# CANYON LAKE DAM STUDY/REPORT

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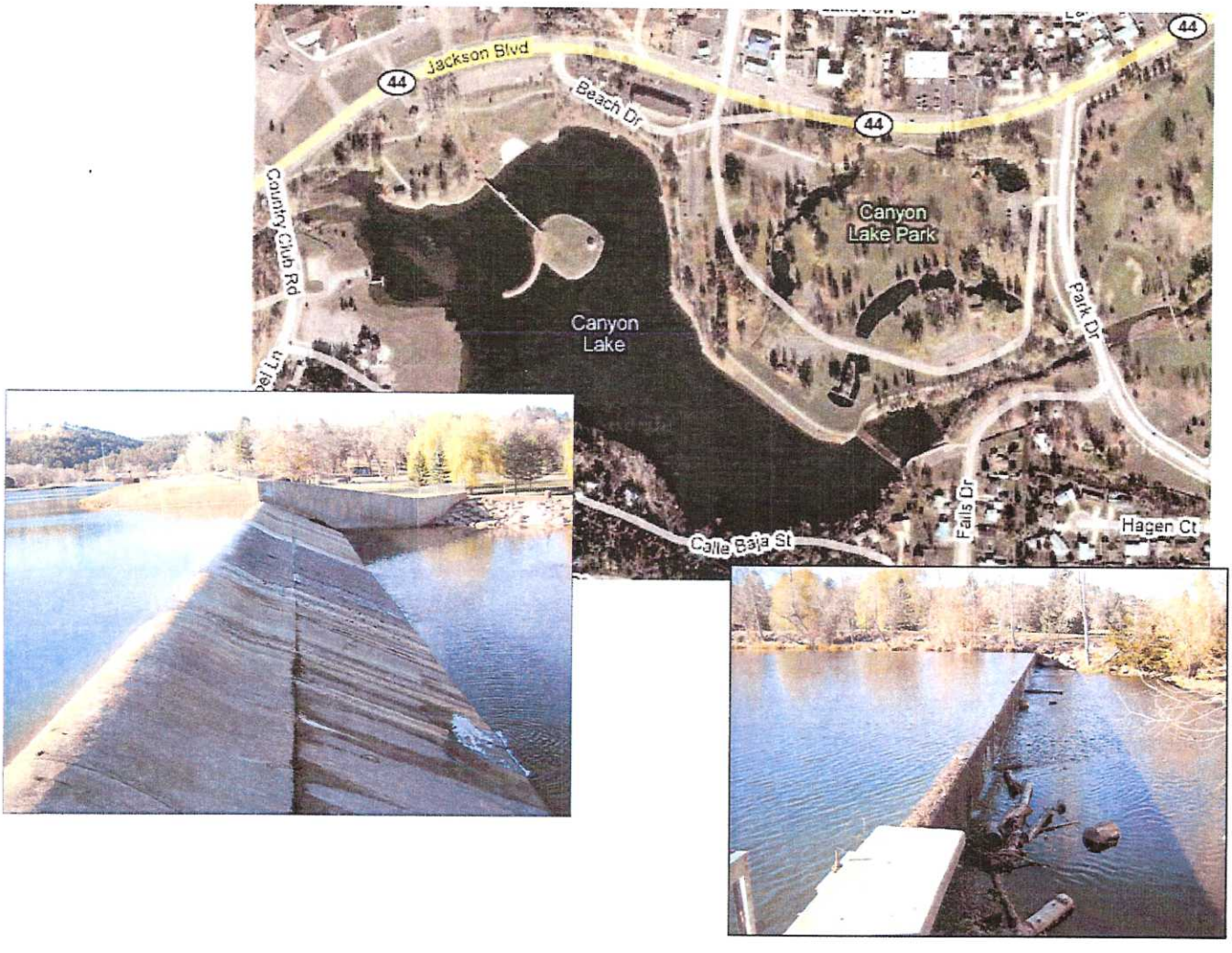
|---|---|
| PROJECT | Canyon Lake Dam Maintenance Project |
| PROJECT NUMBER | DR04 - 1433 |
| LOCATION | Canyon Lake Park, Adjacent to Jackson Boulevard and Park Drive, Southwest corner of City of Rapid City, SD |
| OWNER | City of Rapid City |
| DATE | February 4th, 2008 |
| ENGINEER | HDR Engineering Inc.<br>3820 Jackson Boulevard, Suite 1<br>Rapid City, SD 57702 |
| CERTIFICATION | I hereby certify that this Technical Memorandum and associated documents were prepared and assembled under my direct supervision and that I am a Professional Engineer Registered in the State of South Dakota. |

# CANYON LAKE DAM
# STUDY & REPORT

## City of Rapid City, South Dakota
**DR04-1433**




Memorandum Prepared By:
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3820 Jackson Boulevard Suite 1
Rapid City, South Dakota 57702

