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Report to the Congress; by Elmer B. Staats, Comptroller General.

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Authority: Flood Control Act of 1962 (P.L. 87-874).

The cost of the Clarence Cannon Dam and Reservoir project has more than tripled since 1962, primarily because of inflation and estimating and design refinements. Scheduled completion has been delayed 8 years. Findings/Conclusions: In 1962, the estimated project cost was $63.3 million. The estimate has now increased to $232 million. Certain estimates still lack supporting data, and others appear too high because they contain an excessive amount for contingencies. About half of the delays in project completion was due to funding restrictions imposed by Corps of Engineers Headquarters or by the Office of Management and Budget. Other delays resulted from reassessment of construction schedules and from difficulties in negotiating with the State on road relocation designs. The main dam may not be as safe as planned because defective fill material was used in the foundation. Recommendations: The Secretary of the Army should: have the corps review and strengthen its cost estimating procedures to develop more realistic estimates; identify for Congress those corps projects involving construction factors, such as availability of long leadtime items, which are particularly sensitive to schedule delays; and obtain an evaluation of the overall safety of the project from an expert, independent consultant. (SC)

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REPORT TO THE CONGRESS

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Clarence Cannon Dam And Reservoir: Cost, Schedule, And Safety Problems

Corps of Engineers (Civil Functions)
Department of the Army

The cost of the Clarence Cannon Dam and Reservoir project has more than tripled since 1962 primarily because of inflation and estimating and design refinements. Scheduled completion has been delayed 8 years.

The main dam may not be as safe as originally designed because wet fill material was used in the foundation. Dam safety should be verified by an independent consultant.

PSAD-77-131

JULY 18, 1977

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-181997

To the President of the Senate and the
Speaker of the House of Representatives

This report describes the status of the Clarence Cannon Dam and Reservoir project and suggests ways to improve its construction. The report was prepared as part of our continuing effort to give the Congress information concerning the acquisition of major projects.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

Copies of the report are being sent to the Secretaries of Defense and the Army.

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

CLARENCE CANNON DAM AND RESERVOIR: COST, SCHEDULE, AND SAFETY PROBLEMS

Corps of Engineers (Civil Functions)
Department of the Army

D I G E S T

The Clarence Cannon Dam and Reservoir in northeast Missouri is a multipurpose Corps of Engineers water resources project designed to provide flood control, hydroelectric power, recreation, fish and wildlife, water supply, and navigational benefits.

In 1962 when the Congress authorized the project, it was estimated to cost $63.3 million. The estimate has increased to $232 million due to

--inflation (50 percent) and

--design changes to correct errors or refinements of earlier estimates (most of the remaining 50 percent).

Certain estimates still lack supporting data, and others appear too high because they contain an excessive amount for contingencies. (See p. 7.) The Secretary of the Army should have the Corps review and strengthen its cost estimating procedures to develop more realistic estimates.

The project will not be completed until 1981--8 years later than planned. About half the delays were due to funding restrictions imposed by Corps headquarters or by the Office of Management and Budget. Other delays resulted from reassessing construction schedules and from difficulties in negotiating with the State on road relocation designs.

Because of delayed project completion, turbines were delivered earlier than needed. Storing and maintaining them is creating added costs. (See p. 8.)

The Corps advises the Congress, in budget justifications and testimony, of the reasons for delays. More information should be reported, particularly for projects with unique

construction factors that cause the project cost to be particularly sensitive to schedule delays. The Secretary of the Army should identify those Corps projects involving construction factors, such as availability of long lead-time items, which are particularly sensitive to schedule delays.

Is the project's hydroelectric power capability financially justified? In 1962 Corps officials thought that costs could be repaid through power revenues; now this is questionable, as costs have increased--most recently to $51.4 million. (See p. 21.) The Corps believes the project will be financially feasible as power rates increase and contracts are renegotiated over the next several years. However, GAO believes the costs allocated to power can also increase since construction will not be complete until 1981.

The main dam may not be as safe as planned because defective fill material was used in the foundation. In 1973 the district engineer proposed to replace the defective fill. Instead, the Corps decided to wait until phase II construction on the foundation begins (in 1977 or 1978) to determine whether remedies, such as enlarging the size of the dam, would be necessary.

The Corps commented that it is sensitive to the dam safety problem and will make the necessary design changes to guarantee a safe project. (See p. 18.) The Secretary of the Army should obtain an evaluation of the overall safety of the project from an expert, independent consultant.

Contents

CHAPTER 1

INTRODUCTION

We reviewed certain aspects of the Corps of Engineers planning and construction of the Clarence Cannon Dam and Reservoir project as part of our continuing effort to give the Congress information on major acquisition programs. Our main objective was to examine the status and management of the project.

The Clarence Cannon Dam and Reservoir, formerly named the Joanna Dam and Reservoir, was authorized by the Flood Control Act of 1962 (Public Law 87-874) to provide flood control, hydroelectric power, recreation, fish and wildlife, water supply, and navigational benefits. Flood control, power, and recreation account for about 91 percent of the $11.6 million estimated annual benefits. The cost allocated to water supply is to be repaid by the Missouri Water Resources Board.

