Opuha Dam Downstream Weir – Construction Update No. 3

As I said in my earlier post, two key considerations for the design and construction of the Opuha Dam Downstream Weir Enhancement are:

- Construction flood risk management.
- Minimising operational impact during construction.

The downstream weir is a regregulation dam, that is, it serves to collect flows from the Opuha Dam power station, which is used as a peaking station. The weir balances out the 'peaks' and 'troughs' associated with peak period power generation. Flows are then released from the weir, through the existing radial gate, in a controlled manner back into the river to suit environmental requirements and/or irrigation demand. Construction of the enhancement therefore needs to occur so that there is minimal impact on generation and irrigation/environmental releases from the weir.

As detailed in my previous post, managing the risk of flooding during construction is also a critical consideration for the design and construction of the enhancement works, as the upgrade works are occurring to the primary means floods are passed through the weir.

In order to reduce the risk of construction flooding and the impact on operations, significant planning went into the design of the upgrade works. This included assessing the constructability of the proposed works, and how the construction works would be sequenced.

Constructability

A key component of the constructability assessment undertaken during design was to determine the preferred arrangement for the cofferdam. A cofferdam is required to isolate the concrete spillway for the duration of construction from the pond, to allow the upgrade works to occur.

Development of a conventional cofferdam is straightforward for most of the concrete spillway, as a rock apron is present immediately upstream of the weir (refer image below). This reduced the height of the cofferdam at this location and makes it readily constructible.

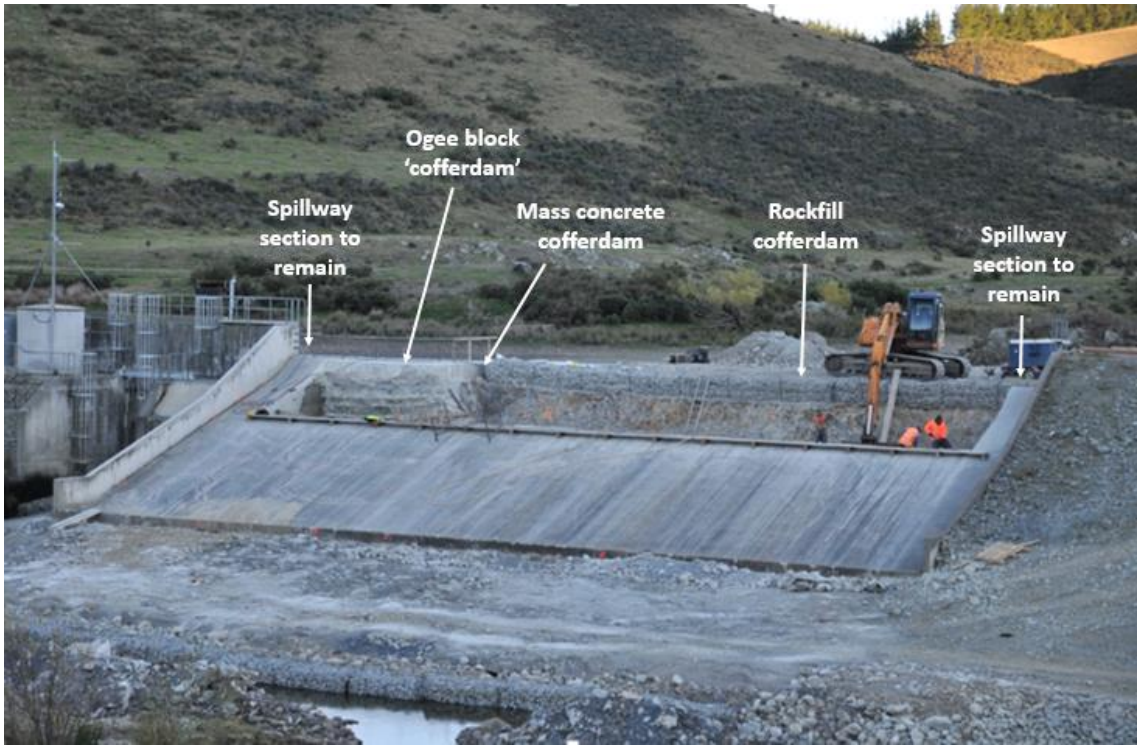
Over the right side of the concrete spillway however, the rock level is much lower (refer above, near the location the person is standing). In addition, this section of the concrete spillway is immediately adjacent to the existing radial gate, which acts as the diversion works for construction (refer above, submerged).

