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UNITED STATES DEPARTMENT OF AGRICULTURE

HANDBOOK
PRELIMINARY EXAMINATIONS AND SURVEYS
OF
WATERSHEDS
FOR
RUNOFF AND WATERFLOW RETARDATION
AND
SOIL EROSION PREVENTION
IN THE INTEREST OF
FLOOD CONTROL



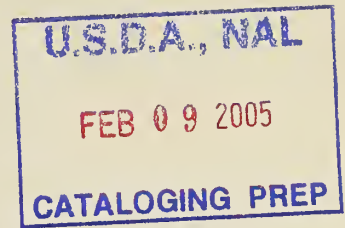
JANUARY, 1947

**United States
Department of
Agriculture**



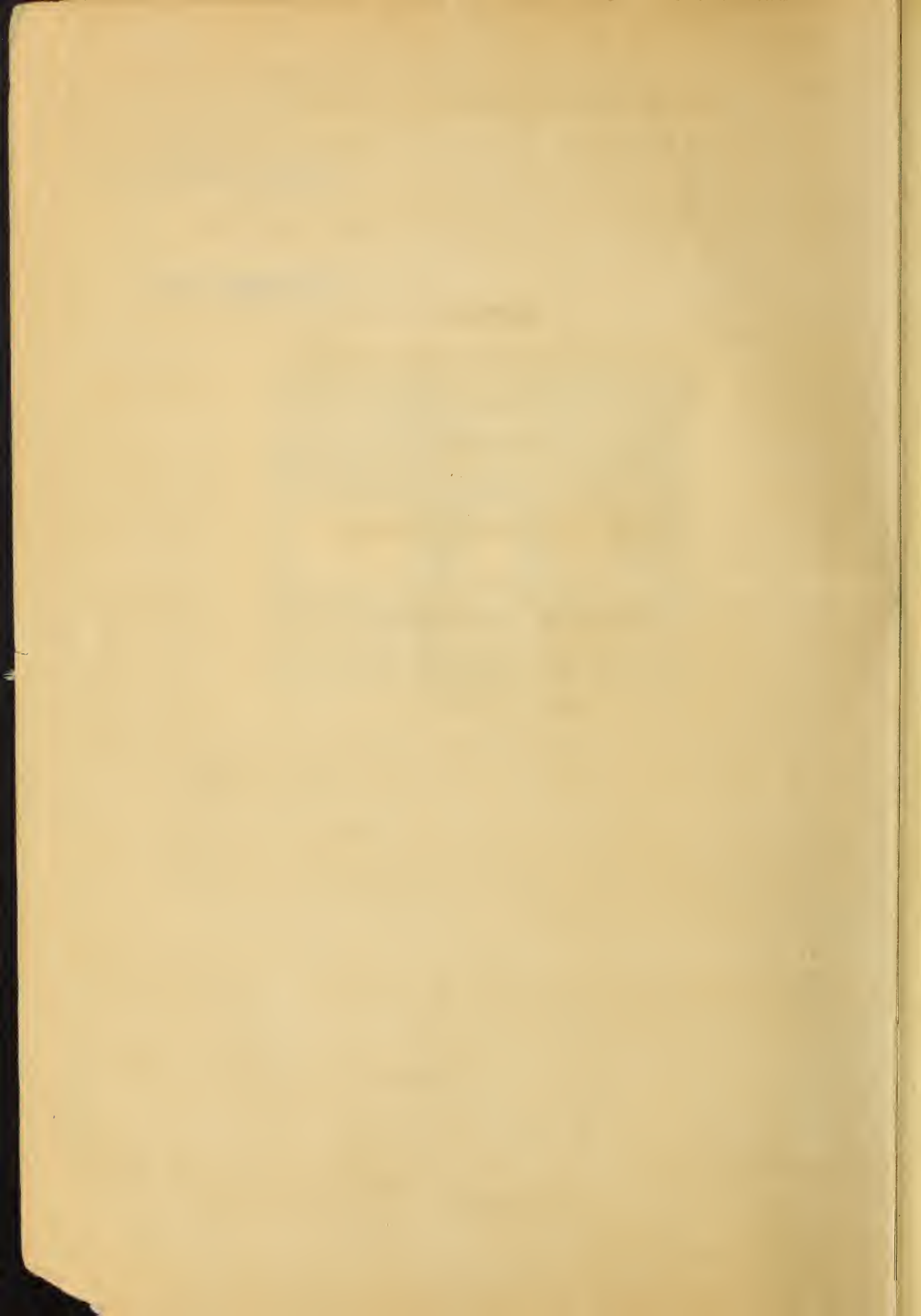
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January 1947



TO: The Secretary of Agriculture

DATE: December 9, 1946

FROM: Lyle F. Watts, Chief, Forest Service
H. H. Bennett, Chief, Soil Conservation Service

SUBJECT: Handbook for Preliminary Examinations and Surveys—Flood Control

In our letter of April 24, 1946, to the Assistant Secretary, the Forest Service and the Soil Conservation Service jointly expressed the intention to cooperate further in undertaking a closely coordinated program of investigations under flood control legislation. This was confirmed in your Memorandum No. 1166. During the intervening months, both Services have developed a program and strengthened their working relations.

We have also reached agreement upon a set of basic principles to guide the conduct of flood control examinations and surveys. To our minds this is a very significant forward step because now the two Services, although proceeding in different areas and at different times, will operate under the same policy. This action will further help unify the program and assure full coordination.

With these principles as a foundation, both Services have agreed upon a common procedure that will further increase the effectiveness of the program. These procedures have been developed in collaboration with a representative of your staff to include Departmental policy and brought together in a handbook for use by both Services. Although neither Service is completely satisfied with the document as it stands, it does nevertheless represent our current thinking. Adoption of these policies and procedures will, we feel, provide a uniform approach to the problems, result in better integration of the work and better correlation in the preparation of programs. For this reason, we desire to follow these agreed upon procedures until sufficient experience has been obtained to warrant a thorough revision.

With your approval, we will duplicate this manuscript for current use by our respective field organizations. Then after a reasonable period of time, probably within the next two years, we will plan for a suitable revision. This will be undertaken in the same spirit of cooperation between the two Services as now exists.

We wish to assure you of our continued joint efforts in the interest of a technically sound and unified watershed program for the Department. We recommend you indicate your approval in the space provided below.

Lyle F. Watts 12/9/46
Forest Service

H. H. Bennett
Soil Conservation Service
December 3, 1946

Approved: December 19, 1946

Samuel Anderson
Secretary



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CHAPTER 1

LEGISLATIVE AUTHORIZATIONS, GUIDING PRINCIPLES, AND
ADMINISTRATIVE RESPONSIBILITIES



CHAPTER I

LEGISLATIVE AUTHORIZATIONS, GUIDING PRINCIPLES, AND ADMINISTRATIVE RESPONSIBILITIES

I. LEGISLATIVE AUTHORIZATIONS

- A. The Flood Control Acts are an outgrowth of many years of increasing understanding of the relationships between watersheds, waterways and floods and of increasing recognition of the important relationships between the condition of watersheds and the rate of run-off and the character and volume of soil lost from them.

These Acts provide that "Federal investigations of watersheds and measures for run-off and waterflow retardation and soil erosion prevention on watersheds shall be under the jurisdiction of and shall be prosecuted by the Department of Agriculture under the direction of the Secretary of Agriculture, except as otherwise provided by Act of Congress." The Acts are:

- Pub. No. 738 - 74th Congress, approved June 22, 1936
- Pub. No. 406 - 75th Congress, approved August 28, 1937
- Pub. No. 761 - 75th Congress, approved June 28, 1938
- Pub. No. 396 - 76th Congress, approved August 11, 1939
- Pub. No. 228 - 77th Congress, approved August 18, 1941
- Pub. No. 534 - 78th Congress, approved December 22, 1944
- Pub. No. 526 - 79th Congress, approved July 24, 1946

(A consolidation of the portions of the Flood Control Acts which directly apply to the Department of Agriculture, except the parts which enumerate the watersheds or portions of watersheds authorized for examination and survey, will be found as Appendix 1.)

The Flood Control Acts authorize the Department of Agriculture to cope with the run-off and erosion problems, as they have a bearing upon flood control, on a watershed basis. They enable the Department to investigate authorized watersheds, to devise watershed treatment programs for retardation of run-off and reduction of erosion and to install or arrange for installing the necessary treatment measures. Because the Acts in which the Department's authority for such work is contained are known as Flood Control Acts, and because the watershed treatment work which the Department is authorized to do is in the interest of flood control, it has been commonly referred to as "flood control" work.

The watershed treatment program devised for a watershed in the interest of flood control may consist of adjustments in land use, adoption of improved cropping or other management practices, adoption of soil and water conservation practices, construction of soil and water conserving works, and other measures, and of various combinations of such measures.

The measures recommended may be the same as or similar to those which the Department is advocating the use of or helping to get applied under other legislation or they may differ from such measures. They may consist of various combinations of both. The important difference is that under this program they will be applied on a watershed basis, instead of on an individual operating unit basis, in such combination and amount or intensity and at such rate as will accomplish the recommended improvement of watershed conditions.

Operation and management improvement measures on an individual operating unit basis, planned for installation by activities of Department agencies under other legislation than the Flood Control Acts, will, of course, be taken into consideration in developing watershed treatment programs. To the extent that necessary measures will be installed under such other legislation in accordance with required standards and rates, they will not be included for installation with funds provided for the watershed treatment program in aid of flood control.

B. The War Department Civil Functions Appropriation Acts were the source of all funds made available to the Department of Agriculture for preliminary examinations and surveys and for operations work, prior to those provided by the Department of Agriculture Appropriation Act of June 1946. Such funds were made available to the Department of Agriculture by transfer. As a result, certain provisions of these Civil Functions Appropriation Acts relate specifically to funds transferred to the Department of Agriculture from the War Department. Included in these provisions are:

1. Limitations on the amount of funds that can be used for purchase of motor-propelled passenger-carrying vehicles and motorboats.
2. A requirement that no part of appropriations made available to the Secretary of Agriculture for authorized preliminary examinations and surveys for run-off and waterflow retardation and soil erosion prevention on the watersheds of flood control projects shall be obligated from the tenth day after the effective date of the Act of April 28, 1942, for initiating work upon new projects or for prosecuting work upon projects previously commenced, unless they accord with priorities specifically approved by the Secretaries of War and Agriculture.

In this connection, the Secretaries of War and Agriculture have approved (as of January 1, 1947) as being of high priority for survey some 134 authorized watersheds or parts of watersheds for which favorable preliminary examinations have been completed or upon which, in the early days of the program, surveys were initiated without a preliminary examination.

II. GUIDING PRINCIPLES

Involved in the conduct of watershed investigations in compliance with the Flood Control laws are various matters such as objectives to be attained, approaches to be taken, standards to be met, rights to be recognized and working relationships to be maintained.

To help assure that preliminary examination and survey reports consistently meet acceptable standards and that the work of developing them progresses smoothly, the guiding principles listed below shall be followed.

A. Guiding Principles for U. S. Department of Agriculture Flood Control Investigations.

1. The Flood Control Acts authorize the Department of Agriculture to work on the "watersheds" and the War Department to work on "rivers and waterways." No sharp line of demarcation can be generally defined between their areas of responsibility but together they completely cover any authorized drainage basin or portion thereof.

Whenever, in the investigation of a watershed, doubt arises as to which Department should have responsibility for any proposed work in a stream channel, field representatives of the Department of Agriculture should consult with representatives of the War Department and mutually agree upon who should assume the responsibility. Representatives of the Bureau of Reclamation should be similarly consulted if investigations and river improvement incident to reclamation projects are involved.

2. The primary purpose of the Department's program of run-off and waterflow retardation and soil erosion prevention in aid of flood control, on any watershed or portion thereof, will be the reduction of flood damages caused by water and sediment. Other benefits may accrue, but they will be considered incidental to the primary purpose of the program.
3. The Department will conduct preliminary examinations, surveys and operations on a watershed or sub-watershed basis. This concept will be consistently followed from the initiation of the preliminary examination to the completion of the work program on any watershed or portion thereof and justification of any recommended program will be determined on the basis of the watershed or sub-watershed under investigation whether the needs can be met by land treatment measures or engineering works or a combination thereof.

4. Watershed surveys or investigations will be conducted on a watershed-wide basis to develop over-all estimates of types and quantities of remedial measures and works, their anticipated costs, and their resulting physical and monetary benefits. They will not include plans for the location or designs for the construction of specific works or measures on specific sites or locations except that vicinity locations will be given for large structures and channel improvements.
5. An interim report may be prepared for one or a group of sub-watersheds within a given watershed authorized for survey. The area covered by an interim report may or may not be selected before the survey has been initiated. The report should be of the same form and character as for an entire watershed. (See Paragraph 4 above.) The submission to the Congress of an interim report will not preclude the preparation and submission to the Congress of reports on other sub-watersheds or on the balance of the authorized watershed.
6. Proposed watershed improvement programs, that otherwise meet Department requirements, will be recommended to the Congress for authorization of operations for run-off and waterflow retardation and soil erosion prevention in the interest of flood control if they meet the following conditions:
 - a. The estimated monetary benefits to whomsoever they may accrue, including the total of both the estimated off-site and on-site benefits, are in excess of the estimated costs of the programs recommended; and
 - b. The estimated monetary flood and sediment reduction benefits and monetary off-site benefits from water conservation exceed one-half the estimated Federal costs of the recommended watershed improvement programs in the interest of flood control; or
 - c. If either or both of these relationships are not met but the intangible or non-monetary benefits, particularly those involving the protection of life and social security, are dominant.
7. In converting future benefits and costs in survey reports to their present worth for comparison purposes, a 2 percent compound interest rate will be used, the time to extend from the end of the year the first expenditure is made. It will be assumed that the program will be maintained indefinitely with benefits accruing as outlined in the report.
8. The Department will continue to recognize the State codes of rights to the beneficial use of water.

9. Where various alternate means may be used to reduce water and sedimentation damages by floods, the Department will give consideration and priority to those measures and practices which will also aid in the conservation of water for beneficial use, ameliorate pollution and benefit wildlife.
10. Watershed survey reports will include recommendations for remedial programs for public lands within the recommended areas. Execution of authorized operations will be contingent upon appropriate agreements between the Department of Agriculture and other public agencies concerned.
11. In general, measures and practices installed on non-Federally owned lands will be maintained by local interests. However, the Department of Agriculture has a responsibility to see that the installed improvements on such lands are so maintained. In the case of any major works, special consideration will be given to Federal responsibility for their maintenance or for Federal supervision of their maintenance by other than a Federal agency. Survey reports will indicate the proposed maintenance responsibility for the recommended types of remedial measures, together with allocated cost estimates.
12. The survey reports for representative watersheds may include estimates for measuring the quantitative effects of the watershed improvement programs on selected treated sub-watersheds or proper segments thereof, including the reduction or other effects upon stream discharge, the reduction of sediment loads transported by streams, and the reduction in rates of soil deterioration.
13. Beginning with the initiation of surveys and intermittently throughout their preparation, as seems appropriate, contact shall be established and maintained with regional representatives of other Federal agencies and with State and local agencies that may be concerned with the areas under investigation, in order to assure that appropriate consideration is given to their interests while the survey is being made and the survey report is being prepared.