The project is in northeast Missouri along the Salt River, which flows into the Mississippi River 63 miles downstream from the damsite. In constructing the project, the Corps plans to acquire fee title to about 53,000 acres of land and flowage easements for an addicional 11,200 acres. The reservoir will have about 285 miles of shoreline, and will cover about 18,600 acres at the normal pool level and about 38,400 acres at the flood pool level. The project will serve a watershed, or drainage area, of about 2,300 square miles above the main dam and about 600 square miles downstream to the Mississippi River.

The Corps has assigned 11,000 acres of project lands to recreational and open space use. Estimated annual attendance at the project for all recreational purposes will be about 3.9 million in the first 3 years of full-scale operations. The recreation plans provide for 18 recreational areas, with most of the development concentrated in 2 major access areas--1 covering 1,395 acres and the other 485 acres. Recreational facilities include campsites, picnic areas, and boat-launching ramps. Facilities constructed in two of the areas will become part of the Mark Twain State Park, operated by the Missouri State Park Board.

The hydroelectric powerplant will consist of two turbine-generator units having a 62,000-kilowatt dependable capacity, and an 8,000-kilowatt interruptable capacity. It is expected to generate an average of 87,892,900 kilowatt hours of energy annually. The project will have a re-regulation dam about

9.5 miles downstream from the main dam to retain some of the water released through power generation. One of the turbine-generators is reversible so that it can pump water from the re-regulation pool back into the main reservoir for reuse in generating additional hydroelectric power. Although the pumpback operation will consume about 1-1/2 times the energy produced from the "recovered" water, the pumping energy is expected to be less costly because it will be purchased during periods of low demand.

PROJECT BENEFITS

The Corps has increased its estimate of annual project benefits several times. The following table shows the amount of benefits estimated in the project authorization document and at various times since then, including the latest estimate for 1975.

Type of benefit	Amount of annual benefits			
	1962 authorization	1967	1972	1975
	(thousands)			
Hydroelectric power	$1,089.7	$1,182.7	$2,004.0	$ 4,248.0
Flood control	1,317.5	1,840.9	2,731.0	3,797.0
Recreation	1,380.0	1,458.7	2,188.0	2,513.0
Fish and wildlife	261.5	318.6	319.0	319.0
Water supply	105.0	141.6	235.0	370.0
Navigation	3.1	4.6	8.0	9.0
Redevelopment	-	-	-	a/379.0
Total	$4,156.8	$4,947.1	$7,485.0	$11,635.0
Benefit to cost ratio	1.3:1	1.5:1	1.4:1	1.3:1

a/The Corps added redevelopment benefits in 1974.

About 93 percent of the approximately $3.2 million increase in hydroelectric power benefits is due to higher market values provided to the Corps by the Federal Power Commission. The values increased from $16.50 a kilowatt at the time of project authorization to $56.90 in 1975. The remaining 7-percent increase results from an increase in the estimated capability of the generators and turbines.

The approximately $2.5 million increase in flood control benefits was due, in part, to adjustments for price-level increases. Those increases were developed separately for crops, general building, and heavy construction. Another factor allowed for was increased crop yields.

The more than $1 million increase in recreational benefits resulted from increasing the annual visitor-day estimate from 1.2 million to 1.7 million and increasing the value of a visitor day from $1.15 to $1.50. A major factor in the increase in benefits was expanding the Corps recreational facilities from the minimal type provided for in the project authorization document to very extensive facilities. The Corps also considered experience from other projects and population growth.

SCOPE OF REVIEW

The data in this report is based on interviews with Corps officials at Corps headquarters and at the St. Louis district office and on our review of records and documents these officials made available. Also, we discussed the power feasibility aspects of the project with Southwestern Power Administration officials.

CHAPTER 2

COST AND SCHEDULE EXPERIENCE

Since the Congress authorized the project in 1962, estimates of both the cost and the time required to complete the project have increased significantly. The latest estimate is nearly four times the 1962 estimate, and the scheduled completion date has slipped 8 years.

COST EXPERIENCE

As of October 1, 1976, the latest estimate for fiscal year 1978 budget submission was $232 million, an increase of $168.7 million, or about four times the amount on which the 1962 congressional authorization was based. The following table shows the increases by project features.

	Estimates (millions)	
Project feature	Project authorization 1962	Latest estimate 1976
Lands and damages	$ 7.7	$ 17.4
Relocations	15.5	77.8
Reservoirs	1.5	5.2
Dams	21.4	54.6
Fish and wildlife facilities	-	1.1
Powerplant	9.0	23.0
Roads, railroads, and bridges	0.1	2.4
Recreational facilities	0.8	15.5
Buildings, grounds, and utilities	0.3	1.1
Permanent operating equipment	0.2	1.9
Engineering and design	3.8	20.5
Supervision and administration	3.0	10.5
Total	$63.3	$232.0

Reasons for cost growth

The following table shows the reasons for project cost growth from the 1962 authorization to the latest estimate of October 1976.