Construction of a conventional cofferdam at this location would have:

- Significant operational impact as pond levels would be needed to be drawdown for construction.
- Been costly to construct, due to its height and volume.
- Taken sometime to construct thereby increasing the programme of works and increased the associated likelihood of a flood during construction.
- Possible implications for the operation of the radial gate.

It was therefore determined by MWH that a section of the concrete spillway ogee crest should be used as part of the cofferdam. The upgrade works could then be completed behind the cofferdam, with the remaining section of spillway crest removed at the end of construction. Below is a view of the completed cofferdam, including the section of ogee crest which forms part of the cofferdam. The cofferdam arrangement is also depicted below in the construction staging. This arrangement greatly reduced temporary works (cost and schedule) and helped reduce construction risks.

Another key MWH idea to improve constructability was to avoid spillway lowering over the full width of the spillway. A short section of ogee crest is being left at each side of the spillway, separated from the lowered spillway section by new internal training walls. The excavation has therefore been made narrower and deeper, to get the same flood capacity. This idea removed the requirement to tie the new works into the existing training walls, together with the associated risks (such as the potential to destabilise the training walls and the associated embankment behind (true left)). The section of spillway ogee crest being left in place can be seen in the image below, viewed from downstream.



Construction Sequencing

A 3D model of the weir upgrade was prepared to support design, due to the complexities associated with upgrading an existing structure. The 3D model was also used to prepare construction staging drawings and a construction staging animation. The 3D model of the weir enhancement was important to illustrate what the works would look like, where works were to occur and when they would be completed. The 3D model helped explain these items to all project stakeholders.

The animated 3D model was also made available to tenderers for the construction contract, as part of the tender documents. It helped tenderers understand these items also and ensured consistent tendering (in terms of cost, schedule and project risks).

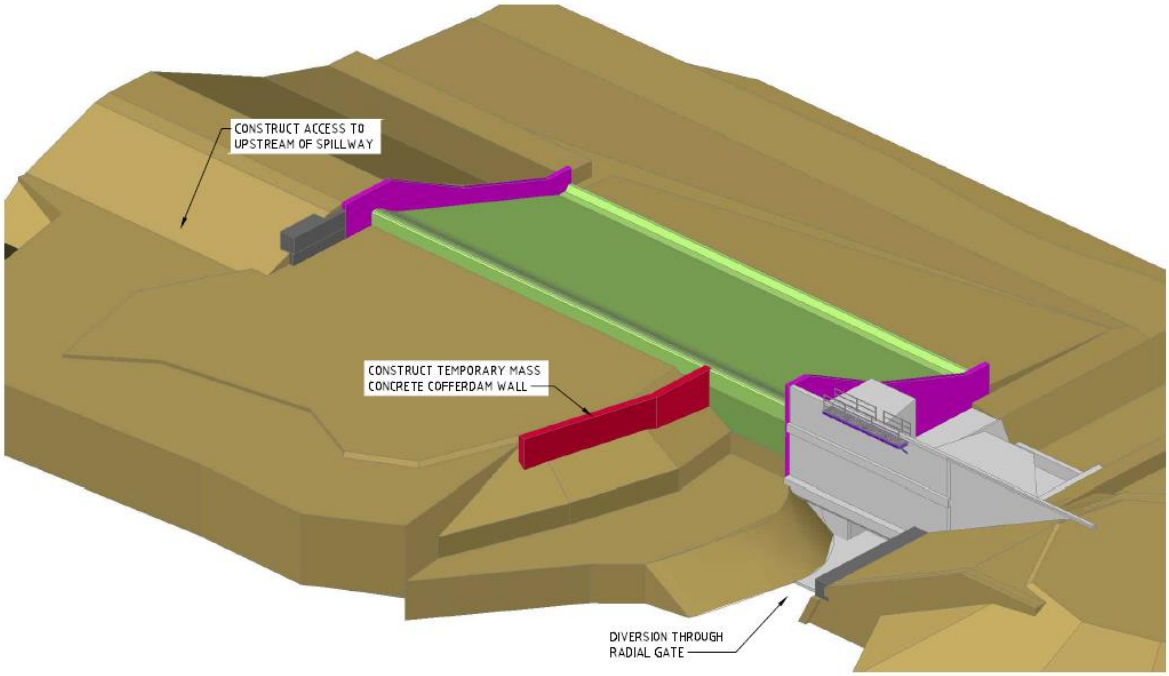
The construction sequencing is detailed below, together with a summary of the key enhancement works.