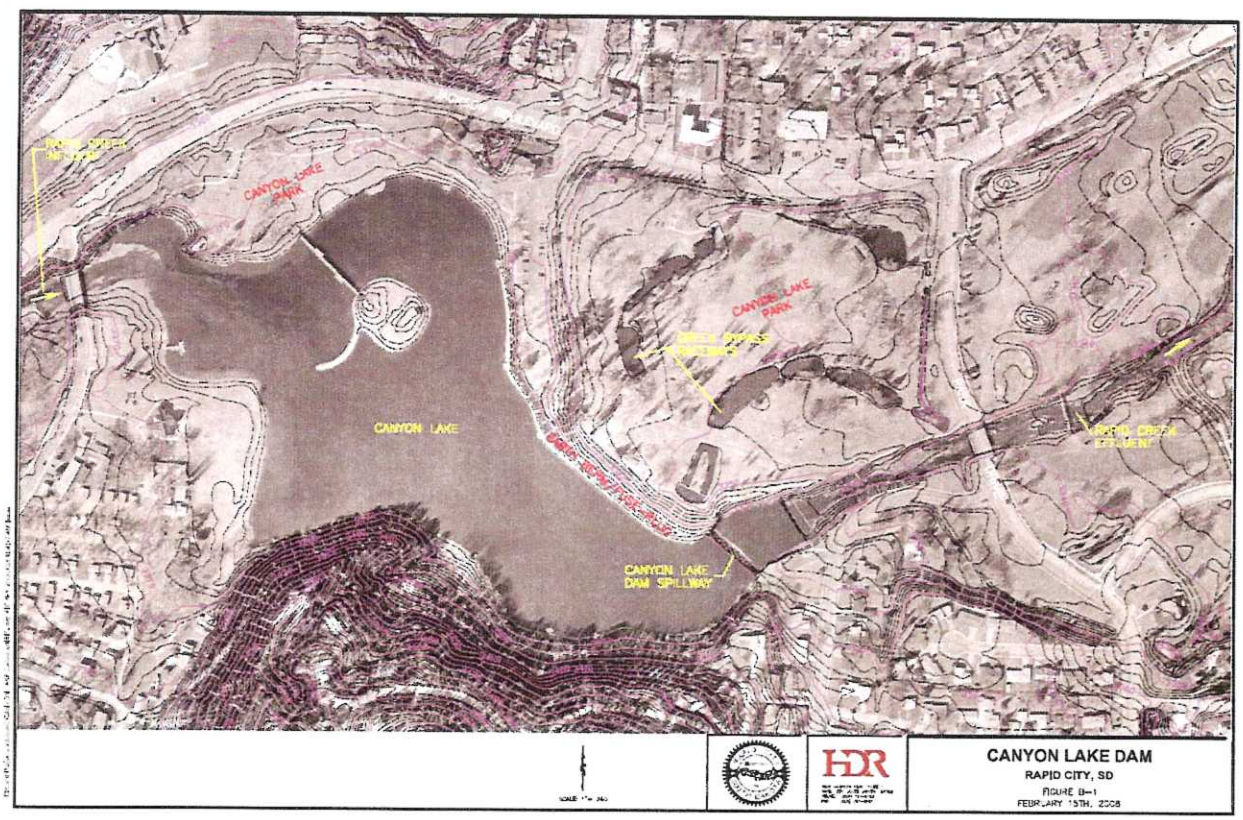
**March, 2008**

## Section A – Background

The Canyon Lake Dam in the City of Rapid City has been experiencing seepage issues throughout the past 20 years. Since the dam was rebuilt following the 1972 flood, there have been multiple studies and projects completed on the dam in attempt to address these issues, with the latest being in 2006. The sum of these projects has helped control the seepage and piping. However, the issues still remain and have re-emerged as a priority with a new leak that has materialized in the face of the spillway.

The Canyon Lake Dam, as shown in Figure B -1 is on Rapid Creek located in Canyon Lake Park in the southwest corner of the City of Rapid City. The dam is classified as a Category I High Hazard Dam and has a normal storage capacity of 140 acre-feet with reservoir level at the spillway elevation and a maximum storage capacity of 610 acre-feet with the reservoir level at the top of dam elevation. An old dam structure was overtopped during the flood of 1972 and the existing dam was constructed in 1976. The current dam contains a 200' wide concrete faced ogee-crest spillway that is founded on bedrock at the right abutment and on a clay core material at the left abutment.

**Figure B-1 – Canyon Lake Dam**




There have been noted seepage issues throughout the dam's lifetime and several projects have been completed in attempt to control or stop these issues. Below is a synopsis of the history of the construction and repair projects that have been completed on the dam and spillway:

1972 Old Canyon Lake Dam structure overtops and fails during the Rapid City flood.

1976 Construct existing configuration of an earthen dam embankment and concrete spillway

1985 Corp of Engineers inspection identifies seepage and boils in stilling pool and voids between clay core and concrete crest structure.

1986 Canyon Lake Spillway Maintenance Project installed a one-foot wide cutoff wall at the upstream face of the spillway, cleaned and sealed concrete joints, and filled voids beneath concrete structure with sand. Corps of Engineer report following repairs notes continued seepage under the spillway and identified sinkhole upstream of the structure.

1989 Trees removed from dam embankment areas. Department of Natural Resources noted seepage through joints in the spillway.

1995 Continued seepage noted in inspection reports.

1996 Canyon Lake Dam Maintenance Project cleaned and resealed joints on spillway. Shallow holes were drilled in the concrete for grout injection into voids, but no grout was installed since no voids were found immediately beneath the spillway. The lake was drained for the completion of this and other upstream improvements which caused a violation of sediment discharge limits in Rapid Creek.

2005 An underwater survey and dye testing project indicates a direct connection between three upstream sinkholes and downstream boils and spillway under drain pipes. An inspection report notes that the center of the spillway appears to have settled and several cracks have appeared in the spillway and basin walls, along with seepage noticeable through the weep holes and boil in the basin area.

2006 Canyon Lake Dam Maintenance Project constructed a filter berm to cover several of the largest boils downstream with coarse rock and riprap in attempt to prevent the piping of foundation materials from beneath the spillway.

2007 Reports note that a large boil has developed in the downstream apron along with a leak in the concrete spillway face where a "rooster tail" has water shootings out the hole.

## Section B – Purpose

The Canyon Lake Dam in the City of Rapid City has been experiencing seepage issues throughout the past 30 years. Since the dam was rebuilt following the 1972 flood, there have been multiple studies and projects completed on the dam in attempt to address these issues, with that latest being in 2006. The sum of these project results have helped control the seepage and piping, but the issues still remain and have re-emerged as a priority with a new leak that has materialized in the face of the spillway.

The City of Rapid City has retained HDR Engineering Inc. to review past reports and other pertinent information, examine the existing conditions of the dam, and develop a work plan to guide the City of Rapid City in planning the necessary investigations and methods required to repair the dam.