Reason for cost growth	Amount	Percent of total increase
	(millions)	
Price-level increases	$ 84.6	50.1
Refinement of previous estimates	44.3	26.3
Design changes	37.4	22.2
Additional functions	2.4	1.4
Total	$168.7	100.0

Price-level increases

The Corps updates cost estimates annually to reflect price-level increases, design changes, and receipt or development of better estimating data; but they do not include future price-level increases and other cost growth factors. For example, the October 1976 estimate did not include inflation anticipated beyond October 1, 1976. This is in accordance with a long established policy of the Office of Management and Budget which generally precludes allowances for future price-level increases in budget estimates presented to the Congress.

The Corps estimates price-level increases primarily by applying a construction industry index to construction cost estimates and applying Federal salary rate increases to estimates for engineering, design, supervision, and administration. Each year the Corps' Lower Mississippi Valley Division office provides the price-level increase percentages to be used uniformly by district offices.

In developing its latest cost estimate, the Corps used a 10-percent factor to update construction cost estimates from the October 1975 price level to the October 1976 price level. The division office developed the factor by estimating what the Engineering News Record national index (20 U.S. cities average) for the heavy construction industry would be in October 1976. A Corps official said the national index is used in the division because it is simpler than using a separate index for each district.

Refinement of previous estimates

This category includes revisions based on additional or later data, correction of errors or omissions, receipt of contractor bids, and award of contracts. Principal revisions to date include a:

--1972 increase of $1.3 million for additional Corps effort required because the scheduled completion date had slipped 5-1/2 years.

--1973 increase of $16.1 million because the contract price for constructing phase II of the main dam was higher than the Corps estimated.

--1975 increase of $5.1 million required for "correction of errors and inadequacies in prior estimates" of road relocation costs.

--1975 increase of $5 million because the contingency allowance percentage was increased.

--1976 increase of $2.9 million due to reanalyzing funding requirements for engineering and design.

Design changes

The increase attributed to design changes is for modifying earlier designs or incorporating additional design features into the project. Major increases included are a:

--1975 increase of $15.5 million in road relocation costs to provide for wider bridges and roads required by State design standards.

--1975 increase of $2.2 million for additional engineering and design work related primarily to redesigning road relocations and recreational facilities. Additional engineering and design increases totaling $2.8 million were made in 1970 and 1972 for restudying the feasibility of power and redesigning the right dam abutment and highway relocations.

--1972 increase of $1.25 million to provide for longer and wider access roads to recreational areas.

Additional functions

This category includes project functions not originally anticipated, but authorized by subsequent legislation. An increase of $850,000 was provided for relocation assistance required by Public Law 91-646, $673,000 for meeting requirements of the Environmental Protection Act, and $620,000 for making archeological investigations pursuant to Public Law 93-291.

NEED FOR BETTER COST ESTIMATES

Our review of selected parts of the latest Cannon project cost estimate of $232 million showed a need for improvement in cost estimating procedures. We found a lack of documentation and an excessive allowance for contingencies. While a major part of the $232 million cost estimate is based on actual expenditures or contracts, our review of amounts required to complete certain items disclosed some questionable estimates. These are discussed in the following paragraphs.

State highway relocations

The latest Corps estimate of $66.4 million for State highway relocation is the product of a 1972 estimate developed from preliminary design data that has been updated to include revised design criteria and to reflect 1976 price levels.

We reviewed the estimates for five relocations which the Corps district office had estimated to cost about $50 million. We found no documented support for the unit prices for two of these relocations. Also, the estimator increased unit prices of items in the preliminary design stage for all five relocations from 10 to 50 percent, even though a 25-percent factor was also added to the estimates for normal contingencies, such as unexpected cost increases and later design changes. We were told that the 10- to 50-percent increase was to offset anticipated increased quantities. A Corps official stated that the unit price increase was an extra allowance to make sure sufficient money is appropriated. We believe this procedure permits an excessive allowance for contingencies to be included in the overall cost estimate.

Subsequently, the Corps contracted with the State highway department to develop the detailed design, prepare the plans and specifications, and award and supervise the construction contracts. The State's cost estimates for the five relocations amount to about $29 million, or about $21 million less than the Corp's estimates. The State's estimates appear more reasonable because the contract award for the first of the five relocations was about 2 percent less than its estimate.

Engineering, design, supervision, and administration

The Corps estimated that $12.9 million would be required after September 1975 to complete engineering, design, supervision, and administration work on the project. The estimator

said he had developed the estimate by analyzing the work yet to be completed but had prepared no documentation showing how he had developed the estimate.

SCHEDULE EXPERIENCE

The original schedule provided for the project, including the hydroelectric power portion, to be completed in June 1973, whereas the latest schedule (October 1976) provides for both power units to be in service by October 1979 and for the total project to be complete in June 1981, 8 years later than originally scheduled.

Delays due to inadequate funding

Agency officials informed us that about a 3-year delay is due to funding restrictions imposed by Corps headquarters or the Office of Management and Budget. Over 2 years of that delay was caused by reductions of $2.7 million, $1.2 million, and $5.7 million from amounts recommended by the division and district offices in fiscal years 1969, 1970, and 1972, respectively. The additional 1-year delay resulted from Office of Management and Budget requirements that projected funding for the project for fiscal years 1978-81 to be limited to prescribed amounts.

