Attachment A

Stantec

07 December 2021

The Queenstown lakes District Council

Attn Thunes Cloete

General Manager Community Services

Dear Thunes,

Kawarau Falls Dam Structure Condition

This email is to elaborate on the likely seismic capacity of the Kawarau Falls Dam and follows discussion of the risks and costs associated with Council ownership of the structure.

This letter follows our earlier reports on the structure which are briefly described below.

- 2013 report 'Kawarau Falls Bridge Condition and maintenance Cost Assessment'. This report described the condition of the structure at the time of the inspection, described risks associated with ownership of the structure and summarised estimated maintenance costs.
- 2021 Condition Survey letter. This letter recorded an inspection of the structure during July 2021 which was undertaken in coordination with the intended incorporation of the structure in the active travel network in the area

<u>Absence of reinforcing within the piers and abutments</u>

We have not been able to locate construction drawings for the structure, but we have located old photographs of the construction at the Hocken Library. These photographs show that the piers are constructed from mass concrete only and the photographs show no detectable reinforcing. In addition, the photographs show that piers have shallow sockets into the rock bed of the river. The dearth of reinforcing and the shallow sockets are shown in the two photographs reproduced below.

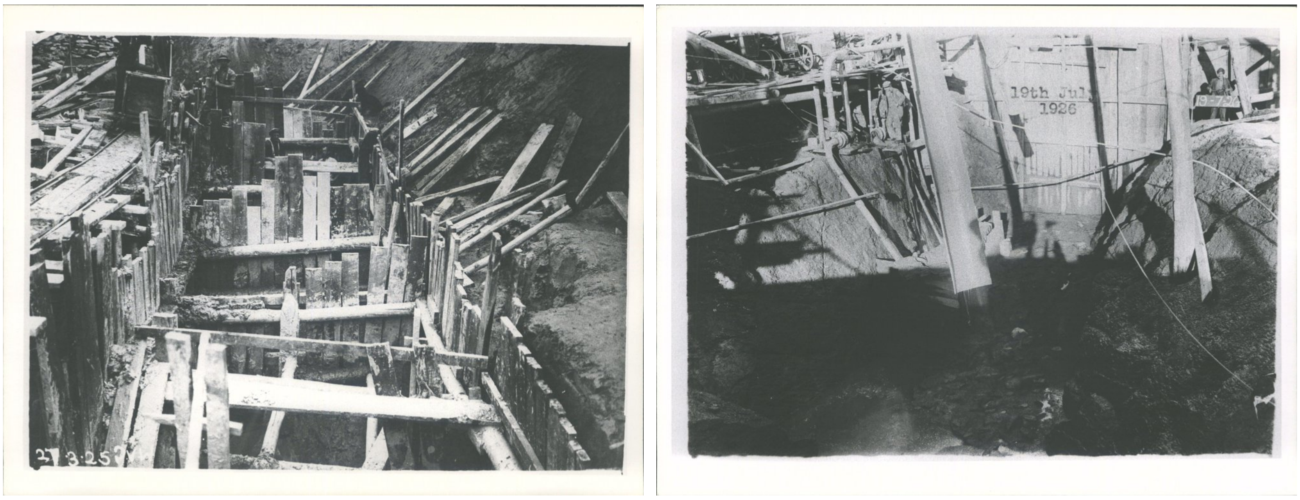

Fig 1. Historic pictures showing absence of reinforcing in the piers

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We have been unable to locate photographs that specifically showed the abutments, but nor could we locate any photographs that showed any type of reinforcing anywhere. Thus, it is possible, and even likely, that the abutments are mass concrete too.

Our inspections have not detected rust staining of the concrete surface of either the abutments or piers. This would indicate that there is little or no reinforcing in the structure. Thus, it is reasonable to expect that the entire concrete component of the structure is without significant reinforcing steel.

<u>Seismic stability of piers</u>

In the absence of detailed drawings, lack of information on the pier socket geometry and the likelihood that the structure is effectively completely unreinforced, it is not practical to make an accurate prediction of the structure's seismic capacity. In the upstream/downstream direction the structure is likely sufficiently massive that the piers are likely to be stable in a design level earthquake. But we anticipate that a design level earthquake is likely to cause some damage to the wing walls on the abutment.

