7. Mechanical and Electrical Works

7.1 Introduction

As outlined in section 5.3, we believe that the plant items critical to dam safety are:

- *The service spillway gates including their operating equipment and power supplies*. Gate lowering is essential for the passage of floods.
- *The bypass valve including its operating equipment and power supplies*. Valve operation is important for lowering the pond level in response to a dam safety emergency.
- *The radial gate installed in the re-regulation pond outlet structure, including its operating equipment and power supplies.* Although the re-regulation pond is a "low" PIC structure, gate opening is important for lowering the pond level in response to a dam safety emergency.
- *The control and communication systems necessary for operation of the above facilities.* The performance reliability of these systems is critical for an automatic and remotely controlled facility.

7.2 Mechanical and Electrical Inspection

Observations made during our site inspection on the 23rd of March 2012 are summarised in table 7.1. The weather was initially foggy and then cloudy, and mild with no wind. The Opuha reservoir level was RL390.19m and remained fairly constant throughout the inspection. The re-regulation pond water level was RL338.17m and the radial gate was discharging $12m^3/s$.

Table 7.1: Site Inspection

Feature	Remarks
Spillway Gates	
Access	Easy access from State Highway 79 via Trentham Road and the unsealed Opuha dam road.
Power Supplies	A 100kVA, 33/0.4kV pole mounted transformer connected to the 33kV line feeds the powerhouse 400V switchboard, from which a 400V cable feeds the gatehouse equipment.
Security	The gatehouse has no intruder alarm, but has a robust metallic padlocked door. There is however a CCTV camera mounted on a pole in the parking area on the right abutment, which can be panned and zoomed, with a display at the TrustPower Control Centre.
Gates	Appeared to be in reasonably good working condition.
Gate Controls	Looked in good working order inside the gatehouse, but they are known to be unreliable.
Bypass Valve	

Feature	Remarks
Access	Down a rung ladder from the powerhouse area.
Power Supplies	Hydraulic power supply required for operating the two servomotors is provided by a hydraulic pumping set inside the powerwhouse.
Security	Locked gate.
Valve	In excellent working condition.
Valve Controls	Installed on top of the hydraulic pumping set. In excellent condition.
Radial Gate (Re-regulation Pond)	
Access	Via a metal road from the powerhouse area, which crosses Gooseberry Stream as a ford and continues along the left bank of the river.
Power Supplies	A 400V buried cable from a 11/0.4kV transformer on the right bank of the river between the powerhouse and the re-regulation pond.
Security	No intruder alarm; just a robust metallic padlocked door to the gatehouse.
Gates	The radial gate appeared to be in good orprating condition.
Gate Controls	In good working order.

7.3 Spillway Gates

7.3.1 Access

Opuha dam can be reached from SH 79, a 4.5km sealed road (Trentham Road) and a 2.5km long unsealed road (Opuha Dam Road).

7.3.2 Security

The gatehouse on the right abutment of the spillway, which houses the air compressor and controls for the spillway gates, has a metallic padlocked access door but no intruder detection/alarm. However, in the car park on the right abutment there is a pole-mounted CCTV camera which can be panned and zoomed. A visual display for the camera is installed at TrustPower's Control Centre.

Asset Management Recommendation - Install an intruder detection/alarm at the spillway gatehouse.

7.3.3 Function, Design and Description

The primary functions of the spillway gates are to increase the storage of the reservoir by 7.3 million cubic metres and to discharge flows during a flood event to maintain the reservoir level below RL391.7m. To enable the discharge of extreme flood events, the gates must be fully lowered whenever the reservoir level exceeds RL391.7m.

Each flap gate is fabricated by assembling 3.0m long, 1.15m wide, 12mm thick, 6m radius curved steel plates. Each flap gate plate features ten 12mm thick, 50mm high ribs, acting as stiffeners, equally spaced and welded to the upstream face. A flat bar is centrally located on each plate and extends above the top edge of the plate to break the nappe flow over the gate and allow air entry to the underside of the nappe, thereby preventing nappe instability and load variations on the gate.

The gap between adjacent steel plates is bridged by a reinforced rubber strip held in place by steel flat bars bolted onto the flap gates. The seals at the ends of all gates are provided by rubber strips that the reservoir water presses against stainless steel plates embedded on the concrete abutment walls and bridge piers. The gates are hinged by clamp bars that are anchored to the spillway crest.

The flap gates are designed to sustain safely up to 0.3m of water flowing over their top edges. The gates have also been designed to sustain stresses induced by the OBE, without exceeding 80% of the yield stress, and the MDE without exceeding 100% of the yield stress.

The gates appeared to be in good working condition, apart from a bolt missing from one of the steel bars that clamp the rubber strip between two central flap plates.

The flap gates have slots in the concrete walls upstream but no stoplogs are available. Obviously any maintenance/inspection of the flap gates is completed when the reservoir level is below the spillway crest.

7.3.4 Actuation and Release Systems

Lifting/lowering of each flap gate is effected by reinforced rubber bladders (one under each panel) which are inflated/deflated by admitting/discharging compressed air in/from the bladders. One side of each bladder is folded and clamped to the bottom edge of the gate plate, thereby performing the functions of both seal and hinge. Restraining straps (two per plate), made of reinforced rubber, are clamped on the back of the plates and to the spillway crest so as to prevent the gates from rotating in the upstream direction.

The air bladders for each gate are connected to a pneumatic control system by an individual steel pipe running from the pneumatic control panel in the gatehouse, through the spillway abutment wall, and beneath the spillway crest to the underside of the bladder.

The bladders are inflated/deflated automatically, or manually, under the control of a directional control valve that controls the pressure in the bladder, and hence the position of the flap gates, according to the reservoir level measured by a bubbler device. This is essentially an open loop control system which should be reasonably stable given the relatively long constant of time of the controlled variable (reservoir level) and the controlling element (flap gates). However, the reliability of the automatic control system, as well as the backup control system, has been questioned by Opuha Water management. As a result, the additional storage capability is not currently being used pending the completion of corrective actions to restore confidence in the reliability of the gate control system.

