critical dimensions</td></tr>
<tr><td>Reinforced concrete structure tolerance</td><td colspan="2">In accordance with NZS 3109 unless advised otherwise by MTL.</td></tr>
<tr><td>Width of proposed radial gate</td><td colspan="2">2 no. gates each 5.7 m wide clear width between the face of the concrete walls.</td></tr>
<tr><td>Width of chute</td><td colspan="2">12.2 m (2 no. 5.7 m wide gates with 0.8 m wide central pier)</td></tr>
<tr><td>Width of central pier</td><td colspan="2">0.4 m at upstream extent of bridge increasing to 0.8 m at downstream extent of bridge and intermediate gate pier.</td></tr>
<tr><td>Slope of chute</td><td colspan="2">2.25 H:1 V</td></tr>
<tr><td>Gate height</td><td colspan="2">Top of new gates set at 342.25 m RL in closed position as advised by MTL with gates 4.25 m high above crest of proposed ogee weir at 337.9 m RL.</td></tr>
<tr><td>Maximum retained height</td><td colspan="2">6.33 m at upstream edge of bridge abutment (342.25 m RL – 336.4 m RL + 0.4 m + 0.08 m)
Approach wall varies up to 5.85 m (342.25 m – 336.4 m RL)</td></tr>
<tr><td>Free board</td><td colspan="2">1.5 m from closure embankment crest at 342.25 m RL to maximum pond normal top water level coincident with existing ogee weir crest at 340.75 m RL.</td></tr>
</table>

