

RECLAMATION

Managing Water in the West

High Lakes Stabilization Clements Lake Brown Duck Basin Technical Memorandum Uinta Basin Replacement Project



**U.S. Department of the Interior
Bureau of Reclamation
Provo Area Office
Provo, Utah**

June 2007

High Lakes Stabilization Clements Lake Brown Duck Basin Technical Memorandum

Uinta Basin Replacement Project

prepared by

**Provo Area Office
Upper Colorado Region**



U.S. Department of the Interior
Bureau of Reclamation
Provo Area Office
Provo, Utah

June 2007

Concurrence

The undersigned concur with the recommendations identified in this Technical Memorandum.
This Technical Memorandum will serve as a Decision Memorandum.

Jerry Olds, P.E. Date
Utah State Engineer

Reed R. Murray Date
Department of the Interior
CUPCA Office

Jack Troyer Date
Regional Forester
U.S. Forest Service

Michael C. Weland Date
Executive Director
Utah Reclamation Mitigation and Conservation Commission



U.S. Department of the Interior
Bureau of Reclamation
Provo Area Office
Provo, Utah

June 2007

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Introduction

The Uinta Basin Replacement Project (UBRP Project) was authorized by Section 203 of the Central Utah Project Completion Act [CUPCA: Titles II through VI of P.L. 102-575, as amended]. The UBRP Project is located in Duchesne County near the towns of Altamont, Upalco, and Roosevelt, within the Uinta Basin of northeastern Utah. Its purposes are to increase efficiency, enhance beneficial uses, and achieve greater water conservation within the Uinta Basin. The Central Utah Water Conservancy District (District) is implementing the water development portions of the UBRP Project, and the Utah Reclamation Mitigation and Conservation Commission (Commission) is responsible for mitigating project impacts to fish, wildlife and wetland habitats. Funding for mitigation measures is provided under Title II of CUPCA through the U.S. Department of the Interior. The Final Environmental Assessment for the UBRP Project was prepared by the District and was signed by the Department of the Interior in October 2001. Project construction began in 2003. The Commission issued a Decision Notice and Finding of No Significant Impact in February 2004 for implementing fish and wildlife mitigation features of the UBRP Project.

A component of the UBRP Project is that thirteen high mountain lakes formerly used to store water rights would be stabilized at No-Hazard levels, and the water rights transferred downstream for storage in the enlarged Big Sand Wash Reservoir, another feature of the UBRP Project. The stabilization of the thirteen reservoirs is mitigation for the enlargement of Big Sand Wash Reservoir. Because of the breach potential of the High Lakes Dams, and the difficulty in monitoring and maintaining these dams in the Wilderness area, the Mitigation Commission is undertaking the stabilization of the thirteen dam structures. Storage of the water rights will be downstream in the expanded Big Sand Wash dam where maintenance and monitoring is practical. These wilderness dams vary in size, hazard rating and condition and have peak breach flow potential ranging from hundreds to several thousand cubic feet per second (cfs). Breach flows of this magnitude far exceed the carrying capacity of existing streams and they would cause extensive damage to the downstream forest resource, campgrounds, trails, roads, dams and in some cases, private property and residents. The “Do Nothing” option was not considered appropriate because of the eventuality of the deterioration and catastrophic failure of these dams.

There are no absolute criteria for defining a No-Hazard dam. The Utah State Engineer is authorized to make that determination. Section R655-10-5 of The State of Utah Statutes and Administrative Rules for Dam Safety dated July 1996 states “The State Engineer is the ultimate authority on the hazard classification designation for a given dam”. However, the Forest Service also has dam safety responsibilities and the two agencies have outlined a number of protocols regarding dam safety matters in a memorandum of understanding between the two agencies (attached as Appendix A).

Therefore, all decisions and recommendations regarding these structures are mutually agreed on by both parties.

Essentially, the No-Hazard rating is achieved by demonstrating that in the event of failure, there is no appreciable damage or adverse affects downstream of the dam. For the more significant structures, this demonstration is accomplished through a dam break analysis. Various stabilized reservoir elevations are assumed and the resulting flood from a sunny day break is compared to the existing downstream channel capacity. When the reservoir elevation results in a flood that can be contained within the downstream channel, the dam can be considered to be No-Hazard.

The thirteen reservoirs are located in the High Uintas Wilderness Area. The U.S. Forest Service, Moon Lake Water Users Association, U.S. Bureau of Reclamation and Duchesne County Water Conservancy District all have knowledge and experience with operation, maintenance and stabilization of the high mountain lakes. The Commission entered into Interagency Agreement No. 05-AA-UT-1300 with Reclamation to provide engineering, design, construction, and oversight services for the stabilization project. This technical memorandum is a work product under the Interagency Agreement and addresses design criteria needed to achieve “No Hazard” ratings as defined by the State of Utah and as agreed to by the Forest Service, for the four lakes in Brown Duck Basin.

Typically, the stabilization of these dams will require the excavation of an outlet channel notch, with stable side slopes, through the middle of the embankment and the removal of the low level outlet. An armored, stabilized low level channel would then be constructed in the notch to pass normal runoff as well as large storm events without jeopardizing the remaining structure by impounding excess water. In some cases the embankment may be removed or rolled over on itself to decrease the height and increase the stability and ability of the remaining embankment to withstand any seismic event or overtopping during extreme events. This work is the minimum necessary to stabilize these dam structures and restore natural hydrologic flows to the greatest extent possible, while still meeting a "No Hazard" dam safety rating.

Stabilization of the thirteen high mountain lakes at No-Hazard levels will provide constant lake water levels year-round. Nine of these lakes (Bluebell, Drift, Five Point, Superior, Water Lily, Farmers, East Timothy, White Miller, and Deer) are located in the Upper Yellowstone River watershed and four (Brown Duck, Island, Kidney and Clements) are in the Brown Duck Basin of upper Lake Fork watershed. Consequently, streamflows originating in these upper watersheds will return to natural hydrologic runoff patterns, wilderness fishery and recreational values will be restored within the High Uintas, and operation and maintenance impacts will be eliminated in the wilderness area.