Since commissioning the re-regulation pond overflow embankment has breached on two occasions (2002 and 2009). We assume that both breaches were initiated by large flood events in the river system, not by incorrect operation of the flap gates. However, incorrect operation of the flap gates could result in a discharge sufficient to increase the level of the re-regulation pond and fuse the overflow embankment. The risk that incorrect operation of the flap gates could fuse the overflow embankment obviously increases with high water levels in the re-regulation pond.

While a breach of the overflow embankment does not appear to have great safety consequences, it does result in a financial loss for repairing the embankment.

The flap gate control system has two lines of defence against incorrect operation if the automatic control system fails to lower the gates:

- The PLC automatic control which should operate the deflating solenoid.
- Direct manual local control by operating the isolation and the manual deflating valves.

Obviously direct manual local control involves a time delay, since the station is not manned and the on-call operators may not arrive on site until one hour or more after the detection of the control malfunction. Additionally, in adverse weather conditions, access to the site may be very difficult.

There is also a third line of defence but its effectiveness is limited. The pressure relief valve, connected to each air line to the bladders, will discharge air automatically from the bladders when the reservoir level increases well above the top edge of the flap gates. However, the technical documentation does not provide any indication of the extent of gate lowering achieved by these pressure relief valves for the possible range of reservoir levels.

We believe that possible scenarios that could lead to incorrect gate operation and a failure of the overflow embankment are:

- A failure of the normal automatic gate control and the backup control system, followed by an excessively fast manual lowering of the gate, resulting in too high a discharge into an already full re-regulating pond.
- A failure of the normal automatic gate control, followed by operation of the backup control, but with the latter being either delayed by a wrong set point or inaccurate components, or being operated at the right set point but resulting in too high a discharge into an already full re-regulating pond.

A simple solution to fix an excessive discharge, caused by operation of the backup control system, would be to throttle the air discharge from the solenoid valve and initiate pre-emptive lowering of the re-regulation pond. However, the troubleshooting should be simply a matter of focusing on the bubbler driven automatic control, and the backup automatic control effected by the hydraulic structure PLC once the input of the reservoir level transducer exceeds the set point that should trigger the deflate solenoid.

Of course the troubleshooting should have an holistic approach aimed at checking all aspects that influence the operability of the normal and backup controls, including power supplies to the PLC and solenoid valves, settings, transducer accuracies, control valve responsiveness, etc. Possibly the investigation should be complemented by a hydraulic model simulation to assess the hydraulic transients for various initial levels of the re-regulation pond.

7.3.5 Power Supplies

The power supply to the equipment installed in the gatehouse is provided by a 400V cable from the station 400V switchboard. There is no redundancy of power supply.

7.3.6 Control and Communication Systems

The spillway gates are automatically controlled by the Obermeyer actuator as a function of the reservoir level or, as a backup, by the Hydraulic Structure PLC which is housed in the powerhouse. It is important to note that the Hydraulic Structure and the Station PLC are combined and located in the powerhouse.

It should be noted that when the flap gates are automatically controlled they are raised and lowered simultaneously, because in automatic control there is one single actuator that drives one single control valve which regulates the pressure in the distribution manifold to which all three gate pipelines are connected. However, it should be noted that by using the manual isolation valve on each pipeline one or two, or all of the gates can be excluded from the automatic control. In manual control the gates can be operated individually.

The compressed air for operating and controlling the spillway gates is provided by a two stage compressor, air receivers, an automatic gate control panel, an air distribution control panel and two water level bubblers. It should be noted that the loss of compressed air is failsafe in the sense that the flap gates will lower.

One bubbler provides the reservoir level input, in the form of air pressure, to a pneumatic actuator whose elastic displacement drives the spool of a directional valve which, in turn, directs air to the gate bladders to inflate them or exhausts air from the bladders to deflate them. This is control Mode I, which is the normal automatic control mode to maximise water storage. The time required to fully raise the gates is 60 minutes.

The second bubbler provides the reservoir level input to the gate PLC whose logic can override the automatic control by energising a 24v dc solenoid valve for deflating the bladders. This is control Mode II, which is the control required as a pre-emptive measure to lower the gates fully in response to a warning of a large incoming flood, or whenever the reservoir level reaches RL392.4m. The time required to fully lower the gates is 10 minutes.

Additionally the gate bladders can be individually raised or lowered by manually operating the relevant isolation and exhaust valves located on the air distribution control panel. A pressure relief valve on each branch to the bladders limits the maximum pressure in the bladders if the automatic controls fail to lower the gates.

An investigation into the performance of the flap gate control system was initiated by Opuha Water in November 2011. A report was produced (ref. 31) and concluded:

- Abandon the use of the flap gates for increasing storage, or
- Install a dedicated PLC at the gatehouse and use a simple water level float switch to trigger the lowering of the gates, and accept the necessity of carrying out regular checks, testing and maintenance.

The initial conclusion is not justified without an in-depth and detailed analysis of the gate control system. The second conclusion is in line with current best practices (ie installation of the Hydraulic Structure PLC and its UPS at the hydraulic structure gatehouse), but it fails to address other causes leading to unreliable or simply poor control due to hardware, logic, setting, power supply, etc.

The following telecommunication media are in place for data and control:

- Two fibre optic cables from the re-regulation pond gatehouse to the powerhouse, connecting the re-regulation pond PLC and its CCTV to the power station PLC and Citect Server.
- A point to point radio link between the main dam right bank CCTV and the station MOXA Switch.
- Ethernet and serial cables inside the powerhouse.
- A TelstraClear link to TrustPower's Control Centre in TeMaunga.
- A backup satellite link between the power station and TrustPower's Control Centre in TeMaunga.

There is no telephone in the gatehouse, but a land line phone is available in the powerhouse. It was successfully tested during the inspection by ringing the TrustPower Control Centre in TeMaunga.