This technical memorandum documents the results of HDR's review of the body of documentation relating to the dam, observations and analyses of the existing conditions of the dam, and recommendations for a work plan to address the current deficiencies presented by the Canyon Lake Dam.

Sections C through F of this memorandum document the reference data reviewed in the analysis, summarize the site observations made during the site visit and from previous photographs, discuss the issues relating to the dam performance and safety, and provide some overall analyses of the potential drivers behind the dam's current issues.

The final sections G and H provide recommendations for an overall course of action to address the Canyon Lake Dam deficiencies and a suggested work plan for completing the course of action. Planning level,

conceptual opinions of probable costs for the work plan items are also presented to assist the City of Rapid City with implementation.

## Section C – Reference Data

The following reference materials were reviewed as part of this technical memorandum and the information contained therein was considered in the review of the Canyon Lake Dam issues:


1. Correspondence, Francis-Meador-Gellhaus, Inc. to City of Rapid City, Re: Canyon Lake Dam, Approved Shop Drawings, Inspection Reports 12 through 21, M-D Curves, Payroll data, March 8, 1976
2. Correspondence, City of Rapid City, South Dakota to USACE, Re: CLDM 86-1, Canyon Lake Dam Spillway Maintenance, November 17, 1986
3. Specification, Section 03600 PRESSURE GROUTING, Jones Lake Dam, Pages 1-4, July 1989
4. Specification, Partial Specification Section – B. Clay Core, Page 22, Date Not Indicated
5. Correspondence, South Dakota Department of Water & Natural Resources to City of Rapid City, Re: Summary Report of Canyon Lake Dam, Inspection Report - Summary Report of Canyon Lake Dam, April 25, 1990, Letter Dated February 7, 1991
6. Correspondence, South Dakota Department of Water & Natural Resources to City of Rapid City, Re: Copy of Safety of Dams Rules, March 22, 1991
7. Canyon Lake Management Plan, Final Report, City of Rapid City, Prepared by The Alliance and HDR Engineering, Inc., January 13, 1992
8. Pre-Letting Data Form, City of Rapid City, Canyon Lake Dam Maintenance Project D96-613, December 15, 1995
9. Specifications and Drawings, Canyon Lake Dam Maintenance Project No. D96-613, City of Rapid City, January 9, 1996
10. Correspondence, City of Rapid City, SD to J.V. Baily Company, Inc., Re: Canyon Lake Dam Maintenance Project No. D96-613 [Submittals] Joint Sealant, Grout Mix Design, Grouting Method, Construction Schedule, Sand Filler, January 12, 1996
11. Investigation Report (Fax Copy), S.D. Governor's Office, Canyon Lake Project Violation Investigation Report, Pages 4-8, February 13, 1996
12. Specifications and Drawings, Canyon Lake Dam Maintenance Project No. DR04-1433, City of Rapid City, December 20, 2004
13. Project Overview, Prepared for City of Rapid City by Bareis Engineering, Date Not Specified
14. Comprehensive Underwater Survey and Dye Testing Report, Midco Diving and Marine Services, Inc., Project Photographs, March 2005.
15. Meeting Minutes, Canyon Lake Dam Maintenance – Project No. DR04-1433 Design Report – Initial Findings and Recommendations, Progress Meeting, August 24, 2005
16. Bareis Engineering, Inc., Construction of Filter Berm in Spillway Stilling Pool – Canyon Lake Dam Maintenance – Rapid City, SD – Project No. DR04-1433, January 31, 2006
17. Harlan, Bill, "Canyon Lake Dam safe for now, but study, repair needed", Rapid City Journal, November 2007 <http://www.rapidcityjournal.com/articles/2007/10/17/news/top/doc47140d73161640000652.html>
18. Photographs of the Canyon Lake Dam obtained at different periods of time.

## Section D – Site Observations

A site visit was conducted on January 21, 2008 by HDR Engineering and the City of Rapid City. The following individuals attended the site visit:

Mr. Keith Johnson, City of Rapid City, Project Manager

Mr. Jody Page PE, HDR Engineering, Rapid City South Dakota, HDR Project Manager

Mr. J. Mike Coleman PE&LS, HDR Engineering, Sioux Falls South Dakota

Mr. John Larson PE (Minnesota), HDR Engineering, Minneapolis Minnesota

Mr. Mike Johnson PE (Minnesota), HDR Engineering, Minneapolis Minnesota

During the site visit, the assessment team walked out to the northern abutment through the municipal park area to observe the dam. At the time of the visit, water was flowing over the dam spillway and several areas of seepage were visible in the form of a small "rooster tail" emanating from a downstream crest face seam and a noticeable boil in the tail water area south of the north abutment just downstream of foot of the dam crest.

The assessment team also reviewed photographs taken in the fall and winter of 2007 that showed other seepage areas. In addition, the photographs taken during the execution of the underwater survey and dye testing conducted by Midco Diving and Marine services were reviewed. These images are provided as an appendix to this memorandum.

## Section E – Issues of Concern

The main issue of concern is the concentrated seepage which could result in the sudden failure of the dam, flooding down stream and loss of the reservoir. The dam is listed in the National Dam Safety Inventory as a high hazard dam. High hazard dams are deemed to have significant potential for loss of life in the event of a structure failure.

The specific areas of concern include the following:

- Boil just down stream which was stopped with a filter.
- Boil through the stilling basin concrete joint which increased with the filter placement in 2006.
- Persistent leaks through the concrete joints.
- Voids between the mass concrete crest and the clay core as evidenced in 1986.
- Existence of fractured and layered limestone bedrock cliff as a point of interface with the clay core.
- Potential for poor compaction at the base of the core as evidenced in the construction logs.
- Sink hole in the upstream reservoir. (Dye placed upstream was found to be drawn into the sink hole and discharged at the boil in a very short time.)

The long-lasting and persistent existence of the concentrated seepage is of concern. As indicated in the reference data, the conditions became of concern in the first decade after the dam was constructed and has been an ongoing area of repair and concern to date. The first seepage repair was performed in 1986, 10 years after the construction. Subsequent repairs were performed in 1996 and 2007.