In the transverse (span) direction the piers and abutments are less seismically stable. Effectively the tops of the piers are propped by the deck beams for the length of the structure against the abutment shelf. However, the seismic loads on the piers are quite high and it is conceivable that the upstand at both the abutment and the piers is unreinforced. Thus, in a sufficiently large quake, the beams may simply punch through the walls at the abutments and pier tops and support to the top of the piers will be reduced or lost. In this situation it is possible that both the abutments and the piers could topple as a result of removal of effective support at the top. Without further analysis we cannot accurately quantify this. Such an analysis would require several significant assumptions and is consequently likely to me more of an academic exercise than a practical one.

<u>Seismic stability of gates and counterweights</u>

We expect that even a moderate earthquake will derail the gate counterweights and it is highly likely these will fall off the rear face of the piers. The gates themselves are confined within slots in the piers and, and as a result are unlikely to sustain significant damage unless the piers or abutments displace significantly.

Fig 2. Gate counterweights which are likely to derail in a sufficiently large earthquake

Fig 3. The gates in slots in the piers. Note water and power services above the gates

<u>Seismic capacity of the structure vs current standards</u>
It is clear the structure is not up to current seismic standards and an ultimate limit state design earthquake may cause significant damage to the abutments and piers. We anticipate that an earthquake likely to damage the Kawarau Falls Dam would also cause significant damage to other critical infrastructure in Queenstown including the Frankton Road formation, the Edith Cavell Bridge, the Skippers Road, The Shotover pedestrian bridge at Quail Rise, the Crown Range Road, the Skippers Suspension bridge, the Glenorchy Road, much of the True Right Bank of the Shotover at Arthurs Point, Councils older reservoir structures and all of Glenorchy plus the risk of significant rockfall throughout the area.

It is likely that the structure could sustain significant damage in an ultimate limit state earthquake, particularly if the direction of shaking is in the direction of the bridge span. We anticipate that significant settlement and potential movement of the abutments and approaches to the structure will occur in an ultimate limit state design earthquake. It is more difficult to predict if the beams will shear off the top of the piers and abutments because of the assumptions that would have to be made to undertake this calculation.

The presence of important infrastructure on the Kawarau Falls Dam, such as water supply, power, telecom and wastewater are not desirable. Significant displacement of the structure or approaches to the structure may occur in an earthquake and this is likely to result in damage to services on the dam, particularly inflexible services such as rigid pipelines. It is it is good stewardship to have either redundancy in these services or to have them located on the new and more robust bridge.

<u>Richter vs Design Earthquake ground movement</u>
We have been asked to comment on the Richter magnitude of an earthquake that may damage the structure. It is not useful to talk in terms of the Richter earthquake only. The Richter scale only assesses the magnitude of an earthquake at its point of origin and does not consider the foundation conditions at a particular site, distance to the site, earthquake depth, location seismicity nor the criticality of the particular

piece of infrastructure being assessed. Thus, discussion of an ultimate limit state design event is more meaningful than discussing the Richter value of an earthquake. The ultimate limit state earthquake is calculated in a mechanism prescribed in various standards which depends on these site and structure factors. For example, as a pedestrian bridge the Kawarau Falls dam is likely to be an importance level 2 structure, however the presence of the wastewater pipelines could potentially make the structure importance level 3. The return period of the earthquake and thus the resulting seismic requirement of the structure is dependent on its importance level and design life. If we assume that the Kawarau Falls structure has a remaining 'design life' of 50 years (which is probably reasonable for a 100-year-old structure already) the return period for an ultimate limit state earthquake for importance level 2 is 1/500 and for a importance level 3 building it is 1/1000. This method of calculation is used to rank structures in terms of design robustness.

<u>Strengthening options</u>
We believe that there are few or no practical or economically feasible measures available to bring the structure up to current seismic level and that risk of earthquake damage to the structure is one that Council may choose to accept. Council chooses to accept greater risks for other of its existing structures, the Edith Cavell bridge, the Shotover Pedestrian Bridge and the Skippers Suspension Bridge being cases in point. The seismic risk to the Kawarau Falls Dam was accepted by Transit New Zealand (now Waka Kotahi) who did not consider that additional strengthening works were warranted. Ultimately the bridge was replaced for primarily traffic reasons.

We believe that it is desirable to either move or provide alternatives for important services on the structure (such as the water supply line and the wastewater line). The new bridge carries both water and wastewater pipes, which can be employed as alternative routes, but we do not know whether redundance is provided for other services such as power, telecom and gas.

I trust that this is useful and puts the risk into perspective, I can elaborate further if you wish. Please don't hesitate to contact me should you require more elaboration on this.

Yours sincerely

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