REPORT

Opuha Water Ltd

Opuha Dam
Annual Dam Safety Inspection 2013

Report prepared for:

Opuha Water Ltd

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Table of contents

Executive summary

The annual safety inspection of Opuha Dam for 2013 was undertaken on 26 March 2013. This report incorporates the inspection on that day and a review of the dam's performance for the period between 1 April 2012 and 31 March 2013. The review is undertaken in accordance with the recommendations of NZSOLD Dam Safety Guidelines (2000).

The inspection and monitoring data for the period suggest that the dam is operating in a satisfactory manner.

Previous proof load testing undertaken on the conduit Anchor Block 2 (AB2), in June 2010, caused a failure to occur on one of the anchors at a load considerably lower than the rated bar capacity. During the period, the concrete anchor block was modified (additional mass concrete added) in order to provide an adequate gravitational force to resist unbalanced hydraulic forces on the bend of the conduit below.

A conduit inspection is due to take place during the beginning of June 2013. Documentation and requirements surround this are in the process of being prepared. A dive inspection and examination of the 450mm bypass conduit will be scheduled to occur before the inspection takes place.

The service spillway operated three times during the period in August and October of 2012, and January 2013. The flows produced were<25m^3/s, <20m^3/s and <15m^3/s respectively. Due to the low levels of flow, no pneumatic piezometer readings were taken during spilling.

Areas of leakage on the downstream face of the overflow embankment at the downstream weir were observed when the regulation pond was raised in order to achieve the desired flow during the flushing trial performed February 2013. Reinstatement of this area was carried out during March 2013 by excavation and backfilling of the sinkhole features on the upstream face.

There were no other significant operational incidents during the period.

The Comprehensive Safety Review completed in 2012 provided a number of recommendations in addition to the recommendations provided as a consequent of previous Annual Safety Inspections. Recommendations have either been actioned or are in the process of being actioned.

This report has discussed and addressed several of the CSR recommendations. The issues discussed include completion of an internal inspection of the low level conduit and works involving piezometer alert levels and equipment reliability.

The recommendations relating to information reported in Annual Inspection Reports, outlined in the 2012 CSR, that the report has incorporated are:

- Inclusion of summary descriptions of plant critical to dam safety and their dam safety functions
- Comment on the adequacy of the completed maintenance and testing activities of the gates and valves
- Comment on the performance of the main dam and a brief compliance section reporting compliance/non-compliance against the recommendations included in NZSOLD's Dam Safety Guidelines

The dam safety related recommendations that have been made as a consequence of the 2013 annual inspection are as follows:

- Investigate an alternative method for accurately measuring sediment flux from the drains and collection of samples for particle size distribution analysis.
- Sediment sampling and particle size distribution analysis of sediment collected from drain D10
- Installation of an automatic turbidity monitoring system on the chimney drains
- Revision of the Alert Level for D21
- Replacement of all broken piezometer gauges.
- Regular readings of the standpipe in the toe remediation.
- Outstanding deformation survey to be undertaken as soon as practical.
- Investigation into source of wet patch on downstream face of Dam.
- Requirements for the outstanding dive inspection be confirmed, and the inspection undertaken as soon as practical.
- Investigation into D18 flow path and visual monitoring of slumped area on upstream face of auxiliary spillway
- Check functionality of existing seismograph
- Repair of the infiltration through the DSWOE.
- Ongoing visual monitoring be undertaken by OWL of area of scour of downstream face of the Dam, below the road.

Some general suggestions regarding the maintenance of the dam have also been provided as summarised below:

- Servicing tower crane
- Ongoing cleaning of H flumes
- Testing and establishment of the condition of the pneumatic piezometer readout box.
- Ongoing monitoring of sill and chute erosion of service spillway chute and stilling basin

1 Introduction

The 2013 Annual Safety Inspection of the Opuha Dam was undertaken on 26 March 2011, by Tim Morris and Janelle Cowley of Tonkin and Taylor (T&T), together with Tony McCormick (CEO of Opuha Water Limited, OWL) and the Operation and Asset Manager Steve Pagan (OWL). The weather for the inspection was still and overcast. The reservoir level was at 387.4m RL.

The inspection took approximately 4 hours and progressed along the following route:

- Downstream Weir
- Service spillway approach channel and Obermeyer gate structure
- Dam crest and exposed area of the upstream face
- Auxiliary spillway and true left abutment including abutment benches
- Powerhouse
- H flume drains
- True right abutment and Service Spillway
- Areas of the embankment downstream face.

This report incorporates the inspection on that day and reviews the performance of the dam in the period from 1 April 2012 to 31 March 2013 in accordance with the recommendations of the New Zealand Dam Safety Guidelines NZSOLD (2000). Throughout the report recommendations are made *in italics.* In addition, general comments relating to routine maintenance works have also been made. All recommendations and general comments are summarised in Section 10.

This report covers the following:

- The Dam, comprising the embankment crest and slopes
- Dam instrumentation
- The reservoir, including the intake tower
- The service and auxiliary spillways
- The power station and tailrace
- The downstream weir
- Access roads
- Surveillance and monitoring during the period including consideration of any operation incidents of note that have occurred during this time.

The previous period included a Comprehensive Safety Review (CSR). With ECan's agreement, no Annual Safety Inspection was carried out in this period because it was considered to be duplicative on account of the CSR being conducted. The 2012 CSR recommendations are being progressed by OWL, and some of the recommendations from the CSR relating to the annual inspection process have been addressed in this report.

Various parties are involved in operation and maintenance of the Opuha Dam. These parties include: OWL (the Operator), TrustPower (the Power Station Operator), Environmental Consultancy Services Ltd (data service provider), and Tonkin and Taylor, (Dam Safety Supervisor).

2 Compliance

NZSOLD's Dam Safety Guidelines recommend that the Annual Inspection (referred to in the Guidelines as Intermediate Inspection) involves:

"The confirmation of satisfactory behaviour or identification of deficiencies by visual examination of the dam and review of surveillance data against prevailing knowledge"

This annual inspection is undertaken in accordance with the recommendations of NZSOLD Dam Safety Guidelines (2000).

3 Dam instrumentation

3.1 Overview

This section reviews the data for the dam instrumentation for the period 1 April 2012 to 31 March 2013. The layout of the dam instrumentation is presented in Figure 1 below. In general, the dam and spillway instrumentation continues to operate satisfactorily.