The typical failure mechanism of concern associated with concentrated seepage is the development of a "pipe". The pipe begins from the downstream end with the loss of soil material and progresses upstream towards the reservoir. With the material loss the resistance to flow decreases, causing the volume of flow to increase which correspondingly causes the amount of material loss to increase and the size of the pipe to increase. Some soils and structural configurations like a clay core or bedrock interface can restrict or resist the erosion or even "bridge" or "arch" over the "pipe". Unfortunately, this type of formation can suddenly collapse and result in a sudden failure or progressive failure exhibiting periodic collapse followed by washing out of collapsed material. This cycle can repeat itself resulting in critical damage and failure of the dam.

Seepage failures tend to gradually increase and then suddenly progress in an "exponentially" increasing failure or sudden collapse. At times the loss of soil material will also cause a "structural failure" of the concrete apron or other structure – compromising the erosion protection surface. The most vulnerable time for such a collapse is during flood events with the stilling basin flows, surging hydraulic jump and additional weight and pressures of the water.

Concentrated seepage and piping seldom improve over time. In addition, once a pipe starts, the installation of a downstream filter often simply increases the pressure and causes the failure to move to another location. The filter installation and the subsequent movement of the boil upstream to the slab of the dam indicates that the fundamental piping problem remains. In fact, the resulting seepage path is now shorter and the potential for undermining the slab and a structural collapse is probably greater.

## Section F – Basic Design Analyses

The adequacy of the original design was evaluated using Lanes weighted creep ratio theory. The analysis method is based on the analysis of over 200 dams with consideration given to both seepage failure and non-failure for dams on permeable foundations. The method is particularly applicable for evaluating the potential for piping along interfaces. This includes along the bedrock/clay core interface, mass concrete/clay core interface and the base soil/clay core interface. Although the theory is empirical the results are representative, especially considering the non-uniformity of the seepage conditions.

The method can be summarized as follows:

1. The weighted –creep distance of a cross section of a dam is the sum of the vertical distances plus one-third of the horizontal creep distances.
2. The weighted-creep head ratio is the weighted-creep distance divided by the effective head.
3. Filter drains, weep holes and pipe drains are an aid to security from under seepage, and the recommended safe weighted-creep head ratios may as a result be reduced by as much as 10 percent.
4. Cutoffs should be carefully tied in at the ends to avoid "outflanking" or "short circuiting" of the seepage path.

Acceptable weighted-creep ratios represent the ability of various types of soil to resist the forces of moving water and preclude piping. The recommended ratios are shown in Table 1.

**Table 1 - Lanes Weighted-Creep Ratio Soil Values**

| Number | Material | Ratio without drains | Max ratio with drains (-10%) |
|---|---|---|---|
| 1 | Very fine sand or silt | 8.5 | 7.65 |
| 2 | Fine sand | 7.0 | 6.3 |
| 3 | Medium sand | 6.0 | 5.4 |
| 4 | Coarse sand | 5.0 | 4.5 |
| 5 | Fine gravel | 4.0 | 3.6 |
| 6 | Medium gravel | 3.5 | 3.15 |
| 7 | Coarse gravel with cobbles | 3.0 | 2.7 |
| 8 | Boulders with cobles and gravel | 2.5 | 2.25 |
| 9 | Soft clay | 3.0 | 2.7 |
| 10 | Medium clay | 2.0 | 1.8 |
| 11 | Hard clay | 1.8 | 1.62 |
| 12 | Very hard clay or hardpan | 1.6 | 1.44 |

The results of the analysis give an indication of potential deficiencies in the original design. These analysis results when combined with the issues of concern provide an indication of the likely deficiencies. They also provide an indication of the type of corrective measures which are anticipated to be required to resolve the problem. Table 2 provides results of the analysis on potential seepage paths.

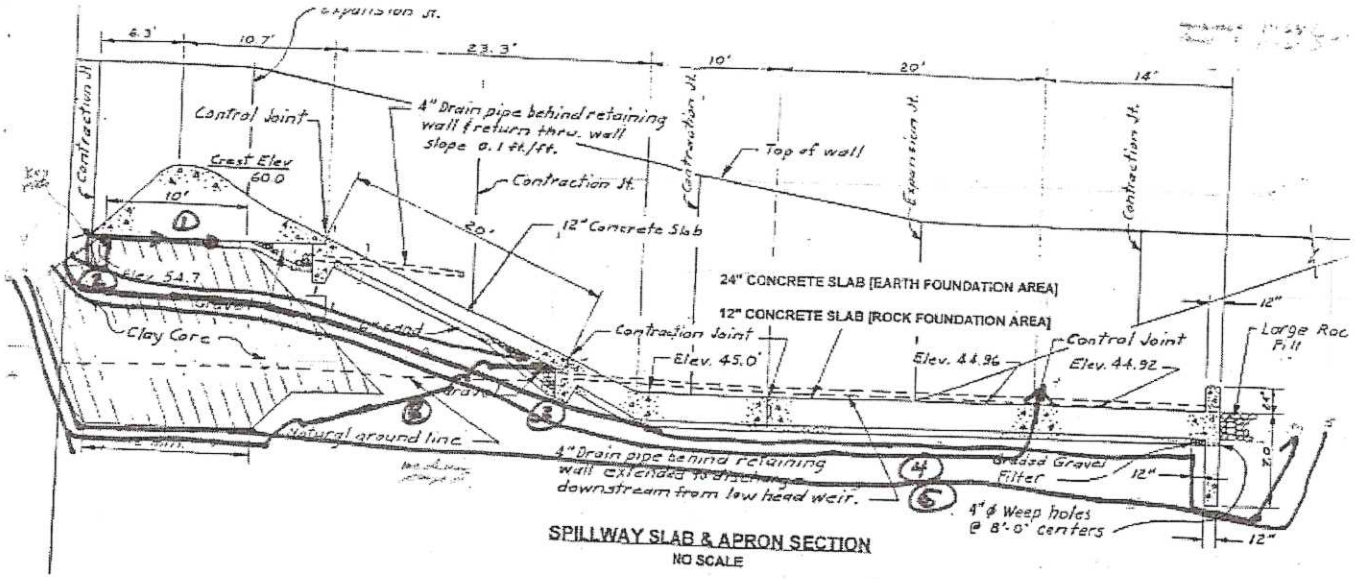
**Table 2 – Seepage Path Analysis Results**