Stage 1 – Mass Concrete Cofferdam

A mass concrete wall is constructed upstream of the concrete spillway (shown in red), which is to connect the traditional rockfill cofferdam to the concrete spillway (green). The location of the wall is chosen to reduce the extent of the wall in terms of height/length and maximise constructability.

The pond level is lowered to construct the wall, with the pond returned to 'normal' operation when the wall has adequately cured. The existing radial gate within the gate structure (grey), serves as the diversion for the duration of construction.

This stage of works was completed in early May 2016.



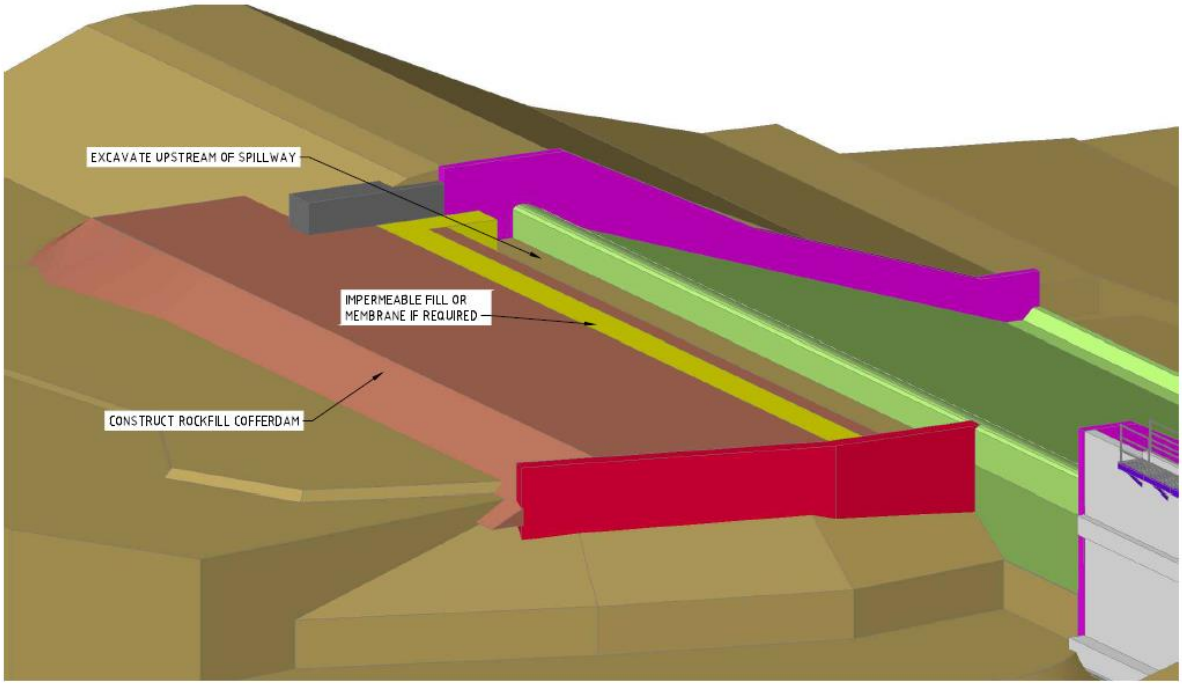
STAGE 1

Stage 2 – Rockfill Cofferdam

The conventional rockfill cofferdam is constructed (dark orange), tying the mass concrete wall (red) into the concrete spillway (green). A low permeability core is constructed in the rockfill cofferdam to reduce the risk of seepage into the works area (yellow). The section of concrete spillway used as part of the cofferdam, the ogee block 'cofferdam', is the section of the concrete spillway to right of the mass concrete wall (red) and the left of the gate structure (grey).

