OPERATIONAL PROCEDURE

The scheme was commissioned in 1922 and has operated continuously since then other than periodic upgrades. The generator takes water from the Waiaua River via a storage lake (Lake Opunake) and operates at an average power output of 310kW. The generator is a submersible Flygt Turbine generating at 415V which is stepped up to 11kV for reticulation into the Powerco network.

The lake is an artificial lake and its primary purpose is to store water for Hydro Electric Generation. When inflows to the lake are less than the outflow through the generator, the generator will operate in a start stop manner whereby it draws from the lake until the lake reduces to a preset level (about 505mm). The generator will then stop and the lake will refill. Once the lake reaches a preset level the screen cleaner operates and generator starts. This operation is programmed to run in an automated manner. This can be overridden by manual controls but generally it will follow this predetermined operation.

The following considerations must be taken into account when determining the optimum operation of the power scheme. References to scheme components can be found in the map and diagram in Appendix 1.

1. Head Works - Operations that occur:

a) Sluice the intake bywash and screens Gate1.
b) Sluice the intake sand and stone trap Gate2.
c) Sluice the Weir of sand and stones Weir Bypass Gate5.
d) Clean debris from screens.
e) Close the intake gates at Dirty flood times Gate3 and Gate4 >250mm
f) Sluice the canal via the sand trap SG.
g) Flush the fish pass.
h) Operate the station at critical peak times.
i) Maintain a constant flow in the fishpass of 80l/s level of 435mm
j) Maintain 180l/s per second residual flow for the combination of the fish pass (80l/s, 435mm level) and weir gate leakage/canal sluice outlet (100l/s).
k) Automatic functions when set to AF (Auto Flush)

Operational factors that occur:

a) Continuous fluctuations in the lake level, with intake and generation
b) Fluctuations in the canal level with lake level
c) Silt and stones in the intake basin.
d) Stones and debris in front of the intake screens especially after floods.
e) Debris on the penstock intake screens caused by weed in the lake and other debris
f) Silt depositing in upper and lower canal.
g) Silt depositing in the fishpass.
h) Dirty Floods.
i) Very low river levels.

In order to establish the appropriate operational requirements, it is necessary to define the optimum performance outcomes. The optimum performance outcome would be defined as:

Achieving peak generation performance and duration whilst still maintaining adequate habitat in the lake, adequate residual flow in the river system and adequate fish passage in the fish pass.

It is obvious that the "optimum performance outcome" and or parts thereof cannot be achieved 100% of the time. The operation of the scheme needs to be structured in such a way that the optimum performance outcome is being targeted, while achieving the highest possible compliance.

To establish how the operational measures will be undertaken, it is logical to work through the operational requirements from the weir through to the Lake while taking into consideration the compelling factors that may occur during those operations, these being:

a) From time to time quantities of gravel and sand/debris accumulates in front of the screens at the weir. This reduces the flow into the screens and inhibits the flow of water into the intake. These debris can be removed by opening the bywash Gate2 and sluicing the debris away. This should be done whenever there is a flood or sustained high levels over the weir.

b) Between the intake screens and the intake gates is a settling basin, this collects smaller debris that passes through the screens. From time to time this requires flushing by opening Gate1.

c) From time to time dirty floods occur in the river. Floods carry very large bed loads which quickly can silt up the canal, fishpass and Lake. In these conditions the intake gates need to shut so as to prevent ingress of silt and gravel into the canal system the Gates G3 and G4 close after the river level is greater than 300mm for greater than 1 minute and will open again automatically on the lowering of the river level.

d) With regular sluicing of the intake bywash and settling basin, fine debris (silt) still finds its way into the canal, fishpass and lake. Silt builds up in the fishpass and inhibits its effective operation. Flushing of the fishpass with a large flow of water removes this silt, this is done naturally after a flood or when G3/4 are closed as the control is set to minimum level (Maximum flow) when the canal level drops. When the canal level returns the control takes several minutes to correct the level, but allows maximum flow for a period – flushing sand and silt.

e) Silt also accumulates in the canal and lake. This creates a restriction to the inflow water, as well as changing the lake habitat, recreational value and generation capacity. To prevent this from occurring, the silt that does enter the canal and lake needs to periodically be flushed out.