Clements Lake is one of four lakes in the Brown Duck Basin to be stabilized. The other lakes are Kidney Lake, Island Lake and Brown Duck Lake. The stated objective for these lakes is to create conditions such that any dam, if remaining, is assigned a “No

Hazard” classification with a minimum design life of 100 years (essentially a permanent fix). In order to achieve a No-Hazard rating, the stabilized dams and associated reservoir levels must be approved by the State Engineer and concurred with by the Forest Service.

An additional constraint is that each individual dam stabilization project would need to be completed in one construction season (usually July through September) because of the vulnerability of a partially removed embankment. These partially completed dams could easily overtop and fail from snow melt runoff or storms, even if the outlet were still in place and open. Breach flow potential would be extensive even from the reduced lake storage volumes. Existing spillways would be too high to assist in flood routing under these circumstances and it would be prohibitive to build auxiliary or temporary spillways over the excavated embankment or on bedrock at the proper level, even if it could be located.

Multi-year construction projects to stabilize a single dam have serious potential problems, including:

- Increased vulnerability to failure from hydraulic overloading when partial breaches may not be adequately stabilized;
- High potential for erosion and soil disruption from over-wintering and unexpected weather events;
- Additional required work and disturbance to reconstruct and stabilize the dam at the end of each construction season
- Increased mobilization and demobilization costs from additional work cycles;
- Increased site disturbance from multi-year operations at camps, travel routes, and activity on-site;
- The U.S. Forest Service does not allow riprap spillways on moderate-hazard earth fill dams; therefore any intermediate “spillway” or outlet channel on a partially stabilized dam would be required to be hardened, probably with concrete;
- for unexpected, early adverse weather conditions which could close the construction project prior to adequate stabilization.

In addition, because these dams were constructed at the turn of the century there is no guarantee that plans are accurate. Once breached, there may be unexpected materials or inappropriate materials in the dam that would not support a partial breach option. Partial breaches may also create unanticipated new flow regimes.

Other considerations with multi-year projects include:

- Uncertainty of weather from year to year which may require additional measures to ensure partially breached dams are secure;
- Longer exposure of crews to accident vectors during the multi-seasons;
- Increased risk of personnel changes leading to loss of skills and experience; and
- Loss of availability of equipment.

Based on past experience, success with multi-year staged construction projects has been low.

The Forest Service does not recommend planning for a multi-year project to stabilize an individual dam. Further, they have advised that at the completion of each season of activity the partially-stabilized dam will be required to fully meet State of Utah and U.S. Forest Service dam safety specifications. Due to the existing condition of many of the dams, achieving this requirement could entail even more extensive work and could be more difficult to achieve than completing the stabilization to its final proposed configuration.

It was determined that this risk possibility was inconsistent with the projects goals of safety and stabilization as well as minimum impact and the preservation of the Wilderness resources and values.

As indicated by the concurrence page, the purposes of this memorandum are to document the design decisions and rationale used in the final design and to ensure that each of the participating agencies are in agreement with and approve of the final design. This memorandum describes the design for stabilizing Clements Lake dam in the Brown Duck Basin.

The appendices contain design drawings and backup data that support the design conclusions and recommendations. Appendix A contains a copy of the MOU between the State of Utah and the U.S. Forest Service for dam safety. Appendix B contains design drawings showing a location map and applicable details. Appendix C contains portions of the HEC-1 output files for the inflow hydrology that was performed. The total output file for this work contains numerous pages, most of which is hydrograph data that is not necessarily meaningful to most readers. Rather than include the entire output, select pages that contain relevant flow data have been provided. The remaining output will be kept on file and made available upon request. Appendix D contains a summary table of the construction quantities for the designed work. Appendix E contains a summary of the Simplified Dam Break analysis for Clements Lake. The total output file for the dam break analysis also contains additional pages which are kept on file and are available upon request. Appendix F contains the slope stability analysis that was performed to determine the slope of the outlet channel walls. Appendix G contains historical drawings of the Clements Lake Dam and features.

Another item of note concerns the apparent elevation discrepancies between the various data sets. Each dam was topographically surveyed using global positioning satellite (GPS) equipment. The elevations measured and used for the drawings are actual elevations tied to the State Plane Coordinate System. However, the Digital Elevation Models (DEM) used for the hydrology and dam break analyses were obtained from the U.S. Geologic Survey (USGS) data base which does not necessarily match the State Plane elevations. Although there are differences, they can be accounted for and adjustments made accordingly. As long as the relative differences in elevation are accounted for, the data will be accurate and usable. Although some of the elevations

for spillway and dam heights in the DEMs do not match the actual elevations as obtained through the surveys, they are still applicable because the relative differences are consistent.

Design Considerations

A number of issues and considerations must be accounted for in the design. These include the following:

- Inflow hydrology
- Dam break analysis
- Outlet works removal or plugging with associated cutoffs and filters
- Outlet channel configuration including width, armoring, and side slopes
- Downstream ramp is required to accommodate drop in elevation between outlet channel and original ground to allow passage of fish into the reservoir basin.
- The downstream fish passage ramp will need to be arranged in the field to allow passage of native fish. A maximum of 10 percent slope will be used to construct the ramps.
- All efforts will need to be made to blend the ramps and compacted side embankments into the natural drainage in the area, by using boulder scatter or other techniques.

Summary									
	Surface Area	Res. Volume	Dam Height	Basin Area	100 yr. Storm	Peak Runoff (*)	Max. Flow	IDF	PMF
	(ac.)	(ac.ft.)	(ft.)	(sq.mi.)	(in.)	(cfs)	(cfs)	(cfs)	(cfs)
Clements	85	631	13	1.9	2.55	220	94	880	1371

* - Peak runoff is for individual drainage basins.

Clements Lake

Clements Lake is located on Clements Creek approximately 2 miles above Lake Fork River. It has a surface area of about 85 acres at the spillway and holds approximately 631 acre-feet of water. The dam is reported as a homogeneous embankment 13 feet high and has a 27-inch diameter low-level outlet located at the maximum section.

