CHAPTER 1

INTRODUCTION

Section I. General

1-1. Purpose. This manual was designed to guide the engineer in planning, conducting and reporting the results of a sedimentation study. Help is provided in selecting appropriate methods and levels of detail for studies typically encountered in river and reservoir engineering. The format is: point out potential problems, suggest acceptable approaches for their analysis, and identify checkpoints and pitfalls. This manual does not present detailed procedures for solving sediment equations, but a Sedimentation Glossary is provided to aid in reading the references.

1-2. Scope. This manual identifies typical sediment problems encountered in the development of flood control, navigation and hydropower projects in inland waters and presents appropriate procedures to resolve these problems.

a. Chapter 1 - Introduction. This chapter provides a summary of the requirements for sedimentation studies in the reports and continuing authorities for Civil Works projects in the Corps of Engineers. It was written as guidance for management.

b. Chapter 2 - Formulation and Planning of Sediment Studies. This chapter explains how to develop a sediment study plan. It includes guidance for identifying the sediment problem, defining the appropriate level of study, estimating the required time and costs for the work, organizing the tasks, and managing the investigation.

c. Chapter 3 - Sediment Yield. This is the first technical chapter. It presents systematic methods for determining the amount of sediment entering a project area.

d. Chapter 4 - River Sedimentation. This is the second technical chapter. It presents guidance for forecasting the future base condition of a stream system and for predicting the impact of a proposed project on that future base condition.

e. Chapter 5 - Reservoir Sedimentation. This is the final technical chapter. It presents guidance for conducting reservoir sedimentation studies.

f. Chapter 6 - Model Studies. Guidelines on the selection and application of models are discussed.

g. Appendices. The appendices contain examples that illustrate the concepts presented in the technical chapters.

1-3. Need for Sediment Investigation.

a. Physical Processes. Nature maintains a very delicate balance among the following variables: the water yield from the basin, the water velocity and depth; the concentration and size of sediment particles moving with the water; and the width, depth, slope, hydraulic roughness, planform, and lateral movement of the stream channel. That balance is dynamic not static.

b. Impact of Sedimentation on Projects. All surface water resource projects impose some changes on the above mentioned stream variables. In some instances, these changes increase the erosive forces to such an extent that the costs for providing necessary scour protection will exceed the potential benefits of the proposed project. In other instances, the rate of sediment deposition within various stream reaches may increase to the point where anticipated channel flood capacity or navigation depths are lost. The consequent costs of regularly removing the sediment depositions may be too great to maintain operation of the proposed project. These examples illustrate how sediment has impacted the design, operation and maintenance of project.

c. Impact of Project on Stream System Morphology. The second half of the question in water resource development is "to what extent will a project affect the behavior of the stream system?" When nature's balance is modified at one location, changes will migrate both up and down the basin. Sediment investigations need to estimate how far and how significant those changes might be.

1-4. Project Formulation. District offices in the Corps of Engineers follow established procedures in developing civil works projects. The typical functions and current project documents resulting from this procedure are listed on Table 1-1. An understanding of these documents and what they contain is needed to logically mesh the required sediment studies into the project planning and design process. Topics to include in sedimentation investigation reports are suggested in Section II of this chapter.

1-5. Level of Detail for Sediment Investigation. The Water Resources Development Act of 1986 (Public Law 99-662) as passed by the US Congress established new requirements of those local entities which sponsor the Corps water resource projects. Under these new requirements, local sponsors are liable for more of the project design and construction costs. Consequently, they are assuming a more active role in the design process. These new requirements have caused the Corps to adopt a policy that allows no project costs escalations once the local cost-sharing agreement (LCA) is signed. Because the LCA must be signed prior to initiation of project feasibility reports, firm project cost and time estimates must be established during the preparation of the first planning document - the reconnaissance report. This policy requires that the scope, time and cost requirements for sediment studies be established early in the project planning process.

TABLE 1-1. Studies, Reports and Continuing Authorities For Civil Works Projects

I. PLANNING FUNCTIONS
- A. Reconnaissance Reports
- B. Survey Reports
- C. Continuing Authorities
  1. Section 14 Emergency Bank Protection
  2. Section 103 Small Beach Erosion Projects
  3. Section 107 Small Navigation Projects
  4. Section 205 Small Flood Control Projects
  5. Section 208 Clearing and Snagging of Navigation Channels
  6. Section 221 Project Sponsorship Contract Assurances
- D. Recreational Master Plans
- E. Metropolitan Urban Studies
- F. Framework Studies (Level A)
- G. Regional or River Basin Studies (Level B)
- H. Implementation Studies (Level C)
- I. EPA 208 Studies, Wastewater Management

II. ENGINEERING FUNCTIONS
- A. Hydrology Design Memos
- B. Project Site Reports
- C. General Design Memos
- D. Specific Design Memos
- E. Water Control Management
  1. Reservoir Regulation Manuals
  2. Water Quality Reports
  3. Reservoir Sedimentation Investigations
- F. Notes on Sedimentation Activities
- G. CE-USGS Cooperative Stream Gaging Program