Other delays

The Corps attributed an 18-month extension to the need to extend the main dam and spillway construction period to allow for foundation and abutment treatment found to be necessary after abutment exploration. The Corps included that extension in its fiscal year 1974 budget submission. In fiscal year 1977 appropriation hearings, the Corps reported that an 18-month delay had resulted from extended negotiations with the Missouri State Highway Commission on the design of road relocations. An additional year's extension resulted from Corps studies in 1968 and 1969 to determine whether retaining hydroelectric power in the project could be justified. (See ch. 3.)

Impact of schedule changes

The Corps has not analyzed the impact of slipping the completion date from 1973 to 1981, but one cost factor would be price-level increases since 1973. Since June 1973 the Corps has increased its cost estimate $27 million to recognize price-level escalation to October 1976.

Due to delays in project completion, the powerplant turbines were completed and delivered earlier than needed. The Corps advised us that the added cost for storing and preserving the equipment is $89,000. As a result of the slippages, the manufacturer's warranty on the turbines will expire in February 1978, before they are placed in use. The powerplant is scheduled for operation in October 1979. In September 1976 the manufacturer quoted a price of about $220,000 to extend the warranty through the first year of turbine operations, if the current completion schedule is maintained.

Delaying project completion will also result in deterioration of recreational facilities being constructed. The facilities, including asphalt roads and parking areas, a sewage disposal plant, an electrical system, and picnic tables and grills, were to be completed by June 1977--the dam closure date scheduled when the Corps awarded the recreation facilities contract. The dam closure date has slipped 21 months, subjecting the facilities to additional deterioration before they are used.

CONCLUSIONS

Corps estimating procedures are not adequate to assure that estimates are reasonable. Specifically, the Corps needs to document the basis for estimates and exclude excessive allowances for contingencies.

During the construction of this project, long lead-time items--turbines--were purchased early in the construction process so as to be available when needed. Due in part to funding restrictions which have delayed the project for 3 of the 8 years, this equipment, which has now been delivered, will not be needed for several years. As a result, the Corps is incurring added costs to store and preserve this idle equipment. Further, the manufacturer's warranties for the equipment are likely to expire before it is placed in service.

The Corps is experiencing schedule delays on other multipurpose projects. For example, we reported a schedule slippage of 9 years for the Harry S Truman Dam and Reservoir project in an April 1975 report. Thirteen major multipurpose Corps projects remain uncompleted 11 years after the detailed construction estimate was completed. This information is based on data provided by the Corps and included in our report on the "Financial Status of Major Acquisitions, June 30, 1976" (PSAD-77-62, Jan. 18, 1977). These projects may also have unique construction factors which may be sensitive to schedule

delays; however, in this review we have not obtained specific information concerning these factors.

AGENCY COMMENTS AND OUR EVALUATION

In an April 27, 1977, letter, the Assistant Secretary of the Army commented on the difficulty in developing estimates that closely approximate future bid prices because of factors such as inflation, labor strikes, and delivery schedules. Therefore, the Corps believes that, although the Government's estimate and the eventual bid may not match closely, this is not necessarily a reliable indicator that the estimate was unrealistic when prepared. (See app. I.)

We recognize the problems involved in developing adequate cost estimates and realize that an allowance for normal contingencies, such as unexpected cost increases and design changes, are necessary. We believe that inclusion of an additional allowance for increased quantities is excessive. This can result in overstated, unrealistic estimates.

The Corps also indicates that the level of funding is the consequence of Federal priorities and that it advises the Congress of such delays as have been, or might be, occasioned.

We recognize that reduced funding will cause delays. However, we believe that, within a limitation of total funds, certain projects are more sensitive to schedule delays and should be given priority for increased funding. This approach would help reduce the cost growth of Corps of Engineers projects.

RECOMMENDATIONS

We recommend that the Secretary of the Army have the Corps review and strengthen its cost estimating procedures to develop more realistic cost estimates. We also recommend that the Secretary identify for the Congress, from among the many active Corps projects, those involving construction factors, such as availability of long lead-time items, which are particularily sensitive to schedule delays.

CHAPTER 3

HYDROELECTRIC POWER FEASIBILITY

Since the Congress authorized the Cannon project in 1962, questions have arisen intermittently concerning whether retaining power in the project was justified. Some of the resulting Corps studies were not based on the most complete and current data. As a result of the questions, completion of the Cannon Dam and Reservoir has been delayed and additional design work has been necessary.

ECONOMIC FEASIBILITY

Inclusion of hydroelectric power in a water resource project requires that two tests of feasibility be met: (1) financial feasibility--that power revenues be adequate to repay the Federal investment within 50 years--and (2) economic feasibility--that separable costs of power (added cost of constructing the project with power versus constructing it without power) be no greater than the cost of an alternative single-purpose power project. The Federal Power Commission provides the alternative power project cost data.

When the Congress authorized the Cannon project in 1962, the Corps determined that hydroelectric power was both financially and economically feasible. However, in 1965 and intermittently since then, either economic or financial feasibility has been in question.

For example, in early 1966 the Corps reassessed economic feasibility based on updated alternative power project values received from the Federal Power Commission and found that power was no longer feasible because separable costs exceeded costs for an alternative power project. As a result, the Corps decided in February 1966 to redesign the project without hydroelectric power. In July 1966 the Commission reconsidered the power values and concluded that higher values were appropriate. The Corps then reassessed feasibility based on the higher values and found power to again be economically feasible. The Chief of Engineers authorized reinstating power as a project feature in December 1966.