The watershed improvement work of the Department under the Flood Control Acts has an important relationship to the work of other agencies of Government in rivers and other waterways and on watershed lands. As indicated by Guiding Principle 13, field representatives of Department agencies shall keep in touch with field representatives of other Government Departments and agencies which are concerned with waterway developments, particularly while they are investigating watersheds and developing proposed watershed treatment programs. The Federal Inter-Agency River Basin Committee has been set up to assure and to facilitate such

contacts with other Federal agencies. Relationships between representatives of this Department and representatives of other Federal Agencies that comprise the Committee shall be maintained in the field and in Washington in accordance with procedure adopted by it. Such voluntary correlation during development of programs will facilitate formal clearance of completed survey reports with these agencies and with the Bureau of the Budget before their submission to the Congress.

III. FEDERAL INTER-AGENCY RIVER BASIN COMMITTEE

A. Agreement

The following is a copy of the over-all agreement entitled "Procedure to Insure Cooperation in the Preparation of Reports on Multiple-Purpose Projects" agreed upon by representatives of the Departments of War, Interior and Agriculture and the Federal Power Commission under which the Federal Inter-Agency River Basin Committee is operating.

"To permit agencies of the Departments of War, Interior, and Agriculture, and the Federal Power Commission, to cooperate more completely in the preparation of reports on multiple-purpose projects and to correlate the results to the greatest practicable extent, the following procedure is established:

1. When investigations on multiple-purpose projects are ordered by any one of the agencies named above, each of the others will be advised.
2. To insure that prompt contact is established by field offices, whenever the Chief of Engineers, the Commissioner of the Bureau of Reclamation, the Land Use Coordinator of the Department of Agriculture, or the Chairman of the Federal Power Commission shall determine that his organization has a direct responsibility in a project to be investigated by another agency, he shall notify the latter to that effect.
3. In all cooperative projects the field offices will be instructed to communicate and confer with each other to:
 - a. Determine what pertinent data is in existence and to arrange for the interchange of such data so as to avoid duplication of effort.
 - b. Determine what pertinent data each agency intends to secure for its own purposes and to arrange a schedule which will avoid duplication and facilitate the concurrent submission of reports so far as practical.
 - c. Arrange for interchange of information throughout the preparation of reports.

- d. Arrange for conferences between field offices during preparation of reports and when reports are completed and ready to forward. Each office will be authorized to submit its comments on the reports of other agencies, such comments to be forwarded with the reports.
4. Conferences will be held in Washington not less often than once each calendar month between the Chief of Engineers, the Commissioner of Reclamation, the Land Use Coordinator and the Chairman, Federal Power Commission, or their duly authorized representatives, for the purpose of discussing the results of studies and investigations, adjusting differences of opinion and promoting ways and means for the implementation of this agreement.
5. All work done by one agency at the request of and for the use of a second agency will be paid for by the latter; all work performed by one agency for its own purposes, even though the resulting data are made available to a second agency, shall be paid for by the former.
6. Information obtained by one agency from another will be treated as confidential until released by the giving agency or until the final report is released."

(SIGNED) E. Reybold
Chief of Engineers

H. W. Bashore
Commissioner, Bureau of Reclamation

E. H. Wiecking,
Land Use Coordinator, U. S.
Department of Agriculture

Leland Olds,
Chairman, Federal Power Commission

29 December 1943

B. Procedure

Following is the procedure adopted by the Federal Inter-Agency River Basin Committee for coordination of reports by Federal agencies:

(Here quote the procedure adopted by the Committee, when it is finally approved.)

IV. ADMINISTRATIVE RESPONSIBILITIES

Because the technical and operational phases of run-off and water-flow retardation and soil erosion prevention work on watersheds is closely related to regular activities of the Forest Service and Soil Conservation Service and because those Services can readily adapt their administrative organizations to handle such work, they have been assigned primary responsibility for it. Memorandum No. 1166, dated June 27, 1946, sets forth the responsibilities of offices and agencies within the Department for administration of the program, together with certain controlling procedure to be followed.

A. UNITED STATES DEPARTMENT OF AGRICULTURE
Office of the Secretary
Washington 25, D. C.

June 27, 1946

MEMORANDUM NO. 1166

Administration of the Department of Agriculture Program for
Waterflow and Run-Off Retardation and Erosion Prevention on
Watersheds in the Interest of Flood Control

The Secretary of Agriculture is authorized under the Flood Control Acts to make preliminary examinations and surveys and to carry out operations on the watersheds of certain streams. This work will be carried out in accordance with the following provisions:

1. The Office of the Secretary shall be responsible for inter-departmental and interbureau coordination, for establishing over-all program policies, for approving watershed reports and transmitting them to the Congress, for presenting the program before the Bureau of the Budget and Congressional committees, for correlation of estimates and allocation of flood control funds, and for the over-all Departmental phases of the program.
2. The Forest Service and the Soil Conservation Service shall be responsible for making preliminary examinations and surveys of watersheds within areas of assigned territorial responsibility and for technical and administrative determinations involved in making such examinations and surveys. They shall also be responsible for carrying on operations within approved areas. They shall work cooperatively at all stages throughout the conduct of such preliminary examinations, surveys and operations.

3. In conducting examinations and surveys for which the Forest Service is responsible, the Soil Conservation Service shall participate and detailed personnel shall work under the direction and supervision of the Forest Service. In conducting examinations and surveys for which the Soil Conservation Service is responsible, the Forest Service shall participate and detailed personnel shall work under the supervision and direction of the Soil Conservation Service.
4. In conducting examinations and surveys for which they are responsible, the Forest Service and the Soil Conservation Service may obtain the assistance of other bureaus and agencies within and outside of the Department. They shall consult with the Bureau of Agricultural Economics with respect to the development of standard techniques and methods to be used in the evaluation of costs and benefits and in other economic and statistical analyses required for watershed surveys and may arrange with that Bureau to make studies of special economic problems that arise in connection with such surveys. Personnel detailed to the Forest Service and the Soil Conservation Service from other bureaus or agencies within the Department shall work under the supervision and direction of the bureaus to which they are detailed. Personnel detailed to the Forest Service and the Soil Conservation Service from bureaus or agencies outside the Department shall work with them in accordance with memoranda of understanding between them and the other bureaus or agencies concerned.
5. When responsible for a preliminary examination or survey, the Soil Conservation Service (1) shall look to the Forest Service to collect data and make recommendations (a) for treatment of all national forests and other lands in the watershed administered by the Forest Service, (b) for treatment of range areas adjacent to national forests in the watershed and used in conjunction with such forests, and (c) for treatment of other forest lands, and (2) shall formally submit the preliminary examination or survey report to the Forest Service for review before submitting it to the Secretary.
6. When responsible for a preliminary examination or survey, the Forest Service (1) shall look to the Soil Conservation Service to collect data and make recommendations (a) for treatment of all lands in the watershed administered by the Soil Conservation Service and (b) for treatment of farm and ranch lands, and (2) shall formally submit the preliminary examination or survey report to the Soil Conservation Service for review before submitting it to the Secretary.
7. Funds for financing examinations and surveys within assigned areas shall be allotted to the responsible bureau; the administering bureau shall compensate the assisting bureaus and agencies by reimbursement or otherwise for detailed personnel and for other services.

8. Preliminary examinations shall contain such information as is necessary to determine whether watershed treatment programs under the flood control legislation appear to be justified and whether surveys of watersheds should be made.
9. Survey reports shall describe the watersheds, their condition, flood history and flood damages and shall outline remedial watershed programs and present estimates of their costs and benefits.

This memorandum supersedes Memorandum No. 890, dated February 27, 1941.

/s/ N. E. Dodd
Acting Secretary

- B. Assignment of Surveys. The territorial assignments by watersheds for making preliminary examinations and surveys called for in provision 2 of Memorandum 1166 follow and are graphically shown on the map on page 16.

The watersheds listed are the same as those given on the drainage basin maps of the Water Resources Committee of the NRPB except as otherwise indicated.

1. Maine Rivers - FS
- 2, 3, 4, 5. New England Rivers - FS
6. Hudson - FS
7. New Jersey, N. Y. Coast - SCS
8. Delaware - SCS
9. Susquehanna
 - Drainages above Harrisburg - FS
 - Drainages below Harrisburg - SCS
- 10, 12, Chesapeake Bay - SCS
11. Potomac - FS
13. James - FS
14. Roanoke - SCS
15. Tar-Neuse - SCS
16. Cape Fear - SCS
17. Pee Dee - SCS
18. Santee - SCS
19. Edisto - SCS
20. Savannah - SCS
21. Altamaha - SCS
22. St. Marys - SCS
23. Apalachicola - SCS
24. Aucilla - SCS
25. Escambia - SCS
26. Mobile - SCS
- 27, 28, 29, 30. South Florida - SCS

31. Tennessee - FS
32. Cumberland - FS
33. Upper Ohio - FS
34. Beaver - FS
35. Kanawha - FS
36. Muskingum - SCS
37. Scioto - SCS
38. Miami - SCS
39. Big Sandy - FS
40. Kentucky-Licking - SCS
41. Green - SCS
42. Wabash - SCS
43. Lower Ohio - FS
- 44, 45, 46. Great Lakes - FS
47. Erie - SCS
- 48, 49, 50. Northern New York - FS
51. Devils Lake - SCS
52. Red River of North - SCS
53. Rainy - FS
- 54, 55, 56, 57, 58. Upper Mississippi - SCS
- 59, 60, 61. Illinois Tributaries - SCS
- 62, 63, 64. Iowa Tributaries - SCS
65. St. Louis-Meramec - FS
66. Missouri Headwaters
 - Above Great Falls - FS
 - Below Great Falls - SCS
67. Yellowstone
 - Above Huntley Irrigated Area - FS
 - Huntley Irrigated Area and below - SCS
- 68, 69, 70, 71. Upper Missouri - SCS
72. Platte
 - Laramie River Above Goshen - FS
 - North Platte above Pathfinder Reservoir - FS
 - Balance of North Platte - SCS
 - South Platte W. from just below Greeley - FS
 - South Platte E. from just below Greeley - SCS
73. Kansas - SCS
74. Osage - SCS
75. Gasconade - FS
76. Chariton - SCS
77. Lower Missouri - SCS
78. Upper Arkansas
 - Above Pueblo - FS
 - Below Pueblo - SCS
79. Central Arkansas - SCS
80. Cimarron - SCS
81. Canadian - SCS
82. White-Black-St. Francis - FS
83. Neosho - SCS
84. Lower Arkansas - SCS
- 85, 86, 87. Red River - SCS

- 88. Ouachita - FS
- 89, 90, 91, 92. Lower Mississippi River - FS
- 93. Pearl-Pascagoula - FS
- 94. Sabine-Neches - SCS
- 95. Trinity - SCS
- 96, 97. Brazos-Colorado of Texas - SCS
- 98, 99. South Gulf - SCS
- 100. Pecos, Lower Rio Grande - SCS
- 101. Upper Rio Grande
 - Above Rio Chama - FS
 - Rio Chama and below - SCS
- 102. Upper Colorado - FS
- 103. Lower Colorado
 - Gila River except Salt, Aqua Fria and Hassayampa tributaries - SCS
 - Balance of Lower Colorado - FS
- 104. (a and b). Interior Basins - FS
- 105. Northern California Coast
 - all except Russian River - FS
 - Russian River - SCS
- 106. Central Valley
 - Above Juncture Sacramento and San Joaquin - FS
 - Below " " " " " " - SCS
- 107. Central California Coast - SCS
- 108. Southern California Coast - FS
- 109. (Drainage basin number not used by MRPB)
- 110. Snake
 - Above Lewiston - FS
 - Below Lewiston - SCS
- 111. Upper Columbia - FS
- 112. Middle Columbia - SCS
- 113. Lower Columbia - Willamette - FS
- 114, 115. Northwest Washington - FS
- 116. Oregon Coast - FS



CHAPTER 2
ADMINISTRATIVE PROCEDURE



ADMINISTRATIVE PROCEDURE

Preliminary examinations and surveys of watersheds by the Department of Agriculture for run-off and waterflow retardation and soil erosion prevention in the interest of flood control are authorized by the Flood Control Act of 1936 as amended and supplemented. The War Department is authorized by the same legislation to conduct similar investigations on rivers and waterways in the interest of flood control. The Flood Control Acts have authorized preliminary examinations and surveys on some 600 watersheds within which are included approximately 85 percent of the continental land area of the United States.

Examinations and surveys may be made only of watersheds which have been authorized by the Congress.

Once a report on an authorized watershed or portion thereof has been submitted to the Congress, no modification of or addition to the report may be made without first obtaining Congressional authorization for a review of the report.

When the flood control problem in an unauthorized watershed becomes so serious that the local people want Federal assistance, they should call the attention of their representatives in the Congress to their problem.

Following is the procedure to be used in carrying out preliminary examinations and surveys of watersheds by the Department of Agriculture under the Flood Control Acts.

I. Preliminary Examinations

A. Authorization

A preliminary examination of a watershed, or portion thereof, may be undertaken only if the watershed or the portion to be examined has been authorized by the Congress.

B. Order of Examination

1. The Forest Service and the Soil Conservation Service will undertake preliminary examinations of authorized watersheds within their respective areas for responsibility for investigations as funds and personnel are available.

2. Since the watersheds of certain rivers may be too large and complex to be considered as a unit for efficient investigation, it may be necessary to break down such larger watersheds into component smaller watersheds, the boundaries of which may be delineated on the basis of factors such as:
 - a. Similarity of problem
 - b. Location of control points such as Army dams, Bureau of Reclamation projects, etc.
 - c. Amount and kind of damage
 - d. Density of population
 - e. Size from the standpoint of facility in administration of investigation

For example, it may be practicable to select an area as small as Cherry Creek, Colorado, 412 square miles, (a tributary of Platte River watershed) where damages are high in the densely populated Denver district; and an area as large as the Pecos River watershed, 37,286 square miles, sparsely settled and with comparatively low land values in a predominately range country.