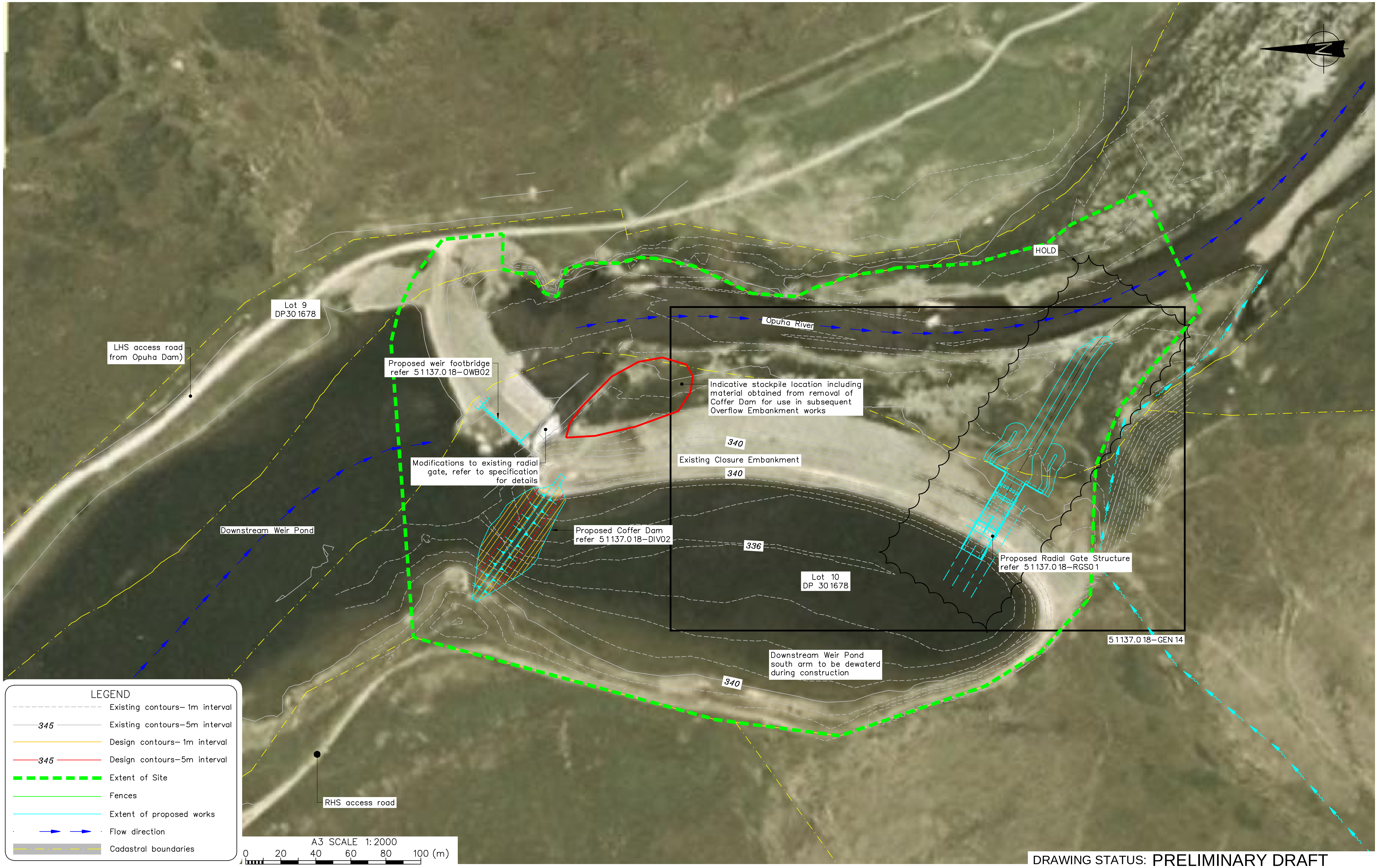
Parameter	Adopted criterion
	0.3 m from closure embankment crest at 342.25 m RL to crest of overflow embankment at 341.95 m RL. Freeboard reduces below 0.3 m during initial operation of the overflow embankment. Free board consistent with existing arrangements.
Radial gate structure vehicle bridge	
Deck arrangement	2 no. simply supported spans 0.4 m thick utilising proprietary precast prestressed components.
Live load (Q)	To accommodate Class One live load equivalent to 0.85 HN in accordance with the NZTA Bridge manual
Deck width	3.7 m clear width between kerbs with 2.0 % cross fall. Overall width between outside of kerbs 4.0 m.
Parameters adopted for structural design	
Live load on bridge abutments	0.85 x 12 kPa = 10.2 kPa in accordance with NZTA criteria.
Soil strength parameters	Greater lateral pressure arising from either ϕ = 40^{o} and 0 kPa or ϕ = 36^{o} and 1 kPa.
Density of back fill (γ)	2.2 t/m^3
Concrete strength parameters	Reinforcement f_y = 500 MPa Concrete f'_c = 30 MPa
Seismic loading (assessed in accordance with NZS1170.5:2004)	
Site class	Class B rock (assuming that there may be a surficial gravel layer not exceeding 3.0 m in depth underlying the structure)
Z factor	0.24 g (Fairlie)
Ultimate Limit State (ULS)/Maximum Design Earthquake(Note 1)	R = 1.8 arising from a 1 in 2,500 AEP event consistent with 50 year design life for importance level 4.
Serviceability Limit State (SLS)/Operating Basis Earthquake(Note 2)	R = 0.6 arising from a 1 in 150 AEP event (interpolated)
MDE peak horizontal ground acceleration (PGA – spectural shape factor = 1.0), C(0)(Note 1)	0.43 g
OBE peak horizontal ground acceleration (PGA – spectural shape factor = 1.0), C(0))(Note 2)	0.14 g
Proposed foot bridge over existing ogee weir	

Parameter	Adopted criterion
Span	Three equal spans approximately 10 m with two intermediate supports
Deck width	Utilise 1,050 mm wide Webforge proprietary panels
Live load (Q) applied to bridge deck	4 kPa

Note 1 Maximum Design Earthquake is the earthquake that would result in the most severe ground motion which the dam structure must be able to endure without the uncontrolled release of water from the reservoir. Gate functionality, as may be constrained by deformation of civil works, is uncertain up to this level of shaking and has not been quantified. Up to MDE level shaking some damage is acceptable so long as catastrophic failure does not occur (with regard to acceleration and subsequent the event to in relation to time)

Note 2 Operating Basis Earthquake. Up to OBE level shaking (and subsequent to an OBE level event) there should either be no damage or minor repairable earthquake damage.

Appendix B: Selected developed design stage general arrangement drawings



DRAWING STATUS: PRELIMINARY DRAFT

1	Second Issue		
0	First Issue	TGM	Apr. 14
REVISION	DESCRIPTION	BY	DATE

DESIGNED :	TGM	Jun. 14
DRAWN :	NSW	Jun. 14
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\51137.018–GEN13.dwg		

APPROVED :

NOT FOR CONSTRUCTION

This drawing is not to be used for construction purposes unless signed as approved

NOTES :

1. All dimensions are in millimetres unless noted otherwise.
2. Aerial photo sourced from Terralink International (Copyright 2002–2005 Terralink International Limited and its licensors).
3. Property boundaries sourced from Land Information New Zealand data (Crown Copyright Reserved).