Inflow Hydrology

The Clements Lake drainage basin is 1.9 square miles in area and is comprised of partially wooded slopes, interspersed with brush, and grassy areas. The WMS software package was used to model the drainage basin using DEM obtained from the USGS web site. Hydrologic characteristics for the basin were then incorporated for full analysis. The 100-year, 6-hour storm estimate of 2.55 inches was obtained from the NOAA Precipitation Frequency Data Server, Atlas 14, Volume 1, Version 3. This storm has a volume of 54 acre-feet and a peak runoff of 220 cfs. When this storm is routed through the reservoir, the peak flow is attenuated to 94 cfs through the outlet channel. The Basin Average method was combined with the SCS Type-III, 6-hour curve to define the series. The SCS curve number method was used to model the basin losses, with a curve number of 69 (corresponding to AMC III fair conditions) provided by the State of Utah Office of Dam Safety. The SCS method was used within WMS to compute a Lag time of 1.6 hours. The Muskingum-Cunge method was used for stream routing with averaged stream characteristics based on actual survey data. Actual reservoir area-capacity curves were input for routing purposes.

Dam Break Analysis

The SMPDBK model contained within the WMS package was used to model multiple runs of dam break scenarios using varying parameters. Various breach outlet channel elevations were modeled to obtain maximum flows in the downstream channel so that the effects of a dam break could be understood and acceptable limits set. The dam break scenario table in Appendix C tabulates the results of various reservoir elevations and the corresponding dam break maximum flow.

A 15-foot-wide breach was used with a 300 minute time-to-breach, corresponding to half of the inflow hydrograph. A sunny day break of Clements Lake Dam with the outlet channel at elevation 10,447 produces a maximum flow of 276 cubic feet per second and a maximum water depth in the downstream channel of about 2.2 feet. By the time the breach flow reaches Moon Lake in 5.4 hours it is about 2 feet deep. Stream cross sections were determined by WMS from the DEM data and verified by cross-sectional surveys obtained by Reclamation survey crews.

Outlet Works

In order to have a No Hazard classification there can be no operable outlet works. The existing outlet works could either be left in place and plugged or the entire outlet works could be removed. In either case the existing outlet works gate would be removed.

The preferred choice is to remove the outlet pipe, re-compact the trench from which it is pulled, and build the new outlet channel over top of the trench, with adequate protection to prevent erosion and down cutting. However, examination of historic design drawings for Clements Lake Dam show the outlet pipe is encased in concrete, and has several

large reinforced concrete cut-off collars along its length (Appendix G). These appear to be larger and more substantial than those on Brown Duck, Island and Kidney Lakes. Because of the level of effort required to excavate and remove the outlet pipe and associated cut-off collars from the wilderness, and to re-compact the trench, an acceptable alternative is to leave the outlet in place and fill it with grout. A cutoff wall will be constructed at the upstream end of the breach channel to insure a stabilized elevation. A cutoff wall will be constructed at the downstream end of the breach channel, and a steep boulder-pool channel will be constructed to transition the new channel slope into the existing downstream grade.

As shown on the drawings, the breach will be protected on the upstream and downstream ends with a grouted rock gabion basket cutoff wall. The compacted backfill will have additional protection at the downstream end in the form of a filter material that will prevent migration of fines in the event that some water is able to flow through the backfill. The upstream cutoff will be designed to prevent any water flows through the pipe or its bedding but the filter is an additional protection that provides redundancy in the design and will help to ensure a permanent fix.

The filter material will consist of a well-graded sand that will be obtained onsite. During excavation, sandy materials encountered will be stockpiled for use as the downstream filter. A 3/8-inch minus screen will be utilized to remove any oversized material. The filter will be placed in the last 8 feet of the outlet works excavation trench resulting in an approximate volume of 5 to 6 cubic yards of material required. In the unlikely event that adequate sand is not available from onsite excavations, contingency plans would be required. This would include either locating an adequate source within the proximity of the work or flying in bagged sand by helicopter. If sand is required to be flown in, the quantity of filter material required would likely be reduced to 1 to 2 cubic yards due to the high cost of transport. Geotextile fabrics were not considered due to the potential of plugging over time.

Outlet Channel

To enable a “No Hazard” classification, the maximum height of the outlet channel elevation can be set no higher than 10,449 feet. To accommodate the objective of reestablishing a naturally functioning (stabilized) outlet channel, the design was adjusted to have the stabilized floor of the outlet channel at a finished elevation of 10,447 feet (at its upstream end). This reduced the amount of the “drop” on the downstream side of the dam by two feet, making a transition to natural grade more readily accomplished. The design drawing in Appendix B shows a plan to achieve this objective; however, the objective of creating a more naturally-functioning stream channel will require some field-fitting by river geomorphologists working together with the engineers and crew supervisors. Construction quantities shown in Appendix D for the “outlet Channel below Breach” are at the upper range of what likely will actually be constructed. Finished elevation of the upstream end of the outlet channel will be between 10,447 and 10,449 feet.

The recommended width of the outlet channel at the invert is 15 feet. Keeping the outlet channel a minimum width of 15 feet will help ensure that plugging of the channel due to ice, snow, and debris will be prevented. The outlet channel will be armored with placed riprap along the invert and for a vertical height of 4 feet on the side slopes. Beyond the riprap, the remainder of the side slopes will consist of loosely placed riprap armoring. The armoring of the invert and side slopes will provide protection against erosion and will ensure stable and permanent side slopes. It is critical that the toe of the side slopes does not experience erosion because of slope stability issues. Without toe protection, substantial erosion or undermining of the bottom of the side slopes could result in a complete slope failure.

A slope stability analysis was performed on the side slopes of the outlet channel. The slopes were required to be flat enough to allow a safety factor of at least 1.5 against failure. The existing embankment consists of cohesionless silty sands and an assumed friction angle of 31 degrees was used. Typical friction angle values for this type of material range from 30 to 32 degrees. To allow a higher friction angle than what was assumed would require a more thorough investigation of the material. Because of the nature of the materials, the cohesion was assumed to be zero.