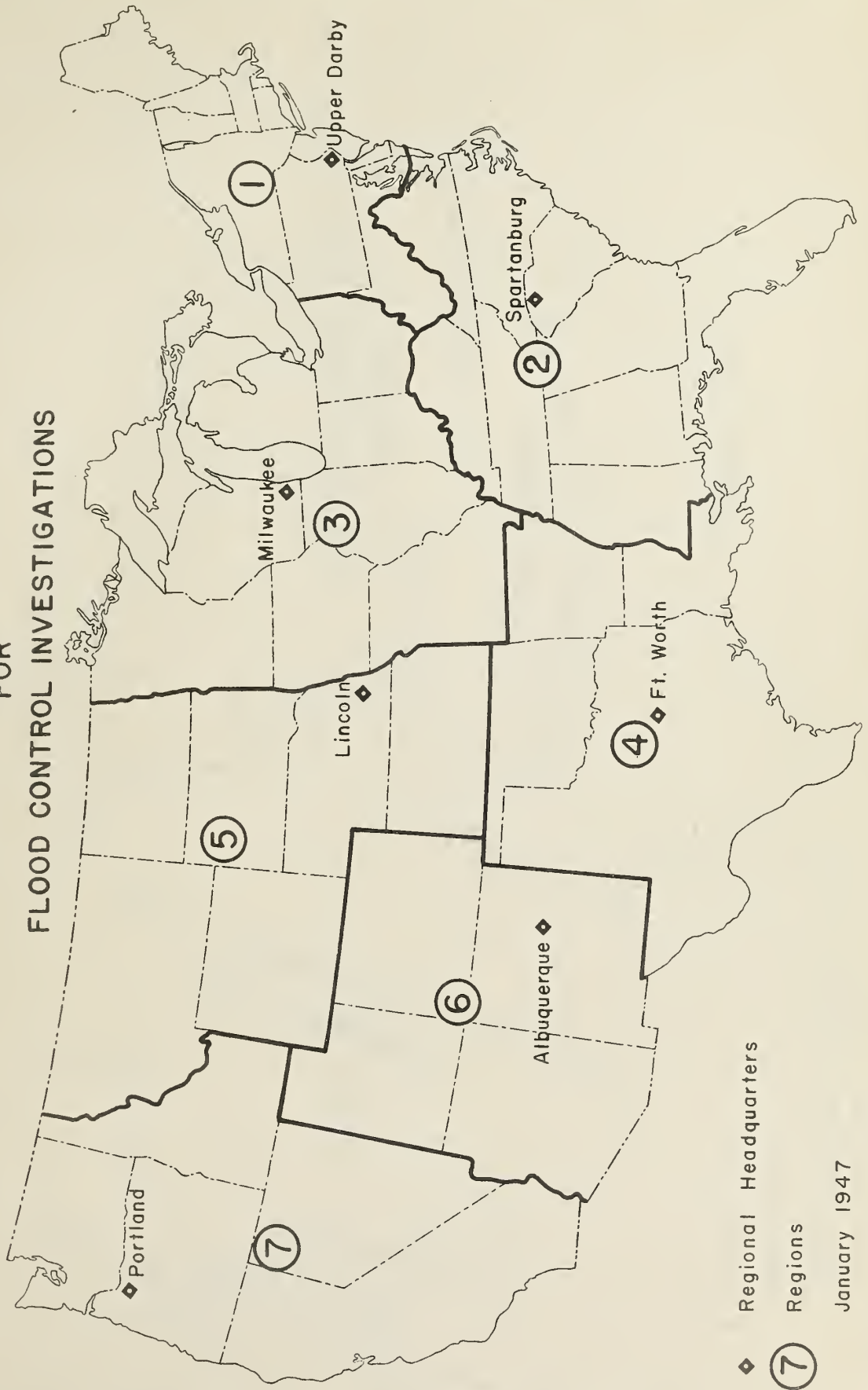
3. When funds are appropriated by the Congress, the Secretary's office will make allocations for preliminary examinations to the Soil Conservation Service and the Forest Service.

C. Correlation of Agency Activity

1. On watersheds for which the Soil Conservation Service has responsibility for investigations, the Regional Conservator will consult with the Director of the Forest Experiment Station* as to the personnel and other facilities needed in order adequately to conduct the preliminary examinations. On watersheds for which the Forest Service is responsible, the Director of the Forest Experiment Station will consult with the Regional Conservator, Soil Conservation Service. These consultations should be made as far in advance as possible to permit efficient administrative arrangements.
2. The responsible Service will conduct the examination and make the report for each watershed for which it is responsible.

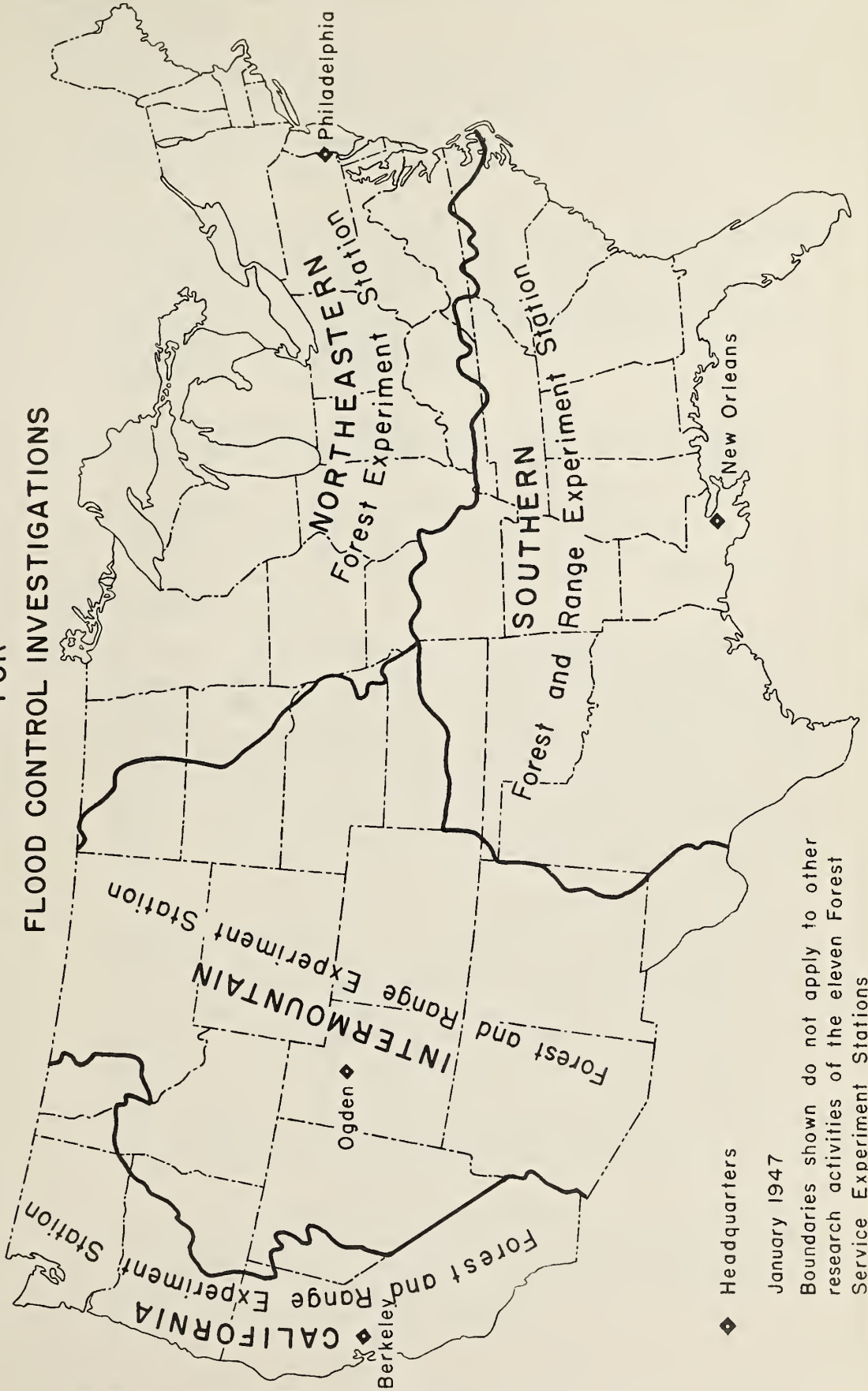
* The two maps immediately following show the respective administrative areas of the Soil Conservation Service and the Forest Service for making investigations.

SOIL CONSERVATION SERVICE
ADMINISTRATIVE AREAS
FOR
FLOOD CONTROL INVESTIGATIONS



January 1947

FLOOD CONTROL INVESTIGATIONS
FOR
ADMINISTRATIVE AREAS
FOREST SERVICE



◆ Headquarters

January 1947

Boundaries shown do not apply to other research activities of the eleven Forest Service Experiment Stations

3. The procedure when the preliminary examination report recommends a survey:
 - a. When the completed preliminary examination report recommends a survey, 2 copies are sent to the other Service and 4 copies to the Washington Office of the responsible Service, two of which will be sent to the Secretary for his use and files.
 - b. The Chief of the Soil Conservation Service or the Chief of the Forest Service, as the case may be, will transmit the report to the Secretary of Agriculture with his determination as to its relative priority for survey. Determination as to order of priority within the concerned Service for undertaking surveys should be made in two categories; i.e., high and low.
 - c. A list of completed preliminary examination reports will be maintained in the Washington Office of each Service
 - d. The Secretary's Office will keep each Service informed currently on the status of submitted reports.
4. The procedure when the preliminary examination report does not recommend a survey:
 - a. When the recommendation in the preliminary examination report is adverse to making a survey, the responsible Service will solicit the comments of the other Service. When the recommendations are concurred in by both Services, the responsible Service will request the comments of the regional offices of the agencies represented on the Federal Inter-Agency River Basin Committee (refer to procedure for distribution of reports by members of the Federal Inter-Agency River Basin Committee in Chapter 1.)
 - b. The Regional Conservator or the Director of the Forest Experiment Station, as the case may be, will send 32 copies of the report to the Washington Office indicating in the letter of transmittal that the participating Service has concurred in the recommendations given in the report, together with the comments of the regional offices of agencies represented on the Federal Inter-Agency River Basin Committee. The Secretary's Office will require 26 of these copies of the report for its use and files and for transmitting copies to the members of the Federal Inter-Agency River Basin Committee.
 - c. The Chief of the Soil Conservation Service or the Chief of the Forest Service, as the case may be, will transmit the report to the Secretary of Agriculture indicating in his letter of transmittal that the report has been concurred in by the other Service.

- d. The Secretary's Office will solicit the comments of the members (Washington, D. C.) of the Federal Inter-Agency River Basin Committee in accordance with the agreement of December 29, 1943.
 - e. When a preliminary examination report does not recommend a survey, it will be submitted to the Congress through the Bureau of the Budget in lieu of a survey report. The Secretary's letter of transmittal will indicate that the report has been reviewed by members of the Federal Inter-Agency River Basin Committee and their comments will be included. Such a report is filed with the appropriate Congressional Committee but is usually not printed by the Congress.
5. Preliminary examination reports are public documents and may be made available to any interested responsible group or agency, local, State, or Federal upon request. Confidential material or other data not ready for publication should not be included in the reports. Such data should be considered as confidential material by the responsible Service and treated accordingly in transmitting it to the Washington Office.

III. Surveys

A. Authorization

A survey of a watershed or portion thereof may be undertaken only after a preliminary examination report recommending a survey has been completed.

B. Order of Surveys

1. For budgetary purposes the Forest Service and the Soil Conservation Service will annually designate by May 1, the watersheds for which each plans to initiate and/or continue surveys in the fiscal year beginning the second succeeding July 1. The watersheds will be selected for initiation of survey generally on the basis of priority categories (see I, C, 3, b of this chapter) recognizing that a watershed may be shifted from one category to another due to changing physical and economic conditions and evidence of interest or lack of interest on the part of concerned people and agencies. The Office of the Secretary will be advised of any change in determination as to the relative priority for survey of any watershed for which a preliminary examination report has been completed.

2. The list of watersheds planned for initiation of survey by each Service, together with the cost estimates, and justification, will be combined in the Secretary's Office for departmental presentation to the Bureau of the Budget and to the Congress.
3. When funds have been appropriated by the Congress, the Secretary's Office will make allocations to the Soil Conservation Service and the Forest Service.

C. Correlation of Agency Activities

1. Work outline for survey

- a. The Service responsible for conducting a survey will prepare a survey work outline. The factors to be considered in preparing a work outline are enumerated and explained in Chapter 4, Part III.
- b. The cooperating Service will be requested to participate in preparing the survey work outline by the Regional Conservator or the Director of the Forest Experiment Station, as the case may be, to the degree necessary that the survey will be planned to utilize appropriately the technical resources of both Services.
- c. Whenever substantial changes or additions are found to be necessary as the survey progresses, a supplement or amendment to the survey work outline will be required and prepared in the same manner as the survey work outline is prepared.
- d. The Survey work outline, concurred in by the cooperating Service, will be transmitted to the Washington Office of the responsible Service. The chief of the responsible Service will review the work outline for adequacy from both the technical and administrative standpoints and obtain the recommendation and concurrence of the chief of the cooperating Service.
- e. A copy of the survey work outline concurred in by the Chief of each Service will be provided the Secretary's Office by the Chief of the responsible Service.
- f. The preparation of a survey work outline should be scheduled so that the approved work outline is back in the hands of the Regional Conservator or Director of the Forest Experiment Station ninety days in advance of initiating work so that final arrangements for making the survey can be completed in an orderly manner.

2. The survey

- a. The responsible service will have complete administrative direction of the survey which will be carried out substantially in accordance with the survey work outline. It will be provided with all the funds made available for the survey and will reimburse the cooperating Service for personnel and other expenses as set forth in the survey work outline in accordance with prescribed fiscal procedure.
- b. Technicians detailed from the cooperating Service are technically responsible to that Service. They will function as part of the survey party and be under the direction of the survey party leaders.
- c. The Service in charge of the survey will be responsible for relationships with the Corps of Engineers, Bureau of Reclamation, Federal Power Commission, Department of Commerce, and other Federal and State agencies. The Regional Conservator or the Director of the Forest Experiment Station, as the case may be, will arrange for consultation and exchange of information with the regional offices* of those agencies throughout the survey.

3. The survey report (The report as hereinafter referred to means both the body of the report and the appendices)

- a. The responsible Service will prepare the report substantially following the standard outline, consulting with the cooperating Service as to essential features of the report.
- b. The Regional Conservator or Director of the Forest Experiment Station, as the case may be, will arrange for meetings as needed during the preparation of the report so that the completed draft will represent the combined judgment of the two Services.
- c. The report will be transmitted, as concurred in by the Regional Conservator or the Director of the Forest Experiment Station, as the case may be, to the Chief of the responsible Service in Washington. The comments of the chief of the responsible Service together with those obtained from the chief of the cooperating Service will

* The term "regional offices", as used here, is intended to include the District and Division Offices of the Corps of Engineers, Regional Offices of the Bureau of Reclamation, Regional Engineers of the Federal Power Commission, etc.

be transmitted to the originating office for use in preparing the final draft of the report before mimeographing. The body of the report will be prepared in such a form and to such standard as to be suitable for publication as a House or Senate Document. The appendices should be prepared with care but not necessarily to such standard because they are rarely printed.

- d. It is the desire of all concerned that contact between Washington and Regional or Station personnel be maintained throughout the survey and during the drafting of the report to keep to a minimum, or eliminate entirely, revisions of the report.
- e. Two copies of the mimeographed report will be transmitted to the chief of the responsible Service in Washington. He will prepare a transmittal letter to the Secretary which will be concurred in by the Chief of the cooperating Service. Mimeographed copies of the letter will be furnished the originating office for insertion in the mimeographed report. This letter would serve to identify all copies of the approved report. The originating office will then transmit 32 copies of the report to Washington. The Secretary's office will require 26 of these copies for its use and files and for transmitting copies to the members of the Federal Inter-Agency River Basin Committee for comment.
- f. The Chief of the Soil Conservation Service or the Chief of the Forest Service, as the case may be, will transmit the report to the Secretary of Agriculture indicating in his letter of transmittal that the survey report has been concurred in by the other Services.
- g. The Secretary's office will solicit the comments of the members (Washington, D. C.) of the Federal Inter-Agency River Basin Committee in accordance with the agreement of December 29, 1943.
- h. The completed report, including the appendices, will be transmitted to the Congress through the Bureau of the Budget. The main body of reports which recommend a watershed improvement program under the Flood Control Acts are customarily printed as Congressional documents. The appendices of such reports and reports which do not recommend a watershed improvement program under the Flood Control Acts are filed by the committee to which they are referred but are not usually printed.

CHAPTER 3

THE PRELIMINARY EXAMINATION

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I. Objective

The objective in making preliminary examinations in authorized watersheds is to determine whether a remedial program of waterflow retardation and soil erosion prevention in the interest of flood control appears to be sufficiently feasible to warrant further investigations.

II. Type of Examination

The investigation for a preliminary examination is of a reconnaissance nature with the data ordinarily being obtained by Regional personnel from a brief field examination, discussion with residents of the watershed, discussion with representatives of city, county, State, and Federal agencies, and from available data such as reports and maps. To a large degree recommendations for further investigations will be based on the judgment of the investigating personnel.