REFERENCE :

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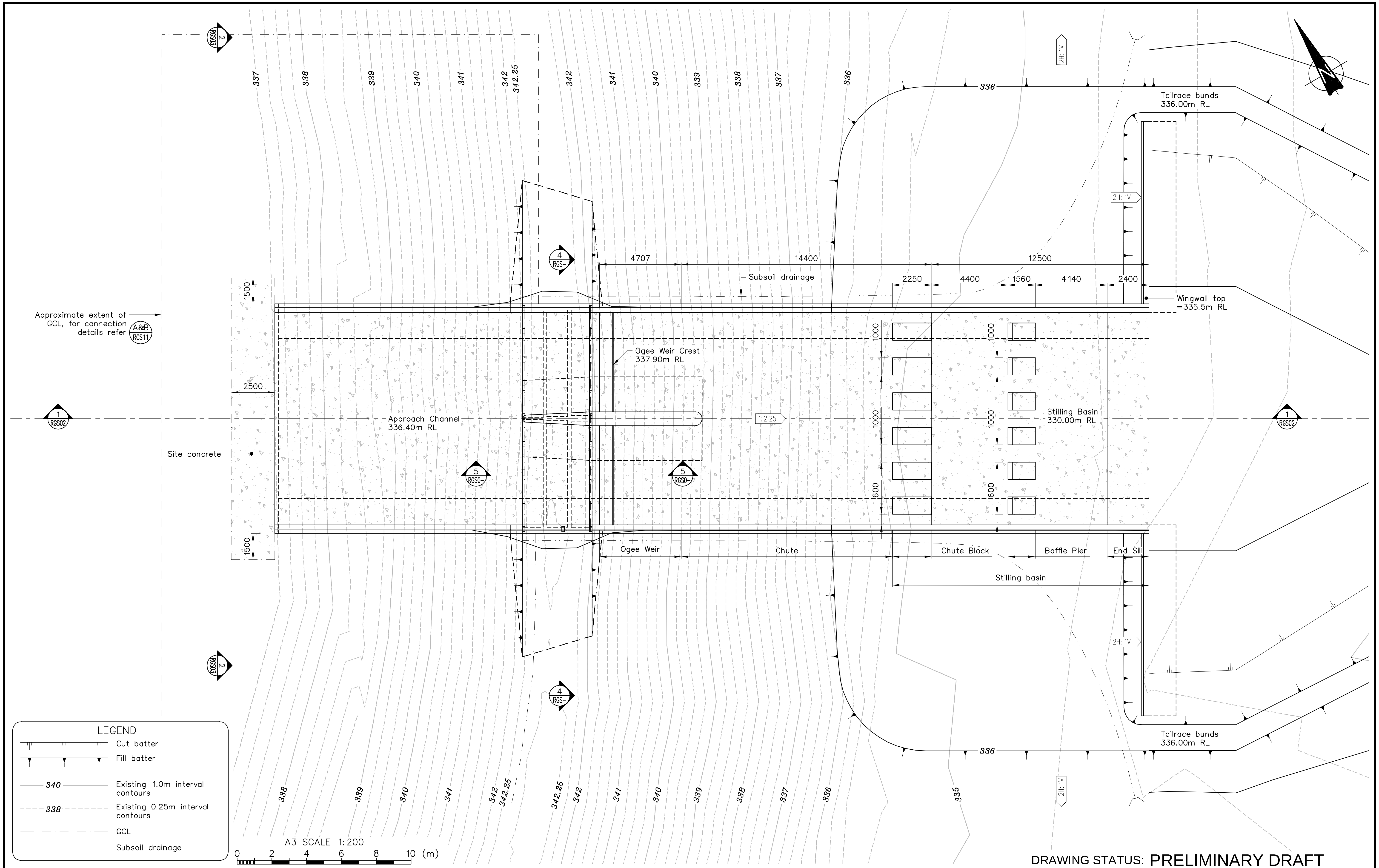
CLIENT, PROJECT
OPUHA WATER LIMITED
OPUHA DAM

