State of Colorado

Department of Natural Resources

Division of Water Resources

Office of the State Engineer

GUIDELINES FOR CONDUIT INSTALLATION AND BREACHING AT LOW AND NO PUBLIC HAZARD DAMS

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Section 1. **Introduction**

1.1 Upon receiving direction to bring a pond (above grade stored water created by a dam) into compliance with Colorado Division of Water Resources' (DWR) requirements, an owner can pursue two options for physically modifying the dam: installing a low level outlet conduit OR permanently breaching the dam.

The owner's decision for which is the most appropriate option will be based on their own cost benefit analysis and documented approval from DWR with respect to water rights administration. The work presented herein can be conducted by the owner or their representative or by hiring a consulting engineer and/or licensed contractor.

1.2 This guidance is provided solely for Non-Jurisdictional sized, Low and No Public Hazard dams. If a structure exceeds the dimensions of jurisdictional size (10-ft jurisdictional height or 100 acre-ft or 20 surface acres) OR a breach of the dam might cause significant damage or potential loss of life (2020 Dam Safety Rules, Rule 4.6.1 & 4.13), a more complete assessment by DWR staff will be required for recommended path forward.

1.3 Non-jurisdictional size dams are regulated and subject to the authority of DWR consistent with sections 37-87-107 and 37-87-105 C.R.S.

The following sections provide additional information and guidance.

Section 2. **Preparations for Option 1 - low-level outlet installation**

Before proceeding with either option, the pond/reservoir should first be drained in a controlled manner. It is the dam owner's responsibility that stored water be pumped completely down prior to initiation of any breach into the embankment for either the purposes of outlet installation OR permanent breach. This will require coordination and approval from the US Army Corps of Engineers Regional Regulatory Office & DWR Division office to ensure the work complies with USACE Regulatory Guidance Letter (RGL) 05-04 and results in no negative impacts to the downstream channel.

A properly constructed low level outlet can provide a reliable way to release water from a reservoir. This provides benefit during a potential emergency condition to reduce the pressure on the dam embankment AND allows for administrative releases that may be owed to downstream water rights holders. Proper installation of a low level outlet through an earthen dam is a critical step that, if done properly, can provide many years of safe, reliable operations. Improper installation of an outlet conduit in a dam can create a weak point in the dam and lead to failure of the dam and the loss of the owner's resource. Key potential dam failure mechanisms the recommendation of this guidance document protect against include:

- Conduit itself presents a discontinuity and a new potential pathway for concentrated leakage and erosion of embankment soil particles to occur along its length.
- Defects in the conduit or level control structure (open joints, corrosion, etc.) present a pathway for concentrated leakage into and out of the pipe.
- The excavation or "cut" slope planes through the dam to install the conduit present two new pathways for concentrated leakage to occur.

Figure 1 presents the dam failure consequences of an inadequately installed low level outlet

Figure 1 – "Piping" failure of a dam due to inadequate protective measures or construction methods.

The following presents the minimum recommended guidance for installing a low level outlet to mitigate the above concerns:

Section 3. **Earthwork Requirements**

3.1 Excavation area should be cleared of all vegetation and topsoil stockpiled for reuse after backfilling.

3.2 Excavation side slopes should be no steeper than 2H:1V (horizontal to vertical).

3.3 Foundation of excavated areas should be prepared through scarification/roughening, moisture conditioning, and compaction of subgrade material to prevent pipe deflection after construction.

3.4 Excavated material should be saved and used for backfill. Backfill material should have a maximum individual particle size of 4 –inches.

3.5 Backfill material should be thoroughly moisture conditioned prior to placement to prevent post-construction embankment settlement. The proper moisture condition should allow the soil to be rolled into a small ball by hand. If this cannot be done, the soil is likely too dry or does not have adequate clay content. Maintaining a thorough moisture content near optimum throughout the backfill is critical. The soil should not be too dry or too wet.

3.6 Backfill material should be placed in uniform horizontal lifts not exceeding 1-ft in thickness. Lifts should be compacted with heavy enough equipment that compacts the full thickness of the lift. Compact material by a minimum of 4 passes over the entirety of the lift. The top of each compacted lift should be roughened and wetted prior to placement of next loose lift to prevent creation of transverse planes.

