PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

15

EAST FORK, ROCK CREEK DAM (FLINT CREEK PROJECT) CLINTON, MONTANA GRANITE COUNTY MT-15

PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

STATE OF MONTANA
(OWNER)

FLINT CREEK WATER
USERS ASSOCIATION
(OPERATOR)

PREPARED BY:
CH2M HILL
BELLEVUE, WASHINGTON

MAY 1980

SEATTLE DISTRICT
UNITED STATES ARMY CORPS OF ENGINEERS

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TABLE OF CONTENTS

Page

CHAPTER 3 - FINDINGS AND RECOMMENDATIONS

PHOTOS
(Bound at end of text)

PLATES

EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers, and with representation from the Corps, the State of Montana Department of Natural Resources and Conservation, the U.S. Forest Service, and the Flint Creek Water Users Association, CH2M HILL inspected East Fork, Rock Creek Dam on June 7, 1979, under the authority of Public Law 92-367. The dam is located on the east fork of Rock Creek in Granite County, about 15 miles south of Phillipsburg and 25 miles west of Anaconda, Montana.

This report was compiled from information obtained during an onsite inspection, review of construction plans, and analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

East Fork, Rock Creek Dam (Flint Creek Project) is owned by the State of Montana and is operated by the Flint Creek Water Users Association. The dam and reservoir are located on public land administered by the U.S. Forest Service. The reservoir is used primarily for storage of irrigation waters and is also used for recreation.

Use of National Forest land for such purposes is through special use permits issued by the U.S. Forest Service.

The 83-foot-high earth dam will impound 19,850 acre-feet of water at top of dam, elevation 6065.6 feet National Geodetic Vertical Datum (NGVD), previously Mean Sea Level (MSL). On the basis of criteria in U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. The dam is located such that its failure could endanger many lives and cause extensive property damage. No dam breach analysis or routing of a dam breach flood was made for the downstream area; therefore, the conclusions of probable damage are based on a brief field visit and engineering judgment. The project is classified as having a high (Category 1) downstream hazard potential. Inspection criteria (Ref. 1) recommend that the spillway design flood for an intermediate-sized project with a high downstream hazard potential be the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

An estimated PMF was developed for the 30.9-square-mile drainage basin. The PMF resulting from the 6-hour thunderstorm has an estimated volume of 10,200 acre-feet and a peak flow of 75,000 c.f.s. The spillway has a maximum discharge capacity of 8,600 c.f.s. with the reservoir at top of the dam, elevation 6065.6 feet NGVD. The PMF routing was started with the reservoir at spillway crest, elevation 6055.5 feet NGVD.

The PMF routing indicates that the dam is overtopped during the PMF when approximately 43 percent of the total flood volume enters the reservoir. Routings also were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 52 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam. The dam is constructed of materials that would quickly erode and rapidly fail when overtopped by flood waters.

On the basis of the field inspection and study of hydrologic data, East Fork, Rock Creek Dam does not conform to Corps guidelines with respect to discharge and/or storage capacities to safely handle the PMF, which could lead to potential loss of life and property destruction. The spillway chute walls will be overtopped by spillway discharges significantly less than the calculated maximum of 8,600 c.f.s. However, the associated erosion is not expected to endanger the dam because the spillway and dam are separated by a wide ridge. However, the concrete spillway will probably be destroyed during such an event.

The concrete outlet conduit is cracked at each construction joint. Since the seals on the operating valve were leaking, inspection could not be made for cavitation damage.

No stability analysis of the dam embankment is on file. Strength tests of the various materials actually used in embankment construction are not available. Location of the phreatic surface in the downstream slope is unknown. Embankment stability may conform to the recommended guidelines; however, because of the dam's high downstream hazard potential, this needs to be confirmed by stability analyses.

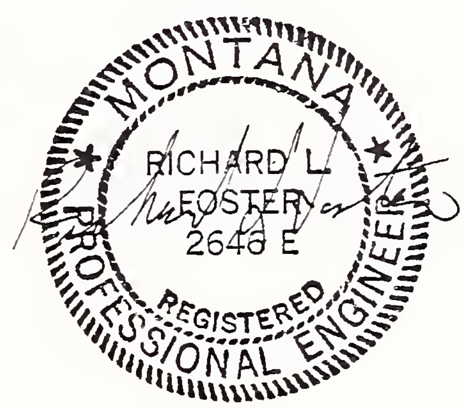
RECOMMENDATIONS

A downstream warning plan of action for use in the event of possible dam overtopping or structural failure, must be

developed and immediately placed in action. Inspect the areas on or near the butterfly valve for cavitation damage and repair as required. Construct a log boom to protect the spillway from floating debris.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate.

Install piezometers, obtain soil samples, test and conduct embankment stability analyses. If required, modify project for stability as studies indicate. Install weirs in the downstream toe area and monitor seepage. Drain the downstream area to facilitate inspection for seepage. Conduct periodic inspections of the project at intervals not to exceed 5 years by engineers experienced in dam design and construction.



Richard L. Foster
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal ID No.	MT-15
Owner	State of Montana
Operator	Flint Creek Water Users Association
Date Constructed	1938
Purpose	Irrigation, Recreation
Location	Section 6, T4N, R14N, Principal Meridian
County, State	Granite County, Montana
Watershed	East Fork, Rock Creek, a tributary to Clark Fork River
Downstream Hazard Potential	Category 1 (High)
USGS Quadrangle	Potato Lakes, Carpp Ridge, Storm Lake, Georgetown Lakes

2. RESERVOIR

Surface Area at Spillway Crest, Elevation 6055.5 feet NGVD	390 acres
Drainage Area	30.9 square miles
Storage at Spillway Crest, Elevation 6055.5 feet NGVD	16,040 acre-feet
Storage at Dam Crest, Elevation 6065.6 feet NGVD	19,850 acre-feet
Surcharge Storage (Between spillway & dam crests)	3,810 acre-feet
Reservoir Elevation at time of inspection	6055.2 feet NGVD

3. SPILLWAY

Type	Uncontrolled concrete chute
Bottom Width	60.5 feet at crest
Crest Elevation	6055.5 feet
Capacity with Reservoir at Dam Crest	8,600 c.f.s.

4. OUTLET WORKS

Conduit	54-inch-diameter, straight-legged horseshoe, concrete conduit
Conduit Length	400 feet
Valves	One 54-inch-diameter gate valve One 54-inch-diameter, pivot butterfly valve
Capacity with Reservoir at Dam Crest	630 c.f.s.

5. DAM

Type	Rolled earthfill with upstream core
Length	1,075 feet
Crest Width	25 feet
Crest Elevation	6065 feet NGVD
Hydraulic Height (Crest to toe)	87 feet
Upstream Slope	1 V on 3 H
Downstream Slope	1 V on 2 H

Chatper 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of East Fork, Rock Creek Dam owned by the State of Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-Federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued Recommended Guidelines for Safety Inspection of Dams in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on National Program of Inspection of Dams in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety of the dam.

(2) based upon an evaluation of the available data and a visual inspection.

(3) performed to determine if any emergency measures and/or additional studies, investigations, and analyses are necessary or warranted.

(4) not intended to include extensive explorations or analysis, nor to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-Federally owned dams is limited to Phase I investigations, with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies, but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, nor any action or failure to act under this Act, shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project, a detailed review of available plans and specifications, and design analyses. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the June 7, 1979, inspection included:

Richard Eckerlin, Geologist, Seattle District, Corps of Engineers

Larry Tegg, Engineer, State of Montana, Department of Natural Resources and Conservation

Robert Clark, Engineer, State of Montana, Department of Natural Resources and Conservation

Vic Johnson, Flint Creek Water Users Association

Ed Lord, Flint Creek Water Users Association

Jerry Tackitt, Dam Operator, Flint Creek Water Users Association

Norman Ward, U.S. Forest Service

CH2M HILL personnel who participated in the field inspection and contributed to this report are:

Miles C. Bubenik, Geotechnical Engineer, Team Leader

Jerry Jacksha, Geotechnical Engineer

Loren Bottorff, Hydrologist/Hydraulics Engineer

This report has been reviewed by the State of Montana Depa rtment of Natural Resources and Conservation, the Flint Creek Water Users Association, and the U.S. Forest Service. Their comments are included in the Appendix.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

East Fork, Rock Creek Dam (Flint Creek Project) and East Fork Reservoir are located on Rock Creek, a tributary of Clark Fork River, in Granite County, Montana, approximately 25 miles west of the town of Anaconda (see Plate 1). The dam is currently listed in the National Inventory of Dams and its Federal identification number is MT-15. The 87-foot-high dam impounds 19,850 acre-feet at dam crest elevation 6065.6 feet NGVD. Based on a visual reconnaissance and engineering judgment, residences, a Forest Service campground, and agricultural land could be affected by a sudden breach of the dam.

On the basis of this information and in accordance with the recommended guidelines (Ref. 1), the project is classified intermediate in size and the downstream hazard potential is high (Category 1).

Principal use of the 390-acre reservoir is for irrigation storage, and although the project is owned by the State of Montana, operation and maintenance is performed by the Flint Creek Water Users Association.

The 525-foot-long spillway channel is located on the left abutment, as shown on Plate 2. A 54-inch, horseshoe-shaped outlet with two 54-inch-diameter gates and gate controls at the dam crest is used for irrigation releases.

This dam is not to be confused with Flint Creek Dam located on Flint Creek, which impounds Georgetown Lake, 6 miles to the northwest.

1.2.2 Regional Geology and Seismicity

The area geology and seismicity was addressed in a memorandum by R.D. Eckerlin (Ref. 2). The following is taken from the memorandum:

> "This area is in a region of extremely varied and complex geology. The dominant structural feature is the Georgetown Thrust where Precambrian Belt sediments have been thrust over Precambrian and Paleozoic rocks. The lower plate of this thrust is characterized by rocks compressed into tight, symmetrical, well-defined folds that trend north to northeast and plunge to the north. Folds within the upper thrust plate are poorly defined.
>
> East Fork Reservoir lies within the lower plate on the east limb of the Rock Creek Anticline and within 1/2 mile of the anticlinal axis. The anticline trends north paralleling the reservoir and is convex to the east. The Rock Creek Syncline lies within 2 miles east of the reservoir and is the only major structure that is well defined in both plates of the Georgetown Thrust. The syncline is symmetrical, with flanks dipping as high as 80 degrees.
>
> Compressive stresses dominated the early stages of structural evolution, followed by tensional or torsional forces, which produced normal faulting and strike-slip faulting. Evidence of Pleistocene alpine glaciation can be seen in the region in the form of cirques, moraines, and outwash terraces extending down the valleys.
>
> The dam lies in Zone 3 of the Seismic Zonation Map of Contiguous States (TM5-809), shown in the "Recommended Guidelines" (Ref. 1). The seismic probability of

Zone 3 is one of major damage and is based on known distribution of damaging earthquakes and their associated intensities. Algermissen and Perkins (Ref. 9) recommend a design acceleration of close to 0.1g with a 90 percent probability of not being exceeded in 50 years. The strongest historic earthquake to affect the area was the Hebgen Lake 1959 event with site intensity VI. The estimated acceleration from this event was less than 0.1g. The closest historic seismicity was a magnitude 5.0 event, which occurred in 1958 about 15 miles northeast of the dam near Phillipsburg, Montana."