Another factor that affects the results of the analysis is the assumed level of saturation within the embankment. For normal operating conditions, the saturation level will be less than 1 foot high. However, if the outlet channel was to become plugged or there was an extreme inflow event, the saturation level could become somewhat higher. The higher the saturation level, the flatter the side slopes need to be to maintain an adequate safety factor. In order to maintain a conservative design that will be considered to be permanent, a saturation level of 2 feet was used for the stability analysis. Although this level is likely to be higher than what will actually occur, the analysis did not assume any erosion of the toe and therefore should be considered as reasonable. It is possible through a combination of outlet channel plugging and high inflows that the saturation level of the embankment could rise above 1 foot. Therefore, a 2 foot high saturation level is not overly conservative. Based on the assumptions given above, the recommended slope configuration for the outlet channel is 2.5 horizontal to 1 vertical.

Because the main criteria for sizing the outlet channel width is to prevent snow, ice and debris from building up and blocking or plugging the channel, the recommended width of the channel is much greater than necessary to pass normal outflows. Therefore, a low flow channel that will generally contain all outflows is incorporated into the design. Even for the 100 year storm outflow, the water level is less than 1.0 foot above the top of the low flow channel. Details of the low flow channel are shown on the drawings in Appendix B.

The outlet channel was set to match the new reservoir level at the upstream and to tie into the existing outlet works channel on the downstream to provide as smooth and even of a transition as possible. The maximum grade within the outlet channel was limited to approximately 5 percent. In order to prevent erosion at the toe of the outlet

channel slopes, channel velocities need to be minimized. This will require additional riprap armoring at the downstream end of the new outlet channel and existing outlet works channel transition. Field crews will be directed to minimize the amount of material placed at the downstream end of the dam embankment while constructing the transition channel as much as possible.

The Storm Outlet channel Hydraulics table in Appendix C provides 100 year storm hydraulic data for the outlet channel flows for Clements Lake dam.

Appendix A - Memorandum of Understanding between State of Utah and U.S. Forest Service

RECEIVED

JAN 20 1961

MEMORANDUM OF UNDERSTANDING

**DIVISION OF WATER RIGHTS
VERNAL, UTAH**

Intermountain Region
Forest Service
U. S. Department of Agriculture

Division of Water Rights
Department of Natural Resources
State of Utah

THIS MEMORANDUM OF UNDERSTANDING is entered into by the Division of Water Rights, Department of Natural Resources, State of Utah, hereafter called the Division, and the Intermountain Region, Forest Service, Department of Agriculture, hereafter referred to as the Forest Service.

WHEREAS, the Forest Service and the Division have certain responsibilities for the safety of dams by virtue of land status or public safety, and

WHEREAS, the Division has been created under Utah Statutes 73-5-5, 6, 7, 12, and 13, to provide public safety and resource protection by supervision and administration of a system to safeguard dams in the State of Utah, and

WHEREAS, the Forest Service under Acts of June 4, 1897 (16 U.S.C. 551), February 1, 1905 (16 U.S.C. 473), July 22, 1937 (16 U.S.C. 1010), June 12, 1960 (16 U.S.C. 528), as amended, is directed to regulate the occupancy and use of the National Forests and National Grasslands, and

WHEREAS, the Forest Service under administrative Manual requirements is directed to supervise and administer a system of inspections to safeguard dams located on National Forest lands, and

WHEREAS, the Forest Service and the Division mutually desire:

1. To periodically inspect dams located on National Forest lands.
2. To develop and document procedural methods to minimize duplication of effort and facilitate complementary inspections of dams.

NOW THEREFORE, the parties agree as follows:

1. The Forest Service agrees:
 - a. To coordinate with the Division at the local and state levels in developing an annual inspection schedule for dams.
 - b. To provide the Division copies of dam inspection reports made by Forest Service engineers.

c. To notify the Division of suspected safety hazards of dams located on National Forest lands.

2. The Division agrees:

a. To provide notification to the appropriate Forest Supervisor of the dams scheduled for Division inspection each calendar year.

b. To provide the Forest Service copies of dam inspection reports made by Division engineers.

c. To notify the Forest Service of suspected safety hazards of dams located on, or affecting, National Forest lands.

3. It is mutually agreed:

a. To cooperate in the periodic inspection of dams located on National Forest lands in the State of Utah.

b. To develop and seek application of safety measures required to protect public safety and resources.

c. That nothing herein shall be construed in any way as limiting the authority of the Division in carrying out its legal responsibilities for management or regulation of dam safety.

d. That nothing herein shall be construed as limiting or affecting in any way the legal authority of the Forest Service in connection with the proper administration and protection of National Forest System lands, in accordance with Federal laws and regulations.

e. That nothing in the Memorandum of Understanding shall be construed as obligating the Forest Service or the Division to expend funds in any contract or other obligation for future payment of funds or services in excess of those available or authorized for expenditure.

f. That amendments to this Memorandum of Understanding may be proposed by either party and shall become effective after written approval by both parties.

g. That this Memorandum of Understanding shall continue in force unless terminated by either party upon thirty (30) days notice in writing to the other of intention to terminate upon a date indicated.

h. Forest Service and local Division inspection personnel¹ will coordinate their annual inspection schedules to avoid duplication of effort.

¹ See Exhibit 1 attached hereto.


High Lakes Stabilization Technical Memorandum – Clements Lake, Brown Duck Basin

i. That agreements between Forest Supervisors and local dam inspection personnel of the Division can be made as amendments to this document if such agreements are deemed necessary.

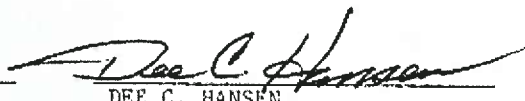
j. That no member of or delegate to Congress, or Resident Commissioner of the United States shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom.

k. That each and every provision of this Memorandum is subject to the laws of the State of Utah, the laws of the United States, the regulations of the Secretary of Agriculture, and the regulations of the Division.

IN WITNESS THEREOF, the parties hereto have caused this Memorandum of Understanding to be executed as of the last date signed below.


