3 NAVIGATION LOCKS AND DAMS

A canalized river is a river that has been transformed from a free-flowing stream to a series of "slackwater" pools with low flow velocities by a series of locks and dams along the stream. Navigation dams impound the pools, and the locks make it possible for vessels to pass through the dams, either upstream or downstream, from one pool level to the next, Figure 3.1. "Low-head" dams are dams with heads of 10 to 40 ft, and "high-head" dams have heads in excess of 40 ft. Lock with lifts of less than 30 ft are classified as low-lift locks; with lifts of 30 to 50 ft as medium-lift; and with lifts of more than 50 ft as high-lift locks.

Principal criteria for selection of sites for navigation locks and dams in a particular reach are related to physical characteristics of the reach (foundation conditions, current directions and magnitude, sediment transport); local drainage conditions; stability of the channel bed at the site; urban, industrial, and agricultural development; transportation infrastructure; and environmental resources, as follows:

a. Reach conditions.

- A history of relatively permanent banks in the reach because recently formed banks are usually low and costly to protect.
- A channel alignment that provides fairly straight approaches to the lock, without a sharp bend upstream or a crossing downstream near the lock, to minimize cross currents in the lock approaches.
- Sufficient width of main channel to accomodate the required spillway length and the lock, but not excessively wide and costly, or so narrow as to require extensive bank excavation. As lock sites are frequently on the deep concave side of the channel with the lock set out from the bank to provide adequate approach alignment, space left in the main channel for the spillway may be materially reduced.
- A high narrow overbank that eliminates the need for embankments to impound the normal pool and reduces embankment heights required for roads to provide land access to the lock. A narrow overbank also tends to concentrate flood flows in the main channel, tending to maintain a deeper channel downstream of the dam in the head of the next pool where adequate navigation depth is critical.

b. Drainage. Insofar as conditions permit, navigation locks and dams should be sited so that principal tributaries and drains enter the channel near the head of a navigation pool, rather than in the lower part of the pool, to avoid interference with drainage.

c. Channel bed. The elevation of the future stable bed of the stream must be estimated, taking into account the effects of any cutoffs, any reduction in sediment load due to upstream storage reservoirs, the effects of any channel contraction works, and the backwater effects of the navigation dams.

Most locks on inland waterways in the United States are 110 ft wide by 600 or 1200 ft long, with gates at both ends (at the upper pool and at the lower pool). There are water passages in the lock walls, floor, gate sills, or in the gates themselves to admit water to the lock chamber

from the upper pool to fill the lock and to discharge water from the lock chamber to the lower pool to empty the lock, as illustrated schematically in Figure 3.2.

For a vessel to proceed *downstream* through a lock, the lock is operated in the following sequence:

a. The emptying valves and lower and upper lock gates are closed.
b. The filling valves are opened to fill the lock and raise the water surface in the lock chamber to the same elevation as the upper pool.
c. The upper lock gates are opened, and the vessel moves into the lock chamber.
d. The upper lock gates and filling valves are closed.
e. The emptying valves are opened to lower the water surface in the lock (and the vessel) down to the level of the lower pool.
f. The lower lock gates are opened.
g. The vessel moves out of the lock chamber and into the lower pool.

Locks are sized for a design vessel or design tow (a towboat and barges), usually those in use on the waterway, or adjoining waterways, at the time. However, if changes in equipment size can be anticipated in the future with the project, such changes should be given due consideration in selecting lock chamber size. In the United States dimensions of barges and towboats have changed little over the years, but the number of barges in a tow has increased as towboat engine horsepower has increased.

Lock size affects the economic success of a waterway. If the locks are too small, traffic may not develop as projected because of traffic delays in passing through the locks. If the locks are too large, fixed and operating costs may be so large as to make the project uneconomical. Uniformity of lock size from one waterway to another linking waterway is desirable to permit through navigation. Careful consideration should be given to lock size and to the number of locks at a given site. Two smaller locks may be more efficient in passing tows that one large lock.

