APPRAISAL STUDY

OFFSTREAM STORAGE TO SUPPLEMENT FLOWS IN THE LEMHI RIVER

BIG TIMBER CREEK DAM
LEADORE, IDAHO

Looking Upstream from Proposed Dam

Prepared by the
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LEADORE, IDAHO (EASTERN IDAHO)

July 29, 2002

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1.0 INTRODUCTION

The viability of constructing a dam across Big Timber Creek near Leadore, Idaho was studied to provide 6,000 acre-ft of reservoir storage capacity to maintain year around consistent flows on a reach of the Lemhi River below the L-6 diversion that goes dry. This study mainly characterized hydrologic, hydraulic, structural, construction, and environmental issues and estimated appraisal level construction costs.

This work was performed by the Technical Service Center (TSC)[1] of the Bureau of Reclamation (Reclamation) in Denver, Colorado on behalf of the Snake River Area Office (SRA) in Boise, Idaho in response to requests received by that office from Mr. John Folsom, Project Coordinator, Upper Salmon River Basin Watershed Project; Mr. Jim Lukens, Regional Supervisor, Idaho Department of Fish and Game; and Mr. Robert Thomas, Chairman, Lemhi Irrigation District.

The proposed location for the dam was a few miles up Big Timber Creek in a relatively narrow rock canyon at 44.5881E N latitude and 113.3958E W longitude (about 1 mile west of Leadore Hill). Hydrologic studies indicated sufficient water in the drainage basin to support the 6,000 acre-ft storage requirement. The geology of the reservoir area is suitable to store water. Being a narrow rock site, the most appropriate dam for this topography and foundation was judged to be a roller-compacted concrete (RCC) dam. A dam with a structural height of 133 feet, a hydraulic height of 110 feet, and a crest length of 856 feet was capable of holding the required 100-year silt level and 6000 acre-feet of storage up to the spillway crest. A 20-foot-wide uncontrolled ogee spillway on the dam crest passes the 500-year flood without overtopping the dam. Above the 500-year flood event, the dam was designed to overtop without damage. The outlet works would be manually operated.

Addition of a powerplant is not viable. Estimated revenues generated from the powerplant were too low to recover construction and maintenance costs.

Designing a fish passage system through this dam was not explicitly performed. Various systems that have been used to pass fish at other projects are provided in this report. If required, fish passage for this height of dam would be very costly.

Manually operated outlets were estimated and would provide some selective withdrawal

[1]Reference numbers are in brackets [ ], acronyms and notes are in parenthesis ( ).

capability. A more elaborate selective withdrawal system would be considerably more expensive as discussed in the report.

This appraisal study did not address or develop operational costs (except for the powerplant), risks associated with a new dam, or seismic analyses.

1.1 Background

The Lemhi River flows into the Salmon River at Salmon, Idaho. The Lemhi River provides critical spawning and rearing habitat for endangered salmon and steelhead. However, virtually all of the water in the Lemhi River is appropriated during the irrigation season between April and October, and irrigation diversions can dewater short reaches of the river during especially dry periods. Dewatering interferes with the migration of smolts to the ocean and the return of adults to a suitable spawning site.

A critical reach on the Lemhi River that has been dewatered in the past occurs between the L-6 diversion and the stream flow gaging station at the site of the former L-5 diversion. The L-6 diversion is several miles upstream from the mouth of the Lemhi River. Water rights at the L-6 diversion are among the oldest in the Lemhi River basin and effectively guarantee streamflow in the Lemhi River upstream from the L-6 diversion. However, during extreme drought years, irrigators at the L-6 diversion may divert all of the streamflow in the river to meet their water rights. Consequently, when these extreme conditions occur, the reach between the L-6 diversion and the gaging station at the L-5 diversion site can be essentially dry. Irrigation return flows downstream from the L-5 gaging station restore adequate stream flow to the Lemhi River down to the mouth on the Salmon River.

If sufficient flow could be maintained between the L-6 diversion and the gaging station, migrating anadromous fish would be able to travel the entire main stem of the Lemhi River from the mouth on the Salmon River all the way to Leadore. One option to meet this objective is through reservoir storage. (Lemhi Irrigation District, Model Watershed Project, Idaho Department of Fish and Game)

The Bureau of Reclamation was requested by local interests to conduct an appraisal- level investigation to describe the potential for constructing a dam and reservoir to store water in upstream reaches of the basin during the non-irrigation season for release during the irrigation season to meet target stream flows in the Lemhi River. Recent negotiations (March, 2002) among private, State, and Federal parties have targeted a flow of at least 25 cfs to be measured at the gaging station at the L-5 diversion site for fish migration. Another requirement is that water provided from the reservoir must not exceed temperature criteria for cold water biota.

Two potential sites for the dam and reservoir were suggested by local interests for investigation. One site was on Big Timber Creek; another was on Texas Creek. This report

focuses on the Big Timber Creek site for the following reasons: 1) The crest length (about 1 mile) of the dam at the Texas Creek site would make the project more expensive than the Big Timber Creek site. 2) The shallow depth of the Texas Creek site compared with the Big Timber Creek site would likely result in higher water temperatures. 3) The geology at the Texas Creek site may be too impervious and may not support a reservoir.

This appraisal study was conducted under authority of the Reclamation Act of 1902 (section 2).

1.2 Location and Access to the Dam

The Big Timber Creek damsite is near the town of Leadore, Idaho in eastern-central Idaho near the border with Montana (see figure 1.1). The largest town in the vicinity is Salmon, Idaho. Access to the Big Timber Creek site is as follows. Starting at Salmon, travel 60 miles southeast on Highway 28 to Leadore. Turn south at Leadore for 1 mile on a State maintained gravel road toward Big Timber Creek. Turn on an unimproved (4-wheel drive) road for approximately 3 miles to Big Timber Creek. An unimproved road traverses upstream along the left side of the canyon (looking downstream) for approximately 1 mile, eventually becoming a narrow trail. The proposed dam is about 1 mile west of Leadore Hill at 44.5881E N latitude and 113.3958E W longitude.

1.3 Team members

Team members for the appraisal study were:

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2.0 DESIGN CONSIDERATIONS

2.1 Site visit

Two visits were made to the site. The first visit was on March 28, 2001 by Larry Nuss, Al Simpson, Bob Swain, Pete Rohrer, Karl Tarbet, Pam Brown, and Noel Copenhagen (see travel report in appendix A). The second visit was on July 17, 2001 by Chris Powell and Al Simpson (see report section 2.5).

2.2 Hydrologic Analyses

2.2.1 Water Availability

The water supply available for storage in a reservoir on Big Timber Creek or Texas Creek was estimated using data in United States Geological Survey (USGS) Professional Paper 1604 entitled, "Hydrologic Classification and Estimation of Basin and Hydrologic Characteristics of Subbasins in Central Idaho," written by Stephen W. Lipscomb in 1998 [5]. The November 1 through March 31 mean monthly discharges are presented in Table 1.

Gaged streamflow information was not available at the dam sites. However, the water supply derived from USGS Professional Paper 1604 was compared to data from nearby gages for consistency. The following gages had some streamflow records:

Gage	Period of Record
Timber Creek near Leadore (13303500)	5/24/1912 to 9/21/1912
	11/12/1938 to 7/6/1939
West Fork Timber Creek near Leadore (13304000)	5/23/1912 to 9/21/1912
Texas Creek near Leadore (13303000)	12/1/1938 to 6/30/1939
	6/1/1955 to 9/30/1963

The limited gage records appear consistent with the USGS data based on a visual inspection. Sufficient gaged data were not available for any analysis. A stream gage should be installed at the dam site as soon as possible to start collecting site-specific streamflow information, since meaningful data requires a period of time. This data would help address water supply and environmental issues that require information about flow variability and reliability.

The data presented in Table 1, developed from the above streamflow data, was compared with a demand for water of 35 ft^3/s for 30 days (about 2080 acre-feet) and 35 ft^3/s for 60 days (about 4160 acre-feet). For this appraisal study, a dam with a reservoir capacity of 6,000 acre-ft was estimated. Indications are that sufficient water is available at either site to satisfy project needs. Evaporation and seepage losses should also be considered in reservoir sizing in

final design. During the field trip to the sites it appeared that larger seepage and evaporation losses would occur at the Texas Creek site.

2.2.2 Floods: 10-year, 100-year flood, and PMF

The magnitude and frequency of floods developed for the Big Timber Damsite were based on regression equations found in U.S. Geological Survey Water Resources Investigations Report 94-4002 titled, *Nationwide Summary of U.S. Geological Survey Regional Regression Equations for Estimating Magnitude and Frequency of Floods for Ungaged Sites, 1993* (Jennings et al., 1994) [17]. The regression equation for Region 5 in Idaho was used to determine the 10-year flood. The 25- and 50-year floods were obtained by applying ratios to the 10-year flood. Since Big Timber Creek is very close to Montana, and Idaho data was not available to determine the 100- and 500-year floods, Montana data was used for estimating ratios for 100- and 500-year floods that could be applied to the 10-year flood.

The 10-year flood was determined from the following equation:

$$Q_{10} = 13.0\ A^{0.918}$$

Where Q_{10} represents the 10-year flood in ft^3/s, and A is the drainage area in square miles. The 25- and 50-year floods, Q_{25} and Q_{50}, were determined using a Q_{25}/Q_{10} ratio of 1.3 and a Q_{50}/Q_{10} ratio of 1.5. Q_{100}/Q_{10} and Q_{500}/Q_{10} ratios were not available for this part of Idaho. However, since Montana Q_{25}/Q_{10} and Q_{50}/Q_{10} ratios were the same as those for Idaho, the Q_{100}/Q_{10} and Q_{500}/Q_{10} ratios from Montana were adopted for use with the Idaho 10-year flood data. The Q_{100}/Q_{10} and Q_{500}/Q_{10} ratios were 1.7 and 2.2, respectively.

Table 7 shows the magnitude and return period of peak flows developed for the Big Timber Damsite. These values are suitable for appraisal level designs.

Two probable maximum floods (PMF) were developed for the Big Timber Dam site. One was based on the 6-hour local storm, and the other was based on the 72-hour general storm. Since the proposed dam was concrete and able to withstand overtopping, the PMF peak discharge was the most critical design parameter. Flood volumes were not as important to the design because the reservoir surcharge capacity was small.

Meteorological data came from Hydrometeorological Report No 57 (Hansen et al, 1994 [7]). Tables 2 and 3 present depth-duration data for the probable maximum precipitation for the local and general storms, respectively.

Unit hydrograph theory was used to convert excess rainfall into runoff following procedures described in the Flood Hydrology Manual (Cudworth, 1989 [6]). The lag time was computed using the general lag equation:

$$L_g = C_t \, (L \, L_{ca} / S^{0.5})^{0.33}$$

where:

- L_g = lag time (hours),
- C_t = a constant that accounts for basin runoff efficiency,
- L = the length of the longest watercourse (miles),
- L_{ca} = length along L from the point of interest (damsite) to a point opposite the centroid of the basin (miles), and
- S = overall slope of L (feet per mile).

Table 4 shows the parameters used for computing the lag times for Big Timber Creek Dam site.

The unit duration selected for hydrograph computations was 15 minutes for the local storm and one hour for the general storm. A constant loss rate of 0.15 in/hr was used to convert basin rainfall into precipitation excess. No initial losses were used in this process.

The probable maximum flood resulting from the local storm has a peak discharge of 65,106 ft^3/s as shown on Table 5. The probable maximum flood resulting from the general storm has a peak discharge of 19,836 ft^3/s, which is shown in Table 6. The general storm PMF should probably have a snowmelt component added, but for a concrete dam that will pass the peak of the PMF and since the local PMF peak is so large, the snowmelt component was judged to be inconsequential and was not added to the hydrograph.

2.2.3 Silt accumulation

The Big Timber Dam site in the Lemhi basin drains an area of 62.3 square miles. Historical measured reservoir sedimentation survey data has been collected on many reservoirs in Idaho and Montana that gave an indication of the area necessary for dead storage. Mann Creek Reservoir, located in Idaho, showed a measured sediment yield rate of 0.39 ac-ft/ $mile^2$/year. Clark Canyon Reservoir, located in Montana on Beaverhead River, showed a measured sediment yield rate of 0.066 acre-ft/$mile^2$/year. The reasonable estimate for the annual yield rate for the Big Timber Dam site in the Lemhi drainage basin is 0.2 ac-ft/$mile^2$ /year (the average of these two sites). This yield rate would result in a dead storage of 620 acre-ft for a 50 year design life or 1250 acre-ft for a 100 year design life.

2.3 Hydraulic Analyses

2.3.1 Reservoir Capacity and Allocation

Based on the water storage requirements and sediment estimates, storage and associated reservoir water surfaces were identified. These include:

$ Low point of excavation. - Elevation 6620 (assumed 20-foot depth between streambed, alluvium, to moderately weathered rock).

$ Streambed. - Elevation 6640 (assumed low point along dam axis, based on USGS topography (see figure 1.3)).

$ Top of dead storage. - Elevation 6688.7 (equated to the elevation associated with the top of the 100-year sediment level).

$ Top of active conservation. - Elevation 6746.5 (equated to the elevation associated with 6000 acre-feet of storage above the top of dead storage).

$ Spillway crest. - Elevation 6746.5 (equated to the top of active conservation).

$ Dam crest. - Elevation 6753.3 (equated to the maximum reservoir water surface associated with the 500-year event).

$ Top of upstream and downstream railing. - Elevation 6756.8 (assumed 3-foot, 6-inch high open railing).

$ Structural height. - 133.3 feet (difference between dam crest elevation and elevation of low point of excavation).

$ Hydraulic height. - 106.5 feet (difference between top of active conservation and streambed elevation).

Prior to any additional studies, more detailed topography (2-foot contours in the area of the dam), and the depth of alluvium and weathered rock should be determined.

2.3.2 Diversion During Construction

General guidelines were considered for diversion during construction. These guidelines included:

$ As a rule-of-thumb, diversion should be capable of passing a flood with a return

period of five times the estimated length of the construction period. For the estimated two season (2 year) construction period for Big Timber Creek Dam, the minimum event would be a 10-year diversion flood with an estimated peak flow of 455 ft^3/s. However, given that a 25-year event is not significantly larger (estimated peak of 581 ft^3/s), consideration for a larger diversion flood and additional protection might be considered. The cost estimate included provisions for a 10-year flood diversion scheme.

$ A 40-foot-high (30 percent the height of concrete dam) upstream embankment cofferdam and a 4-foot-diameter corrugated metal pipe extending from the upstream face of the cofferdam, attaching to the outlet works in the dam, and extending past the downstream cofferdam would serve as the diversion system.

$ A 30-foot-high embankment cofferdam was estimated downstream to prevent back flows into the dam excavation and work area.

Prior to any additional studies, diversion flood hydrographs should be prepared, along with a better understanding of the construction sequencing.

2.3.3 Spillway and stilling basin

An uncontrolled ogee spillway on the crest of the dam with steps on the downstream face capable of passing the 500-year flood was evaluated (figures 2.3a and 2.3b show the stepped-spillway at Santa Cruz Dam in New Mexico). Allowing the dam to overtop for floods greater than the 500-year event, the dam crest acts as an auxiliary spillway. The spillway chute was positioned adjacent to the low-level outlet works. Design considerations were based on historical hydraulic and geometry parameters which have been successfully used for other stepped-spillways [1]. These include:

$ Unit discharge range (without model study) - 36 to 123 ft^3/s.

$ Head above spillway crest (without model study) - 4.5 to 9.8 feet.

$ Step height - 2 feet

$ Downstream slope (without model study) - 0.6 to 0.875 (H:V)

Given these parameters and the assumption that the spillway would have a capacity equal to the 500-year flood peak, 1270 ft^3/s, the spillway hydraulic and geometric characteristics included:

$ Crest width (L). - 20 feet (based on an assumed unit discharge of 75 ft^3/s).

$ Design head (H_o). - 6.8 feet (based on an assumed design coefficient, C_o of 3.7).

$ Downstream slope. - 0.75 (matches the downstream slope of the dam).

Using current Reclamation practices for a vertical upstream-faced ogee crest, a crest height (P) of 4.0 feet above an approach channel (at elevation 6742.5) was selected [2, 3]. Based on the assumed crest height, unit discharge, and design head, the ogee crest flow surface was laid out.

A hydraulic-jump stilling basin was sized using current Reclamation practices. One advantage of a stepped-spillway is that the significant amounts of the kinetic energy associated with moving water are reduced as the water passes down the steps. For this particular layout approximately 40 percent of the kinetic energy was eliminated, which translated into a reduced stilling basin size (from 108- to 63-feet long). An assumed tailwater depth at elevation 6645 (5 feet above ground surface) was used to size the stilling basin. Prior to any additional studies, tailwater data should be prepared.

For details, refer to the attached drawings in figures 2.1 and 2.2.

2.3.4 Overtopping Protection

The dam would be overtopped for floods greater than the 500-year event. Maximum overtopping depths were estimated by routing the 2001 Hydrometeorological Report (HMR) 57 probable maximum floods (PMFs) [7]. As previously discussed in the hydrology section, two PMFs were developed, including the Local Storm PMF with a peak of 65,106 ft^3/s, and a 18.25-hour volume of 12,450 acre-feet; and the General Storm PMF with a peak of 19,387 ft^3/s and a 99-hour volume of 21,720 acre-feet. Key assumptions and criteria included:

$ Initial reservoir water surface at the beginning of the flood routing equaled the top of active conservation (spillway crest) at elevation 6746.5.

$ Outflow equals inflow until the outlet works capacity was exceeded. Reservoir surcharging began when the outlet works capacity was exceeded.

$ The outlet works was not used in the flood routing, due to its relatively small capacity (113 ft^3/s at top of active conservation at elevation 6746.5).

Results of the flood routings are summarized in Table 8.

There is very limited information about erodibility of the dam abutments and foundation. However, it is felt the native rock is pretty tough and the foundation would be unlikely to erode during overtopping flows. Given the small size of the drainage basin, the

duration of overtopping should be relatively short. Therefore at this appraisal stage, estimating overtopping protection would be too conservative, so costs for overtopping protection along the downstream groin were not developed. Geologic data about the dam abutments and foundation should be gathered to confirm this assumption before more refined designs are performed.

2.3.5 Outlet Works

A low-level outlet works was laid out and sized based on a number of assumptions including:

$ Horizontal alignment of the outlet works from the upstream face to the downstream face of the dam was assumed to be at streambed elevation 6640.

$ Given the sizable sediment accumulation, a drop-inlet attached to the upstream dam face was estimated. The intake sill elevation was equated to the top of dead storage and the top of 100-year sediment at elevation 6688.7.

Sizing of the outlet works was controlled by emergency evacuation guidelines for a low risk, high hazard dam [4]. Results included:

$ Dual gates were assumed, including a 36- by 36-inch unbonneted guard slide gate on the upstream face of the dam, and a 21-inch jet-flow regulating valve located on the downstream face of the dam. This gate and valve controls flow through a 24-inch steel pipe that extends through the dam.

$ A hydraulic jump stilling basin was located adjacent to the spillway stilling basin. As with the layout of the spillway stilling basin, it should be noted that an assumed tailwater depth (elevation 6645) was used to size the stilling basin. Prior to any additional stilling basin studies, tailwater data should be prepared.

$ Estimated capacity of the outlet works is 114 ft^3/s at reservoir water surface elevation 6746.5 (top of active conservation and spillway crest elevation).

For details, refer to the attached drawings in figures 2.1 and 2.2.

2.4 Description and Layout of Dam

2.4.1 Type of dam

The proposed site for the Big Timber Creek Dam is a relatively narrow rock-foundation canyon. The foundation appeared to be quartzite rock appropriate for a concrete gravity or concrete arch dam. However, the site is slightly too wide for a thin arch dam to be

economical and viable. Based on Reclamation experience, the maximum crest length-to-height ratio for an arch dam is approximately 6 to 1. For a 133-foot-high dam in this canyon, the crest length to height ratio would be 6.4 (856 feet to 133.3 feet). A concrete gravity dam would be constructed with either roller-compacted concrete (RCC) or mass concrete and would be designed straight across the canyon or curved in plan. A straight RCC dam was estimated for this study, but cost savings might be realized during final design with a curved RCC dam. RCC, being more economical than mass concrete, was chosen. RCC construction uses large equipment to place the vibrate RCC into place, similar to highway construction or embankment construction.

The dam was sized to have a 16-feet wide crest (typical for many RCC dams) and a downstream slope of 0.75:1 (horizontal:vertical) starting at the upstream edge (axis) of the dam at elevation 6763.83 (maximum water elevation). From experience with other Reclamation gravity dams in similar seismic zones, this is an appropriate shape for stability of the dam for all loading conditions.

2.4.2 Contraction of the dam and crack control

Crack inducers (metal sheets) at every other RCC lift were estimated and would be placed from upstream to downstream at 50-foot centers across the canyon to form contraction joints. This would minimize future thermal-induced cracking of the dam from seasonal temperature changes and cooling from heat-of-hydration temperatures as the concrete cures. PVC waterstops along the upstream side for seepage control were included in the cost estimate.

2.4.3 Drainage, seepage, and uplift pressures

A 4-foot wide by 7-foot tall drainage gallery was estimated across the entire width of the dam near the base of the dam. Costs for gallery lighting and ventilation were included in the cost estimate. Drains in the dam and foundation would discharge here and exit the dam. Drains (6-inch diameter) in the dam were estimated at about 8-feet from the upstream face drilled vertically from the crest into the gallery at 10-feet centers across the dam. The drains could be positioned downstream further to make it easier for drillers to intercept the foundation gallery. Water stops embedded along the contraction joints would be installed (assumed in unlisted items in cost estimate). Foundation drains (3-inch diameter) would be drilled from the gallery into the foundation at 10-feet centers across the dam. A foundation grout curtain was estimated upstream of the foundation drains by drilling 2-inch diameter holes from the gallery into the foundation at 10-feet centers across the dam and then pressure grouting the holes with cement grout.

2.4.4 Concrete mix design

The RCC was estimated with 300 lb per cubic yard cementitious material consisting of 60% flyash and 40% cement. A haul distance for aggregates from the Lemhi Valley of 25 miles was assumed. RCC would be placed in 2-foot-high lifts. A half-inch-thick layer of cement mortar was estimated on every RCC lift to improve bond and reduce potential seepage

paths through the dam.

2.4.5 Spillway

The concrete for the top surface of the ogee spillway and the roadway on top of the dam was estimated with air-entrained structural concrete for improved durability against spillway flows and freeze-thaw damage.

2.4.6 Outlet works and intake structure

A 24-inch diameter, 100 lb/in^2 rated steel pipe with one 21-inch diameter Jet Flow valve was estimated for the outlet works. The intake structure would be constructed with precast concrete panels and have trashracks to prevent inflow of debris. As silt accumulates along the upstream face of the dam, 3-foot by 3-foot precast concrete panels would be inserted in slots in the intake structure.

2.4.7 Instrumentation

Foundation piezometers, collimation deflection measurements, and drainage flow weirs were included in the cost estimate for instrumentation.

2.4.8 Concrete forms

An estimate was included for conventional-concrete slip-formed upstream and downstream faces of the dam to serve as forms for the RCC placement.

2.5 Structural Stability Considerations

To determine if the shape of the proposed Big Timber Creek Dam was appropriate, sliding factors of safety and vertical stresses at the heel and toe for various reservoir elevations were calculated using the traditional limit equilibrium stress and stability calculations. These analyses assume plane sections remain plane and deformation properties of the dam and foundation do not enter into the calculations. The loads included reservoir, tailwater, silt, dam weight, and uplift.

Based on the applied forces, the normal stress distribution at the base of the dam (or at any selected elevation) was assumed to linearly vary from upstream to downstream along a horizontal plane and was calculated using equation 1.

$$\sigma = P/A \ \forall \ Mc/I \qquad \text{(EQ 1)}$$

where:

- σ = stress normal to the plane at location c,
- P = vertical force,
- A = horizontal surface area,
- M = moment about the center of the base,
- c = distance from the center of the base to the upstream or downstream face, and
- I = moment of inertia about the center of the base.

Sliding factor of safety along a horizontal plane is the ratio between the resisting forces keeping the dam in place and the forces driving the dam as expressed in equation 2. The normal stress and associated shear strength distribution determined the resisting force.

$$SF = [(P-U)\mu + CA] / DF \qquad \text{(EQ 2)}$$

where (for horizontal potential sliding planes):

- SF = sliding factor of safety
- P = vertical force
- U = uplift force (assumes Corps of Engineers criteria and a drain efficiency of 67%)
- μ = friction coefficient
- C = cohesion (true cohesion for bonded surfaces and apparent cohesion for unbonded surfaces appropriate for the normal stress range of interest)
- A = horizontal surface area
- DF = driving force (summation of horizontal components of reservoir, and tailwater)

Static traditional limit equilibrium stress and stability calculations were performed for the a two-dimensional vertical section through maximum height section (see drawing in figure 2.2). Detailed results of these analyses are in appendix B (see figures B1 through B2), a summary of the results is in figure 2.6.

Analyses were made using the most probable RCC material properties expected in the dam. The most probable density for the RCC from laboratory tests from other projects was between 145 lb/ft^3 and 150 lb/ft^3, so 147.5 lb/ft^3 was used in the analyses. There is much less data for shear strength along RCC lift surfaces than on mass concrete lift surfaces. A relatively low (below average) shear strength of 50 lb/in^2 cohesion and 40E friction angle was assumed for the RCC based on tests from mass concrete from other projects (see figure 2.5).

The following reservoir and tailwater elevations were used in the analyses. Also, the reservoir elevation that induced zero compressive stress at the heel was computed and reported in figure 2.2.

Reservoir	Tailwater
6763.83 (PMF)	6645 (maximum tailwater)
6757.3 (Top of handrail)	6643 (interpolated)
6753.3 (Top of dam)	6642 (interpolated)
6746.5 (Spillway crest)	6640 (original ground surface)
6720.0 (Low Reservoir)	6640 (original ground surface)

Silt load at elevation 6688.7 was assumed with a horizontal equivalent fluid pressure of 85 lb/ft^3.

The following was determined from these analyses:

Sliding safety - The dam was stable against sliding for all reservoir elevations with or without effective drains using 147.5 lb/ft^3 concrete density, 50 lb/in^2 cohesion, and 40E friction angle (see figure 2.6). Sliding factors of safety using effective drains were 2.5 (2.3 using plugged drains) for reservoir at the top dam elevation 6753.3 and 2.2 (2.0 using plugged drains) for reservoir at the PMF elevation 6763.83. These were appropriate sliding factors of safety for a new dam. Drainage had a relatively small effect on the sliding factor of safety.

Stress - With effective drains, the base of the dam remained in compression up to reservoir elevation 6764.9 which was 1.1 feet above the PMF reservoir level using 147.5 lb/ft^3 concrete density (see figure 2.6). With plugged drains, the base of the dam was in compression up to reservoir elevation 6753.42 (0.1 feet above the crest of the dam) and had 22.5 lb/in^2 tension at the PMF reservoir level. It was desirable to have the upstream face of the dam in compression for all reservoir loading conditions. This was the case if the drains were effective. Since the PMF is an extremely remote event, the low level of tension at the heel (22.5 lb/in^2) was acceptable.

The conclusion drawn from these analyses for the maximum vertical section through the dam was that the designed shape of the dam was appropriate and not overly conservative. The dam was stable for overtopping reservoir elevation up to the PMF using reasonable values of 147.5 lb/ft^3 concrete density, 50 lb/in^2 cohesion, and 40E friction angle. The vertical stress at the heel of the dam (upstream base), was in compression up to the PMF level with effective drainage and had a small 22.5 lb/in^2 tension with plugged drains. If constructed, testing should be performed to verify the actual properties attained during construction.

A seismic structural analysis was not performed for this study. However, from experience from other projects, this dam shape should be stable for earthquakes with peak horizontal accelerations of up to about 0.6 g.

2.6 Geology and Geotechnical Considerations

2.6.1 Regional and Site Geology

The proposed dam site is within the Cordilleran fold and thrust belt of east-central Idaho. The rocks of this area have a long and complex history of deformation driven, in large part, by the Precambrian bolide which formed the Beaverhead Impact Structure, Cretaceous eastward thrusting of the near-surface rocks, and Eocene volcanism. The area is extensively faulted and folded and has experienced numerous periods of significant glaciation, erosion and deposition of sediments. The volcanism and structural deformations have yielded widespread mineralization of the host rock. Commercial mining of these ores has occurred since the early 1900s.

The area is part of the northern Basin-and Range physiographic province that is actively extending along a system of dominantly north-northwest-striking normal faults. The most significant recorded earthquake to affect the area was the 1983, magnitude 7.3, Borah Peak event. Figure 2.9a shows the site surface geology as mapped by Ruppel [15] overlain on an orthophotograph. Ruppel=s work indicates that the bedrock at the site is Precambrian quartzite (PCb). This rock is exposed along the upper left abutment at the proposed dam axis; but is concealed beneath a mantle of Recent alluvium (Qal) in the channel floor and Recent talus (Qt) on the middle and lower left abutment and on the right abutment. This quartzite will provide a competent foundation for the dam for all loading conditions. There is very limited data, but it is felt this native rock is pretty tough and the foundation would be unlikely to erode during overtopping flows.

Above the crest of the dam, the higher slopes of the left abutment are formed by Miocene and Pliocene tuff and tuffaceous conglomerates (Tt); and Ordovician Kinnikinic quartzite (Ok) comprises the higher slopes on the right abutment. Ruppel has mapped outcrops of Kinnikinic quartzite and Ordovician Saturday Mountain Formation (Osm) dolomite along the upstream left rim of the proposed reservoir; and these rock types might be present, but concealed by colluvial and alluvial materials, at the proposed dam site. These rock types would also provide a satisfactory dam foundation. Figure 2.9b is a geologic cross section located about 1 mile upstream of the proposed dam axis; and is provided to illustrate the geologic complexity of the area.

Scattered deposits of other alluvial (Qfy), colluvial (Qc), landslide (Qls) and glacial (Qma), (Qmb), (Qab), (Qac) materials also occur at the site.

The valley cross section is roughly symmetrical at the proposed dam axis. The existing slopes are slightly steeper on the left abutment, and range from a low of about 1:3.5 (vertical to horizontal) on the lower right abutment to a high of about 1:1.5 on the upper left abutment.

2.6.2 Geologic Discontinuities

The dashed, dotted and barbed heavy lines shown on Figures 2.9a and 2.9b are mapped strike-slip, normal and thrust faults. Although none of the mapped features crop out in the proposed dam foundation, it is probable that zones of ancient shearing will be encountered in the surface rock within the footprint of the dam (see report section 2.6.5 - Geotechnical considerations).

2.6.3 Borrow

Soil for cofferdam construction and aggregates for concrete are likely available within a few miles of the site. The aggregate particles are the erosional products of many rock types and likely have a wide range of durability and strength. Potential sources include:

a. The alluvial channel of Big Timber Creek. The channel is fairly broad for a distance of about two miles upstream of the damsite.

b. Glacial moraine deposits (Qmb) about 1.5 miles upstream of the damsite.

c. Alluvium and alluvial fan materials extending from about two miles downstream of the damsite to the Lemhi River.

2.6.4 Design and Construction Considerations

Sheared and brecciated zones will likely be encountered within the footprint of the dam. These zones might require over excavation and replacement with concrete backfill to provide a sound dam foundation. Leveling concrete 3-feet thick across the base of the dam was included in the cost estimate.

The various rock types possibly present and the highly disturbed condition of the rock have probably produced an irregular weathering profile. Foundation shaping will likely be required to achieve a satisfactory foundation surface for RCC placement. Leveling concrete 3-feet thick across the base of the dam was included in the cost estimate. The depth of extensive weathering of the rock should not be great at this site. Moderately weathered to slightly weathered bedrock should be present at depths no greater than about 5 to 10 feet below the current bedrock surface. For this appraisal study, 20 feet of excavation was assumed.

The bedrock at the site is highly fractured. The fracture walls are likely weathered to considerable depth, variably filled with sand and fines at the near surface, and only partially healed at depth. Foundation grouting and foundation drainage will likely be required to control uplift on the base of the dam and within the abutments. Grouting and drainage were included in the cost estimate.

The maximum thickness of alluvium in the creek channel was not known. An

average thickness of 20 feet alluvium and rock excavation was assumed and included in the cost estimate.

The left and right abutment slopes above the proposed dam crest are steep. Slope stabilization measures might be required to prevent rock falls and colluvial slides from damaging the proposed facilities. This was not specifically included as a line item in the cost estimate, but incorporated in the unlisted items.

2.6.5 Geotechnical considerations

Chris Powell and Al Simpson visited the proposed site for Big Timber Creek Dam on July 17, 2001. The main purpose of this site visit was to photograph the site and obtain some basic information on the jointing in the abutment rock mass. Due to inclement weather, limited access to the right abutment, and few accessible rock outcrops in the vicinity of the left abutment (the majority of the left abutment is covered with talus), only a few joint orientations were measured. However, the one rock outcrop that was inspected more closely was assumed to be representative of the foundation rock, and was characterized by the following three joint sets:

$ Joint Set A - N 85E E, 68E SE (Dip/Dip Direction 68E/175E)

$ Joint Set B - N 13E E, 53E SE (Dip/Dip Direction 53E/257E)

$ Joint Set C - N 40E E, 70E SE (Dip/Dip Direction 70E/130E)

Figure 2.7 is a plan view of the dam site, that shows the existing topography downstream of the proposed dam. Figure 2.8 is a stereonet that shows projections of the three joint sets, the downstream abutment slopes, and the dam axis. Based on the very limited joint data described above, there does not appear to be any potential foundation stability problems (isolated rock wedges that could slide when acted on by dam and uplift forces). This assessment is very crude and should be refined if a decision is made to construct Big Timber Creek Dam. Figure 2.23 is a photograph of the rock outcrop in the vicinity of the proposed left abutment that was used to obtain joint orientation data. Photos in figures 2.10 through 2.25 were taken during the site visit.

2.7 Fish Passage

2.7.1 Upstream migration

Alternatives considered for upstream migration for fish passage at Big Timber Creek Dam included a vertical slot fish ladder/false weir, a bypass channel, mechanical lifts, trap and truck, and locks (also see appendix D).

Vertical Slot Fish Ladder/False Weir: The vertical slot fish ladder is a common style of fish ladder that allows fish to migrate upstream, but at the same time provides resting areas for the fish. Ladders of this type are designed for a slope of approximately 10:1. The ladders are equipped with a series of pools which are controlled with two baffles at each pool. A narrow, vertical slot between the baffles allows the fish to migrate from pool to pool. Fish can rest in the pools in the backwater behind the baffles.

A vertical slot fish ladder on a 10:1 slope would require a length of 1000 feet to climb a 100-foot high dam. The engineer=s estimate for a recently designed vertical slot fish ladder at Reclamation over a 10-foot-high dam was $3,000,000.

Upon reaching the top of the dam, the fish pass a false weir. Once beyond the false weir the fish are dropped into a flume which sweeps the fish down the upstream portion of the dam and into the reservoir.

Water to supply the ladder and flume must be pumped to the top of the dam.

Bypass Channel: The bypass channel would essentially consist of a vertical slot fish ladder to carry fish up the downstream face of the dam. At the dam crest, the fish ladder would transition to a channel that would allow fish to proceed past the reservoir and continue into the stream upstream of the reservoir. Water for this arrangement can be supplied by gravity from the stream upstream of the reservoir.

The length of the channel would extend upstream of the reservoir and would have to be slightly longer than the length of the reservoir at the highest elevation of the reservoir.

Mechanical Lift: Mechanical lifts have been used successfully incorporated into dams of this height, most recently on the Susquehanna River at Conowingo and Safe Harbor dams. Fish are lured into a hopper by an attraction flow. Periodically a gate closes on the hopper entrance, trapping the fish within the hopper. The hopper is then lifted to the top of the dam and fish are released to the opposite side. The reported cost for the Conowingo mechanical lift was $12,000,000.

Trap and Truck: Trapping and trucking is similar to the mechanical lift system

except that trapped fish are trucked around the dam rather than lifted over the dam by mechanical lift. The cost of this method is labor intensive and depends on the number of trips required to transport the fish. This is probably the preferred alternative initially for Big Timber Creek Dam.

Lock: A lock is similar to a mechanical lift. The lock consists of a chamber that is gated both on the reservoir side and on the downstream side. To pass fish from the downstream side to the upstream side, the chamber is initially set with the reservoir gate closed and the downstream gate open. When enough fish are attracted into the chamber, the downstream gate is closed and the reservoir gate is open, providing the fish with a channel into the reservoir.

Lock systems are an effective manner of moving fish, although lock systems are better suited to relatively low head differentials so that fish are not subjected to large pressure changes over a short period of time. This method is not suited for Big Timber Creek Dam.

2.7.2 Downstream Migration

Downstream migration can often be more difficult than upstream migration, depending on the species and local conditions. If downstream migration is required only during low reservoir periods, fish can simply pass through the outlet works when the reservoir is low. If downstream migration is required on a full time basis then other provisions will have to be made. Bull trout, a federally listed species, are present in Big Timber Creek. Conditions in a reservoir environment are often times preferred by Bull trout. Some Bull trout would likely choose to reside in the reservoir except during spawning periods at which time they would migrate upstream to spawn and then return to the reservoir.

2.8 Powerplant

The feasibility of a powerplant at the site was studied with possible generating heads of 80, 100, 120 and 140 feet with a flow rate of 35 ft^3/sec occurring 60 days per year. Given this data, Table 9 illustrates the energy potential at this site.

Table 10 is a comparison of head, estimated powerplant costs (Based on the rule-of-thumb of $2000 per kw), capitol recovery (paying back investment), operating and maintenance (O&M) costs (Note: O&M costs estimated at $10,000 per year), and the required selling price of energy to break even on the powerplant. These costs do not include the additional expense of running electrical transmission lines into the site.

Based on Table 10, a powerplant does not appear to be economically feasible. The computed required selling price to break even is 9 to 11 cents per kilowatt-hour which is two to three times more than what the energy could be purchased for elsewhere. The largest contributor to the high selling price is the fact that the powerplant would only operate 60 days per year. Of course, if the powerplant was expected to make a profit, then the required selling price would be even higher.

2.9 Selective withdrawal

Selective withdrawal provides the capability to release reservoir water from various elevations in the reservoir and control the temperature of the released water for fish. The cost of providing selective withdrawal capabilities was not specifically designed for this dam, but a general range of costs and discussion are provided. The selective withdrawal outlets would consist of an enclosed Abox A or Atube@ down the upstream face of the dam, with several individually operable gates. The Abox@ or Atube@ would be connected to the outlet pipe, and sealed against the dam. The water temperature at different water depths would be monitored and one or more gates opened to allow the desired temperature water to be released.

The estimated costs for the selective withdrawal outlets were based on a selective withdrawal outlet currently being designed for the same capacity (35 ft^3/s) as this study. The estimated costs ranged from $400,000 to $600,000 for the various dam heights.

3.0 FIELD COST ESTIMATES

Appraisal level field costs for the Big Timber Creek Dam would total $23,000,000 (see appendix C - Estimate Worksheet for details). The pay items in the estimate included: mobilization and preparatory work, clearing and grubbing reservoir area, road improvements, an upstream and downstream cofferdam, diversion during construction through a 4-foot diameter steel pipe, unwatering the excavation area, foundation excavation, fault treatment, dental and leveling concrete, foundation grouting, foundation drainage, constructing the RCC dam, furnishing and installing river outlet works including the intake structure and 21-inch Jet Flow valve, constructing a concrete stilling basin, instrumentation, running electrical power to the site, 15% unlisted items, and 25% contingencies. The dam included a 20-foot-wide ogee spillway, an interior drainage gallery, drilled formed drains from the dam crest to the gallery, and upstream and downstream concrete facing elements.

The above costs did not include the following:

1. Data collection. This includes design level foundation exploration, seismotectonics, hydrology, and laboratory studies.
2. Final design costs
3. Project coordination and inspection
4. Contract administration

5. Construction management

6. Operation and maintenance costs
7. Land purchases
8. Permits:
    404 Permit from the Corps of Engineers
    Stream Alteration Permit from the Idaho Department of Water Resources
9. Environmental Impact Statement (EIS). An EIS would take approximately one year to complete and would cost about $200,000.
10. Coordination Act Report (CAR).
11. Fish ladder (see report section 2.7)
12. Selective withdrawal system (see report section 2.9)
13. Powerplant (see report section 2.8)

4.0 CONSTRUCTION CONSIDERATIONS

4.1 Electrical power

Electrical power for construction would be run from Leadore and was included in the cost estimate.

4.2 Constructor work area

A construction work area could be built between the dam and upstream cofferdam or between the dam and the downstream cofferdam. The reservoir basin widens upstream of the dam and provides more work area than downstream of the dam.

4.3 Transport and access to the site

There is a railroad line and small commuter airport in Salmon, Idaho about 60 miles from Leadore, Idaho. A small airstrip in Leadore is shown on the local map (figure 1.2). A railroad line no longer exists from Salmon to Leadore. The road from Salmon to Leadore is a very good 2-lane paved state road. A good 2-lane gravel county road extends about 1 mile from Leadore toward the site. A very crude and rocky 2-rut road extends from the gravel road part of the way to the site. This road would require improvement including upgrades to two small bridges. This is included in the cost estimate.

5.0 OPERATIONAL AND MAINTENANCE CONSIDERATIONS

5.1 Operations and maintenance

The outlet works would require routine maintenance of the Jet Flow valve and inlet structure. The overflow ogee spillway is un-gated and would not require maintenance. Freeze-thaw damage can be minimized with air-entrained concrete. A fish passage system would require maintenance depending on the system used.

5.2 Upstream considerations

There are no residence or towns upstream of the dam. Land purchase was not included in the estimate.

5.3 Overtopping

The dam was designed to carry forces from floods that overtop the dam (floods greater than the 500-year event). Overtopping flows will likely wash away alluvium and weathered rock along the downstream groin of the dam. Flows are not expected to erode the foundation rock and cause a dam stability problem due to limited duration and rock type.

5.4 Downstream considerations and release strategies

Release strategies for the reservoir water should be developed that will best supplement and optimize flows in the Lemhi River.

5.5 Storage strategies

Storage strategies for the reservoir water should be developed that will best supplement and optimize flows in the Lemhi River and optimize available water in the drainage basin.

6.0 AFFECTED ENVIRONMENT

In 1993, an Environmental Impact Statement documented the analysis of nine alternatives for timber sale in the Big Eightmile, North Fork Timber, and Alder Creek sites [18]. Excerpts from this report relative to Big Timber Creek (and Eightmile Creek) are included here as informational material.

6.1 Fisheries

Since the area is higher in elevation and the reservoir would likely be deeper at the Big Timber Creek site than the Texas Creek site, establishing a good fishery within the Big Timber Creek reservoir would be more feasible than at the Texas Creek site. Also, a dam at the Big Timber Creek site would allow more control over the temperatures of water released into Big Timber Creek and the Lemhi River, especially if the dam was constructed with valves lower on the structure so colder water could be released when desired. The Big Timber Creek Dam would provide flows for re-connection of Big Timber Creek to the Lemhi River, since the lower section of the creek is dry for the greater part of the summer due to irrigation withdrawals. Habitat for

resident bull trout (Federally listed as threatened) and other fish in both Big Timber Creek and the Lemhi River would be increased and enhanced. Fish located above the dam site are currently prevented from year round downstream migration since lower Big Timber Creek is seasonally

disconnected from the Lemhi River.