1.2.3 Site Geology

The discussion of site geology is also extracted from the R.D. Eckerlin memorandum (Ref. 2).

At the site, Rock Creek has incised into a moraine, forming a small valley with a width of about 500 feet. The floor of this valley is underlain with an unknown thickness of clay, sand, gravel, and boulder alluvium on which the dam is apparently founded.

Both abutments of the dam are presumed to be founded in morainal deposits composed of a poorly sorted mixture of silt, sand, gravel, and boulders. One of the main borrow areas from which fill for the dam embankment was derived consists of morainal deposits and is located about 1,000 feet west of the dam.

The spillway is excavated through the left (southwest) abutment glacial moraine deposits. The stilling basin is unlined and consists of an assortment of cobbles and boulders.

The outlet conduit is located at the base of the embankment, about 250 feet from the northeast end of the dam, and is founded on alluvial sediments as previously described. The outlet channel is several hundred feet long and consists of a trench about 20 feet wide cut in moraine deposits.

East Fork Reservoir is elongate in the north-south direction and lies within an alpine glaciated valley. The shoreline along the northern third of the lake is predominantly lateral and recessional moraines that are composed of sand, gravel, and boulders. These slopes pose little threat from major landsliding. Wave erosion of the reservoir sides is locally present. The remaining two-thirds of the reservoir shoreline consists of Paleozoic sedimentary rocks locally covered by a thin mantle of colluvium and glacial outwash. The stratigraphy and bedding attitudes of these rocks suggest a potential for major rock slides into the reservoir. Cambrian

shales and limestones compose portions of the west shoreline slope. The south end of the reservoir consists of a nearly flat plain underlain with stream alluvium. A reconnaissance of the reservoir was not made. The description of reservoir geology is based on USGS topography maps of the area and on Geologic Investigation Map No. 1, "Geology of the Georgetown Thrust Area Southwest of Phillipsburg, Montana."

1.2.4 Design and Construction History

East Fork, Rock Creek Dam was designed from 1935 to 1936 by the State Water Conservation Board, Helena, Montana. Construction began in 1936 and was completed in 1938. Plates 2, 3, 4, 6, 7, 8, and 9 were developed from the original drawings that are on file with the State of Montana, Water Conservation Board. Neither a detailed set of construction as-built drawings nor information on construction control testing are available. A final project report discussing some details of construction was available for review.

A plan drawn in 1959 shows a 25-foot-high, 30-foot-wide, rock-filled berm to be added at the downstream embankment toe. This berm was not constructed.

Chapter 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for East Fork, Rock Creek Dam (Flint Creek Project) is located in natural ground on the left abutment. Approximately 200 feet of unlined approach channel leads from the reservoir to the uncontrolled concrete chute spillway. The approach channel has an 80-foot bottom width with 1 V on 1.5 H side slopes. The channel has no log boom and is free from obstructions, except for two piers supporting a vehicle bridge. The bridge crosses the channel about 30 feet upstream from the concrete spillway crest. Some floating debris was seen at the crest. The bottom width of the approach channel narrows to 50 feet just before the concrete spillway chute.

The uncontrolled concrete spillway begins as a trapezoidal section with a 50-foot bottom width and 1 V on 1.5 H side slopes (see Photo 1 and Plate 4). A concrete crest, formed to an ogee shape of approximately 5-foot design head, is located in the upstream end of the chute. The apex of the spillway crest is at elevation 6055.5 feet NGVD, 10.1 feet below the low point on the dam crest. The width of the crest at the apex was 60.5 feet. The bottom width of the chute narrows to 21 feet within 50 feet downstream of the crest and to 8 feet within 325 feet downstream of the crest. The bottom width continues at 8 feet for an additional 190 feet to the end of the chute. The concrete of the chute contained minor cracking and spalling and some old deteriorated patches were observed. The slope of the chute varies throughout its 525-foot length, but the total elevation drop is 75.5 feet (Plate 5). The chute ends with a flip bucket. Large riprap exists at the end of the chute and the downstream channel is neither eroding nor backcutting.

The spillway discharge rating was developed by using weir-head discharge coefficients varying from 3.3 to 4.14.* The coefficients are for an ogee crest with a 5-foot design

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*The maximum coefficient may be too large; however, it has little effect on flood routing discussed in Paragraph 2.2.4.

head. The maximum discharge capacity of the spillway, with the reservoir at top of dam, elevation 6065.6 feet NGVD, was estimated to be 8,600 c.f.s. The discharge rating curve is presented on Plate 6. Estimates indicate that the spillway chute walls will overtop much before the maximum discharge of 8,600 c.f.s. is reached. However, although the chute concrete will probably be destroyed, we believe the associated erosion will not endanger the dam because the spillway and dam are separated by a large ridge.

2.1.2 Outlet

The outlet works for East Fork, Rock Creek Dam is located through the embankment near the right abutment. The intake structure could not be inspected because of the reservoir level but construction plans show it is a pair of parallel walls fitted with a trashrack. The 54-inch-diameter, straight-legged, horseshoe, concrete conduit is about 400 feet in length.

A gate tower is located in the reservoir about 185 feet downstream of the intake structure and 65 feet upstream from the axis of the dam. The gate tower is covered by a locked gatehouse and is reached by a catwalk from the crest of the dam. The jet pump used for dewatering the tower may require minor maintenance as there was water 2 to 3 inches deep on the floor of the tower. The control for the 54-inch-diameter emergency gate valve is located at the bottom of the tower and the control for the 54-inch-diameter, operating pivot butterfly valve is located at the top of the tower (Plate 7). The emergency valve was not operated. The control for the pivot butterfly valve is fitted with a chain drive to a gasoline engine, but this can be removed for hand cranking the control.

The outlet structure consists of a pair of walls about 20 feet in length. The walls show considerable spalling caused by freeze/thaw action. The flow discharges to an excavated channel at the end of the outlet structure (Plate 2). The channel is neither eroding nor backcutting.

The operating valve was closed during the inspection and the conduit was entered from the downstream portal. The conduit contained cracking at each construction joint, which was approximately every 7 feet. One joint showed a vertical displacement of the ceiling measuring about 1/4 inch. A hole, about 2 inches in diameter, has been drilled in the floor of the conduit about 30 feet downstream of the operating valve, apparently to relieve hydrostatic uplift. Water was flowing from the hole to a height about 4 to 6 inches above the conduit floor. The seals on the operating valve

were leaking and it was not possible to get within 15 feet of the valve. Because of this leakage, inspection for cavitation damage could not be made.

The discharge rating for the outlet works was developed with both valves assumed to be fully open. A Mannings "n" of 0.014 was used to estimate friction losses with the conduit flowing full. The maximum discharge capacity of the outlet works, with the reservoir at top of dam, elevation 6,065.6 feet MSL, was estimated to be 630 c.f.s.

2.1.3 Freeboard

Since the dam overtops during the probable maximum flood (PMF see paragraph 2.2.4), there is no freeboard. The vertical distance between the low point on the dam crest and the reservoir level at the time of the inspection was 10.4 feet.

The spillway crest is 10.1 feet below the low point on the dam crest. The crest of the dam varies 0.5 feet over its 1,075-foot length. The fetch for wind-generated waves is about 0.7 miles and wave runup on the embankment is estimated to be about 3.5 feet. Although the dam will overtop during the PMF, the vertical distance between the dam crest and the normal reservoir level is adequate to prevent overtopping the embankment by wind-generated waves.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 General

The climate of the area is modified continental in nature characterized by warm summers, cold winters, and a semiarid precipitation regime. The nearest climatological station is at Silver Lake (elevation 6480 feet NGVD), about 10 miles northeast of the center of the East Fork, Rock Creek Dam drainage basin. Mean annual precipitation at the station is 18.8 inches with 40 percent falling from April through June. Mean February precipitation is 0.92 inches and mean June precipitation is 3.44 inches. Mean annual precipitation on the East Fork, Rock Creek Dam drainage basin is probably near 25 inches. Mean annual temperature at East Anaconda (elevation 5511 feet NGVD), about 18 miles east of the basin, is 42.4 degrees F. Mean January temperature at Anaconda is 22.3 degrees F, and mean July temperature is 65.6 degrees F. Temperatures on the East Fork, Rock Creek Dam drainage basin may average about 10 degrees cooler than Anaconda. Occasionally, summer temperatures exceed 100 degrees F and winter temperatures dip below -40 degrees F.

The drainage basin area for East Fork, Rock Creek Dam is 30.9 square miles and is on the west slope of the Continental Divide. Basin elevations range from 6,065 feet at the dam to 10,233 feet at Fish Peak on the southern boundary of the basin. The basin is bordered by the Continental Divide (exceeding 9,000 feet elevation) along the southern portion for 8.3 miles. The basin is very mountainous and heavily forested. The east fork of Rock Creek is the inflow stream to the reservoir and has an average gradient of 380 feet per mile. Several creeks are tributary to the east fork of Rock Creek above the reservoir.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 390 acres and a storage of 16,040 acre-feet at spillway crest, elevation 6055.5 feet NGVD. Approximately 3,810 acre-feet of surcharge storage is available in the reservoir between the spillway crest and the dam crest. The spillway discharge with the reservoir at the dam crest is 8,600 c.f.s. or about 710 acre-feet per hour.

2.2.3 Estimated Probable Maximum Flood

The inspection guidelines recommend that the spillway design flood for a project of this type be the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. An estimate of the PMF was made during this dam safety analysis and was routed through the reservoir. Procedures available for the area west of the Continental Divide allow for development of a probable maximum precipitation (PMP) from a thunderstorm or a general storm. Because of the size of the East Fork, Rock Creek Dam drainage basin, a thunderstorm was believed to cause the most critical flood.

The procedures contained in the U.S. Weather Bureau's Hydrometeorological Report No. 43 (Ref. 3) and the Weather Bureau's 1967 memo (Ref. 4) were used to compute the thunderstorm PMP. The memo allows for some reduction of the PMP that was not originally contained in Report No. 43. The thunderstorm produces 4.6 inches in one hour and 6.9 inches in 6 hours.

Because of the high intensity rainfall and the possibility of near-saturated soil conditions from thunderstorms on preceding days, a constant 0.15-inches-per-hour loss to the soil was assumed during the thunderstorm PMP. A base flow of 150 c.f.s. was used for the entire flood.

A triangular unit hydrograph for a 10-minute rainfall duration was developed for the 30.9-square-mile drainage basin by procedures outlined in Design of Small Dams (Ref. 5). A curvilinear fit of the triangular unit hydrograph was used. The PMP was applied to the unit hydrograph by means of the computer program, HEC-1 (Ref. 6). This estimate of the PMP produced a flood with a peak flow of 75,000 c.f.s. and a volume of 10,200 acre-feet.