The sand trap designed to do this, and is installed within the canal. With a back flow stop gate (Prevents the lake draining via the canal sluice gate). For this sluicing action to work effectively, the correct flow needs to be flowing within the canal thereby ensuring an effective sluicing action. The best sluicing action is achieved by fully opening the Canal Sluice gate and closing G3 fully and then cycle the opening and closing of G4, this causes a wave effect down the canal flushing silt and sand back into the river ideally this should be done during high river flows. The Canal Sluice gate can be set to auto flush – this completes a periodic automatic flush.

4. Operational Procedure:

The following Operational procedure, taking into account the factors described above, endeavors to optimize the scheme's performance.

During normal river and Network System conditions the scheme would typically run in the following manner

- The river intake gates G3 and G4 would be fully open and the weir bypass G5, bywash gates G1 and G2 shut

- For normal low river flows there would be no overflow of the weir however it is likely that there would be seepage from the gates and weir itself.
- The canal sluice gate would be closed (or partly open to allow 100l/s residual flow) and the canal stop gate at the sand trap open as the flow to the lake opens it.
- A residual flow of 80l/s per second would be maintained down the fish pass and a residual flow of greater than 180l/s in the main river system below the canal sluice outlet.
- The lake would rise and fall typically between a level of 505mm and 950mm on the lake staff gauge.
- The generator would typically run during the morning (06:00 to 12:00) and evening (16:00 and 22:00), i.e. the system peak periods.
- An automated regime of flushing the weir intake and canal sand trap can occur on a periodic
- basis. A manual flush of the Weir gates G5 and G2 may occur on a weekly basis. The Canal and sand trap should have a manual flush as required to clear the sand and silt.

The Automated Regime of G5 (to stop gate being blocked closed by gravel).
There are two operational regimes in the PLC

1. When the river level is less that 50mm above dam – every 6hours open G5 for 10Seconds then close for 20Seconds
2. When river level is Greater than 50mm above dam – every hour open G5 for 10seconds and then close for 20 seconds

The Automated Regime of flushing.
This is known as an 'Autoflush'. There are several means by which an Autoflush can be triggered. They are:

a) At a set, regular interval, e.g. 2 times a week at 01:00hrs morning
b) After a receding flood event.
c) At a manual request locally.
d) At a manual request remotely.

The auto flush has a set routine that it follows. This can alter slightly depending on the position of the gates at the time it does its routine, e.g. when a flood occurs the two intake gates G3 & G4 shut automatically. Therefore after the flood when an Autoflush routine occurs it will not have to do the function of shutting down G3 & G4 because they will already be shut.

The routine for an Autoflush is as follows and is in this order: It is sequential on either proximity operation (Open Closed) or time (if proxes are not working)

- Gate 5 (the Weir Bypass gate) opens up. At the same time the Canal Sluice Gate also opens fully.
- Gate G2 (the Bywash gate) opens up.
- Gate G1 (the Intake Sluicing Gate) opens up.
- Gate G3 larger Intake gate shuts down.
- Gate G4 smaller Intake gate shuts down.
- Then,
- Gate G3 opens up, Gate G4 opens up.
- Gate G1 shuts down, Gate G2 shuts down.
- Gate G5 shuts down.
- The canal sluice gate will shutdown again 120 seconds after Gate 5 reaches its closed position.
- Once this is complete the Autoflush routine is finished.

The Autoflush achieves the following;

- Cleans the silt and gravel away from the base of Gate 5
- Cleans the silt away from the base of Gate 2
- Cleans the debris off of the Intake screens
- Cleans the silt away from the settling basin between the screens and Gates 3 & 4
- Cleans the silt that has accumulated in the sand trap basin by the canal sluice
- Moves the silt in the canal further down the canal to the sand trap
- Cleans the silt in the Fish Pass. This occurs due to the fact that the regulator in the Fish Pass lowers its level as the Canal level initially falls during the dewatering of the canal. When the flow is returned to the canal the level increases quicker that what the Fish Pass Regulator can adjust and hence a larger than normal flow occurs down the Fish Pass for several minutes while the Flow regulator slowly re-adjusts the flow.