In 1993 [18], there were no Threatened or Endangered fish species occuring in the proposed areas for the timber sale. The mainstrem reaches of Big Eightmile Creek and Big Timber Creek contain well-established populations of resident salmonid: Westslope Cutthroat Trout (Oncorhynchus clarkl)**, Bull Trout (Salvelinus confluentus)**, Rainbow Trout (Oncorhynchus mykiss), Mountain Whitefish (Prosoplum williamsonl), and Sculpin (Cottus spp.). The Westslope Cutthroat Trout and the Bull Trout are Intermountain Region Vertebrate Sensitive Species and Idaho Department of Fish and Game Species of Special Concern. Grove Creek and Alder Creek may provide additional spawning and nursery habitat for the mainstream Big Timber Creek trout species, but were not believed to support independent fish populations.

The closest anadromous fisheries to the site of the 1993 timber sale were in the Hayden Creek drainage and in the mainstem Lemhi River channel downstream of Leadore. Use of the Big Eightmile Creek and Big Timber Creek drainages by salmon and steelhead were precluded by irrigation withdrawals below their Forest boundaries which entirely dewater the lower reaches of both streams during the summer months.

Big Eightmile Creek and Big Timber Creek had no water quality problems in 1993 [18]. The presence of well-established populations of cleanwater benthic macroinvertebrates in Big Eightmile Creek and Big Timber Creeks indicated that waters were cool, clear, and well-oxygenated. Production capabilities for both creeks were placed at 70 pounds of fish per surface acre [18, p.S21].

A current evaluation will be needed to determine the full potential for impacts upon the present fishery and potential for benefits.

6.2 Recreation

The surrounding area supports a wide range of recreation activities including hiking, horseback riding, trail bike riding, hunting, fishing, and camping [18]. Undeveloped campgrounds are located in Big Eightmile Creek and at Timber Creek Reservoir. A trailhead facility on Forest Road 105 leads into Big Timber Creek. The heavy recreation use season is generally from June through November. In 1993, one outfitter/guide took fishing and big game hunters into the Big Timber Creek drainage. The Big Timber Creek site currently is limited for recreation opportunities due to access. The site is located in steep, rocky and timbered topography making it difficult to access many areas of the proposed reservoir. The road to the dam improved during construction will greatly enhance access to the reservoir. There are a few existing 4-wheel drive trails accessing the north rim of the reservoir. With the proper infrastructure, power boating, fishing, waterskiing, camping, and day-use sites could be developed. It is likely that a managing partner or concessionaire would need to be sought to provide the necessary facilities such as restrooms, garbage containers, potable water, boat ramps and camping facilities. The proximity to the small town of Leadore will have economic benefits through recreation opportunities offered by the reservoir. Increased law enforcement might be

needed to patrol the reservoir and dam.

6.3 Realty

Part of the footprint of the dam and reservoir area is on private land, and part of the area is in private ownership. Negotiations on disposition of affected lands would have to transpire among landowners and the party or parties responsible for construction of the dam. Land acquisition costs are not included in the preliminary cost estimate prepared for this report.

6.4 Cultural Resources

Cultural resource surveys, inventory, and possible mitigation would be required prior to construction of a dam.

6.5 Threatened and Endangered Species

The bald eagle, gray wolf, Canada lynx, Ute ladies= tresses, bull trout, sockeye salmon, spring/summer chinook salmon, and steelhead are listed species that could occur in the Lemhi county area. Surveys verifying the presence of these species in the area may be required prior to construction of a dam.

6.6 Wildlife and Vegetation

The lower reaches of Big Eightmile and Big Timber Creeks are located in low to moderate gradient, moderately wide to wide (600 to 1,000 feet) flat-floored valley bottoms [18]. The moderate gradient portions have dense riparian vegetation with a good mix of woody and herbaceous plants. The low gradient reaches are an array of beaver dams intertwined with willow patches. The upper reaches of both these drainage areas are characterized by high gradient, U-shaped, glacier-carved valley bottoms.

In 1993, there were no Federally-listed Threatened or Endangered plants occurring in the area [18]. Three Forest Service Region 4 Sensitive Species might occur in the area: Lemhi penstemon, Salmon twin bladderpod, and pink agoseris. Pink agoseris occurs in the wet meadows where the soil remains saturated throughout the growing season. It was observed in the upper Big Eightmile Creek and in the Big Timber Creek drainage area in 1993.

In 1993, no Federally-listed Threatened or Endangered species inhabited the proposed timber sale area [18]. One Endangered species, the Northern Rocky Mountain gray wolf, would find the habitat suitable if a Lemhi Range population existed. However, no confirmed sightings had occurred. The site was not a designated Wolf Recovery Zone or Dispersal Corridor. One sighting of the North American lynx, a Forest Service Region 4 Sensitive Species, was confirmed in the area in 1993. Six other Forest Service Region 4 Vertebrate Sensitive Species have preferences that would allow them to inhabit the area, but had not been sighted in 1993 that include: wolverine, Western (or Townsend=s) big-eared bat, boreal owl, Northern three-toed woodpecker, great owl, and the spotted frog.

The area for the timber sale was mapped as key elk summer range and several elk calving areas were identified [18]. The areas receive heavy spring, summer, and fall elk and mule deer use. Limited numbers of both species winter in the area, especially in the southern portion around Grove Creek and Big Timber Creek. Mountain goats were found in the upper elevations of the drainage areas. Antelope were found along the lower elevations and non-timbered portions.

A current evaluation of the effects of a dam and reservoir upon area fish and wildlife and their habitat would be required. Close coordination with the Federal and State agencies would be necessary.

6.7 Water

Big Eightmile Creek and Big Timber Creek are major tributaries of the Lemhi River, although in summer these streams are usually totally diverted for irrigation before they reach the Lemhi River [18]. The primary existing beneficial water uses are for agricultural water supply, cold water biota, salmonid spawning, secondary contact recreation, and livestock. No water quality data was collected on Big Timber Creek, its tributaries, or any of the intermittent streams within the proposed timber sale in 1993 [18]. Water temperature, pH, and conductivity were believed to be similar to Big Eightmile Creek which was measured to be an excellent source of irrigation and livestock water and in the range necessary for cold water boita and salmonid spawning.

6.8 Wetlands and Riparian Habitat

In 1993 [18], riparian stringer wetlands were found adjacent to the smaller perennial streams and along segments of Big Eightmile and Big Timber Creeks. Stream banks were characterized by willows, aspen, and/or alder. These wetland types were typically very narrow with vegetation occurring in very narrow bands adjacent to the streams. The most extensive wetlands occurred in the valley bottoms adjacent to Big Eightmile and Big Timber Creeks where vegetation was mostly overstories and sedge understories. The wetlands found were relatively common. The kinds of wetlands and vegetation communities associated with them were not restricted or unique to the area.

6.9 Environmental Compliance

An Environmental Impact Statement (EIS) is required to comply with National Environmental Policy Act (NEPA) requirements as part of the detailed studies that would lead to construction of this project. The EIS provides a more detailed analysis of the environmental effects of a dam and reservoir on fish and wildlife, recreation, Indian Trust assets, property, cultural resources, threatened and endangered species, and vegetation. An EIS takes about two years to complete and would cost about $200,000.

Under the Fish and Wildlife Coordination Act, the US Fish and Wildlife Service prepares a Coordination Act Report (CAR) that evaluates the potential impacts a reservoir would have upon fish and wildlife. The US Fish and Wildlife Service requires financial compensation for preparation of this report.

Any work in public waterways requires a 404 permit from the Corps of Engineers and a stream alteration permit from the Idaho Department of Water Resources. A delineation of wetlands is needed. Mitigation for impacts to wetlands and riparian habitat loss is probably required. Obtaining these permits takes approximately 3 months.

Under Section 7 of the Endangered Species Act, consultation with the National Marine Fisheries Service and the US Fish and Wildlife Service is required. Surveys for presence of threatened or endangered species are necessary. Mitigation for impacts to listed species or habitat is probably required and might add significantly to the overall cost. The consultation process takes from 6 to 12 months to complete.

7.0 CHANGE IN RISK

A dam in Big Timber Creek potentially changes the risk for downstream populations. However, the risks are estimated to be very low given current day design and construction standards for concrete dams.

8.0 CONCLUSIONS

An RCC dam in Big Timber Creek is a viable option to provide 6,000 acre-ft of reservoir storage capacity to maintain year around consistent flows on a reach of the Lemhi River between the L-6 and L-5 diversions that typically go dry.

9.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Recommendations for future actions prior to any additional designs include:

1. Install a stream gage to begin collecting data. This would help address water supply and environmental issues that require information about flow variability and reliability.

2. Prepare more detailed topography (2-foot contours in the area of the dam) of the site and determine the depth of alluvium and rock contact.

3. Prepare diversion flood hydrographs along with a better understanding of the construction sequencing.

4. Gather additional geologic data about the dam abutments and foundation. This could include joint mapping, core drilling, and laboratory testing.

5. Prepare tailwater data prior to any additional stilling basin studies.

6. Locate and test a suitable borrow source for concrete aggregate and sand.

7. Develop an Environmental Impact Statement.

8. Obtain appropriate permits.

9. Perform mix designs for the RCC using the actual fly ash, cement, and aggregates being supplied for the dam.

10. Perform a design level seismotectonic study of the area.

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[13] ASurface-Water/Ground-Water Relations in the Lemhi River Basin, East-Central Idaho, A by Donato, M.M., USGS/USBR Water-Resources Investigations Report 98-4185, 1998.

[14] ASheephorn Peak Quadrangle 7.5 minute series (topographic), A USGS, 1987.

[15] AGeologic Map of the Leadore Quadrangle, Lemhi County, Idaho, Map GC-733, A by Ruppel, E.T., 1968.

[16] ASalmon National Forest (Cobalt, North Fork, Leadore, and Salmon Ranger Districts), Idaho-Montana,@ compiled by the Geometronics Service Center, Salt Lake City, Utah, 1979.

[17] ANationwide Summary of U.S. Geological Survey Regional Regression Equations for Estimating Magnitude and Frequency of Floods for Ungaged Sites, A by Jennings, M.E., W.O. Thomas, Jr., and H.C. Higgs, U.S. Geological Survey Water Resources Investigations Report 94-4002, 1994, 1993.

[18] AFinal Environmental Impact Statement - Big Eightmile, North Fork of Timber, and Alder Creek Timber Sale,@ by USDA Forest Service, John Burns (Forest Supervisor), Lynn M. Bennett (Environmental Coordinator), and Richard Ward (Leadore District Ranger), 1993.

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1 - Big Timber and Texas Creek Water Supply
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Flood routing:
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9. - Energy Potential at the Big Timber Creek Site
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Table 1 - Big Timber and Texas Creek Water Supply						
Dam Site	Mean Monthly Discharge (ft^3/s)					
	Nov	Dec	Jan	Feb	Mar	
Big Timber Creek	24	20	20	20	22	
Texas Creek	22	19	18	19	20	
	Mean Monthly Discharge (acre-feet)					Total Water Supply (acre-feet)
Big Timber Creek	1,430	1,230	1,230	1,110	1,350	6,350
Texas Creek	1,310	1,170	1,110	1,060	1,230	5,880

Table 2 - Probable Maximum Precipitation for Local Storm	
Duration (hours)	Accumulated Precipitation (inches)
0.25	1.50
0.50	2.51
0.75	3.17
1.0	3.65
3.0	4.16
6.0	4.34

Table 3 - Probable Maximum Precipitation for General Storm	
Duration (hours)	Accumulated Precipitation (inches)
1.0	1.53
6.0	5.15
24.0	9.99
48.0	13.15
72.0	14.61

Table 4 - Lag Time Parameters and Calculated Lag Times (hours)	
Parameter	Value
L	13.0
L_{ca}	6.3
S	323.1
C_t for local storm	1.3
C_t for general storm	4.0
Lag time for the local storm	2.14
Lag time for the general storm	6.60

Table 5 - Big Timber Creek Damsite - Local Storm Probable Maximum Flood							
Hour	Flow (ft^3/s)	Hour	Flow (ft^3/s)	Hour	Flow (ft^3/s)	Hour	Flow (ft^3/s)
0.00	0	5.00	44,904	10.00	3,512	15.00	510
0.25	0	5.25	57,524	10.25	3,184	15.25	462
0.50	0	5.50	65,106	10.50	2,894	15.50	427
0.75	0	5.75	64,758	10.75	2,632	15.75	396
1.00	0	6.00	55,753	11.00	2,393	16.00	366
1.25	0	6.25	44,593	11.25	2,174	16.25	338
1.50	0	6.50	34,156	11.50	1,975	16.50	308
1.75	0	6.75	25,412	11.75	1,796	16.75	278
2.00	0	7.00	19,366	12.00	1,630	17.00	215
2.25	0	7.25	15,300	12.25	1,481	17.25	136
2.50	3	7.50	12,495	12.50	1,344	17.50	34
2.75	14	7.75	10,467	12.75	1,220	17.75	3
3.00	61	8.00	8,886	13.00	1,103	18.00	1
3.25	211	8.25	7,680	13.25	1,000	18.25	0
3.50	613	8.50	6,718	13.50	908	18.50	0
3.75	1,474	8.75	5,904	13.75	825	18.75	0
4.00	3,686	9.00	5,232	14.00	749	19.00	0
4.25	8,898	9.25	4,699	14.25	685	19.25	0
4.50	18,161	9.50	4,266	14.50	625	19.50	0
4.75	31,209	9.75	3,875	14.75	566	19.75	0

Table 6 - Big Timber Creek Damsite - General Storm Probable Maximum Flood							
Hour	Flow (ft^3/s)	Hour	Flow (ft^3/s)	Hour	Flow (ft^3/s)	Hour	Flow (ft^3/s)
0	0	27	0	54	15,085	81	522
1	0	28	3	55	13,378	82	461
2	0	29	15	56	11,752	83	407
3	0	30	42	57	10,214	84	354
4	0	31	102	58	8,831	85	309
5	0	32	185	59	7,611	86	267
6	0	33	293	60	6,569	87	223
7	0	34	425	61	5,677	88	176
8	0	35	591	62	4,934	89	130
9	0	36	798	63	4,320	90	68
10	0	37	1,061	64	3,807	91	41
11	0	38	1,363	65	3,365	92	28
12	0	39	1,722	66	2,987	93	19
13	0	40	2,120	67	2,658	94	12
14	0	41	2,575	68	2,368	95	7
15	0	42	3,071	69	2,112	96	4
16	0	43	3,624	70	1,884	97	2
17	0	44	4,242	71	1,681	98	1
18	0	45	5,044	72	1,500	99	0
19	0	46	6,183	73	1,340	100	0
20	0	47	7,961	74	1,195	101	0
21	0	48	10,619	75	1,063	102	0
22	0	49	14,089	76	941	103	0
23	0	50	17,127	77	835	104	0
24	0	51	19,836	78	743	105	0
25	0	52	19,387	79	662	106	0
26	0	53	17,051	80	587	107	0

Table 7 - Magnitude and Frequency of Floods Developed for the Big Timber Dam Site	
Return Period (years)	Peak Discharge (ft^3/s)
10	577
25	750
50	866
100	981
500	1270

Table 8 - PMF Flood Routing Results

Flood Type	Maximum Reservoir Water Surface (feet)	Maximum Discharge (ft^3/s)		Maximum Overtopping Depth (feet)	Overtopping Duration (hours)
		Spillway	Dam		
Local Storm PMF	6762.53	5,124	55,535	9.23	8.3
General Storm PMF	6757.59	2,968	16,771	4.29	30.3

Table 9 - Energy Potential at the Big Timber Creek Site				
Head (feet)	Flow (ft^3/s)	Horsepower (HP)	Kilowatts (Kw)	Kilowatt Hours in 60 Days
80	35	286	213	306,926
100	35	357	266	383,657
120	35	429	320	460,389
140	35	500	373	537,120

Table 10 - Powerplant Break Even Power Selling Price					
Water Head (feet)	Estimated Powerplant Costs ($)	Capital Recovery at 5% Interest ($)	Total costs (Capital and O&M) ($)	Generation capability (Kwhrs per 60 days)	Required Selling Price of Power to Break Even ($ / Kwhr)
80	$426,286	$23,351	$33,351	306,926	$0.11
100	$532,857	$29,188	$39,188	383,657	$0.10
120	$639,429	$35,026	$45,026	460,389	$0.10
140	$746,000	$40,863	$50,863	537,120	$0.09

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2.24 Panorama of left (west) abutment talus slope.
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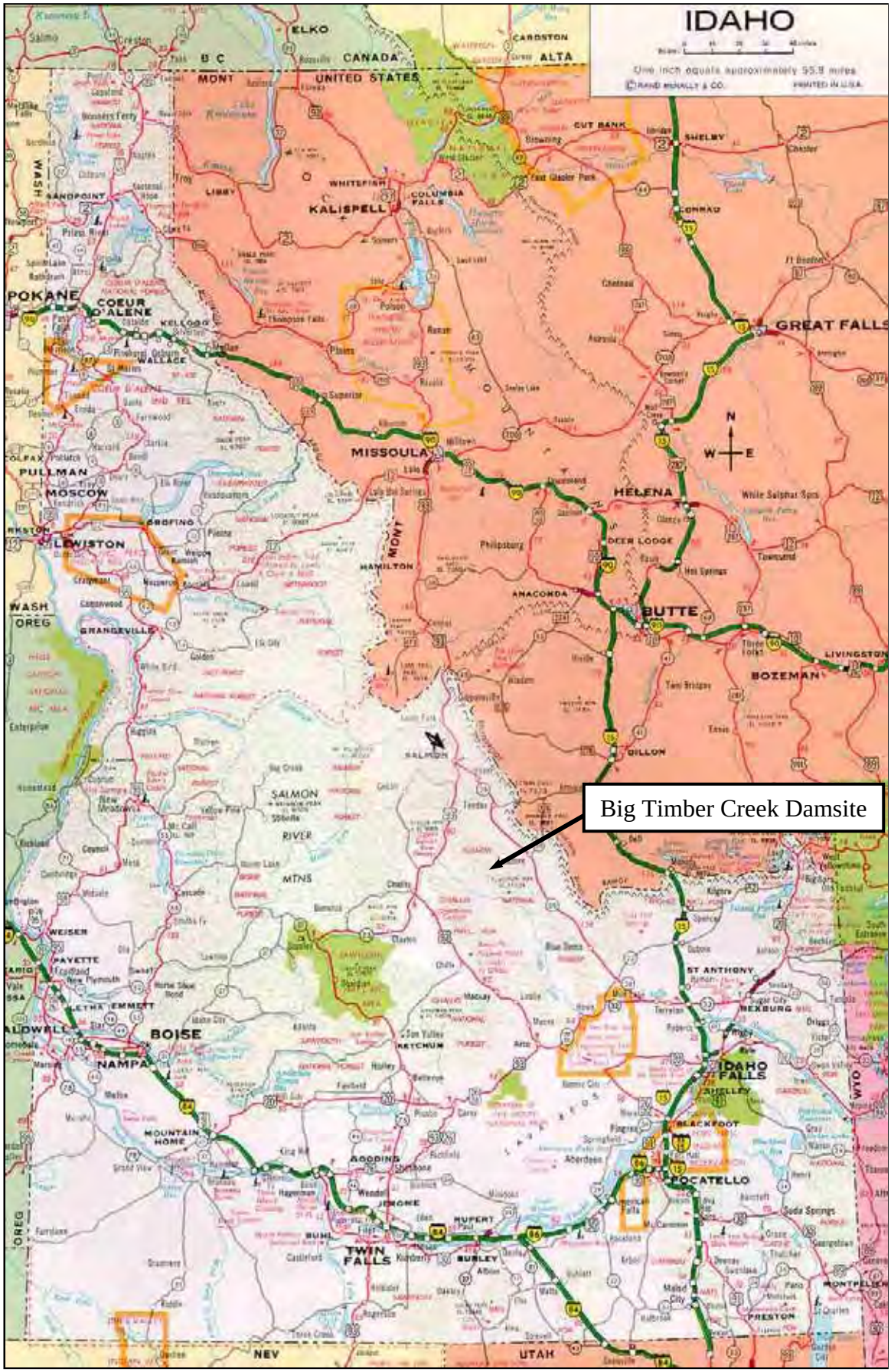


Figure 1.1 – General location for Big Timber Creek Dam south of Leadore, Idaho.

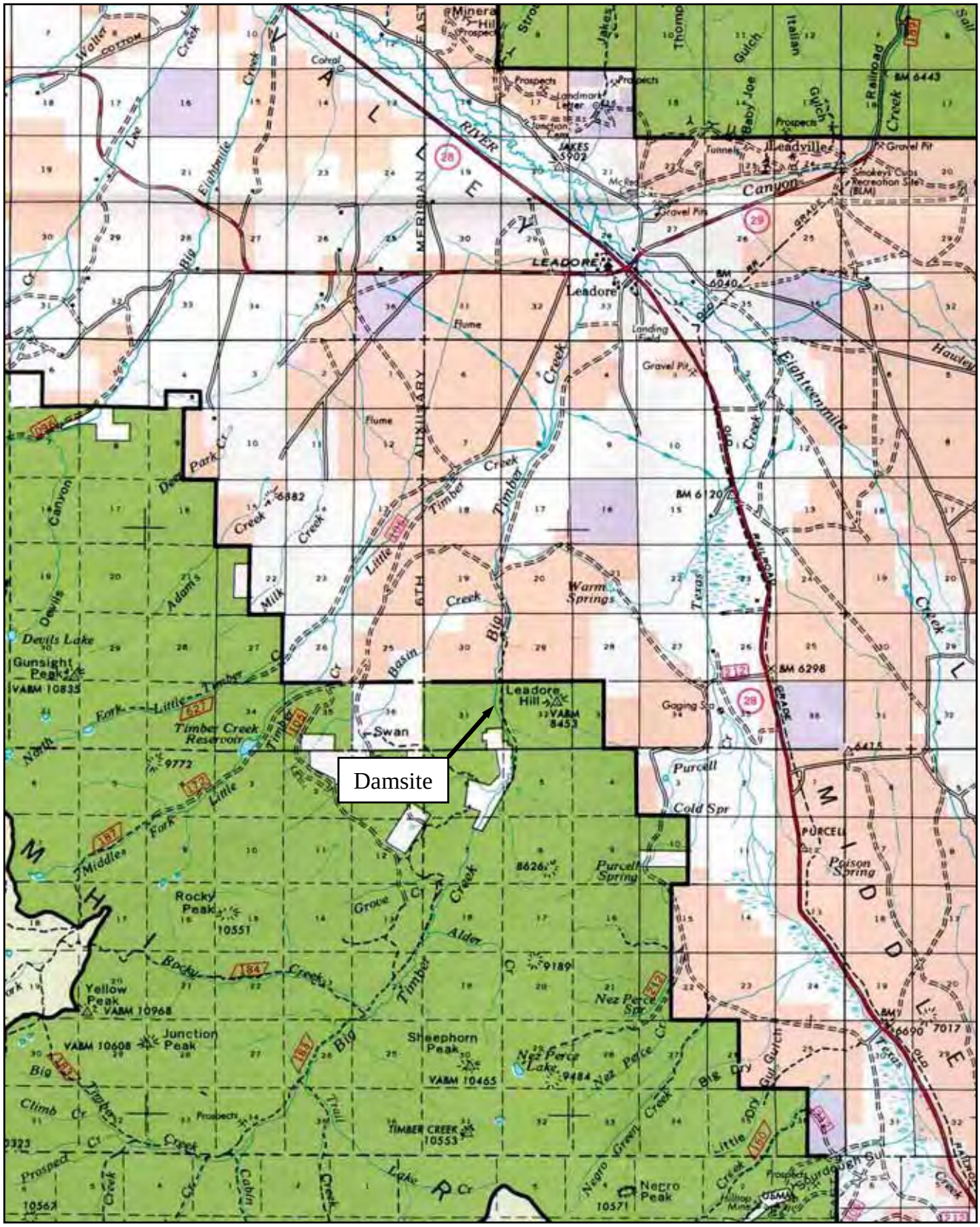


Figure 1.2 – Local map of Leadore, Idaho and proposed site for Big Timber Creek Dam (each square is one square mile).

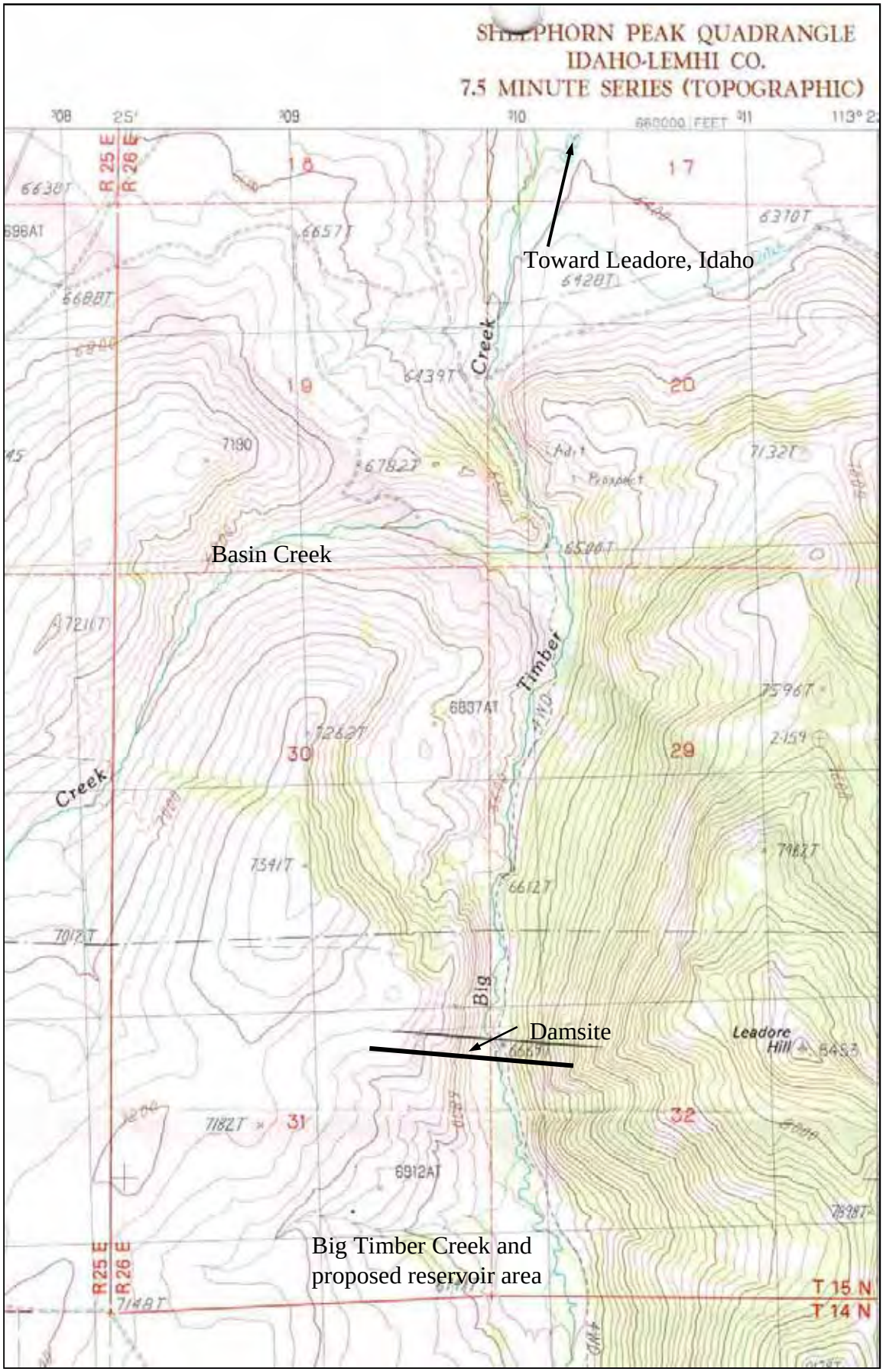


Figure 1.3 – Topography map of Big Timber Creek damsite showing location of dam, Big Timber Creek,, and Basin Creek. Damsite is about 1 mile west of Leadore Hill. (each square is one square mile)

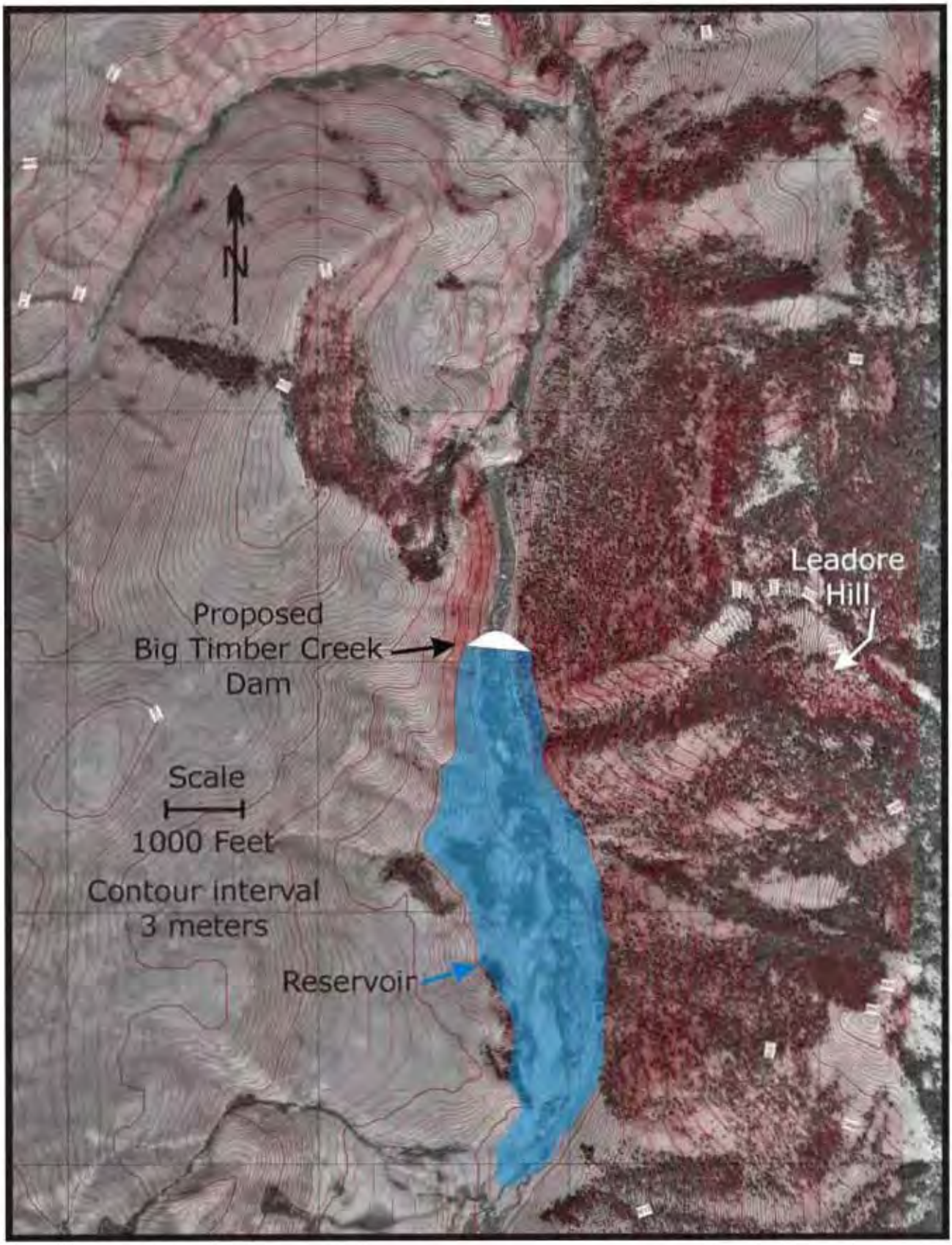
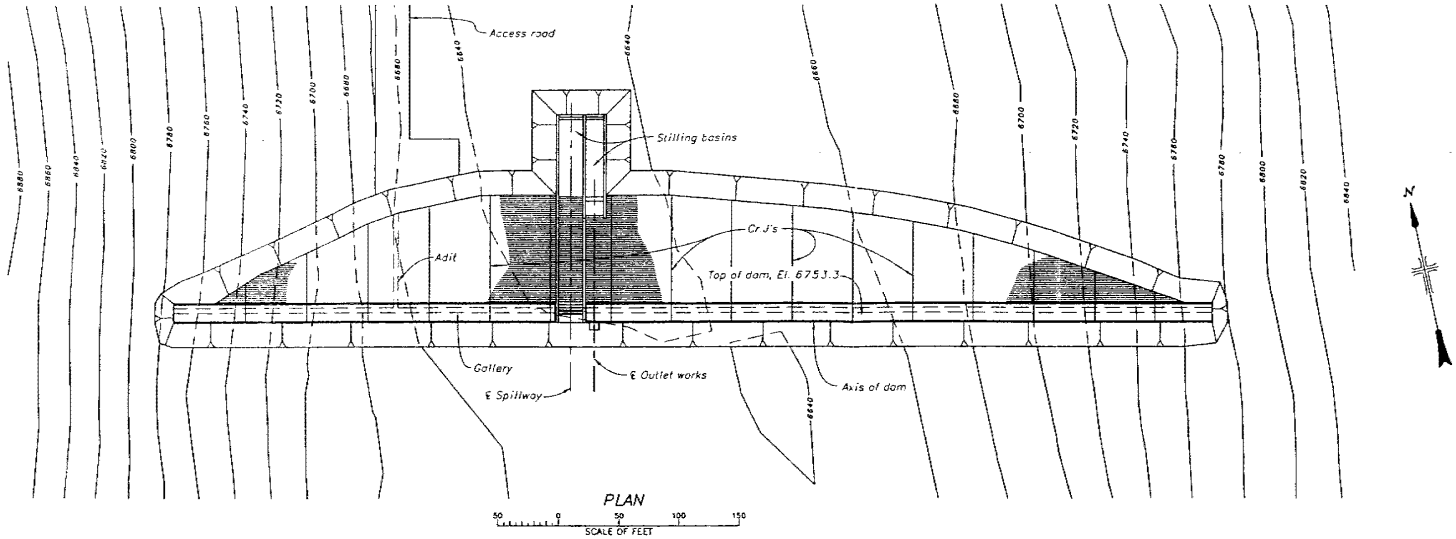
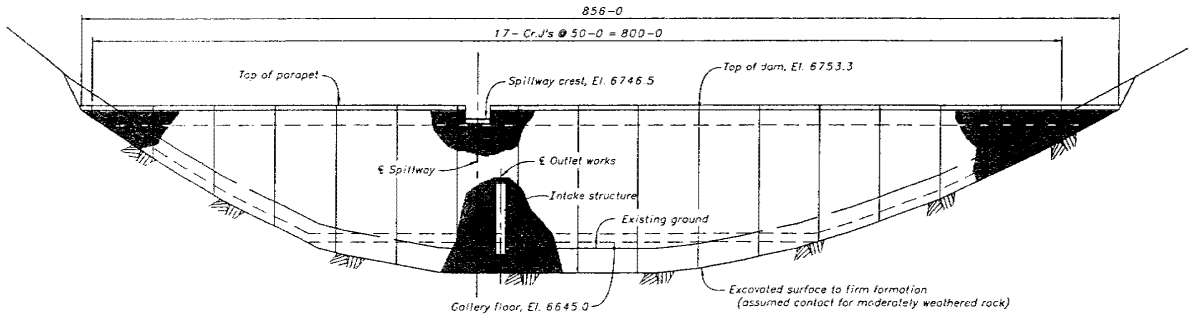


Figure 1.4 – Proposed Big Timber Creek Dam and reservoir superimposed on a map of the topography.

Figure 2.1





PROFILE ALONG AXIS OF DAM

NOTES

Topography taken from Sheephorn Peak Quadrangle dated 1987.

For this study overtopping protection was assumed to not be required and therefore is not depicted.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Offstream Storage To Supplement Flows in the Lambi River

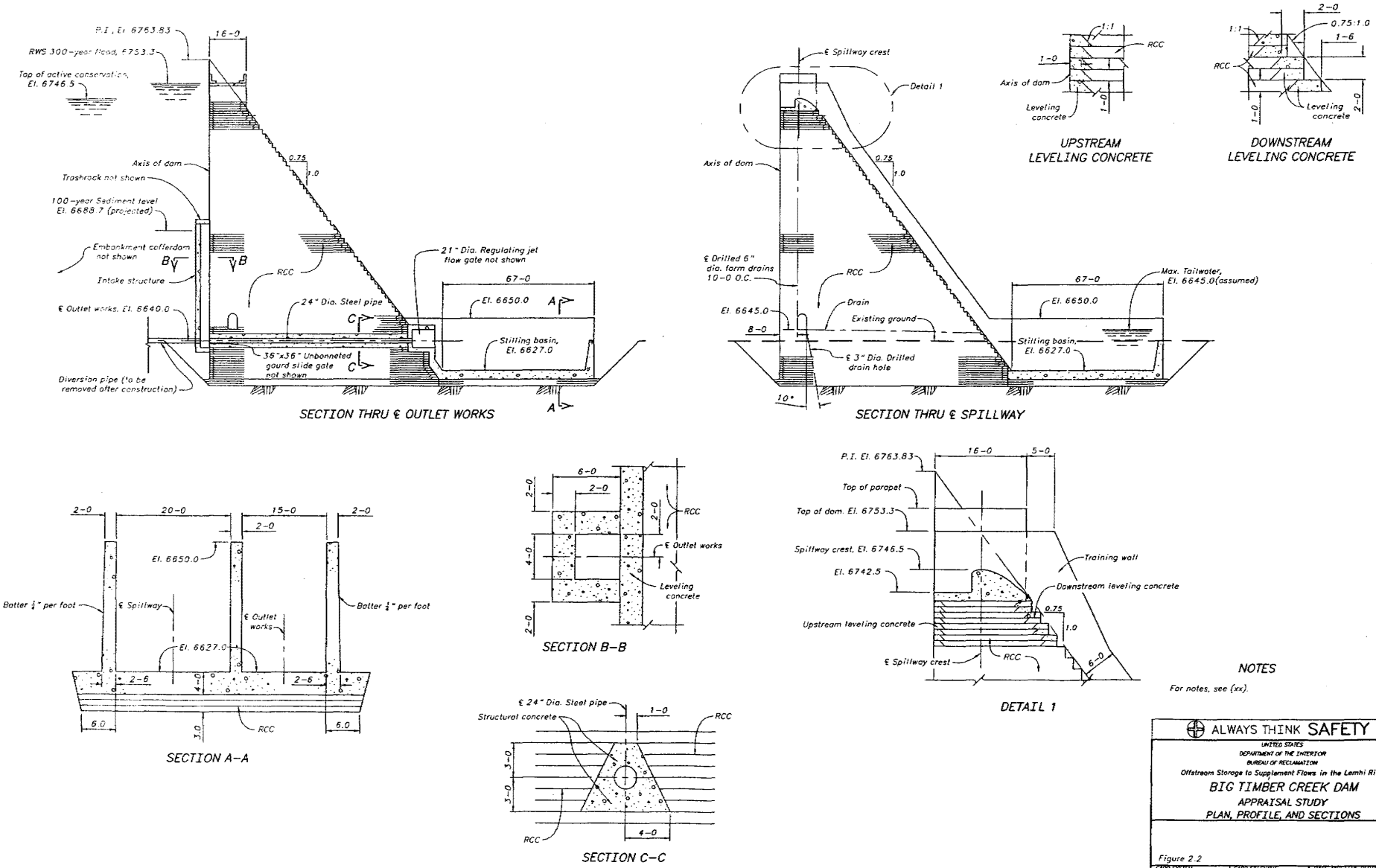
BIG TIMBER CREEK DAM
APPRAISAL STUDY
PLAN, PROFILE, AND SECTIONS

Figure 2.1

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 13.0c	SHEET1.DWG	SEPTEMBER 17, 2001 14:03
DENVER, COLORADO	SEPTEMBER 17, 2001	
	SHEET 1 OF 2	

SPECIFICATIONS NO. 0000

Figure 2.2



NOTES

For notes, see (xx).

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UNITED STATES
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BUREAU OF RECLAMATION

Offstream Storage to Supplement Flows in the Lemhi River

BIG TIMBER CREEK DAM
APPRAISAL STUDY
PLAN, PROFILE, AND SECTIONS

Figure 2.2

CADD SYSTEM AutoCAD Rel. 13.06 | CADD FILENAME SHEET1.DWG | DATE AND TIME PLOTTED SEPTEMBER 17, 2001 14:09
DENVER, COLORADO | SEPTEMBER 17, 2001 | SHEET 2 OF 2

SPECIFICATIONS NO. 0000

Figure 2.3a – Stepped spillway at Santa Cruz Dam, New Mexico

Figure 2.3b – Water flowing over stepped spillway at Santa Cruz Dam, New Mexico.