During resolution of the feasibility question, the Corps was required to revise its September 1965 general design memorandum twice--once to delete power and again to reinstate power--and as a result, delayed completion of the project's general design for 18 months.

FINANCIAL FEASIBILITY

In October 1968 the Corps informed the Southwestern Power Administration, the agency responsible for marketing the power, that the cost allocated to power was $17.9 million, an increase of $2.2 million. The Administration in turn advised the Corps that the increased costs could not be repaid and requested a restudy of power feasibility.

In 1969 Corps headquarters directed that additional studies of ways to reduce power costs be made. Eventually the agency developed a plan based on July 1969 price levels which resulted in a $21.5 million cost allocation to power. After negotiating with two electric cooperatives for about a year, the Southwestern Power Administration reported that the cooperatives had agreed to purchase the power directly at rates that would repay the costs in 50 years. Although the Power Administration concluded power was financially feasible, based on the cooperatives' purchase agreements, it cautioned the Corps that the repayment potential was marginal--annual revenues of $1,061,200 compared to annual costs of $1,054,500--and that any increase in costs allocated to power would jeopardize financial feasibility. Based on this qualified confirmation of financial feasibility, the Corps decided to retain power as a project feature. At that time, 1 year's price level increases had increased the annual costs to $1,136,000, or about $75,000 more than the cooperatives had agreed to pay.

Between August 1969 and August 1975, the investment allocated to power continued to climb, increasing from $21.5 million to $51.4 million in 1975, when the project cost estimate was $215 million.

Upon receipt of the $51.4 million allocation information, the Southwestern Power Administration questioned how such a large increase could occur and noted the cooperatives' 1970 offer could hardly be expected to cover a more than doubling of the power costs. On August 17, 1976, the power-marketing agency informed the Corps that power was no longer financially feasible because the $51.4 million allocation could not be recovered by selling the power through the agency's integrated system. No mention was made of selling the power directly to the cooperatives. In September 1976 the marketing agency advised us (see app. II) that:

--If negotiations to sell the power directly to the cooperatives at rates adequate to recover costs were successful, the power would be financially feasible.

--If these negotiations failed and the power output were sold from the integrated system at present rate levels, costs would exceed revenues by about $2 million annually.

The Administration said that under these conditions the deficit would accumulate to about $234 million during the 50-year repayment period at the project interest rate and that systemwide rates would have to be increased to offset the deficit.

The final investment allocated to power may be substantially higher than $51.4 million because that amount is based on cost estimates at 1975 price levels, whereas the project is not scheduled for completion until 1981.

In an April 1975 staff study we reported a similar problem with the Corps' Harry S Truman Dam and Reservoir. In that case, it was estimated that by the end of the 50-year repayment period, power costs would exceed power revenues by more than $340 million.

AGENCY COMMENTS AND OUR EVALUATION

The Corps recognizes that the project is not currently financially feasible, but it believes the feasibility will be established in the future as power rates increase. Although power rates might increase in the future, costs allocated to power might also increase, since the construction will not be completed for 4 years.

If the power output from the Clarence Cannon Dam cannot be sold directly to cooperatives, it will have to be sold from the Southwestern Power Administration's integrated system, and, based on present rates, costs will exceed revenues by about $2 million annually, or $234 million for the 50-year repayment period.

CHAPTER 4

DAM FOUNDATION SAFETY

The Cannon main dam, an earthen structure, may not be as safe as originally designed because wet fill material was used in the foundation. Incorrect contract specifications and unresolved differences on the fill's optimum moisture content contributed to the use of wet fill material. A Corps study shows this contract specification error reduces foundation design strength. However, the Corps has concluded that, when completed, the dam will still exceed its design standards.

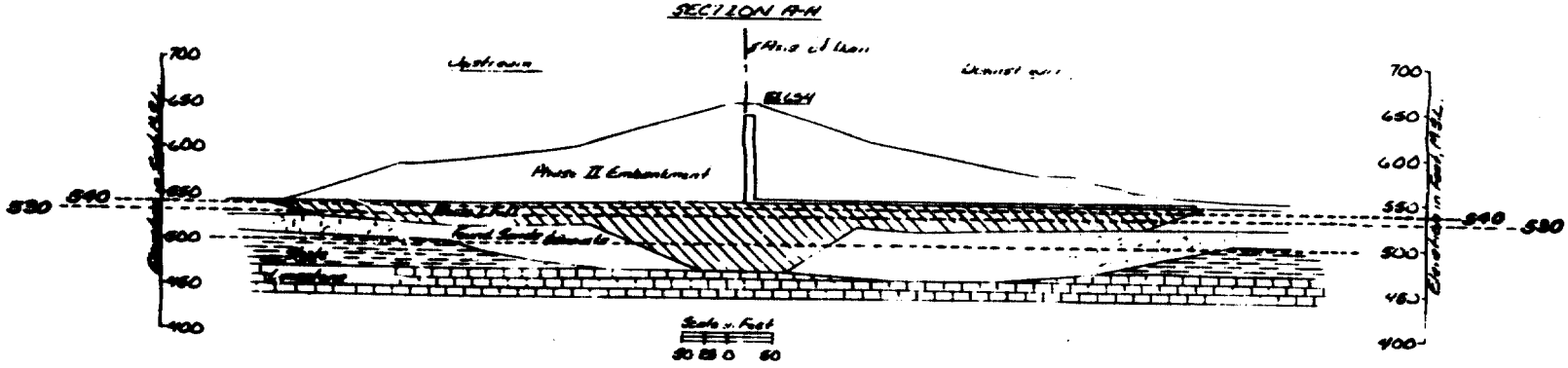
The contract for constructing the main dam foundation was awarded in October 1970 and was completed in August 1972. Construction of the remainder of the earthen dam is scheduled to begin in late 1977 or early 1978. The contract required that the earthen foundation area be excavated and then portions filled with impervious, earthen materials. The earthen fill, referred to as phase I fill, was between elevations 470 feet and 540 feet above mean sea level and averaged about 20 feet in depth. To assure a stable and safe foundation, Corps designers specified moisture tolerances for the fill. Tests during and after construction showed excessive moisture in part of the fill. These "suspect materials" were between elevations 530 and 540 and also near elevation 500 in a buried river channel. The sketch on page 15 shows the phase I fill and excessive moisture areas.