2.2.4 Flood Routing

The PMF was routed through the reservoir by using the computer program HEC-1 (Ref. 6). The reservoir level was assumed to be at the spillway crest at the beginning of the PMF. The outlet works was assumed to be fully open during the entire flood. The routing shows that the dam will be overtopped during the PMF when approximately 43 percent of the total flood volume enters the reservoir. Routings also were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 52 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam Embankment

The 87-foot-high, straight-axis, earth, gravel, and rockfill embankment is 1,075 feet long and has a crest width of 25 feet. The downstream slope is 1 V on 2 H and the upstream slope is 1 V on 3 H (see Plate 7). The slope between the upstream impervious zone and the downstream sand, gravel, and rock zone is 1 V on 0.33 H, inclined downstream.

The final project report (Ref. 7) states that the upstream impervious zone of the dam contains 60 percent soil and 40 percent gravel and rock. This report further states that the downstream pervious section is a compacted sand, gravel and rock mix.

During design, materials were sampled and tests conducted by the Corps of Engineers at Fort Peck Dam Laboratory. Test results indicate that borrow materials proposed for use in the construction were well-graded sand and gravels with clay and silt fines. Permeabilities ranged from 0.0001 to 0.00001 feet per day. A summary of the design test data is shown in the Appendix.

The actual construction procedures are unknown. The placement methods specified for the upstream earth-fill and downstream sand, gravel and rock-fill zones were 6-inch and 8-inch horizontal lifts, respectively. Compaction equipment specified was a toothed roller generating 1,150 pounds per inch. Rock, "large enough to interfere with the rolling," was to be placed on the downstream face as work progressed.

Embankment materials were obtained from spillway, outlet works, and cutoff excavations, as well as onsite borrow pits. The actual quantities obtained from the several sources is unknown. Should the dam be overtopped, the materials would rapidly erode and fail the dam.

The upstream slope is protected from erosion by a covering of 12-inch-minus riprap. The actual riprap thickness is unknown; however, the specifications indicate that riprap was to be 18 inches thick over a 6-inch bedding layer (Photo 3). The downstream embankment slope had a sparse covering of brush (Photo 4). No slope erosion, irregularities, slumps, or cracks were present on the dam crest or slopes.

Foundation information indicates that the 54-inch outlet conduit was placed on alluvial sediments consisting of clay, sand, gravel, and boulders. The plans show that the conduit was concrete lined throughout the entire section. Six concrete cutoff collars are shown under the upstream cut and cover section of the conduit. Plans state that a gravel-filled drain trench exists under the conduit, downstream of the last cutoff collar; it connects to the longitudinal toe drain (see Plate 7).

2.3.2 Foundation Conditions, Seepage, and Drainage

Logs of preconstruction boreholes which were drilled at the dam site show that the foundation materials consist of unconsolidated to cemented mixtures of clay, sand, gravel, and boulders (alluvium). Preconstruction drawings show a cutoff trench to have been excavated 15 feet into the foundation between the upstream toe and the centerline of the dam. There are no piezometers installed in the dam.

Both abutments of the dam are glacial morainal deposits composed of a poorly sorted mixture of silt, sand, gravel, and boulders. Boulders are rounded to angular, may be up to 6 feet in diameter, and are composed of granitic rocks and quartzite with some carbonates and argillites.

The extent of foundation preparation is not known; however, the specifications state "the entire base under the embankment shall be stripped or excavated to sufficient depth to

remove all material not suitable for use in the embankment." In addition to stripping, an upstream cutoff was excavated into the alluvial sediments beneath the dam. A description of the cutoff is quoted from the final project report (Ref. 7), as follows:

> "The cut-off wall or puddled, clayey, backfill is about half-way between the axis and upstream toe of the dam and is extended from 20 to 30 feet below the creek bed with bottom width averaging 20 feet. The cut-off wall is extended into the rock formation of the easterly (right) abutment. On the westerly (left) abutment a sandy gravel pocket with a 10-foot overburden of clayey material was excavated deep into the abutment and extended above the upstream toe of the dam to a depth of approximately 20 feet below the creek bed.
>
> A key was also excavated from the main cut-off into a good clay structure on the northerly side. The entire cut-off area was then puddle backfilled, and blanketed above the original ground surface. Under the pervious section of the dam, several drain ditches filled with rock and leading to a main 10-inch perforated culvert pipe embedded in coarse gravel, is located approximately midway under the dam with outlet at the downstream toe near the old creek channel. A secondary 10-inch culvert pipe drain on the westerly side connects with the gravelly pocket mentioned in the west abutment. At this writing the water flow in the main drain is approximately 10 miner's inches, which is about half of the amount at the original installation. From the secondary 10" culvert pipe there is no flow of water. The water in the reservoir at this time is 5 feet above the top of the head wall on the conduit inlet."

During the June 7, 1979, inspection, seepage of about 4 gpm was observed at the downstream toe near the left abutment contact (Photo 4). Seepage of about 40 gpm was observed downstream of the embankment toe and near the right abutment (Photo 5). The flow appeared to emerge along the contact between the overburden sandy clay and the alluvial sand and gravel sediments. The source of this seepage may be from the outlet conduit discharge channel as the invert of the channel is 2 to 3 feet above the seepage exit. Minor erosion was observed at the seepage exit (Photo 5). No mention is made of this seepage in the September 26, 1977, inspection report by the Department of Natural Resources. However, in a letter written after the first filling of the reservoir in 1940 (Ref. 8), the following statement is quoted:

"Water reached the crest of the spillway on May 18th and continued spilling until July 8th. Water was being discharged during the same period through the reservoir outlet. The stages of the reservoir, when above spillway grade, were not recorded but in general were only about 0.5 feet above the crest. There was no gauge on the weir in the reservoir outlet channel. On June 23rd the weir was enlarged to 12 feet in width, the walls raised 2 feet, and a rating table calculated. A gauge was established and a record of discharge kept from June 24th. The discharge on June 24th through the outlet was 46.5 c.f.s. but the spillway discharge is not known.

On July 8th when the reservoir stopped spilling, the discharge through the outlet was 123.7 c.f.s. and from July 9th to 18th the rate was 131.2 c.f.s.

The estimated seepage loss from the reservoir visible for a few hundred feet below the dam was about 4 c.f.s. It is probable that the total seepage between the dam and headgate of the canal is around 12 to 15 c.f.s. This is only an estimate and measurements should be made to determine it more closely."

At the time of the June 7, 1979, inspection, the channel downstream of the embankment toe could not be inspected for seepage because of ponding water created by beaver dams (Photo 6). The pond water was clear, which would suggest that fresh water was coming into the pond probably from seepage under the embankment and the quantity may be more or less than that observed at first reservoir filling in 1940 (Ref. 8).

2.3.3 Stability

Guidelines for dam safety inspections (Ref. 1) recommend that stability analyses be on file for all dams in the high-hazard category. No stability analyses were available for review. Model tests on the dam embankment, using materials sampled at the dam site, were performed in 1936 by the Corps of Engineers at Fort Peck Dam laboratory to determine saturation zones (phreatic water surfaces) in the embankment. These tests concluded that a zoned embankment similar to section, Plate 7, may have an essentially non-saturated downstream zone at normal reservoir levels. With this information, and based on the type of materials most likely used in embankment construction, it is our preliminary judgment that embankment stability may conform with the Corps guidelines. However, because of the high hazard involved, this should be confirmed by stability analysis,

which takes into account the actual position of the phreatic surface in the downstream slope of the dam and foundation, as determined by piezometer observation.

2.4 PROJECT OPERATION AND MAINTENANCE

The facility is owned by the State of Montana Department of Natural Resources and Conservation (DNRC) and is operated by the Flint Creek Water Users Association. Information on operation and maintenance was obtained from discussions with members of the Water Users Association as formal project operation and maintenance programs for the dam do not exist.

2.4.1 Dam

Maintenance of the dam is performed as required. Cavitation damage at the butterfly valve is periodically repaired with epoxy steel; debris is cleared from the upstream face of the dam; and brush is cleared from the downstream face of the dam. There was some cracking and spalling of the spillway chute concrete, cracking of the outlet conduit, and spalling of the outlet structure concrete; but in general, the project appeared to be well maintained.

The State of Montana DNRC conducts annual inspections of the facility and makes appropriate recommendations for maintenance and repairs.

2.4.2 Reservoir

Water from East Fork, Rock Creek Reservoir is used primarily for irrigation, but the reservoir also receives heavy recreational use. Mr. Jerry Tackitt is the dam operator and he visits the dam almost daily. The reservoir is filled in the spring by snowmelt and the water is used as needed for irrigation.

2.4.3 Warning System

There is no formal warning plan for use in the event of impending dam failure.

Chapter 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in terms of the recommended guidelines performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with inspection guidelines, East Fork, Rock Creek Dam is intermediate in size with a high downstream hazard potential rating. The recommended spillway design flood (SDF) for this project is the full PMF. Because the project can handle a flood having only 52 percent of the PMF hydrograph ordinates without overtopping and causing the dam to fail, East Fork, Rock Creek Dam does not conform to the inspection guidelines (Ref. 1).

3.1.2 Embankment Dam

A visual inspection of the dam revealed neither longitudinal or transverse cracking nor any embankment, abutment contact, or toe erosion. Seepage observed at the downstream embankment toe and at the right abutment toe did not appear to be adversely affecting embankment stability. However, seepage observed in the Beaver Ponds downstream of the embankment is considered to be underseepage from the reservoir. The exact amount of this seepage or the exiting areas could not be determined during our inspection. Therefore, additional work needs to be performed to determine whether soil fines are being transported. Also, there are no piezometers in the dam and the position of the phreatic surface within the dam is unknown.

The upstream and downstream slopes were uniform with no irregularities or slumps. The downstream slope supports a sparse covering of small brush. Riprap on the upstream slope adequately protects against erosion, and the normal freeboard is adequate to prevent wind-generated waves from overtopping the dam crest.

No stability analysis of the dam embankment is on file. No strength tests of the various materials actually used in embankment construction are available for review. Embankment stability may conform to the recommended guidelines; however, because of the dam's high downstream hazard potential, this needs to be confirmed.

3.1.3 Spillway and Reservoir Capacity

The reservoir has a surface area of 390 acres and a storage of 16,040 acre-feet at spillway crest, elevation 6055.5 feet NGVD. Approximately 3,800 acre-feet of surcharge storage is available in the reservoir between the spillway crest and the dam crest. The discharge of the spillway, with the reservoir at the dam crest, is 8,600 c.f.s. The spillway chute walls will overtop at flows much less than this maximum discharge, but the associated erosion is not expected to endanger the dam.

3.1.4 Outlet Works

The outlet works contained cracking at the construction joints. The seats on the operating valve were leaking and it was not possible to get within 15 feet of the valve. Because of this leakage, inspection for cavitation damage could not be made. The emergency valve was not operated. There were 2 to 3 inches of water on the floor of the gate tower suggesting that minor maintenance of the jet pump may be required.