The cofferdam arrangement is complete and permanent works can commence. The rock immediately between the cofferdam and the concrete spillway ogee crest is excavated.

This stage of works was completed in early May 2016.



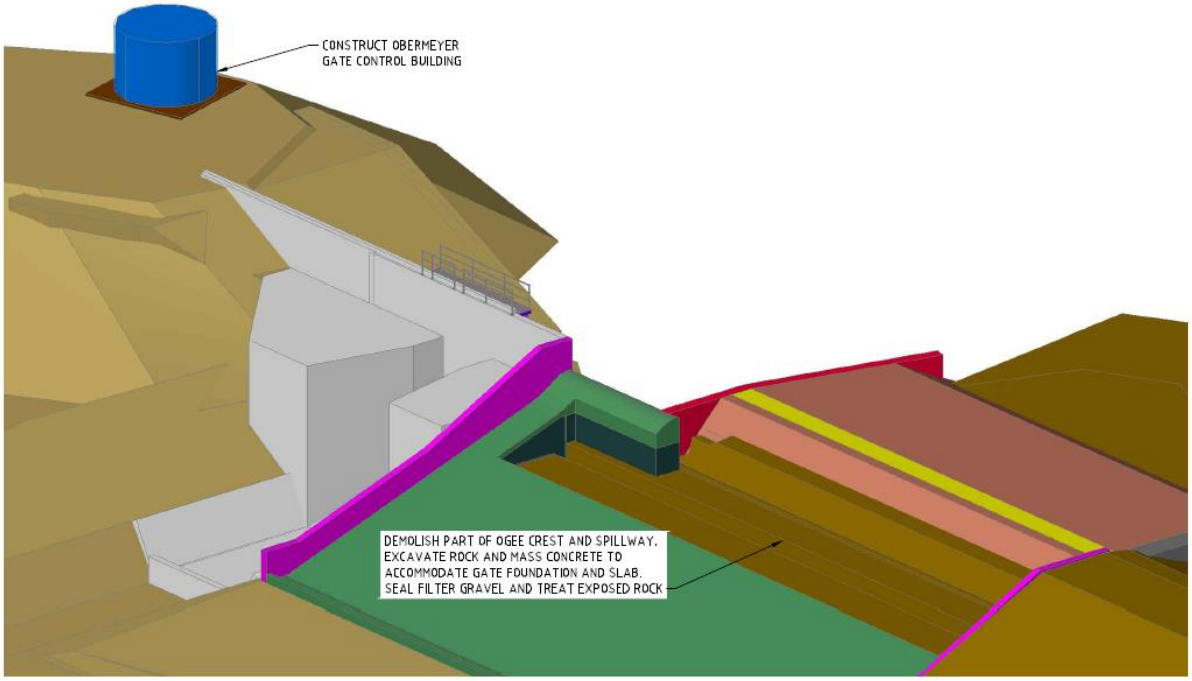
STAGE 2

Stage 3 – Spillway Cut Down

The mass excavation for the spillway cut down is then completed, to expose the foundation (brown) for the new slab on which the Obermayer gate is founded. This is with the exception of the section of spillway crest being used as part of the cofferdam arrangement (ogee block 'cofferdam'), as can be seen below. The new gate centreline lies downstream of this ogee block and therefore the bulk of the works can be completed behind it.

Foundation preparation and foundation anchoring are completed at this time. Other minor works include the installation of the new control building for the gate (blue), located on the permanent embankment. Key controls for the new gate are constructed between the new control building and the concrete spillway, across the existing gate structure (grey).