TITLE
DOWN STREAM WEIR ENHANCEMENT
General Arrangement Plan (Sheet 1 of 2)

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 2000	51137.018–GEN 13	1

P:\51137\51137.0180\WorkingMaterial\02 CAD\DWG\GENERAL\51137.018-GEN13.dwg, GEN13, 11/06/2014 4:48:58 p.m., nsw



DRAWING STATUS: PRELIMINARY DRAFT

3	Third Issue		
2	Second Issue	TGM	Apr. 14
1	Minor Amendments	TGM	Apr. 14
0	First Issue	TGM	Apr. 14
REVISION	DESCRIPTION	BY	DATE

DESIGNED :	TGM	Jun. 14
DRAWN :	NSW	Jun. 14
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\51137.018-RGS01.dwg		
APPROVED : NOT FOR CONSTRUCTION		

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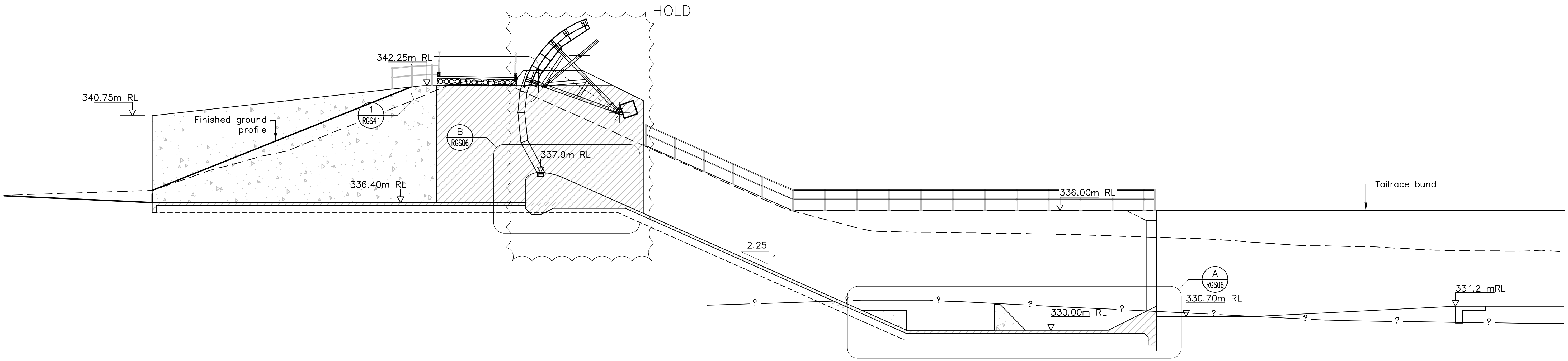
CLIENT, PROJECT
OPUHA WATER LIMITED
OPUHA DAM

TITLE
DOWN STREAM WEIR ENHANCEMENT
Radial Gate Structure General Arrangement Plan

SCALES (AT A3 SIZE) 1: 200
DWG. No. 51137.018-RGS01
REV. 3

P:\51137\51137.0180\WorkingMaterial\02 CAD\DWG\RADIAL GATE STRUCTURE\51137.018-RGS01.dwg, S01, 11/06/2014 4:47:49 p.m., nsw



LONG SECTION 1 RGS01 RADIAL GATE STRUCTURE
SCALE 1:200

LEGEND

- — — — — — — Existing Ground profile
- —— ? ———— Existing Rock profile

A3 SCALE 1: 200
0 2 4 6 8 10 (m)

DRAWING STATUS: PRELIMINARY DRAFT

REV.	DESCRIPTION	BY	DATE
2	Third Issue		
1	Second Issue	TGM	Apr. 14
0	First Issue	TGM	Apr. 14

DESIGNED :	TGM	Jun. 14
DRAWN :	NSW	Jun. 14
DESIGN CHECKED :		
DRAFTING CHECKED :		
CADFILE : \\51137.018-RGS02.dwg		
APPROVED : NOT FOR CONSTRUCTION		

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CLIENT, PROJECT
OPUHA WATER LIMITED
OPUHA DAM

TITLE
DOWN STREAM WEIR ENHANCEMENT
Radial Gate Structure Long Section

SCALES (AT A3 SIZE): AS SHOWN
DWG. No.: 51137.018-RGS02
REV.: 2

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