JEFF M. SIRMON
Acting Regional Forester
Intermountain Region
USDA Forest Service

Date 4/4/80


DEE C. HANSEN
State Engineer
Division of Water Rights
Department of Natural Resources
State of Utah

Date April 14, 1980

This Memorandum of Understanding is applicable to the following National Forests:

Ashley National Forest
437 East Main
Vernal, Utah 84078

Dixie National Forest
Federal Building
82 North 100 East
P.O. Box 580
Cedar City, Utah 84720

Fishlake National Forest
P.O. Box 628
170 North Main Street
Richfield, Utah 84701

Manti-LaSal National Forest
350 East Main Street
Price, Utah 84501

Uinta National Forest
P.O. Box 1428
88 West 100 North
Provo, Utah 84601

Wasatch National Forest
8226 Federal Building
125 South State Street
Salt Lake City, Utah 84138

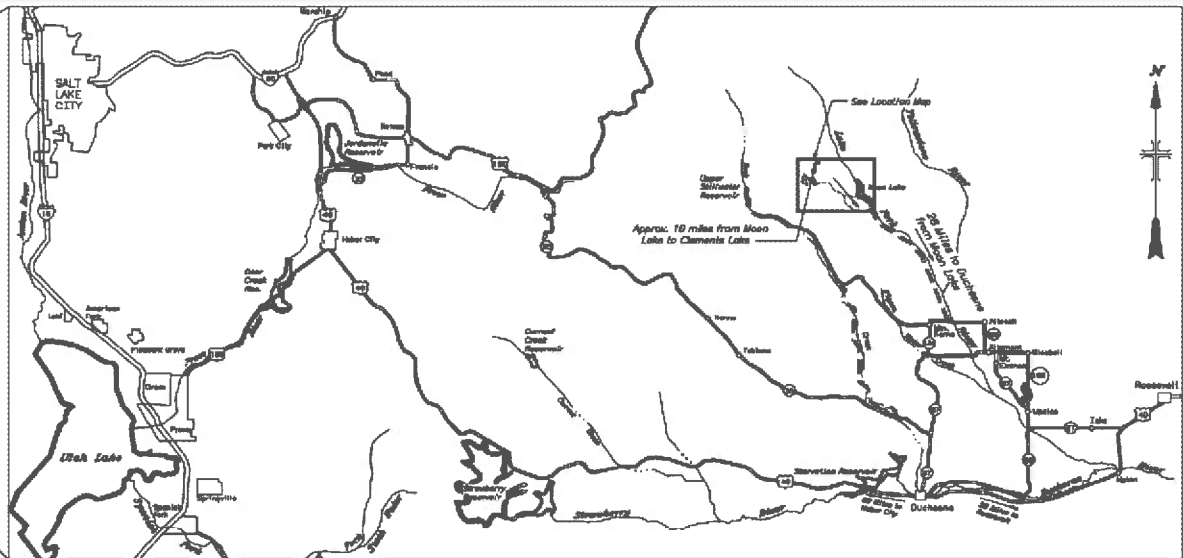
Appendix B – Design Drawings

High Lakes Stabilization Technical Memorandum – Clements Lake, Brown Duck Basin

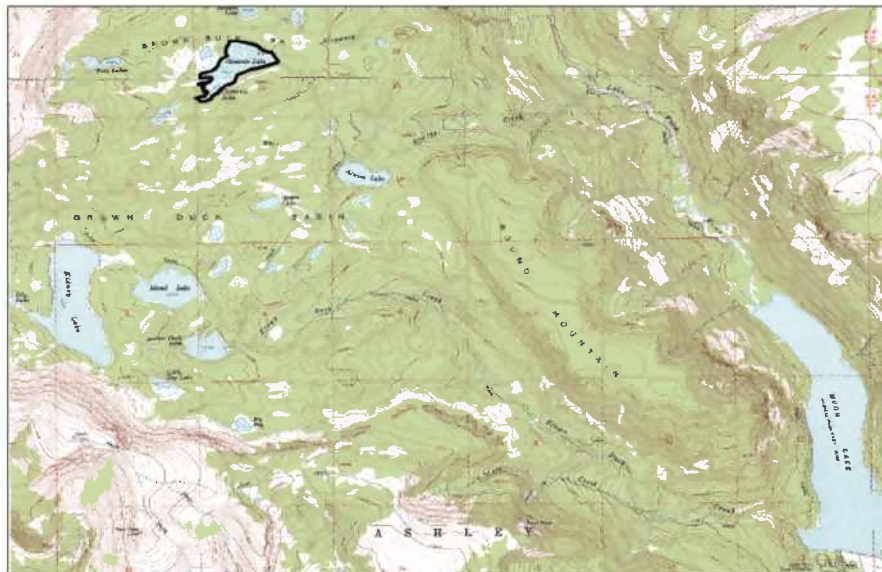
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KEY MAP