This stage of works was completed in late May 2016.

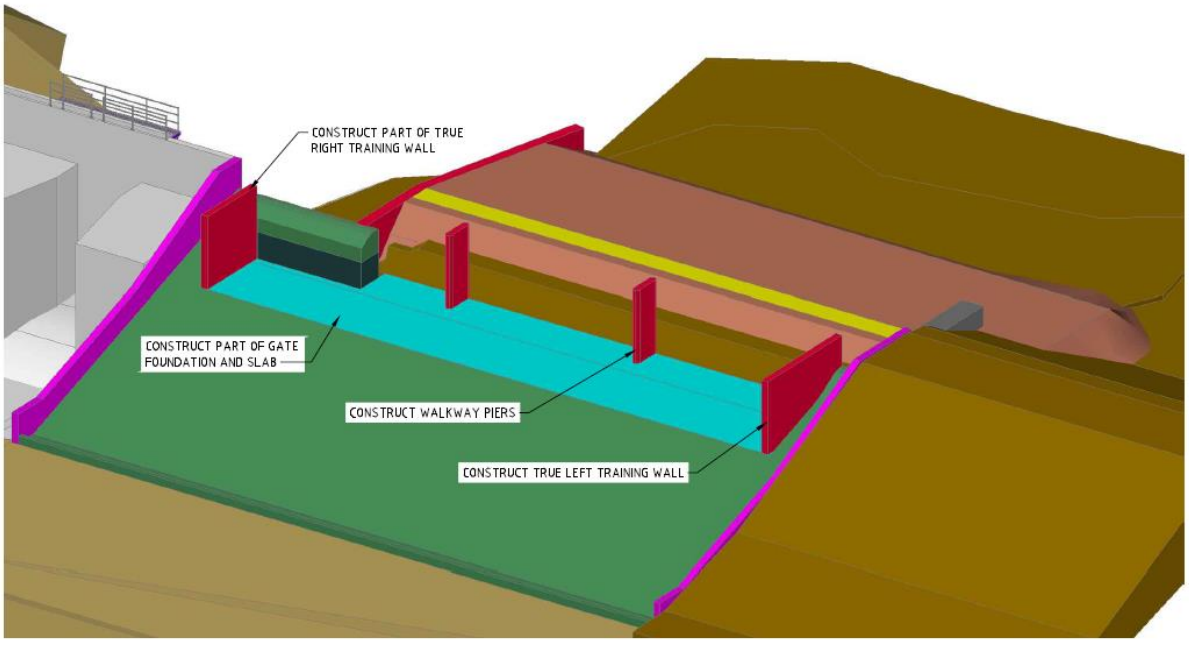


STAGE 3

Stage 4 – Main Structural Works

The main structural works are then completed. This includes the new foundation slab (light blue), internal training walls (red) and bridge piers (red). Some key controls for the new gate are cast into the foundation slab and so are placed prior to concreting.

This is the current status of the works as of June 2016, with steelwork currently being placed for the main structural components.

