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

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NOV 14 1974

The Honorable M. Caldwell Butler
House of Representatives

Dear Mr. Butler:

Pursuant to your February 1, 1974, request and as agreed with you in our July 22, 1974, discussion, we are providing you with information relating to the geological problems associated with the Corps of Engineers' Gathright Dam and Lake project in Virginia.

We interviewed officials of the Corps' headquarters and Norfolk district offices, the JARFO Company (prime contractor engaged in the construction of the dam), and the Kemper-Frontier Construction Company (subcontractor) and reviewed pertinent records.

BACKGROUND INFORMATION

The Flood Control Act of 1946 (Public Law 79-526, July 24, 1946) authorized the Gathright project to be developed as a multiple-purpose project for flood control, water quality, recreation, and power purposes; however, during project formulation in 1965, the Corps concluded that power facilities were not economically feasible and deferred their construction until they would become so. Corps officials said that there were no plans to further consider power facilities at this project.

Concerning the geological problems, a 1940 Corps geology report stated that there were solution cavities (water eroded caverns within the rock abutment) in the damsite area. The report concluded that extensive grouting[1] would be adequate to control the water seepage. A 1945 update of this report, before project authorization, resulted in the same conclusions. In 1965 the Corps began additional geological studies to develop data for project formulation. During stripping operations in 1968, one large cave and two smaller ones were uncovered leading the Corps to conduct further geological investigations.

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[1]The process of drilling and then filling holes with concrete under pressure to seal joints and cracks in the rock.

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The Corps believed that grouting would adequately control the anticipated seepage until October 1970, when it identified the extensiveness of the geological problems: solutioned joints in the soluble limestone abutment resulting in caverns and solution paths which would permit the impounded water to leak around the dam.

The Corps said that, in accordance with recommendations from a panel of consulting engineers, it subsequently decided to construct a concrete membrane wall, designed to prevent leakage from the reservoir by intercepting the caverns and solution paths. On April 3, 1973, the Corps awarded a contract to the JARFO Company for construction of the dam and membrane wall. The JARFO Company, in turn, subcontracted the membrane wall construction to the Kemper-Frontier Construction Company.

In the fiscal year 1975 budget submission to the Congress, the project was estimated to cost $49.8 million, including about $10 million for additional construction work to correct the geological problems.

POTENTIAL FOR ADDITIONAL COST INCREASES

The construction contract for the membrane wall required that the contractor select the construction method and submit its detailed plans to the Corps for approval. The contractor decided, with the Corps' approval, to construct the wall using a top-down method (by which construction begins at the top of the wall and proceeds down to the base). Construction of the wall started on September 20, 1973, but on October 26, 1973, the contractor notified the Corps that it was stopping construction on the wall because the conditions, specified in the original contract, had changed. The contractor cited safety and the need for additional support items (steel, timber, rock bolts, etc.) as examples of this changed condition.

Between October 26, 1973, and January 29, 1974, the Corps and the contractor continued to discuss the changes with major emphasis on the construction method. On January 29, 1974, the Corps approved the use of the contractor's proposed bottom-up method of construction although variations of this method would continue to be considered. It said it would negotiate a change order for additional construction materials needed to complete the work. On February 7, 1974, the contractor resumed construction of the wall using the bottom-up method.

As of September 1974 the Corps and the contractor were negotiating the amount of concrete and number of supports to be used in construction, and the reduction in adit (horizontal passage) excavation

and the amount of grouting attributable to the method of construction. Corps and contractor officials told us that they basically agreed on the bid items to be negotiated but that they were continuing to negotiate the specific quantities and price. Without knowing the total number of support items that will be required due to the cavernous nature of the rock formation being excavated, Corps and contractor officials have agreed to negotiate support items in lots (major quantities) as needed. The contractor's proposal to the Corps for a lot of 400 support items was estimated at $9.5 million; its estimates for 800 items was about $15 million and for almost 1,400 items, (which it feels may be required), $28.5 million. Corps officials said their estimates were considerably lower. These costs would be in addition to the $10 million identified in the fiscal year 1975 budget submission.