3.7 Backfill within 2-ft of the pipe should be compacted using jumping jacks or other small equipment to prevent damage to the pipe. Special effort to constrain the pipe from movement during backfill and to thoroughly compact the soil beneath the lower haunches of the pipe is critical.

3.8 Each backfill lift should be "stitched" into the excavation side slopes by roughening and wetting the surface of the side slopes, and "working" the compaction equipment (parallel to conduit) to thoroughly mix and blend backfill material with the existing embankment material.

Section 4. **Sand Filter Diaphragm**

To prevent internal erosion along the conduit, a sand filter diaphragm is recommended and should be considered by the owner. The recommended dimensions and location of the diaphragm along the conduit are presented below:

4.1 Sand filter diaphragm material shall conform to ASTM C-33 specification for fine concrete aggregate and is typically available from local concrete suppliers.

4.2 Filter diaphragm surface shall be maintained at least 12-inches above adjacent fill material at all times to avoid mixing of embankment fill and sand filter diaphragm materials.

4.3 Prior to compaction, filter sand diaphragm should be thoroughly wetted and compacted in a saturated condition.

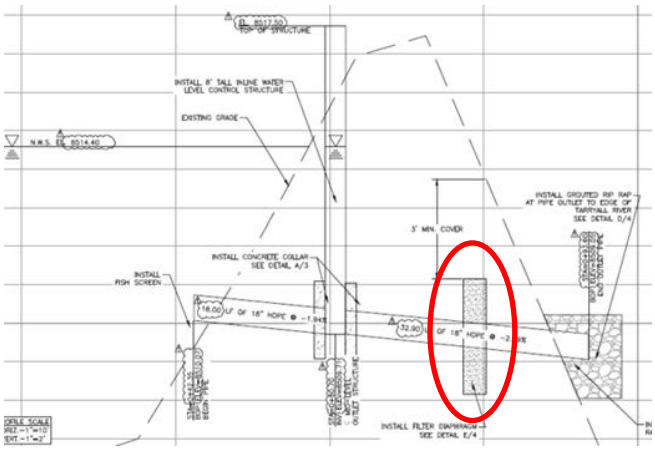

Figure 2 – Illustration of relative location of sand filter diaphragm (red oval).

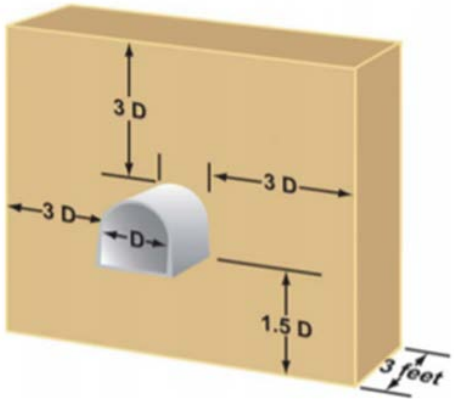

Figure 3 – Dimensions of sand filter diaphragm relative to pipe diameter D.

Figure 4 - Example of sand filter diaphragm around low level outlet pipe

4.4 The sand filter should be placed closer to the downstream end of the pipe, while still maintaining at least 3-ft of embankment cover above the top elevation of the diaphragm itself, as shown in Fig 2.

4.5 The dimensions of the sand diaphragm filter should be as shown in Fig. 3.

4.6 A pictorial example of construction of a filter diaphragm around a low level outlet pipe is shown on Figure 4.

Section 5. **Seeding**

5.1 Prior to seeding, any stockpiled topsoil should be replaced and the soil surface should be roughened.

5.2 Areas disturbed by earthwork should be revegetated with a local seed mix suitable for the climate and site elevation.

5.3 After placing seed, the surface should be lightly compacted with excavation equipment parallel to slope direction.

Section 6. **Outlet Pipes**

6.1 A minimum pipe diameter of 12-inches is recommended.

6.2 Corrugated metal pipe should NOT be used due to its short life span.

6.3 A smooth interior, HDPE pipe with gasketed watertight jointing (ADS N-12, or similar) is the minimum acceptable pipe type.

6.4 Trench shall be kept dry until pipe laying and joining are complete

6.5 Pipe shall be joined and installed in accordance with manufacturer's instructions.

6.6 Inspect pipe and fittings prior to backfilling to ensure that pipe interior is clean and free of foreign matter and dirt with special attention paid to the joint area is sealed completely.

