Appendix B

Canyon Lake Dam Description and Operations

(The information provided in this section largely taken from CCID's application to the DNRC Renewable Resource Grant and Loan Program)

Canyon Lake Dam is located in the Canyon Creek drainage in Ravalli County, about 8 miles west of Hamilton. The dam is located at an elevation of approximately 7,300 feet within the Selway-Bitterroot Wilderness in the Bitterroot Mountains. The dam is in Section 27,

Township 6N, Range 22W, at a latitude and longitude of 46.2451°N, 114.3282°W. The dam is primarily accessed by hiking 5 miles from the Canyon Creek Trailhead. Wyant Lake is located upstream of Canyon Lake, and East Lake, a shallow marshy lake, is located downstream. Canyon Creek flows eastward to its confluence with the Bitterroot River near Hamilton.

Canyon Creek Irrigation District (CCID) owns and maintains the dam under a pre-Forest easement. Canyon Lake Dam is classified as a high hazard dam. The dam is not managed for flood control, but the reservoir naturally attenuates peak flows from large runoff events. Canyon Lake Dam was constructed in 1891 and enlarged in 1918. The dam is a zoned embankment dam with a structural height of 21 feet and a length of about 400 feet. The dam features a rock crib core and otherwise consists primarily of very loose, fine, silty sand (SM) (Hydrometrics, 2002). Soil gradation results for several boreholes completed in the dam embankment are included in Attachment A. A deteriorating concrete wall 160 feet long exists along a portion of the dam near its maximum section. A new concrete wall constructed in 2004 partially replaced the old wall and sits on a portion of the remaining wall.

The impounded reservoir has a normal storage capacity of approximately 425 acre-feet at the primary spillway invert and a maximum capacity of 500 acre-feet at the dam crest. A rocklined principal spillway is located near the north abutment and features a 10.5-foot wide concrete control section with stoplogs. A 50-foot wide concrete weir auxiliary spillway is in the new concrete wall near the middle of the dam. The outlet penetrates the concrete wall and consists of a 14-inch high density polyethylene (HDPE) pipe with a concrete inlet structure and hand operated gate. In the local datum, the primary spillway stoplog invert is 94.5 feet and the auxiliary spillway weir invert is 95.3 feet. The dam crest elevation is 97.0 feet, but is currently slightly lower in some areas. The crest varies in width from about 5 feet to more than 10 feet. The inlet structure invert is 80.0 feet and the pipe invert is 76.8 feet.

CCID accesses Canyon Lake Dam several times a year for normal operations. In late fall, the outlet gate is fully opened to allow the passage of spring runoff flows. Runoff inflows exceed the outlet capacity and the reservoir partially fills during this time. Regional snowpack is monitored via Natural Resource Conservation Service (NRCS) snow telemetry (Snotel) sites in the area (NRCS, 2018a). The dam is typically accessed to close the outlet gate when the remaining snowpack is about equal to the amount required to fill the reservoir.

Once the reservoir fills, inflow to the lake is routed through the primary spillway and, at times, the auxiliary spillway. In mid-summer, when the spillway outflow approaches zero and water users require additional flow, the gate is partially opened to allow a controlled irrigation release. In fall, after the reservoir has been drawn down to the outlet level, the outlet gate is fully opened for the following winter and spring. On each of the operational trips to the dam, personnel perform informal dam inspections and routine maintenance tasks as needed. Between trips, the reservoir is monitored via a satellite based remote monitoring system.

The system was installed in 2007 and includes a pressure transducer for sensing lake level and a high water alarm float.

Current Condition

The current condition of Canyon Lake Dam threatens the preservation of the water resources impounded by the dam. The combination of embankment materials and geometry are the primary underlying cause of existing issues. Hydrometrics' 2002 geotechnical report documented these shortcomings. Downstream seepage measurements made since 2009 confirm the high seepage volumes currently lost through the dam, with an estimated 0.4 acre feet per day lost when the reservoir is at normal full pool. High seepage volumes translate to seepage velocities with the potential to erode internal soil and threaten embankment stability.