Maintenance.

From time to time maintenance personal may operate any of this equipment either individually or collectively. This can also be done remotely. There are various reasons why this may occur, some of which may be;

- Frequency of Automated regime inadequate due to river conditions
- Routine maintenance of equipment
- Unscheduled maintenance of equipment
- Monitoring checks on Fish Pass and canal
- Manual Back wash of canal or Weir

Fish Pass Trap

The TRC have requested a fish trap be installed as they believe the small fish species cannot traverse the intake pipes and screens to the river reaches above the weir. The fish trap was installed on the output of the fish pass into the canal. The fish it catches will be monitored and released above the weir, this is to re-habitat the river reaches above the weir with small fish and eels. The period between fish relocation will be dependent on the quantity caught in the net.

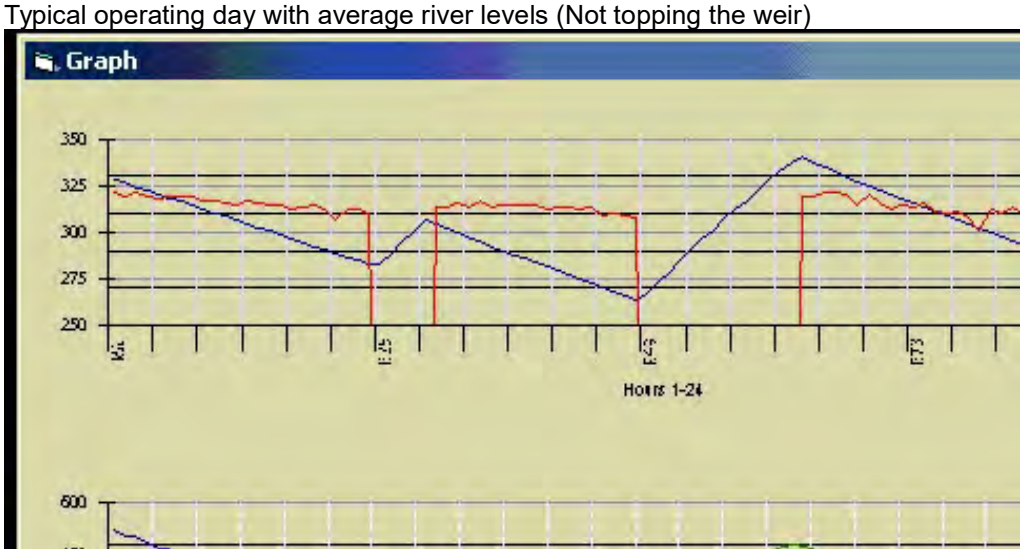
Generator Operation.

The time when the generator will run depends on several factors. They are

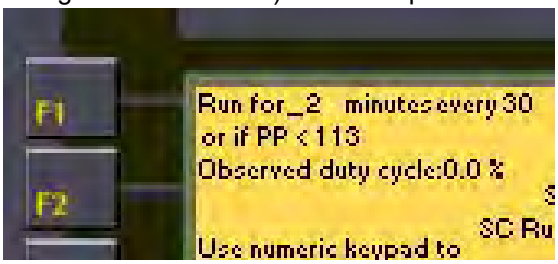
- Time Scheduled Morning peak and Afternoon peak
- Lake level >850mm non pre peak and >950mm pre peak time (Levels may vary)
- The inflow to the lake
- The status of the intake (may be shutdown in a flood)
- The level of the lake
- The time of the day (network peak loading)
- The availability of the Network (faults and maintenance)
- Serviceability of the Generation equipment (faults and maintenance)

The generator gets its water from the storage lake (Lake Opunake). The lake is an artificial lake and its primary purpose is to store water for Hydro Electric Generation. When inflows to the lake are less than the outflow through the generator, the generator will operate in a start stop manner whereby it draws from the lake until the lake reduces to a preset level (about 505mm). The generator will then stop and the lake will refill. Once the lake reaches a preset level the screen cleaner operates and generator starts up again. This operation is programmed to run in an automated manner. This may be overridden by manual controls but generally it will follow this predetermined operation.