Figure 2.4a

Big Timber Creek								
Elev	Area			Volume			Crest Length	
	Sq Meters	Sq Feet	Acres	Cu Ft	Cumm-Ft	Cumm-Ac-ft	Meters	Feet
6620	0	0	0.0	0	0	0		
6640	7296	78533	1.8	785335	785335	18.0	66.5	218.18
6660	74809	805237	18.5	8837709	9623044	220.9	108.5	355.97
6680	150755	1622713	37.3	24279507	33902550	778.3	143.2	469.82
6700	290345	3125248	71.7	47479609	81382159	1868.3	168.5	552.82
6720	423031	4553468	104.5	76787154	158169313	3631.1	191.8	629.27
6740	602366	6483814	148.8	110372814	268542127	6164.9	213.6	700.79
6760	742294	7989986	183.4	144737998	413280125	9487.6	234.4	769.03
6780	905033	9741694	223.6	177316803	590596928	13558.2	255.8	839.24
6800	1101303	11854327	272.1	215960210	806557137	18516.0	278.0	912.07
6820	1276143	13736289	315.3	255906158	1062463295	24390.8		
6840	1541927	16597164	381.0	303334530	1365797825	31354.4		
6860	1868534	20112733	461.7	367098967	1732896792	39781.8		
6880	2226746	23968494	550.2	440812271	2173709063	49901.5		
6900	2668386	28722268	659.4	526907623	2700616686	61997.6		

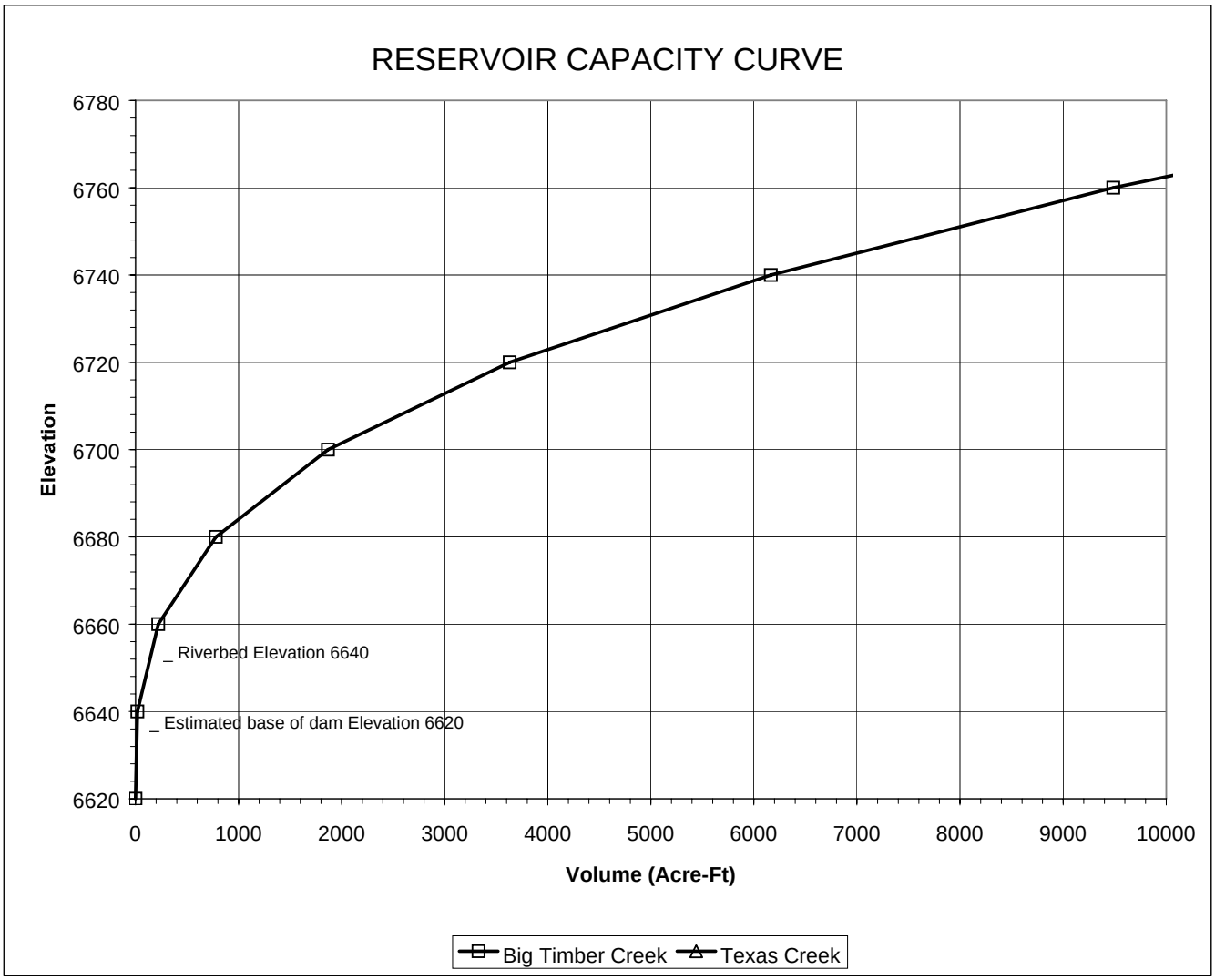
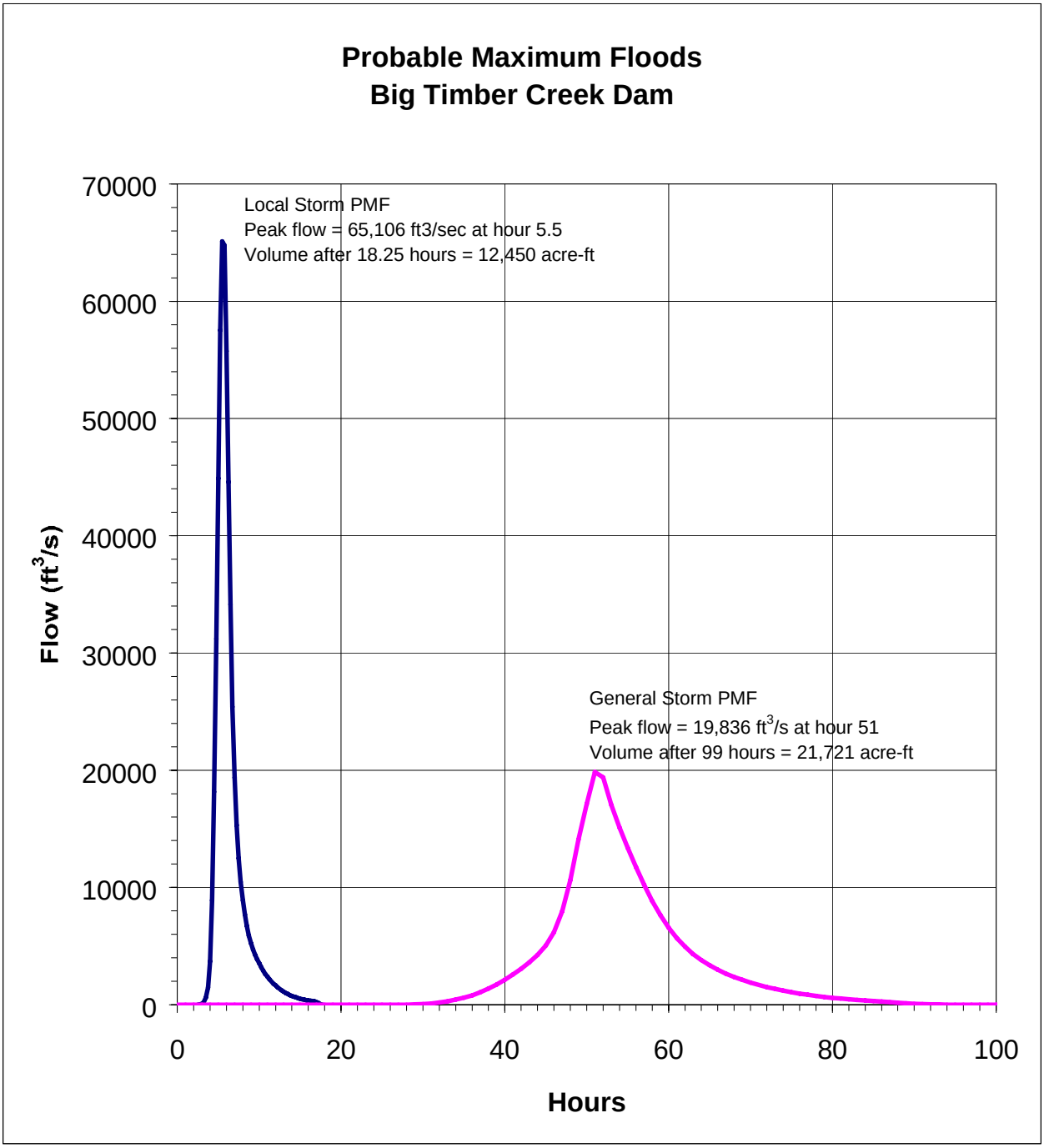


Figure 2.4b


Probable Maximum Floods
Big Timber Creek Dam
Local Storm PMF
Peak flow = 65,106 ft3/sec at hour 5.5
Volume after 18.25 hours = 12,450 acre-ft
General Storm PMF
Peak flow = 19,836 ft3/s at hour 51
Volume after 99 hours = 21,721 acre-ft
Flow (ft3/s)
70000
60000
50000
40000
30000
20000
10000
0
0
20
40
60
80
100
Hours

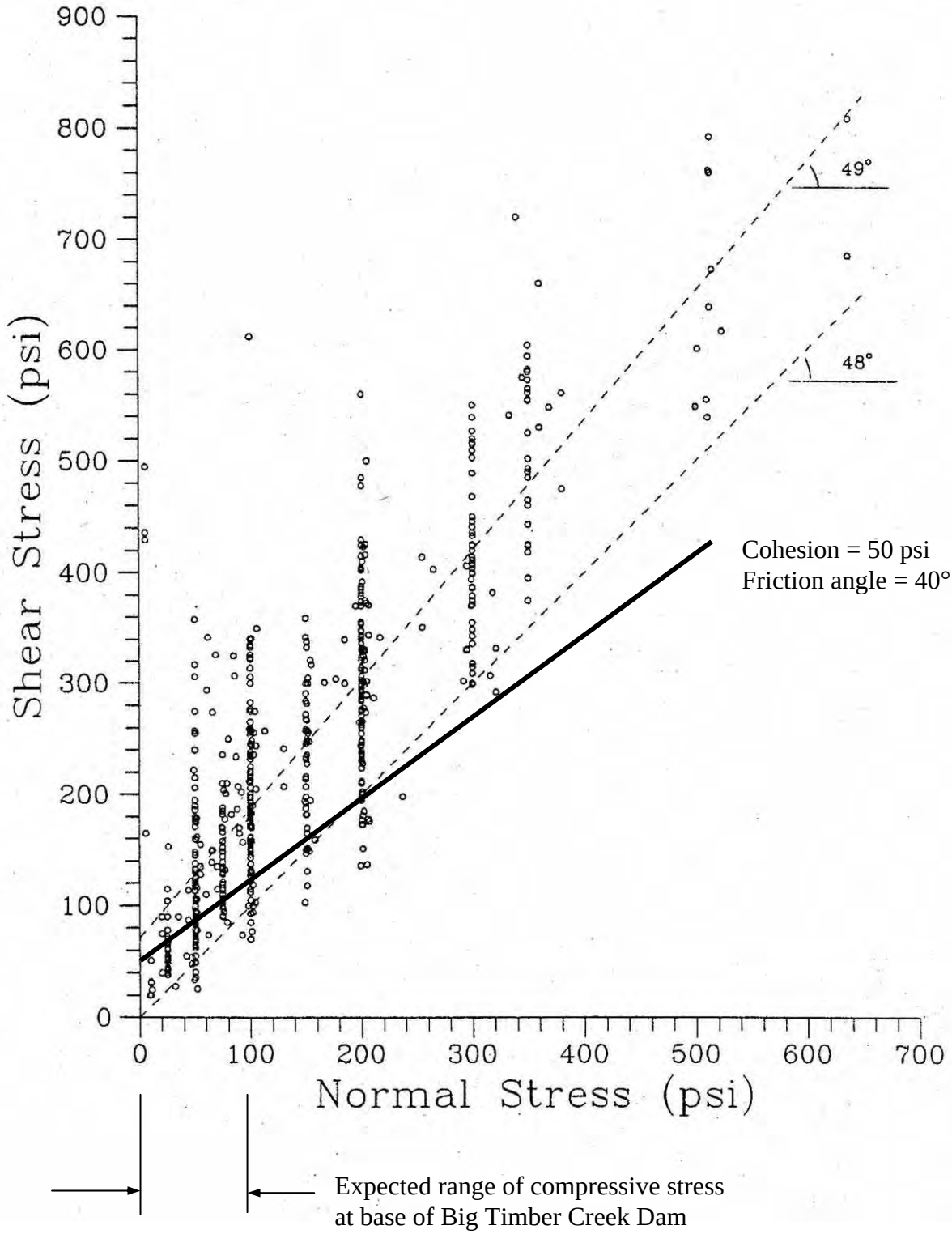


Figure 2.5 – Estimated lower limit for shear strength along RCC lift lines.

Big Timber Creek Dam

Stability Analyses Using Traditional Limit Equilibrium Analyses

By: Larry K.Nuss
Date: March 20, 2002
Checked: Rick Munoz

Drains 67% Efficient

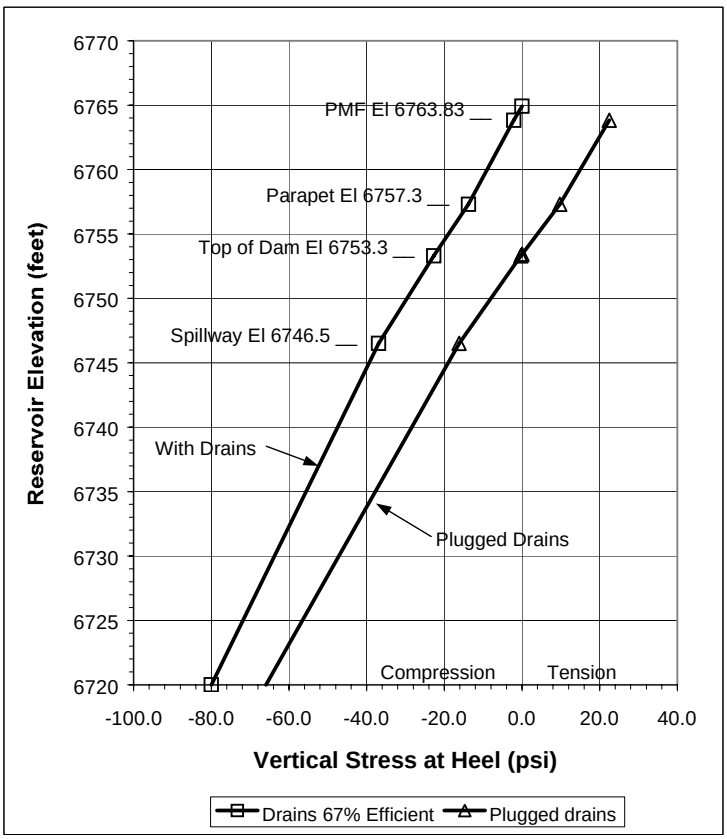
Drain Criteria	Drain Efficiency	Gallery Elevation (feet)	Concrete Density (pcf)	Bonded Cohesion (psi)	Bonded Friction Angle	Unbonded Cohesion (psi)	Unbonded Friction Angle	Percent Bond %
Colo	0.67	6645	147.5	50	40	50	40	100

		Allow concrete to crack if in tension							Do not allow concrete to crack if in tension					
Reservoir Elev (feet)	Tailwater Elev (feet)	Crack Length (feet)	U/S Stress (psi)	Slide FS	Overturn FS	Req Coh (psi)	H3 (feet)	D/S Stress (psi)	U/S Stress (psi)	Slide FS	Overturn FS	Req Coh (psi)	H3 (feet)	D/S Stress (psi)
6720	6640	0.0	-80.0	4.4	3.0	19.3	48.0	-36.5	-80.0	4.4	3.0	19.3	48.0	-36.5
6746.5	6640	0.0	-36.9	2.8	2.0	57.4	56.2	-75.3	-36.9	2.8	2.0	57.4	56.2	-75.3
6753.3	6641.97	0.0	-22.7	2.5	1.8	68.2	58.3	-87.7	-22.7	2.5	1.8	68.2	58.3	-87.7
6757.3	6643.12	0.0	-13.8	2.4	1.7	74.9	59.6	-95.7	-13.8	2.4	1.7	74.9	59.6	-95.7
6763.83	6645	0.0	-2.1	2.2	1.6	84.8	61.6	-107.1	-2.1	2.2	1.6	84.8	61.6	-107.1
6764.91	6645	0.0	0.0	2.2	1.6	86.6	62.0	-109.2	0.0	2.2	1.6	86.6	62.0	-109.2

Plugged drains

Drain Criteria	Drain Efficiency	Gallery Elevation (feet)	Concrete Density (pcf)	Bonded Cohesion (psi)	Bonded Friction Angle	Unbonded Cohesion (psi)	Unbonded Friction Angle	Percent Bond %
Corp	0	6645	147.5	50	40	50	40	100

		Allow concrete to crack if in tension							Do not allow concrete to crack if in tension					
Reservoir Elev (feet)	Tailwater Elev (feet)	Crack Length (feet)	U/S Stress (psi)	Slide FS	Overturn FS	Req Coh (psi)	H3 (feet)	D/S Stress (psi)	U/S Stress (psi)	Slide FS	Overturn FS	Req Coh (psi)	H3 (feet)	D/S Stress (psi)
6720	6640	0.0	-65.9	4.1	2.2	25.4	94.1	-36.1	-65.9	4.1	2.2	25.4	94.1	-36.1
6746.5	6640	0.0	-16.2	2.5	1.5	66.5	118.6	-74.3	-16.2	2.5	1.5	66.5	118.6	-74.3
6753.3	6641.97	0.0	-0.3	2.3	1.4	78.1	125.0	-86.6	-0.3	2.3	1.4	78.1	125.0	-86.6
6753.42	6642	0.0	0.0	2.3	1.4	78.3	127.3	-86.9	0.0	2.3	1.4	78.3	125.2	-86.9
6757.3	6643.12	29.6	0.0	2.0	1.2	85.2	137.3	-98.2	9.7	2.1	1.3	85.2	128.8	-94.5
6763.83	6645	76.9	0.0	1.6	1.0	95.8	143.8	-161.4	22.5	2.0	1.2	95.8	135.0	-105.6



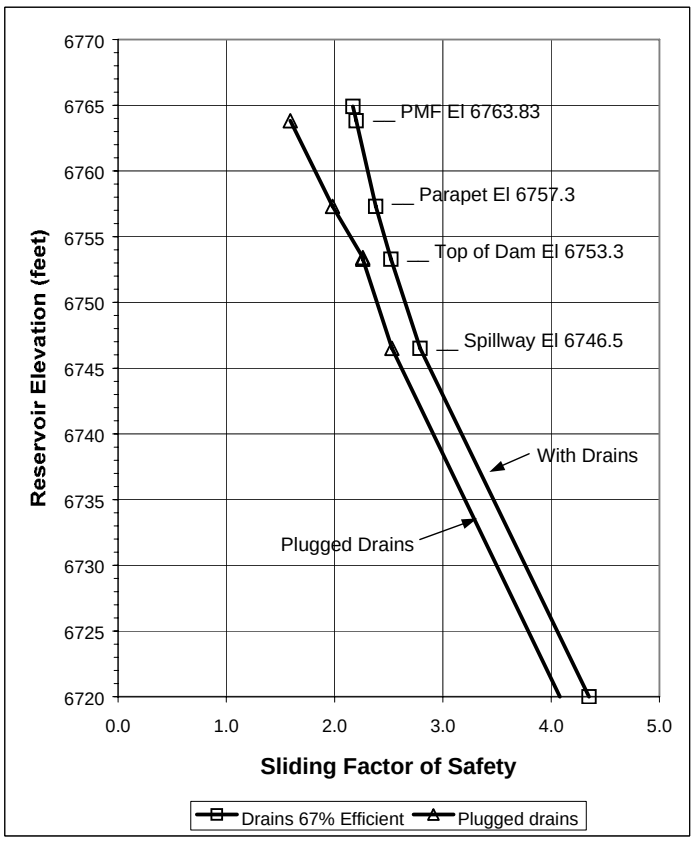


Figure 2.6 – Stability calculations for Big Timber Creek Dam

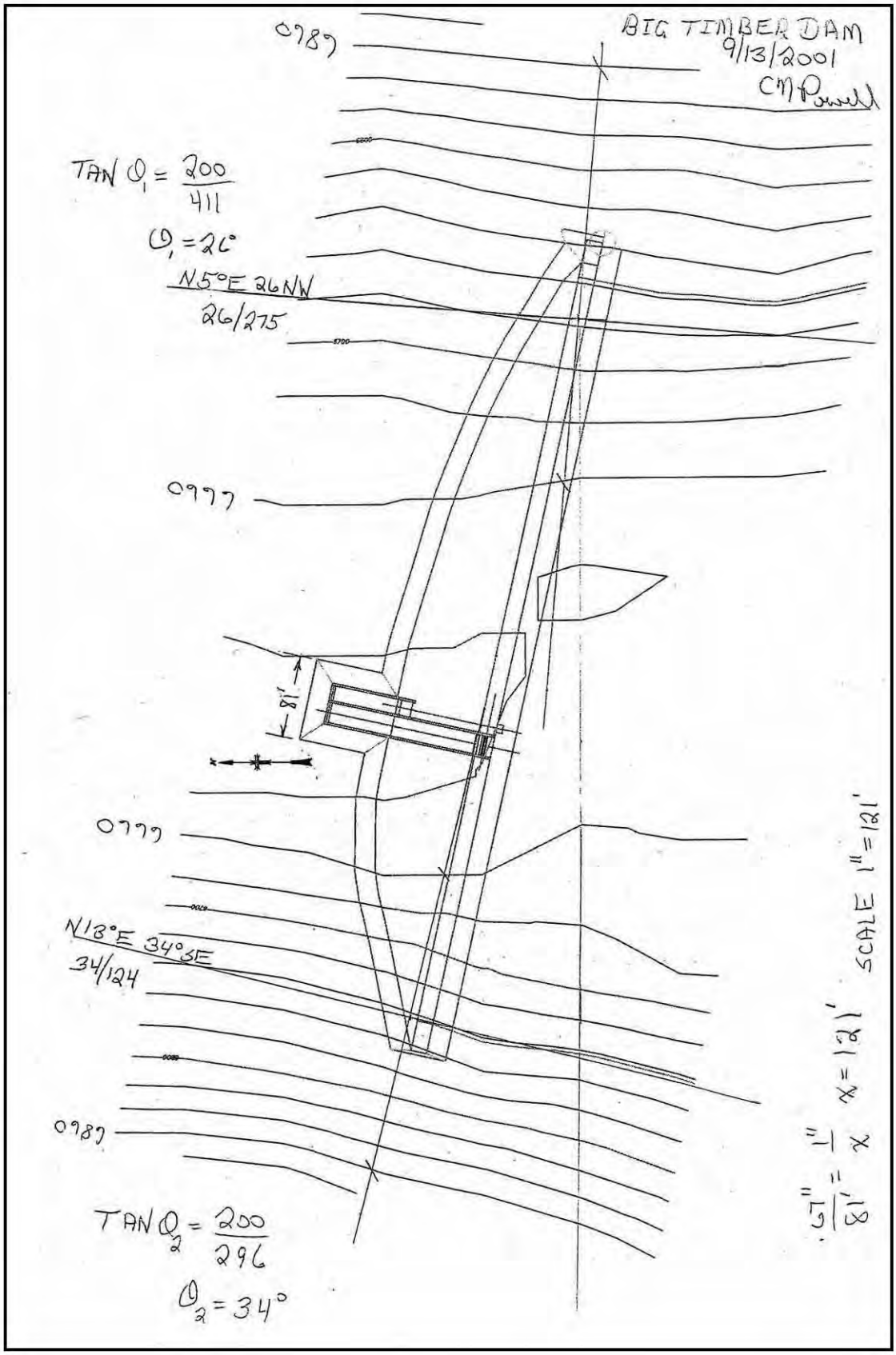


Figure 2.7 – Dam orientation to plot on stereonet in figure 2.8

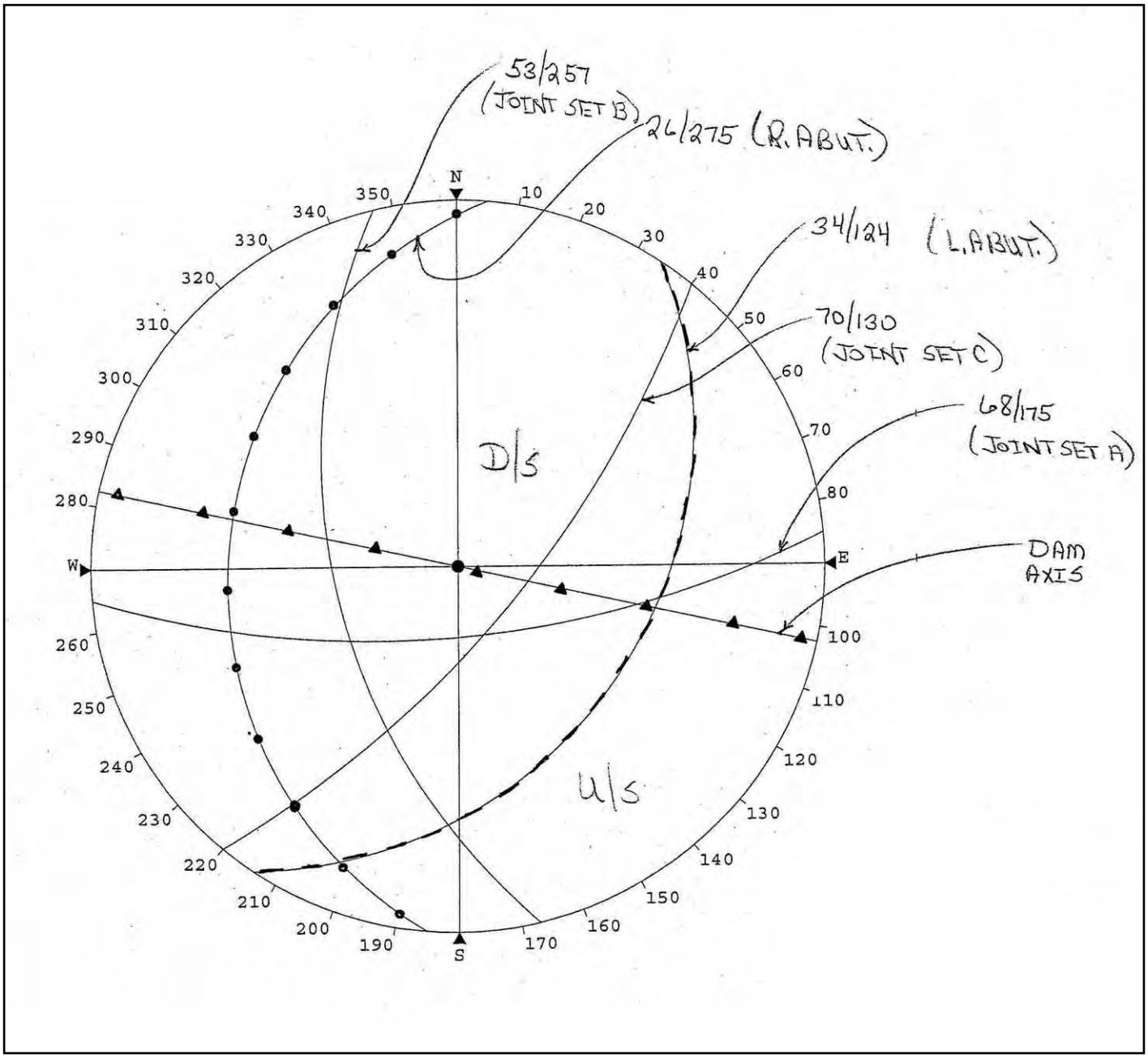


Figure 2.8 – Stereonet showing dam orientation and joint sets identified during second site visit.

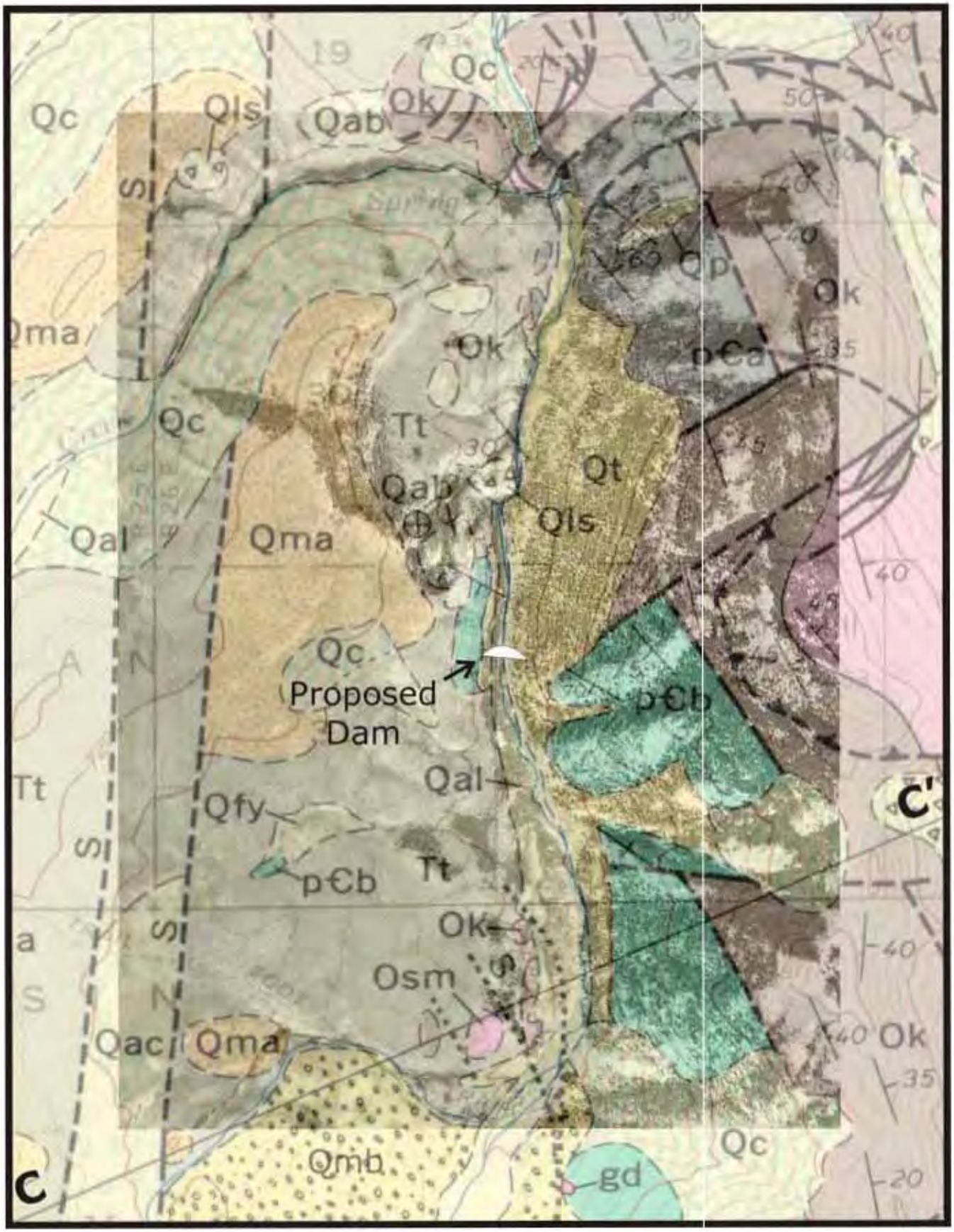


Figure 2.9a – Surface geology as mapped by Ruppel [15]

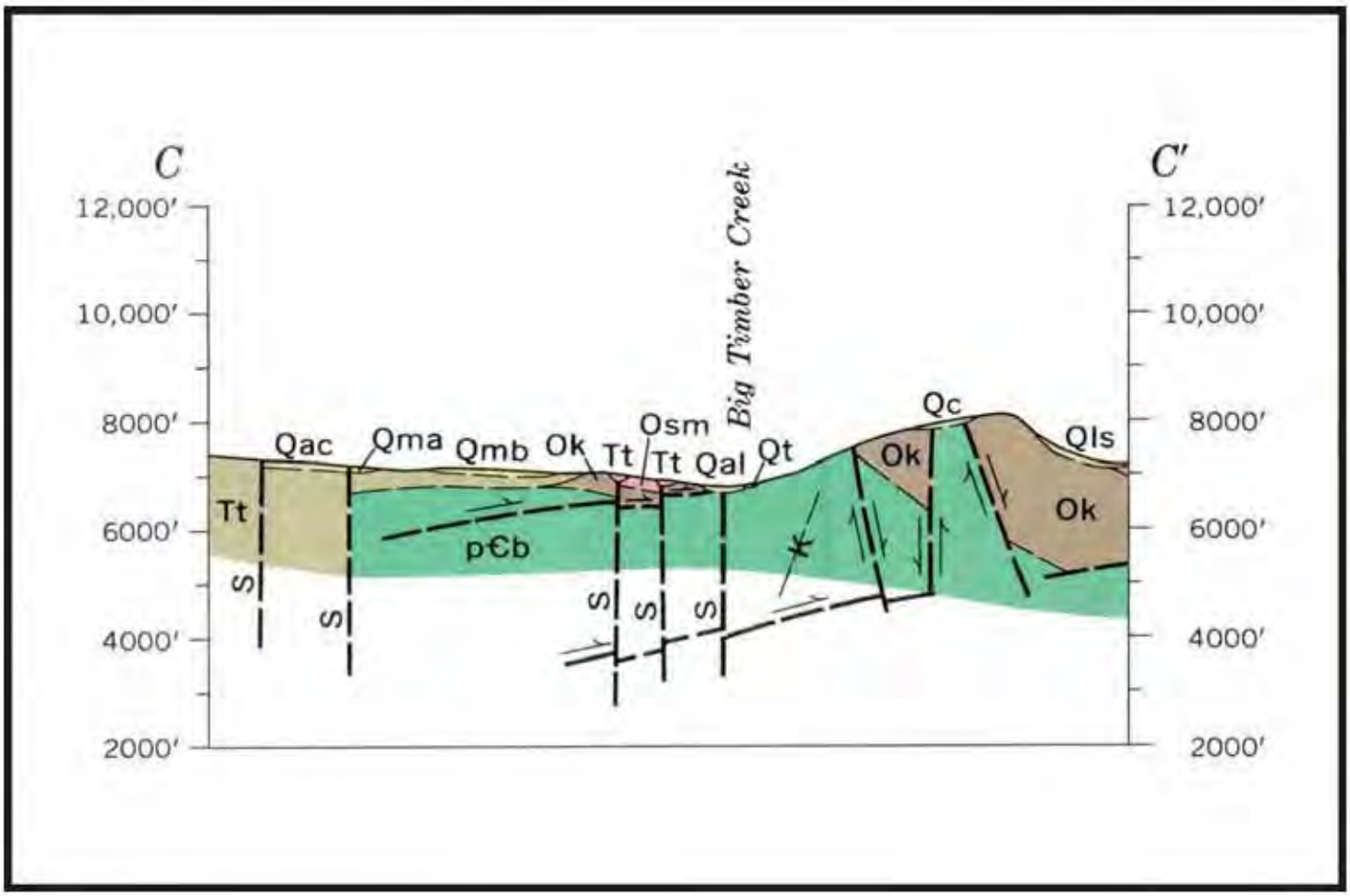


Figure 2.9b – Geologic cross section

Figure 2.10 - Diversion structure at mouth of Big Timber Creek canyon

Figure 2.11 - Diversion structure at mouth of Big Timber Creek canyon

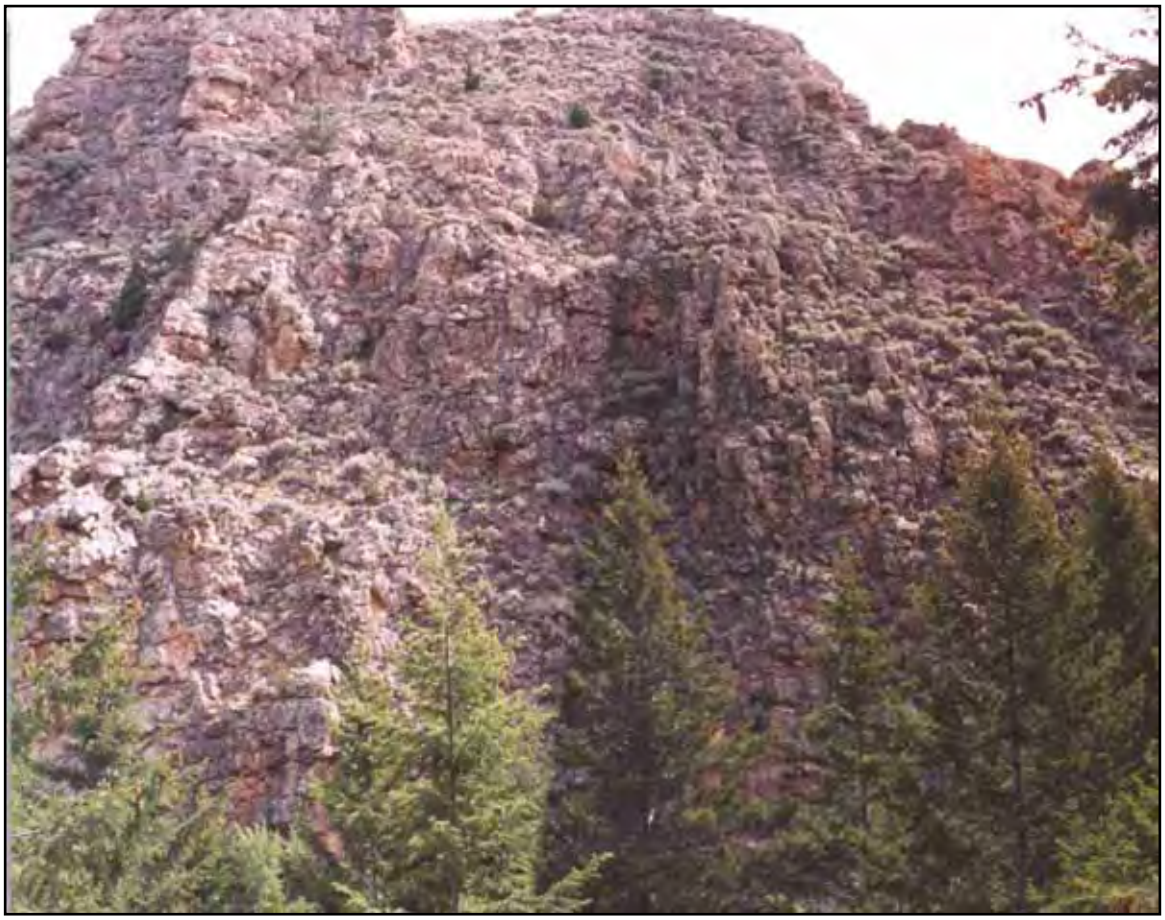


Figure 2.12 - Panorama looking across Big Timber Creek toward area downstream of the dam site on right side. Downstream of where Basin Creek comes into Big Timber Creek. (Note: Merged photos cause difference in color)

Figure 2.13 - Looking upstream from Basin Creek

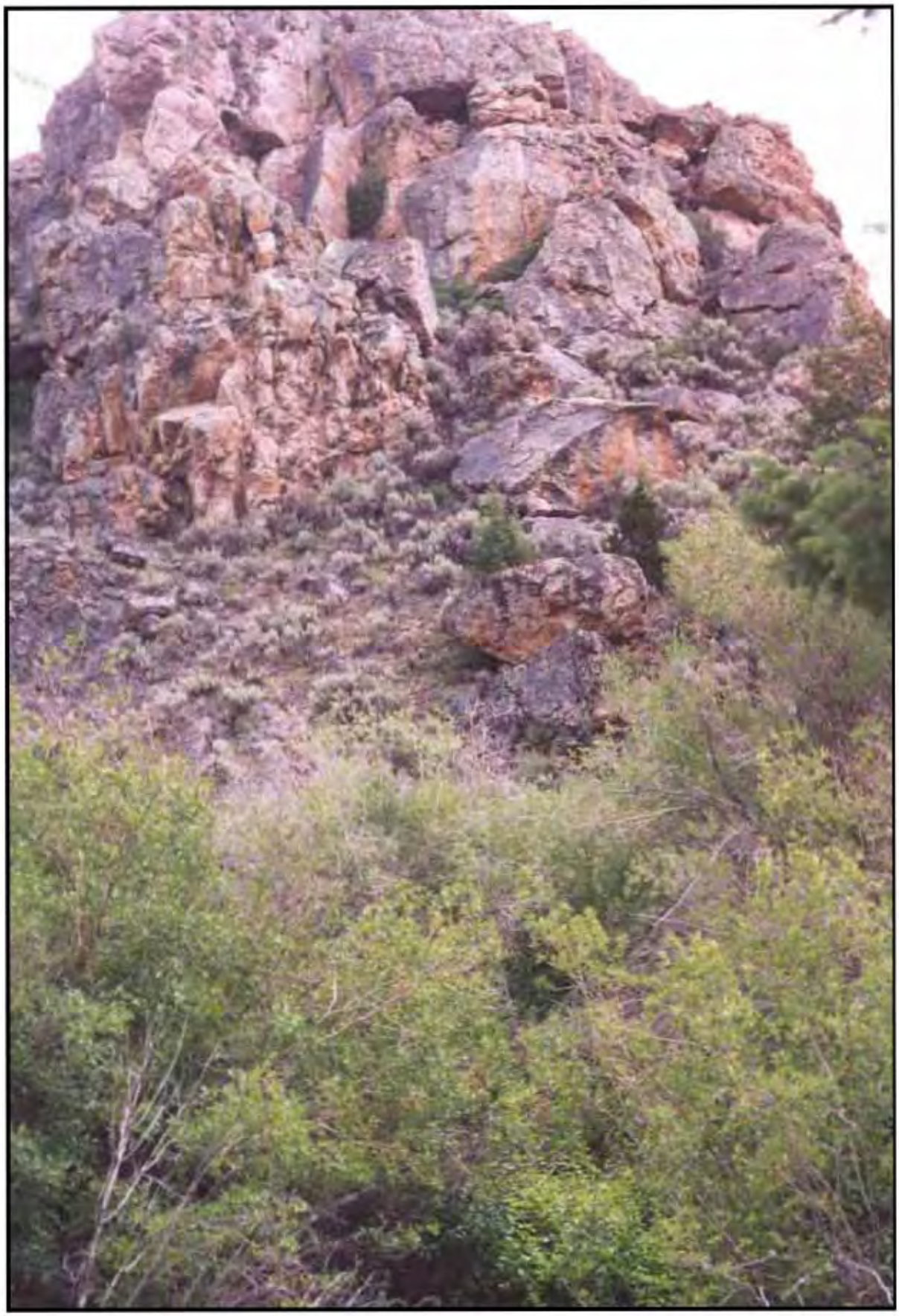


Figure 2.14 - Same rock outcrop as in Figure 2.15 from different vantage point.

Figure 2.15 - Rock outcrop on right side of Big Timber Creek

Figure 2.16 - Looking upstream farther up the hill.

Figure 2.17 - Panorama view of proposed Big Timber Creek Dam site looking upstream.

Figure 2.18 - At dam site looking just downstream of right abutment.

Figure 2.19 - At dam site looking upstream at proposed reservoir area.

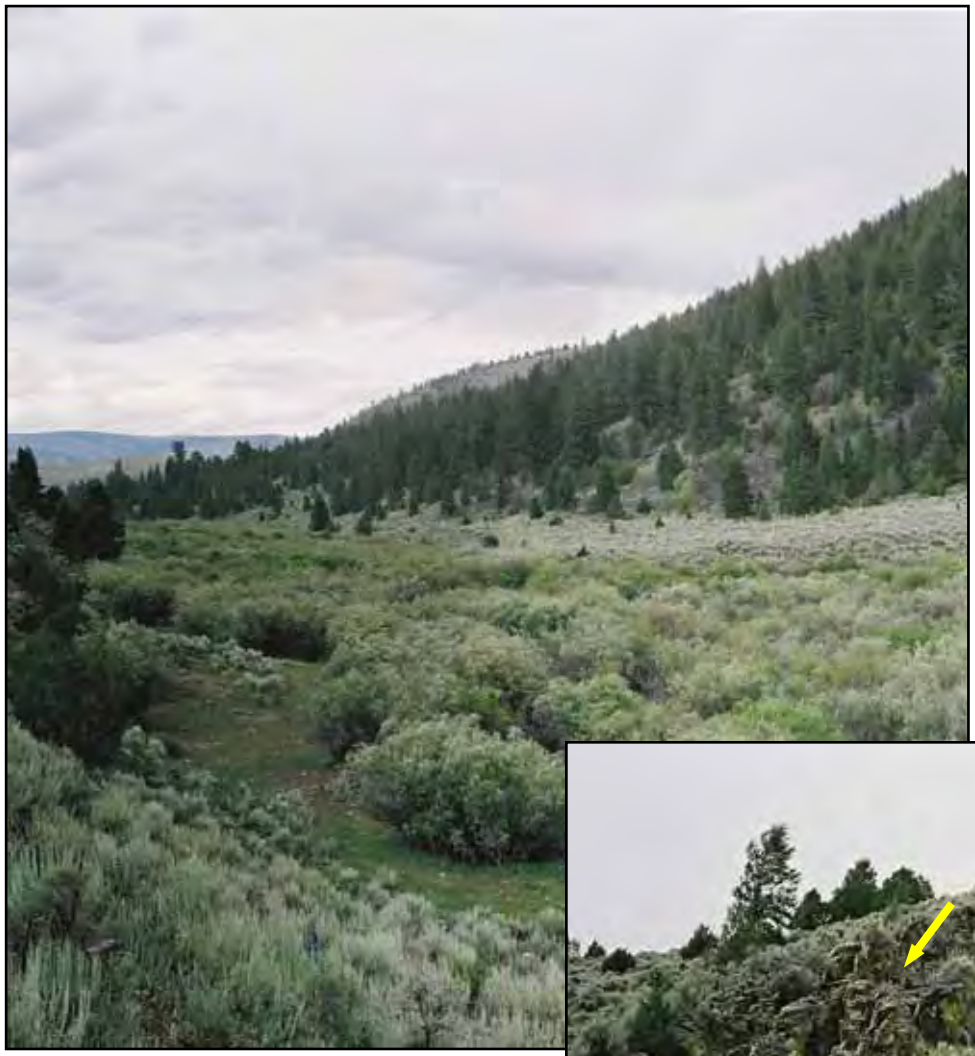


Figure 2.20 - At dam site looking downstream from proposed dam site.