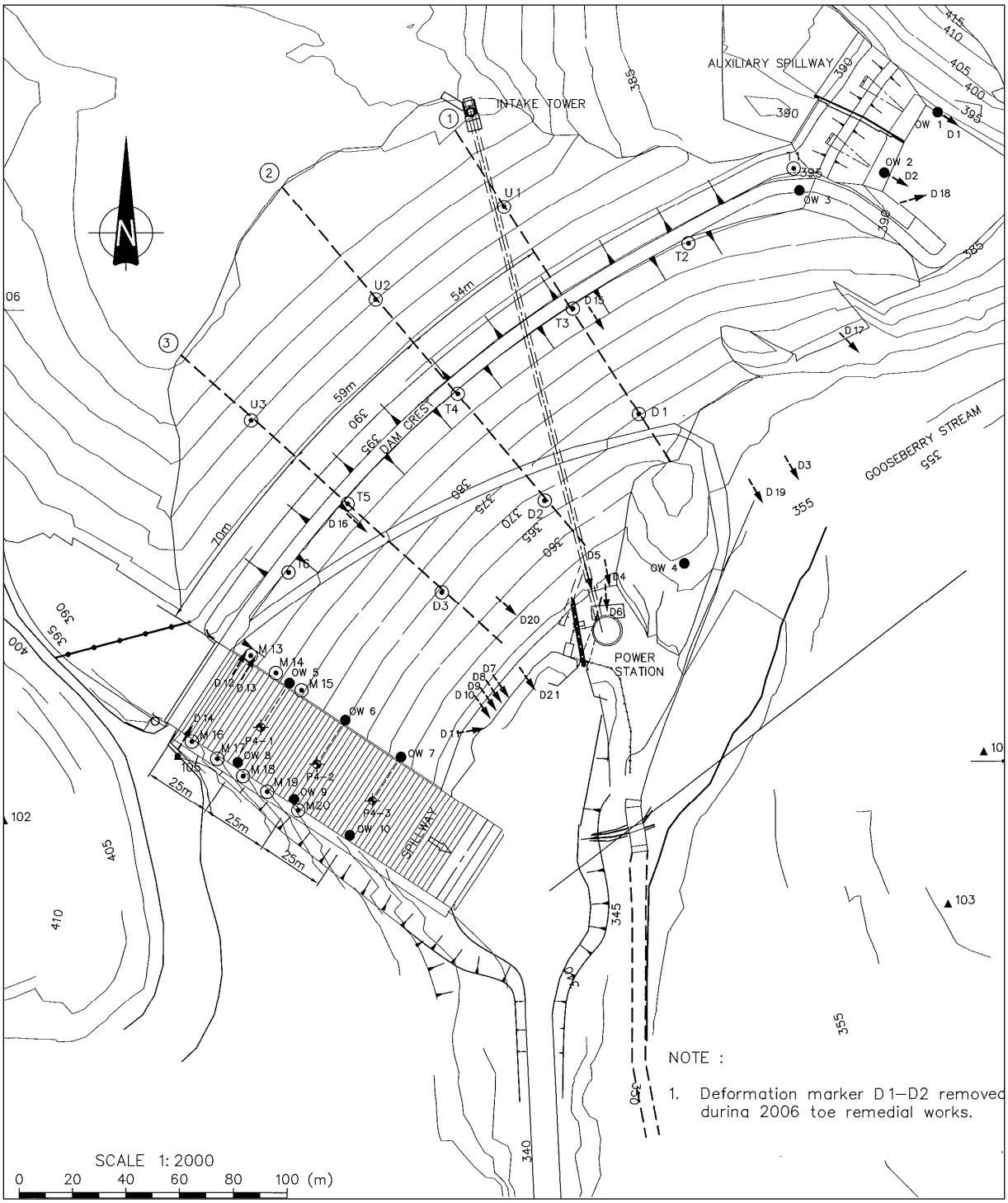

Figure 1 Instrument Layout

The instrumentation consists of a series of:

- Drains, including H Flumes with water level recorders for flow measurements from selected drains
- Turbidity meter located within the drains for turbidity monitoring
- Hydraulic piezometers with gauges in the power house
- Pneumatic piezometers located under the Service Spillway and read when the Service Spillway operates
- Standpipes
- Rain gauge
- Settlement monitors - Deformation survey not undertaken in this reporting period

The alarm criteria have been separated into two cumulative level criteria, initial Alert Levels and secondary Trigger Levels, each requiring specific response actions. The intent of each of these criteria is as follows:

- Alert level – Where recorded data exceeds the normal operating levels requiring further review of observed dam performance
- Trigger Level – Where recorded data significantly exceeds normal operating and/or design performance levels such that urgent action is required.

3.2 Drains

3.2.1 General

There is a continuous flow monitoring system for the seepage flow from drains D7, D8, D9, D10 and D21. Water levels in these five drains are recorded electronically via the scheme SCADA system operated by TrustPower, and an hourly average level is produced, hence an inferred average hourly flow. Drain flows are also manually read monthly by recording the time taken to fill a container of a known volume.

Measured drain flows have provided generally consistent and satisfactory results over the 12 month monitoring period, responding to fluctuations in reservoir level. Of the 21 drainage outflow measuring points, 8 have had measurable flows since the 2011 report:

- the 350 m RL conduit drain (D4)
- the base drainage outlet (D7)
- the outlet from the second diversion channel (D17)
- the three chimney drain sumps (D8, D9, D10)
- the right hand side Auxiliary Spillway fuse plug base (D18)
- the seepage cut off wall drain (D21).

Graphs of flow readings since March 2007 are provided in Appendix A, for:

- drains D7, D8, D9, D10 and D21 on Sheet A1/1 (manual data)
- the sum of D7-D10 on Sheet A1/2
- D4, D17, and D18 on Sheet A1/3.
- drains D7, D8, D9, D10 and D21 on Sheet A1/4 (water level recorder data)

Review of flow rates derived from water level recorder data in the H flumes over the period has highlighted that the water levels are sensitive to the accumulation of algae and other debris in the flumes. Algae causes water level in the flumes to increase and thus the level recorders incorrectly overestimate flow rates.

The recent Surveillance and Monitoring Regime review has shown that in the case of drains D7-D10 flow rates derived from the manual readings and water level recorders are in good agreement when the flumes are clean. Recorded flow rates diverge when the flumes become dirty.

Anti-fouling coating put in place in the four H-flumes D7-D10, during the 2010-2011 period, remains in reasonable condition. D21 is still to have an anti fouling coating applied and OWL advise that this will be completed once an effective way of diverting the flow has been established.

The H-flumes are regularly cleaned by OWL. Recommendations regarding this matter are set out in the Surveillance and Monitoring Plan review that is reported separately.

OWL advise that they are considering conveying the flow from D4 and D5 to the sump adjacent to the switch yard. This is order to keep the site tidy and eliminate any affect this water may have on potential ground movement in the area.

3.2.2 Drain flow turbidity and total suspended solids

Samples from the flows conveyed by drains D7-10 and D21 were analysed for turbidity and total suspended solids in March 2013. These results show that at the time of testing, turbidity levels and the total suspended solids were consistent with prior readings. Comparison to results produced from an analysis carried out February 2012 show that both parameters have remained stable over the period. It is recommended that a Total Solids mass flow analysis also be performed on the drain flows. This will require accurate measurements of sediment load in the drain flows. Some laboratory measurements of suspended solids in samples from the drains have been completed with solids levels close to the detection level of the test. An alternative method for accurately measuring sediment flux from the drains should be investigated and trialled. Sediment samples that are collected should be analysed for particle size distribution.

RCM2013-01: Investigate an alternative method for accurately measuring sediment flux from the drains and collection of samples for particle size distribution analysis.

3.2.3 Drain flow turbidity meter

The turbidity meter installed in the D7 H-flume is to detect changes in sediment concentrations in the drainage discharge. However, we understand that the build up of algae on the instrument lens causes a false reading to be provided. ECS has indicated that OWL will be cleaning the lens on a regular basis in the hope that the data provided will be more accurate. Raw data has been recorded over the period and has yet to be processed. ECS have advised that this is due to the data collected not being an accurate representative of the actual turbidity, due to the build up of algae on the lens.

Figure 2 Turbidity meter in D7 H-flume

OWL continues to measure and report the turbidity of drainage flows by way of manual turbidity measurements taken at the time of the manual flow rate recordings. Reported turbidity readings appear to be relatively stable and are reviewed by T&T as part of the ongoing dam surveillance and monitoring requirements.

3.2.4 Chimney drains

Flow through the chimney drain is collected by D8, D9 and D10, with water being conveyed from the left chimney sump, central chimney sump and right chimney sump via the respective drains. The outlet for these flows is located at the base of the dam, adjacent to the spillway stilling basin. The outlet for flows conveyed from the base drain, D7, is also at this location.

Figure 3 Chimney drains D8-10, and D7

3.2.4.1 D10 sediment

The surveillance regime carried out by OWL over the period has allowed for observation of the levels of solids within the drains. OWL advise that the observed sediment in D10 drain flow had increased in terms of the volume of sediment that is settling in the H flume. Though recorded flow rates were within the acceptable bounds, sediment levels within the flow have apparently increased.

Figure 4 Sediment deposited in the D10 H-flume

The source of the sediment is unknown, with potential for it to have originated from the chimney drain material. The location of the D10 flume also may allow for accumulation of windblown dust and grit. OWL advise that a sample of the drain flow will be collected for material analysis. Drain D10 should be included in the sediment flux measurement trial recommended in Section 3.2.2.