| Path | Description | Weighted Creep Ratio | Recommended ratio |
|---|---|---|---|
| 1 | Along clay core/mass concrete crest before 1986 repair | 0.58<br>Not Good | 1.62 if hard clay and drain |
| 2 | Along clay core/mass concrete crest after 1986 repair | 1.51<br>Not Good | 1.62 and assuming blown sand ineffective in resisting flow compared to clay. |
| 3 | Along diagonal bedrock interface and clay core to tail water | 3.39<br>OK | 1.8 if through clay core. |
| 4 | Along diagonal bedrock interface and lower joint | 2.66<br>OK | 1.62 if through clay core |
| 5 | Along diagonal bedrock interface to lower drain | 1.38<br>Not Good | 1.62 if through clay core. |
| 6 | Beneath clay core and to tail water | 3.62<br>Not Good | Depends on the soil type |
| 7 | Beneath clay core and to lower drain | 2.24<br>Not Good | Depends on the soil type |

The results of the analysis indicate the following:

1. Path 1 - The weighted creep ratio is very marginal. Piping should occur along the mass concrete and clay core as evident in the 1986 repair.
2. Path 2 - The analysis also indicates that the 4 feet deep core when combined with the blown sand in the piped areas does not meet the recommended values but is close. Deficiencies and leakage would be expected in the long term.
3. Path 3 and 4 – The weighted creep ratio is 3.39 and 2.66. If the clay core is a hard clay and the native soil is not overly susceptible to seepage, the seepage path should be adequate. Beyond the direct analysis, construction deficiencies and geologic flaws like cracking and jointing would be a likely cause for extensive seepage that could make the problem worse than indicated in the analysis.
4. Path 5 – The weighted creep ratio is 1.38 which is less than the recommended. This would indicate that seepage could occur along the bedrock clay core interface and overwhelm the ability of the drain to handle the seepage amount.
5. Path 6 – The weighted creep ratio is 3.62. Beyond the direct analysis, the difficulty in preparing and compacting the subgrade with both water and freezing conditions could make the problem worse than indicated. The adequacy depends on the native soil material. If medium gravel to very hard clay or hardpan is present (number 6-12), the seepage would be considered adequate. However, if fine sand/silt to fine gravel (number 1-5) is present, then the design is not adequate.
6. Path 7 – The weighted creep ratio is 2.24. Similar but more critical to Path 6 the adequacy depends on the soil type beneath the clay core and the effectiveness in placing and compacting the soil during the original construction. However only medium to hard clay or soil with boulder and cobbles would be considered adequate. Soil types 8, 10, 11 and 12.

**Figure 2 – Seepage Pathways**




## Section G – Discussion and Recommendations

The issues of concern, observations, and analysis all indicate that the Canyon Lake Dam has seepage conditions of concern. The seepage conditions began within the first decade the dam was constructed and have persisted despite repeated attempts to correct the issues. Corrective action like the 4-foot deep cutoff wall marginally improved the safety. The filter drain installed in the tail water area likely only pushed an already developed pipe/boil to a new location; likely making the seepage path shorter, pressures/velocities greater and worsening the condition. The sink hole and dye tests indicate a direct seepage path through or under the dam from upstream to downstream. Under seepage failures can expand exponentially and, at times, precipitate a sudden collapse of the dam in a very short time. Given the dams condition, predicting a time of failure under this scenario is virtually impossible. The dam is a high hazard dam with the potential for loss of life if it should fail.

After analyzing the available data on the dam, corrective actions with both immediate and long term components are recommended. Short term actions should be considered as soon as possible and within the next few months and long term should be considered within two years. The recommended actions are as follows:

- Short Term Immediate Measures
    - Monitor the Dam Daily - Monitor the dam daily for signs of increased seepage through winter conditions and spring runoff.
    - Mitigate the upstream Seep Hole - Place layers of progressively finer material in the upstream sink hole to reduce seepage flow and downstream pressures (Important to do from upstream side). Layers would start with coarse gravel, followed by sand and ending with a sand/bentonite mix.
    - Perform a detailed breach analysis to determine the critical areas that may be affected by the combination of a high flow event with a simultaneous spillway failure. An analysis of the effects of the sidewalk installation on the fuse plug should also be evaluated.
    - Implement a Consistent Monitoring Protocol – After the seep hole mitigation is complete, implement a consistent monitoring plan while longer term solutions are executed. Monitor the dam and apron slab for seepage, settlement and displacement. The monitoring plan may require daily observations of the dam integrity and a reporting protocol for documentation and notification if the dam's status begins to degrade.
    - Evaluate the effectiveness of the short term measures during the monitoring period. The City should review the County emergency response plan (ERP) and formulate a plan that

coordinates actions between the Public Works, Fire Department, and Police Department in case the monitoring activities show that dam failure is imminent. The ERP should include provisions for reverse 911 notification and evacuation plans for downstream citizens and property that is within the inundation zone.

- Long Term Measures
  - Design either a combination of seepage cutoffs, grouting, support grouting, filtered drains and other efforts to provide an adequate safety for seepage or a new spillway structure. This includes between the concrete crest and clay core, the bedrock interface with the clay core, the abutments and other areas.
  - Implement the repairs.