Most locks on the Upper Mississippi River, constructed in the 1930s, have lock chambers 110- by 600-ft, and many tows using the river today are too large to pass through the locks in a single lockage. The 15-barge tow at Lock and Dam 22, Canton, Missouri, shown in Figure 2.3, will require two lockages. The 12-barge tow exiting Lock and Dam 15, Rock Island, Illinois, has been reassembled after double lockage, Figure 2.1. Larger tows, such as the 48-barge tow shown in Figure 2.2, are common on the Lower Mississippi River where open-river conditions prevail, the channel is wide, and there are no locks.

"Lockage time," or "lock transit time," includes the time from when a tow or vessel begins to proceed into a lock, is locked through, and exits the lock to the point where an opposite-bound tow can enter the lock. Large tows must be slow and cautious when entering a lock because the water displaced flows out of the lock along the sides of and under the tow. Filling and emptying times for a lock are designed to be as short as possible without causing excessive turbulence, surges, or cross currents in the lock chamber that might damage the tow or cause the tow to damage the lock.

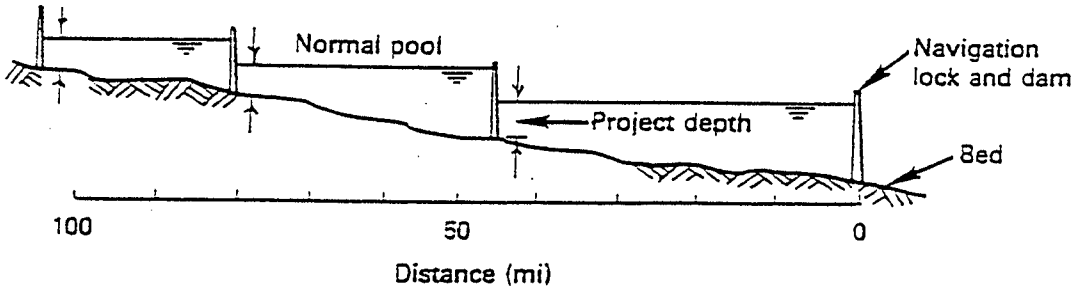
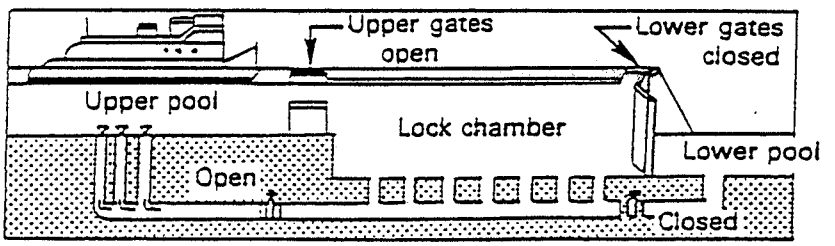
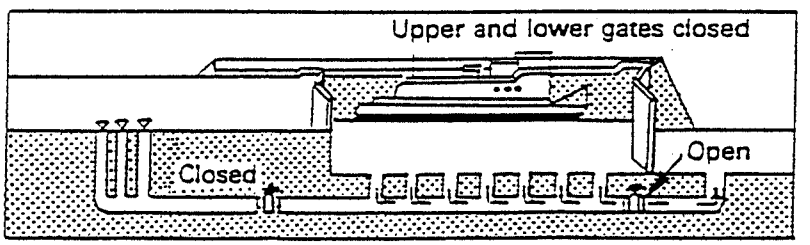


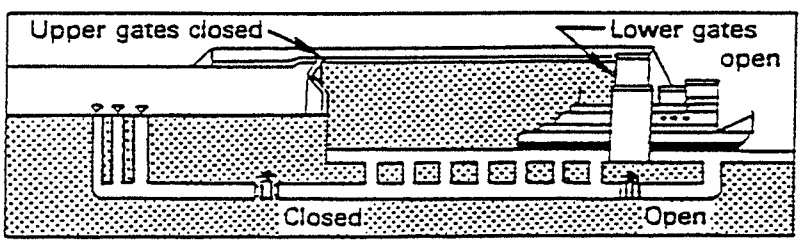
Figure 3.1 Spacing of navigation dams.



Filling valve open; emptying valve closed. Lock filled to upper pool level. Tow enters lock.



Filling valve closed; emptying valve open. Lock emptying to lower pool level.



Filling valve closed; emptying valve open. Lock at lower pool level. Tow leaves lock.

Figure 3.2 How locks operate.