If circumstances are such that further investigations cannot be recommended, a report is prepared for submission to the Congress in lieu of a survey report. This report will be based on sufficient documented data of a reliable nature to preclude errors in judgment.

During the entire period of the preliminary examination, the following questions should be kept in mind. If answers to these questions are favorable, a survey report may be recommended. If answers to one or more questions are unfavorable, it may be advisable to discontinue the examination and assign a low priority to the watershed. For such watersheds, investigations should be made only after watersheds with more urgent flood problems have been investigated.

- A. Are flood and sedimentation damages which occur, within and outside the watershed and which may be traceable to the watershed, of sufficient magnitude to warrant further Federal study?
- B. If so, are these damages related to a significant degree to watershed land use and erosion conditions?
- C. Does the degree to which flood damages, present or potential, might be remedied by a remedial program appear to be sufficient to warrant further consideration?
- D. Would flood water and sediment reduction benefits appear to be created in a substantial amount by watershed treatment?

- E. Does the degree of advantage, in terms of probable total benefits from the program compared to the probable total costs, appear to be sufficient to warrant further investigation?
- F. Do the present land-use activities and programs in the watershed need assistance to solve adequately the flood and sedimentation problem within a reasonable period of time?
- G. Would irreparable damage occur to land resources and downstream structural improvements before present land-use activities and programs could solve adequately the flood and sedimentation problems?
- H. Are the attitudes of the affected people, such as farmers, land owners, and officials such that cooperation in the execution and maintenance of a flood control operations program is likely to materialize?

III. Procedure for Conducting Preliminary Examinations

The following procedure is recommended for obtaining the information required to prepare the report of the preliminary examination.

- A. Assemble and study all available data on the watershed, such as maps, reports, etc.
- B. Make a field inspection of the watershed.
- C. Interview local people and representatives of city, county, State, and Federal agencies.
- D. Prepare recommendations
- E. Contact regional Forest Service or Soil Conservation Service representatives, as the case may be, for suggestions or assistance.
- F. Prepare report.

IV. Report

The report on the preliminary examination will be used in Washington as a basis for establishing priorities of surveys and as a source of information for answering inquiries until survey reports are available. Reports will be brief and for the purpose of uniformity in presentation the following broad outline indicates the major headings.

A. Recommendations

Recommendations for or against making a flood control survey of the watershed and reasons.

B. Purpose and scope

The purpose of the report should be stated and cognizance should be taken of factors most questionable because of shortage of data.

C. Authority

D. Description of the watershed

A brief description of the watershed including such items as physical characteristics, state of development, special problem areas, a location map, etc.

E. Flood, sedimentation and erosion damage

Description of kinds and extent of damage

F. Potential remedial program

Generalized description of the remedial work likely to predominate in a flood control program designed to achieve the most favorable utilization of the capacity of the soil to absorb and hold water, without unduly disrupting the economy of the watershed, supplemented by complete water disposal systems including waterflow retarding structures and measures to prevent the production and movement of sediment.

No appendix will be submitted with the preliminary examination report, but supporting data will be kept on file in the field office for ready reference.

CHAPTER 4

THE SURVEY



THE SURVEY

The primary purpose of the watershed survey in the interest of flood control is to determine the feasibility of conducting a Department program of waterflow retardation and soil erosion prevention in aid of flood control on a specific watershed. The survey should be directed toward developing a remedial program in sufficient detail to permit determination of the relationship between benefits and costs, estimated mainly by sampling methods, as the basis of a report requesting authorization from Congress to initiate operations. The survey should be based on pertinent available information and additional essential data that can be obtained under reasonable limiting conditions of personnel, funds, and time.

The survey report is reviewed by interested agencies before presentation to Congress, and upon approval by Congress becomes the legislative basis for flood control operations.

I. Orientation

A. Advance Studies

Advance studies are introductory survey activities of restricted extent on watersheds covered by favorable preliminary examination reports and selected for future survey. Their major purposes are: (1) to insure the orderly progression of the longtime survey program, and (2) to provide for the collection of certain hydrologic, sedimentation, damage and related data needed in advance of the actual surveys.

Primary emphasis should be placed upon building up a file of useful and pertinent information for watersheds included in the shelf of favorable preliminary examination reports. On survey priority areas special attention should also be paid to meeting serious deficiencies in precipitation, run-off, sedimentation, and flood damage data. The collection of these data would be particularly helpful in making the survey and would provide essential information.

In general, advance studies will stress the following major items:

1. The assembly of maps, reports, water supply papers, precipitation data, flood histories, and other information needed for future survey purposes (see Part B following) setting up of watershed information files, and arranging for necessary aerial photographs when needed;
2. The installation of measuring equipment for small watersheds to obtain adequate data on infiltration rates for the dominant evaluation classes, and snow and frost courses in conjunction with the small watersheds;

3. The establishment of contacts and cooperative arrangements with various Federal, State, and local agencies for the collection of flood damage and related economic data and the determination of the extent and availability of such information;
4. Follow up of current floods as they occur prior to actual initiation of surveys;
5. The installation of stream flow and intensity precipitation gages;
6. The measurement of sediment loads;
7. The establishment of sedimentation ranges in reservoirs and stream channels;
8. The installation of staff gages on damage reaches for obtaining flood water profiles.

The kind and extent of activities undertaken by this phase will be limited by available funds. Therefore, every precaution should be taken to avoid initiating studies or arrangements which do not provide the essential information desired.

B. Assembly of Available Data

The following list indicates the types of data that may be available and some sources from which they may be obtained.

1. Maps
 - a. Base
 - b. Areal
 - c. Geologic
 - d. Climatological
 - (1) Isohyetal
 - (2) Storm paths
 - (3) Frost dates
 - e. Soils
 - f. Soil Erosion
 - g. Topographic
 - h. Drainage

- i. Land forms
 - j. Land classification
 - k. Land capability
 - l. Land management and ownership
 - m. Land use
 - n. Land cover
 - o. Other
2. Publications
- a. U. S. Geological Survey
 - (1) Water Supply Papers
 - (2) Geologic reports
 - b. Forest Service
 - c. Soil Conservation Service
 - d. Bureau of Plant Industry
 - e. State publications
 - (1) State colleges and universities
 - (2) Geologic
 - (3) River authorities
 - (4) Planning commissions
 - f. Corps of Engineers, U. S. Army
 - g. U. S. Weather Bureau
 - h. Other publications pertinent to physical, economic, or social factors relative to flood abatement and sedimentation control in the basin
3. Unpublished data
- a. All available unpublished data relative to the problem being considered

C. Familiarization Reconnaissance

Persons to be in responsible charge of the flood control survey should have a general over-all knowledge of the physical.

and economic characteristics of the entire watershed before the preparation of the survey work outline is undertaken. If this familiarity has not been achieved during the preliminary examination, the advance study, or otherwise, it should be obtained before survey work is outlined. It should generally include a reconnaissance of the watershed, and interviews with reliably informed sources of opinion, including State officials, district supervisors and others. The reconnaissance should provide a general impression of the flood and sedimentation problems.

The tentative division of the watershed into subwatersheds for investigation should be kept in mind during the reconnaissance. Furthermore, a general idea of the representativeness of various tributary areas in each subwatershed should be obtained to facilitate selection of sample tributary areas if their use is later found to be necessary. Conditions bearing on the subdivision of the main stream of the watershed and the main stem of each subwatershed into reaches or areas for the determination of flood and sediment damages should be noted. A general idea of relative damages from floods and from sedimentation in various parts of the watershed should be obtained, and tentative judgments as to the possibility of making quantitative evaluations of a remedial program or reduction in rates of run-off and sedimentation should be formed.

II. Major Factors to be Considered in Making a Survey

The following list presents the major factors that should be considered during a flood control survey and is intended to cover the factors that may be found important in any watershed in the United States. It is realized that, because of widely varying conditions throughout the country, all of the factors listed will seldom if ever be found to be significant in any specific watershed. The list has been made inclusive to permit its use as a check list from which to select the factors significant to the specific watershed to be surveyed in obtaining a perspective of the diversity and magnitude of the survey investigations which should be obtained as early in the investigations as possible. It should be particularly useful in preparing the survey work outline for which only the factors pertinent to the specific watershed should be selected and the factors selected should receive only the emphasis warranted by conditions in the watershed under investigations.

Outline of Major Factors to be Considered

A. Size and Cartographic Coverage

1. Size

The size of watershed and diversity of problems to be met should be evaluated as early in the study as possible for effective translation into needed studies.

2. Cartographic coverage

Standard base maps should be prepared that are acceptable for superimposition of various types of field data to be presented or analyzed on or from maps. Where aerial photographs will expedite the survey in terms of time and expenditure for field surveys, arrangements for such coverage should be originated through proper channels, soon enough to get them when needed.

B. Factors Relative to Floods, Sedimentation, and Maintenance of Soil Resources

1. Physical Factors

The physical factors listed hereinafter should all be considered in making a flood control survey. Obviously, their relative importance to the flood problem and its correction will vary over wide latitude between watersheds. It is possible that in specific watersheds certain listed factors will have no direct bearing upon the problem, but all should be considered at least during the preparation of the work outline. Field judgment will necessarily decide the degree of emphasis in consideration and study of the various items listed and will also be responsible, within subject matter fields, for determination of emphasis upon phases directly relative to cause and solution of the flood and sediment problem.

a. Physiography

(1) Geology

Geology should be considered in direct relation to flood production areas and with regard to the physical characteristics of sediments that may offer opportunity for flood abatement. Attention will largely be directed to examination of strata porosity and permeability rather than to other lithologic characteristics, strata sequence, paleontology and age. Impermeable sediments that preclude downward percolation of precipitation should be noted; their extent and run-off production capabilities pointed out to those concerned with the hydrologic and infiltration examinations. Conversely, of equal importance is quantitative examination of those sediments whose fracture, or percentage of porosity is such that an opportunity for sub-surface storage of flood waters is offered through diversion or retention of such waters to or on infiltration areas.

(2) Topography and drainage pattern

Topographic characteristics directly affecting flood problems and concentrations such as slope, relative elevations, shape of valleys and gradients of streams are to be considered.

b. Climate

Precipitation is discussed under hydrology. Other climatic factors to be considered are net evaporation rates; winds for their effects on soil moisture; erosion; dates of frost; occurrence and frequencies of ice and frozen ground for their effect on flood discharge and upon effectiveness of remedial measures.

c. Vegetal cover

Consider the extent and condition of the following types of cover in relation to waterflow and run-off retardation:

- (1) Forest land
- (2) Brush
- (3) Pasture and range
- (4) Meadow
- (5) Cultivated land
- (6) Waste land
- (7) Other

d. Soils

Consider soils with special reference to characteristics which affect land use, infiltration and all aspects of land and water management. Usually these include effective depth, texture, permeability, character of substratum, plant nutrients, and special factors such as slope, degree of erosion or other local conditions. These special factors are sometimes referred to as site factors.

Soils should be grouped on the basis of the following characteristics. For suggestions on soil groups and significant characteristics listed below see mapping legends prepared by Soil Conservation Service for conservation surveys in nearby areas. If a conservation survey has been made for the watershed, it may furnish much of the soils data needed.

(1) Effective depth

Effective depth is the distance from the surface to any layer which inhibits root growth or water penetration as for instance bedrock, hardpan, claypan, and dense caliche. It refers to thickness or volume of soil in which plant roots develop and extract water and nutrients. Consideration should be given to:

- (a) Depth from surface to inhibiting layer,
- (b) Thickness of inhibiting layer,
- (c) Influence of effective depth on land use, management practices, crop yields, and crop adaptation.

(2) Texture, structure, and organic content

These factors are expressions of the relative amounts of sand, silt, and clay in the soil, porosity, organic content, and humus layer. Consider these factors as they affect the following:

- (a) Rate of infiltration
- (b) Rate of water movement in the soil
- (c) Rate of surface run-off
- (d) Water holding capacity
- (e) Time of planting
- (f) Tillage operations
- (g) Crop adaptation
- (h) Adaptation to forest or grass cover

(3) Permeability

Permeability refers to the rate of movement of water in soils. It has a direct bearing on the ability of soils to transmit, retain, and release water for plant growth. It also indicates the degree of aeration. Consideration should be given to the following:

- (a) Influence of permeability on the moisture holding capacity of soils,
- (b) Effect of permeability on soil-water-plant relationships,
- (c) Influence of permeability on cultural practices, soil management and crop production,
- (d) Permeability as it affects drainage and irrigation,
- (e) Effect of permeability on erosion control practices.

(4) Substratum

This refers to material immediately below the sub-soil. Consideration should be given to:

- (a) Character of material, such as sand, hard bedrock, porous gravel, or degree of consolidation, texture
- (b) Depth below the surface
- (c) Porosity of substratum

(5) Nutrient level

Consideration should be given to the presence or absence of plant nutrients, and to general fertilizer requirements necessary to develop and maintain the vegetative cover needed.

(6) Special factors

These are often needed in planning a good land use and management program. Consideration should be given to such factors as:

- (a) Susceptibility and frequency of overflow,
- (b) Degree of drainage,
- (c) Degree of salinity,
- (d) Bottom areas with accentuated stream meanders,
- (e) Stream bank cutting.

(7) Slope

Slope has a definite influence on soil development, external and internal drainage, erosion, velocity of run-off, operation of machinery, and management practices. Although steepness of slope is of paramount importance in slope classification and the determination of slope groups, other slope characteristics, particularly length, uniformity, direction and pattern must be considered in formulating a remedial program.

(8) Erosion

(a) Sheet erosion

Consider the extent and rate of soil loss from sheet erosion for each major physical land unit. (See Part IV, Phase 3 of this Chapter).

(b) Gully Erosion

Consider the extent and rate of gullying based on acres damaged, acres ruined for cultivation, and relative contribution to the down stream sediment problem. This should include acres damaged annually and total remaining acres damageable.

(c) Streambank erosion

Consider the extent, rate, and type of bank erosion, causative factors, compensating deposition, and relative contribution to the downstream sediment problem.

(9) Adjustments in land use needed for run-off retardation and soil erosion prevention. Consideration should be given to:

(a) Land suitable for cultivation

- 1) Amount now cultivated; practices needed
- 2) Intensity of cultivation
- 3) Amount available for cultivation

(b) Land not suitable for cultivation

- 1) Amount now cultivated but needing revegetating
- 2) Practices needed on grazing land and forest land not suitable for cultivation

e. Stream channel hydraulic characteristics

Consider all characteristics of the stream channels that will affect their discharge capacity, such as, character of bed and banks, slope, cross-sectional areas, roughness coefficient, and aggradational or degradational trends that will alter the present hydraulic characteristics, such as:

- (1) Maximum discharge capacity of minimum section within various channel or floodway segments
- (2) Constrictions and obstructions

Consider the number, type and location of constrictions and obstructions that influence flood heights, areas of inundation, and deposition of sediment, such as:

- (a) Bridges and culverts
 - (b) Log jams
 - (c) Sediment plugs
 - (d) Diversion dams
 - (e) Other
- (3) Sediment transportation factors

Consider the hydraulic characteristics of channels which affect their capacity to transport sediment.

f. Hydrology

- (1) Precipitation characteristics must receive detailed consideration. Particularly the annual and seasonal water yield and the characteristics of flood producing rainfall are important. Included are storm types and their seasonal occurrence, intensities, duration, areal distribution, direction and their frequencies. In certain basins the relation of snow to flood producing storms must also be considered, as well as the coincidence of storms with frozen ground conditions.
- (2) Minimum infiltration rates for each evaluation class (See IV, Phase 4, of this chapter) are needed in the analysis. In some instances, these may be developed from existing rainfall and run-off records. In other instances they may be developed through infiltrometer investigations.

