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Development Victoria
Level 9, 8 Exhibition St, Melbourne VIC 3000
Sent via email

RE: CULVERT SPILLWAY INSPECTION OF KNOX DAM, 621 BURWOOD HIGHWAY, KNOXFIELD

INTRODUCTION

Engeny Water Management (Engeny) was engaged by Development Victoria to undertake an inspection of the culvert spillway at the Knox Dam, located at 621 Burwood Highway, Knoxfield, Victoria. Engeny was made aware by Development Victoria on 23 November 2021 of observations from 19 November of water flow emanating from underneath the concrete slab of the culvert spillway. The dam was operating at a high water level following 40-50 mm of rainfall in the week prior. A screen capture of a video provided by Development Victoria (and annotated) is shown in Figure 1 below. This document summarises the findings of the inspection, and an engineering assessment of the observed water flow, potential risks, recommendations and limitations.

Figure 1: Flow emanating from underneath concrete slab (circled)

KNOX DAM BACKGROUND

Limited design and construction information is available for the Knox Dam. Based on available information, it is understood that the Knox Dam is an approximately 31 ML water storage structure with embankments along the western and northern sides and a concrete culvert (overflow) spillway. The dam has a total catchment area of approximately 45 hectares, of which 1.6 ha is the dam's internal catchment. A general layout of Knox Dam is shown in Figure 2 below.

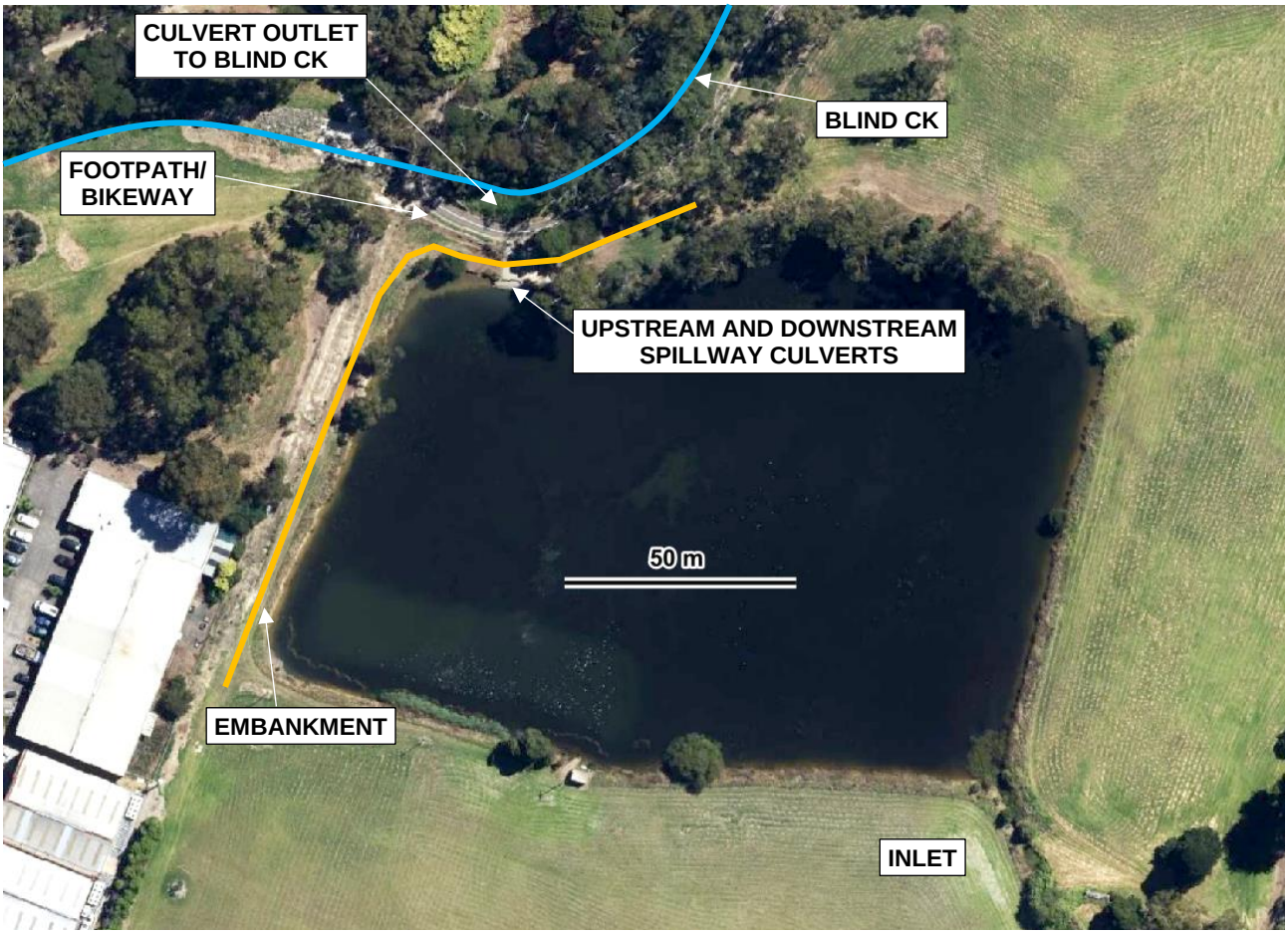

Figure 2: Knox Dam general layout

INSPECTION FINDINGS AND DISCUSSION

Two representatives from Engeny undertook the inspection of the culvert spillway and nearby surroundings on the morning of 23 December 2021. A number of key observations were made:

- There are two culvert structures which form the dam spillway, comprising an upstream set of 10x 225 mm diameter concrete pipes (hereunder referred to as the 'upstream culverts'), and a downstream set of 2x 475 mm diameter concrete pipes which are assumed to overflow to Blind Creek during high rainfall/ spillway flow events ('downstream culverts').
  - The location where flow was observed to emanate from beneath the concrete is between the upstream and downstream culverts (refer Figure 3 for schematic, and Figure 4 and Figure 5 for photos).
  - In the absence of design/ construction document of these culvert structures or engineering calculations, it is uncertain which of the two (upstream or downstream culverts) forms the hydraulic control for the dam. However, assuming the downstream culverts would provide at least the hydraulic capacity of the upstream culverts (as would accord with typical engineering practice), it is potentially the case the upstream culverts may have been constructed to allow access across the concrete structure only and/or to raise the dam's full supply level.

- The dam water level was below the invert of the upstream culverts (estimated to be approximately 0.25 to < 0.5 m below the invert level, and similar level to a previous condition assessment inspection undertaken by Engeny in 2017). As such, no flow was observed through the culverts or through the base slab. Given that October and November both experienced above average rainfall (October almost double the monthly average) and there is no know reuse of water from the dam, a higher water level in the dam would have been expected if there was no flow bypassing the upstream culverts. It is noted that water flow in the video provided by Development Victoria appear relatively clear (i.e. not turbid). Turbid flow may indicate severe soil erosion.
- A visible void was apparent where water had flowed through the concrete slab. Depth of the void was greater than 15 cm (refer Figure 6). It would also appear, from the condition of the concrete, that the two culvert structures may have been constructed separately or at different times, with the void forming at the interface of these structures.
- There is significant erosion of the upstream slope of the embankment, which has resulted in a small vertical scarp on the batters and erosion behind and below the inlet of the concrete upstream culverts (refer Figure 7 and Figure 8), though they appeared to be in a similar condition as was recorded during an inspection in 2017.
- Soils in the vicinity of the dam also appeared to be erodible, with mildly turbid water and common erosion / scour around nearby drainage pits.
- Observations could not be made downstream of the downstream culverts (near Blind Creek) due to the dense vegetation preventing observation of seepage/erosion features on the creek bank.
- No other signs of seepage were observed around the toe of the embankment.
- It was unclear if the previously observed water flow through the slab was the first instance, or had previously occurred.

Based on the observations made during the inspection, the most plausible explanation for the water flow observed from beneath the slab is due to a combination of:

- Undermining of the slab due to wave action on the upstream batter, which may have resulted in gradual seepage-induced erosion of the soil beneath the slab (and formation of a permeable void), or may have exposed high permeability crushed rock (concrete bedding) beneath the slab;
- An open/unsealed joint between the two slabs of the upstream culverts and downstream culverts; and
- The dam water level reaching up to the level of the concrete joint.

Allowing flow to continue beneath the slab, unmitigated, may result in:

- Continued undermining of the slab, and potentially erosion of the portion of the embankment which may be structural or water-retaining (e.g. the clay core if the embankment includes this feature).
- Promotion of flow to further undermine the downstream culverts and potentially resulting in the development of a direct internal erosion/ seepage pathway between the dam and Blind Creek, and consequently significantly increasing the risk of an internal erosion/ piping failure of the dam. Note: due to the overgrown nature of vegetation on the banks of Blind Creek, it was not possible at the time of inspection to verify if such features (seepage expression in Blind Creek) already exist.

Accordingly, a number of recommendations are made to address the above.