A CCTV, with zooming and panning capability, has been installed on the pole located on the right abutment of the dam. This allows the Control Centre operator to see on a screen the gates and any water spilling over them. However, it should be remembered that the TrustPower Control Centre in TeMaunga has only a single operator on shift whose duty is to monitor and control remotely more than twenty power stations (with a total of sixty generating units), thus the time that he/she can dedicate to monitoring and controlling a flood at Opuha dam may, at times, be inadequate.

7.3.7 Testing

At the time of the site inspection the reservoir level was below the spillway crest and the only test completed was the manual raising and lowering of the gate closest to the right hand abutment. On reflection, more time should have been allocated to the inspection and test, and an engineering technician should have been on site with equipment to alter the analogue signal from the reservoir level transducer and verify the performance of the PLC backup control by simulating a reservoir level in excess of RL392.4m.

7.3.8 Conclusions

The gatehouse is in reasonably tidy condition, but its remoteness warrants an intruder detection/alarm system.

The flap gates are in good working order, but their control appears to be unreliable, or simply wrongly set. There have been two breaches of the re-regulating pond overflow embankment since commissioning; however, it is not clear whether the breaches were initiated by flood events in the catchment, malfunctions of the PLC backup control hardware or the PLC logic, or excessively fast air discharges from the deflating solenoid resulting in a rapid lowering of the gates.

An investigation initiated by Opuha Water at the end of 2011 has identified some problem areas in the gate control system, but has not covered all possible causes of unreliable gate operation (eg simply wrong control settings). The risk posed by the gate control system is currently being managed by not lifting the flap gates, thereby not reaping the benefit of increased water storage for irrigation.

We believe that an in-depth investigation into the cause(s) of the gate control problems should be completed by a control systems expert and that the necessary remedial actions should be implemented.

7.4 Bypass Valve

7.4.1 Access

As described under Section 7.3.1.

7.4.2 Security

The valve is inherently secure given its location and robustness; however, intruders/vandals could damage its hydraulic flexible hoses, or the position transducer, by reaching the valve platform from outside the station fence and down the rung ladder. A simple solution would be to install a removable and lockable means to prevent unauthorised rung ladder access.

Asset Management Recommendation - Install a lockable and removable means for preventing unauthorised access to the bypass valve platform.

7.4.3 Function, Design and Description

The fixed cone disperser valve functions are to bypass discharges during outages of the 7MW generating unit, and to lower the reservoir level in response to a dam safety emergency.

The valve is designed to discharge $16m^3/s$ to the downstream river when it is fully opened and under 52m of head. The valve axis is inclined 15º downwards and is located approximately nine metres directly above the centreline of the turbine outlet. Most of the hydraulic energy of the water discharged through the valve is dissipated in the air above tailwater level.

The valve seal is achieved by the bevelled end of the sleeve being pressed against a rubber seal mounted on the sleeve seat at the base of the cone.

The design of the valve is in accordance with current best practice. It requires no lubrication and a very low level of maintenance.

While there are two sets of the fixed cone valve description in Volume 2 of the Station Manual, the fixed cone valve drawings are missing.

7.4.4 Actuation Systems

A position transducer, coupled to the valve sleeve, provides the position of the valve as an analogue input to the station PLC. When the bypass valve is opened a siren is activated to warn any member of the public or staff in the vicinity of the valve.

The valve cylindrical sleeve is operated by two oil hydraulic cylinders fixed on the upstream flange of the valve, with their piston rods coupled to the sleeve ring which slides on radial ribs.

Oil from the 84bar hydraulic pumping set installed beside the turbine (comprising two 5.5kW electric motor driven pumps and two bottles of N_2 charged oil accumulator) is controlled by an isolation servo valve and by a three position, four port directional solenoid valve, with the spool also operable by hand. A small N_2 oil accumulator, downstream of the directional valve and pilot check valves, ensures that the servomotor piston's position is maintained when the directional valve is in the neutral position.

7.4.5 Power Supplies

The power supply required for operating the fixed cone valve is from the station 400V switchboard. The valve sleeve position transducer 24V dc supply is from the station 110Vdc-24Vdc converter distribution board.

7.4.6 Control and Communication Systems

The valve position is controlled by the three position, four port directional valve either by energising its coils via the station PLC, or by pushing manually the directional valve spool in the opening or closing direction.

The position of the valve is transmitted to the station PLC by twisted pair cable.

There is no dedicated telephone by the fixed cone valve.

7.4.7 Testing

The fixed cone valve was not tested during the site inspection because documented evidence (photographic and from the station data logger) was provided to confirm its operation on the 9th of October 2011 (opened up to 60%), on the 22nd, 24th, 27th and 28th of February 2012 (opened up to 70%), on the 24th of March 2012 (opened up to 100%), and on the 27th of March 2012 (opened up to 68%).

During the inspection the valve was closed and no water leakage was visible.

7.4.8 Conclusions

The fixed cone bypass valve is inherently secure given its location and robustness; however, some additional security would minimise the potential for damage by intruders or vandals.

The valve is in very good working condition.

7.5 Radial Gate (Re-regulation Pond)

7.5.1 Access

From the power house an unsealed road leads first to the Gooseberry Stream ford and then along a flat on the left bank of the river to the left abutment of the re-regulation pond overflow embankment. Access to the radial gate gatehouse is then by foot across the crests of the overflow embankment and spillweir.

The gatehouse can also be accessed via a track, that leads to the right bank of the river, and the crest of the closure embankment.

7.5.2 Security

Access to the circular concrete gatehouse is through a robust metallic padlocked door. There is no intruder detection/alarm system.

A CCTV is mounted on a pole beside the gatehouse.

There is no log boom across the front of the radial gate intake to protect the public from the outlet structure.

Asset Management Recommendation - Install an intruder detection/alarm at the re-regulation gatehouse.

Asset Management Recommendation - Install a log boom across the front of the radial gate outlet structure.

7.5.3 Function, Design and Description

The 2.9m wide, 1.6m high, radial gate features a 12mm thick skinplate that transmits the water thrust via three vertical 16mm thick steel ribs and three horizontal 12mm thick steel ribs to two 150x150x5 RHS sections which form the gate arms on each side of the gate. The gate arms transmit the thrust to gate bearings which are bolted to a horizontal gate support beam spanning between the buttress walls of the outlet structure.