In addition, Corps officials have said they are planning to extend the length of the 730 foot wall by about 55 to 60 feet. Upon completion of the design plans in about 2 months, negotiations will begin on a change order for the wall extension.

POTENTIAL FOR LEAKAGE AROUND MEMBRANE WALL

The membrane wall currently under construction was initially designed to prevent reservoir leakage up to an elevation of 1,610 feet since it was to be embedded in impervious rock which was expected to reach this elevation at the end of the wall. According to the Corps' Flood Frequency Chart, Gathright project floods would be expected to reach this elevation once every 2,000 years. Corps officials told us that during subsequent explorations they found that the impervious rock reached an elevation of only 1,591 feet at the end of the wall and that floods would be expected to reach or exceed this elevation about once every 7 years. Corps officials said that the potential exists for water to leak around the end of the wall during floods exceeding this elevation but that the Corps does not consider this to be a problem because the wall design includes a drainage system to remove both the normal ground water seepage and any flood seepage which may occur around the end of the wall.

The prime contractor agreed with the Corps that adequate drainage was provided, but the subcontractor disagreed. The subcontractor felt that a satisfactory system of drainage was impossible because of the cavernous composition around the membrane wall area. This is further discussed in the next section of this report.

The impervious rock is expected to reach an elevation of 1,602 feet at the end of the planned 55 to 60 foot long membrane wall extension. The potential for flood leakage at this point would be

once every 250 years. Corps officials said the top of the wall extension would reach a 1,605-foot elevation as opposed to a 1,630-foot elevation for the rest of the wall. Although leakage may occur around the wall at a 1,602-foot elevation, it would require a flood which would be expected to occur once every 600 years to overflow the wall extension at a 1,605-foot elevation.

Corps officials said that the geological mapping of the reservoir area had been completed, that the natural reservoir rim was sound, and that any major leakage would be most unusual and geologically unexpected. The Virginia State Geologist reviewed this data in July 1974 and agreed with the Corps' conclusions.

CORPS AND CONTRACTOR VIEWS ON SAFETY OF DAM

The Corps is providing extensive grouting along the dam foundation and abutment walls and in the membrane wall foundation. This is to insure a good foundation for both the dam and the wall.

The contractor told us that during the early stages of wall construction, it found caverns and solution joints which were more extensive than previously anticipated from the bid documents. The contractor subsequently hired a consultant to obtain additional information on the impact of these caverns and solution paths.

This consultant's report states:

> "The present Contract Specifications, as confirmed in informal conversation with the (Corps) Engineer, do not require nor intend that measures be taken to systematically fill large solution cavities around the membrane. * * *. It is the writer's opinion that the integrity and satisfactory operation of the concrete membrane can not be ensured unless some systematic attempt is made to fill large solution cavities for some distance about the membrane. It would not be necessary to completely fill * * * all cavities adjacent to the membrane, but only fill cavities to a distance of perhaps 10 to 15 feet from the membrane * * *."

Corps officials told us that the plan was to fill all cavities near the membrane wall with concrete or reinforced concrete as they considered necessary, based upon the most economical and reasonable method, to insure the safety of the wall.

During a later survey of the membrane wall area, the contractor's consultant explored a previously unmapped cave system and discovered large caves beyond the limits of the membrane wall. It concluded that the membrane wall might not be effective in preventing leakage when the reservoir level exceeded a 1,602-foot elevation. Corps officials said that these caves were extensions of existing known conditions which would be corrected by the construction of the wall.

Corps and contractor officials generally agreed the dam would be safe provided the following corrective actions were taken: construction of membrane wall and drainage system, filling cavities adjacent to the wall, and extensive grouting. The Virginia State Geologist inspected the dam on July 26, 1974, and said he found nothing which would render the dam unsafe.

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We discussed the contents of this report with Corps officials who concurred with the information presented.

We do not plan to distribute this report further unless you agree or publicly announce its contents.

Sincerely yours,

Deputy Comptroller General
of the United States