(3) Run-off and streamflow, both in their normal and abnormal aspects, are to be considered. The annual and seasonal water yields with maximum, minimum, and mean quantities, as well as the maximum, minimum and mean rates, are factors involved. In particular, however, attention to flood discharges, their magnitudes, and their frequencies in relation to magnitudes must be developed. Of almost equal importance is the relation of these frequencies to the seasonal variation in the changing physical conditions of the watershed. The flood frequency interrelations of each of the following factors in all of their various combinations as found on each important segment of the drainage system should receive consideration:

(a) Discharge

(b) Area inundated by:

1) Depth of flood

2) Time of year

3) Duration

(4) Groundwater, particularly the variations in water table height in those areas where the water table is in close proximity to the land surface, should be studied. If water table manipulation offers possibilities for storage, and later recovery, of consequent amounts of unclaimed flood discharge, and appears to be economically feasible, the opportunities should be appraised quantitatively. The possibilities of economically justified replenishment of ground water supplies with surface discharge through off channel percolation beds may in certain areas offer a quantitatively significant release for flood flows and should therefore be examined. In general, in any area where diversion of flood discharges may be used to supplement groundwater supplies that are, or may be made, an integral part of the area economy, full consideration should be given to such diversion as a means of lessening flood damage.

g. Sedimentation

Consider the sources and effects of the sediment produced in a watershed and their relation to the types and amount of damage, attributable to sediment, that have occurred; the trend of occurrence of such damages under present conditions; and the measures necessary to materially alter this trend.

(1) Rates of sediment production

Records of sediment load measurements and reservoir sedimentation obtained within the watershed or available from watersheds of similar characteristics should be analyzed to determine coefficients of annual sediment production or, if adequate records of this type are not available, the type of additional investigations needed should be considered.

(a) Rates of sediment production should be related to size, land use, and physical character of drainage area, such as topography, geology, and soils, for consideration in designing a remedial program and estimation of its effects.

(b) Proportion of fine to coarse sediment

Consider existing records of mechanical analyses of sediment and the need for additional analyses to evaluate sources and types of sediment in their relation to downstream problems.

(c) Concentrations in stream flows

Consider the existing records of sediment load measurements and the need for additional measurements.

1) Effect on bulking flood flows

Consider varying sediment concentrations in relation to the height and duration of flood flows and the possibility of lowering crests by reduction of sediment concentrations.

2) Effect on water purification for domestic, industrial, and other uses

Relate needs for and costs of raw water treatment to sediment concentrations.

3) Effect on quality of water for irrigation

Relate effects of sediment concentrations in irrigation waters on adaptability of soils for irrigation.

(d) Future change in rates of sediment production without a remedial program

Examine types of sediment source areas to determine whether rates of sediment production will accelerate, decelerate, or maintain the experienced rate which has been established by past or current studies of reservoir sedimentation surveys and sediment load measurements.

(2) Effects of sedimentation on reservoirs

Consider effects on reservoirs used for all purposes.
For example:

- (a) Domestic and industrial water supply
- (b) Power
- (c) Irrigation
- (d) Navigation
- (e) Recreation
- (f) Flood Control
- (g) Debris storage
- (h) Multiple-purpose
- (i) Other

For each important reservoir in the watershed consider each of the following factors: Individual characteristics of the reservoir in relation to the characteristics of its drainage area and present knowledge of rates of sediment production; rates of capacity loss under present and future conditions; present available storage; useful life under present and future conditions; availability of additional or replacement reservoir sites; replacement cost of reservoir; dredging costs; method of reservoir operation; trap efficiency; sediment source areas classified according to relative contribution; capacity -- watershed ratio; cost of supplying services from replacement reservoir; anticipated rates of sedimentation in proposed or authorized reservoirs; relative effects of bedload and suspended load; and effect of storage loss on current operating efficiency.

(3) Effects on natural channel stability

Consider effects of channel aggradation or degradation on flood heights and frequencies, effect of

local obstructions or plugs on channel avulsions and bank erosion, and the general acceleration of bank erosion by sediment accumulation in channels.

(4) Effect of sediment on agriculture

(a) Effect on soil fertility

Consider the effect of different types of sediment of varying depth on soil fertility and associated land value or earning capacity in order to classify sediment deposits in categories of equal damage.

(b) Effect on natural drainage

Consider effects of drainage impairment on land values or earning capacity as reflected by depth to water table and classify in categories of equal damage.

(c) Effect on growing crops

Consider the effect that sediment deposited from flood waters has on growing crops as compared with flooding without deposition and the relative effects of different thicknesses and types of deposit.

(d) Weed infestation

Consider damage caused by infestation with noxious weeds.

(e) Water consuming vegetation on sediment deposits

Consider the loss of irrigation water supplies by Tamarisk and similar growth on large sediment deposits, the influence of sediment on such growth, and its effect on downstream sedimentation.

(5) Effects of deposition in artificial channels

Consider the quantities of sediment that must be removed periodically for successful operation and the effects of suspension of operation as a result of excessive sedimentation in:

(a) Drainage canals

(b) Floodways

- (c) Irrigation canals
- (d) Waterways
- (e) Harbors
- (6) Effect of deposition on roads, railroads, and other property

Consider the quantities of sediment that must be removed periodically for proper maintenance, the effects of deposition on transportation services, and safety hazards created.

- (7) Effects on fish and aquatic wildlife

Consider the effect of deposited sediment or high sediment concentrations in natural waters on the habitats of fish or aquatic wildlife, and the possibility of maintaining or increasing commercial and recreational opportunities by a reduction of sediment production:

- (a) On feeding of game fish
- (b) On fish spawning
- (c) On maintenance of oyster and mussel beds
- (d) On habitats of fur-bearing animals

- (8) Effects on beach characteristics

Consider the loss of recreational facilities by excessive muddying of beaches which can be prevented by reducing rates of sedimentation.

- (9) Effects on insect control

Consider the areas where excessive sedimentation has been responsible for an increase in the insect population thereby creating an additional health hazard with a corresponding increase in cost for insect control measures.

2. Economic and social factors

Sufficient information on the occupancy, ownership, and use of the watershed will be needed to give a picture of its state of development and significant differences in various parts of the watershed.

a. Development of the watershed historically

Consider the relation between the historical development of the watershed and of flood, sediment, and soil erosion problems.

b. Population

The relative importance in relation to total population of farm, rural, town, and urban populations should be considered. Other factors are density of population, particularly in areas subject to flood, and the approximate numbers and characteristics of any significant groups differing from the usual sufficiently to influence the type or development of the program that will be proposed. Such conditions may require special features in the program to obtain a high degree of participation.

c. Occupancy and tenure

Consider the effect on the proposed program of land in different types of ownership, such as Federal, State, county, and private. In some areas absentee ownership of private lands may be of sufficient importance to be given special attention.

Consider also the major land uses in the watershed such as land in farms, in forests, parks and other reserves, and in cities and towns.

d. Land economy and management

(1) Farm land

Consider the delineation of farm lands of the watershed into significant type of farming and ranching areas for sampling purposes. For each area consider the following types of generalized data in selecting and delineating sample areas, as a partial basis for computing effects of the remedial program on farmers' income: size of farm, prevalent land practices, ownership and tenancy, land values, indebtedness and taxes, and any significant trends in land use.

(2) Other rural lands

Consider the delineation of non-farm rural lands into significant use-areas such as forests, range lands, and non-productive areas, for sampling purposes. For each area the following types of data may be needed: Productivity, land values, taxes, present

system of management including fire protection, grazing, silvicultural practices, balance of game to natural food supply, and other factors bearing on profitableness of operation under private ownership.

e. Water economy

Consideration should be given to the various purposes for which water is used or may be used in the watershed, such as. municipal, industrial, domestic, and livestock water supplies, irrigation, hydro-electric power, and transportation. (See Guiding Principle 9.)

f. Legislation, regulations, and customs affecting the program

Consider the need for a legislative analysis and investigations of regulations and customs that would facilitate or obstruct the program to be proposed. These might include examination of interstate and international compacts, water right regulations, and enabling legislation for public land acquisition, flood plain and rural zoning and soil conservation, irrigation, drainage and other districts.

C. Monetary Value of Damages

Flood damages are evaluated on the basis of one or more past floods usually by sampling. Past flood damages are converted to expected future flood damages. The computation of flood damages is usually facilitated by dividing flood plains into reaches and sample tributaries. (See IV, step 3 of this Chapter.) In evaluating in monetary terms the physical damages from past floods, as indicated in previous sections, the possibility of errors in duplication and omission may be reduced by considering direct and indirect damages separately. For this purpose the following definitions are used in the interest of uniformity in flood control reports. The distinctions between the two types of damage are arbitrarily made for convenience.

Direct damages are physical damages caused directly to property by floods. Either the damaged property itself or property upon which it depends for structural support has come in contact with floodwaters or debris carried by them.

Indirect damages are losses arising from direct flood damage but not directly by the flood itself such as interruption of service and losses caused thereby, the cost of evacuating and reentering premises made uninhabitable by flood, and the cost of rescue work and caring for the sick and injured.

Intangible or non-monetary damages. Floods cause losses of an intangible or non-monetary nature which are not susceptible to measurement in monetary terms either because of their indefinite nature or because such evaluation is too difficult. Although less concrete, such intangible damages may have an important effect on the welfare of the local residents. They should be investigated sufficiently to permit careful description in the survey report. Intangible or non-monetary damages include such factors as loss of life, mental distress caused by floods and illness or discomfort. (See also F, 2 of this section.)

The evaluation of damages from past floods may be facilitated by determining separately the damages to rural areas, to urban and town areas, to works along streams, and miscellaneous damages.

1. Rural areas

a. Flood water and sediment damage

(1) Land damage

Direct damages from flood waters and sediment to land may include: overbank deposition of infertile sediment, scour, swamping, excessive silt or other material in irrigation water which damages the land irrigated, weed infestations, or other damages. Indirect land damages should also be considered.

(2) Crop damage

Consider damages to harvested crops, to growing crops, and to crops for which flooding prevents timely planting

(3) Livestock

Consider losses of livestock caused by floods, and reduction in production, or losses of livestock products.

(4) Buildings and contents

Consider damage from flood waters and sediment to buildings and personal and other property in the buildings.

(5) Other improvements

Consider flood water and sediment damage to such improvements as fences, roads, silos, wells, facilities for farmstead water supplies, irrigation and drainage ditches (other than main canals which are considered elsewhere) and other rural improvements.

(6) Machinery and equipment

(7) Streambanks and channels

Consider damages to stream banks from caving, damages caused by the shifting of stream channels and other similar damages.

(8) Other flood water and sediment damages that are not classified above, also should be considered.

b. Deterioration of the soil resources

(1) Sheet erosion

It will usually facilitate the estimation of damages from erosion to consider sheet erosion separately from gully erosion to permit estimations on the basis of percent of topsoil loss or other similar means in estimating future operating unit conditions without the proposed program.

(2) Gully erosion

Consider damages from gully erosion, such as, losses occasioned by complete or partial destruction of land.

(3) Other

2. Works along stream channels

Damage to works along and in stream channels is usually sufficiently serious to necessitate separate investigation.

a. Reservoirs

Consider direct damage to reservoirs and their dams and other works. Damage may be caused by the floodwaters and by sedimentation. Consider sedimentation damage causing loss of storage space and thereby shortening the useful life of the reservoir or increased cost of operation or decreased benefit or income.

Consider any indirect damage that may result from reduced capacity of reservoirs due to sedimentation or from other flood water or sedimentation causes.

b. Other works along stream channels

Consider any direct or indirect damage that may result from flood waters or sedimentation to diversion dams; canals for irrigation; drainage or other purposes;

desilting basins or other works; navigation channels both in streams and harbors; levees and other flood control works; and other types of works along stream channels that may sustain flood damage.

3. Towns, urban and suburban areas

a. Direct damage

Consider direct damage from floods and sediment to property in towns, cities and suburban areas. The following types of property may be damaged:

- (1) Privately owned property such as real estate, buildings, personal property, equipment and machinery, merchandise, and similar types;
- (2) Public utilities including railways, both steam and electric, transmission lines, telephone and telegraph lines and similar types of property;
- (3) Public property, including real estate, buildings, and their contents, equipment, streets, highways, and other public property;
- (4) Any other property in towns, cities, or suburban areas.

b. Indirect damage

Indirect damages should receive closer consideration in towns and cities as they are usually larger in relation to direct damage than in rural areas. They include:

- (1) Reduction of income
- (2) Cost of evacuation and reentering premises
- (3) Cost of relief, policing, caring for the sick and injured, and similar losses or increased costs
- (4) Other indirect damages and losses not covered elsewhere

4. Miscellaneous damage

All other tangible or monetary damage not classified elsewhere may be included under miscellaneous damage

5. Intangible or non-monetary damage

D. Past, Current, and Expected Measures, and their Effects

Consider all works or measures that have a bearing on floodwater and sediment problems, either installed, in the process of installation, or reasonably certain of installation in the immediate future. In the light of these works, determine additional necessary measures and how they will be coordinated with that which has been or will be accomplished:

1. For flood control

a. Existing and authorized works

- (1) Consider all channel storage, levee, drainage, or other developments installed or to be installed by the Army Engineers, Bureau of Reclamation, and other Government or local agencies to protect an area against floods and related water damages.
- (2) Analyze the effects of the above works. Determine whether a significant flood problem still exists and what measures will best supplement that which has already been accomplished or is expected to be accomplished.

2. For sediment control

a. Existing and authorized works

- (1) Consider such measures as debris basins, and other devices installed or to be installed by Governmental or local agencies for the protection of specific developments against the detrimental effects of sedimentation.
- (2) Analyze the effects of the above sediment control measures, determine need for additional control, and coordinate supplementary sediment control plans with those in existence or planned by other agencies.

3. For maintenance of the soil resource

a. Measures practiced

- (1) Consider all practices used in the area which are primarily for the maintenance of the soil resource but which also are recognized as valuable aids to waterflow retardation and sediment control. Determine the extent to which these practices are used and at what rates they are being applied to the land as a result of Governmental and local agency participation and private initiative.

- (2) Analyze the effect of installed land measures and determine the extent to which their installation should be accelerated to achieve maximum results in maintaining the soil resource and in aiding flood control.

E. Determination of Remedial Watershed Treatment Program

In designing a remedial watershed treatment program the utmost consideration should be given to those measures that will accomplish run-off and sediment reduction in the most rapid, efficient, and economical manner consistent with the desires of the local people and their ability to cooperate. (See Guiding Principle 2.) All measures pertinent to the solution of the flood water and sediment problems of a watershed should be considered and care should be exercised not to overemphasize any one measure at the expense of other equally important measures.