3.1.5 Operation and Maintenance

The State of Montana DNRC conducts annual inspections of the facility and makes appropriate recommendations for maintenance and repairs. The Flint Creek Water Users Association is responsible for operations and maintenance. Mr. Tackitt is the dam operator and visits the project almost daily. Cavitation damage at the butterfly valve is periodically repaired with epoxy steel, debris is cleared from the upstream face of the dam, and brush is cleared from the downstream face of the dam. There was cracking and spalling of the spillway chute concrete, cracking of the outlet conduit, and spalling of the outlet structure concrete but in general, the project appeared to be well maintained. The reservoir is filled in the spring by snowmelt and the outlet is operated as needed for irrigation. There is no formal downstream warning plan of action for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

Because of storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of impending dam overtopping or structural failure.

2. Inspect the areas on or near the butterfly valve for cavitation damage and repair as required.

3. Construct a log boom to protect the spillway from floating debris. The boom should be placed in the reservoir near the entrance of the approach channel with its ends positioned so it functions for all reservoir levels.

4. Install weirs and monitor all seepage. During a normal high pool, obtain water samples of seepage near the embankment toe and conduct tests to determine if soil fines are being transported.

5. Drain the immediate downstream toe area to facilitate inspection for seepage.

The above recommendations will not make the dam conform to the inspection guidelines, but will reduce risk to life and property while the following actions are being taken:

6. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate.

7. Install piezometers in the downstream embankment zone to determine the location of the phreatic surface and conduct stability analyses of the embankment using water level data obtained from piezometer observations. Obtain soil samples from piezometer borings and test as appropriate to determine strength properties for stability analyses. The stability analyses must take into consideration static and seismic loading conditions and be performed by a qualified geotechnical engineer. If required, modify the project for stability as studies indicate.

8. Conduct periodic inspections of the project (not to exceed 5-year intervals) by engineers experienced in dam design and construction. In addition, immediately inspect the dam, if a moderate magnitude earthquake occurs in the proximity of the project.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C., Department of the Army, May 1975.

2. Richard D. Eckerlin, U.S. Army Corps of Engineers, Memorandum on Flint Creek (East Fork, Rock Creek) Dam Inspection, August 1979.

3. U.S. Weather Bureau, Hydrometeorological Report No. 43, "Probable Maximum Precipitation, Northwest States," Washington, D.C., 1966.

4. Hydrometeorological Branch, U.S. Weather Bureau Office of Hydrology, "Memorandum: Probable Maximum Thunderstorm Rain for the Columbia River Basin East of the Cascade Ridge," 20 September 1967.

5. U.S. Bureau of Reclamation, "Design of Small Dams," 2nd Edition, 1974.

6. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, 1973.

7. G.J. Hagen, Project Engineer, State of Montana, State Water Conservation Board, "Final Report -- Flint Creek Storage Project," January 18, 1938.

8. Letter to W.F. Krukeburg, Field Engineer, State of Montana, State Water Conservation Board, "Operation of Flint Creek Project Season of 1939," January 15, 1940, (Author Unknown, presumed written by Flint Creek Water Users Association).

9. S.T. Algermissen and D.M. Perkins, "A Probabilistic Estimate of Maximum Accelerations In Rock In The Contiguous United States," Bulletin, U.S. Department of the Interior, Open file report, U.S. Geological Survey, No. 76-416, 1976.

APPENDIX

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

STATE OF MONTANA

406 449-2872

HELENA, MONTANA 59601

March 26, 1980

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on the East Fork, Rock Creek (Flint Creek) Dam MT-15. We concur with the findings and recommendations and feel that the report satisfies the criteria for the Phase I evaluation. Minor comments have been discussed with your staff and we understand that these will be included in the final report.

We sent copies of the report to the Flint Creek Water Users Association for comment. They did not want to make a formal reply, but elected instead to discuss their comments with us by phone. Their comments were taken into consideration when we discussed our comments with your staff.

Thank you for this opportunity to review and comment on the final draft report for this project.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:LT:mb

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

7530

FEB 2 5 1980

Mr. Sidney Knutson, P.E.
Seattle District Corps of Engineers
P. O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

As reported in your letter of January 24, 1980, we have reviewed the draft report of the Phase I inspection of East Fork, Rock Creek Dam and have the following comments:

1. We agree with the recommendations of the report.

2. We note that a thunderstorm event was used to determine the preliminary PMF over this 30.9 square mile drainage area "because of the size of the drainage area"; yet a general storm was selected for the 1.1 square mile drainage area for Bass Lake Dam. These criteria do not appear consistent with usual practices.

Sincerely,

R. W. Larse

R. W. LARSE
Regional Engineer

TABLE I.

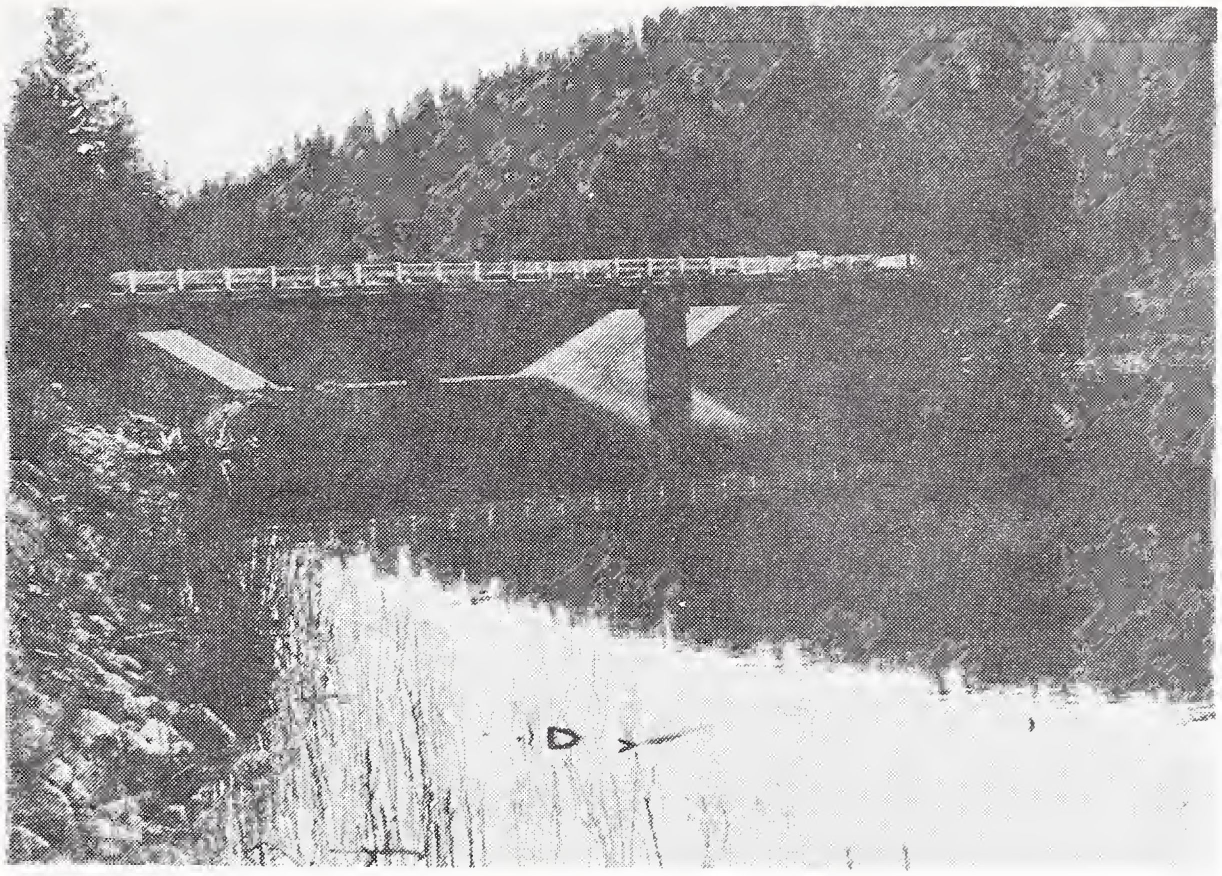
Summary of Test Results on Samples Submitted from Flint Creek Storage Reservoir Site

Sample No. or Combination Thereof*	Tested For	Mechanical Analysis % Gravel	% Sand	% Silt	% Clay	Specific Gravity.	Optimum Moisture %/Dry Weight	Dry Wt. Per Cu. Ft. @ Optimum Moisture	Permeability Under Vertical Load - Ft. per Day @ 50° F. 1 T/sq. ft.	3 T/sq. ft.	5 T/sq. ft.	7 T/sq. ft.
1, 3	Mech. anal.**	21	51	18	10							
1, 3	Opt. Moisture.	ø	65	21	14	2.69	9	128.5				
1, 3	Cons. & Perm.	ø	67	22	11	2.66			2.35×10^{-4}	1.55×10^{-4}	1.60×10^{-4}	1.31×10^{-4}
2, 5, 7	Mech. anal.**	35	36	12	17							
2, 5, 7	Opt. Moisture.	ø	49	21	30	2.63	16	110.5				
2, 5, 7	Cons. & Perm.	ø	48	24	28	2.63			17.25×10^{-5}	4.93×10^{-5}	7.44×10^{-5}	3.84×10^{-5}
4	Mech. anal.**	20	53	21	6							
4	Opt. Moisture.	ø	60	31	9	2.68	13	114.5				
4	Cons. & Perm.					2.68			12.6×10^{-5}	6.6×10^{-5}	6.4×10^{-5}	7.5×10^{-5}
6	Mech. anal.**	38	45	9	8							
6	Opt. Moisture.	ø	70	15	15	2.66	10	128.5				
6	Cons. & Perm.					2.67			6.77×10^{-5}	3.74×10^{-5}	3.71×10^{-5}	3.78×10^{-5}
4, 6	Cons. & Perm.	ø				2.69			20.4×10^{-5}	13.1×10^{-5}	21.1×10^{-5}	5.20×10^{-5}
7, 8, 9, 10	Cons. & Perm.	ø	56	24	20	2.68			6.75×10^{-5}	3.62×10^{-5}	5.12×10^{-5}	3.71×10^{-5}
8 - 19, incl.	Cons. & Perm.	72	28	0	0	2.71			7.42	7.91	7.95	7.20
8	Mech. anal.**	50	40	7	3							
9	" "	49	44	5	2							
10	" "	32	57	6	5							
11	" "	49	42	5	4							
12	" "	42	49	4	5							
13	" "	54	40	4	2							
14	" "	42	55	2	1							
15	" "	42	44	9	5							
16	" "	52	42	4	2							
17	" "	52	38	6	4							
18	" "	32	56	8	4							
19	" "	41	50	7	2							