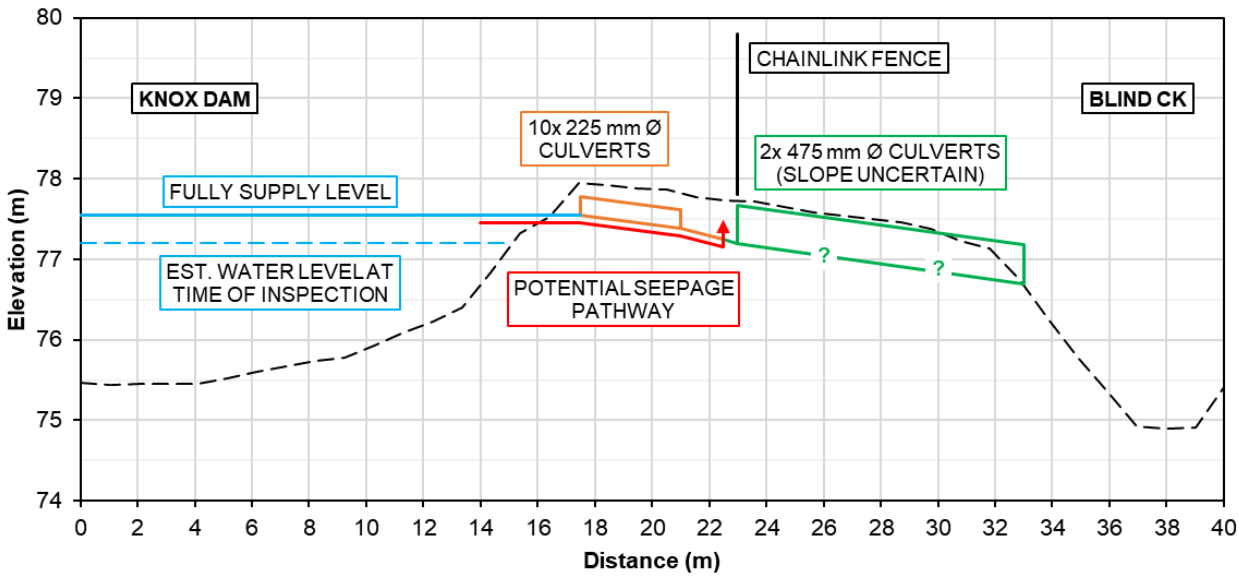

Figure 3: Schematic of Knox Dam spillway cross-section (vertically-exaggerated) and observed water flow location (schematic based on survey provided by Development Victoria)

Figure 4: Location of past flow observations (circled); Knox Dam to photo top-right

Figure 5: Location of past flow observations (circled); Knox Dam to photo right.

Figure 6: Visible void in concrete slab (note also the difference in concrete)

Figure 7: Erosion of upstream embankment and erosion around/ undercutting of upstream culverts (western side)

Figure 8: Erosion around/ undercutting of upstream culverts (eastern side)

Figure 9: Blind Creek, heavily vegetated (increases difficulty to observe potential seepage from Knox Dam)

RECOMMENDATIONS

On the basis of the site inspection observations and subsequent assessment, Engeny recommends Development Victoria to undertake the following:

- As soon as is reasonably practical from the issue of this document, provide temporary sealing of the visible void between the upstream and downstream culverts, using a cement-bentonite grout (bentonite is added to reduce the shrinkage cracking potential of cement-only grout). Grouting should be undertaken until no further grout can be added to the voids. Depending on the extents of the voids beneath the slab (as indicated by the grout quantities used), additional holes may be required to be drilled through the concrete and further grouting undertaken. The objective is intended to be short-term in nature only, to prevent / discourage further flow through the existing void and hence deterioration, until the scoping and detailed design of longer-term works can be completed and approved, and to minimise disturbance to the dam during bird nesting season.
- As soon as is reasonably practical from, remove any vegetation at the inlet and outlet of both the upstream and downstream culverts to maintain the full capacity of the culverts and minimise the risk of culvert blockage or embankment overtopping.
- In the period between the above short-term works and subsequent final remediation works, monitor the performance of the grouting works and the presence of other seepage through field inspections during high dam water levels (i.e. water levels less than 0.1 m below the invert of the upstream culverts, or higher).
- Within 6 months (long-term works) or as soon as can be arranged, demolish the existing upstream culvert. Excavate and replace with compacted low-permeability backfill any eroded / unstable soils beneath the original culvert. Replace the concrete inlet/ apron slab with dumped rock protection (and a concrete sill where required, including consideration of any opportunity to reduce the full supply level/ storage volume of the dam). Where undermining/ erosion beneath the downstream culvert exists, additional works may be required to cut-off any further potential seepage/ erosion pathways.

In addition to the above works on the concrete culverts, a number of relevant recommendations are made:

- Liaise with Melbourne Water to obtain permission to locally slash vegetation around the outlet of the downstream culverts (i.e. in Blind Creek) to allow inspection and monitoring of potential dam seepage (generally along Blind Creek, and specifically around the outlet of the downstream culverts).
- Regularly monitor dam water levels to identify any potential rapid (or quicker than expected) drops in water level, especially during high dam water levels, which may identify the existence of any other seepage mechanisms (and their location/ elevation).
- Execute the recommendations as per the 2017 dam condition assessment report (Engeny 2017).

LIMITATIONS

Visual assessments are limited to accessibility and visibility at the time of the site visit. Certain restrictions including but not limited to accessibility, visibility due to vegetative cover, water levels (both inside and outside the dams), weather conditions such as rainfall, timing and once-off nature of visual inspections may prevent all issues from being identified.

The advice tendered in this report is not warranted with respect to:

- any conditions that either reveal subsequent to this inspection or were not able to be observed during the inspection.
- any other dam conditions not subject to the intent of the inspection of the culvert spillways.

REFERENCES

Engeny. 2017. “Dam Condition Assessment Report, 621 Burwood Highway, Knoxfield.” V6000_002.

Regards,

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