Typical operating day with average river levels (Not topping the weir)



The generator will typically operate within the range 505mm to 950mm on the staff gauge which is located at the outlet from the lake (Lake Screen cleaner). The times of generating will typically follow the System peak periods of 0600 to 1100 o'clock and 1600 to 2200 o'clock. When inflows are high these periods will be longer and when the inflows match or exceed the outflow then the generator will run continuously. The penstock screen cleaner will start prior to the main control valve opening and will operate for 2minutes every 30minutes (The timer can be varied depending on weed build up) or if the pressure drops in the penstock (Sensing blocked screens) below 113psi.



The operating level of 505mm to 950mm is critical to the optimum operating level of the fish pass. This is because the regulator that controls the flow down the fish pass has a working range that corresponds to these lake levels during normal inflows down the canal system. When the lake level exceeds these limits the performance of the fish pass is reduced because the flows down it either become to low or high.

During abnormal periods, the generator may operate outside of this lake level range. This may be due to,

- Low inflows increasing the time to store water outside of a Network peak period.
- No inflows due to a flood causing the intake to shutdown.
- High inflows causing an increase in lake level which eventually spills at the lake spillway.
- Prolonged Network peaks or abnormal times for peaks.
- Unordinary demand on the Network. (maintenance)
- Scheduled and unscheduled maintenance of the lake equipment. Ie: Canal stop gate, Lake screen cleaner, spillway, etc.

Residual Flows.
A residual flow is required to be maintained down the of the Fish Pass. Currently this level is set at 80l/s. In conjunction with the Taranaki Regional Council (TRC) fishery's officer, it has been proven that the optimum performance of the fish pass for successful fish passage is approximately 80l/s. Previously NZE/OHL have consulted with Charles Mitchell, the Fisheries expert who was responsible for designing the fish passage and he confirmed that this flow was more appropriate. This means that the remaining residual flow must come from other sources.

During the NZE consent renewal process in 2000, a residual flow of 180l/s was proposed by the TRC. NZE at the time disagreed with this flow. At that stage there was no evidence to support what was or wasn't an appropriate amount. The main issue at the time was the passage of fish. It was agreed that a period of three years would provide for further monitoring and most importantly, the chance for NZE to modify the fish pass so that it would work successfully. Subsequently the residual flow was set at 180l/s for the current consents.

It is clear from the work NZE and TRC have done, that the fish pass does work successfully when the appropriate flow is flowing down it.

The habitat in the river system immediately below the confluence with the canal sluice outlet is improved by the residual leakage flow that is released from the canal sluice and the weir gates leakage. The TRC officers have gauged the flow down stream of this point during a normal period to be in excess of 220l/s (Nov 2016). This amount exceeds the 180l/s in the resource consent requirements.

These residual flows however are dependent on the system operating in its normal manner. Unfortunately, there can be no guarantee that the system can remain compliant 100% of the time. River conditions and equipment failure have proven to be a major factor in achieving full compliance. It is for this reason that OPL can only endeavor to achieve compliance but are unable to guarantee compliance.

That aside, the operational regime provides for a flushing flow down the river system on a regular basis. The whole flow of the river plus the water that is pooled behind the weir and within the canal is discharged down the river for a period. This equates to approximately 2,900,000l/s (2.9C/s) of additional flow down the river.

Appendix 1

Scheme Components and Map

Photo 1 Opunake Power Limited scheme on the Waiaua River

Headworks

Map and Equipment layout

River Weir, Bypass Gate5 & backwash Gates1&2. Intake Gate3&4.Head works Control Equipment, PLC & Hydraulic Pac

Intake tunnels to Cannel and Lake

Fish Pass and regulator flow Control

Cannel Sluice gate output to River

Sand trap and Cannel Sluice gate Green Shed

Lake Spillway (1000mm) to river

Generator Intake and Screen Cleaner

Surge Chamber tank and Penstock shutoff Valves. Penstock to valve.

Generator Valve and Control Equipment Chamber. 11kV Transformer and Fused Switch

Flygt Generator (Under steel plate)

Generator Outlet to Tasman Sea

Headwork diagram