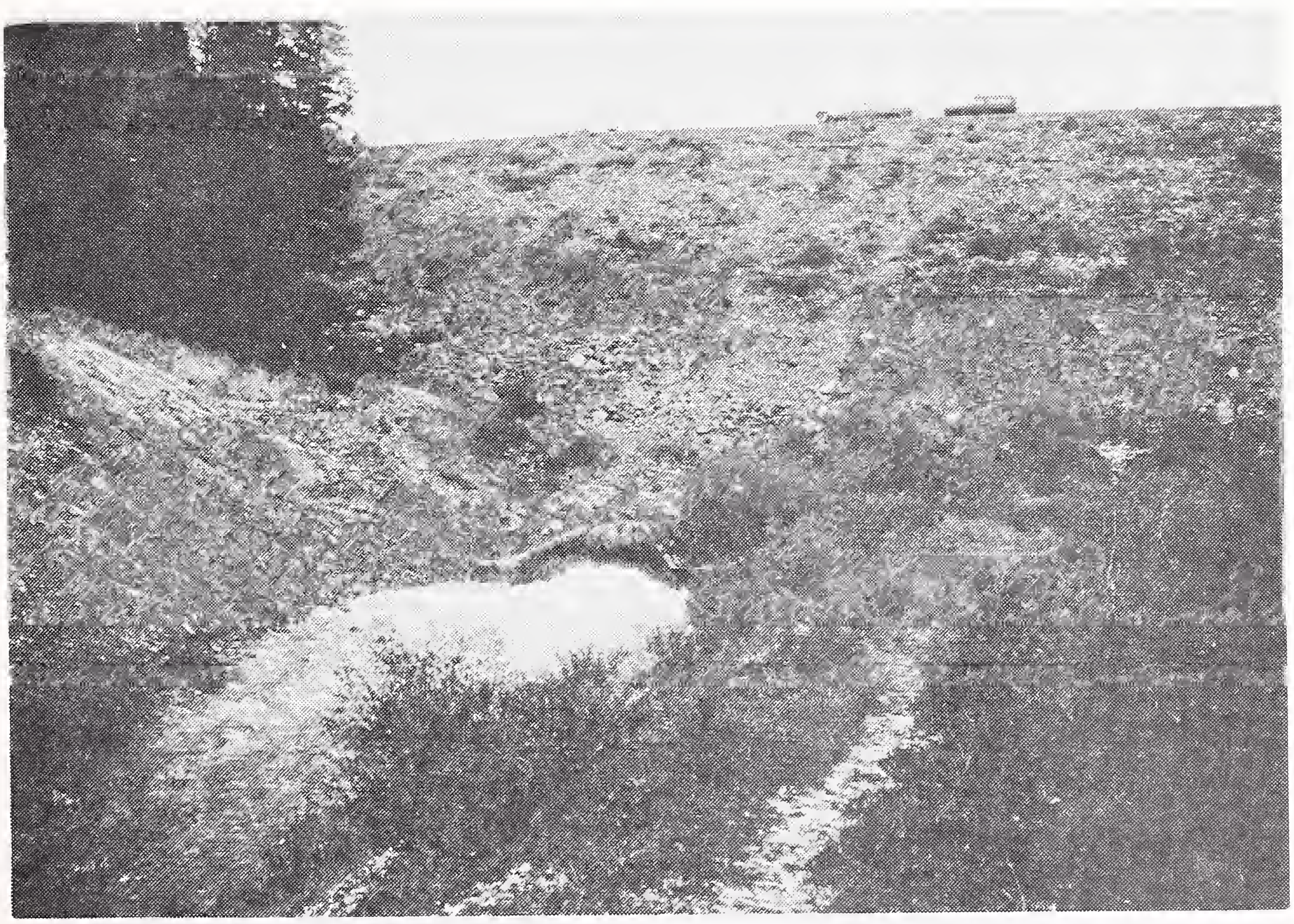
*Where more than one sample number is shown the results refer to the analysis of a composite sample.

**Actual samples as received.

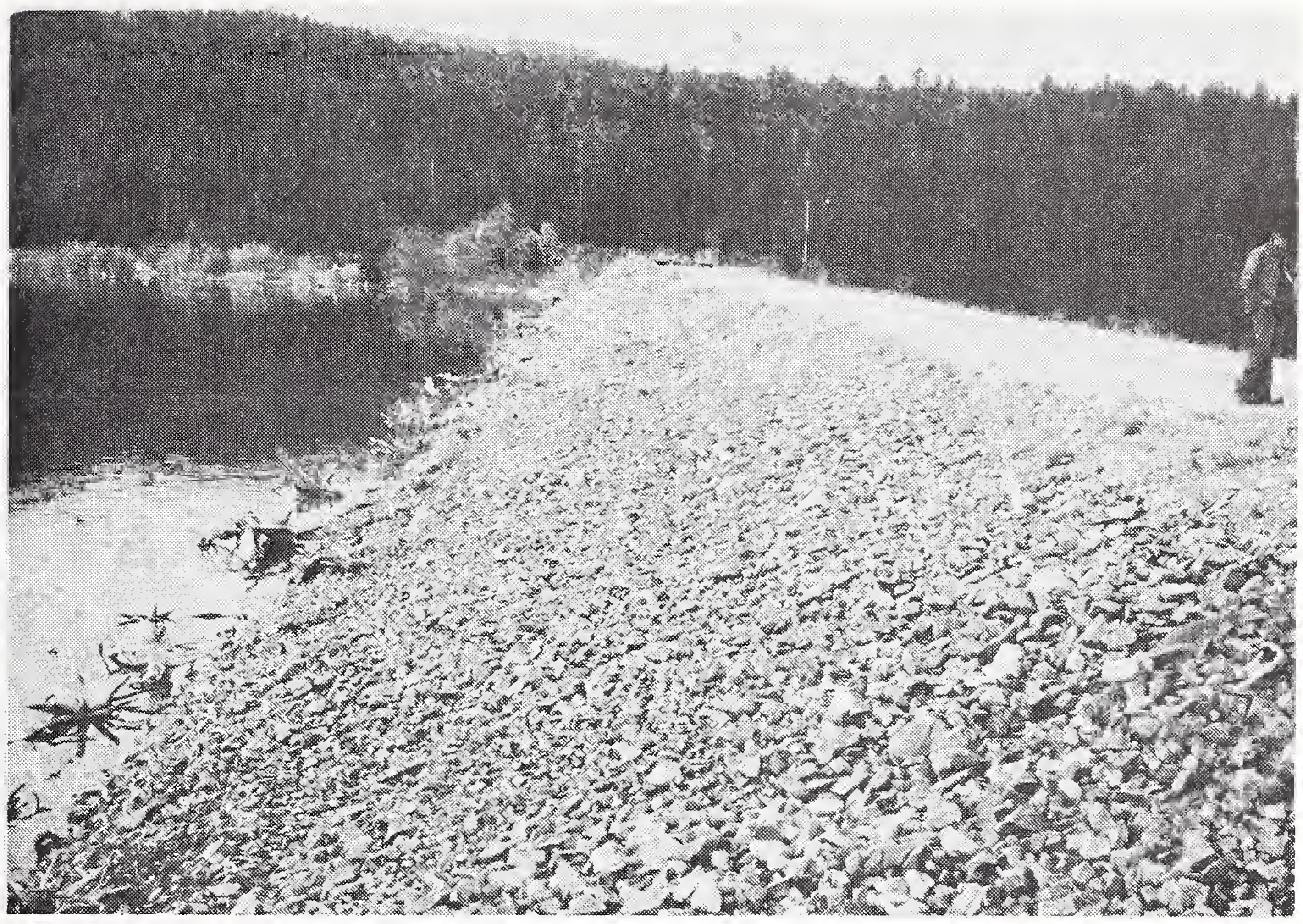
øAll particles retained on a #4 sieve screened out of sample before testing.



(PHOTO 1) Flint Creek (East Fork Rock Creek) Dam
Spillway approach channel.



(PHOTO 2) Outlet channel and Right abutment.



(PHOTO 3) Embankment Upstream Slope.

(PHOTO 4) Seepage at Downstream Slope near Left Abutment.

(PHOTO 5) Seepage at Right Abutment Toe.

(PHOTO 6) Ponding Downstream of Embankment.