RCM2013-02: Inclusion of D10 in sediment trial

3.2.4.2 Turbidity

Monitoring of the turbidity of the chimney drain flow has yet to be successfully achieved. Past attempts have shown the difficulty of installing a meter in the drain where the three chimney drain flows meet, due to turbulence issues. ECS have recommended that a small stilling well be installed and a turbidity meter hung to obtain the reading. An automatic turbidity monitoring system should be installed on the chimney drain flow outlet and incorporated into the monitoring system.

RCM2013-03: Installation of an automatic turbidity monitoring system on the chimney drains.

3.2.5 Drain Flows

Out of the eight drains that produced measurable flows throughout the period, majority of the flows produced are within the expected range. Specific details are and explanations are provided in Sections 3.2.5.1 and 3.2.5.2 below where flows have exceeded Alert Levels in D21 and D18. No other drains exceeded their Alert Levels during the period.

Specific comments relating to the drains are:

- Changes in inferred flow for all chimney drains (D7-D10) were apparent when cleaning of the flumes to remove algae has occurred during the summer months.
- A reduction in electronic 'noise' during August 2012 was noted. This was rectified by converting the data received to an average of minute samples rather than the previous quarterly-hour samples.
- Flows produced by drain D4 during the period are fitting with historical flows produced at similar reservoir levels.
- Water level recorded flow for the chimney drains (post quarterly hour samples) have remained relatively consistent throughout the period. However, the manual readings have produced a wider range of flows over the period. This is attributed to the electronic readings being an average over the hour.
- Drain D7 flow has historically been very responsive to reservoir level. This trend has not been so apparent since January 2011. D7 flows produced during the period are in trend with flows produced for respective reservoir levels since January 2011.
- Drains D8, D9 and D10 produced flows during the period that are in accordance with historical trends. There has been no observed change in the base trend. It is observed that D10 flow is more affected by reservoir level than flow in D8 and D9.
- Flows produced by drain D17 during the period are fitting with historical flows produced at similar reservoir levels.

Drain D6 flows were recorded as dripping and are too small to accurately measure.

3.2.5.1 D21flows

D21flow rates have exceeded the lower bound Alert Level on several occasions throughout the period. D21 is very responsive to lake level, and the exceedance has occurred when the lake is operating close to its top water level. The recorded flow from D21continuously exceeded the Alert Level criteria from October 2012 to February 2013. The Alert Level criteria was also exceeded during the first half of August 2012. It should be noted that the Alert Level varies depending on reservoir level. Periods where the flow exceeded the Alert Level were appropriately investigated. At all times flows were well below the upper bound D21 Trigger Level criteria of 500 l/s for all reservoir levels. Figure A1-4 in Appendix A shows the data.

A drop in D21 flow of approximately 0.9l/s was noted between the hourly readings of 12pm and 1 pm on 15 February 2013. This brought the D21 flow to below the alert level. The change in flow did not reconcile with cleaning of the flumes or any other apparent event. This flow was attributed to an inconsistency in the instrument measuring water level in D21. However, ECS indicated that the instrument was functioning properly to the best of their knowledge. This unexplained drop in flow may mean that some earlier flow readings that exceeded the Trigger Level may not be accurate.

Based on flow rates derived from water level recorder information, surveillance data indicates that the D21 flows depart from the baseline trend when the reservoir level rises above approximately 390.8m RL. Over the period the reservoir level has been kept relatively high in comparison to previous periods. This has attributed to the large number of Alert Level readings that have been recorded throughout the period. There seems to have been no other occurrences that have had an influence on the D21 flow rate. The drain flows being observed at the higher lake levels are not considered to be of concern from a hydraulic flow capacity point of view, and there is no evidence of increased turbidity at the higher flows.

The large number of alerts produced at high reservoir levels indicates that at these higher levels the Alert Level is not well represented. When the Alert Level was last revised in April 2010, very few flows had been recorded at these higher reservoir levels. An Alert Level more relevant to the flows produced at higher reservoir levels can now be determined.

We recommend that the Alert Level is revised accordingly.

We note that electronic readings for D21 have been influenced to some extent by algae growth in the flume. During the summer months, when algae is an issue, cleaning of the H-flume occurred before manual readings were taken.

Figure 5 H-flume used to measure D21 flow

RCM2013-04: Revision of the Alert Level for D21

3.2.5.2 D18 flow

Drain D18 is located at the RHS base of the auxiliary spillway fuse plug and only flows when reservoir levels exceed 390 m RL. This level corresponds to the base of the right hand side auxiliary spillway channel.

Figure 6 Location of D18

Flows were observed and measured between 20 August 2012 and 26 February 2013. The Alert Level was not exceeded and all flows were reported to be clear.

It is unclear exactly where the drain flow originates from. However, there is an area of interest in the upstream face where it is suspected that seepage occurs. Flow may originate from seepage in this area and connect through to the upstream end of the D18 drain that runs along the right hand side training wall of the auxiliary spillway. D18 extends under the auxiliary spillway concrete slab drain to below the crest of the spillway[1].

Grouting of the upstream three meters of D18 was carried out in July 2000 as a result of the April 2000 Six Monthly Inspection recommendation. Figure 7 below shows the flow produced pre-grouting, post-grouting and current flows from the drain. From the plot it can be seen that at equivalent reservoir levels, flow has increased from post-grouting to current flows produced.

Given the long term trend of increasing flow from this drain, we recommend that an investigation is completed to identify the source of the seepage, and a concept developed for works to reduce this seepage. This is outlined in Section 7.3.

OWL advise that they will be performing a test to pump water into the small depression near the entrance to the auxiliary spillway to determine if this is the location of the origin of the seepage.