Figure 2.21 - At dam site looking at left abutment talus slope. Note rock outcrop in top left photo.

Figure 2.22 - At dam site looking at close-up of rock outcrop on left abutment (as noted in figure 2.21).

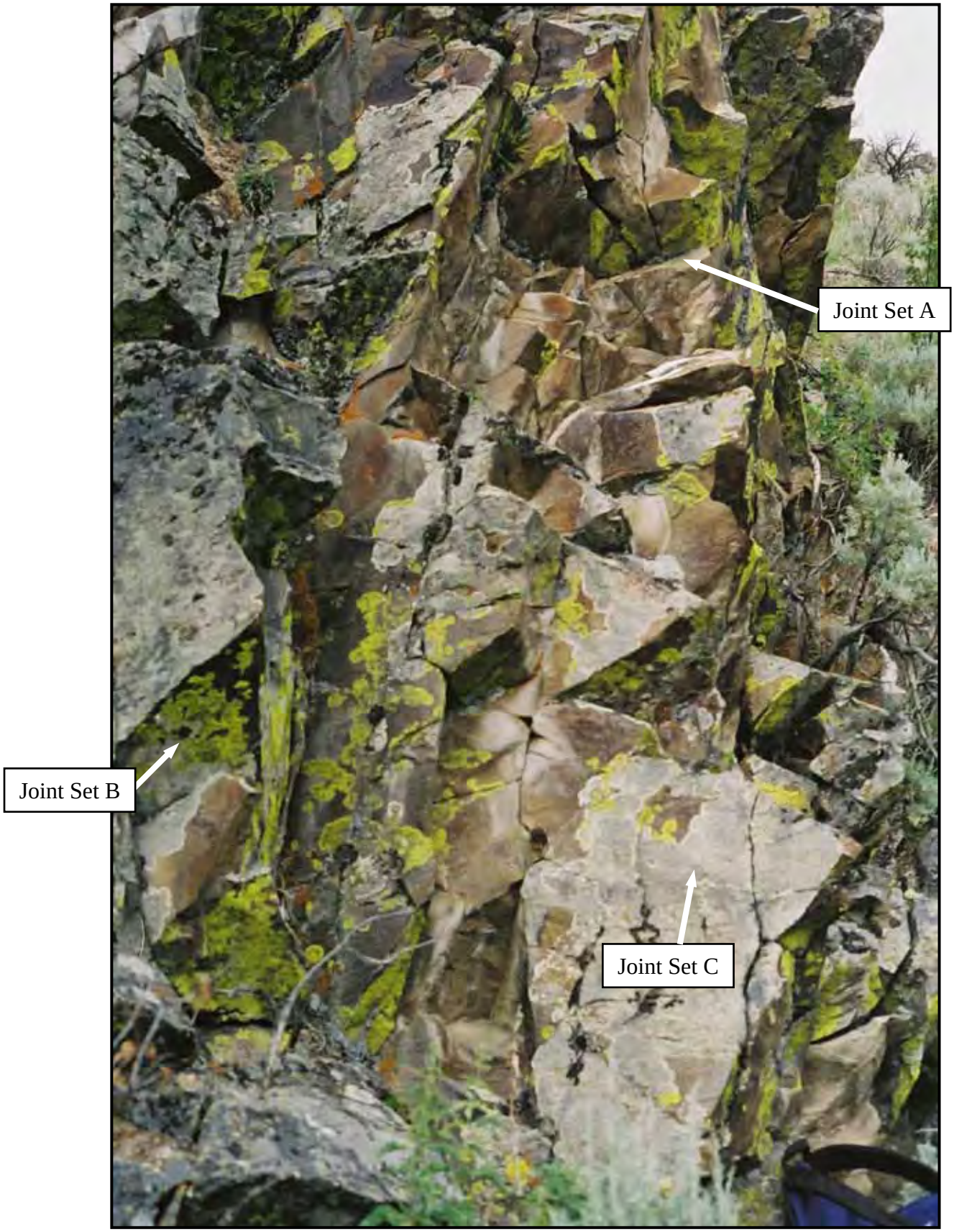


Figure 2.23 - At dam site looking at close-up of rock outcrop (as noted in figure 2.21).

Figure 2.24 - At dam site looking at panorama view of left abutment area.

Figure 2.25 - Rock outcrop downstream of proposed dam site (looking downstream). Note, this rock outcrop is visible in the right center of figure 2.13 (looking upstream).

Appendix A - Travel Report from the First Site Visit

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Project
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BUREAU OF RECLAMATION
Denver Office

TRAVEL REPORT

Code : D-8110 Date: May 9, 2001

To : Thom Fisher, D-8110
Lowell Pimley, D-8100

From : Larry K. Nuss, D-8110, Bob Swain, D-8530, Pete Rohrer, D-8321

Subject: Travel Report to Salmon, Idaho

1. Travel period (dates): March 27 to 29, 2001

2. Places or offices visited: Salmon, Idaho and Leadore, Idaho.

3. Purpose of trip: The purpose of the travel to Salmon, Idaho was to look at two potential new dam sites near Leadore, Idaho. Leadore is about 50 miles southeast of Salmon, Idaho.

4. Synopsis of trip:

The Lemhi River flows into the Salmon River at Salmon, Idaho. The Lemhi River provides critical spawning and rearing habitats for endangered salmon and steelhead. However, all of the water in the Lemhi River is appropriated, and irrigation diversions can dewater short reaches of the river during especially dry periods. This can have a devastating effect on smolts trying to migrate to the ocean or on adults trying to return to a suitable spawning site. A critical reach that has been dewatered in the past occurs between the L-6 and L-5 diversions. If 25 cfs could be maintained in this reach, there would be continuity in flow from upstream of the first irrigation diversion on the Lemhi River all the way down to the mouth of the Salmon River (Note: on Thursday, 35 ft^3/s for 60 days was mentioned).

The main purpose of the dam is to store water that can be released when needed during the irrigation season from April to September to provide 25 cfs at the L-5 gage on the Lemhi River. Water provided from the reservoir must not exceed temperature criteria for cold water biota.

The Reclamation team included Bob Swain, Pete Rohrer, and Larry Nuss from the Technical Service Center (TSC) in Denver, Colorado; Pam Brown from Burley, Idaho; Noel Copenhaven from Boise, Idaho; and Al Simpson from Salmon, Idaho.

Wednesday:

Texas Creek: On Wednesday, the team drove to the first potential damsite on Texas Creek about 68 miles from Salmon, Idaho, (18 miles southeast of Leadore, Idaho) on Highway 28. The dam site is about 1 mile west of Highway 28. Noel, Pete, and Larry walked the proposed dam axis and took Global Positioning Surveys (GPS). The rest of the team went upstream to inspect the reservoir and drainage area (about 7.8 sq miles). The damsite is entirely blanketed by Recent alluvium and adjacent alluvial-terrace remnants; and an embankment dam is probably the appropriate choice for this 1-mile-wide site. The dam could be approximately 45 feet in height above the stream bed. However, the geology may not be suitable for the dam depending on the depth to bedrock or appropriate impervious soil layer. The Lemhi River basin is floored by a permeable alluvium, which according to water-well records is up to 200-feet thick in the vicinity of Leadore. The thickness of alluvium at the Texas Creek site might make construction of a suitable seepage cutoff impractical. The site is an excellent location for recreation in the area and is easily accessible. The proposed reservoir site at Texas Creek is visible from the highway. However, the fisheries value to recreationists may be limited as it is likely to be a shallow reservoir affected by high summer temperatures in addition to draw down. There are no trees in the area, any camping or hiking would be in an open setting. Wildlife values, particularly for waterfowl, would be greater than at the Big Timber Creek site because it is in a low-lying area with gradual slopes which would provide excellent habitat for waterfowl flying north and south through the valley and for shorebirds.

The team went back to Leadore at lunch and met with representatives from the Forest Service, Fish and Wildlife Service, and a Water Board Member. The team went back out to the Texas Creek site to show the representatives the location for the dam and the reservoir.

Big Timber Creek: The team and representatives drove to the second potential damsite on Big Timber Creek about 5 miles south of Leadore. This site is not as accessible as the first site. Everyone walked along the left bank of the creek to the site at the mouth of a narrow V-shaped rock canyon to get a sense of the geology and canyon profile. The side walls are very steep so determining site location by GPS was not possible; and any conceptual dam layouts will have to be from USGS topography maps. Bedrock (probably quartzite) is exposed along the entire right abutment and likely occurs at a shallow depth beneath surficial colluvium on the left abutment. The narrow channel section is covered by alluvium containing large boulders. A concrete dam is probably the appropriate choice for this site. The dam could be approximately 100 feet in height above the stream bed. This site seemed the preferred site among the representatives. Subsequent discussions and review of aerial photographs and topographic data indicate that a site providing greater reservoir capacity using an equivalent dam might lie approximately 1.4 miles upstream from the visited site. Although this site is further from the highway than the Texas Creek site, access to the area is good for most of the way. Recreation would likely be as good or better at this site since it is set in the trees and the fishing would probably be better than at the

Texas Creek site. Since the area is higher in elevation and the reservoir would likely be deeper, establishing a good fishery within the reservoir would be more feasible than at the Texas Creek site. Also, a dam at this site would allow more control over the temperatures of water released into Big Timber Creek, especially if the dam is constructed with valves lower on the structure so colder water could be released when desired. A dam in this location would also reconnect Big Timber Creek to the Lemhi River, apparently this creek is dry for the greater part of the summer due to irrigation withdrawals. This would provide additional habitat for bull trout in both Big Timber Creek and the Lemhi River. Downstream effects to bull trout would probably be minimal. Any bull trout above the dam site are currently prevented from downstream migration for the most part since Big Timber Creek is not connected to the Lemhi River.

Thursday: Larry left Thursday morning for his flight out of Missoula, Montana. The rest of the team met with Rick Sager, Water Master District 74 (208-756-2824), on Thursday morning and discussed Lemhi River streamflow records and river diversions. The critical river reach is downstream from the L-6 diversion on the Lemhi River. This area is completely dry for about 60 days during the adjudication period from April 1 through November 1, and usually in July and August. The flow requirement for restoring the fishery below the L-6 diversion varies from 10 cfs (the survival flow) to 60 ft^3/s (the desired flow). We agreed in the meeting that a reasonable goal for this project is to provide 35 cfs for 60 days during the summer months. Generally, the water supply which would be available to meet these needs will come from flows originating from November 2 through March 31. Some water may also be available in June.

Process for Appraisal Study

1. State the exact purpose and requirements for the dam.

2. Determine the required flow at the desired downstream location at the desired time of the year to accomplish the intended purpose for the dam.

3. Determine the required releases from the dam to achieve the intended purpose. In a perfect world, the release at the dam would equal required downstream requirements. So if X ft^3/s is required 20 miles downstream, then X ft^3/s could be released from the dam to accomplish the intended purpose. However, in the real world, there will be water losses between the dam and the required downstream location from seepage into the ground, evaporation, etc. Releases from the dam will have to compensate for these losses to accomplish the purpose. If the losses are too great, an alternate delivery system from the dam, like a lined canal or pipeline, should be considered.

4. Determine the required duration and dates for the releases. This will determine the volume of water needed in the reservoir to accomplish the purpose.

5. Determine the historic runoff from the drainage basin to estimate if the amount of water and the time frame to store the water can be accomplished.

6. Determine the geometric shape of the reservoir valley to determine the volume capacity of the reservoir to store water.

7. Determine the 100-year silt level to estimate the loss in reservoir capacity over time.

8. Determine the required freeboard and spillway capacity to handle flooding.

9. Determine the height of the dam given the required reservoir capacity, losses from silt accumulation, and freeboard.

10. Design the shape of the dam, spillway, outlets, and other requirements (i.e., fish passage).

11. Determine the impacts to the downstream river.

12. Determine the impacts to the upstream reservoir area.

13. Evaluate the effect of storage on the temperature of water released from the dam.

General Issues or Data Needs for Appraisal Study

1. Determine if there are stream flow gauges on Texas Creek and Big Timber Creek.

2. Determine which Water Districts are involved.

3. Water rights control all the water between April 1 through October 31. Therefore, the only available water to store in the dam might be from November 1 through March.

4. Can the water in the proposed new dams effectively provide the desired benefit at the required downstream location.

5. What kind of fish passage facilities can be provided at the new dam.

6. Who are Reclamation's financial partners in this endeavor?

7. Determine the water right issues.

8. Determine the land ownership issues.

9. Identify environmental issues that would need to be addressed if project goes to feasibility level.

10. Identify permit requirements and time frames.

11. Identify known cultural resource issues and outline requirements and time frames for addressing those issues if project goes to feasibility level.

12. Identify known historical and archeological issues and outline requirements and time frames for addressing those issues if project goes to feasibility level.

13. How would flow in the source stream be affected by storage? What releases would be necessary throughout the year to maintain ecology downstream from the dam?

14. Big Timber Creek is dry for much of the summer, so the question is, how much water would actually be necessary for release from the dam, accounting for evaporation and a dry river bed, to actually reach the Lemhi River and continue its flow to the Salmon River?

15. Develop strategies to ensure water released from the dam reaches downstream to where the water is needed.

16. Developing water conservation strategies in the Lemhi Valley would be beneficial. Currently most tributaries to the Lemhi River go dry each year. Improving methods to conserve

valley water might begin to restore the network of tributaries to the Lemhi River. This would provide overall benefits on additional tributaries to both residents and downstream species and supplement the benefits gained from a dam on Texas creek or Big Timber Creek.

Attendees:

Reclamation Team

SRA-1204, Fishery Biologist
Al Simpson 208-756-6022 asimpson@pn.usbr.gov

D-8530, Flood Hydrology Technical Specialist
Bob Swain 303-445-2547 rswain@do.usbr.gov

D-8321, Geologist
Pete Rohrer 303-445-3150 prohrer@do.usbr.gov

D-8110, Structural Analysis and Design
Larry K. Nuss 303-445-3231 lnuss@do.usbr.gov

PN-3800, Hydraulic Engineer
Karl Tarbet 208-378-5186 ktarbet@pn.usbr.gov

SRA-6350, Concessions Specialist
Pam Brown 208-678-0461 pbrown@pn.usbr.gov

SRW-6124, Natural Resources Specialist
Noel Copenhaver 208-334-9858 ncopenhaver@pn.usbr.gov

Representatives on Wednesday, March 28, 2001

Fish and Wildlife Service - Field Supervisor, Eastern Idaho Office
Deb Mignogro 208-237-6975 debbie-mignogro@fws.gov

Forest Service - Fisheries Program Manager
Bruce H. Smith 208-756-5109 bhsmith@fs.fed.us

Forest Service - Leadore District Ranger
J. Richard Ward 208-768-2500 rward@fs.fed.us

Local Rancher and Water Board member
Blair Kauer 208-768-2718 chaos@salmoninternet.com

Representative on Thursday, March 29, 2001

Water Master District 74
Rick Sager 208-756-2824

5. Conclusions:

   Develop service agreement for appraisal level studies.

6. Client feedback:

   None

7. Action correspondence initiated:

   None

cc: See attached list of Reclamation attendees

WBR:LNuss:jp:5/9/01-303-445-3231

SIGNATURES AND SURNAMES FOR:

Travel to: Salmon, Idaho and Leadore, Idaho

Date or Dates of Travel: March 27 to 29, 2001

Names and Codes of Travelers: Larry K. Nuss, D-8110, Pete Rohrer, D-8321, Bob Swain, D-8530

Travelers	Date
Larry K. Nuss Larry K. Nuss, D-8110	5/9/2001
Robert E. Swain Bob Swain, D-8530	5/10/01
Peter M Rohrer Pete Rohrer, D-8321	5/9/2001

Noted and Dated By:

[illegible] 5/11/01 D-8110

[illegible] 5/22/01 D-8100

Lemhi River Appraisal Study
Dam Site Photos, March 28, 2000

Photo No. 1: Texas Creek dam axis looking west to east

Photo No. 2: Looking upstream on Purcell Creek from Texas Creek dam site

Photo No. 3: Purcell Spring

Photo No. 4: Looking downstream from Purcell Spring

Photo No. 5: Flow from 24-inch CMP out of Purcell Spring (estimated at about 3 cfs)

Photo No. 6: Nez Perce streambed (dry) looking downstream from near Nez Perce Spring

Photo No. 7: View of watershed from near Nez Perce Spring looking north

Photo No. 8: View of reservoir area looking downstream toward dam site from Purcell watershed

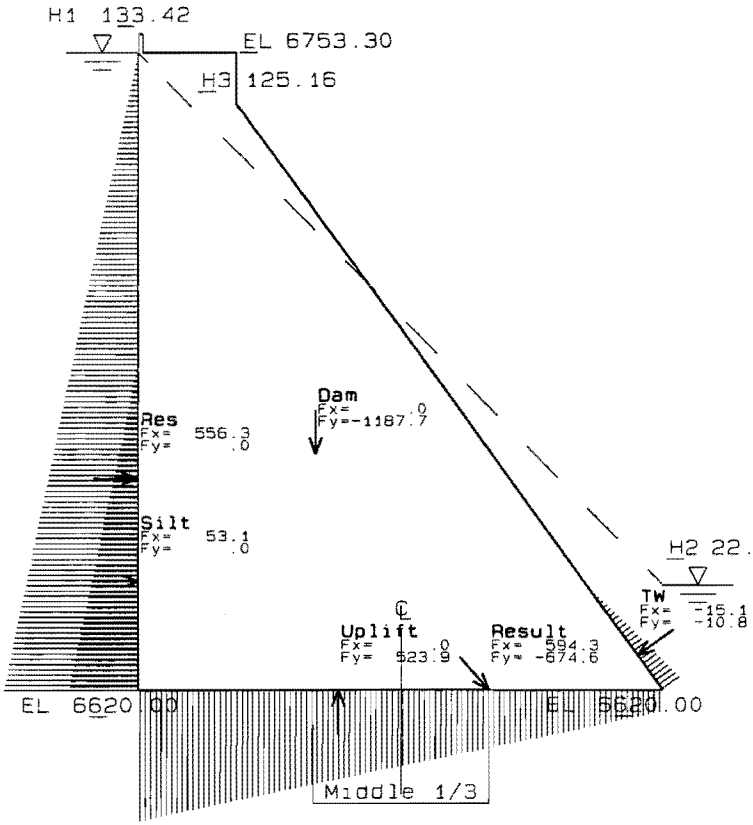
Photo No. 9: Looking upstream toward Big Timber dam site from dirt road located just below the dam site

Photo No. 10: Right canyon wall in Big Texas Creek canyon downstream from proposed dam site.

Appendix B - Traditional Limit-Equilibrium Structural Stability Analyses

Big Timber Creek Dam

Coh=50, Frict=40, Den=145, No Drains



DAM DIMENSIONS AND CRITERIA

Analysis type				CrackInit			
Criteria at drains				Corp			
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0		
nus 3	.0	6757.3	nds 6	20.0	6753.3		
Top of dam elevation				6757.300			
Base of dam elevation				6620.000			
Thickness of crest				20.000			
Base width				107.873			
Reservoir elevation				6753.420			
Tailwater elevation				6642.000			
Silt elevation				6688.700			
Initial crack length				.000			
Drain distance from axis				8.000			
Drain distance from heel				8.000			
Drain efficiency				.000			
Drainage gallery elevation				6645.000			
Head at H1, Heel				133.4203			
Head at H2, Toe				22.0001			
Head at H3, Drain				125.1572			
Head at H4, Gallery				25.0000			

CORPS H3=((H1-H2)(L-DRN)/(L-CRK)+H2-H4)(1-E)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Conesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1187.7	36.3	6669.4		.0-20996.7
Res	556.3	.0	.0	6664.5	24739.7	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-15.1	-10.8	102.6	6627.3	-110.9	528.1
Uplt	.0	523.9	41.0	6620.0	.0	6752.8
Rslt	594.3	-674.6	71.9	6620.0	12128.9	.0

RESULTANT FORCE	w/uplift	w/o uplift	
Horizontal component (+=d/s)	594.25	594.25	K
Vertical component (+=up)	-674.62	-1198.55	K
Resultant force	899.03	1337.78	K
Distance from CL to resultant	17.98	4.49	
to 1/3 base	17.98		
to 1/2 base	26.97		
Moment at 53.94 from heel	12128.93	5376.13	k-ft
OVERTURNING SF =	1.40		

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A		107.87	ft2
Moment of inertia, I		104604.65	ft4
Moment arm, c		53.94	ft
Stress	w/uplift	w/o uplift	
Axial stress, P/A	-43.43	-77.16	lb/in2
Moment stress, Mc/I	43.43	19.25	lb/in2
Vertical stress at heel	.00	-57.91	lb/in2
Vertical stress at toe	-86.86	-96.41	lb/in2

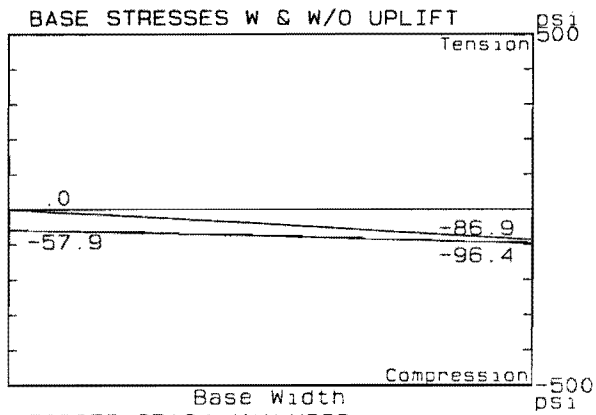
RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= 1.000, Safety factor(s)= 3.00

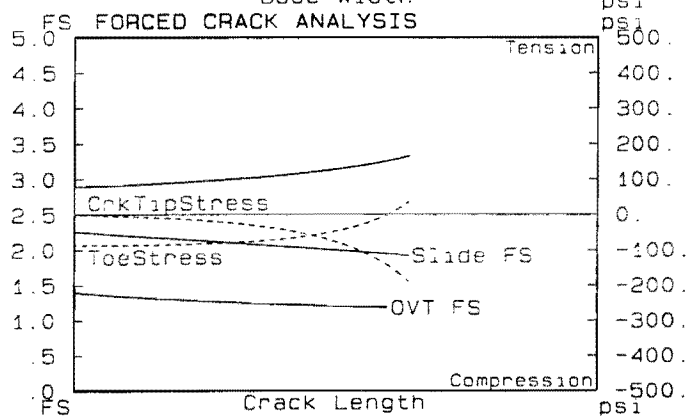
Tension(ft) psi	szu psi	Crack Prediction
.00	57.91	Cracked
25.00	49.57	No crk
75.00	32.91	No crk
125.00	16.24	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)				594.25 kips		
Total vertical forces				-674.62 kips		
Safety Factor for above strengths				2.26		
Cohesion(Bonded)= 78.33 psi req for FS= 3.0						
Sliding safety factors for various cohesions:						
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	566.1	954.4	1342.8	2119.4	2896.1	3672.8
Safety factor	.95	1.61	2.26	3.57	4.87	6.18
Required strengths to get these safety factors while other given values constant SF=				1.0	2.0	3.0
Bonded area: cohesion (psi)				1.8	40.1	78.3
friction angle (deg)				.0	31.4	56.2

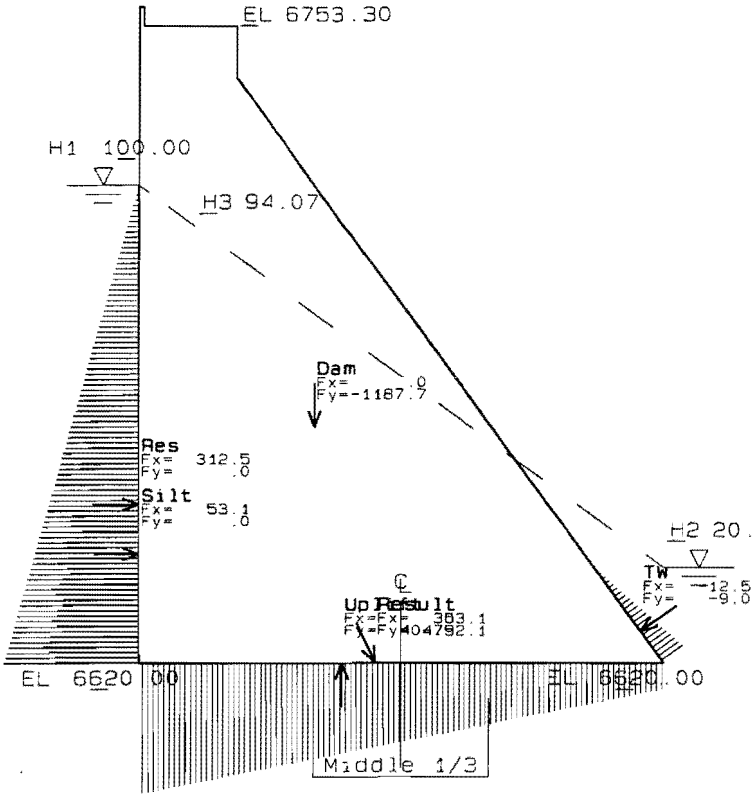
FORCED CRACK RESULTS
Heel initially in tension
Crack stops at .00ft from heel





Big Timber Creek Dam

Coh=50, Frict=40, Den=145, No Drains



DAM DIMENSIONS AND CRITERIA

Analysis type		VaryReserv	
Criteria at drains		Corp	
nheel 1	.0 6620.0	ntoe 8	107.9 6620.0
nus 3	.0 6757.3	nds 6	20.0 6753.3
Top of dam elevation		6757.300	
Base of dam elevation		6620.000	
Thickness of crest		20.000	
Base width		107.873	
Reservoir elevation		6720.000	
Tailwater elevation		6640.000	
Silt elevation		6688.700	
Initial crack length		.000	
Drain distance from axis		8.000	
Drain distance from heel		8.000	
Drain efficiency		.000	
Drainage gallery elevation		6645.000	
Head at H1, Heel		100.0000	
Head at H2, Toe		20.0000	
Head at H3, Drain		94.0671	
Head at H4, Gallery		25.0000	

CORPS H3=((H1-H2)(L-DRN)/(L-CRK)+H2-H4)(1-E)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
	water	.06250	K/ft3
	horiz sat silt	.085	K/ft3
	vert sat silt	.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1187.7	36.3	6669.4	.0	-20996.7
Res	312.5	.0	.0	6653.3	10416.7	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-12.5	-9.0	103.1	6626.7	-83.3	440.7
Uplt	.0	404.5	42.0	6620.0	.0	4848.5
Rslt	353.1	-792.1	48.7	6620.0	-4158.1	.0

RESULTANT FORCE	w/uplift	w/o uplift	
Horizontal component (+=d/s)	353.10	353.10	K
Vertical component (+=up)	-792.14	-1196.66	K
Resultant force	867.28	1247.67	K
Distance from CL to resultant	-5.25	-7.53	
to 1/3 base	17.98		
to 1/2 base	26.97		
Moment at 53.94 from heel	-4158.15	-9006.68	k-ft
OVERTURNING SF =	2.22		

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87	ft2
Moment of inertia, I	104604.65	ft4
Moment arm, c	53.94	ft

Stress	w/uplift	w/o uplift	
Axial stress, P/A	-51.00	-77.04	lb/in2
Moment stress, Mc/I	-14.89	-32.25	lb/in2
Vertical stress at heel	-65.88	-109.29	lb/in2
Vertical stress at toe	-36.11	-44.79	lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= 1.000, Safety factor(s)= 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	43.40	No crk
25.00	35.07	No crk
75.00	18.40	No crk
125.00	1.74	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	353.10	kips
Total vertical forces	-792.14	kips
Safety Factor for above strengths	4.08	

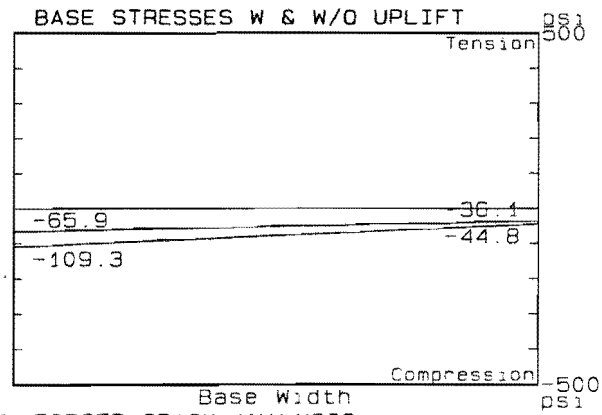
Cohesion(Bonded)= 25.40 psi req for FS= 3.0
Sliding safety factors for various cohesions:

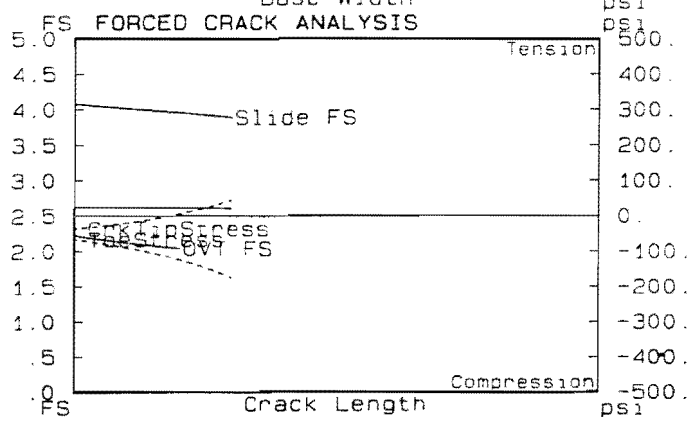
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	664.7	1053.0	1441.4	2218.1	2994.7	3771.4
Safety factor	1.88	2.98	4.08	6.28	8.48	10.68

Required strengths to get these safety factors while other given values constant

SF=	1.0	2.0	3.0
Bonded area: cohesion (psi)	.0	2.7	25.4
friction angle (deg)	.0	.0	19.6

FORCED CRACK RESULTS
Initially compression at heel
No length of crack causes crack growth





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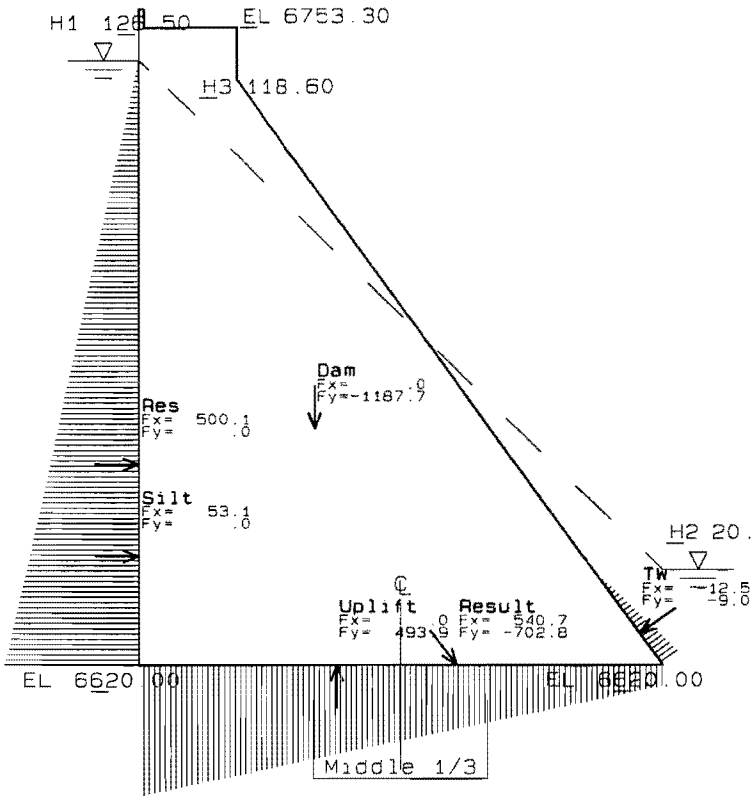
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, No Drains



DAM DIMENSIONS AND CRITERIA

Analysis type		VaryReserv	
Criteria at drains		Corp	
nheel 1	.0 6620.0	ntoe 8	107.9 6620.0
nus 3	.0 6757.3	nds 6	20.0 6753.3
Top of dam elevation		6757.300	
Base of dam elevation		6620.000	
Thickness of crest		20.000	
Base width		107.873	
Reservoir elevation		6746.500	
Tailwater elevation		6640.000	
Silt elevation		6688.700	
Initial crack length		.000	
Drain distance from axis		8.000	
Drain distance from heel		8.000	
Drain efficiency		.000	
Drainage gallery elevation		6645.000	
Head at H1, Heel		126.5000	
Head at H2, Toe		20.0000	
Head at H3, Drain		118.6018	
Head at H4, Gallery		25.0000	

CORPS H3=((H1-H2)(L-DRN)/(L-CRK)+H2-H4)(1-E)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1187.7	36.3	6669.4	.0	-20996.7
Res	500.1	.0	.0	6662.2	21086.3	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-12.5	-9.0	103.1	6626.7	-83.3	440.7
Uplt	.0	493.9	40.9	6620.0	.0	6454.6
Rslt	540.7	-702.8	65.5	6620.0	8117.6	.0

RESULTANT FORCE	w/uplift	w/o uplift
Horizontal component (+=d/s)	540.67	540.67 K
Vertical component (+=up)	-702.81	-1196.66 K
Resultant force	886.72	1313.14 K
Distance from CL to resultant	11.55	1.39
to 1/3 base	17.98	
to 1/2 base	26.97	
Moment at 53.94 from heel	8117.56	1662.96 k-ft
OVERTURNING SF =	1.54	

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87 ft2	
Moment of inertia, I	104604.65 ft4	
Moment arm, c	53.94 ft	
Stress	w/uplift	w/o uplift
Axial stress, P/A	-45.24	-77.04 lb/in2
Moment stress, Mc/I	29.07	5.95 lb/in2
Vertical stress at heel	-16.18	-71.08 lb/in2
Vertical stress at toe	-74.31	-82.99 lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= 1.000, Safety factor(s)= 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	54.90	No crk
25.00	46.57	No crk
75.00	29.90	No crk
125.00	13.24	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	540.67 kips
Total vertical forces	-702.81 kips
Safety Factor for above strengths	2.53

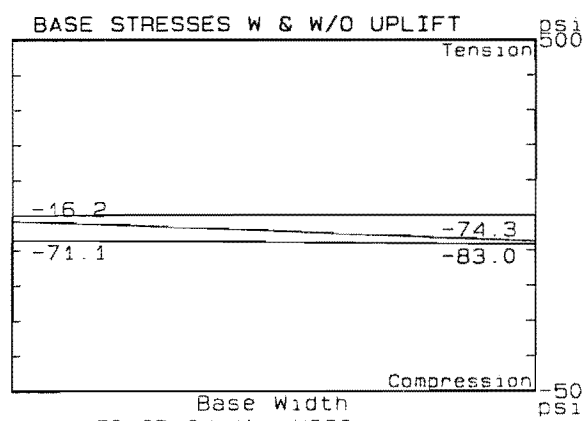
Cohesion(Bonded)= 66.45 psi req for FS= 3.0
Sliding safety factors for various cohesions:

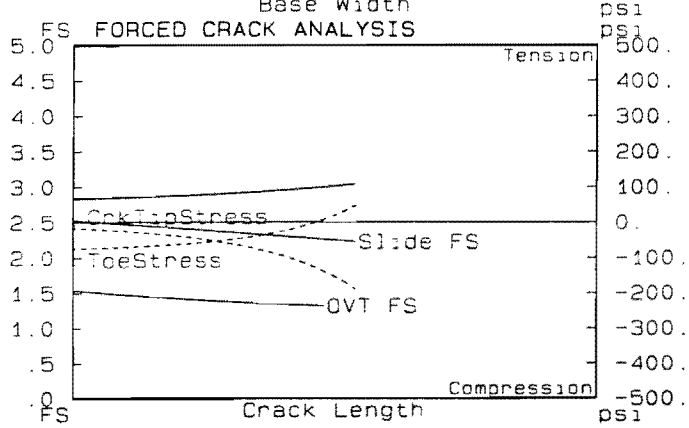
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	589.7	978.1	1366.4	2143.1	2919.8	3696.5
Safety factor	1.09	1.81	2.53	3.96	5.40	6.84

Required strengths to get these safety factors while other given values constant SF= 1.0 2.0 3.0

Bonded area:	cohesion (psi)	.0	31.6	66.5
	friction angle (deg)	.0	23.4	50.3

FORCED CRACK RESULTS
Initially compression at heel
No length of crack causes crack growth





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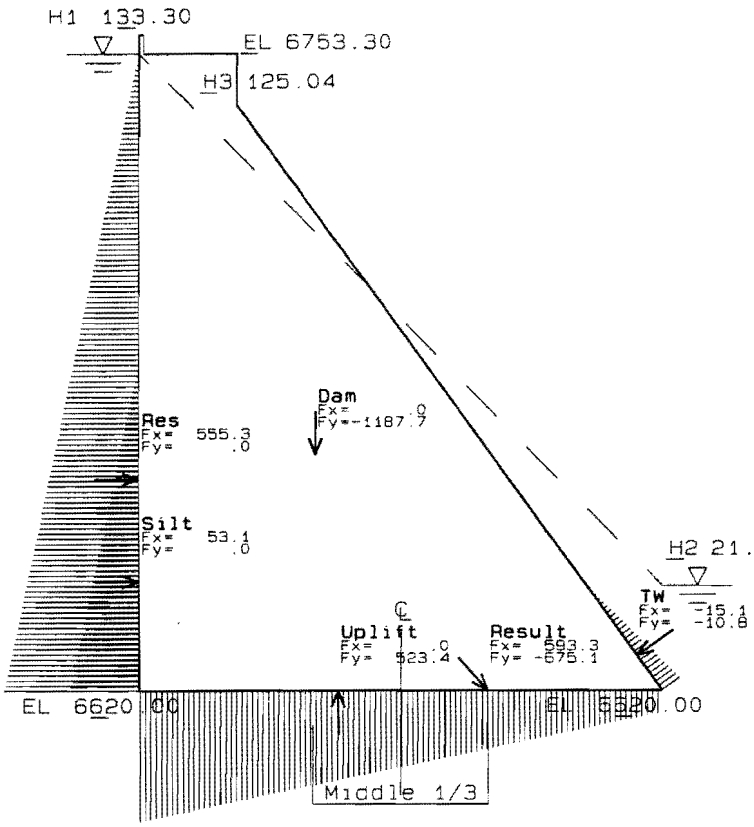
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, No Drains



DAM DIMENSIONS AND CRITERIA

Analysis type			VaryReserv		
Criteria at drains			Corp		
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0
nus 3	.0	6757.3	nds 6	20.0	6753.3

Top of dam elevation	6757.300
Base of dam elevation	6620.000
Thickness of crest	20.000
Base width	107.873
Reservoir elevation	6753.300
Tailwater elevation	6641.965
Silt elevation	6688.700
Initial crack length	.000
Drain distance from axis	8.000
Drain distance from heel	8.000
Drain efficiency	.000
Drainage gallery elevation	6645.000
Head at H1, Heel	133.3000
Head at H2, Toe	21.9653
Head at H3, Drain	125.0432
Head at H4, Gallery	25.0000

CORPS H3=((H1-H2)(L-DRN)/(L-CRK)+H2-H4)(1-E)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1187.7	36.3	6669.4	.0	-20996.7
Res	555.3	.0	.0	6664.4	24672.9	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-15.1	-10.8	102.6	6627.3	-110.4	526.5
Uplt	.0	523.4	41.0	6620.0	.0	6747.6
Rslt	593.3	-675.1	71.8	6620.0	12055.9	.0

RESULTANT FORCE	w/uplift	w/o uplift	
Horizontal component (+=d/s)	593.30	593.30	K
Vertical component (+=up)	-675.11	-1198.51	K
Resultant force	898.76	1337.32	K
Distance from CL to resultant	17.86	4.43	
to 1/3 base	17.98		
to 1/2 base	26.97		
Moment at 53.94 from heel	12055.85	5308.24	k-ft
OVERTURNING SF =	1.40		

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87	ft2
Moment of inertia, I	104604.65	ft4
Moment arm, c	53.94	ft

Stress	w/uplift	w/o uplift	
Axial stress, P/A	-43.46	-77.16	lb/in2
Moment stress, Mc/I	43.17	19.01	lb/in2
Vertical stress at heel	-.29	-58.15	lb/in2
Vertical stress at toe	-86.63	-96.16	lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= 1.000, Safety factor(s)= 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	57.86	No crk
25.00	49.52	No crk
75.00	32.86	No crk
125.00	16.19	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	593.30 kips
Total vertical forces	-675.11 kips
Safety Factor for above strengths	2.26

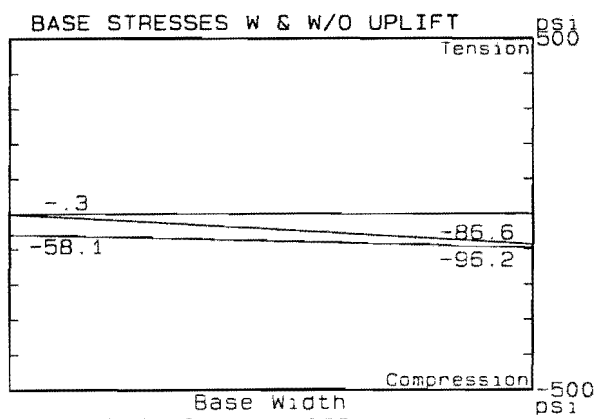
Cohesion(Bonded)= 78.11 psi req for FS= 3.0
Sliding safety factors for various cohesions:

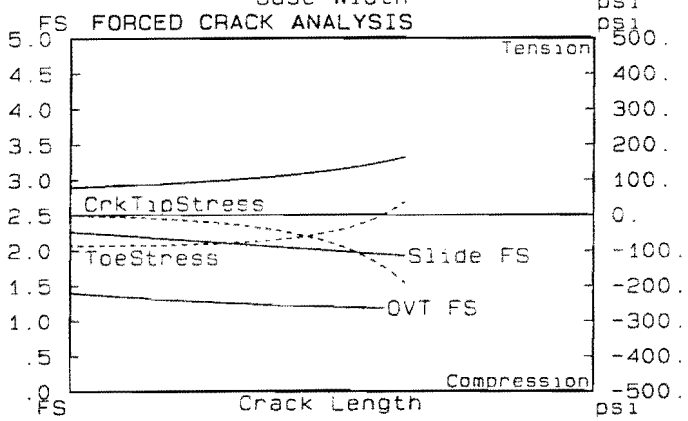
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	566.5	954.8	1343.2	2119.8	2896.5	3673.2
Safety factor	.95	1.61	2.26	3.57	4.88	6.19

Required strengths to get these safety factors while other given values constant

SF=	1.0	2.0	3.0
Bonded area: cohesion (psi)	1.7	39.9	78.1
friction angle (deg)	.0	31.3	56.1

