HARRISON WESTERN

February 28, 2024

Silver Lake Ditch & Reservoir Company
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Reference: Technical Solutions Memo for the Silver Lake Ditch Tunnel
Tunnel Rehabilitation
Boulder County, CO

Mr. Merritt,

Representatives from Harrison Western (HW) and the Silver Lake Ditch Company met on site on January 22, 2024 to evaluate the ground conditions inside of the Silver Lake Ditch Tunnel. HW was asked to provide solutions that reduce the risk of obstructions from degrading tunnel strata and falling rocks adjacent to portals that can potentially impede water flow through the tunnel.

Existing Conditions

The existing tunnel consists of a 24" diameter pipe that is hung from the adjacent rock slope outside the tunnel that daylights into the West portal entry of the tunnel. The existing West portal headwall has concrete delamination occurring which ultimately results in an amount of water bypassing the West tunnel portal entry causing further erosion at this location as well as water loss. In addition, there are several boulders above the West tunnel portal that pose a safety risk as well as have the potential to impact water flow if they become dislodged. The tunnel varies in width and height, with some locations approximately shoulder width, and with heights ranging from 5' to 12'. Timber cribbing is present inside of the tunnel and supports sections of decomposing rock that are shearing from the tunnel ribs and back. This poses a safety risk when accessing the tunnel as well as a risk of further obstructing water flow. The Eastern portal of the tunnel daylights into an existing 36" corrugated metal pipe, which is buried underneath rockfall debris and is understood to be out of round due to this undesirable loading and is separated in several locations.

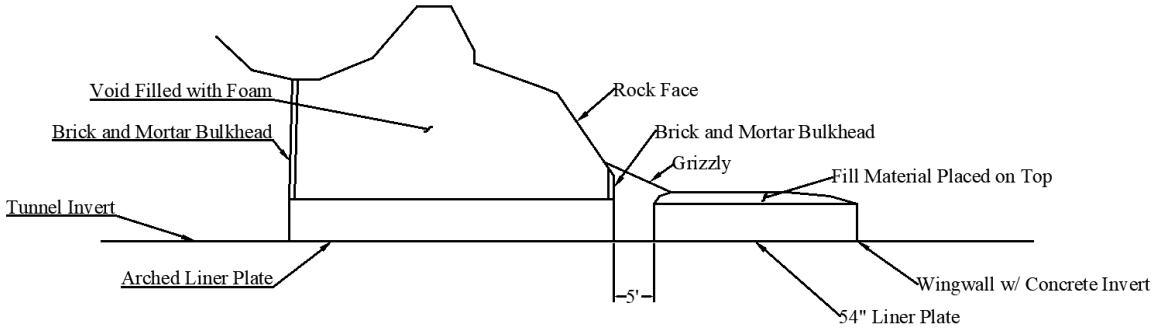
Proposed Solution

Initially HW will scale any loose material at the Western portal and inside of the tunnel, then re-install timber cribbing in locations where deemed necessary to allow for safe access to work locations. The sheared sections of rib and any loose boulder material will be removed and placed along the sides of the open ditch beyond the East portal exit. The existing concrete headwall at the Western portal will be removed and replaced with a 1' thick x 2' tall headwall the full width of the tunnel opening, and include a concrete invert.

HW proposes multiple improvements to the Eastern portal of the tunnel so that there is less risk of loose, falling material impacting water flows. In the tunnel, 31 LF of a 48" wide x 61-11/16"

tall arched liner plate system with brick and mortar bulkheads will be installed at each end. Following liner plate and brick and mortar bulkhead installation, HW will backfill the existing void space surrounding the liner plate in multiple lifts with an expansive geotechnical foam to serve as lightweight backfill. This is intended to prevent any damage to the liner plate via rockfall. The existing gate on the Eastern portal will be reinforced to serve as a grizzly to deflect rockfall away from the tunnel portal, and to aide in the prevention of unauthorized access into the East portal.

Outside of the East portal, HW will remove the existing corrugated metal pipe on the exterior of the tunnel and replace with a new 54" outside diameter (48" inner diameter) liner plate that is then buried with compacted in-situ material and reinforcing fabric. A cast-in-place headwall and concrete invert will be placed on the in-by and out-by sections of the liner plate to create a smooth entrance and exit for water to flow. The reinforced in-situ material will serve as a barrier to future rock fall and prevent damaging of the pipe which has been observed on the existing 36" pipe. A sketch of the East portal repair is presented below.



Other Solutions Considered

HW considered various options when selecting risk mitigation measures for the Silver Lake Ditch portal/tunnel repairs that were determined to be either uneconomical or unsuitable. One option that was initially considered was to stabilize the rock mass utilizing split sets or other ground support methodologies on the interior of the tunnel to prevent rockfalls. However, this was deemed unfeasible due to the existing ground conditions. It was HW's opinion that traditional split sets would not extend past the fracture plane to provide stabilization. Similarly, using rock bolts to extend into the rock mass would be challenging for drilling equipment in the limited space that exists inside of the tunnel.

Another option considered was providing rockfall protection on the exterior of the rock faces. However, traditional rockfall mitigation techniques, such as draped mesh with top anchorage points, would not mitigate the concerns over debris blocking water flows, and would require periodic maintenance and clearing of debris. Similarly, installation of such a system would require access to the top of the slope, which would be economically prohibitive.

Steel casing was also considered for the water conveyance at the tunnel portal locations in lieu of liner plate. However, this was also disregarded because the weight and lengths of steel casing would require helicopters for delivery and to stage the steel casing in place.

We hope this technical memo provides you with the information you require at this time. Should you have any questions or require further information please contact us.

Sincerely,
Harrison Western Construction

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