[1] May 1999 Construction Review

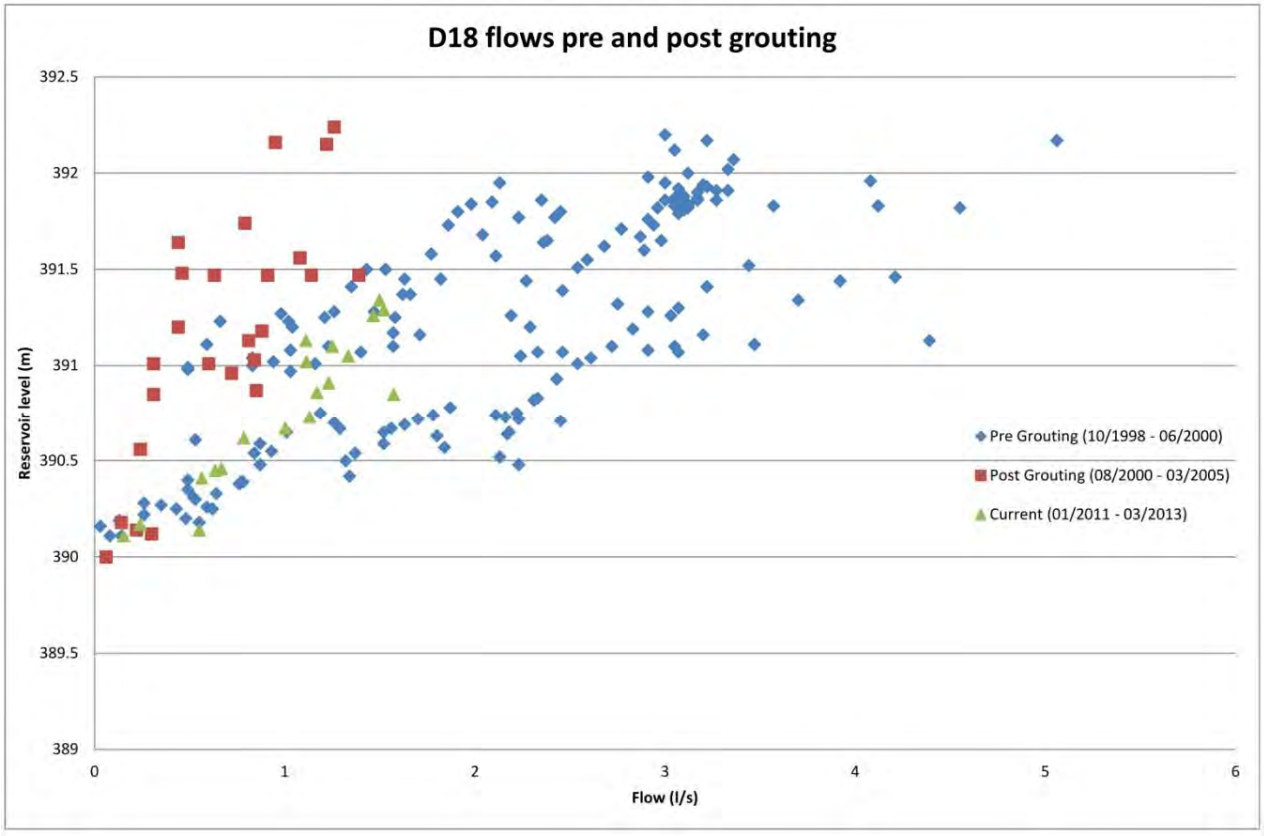

Figure 7 Drain D18 flows, pre and post grouting Piezometers

3.3 Piezometers

3.3.1 General

Graphs of the data since May 2007 are provided in Appendix A2. The locations of the three lines of piezometers are shown in Figure 1(above picture) and the positions of each piezometer in Figure 8.

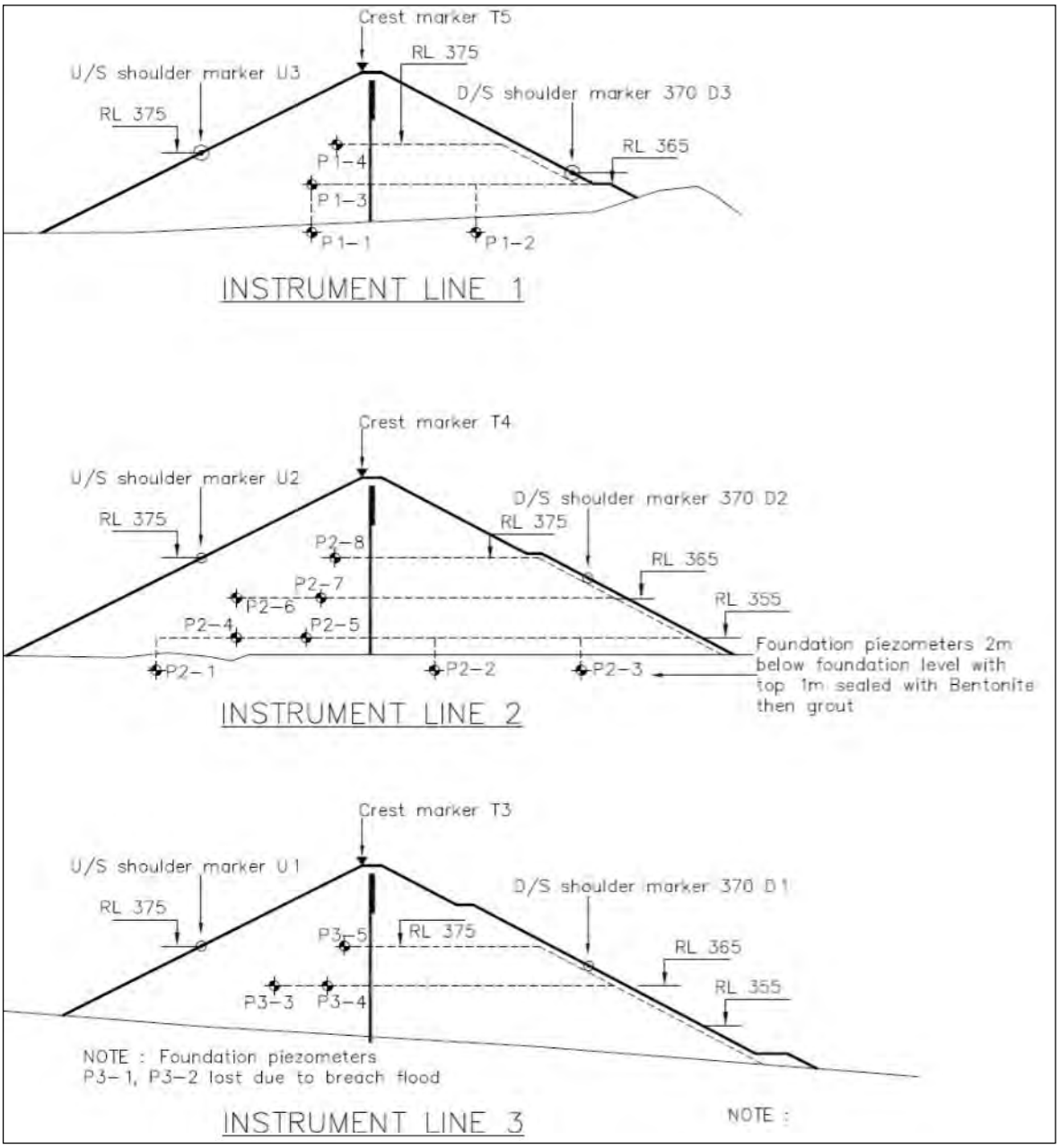

Figure 8 Piezometer positions

The 2006 remedial works disrupted the piezometer monitoring. The background to these effects is detailed in the 2007 report and is summarised as follows:

- Piezometers P2-5, P3-3 and P3-5 have been decommissioned because they are unresponsive. The readings are still recorded on site but are not reported.
- The gauges for piezometers P1-2, P1-3, P2-6, P2-7, P3-4, P1-4 and P2-8 were being repaired or replaced during early 2007 and readings were restarted on 8th August 2007.
- The remaining piezometers P1-1, P2-1, P2-4, P2-2 and P2-3 recommenced readings on 5th March 2007.

Five piezometers are considered to be no longer functioning reliably and hence have been excluded from the monitoring requirements. These discontinued piezometers are P1-4, P2-2, P2-5, P3-3 & P3-5.

The following 10 hydraulic piezometers are currently monitored:

- Piezometers P1-1, P1-2, P2-1, P2-3, P2-4, P1-3, P2-6, P2-7, P3-4 & P2-8.

These remaining hydraulic piezometers are currently read monthly in accordance with the Surveillance and Monitoring Plan, with provision for additional readings if warranted by specific circumstances.

The pneumatic piezometers under the service spillway are to be read following spillway operation. The service spillway operated on 3 occasions during the period and the pneumatic piezometers were not read due to the low volume discharged down the spillway.

3.3.2 Piezometer data

Piezometer gauges are located at the base of the power station to read the hydraulic piezometer tip pressures. It is noted that these have not been calibrated since April 1999. Prior to April 1999; the gauges were calibrated at the end of construction.

Readings produced by piezometers over the monitoring period were generally within the acceptable range and coincide with their respective reservoir levels. Specific details relating to the piezometers are:

- P1-1 has produced readings that are very responsive to reservoir level. This is consistent with historical trends.
- Levels produced at P1-2 have remained at a similar level throughout the period, with little response to reservoir level. This is fitting with historical trends. The baseline reading for this piezometer has not changed.
- The same gauge pressure was recorded at P1-3 between 14 June 2011 and 23 September 2011 (9 piezometer readings) despite changes in reservoir level. Subsequent readings have been inconsistent with prior behaviour. The readings produced August 2012 – February 2013 were particularly low relative to historical data at equivalent reservoir levels. Hence, the performance of P1-3 over the monitoring period is uncertain.
- A shift in base line for P2-1 was observed during July 2010. Readings during the last 12 months were responsive to reservoir level and fitting with historical data since this change in trend occurred.
- P2-3 is located under the downstream shoulder of the dam. P2-3 readings over the period are showing a slowly increasing water level with time. The current reading of RL 389 is not of concern. The ongoing trend should be monitored. .
- Historically, P2-4 levels are similar to that of the reservoir level. Levels produced over the period follow historical trends.
- Two readings from piezometer P2-6 have marginally exceeded the reservoir water level, which is unlikely to be the case and is most likely due to the calibration factor used (+0.5m). This indicates that a revision to the calibration factor for the piezometers is warranted.
- Levels at P2-7 are consistent with historical readings at similar reservoir levels.
- P3-4 historically changes with water reservoir level. Readings produced over the period are consistent with historical trends.