FORCED CRACK RESULTS
Initially compression at heel
No length of crack causes crack growth





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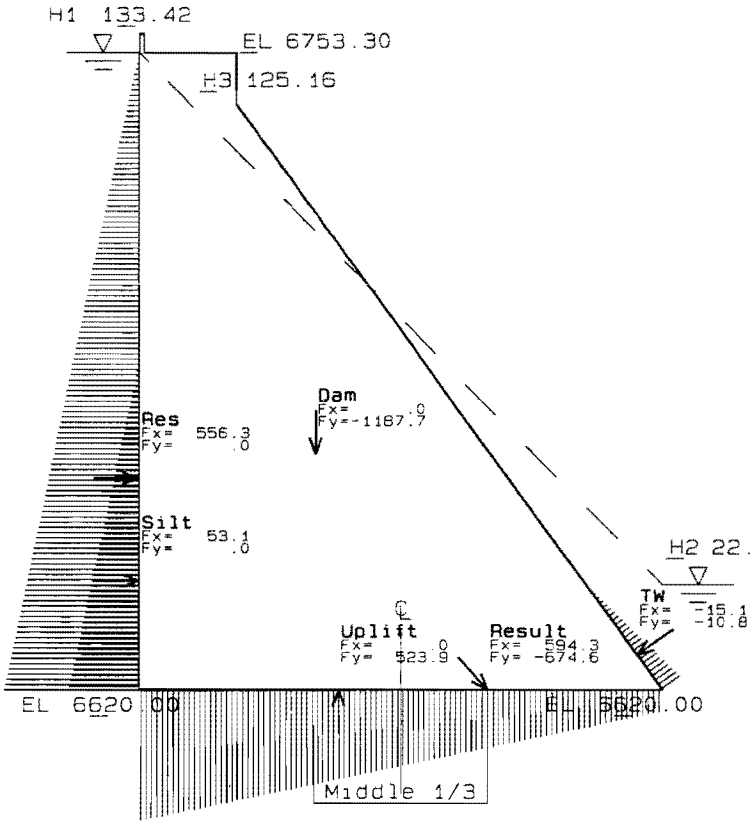
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, No Drains



DAM DIMENSIONS AND CRITERIA

Analysis type			VaryReserv		
Criteria at drains			Corp		
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0
nus 3	.0	6757.3	nds 6	20.0	6753.3

Top of dam elevation	6757.300
Base of dam elevation	6620.000
Thickness of crest	20.000
Base width	107.873
Reservoir elevation	6753.420
Tailwater elevation	6642.000
Silt elevation	6688.700
Initial crack length	.000
Drain distance from axis	8.000
Drain distance from heel	8.000
Drain efficiency	.000
Drainage gallery elevation	6645.000
Head at H1, Heel	133.4203
Head at H2, Toe	22.0001
Head at H3, Drain	125.1572
Head at H4, Gallery	25.0000

CORPS H3=((H1-H2)(L-DRN)/(L-CRK)+H2-H4)(1-E)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1187.7	36.3	6669.4	.0	-20996.7
Res	556.3	.0	.0	6664.5	24739.7	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-15.1	-10.8	102.6	6627.3	-110.9	528.1
Uplt	.0	523.9	41.0	6620.0	.0	6752.8
Rslt	594.3	-674.6	71.9	6620.0	12128.9	.0

RESULTANT FORCE	w/uplift	w/o uplift
Horizontal component (+=d/s)	594.25	594.25 K
Vertical component (+=up)	-674.62	-1198.55 K
Resultant force	899.03	1337.78 K
Distance from CL to resultant	17.98	4.49
to 1/3 base	17.98	
to 1/2 base	26.97	
Moment at 53.94 from heel	12128.93	5376.13 k-ft
OVERTURNING SF =	1.40	

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87 ft2
Moment of inertia, I	104604.65 ft4
Moment arm, c	53.94 ft

Stress	w/uplift	w/o uplift
Axial stress, P/A	-43.43	-77.16 lb/in2
Moment stress, Mc/I	43.43	19.25 lb/in2
Vertical stress at heel	.00	-57.91 lb/in2
Vertical stress at toe	-86.86	-96.41 lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p) = 1.000, Safety factor(s) = 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	57.91	Cracked
25.00	49.57	No crk
75.00	32.91	No crk
125.00	16.24	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	594.25 kips
Total vertical forces	-674.62 kips
Safety Factor for above strengths	2.26

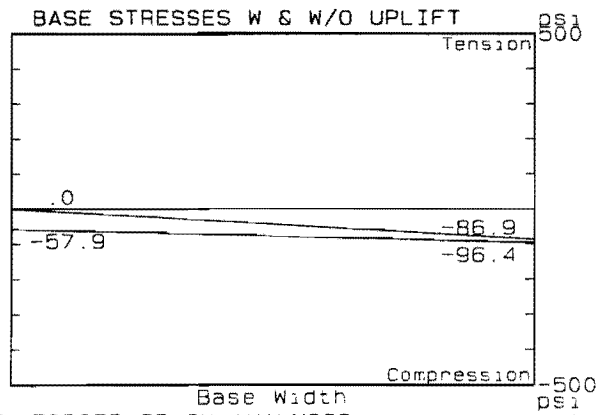
Cohesion(Bonded) = 78.33 psi req for FS= 3.0
Sliding safety factors for various cohesions:

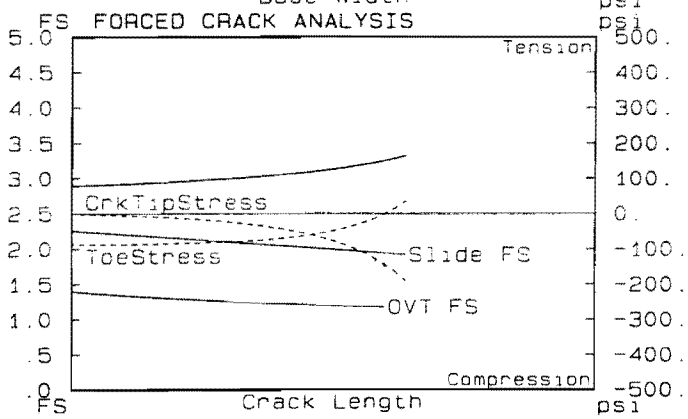
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	566.1	954.4	1342.8	2119.4	2896.1	3672.8
Safety factor	.95	1.61	2.26	3.57	4.87	6.18

Required strengths to get these safety factors while other given values constant

SF=	1.0	2.0	3.0
Bonded area: cohesion (psi)	1.8	40.1	78.3
friction angle (deg)	.0	31.4	56.2

FORCED CRACK RESULTS
Heel initially in tension
Crack stops at .00ft from heel





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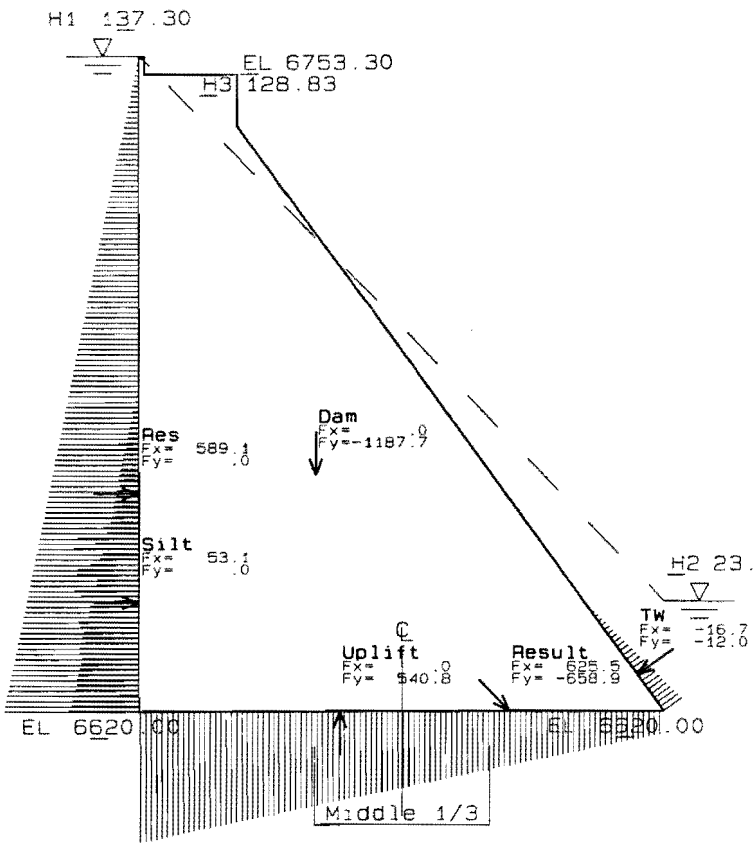
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, No Drains



DAM DIMENSIONS AND CRITERIA

Analysis type		VaryReserv	
Criteria at drains		Corp	
nheel 1	.0 6620.0	ntoe 8	107.9 6620.0
nds 3	.0 6757.3	nds 6	20.0 6753.3
Top of dam elevation		6757.300	
Base of dam elevation		6620.000	
Thickness of crest		20.000	
Base width		107.873	
Reservoir elevation		6757.300	
Tailwater elevation		6643.121	
Silt elevation		6688.700	
Initial crack length		.000	
Drain distance from axis		8.000	
Drain distance from heel		8.000	
Drain efficiency		.000	
Drainage gallery elevation		6645.000	
Head at H1, Heel		137.3000	
Head at H2, Toe		23.1214	
Head at H3, Drain		128.8323	
Head at H4, Gallery		25.0000	

CORPS H3=((H1-H2)(L-DRN)/(L-CRK)+H2-H4)(1-E)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750 K/ft3	
water		.06250 K/ft3	
horiz sat silt		.085 K/ft3	
vert sat silt		.120 K/ft3	
Cohesion:	Break bond	50.000 lb/in2	
	Apparent	50.000 lb/in2	
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1187.7	36.3	6669.4	.0	-20996.7
Res	589.1	.0	.0	6665.8	26961.3	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-16.7	-12.0	102.3	6627.7	-128.8	560.1
Uplt	.0	540.8	41.1	6620.0	.0	6920.0
Rslt	625.5	-658.9	76.0	6620.0	14551.8	.0

RESULTANT FORCE	w/uplift	w/o uplift	
Horizontal component (+=d/s)	625.49	625.49	K
Vertical component (+=up)	-658.90	-1199.68	K
Resultant force	908.51	1352.95	K
Distance from CL to resultant	22.09	6.36	
to 1/3 base	17.98		
to 1/2 base	26.97		
Moment at 53.94 from heel	14551.85	7631.87	k-ft
OVERTURNING SF =	1.33		

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87	ft2
Moment of inertia, I	104604.65	ft4
Moment arm, c	53.94	ft

Stress	w/uplift	w/o uplift	
Axial stress, P/A	-42.42	-77.23	lb/in2
Moment stress, Mc/I	52.11	27.33	lb/in2
Vertical stress at heel	9.69	-49.90	lb/in2
Vertical stress at toe	-94.52	-104.56	lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= 1.000, Safety factor(s)= 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	59.59	Cracked
25.00	51.26	Cracked
75.00	34.59	No crk
125.00	17.93	No crk
175.00	1.26	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	625.49	kips
Total vertical forces	-658.90	kips
Safety Factor for above strengths	2.13	

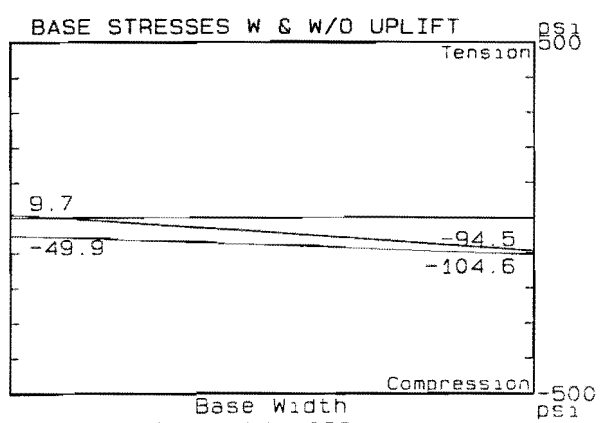
Cohesion(Bonded)= 85.21 psi req for FS= 3.0
Sliding safety factors for various cohesions:

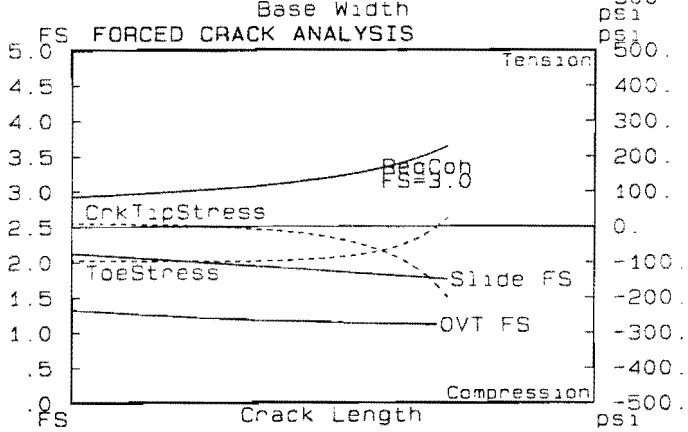
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	552.9	941.2	1329.6	2105.2	2882.9	3659.6
Safety factor	.88	1.50	2.13	3.37	4.61	5.85

Required strengths to get these safety factors while other given values constant SF= 1.0 2.0 3.0

Bonded area:	cohesion (psi)	4.7	44.9	85.2
	friction angle (deg)	.0	35.7	59.1

FORCED CRACK RESULTS
Heel initially in tension
Crack stops at 29.60ft from heel





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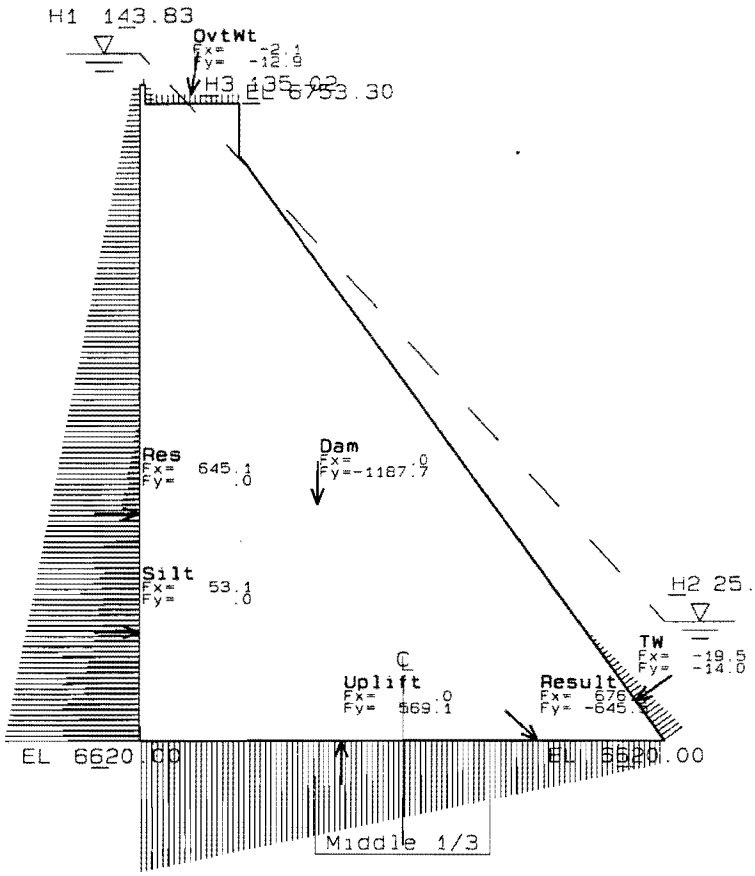
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, No Drains



DAM DIMENSIONS AND CRITERIA

Analysis type			VaryReserv			
Criteria at drains			Corp			
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0	
nus 3	.0	6757.3	nds 6	20.0	6753.3	
Top of dam elevation			6757.300			
Base of dam elevation			6620.000			
Thickness of crest			20.000			
Base width			107.873			
Reservoir elevation			6763.830			
Tailwater elevation			6645.000			
Silt elevation			6688.700			
Initial crack length			.000			
Drain distance from axis			8.000			
Drain distance from heel			8.000			
Drain efficiency			.000			
Drainage gallery elevation			6645.000			
Head at H1, Heel			143.8300			
Head at H2, Toe			25.0000			
Head at H3, Drain			135.0174			
Head at H4, Gallery			25.0000			

CORPS H3=((H1-H2)*(L-DRN)/(L-CRK))*(1.0-E) + H2

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1187.7	36.3	6669.4		.0-20996.7
Res	645.1	.0	.0	6667.8	30808.1	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-19.5	-14.0	101.9	6628.3	-162.8	671.9
Uplt	.0	569.1	41.3	6620.0	.0	7201.9
OvtW	-2.1	-12.9	10.2	6755.1	-288.2	-565.0
Rslt	676.6	-645.5	81.6	6620.0	17885.2	.0

RESULTANT FORCE	w/uplift	w/o uplift
Horizontal component (+=d/s)	676.57	676.57 K
Vertical component (+=up)	-645.49	-1214.62 K
Resultant force	935.10	1390.34 K
Distance from CL to resultant	27.71	8.80
to 1/3 base	17.98	
to 1/2 base	26.97	
Moment at 53.94 from heel	17885.25	10683.37 k-ft
OVERTURNING SF =	1.24	

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87 ft2	
Moment of inertia, I	104604.65 ft4	
Moment arm, c	53.94 ft	
Stress	w/uplift	w/o uplift
Axial stress, P/A	-41.55	-78.19 lb/in2
Moment stress, Mc/I	64.04	38.25 lb/in2
Vertical stress at heel	22.49	-39.94 lb/in2
Vertical stress at toe	-105.60	-116.45 lb/in2

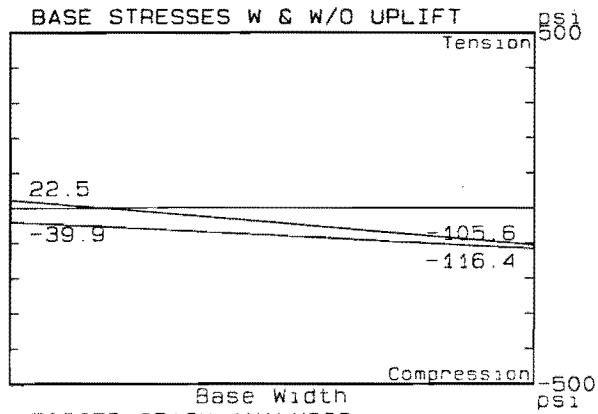
RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= 1.000, Safety factor(s)= 3.00

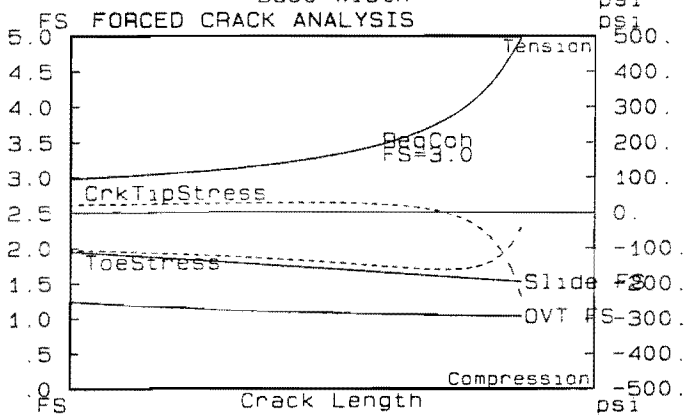
Tension(ft) psi	szu psi	Crack Prediction
.00	62.43	Cracked
25.00	54.09	Cracked
75.00	37.43	No crk
125.00	20.76	No crk
175.00	4.09	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	676.57 kips					
Total vertical forces	-645.49 kips					
Safety Factor for above strengths	1.95					
Cohesion(Bonded)= 95.80 psi req for FS= 3.0						
Sliding safety factors for various cohesions:						
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	541.6	930.0	1318.3	2095.0	2871.7	3648.4
Safety factor	.80	1.37	1.95	3.10	4.24	5.39
Required strengths to get these safety factors while other given values constant SF=			1.0	2.0	3.0	
Bonded area: cohesion (psi)			8.7	52.2	95.8	
friction angle (deg)			.0	41.8	62.7	

FORCED CRACK RESULTS
Heel initially in tension
Crack stops at 76.86ft from heel





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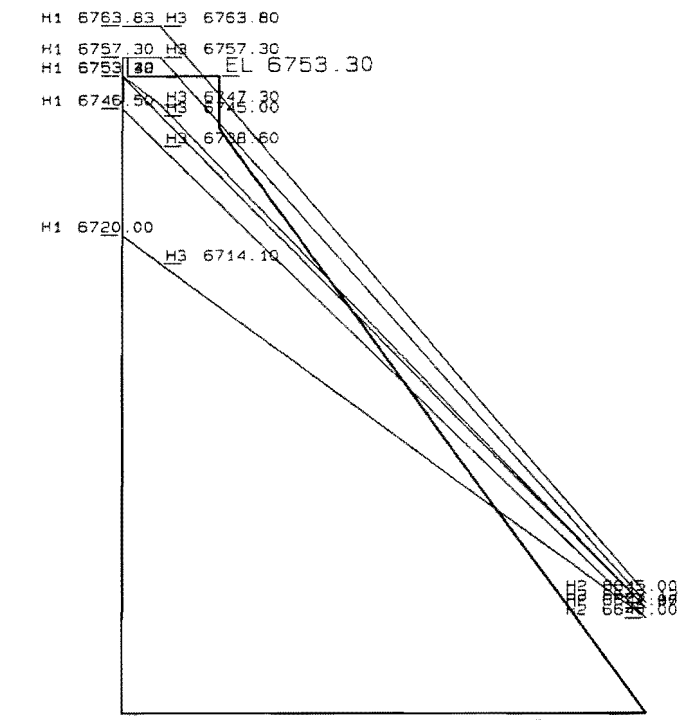
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, No Drains



DAM DIMENSIONS AND CRITERIA

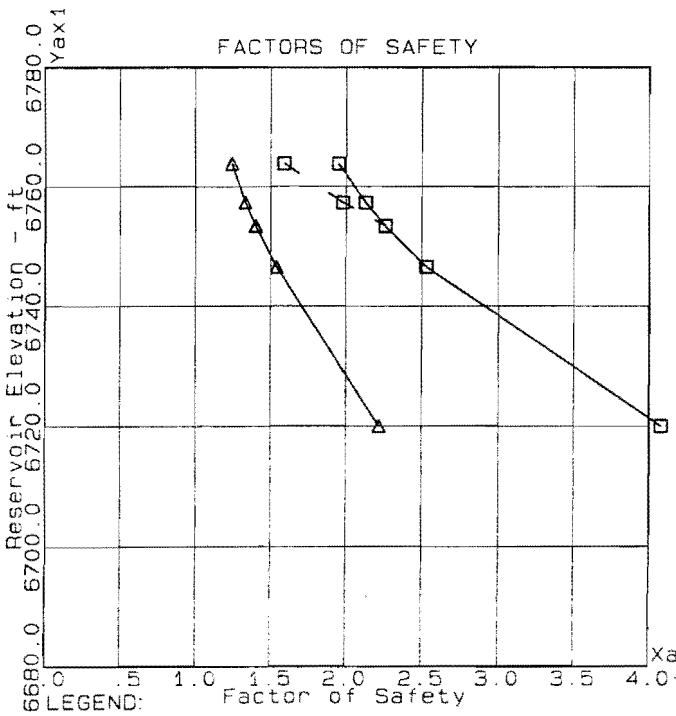
Analysis type		VaryReserv	
Criteria at drains		Corp	
nheel 1	.0 6620.0	ntoe 8	107.9 6620.0
nus 3	.0 6757.3	nds 6	20.0 6753.3
Top of dam elevation		6757.300	
Base of dam elevation		6620.000	
Thickness of crest		20.000	
Base width		107.873	
Silt elevation		6688.700	
Initial crack length		.000	
Drain distance from axis		8.000	
Drain distance from heel		8.000	
Drain efficiency		.000	
Drainage gallery elevation		6645.000	

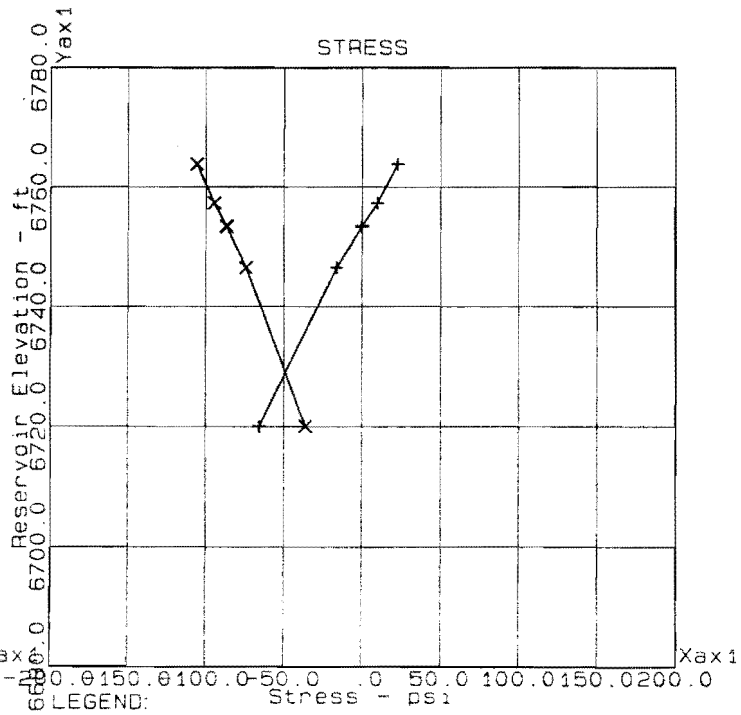
CORPS H3=((H1-H2)*(L-DRN)/(L-CRK))*(1.0-E) + H2

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

			Cracked						Uncracked					
Res Elev	TW Elev	Crack Length	U/S Stress	Slide FS	Over FS	Req Coh	H3	D/S Stress	U/S Stress	Slide FS	Over FS	Req Coh	H3	D/S Stress
6720.00	6640.00	.00	-65.9	4.08	2.22	25.4	94.1	-36.1	-65.9	4.08	2.22	25.4	94.1	-36.1
6746.50	6640.00	.00	-16.2	2.53	1.54	66.5	118.6	-74.3	-16.2	2.53	1.54	66.5	118.6	-74.3
6753.30	6641.97	.00	-.3	2.26	1.40	78.1	125.0	-86.6	-.3	2.26	1.40	78.1	125.0	-86.6
6753.42	6642.00	.00	.0	2.26	1.40	78.3	127.3	-86.9	.0	2.26	1.40	78.3	125.2	-86.9
6757.30	6643.12	29.60	.0	1.98	1.20	85.2	137.3	-98.2	9.7	2.13	1.33	85.2	128.8	-94.5
6763.83	6645.00	76.86	.0	1.59	1.04	95.8	143.8	-161.4	22.5	1.95	1.24	95.8	135.0	-105.6





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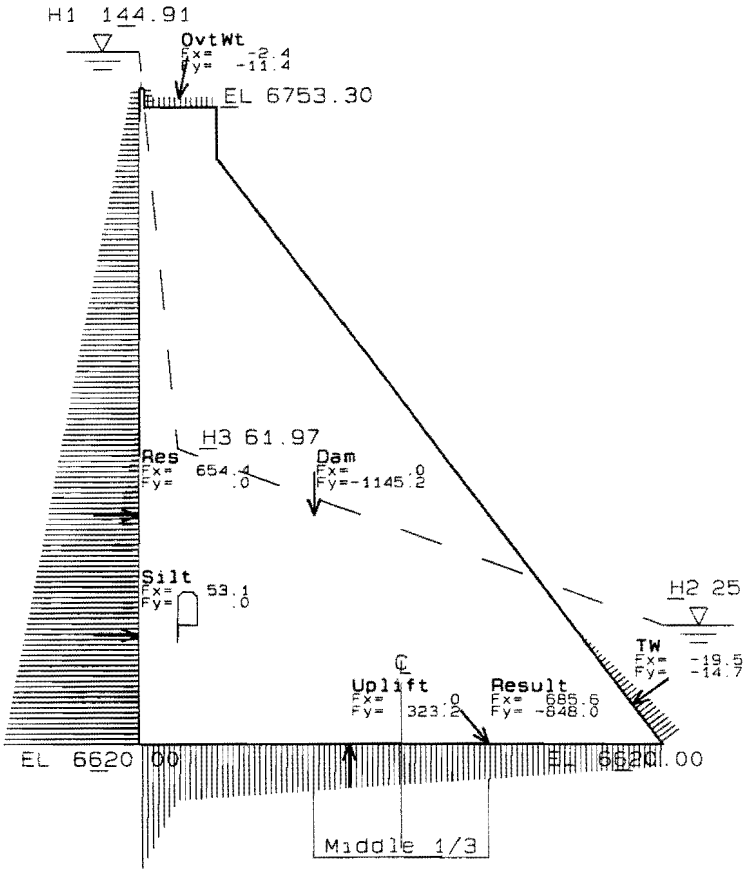
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, Drains, Eff=.67



DAM DIMENSIONS AND CRITERIA

Analysis type			CrackInit			
Criteria at drains			Colo			
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0	
nus 3	.0	6757.3	nds 6	16.0	6753.3	
Top of dam elevation			6757.300			
Base of dam elevation			6620.000			
Thickness of crest			16.000			
Base width			107.873			
Reservoir elevation			6764.914			
Tailwater elevation			6645.000			
Silt elevation			6688.700			
Initial crack length			.000			
Drain distance from axis			8.000			
Drain distance from heel			8.000			
Drain efficiency			.667			
Drainage gallery elevation			6645.000			
Head at H1, Heel			144.9136			
Head at H2, Toe			25.0000			
Head at H3, Drain			61.9699			
Head at H4, Gallery			25.0000			

COLO H3=((H1-H2)*(L-DRN)/(L))*(1.0-Ecolo) + H2

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1145.2	36.0	6668.0	.0	-20551.6
Res	654.4	.0	.0	6668.1	31446.5	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-19.5	-14.6	101.6	6628.3	-162.8	698.5
Uplt	.0	323.2	43.3	6620.0	.0	3445.3
OvtW	-2.4	-11.4	8.2	6755.2	-324.8	-520.1
Rslt	685.6	-848.0	71.9	6620.0	15246.8	.0

RESULTANT FORCE	w/uplift	w/o uplift	
Horizontal component (+=d/s)	685.60	685.60	K
Vertical component (+=up)	-848.05	-1171.20	K
Resultant force	1090.52	1357.11	K
Distance from CL to resultant	17.98	10.08	
to 1/3 base	17.98		
to 1/2 base	26.97		
Moment at 53.94 from heel	15246.80	11801.54	k-ft
OVERTURNING SF =	1.57		

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87	ft2
Moment of inertia, I	104604.65	ft4
Moment arm, c	53.94	ft

Stress	w/uplift	w/o uplift	
Axial stress, P/A	-54.59	-75.40	lb/in2
Moment stress, Mc/I	54.59	42.26	lb/in2
Vertical stress at heel	.00	-33.14	lb/in2
Vertical stress at toe	-109.19	-117.66	lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= .527, Safety factor(s)= 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	33.14	Cracked
25.00	24.81	No crk
75.00	8.14	No crk
125.00	.00	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	685.60	kips
Total vertical forces	-848.05	kips
Safety Factor for above strengths	2.17	

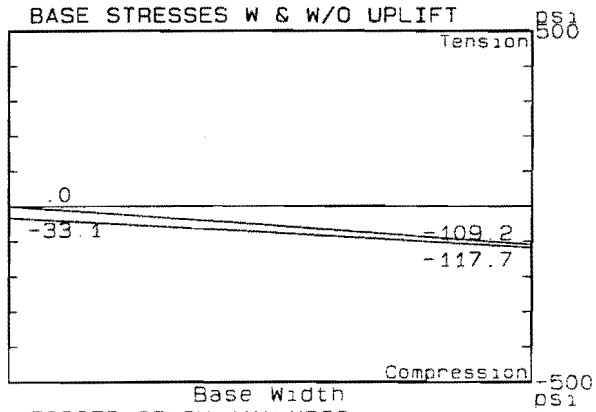
Cohesion(Bonded)= 86.60 psi req for FS= 3.0
Sliding safety factors for various cohesions:

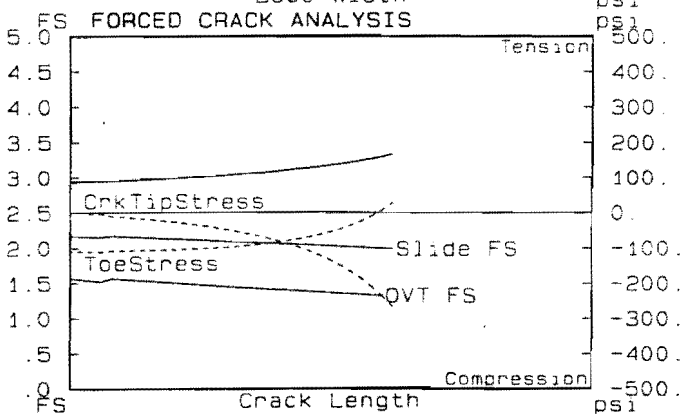
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	711.6	1099.9	1488.3	2265.0	3041.6	3818.3
Safety factor	1.04	1.60	2.17	3.30	4.44	5.57

Required strengths to get these safety factors while other given values constant

	SF=	1.0	2.0	3.0
Bonded area:	cohesion (psi)	.0	42.5	86.6
	friction angle (deg)	.0	35.0	56.5

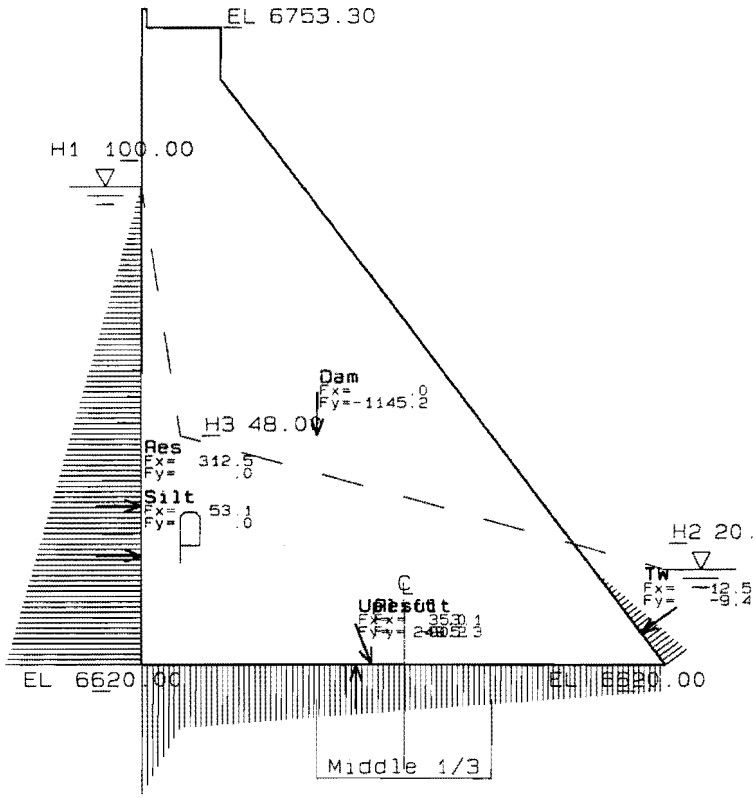
FORCED CRACK RESULTS
Heel initially in tension
Crack stops at .00ft from heel





Big Timber Creek Dam

Coh=50, Frict=40, Den=145, Drains, Eff=.67



DAM DIMENSIONS AND CRITERIA

Analysis type				VaryReserv			
Criteria at drains				Colo			
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0		
nus 3	.0	6757.3	nds 6	16.0	6753.3		
Top of dam elevation				6757.300			
Base of dam elevation				6620.000			
Thickness of crest				16.000			
Base width				107.873			
Reservoir elevation				6720.000			
Tailwater elevation				6640.000			
Silt elevation				6688.700			
Initial crack length				.000			
Drain distance from axis				8.000			
Drain distance from heel				8.000			
Drain efficiency				.667			
Drainage gallery elevation				6645.000			
Head at H1, Heel				100.0000			
Head at H2, Toe				20.0000			
Head at H3, Drain				47.9993			
Head at H4, Gallery				25.0000			

COLO H3=((H1-H2)(L-DRN)/(L)+H2-H4)(1-Ecolo)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS

Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1145.2	36.0	6668.0	.0	-20551.6
Res	312.5	.0	.0	6653.3	10416.7	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-12.5	-9.4	102.9	6626.7	-83.3	458.8
Uplt	.0	249.2	44.0	6620.0	.0	2470.6
Rslt	353.1	-905.3	47.2	6620.0	-6073.0	.0

RESULTANT FORCE	w/uplift	w/o uplift	
Horizontal component (+=d/s)	353.10	353.10	K
Vertical component (+=up)	-905.34	-1154.56	K
Resultant force	971.76	1207.35	K
Distance from CL to resultant	-6.71	-7.40	
to 1/3 base	17.98		
to 1/2 base	26.97		
Moment at 53.94 from heel	-6072.98	-8543.61	k-ft
OVERTURNING SF =	2.99		

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87	ft2
Moment of inertia, I	104604.65	ft4
Moment arm, c	53.94	ft

Stress	w/uplift	w/o uplift	
Axial stress, P/A	-58.28	-74.33	lb/in2
Moment stress, Mc/I	-21.75	-30.59	lb/in2
Vertical stress at heel	-80.03	-104.92	lb/in2
Vertical stress at toe	-36.54	-43.73	lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)

Drain factor (p)= .573, Safety factor(s)= 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	24.89	No crk
25.00	16.56	No crk
75.00	.00	No crk
125.00	.00	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	353.10	kips
Total vertical forces	-905.34	kips
Safety Factor for above strengths	4.35	

Cohesion(Bonded)= 19.29 psi req for FS= 3.0

Sliding safety factors for various cohesions:

BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	759.7	1148.0	1536.3	2313.0	3089.7	3866.4
Safety factor	2.15	3.25	4.35	6.55	8.75	10.95

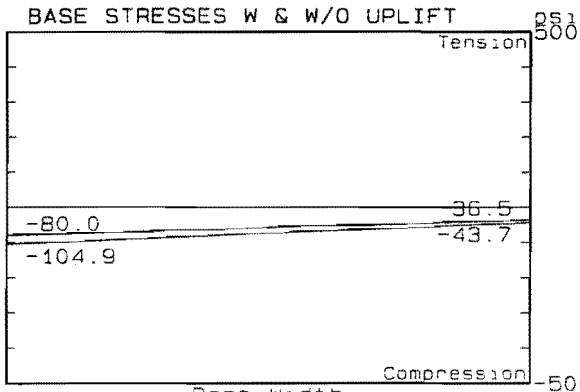
Required strengths to get these safety factors while other given values constant

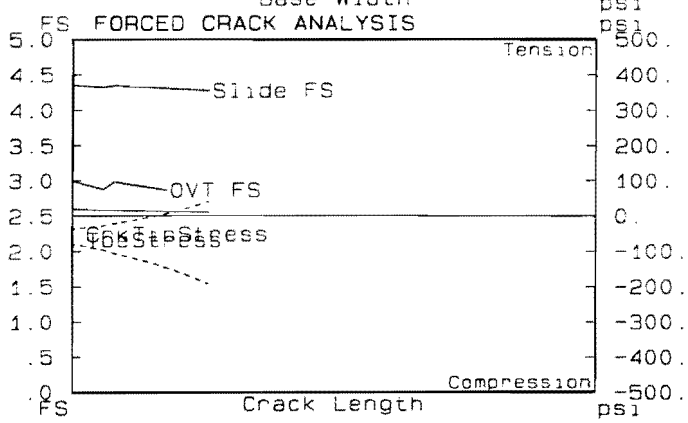
SF=		1.0	2.0	3.0
Bonded area:	cohesion (psi)	.0	.0	19.3
	friction angle (deg)	.0	.0	17.3

FORCED CRACK RESULTS

Initially compression at heel

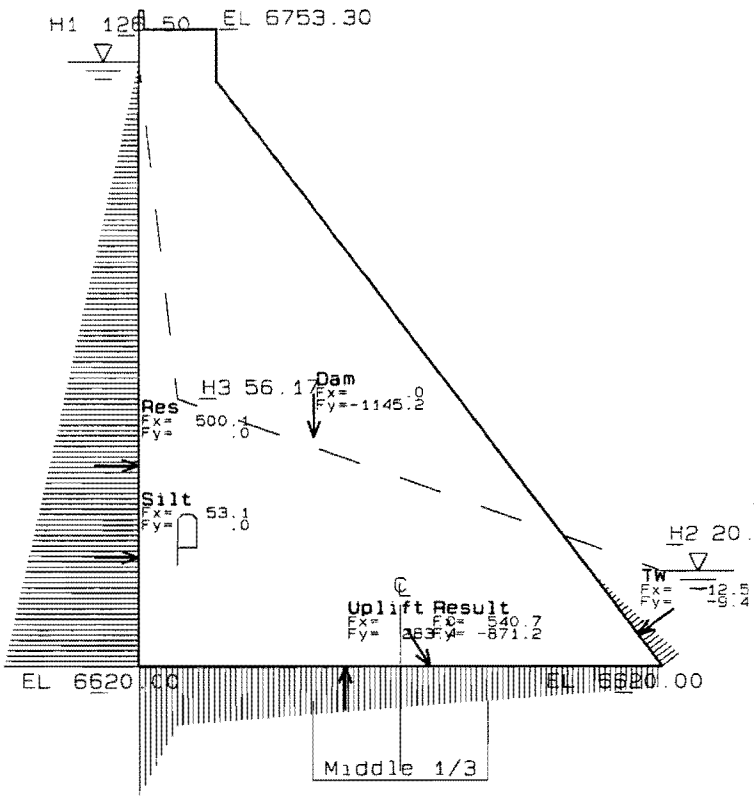
No length of crack causes crack growth





Big Timber Creek Dam

Coh=50, Frict=40, Den=145, Drains, Eff=.67



DAM DIMENSIONS AND CRITERIA

Analysis type			VaryReserv		
Criteria at drains			Colo		
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0
nus 3	.0	6757.3	nds 6	16.0	6753.3
Top of dam elevation			6757.300		
Base of dam elevation			6620.000		
Thickness of crest			16.000		
Base width			107.873		
Reservoir elevation			6746.500		
Tailwater elevation			6640.000		
Silt elevation			6688.700		
Initial crack length			.000		
Drain distance from axis			8.000		
Drain distance from heel			8.000		
Drain efficiency			.667		
Drainage gallery elevation			6645.000		
Head at H1, Heel			126.5000		
Head at H2, Toe			20.0000		
Head at H3, Drain			56.1694		
Head at H4, Gallery			25.0000		

COLO H3=((H1-H2)(L-DRN)/(L)+H2-H4)(1-Ecolo)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1145.2	36.0	6668.0	.0	-20551.6
Res	500.1	.0	.0	6662.2	21086.3	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-12.5	-9.4	102.9	6626.7	-83.3	458.8
Uplt	.0	283.4	42.5	6620.0	.0	3232.0
Rslt	540.7	-871.2	60.1	6620.0	5358.0	.0