III. CONSTRUCTION-OPERATION FUNCTIONS
- A. Design Modifications
- B. Facilities Maintenance (Including dredging)
- C. Facilities Rehabilitation/Relocation
- D. New Cost-Share Facilities (Code 710)
- E. Project O&M Manuals

IV. REAL ESTATE FUNCTIONS
- A. Real Estate Design Memos
- B. Modification to Project Boundary Lines

1-6. Staged Sedimentation Studies.

a. General. In early stages of project formulation there is usually little or no sediment data and considerable pressure to forecast the type and

magnitude of sedimentation problems for project screening purposes. These conflicting positions can usually be resolved by initiating "staged sediment studies." Three stages are proposed: Sediment Impact Assessment, Detailed Sedimentation Study and Feature Design Sedimentation Study. These three levels provide information for decision makers as project formulation moves from preliminary to final results.

b. Stage 1. Sediment Impact Assessment.

(1) Purpose. The purpose of the sediment impact assessment report is to convey to reviewing authorities (1) the amount of effort expended to date in investigating sedimentation problems; (2) the amount and type of field data available for the assessment; (3) the anticipated impact of sedimentation on project performance and maintenance, and (4) the anticipated impact of the project on stream system morphology. This assessment is expected in the initial planning document with amplification as necessary in subsequent reports. A negative report is as important as one identifying problems.

(2) Scope. This report should discuss, at a minimum, the reservoir or river sedimentation problems identified in Chapters 4 and 5, as well as any unique problems anticipated for a project or site. It should forecast the remaining tasks needed to complete the sediment investigation.

c. Stage 2. Detailed Sedimentation Study.

(1) Purpose. The purpose of the detailed sedimentation study is to (a) refine problems reported in the sediment impact assessment (b) recommend corrective measures, and (c) calculate the effectiveness of these measures. The detailed study is conducted if the sediment impact assessment predicted an adverse sedimentation problem or if an on-going project is experiencing sedimentation problems.

(2) Scope. The scope of Stage 2 is assumed to be the same as Stage 1, but the depth of study in Stage 2 should be controlled by the level of technical details required to solve the problems whereas it was controlled by project formulation economics in Stage 1. The end product of stage 2 is a plan showing design features that handle the general sedimentation problems.

d. Stage 3. Feature Design Sedimentation Study. The purpose of the Feature Design Sedimentation Study is to protect the structure against failure from local scour of deposition and to establish special operational procedures as necessary.

e. Risks and Consequences.

(1) Risks. There are risks in utilizing the "staged study" approach. For example, screening of potential problems is proposed using data in hand. The end product is an assessment about the magnitude of potential sedimentation problems. The screening assessment is then refined as field data becomes available. However, there are gaps between available theories and the temporal and spacial variations in sedimentation processes. The only way to bridge those gaps is to confirm the empirical, analytical procedures with

measurements from the field. Therefore, staged sedimentation studies should adopt a project impact concept in which a safety factor, perhaps from 1.5 to 2 times the best initial estimate of the problem, is used to develop an impact on project costs. If such an impact does not affect basic go/no-go decisions, the sedimentation study can be staged and refined as the project moves through planning and design stages. However, when sediment problems appear to dominate project design and economics, the staged concept should be avoided in favor of a more defendable sedimentation study based on field data.

(2) Consequences. To follow the staged concept requires that planners and designers be prepared to modify basic project features, schedules, and economics as sediment data becomes available because there is presently no reliable method for either transposing, or calculating theoretically, bank erosion, channel location, or the sediment yield from an ungaged watershed. Examples are

(a) size and type of levee, flood wall, or channel feature;

(b) the size and type of dam or stilling basin;

(c) the type of outlet works or intake structures;

(d) the location and amount of land acquisition and relocations; and

(e) the reservoir operating rules

Section II. Reporting Requirements

1-7. General. A Corps project will seldom deal solely with sediment problems. Consequently, the reporting requirements for sediment studies are typically a part of the overall hydrologic and hydraulic portion of the reporting document. All project reports listed in Table 1-1 are expected to include at least a summary statement of the sediment conditions encountered in the proposed project. If no significant problem was found, present that for higher review in sufficient detail to justify the conclusion. Following is guidance on the specific information to be presented in those project reports which normally cover sediment conditions in detail.

1-8. Feasibility Report. The feasibility report consists of two phases as described in Planning Guidance Notebook.

a. Reconnaissance Phase. The initial phase is basically one of problem identification and preliminary (usually very qualitative) analysis as to the Federal interest in continuing the study. As a minimum, described historical sedimentation problems and predict a future base condition as if no project were built. The project study, design and construction costs are established for the local cost-sharing agreement. Consequently, existing sediment problems should be identified, the magnitude of the problem evaluated, and the method of future analysis described. The level of detail for further sediment studies should be defined.