3.3.3 Piezometer maintenance and repair

Piezometer maintenance and repair was initiated on 25-27 March 2013 in order to remediate all outstanding piezometer issues outlined in previous Annual Inspection Reports. Work onsite consisted of maintenance of the de-airing board and de-airing of the manifold and piezometers. The results of the recent works are reported separately.

It was noted that the four Nuova Fima and four Wika gauges were registering within acceptable tolerances. Of the seven Soil gauges on site, three were unusable, two had bent needles and two were in acceptable condition. It is also recommended that P1-1 and P1-2 gauges are visibly marked as unusable.

T&T recommend that the broken gauges are replaced, in the interim; the piezometers can be read using adjacent gauges.

Due to these recent works, Drawing Number 51137.008-01 will subsequently need to be updated.

Calibration of all piezometers is recommended in accordance with the 2012 Annual Report recommendation.

RCM2013-05: Replacement of all broken piezometer gauges, and calibration of gauges that are reading serviceable piezometers.

3.3.4 P2-8

The leads to piezometer P2-8 were disturbed by a digger from The Breen Construction Company Ltd during the construction of remediation of Anchor Block 2. The results of the recent works are reported separately.

OWL advise that they will be placing frost protection cover material over the exposed P2-8 leads to prevent freezing of the piezometer lines, and the associated erratic readings.

3.3.5 Pneumatic piezometers

The pneumatic piezometers are located under the service spillway and are read on the left hand side of the service spillway when the spillway operates.

Maintenance of the pneumatic piezometers was also carried out during March 2013. It was recommended that the lead terminals should be secured on a board and the board placed in an insulated box for protection.

The pneumatic piezometer read-out box should be tested and the pneumatic piezometer results can be re-assessed when the condition of the read-out box is established.

3.4 Observation wells

The ten observation wells are all read monthly. These are:

- three in the left abutment area of the dam (OW1 – OW3)
- one near the downstream toe near the power station (OW4)
- six along the sides of the main spillway (OW5 – OW10).

Graphs of these readings since May 2007 are attached at Appendix A3. The graphs show the two or three levels at which readings are taken in individual tubes, for the purpose of checking discrete ground water levels at a range of selected locations and elevations.

Observation well readings for the reviewed period are generally in keeping with historical readings. During August 2012, OW1, 3, 5 and 7 exhibited a small increase in level relative to the

previous months. This increase was likely to be due to the increased rainfall during the month. However, the levels were generally similar to previous readings at equivalent reservoir levels. Increased levels occurring in August reduced back to more normal levels in October 2012.

T&T recommend that regular readings of the standpipe in the toe remediation be carried out.

Figure 9 Toe remediation standpipe

RCM2013-06: Regular readings of the standpipe in the toe remediation.

3.5 Deformation survey

Deformation surveys are required to be carried out to monitor settlement and movement of the dam structure. The most recent bi-annual Type B Deformation Survey was conducted in May 2011[2]. This matter was the subject of recommendation RCM2011-02. The downstream row of survey markers, D1, D2 and D3 were replaced in June 2008 and picked up during the course of the 2011 survey. Subsequently, the drawings were amended to include these replaced survey markers.

The 2011 Deformation Survey indicated some very minor movement both vertically and horizontally at different positions along the crest. Deformation markers at the true left and true right edges of the Dam (near auxiliary spillway and service spillway respectively) have indicated that settlement at rates ranging from 0.0001 m to 0.0022 m per annum has occurred since June 2001. The deformation marker at the centre of the crest indicates that the crest is now 0.0128 m downstream of its March 1998 position. The movement has occurred in two stages. The majority of the movement occurred between March 1998 and April 1999, with the marker moving 0.0196m downstream. Since April 1999, the marker has moved upstream 0.0068 m to its current location. The measured levels of settlement are within an acceptable range.

A deformation marker needs to be installed on the conduit Anchor Block (AB2) to allow for the marker to be included in the next Type B deformation survey. It will allow for additional information on performance and integrity of the anchor block.

The next deformation survey should be carried out as soon as practical.

RCM2013-07: Outstanding deformation survey to be undertaken as soon as practical

[2] Opuha Dam – Deformation Survey No 6, April 2011, Prepared by Opus

4 Dam embankment crest and slopes

4.1 Overview

Visual inspection of the embankment included:

- Upstream face to the extent permitted by the reservoir water level (387.4 m RL at time of inspection)
- Areas of the downstream face
- Crest.

4.2 Upstream face

The upstream slope and riprap appeared to be in satisfactory condition to the extent visible above the 387.4m RL reservoir water level.

Figure 10 Upstream face

Accumulation of debris was visible on the face. Periodic debris removal is undertaken and this should continue. There were no visible deep rooted weeds and only a small amount of surface weeds. To the extent that it was visible, the riprap is robust and sound.

4.3 Downstream face

The downstream face appears to be in good condition. Periodic spraying continues to control local growth of scrub and bushes to prevent them from penetrating through the riprap into the embankment fill below.

Figure 11 Downstream face

During the 2011 Annual Inspection, OWL raised the issue of stock tracks on the downstream face of the dam. We understand they were concerned about the potential concentration of stormwater flows if stock tracks become embedded. No stock tracks of concern relating to concentration of stormwater runoff were noted during the inspection.

During the 2010-2011 period it was suspected that minor movement/slumping of the Type 1 rock fill behind the power station near the foundation pressure relief well occurred. No evidence has been noted during the period that indicates further movement has occurred and the ground conditions on the day of the inspection looked adequate. It is likely that this movement in 2010-2011 was earthquake related if indeed there was any, and it is suspected that there was not. It is not considered to be of concern.

4.3.1 Wet patch (near D16)

OWL report that the historical small wet patch on the upper part of the embankment dam face, on the access road and near the D16 drain outlet, has grown in size between January 2013 and March 2013.

Figure 12 Wet patch located on dam road near D16

The location of the wet patch is just above the drain outlet of D16 which is a high level connection to the true right base of the thickened chimney drain at 383 m RL.

Previously it was understood that there is no significant response of the damp spot to either heavy rainfall or reservoir level. At present the source of this water remains unsolved. It may be related to one or more of the following:

- Surface water infiltrating the embankment and exiting at this location. The level of the D16 drain coincides with a change in dam fill type in the downstream shoulder from Type A (NSCZ) fill to Type B (NSCZ) fill. The upper fill is expected to be more permeable than the lower fill and it is therefore conceivable that rainwater infiltration into the shoulder is tracking sideways when reaching this lower permeability zone and existing at the downstream face.

- Seepage from the chimney drain may be tracking along the outside of the D16 drain pipe (considered unlikely as the chimney drain is well drained and highly unlikely to be saturated at this level)
- Leakage from the D16 drain pipe. Considered unlikely as this pipe remains dry.

Growth of the wet patch up the hill away from D16 implies that water running along the outside of the D16 drain pipe or leakage from D16 is unlikely to be the source of the wet patch. The wet area has grown following times of relatively high rainfall and reservoir levels. On the day of the inspection the wet patch extended eight to nine meters up the slope. It is recommended that shallow excavation of the area is carried out to investigate the source of the damp area. Investigation of the source of this seepage was a recommendation of the 2009 and 2011 Annual Report. It is further recommended that this area is investigated.

RCM2013-08: Investigation into source of wet patch near D16 on the downstream face of the dam.