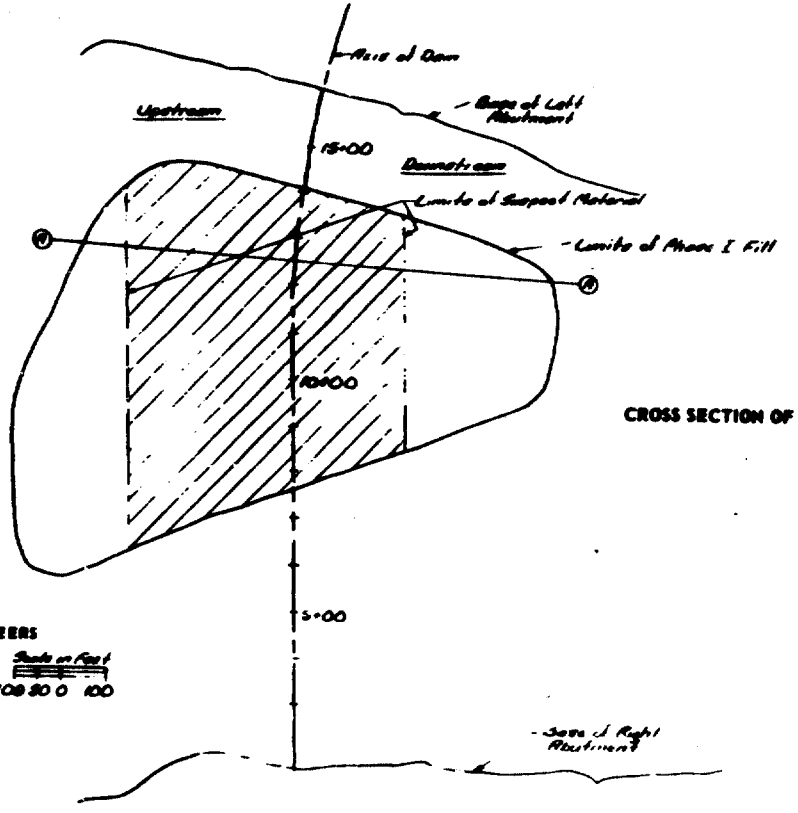
EXCESS MOISTURE IN PHASE I FILL

About 6 months after the phase I contract was awarded, the Corps realized that contract specifications allowed a 3-percent above optimum moisture content rather than the 2 percent prescribed in design specifications.

A study showed that a 3-percent limit would reduce the foundation strength 15 percent. During 1972, tests of the partially completed phase I fill showed that portions of the fill between elevation 530 and 540 contained excessive moisture. Although agency officials were aware of the moisture problems when a substantial amount of the fill was yet to be placed, they did not revise the contract specifications or require replacement of the substandard fill. Instead they emphasized the need for better controls to assure that the remaining fill did not exceed the 3-percent limit.

Problems also arose in determining the optimum moisture content for the fill. Tests of identical material by the





CROSS SECTION OF DAM SHOWING SUSPECT PHASE I FILL MATERIAL

SOURCE: U.S. ARMY CORPS OF ENGINEERS

Corps St. Louis district's resident office consistently produced a higher optimum moisture content than the Corps division laboratory. Partially to compensate for the inconsistency in test results, the moisture limit for the remainder of the earthen dam was reduced to 1 percent above optimum from the 2 percent in the design requirements.

In January 1973 the district engineer proposed to replace the substandard fill because he was "* * * convinced that this material is not acceptable under any conditions." In March 1973 a conference involving several levels of Corps management evaluated the problem and decided to leave the fill in place assuming that more stringent specifications and quality control for the upper portion of the earthen dam would produce adequate average strength. This decision was based on shear tests and stability analyses which indicated a significant number of low shear strength areas primarily between elevations 530 and 540. The conferees agreed that this approach involved some risk and decided that additional instruments should be placed in both the fill and in the earthen dam while it was under construction, to see if critical shear strains or strength problems developed. Headquarters and division officials both stressed the need for better inspection and quality control on the phase II work.