## Section H – Work Plan

This section describes a recommended work plan for accomplishing the objective of addressing the deficiencies found in the existing Canyon Lake dam. The intent of the work plan is to provide the City with a suggested framework from which to finalize a plan of attack to address the problems at the Canyon Lake Dam. This work plan may change based on several factors as the mitigation plan moves forward, funding sources and timelines are clarified, and other requirements come to light. Additionally, not all stages of the work plan may be authorized at the same time and earlier activities may change the scope of planned, later activities. The work plan is presented in a task based format so that individual tasks can be specifically described, scoped, and scheduled in the future.

Task 1 - Project Management

Task 1 includes the management activities necessary by City Staff, retained consultants, and other project team members necessary to manage subsequent tasks and project activities, monitor task progress, and to drive the project elements to the cumulative conclusion of completed repairs to the Canyon Lake Dam.

Subtask 1.1 - Project Management

Formulate a project management plan that incorporates action items from the following work plan and ties this to schedule items. Under this task, the City would name a project manager assigned to complete the work plan. Additionally, processes for retaining consultants and other outside resources would be identified and executed. The activity would also incorporate any monthly progress reporting, standing management meetings, and other miscellaneous management activities.

Subtask 1.2 - Scheduling

In conjunction with Subtask 1.1, compile a schedule for implementation of emergency repairs, field work, design, and long term repairs. The schedule must also consider timelines for permitting and incorporate appropriate public/agency involvement. City plans to work within the lake or draw the lake down should also be considered as emergency repairs and field investigations may be able to be accomplished in conjunction with any already planned maintenance activities.

Subtask 1.3 - Budgeting and Appropriations

Based on the projected cash flow and expenditure projections, appropriate funding sources and budgeting reviews will need to be undertaken in order to execute the recommended projects. As part of this task, the City may need to seek funding from State and Federal entities to secure grants or emergency funding.

Task 2 - Immediate Response Actions

The seepage condition is an area of serious and immediate concern. The current documented seepage conditions are significant; however it is difficult to assess the magnitude of the situation at the present time. On the other hand, if a sudden increase of seepage develops that threatens the spillway then an emergency response would be warranted and a timely response is often key in such conditions. In

addition, to improve the short term safety of the dam, it is recommended to perform some immediate construction to reduce the seepage volume and pressures as an interim measure.

Subtask 2.1 - Review the City's Emergency Response Plan

The City and County's current ERP should be updated to address contingencies for dam failure. The ERP should be formulated and coordinated with the appropriate City departments and other emergency responders, as needed.

Subtask 2.2 - Formulate and Implement Monitoring Plan

Daily observation of the seepage and related conditions is recommended until some emergency measures can be performed. It is expected that such emergency measures would need to be delayed until winter and spring runoff conditions occur. If sudden increases of seepage should occur or movement/displacement of the structure worsens, the condition needs to be assessed in a timely manner and emergency response made as appropriate.

Subtask 2.3 - Sink Hole Mitigation

2.3.1 - Prepare Construction Plans

Immediate repairs to fill and reduce the flow from the upstream sink hole are recommended. Dye tests have indicated a direct connection from the sink hole to the boil that is present downstream. Installation of the downstream filter appears to have simply redirected the leakage. Emergency repairs from the upstream side are recommended to reduce the seepage volumes and pressures. The emergency effort would best be performed by draining the reservoir, cleaning out the sink hole area and installing a graded material (coarse gravel, sand and then sand/bentonite mixture, or bentonite geotextile). As an alternative, sealing of the sink hole could be attempted from a barge without draining the reservoir. Although not expected to be as effective, it hopefully would improve the seepage conditions. Discussion with the agencies about draining the reservoir for emergency repairs is recommended.

2.3.2 - Execute Sink Hole Mitigation Construction

Sink hole short term repairs will be executed under this task. The City may retain a contractor on a bid or emergency procurement basis to undertake this work.

Task 3 - Long Term Preliminary Investigations

In order to adequately evaluate and design the final mitigation measures for the dam, some additional field investigations may be necessary. Consideration should also be given to a replacement project in lieu of a mitigation project. At the completion of the geotechnical investigation, sufficient information will exist to evaluate a replacement project as opposed to a mitigation project.

Subtask 3.1 - Geotechnical Investigations

To date, no test borings or other geotechnical information at the project site were available for our review for this report. A geotechnical investigation will be required to characterize the underlying soil and rock stratigraphy at the site and to assist in the assessment of the seepage issues and in the development of mitigation measures. Based on the limited information available, the existing dam is founded on a compacted clay core and limestone bedrock.

The geotechnical work at the site will consist of soil borings and rock corings and a laboratory testing program. The preliminary scope for this work is anticipated to consist of the following tasks:

Three (3) borings are proposed along the upstream face of the dam. One (1) boring is proposed in the reservoir area.

Three (3) borings are proposed along the downstream sill of the spillway. One (1) boring is proposed through the apron.

The borings will be completed from a floating barge as needed and will be extended through the any overburden soils and into the limestone bedrock. Soil sampling will be completed at 5-foot intervals. The coring distances in the bedrock will range from 10 to 40 feet and will be continuous.

A laboratory testing program is proposed to evaluate the mechanical properties and engineering characteristics of the foundation materials. The testing will include gradation tests, plasticity tests and strength testing. The degree of fracturing of the bedrock will be evaluated with RQD (Rock Quality Designation) and % recovery measurements. No field or lab permeability testing of soil or rock is proposed at this time.

Subtask 3.2 - Surveying

Additional surveying data may need to be obtained to supplement existing data to a level that is adequate for existing design. Under this task, the existing body of surveying data and the need to acquire supplemental data will be evaluated. If additional surveying data is needed, it will be acquired under this task.

Task 4 - Permitting / Public Outreach

Coordination with the relevant regulatory agencies and project stakeholders will be required to inform them of the project work plan, request input, coordinate actions, obtain necessary permits, and to keep them informed. The sub-tasks under Task 3 are intended to provide an organized public outreach plan.

Subtask 4.1 - Coordination with Regulatory Agencies

This subtask includes initial and follow-on coordination with regulatory agencies such as Dam Safety and other State and Federal agencies that need to be informed or consulted on the projects or that have permitting authority over the project.