RESULTANT FORCE	w/uplift	w/o uplift
Horizontal component (+=d/s)	540.67	540.67 K
Vertical component (+=up)	-871.17	-1154.56 K
Resultant force	1025.31	1274.89 K
Distance from CL to resultant	6.15	1.84
to 1/3 base	17.98	
to 1/2 base	26.97	
Moment at 53.94 from heel	5358.03	2126.02 k-ft
OVERTURNING SF =	2.02	

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87	ft2
Moment of inertia, I	104604.65	ft4
Moment arm, c	53.94	ft

Stress	w/uplift	w/o uplift	
Axial stress, P/A	-56.08	-74.33	lb/in2
Moment stress, Mc/I	19.19	7.61	lb/in2
Vertical stress at heel	-36.90	-66.71	lb/in2
Vertical stress at toe	-75.27	-81.94	lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= .543, Safety factor(s)= 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	29.82	No crk
25.00	21.48	No crk
75.00	4.82	No crk
125.00	.00	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	540.67	kips
Total vertical forces	-871.17	kips
Safety Factor for above strengths	2.79	

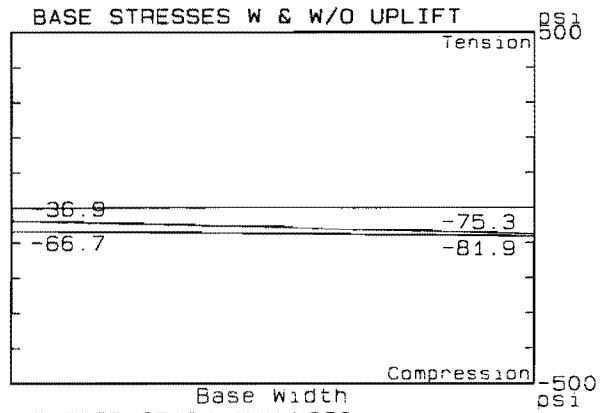
Cohesion(Bonded)= 57.36 psi req for FS= 3.0
Sliding safety factors for various cohesions:

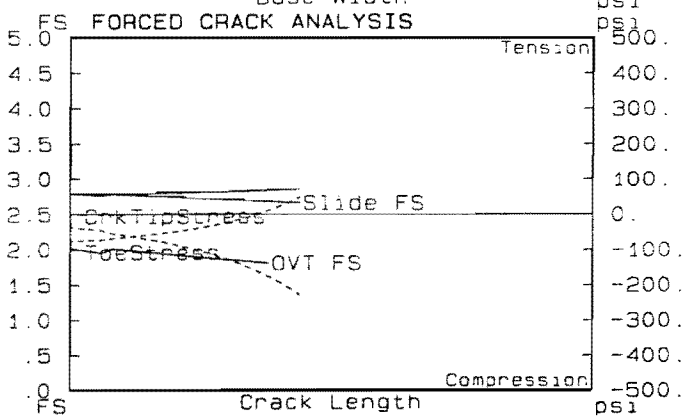
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	731.0	1119.3	1507.7	2284.4	3061.0	3837.7
Safety factor	1.35	2.07	2.79	4.23	5.66	7.10

Required strengths to get these safety factors while other given values constant

	SF=	1.0	2.0	3.0
Bonded area:	cohesion (psi)	.0	22.6	57.4
	friction angle (deg)	.0	19.3	44.1

FORCED CRACK RESULTS
Initially compression at heel
No length of crack causes crack growth





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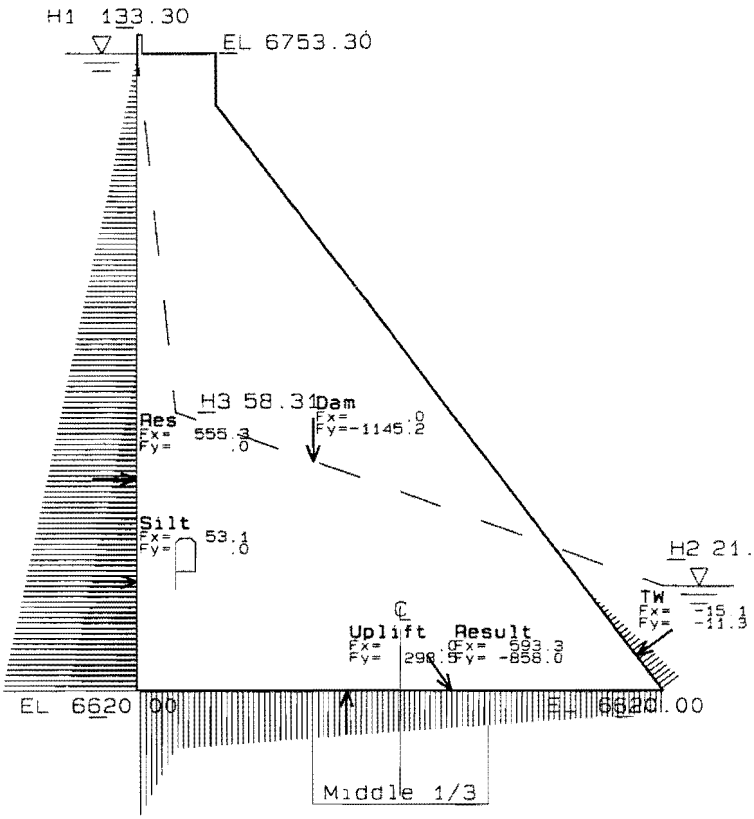
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, Drains, Eff=.67



DAM DIMENSIONS AND CRITERIA

Analysis type				VaryReserv	
Criteria at drains				Colo	
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0
nus 3	.0	6757.3	nds 6	16.0	6753.3
Top of dam elevation				6757.300	
Base of dam elevation				6620.000	
Thickness of crest				16.000	
Base width				107.873	
Reservoir elevation				6753.300	
Tailwater elevation				6641.965	
Silt elevation				6688.700	
Initial crack length				.000	
Drain distance from axis				8.000	
Drain distance from heel				8.000	
Drain efficiency				.667	
Drainage gallery elevation				6645.000	
Head at H1, Heel				133.3000	
Head at H2, Toe				21.9653	
Head at H3, Drain				58.3144	
Head at H4, Gallery				25.0000	

COLO H3=((H1-H2)(L-DRN)/(L)+H2-H4)(1-Ecolo)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1145.2	36.0	6668.0	.0	-20551.6
Res	555.3	.0	.0	6664.4	24672.9	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-15.1	-11.3	102.4	6627.3	-110.4	547.8
Uplt	.0	298.5	42.9	6620.0	.0	3303.3
Rslt	593.3	-858.0	64.5	6620.0	9077.8	.0

RESULTANT FORCE	w/uplift	w/o uplift	
Horizontal component (+=d/s)	593.30	593.30	K
Vertical component (+=up)	-858.04	-1156.50	K
Resultant force	1043.18	1299.80	K
Distance from CL to resultant	10.58	4.99	
to 1/3 base	17.98		
to 1/2 base	26.97		
Moment at 53.94 from heel	9077.80	5774.54	k-ft
OVERTURNING SF =	1.82		

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87	ft2
Moment of inertia, I	104604.65	ft4
Moment arm, c	53.94	ft

Stress	w/uplift	w/o uplift	
Axial stress, P/A	-55.24	-74.45	lb/in2
Moment stress, Mc/I	32.50	20.68	lb/in2
Vertical stress at heel	-22.73	-53.77	lb/in2
Vertical stress at toe	-87.74	-95.13	lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p) = .537, Safety factor (s) = 3.00

Tension (ft) psi	szu psi	Crack Prediction
.00	31.04	No crk
25.00	22.71	No crk
75.00	6.04	No crk
125.00	.00	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	593.30	kips
Total vertical forces	-858.04	kips
Safety Factor for above strengths	2.52	

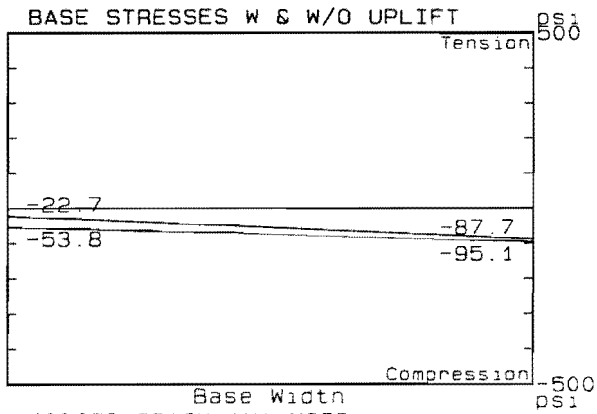
Cohesion (Bonded) = 68.23 psi req for FS= 3.0
Sliding safety factors for various cohesions:

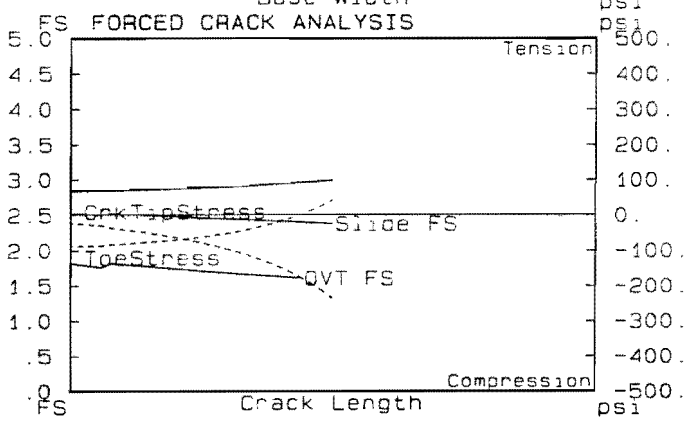
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	720.0	1108.3	1496.7	2273.3	3050.0	3826.7
Safety factor	1.21	1.87	2.52	3.83	5.14	6.45

Required strengths to get these safety factors while other given values constant

SF=	1.0	2.0	3.0
Bonded area: cohesion (psi)	.0	30.0	68.2
friction angle (deg)	.0	25.5	49.5

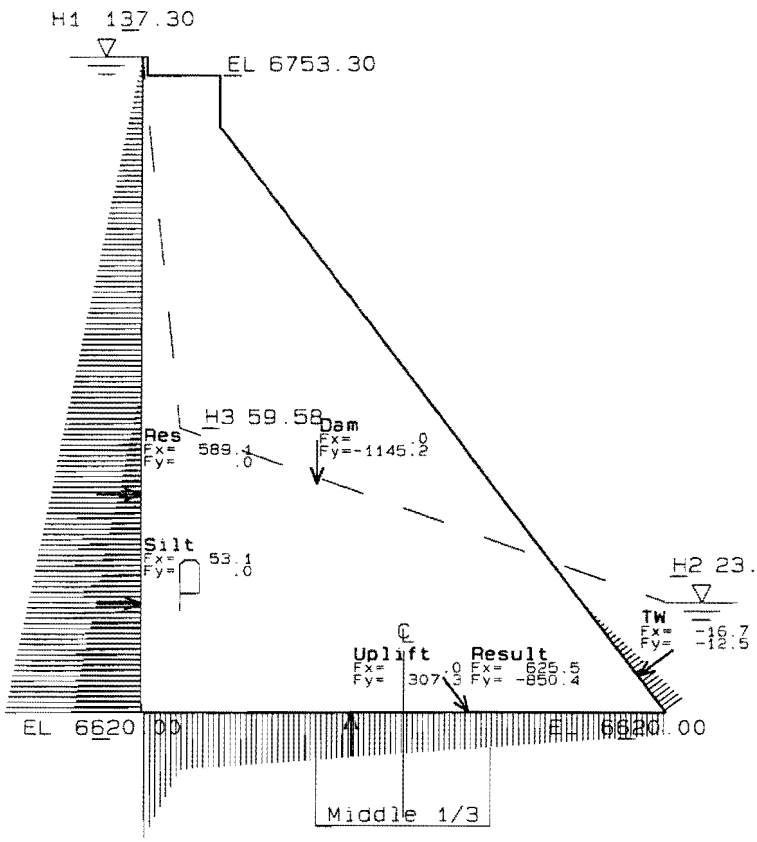
FORCED CRACK RESULTS
Initially compression at heel
No length of crack causes crack growth





Big Timber Creek Dam

Coh=50, Frict=40, Den=145, Drains, Eff=.67



DAM DIMENSIONS AND CRITERIA

Analysis type			VaryReserv		
Criteria at drains			Colo		
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0
nus 3	.0	6757.3	nds 6	16.0	6753.3
Top of dam elevation			6757.300		
Base of dam elevation			6620.000		
Thickness of crest			16.000		
Base width			107.873		
Reservoir elevation			6757.300		
Tailwater elevation			6643.121		
Silt elevation			6688.700		
Initial crack length			.000		
Drain distance from axis			8.000		
Drain distance from heel			8.000		
Drain efficiency			.667		
Drainage gallery elevation			6645.000		
Head at H1, Heel			137.3000		
Head at H2, Toe			23.1214		
Head at H3, Drain			59.5762		
Head at H4, Gallery			25.0000		

COLO H3=((H1-H2)(L-DRN)/(L)+H2-H4)(1-Ecolo)+H4

MATERIAL PROPERTIES:

Density of concrete		.14750 K/ft3	
water		.06250 K/ft3	
horiz sat silt		.085 K/ft3	
vert sat silt		.120 K/ft3	
Cohesion:	Break bond	50.000 lb/in2	
	Apparent	50.000 lb/in2	
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1145.2	36.0	6668.0		.0-20551.6
Res	589.1	.0	.0	6665.8	26951.3	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-16.7	-12.5	102.1	6627.7	-128.8	603.4
Uplt	.0	307.3	43.1	6620.0	.0	3345.2
Rslt	625.5	-850.4	67.4	6620.0	11445.3	.0

RESULTANT FORCE	w/uplift	w/o uplift
Horizontal component (+=d/s)	625.49	625.49 K
Vertical component (+=up)	-850.40	-1157.72 K
Resultant force	1055.66	1315.88 K
Distance from CL to resultant	13.46	7.00
to 1/3 base	17.98	
to 1/2 base	26.97	
Moment at 53.94 from heel	11445.33	8100.17 k-ft
OVERTURNING SF =	1.72	

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87 ft2	
Moment of inertia, I	104604.65 ft4	
Moment arm, c	53.94 ft	
Stress	w/uplift	w/o uplift
Axial stress, P/A	-54.75	-74.53 lb/in2
Moment stress, Mc/I	40.98	29.00 lb/in2
Vertical stress at heel	-13.76	-45.53 lb/in2
Vertical stress at toe	-95.73	-103.53 lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= .533, Safety factor(s)= 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	31.76	No crk
25.00	23.43	No crk
75.00	6.76	No crk
125.00	.00	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	625.49 kips
Total vertical forces	-850.40 kips
Safety Factor for above strengths	2.38

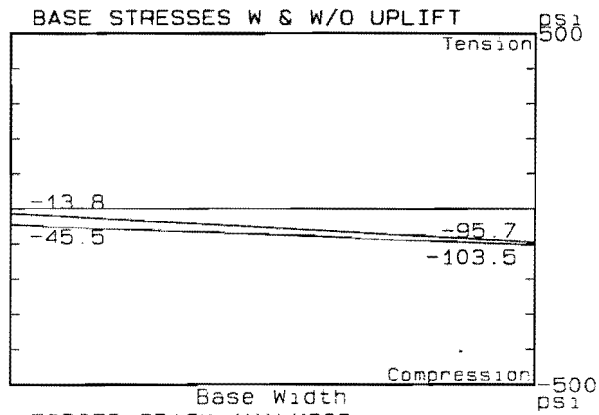
Cohesion(Bonded)= 74.86 psi req for FS= 3.0
Sliding safety factors for various cohesions:

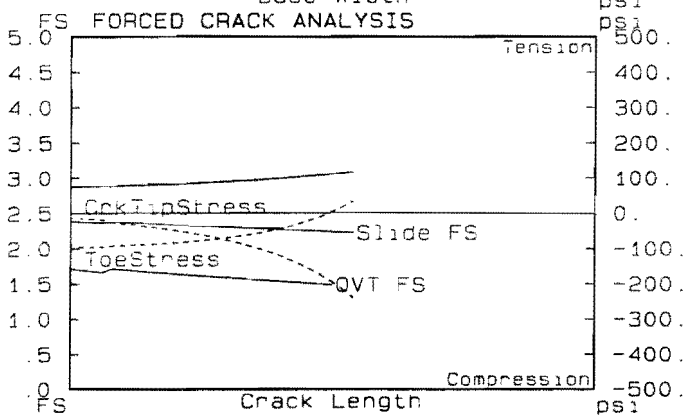
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	713.6	1101.9	1490.3	2266.9	3043.6	3820.3
Safety factor	1.14	1.76	2.38	3.62	4.87	6.11

Required strengths to get these safety factors while other given values constant

SF=	1.0	2.0	3.0
Bonded area: cohesion (psi)	.0	34.6	74.9
friction angle (deg)	.0	29.2	52.3

FORCED CRACK RESULTS
Initially compression at heel
No length of crack causes crack growth





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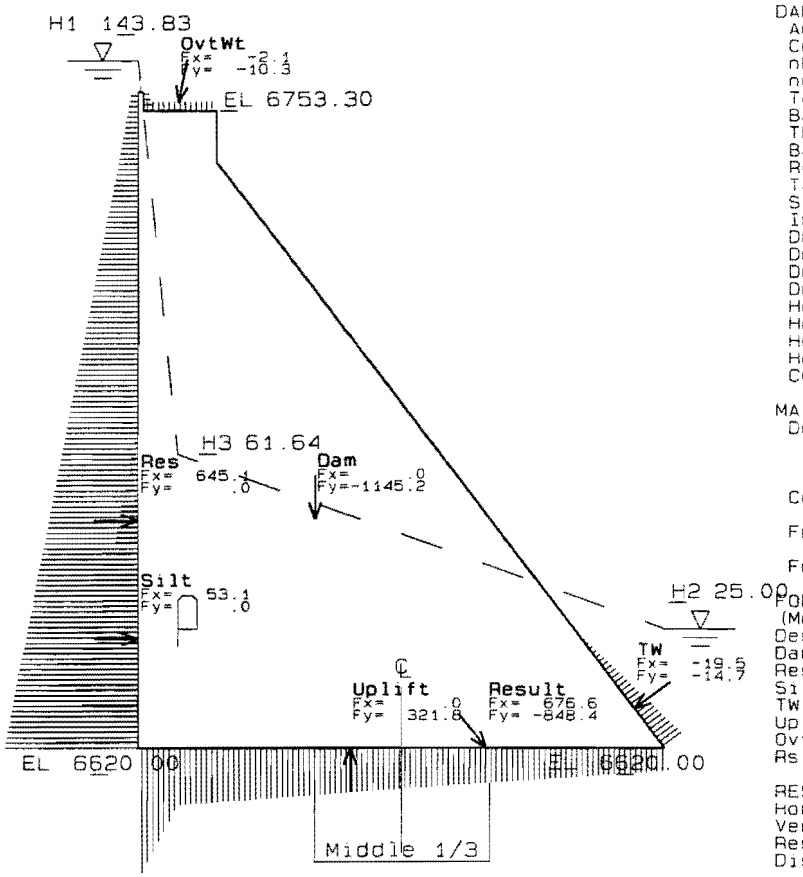
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, Drains, Eff=.67



DAM DIMENSIONS AND CRITERIA

Analysis type				VaryReserv			
Criteria at drains				Colo			
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0		
nus 3	.0	6757.3	nds 6	16.0	6753.3		
Top of dam elevation				6757.300			
Base of dam elevation				6620.000			
Thickness of crest				16.000			
Base width				107.873			
Reservoir elevation				6763.830			
Tailwater elevation				6645.000			
Silt elevation				6688.700			
Initial crack length				.000			
Drain distance from axis				8.000			
Drain distance from heel				8.000			
Drain efficiency				.667			
Drainage gallery elevation				6645.000			
Head at H1, Heel				143.8300			
Head at H2, Toe				25.0000			
Head at H3, Drain				61.6358			
Head at H4, Gallery				25.0000			

COLO H3=((H1-H2)*(L-DRN)/(L))*(1.0-Ecolo) + H2

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1145.2	36.0	6668.0	.0	-20551.6
Res	645.1	.0	.0	6567.8	30808.1	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-19.5	-14.6	101.6	6628.3	-162.8	698.5
Uplt	.0	321.8	43.3	6620.0	.0	3414.1
OvtW	-2.1	-10.3	8.2	6755.1	-288.2	-470.3
Rslt	676.6	-848.4	71.2	6620.0	14663.7	.0

RESULTANT FORCE	w/uplift	w/o uplift
Horizontal component (+=d/s)	676.57	676.57 K
Vertical component (+=up)	-848.36	-1170.12 K
Resultant force	1085.11	1351.64 K
Distance from CL to resultant	17.28	9.61
to 1/3 base	17.98	
to 1/2 base	26.97	
Moment at 53.94 from heel	14663.74	11249.61 k-ft
OVERTURNING SF =	1.59	

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87	ft2
Moment of inertia, I	104604.65	ft4
Moment arm, c	53.94	ft

Stress	w/uplift	w/o uplift	
Axial stress, P/A	-54.61	-75.33	lb/in2
Moment stress, Mc/I	52.51	40.28	lb/in2
Vertical stress at heel	-2.11	-35.05	lb/in2
Vertical stress at toe	-107.12	-115.61	lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p) = .528, Safety factor(s) = 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	32.94	No crk
25.00	24.61	No crk
75.00	7.94	No crk
125.00	.00	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	676.57	kips
Total vertical forces	-848.36	kips
Safety Factor for above strengths	2.20	

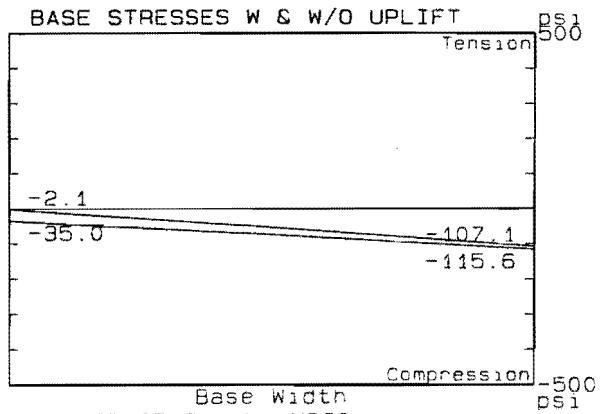
Cohesion(Bonded) = 84.84 psi req for FS= 3.0
Sliding safety factors for various cohesions:

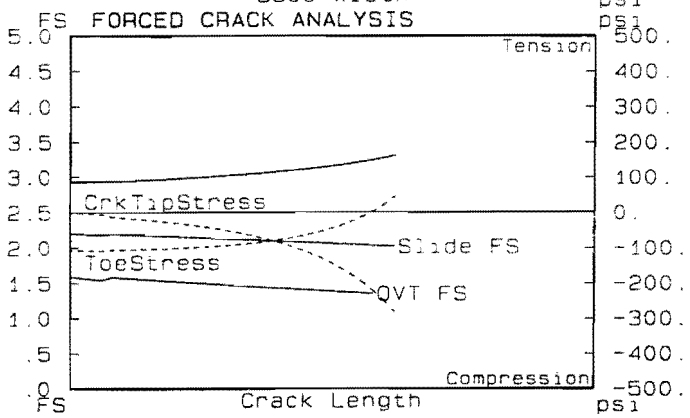
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	711.9	1100.2	1488.5	2265.2	3041.9	3818.6
Safety factor	1.05	1.63	2.20	3.35	4.50	5.64

Required strengths to get these safety factors while other given values constant SF= 1.0 2.0 3.0

Bonded area:	cohesion (psi)	.0	41.3	84.8
	friction angle (deg)	.0	34.2	55.9

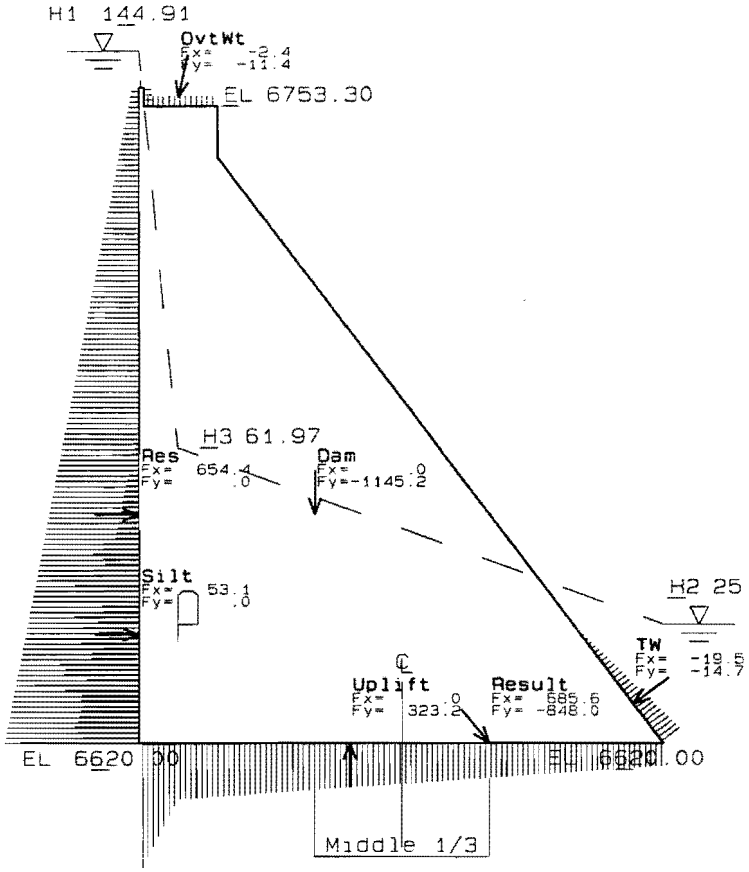
FORCED CRACK RESULTS
Initially compression at heel
No length of crack causes crack growth





Big Timber Creek Dam

Coh=50, Frict=40, Den=145, Drains, Eff=.67



DAM DIMENSIONS AND CRITERIA

Analysis type			VaryReserv			
Criteria at drains			Colo			
nheel 1	.0	6620.0	ntoe 8	107.9	6620.0	
nus 3	.0	6757.3	nds 6	16.0	6753.3	
Top of dam elevation				6757.300		
Base of dam elevation				6620.000		
Thickness of crest				16.000		
Base width				107.873		
Reservoir elevation				6764.914		
Tailwater elevation				6645.000		
Silt elevation				6688.700		
Initial crack length				.000		
Drain distance from axis				8.000		
Drain distance from heel				8.000		
Drain efficiency				.667		
Drainage gallery elevation				6645.000		
Head at H1, Heel				144.9136		
Head at H2, Toe				25.0000		
Head at H3, Drain				61.9699		
Head at H4, Gallery				25.0000		

COLO H3=((H1-H2)*(L-DRN)/(L))*(1.0-Ecolo) + H2

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

FORCES, POINT OF APPLICATION, AND MOMEMTS
(Moments about uncracked base at 53.9 6620.0)

Desc	ForceX	ForceY	CGX	CGY	MomentX	MomentY
Dam	.0	-1145.2	36.0	6668.0	.0	-20551.6
Res	654.4	.0	.0	6668.1	31446.5	.0
Silt	53.1	.0	.0	6642.9	1215.9	.0
TW	-19.5	-14.6	101.6	6628.3	-162.8	698.5
Uplt	.0	323.2	43.3	6620.0	.0	3445.3
OvtW	-2.4	-11.4	8.2	6755.2	-324.8	-520.1
Rslt	685.6	-848.0	71.9	6620.0	15246.8	.0

RESULTANT FORCE	w/uplift	w/o uplift
Horizontal component (+=d/s)	685.60	685.60 K
Vertical component (+=up)	-848.05	-1171.20 K
Resultant force	1090.52	1357.11 K
Distance from CL to resultant	17.98	10.08
to 1/3 base	17.98	
to 1/2 base	26.97	
Moment at 53.94 from heel	15246.80	11801.54 k-ft
OVERTURNING SF =	1.57	

VERTICAL STRESSES AT HEEL AND TOE (Tension is positive)

Area of base, A	107.87 ft2
Moment of inertia, I	104604.65 ft4
Moment arm, c	53.94 ft

Stress	w/uplift	w/o uplift	
Axial stress, P/A	-54.59	-75.40	lb/in2
Moment stress, Mc/I	54.59	42.26	lb/in2
Vertical stress at heel	.00	-33.14	lb/in2
Vertical stress at toe	-109.19	-117.66	lb/in2

RECLAMATION CRACKING CRITERIA (szu = pwh - ft/s)
Drain factor (p)= .527, Safety factor(s)= 3.00

Tension(ft) psi	szu psi	Crack Prediction
.00	33.14	Cracked
25.00	24.81	No crk
75.00	8.14	No crk
125.00	.00	No crk
175.00	.00	No crk
225.00	.00	No crk

SLIDING FACTORS OF SAFETY

Total horizontal forces (driving)	685.60 kips
Total vertical forces	-848.05 kips
Safety Factor for above strengths	2.17

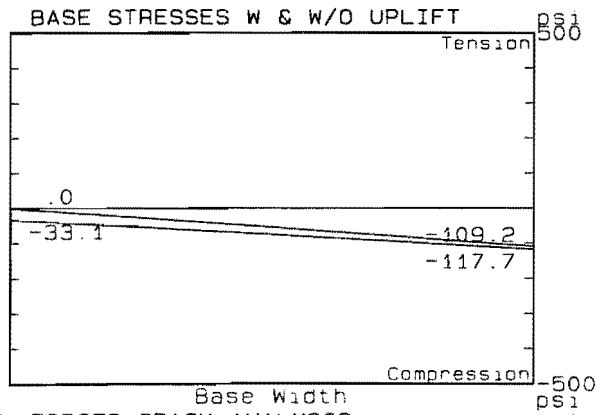
Cohesion(Bonded)= 86.60 psi req for FS= 3.0
Sliding safety factors for various cohesions:

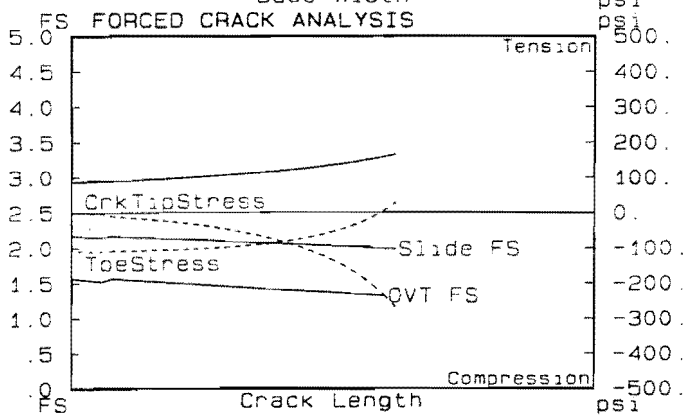
BreakBond-psi	.0	25.0	50.0	100.0	150.0	200.0
Resisting-K	711.6	1099.9	1488.3	2265.0	3041.6	3818.3
Safety factor	1.04	1.60	2.17	3.30	4.44	5.57

Required strengths to get these safety factors while other given values constant SF= 1.0 2.0 3.0

Bonded area:	cohesion (psi)	.0	42.5	86.6
	friction angle (deg)	.0	35.0	56.5

FORCED CRACK RESULTS
Heel initially in tension
Crack stops at .00ft from heel





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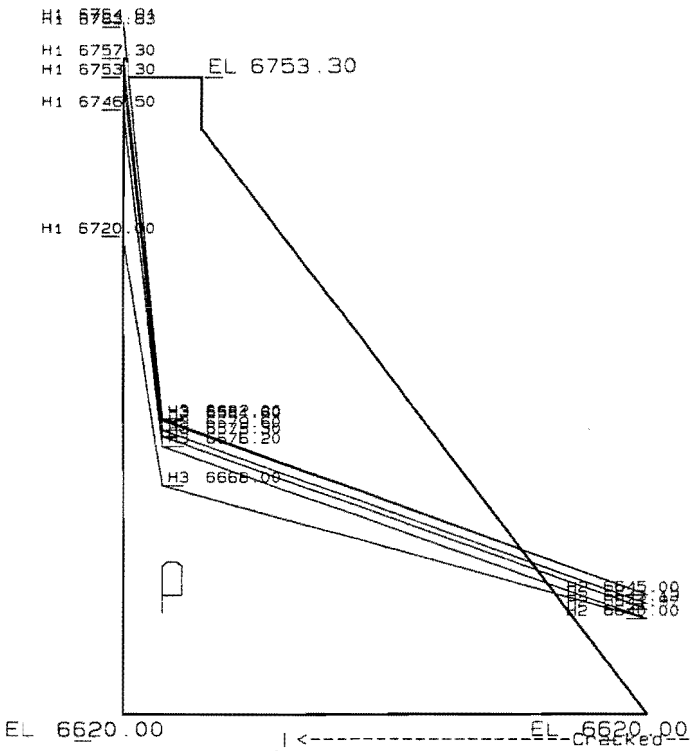
Big Timber Creek Dam

Coh=50, Frict=40, Den=145, Drains, Eff=.67



DAM DIMENSIONS AND CRITERIA

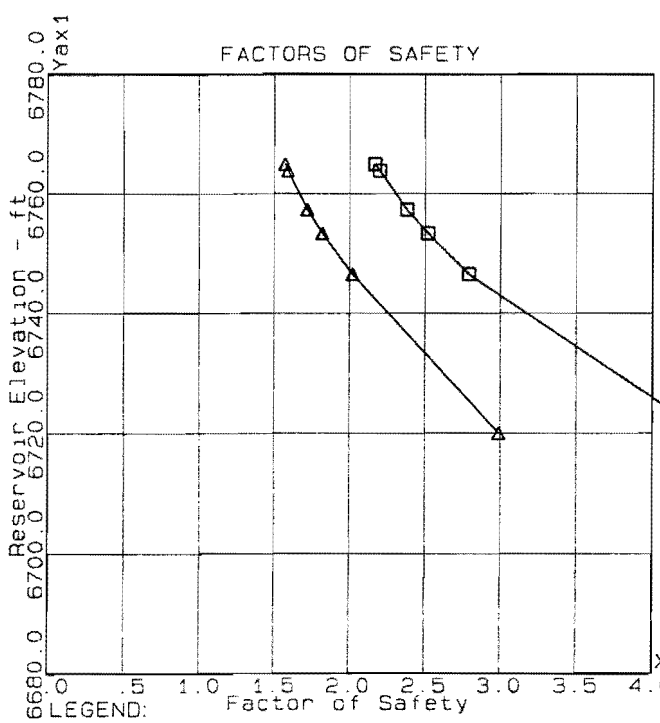
Analysis type		VaryReserv
Criteria at drains		Colo
nheel 1	.0 6620.0	ntoe 8 107.9 6620.0
nus 3	.0 6757.3	nds 6 16.0 6753.3
Top of dam elevation		6757.300
Base of dam elevation		6620.000
Thickness of crest		16.000
Base width		107.873
Silt elevation		6688.700
Initial crack length		.000
Drain distance from axis		8.000
Drain distance from heel		8.000
Drain efficiency		.667
Drainage gallery elevation		6645.000

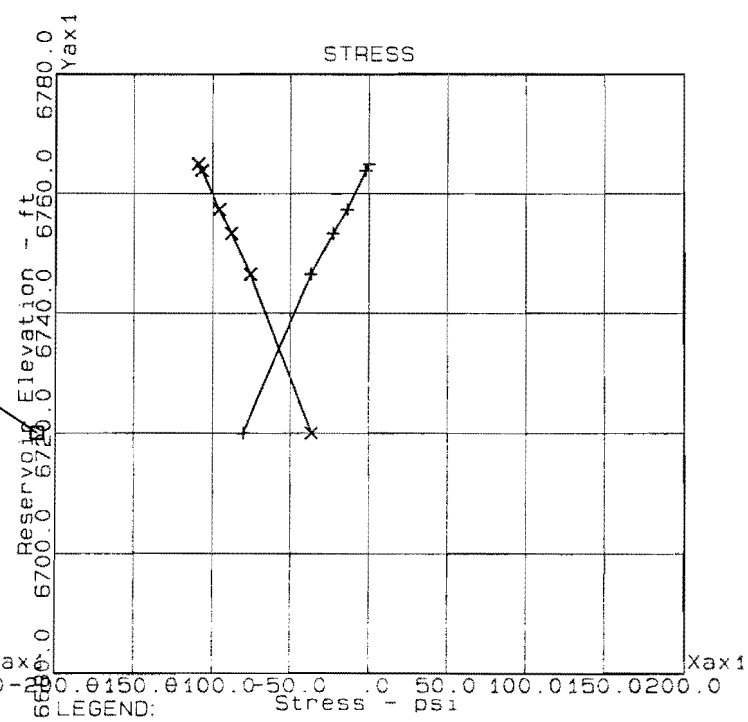
COLO H3=((H1-H2)*(L-DRN)/(L))*(1.0-Ecolo) + H2

MATERIAL PROPERTIES:

Density of concrete		.14750	K/ft3
water		.06250	K/ft3
horiz sat silt		.085	K/ft3
vert sat silt		.120	K/ft3
Cohesion:	Break bond	50.000	lb/in2
	Apparent	50.000	lb/in2
Friction:	Bonded	.839	40.0 deg
(tangent&angle)	Unbonded	.839	40.0 deg
Fraction of area bonded		1.000	

			Cracked						Uncracked					
Res Elev	TW Elev	Crack Length	U/S Stress	Slide FS	Over FS	Req Coh	H3	D/S Stress	U/S Stress	Slide FS	Over FS	Req Coh	H3	D/S Stress
6720.00	6640.00	.00	-80.0	4.35	2.99	19.3	48.0	-36.5	-80.0	4.35	2.99	19.3	48.0	-36.5
6746.50	6640.00	.00	-36.9	2.79	2.02	57.4	56.2	-75.3	-36.9	2.79	2.02	57.4	56.2	-75.3
6753.30	6641.97	.00	-22.7	2.52	1.82	68.2	58.3	-87.7	-22.7	2.52	1.82	68.2	58.3	-87.7
6757.30	6643.12	.00	-13.8	2.38	1.72	74.9	59.6	-95.7	-13.8	2.38	1.72	74.9	59.6	-95.7
6763.83	6645.00	.00	-2.1	2.20	1.59	84.8	61.6	-107.1	-2.1	2.20	1.59	84.8	61.6	-107.1
6764.91	6645.00	.00	.0	2.17	1.57	86.6	62.0	-109.2	.0	2.17	1.57	86.6	62.0	-109.2





Appendix C - Cost Estimate Worksheets

ESTIMATE WORKSHEET

FEATURE: 10-Jun-2002
Lemhi River Offstream Storage
Big Timber Creek Dam
Dam Height = 133.3 ft, Crest = 860 ft
Top of Dam= El. 6753.3
Active Storage= 6,000 Acre-feet
(Assume Haul Aggregate to Site)

PROJECT
Lemhi River

REGION:
PN

FILE:
H:\Home\D8170-EST\Spreadsheet\Grush\Lemhi\[Big Timber Creek Dam June 2002 Revision.xls]Sheet 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Mobilization and Preparatory Work (+/- 5%)		1	LS	$770,000	$770,000.00
	2	Clear and grub reservoir area (small brush)	D8110	200	AC	$1,000.00	$200,000.00
	3	Road Improvements for Construction Access		7	MI	$16,500.00	$115,500.00
		(Include upgrade of 2 small bridges.)					
	3a	Run temporary electrical power line to site		7	MI	$100,000.00	$700,000.00
		Diversion/Dewatering During Construction:					
		Upstream and Downstream Cofferdams:					
	4	Construct U/S earth cofferdam	D8130	6,800	CY	$15.00	$102,000.00
		(Top of Dam El.6660, Ht=40 ft)					
	5	F&I geomembrane on U/S cofferdam	D8130	1,400	SY	$10.00	$14,000.00
	6	Construct D/S earth cofferdam	D8130	6,800	CY	$15.00	$102,000.00
		(Top of Dam El.6650, Ht=30 ft)					
	7	F&I geomembrane on D/S cofferdam	D8130	1,400	SY	$10.00	$14,000.00
	8	F&I 4ft dia pipe btwn U/S & D/S cofferdams	D8130	300	LF	$80.00	$24,000.00
		(corr. metal pipe attach to outlet pipe through dam)					
	9	Unwatering Excavation	D8130	1	LS	$100,000	$100,000.00
		- assume sumps and surface pumps					
	10	Remove cofferdams and diversion structures	D8130	1	LS	$125,000	$125,000.00
		Foundation Excavation:					
		- assume 1/2 of total is common, 1/2 total is rock					
		- assume haul to waste area and spread (2 miles)					
	11	Excavate Common Material:					
	a	For Dam	D8110	28,100	CY	$8.00	$224,800.00
	b	For Stilling Basin (Outlets and Spillway)	D8130	1,600	CY	$8.00	$12,800.00
	12	Excavate Bedrock:					
	a	For Dam	D8110	28,100	CY	$15.00	$421,500.00
	b	For Stilling Basin (Outlets and Spillway)	D8130	1,600	CY	$15.00	$24,000.00
		Subtotal for Sheet 1					$2,949,600.00

QUANTITIES		PRICES	
BY Larry K. Nuss	CHECKED for Dave Godeire	BY Craig A. Grush	CHECKED 6/1/02
DATE PREPARED 6-Sep-2001	DATE	DATE 10-Jun-02	PRICE LEVEL Appraisal 2001

ESTIMATE WORKSHEET

FEATURE: 10-Jun-2002
Lemhi River Offstream Storage
Big Timber Creek Dam
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(Assume Haul Aggregate to Site)

PROJECT
Lemhi River

REGION:
PN

FILE:
H:\Home\D8170\EST\Spreadsheet\Grush\Lemhi\[Big Timber Creek Dam June 2002 Revision.xls]Sheet 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Foundation Treatment:					
	13	Extra rock excavation for possible fault treatment	D8110	640	CY	$15.00	$9,600.00
		- assume fractured, can be exc with hyd. excavator					
		- assume 2 faults, 4-ft wide, 20-ft deep					
	14	Dental concrete for possible fault treatment	D8110	640	CY	$100.00	$64,000.00
		- assume 2 faults, 4-ft wide, 20-ft deep					
	15	Leveling Concrete for Foundation	D8110	6,960	CY	$120.00	$835,200.00
		- assume 6 bag mix; assume 3' thick					
	16	F&I 4-in. dia. steel pipe nipples	D8110	345	LF	$50.00	$17,250.00
		- assume 4-ft long pipe per foundation drain					
	17	Drill foundation drains from gallery	D8110				
	a	Setups (Assume 10-ft on centers)		92	EA	$120.00	$11,040.00
	b	Drill holes (Assume 4" dia w/ length= 20% dam height)		1,638	LF	$40.00	$65,520.00
	18	Drill formed drains in dam body along U/S face	D8110				
	a	Setups (Assume 10-ft on centers)		86	EA	$120	$10,320.00
	b	Drill holes (Assume 6" dia)		6,185	LF	$50.00	$309,250.00
	19	Grout foundation	D8110				
	a	Setups for Drilling Grout Holes		184	EA	$120.00	$22,080.00
		- assume 2" dia. drilled on 5-ft centers					
	b	Drill Grout Holes		6,552	LF	$30.00	$196,560.00
		- Assume 2" dia w/ length= 40% dam height)					
	c	Hookups to Grout Holes		184	EA	$80.00	$14,720.00
	d	Pressure Grout		6,552	CF	$30.00	$196,560.00
		- assume grouting process only minus cement					
		- assume 1 CF per 1 LF of hole					
	e	Furnish and handle cement for Pressure Grouting		6,552	BAG	$10.00	$65,520.00
		- assume 1 bag cement per CF					
		Subtotal for Sheet 2					$1,817,620.00