Since the 1973 decision, some of the instruments have become inoperable because of accidents and the Corps has questioned the reliability of data from other instruments. Corps officials concluded that until construction of phase II of the earthen dam is underway in 1978, they will not know how much overall strength loss will result from the substandard fill. The phase II dam contract includes an option to have the fill removed at a cost of about $237,000. However, this will be economically unrealistic after very much of the earthen dam is completed. Should strength loss be significant after construction for phase II starts, it would be possible to compensate by enlarging the sides of the dam. The Corps has not determined the cost and schedule impact of this alternative.

MOISTURE IN BURIED RIVER CHANNEL AROUND ELEVATION 500

The foundation contains a buried river channel around elevation 500 that the contractor excavated and filled with earthen materials. Cannon project office personnel reported encountering excessive moisture in the fill when boring holes for instruments. They described the soft area as being 1- to 2-feet thick and having so much moisture that a drilled hole filled with several feet of mud and water in a few hours.

The project office suggested that excessive moisture in the upper levels of the foundation may have filtered down to the buried channel area.

Project and district office officials have discussed the problem many times since late 1973. Some construction officials believe that the moisture problem is a serious threat to the integrity of the dam. District engineering officials indicate that the soft areas pose no threat to the integrity of the dam because they are confined to the cut-off trench within the buried channel. They noted that the trench is bounded both upstream and downstream by natural sands and gravels which would provide greater resistance than the phase I fill materials. As of October 1976 no further action had been taken on the excessive moisture in the buried channel.

AGENCY COMMENTS

Corps officials commented about their planned remedial measures which they believe will rectify the excess moisture problem in the phase I fill. These measures include increased embankment instrumentation, closer construction inspections, revised phase II fill specifications, and the use of compacted soils in the upstream diversion channel and the downstream valley.

CONCLUSION AND RECOMMENDATION

Although the officials believe that these measures will insure a safe project, we do not know whether these planned actions concerning phase I fill will rectify the excess moisture problem. In our view, the question of dam safety has not been completely resolved, particularly in light of the current concern over dam safety, and will remain so until the project is evaluated independently.

Therefore, we recommend that the Secretary of the Army obtain an evaluation of the overall safety of the project from an expert, independent consultant.

We made a similar recommendation concerning the use of independent consultants in a recently issued report to the House Subcommittee on Environment, Energy, and Natural Resources, Committee on Government Operations. (Actions Needed to Increase the Safety of Dams Built by the Bureau of Reclamation and the Corps of Engineers, CED 77-85, June 3, 1977.)

APPENDIX I

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

27 April 1977

Mr. Henry Eschwege
Director, Community and Economic
Development Division
General Accounting Office
Washington, D.C. 20548

Mr. Eschwege:

This is in reply to your letter to the Secretary of Defense regarding your draft report dated January 1977 on Clarence Cannon Dam and Reservoir Cost and Schedule Problems, OSD Case #4510.

We appreciate the concern expressed in the report regarding estimating procedures and documentation. Estimates are necessarily revised to reflect project changes and further design studies. The Corps will further emphasize the importance of maintaining adequate documentation to clearly define continuity from one project estimate to the other. Developing estimates which closely approximate future bid prices is a more difficult task. Many factors contribute to what may appear in hindsight to be an unrealistic estimate. Probably the most important factor is the accelerated rate in which general construction cost levels have increased in recent years. Also, labor strikes may affect material availability and delivery schedules which impact on the contractors estimate. The current state of the National economy and level of construction activity at the time the project is bid is another factor influencing project costs. Therefore, although the Government's estimate and the eventual contractor's bid may not match closely, that is not necessarily a reliable indicator that the estimate was unrealistic at the time it was prepared. However, corrective measures will be taken where needed to improve the Corps' estimating procedures.

[See GAO note 1, p. 20.]

The report discusses on page 10 delays due to inadequate funding. Although increased funding will permit projects to be completed in less time, the level of funding is the consequence of Federal resource limitations and priorities.

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[See GAO note 1, p. 20.] Further, with respect to your recommendation on page 13, we annually reveal in the justifications and testimony to Congress such delays as have been or might be occasioned for any reason, including Federal budget limitations.

[See GAO note 2, p. 20.]

The report discusses the problem of financial feasibility of hydropower production at the Clarence Cannon project. As the economic analysis based on Federal Power Commission power values shows, power at Clarence Cannon is economically feasible. The current problem of financial feasibility is due to the rate structure of the Southwestern Power Administration which is dependent on power contracts signed many years ago. However, as these contracts are renegotiated within the next few years at the current market values for power, financial feasibility will be established.

A concern is expressed in the report regarding the safety of the dam due to fill material being placed during Phase I fill construction at other than optimum moisture content. This situation has been studied by experts in soil mechanics in the St. Louis District, the Lower Mississippi Valley Division, the U. S. Army Engineer Waterways Experiment Station and the Office, Chief of Engineers. Removal of the weakened material was considered as suggested in the draft report. However, this was only one of several remedial actions that could have been taken without jeopardy to the structure's safety. It was judged more prudent to increase planned embankment instrumentation, provide for compensating remedial measures in the specifications for the Phase II fill contract, and to proceed with construction of the embankment under strict controls and close observation to determine if any additional measures are required. As a result of subsequent studies and as an additional assurance to safety of the embankment against sliding, current plans provide that the upstream diversion channel will be filled with compacted soils and that additional downstream valley clays will be removed and replaced with select compacted soil.