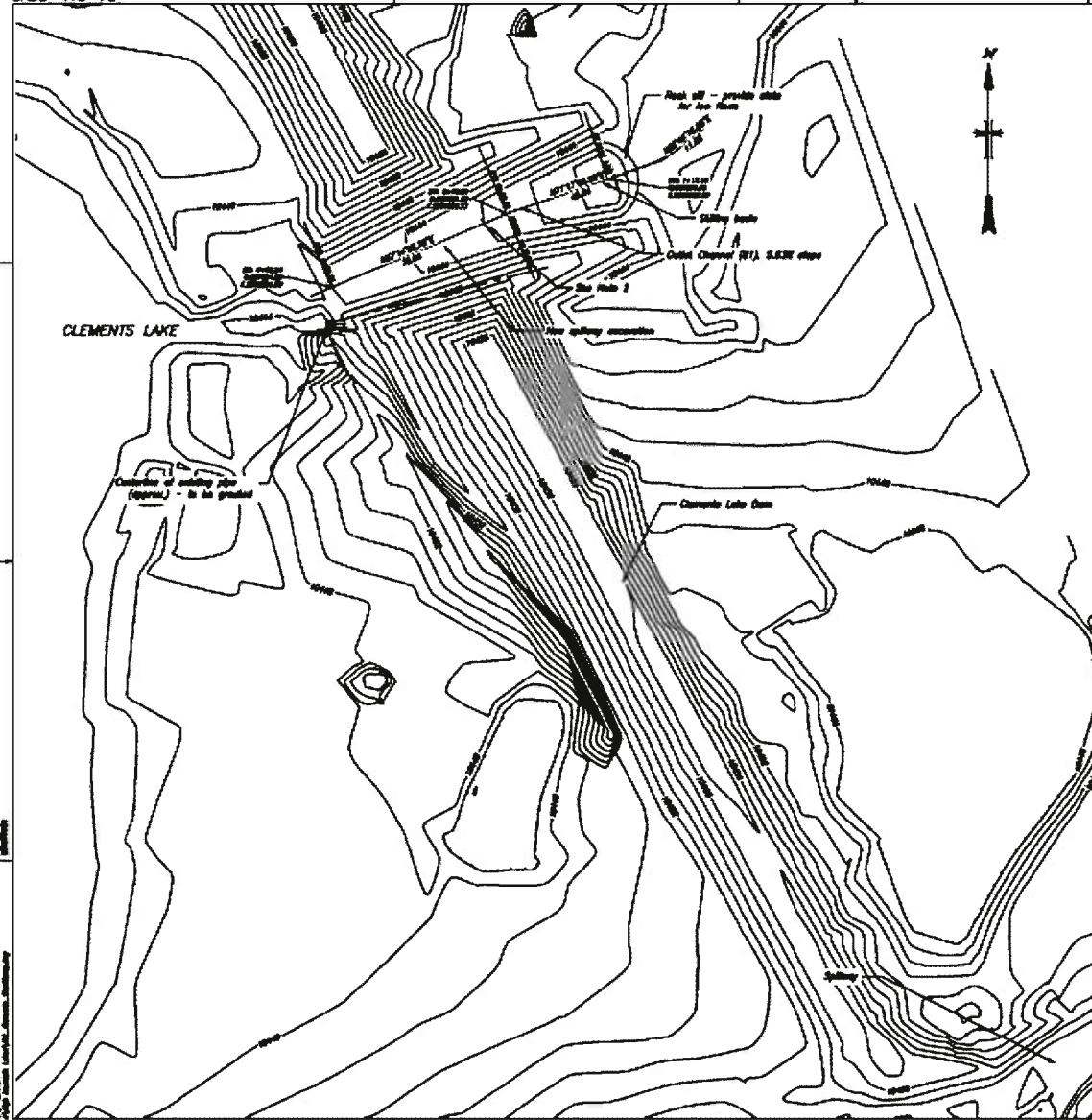
VICINITY MAP



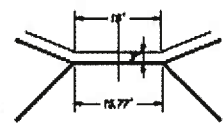
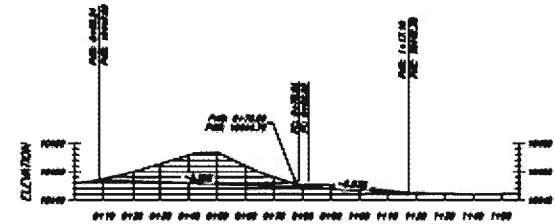
LOCATION MAP
NOT TO SCALE

ALWAYS THINK SAFETY	
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION PROJECT AREA OFFICE PROVO, UTAH	
BROWN DUCK BASIN LAKES DAM STABILIZATION CLEMENTS LAKE VICINITY AND LOCATION MAP	
DESIGNED _____	CHECKED _____
DRAWN _____	FIELD APPR. _____
APPROVED _____	DATE _____
PROJECT NO. 0A58-418-71	0A58-418-71

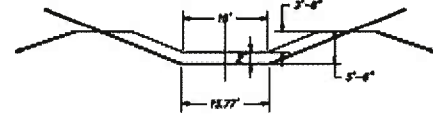
0A58-418-72



PROFILE: CLEMENTS SHORT
SCALE: 20



Breach - 24" Riprap Thickness
12 ft. below water
Depth to daylight
2.5:1 Cut slopes



Outlet Channel - 24" Riprap Thickness
15 ft. below water
5.5 ft. depth
2.5:1 Cut slopes
3 ft. wide berm
3:1 fill slopes
Outlet Channel Riprap Cross-sectional Area: 78.23 sq. ft.
Outlet Channel Surface Length: 45.39 ft.