The gate side and top seals are made of music note solid rubber, pressed against seal plates embedded in the walls and top lintel, whereas the bottom seal is made of a flat rubber strip clamped on the edge of the skinplate and butting on a stainless steel flat bar embedded in the concrete floor.

Three spacer blocks bolted on each side of the gate keep the gate centralised with 5mm clearance from the stainless steel plates on each side.

The radial gate has no slots for stoplogs. However, this is not a great limitation since any leakage past the gate is inherently tolerable given the irrigation and minimum compensation flow requirements. Any major repairs to the gate would necessitate either the removal of a section of the overflow embankment or the installation of a bulkhead on the upstream face of the outlet structure.

7.5.4 Actuation Systems

The gate is lifted by a single hydraulic cylinder located centrally above the gate and hinged on a solid bracket anchored to the upstream concrete wall, with its piston rod connected to the top of the gate.

The oil necessary to operate the gate servomotor is provided by a pumping set, housed inside the circular gatehouse on the right hand side of the outlet structure, comprising a 3kW 400V ac motor driven pump, a 0.37kW, 24V dc motor driven pump and a 10ltr N_2 charged oil accumulator.

A three position, four port solenoid valve (with hand control of the spool) controls the position of the servomotor piston and hence the gate. The gate is held in the selected position by a pilot check valve. A piston position transducer is an integral part of this servomotor and transmits the gate position as an analogue input to the station PLC.

7.5.5 Power Supplies

The source of ac power supply for the re-regulation gate pumping set and auxiliary equipment inside the gatehouse is not shown on any drawing and there is not sign of overhead lines in the vicinity of the gatehouse. However, we understand that the supply comes from a pole-mounted 11/0.4kV transformer located near the pump shed half way down the true right bank of the river from the powerhouse. The 11kV line that feeds that transformer is owned by Alpine Energy. A buried 400V cable runs from the transformer, beneath the river and along the left bank of the river to the gatehouse.

The 24Vdc supply is provided by a 100Ah battery bank and battery charger installed in the gatehouse. During the inspection it was noted that the two 12V batteries contained in the cabinet were not securely clamped and could be damaged during an earthquake.

Asset Management Recommendation - Secure the two 12V batteries contained in the cabinet located in the re-regulation pond gatehouse.

7.5.6 Control and Communication Systems

The position of the radial gate can be controlled locally by pushing the open or close buttons on the control panel, or remotely via the PLC installed in the re-regulation pond gatehouse thereby energising the open or close solenoids of the three way, four port directional valve, installed on top of the hydraulic pumping set. At the time of our inspection the displays on the gatehouse control panel indicated that the pond was 3.25m above the sill of the gate and that the gate was 40% open.

There is no telephone installed in the gatehouse.

A laminated hydraulic schematic diagram is available inside the gatehouse along with a laminated operating procedure.

7.5.7 Testing

No test was completed during the site inspection as the gate is frequently operated for the day-to-day management of discharges to the downstream river.

7.5.8 Conclusions

The mechanical and electrical equipment for the radial gate are in good operating condition. The gatehouse is kept very tidy, but its remoteness warrants an intruder detection/alarm system.

8. Operation, Maintenance and Testing

8.1 Introduction

Operation and maintenance requirements for the facility are detailed in an operation and maintenance manual (ref. 1). The manual was completed in 1999 and includes:

- An outline of key aspects relating to the safety of the dam.
- An outline of personnel requirements for management of the facility.
- Annual, five-yearly and unusual inspection requirements.
- Routine surveillance requirements.
- Reservoir and flood management requirements.
- Maintenance requirements for the main dam, service spillway, auxiliary spillway, intake tower, low level conduit, powerhouse, powerhouse tail bay and re-regulation pond facilities.
- Dewatering and re-watering procedures for the low level conduit and powerhouse tailbay.

The manual includes no procedures for the operation, maintenance and testing of the service spillway gates, the bypass valve, and the radial gate facility included in the re-regulation pond.

The human resource dedicated to the management, operation and maintenance of Opuha dam is very limited in number, both because the hydropower plant is automated and remotely controlled and because its operation and maintenance is contracted out.

In addition to the Chief Executive Officer, there are three permanent staff members plus one temporary staff member, noting that one of the permanent staff members is an administration officer and another is a raceman looking after the irrigation canal reticulation. As a result there are only two staff members, additional to the Chief Executive Officer, who are available for the management, operation and maintenance of Opuha dam. The permanent staff member is on call all of the time.

Asset Management Recommendation - Review the adequacy of in-house and contract operation resources, and enhance the resources to address any identified deficiencies.

8.2 Operation

Prior to October 2011, the Opuha dam facilities were remotely controlled and monitored on contract by Contact Energy from their Control Centre at Clyde power station. Since that date the facilities have been remotely controlled and monitored, on contract, by TrustPower from their Control Centre in TeMaunga. It should be noted that the TrustPower operator, who is expected to intervene in case of necessity, is based in Darfield which is approximately a 2.5 hour drive from the dam site.

An electrical contractor based in Pleasant Point, which is approximately one hour's drive from Opuha dam, is retained by Opuha Water to carry out checks twice a week at the powerhouse and re-regulation outlet structure and is on call to carry out manual operation of hydraulic structures when necessary. However, the permanent staff member and the temporary staff member at Opuha Water are also capable of manually operating the flap gates and the re-regulation radial gate. In addition, Opuha Water's management and staff can remotely monitor the operational condition of the plant.

Two existing staff members attended a dam surveillance course run by Damwatch in Wellington. There are no other records of operator training and competence certification for carrying out operational procedures at Opuha dam, both for Opuha Water staff and TrustPower personnel.

Asset Management Recommendation - Ensure in-house and contractor staff with responsibilities for operation of Opuha dam are properly trained and their competencies are assessed and documented.