QUANTITIES		PRICES	
BY Larry K. Nuss D8110	CHECKED for Dave Godaire	BY Craig A. Grush	CHECKED Math 4/10/02
DATE PREPARED 6-Sep-2001	DATE	DATE 10-Jun-02	PRICE LEVEL Appraisal 2001

ESTIMATE WORKSHEET

FEATURE: 10-Jun-2002
Lemhi River Offstream Storage
Big Timber Creek Dam
Dam Height = 133.3 ft, Crest = 860 ft
Top of Dam= El. 6753.3
Active Storage= 6,000 Acre-feet
(Assume Haul Aggregate to Site)

PROJECT
Lemhi River

REGION:
PN

FILE:
H:\Home\D8170\EST\Spreadsheet\Grush\Lemhi\[Big Timber Creek Dam June 2002 Revision.xls]Sheet 4

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Construct RCC Dam:					
	20	RCC Dam (Complete in Place)	D8110	137,200	CY	$46.00	$6,311,200.00
		- assume 300 lb/CY cementitious material in mix					
		- assume 60% flyash and 40% cement					
		- includes 290 CY for stilling basin					
		- includes 136800 CY for dam which is reduced					
		for facing elements and leveling conc.					
		- assume 25 mile haul for aggregates					
	21	Bonding Mortar:	D8110	2,680	CY	$200.00	$536,000.00
		- assume 1/2" thick/lift on 67lifts					
	22	Concrete Facing Elements	D8110				
		- Upstream Face - Assume 1.5' thick		4,400	CY	$250.00	$1,100,000.00
		- Downstream Face - Assume 2' thick		7,020	CY	$250.00	$1,755,000.00
	23	FRP Reinforced Concrete ogee cap	D8110	40	CY	$500.00	$20,000.00
		- assume structural concrete in top 2-feet of spillway					
	24	Form drainage gallery within RCC section	D8110	920	LF	$190.00	$174,800.00
		- Assume 4-ft wide x 7-ft high across base of dam					
		- Assume standard Symons Panel System for 12" RCC Lifts					
	25	F&I PVC waterstops for U/S CrJs and facing elemer	D8110	1,530	LF	$15.00	$22,950.00
		- 17 CrJs @ 50' ctrs, 67 hor placement jts @ 2' lifts					
	26	F&I Metal crack inducer plates for CrJs in RCC	D8110	30,920	LF	$6.00	$185,520.00
		- assume place every other lift					
	27	Form OW Conduit in RCC	D8130	2,580	SF	$10.00	$25,800.00
		- Assume standard Symons Panel System for 12" RCC Lifts					
		- Assume 6' High x 8' Wide x 95 feet Long					
	28	F&I Gallery lighting	D8430	1	LS	$10,000.00	$10,000.00
	29	F&I Gallery ventilation	D8420	1	LS	$30,000.00	$30,000.00
		Subtotal for Sheet 3					$10,171,270.00

QUANTITIES		PRICES	
BY Larry K. Nuss	CHECKED for Dave Godaire	BY Craig A. Grush	CHECKED Mathew Reid 6/10/02
DATE PREPARED D8110 6-Sep-2001	DATE	DATE 10-Jun-02	PRICE LEVEL Appraisal 2001

ESTIMATE WORKSHEET

FEATURE: 10-Jun-2002
Lemhi River Offstream Storage
Big Timber Creek Dam
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(Assume Haul Aggregate to Site)

PROJECT
Lemhi River

REGION:
PN

FILE:
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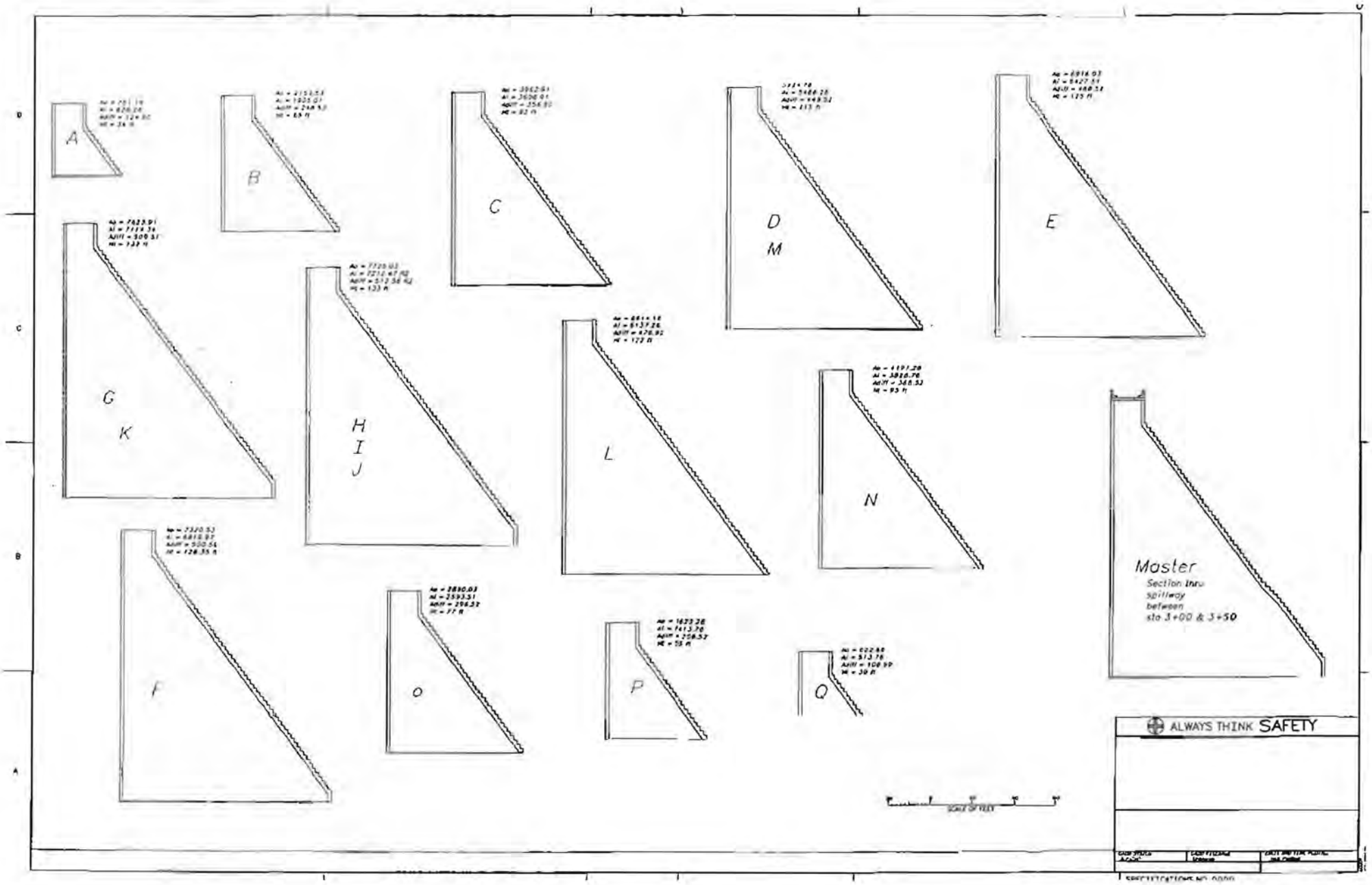
PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Furnish and Install River Outlet Works:					
	30	F&I 2' Dia Steel pipe btwn intake and gates	D8130	95	LF	$135.00	$12,825.00
		- assume 100 psi rated					
	31	F&I One 3' x 3' HP slide gate and control		1	EA	$40,000.00	$40,000.00
		- assume 100 psi rated					
	32	Place backfill concrete btwn steel pipe and RCC	D8130	95	CY	$200.00	$19,000.00
	33	Construct reinforced concrete intake structure w/ precast silt barrier panels:					
	a	FRP Reinforced concrete	D8130	75	CY	$500.00	$37,500.00
	b	Furnish reinforcement	D8130	48,000	LBS	$0.75	$36,000.00
	c	Furnish and handle cement	D8130	90	TNS	$130.00	$11,700.00
	d	F&I Precast silt barrier panels	D8130	4,500	SF	$30.00	$135,000.00
	34	F&I Steel trashracks for intake (Assume 40 psf)	D8410	5,120	LBS	$6.00	$30,720.00
	35	Construct reinforced concrete stilling basin					
	a	FRP Reinforced concrete	D8130	1,110	CY	$400.00	$444,000.00
	b	F&I PVC Waterstop	D8130	970	LF	$15	$14,550.00
	c	Furnish reinforcement	D8130	167,000	LBS	$0.75	$125,250.00
	d	Furnish and handle cement	D8130	310	TNS	$130.00	$40,300.00
	e	F&I 6-inch PVC Drain Pipe	D8130	835	LF	$15.00	$12,525.00
	f	F&I Pervious material	D8130	900	CY	$30.00	$27,000.00
	36	F&I one 21-inch Jet Flow Valve	D8460	1	LS	$175,000	$175,000.00
	37	F&I Instrumentation	D8460	1	LS	$20,000.00	$20,000.00
		- assume piezometers, collimation, weirs					
		Subtotal for Sheet 4					$1,181,370.00
		Subtotal for all sheets					$16,119,860.00
		Unlisted Items +/-	15%				$2,380,140.00
		CONTRACT COST					$18,500,000.00
		Contingencies +/-	25%				$4,500,000.00
		FIELD COST					$23,000,000.00

QUANTITIES		PRICES	
BY Larry K. Nuss	CHECKED for Dave Godaire	BY Craig A. Grush	CHECKED Mark DCR 6/10/02
DATE PREPARED D8110 6-Sep-2001	DATE	DATE 10-Jun-02	PRICE LEVEL Appraisal 2001


A
B
C
D
M
E
G
K
H
I
J
L
N
Master
Section thru
spillway
between
sta 3+00 & 3+50
F
O
P
Q
ALWAYS THINK SAFETY

Lemhi Dam - Quantities Sheet

Prepared By: David L. Godaire, D-8130 Checked by: Larry K. Nuss, D-8110 August 1, 2002

A. EXCAVATION	Station (feet)	Height (feet)	U/S Width (feet)	Area (ft2)	Ave Area (ft2)	CC Length (feet)	Volume (ft3)	Volume (yd3)
Left abutment	0	20	15	300				
A	50	20	26	520	590	100	59000	
B	100	20	58	1160				
C	150	20	76	1520	1513	100	151333	
D	200	20	92	1840				
E	250	20	103	2060	2027	100	202667	
F	300	20	104	2080				
G	325	20	103	2060	2060	50	103000	
H	350	20	102	2040				
I	400	20	104	2080	2057	100	205667	
J	450	20	99	1980				
K	500	20	95	1900	1897	100	189667	
L	550	20	90	1800				
M	600	20	83	1660	1650	100	165000	
N	650	20	73	1460				
O	700	20	58	1160	1183	100	118333	
P	750	20	44	880				
Q	800	20	28	560	570	106	60420	
Right abutment	856	20	15	300				
Sum						856	1253087	46411
Side Slope			Perimeter	Area				
Triangle cross section (1:0.75) *Sum*			1775	150			266250	9861
Stilling Basin-Outlets & Spillway			Length	Area				
side slope excavation			132.3	150			19845	
main basin area			41	1541			63181	
Sum							83026	3075
							Total	**59347**

B. RCC CONCRETE Dam	Station			Area (ft2)	Ave Area (ft2)	CC Length (feet)	Volume (ft3)	Volume (yd3)
Left abutment	0			0.00				
A.	50			628.26	735	100	73501	
B	100			1905.01				
C	150			3608.01	3638	100	363589	
D	200			5488.26				
E	250			6427.51	6338	100	633605	
F	300			6819.97				
G	325			7114.34	7082	50	354082	
H	350			7212.47				
I	400			7212.47	7212	100	721247	
J	450			7212.47				
K	500			7114.34	6968	100	696785	
L	550			6137.26				
M	600			5486.26	5319	100	531851	
N	650			3828.76				
O	700			2593.51	2603	100	260276	
P	750			1413.76				
Q	800			513.76	576	106	61282	
Right abutment	856			0.00				
Sum						856	3696216	136897

Leveling Concrete Dam	Station (feet)	Height (feet)	U/S Width (feet)	Area (ft2)	Ave Area (ft2)	CC Length (feet)	Volume (ft3)	Volume (yd3)
Left abutment	0	3	15	45				
A	50	3	26	78	89	100	8850	
B	100	3	58	174				
C	150	3	76	228	227	100	22700	
D	200	3	92	276				
E	250	3	103	309	304	100	30400	
F	300	3	104	312				
G	325	3	103	309	309	50	15450	
H	350	3	102	306				
I	400	3	104	312	309	100	30850	
J	450	3	99	297				
K	500	3	95	285	285	100	28450	
L	550	3	90	270				
M	600	3	83	249	248	100	24750	
N	650	3	73	219				
O	700	3	58	174	175	100	17450	
P	750	3	44	132				
Q	800	3	28	84	88	108	9063	
Right abutment	858	3	15	45				
Sum						856	187963	6962

FACING CONCRETE (U/S and D/S	Station (feet)			Area (ft2)	Ave Area (ft2)	CC Length (feet)	Volume (ft3)	Volume (yd3)
Left abutment	0			0.00				
A	50			124.90	125	100	12469	
B	100			248.52				
C	150			356.90	354	100	35411	
D	200			448.52				
E	250			483.52	484	100	48388	
F	300			500.56				
G	325			509.58	509	50	25428	
H	350			512.56				
I	400			512.56	513	100	51258	
J	450			512.56				
K	500			509.67	505	100	50462	
L	550			476.90				
M	600			448.52	440	100	43992	
N	650			368.52				
O	700			296.52	294	100	29385	
P	750			208.52				
Q	800			108.90	107	106	11379	
Right abutment	858			0.00				
Total						856	308168	11414

Structural Concrete		Length (feet)	Area (ft2)		Volume (ft3)	Volume (yd3)
Spillway Crest		20	49.64		993	37
Parapet		835	32.8		27388	1014
Concrete around Outlet Pipe		89.125	26.86		2394	89
Stilling Basin		84.25	355		29909	1108
Intake structure		58.7	32		1878.4	70
Total					62562	2317

Notes:

1. Average Area computed by (A1 + 4A2 + A3)/6
2. Volume is Length x Average Area

\\Nuss\Lemhi\Calcs\[DLG_Lemhi_Quan2.xls]Lemhi Quantities

Appendix D - Fish Passage Alternatives

US Army Corps
of Engineers®
Walla Walla District

ICE HARBOR LOCK AND DAM-- LAKE SACAJAWEA

(150 dpi) (75 dpi)

Snake River, Washington

CONDITION OF IMPROVEMENT 30 September 1996

CWIS: 00608

AUTHORIZATION: The Ice Harbor Project was authorized by Section 2 of the River and Harbor Act of 1945 (Public Law 79-14, 79th Congress, 1st Session), and was approved March 2, 1945, in accordance with House Document 704, 75th Congress, 3d Session. Recreation was authorized in the River and Harbor Act of 1944 (Public Law 78-534), as amended. The lake behind Ice Harbor Dam has been designated "Lake Sacajawea."

Ice Harbor Lock and Dam-Lake Sacajawea is Unit 1 of 4 included in the "Lower Snake River Project, Washington, and Idaho"

PROJECT: The project consists of Ice Harbor Dam (photo), powerhouse, navigation lock, two fish ladders, and facilities. The project provides navigation, hydroelectric generation, recreation, and incidental irrigation.

Ice Harbor Dam (150 dpi) (75 dpi): The dam is 2,822 feet long, with an effective height of 100 feet. It is of the concrete gravity type, with an earthfill embankment section at the north abutment. It has a ten-bay spillway that is 590 feet long, ar ten 50-foot tainter gates.

Lake Sacajawea: At elevation 440, Lake Sacajawea extends northeast 32 miles upstream to Lower Monumental Dam, and has a surface area of 9,200 acres.

Powerhouse: The Ice Harbor powerhouse contained three 90,000-kilowatt units initially. It now has three additional 111,000-kilowatt units. Power generation through September 1994 was 73.81 billion kilowatt hours.

Navigation lock: The lock is a single-lift type with clear plan. It has clear dimensions of 86 feet by 675 feet, and a 15-foc minimum depth.

Fish Passage: There are two fish ladders for passing migratory fish.

Lands: There are 3,576 acres of project lands surrounding Lake Sacajawea. These lands include fee lands that are federally-owned and managed by the Corps, as well as easement lands to which the Corps has specific rights or easements (*i.e.*, flowage or access). There are 3,517.3 acres of Corps-managed lands that are utilized for public recreation purposes, wildlife habitat, wildlife mitigation, and water- connected industrial development. At the present time no lands are licensed to state or local park agencies. Public boat launching facilities are available at six locations along tl shoreline.

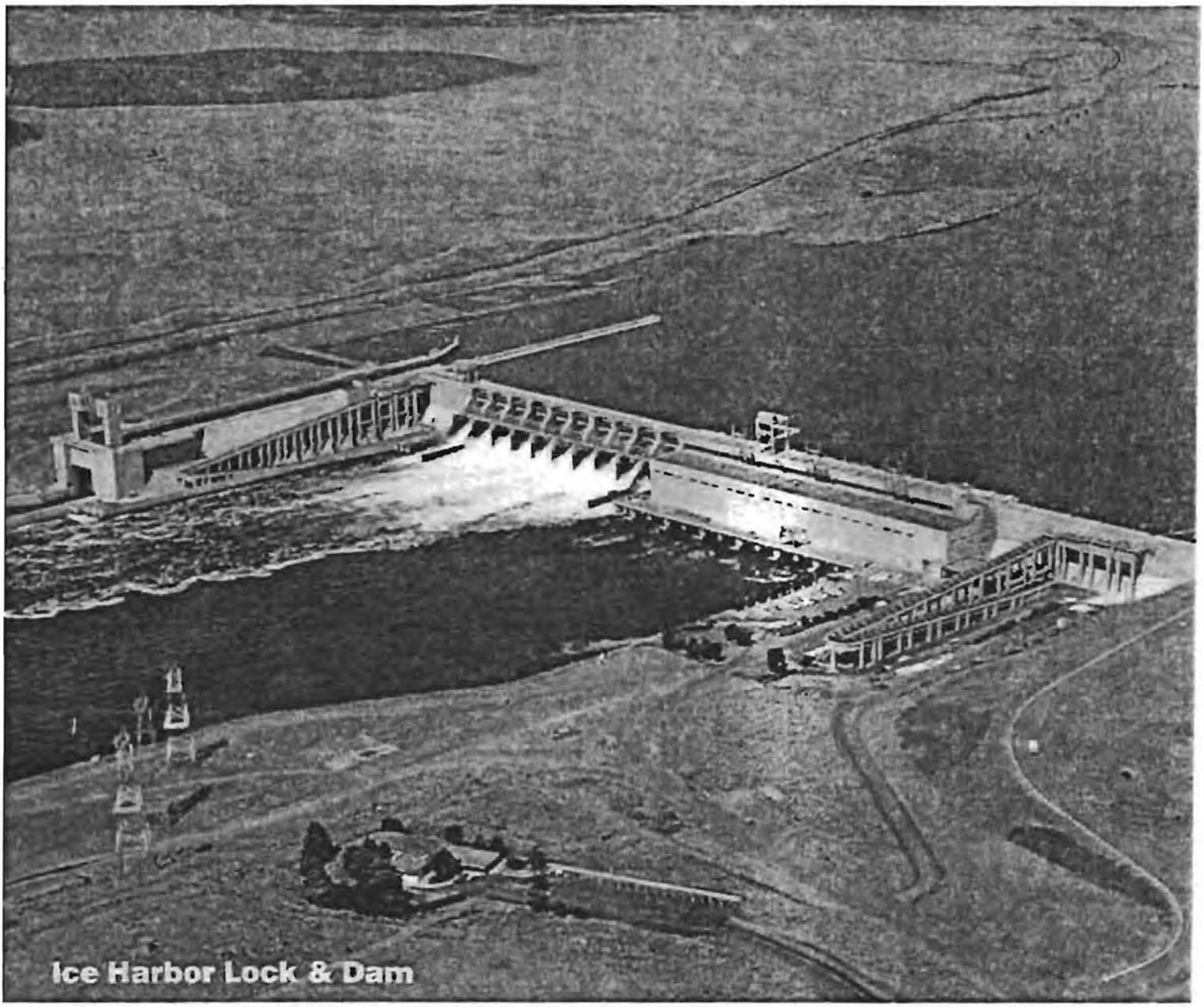
LOCAL COOPERATION: None required.

PROGRESS: Construction of the Ice Harbor Project began in December 1955, and the project began operation in December 1961. Powerhouse units 4 though 6 were installed, with all units producing power by January 1976. The entire project, including recreational facilities, is now complete.

COST: Total expenditures through September 1996 are $168,029,357 for new work (including $36,748,021 for additional units) and $127,558,006 for operation and maintenance. In addition, local interests contributed 82,500 toward an artificial spawning channel.

Ice Harbor Lock and Dam--Lake Sacajawea, Structural Details
(150 dpi) (75 dpi)

Return to Ice Harbor Lock and Dam


Ice Harbor Lock & Dam

Susquehanna Fish Lifts & THE RETURNING SHAD

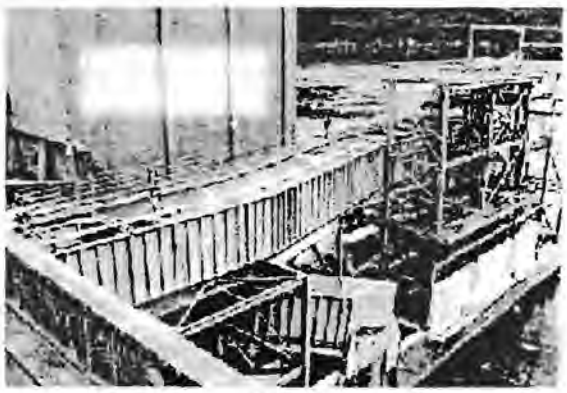
Despite chronic weather-related setbacks, the fish lifts at Holtwood an Safe Harbor dams were completed and in operation by April 1997, marking a major step in the opportunity for American shad and other migratory fish to have free access to historical spawning grounds in Pennsylvania. This May 29, Safe Harbor Water Power Corporation, Baltimore Gas and Electric Company and the Pennsylvania Power anc Light Company will host a joint ceremony dedicating the lifts. Public "open house" at each facility will begin several days after the dedicatio ceremony. Tours of the Safe Harbor fish lift and public viewing windov and the Holtwood fish lift will be conducted throughout the migratory season (April-June). Tour registrations for each facility can be made b contacting Karen Chandler, Safe Harbor Water Power Corporation at (717) 872-0204, and the Pennsylvania Power and Light Holtwood Lanc Management Office at (717) 284-2278. Fishing access within the Safe Harbor project will continue to be prohibited until structural damage t the skimmer wall from the January 1996 flood is repaired.

In the early nineteenth century, American shad were one of the most valued commodities for commerce and daily living in the Susquehanna River Basin. Numerous commercial fisheries operating in the basin recorded annual landings in the thousands of pounds. The sheer numbers of shad migrating up the Susquehanna from Chesapeake Bay seemed inexhaustible. In the mid-nineteenth century, the construction of feeder dams for the Pennsylvania canal system and wate supply dams blocked migrations to most of the upper basin and tributaries. Diminishing water quality from deforestation, coal mining, and industrial and agriculture development; riparian encroachment from urbanization; and overfishing also impacted fish numbers. Public concern over tl depletion of shad and other fishes increased and prompted an 1866 act by the Pennsylvania Legislature establishing the precursor to the present day Pennsylvania Fish and Boat Commission (PFBC).

The final demise of shad and other migratory fishes in Pennsylvania's Susquehanna River came with the construction of four large hydro-electric dams on the lower Susquehanna in the early 20th century. Although one of the first dams constructed (Holtwood) was equipped with fish passage facilities, the design failed to pass shad. As a result, fisheries experts conceded that fish passage was not feasible with the technology available at that time.

The completion of Conowingo Dam just below the Pennsylvania-Maryland border in 1928 completely blocked access to the Susquehanna Basin in Pennsylvania and New York. The seemingly inexhaustible resource and important part of the heritage of Pennsylvania was lost.

In the mid-20th century, water quality and the development of fish passage technology had improved to the point that restoration of shad was determined feasible. During the last four decades, the PFBC along with other federal and state resource agencies and private interests, have worked cooperatively with the utility companies that own the hydroelectric dams to restore American shad and other migratory fishes. Since 1970, the power companies have provided vital funding for the restoration research through a series of cooperative agreements with the resource agencies. These efforts ultimately resulted in establishment of a population of American shad once again imprinted to the Susquehanna Basin.

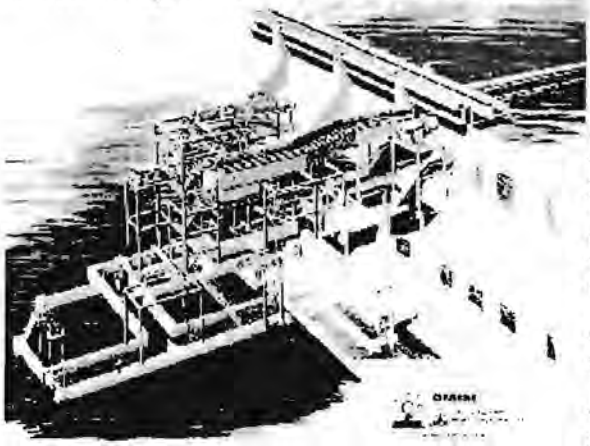


The permanent fish passage facilities now in place at Holtwood and Safe Harbor Dams resulted from an historic agreement signed in 1993 by the governors of Pennsylvania and Maryland, along with utilities, fisheries agencies and public fishing interests. The agreement also provided for fish passage at York Haven Dam by 2000. Fish passage facilities at Conowingo Dam began operation in 1991 under a separate agreement. In addition, the PFBC has secured an agreement in principle with the Pennsylvania Department of Conservation and Natural Resources that calls for the construction of permanent fish passage facilities at the Fabri Dam in Sunbury. With the completion Susquehanna River fish passage projects, over 500 miles of large river habitat will be open to migratory fishes. Hundreds of additional miles of tributary habitat will be restored through smaller fish passage and habitat restoration projects funded by the EPA Chesapeake Bay Program and administered by the PFBC.

Other activities continue. The PFBC is conducting bio-monitoring studies to track shad populations and distributions. Juvenile shad and pre-spawn river herring are stocked throughout the basin to establish populations imprinted to specific waters. Studies have demonstrated that turbines at Safe Harbor and Conowingo dams allow exceptionally high survival of juveniles migrating downstream. Holtwood Dam, however, will be testing a bypass system that will allow out-migrating juveniles downstream passage without going through the turbines. Safe Harbor Water Power Corporation use

material excavated for fish lift construction to stabilize stream banks along the Conestoga River, Lancaster County. Tributary fish passage and habitat restoration projects are restoring free-flowing river conditions through the breaching and removal of non-beneficial low-head dams.

American shad restoration is working. The number of adult shad returning to the Susquehanna to spawn has increased dramatically in recent years. In the early 1970s, only about a hundred shad wer captured annually at Conowingo Dam. Since 1994, the number of adult shad captured at the Conowingo fish lifts has averaged 45,000. Marking studies have determined that the majority of thes were produced by the Commission's Van Dyke Hatchery and stocked into the Susquehanna Basin. Others are the decendents of pre-spawn adult shad collected at the Conowingo lift each spring and released upstream of York Haven Dam.



Restoration is currently managed under the auspices of the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC), whose membership includes the Pennsylvania Fish and Boat Commission, U. S. Fish and Wildlife Service, National Marine Fisheries Service, Marylan Department of Natural Resources, New York Department of Conservation, and the Susquehanna River Basin Commissior Additional support for the restoration has been provided by the Pennsylvania Department of Environmental Protection, Alliance for the Chesapeake Bay, Chesapeake Bay Foundatio and numerous fisheries interests. The program to restore American shad to the Susquehanna River is one of the largest of its kind ever envisioned and has been a model of persistence, cooperation and long-term commitment. The ultimate goal is to restore an annual population of two million American shad and 15 million river herring to the Susquehanna River Basin. The restoration of American shad and other migratory fishes to the Susquehanna will provide enormous angling opportunities and other economic benefits to the citizens of Pennsylvania.

R. Scott Carney is a fisheries biologist in the Commission Division of Research Anadromous Fish Restoration Unit.

Using funding provided by the U. S. Environmental Protection Agency's Chesapeake Bay Program, the Pennsylvania Fish and Boat Commission is providing fisl passage and habitat restoration on major tributaries to the Susquehanna River through the breaching and removal of non-beneficial dams. Environmental effects associated with constructing dams and impounding streams include prohibiting the migratory movements of fish, sediment deposition, formation of nutrient traps and reduction in the levels of dissolved oxygen. In addition, many low-head dams create a dangerous hydraulic that poses a hazard to anglers and boaters. Breaching and removing non-beneficial dams restores the structure and function of the riverine ecosystem and eliminates potential safety hazards. At dams that serve a functional purpose, the Commission is negotiating with the dam owners for fish passage through the construction of permanent fishways or "fish ladders Fishways provide passage over the dam without compromising those benefits the dam provides. However, damaging environmental effects of impounding the river and public safety issues remain unaddressed.

Fish Restoration and Passage on the Susquehanna River is the title of a 16-page full-color publication that explains in detail the history of Susquehanna River migratory fishes, the reasons for their demise, and the efforts to restore their populations. The publication was a cooperative effort among the PA Fish & Boat Commission, U.S. Fish & Wildlife Service, Susquehanna River Basin Commission, PA Department of Environmental Protection, Chesapeake Bay Foundation, and the Alliance for the Chesapeake Bay. It appeared initially as an addition to the February 1996 PA Angler. For a free copy, send a request to: Publications Section, PA Fish & Boat Commission, P.O. Box 67000,

Harrisburg, PA 17106-7000.

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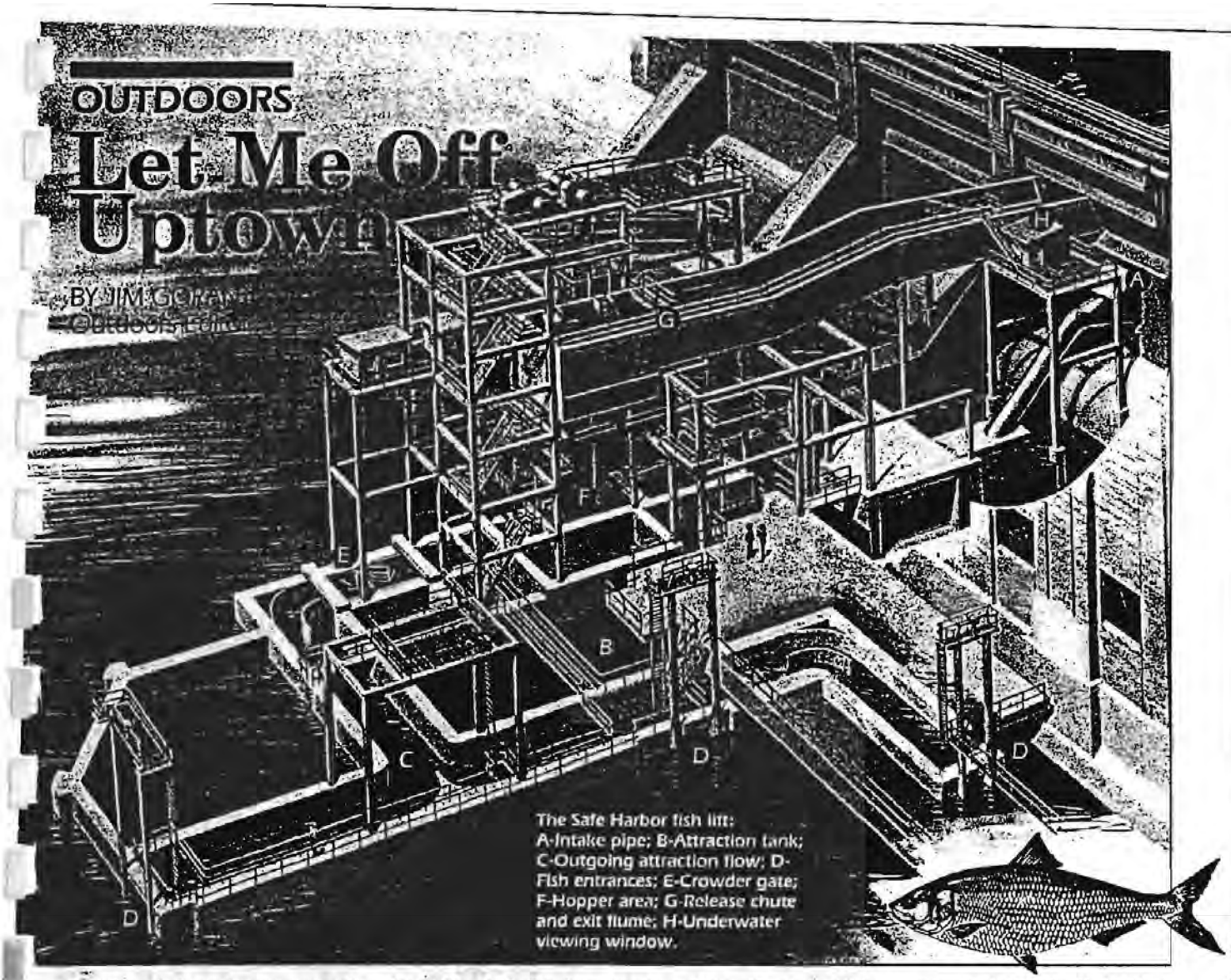
OUTDOORS

Let Me Off Uptown

BY JIM GORANT
Outdoors Editor



The Safe Harbor fish lift: A-Intake pipe; B-Attraction tank; C-Outgoing attraction flow; D-Fish entrances; E-Crowder gate; F-Hopper area; G-Release chute and exit flume; H-Underwater viewing window.

● After six long, boring speeches, the seventh speaker opens with this: "I feel like Mickey Rooney on the day of his seventh wedding. When someone asked him if he was nervous about his wedding night, Rooney said, 'No, I know what to do, I just don't know if I can make it interesting.'"

If the speech is any indicator, by morning Rooney had yet another disappointed bride on his hands. By the third paragraph, I've given up on speechmakers and wandered off to investigate the real reason a small crowd has gathered along the Susquehanna River. We have all come to Conestoga, Pennsylvania, for the dedication of a brand-new fish lift at the Safe Harbor hydroelectric dam.

From the base of the dam, I watch as a giant hopper filled with dozens of fish rises out of the water. Once the lift reaches the top of the dam, the fish will be released into spawning grounds that have been closed to them for 85 years. I'm thinking, "That's a helluva long time to go without spawning."

Biology

There is something in nature that does not love a wall. On the Susquehanna, the Safe Harbor dam is nothing if not a wall, standing 75 ft. high, 84 ft. wide, and stretching some 5000 ft. across the river. The "something" is the American shad, a native fish that dominated the river for hundreds of years. Like salmon, shad are anadromous, which means they migrate from fresh water to salt water and back. Dams make such journeys impossible.

Under normal circumstances, shad head upriver between early April and mid-June, depending on light, water flow and water temperature. Once they identify their home stream, which they sense using a genetically encoded memory of the exact water chemistry, the females will lay between 200,000 and 300,000 eggs. Only 1 to 10% of those offspring will survive the summer, and in October, when they're about 4 in. long, they'll migrate downstream and out to sea. Three to five years later, at their full-grown size of 4 to 8 pounds, the shad will instinctively return upriver to spawn and die.

In 1896, at the height of the Susquehanna shad fishery, more than 140,000 shad were netted along the river. But between 1904 and 1932, utility companies built the Safe Harbor dam and three other dams—the Connowingo, Holtwood and York Haven—on the lower Susquehanna. Despite the inclusion of rudimentary fish passes, by 1921 the shad had disappeared from the river.

Mechanics

Since around the time Samuel Clemens became Mark Twain, sixth-grade science books and fifth-rate documentarians have been portraying America's rivers as its vascular system, a network of ducts and arteries that transport an essential fluid. If that's the case, then our dams are artery-clogging wads of cholesterol. With four such blockages, the Susquehanna—and its shad—are particularly hard hit.

In the early '70s, when the decision was made to restore shad, administrators executed the fisheries-management equivalent of bypass surgery. Since there were almost no shad that still returned to the Susquehanna, upstream tributaries were stocked with hatchery-raised fry. The returning fish were then trapped below the Connowingo Dam, the southernmost of

PRODUCT SYSTEMS INTERNATIONAL/WHITNEY HARKLEROAD ILLUSTRATION; CHESAPEAKE BAY FOUNDATION ILLUSTRATION (FISH)

the four, and transported upstream by truck. After several false starts, the program eventually took hold, and the number of fish returning to the river jumped from about 300 a year in 1972 through 1984 to more than 60,000 in 1995.

Encouraged by these numbers, the Shad Restoration Partnership initiated the construction of fish lifts at the three lower dams and fish ladders at York Haven. In comparison to the initial effort, these methods were more like angioplasty than full-blown heart surgery. After the Connowingo lift was completed in 1993, Holtwood and Safe Harbor followed suit, and both opened fish lifts earlier this year. The key to their success lies in knowing a lot about the fish.

Shad, like most migratory fish, instinctively know that faster-moving water usually follows the most direct path downstream, so they seek out and swim against the strongest available current. Lift operators can attract fish into the system by providing the appropriate current for them to swim against. On the Susquehanna, the rate of current, or attraction flow, that seems to bring in the most fish is about 5 ft. per second (fps).

In order to control the attraction flow, the Safe Harbor dam has a 72-in. intake pipe on the front, or "bay," side of the dam that funnels water into a large central pool called the attraction tank. The intake pipe has a gate system that can vary the flow from 300 cu. fps to as much as 1000 cu. fps depending on bay elevation, tail-raise elevation and river conditions.

From the attraction tank, water flows out of three open channels into the river at the predetermined rate of 5 fps. Once the fish sense the attraction flow, they follow it into the lift system until they pass through a gate and enter the crowder area. At preset intervals, the gate closes and forces the fish into a small area above the hopper. A 75-hp electric motor raises the hopper 80 ft. on a system of pulleys and cables. With a full load of several hundred fish and 5000 gallons of water, the lift's total payload is about 27 tons.

When it reaches the top, both water and fish are released out a chute into an exit flume, which also has a 5-fps flow rate to keep the fish swimming in the right direction. As the fish exit, a marine biologist stationed at a below-surface window classifies and counts them. The cycle time—or the time it takes the hopper to rise, unload and return—is only 5 minutes, which means it can transport 1.25 million fish during the spawning run, according to the lift's operators.

Paradox

The Safe Harbor dam converts the flow of water into as much as 417,500 kilowatts of power, providing electricity for approximately 167,000 homes. At the same time, the dam interrupts nature's cycles. It keeps fish from their appointed rounds. By slowing the river down, it allows silt to build up, and lets runoff collect, polluting the river and spurring algae growth.

In its attempt to fix some of these problems, the Shad Restoration Partnership has spent $50 million since 1971 trying to cure the problems of technology by creating more technology. But while the fish lifts represent a groundbreaking alliance between government agencies, corporations, and environmental and sportsmen's groups, the preliminary results are mixed. With two weeks left in the spawning season, 62,000 shad had passed through the Connowingo lift, and 24,000 of those had continued on past Holtwood, but only 16,000 of those had gone through Safe Harbor. Officials are hopeful that these numbers will continue to rise, but no one is quite sure of what to do if they don't.

It would be comforting to think that we can make "something" and "wall" a bit more neighborly, but when it comes to man-made boundaries, nature has a way of not giving a damn. PM

FISH PASSAGE RESTORATION

- Background
- River and Stream Blockages
- Fish Passage Goals

IMPORTANT TERMS

- anadromous
- catadromous
- estuary
- brackish

SEE ALSO

- Little Falls Dam Fishway Project
- Holtwood / Safe Harbor Fishway Projects (coming soon!)

Background

Anadromous fish migrate from the ocean to spawn in freshwater tributaries. Seven major species of anadromous fish swim in the Chesapeake Bay watershed: American shad, hickory shad, alewife, blueback herring, white perch, striped bass and yellow perch. They spend the majority of their adult lives in the salt water of the Atlantic Ocean or the estuarine Chesapeake Bay. However, when the water temperature begins to rise in the spring, the fish migrate into their freshwater natal streams to spawn. Catadromous fish, such as the American eel, migrate in the reverse direction. Spawning runs for anadromous species can begin as early as February and may last through June. After the adults have finished spawning, they return to saltier waters for another season. The eggs remain in the tributaries of the Bay until they develop into juveniles. In the fall, triggered by a decrease in water temperature and change in daylight, most of the juveniles begin their down-run into more brackish water. The amount of time they spend in the Bay before moving on to the ocean depends on the species. Some species spend their entire lives in the estuary system and move between fresh and brackish water.

River and Stream Blockages

In addition to the critical role that they play in the overall health of the ecosystem, the anadromous fish of the Chesapeake Bay were once the basis for a huge fishery throughout the watershed. Fisherman caught millions of anadromous fish each year. Now, these species are almost nonexistent in the upper reaches of the watershed because many of its streams and rivers are blocked by dams, road culverts, bridge aprons and other structures. More than 2,500 blockages in the watershed keep anadromous and other migratory fish from reaching historic spawning grounds. As a result, the natural reproduction of American shad, in particular, remains low. Currently, stocking programs conducted by the states in the watershed help to restore the shad population in Chesapeake Bay.

Between 1976 and 1985, the commercial harvest of anadromous fish in the Chesapeake Bay declined by 82 percent. Virginia and Maryland have placed moratoriums on several of these species in an effort to reduce the fishing pressure, but the tributary spawning habitat still must be restored.

These blockages, in conjunction with habitat degradation and the pressure of over-fishing, have caused a serious decline in anadromous fish populations. Unless these fish can return to their natural spawning grounds, their populations will continue to decline.

Fish passages are man-made structures designed to enable anadromous fish to bypass these blockages and return

upriver to spawn. There are five major designs of fishway structures used in the Chesapeake Bay watershed: Denil, steeppass, vertical slot, pool and weir and fish lifts. Blockages also can be removed, notched, or breached, particularly if the dam is small or in disrepair.

The life history of the target species must be considered and biological characteristics when designing a fish passage. For example, it is important to know:

- Which species are likely to be found in a particular tributary or at that particular blockage;
- The swimming capabilities of the species, in order to avoid exhausting the fish;
- What water velocity will attract a fish to a fishway without inducing it to spawn halfway up the fishway;
- In which part of the river the fish are likely to be found; and
- How many fish will need to pass the blockage and use the fishway.

The Chesapeake Bay Program and its Fish Passage Workgroup work very closely with biologists and hydraulic engineers who consider all of these factors when choosing a fishway design for a particular impediment.

Fish Passage Goals

Fish passage goals established in 1993 direct Bay Program signatories to open 731 stream miles by 1998 and more than 1,356 miles by 2003. At the end of 1998, 523.5 miles were opened and accessible to migratory fish and 121.5 miles were opened but not yet accessible to migratory fish. Although significant progress was made in 1998, accomplishments fell short of reaching the five-year mileage goal set by the Executive Council. Some of this shortfall is made up in stream miles that were reopened but are not yet accessible to migratory fish because of downstream blockages. These miles eventually will convert to anadromous fish usage and contribute toward Bay Program goals. The 1998 goal will be achieved by the end of 1999 and the fish passage workgroup remains on schedule to achieve the 2003 goal.