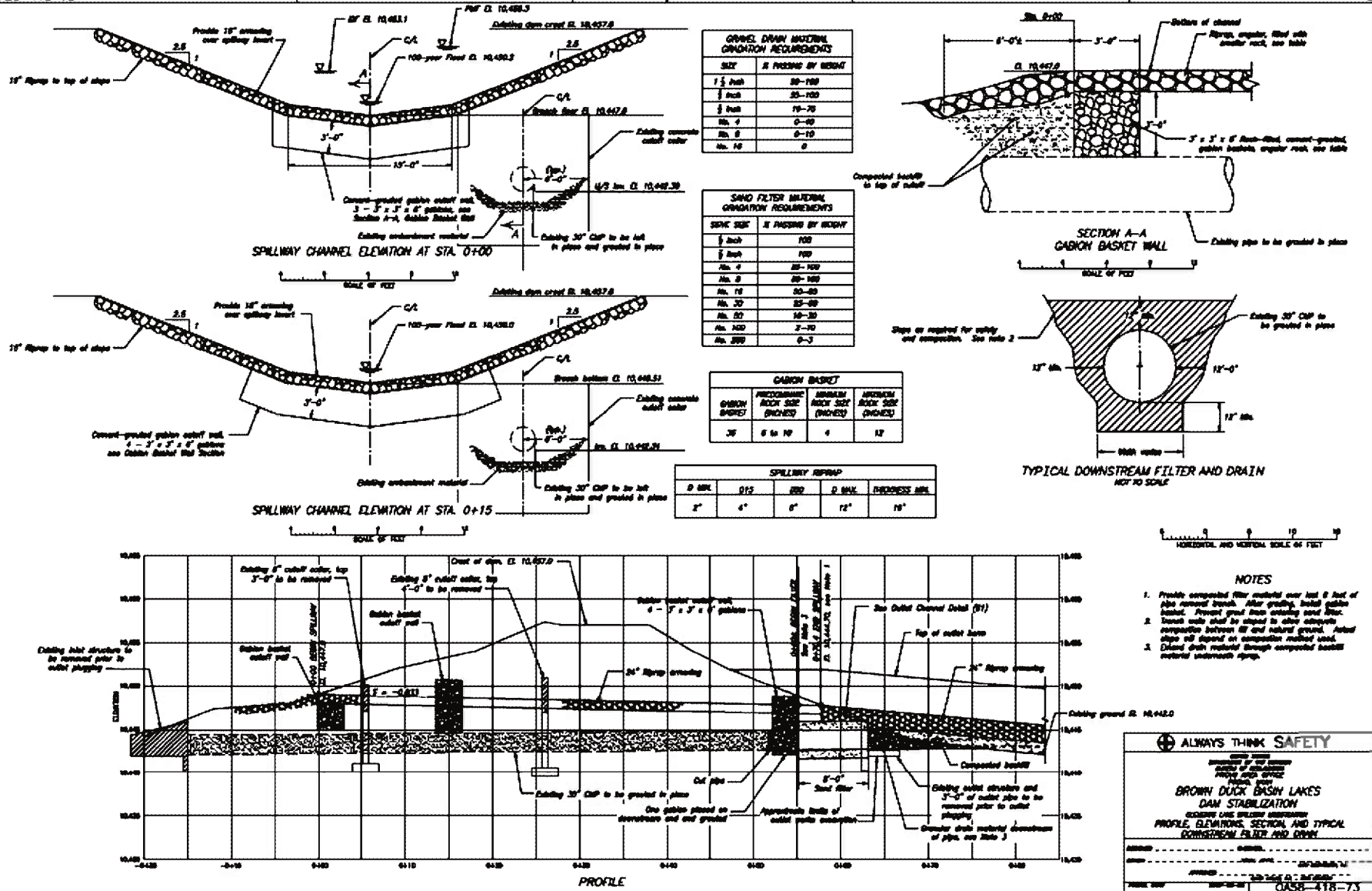
NOTES

1. Contour interval is 1 foot.
2. Very sensitive differential along steep to create routing path.
3. Breach Δ 18,442.00
4. 102 vol. = 777 sq. feet.
5. Contour shown through the breach and outlet channel represent estimated grade before final riprap placement.
6. G&E Factor = 1.000/1.000



⊕ ALWAYS THINK SAFETY	
<small>DESIGN ENGINEER PROJECT SUPERVISOR CHECKED BY PROJECT MANAGER PROJECT NO. 0001 FEBRUARY, 2001</small>	
BROWN DUCK BASIN LAKES DAM STABILIZATION CLEMENTS LAKE BRILLIANT IMPROVEMENT SITE PLAN	
DESIGNED BY	DATE
DRAWN BY	DATE
APPROVED BY	DATE
PROJECT NO.	0A58-418-72
SHEET NUMBER	

OASB-418-73



Appendix C - Inflow Hydrology Output Files

High Lakes Stabilization Technical Memorandum – Clements Lake, Brown Duck Basin

100 yr. Storm Outlet channel Hydraulics(CN=69)

	Flow in Outlet channel (cfs)**	Depth in Outlet channel (ft.)	Velocity in Outlet channel (ft.)
Clements	94.00	1.20	3.5

**100-year, 6-hour, SCS Type III event

Appendix D – Construction Quantities

Construction quantities are approximate

Construction Quantities

	Outlet channel	Outlet channel	Outlet channel	Outlet Grout	Gabion Basket	Breach Riprap	Outlet Channel below breach			Sill	Net Volumes	Filter
	Width*	Elevation	Excavation (cy)	Backfill (cy)	Grout (cy)	Volume (cy)	Fill (cy)	Riprap (cy)	Bern Height (ft)	Riprap (cy)	(Cut/Fill (cy))	Material (cy)
Kidney	15'	10272	2666	19	8	386	4	Ramp Riprap	Bern	15	(2662)	3
Island	15'	10249	1286	17	8	288	170	Vol. (cy)	Height (ft)	15	(1116)	7
Brown Duck	15'	10193.5	961	16	8	258	135	419	7	15	(826)	4
Clements	15'	10447	799	17	8	288	157	181	5.5	15	(777)	5

* 2.5:1 sideslopes, both sides, finished width

Outlet Grout Backfill

	Outlet Diameter (ft)	Outlet Length (ft)	Pipe Area (ft ²)	Pipe volume (ft ³)	Volume (cy)
Kidney	2.5	106	4.9	520.3	19.3
Island	2.5	92	4.9	451.6	16.7
Brown Duck	2.5	89	4.9	436.9	16.2
Clements	2.5	91	4.9	446.7	16.5

Appendix E – Dam Break Output Files

High Lakes Stabilization Technical Memorandum – Clements Lake, Brown Duck Basin

Dam Break Analysis Summary

	Outlet channel Floor Elev.	Bottom of Breach Elev.	Time to Breach (min.)	Dam Break Max. Flow (cfs)	Max. Depth in Channel (ft.)	Max. Depth at Moon L. (ft.)
Clements	10,447	10,444.7	300	276	2.2	2.0

Dam Break Scenarios

	Outlet channel Elevation	Excavation Elevation	Height to Breach	Dam Break Max. Flow (cfs)	Outlet channel Excavation (cy)	
					2:1 Side Slopes	2.5:1 Side Slopes
Clements	10445	10444	2	104	790	920
	10446	10445	3	184	680	760
	10447	10446	4	276	560	630
	10448	10447	5	377	460	520
	10449	10448	6	488	370	420
	10450	10449	7	607	290	310
	10451	10450	8	734	220	250
	10452	10451	9	868	170	190
	10453	10452	10	1010	120	130
	10454	10453	11	1177	80	90
	10455	10454	12	1348	50	60

* Highlighted elevation is the recommended height.

Timed Dam Break Scenarios

	Outlet channel Elevation	Excavation Elevation	Height to Breach	Dam Break Max. Flow (cfs)	Max. Depth in Channel (ft.)	
Clements						
	100 min.	10447	10445	4	335	2.05
	200 min.	10447	10445	4	306	2.00
	300 min.	10447	10445	4	261	1.92
	100 min.	10448	10447	5	465	2.35
	200 min.	10448	10447	5	418	2.25
	300 min.	10448	10447	5	377	2.16
	100 min.	10449	10448	6	608	2.64
	200 min.	10449	10448	6	544	2.52
	300 min.	10449	10448	6	488	2.40
	100 min.	10450	10449	7	763	2.91
	200 min.	10450	10449	7	679	2.77
300 min.	10450	10449	7	607	2.64	

* Highlighted elevation is the recommended height.