4.4 Embankment crest

The crest roadway and fence were generally in good condition. However, there were some instances of slight damage to the fence handrail.

Figure 12 Damage to crest fence handrail

Some areas of the wave barrier had slight damage and there was a gap between the bottom board and the ground.

Figure 13 Damage to wave barrier

We recommend that this minor damage is repaired.

5 Reservoir

5.1 General

The reservoir margin and adjacent slopes in the immediate vicinity of the dam was visually inspected from the dam crest and both abutments. The reservoir level was 387.4 m RL at the time of the inspection.

The public boat ramp located near the service spillway approach channel has developed a hole in the concrete protecting the edge of the ramp. The hollow tapers off towards the ramp and opens up away from the ramp. It is recommended that maintenance work is carried out to infill the void; however, this is not a dam safety matter.

Figure 14 Undermining of boat ramp

The elver pass is functioning and in good condition.

Aside from the undermining of the boat ramp discussed above, based on the extent of visual inspection from the dam crest there is no apparent sign of slope instability at the margin of the reservoir. In addition, OWL has not reported any slope instability at the reservoir margin in the period.

5.2 Intake Tower

Figure 15 Intake tower

A dive inspection of the intake tower has not been undertaken since March 2008. We understand that an inspection was not undertaken in 2010-2011 due to difficulties in scheduling the inspections coincident with low reservoir water level to enable adequate dive time and safe access by divers in accordance with current safety regulations.

Diver inspections should be performed every two years so the inspection is long overdue. OWL advise that a dive inspection will be performed before June 2013, in anticipation of the upcoming penstock inspection.

A number of recommendations from the 2008 report remain outstanding:

- RCM2008-18 – clarification of the labelling of the guide ropes from the SW tower leg
- RCM2008-20 – the loose steel bar/plate at the NE tower leg splice should be investigated during the next diver inspection.

We understand that the intake tower crane does not have certification. OWL advise that this has subsequently been addressed. The intake tower is a critical piece of plant necessary to service the conduit screen and/or bulk head if necessary to seal the conduit. It is important to ensure that the crane remains fully operational in the event that it is necessary to operate the crane at short notice.

A service of the intake tower above water level is currently in progress.

RCM2013-09: Requirements for the outstanding dive inspection be confirmed, and the inspection undertaken as soon as practical.

6 Service spillway

6.1 General

The service spillway provides for the controlled release of water in order to ensure that the reservoir water level does not exceed the maximum allowable level. OWL advise that they can operate the Obermeyer flap gates that are mounted on the spillway crest. Testing activates were carried out prior to storm events to ensure the gates were functioning and the gates were lowered to provide controlled spill on three occasions.

6.2 Spilling Events

The service spillway operated 3 times during the period:

- August 2012 at <25m^3/s
- October 2012 at <20m^3/s
- January 2013 at <15m^3/s

Due to the low levels of flow, no pneumatic piezometer readings were taken during spilling.

6.3 Spillway approach

The approach to the service spillway was visible at the time of the inspection due to the low reservoir level. The approach was reasonably clear of significant debris with a few light sticks scattered around. The approach was in good condition. The repair to the shotcrete coating on the rock on the right hand side of the spillway remains in good order.

Figure 16 Shotcrete repair

The structural concrete spillway approach walls are in good condition with no movement between the spillway left side approach wall and mass concrete bridge abutment (refer to the 2006, 2007, 2008 and 2009 Annual Safety Inspection for background details).

The repair to the slip failure that occurred to the right hand side of the approach channel/road cutting northwest of the service spillway (between the bridge and the boat ramp) is still effective and in good condition.

Figure 17 Slip repair

6.4 Obermeyer gates

High reservoir levels throughout the period required operation of the Obermeyer gates.

The Obermeyer gates operated multiple times throughout the period to allow spilling. Spilling was required due to the high operating range of the reservoir level. The gates functioned as expected with no issues arising from operation.

The Obermeyer gates weren't able to be manually operated on the day of the inspection. The issue was subsequently identified as a consequence of the gate control logic that keeps the gates lowered when the lake level is below a specific level. OWL has requested TrustPower modify this aspect of the control logic to provide manual operability at all lake levels.

Figure 18 Obermeyer gates

6.5 Stepped spillway chute

The spillway steps appeared to be in satisfactory condition. A few large rocks were noted on the spillway; however, there was no visible damage to the step edges due to the rocks being thrown onto the spillway.

Figure 19 Service spillway

These rocks will be washed into the spilling basin at the toe of the spillway. On the day of the inspection there was no substantial accumulation of rocks in the stilling basin.

6.6 Tailrace and Stilling Basin

Inspection indicates that the periods that the spillway flowed during the period did not erode a significant additional quantity of rock from the sill area beyond the stilling basin. Close monitoring of the sill by OWL has been recommended and is part of routine monitoring.

Figure 20 Stilling basin

7 Auxiliary spillway

7.1 Fuse plug and channel

The auxiliary spillway appeared to be in satisfactory condition. The riprap on the upstream face and approach channel were in good condition.

Figure 21 Auxiliary spillway upstream face and crest

The pipe outlet of the right hand side fuse plug triggering device clay tile pipes was partially block by surrounding sand and vegetation.

Figure 22 Right hand side fuse plug triggering device clay tile pipes

It is recommended that this is cleared and any future blockages removed as they arise. The pipe outlets on the left hand side fuse plug triggering device clay tiles were clear. One of the pipe outlets on the LHS was broken but this is of no concern.

Figure 23 Left hand side fuse plug triggering device clay tile pipes

It is recommended that both triggering plugs are washed out to remove any debris that may be inside.

Routine spraying will continue in order to prevent establishment of vegetation on the fuse plug fill, particularly in the vicinity of the drain outlets.

The puddle on the left hand side of the invert of the auxiliary spillway channel was a similar size to that of previous years. OWL advise that they will be removing this puddle through pumping.

7.2 Left abutment cut slope

The left abutment cut benches, above the auxiliary spillway, are in good condition. The historical wedge failure downstream of the fuse plug shows no sign of recent movement. There were no further signs of significant movement on the slope.

Figure 24 Left abutment cut slope

Regular clearing of debris from the cut benches is suggested to avoid prior issues whereby stormwater runoff was concentrating and scouring the fuseplug. Periodic spraying of gorse on the benches is also suggested as part of the ongoing maintenance works. OWL advise that the extent of the helicopter spraying will be increased to include this area.

7.3 Upstream face area of interest

D18 collects seepage from under the auxiliary spillway true right wingwall concrete slab. At present, the origin of this flow is not known. However, there is an area of interest on the right hand side of the upstream face of the auxiliary spillway.

Figure 25 Area of interest on the upstream face of the auxiliary spillway

The area of interest is currently being investigated. Currently, there has been no indication of internal erosion as D18 flows show no visible sediment. There has been some evidence of increased leakage since grouting was carried out in 2000 (outlined in section 3.2.5.2).

The May 1999 Construction Report implies that this flow along the concrete slab drain may be due to the surrounding Type A Fill being more permeable than expected[3]. Drain D18 flow may also be a result of water flowing along the riprap/slab interface.

It is recommended that additional work is carried out to determine the origins of D18 flow. The extent and severity of the area of interest needs to be determined in order to assess whether the flows produced through D18 are of any concern.

RCM2013-10: Investigation into D18 flow path and visual monitoring of the area of interest on upstream face of auxiliary spillway.

[3] May 1999 Construction Report

8 Power station, tailrace and other ancillary structures

8.1 Powerhouse

The external and internal structure appeared to be in satisfactory and tidy condition. The powerhouse was viewed from the access platform and from around the base of the generator and turbine. No seepage was observed around the penstock pipe penetration through the station wall. Also no other internal leakage into the structure was observed. The power station and release valve were not operating at the time of the inspection.

