CHAPTER 6

CONSEQUENCE OF NO DAM SAFETY MODIFICATION

6-01. General.

Failure to consider the results of the seismic analyses and construct the necessary remedial measures could result in the functional loss of the project, loss of all project benefits, and extensive downstream damage.

6-02. Dam Vulnerable to Seismic Action.

a. Degree of hazard.

The Maximum Credible Earthquake (MCE), for which the stability and deformation analyses have been done, has a probability of occurrence of approximately once in 3,000 years. However, a lower seismic event, with a return period of once in about 1,800 years, may critically damage the relief wells and trigger dam failure due initially to piping.

b. Mode and magnitude of expected failure.

(1) Damage to dam and related structures.

Depending on the intensity of shaking, a larger or smaller portion of the embankment is expected to experience deformation. Two different mechanisms of dam failure are probable:

(a) A strong earthquake, with the (Moment) Magnitude M of 5.7 to about 6.2, is expected to induce only minor embankment deformations, especially near the downstream toe. It is very probable that some relief wells be severely damaged. In the absence of pressure relief protection, piping of the foundation soil becomes imminent. If the damage affects a couple of adjacent wells, the piping can get out of control and be followed by formation of an unstable tunnel and subsidence of the embankment above it. Overtopping of the heavily damaged embankment fill would follow.

(b) A very strong earthquake, with M greater than about 6.3 and an epicentral distance of the order of 20 km (12.5 miles) is credited of being capable to induce major deformation of the embankment. Sliding of the downstream slope is more probable than in the upstream portion of the embankment. Although partial loss of freeboard is expected, immediate overtopping is not. However, erosion along transverse cracks is believed to be a phenomenon faster developing than internal erosion (piping) within foundation. Tunnel formation, subsidence, and overtopping follow.

Overtopping of the settled portion of the embankment would quickly (in the matter of few hours) end in breach formation. It is estimated that the terminal breach bottom would be of the order of 500 feet within 5 hours. Depending on the lateral slopes, the volume of material removed from the embankment during breach development varies between 1,260,000 cy for vertical slopes and 1,940,000 cy for 1(v)/3(h) slopes. The estimated time of breach development is presented in Figure 6.1.

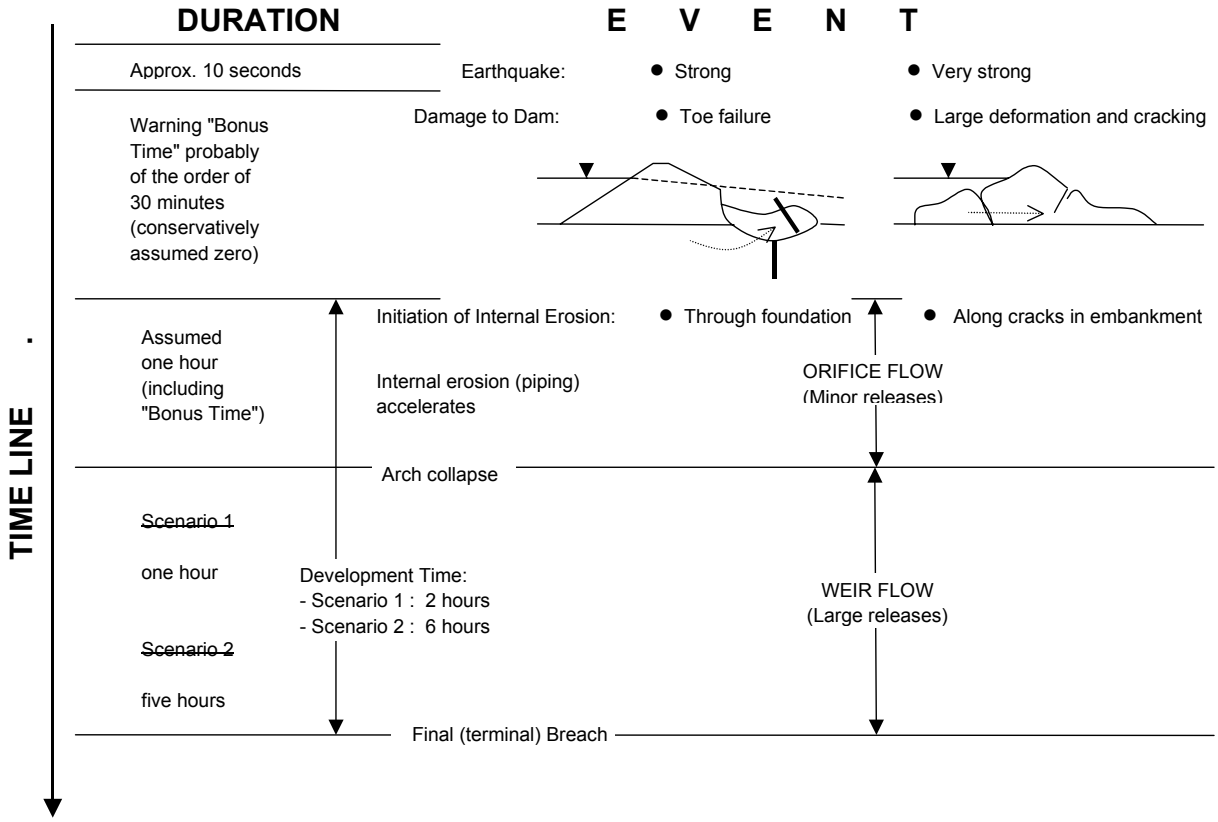

Fig 6.1. Development of Breach Flowchart.

