CHAPTER 1

INTRODUCTION

Section I. General

1-1. Purpose. This manual provides guidance in designing, constructing, and operating navigation dams. Some of the factors affecting the safety and efficiency of waterways that are discussed include: types of dams; environmental considerations; equipment in general use on navigation dams; options of design to accommodate ice/debris passage, emergency operation; normal operation to pass flood flows, removal of sediment, or assistance in hydropower development. Some information is also provided on the repair and rehabilitation of existing structures.

1-2. Applicability. This manual applies to all HQ-USACE/OCE elements and all field operating activities having responsibilities for the design of civil works projects.

1-3. References.

a. National Environmental Policy Act (NEPA), PL 9-190, Section 102(2)(c), 1 Jan 1970, 83 Stat 853.

b. ER 1110-2-50, Low Level Discharge Facilities for Drawdown of Impoundments.

c. ER 1110-2-1403, Hydraulic and Hydrologic Studies by Corps Separate Field Operating Activities and Others.

d. ER 1110-2-1458, Hydraulic Design of Shallow Draft Navigation Projects.

e. EM 1110-2-1405, Flood Hydrograph Analysis and Computation.

f. EM 1110-2-1408, Routing of Floods Through River Channels.

g. EM 1110-2-1409, Backwater Curves in River Channels.

h. EM 1110-2-1411, Standard Project Flood Determinations.

i. EM 1110-2-1601, Hydraulic Design of Flood Control Channels.

j. EM 1110-2-1602, Hydraulic Design of Reservoir Outlet Works.

k. EM 1110-2-1603, Hydraulic Design of Spillways.

l. EM 1110-2-1604, Hydraulic Design of Navigation Locks.

m. EM 1110-2-1611, Layout and Design of Shallow Draft Waterways.

n. EM 1110-2-1612, Ice Engineering.

o. EM 1110-2-1901, Soil Mechanics Design Seepage Control.

p. EM 1110-2-2701, Vertical Lift Crest Gates.

q. EM 1110-2-2702, Design of Spillway Tainter Gates.

r. EM 1110-2-4000, Reservoir Sedimentation Investigations Programs.

s. Hydraulic Design Criteria (HDC) sheets and charts. Available from: Technical Information Center, US Army Engineer Waterways Experiment Station (WES), PO Box 631, Vicksburg, MS 39180-0631

1-4. Bibliography. Bibliographic items are indicated throughout the manual by' numbers (item I, 2, etc.) that correspond to similarly numbered items in Appendix A. They are available for loan by request to the Technical Information Center Library, US Army Engineer Waterways Experiment Station, PO Box 631, Vicksburg, MS 39180-0631.

1-5. Symbols. A list of symbols is included as Appendix B, and as far as practical, agrees with the American Standard Letter Symbols for Hydraulics (item I of Appendix A).

1-6. Other Guidance and Design Aids. Use has been made of the following:

a. Hydraulic Design Criteria (HDC).[s] This loose-leaf design notebook was prepared and is maintained by OCE and WES. References to these criteria are by specific HDC chart numbers. Since the charts are periodically updated, users need to verify the latest versions. Complete notebooks are available from: Technical Information Center, US Army Engineer Waterways Experiment Station (WES), PO Box 631, Vicksburg, MS 39180-0631.

b. Computer Program Library. The WES Computer Program Library (WESLIB) provides time-sharing computer services to CE Divisions and Districts. One such service is the Conversationally Oriented Real-Time Program-Generating System (CORPS) that especially provides the noncomputer-oriented or noncomputer-expert engineer a set of proven engineering application programs, which can be accessed on several different computer systems with little or no training. (Item 9 of Appendix A gives instructions on use of the system and a partial list of available programs. Updated lists of programs can be obtained through the CORPS system.)

c. Project Design Memorandums. Liberal use has been made of design memorandums and model study reports resulting from Corps District studies for specific projects. These references are used generally to illustrate a design concept rather than provide specific feature dimensions for proposed projects.

1-7. WES Capabilities and Services. WES has capabilities and furnishes services in the fields of hydraulic modeling, analysis, design, and prototype testing. Recently, expertise has been developed in the areas of water quality studies, mathematical modeling, and computer programming. Procedures necessary to arrange for WES participation in hydraulic studies of all types are

covered in ER 1110-2-1403. WES also has the responsibility for coordinating the Corps of Engineers hydraulic prototype test program.

1-8. Design Memorandum Presentations. General and feature design memoranda should contain sufficient information to assure that the reviewer is able to reach an independent conclusion as to the design adequacy. For convenience, the hydraulic information, factors, studies, and logic used to establish such basic spillway features as type, location, alignment, elevation, size, and discharge should be summarized at the beginning of the hydraulic design section. Basic assumptions, equations, coefficients, alternative designs, consequences of flow exceeding the design flow, etc., should be complete and given in appropriate places in the hydraulic presentation. Operating characteristics and restrictions over the full range of potential discharge should be presented for all release facilities provided.

Section II. Typical Navigation Projects

1-9. Navigation Dams. The Corps of Engineers has built or operated 182 navigation dams. These dams have normal heads from one foot to over 100 feet. Most dams have spillways with either a gated or uncontrolled crest section. However, a few projects such as Bay Springs on the Tennessee-Tombigbee Waterway or Lock 2 on the Arkansas River System have no spillways; they are both located in canals which traverse two drainage basins. Their upper pools are controlled by spillways located on the main river for the drainage basin on the upstream end of the canal. An inventory of reports on navigation dams is provided in Appendix C. Inland waterway design studies are outlined in ER 1110-2-1458. Lock design procedures are found in EM 1110-2-1604.