Figure 26 Release valve

The seismograph that OWL currently possesses is not operational. Resource Consent CRC950579.3 requires the consent holder to devise and carry out a monitoring programme which measurers and reports on the seismic accelerations at the dam. It is recommended that a seismograph is set up in the powerhouse to allow for a more accurate reading of any future seismic movement at the dam location.

A standby generator was installed adjacent to the powerhouse. OWL advise that this will be commissioned by May 2013.

RCM2013-11: Installation and set-up of the seismograph.

8.2 Switchyard

Fencing and security appeared to be in a satisfactory condition.

8.3 Allandale pipeline

The two valves adjacent to the power station that control small diameter pressurised pipelines that run across the dam toe. The valves are covered by timber lids that are not vandal proof.

It has been identified that there is uncertainty regarding the status of the Allendale stock water pipeline. As-built drawings indicate that the Allendale stock water supply comprises a 100 mm diameter ABS pipeline running along the toe of the dam (length of ABS and other materials

unclear). The pipe is connected to the conduit in the vicinity of the Power Station and passes under the lower portion of the Service Spillway.

The valve to the Allendale line is usually shut and it is understood that the line is not currently used.

We suggest that the status of the pipe crossing the toe of the dam is clarified in accordance with recommendation RCM2010-04. Subject to the review, recommended outcomes could include repair, decommissioning, or clarification of maintenance responsibility. Additionally, we also suggest that all valves in the vicinity of the power station are secured against tampering by vandals.

8.4 Conduit Anchor Block AB2

Previous proof load testing undertaken on the conduit Anchor Block 2 (AB2) caused a failure to occur on one of the anchors at a load considerably lower than the rated bar capacity. During the period, the concrete anchor block was modified (additional concrete mass added) in order to provide an adequate gravitational force to resist unbalanced hydraulic forces on the bend of the conduit below.

Figure 27 Anchor block, AB2

A Completion Certificate and Code of Compliance have been issued for the completed anchor block modification.

A survey marker is yet to be installed on top of the anchor block. It is recommended that this is completed before the next deformation survey.

8.5 450 mm diameter conduit bypass

There is a 450 mm diameter bypass system to circumvent the conduit and enable discharge from the reservoir (via the FCD valve) when the conduit is closed (e.g. as would be the case during a conduit inspection). The intake for the 450 mm diameter bypass is 17 m away from the main conduit intake to enable safe access to the main conduit.

The 450 mm bypass system is controlled by a valve situated in a valve pit near the power station. We understand that OWL has successfully run this valve prior to the last inspection. OWL advise that the valve will be operated in preparation of the upcoming conduit inspection.

8.6 Conduit inspection

The main conduit that runs under the dam to the power station has not been inspected since construction. OWL advise that a conduit inspection is due to take place during the beginning of June. Documentation and requirements surround this are in the process of being prepared. A dive inspection and examination of the 450mm bypass conduit will be scheduled to occur before the inspection takes place.

9 Downstream weir

9.1 General

The Opuha Dam Downstream Weir (ODDW) is approximately 1.4 km downstream of the Opuha Dam and is physically separated from the main dam. The ODDW attenuates the flow released from the main dam and regulates the flow discharged to the Opuha River downstream. The key components consist of a radial gate, fixed spillway, fusible embankment and enclosure embankment. These are shown in Figure 28 below.

Figure 28 ODDW

The crest, part of the upstream face and downstream face of the right hand closure embankment were inspected. Monitoring instrumentation on the downstream weir and appurtenant structures include:

- Regulation pond water level recorder
- Flow meter through the weir
- Turbidity meter through the weir

The upstream and downstream faces of the embankment are in a satisfactory condition.

9.2 Downstream weir overflow embankment

9.2.1 General

The Downstream Weir Overflow Embankment (DWOE) is designed to fuse during a five year or greater Average Recurrence Interval (ARI) flood. The estimated five year ARI routed dam outflow is 100 m^3/s. The present DWOE was constructed in 2009 after it operated during high flows in May 2009.

Figure 29 Downstream face of overflow embankment and spillway

9.2.2 Recent embankment reinstatement

Areas of leakage on the downstream face of the overflow embankment were observed when the regulation pond was raised in order to achieve the desired flow during the flushing trial, performed February 2013. Reinstatement of this area was carried out during March 2013 by excavation and backfilling of sinkhole features on the upstream face. However, some areas of leakage still remain and alternative repair options are currently being investigated.

Figure 30 Seepage area on DWOE face.

Some minor seepage through the structure may be expected based on previous DWOE structures and prior precedent. The liner placed within the embankment has a life expectancy of 5 years with the silts and gravels used in construction having minor compatibility issues. Seepage through the embankment could be due to various reasons, such as disturbed material during repair or a leakage between the material interfaces.

Remedial works were undertaken on 28 & 29 March 2012[4], on the upstream face of the embankment. The Downstream Weir Overflow Embankment[5] letter outlines the procedure required to remediate the seepage observed during the inspection.

RCM2013-012: Repair the area of infiltration through the DWOE.

9.3 Enclosure embankment

9.3.1 General

The enclosure embankment appears to be generally in good condition. Localised areas of weed and gorse were observed on the upstream and downstream faces of the embankment. OWL advise that these will be sprayed and that they will continue to carry out their ongoing spraying regime to ensure that the gorse does not become established on, or in the vicinity of water retaining structures.

A boggy area was noted at a low point in the land just south of the embankment. We recommend that this patch is monitored on a regular basis for any change by OWL as it may be related to the embankment.

9.3.2 Embankment raise

A survey of the embankment carried out during the period indicated that the crest level was not at the original design level, 340.2 m RL. Maintenance of roading in the area was required which allowed for the crest level to be restored to its original design level during these works.

Figure 31 Downstream weir regulation embankment raise

[4] Opuha Dam Downstream Weir Overflow Embankment: Excavation and Backfill of Sinkholes on 28 & 29 March 2012, dated 15 April 2012, addressed to OWL from T&T

[5] Opuha Dam – Downstream Weir Overflow Embankment, dated 15 April 2013, addressed to OWL from T&T

9.4 Weir and control structure

The weir and control structure was generally in good condition. New safety cages had been installed around the ladders over the period. No issues around the repair to the gabion baskets carried out in the 2010-2011 period have been reported.

The concrete weir spillway is in a satisfactory condition, with a few logs having accumulated at the base of the spillway. Inspections of previous years identified a number of small continuous horizontal cracks in the spillway face, as well as occasional small surficial spalls. These features do not appear to have significantly changed in the last year.

Figure 32 Service spillway

The concrete and stone armouring on both banks is generally in satisfactory condition. It was previously noted that the mass concrete beyond the end of the chute right hand training wall (beyond the toe of the ogee weir) is at least partially undermined. This remains unchanged since the previous period but ongoing monitoring of this area by OWL is warranted.

Figure 33 Undermining of chute

Cracking of the concrete wall next to the control shed previously reported has not appeared to have moved during the period.

Figure 34 Cracking of concrete wall

The DC back up for the operation of the radial outlet gate had operated recently and appears to be working as required.

9.5 Flushing trial

A flushing trial was carried out during the period on 13 February 2013. Flows up to 32m^3/s were recorded during the trial. OWL reported that there were no adverse signs of damage or accelerated wear at the weir directly after the trial. No long term effects were evident on the day of the inspection.

9.6 Downstream weir upgrade

The DWOE has overtopped and has fused on two occasions (2002 and 2009). Due to implications around the embankment fusing, OWL has decided to implement works in order to enhance the discharge capacity of the spillway facilities at the downstream weir prior to the fusing of the Overflow Embankment.

New works will take place on the right hand side of the enclosure embankment separate from the existing gate structure. A water level recorder will be required to monitor flow out of the new structure. T&T recommend that the current river flow recorder located approximately 60 m downstream of the outlet gate remain as is and a new recorder be installed at the new location. This will allow for monitoring of flows from both structures.

The elver pass currently located at the radial gate will also be required to be moved to the new gate location.