The embankment soils consist primarily of fine silty sand. Permeability estimates for the soil are on the order of 10-4 centimeters per second (cm/s), which could prevent significant seepage for an appropriate dam section (Hydrometrics, 2002). However, the narrow dam section results in a short seepage path and high phreatic surface through the section. Furthermore, the silty sand is more vulnerable to piping than cohesive soils. Not only does the existing configuration result in high seepage rates, but Hydrometrics has also concluded that the dam is vulnerable to piping erosion (2002). During routine inspections, high seepage areas are examined for signs of piping (e.g., cloudy seepage, sediment deposition). Seepage is generally clear, although sediment deposits have been noted in connection with observed sinkholes.

As discussed previously, Canyon Lake Dam was originally constructed over 120 years ago. The age of the dam also contributes to the current condition. The dam geometry does not meet current design standards. The partial concrete core wall is crumbling and likely no longer provides a seepage barrier. Recent improvements such as the new concrete weir wall and geomembrane seepage cutoff stabilize the dam, but the dam still leaks below these features, and they only encompass a portion of the dam length. A limited amount of information is available on the dam's core and base materials and how those may be contributing to the problem. The geotechnical investigation and site observations indicate that the foundation is solid bedrock and does not contribute significantly to the problem.

Over the past 20 years several projects have been completed at the dam. A feasibility study was completed in 2000 to address safety deficiencies including inadequate spillway capacity, failing outlet works, and an uneven dam crest (DJ Engineering, 2000). Hydrometrics followed this study with a geotechnical investigation in 2002. The investigation included discussions of seepage and stability issues.

Repair work completed at the dam since 2002 has focused on dam safety and operations but not necessarily the seepage problem. A rehabilitation project done between 2002 and 2004 addressed problems with spillway capacity, the outlet, and erosion of the upstream embankment face. That project included installation of the 50-foot auxiliary spillway weir, a new outlet pipe and gate, and geotextile and riprap. The riprap has been successful in stabilizing the upstream embankment from wave erosion. A sinkhole developed on the upstream face of the auxiliary spillway near the outlet gate in 2005 and was repaired. Leakage around the outlet gate has been observed since that time.

In 2010, another sinkhole developed at the north abutment of the auxiliary spillway and was repaired. A geomembrane seepage cutoff was installed in the upper embankment at that time as well. The cutoff consists of a 30 mil HDPE geomembrane liner installed vertically near the center of the embankment crest. The top of the liner is approximately 6 inches below the crest and the bottom extends down about 5 feet to the top of the old concrete core wall.

During this work, the crew discovered the old wall extends about 50 feet to the north and south of the new concrete weir wall and is only about one foot high in the areas beyond the new wall. The cutoff liner helps reduce the phreatic surface in the embankment, but seepage can still pass under the old core wall; furthermore, the aging core wall no longer provides a competent barrier within the dam.

In July 2017, yet another sinkhole developed near the south abutment of the auxiliary spillway. The reservoir level was drawn down and an emergency repair project was completed in October 2017 to repair and stabilize the sinkhole. The history of recent repairs reinforces the need for a larger rehabilitation project at Canyon Lake Dam.

The dam condition warrants the need for a large-scale rehabilitation. By implementing a project aimed at reducing or eliminating seepage issues at the dam, the safety of the dam can be improved long-term while also mitigating the unmanaged seepage releases. The continued safe operation of the dam will ensure that the water resources are conserved, managed, and protected well into the future.

Canyon Creek Irrigation District Canyon Lake Dam Rehabilitation Project

The CCID Canyon Lake Dam Rehabilitation Project is intended to preserve beneficial use of the water supplied by Canyon Lake Dam while improving dam safety. By rehabilitating the dam, the project seeks to conserve sustainable surface water delivery to CCID and maintain agricultural production. Furthermore, reducing or eliminating seepage through the embankment will stabilize the dam while allowing CCID to better manage the release of water resources impounded by the dam. The project seeks to achieve these objectives while preserving continuous use of the water resources and causing minimum impact to CCID irrigation seasons.

Without significant rehabilitation, CCID would likely continue to deal with smaller repairs as they arise. These repairs could impact irrigation seasons and would consume financial resources that could be utilized for other improvements. The dam also presents the risk of a larger failure, although the current condition of the dam does not pose a high risk of sudden catastrophic failure. Ongoing repairs or a larger problem at the dam would impact the benefits described previously.

