REPORT
ANNUAL PROBABILITIES OF EXCEEDANCE
OF SIGNIFICANT DAM DEFORMATION
F.E. WALTER, DOWNSVILLE, AND CANNONSVILLE DAMS
PUBLIC SERVICE ELECTRIC & GAS COMPANY

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INTRODUCTION

We have completed a probabilistic hazard evaluation of three dams to estimate annual probabilities of significant deformation of the crests of the dams in the event of seismic activity in the region. The purpose of this study is to provide input to the analysis of possible impacts of river-borne floating missiles in the Delaware River and to identify the contribution of potential dam failure to this risk at the Hope Creek site.

Analyses have been performed to estimate water levels at the site and in the Philadelphia area resulting from the occurrence of a Probable Maximum Flood (PMF) concurrent with single-dam and multi-dam failures. The dam failures are considered to be seismically induced. The phenomena (PMF and dam failures) are independent of each other. The flood levels were calculated in accordance with accepted standards and are reported elsewhere.*

The flood resulting from the dam failure assumes the complete and sudden disappearance of the dam. There is no credible seismic event which would cause this to occur. For the purposes of this study we have used an estimated crest deformation of two feet as the criterion. This deformation is not expected to cause failure of a rolled fill earth dam but is likely sufficient to initiate some internal deformation of the dam that could lead to eventual breaching. Estimates of larger deformations and higher levels of ground motion that could induce failure of the dams are not believed to be quantifiable at this time; therefore, the two feet deformation criterion was chosen instead.

DAM SITES

The three dam sites considered are:

*Summary, Flood Water Analysis, Hope Creek Generating Station, Lower Alloways Creek, New Jersey, Public Service Electric & Gas Co., January 31, 1985.

1. Downsville - Pepacton Reservoir Dam is a 204 feet high zoned earth fill embankment with a concrete core wall owned by the City of New York and constructed in the early 1950's. The dam is located in Delaware County, New York on the East Branch of the Delaware River.

2. Cannonsville Dam is a zoned earthfill embankment with a height of 175 feet, also owned by the City of New York. This dam was constructed in the early 1960's and is also located in Delaware County, New York. This dam is on the West Branch of the Delaware River near Deposit, New York.

3. F.E. Walter Dam is a zoned earthfill embankment with a height of 234 feet. This dam was originally named the Bear Creek Reservoir in 1957 and since that time the name was changed to the F.E. Walter Dam and appears as such on copies of portions of design drawings we reviewed which covered recent design modifications to the dam. The F.E. Walter Dam is located in Pennsylvania on the Lehigh River approximately 20 miles south of Scranton on the border of Carbon and Luzerne Counties.

GROUND MOTION PROBABILITIES

The seismic hazard exposure was estimated at each of the three dam sites. This probabilistic study was based on two separate tectonic source models used with two acceleration attenuation equations. The tectonic source models were from Hadley and Divine (1974) and Dames & Moore (1977). The acceleration attenuation relationships used were developed by Nuttli (1984) and Campbell (1982). The risk analysis procedures have been described in detail in other reports we have prepared for Public Service (McGuire, 1984).

The results are summarized in Table 1 where the uniformly-weighted results for the analyses are tabulated for each of the three dams.

TABLE 1

SEISMIC HAZARD EXPOSURE RESULTS

Acceleration Level % g	Annual Probability of Exceedance Downsville	Cannonsville	F.E. Walter
20	0.495-03	0.389-03	0.326-03
40	0.794-04	0.546-04	0.369-04
60	0.247-04	0.147-04	0.790-05
70	0.158-04	0.876-05	0.426-05
80	0.103-04	0.534-05	0.232-05
90	0.729-05	0.357-05	0.141-05
100	0.508-05	0.236-05	0.835-06
110	0.376-05	0.167-05	0.538-06
120	0.276-05	0.117-05	0.341-06

It should be recognized that considerable uncertainty exists in the results in Table 1 as they are based on the extremes of distribution functions and do not consider the real possibility that these large ground motion levels at frequencies that may affect the stability of a dam may not be physically possible in this tectonic setting.

DISPLACEMENT ESTIMATES

The estimates of displacement of the dam crest were based on a procedure developed by Newmark (1965). This procedure recognizes that for short periods of time during an earthquake the factor of safety against sliding may be exceeded and some movement may occur. This movement is quickly arrested moments later when the seismic forces reverse direction and act to increase safety rather than lower it. Newmark developed a procedure to estimate the cumulative deformation that may occur. The relationship developed was:

$$d = \frac{v^2}{2gn}\left(1 - \frac{n}{a}\right)\frac{a}{n}$$

where d is the displacement, v is the maximum ground velocity occurring during the earthquake, a is the maximum acceleration value and n is the limiting acceleration, or

that acceleration when applied in a pseudo-static stability analysis, leads to a factor of safety of 1.

In applying this equation we have estimated the peak ground velocity by assuming that the ratio of v/a may be considered a constant ratio of 36 inches/second/g. The only detailed soil properties we were able to obtain from meetings with the dam owners and the Corps of Engineers were for the F.E. Walters Dam which has recently undergone design changes and a raising of the crest elevation. We were able to duplicate static stability analyses on this dam section and estimate the limiting pseudo-static acceleration value to obtain the coeffeicient n. For downstream slope movement, which is believed to be most critical for overall crest stability which could ultimately lead to overtopping, this value was 0.24g. If we use this value with the above equation and the results shown in Table 1, we can find the annual probabilities of exceedance of 2 feet of crest displacement based on our assumptions. These are listed in Table 2.

TABLE 2

ANNUAL PROBABILITIES OF 24 INCH DAM CREST DISPLACEMENT

Downsville	Cannonsville	F.E. Walters
0.5×10^{-5}	0.2×10^{-5}	0.8×10^{-6}

We have used the same stability values for Downsville and Cannonsville Dams as were obtained for the F.E. Walters Dam. This step presumes that all three dams are earth filled zoned embankments which were designed to similar criteria using similar construction materials. We have been able to determine that the construction methods were similar for all three dams. The design assumptions used, however, have proved to be much more difficult to ascertain. Construction plans which we have been able to obtain support our assumptions. Therefore, we believe the probability values in Table 2 are representative values for each dam site.

REFERENCES

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