1. Principal measures

a. Land use adjustment and treatment measures

Consider all measures recommended for the various evaluation classes by Soil Conservation Service and Forest Service with particular emphasis on their effect on reduction of run-off and sediment production and their relation to the water resources available for integrated watershed conservation, use, management, and control, on the following:

- (1) Farm and ranch lands
 - (a) Cultivated
 - (b) Meadow
 - (c) Pasture and range
 - (d) Forest
 - (e) Brush
 - (f) Other lands
- (2) Other rural lands
 - (a) Forest
 - (b) Brush
 - (c) Open range
 - (d) Other lands

b. Land acquisition

Consider land which can be stabilized and maintained only at public expense with little or no possibility of private participation in the cost of installation and maintenance of the recommended remedial program.

c. Channel and channel-type improvement works

(1) Gully control

Consider the type and extent of the gully systems, their relation to the downstream sediment and flood water problem, and the control measures most applicable for rapid stabilization, such as:

- (a) Head cut controls
- (b) Dams
- (c) Sloping
- (d) Vegetating severely gullied and eroded areas
- (e) Diversions
- (f) Water spreading
- (g) Other

(2) Bank stabilization

Consider type of banks, extent of bank erosion, and an integrated plan for an entire channel system, such as:

- (a) Sloping and revegetation
- (b) Jetties
- (c) Revetments
- (d) Current retards
- (e) Ice-jam control on the more northerly streams
- (f) Other

(3) Improved channel and floodway capacity

Consider the possibility of altering channel hydraulic characteristics to increase channel discharge capacity with a corresponding decrease in flood heights by such measures as:

- (a) Snagging and clearing
 - (b) Reopening sediment filled channels
 - (c) Removal of local sediment plugs
 - (d) Establishing adequate gradient
 - (e) Dikes
 - (f) Other
- (4) Road and railroad erosion control
 - (a) Sloping and vegetating cuts and fills
 - (b) Construction of substantial drains and outlets
 - (c) Other

d. Direct sediment control measures

Consider the deposition of damaging sediment in basins, or on areas of low value, or by directing the flow of sediment laden waters away from developments or installations by such measures as:

- (1) Debris basins
- (2) Spreading sediment on cheap land by means of low-dams and channel barriers
- (3) Vegetative screens
- (4) By-pass channels
- (5) Other

e. Waterflow retarding structures

Consider impounding water for short periods behind small headwater structures and providing for its beneficial use wherever feasible. (See Guiding Principle 9.) Such structures should inundate a minimum of cropland. This type of structure includes:

- (1) Ponds with flood detention storage capacity
- (2) Dams designed for waterflow retardation
 - (a) On headwater tributaries
 - (b) In gullies

(3) Other

f. Irrigation works

Consider the effect of existing, authorized, and other feasible irrigation works on stream flow, and the possibilities of increasing the groundwater recharge for well irrigation areas. (See Guiding Principle 9.)

2. Acceptance and participation

It is essential that the remedial program be developed in such a way that it will be acceptable to and can be carried out by the cooperating parties throughout the watershed. In addition to type of program, consideration should be given to steps and Federal cost needed to achieve the required participation.

3. Cost of the remedial program

Careful consideration should be given to apportionment of costs among benefiting participants including individuals, industries, local groups, and the various governmental levels such as city, county, State, and Federal. Allocation should be made largely on the basis of prospective benefits but ability to pay will necessarily qualify apportionment in local instances. At the survey stage cost allocation will necessarily be somewhat general; final allocations will be made during the preparation of the work plan when more precise data become available.

a. Installation costs

The installation costs of the following measures are to be considered:

- (1) Land use adjustment and treatment measures (including sheet erosion control)
- (2) Land acquisition
- (3) Gully control
- (4) Bank stabilization
- (5) Channel improvement works
- (6) Road and railroad erosion control
- (7) Direct sediment control measures
- (8) Waterflow retarding structures
- (9) Other

b. Operation and maintenance costs

Operation and maintenance costs, in addition to installation costs, are to be considered for all measures listed in a. above. (See Guiding Principle 11.)

c. Consider also indirect costs that may be caused by the proposed program. Such costs may include (1) reduction of run-off to the extent of impairing the value of some water rights of the watershed and (2) reduction in income or increased production costs on farms or other enterprises. Such costs must be added to direct costs of the program for equating benefits and costs.

4. Effects of program on reduction of floods, rates of sedimentation, and soil erosion prevention

a. Effect on stream flow

Reduction of flood crests may be a large factor in establishing benefits. The magnitude of reduction of flood crests should be given first consideration; consideration should also be given to benefit provided if the physical characteristics of the area and the proposed remedial program enable regulation of low flow during periods of drought. Consider the effect of waterflow retardation on irrigation water supplies.

b. Effect on rate of sedimentation

To enable computation of benefit, consideration must be given to the effect of the program on reduction in bedload and suspended load. The estimate of the percent of such reductions must be reasonably reliable so that calculations of the length of life and design of future downstream channel structures will be compatible with upstream control efforts.

c. Effect on rate of soil erosion

Soil erosion rates should be examined with a realization that maintenance or increase of productivity, in areas subject to sheet erosion, through land treatment measures creates on-site benefit in addition to downstream benefit; that the on-site benefit may be consequent even though current damage may be slight. Gully erosion and headwater recession should be considered in relation to benefits through savings created from prevention of land destruction beyond the point of practical utility and in relation to reduction in sediment that creates downstream damage.

F. Benefits from Recommended Program

Since a primary purpose of the survey is to establish relationships between benefits and costs of a program of run-off and waterflow retardation and soil erosion prevention in aid to flood control in a watershed, to be used as the basis for a judgment as to whether the program should be authorized, a careful search should be made for all benefits both direct and indirect. All tangible benefits must be evaluated in monetary terms but no attempt should be made to place monetary values on any intangible benefits. Sufficient information should be assembled on each important intangible benefit, however, to permit a comprehensive description in the survey report.

The survey report requires two types of tangible or monetary benefits from the remedial program, (1) total benefits to whomsoever they may accrue, (see Guiding Principle 6a) and (2) flood and sediment reduction benefits and off-site benefits from water conservation (see Guiding Principle 6b). It also requires a description of intangible or non-monetary benefits (see Guiding Principle 6c).

The following outline of benefits is divided on the basis of these types of benefits. All benefits under each type, in addition to the examples shown in the outline, should be considered.

1. Tangible or monetary benefits

Tangible or monetary benefits are benefits that have sufficiently definite financial implications to permit their evaluation in monetary terms. For purposes of the survey they are divided into (a) flood and sediment reduction benefits and off-site benefits from water conservation, and (b) other monetary benefits.

a. Flood and sediment reduction benefits and off-site benefits from water conservation

These benefits consist of the following four types:

(1) Benefits from flood water reduction

Benefits from the reduction of flood waters are the difference between anticipated off-site damages (both direct and indirect) from flood waters without and with the proposed program. They include reduction of flood water damage to such items as:

(a) Crops and livestock

(b) Land, including such damages as scour

- (c) Other property, including damage to such property as buildings, other structures and improvements, and other property both private and public

(2) Benefits from sedimentation reduction

Benefits from the reduction of sedimentation are the difference between damages without and with the proposed program; other off-site increased income or decreased costs of operation resulting from the programs, and the value or capitalized income from reduction of on-site damage which requires group action to accomplish. They include reduction of:

- (a) Land damage, such as deposition of infertile sediment, swamping, gullying, and stream bank cutting.
 - (b) Sedimentation to such works, in or along stream channels, as reservoirs, other water works, and navigation channels.
 - (c) Cost of water purification and similar items of reduced cost.
 - (d) Damage to other activities, such as commercial fishing and trapping.
- (3) Enhancement of property values or income, on lands subject to damage from flood waters and/or sedimentation, over and above benefits included elsewhere. (see Part IV, Phase 6, C of this Chapter)
- (4) Off-site benefits from water conservation

Off-site water conservation monetary benefits result from increased amounts of groundwater, increased low-water flow, and/or improved quality of water. They include increased water supplies during periods of low flow for such purposes as irrigation, hydroelectric power, navigation, pollution dilution, municipal, domestic, livestock, industrial, recreational, and commercial fishing.

- (5) Total monetary benefits from flood and sediment reduction and off-site benefits from water conservation.

This total, the sum of items (1) through (4) above, is required in the survey report (see Guiding Principle 6b) and is used in Part IV, Phase 10 of this chapter.

b. Other monetary benefits

Other monetary benefits include all tangible or monetary benefits other than those included under a. above. For convenience other monetary benefits may be divided into (1) other public benefits and (2) non-public benefits.

(1) Other public benefits

Other public benefits are those that accrue to the public in addition to those under flood and sediment reduction benefits and off-site benefits from water conservation. They include such items as:

(a) Increased income from public lands such as national forests, including:

- 1) For lands already in public ownership - increased gross income with any additional costs being included as costs of the recommended program.
- 2) Total income from lands purchased under the recommended program.

(b) Increased income or decreased operating costs of such government facilities as parks and highways.

(2) Non-public benefits

Non-public benefits are on-site benefits accruing to owners and/or operators of private operating units. They include increased income or decreased costs on:

- (a) Farms and ranches
- (b) Forest operating units
- (c) Range operating units
- (d) Other

c. Total tangible or monetary benefits

The total monetary benefits (the total of a, and b above) is required in the survey report, (see Guiding Principle 6a) and is used in Phase 10, Part IV of this chapter.

2. Intangible or non-monetary benefits

Intangible benefits are not evaluated in monetary terms because of their very indefinite financial nature. They include such kinds of benefits as:

- a. Improved public safety, including reduction in loss of life and personal injury.
- b. Improvement in general welfare and security resulting from such conditions as better sanitary conditions, improved health, and stabilization of income.
- c. Improved public morale resulting from such conditions as elimination of mental suffering caused by floods, elimination of inconveniences caused by interruption of public utility services, improved recreational facilities for boating, hunting and fishing, and greater pleasure derived from clear sparkling streams.

Intangible or non-monetary benefits must be described in the survey report, (see Guiding Principle 6c) and used as partial justification for authorization of operations, particularly in watersheds where relationships between monetary benefits and costs do not meet requirements.

G. Comparison of Benefits with Costs

Comparisons of total benefits with total costs, and of flood water and sediment reduction benefits and off-site benefits from water conservation with Federal cost of the recommended flood control program will be necessary in the survey report. These cost and benefit figures to be comparable must be computed on a comparable average annual or present worth basis. (See IV, Phase 10, this Chapter).

H. Legislation and Cooperative Agreements

To make the considered program fully effective, additional State legislation may be required. An example occurs in statutes of certain states that preclude Federal land purchase. Consideration must therefore be given to the possibility of obtaining such necessary legislation or to the alternative measures necessary if legislative aid appears dubious. Similarly, analysis must be made of all conditions of cooperation that may be required by the Department, preparation of memoranda of understanding and/or other instruments required to assure confirmation with them.

III. The Survey Work Outline

"Administrative Procedure" discussed in Chapter II of the manual indicated that flood control surveys would be initiated upon the basis of an approved survey work outline. In order to expedite technical, personnel, and budgetary elements of general program administration, it will be necessary for the work outline to contain data upon (1) general outline of the proposed study, (2) the number and character of personnel to be involved on various phases and the time necessary to complete the survey, (3) information pertaining to cost of the study and equipment involved, and (4) inter-agency responsibilities.

The portion of the outline relating to the study, (1) above, will be formulated by selection of those items listed in Part II of this chapter that bear upon the evaluation of a remedial program for reduction of flood and sediment damage in the basin under consideration. The outline should be brief and concise.

The survey work outline will be submitted to the Washington Office in the following form: (See Chapter 2, Part II)

A. Outline of work

1. Survey objectives

2. Types and sequence of work

a. Field

(1) Damage appraisals

(2) Hydrologic investigations

(3) Land use studies

(4) Geologic, soil, and erosion conditions

(5) Sedimentation

(6) Occupancy and economy

b. Office

(1) Formulation and evaluation of a remedial program

(2) Preparation of report (see Part V of this Chapter)

B. Survey Party Organization

1. Personnel involved, by grade and time

2. Consulting personnel from other organizations by grade and time

3. Elapsed time contemplated for the survey

C. Cost and Equipment

1. Cost

a. Personnel

(1) Salary

(2) Travel and per diem

- b. Equipment
- c. Office space
- d. Other

IV. Technical Procedure for Conducting a Survey

A. Introduction

The main purpose of the following section on technical procedure is to present a generalized guide for the conduct of a survey until more appropriate methods are devised. Other purposes are to point each item of work undertaken toward the objectives of the survey, and to indicate the interrelation among the different phases. It is intended as a guide and not as a standard for universal adoption and contains some widely recognized principles. However, it is recognized that this is not necessarily the only procedure that could have been suggested, and that procedures will have to be adapted to meet specific conditions of the individual watershed. Undoubtedly shorter and less complicated methods will be developed as time passes. Consequently procedures should be under the constant study and scrutiny of those engaged on the surveys. Imagination and ingenuity should be brought to bear on the problem to provide for adequacy, completeness, and accuracy, and to cut down on time and cost.

Two factors should be kept in mind regarding the surveys to be conducted and reported upon: (1) the survey is not a plan for the location of specific types of remedial works in specific areas, but rather presents an over-all estimate, on a basin-wide basis, of the types and amounts of remedial practices that will be most consistent with the aim of waterflow retardation and soil erosion prevention in the aid of flood control, only in detail sufficient to estimate the monetary costs and benefits thereof, and (2) because the remedial concepts, and their anticipated diminution and control of floodwater and sediment discharge, to be presented in the survey report, can only be analyzed and considered upon a watershed basis, it is essential that the approach to the flood problem be through the watersheds or sub-watersheds. In many cases it will be advisable to subdivide the watershed into component sub-watersheds and select internal sample tributary areas for investigation, to remain consistent with the over-all survey purpose since effective water disposal systems can only be conceived on a watershed basis. Detail for land treatment adjusted to individual farms, and other remedial practices, will be considered during operations but such detail must integrate into the generalized over-all remedial treatment conceived on a basin or sub-basin basis at the survey stage. The phases presented below are therefore designed to this end, rather than to preoccupation or concern over land treatment measures upon specific farms. (See Guiding Principle 4.)

In the following procedure, the major items or primary phases in an agenda for a flood control survey are first listed. Each of these is then broken down into smaller steps, or specific operations that should be carried out where applicable to attain the objective of the primary phase. Analysis of the survey in this manner has the advantage of relating each phase more clearly to its ultimate purpose and thus reducing the possibility of the survey party undertaking unnecessary work.

The following outline comprises the primary phases considered necessary in the conduct of a flood control survey:

- Phase 1. Delineation of Sub-watersheds and Selection of Sample Tributaries for Investigation
- Phase 2. Determination of Flood Water and Sediment Damages
- Phase 3. Outline of Remedial Program
- Phase 4. Calculation of the Effect of the Remedial Program
- Phase 5. Calculation of Cost of Remedial Program
- Phase 6. Calculation of Benefits from Flood Water and Sediment Reduction and Off-site Benefits from Water Conservation
- Phase 7. Calculation of Other Public Benefits
- Phase 8. Calculation of Non-public Benefits
- Phase 9. Calculation of Total Monetary Benefits
- Phase 10. Comparison of Monetary Benefits with Costs
- Phase 11. Summary of Intangible or Non-monetary Benefits

B. Primary Phases

The primary purposes of the flood control program are to reduce damages caused by flood flows and sedimentation by measures applied on the watershed land and along minor tributaries. (See Guiding Principle 2.)

Phase 1. Delineation of Sub-watersheds and Selection of Sample Tributaries for Investigation

Wherever possible the entire watershed will be treated as a unit. Watersheds that are too large to be treated as a unit should be divided into sub-watersheds to facilitate the investigations.

Delineation of sub-watersheds, should conform to the drainage pattern with each sub-watershed being either a single tributary area or a group of several tributary areas with similar characteristics. In the delineation of sub-watersheds, consideration should be given to the availability of established stream gages or to establishing gages during the advance study. Their delineation will require some knowledge of potential flood water and sedimentation damages.