Major projects to open the four largest dams in the Bay region–all located on the Susquehanna River–began in 1991, when Conowingo Dam's fish lift opened. Fish elevators at Safe Harbor and Holtwood dams–the largest-capacity fish lift operations in the nation–opened in 1997. The final project, a fish ladder at the York Haven hydroelectric facility, is scheduled to provide fish passage in the spring of 2000. This ladder will open more than 400 miles of mainstem and major tributaries to migratory fish. In 1998, the last of five dams on the James River was breached. A vertical slot added at Bosher's Dam opened the river from Richmond to Lynchburg. In some locations, such as tributaries throughout Pennsylvania, it is easier to remove the dam rather than construct a passageway. The fishway at Little Falls Dam on the Potomac River is another large project for the watershed; its proposed completion in 2000 will open 10 miles of good spawning habitat.

What YOU can do:

- Help clean and maintain fish passages.
- Encourage your local and state governments to facilitate construction of fish passages.
- Remove old dams that are no longer used and are on your property.
- Support strong management actions to allow stocks to increase and prevent over-fishing.

To bookmark this page, please use this URL: http://www.chesapeakebay.net/fishpass.htm

For more information, contact the Chesapeake Bay Program Office:
410 Severn Avenue, Suite 109, Annapolis, MD 21403 / Tel: (800) YOUR-BAY / Fax: (410) 267-5777 .

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Print

FISHWAY DESIGNS

- DENIL
- STEEPPASS
- VERTICAL SLOT
- POOL AND WEIR
- FISH LIFT

CLOSE WINDOW

These are five major designs of fishway structures which are used in the Chesapeake Bay watershed. Notching, breaching, and removing the dam are also options, especially when a dam is small or in disrepair. These fishways are all designed to provide the optimal water velocity and water depth to allow the fish to efficiently pass the obstacle. Since these obstacles range from twelve inches to ninety feet high, the fish passage designs vary a great deal.

FISHWAY DESIGNS

- DENIL
- STEEPPASS
- VERTICAL SLOT
- POOL AND WEIR
- FISH LIFT

CLOSE WINDOW

A Denil fishway is a series of sloped channels which allow the fish to swim over the dam or obstruction. Wooden baffles are placed at regular intervals within the channels to slow the velocity of the water. There are resting pools between each section of the fishway to conserve the energy of the migrating fish. The slope and length of the fishway are carefully calculated, taking into consideration the swimming ability of the predominant species at the site. The angle and velocity of the attractant flow leaving the entrance chamber at the base of the dam are very important to assist the fish in finding the fish passage. Denil fishways are probably the most common fishway design used in the Chesapeake Bay watershed.

FISHWAY DESIGNS

- DENIL
- STEEPPASS
- VERTICAL SLOT
- POOL AND WEIR
- FISH LIFT

CLOSE WINDOW

Steeppass fishways are very similar to Denils. They are also sloped channels passing over the obstruction, but usually have only one upward sloping section. These also have baffles to slow the water, though of a somewhat different design. This type of fishway would normally be used for a relatively small blockage, so that fish would not require a resting pool during the climb.

FISHWAY DESIGNS

- DENIL
- STEEPPASS
- VERTICAL SLOT
- POOL AND WEIR
- FISH LIFT

CLOSE WINDOW

The vertical slot fishway is basically a variation on the pool and weir design. It is also a series of pools, but two baffles are placed at the entrance to each pool, leaving a narrow vertical slot for the fish to pass through. This serves to concentrate the flow of water leaving the pool. However, the water in each of the pools is calm enough to allow the fish to rest. When utilizing this type of fishway, it is important to consider the size of the fish prevalent at the blockage to ensure that they will be able to fit through the slot easily.

FISHWAY DESIGNS

- DENIL
- STEEPPASS
- VERTICAL SLOT
- POOL AND WEIR
- FISH LIFT

CLOSE WINDOW

A pool and weir fishway is a series of pools in step formation ascending the dam. It is critical that sufficient water be flowing over the "steps" so that the fish are not required to jump from one level to the next, but rather can swim up the stream of water. The water in each of the pools is generally calm enough that the fish can rest if necessary.

FISHWAY DESIGNS

- DENIL
- STEEPPASS
- VERTICAL SLOT
- POOL AND WEIR
- FISH LIFT

CLOSE WINDOW

A fish lift or fish elevator is generally only used at very large obstructions, such as the 90 foot high Conowingo hydroelectric dam on the Susquehanna River. In this design, an attractant flow of water guides the fish into a large hopper, which then raises the fish over the dam. At the top of the dam, the fish can either be released into the river or transferred into holding tanks to be transported to another tributary for stocking.

Tales from the river

For some countries in the northern hemisphere, fish provide both a source of leisure and livelihood. Salmon fishing in the rivers of Scotland and Ireland, for example, becomes an annual pilgrimage for anglers and fish alike. Having faced criticism in the past, hydropower companies realise that they need to ensure that their operations do not cause environmental damage on fish stocks that, in turn, affect the livelihood of local communities.

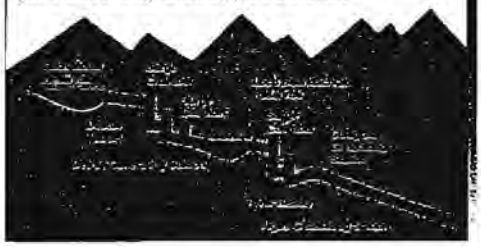
North America, Scotland, Ireland and Scandinavia are all major users of hydroelectric power. To varying degrees and over different time spans, these countries have become aware that hydro power projects can seriously harm fish populations.

The implementation and effectiveness of measures that protect fish populations is due in no small part to the relative importance of fishing - both commercially and for leisure - to areas where hydropower is exploited.

Ireland, for example has legislation dating back to the mid 19th century. This placed a responsibility on dam owners to provide a fish pass for the free passage of salmon, trout and eels at all times and more recent legislation has updated these requirements.

Hydro-Electric, whose operations are based mainly in Scotland, has recently published a major study on the way in which hydro electric development in Scotland has affected fish populations. The main author of the study is Gordon Struthers, an independent fishery consultant with 35 years experience in the field. The aim of this review has been to take a detailed look at the diverse factors that impact on fish populations, individual hydro schemes and outline current research and initiatives to mitigate the effects of hydropower developments.

Typical hydroelectric generation layout, part of Affric/Beauly, Scotland.



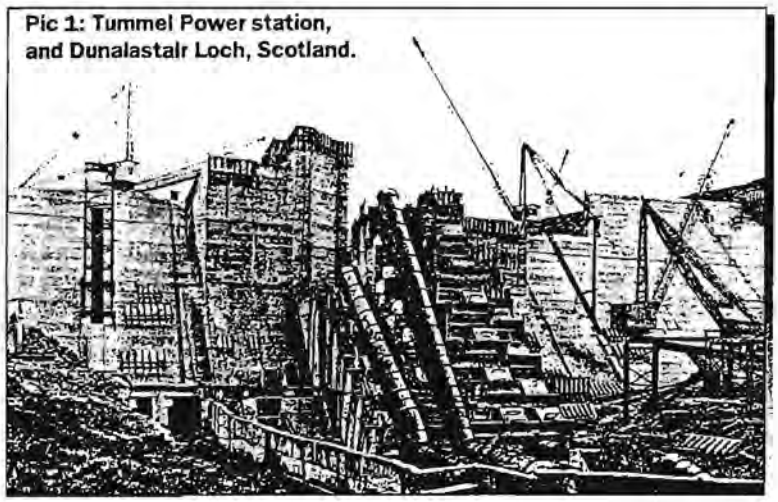
Clear obligations

The 1989 Electricity Act places an obligation on power companies operating in Britain to avoid 'so far as possible, causing injury to fisheries or to the stock in any waters.' Scottish salmon, because of its recreational and economic value, has become the main priority for protection in rivers harnessed for hydroelectric development in Scotland.

There are two stages during the life cycle of the migratory salmon and sea trout that can be harmed by hydroelectric development - juvenile freshwater phase and on their return to fresh water to spawn.

Hydro-Electric and its predecessors in Scotland have addressed issues important to salmon development in collaboration with District Salmon Fishery Boards. This is to mitigate or eliminate detrimental effects on fish stocks. Millions of pounds were invested in schemes to ensure that salmon reached their natural spawning grounds during the massive power stations of the 1940s and 50s, for example.

Pic 1: Tummel Power station, and Dunalastair Loch, Scotland.



Suspicion

But despite these measures, it has been hard to reconcile the need for hydroelectric schemes with the interests of the angling fraternity. Many anglers watched favourite pools and rivers disappear under the reservoirs of the hydro schemes, and even after 40 years or more there is still widespread suspicion that salmon stocks have been damaged irreparably by this development.

This concern, combined with the need with scientific study into brown trout and other salmonid fishes in Scotland, led to the North of Scotland Hydro-Electric Board (NSHEB) with the Scottish Home Department (SHD) setting up the Brown Trout Research Laboratory at Pitlochry in 1948. By 1995 this organisation was under the responsibility of the Scottish Office Agriculture, Environment and Fisheries Department (SOAFED).

Over the years, the emphasis has moved towards salmon rather than trout. NSHEB has consulted the now named Freshwater Fisheries Laboratory particularly over issues of the effects of hydro development on fish stocks. In addition, NSHEB has, since the late 1950s, had its own laboratory that provided research into problems associated with hydro developments. Although the work was mainly associated with engineering factors, considerable research into fish was also pursued, including the development of fish counters and studies on smolt swimming speeds and behaviour in connection with turbine intakes and screening.

Protection

One way of offsetting losses was to create hatcheries. NSHEB set up several including those at Pitlochry, Contin and Invergarry to provide eggs and fry to augment natural stock.

As animals move away from home territories, so their vulnerability increases. One of the main areas of concern is the protection of the salmon during the smolt migration. this includes passage through reservoirs which may contain predators such as pike and trout. In order to alleviate this problem in the past, Hydro-Electric has commissioned the removal of such predators by netting.

One of Hydro-Electric's main responsibilities for fish protection during downstream migration is the provision of smolt streams at

the intakes to high head turbines. Presently, mechanical screens with internal mesh dimensions of 25mm (horizontal) by 12.5mm (vertical) are required for smolts. Smaller mesh screens (12.5mm by 12.5mm) for parr have been tested but are seldom used in practice.

Until recently, smolt screening at low head intakes was considered unnecessary as it was believed the type of turbine normally used (Kaplan) - generally with only four runner blades and substantial spacing between them, was unlikely to cause significant damage. The conclusions from two small studies at Pitlochry and Morar Power Stations in the early 1950s supported this belief. More recent studies, however, indicated that the passage of smolts through some low head stations may result in higher damage and fatalities than first realised.

While the placement of small mesh screens at intakes prevents the entry of smolts into high-head turbines, smolt mortalities have occurred due to excessive water velocities through the screens, resulting in smolts being drawn onto them. This situation occurs where the screened areas is either too small or is reduced through thrashing (an accumulation of water-borne debris).

An example of this was observed at Dunalastair during the 1950s when a substantial smolt kill occurred due to the combination of high generation and restricted sievage through the screens. This problem was resolved by modifying the aqueduct downstream from the intake by creating a 'smolt basin' a much deeper and wider area, into which the screen array is set. This increased screening area is designed to ensure that the velocities through the screens do not exceed 30cm/sec, the maximum speed at which salmon smolts have been found to be able to maintain position for long periods.

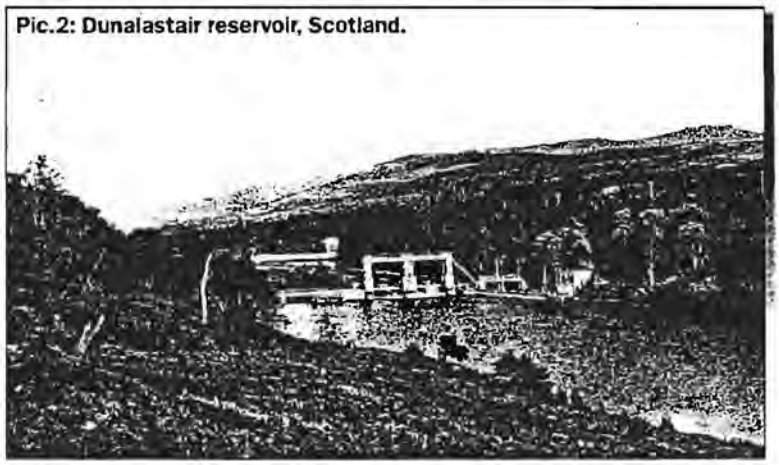
Better monitoring

With today's technology, problems can be predicted by routinely monitoring water levels immediately upstream and downstream from screen arrays. If a significant head loss across the screens is observed, especially during the smolt migration period, this should provide early warning of a potentially hazardous situation.

Screens are required not only to prevent the passage of smolts into hazardous areas, but also to divert them towards an alternative safe bypass route such as a fish pass. In the case of Dunalastair the screen array is aligned diagonally to encourage the fish to move towards an overspill gate which leads them into a settling pool and from there down a smolt chute back into the river.

Downstream migrating kelts must also be prevented from passing through turbines but, unlike smolts, this must apply to low head as well as high head stations. This is achieved by providing mechanical screens, usually heavy, vertically barred structures in which the maximum allowable clear spaces for salmon and sea through kelps are 5.0cm and 3.8cm respectively. In addition, the maximum approach water velocity should not exceed 75-90cm/sec.

Pic.2: Dunalastair reservoir, Scotland.



Fish passes

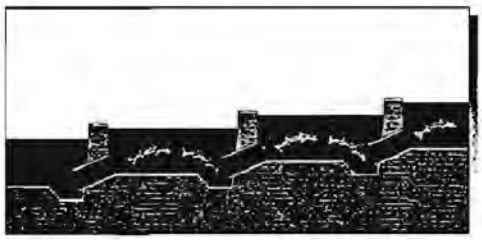
Fish passes are now an established way of allowing adult salmon and sea trout to migrate up to spawning grounds. The earliest such passes were constructed at weirs during the industrial revolution and at natural waterfalls. There are a number of types of such pass in use today. Pool and weir designs (also called the pool-pass, pool-and -traverse or plain fish ladder) are common, with studies recommending minimal pool dimensions and the provision of rest pools at regular intervals to reduce turbulence.

For these type of designs, it is important that the underwater orifices through which fish move between pools do not have water velocities that are beyond the swimming capability of the particular fish species.

Other major types of fish pass in use include the fish lift or Borland Fish Lock which operates on the principle of a canal lock. This design has two chambers, one at the reservoir end, the others in the base of the dam at tail-water level which are connected by a sloping or vertical shaft. At intervals, the bottom chamber is closed and the water level rises in the lock. Fish in the lock can swim up the shaft and out through an overspill gate in the upper chamber.

Other ways of protecting fish populations when hydro schemes are operating include the provision of compensation flows. These ensure that the habitats of juvenile salmonids and other aquatic life is protected and that there is sufficient water to provide holding pools for adult fish, even at low summer levels.

Pool-and-weir fish pass with underwater orifice.

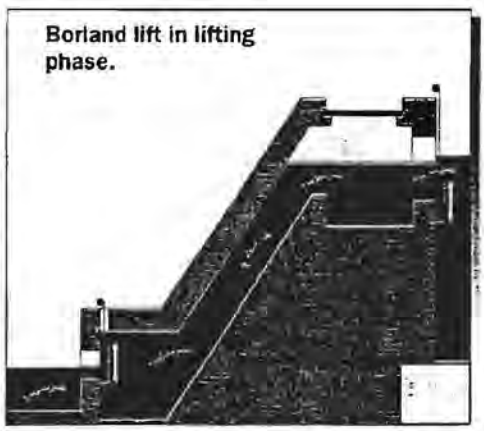


Accurate information

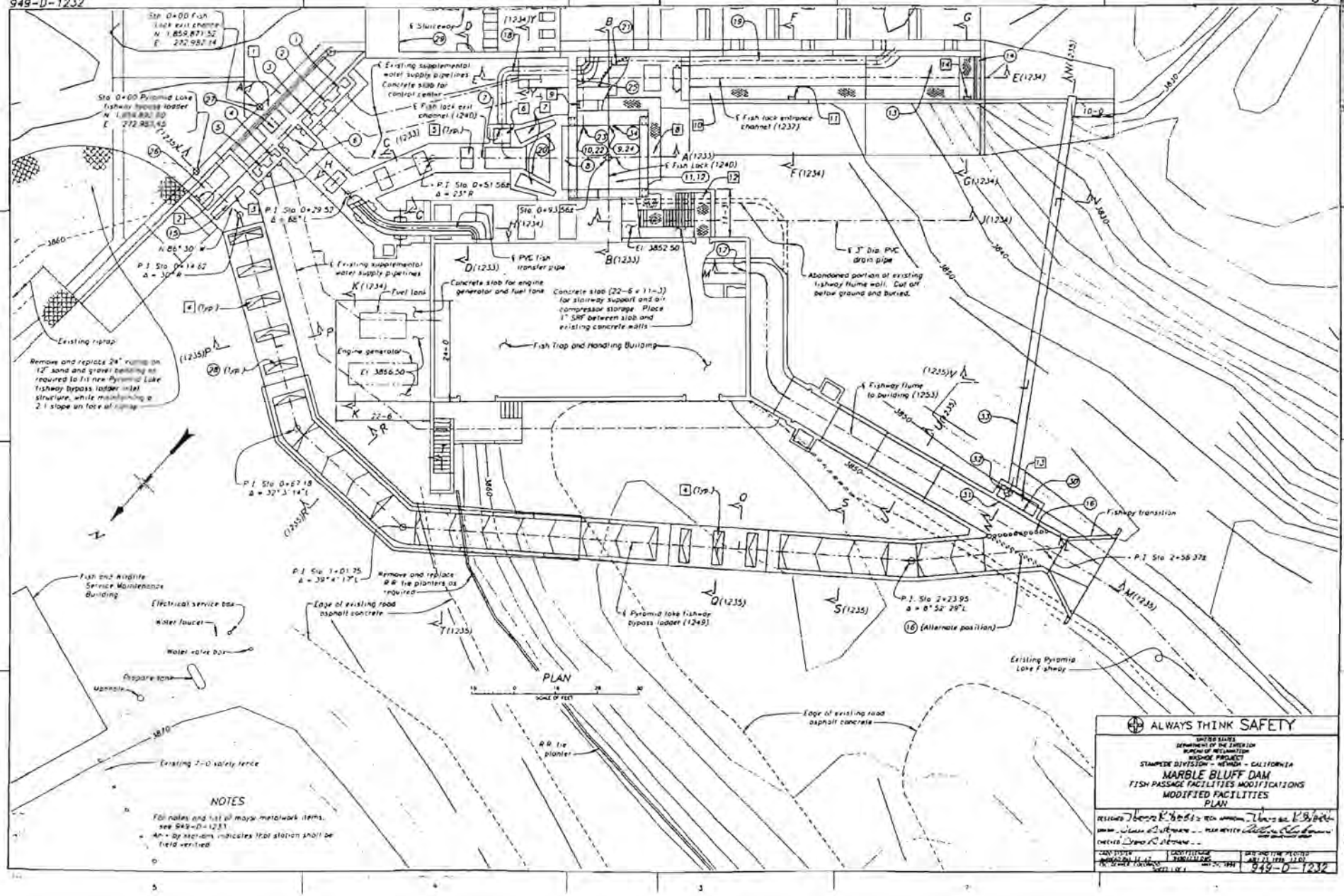
Scotland's experience is that it is important to have accurate information about fish populations and the impact of hydroelectric generation. Equally vital is to assess the effectiveness of mitigation schemes through regular monitoring and control. Other countries still do not have such systems in place which is a cause for continued concern and criticism.

Copies of the report at £5 each can be obtained from Corporate Communications, Hydro-Electric, 10 Dunkeld Road, Perth, Scotland, PH1 5WA, UK.

Borland lift in lifting phase.



949-D-1232


Sta. 0+00 Fish lock exit channel
N 1,859,871.52
E 272,952.14
Sta. 0+00 Pyramid Lake fishway bypass ladder
N 1,874,832.80
E 272,953.45
℄ Sluiceway
℄ Existing supplemental water supply pipelines
Concrete slab for control center
℄ Fish lock exit channel (1240)
℄ Fish lock entrance channel (1237)
℄ Fish Lock (1240)
P.I. Sta. 0+51.56
Δ = 23° R
Sta. 0+93.56
P.I. Sta. 0+29.57
Δ = 88° L
N 86° 30' W
P.I. Sta. 0+14.62
Δ = 30° R
℄ Existing supplemental water supply pipelines
℄ PVC fish transfer pipe
El. 3852.50
Concrete slab for engine generator and fuel tank
Fuel tank
Concrete slab (22-6 x 11-3) for stairway support and air compressor storage. Place 1" SRF between slab and existing concrete walls
℄ 3" Dia. PVC drain pipe
Abandoned portion of existing fishway flume wall. Cut off below ground and buried.
Existing riprap
Remove and replace 24" riprap on 12" sand and gravel bedding as required to fit new Pyramid Lake fishway bypass ladder inlet structure, while maintaining a 2:1 slope on face of riprap
Engine generator
El. 3856.50
Fish Trap and Handling Building
℄ Fishway flume to building (1253)
P.I. Sta. 0+67.18
Δ = 32° 3' 14" L
P.I. Sta. 1+01.75
Δ = 39° 4' 17" L
Remove and replace R.R. tie planters as required
Edge of existing road asphalt concrete
℄ Pyramid lake fishway bypass ladder (1249)
P.I. Sta. 2+23.95
Δ = 8° 52' 29" L
(16) (Alternate position)
Fishway transition
P.I. Sta. 2+58.37
Fish and Wildlife Service Maintenance Building
Electrical service box
Water faucet
Water valve box
Propane tank
Manhole
Existing 7'-0 safety fence
Existing Pyramid Lake Fishway
R.R. tie planters
Edge of existing road asphalt concrete
PLAN
SCALE OF FEET
NOTES
For notes and list of major metalwork items, see 949-D-1233.
* Mark by stations indicates that station shall be field verified.
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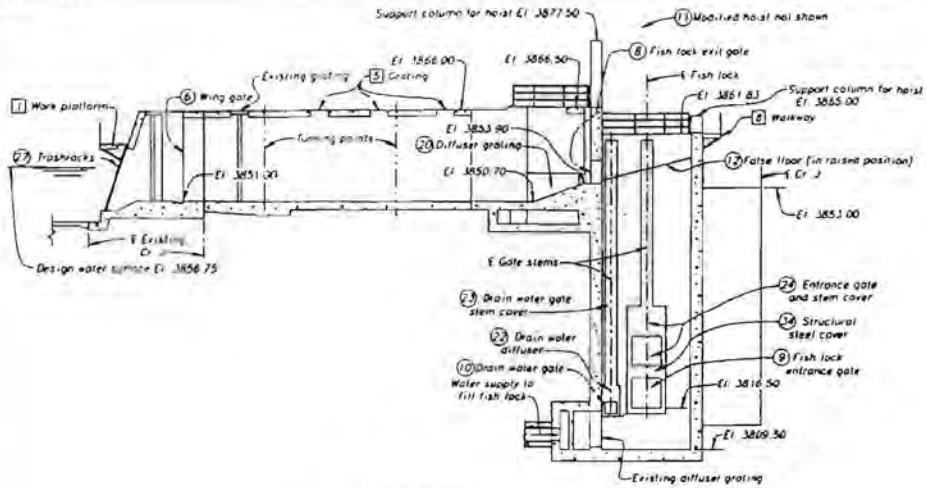
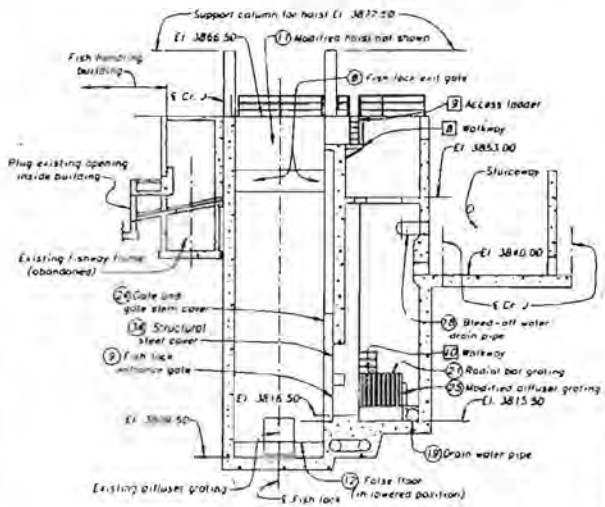
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
KLAMATH PROJECT
STAMPEDE DIVISION - NEWMAN - CALIFORNIA
MARBLE BLUFF DAM
FISH PASSAGE FACILITIES MODIFICATIONS
MODIFIED FACILITIES
PLAN
949-D-1232

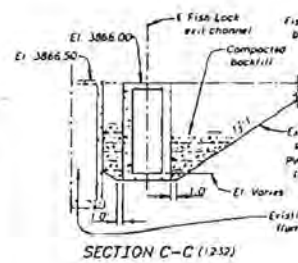


SECTION A–A (1232)

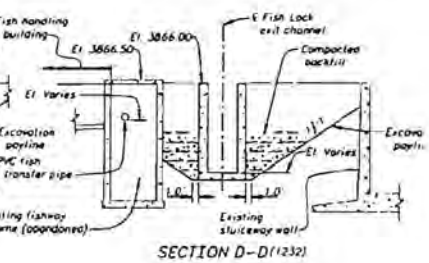
SCALE OF FEET 10 0 10 20 30



SECTION B–B (1232)



SECTION C–C (1232)



SECTION D–D (1232)

REFERENCE DRAWINGS

	949-D-
Fish Lock Entrance Channel – Construction Preparation	1236
Fish Lock Entrance Channel – Plan and Sections	1237
Fish Lock and Exit Channel – Removal of Existing Concrete	1238 and 1239
Fish Lock and Exit Channel – Plan and Sections	1240 thru 1245
Pyramid Lake Fishway Bypass Ladder Inlet – Removal of Existing Concrete	1247
Pyramid Lake Fishway Bypass Ladder Inlet – Plan and Sections	1248
Pyramid Lake Fishway Bypass Ladder – Plan and Sections	1249 thru 1252
Fishway flume to Building	1253 thru 1255

LIST OF MAJOR METALWORK ITEMS

The following metalwork items are integral to the operation for the fish passage facilities:

(1) – Existing 24-inch-diameter cast iron slide gate, with motor operator added under these specifications, supplies water for Fish Lock Entrance Channel.
(2) – Existing 24-inch-diameter cast iron slide gate with manual lift, to be abandoned.
(3) – Existing 24-inch-diameter cast iron slide gate, with motor operator added under these specifications, supplies water for filling the fish lock.
(4) – Existing 24-inch-diameter cast iron slide gate with manual lift, supplies water to the existing fish handling building.
(5) – Existing 24-inch-diameter cast iron slide gate with manual lift, supplies supplemental water for Pyramid Lake fishway.
(6) – Existing 5-foot wide wing gate with motor operator, is the headworks gate for fish lock exit channel.
(7) – New 24-inch by 24-inch cast iron slide gate with motor operator, is the control gate for the fish lock exit channel bleed-off water.
(8) – New 15-foot by 3-foot 9-inch slide gate with motor operator, is the fish lock exit gate.
(9) – New 60-inch by 90-inch gate with motor operator, is the fish lock entrance gate.
(10) – New 24-inch by 24-inch cast iron slide gate with motor operator, is the fish lock drain gate.
(11) – Existing 10-ton vertical fish sweep hoist modified to lift the fish lock false floor.
(12) – New fish lock false floor will guide fish to the fish lock exit gate.
(13) – New 10-foot by 3-foot Pneumatically operated gate will control fish movement into the fish lock entrance channel.
(14) – New 10-foot by 3-foot bulkhead gate with hand operated hoist, at downstream end of the fish lock entrance channel, will allow for dewatering the fish lock and fish lock entrance channel.
(15) – New 96-inch by 84-inch self contained cast iron slide gate with motor operator, is the headworks gate for the Pyramid Lake fishway bypass ladder.
(16) – New swing bar gate will direct fish up the Pyramid Lake fishway bypass ladder or the fishway flume to building.
(17) – Existing bulkhead gate at the entrance to fish handling building from the fishway flume to building.
(18) – New 24-inch-diameter welded steel pipe for the fish lock exit channel bleed-off water.
(19) – New 24-inch-diameter welded steel pipe for the fish lock drainage system.
(20) – New diffuser grating for the fish lock exit channel bleed-off water.
(21) – New radial bar grating to guide fish from the fish lock entrance channel into the fish lock.
(22) – New diffuser grating to cover the fish lock drain gate.
(23) – New metal plate to cover the fish lock drain gate stem.
(24) – New metal plate to cover the fish lock entrance gate and gate stem.
(25) – Modified diffuser grating on opening for supplemental water to the fish lock entrance channel.
(26) – New trashracks at the Pyramid Lake fishway bypass ladder headworks.
(27) – New trashracks at fish lock exit channel headworks.
(28) – New stalled weirs for the Pyramid Lake fishway bypass ladder, 27 required.
(29) – Existing 20'-0" by 12'-0" sluiceway radial gate.
(30) – New adjustable weir blade for skimming weir.
(31) – New diffuser grating for skimming weir.
(32) – Existing 8" gate valve reinstalled to drain fishway flume to building.
(33) – New 24" dia. CMP skimming water drainpipe.
(34) – New structural steel cover over future 5'-0" by 5'-0" gate opening.

The following metalwork is not considered integral to the operation of the fish passage facilities but is required for general operation and maintenance:

[1] – Platform for cleaning existing and new trashracks on the headworks structure.
[2] – Access ladder to cleaning platform.
[3] – Pedestrian grating on opening for the Pyramid Lake fishway bypass ladder headworks gate.
[4] – HS20 grating for openings over Pyramid Lake fishway bypass ladder weirs, 8 required.
[5] – HS20 grating for openings in covered portion of fish lock exit channel, 3 required.
[6] – Pedestrian grating over fish lock exit channel bleed-off water gate sump.
[7] – Pedestrian grating over fish lock exit channel bleed-off water sumps.
[8] – The 3-foot wide metal walkway around top of fish lock chamber.
[9] – Ladder for access to metal walkway around top of fish lock chamber.
[10] – The 3-foot wide metal walkway along the fish lock entrance channel.
[11] – Access ladder to the metal walkway along the fish lock entrance channel.
[12] – New metal stairway system.
[13] – Pedestrian grating for fishway flume to building skimming weir.
[14] – Access ladder from metal walkway to top of stoplog gate.

NOTES

The concrete outlines shown on 949-D-1232 thru 1235, which identify major features and show earthwork details, are a depiction of the facilities after all modifications have been completed.
For plan of existing facilities before modifications and a list of information drawings, see 949-D-1231.
All contours shown are approximate existing contours.
All three rail guardrail shown is pictorial. See detail drawings for exact location of guardrail and spacing of vertical posts.

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UNITED STATES
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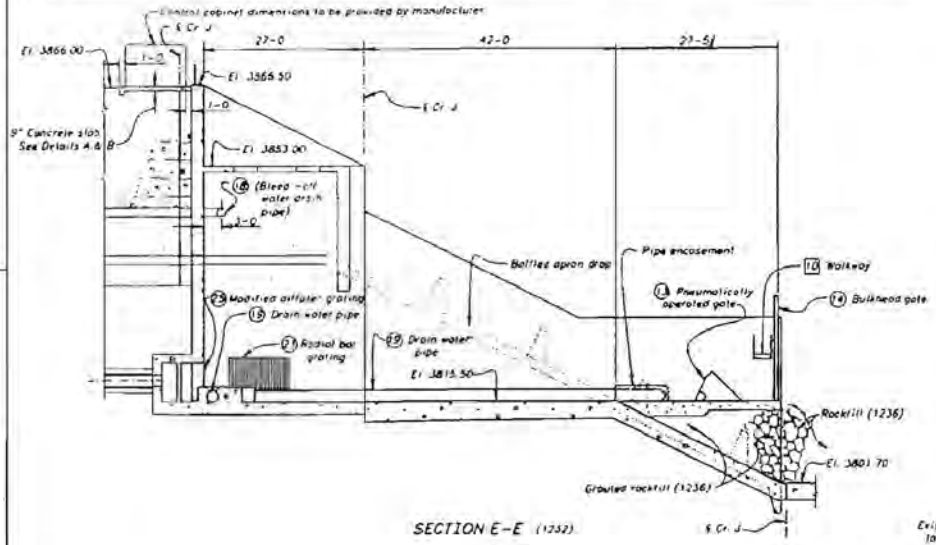
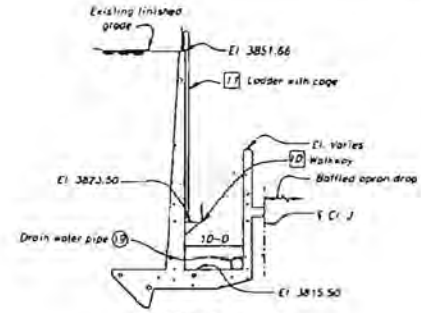
MAGNOR PROJECT
STAMPEDE DIVISION – NEVADA – CALIFORNIA

MARBLE BLUFF DAM
FISH PASSAGE FACILITIES MODIFICATIONS
MODIFIED FACILITIES
SECTIONS AND LIST OF MAJOR METAL WORK ITEMS

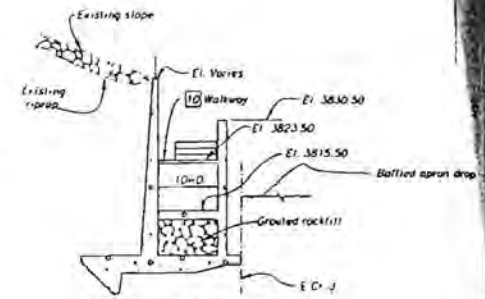
DESIGNED
DRAWN
CHECKED
DATE STATE
DATE FILE
949-D-1233



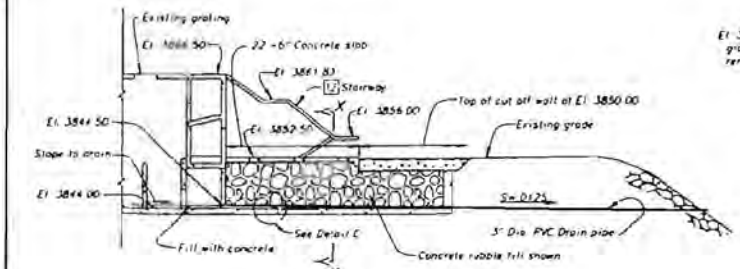
SECTION E-E (1232)



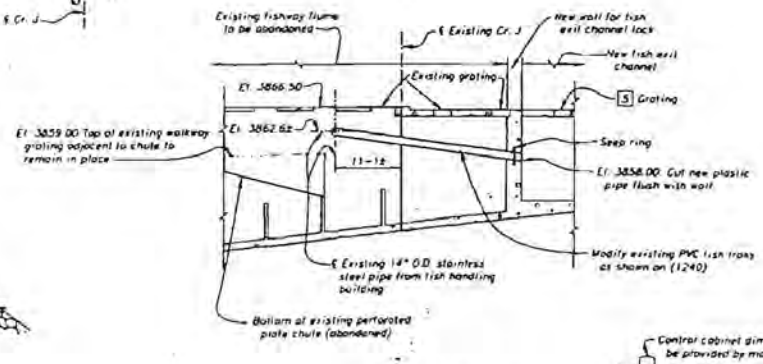
SECTION F-F (1232)



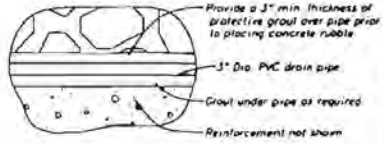
SECTION G-G (1232)



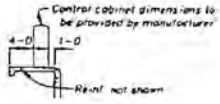
SECTION J-J (1232)



SECTION H-H (1232)



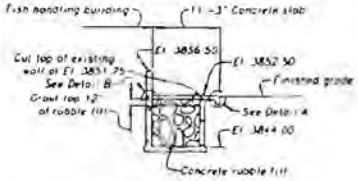
DETAIL C



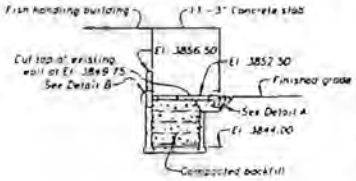
SECTION Y-Y (1232)

NOTE

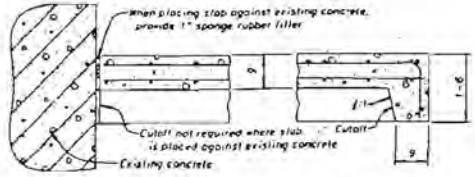
For notes, see 949-D-1233.



SECTION X-X
(Concrete rubble fill option)

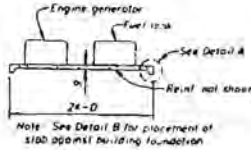


SECTION X-X
(Compacted backfill option)



DETAIL B

DETAIL A



Note: See Detail B for placement of slab against building foundation

SECTION K-K (1232)

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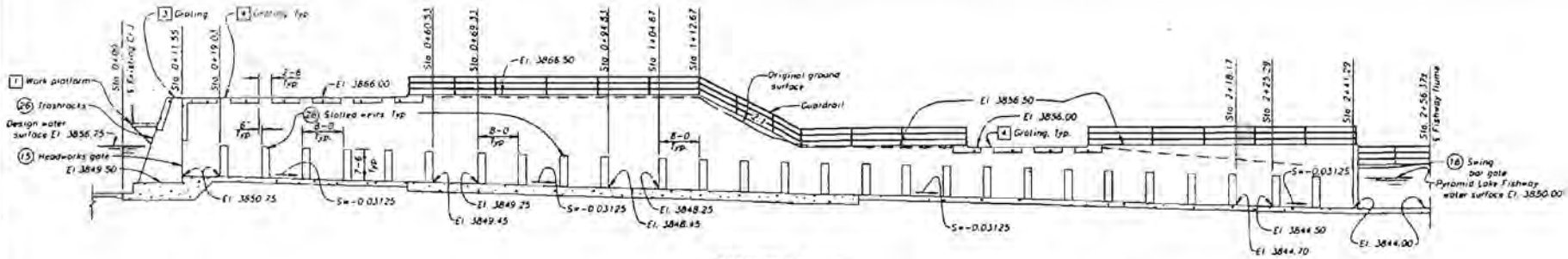
MISSOURI PROJECT
STAMPEDE DIVISION - NEVADA - CALIFORNIA

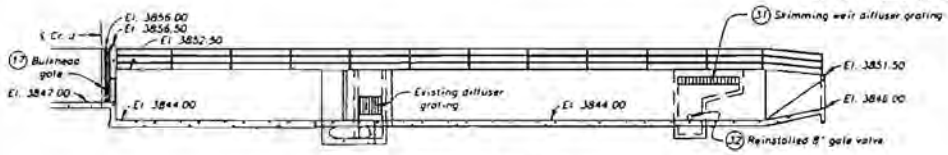
MARBLE BLUFF DAM
FISH PASSAGE FACILITIES MODIFICATIONS
MODIFIED FACILITIES
SECTIONS AND DETAILS

DESIGNED J. Nunez DATE 5/91 TECH. APPROVAL J. Nunez
DRAWN J. Nunez DATE 5/91 PROJ. ENGINEER
CHECKED R. Hayes

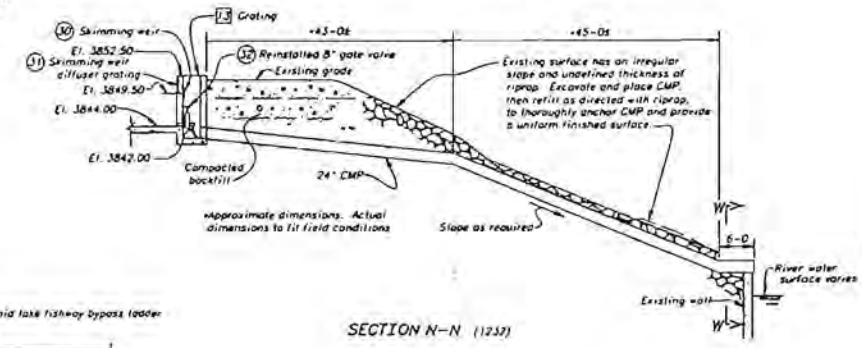
LAST ISSUED	CONSTRUCTION	FILE AND TRACE NUMBER
949-D-1234		949-D-1234



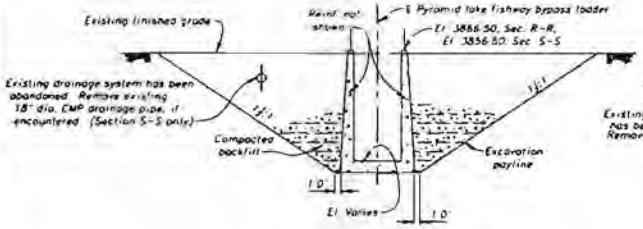
SECTION L-L (1232)



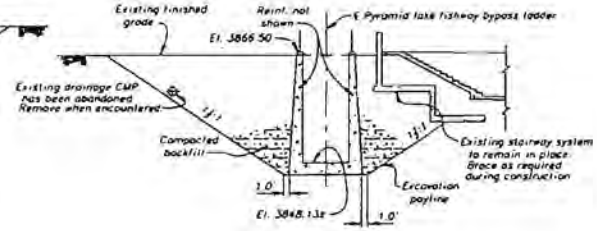
SECTION M-M (1232)



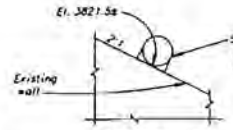
SECTION N-N (1232)



SECTION R-R (1232)
(Section S-S similar)



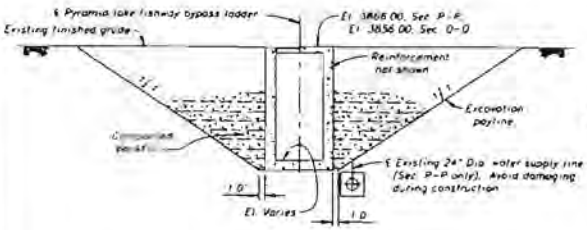
SECTION T-T (1232)



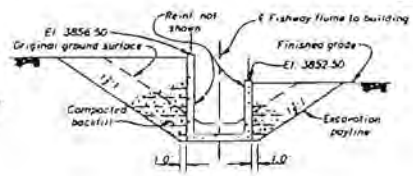
SECTION W-W

NOTE

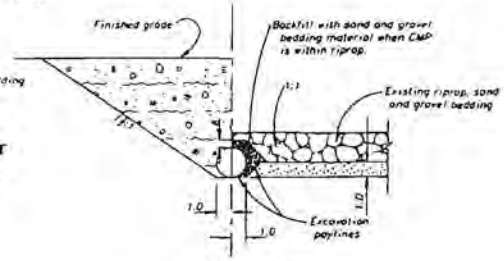
For notes, see 949-D-1233.



SECTION P-P (1232)
(Section O-O similar)



SECTION U-U (1232)



SECTION V-V (1232)

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WASHOE PROJECT
STAMPEDE DIVISION - NEVADA - CALIFORNIA

MARBLE BLUFF DAM
FISH PASSAGE FACILITIES MODIFICATIONS
MODIFIED FACILITIES
SECTIONS

949-D-1235