Subtask 4.2 - Permit Applications and Documentation

Under this subtask and based on consultations, the appropriate permit applications and documentation will be prepared so that both short-term immediate repair actions and long term mitigation actions can be executed.

Subtask 4.3 - Council Briefings / Presentations

During the course of the project, the City Council will require briefings and updates to keep informed on the project issues and progress. This subtask includes the effort to prepare and present these presentations during the anticipated project schedule.

Subtask 4.4 - Public Meetings / Presentations

Disseminating appropriate public information and updates to project stakeholders will be a critical effort during the project execution. Appropriate public meeting dates and times will be established, presentation and informational materials will be compiled, and presentations will be written and presented under this subtask.

Task 5 - Preliminary Design

The intent of this task is to establish the Canyon Lake Dam preferred mitigation plan in terms of the dam stabilization plan to be executed and to detail any design criteria that must be clarified and agreed upon with the regulatory agencies.

Subtask 5.1 - Review of Regulations

In order to comply with present regulations for issues such as dam safety and environmental concerns, a review of the relevant regulations should be conducted in order to define design and execution criteria for the Canyon Lake dam mitigation. The review will be summarized and serve to help define the design criteria for the mitigation options and construction plans.

Subtask 5.2 - Preliminary Design Report / Basis of Design

The design team will prepare a Preliminary Design / Basis of Design report. The report will

assess the potential options for mitigation of the Canyon Lake Dam problems and will make a recommendation, in conjunction with appropriate input from the City, of a recommended plan. The report will also define the critical design criteria that must be observed and achieved by the final design.

Subtask 5.3 - Updated Opinions of Probable Cost

As part of the preliminary design report, an updated opinion of probable cost will be compiled.

Task 6 - Final Design

The Final Design task will produce drawings and specifications suitable for use in obtaining bids for the seepage mitigation work. As part of this task, the final opinions of probable cost for the project would be compiled.

Subtask 6.1 - Final Design

The subtask includes final design activities such as design management, meetings, final design calculations, and additional coordination or field investigations.

Subtask 6.2 - Drawings

Drawings suitable for inclusion in construction contract documents will be prepared with the intent to obtain construction bids for mitigation of the Canyon Lake seepage problems.

Subtask 6.3 - Specifications

Contract documents and technical specifications will be prepared to be used, when combined with the Drawings, to produce a complete construction document set that will be used as a contract vehicle and to obtain bids for the construction of the project.

Subtask 6.4 - Final Opinions of Probable Costs

Based on the final design, a final opinion of probable cost will be prepared.

Task 7 - Land / Right-of-Way Acquisition

As noted in the discussion, right-of-way or land acquisition may not be required if the appropriate right-of-way for the project is already available. The following tasks might be required if additional right-of-way or easements are required to construct or operate the project.

Subtask 7.1 - Identification of Parcels or Right-of-Way to be acquired, if any.

Subtask 7.2 - Exhibit Preparation

Subtask 7.3 - Acquisition

Task 8 - Construction / Construction Administration

These activities include construction administration activities to manage the construction contract and insure quality during the construction period. Some of the tasks under subtasks 8.1 through 8.5 might be performed by the City or by the design engineer under contract to the City. Subtask 8.6 includes the actual construction of the Canyon Lake Dam mitigation project elements. Field inspection services under subtask 8.7 may be provided by the City or under a separate contract.

Subtask 8.1 - Advertisement for Bids / Letting

Subtask 8.2 - Addendum

Subtask 8.3 - Pre-Bid Meeting

Subtask 8.4 - Bid Opening, Evaluation, and Recommendation for Award

Subtask 8.5 - Construction Administration

8.5.1 - Notice to Proceed

8.5.2 - Submittal Reviews

8.5.3 - Payment Application Reviews

8.5.4 - Requests for Information

8.5.5 - Field Orders / Change Orders

8.5.6 - Punch List / Final Inspections

Subtask 8.6 - Construction

Subtask 8.7 - Field Inspection Services

Task 9 - Final Documentation / Record Drawings

After construction is completed, the Contractor will provide the Design Engineer with markups and documentation of any changes required to specific design elements in the field. The Design Engineer will then record and transfer this information to a set of record drawings. The completed record drawings will then be transmitted to the City.

Tables 3.1 and 3.2 provide conceptual, planning level cost ranges for the activities described in the above work plan outline. The costs are presented as part of this memorandum in order to assist the City with planning and to provide a representation of the order-of-magnitude of the potential project costs. These costs are conceptual opinions of probable costs and will change during the course of the project. Additionally, these opinions of probable costs may not include ancillary costs relating to City staff time or other labor, equipment, materials, bonding, or insurance costs that may be necessary as part of the project.

**Table 3.1 – Short Term Repairs Work Plan Cost Ranges**

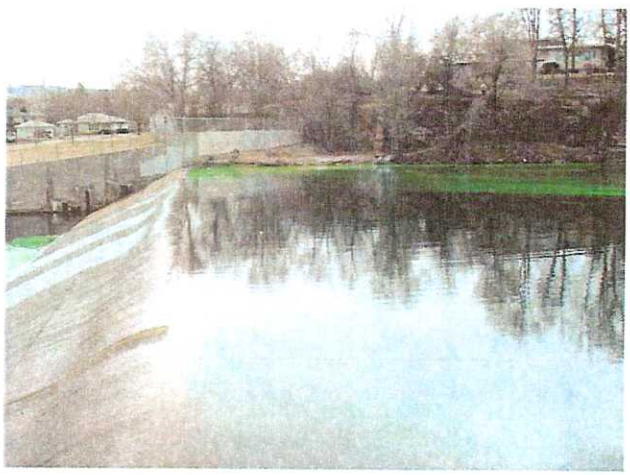
| Work Plan Item | Planning Level Cost Range |
|---|---|
| Task 1 – Project Management | $5,000 to $10,000 |
| Task 2 – Emergency Response Actions | $50,000 to $150,000 |

