10.3 HYDROLOGIC DESIGN FOR WATER EXCESS MANAGEMENT

Hydrologic design is the process of assessing the impact of hydrologic events of a water resource system and choosing values for the key variables of the system so that it will perform adequately (Chow et al., 1988). This section focuses on water excess management; however, many of the concepts are applicable to water supply (use) management.

10.3.1 Hydrologic Design Scale

The *hydrologic design scale* is the range in magnitude of the design variable (such as the design discharge) within which a value must be selected to determine the inflow to the system (see Figure 10.3.1). The most important factors in selecting the design value are cost and safety. The optimal magnitude for design is one that balances the conflicting considerations of cost and safety. The practical upper limit of the hydrologic design scale is not infinite, since the global hydrologic cycle is a closed system; that is, the total quantity of water on earth is essentially constant. Although the true upper limit is unknown, for practical purposes an estimated upper limit may be determined. This *estimated limiting value* (ELV) is defined as the largest magnitude possible for a hydrologic event at a given location, based on the best available hydrologic information.

The concept of an estimated limiting value is implicit in the *probable maximum precipitation* (PMP) and the corresponding *probable maximum flood* (PMF). The probable maximum precipitation is defined by the World Meteorological Organization (1983) as a "quantity of precipitation that is close to the physical upper limit for a given duration over a particular basin." Based on

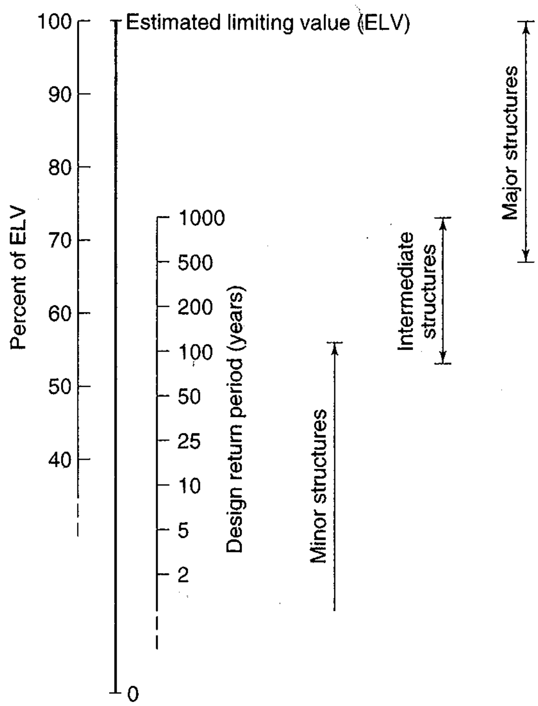

Figure 10.3.1 Hydrologic design scale. Approximate ranges of the design level for different types of structures are shown. Design may be based on a percentage of the ELV or on a design return period. The values for the two scales shown in the diagram are illustrative only and do not correspond directly with one another (from Chow et al. (1988)).

worldwide records, the PMP can have a return period of as long as 500,000,000 years. However, the return period varies geographically. Some arbitrarily assign a return period, say 10,000 years, to the PMP or PMF, but this has no physical basis.

Generalized design criteria for water-control structures have been developed, as summarized in Table 10.3.1. According to the potential consequence of failure, structures are classified as *major, intermediate,* and *minor*; the corresponding approximate ranges on the design scale are shown in Figure 10.3.1. The criteria for dams in Table 10.3.1 pertain to the design of spillway capacities, and are taken from the National Academy of Sciences (1983). The Academy defines a *small dam* as having 50–1000 acre-feet of storage or being 25–40 ft high, an *intermediate dam* as having 1000–50,000 acre-ft of storage or being 40–100 ft high, and a *large dam* as having more than 50,000 acre-ft of storage or being more than 100 ft high. In general, there would be considerable loss of life and extensive damage if a major structure failed. In the case of an intermediate structure, a small loss of life would be possible and the damage would be within the financial capability of the owner. For minor structures, there generally would be no loss of life, and the damage would be of the same magnitude as the cost of replacing or repairing the structure.

Table 10.3.1 Generalized Design Criteria for Water-Control Structures

Type of Structure	Return Period (Years)	ELV
Highway culverts		
Low traffic	5–10	—
Intermediate traffic	10–25	—
High traffic	50–100	—
Highway bridges		
Secondary system	10–50	—
Primary system	50–100	—
Farm drainage		
Culverts	5–50	—
Ditches	5–50	—
Urban drainage		
Storm sewers in small cities	2–25	—
Storm sewers in large cities	25–50	—
Airfields		
Low traffic	5–10	—
Intermediate traffic	10–25	—
High traffic	50–100	—
Levees		
On farms	2–50	—
Around cities	50–200	—
Dams with no likelihood of loss of life (low hazard)		
Small dams	50–100	—
Intermediate dams	100 +	—
Large dams	—	50–100%
Dams with probable loss of life (significant hazard)		
Small dams	100 +	50%
Intermediate dams	—	50–100%
Large dams	—	100%
Dams with high likelihood of considerable loss of life (high hazard)		
Small dams	—	50–100%
Intermediate dams	—	100%
Large dams	—	100%

Source: Chow et al. (1988).