6.7 The outfall of the pipe at the downstream toe should be protected from scour erosion.

Section 7. **Reservoir Level Control Structures**

Many options exist for installing an upstream control structure including vertical or sloping headgates controlled with an operating stem and wheel, etc. Another acceptable option for these size of dams is a reservoir level control structure that utilizes a pre-fabricated HDPE stoplog structure, example illustrated in Fig. 4. A upstream and downstream pipe sections may be needed depending on the location of the structure relative to the dam crest. A suitable trashrack should be incorporated at the structure or upstream end of the piping to prevent debris clogging.

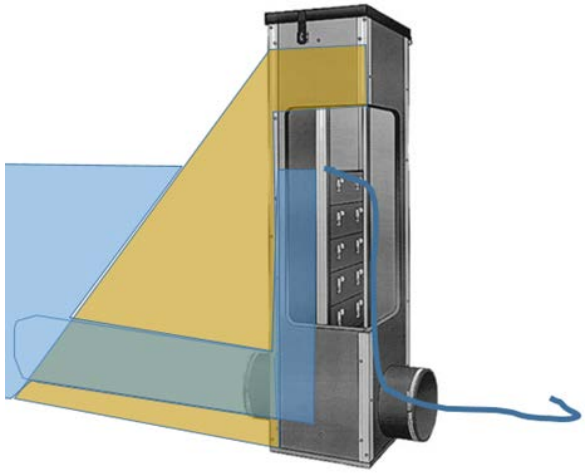

Figure 4 – Schematic of "Agri-Drain" inline reservoir level control structure

7.1 Any connections from the outlet pipe to the reservoir level control structure should be watertight per manufacturer's recommendations.

7.2 The reservoir level control structure elevation should be constructed such that the structure is accessible from the dam crest during a spillway flow event.

7.3 Foundations for structures should be compacted sufficiently to prevent differential settlement that may result in damage to the pipe or separation of connections.

Section 8. **DWR Approvals**

Once the dam owner has worked with the DWR Division office for the appropriate Water Rights Administration requirements, an NOI should be submitted to formally register the dam with DWR. The form can be found at the following link (NOI Form) and should be submitted to the local DWR Division office.

Section 9. **Option 2 - Dam Breaching**

If installing a low level outlet conduit is not feasible from a water rights or cost of installation perspective, the next option is to permanently breach the dam. As described above, the reservoir should be completely drained prior to initiating any breach activities AND the regional US Army Corps of Engineers & DWR Division Offices should be contacted and their approval received.

The owner shall submit a completed breach plan and application to the appropriate Division Engineer in accordance with 2020 Dam Safety Rules (Rule 9.1) on the Application for Removal or Breach of a Dam form. The key excerpts of 2020 Dam Safety Rule 9.1 are presented below, for convenience:

> 9.1 **Breach Plan and Application**. An Owner proposing to permanently remove or breach a dam shall submit an application package to be approved by the State Engineer prior to commencing work. The application shall be completed on a form provided by the State Engineer and shall include the following:
>
> 9.1.1 Documentation demonstrating that notice has been given to land owners and agencies potentially impacted by removal or breach of the dam.
>
> 9.1.2 Documentation showing that all permitting requirements by local, state and federal agencies have been satisfied.
>
> 9.1.3 A breach plan meeting the following requirements:
>
> 9.1.3.1 The breach shall be designed to prevent silt previously deposited in the reservoir and material excavated for the breach from washing downstream.
>
> 9.1.3.2 Water impounded in the reservoir area shall be released in a controlled manner that will not endanger lives or damage downstream properties.
>
> 9.1.3.3 The minimum bottom width of the breach shall be one-half the height of the dam or 10 feet, whichever is greater.
>
> 9.1.3.4 The sides of the breach shall be excavated to a slope that is stable, but not steeper than 2H:1V (horizontal:vertical). A slope stability analysis that demonstrates an adequate factor of safety for slopes steeper than 2H:1V may be accepted by the State Engineer. The breach dimensions shall meet water administration requirements of the Division Engineer. The dam shall be excavated down to the level of the natural ground at the maximum section, or as otherwise necessary to comply with Rule 9.1.3.
>
> 9.1.3.5 The excavated material shall not be placed in the stream channel.