During our site inspection we noted that an operating procedure was in the re-regulation gatehouse for operation of the radial gate, but that there was no operating procedure in the service spillway gatehouse for operation of the flap gates.

Asset Management Recommendation - Prepare flap gate operating procedures and include a copy of the procedures in the spillway gatehouse.

8.3 Maintenance and Testing

Opuha Water's maintenance regime is reactive and any maintenance or repair works are only undertaken when essential. Accordingly, there is no specified testing for the flap gates or the automatic backup to deflate the bladders when the reservoir water level exceeds the setpoint at which the PLC should energise the deflating solenoid valve. In addition, while the bypass valve has been operated on a number of occasions during the last two years, there is also no specified testing for the bypass valve.

This maintenance regime is uncharacteristic in the hydropower industry and at variance with the recommendations included in NZSOLD's Dam Safety Guidelines. Regular testing should be completed for all plant critical to dam safety and the test results should be documented.

Dam Safety Recommendation - Establish and implement a program for the inspection and testing of plant critical to dam safety.

8.4 Conclusions

Operation and maintenance resources and training are not in accordance with good practice, and procedures for the operation, maintenance and testing of plant critical to dam safety are not well documented.

An independent review of operation, maintenance and testing resources and practices should be commissioned, and the identified shortcomings should be addressed.

9. Emergency Management Procedures

9.1 Introduction

Opuha Water has structured and documented its emergency management procedures in an Emergency Action Plan (EAP) (ref. 26). The plan documents:

- Responsibilities of various agencies including the Operator, the Owner and the Owner's Dam Safety Consultant.
- Definitions of emergency situations and unusual occurrences, including their notification to various agencies.
- Actions to be followed during an emergency or unusual occurrence.
- Communication responsibilities, communication systems and notification procedures.
- Site access routes and times.
- Response procedures during periods of darkness or adverse weather.
- Sources of equipment and materials.
- Supporting information including discharge ratings, inundation plans and procedures for testing and modifying the EAP.
- A series of standard operating procedures for the Operator, the Owner, the Owner's Dam Safety Consultant and external emergency management agencies.
- A series of appendices that include an emergency notification form, a notification flow chart, contact details, and ring lists for property owners that could be affected by an emergency.

The EAP is primarily concerned with the uncontrolled release of water which could be caused by floods, earthquakes, sabotage or operational errors. Plant emergency situations such as fires, explosions, hazardous spills, serious accidents or fatalities are not included.

Copies of the EAP were available in the powerhouse and at Opuha Water's offices in Pleasant Point. We assume that copies of the EAP are also held by TrustPower (the Operator) at their Te Maunga office and at Coleridge Power Station.

9.2 Procedures

We have reviewed the EAP and offer the following comments:

- The document provides guidance on responding to a potential dam safety emergency. It includes procedures for the identification and evaluation of a potential dam safety emergency, procedures for declaring an emergency situation and actions for responding to an emergency situation. The procedures enable a quick initial response to a developing dam safety emergency and, as such, are considered to be appropriate.
- It makes no reference to a location where an emergency response would be coordinated. We assume that the initial response to any dam safety emergency

would be coordinated at Opuha Water's Pleasant Point office. As such, the office should include emergency equipment and appropriate resources (maps, drawings, documents, communication equipment and emergency equipment) for responding to a dam safety emergency.

- It includes information on the management of flood events but should be expanded to include spillway gate operating procedures, an overview of the gate control systems and power supplies, and detailed procedures for inspection during and following a large flood event.
- It should be expanded to include post-earthquake inspection procedures and detailed post-earthquake inspection check-lists.
- It is important that the EAP is accurate, that contact details are correct, that personnel with emergency responsibilities are aware of the requirements of the EAP, and that the plan is tested on a regular basis. The EAP provides comment on testing of the plan and modifications to the plan, but includes no frequencies for the review of notification checklists, refresher briefings for personnel with emergency responsibilities, periodic reviews of the plan and briefings to control room personnel, and operational tests.

We appreciate that the EAP is outdated and that it requires revision to reflect the change in Owner and Operator. While the existing EAP provides a framework for the management of dam safety emergencies, some urgency should be given to completing and issuing a revised document.

9.3 Resources

While contact details for specific personnel are included in the EAP, it does not nominate specific personnel to fulfil key emergency management responsibilities (eg the Emergency Manager, the Operations Manager, the Dam Safety Adviser).

We understand that TrustPower personnel can be on site within 2.5 hours, and that Opuha Water and TrustPower personnel are on call at all times. The shortage of operational personnel in Opuha Water would necessitate the importing of backup personnel to resource a continuing emergency (ie an emergency that lasts for more than 8 hours).

We note that Tonkin & Taylor has specific responsibilities during an unusual occurrence or an emergency and understand that a formal agreement is in place with Tonkin & Taylor to provide assistance during such an event. While key personnel in Tonkin & Taylor carry cell phones they do not carry pagers.

9.4 Training

NZSOLD's Dam Safety Guidelines recommend regular emergency training exercises to ensure all emergency management personnel are thoroughly familiar with the EAP, the availability of personnel and equipment, and their responsibilities.

As outlined in section 9.2, the EAP states that the plan will be tested throughout the operational period of the dam to ensure the continued preparedness of all organisations involved and to ensure the plan remains relevant. We understand that no emergency preparedness training or emergency exercises have been initiated for Opuha Dam since the completion of the remedial works, although we are aware that TrustPower emergency management personnel attended an EAP training session in September 2008 and that TrustPower held emergency exercises in February 2008 and early in 2009.

9.5 Conclusions

NZSOLD's Dam Safety Guidelines outline a number of Owner responsibilities relating to the development, content, distribution, maintenance and testing of emergency action plans. The current EAP addresses most of the generic points included in the Guidelines; however, it would be enhanced by expanding the existing content to include:

- The location where an emergency response would be coordinated.
- Procedures for inspection during and following a large flood event.
- Procedures for inspection following a large earthquake.

In addition, the effectiveness of the existing emergency procedures would be enhanced by the completion of regular emergency training exercises.