The Corps has been sensitive to the potential embankment stability problem and has taken appropriate action throughout the course of design and construction. The design of the project is considered adequate and in keeping with conditions revealed in advance of and during construction. The embankment design is being modified as needed to account for conditions revealed during construction to insure a safe project. This type of approach is commonplace to soil stability problems and has been used on other of our Corps embankments without the use of outside consultants.

The opportunity to review the draft report is appreciated.

Sincerely,

Charles R. Ford
Acting Assistant Secretary of the Army
(Civil Works)

GAO notes:

1. Page references in this appendix refer to the draft report and do not necessarily agree with the page numbers in the final report.
2. Deleted material relates to data in our draft report that has been revised in this final report to reflect the agency's comment.

APPENDIX II

United States Department of the Interior
SOUTHWESTERN POWER ADMINISTRATION
POST OFFICE DRAWER 1619
TULSA, OKLAHOMA 74101

IN REPLY REFER TO:

September 27, 1976

Mr. Sam Pines
Assistant Director
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Pines:

This is in response to your letter of August 27, 1976, concerning your review of the hydroelectric power construction at the Clarence Cannon Dam and Reservoir Project in Missouri.

The investment allocated to power at the Clarence Cannon Project is now estimated by the Corps of Engineers to be $51,361,700, with annual costs estimated at $2,391,500. This was the subject of correspondence between this office and the Corps of Engineers dated March 22, August 16 and August 17, 1976, (copies enclosed). In your letter you asked:

> "--How much of the $51.4 million currently estimated for the power portion of the Cannon project can SPA repay during the 50-year required repayment plan?
>
> --What is the annual deficit, if any, and the cumulative deficit at the project interest rate at the end of the 50-year required repayment plan?"

The power project is far removed from the SPA transmission system making it infeasible to construct transmission lines to interconnect. We are negotiating with a preference customer for the sale of the entire power output of this project at the bus for the estimated allocated power and marketing costs. If these negotiations are successful, the power costs can be recovered at a 50-year rate and financial feasibility can be justified.

We have attempted to answer the two questions posed under the unlikely assumptions that the power output would be sold from the integrated system at present rate levels and marketing costs would include transmission wheeling. Under these circumstances, there would be available (after payment of operation and maintenance, major replacement and marketing costs) about $48,000 per year to apply to amortization of the investment with interest at 3-1/8 percent. This would repay only about $5,600,000 of investment in 50 years.

APPENDIX II

Under these assumptions, the annual deficiency would be about $2 million. In analyzing these figures it becomes obvious that the present rates available from the integrated system will not produce adequate revenues for repayment and other projects would be required to contribute to Clarence Cannon payout.

SPA has the responsibility under the law to repay all power costs within a reasonable period of years and system rate payers would be faced with rate increases because of Clarence Cannon costs. We could not consider a $2 million deficiency for this project to exist for a 50-year period, because if it did, it would accumulate to about $234 million during that period at the project interest rate.

Sincerely yours,

Peter C. King
Administrator

Enclosures--3

PRINCIPAL OFFICIALS

RESPONSIBLE FOR THE ACTIVITIES

DISCUSSED IN THIS REPORT

	Tenure of office			
	From		To	
DEPARTMENT OF DEFENSE				
SECRETARY OF DEFENSE:				
Harold Brown	Jan.	1977	Present	
Donald H. Rumsfeld	Nov.	1975	Jan.	1977
James Schlesinger	June	1973	Nov.	1975
William P. Clements, Jr. (acting)	May	1973	June	1973
Elliot L. Richardson	Jan.	1973	Apr.	1973
Melvin Laird	Jan.	1969	Jan.	1973
Clark M. Clifford	Mar.	1968	Jan.	1969
Robert S. McNamara	Jan.	1961	Feb.	1968
DEPARTMENT OF THE ARMY				
SECRETARY OF THE ARMY:				
Clifford L. Alexander, Jr.	Feb.	1977	Present	
Martin R. Hoffmann	Aug.	1975	Jan.	1977
Howard H. Calloway	May	1973	July	1975
Robert F. Froehlke	July	1971	May	1973
Stanley R. Resor	July	1965	June	1971
Stephen Alles	Jan.	1964	July	1965
Cyrus R. Vance	July	1962	Jan.	1964
Elvis J. Stahr, Jr.	Jan.	1961	June	1962
CHIEF OF ENGINEERS:				
Lt. Gen. J. W. Morris	July	1976	Present	
Lt. Gen. William C. Gribble, Jr.	Aug.	1973	June	1976
Lt. Gen. Frederick J. Clarke	Aug.	1969	July	1973
Lt. Gen. William F. Cassidy	July	1965	Aug.	1969
Lt. Gen. Walter K. Wilson, Jr.	May	1961	June	1965