In watersheds where investigations are made by sampling methods, a sample tributary may be selected for investigation as representing all the tributaries of the sub-watershed area. The sample tributary should be selected on the basis of those characteristics that make it most nearly representative of the sub-watershed of which it is the sample area.

Sample tributaries are used as a basis for investigations on hydrology, sedimentation, flood damage, reduction of flood flows and sedimentation, and evaluation of flood water and sediment damages. They are also useful in studies of flood flow routings.

Phase 2. Determination of Flood Water and Sediment Damages

The reduction of damage caused by flood waters and sedimentation is the primary purpose of the flood control program and the primary source of benefits. Flood water and sediment control benefits accrue from reduction of damages and are equal to the difference between average annual damage with and without a remedial program plus any enhancement of property values not included in the reduction of damages.

a. Flood water damages

Average annual flood water damages, based on the basis of prices and values during the year of the survey, may be calculated by various methods differing in detail. However, estimates of future damages should be based on past experience as far as possible. Data on damage from one or more floods of known characteristics are usually enumerated in the field in sufficient detail for conversion to estimates of anticipated future damages by flood stage and season of occurrence. Data on flood water damage may be available from reports and records of the Corps of Engineers, the Weather Bureau, the Geological Survey, and many other sources. Such data will at least be useful in damage calculations and in some instances may obviate the necessity for making field enumerations of past damages on all

reaches. In many watersheds the U. S. Engineers may already have adequate damage data for the reaches in which their works will be effective.

The extent of past flood damages that have occurred in an area may be estimated on the basis of flood stage-damage relationships; by estimating directly through historical questionnaires; or through use of available records of damages that have resulted from floods of known stages, times of occurrence, and other characteristics during a period of years. In the flood stage-damage approach, the damage data enumerated in the field will ordinarily be limited to one or a small number of floods of known characteristics for which damage estimates are made. From these estimates, flood stage-damage relationships are developed, which indicate damage estimates for floods of various magnitudes. This approach has the definite advantage of contributing materially to the calculation of benefits by supplying a large part of the necessary data for estimating expected future damages. A substantial difference between past damages and expected future damages without a remedial program may be caused by changes in the intensity of use and development of the areas subject to floods, by changes in channel characteristics and by variations in property values and prices from year to year.

The calculation of average annual flood water damages may be made in the following manner.

- (1) Delineate the areas for which damages are to be calculated.

Flood water damages are usually calculated separately (a) for reaches along the main stream except the areas for which the Corps of Engineers claim all the benefits, (b) for the main stems of sub-watersheds, and (c) for their tributary streams. Damages for tributary streams of a sub-watershed are ordinarily computed on the basis of damages in the sample tributary.

An hydraulic control point from which flood stages are measured and on which hydrologic calculations are based should be selected in each area in which damages are to be enumerated. This should be a gage, or other measuring device where available, or a rating section. Overflow limits for floods of various magnitudes, with reference to the control point, should be determined in Phase 4.

(2) Estimate flood damages by flood magnitudes

If data are not available from some other source, it will be necessary to make a field enumeration of flood damages, which may be done by sampling each reach and sample tributary.

Flood losses by classes of property or type of damage (see Part II, C of this Chapter) may be estimated at the site of the damage for the particular flood or floods being investigated. Direct flood damages caused by water and by sedimentation to growing crops and to farm lands may be so inter-related in some cases that they would be difficult to segregate. In cases of this nature there is no practical advantage in separating them. Past direct damages for floods of like magnitude or inundating the same areas may be converted into expected future damages without the recommended program by adjusting for any appreciable changes in (a) the amount of damageable property in the areas subject to floods, (b) for differences in values or prices of damaged or damageable property at the time of past floods and during the year of the survey investigation, and (c) for expected changes in watershed and stream channel conditions since the date of the flood or floods for which past damages were enumerated or estimated.

In the conversion of past damages to anticipated future damage, direct and indirect damages will usually be affected differently by such influencing factors. It is, therefore, desirable to enumerate or estimate them separately.

On the larger streams, the increment of loss attributable to intervals of flood magnitude also should be estimated at the site, where feasible, and related to flood heights at the control point to facilitate calculation of damages from individual floods of different magnitudes. In the case of floods recurring before damages from one or more past floods have been repaired, allowance should be made for the reduced damage caused by the later flood. The data on the amount of damage, including both direct and indirect damage, caused by floods of different magnitude may be plotted as a flood stage—damage curve or tabulated in tables.

For crops, data should include damages from flood and sedimentation to various types of crops when inundated for various lengths of time, depths and during particular months or seasons of the year. These damages may be expressed as percentages of average potential value of the crop in computing crop damage factors. Crop damage factors are useful in computing potential crop damage for different seasons or months from data on typical land use and normal yields in areas subject to floods.

(3) Compute average annual flood damage

The expected number of floods of various magnitudes is computed under Phase 4. By applying the flood stage-damage relationship to the series of floods expected during a given number of years, such as 10 or 50 years, the average annual damage from floods expected to occur without a remedial program can be computed. Average annual flood damage will be needed in the survey report.

b. Sedimentation Damages

Most of the types of damages from sedimentation should be determined separately from damages caused by flood waters. The computation of some types of sedimentation benefits require the determination of past damages from sedimentation for use as a basis, or partial basis, for determining probable future rates of sediment damage.

(1) Land damages

Land damages caused by sedimentation may be determined in the following manner:

Select sample tributaries and subdivide the main stems of each sub-watershed and the main stream into reaches for study of land damages such as deposition of infertile sediment, bank erosion, swamping, and scour. Much work may be avoided if the sample tributaries and reaches selected for this purpose are the same as those used for studying flood damages.

Determine the land damage classes to be used on the basis of selected intervals of monetary damages. Determine and map the acreage of flood plain land in each damage class. Determine also the period of years during which

these damages have been accruing. Make adjustments necessary because of changes in channel characteristics, prices, and property values. These data will permit computation of average annual land damage for the entire watershed.

(2) Sedimentation of reservoirs

For the important reservoirs in the watershed that can be benefited by a remedial program, determine past rates of capacity loss, any probable deviation from these past rates, and the probable useful life of each important reservoir without a remedial program. Determine also the effect of capacity loss on costs and income from operation of the reservoirs. These data will be needed in computation of sedimentation benefits from the remedial program. If new reservoirs are to be constructed, determine their probable rate of sedimentation without a remedial program. For this purpose the data on rates of sedimentation of existing reservoirs and sediment load measurements will be useful.

(3) Damage to other works along streams

Determine damages from sedimentation to other works along streams of the watershed such as irrigation and drainage facilities, navigation channels, flood control improvements and other works (see Part II, B, 1, g of this Chapter). If the remedial program will effect reduction in sedimentation in reaches of the stream below the watershed, information on the rate of sedimentation in these reaches also should be obtained. If data are not already available, individual investigations of large works and sampling of types of small works may be necessary. Much of the needed information may be available from operators of the works.

Phase 3. Outline of Remedial Program

The generalized remedial program will be designed for the watershed as a unit or for sub-watersheds, if such a subdivision appears desirable. It should consist of a combination of practices, adjustments, and vegetative plantings calculated to achieve the most favorable utilization of the capacity of the soil to absorb and hold water, without unduly disrupting the economy of the area, to supplement an orderly and well managed water disposal

system, and waterflow retarding structures. It also will include special measures to prevent the production of sediment or to prevent sediment from reaching downstream developments.

The following operations will be involved in selecting the practices and quantities of each, most applicable for each watershed or sub-watershed unit:

- a. Determine the acreage of each evaluation class.

An evaluation class represents a type of cover and condition or treatment within each physical land unit. A physical land unit is an association of soil, slope, erosion, and other conditions which produce under similar cover and treatment essentially uniform run-off, sediment production and deterioration of soil resources. This information should be obtained by sampling methods which will be governed by the type and amount of available data. These data will consist of soils maps, conservation survey data, aerial photographs and information on infiltration, soils, and permanent and transient storage collected in Phase 4.

In the following example of such a classification, "good" grass or forest land represents a condition of cover resulting in a minimum of run-off.

<u>Evaluation Class</u>	<u>Physical Land Unit</u>	<u>Cover</u>	<u>Treatment or Condition</u>
1	A	Row Crops	Untreated
2	A	Row Crops	Treated
3	A	Close Growing Crops	Untreated
4	A	Close Growing Crops	Treated
5	A	Grass	Poor
6	A	Grass	Medium
7	A	Grass	Good
8	A	Forest	Poor
9	A	Forest	Medium
10	A	Forest	Good
11	B	(Same breakdown for each physical land unit)	

- b. Determine for each evaluation class the measures and the number of units of each that will be required to achieve the optimum reduction in run-off and sediment production and deterioration of soil resource. Research data to assist in this determination may be obtained from soil conservation experiment stations, forest and range experiment

stations, and State Agricultural Experiment Stations. Information on standard practices adaptable to the watershed may be obtained from the Soil Conservation Service and Forest Service regional offices, local representatives of the Production Marketing Administration, State colleges, State Forestry agencies and other State agencies.

It will probably be necessary to utilize the sample farm and non-farm studies discussed in Phase 8 to develop the remedial program. Care should be exercised to select sample operating units which in combination will show approximately the same proportion of each evaluation class as is contained in the watershed as a whole.

- c. Other measures to control specific areas contributing excessive amounts of sedimentation downstream will be required if sedimentation is a factor in the flood damage problem. Areas such as large unstabilized gullies, valley trenches, roads, and stream banks and beds will require special measures for adequate control. If the sedimentation problem is serious, measures such as debris basins, systems of barriers and dams by which sediment can be spread on areas of negligible value, or vegetative screens to prevent sediment from reaching the channel systems may be required to supplement measures considered for the control of the critical source areas.

By appropriate sampling methods determine the number of installations of special measures that will be required to furnish adequate sediment control in the watershed.

- d. Determine the need for supplemental waterflow retarding structures, such as, ponds with added flood detention capacity and dams designed for waterflow retardation in gullies and headwater tributaries.

By appropriate sampling methods, estimate the number of this type of structures that should be installed. Detailed investigations will not be made in the survey stage, but estimates will be made of the storage capacity that can be obtained in a given reach. (See Guiding Principle 4). In connection with such structures, consideration should be given to the inundation of a minimum of cropland. Where doubt arises as to agency responsibility for location and size of impounding structures, mutual agreement should be reached with the proper agency in accordance with Guiding Principle 1.

- e. In conjunction with all measures selected for water-flow retardation and soil erosion prevention in aid of flood control, determine what will be required to provide adequate water disposal systems for the run-off that will still be experienced. This must be considered on a watershed basis, beginning at the headwaters and routing the excess waters in a logical and orderly manner to the lower end of the watershed. All measures to accomplish this objective should be estimated as an integral part of the remedial program.
- f. The quantities of individual practices should be tabulated for the watershed. This tabulation should be in a form suitable for use in estimating the costs of the remedial program.
- g. After the remedial program has been fully decided upon its component parts must be so tabulated that they can be reconstructed to fit the samples that have been selected as indicated in Phases 1 and 2. Unless the major watershed has not been divided into sub-watersheds within which sample tributaries are selected for study, the remedial program must be considered on the same watershed and sample tributary basis so that hydrologic conditions within the sample tributaries can be adjusted to the conditions, both before and after installation of the program, within the sub-watershed which it represents.
- h. Public acquisition should be considered only when land in farms or ranches is clearly unsuited to farming or ranching and of land not in farms or ranches when satisfactory cooperation on the part of the operators appears unlikely. (See II, E, 1, b, of this Chapter).

Phase 4. Calculation of the Effect of the Remedial Program

- a. Calculation of the effect of the remedial program on flood run-off. The effect of the remedial program on flood run-off may be calculated in the following manner:
 - (1) Collect the needed basic data on rainfall, flood run-off, flood history, minimum infiltration rates, soil storage capacity, and soil moisture depletion rates. (See II, E, 1, f, of this Chapter).

Infiltration data can be obtained by the analysis of run-off records for experimental watersheds and plots, by securing the results of infiltrometer investigations made by other survey parties or, if necessary, by making infiltrometer measurements on

the more important evaluation classes within the watershed. Infiltrometer investigations should not be undertaken unless it is found impossible to secure sufficient data by other means.

When the temporary storage capacity of the soil mantle may be a limiting factor, that is, where rapid return flow is likely to occur, it is necessary to determine the limiting storage capacity of typical areas and the variation of storage capacity with antecedent moisture. In surveying watersheds where rapid return flow is important, it is usually essential to have records of rain intensity and run-off for typical tributaries within the watershed or in adjacent basins. These are used to determine the effective storage capacity of the tributary watersheds. Permanent storage capacity requires a knowledge of the field moisture capacity and wilting point.

On watersheds where melting snow produces or adds to damaging floods, data must be secured on the rates of snow melt on land in various types of use, cover, and management. Infiltration data for winter periods also may be required. No new snow and/or frost courses should be installed in the basin if applicable data from experimental or adjacent watersheds are available.

- (2) Calculation of the effects of the remedial program will usually require calculation of flood run-off with and without a program, in relation to the control points, for the sample tributaries, and reaches of the larger streams.
- (3) Calculate depths of flood run-off with and without the proposed programs (and with various combinations thereof).

On watersheds that are not likely to change greatly if no action program is installed, the present condition of the watershed can be used in estimating run-off without a program. If it appears likely that the watershed will deteriorate or improve to the extent of substantially affecting flood water or sediment damages in the future, an attempt should be made to predict the future condition of the watershed and the evaluation of damages without a program should be made for these predicted conditions. It is emphasized that consideration should be given to the trends likely to occur in the different evaluation class areas if no action programs designed to improve cover

or reduce soil erosion were to be conducted. It seems likely that without any such program the acreage of the different evaluation classes will materially change, an estimate should be made of the acreage of those classes that would probably be found at the time when conditions seem most likely to stabilize, in the absence of a remedial program that would affect them.

The most appropriate procedure to use for the calculation of flood run-off will depend upon the physical characteristics of the watershed. In general, however, preference should be given to procedures based upon the "infiltration theory" of run-off; the difference in the amount of water intake (minus any rapid return flow to the stream, plus the effect of increased surface storage) with and without a program, being taken as a measure of the reduction in flood volume.

If numerous tributaries are involved, calculations may be made for a sample tributary and applied to groups of tributaries. If stream gages have not been maintained on these sample watersheds, it may be necessary either:

- (a) to calculate the floods that would occur, both with and without a program, if the areas were subjected to a series of storms that could have occurred on the watershed; or
- (b) by some other method, derive a series of floods, called an "evaluation flood series," that could have occurred in the watershed.

In dealing with watersheds larger than are ordinarily covered by single storms it will usually be found necessary to confine the calculations of flood reductions on the main stream to floods that have actually occurred on the watershed. In this way it is possible to take into account the distribution of rainfall in the flood producing storms.

- (4) Relation of calculated flood run-off to measured flood run-off.

This is done to eliminate the effect of any systematic error in the calculated run-off and flood reductions. Where gaging records are available within the watershed the calculated run-off without a program should be compared with the measured

run-off. If records are not maintained in the basin, the calculated run-off should be compared with records of similar watersheds in the locality. If the calculated run-off is significantly different from the measured run-off, a means should be found for correcting the calculated values.

- (5) Develop flood hydrographs for the control points.

To derive hydrographs for the calculated flood volume, recourse is ordinarily had to the "unit hydrograph" concept. It should be kept in mind, however, that on some watersheds the program will alter the shape of the unit hydrograph materially. It may be possible as an alternative to determine a relationship between peak flows and volume of run-off.