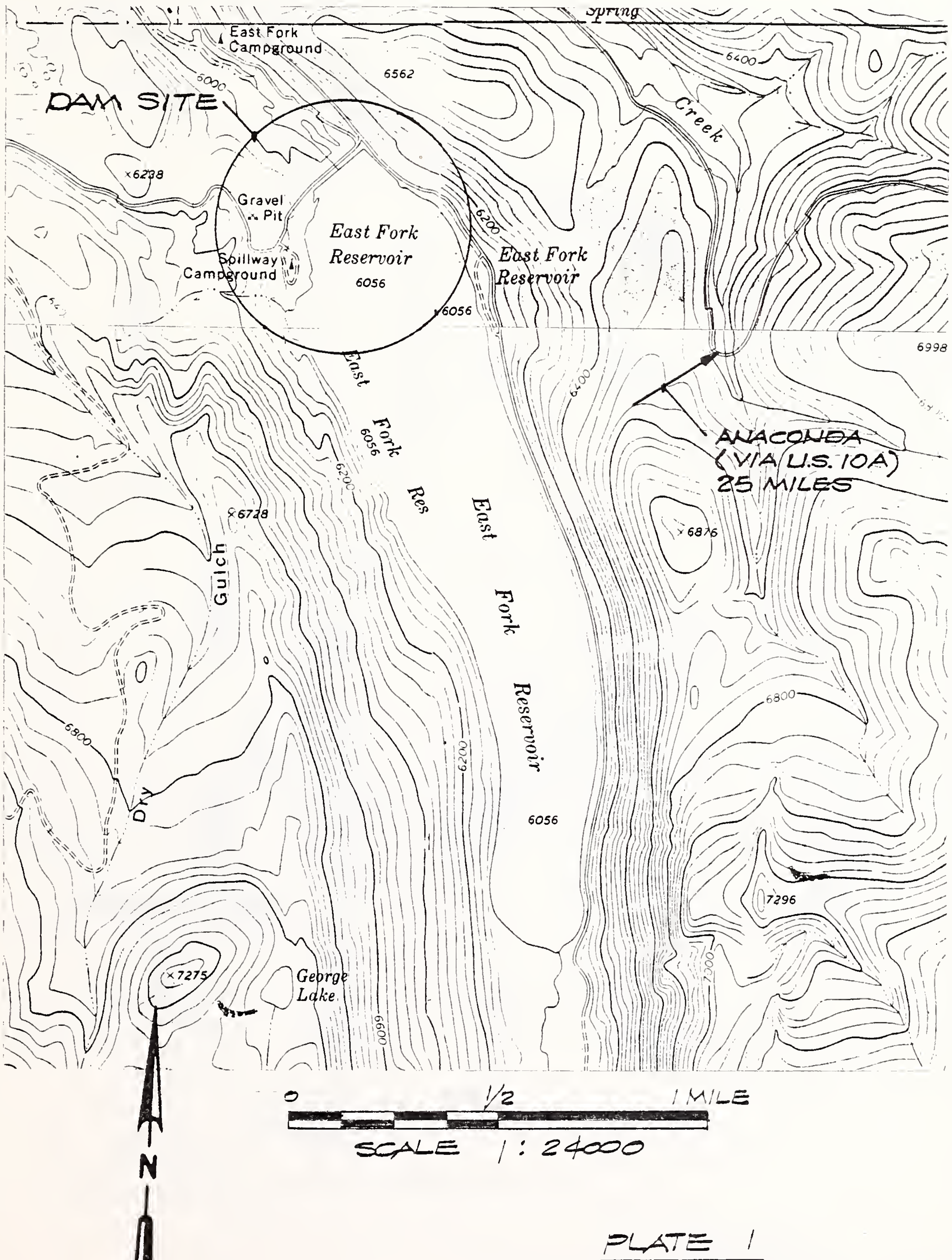


PLATE 1

FLINT CREEK DAM

VICINITY MAP

CH2M HILL

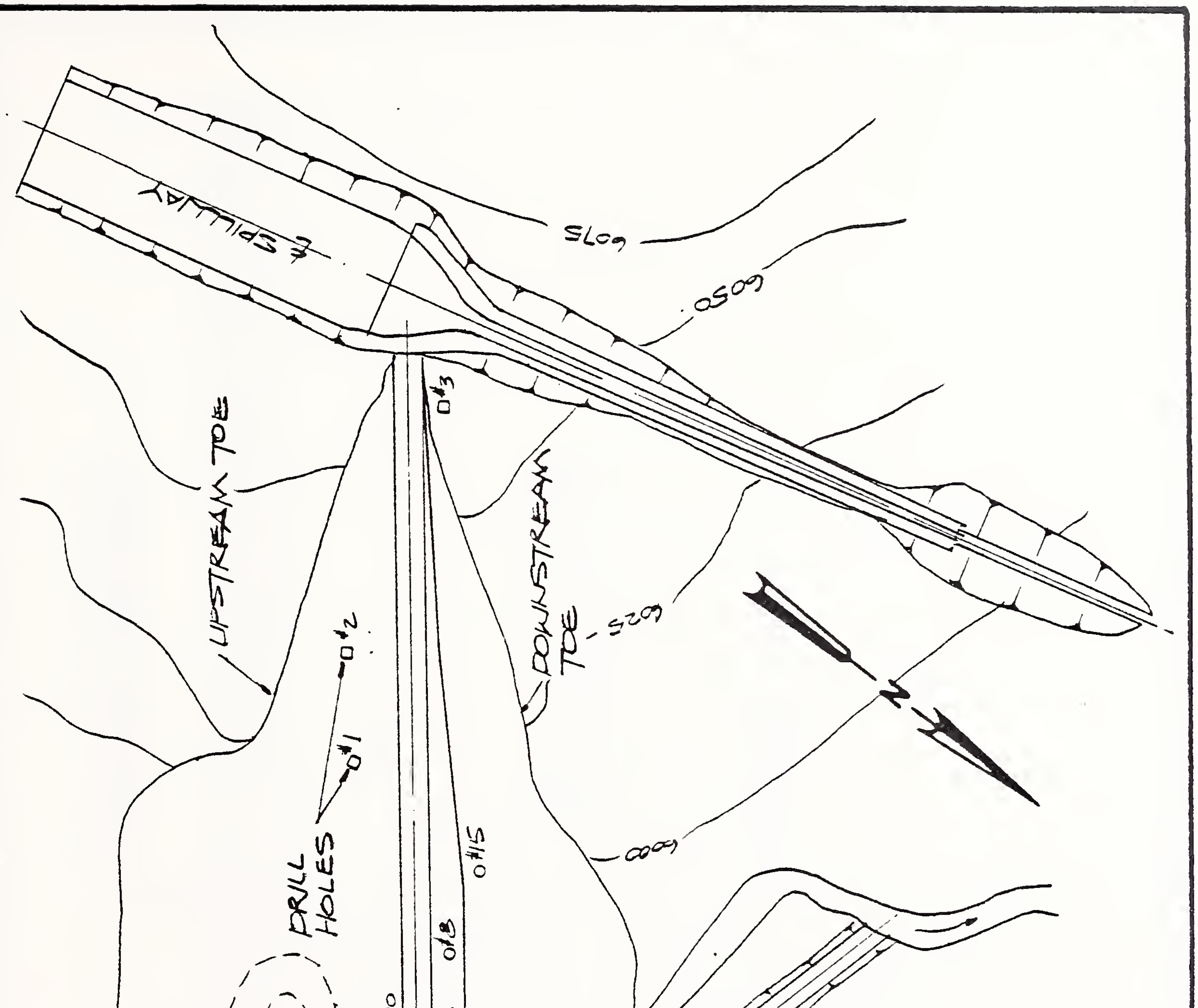
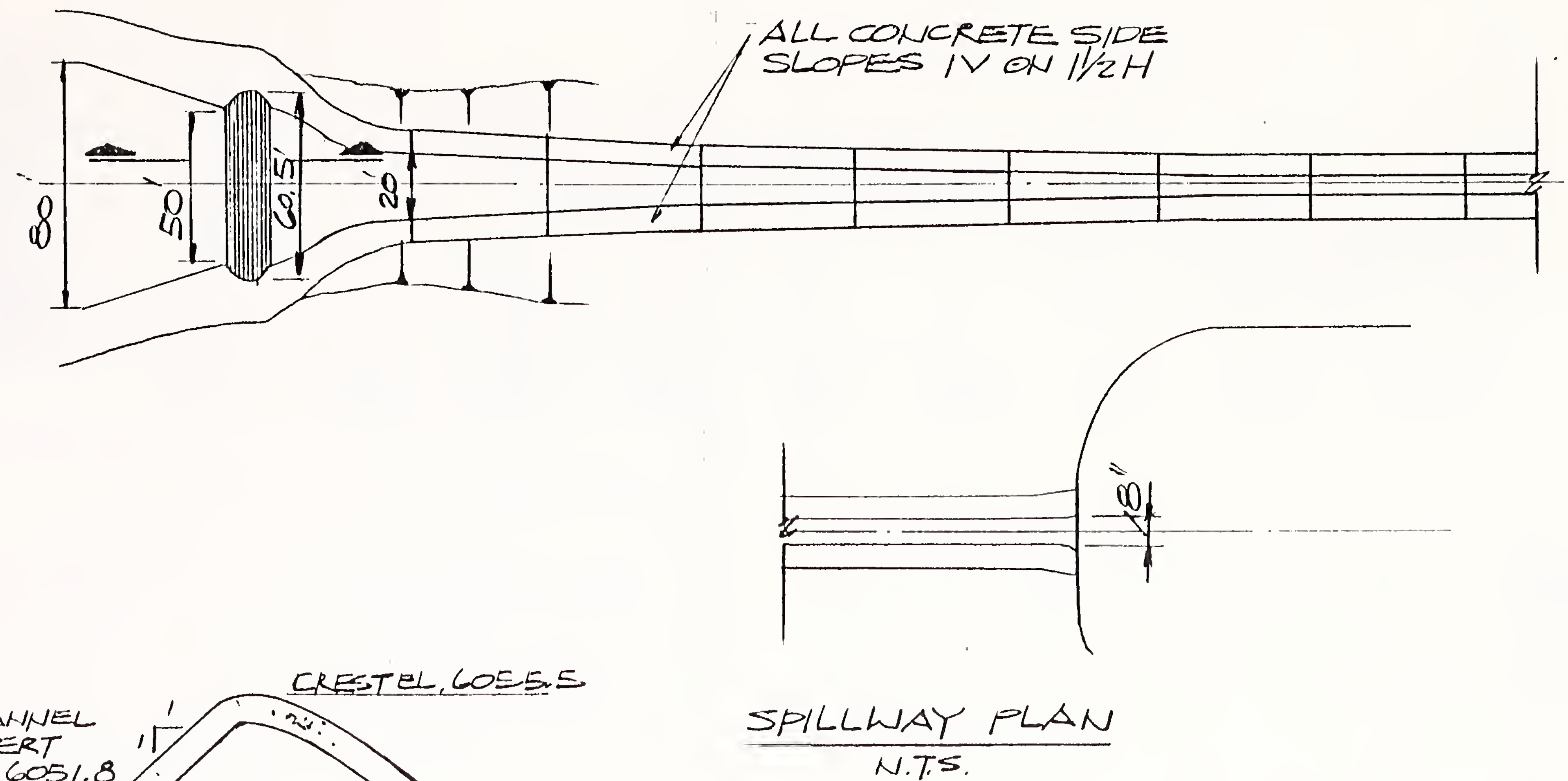