While the existing EAP provides a framework for the management of a dam safety emergency, some urgency should be given to completing and issuing the proposed revised document.

Dam Safety Recommendation – Review and re-issue the EAP.

Dam Safety Recommendation – Undertake and document regular exercises to test emergency procedures and provide emergency personnel with appropriate training.

References

1. "Opuha Dam, Operation and Maintenance Manual", Tonkin & Taylor, May 1999.
2. "Opuha Dam Project, Design Report for Civil Works", Tonkin & Taylor, May 1999.
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Appendices

Appendix A: DSR Study Brief

Pickford Consulting Ltd 22 December 2011
133 Rosetta Rd,
Raumati South

Attention: Tony Pickford

Dear Tony,

Dam Safety Review: "Opuha Water" (Opuha Dam) Irrigation/Hydro-Electric Power Scheme.

TrustPower invites your company to submit a proposal to undertake a Comprehensive Safety Review(CSR) of the hydroelectric power station within the Canterbury region.

Nationally TrustPower Ltd (TPL) owns and operates 18 hydro-electricity schemes and 1 wind farm, separated into five regions. The background of the hydro-electricity schemes is wide and varied with most having been owned by TPL for less than 13 years. Structures incorporated in these schemes range from the very small to some of the largest dams in New Zealand.

Dam safety is managed internally from within the hydro–development group of the Generation division. Recently our operations portfolio was expanded to include Opuha generation. As a result of this relationship with Opuha water we have been asked to manage the schemes five yearly dam safety review.

Opuha Dam is located on the Opuha River, near Fairlie in the South Island. It is about 50 m in height and stores approximately 95 million m3 of water for irrigation and hydro electric generation. The dam has proved a significant asset to the district with outstanding contributions to economic development.

The dams recent history includes changes to owners and operators so that knowledge of the scheme and documentation is spread over a range of companies. As a result of this key staff which need to be involved to provide information come from Opuha water, Tonkin and Taylor, Contact Energy and TrustPower Ltd. Documentation is in various forms and most documentation is available in Opuha Water offices at Pleasant point. T&T have electronic versions of the previous ACI reports and monitoring and surveillance reports. TrustPower have some electronic civil reports available.

General

As part of TrustPower's on going Civil Safety process, it is intended that all structures within the scheme be subjected to an independent review. That review should be undertaken in general accordance with Appendix G of the NZSOLD dam safety guidelines (2000) and the Building act 2004. Its envisaged this review will follow a similar line.

It should be noted that TrustPower does not currently employ a formal SEED programme. Rather, an integrated risk/asset management approach is adopted where deficiencies can be identified and dealt with at any time. This approach incorporates a greater level of ongoing annual external review of which this project is part. In addition, Tonkin & Taylor (T&T) currently fulfils a day-to-day review role of monitoring and surveillance data collected at the Opuha scheme.

A brief description of the main civil aspects of the schemes are included in Appendix A.

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Project Scope

Your company has been selected as one of three having the required skills to undertake this type of project. It is intended that the comprehensive review will examine the dam generally in accordance with the following scope:

1. Review relevant historical documentation and scheme layout with a view to identifying key scheme components critical to dam safety.
2. Assess the criticality of these key components to protecting dam safety. Such scheme components might be upstream gates/valves that isolate the dam from incoming flows, or there may be components at the dam wall that could compromise the integrity of the dam.
3. Assess the adequacy of the dam gates and other key dam safety components in terms of structural adequacy, functionality, security of operation, and reliability.
4. Examine the scheme hydrology, and the spillway's capacity and operational capability to pass the design flood.
5. Review the appropriateness of the dam design and performance, particularly under modern design loading criteria.
6. Assess the reservoir risk in terms of potential upstream effects such as seiche waves.
7. Assess and identify any recent downstream changes that may alter the potential impact classification eg increased or reduced human settlement.
8. Assess the adequacy of the Operational, Maintenance, and Surveillance aspects of the scheme from a dam safety point.
9. Assess the emergency preparedness of the scheme from a dam safety point of view.
10. Review the conclusions and report the findings of this comprehensive safety review. Provide two tables by dividing the recommendations into Dam Safety Recommendations and Asset Management Recommendations. Prioritise those findings into categories of perceived importance.
11. Complete an engineering matrix in the report summary that shows the safety assessment of each critical scheme component. The matrix should be set out generally in accordance with the following table.

Scheme Component Critical to Dam Safety	***Criticality to Dam safety***	***Urgency (years)***	***Performance or Design or Process based issue***	***Deficiency/enhancement***
Earth Dam : Static : Seismic : Piping	Low Med High	2-5 1-2 <1	Design Issue	Deficiency
Spillway : Flood Capacity : Static : Gates				
Etc Etc				

***Criticality = critical level to dam safety: eg Spillway gate= primary critical (high), while butterfly valve = secondary (Medium)**
***Issue type: eg performance issue item may be operationally underperforming, design issue may have incompatible filter material against modern criteria, process based issue may be documentation missing.**
***Seen as a deficiency (spillway wing walls with insufficient freeboard) or enhancement (e.g. modification of a sluice gate to act as additional flood capacity)**

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Key Personnel

TrustPower personnel and service providers that will be available as required throughout this project include:-

Otago	Mike Moehau	TPL	Production Engineer
Canterbury	Helen Stanger	TPL	Opuha Generation Production Co-ordinator
	Nigel Fraser	TPL	Generation Technician
Tauranga	Bruce Walpole	TPL	Civil/Safety/Hydrological Engineer
	Mark Holmberg	TPL	Coms and Controls

Tonkin and Taylor

Canterbury	Tim Morris	T&T	Safety Advisor & Dam Surveillance

Contact Energy

Clyde	Ken Roberts	Contact	Dam safety

Opuha Water

Pleasant Point	Tony McCormick	Opuha	Chief exec & Client

Information Available

The level of documentation and supporting information available for the Schemes is considered reasonable. A list of documents will be available from T&T after their return on the 16th of January. A small list available from TrustPower is included in Appendix B. Numerous other reports and documents are also available as described at Pleasant point in Opuha offices.