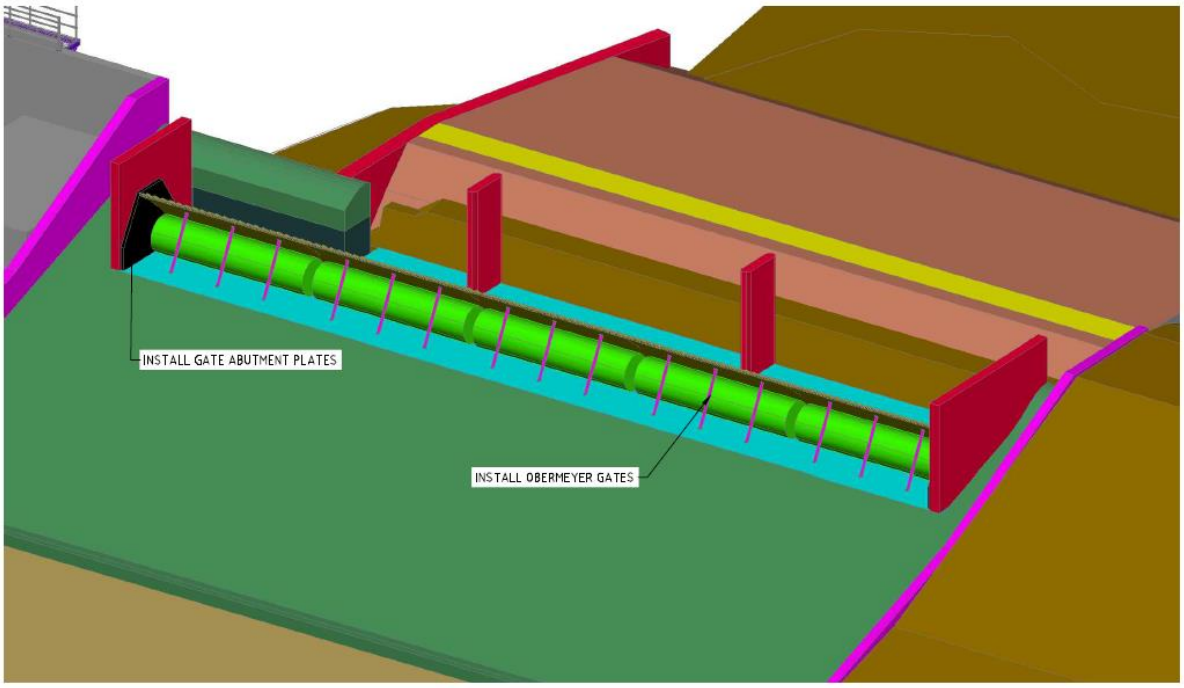


STAGE 4

Stage 5 – Obermeyer Gate

The new obermayer gate is then assembled and installed. If required, some commissioning of the gate can occur at this time (dry testing). This can reduce the length of time and therefore operational impact of commissioning the gate at the completion of the works.

The gate is scheduled to arrive in NZ in early July 2016. Installation is scheduled for late July and August 2016.