PLATE 2
FLINT CREEK DAM
SITE PLAN

CH2M HILL



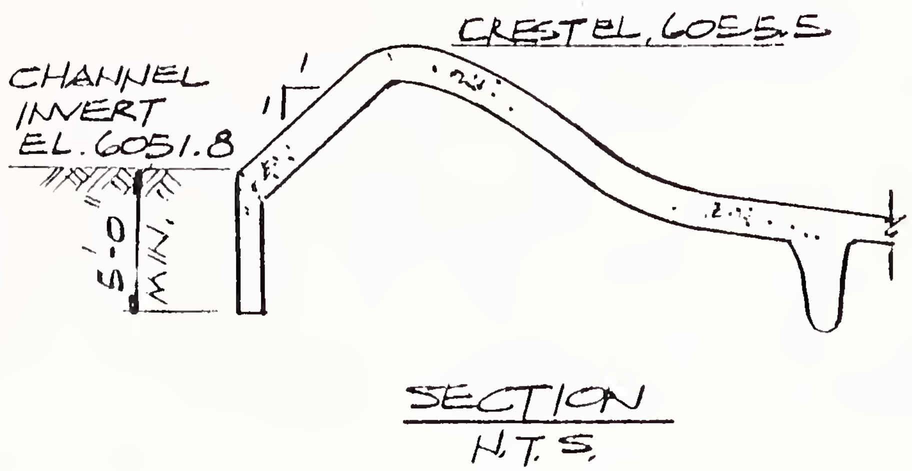
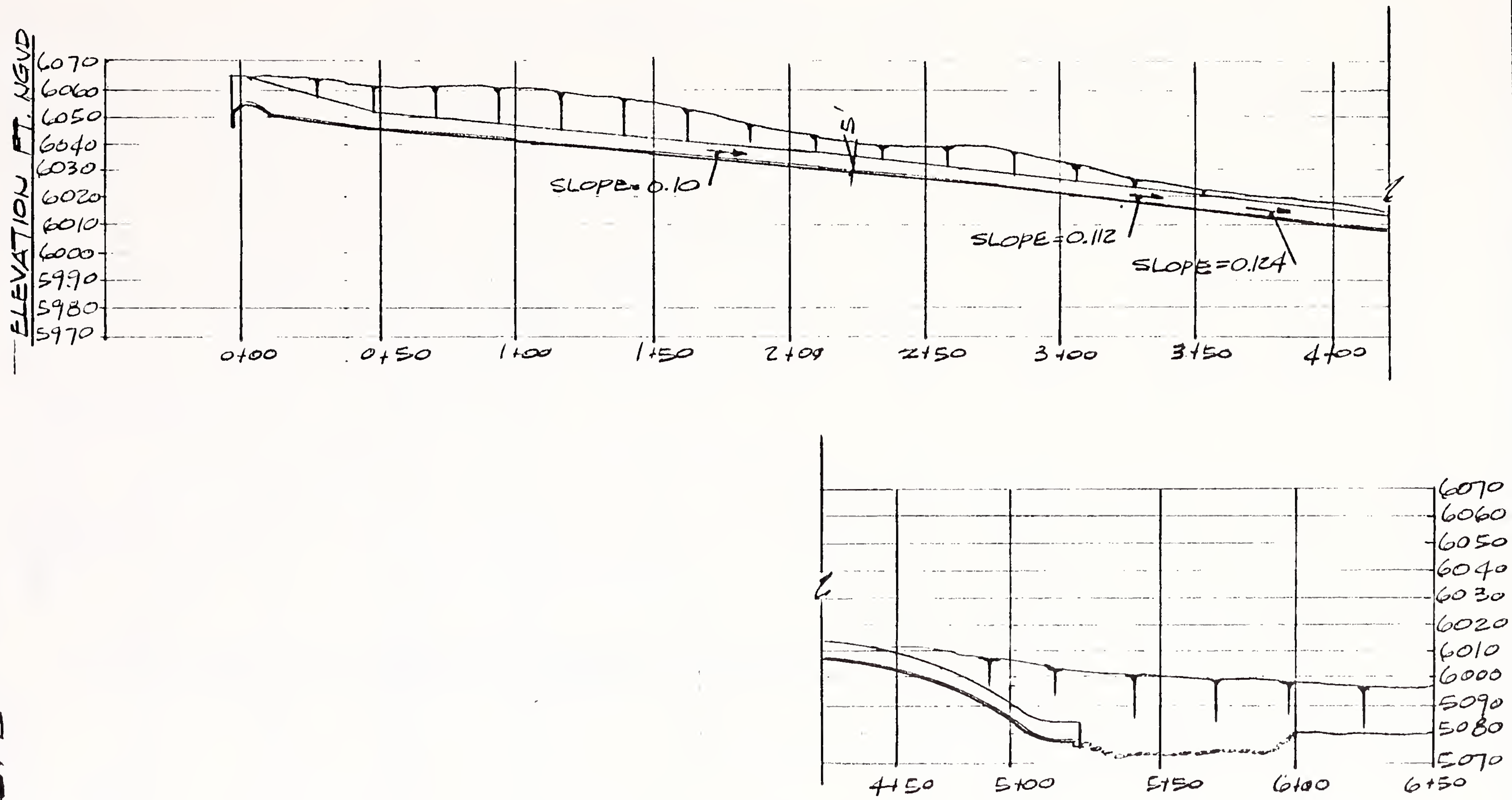


PLATE 3

FLINT CREEK DAM

SPILLWAY PLAN

CH2M HILL



SPILLWAY PROFILE
N.T.S.

PLATE 4
FLINT CREEK DAM
SPILLWAY PROFILE

CH2M HILL

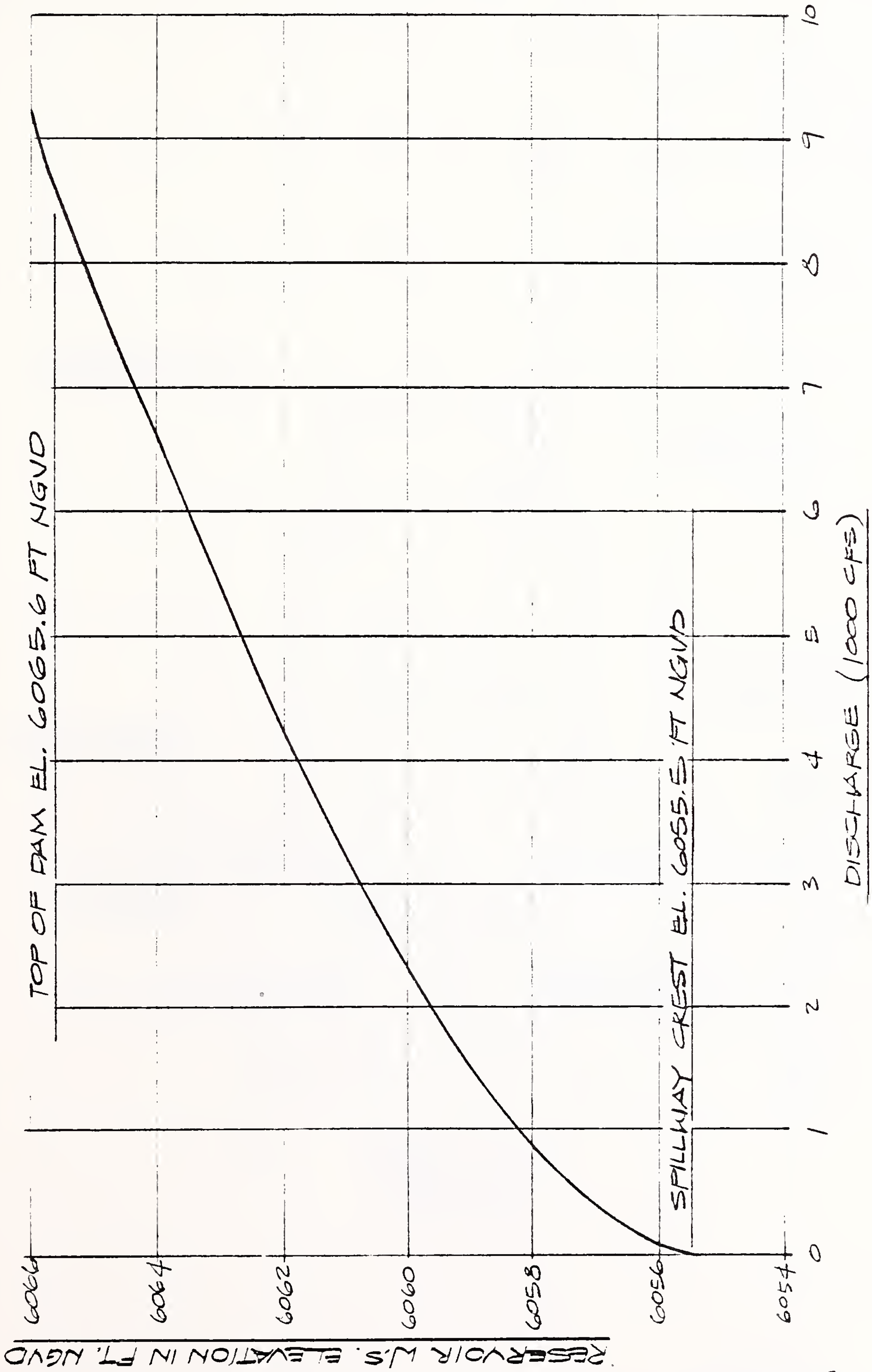


PLATE 5

FLINT CREEK DAM

SPILLWAY RATING CURVE

CH2M HILL

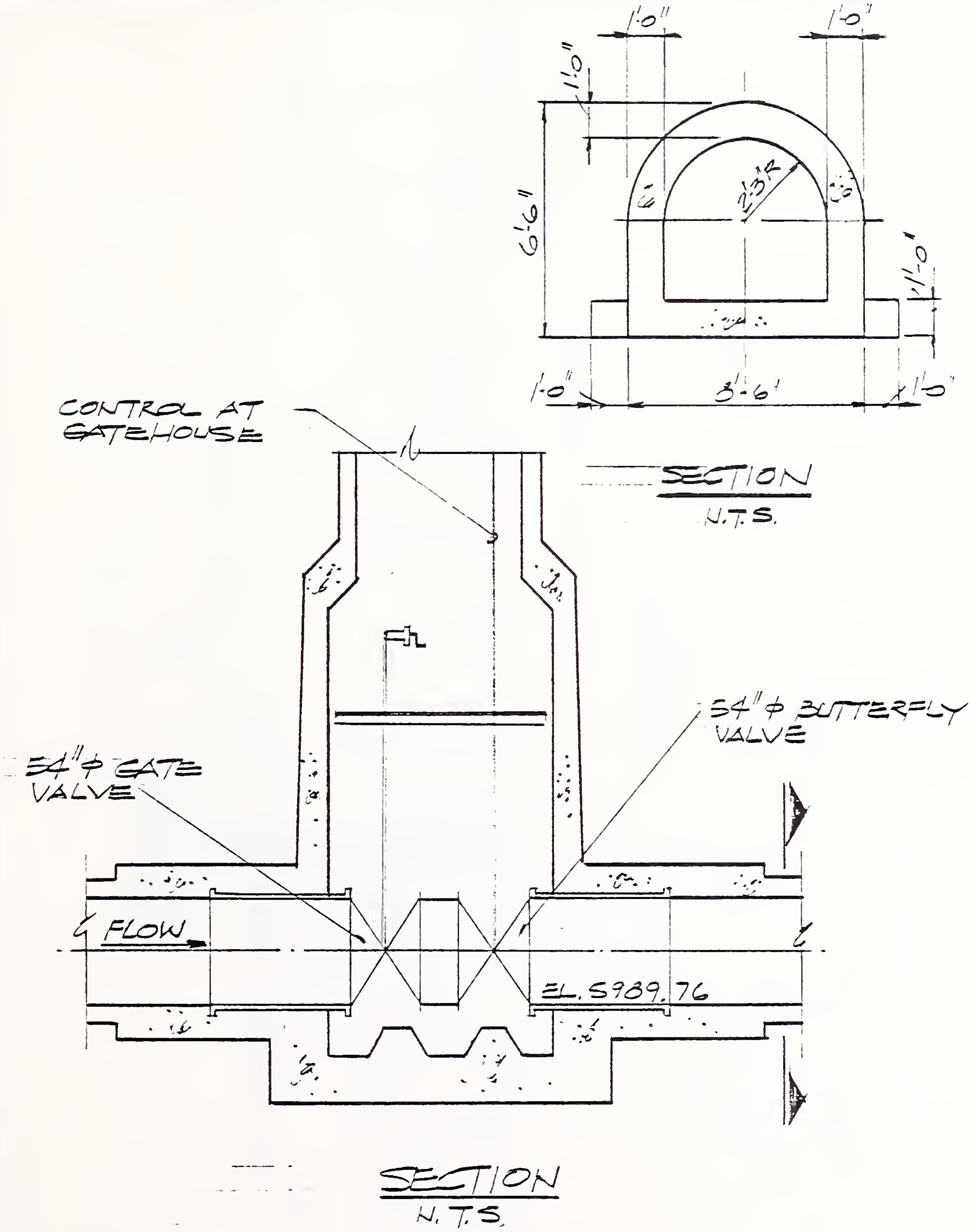
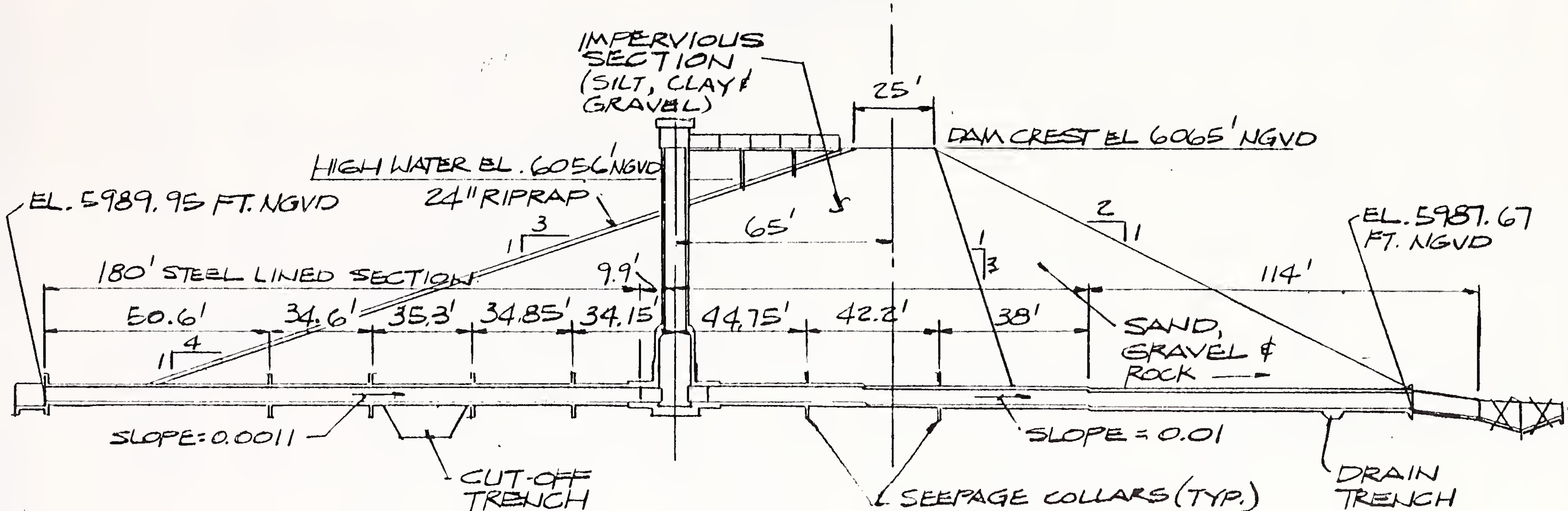