**Table 3.2 – Long Term Repairs Work Plan Cost Ranges**

| Work Plan Item | Planning Level Cost Range |
|---|---|
| Task 1 – Project Management | $45,000 to $125,000 |
| Task 3.1 – Geotechnical Investigations | $35,000 to $65,000 |
| Task 3.2 – Surveying | $8,000 to $15,000, if required. |
| Task 4 – Permitting and Public Outreach | $30,000 to $80,000 |
| Task 5 – Preliminary Design | $30,000 to $75,000 |
| Task 6 – Final Design | $60,000 to $150,000 |
| Task 7 – Land / Right-of Way Acquisition | Unknown at this time. However, if the current right-of-way owned by the City is adequate, then no costs would be anticipated. |
| Task 8 – Construction Costs | $800,000 to $2,000,000 |
| Task 9 – Construction Administration Costs | $56,000 to $140,000 |

# Appendix

## Project Photos



Photos 1 & 2 – March 2005, Midco Diving releasing the dye for seepage testing near the upstream sinkhole.

Photo 3 – March 2005, Midco Diving dye testing reveals a dark plume of dye at the area around the existing boil downstream prior to the dye flowing over the spillway.

Photos 4 & 5 – March 2005, Midco Diving dye testing reveals plumes of dye emerging from the weep holes and areas along the spillway wing walls.

Photo 6 – March 2005, Midco Diving dye testing reveals a small plume of dye at the base of the spillway face prior to the dye flowing over the spillway.

Photos 7 & 8 – March 2005, Midco Diving dye testing shows an extensive amount of dye exiting the underdrain pipe outlet at the base of the concrete apron downstream of the spillway.

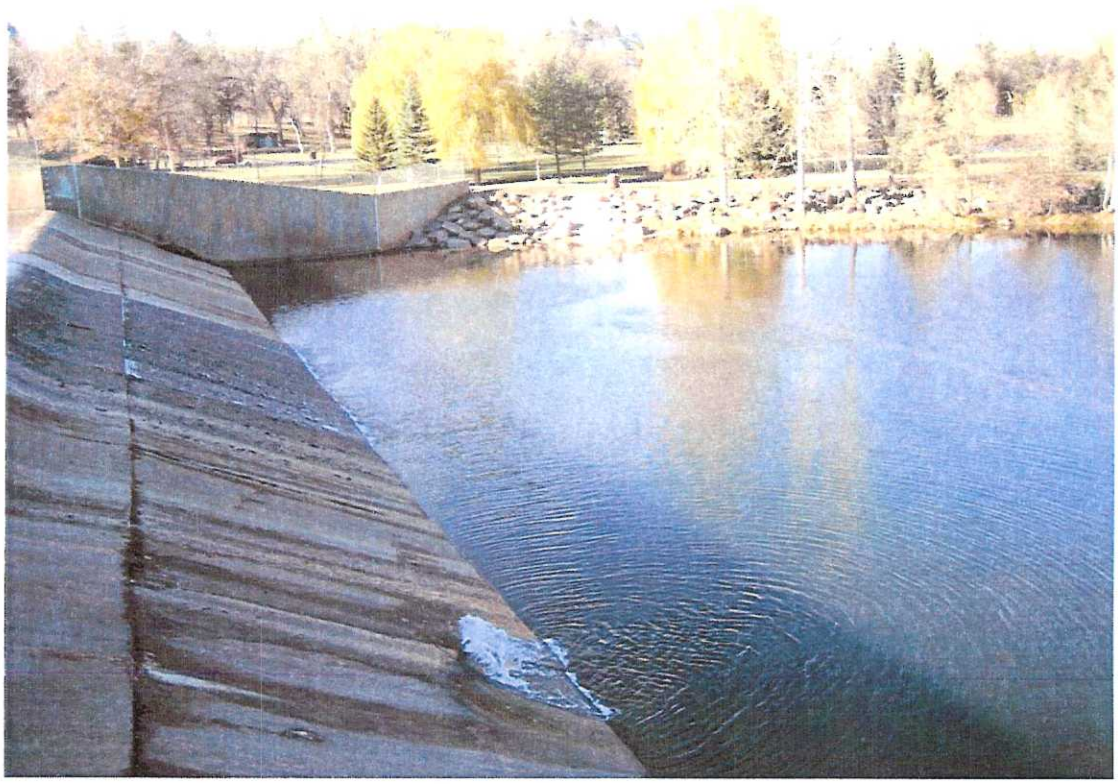
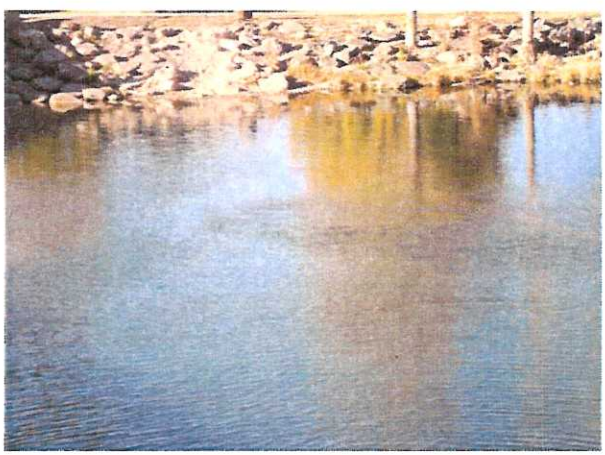


Photo 15 – Fall 2007, Photo looking north showing both the roostertail leak in the concrete spillway and the boil in the downstream apron.



Photos 16 & 17 – Fall 2007, showing the noticeable flow from the seepage boil in the downstream apron.

Photos 9 & 10 – Fall 2007, "Roostertail" leak in the concrete face of the spillway.

Photos 11 & 12 – Fall 2007, "Roostertail" leak in the concrete face of the spillway.

Photos 13 & 14 – Fall 2007, Additional seepage shown by wetted areas around the concrete spillway joints.