1-10. Basic Project Components. Navigation dams can be single purpose and only consider navigation; or a project may be developed for multipurposes such as flood control, hydropower, recreation, and water supply in addition to navigation. Therefore the basic components of a navigation dam could include the following :

a. Spillway (gated or uncontrolled).

b. Overflow embankment or weir.

c. Nonoverflow embankment.

d. Navigation pass.

e. Lock or locks.

f. Out let works.

1-11. Supplemental Project Components. The design of a single purpose or multipurpose project should accommodate each purpose as much as possible and develop a cost-effective functional plan. Common supplemental components are:

a. Powerhouse.

b. Fish passages facilities.

c. Recreation facilities.

d. Water supply intakes.

e. Water quality, low-flow controls, multilevel outlets.

f. Irrigation outlet works.

Section III. Special Considerations

1-12. Safety. The safety of the public is an important consideration in the design and operation of navigation dams. Many individuals do not recognize some of the dangerous situations that exist near hydraulic structures. Uneven gate operation can result in eddy action that can sweep small boats into the stilling basin. Overflow weirs form zones of reverse flow (Figure l-l) for certain tailwater conditions which have resulted in small boats being trapped and capsized by the roller action. Surges downstream of locks and hydropower installations can pose hazards to small boats. The hydraulic designer should have input into determining the limited public access areas downstream of structures.

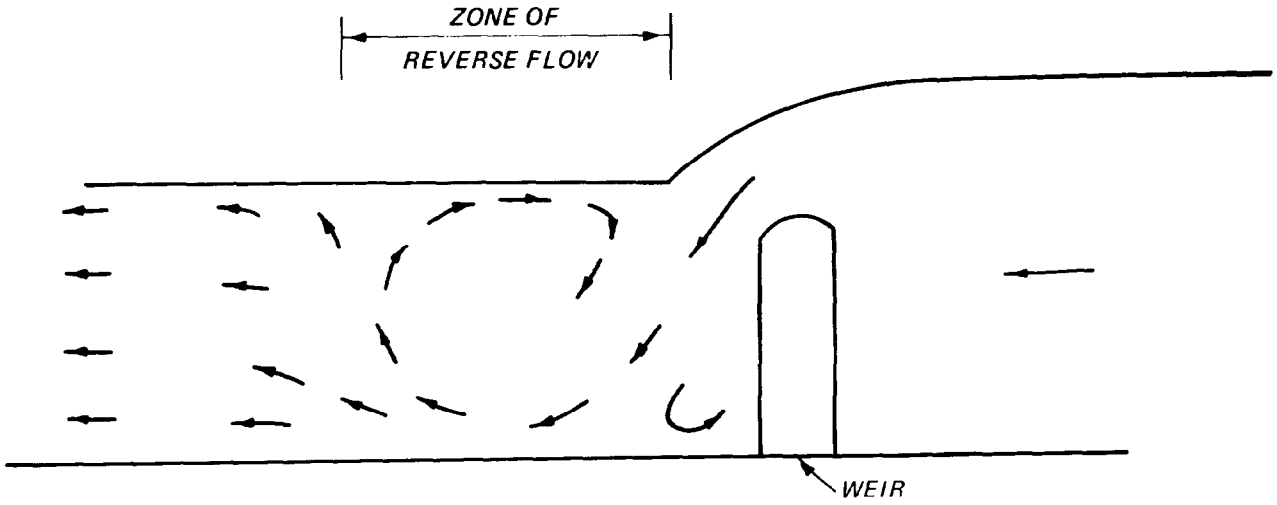

Figure 1-1. Reverse flow downstream of overflow weir

1-13. Environmental. Design of low-head navigation dams should consider measures prevent environmental degradation, as well as enhancement where possible. Design should also facilitate operational procedures for environmental enhancement. Opportunities to add enhancing features should be considered during planning and design. Water quality effects frequently cited for low-head navigation dams are low dissolved oxygen (DO) or nitrogen supersaturation. DO levels in a stream are increased in high turbulence in the

presence of air, such as in a stilling basin. In some cases, stream reaeration can be enhanced by the mode of operation, such as proper gate operation during low-flow periods in the summer and fall when DO levels are typically lower. Aeration devices can be installed on the downstream face of the spillway to promote aeration. Nitrogen dissolved to supersaturation levels can be induced by operation of navigation dams particularly where there is a submerged hydraulic jump and low velocity in the downstream flow. This condition can stress aquatic life. During design, projects should be investigated for nitrogen supersaturation potential. An example of environment enhancement at a low-head navigation dam exists at McAlpine Locks and Dam, constructed at the falls of the Ohio River. These falls were historically a habitat for shore and wading birds. Modernization of McAlpine Dam reduced the flow over the rocks that provided feeding opportunities for the birds. Constructing low-overflow sections in the fixed-weir portion of the dam provided a relatively continuous flow that has improved the habitat measurably.

1-14. Aesthetics. Aesthetics should be given consideration by the designers of navigation structures. The size, shape, and composition of elements of the dam primarily are determined by functional requirements; however, as much as possible, the elements should be designed to be visually pleasing when combined with all other elements of the navigation structure. Some European projects have used streamlined piers with gate-operating mechanisms contained within the piers. This type of installation would provide an improved structure appearance as well as protection for gate-operating equipment. Another method of improving a structure’s appearance is the use of “pebble-finished” concrete surfaces as opposed to a smooth form-finished surface. The hydraulic designer should ensure that these surfaces are not used in areas of high-velocity flow.