Appendix F - Slope Stability Results

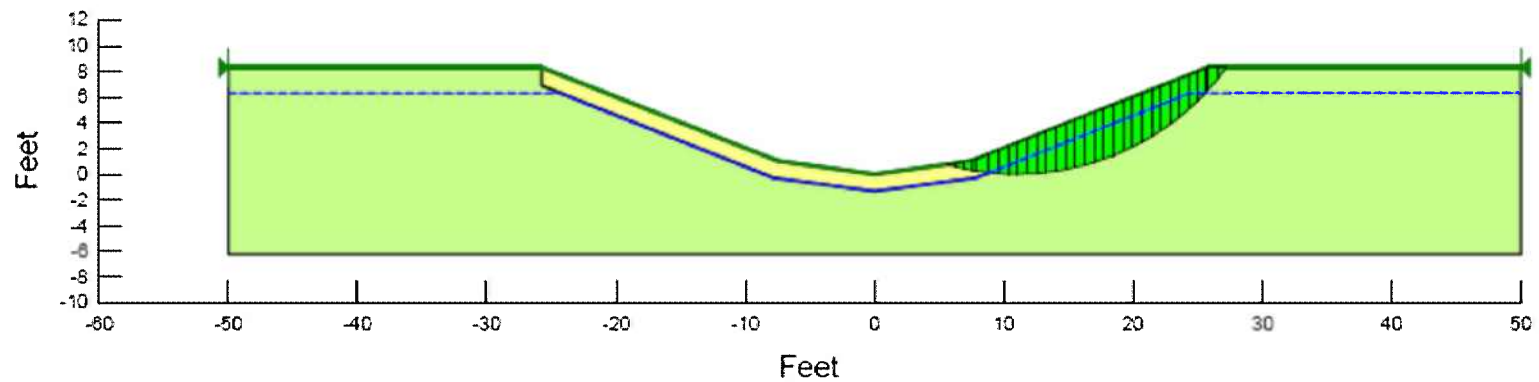
BROWN DUCK BASIN LAKES DAM STABILIZATION

CLEMENTS LAKE

Description: Riprap
Wt: 130
Cohesion: 0
Phi: 40

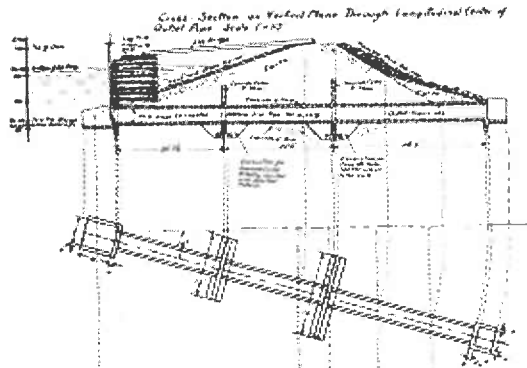
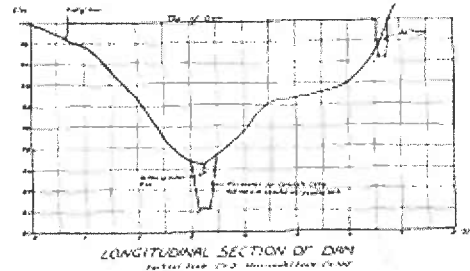
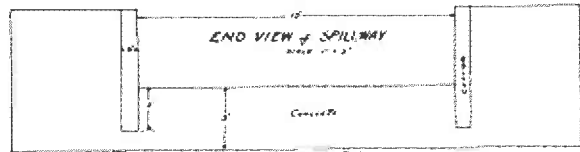
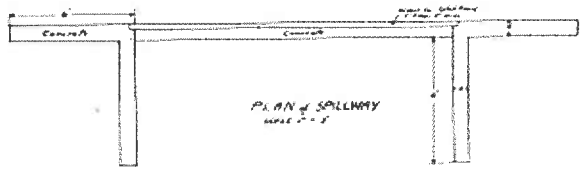
Description: Select Soil (Sand and Gravel)
Wt: 131.4
Cohesion: 0
Phi: 32
Unit Wt. Above WT: 121

Method: Spencer
Factor of Safety: 1.46

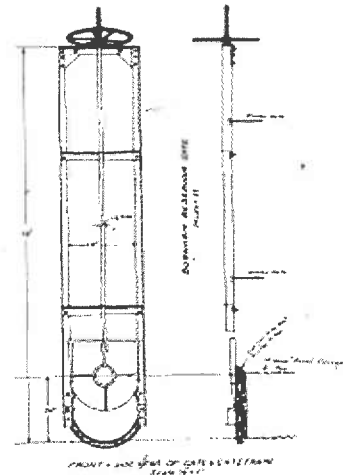


Appendix G – Historical Drawings

High Lakes Stabilization Technical Memorandum – Clements Lake, Brown Duck Basin



Cross Section of Right Angle Plane to Longitudinal Center of Dam Outlet Area



UNDESIGNED ELEMENTS
 The undersigned hereby certify that the dam and spillway shown on the attached drawings were designed by me and that the same are in accordance with the provisions of the laws of the State of Utah, and that the same are in accordance with the provisions of the laws of the State of Utah, and that the same are in accordance with the provisions of the laws of the State of Utah.

Wm. H. ...
 Wm. H. ...
 Engineer

ENGINEER'S CERTIFICATE
 I, the undersigned, hereby certify that the dam and spillway shown on the attached drawings were designed by me and that the same are in accordance with the provisions of the laws of the State of Utah, and that the same are in accordance with the provisions of the laws of the State of Utah.

Wm. H. ...
 Wm. H. ...
 Engineer

MAP, PROFILE AND DRAWINGS
 SHOWING RESERVOIR DAMS, DETAILS OF DAM
 AND SPILLWAY
 CLEMENTS LAKE, DUCHESNE COUNTY
 UTAH
 DRAWN BY
 THE DRY GULCH IRRIGATION COMPANY

FILE NO 4600

Checked by *Cap. ...*
 Drawn by *Nov. 21/22.*
 Approved *April 1928*
J. M. ...

Clements Lake

H-30
 21 1928