PLATE # 6
FLINT CREEK DAM
OUTLET WORKS

CH2M HILL



SECTION

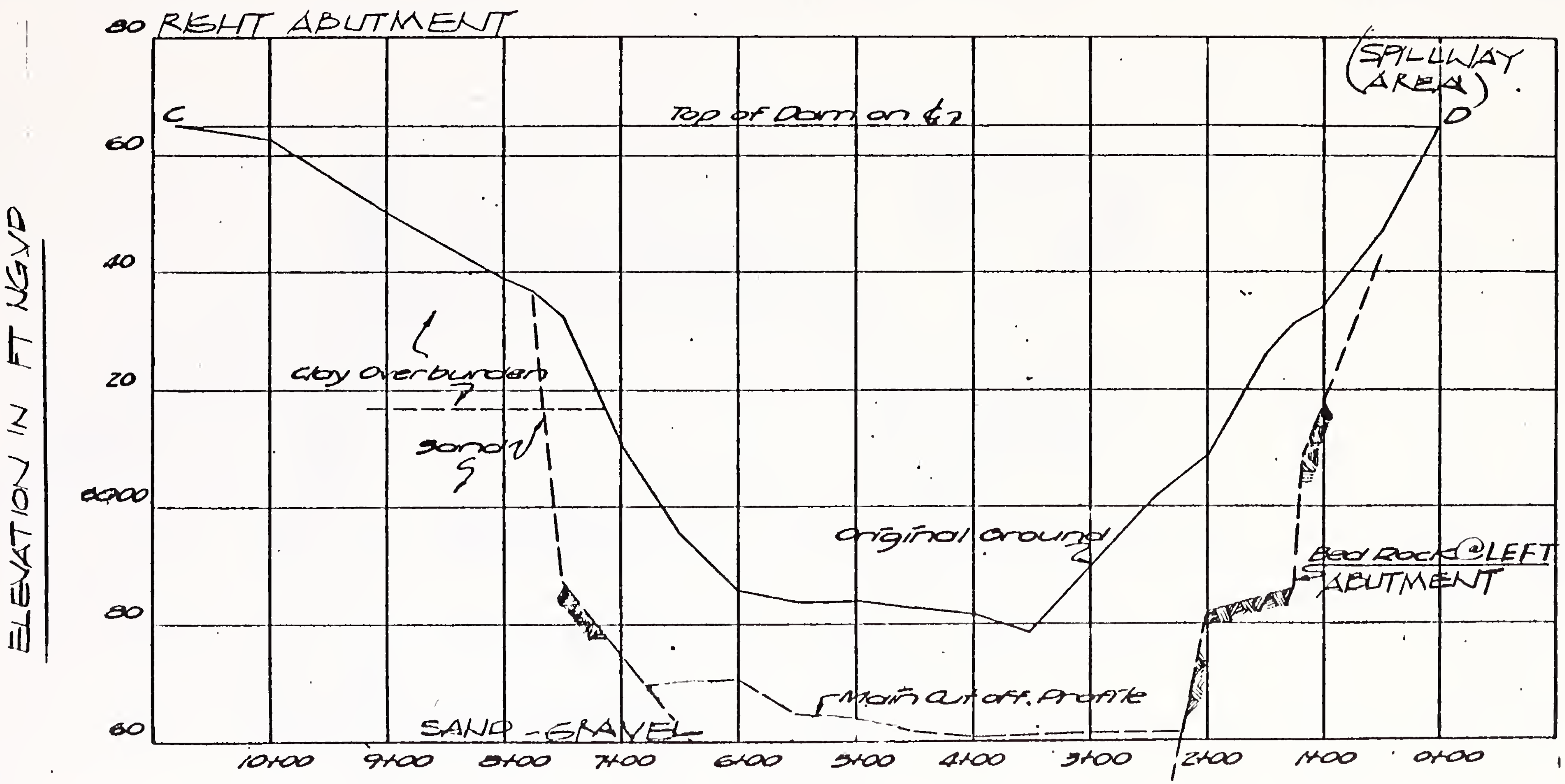
N.T.S.

PLATE 7

FLINT CREEK DAM

DAM SECTION

CH2M HILL



DAM EMBANKMENT PROFILE

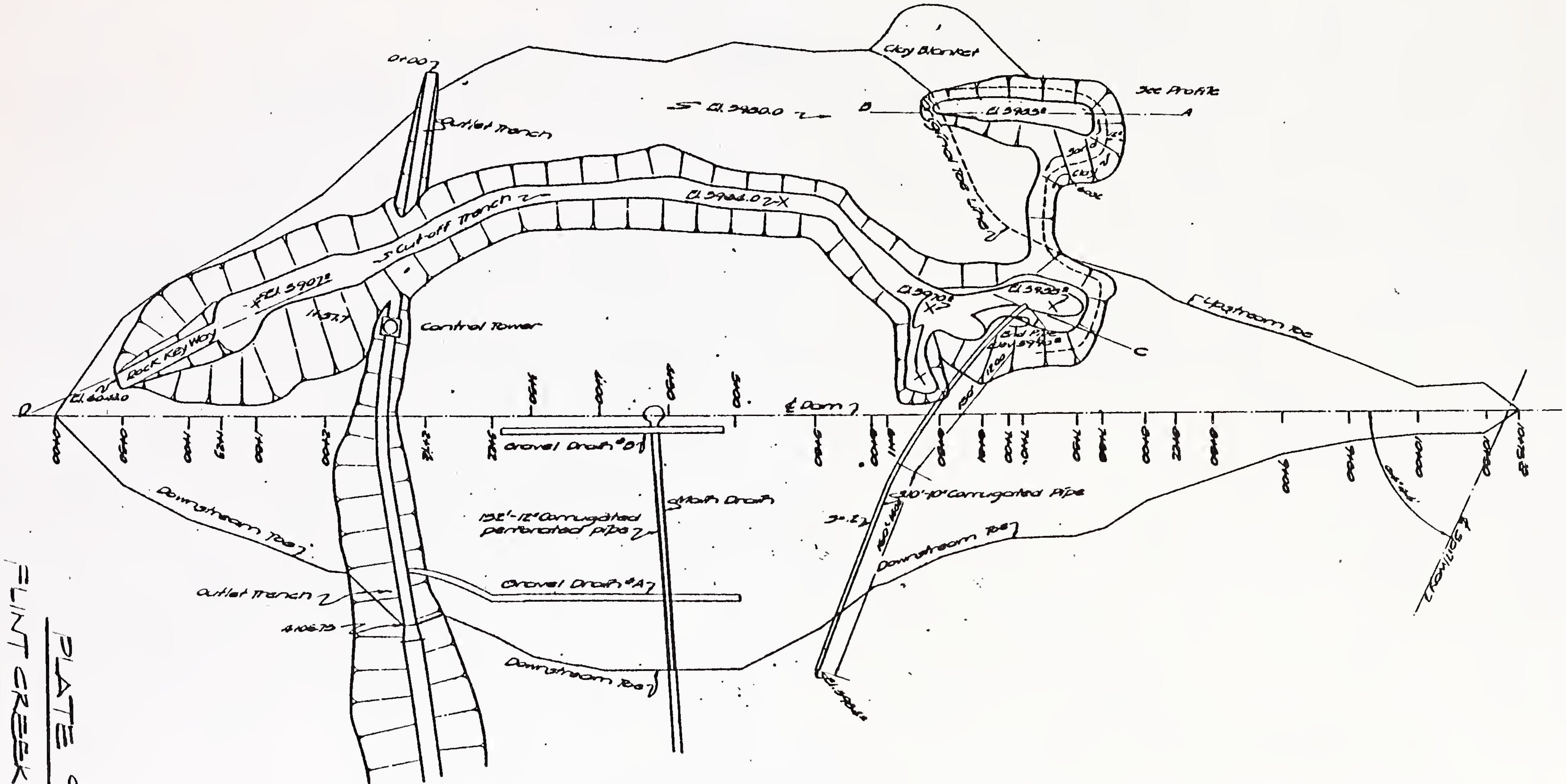
N.T.S.

PLATE 8

FLINT CREEK DAM

DAM EMBANKMENT PROFILE

CH2M HILL



PLAN OF DAM FOUNDATION

N.T.S.

PLATE 9

FLINT CREEK DAM FOUNDATION PLAN

CH2M HILL