While efforts are being made to centralise all data to be held at Pleasant Point, there may be some of this scheme's documentation held at the station (hard copies of drawings). Some items may however only be available from the T&T. In addition some drawings for the scheme are available as scanned digital copies.

Offer of Service

Please consider the above and respond with your offer of service if interested. The offer of service should as a minimum include the following;

1. A brief discussion on methodology and personnel that will be undertaking the work.
2. An indication of information that will be required from Opuha water, TPL and T&T so this may be provided without unnecessary delay.
3. An indication of the field testing programme that will be required (if any) and the resources needed from TrustPower Ltd.
4. An indication of timeframes for any site visits and staff that may be required for the visit(s).
5. A fixed price cost, including an estimate of fees (this should include an estimate of hours and charge out rates) and disbursements.

Timeframe & Tender Inspection.

The offer of service is required by 27th January 2012, and the project must be undertaken and completed by the 1st May 2012. As such, a draft report should be prepared and forwarded to the undersigned by the 20th April 2012 for comment, with a completed report due on 1st May 2012.

Please do not hesitate to contact the undersigned should you wish to discuss any aspect of the above further.

Yours faithfully

Bruce Walpole (bruce.walpole@trustpower.co.nz)
Hydrological Engineer
Engineering Section TrustPower Ltd.

Appendix A: SCHEME SUMMARY AND CIVIL SAFETY ASPECTS

Scheme 1 Opuha Summary

Electricity generation in the Opuha River Catchment had it's beginnings in 1998 with the construction of a 7.7MW plant in south Canterbury. It is renown for its delayed beginnings as a major failure during construction in 1997 after heavy rainfall was one of a few failures in NZ dam construction. Construction on the $32 million Opuha earth dam commenced in 1995 and completed in 1998 after a disaster in February 1997 when water surged down the Opuha River, wiped out the approach to the Skipton Bridge, and tore chunks out of land before roaring into the Opihi River system. It ruined vast tracts of farm land, killed stock, and turned fertile paddocks into instant riverbed and flooded the house at "Blueview" Raincliff Road. The 700ha Lake Opuha flooded the land east of the Clayton Road on Sherwood Downs, Opuha Gorge Road and "Corra Lynn". Land was purchased from seven farmers for the project. The Opuha dam and lake was officially opened 7 November, 1998, by the Mackenzie Mayor Neil Anderson and the power plant has been operating for some time.

Lake Opuha, a recreation reserve, just out of Fairlie at the head of the Opuha Gorge. Mount Walker, named after the first owner, the Walker brothers, of Four Peaks Station, height: 5425 ft. is the snow capped flat top hill reflecting in the man-made lake. Stored winter and spring river flow will be released in summer for stock watering and domestic and industrial use in Timaru and irrigation between Washdyke, Temuka, Cave, Pleasant Point, Totara Valley and Fairlie. The dam will provide about three thousand homes with power (7.5 megawatts).

Civil Safety Aspects and Natural Characteristics of the Site Area

- The location of active faults close to the scheme has not been provided to TPL prior to this scope going out. While recent large Earthquakes in Canterbury the scheme is still operating as normal.
- There is one dam within the scheme that impounds the lake Opuha. Other storage facilities include the regulating pond downstream of the dam. There are no canals that carry water from one part of the scheme to another.
- The scheme also has a supply conduit from the intake to the powerhouse which goes through the dam and is due for inspection. To facilitate inspection there appears to be some complex operational difficulties. TrustPower is currently working on a plan to clarification what needs to be done to make the inspection possible or explore alternative options which could be beneficial.
- Access to the scheme is via SH 79 from Fairlie and then along a series of roads (both private and public) to each subsequent asset or generation plant. Most main access roads are tar-sealed however minor roads to other assets may be gravel.

Staff Personnel

The TrustPower Canterbury production co-ordinator manages the Opuha scheme operations and maintenance. She has four to five staff who are based at Coleridge. The station is operated from the 24hrs operations centre at Te Maunga. The generation technicians and operator maintainers deals with the main day-to-day operation of the station on a weekly basis, their task is to maintain, inspect and operate plant and equipment at the Station. There are also a number of contractors, which deal with the above day-to-day running of the scheme. Ruahihi Station in Tauranga is also is an emergency backup operations centre which is to cover for the Te Maunga operations centre.

Policies and Monitoring

Policies

- Site specific emergency preparedness plans are available. Exact locations of these will become evident during the site inspections. The latest release version was completed in March 2007.

Monitoring and Surveillance

- The dam owner is to conduct weekly flow readings and submit these to the dam safety consultant at least 3 times a calender month. Monthly inspections of flows and peizos are also recorded and passed onto the safety consultant. hydraulic structures in which these procedures are documented in the relevant station operations and maintenance manuals. These inspections include a weekly walkover of all structures and checks of dam seepage flows.

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- An operations and maintenance documents are a combination of documents which are currently undergoing review and therefore will collated into an O & M manual be produced sometime in the 2012/13 financial year. Regular updates of the manual will also occur every 2/3 years.
- A monthly "route march" is conducted T&T whereby specific instrumentation are measured. The observational and measurement data is written up and T&T will provide information on those results.
- Annual Civil Inspections have been completed for the last five years by T&T.
- Any civil safety deficiencies identified for the scheme are incorporated into the risk management system and tasked identified are budgeted for in the annual asset task plan (AATP).
- Flood Review last carried out during design stages in 90's as far as known ?.
- Seismic Review carried out by during design stages in 90s as far as known ?.
- Formal SEED Dam safety inspections are no longer undertaken (are replaced by "Safety Audits"). The last Comprehensive Safety Review was carried out by Damwatch.
-

Appendix B: Documentation available.