The project would involve covering the upstream embankment with an impermeable geomembrane liner. The major components of this alternative involve temporarily removing and stockpiling the upstream riprap, preparing the geomembrane subgrade, installing and anchoring the geomembrane, placing a protective cover, and replacing the upstream riprap.

Approximately 610 cubic yards of riprap will need to be removed and stockpiled. Removing the riprap will expose the underlying filter geotextile. Recent inspections have revealed the 16-ounce nonwoven filter geotextile is in generally good condition and can probably remain in place where the subgrade is adequately smooth for geomembrane placement. Localized areas may require additional fill and grading to provide a suitable geomembrane subgrade.

Geotextile would be replaced in disturbed areas. In addition to the anchor trench, the existing geotextile is secured in place with steel staples. Next, geomembrane would be installed on the prepared subgrade. The embankment slope to be lined is approximately 1,050 square yards. When accounting for the crest anchor trench and toe anchorage, the total liner area is approximately 1,350 square yards. This assumes 2.5 feet of runout at the crest and a 2-foot deep by 1.5-foot wide anchor trench plus 2 feet for toe anchorage or runout. Actual anchor dimensions would be determined during final design. A portion of the liner would be battened to fixed objects rather than anchored in a trench.

Batten locations will include the auxiliary spillway wall, the intake structure, and exposed bedrock along the liner edge. Geomembrane would likely consist of a textured HDPE liner. HDPE provides strength, durability, and relative ease of installation. The liner would probably be 40 mil thickness to provide a balance of weight, strength, durability, and flexibility. A minimum thickness of 35 mils is recommended for high installation survivability (Koerner, 2012). Geomembrane requirements will be modeled after Geosynthetic Institute specification GRI-GM13 (GSI, 2016).

A heavyweight non-woven geotextile would be installed on top of the liner as a cushion for the riprap armoring. Riprap would be replaced to protect the geosynthetic materials. Replacing riprap would be a difficult installation task. Equipment would need to be operated carefully to place riprap without damaging the geotextile or geomembrane. The protective geotextile cannot be stapled in place, and would be secured by the anchor trench and friction with the geomembrane. The greatest risk to stability between geosynthetic materials will be during installation and riprap replacement. A soil cover would be easier to place on the liner, but riprap is preferred because it both protects the liner and is erosion resistant.

The embankment slope is approximately 1:1 for 6 feet at the intake structure. This small, excessively steep area could be improved as a part of the project. By lengthening the inlet pipe and moving or replacing the intake structure 6 feet to the west, the slope could be flattened to 2:1 in this location. This work is not required but would be beneficial. The flattened slope would more or less match the adjacent slopes, which would aid in liner installation. Lengthening the pipe and relocating the intake structure would require 2 to 3 cubic yards of excavation in the inlet channel, which would include rock excavation. A coffer dam or other dewatering method would be needed during excavation and intake structure installation. About 8 cubic yards of fill would be required to flatten the slope.

Additional earthwork quantities include approximately 32 cubic yards of embankment to level the crest at an elevation of 97 feet and 22 cubic yards of cut and fill to smooth the upstream embankment subgrade prior to liner installation.

The project will conserve the water resources provided by Canyon Lake Dam and improve the ability of the Irrigation District to manage those resources. The proposed project also protects human safety, water quality, and aquatic and riparian habitat by stabilizing the dam and reducing the potential for impacts from a dam failure.

Permits and Regulatory Approvals

Permits required to complete the project will be determined during final design. Anticipated permits are the Section 404 Permit and 318 Authorization. A 404 Permit, issued by the U.S. Army Corps of Engineers, is required to discharge or place dredged or filled material in streams or wetlands. Relocating the intake structure in the lake channel may trigger this permit. A 318 Authorization is required for work carried out in water that causes temporary turbidity. Again, the only planned activity below the reservoir low water level is relocating the intake structure. Construction best management practices (BMPs) will be utilized to mitigate potential water quality impacts.

The project will require a DNRC Construction Permit for a High Hazard Dam. CCID may need to obtain an Operating Permit from DNRC after construction.

A construction Storm Water Permit is not anticipated for the project because the total disturbance area should be less than one acre. The upstream embankment and crest are around one-third of an acre, and disturbance associated with borrow and construction support is expected to be less than one-half acre.

No easements are required for the project.