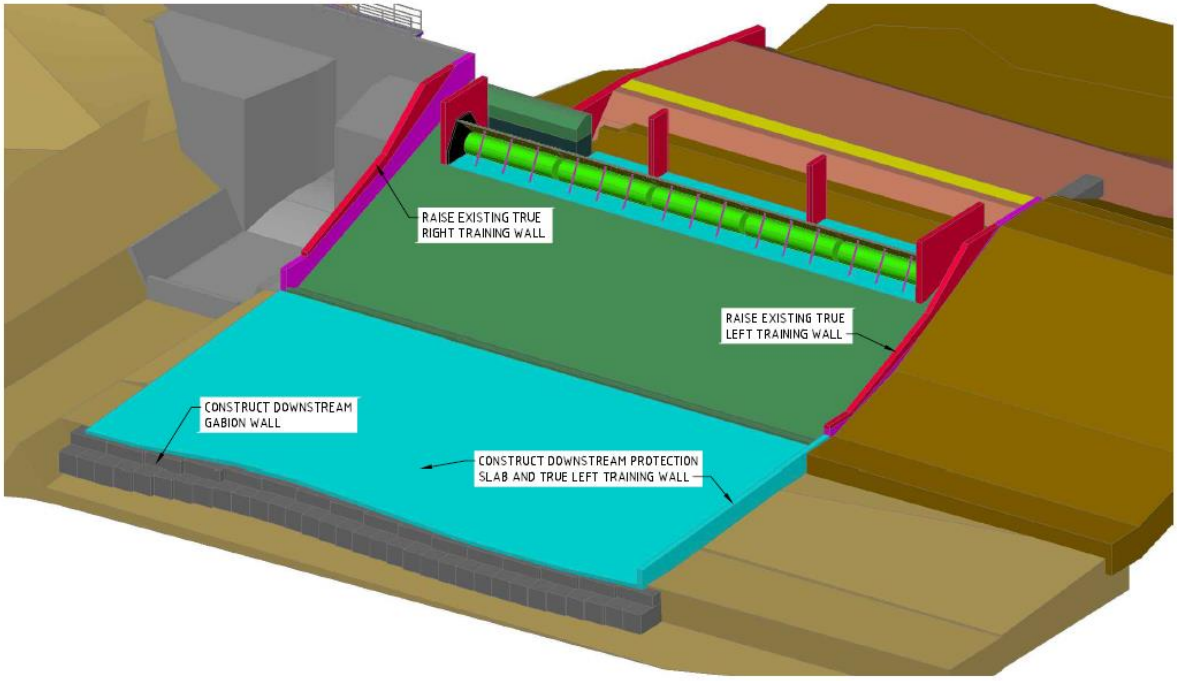
STAGE 5

Stage 6 – Erosion Protection Works

Erosion protection is required downstream of the spillway, due to the increase in flows and minor increases in velocities following the upgrade. The erosion protection works comprise a new cutoff to rock at the downstream toe of the existing spillway (not shown), a new reinforced topping slab (light blue) placed on an existing erosion protection slab and placement of new gabion baskets (grey). The staging of the erosion protection works is less critical than other works. The works need to be completed prior to the spillway capacity increasing occurring (i.e. removal of the cofferdam).

The existing left training wall is also extended at this time (light blue), to direct spillway flows away from the toe of the adjacent fusible embankment. The existing training walls on the concrete spillway are also raised at this time (red).

Works commenced on the downstream erosion protection works in May 2016 and will be completed in August 2016.

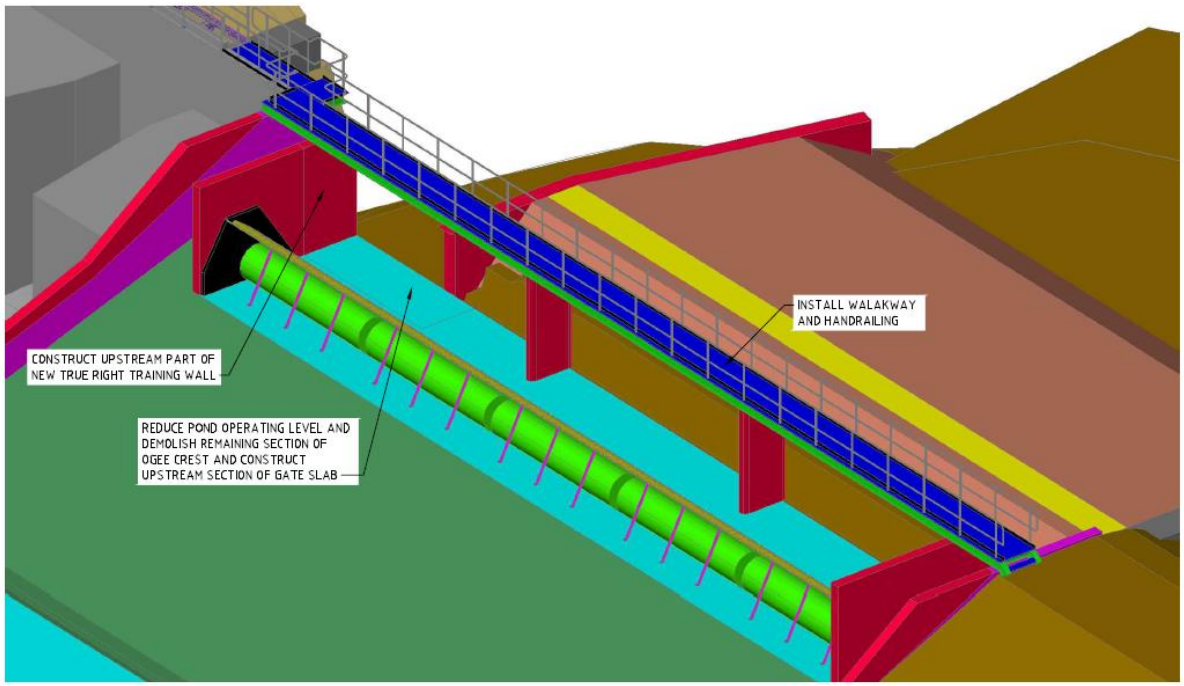


STAGE 6

Stage 7 – Additional Structural Works

The pond level is then lowered and the ogee block 'cofferdam' is removed. This allows the remaining concreting works to be completed under the lower pond level, upstream of the installed gate. The bridge deck and handrails will also be installed at this time.