Scheme 1 Opuha Scheme Summary

TrustPower have the following

Documents Available for the Scheme

01 RMD210205[1].Opuha Abutment & Downstream Investigation Report.pdf	10,509 KB	Adobe Acrobat Doc...
02 RMD240105[1].Opuha Embankment modelling.V2.pdf	4,837 KB	Adobe Acrobat Doc...
03 jje040405[1].Opuha abutment options.v6.pdf	1,647 KB	Adobe Acrobat Doc...
04 RMD20060828[1].AbutmentsDetailedDesign-Final.Rep.pdf	4,038 KB	Adobe Acrobat Doc...
04a rmd20060828[1].DesignReportAddendum.mem.pdf		Doc...
05 rmd190905[1].ToeWorksIssues.rep.pdf		Doc...
06 rmd081005[1].ToeWorksOptions.rep.pdf		Doc...
07 rmd261005[1].DSToeDetailedDesign.rep.pdf	9,251 KB	Adobe Acrobat Doc...
08 rmd080906[1].DSToeDetailedDesignAddendum.rep.pdf	3,829 KB	Adobe Acrobat Doc...

Type: Adobe Acrobat Document
Size: 1.60 MB
Date Modified: 22/08/2007 9:56 a.m.

T&T Opuha Dam surveillance and monitoring plan - Nov 2011

Also a copy of the 2007 EAP

Appendix B: Photographs

Photo 1: Main Dam – Upstream Slope from Left Abutment

Photo 2: Main Dam – Downstream Slope from Left Abutment

Photo 3: Main Dam – Left Abutment

Photo 4: Main Dam – Toe Drain Discharges

Photo 5: Main Dam – Foundation Seepage Cutoff

Photo 6: Main Dam – Foundation Seepage Cutoff Discharge

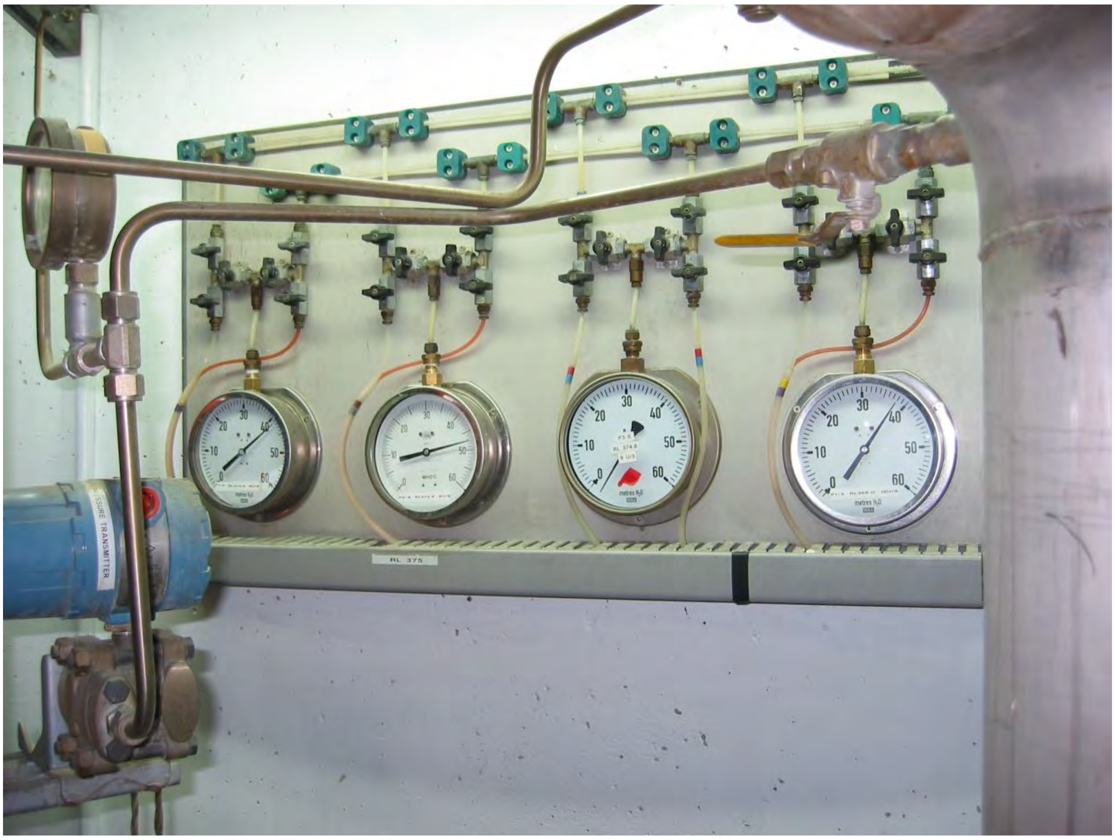

Photo 7: Main Dam - Piezometer Gauges in Power House

Photo 8: Main Dam – Service Spillway, Gate Structure

Photo 9: Main Dam – Service Spillway, Gate Structure and Upper Chute

Photo 10: Main Dam – Service Spillway, Right Sidewall and Chute

Photo 11: Main Dam – Service Spillway, Left Sidewall and Chute

Photo 12: Main Dam – Service Spillway, Downstream End of Stilling Basin

Photo 13: Main Dam – Auxiliary Spillway, Upstream Slope and Concreted Rip-Rap

Photo 14: Main Dam – Auxiliary Spillway, Crest

Photo 15: Main Dam – Auxiliary Spillway, Downstream Slope and Splitter Wall

Photo 16: Main Dam – Auxiliary Spillway, Right Sidewall and Drain 18

Photo 17: Main Dam – Auxiliary Spillway, Downstream Channel

Photo 18: Main Dam – Low Level Conduit, Anchor Block and Drains 4, 5 & 6

Photo 19: Re-Regulation Pond – Overflow Embankment, Sinkhole on Upstream Face

Photo 20: Re-Regulation Pond - Overflow Embankment, Downstream Face

Photo 21: Re-Regulation Pond – Overflow Embankment, Fines on Downstream Face

Photo 22: Re-Regulation Pond – Outlet Structure , Downstream Wall & Stilling Basin

Photo 23: Re-Regulation Pond – Closure Embankment, Upstream Face

Photo 24: Re-Regulation Pond – Closure Embankment, Crest and Downstream Face