(1) Project Features Influence Sedimentation Problems. If extensive modifications are proposed to the channel cross section, alignment or bank-full discharge or if water diversions or reservoirs are proposed, the possibility of sediment problems requires a considerable detail in the sedimentation analysis. The technical requirements that should be included are presented in reference [57].

(2) Operation and Maintenance. The consideration of channel maintenance and periodic dredging in the design of the proposed project should be discussed. Cost for the sediment monitoring program should be estimated. Reference [54] describes procedures for establishing a stream gaging program with the U. S. Geological Survey. Appendix K in this manual describes reservoir ranges, and the same concepts should also be applied to sediment ranges for channel projects.

b. Feasibility Phase. This phase will feature the detailed evaluation of the existing problem and the development of the recommended solution. A sediment impact assessment should be reported. It may require as little effort as a field reconnaissance interpreted with engineering judgment or as much effort as a period-of-record sediment routing analysis. The objective is to determine whether or not a sediment problem exists and, if so, whether or not it can be eliminated within the funds available for the project.

1-9. Design Memorandum. Whereas pre-authorization sedimentation studies are needed to determine whether or not a problem exists; design memoranda report the detailed design to handle the problem. In addition, these studies should design the sediment monitoring facilities needed for project operation and maintenance.

a. Analytical Techniques. Analytical techniques, numerical models and/or physical models are available to develop such solutions. No one method or technique is appropriate for all types of problems or studies. The engineer must determine the problem, select the means of analysis, and report the results so well-informed decisions can be made.

b. Real Estate Requirements. Analyses for real estate requirements should be explicitly presented. Plans should include access requirements and facilities for sediment monitoring and removal as needed to maintain and operate the project.

c. Reporting Requirements. Study and reporting requirements are similar to those previously described for feasibility studies. However, when sediment represents significant problems requiring extensive studies, a separate technical report, or a sediment appendix, may be appropriate.

1-10. Post-Construction Reports. Monitoring and reporting requirements for sedimentation should be included in the operation and maintenance manuals currently developed for all projects. The location of sedimentation ranges upstream, downstream and within the project limits should be displayed. Time periods for periodic resurveys should be specified. Guidance for dredging intervals for flood control channels should be given. Care of vegetation should be described relative to erosion, deposition and hydraulic roughness.

Studies performed during the construction/operations stage may rely more on the analysis of prototype measurements and data collection, such as a reservoir sediment survey or the periodic resurvey of sediment ranges than on modeling.

1-11. Continuing Authority Studies. An entire series of continuing authority reports (PL99, Type 201, Section 14, etc.) involve sediment analysis. Most of these studies are applicable only to limited, site-specific modifications however, and a simple sediment-impact analysis will suffice. The Type 205 Small Flood Control Continuing Authority Report is a possible exception. Potential flood control solutions proposed by a 205 study can be of sufficient magnitude to necessitate detailed evaluation of sediment. Since construction can follow the completion of a favorable 205 study, the level of detail would be similar to that in a combined survey report-design memorandum. Current planning criteria, presented in the Planning Guidance Notebook, describes the three stage process for a 205 study:

a. Initial Reconnaissance. This phase features a very brief and inexpensive study to determine if there is a Federal interest in continuing the project. Sediment reporting would largely consist of a presentation of any problems and the means of further study. Since this report is used to develop the local cost-sharing agreement, a firm estimate of the total time and cost for conducting the sediment studies is needed.

b. Expanded Reconnaissance. If a Federal interest is present, an Expanded Reconnaissance Report (ERR) is prepared prior to obtaining fiscal support from a local sponsor. This report is similar to much of the feasibility phase of the survey report procedures. Most of the hydrologic-hydraulic-sediment effort in the overall study report will be performed in the ERR. As a minimum, a sediment impact study would be done for the most feasible solution to the problem under study. If sediment plays a major role in the selection or feasibility of the recommended plan, detailed studies using sediment routing computer models would be performed and reported in the ERR.

c. Detailed Project Report. If the proposed project passes all tests for feasibility in the ERR, a Detailed Project Report(DPR) is prepared. The DPR is similar to a design memorandum, and is the design document for the recommended plan. The sediment analysis performed in the ERR may be updated in the DPR if additional data has been collected.

1-12. Sedimentation Reports. The Corps of Engineers has a responsibility for reporting data gathered, studies performed, and research activities undertaken in the sedimentation field. Annually, by 15 February, all Corps Field Operating Agencies and laboratories report the work performed in sedimentation over the past 12 months (ending 31 December). This information is combined with data from the other Federal agencies and published annually by the Subcommittee on Sedimentation of the Interagency Advisory Committee on Water Data in a publication entitled, "Notes on Sedimentation Activities." Reporting criteria is given in reference [56]. Details for the "Reservoir Sedimentation Investigation Program" are contained in Appendix K of this manual.