This work is scheduled for late August 2016.

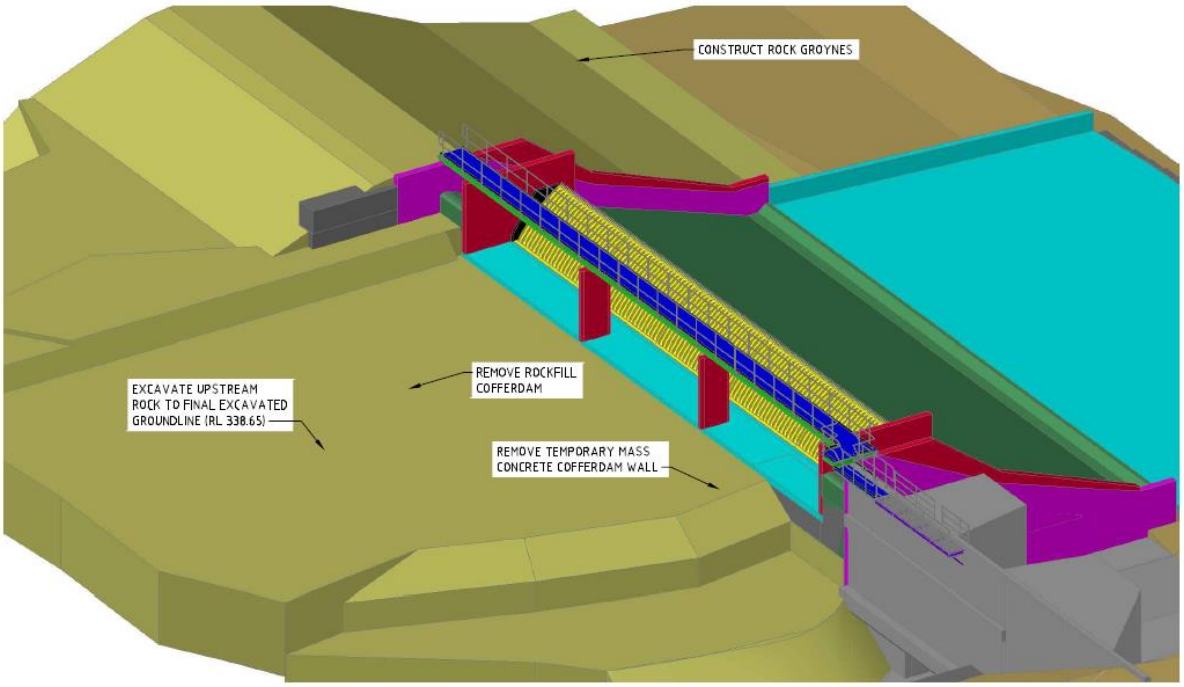


STAGE 7

Stage 8 – Remove Cofferdam and Upstream Excavation

The final stage of the works is to remove the cofferdam and lower the rock apron upstream of the spillway. Once this is completed, final commissioning of the gate can occur. Normal pond operation can be resumed.

This work is scheduled to occur in early September 2016.



Summary

Consideration of constructability and consequence sequencing were the key drivers for the design of the enhancement works. This was to ensure that the enhancement works are completed as efficiently as possible, with minimal impact on ongoing operations of the weir/pond and to reduce construction risks as much as practical.

Now that I have touched on some of the more general background to the downstream weir enhancement, in future posts I will document construction progress.

Thank you for reading.

- Owner: Opuha Water Limited
- Contractor: Breens Construction Company
- Designer: MWH Global
- ETC: Tim Anderson