10 Access road

10.1 Access to dam

The maintenance of the access road to the dam is the responsibility of the District Council, including removal of slumps from the batters on the west side of the access road leading to the dam. Road access was clear at the time of the inspection.

10.2 Dam road

The dam road was generally in good condition, with a few potholes on the road above the service spillway. OWL is responsible for maintenance of the road down the dam face and has advised that these will be filled in and maintained.

Figure 35 Dam road pothole

The dam crest road has a safety barrier on the upstream edge. In addition, public access is restricted by a locked chain with signage.

Access to the powerhouse and downstream weir were clear at the time of inspection.

Some scour has occurred on the downstream face below the road due to surface water runoff. This is an issue that relates to the grading of the road by the contractor (slope of the road, extent of swale and extent of longitudinal bund along the outside edge). OWL advise that they will continue to monitor the grading of the road.

Figure 36 Scouring of downstream face

RCM2013-13: Ongoing visual monitoring of the area of scour on the downstream face of the dam, below the road.

11 Recommendations

11.1 2013 recommendations

Dam safety recommendations arising from the 2013 inspection are collated below in Table 10.1. The recommendations are numbered and, referenced to the section in this report where they arise and are categorised as:

- N (Necessary) to be done as a priority (within 12 months) or regularly
- D (Desirable) to be done at a suitable time before the next Comprehensive Safety Review (CSR).

Table 10.1 Opuha Dam 2013 Annual Review recommendations

Reference	Report section	Recommendation	Category
RCM2013-01	3.2.2	Investigate an alternative method for accurately measuring sediment flux from the drains and collection of samples for particle size distribution analysis.	N
RCM2013-02	3.2.4.1	Particle size distribution analysis of D10.	N
RCM2013-03	3.2.4.2	Installation of an automatic turbidity monitoring system on the chimney drains.	N
RCM2013-04	3.2.5.1	Revision of the Alert Level for D21.	N
RCM2013-05	3.3.3	Replacement of broken piezometer gauges.	N
RCM2013-06	3.4	Regular readings of the standpipe in the toe remediation.	D
RCM2013-07	3.5	Outstanding deformation survey to be undertaken as soon as practical.	N
RCM2013-08	4.3.1	Investigation into source of wet patch on downstream face of Dam.	N
RCM2013-09	5.2	Requirements for the outstanding dive inspection be confirmed, and the inspection undertaken as soon as practical.	N
RCM2013-10	7.3	Investigation into D18 flow path and visual monitoring of the area of interest on upstream face of auxiliary spillway.	N
RCM2013-11	8.1	Installation of the seismograph.	N
RCM2013-12	9.2.2	Repair the area of infiltration through the DWOE.	D
RCM2013-13	10.2	Ongoing visual monitoring be undertaken by OWL of area of scour of downstream face of the Dam, below the road.	N

11.2 2013 suggestions

Some general suggestions regarding the maintenance of the dam have also been provided for consideration by OWL as summarised below:

- Complete Certification of intake tower crane
- Ongoing cleaning of H flumes
- Ongoing monitoring of sill and chute erosion of service spillway chute and stilling basin
- Testing and establishment of the condition of the pneumatic piezometer readout box.
- Secure all valves in the vicinity of the power station against tampering by vandals.

11.3 2012 CSR recommendations

The 2012 CSR highlighted some issues around dam safety that required action. OWL is currently following through with the recommendations. Recommendations that have not yet been actioned are shown in Table 10.2 below. All other recommendations have either been completed or have been actioned. A full list of the conclusions reached during the completion of the DSR are stated in the June 2012 Opuha Dam Safety Review Report[6].

Table 10.2 Opuha Dam unactioned CSR recommendations

Recommendation	Comment	Current status
Develop a dam safety assurance programme that meets the requirements of the Building (Dam Safety) Regulations	OWL's current Dam Safety Assurance Programme meets current NZSOLD Guideline requirements and will be expanded for new Regulations.	Not actioned
Complete a Failure Modes and Effects Analysis (FMEA) before the next CSR.	This will be coordinated after upgrade of the DSW spillway project.	Not actioned
Undertake and document regular exercises to test emergency procedures and provide emergency personnel with appropriate training.	Regular training exercises will ensure that personnel are aware of their responsibilities and are familiar with all emergency procedures.	Not actioned
Install an intruder detection/alarm at the spillway gatehouse.	To reduce/manage the risk of intrusion and vandalism.	Not actioned
Install an intruder detection/alarm at the re-regulation gatehouse.	To reduce/manage the risk of intrusion and vandalism.	Not actioned
Install a log boom across the front of the radial gate outlet structure.	To improve public safety.	Not actioned

11.4 Previous Annual Inspections

The current status of all recommendations are based on advice provided by the Operator (OWL).Outstanding recommendations arising from the inspections of 2008-2011 are presented below in Table 10.3.

6

Table 10.3 Opuha Dam 2011 and earlier Annual Review recommendations

Reference	Recommendation	Category	Current status
RCM2011-01	Hydraulic piezometer gauge calibration factors to be checked and gauge maintenance works to be undertaken. Pneumatic piezometer leads to be repaired and rehoused.	D	In progress
RCM2011-03	Requirements for the outstanding dive inspection be confirmed, and the inspection undertaken as soon as practical.	D	Scheduled May/June 2013
RCM2011-06	Routine maintenance to ensure that the inlets to the fuse plug triggering device clay pipes are kept clear of debris.	N	Maintenance ongoing
RCM2011-09	*Ongoing visual monitoring be undertaken by OWL of wet spot on DSWOE*	N	Ongoing
RCM2010-01	Complete a comprehensive review of the hydraulic piezometer system and identify necessary upgrade and maintenance works (e.g. gauge calibration, consideration of a requirement for a control gauge, review of bladder and the like).	D	In progress
RCM2010-03	Clear fuse plug triggering device clay tile outlet pipes and maintain these pipes free from blockage.	N	Completed. Maintenance ongoing.
RCM2010-04	Review status of Allendale water supply pipe line and ensure all valves in the vicinity of the power station are secured against tampering by vandals.	D	Outstanding
RCM2009-01	Develop and implement an investigation procedure to determine the source of seepage emerging at the embankment face near Drain D16.	N	Ongoing
RCM2009-08	Spray gorse on the Downstream weir closure embankment	N	Maintenance ongoing
RCM2008-18	The guide rope between the SW tower leg and the bypass valve should be reinstated and the bypass valve then inspected. (3.2)	D	Outstanding
RCM2008-19	The location of the bulkhead valve handle should be established or a new handle obtained (3.2)	D	Outstanding
RCM2008-20	The loose steel bar/plate at the NE tower leg splice should be further investigated during the next diver inspection in 2010. (3.2)	D	Outstanding
RCM2008-28	The damage to the spillway basin downstream sill should be repaired with concrete. The use of mesh reinforcement or alternatively fibre reinforced concrete is recommended to reduce the chance of further damage, preceded by clearing off all loose rock and growth. (4.1)	N	Ongoing monitoring occurring

RCM2008-32	The damage to the tailbay concrete should be investigated in greater detail to assess the effects and consequences and determine whether immediate repairs are required. (5.3)	N	Outstanding
RCM2008-37	Debris should be regularly removed to prevent it from becoming stuck in the gate. (6.3)	N	Debris removed August 2008. Monitoring ongoing

12 Conclusions

The annual safety inspection for Opuha Dam was undertaken on 26 March 2013 in accordance with the NZSOLD Dam Safety Guidelines (2000). The inspection was undertaken by Tonkin and Taylor and accompanied by the Owner. The dam is in satisfactory condition.

The report also presents the findings and recommendations from the inspection and also reviews data gathered in the last year from the dam monitoring instruments.

Many of the recommendations from the CSR report and previous annual inspections have been actioned or are in the process of being implemented. Further dam safety related recommendations have been made as a consequence of the 2013 annual inspection. These recommendations are as listed in Table 10.1 above.

Some general suggestions regarding the maintenance of the dam have also been provided and listed in Section 10.2.

13 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.

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