On average, it is estimated that some 1.5 million cubic yards of embankment fill would be washed out and should be replaced, including central impervious core, outer shells, and pervious zone downstream. It is also believed that approximately 100,000 cy of foundation soil will be eroded and must be replaced.

No damage to the appurtenant structures (outlet works, spillway) is expected.

(2) Downstream impact.

Tuttle Creek Dam is located about six miles north of the city of Manhattan, Kansas on the main stem of the Big Blue River. The reservoir is situated about 12 miles upstream of the mouth of the Big Blue River, which is one of the largest contributors to floods on the Kansas River. Tuttle Creek Lake is a key unit in the Kansas River Basin system. At its multipurpose pool level, Tuttle Creek Lake is the second largest body of water in Kansas. If the required remedial measures

(modifications) are not constructed, there could be dam failure associated with a major earthquake event. Consequences of a seismic breach of the dam would include loss of the function of the project, loss of project benefits, the incurrence of extensive downstream damages, and high potential for loss of life. The foundation sand of the City of Manhattan owned levee unit would also liquefy and it is assumed that the levee would fail with a seismic breach of the dam. Details on the stability analysis of the Manhattan levee are presented in Appendix X.

6-03. Dam Hydrologically Deficient.

a. Degree of hazard.

The Probable Maximum Flood (PMF) occurrence is a very remote event. Even assuming the PMF occurrence, the embankment would not be overtopped, but the freeboard would not correspond to design requirements (2.2 feet of freeboard as compared to 4.6 feet required). However, if some of the 18 tainter gates are not fully functional during the design event overtopping is probable. The maximum pool elevation becomes higher than the crest elevation if two gates malfunction during this extreme event.

b. Mode and magnitude of expected failure.

(1) Damage to dam and related structures.

The breach initiation by overtopping is expected to induce a faster development of the breaching than the initiation by piping or internal erosion following a failure due to a strong earthquake. However, the final breach dimensions and, therefore, the damage to dam, should be very similar. It is considered that the same extend of damage as presented at 6-02.b(1) will be induced by overtopping due to hydraulic inadequacy. Again, no damage to appurtenant structures (outlet works and spillway) is expected.

(2) Downstream impact.

The comments at 6-02.b(2) apply to this case also, except that the City of Manhattan owned Manhattan levee unit would be overtopped well before a PMF breach of Tuttle Creek Dam.

6-04. Effectiveness of Existing Flood Warning System and Evacuation Plans.

a. General. Emergency procedures to be implemented when any condition that endangers the structural integrity of the dam occurs are presented in the Operation and Maintenance Manual, Volume II "Emergency Action Plan", dated January 2000 (revised January 2002).

b. Flood Warning System. The Project Office is responsible for initiating the public warning. First contact should be the Emergency Management Duty Officer (24-hour phone). A "District Office Calling Tree" should be followed if there is any difficulty in contacting any of the parties listed in the Emergency Action Plan (EAP). The Project Office should also

recommend immediate evacuation to local authorities and homes/businesses immediately downstream of the dam.

If the failure is imminent or already has occurred and, consequently, there is no time available to attempt corrective measures to prevent failure and large uncontrolled releases are imminent, the Project Office should proceed notifying all parties on a Notification Flow Chart by phone or radio (County Sheriffs and Park Rangers). After that, the Project Office should concentrate on taking emergency actions in an attempt to slow the failure. Police Departments are responsible for implementation of the local evacuation plans in each affected county. Rangers have the responsibility of evacuating persons using the park facilities.

c. Evacuation Plans. The Police and Sheriff's Departments of 9 potentially affected counties (Riley, Pottawatomie, Wabaunsee, Shawnee, Jefferson, Douglas, Leavenworth, Johnson, and Wyandotte) are responsible for issuing public warnings and evacuation of the area along the path of the flood within each county jurisdiction.

The evacuation plans were developed based on inundation maps prepared for the extremely remote event of dam failure concurrent with spillway design flood discharges. During a PMF event, the existing Emergency Action Plan is considered to be fully effective. The Emergency Action Plan has been specifically modified to address earthquakes. However, in the event of an earthquake larger than a 5.7 magnitude, the existing warning and evacuation system may approach its functional limitation.