- (6) Tabulate reductions in volumes, rates of discharge, and stages.

This tabulation should be of the form most suitable for use in calculating reductions in areas inundated and damaged.

- (7) Make calculations necessary to allocate flood reductions at control points to the treatment of the sub-watershed.

This will usually necessitate "flood routing" calculations for various combinations of programs. In some instances, however, a trial calculation will show that a sufficiently close estimate may be made by allocating flood reductions at the control points in proportion to the volume reduction attributable to treatment of the individual sub-watersheds.

- (8) Determine effects of the program in the interval between installation and full effectiveness.

Computation of the monetary evaluation of benefits discussed under Phase 6 will necessitate estimation of the rate at which the program approaches the full degree of effectiveness claimed.

In most instances it will be found convenient to group like individual measures and construct a single time effectiveness curve for the whole group. These curves will be found very helpful in developing a composite curve for the program.

The procedure for obtaining such a curve for each program will vary greatly with the characteristics of both the watershed and the program. In some instances the group curves can simply be weighted by the acreages of treatment represented and a composite curve for the program derived by combining these weighted curves. At the other extreme, conditions on some watersheds may be so complicated as to require separate determinations of flood reductions for each group of measures at different times after the installation of the program; and the combination of these flood reductions to derive the curve for each program. Between these two extremes there may be a wide variety of approximate methods suitable for particular watersheds.

b. Effect of remedial program on areas inundated

To determine the effect of the flood reductions on the areas inundated, it is necessary to know the relation between the stage of the stream at the control points and the area inundated by floods that reach a given stage at these points. This relation can be established in various ways. One of the most satisfactory methods is to obtain cross-sections of the valley and high water profiles for a few floods of various magnitudes. By use of hydraulic calculations and the observed high water profiles fair estimates of areas inundated can be made. The greater the amount of information that can be obtained on the areas inundated by actual floods of record the less laborious the hydraulic calculations become.

Other elements that may need to be determined are the depth and duration of inundations. The former may be accounted for by tabulating the areas inundated between the various limits of depth at the control points, using the area inundated curve and correcting for differences between stage increments at these points and the average stage increment in the entire reach under consideration. The minimum duration of inundation can be determined from the length of time that the hydrograph of the flood (either an actual hydrograph or one developed by application of the unit hydrograph principle) indicates that the flow exceeded the volume corresponding to the stage under consideration. This is called the minimum duration because on most streams large expanses of water remain over parts of the bottom lands long after the flood has receded in the main channel. Where this has an important effect on damages, local studies must be made to evaluate it.

The steps that need to be taken in most watersheds to determine the effect of the program on areas inundated are briefly outlined in the following:

(1) Survey valley cross-sections

These cross-sections should be obtained with accuracy consistent with the configuration of the cross-section in order to obtain reliable figures on the area inundated.

(2) Obtain data on high water profiles

High water data on past floods should be obtained as the cross-sections are surveyed.

It may have been found profitable to install a number of temporary staff gages on the sample tributaries and along the main stems during the advance study for the survey so that if a flood occurs during the period of the advance study or the survey, dependable profile data may be obtained.

(3) Develop curves showing the relation between area inundated in various portions of the drainage system and the peak stage (or flow) at the control points.

(4) Determine the areas inundated by the series of floods to be used in the evaluation and tabulate in a form suitable for use in the calculation of damages and benefits.

(5) Determine the areas inundated by different depths of water where this is a factor.

(6) Determine the duration of inundation for different portions of the flood plain where this is a factor.

(7) Develop any additional physical factors required in the calculation of damages.

(8) Tabulate total areas inundated, increments of area inundated to different depths for various periods of time, and any other factors required in the damage calculations.

c. Effect of the remedial program on sedimentation

- (1) Make a sediment source survey to determine those sources of sediment that are contributing directly to the channel system and analyze the effect of the remedial program on these areas.
- (2) By utilizing available plot and small watershed data, comparative reservoir surveys before and after installation of remedial programs, and other similar sources of information on the effect of land measures on sediment control, determine quantitatively the effect of the remedial program on reductions in sedimentation damage. A quantitative estimate of the reduction of sediment production will, of necessity, depend on technical judgment after a careful analysis of all phases of the remedial program. In many instances, it will be found that accurate measurements applicable to entire watershed areas of the effect of this type of program on rates of sediment production are meager.
- (3) If channel and floodway aggradation or degradation is now a problem, determine the rate that will occur with and without the program.
- (4) Determine, for the samples selected for damage studies, the areas that will be in each damage class at the end of a specified period with and without the recommended remedial program. Expand these areas to the entire watershed and compare the results for determination of reduction of land damage.
- (5) Determine the rate of capacity loss for each reservoir studied in Phase 2, b, with the remedial program in effect.
- (6) Determine the quantitative (or monetary) effect of reduced rates of sedimentation on such factors as irrigation and drainage works, navigation channels, harbors, flood control improvements, recreation, and health.

d. Acceptance and participation

The percent of participation will be determined locally and used in computing the effect, cost, and benefits of the program. The percent of participation determined for the watershed must be substantiated in the survey report.

Phase 5. Calculation of cost of Remedial Program

The total costs of the program consist of (a) expenditures for installing, operating, and maintaining the measures and practices; and (b) increase in costs of operation and/or decreases in income on operating units or other possible decreases in property values resulting from the program.

a. Installation and operation and maintenance

The cost of installing and maintaining the program may be estimated by applying average unit costs for the year of the survey to quantities of treatment. All measures of like units and of equal average unit cost are grouped and the cost for each calculated. If the watershed has been divided into sub-watersheds, it may be easier to calculate the costs for each sub-watershed and then summate to arrive at the cost for the entire watershed.

The costs for treating the various evaluation classes that were determined in Phase 3 can probably be calculated on the cost per acre to treat each class multiplied by the estimated number of acres in that class. The cost for special measures for the control of water or sediment can be estimated by an average cost per unit multiplied by the number of units. In brief, the procedures for estimating costs are as follows:

- (1) Formulate tables showing average unit costs based on prices and costs in the year of the survey for installation, and for annual maintenance including any necessary Federal cost of supervision. (See Guiding Principle 11). The unit costs should be developed by:
 - (a) Securing the suggestions of Soil Conservation Service and Forest Service regional offices.
 - (b) Analyzing the cost of operations programs already underway in the watershed or in similar locations.
 - (c) For special sediment and water control measures, estimate unit costs on the basis of present material and construction costs, and indicate the date to which estimates apply.
- (2) Apply these unit costs to the total number of units estimated as necessary to install and maintain the remedial program and to this add an adequate allowance for overhead and investigational costs.

- (3) Allocate the total costs of each measure or kind of treatment between public and private sources of funds.

When the final cost estimates are available, an estimate should be made of the amount of Federal, other public, and private funds required to install, and maintain the flood control program. These must be indicated in the survey report. Care should be exercised that the allocation to private or other public funds is based on indicated desire and ability of these parties to participate in the program. Total monetary cost of the program, and Federal cost of the flood control program are required by general principle 6a and 6b, and will be needed in Phase 10 for comparison with benefits.

- (4) If public acquisition is involved in all or part of a watershed, the cost of purchase together with any cost of relocating farm families should be added to the cost of treatment measures.

b. Increases in cost and/or decreases in income of operating units.

- (1) Any increases in cost of operation on operating units resulting from the remedial program, should be included as costs of the program as a counterpart to on-site benefits (See Phase 8).
- (2) Decreases in gross income are also carried as costs of the program.

Phase 6. Calculation of Benefits from Flood Water and Sediment Reduction and Off-site Benefits from Water Conservation

Benefits from floodwater and sediment reduction, and off-site benefits from water conservation are comprised of benefits of the entire recommended program from the reduction of floodwaters, from the reduction of sedimentation, from enhanced values of flood plain property, and from the beneficial effects caused by the use of the water conserved. The sum of the monetary values of these four types of benefit is needed in the comparison of benefits and costs of the recommended program. (See Phase 10, and Guiding Principle 6b). They should be converted to average annual benefits. Individual measures are not evaluated separately.

a. Benefits from flood water reduction

Average annual flood water damage reduction benefits are the difference between average annual damages without the recommended program and average annual damages with the program.

For areas in which flood damages without the recommended program have been determined (Phase 2 of this Chapter), computes average annual flood damages expected to accrue with the program in effect.

This may be done by applying the flood stage-damage relationships computed in Phase 2 to the series of floods of various magnitudes expected during a given number of years or to the expected frequency of various flood stages when the program is in effect. From these damage data average annual damages may be computed.

The difference between average annual flood damages without the program and with the program will be the average annual benefits from flood water reduction.

b. Benefits from sedimentation reduction

(1) Benefits from reducing land damage

Land damages without the recommended program have been computed on the average annual basis in Phase 2. Using the same damage classes, determine the acreage that will be in each damage class, when the program is in effect, at the end of the period of years used in Phase 2. This will permit the computation of average annual land damage for each area.

The difference between average annual land damage with and without the remedial program will be the benefits of the program from reducing land damages caused by sedimentation.

(2) Benefits from reducing sedimentation of reservoirs

The probable useful life of each important reservoir in the watershed has been determined for conditions without a remedial program in Phase 3. The effect of the remedial program on the useful life of each reservoir has been determined in Phase 4. The difference in the number of years of useful life of a reservoir with and without the remedial program may be assumed to be the result of the program.

(3) Benefits from reducing sedimentation of other works along streams

Damage from sedimentation to other works along streams has been determined for conditions without a remedial in Phase 2. In some cases the reduction in the rate of sedimentation resulting from the remedial

program will have been determined in Phase 4 and this reduction should be evaluated in monetary terms. In other cases it may only be feasible to estimate reduction of damages directly in monetary terms. In either case, the benefits will be the value of the amount of damage reduction. Estimation of benefits will probably have to be made by surveys of individual works.

c. Benefits from enhancement of property values

Other benefits from reducing run-off and sedimentation are reflected in the enhancement of property values coming as a result of decreasing the apprehension associated with possible recurrence of floods.

In estimating these benefits care must be taken to avoid duplication of the benefits from reduction of the expected physical flood damages calculated in earlier steps.

Such items of additional benefits should be included only where there is evidence that they will be of significance.

Consideration may be given to this type of benefits under the following conditions:

- (1) Areas where the flood hazard has always existed and where no major change in land use is expected as a result of reduction of the flood hazard.

If, for a given area, the capitalized value of the expected annual benefit from reduction of the physical damage caused by floods does not approximate the expected increase in total property value in that area, then the difference may be considered as a benefit derived from the reduction of the public apprehensiveness of floods.

- (2) Areas where past physical flood damages have not been significant although property values are expected to increase as a result of the reduction in damages.

The situations in which benefits of this nature are likely to arise are of two types:

- (a) Areas in which past physical damages have been limited because the areas have not been developed or utilized in such a manner that they were subject to damage.

Benefits in such situations should be evaluated only where it is evident that a major change

in land use will come about as a result of flood protection. An example of such a situation is an area of low lying timber land, considered to be worth \$10 per acre in its present use, but as a result of flood protection is expected to be worth \$15 per acre because when cleared it will be suitable for farming. The amount of these benefits is the difference in the value of the property before and after protection. These value estimates may be derived through either the comparative approach of property valuation or through the capitalization of increased net income.

- (b) Areas contiguous to flood damage areas, although not themselves subject to physical flood damages.

The benefits will be of the same type as those discussed under 2 (a) above. Among the factors that may contribute to such an enhancement through increased desirability of the property are: reduction in inconveniences, general improvement of neighborhood, improvement of public health, and reduction in apprehension with respect to floods. This increased desirability may be measured through comparative values or through the capitalization of the increase in rents that is expected.

Benefits from such enhancement of property values may accrue only over a considerable period of time or after a lapse of time. In such cases the benefits should be computed on an average annual basis for the period in the future when they are expected to accrue.

- d. Off-site benefits from water conservation

The average annual value of off-site benefits from the use of water conserved by the program may be represented by increases in annual net income or decreases in annual cost of operations resulting from the use of the water. These benefits are generally indirect results of the program and may accrue in widely different places and in connection with various activities. (See II, F, 1, a (1), (d)). For this reason, the determination of average annual benefits from the program will necessitate evolving methods and procedures to fit the conditions surrounding specific cases.

- e. Total benefits from flood and sediment reduction and off-site benefits from water conservation.

This total will be the sum of items a. through d. above. It is needed in Phase 10 for comparison with Federal flood control costs.

Phase 7. Calculation of Other Public Benefits

Other public benefits comprise benefits which accrue to the public in addition to those discussed in Phase 6. They accrue mostly on public lands and facilities through increased income or decreased operating or maintenance costs. The principle sources of these benefits are as follows:

a. Increased income from public lands

Annual benefit from the program for units of land already in government ownership is represented by the increased annual income but any additional cost necessary to obtaining the increased income must be included in the cost of the recommended program. (Phase 5, b, 1) For lands recommended for purchase under the proposed program, annual total income will equal the annual benefits because operating costs are included in the cost of the program.

b. Decreased cost of maintenance of roads and highways.

Where the recommended program includes such measures as erosion and run-off control on rights-of-way of highways or roads, the average annual savings is the cost of maintenance resulting from the program should be included as an annual public benefit.

Phase 8. Calculation of Non-Public Benefits

On-site benefits from measures and practices to influence run-off and waterflow retardation and soil erosion prevention are computed as the difference between average annual income of operating units with and without the remedial program in effect. Individual measures are not evaluated separately. Income is computed largely on the basis of sample operating units so selected that the types and sizes of operating units on the combined sample will be approximately the same as the aggregate of all operating units in the sub-watershed. This may be facilitated by dividing the watershed into areas of similar land use or type of farming termed land use areas. The portion of each of these land use areas in each sub-watershed must be sampled when the basin is studied by sub-watersheds.

It will usually be necessary for sampling purposes to subdivide the watershed, or sub-watershed as the case may be, into land use areas sufficiently uniform with respect to the pattern of soil, cover, and types of operating units, that the same general type of land use program can be evaluated for each type of use area.

Each land use area should be so constituted that when sampled by taking representative operating units from within it, the pattern of physical characteristics and land use on the combined sample operating units will be approximately the same as in the area sampled.

Each land use area should be fairly uniform as to distribution or combination of soils with different infiltration characteristics found within it. Distribution or percentage of cropland, pasture and woodland should be fairly uniform throughout each designated area. Distribution of farms of different sizes and types should not vary greatly within such areas. An area mainly in public ownership such as national forests would ordinarily be placed in a different category than one mainly in private ownership since the adopted program would undoubtedly be affected by this difference in ownership.

Most data relative to on-site benefits from proposed land practices will, of course, be obtained by sampling of representative operating units. Supporting data can also be obtained from (1) the Forest Service about forested areas, (2) operators who have applied measures similar to those called for in the proposed remedial program, (3) Soil Conservation Service or Forest Service evaluation survey data from treated and untreated fields, plots, and other units, and (4) analyzing results of experiment station field and plot tests conducted under conditions similar to those in the watershed.

Difference in income from different farm enterprises will be measured in monetary terms to evaluate benefit. In calculating benefits, prices and costs for the year of the survey should be used, and full account should be taken of any increases or decreases in costs due to altered conditions of operation.

The general steps required in the determination of on-site benefits are:

- a. Make a budget analysis for sample operating units representing all of the important sizes of units in the watershed to determine income with and without the program, taking account of changes in cost of operation and gross income due to altered conditions caused by the program and using prices and costs for the year of the survey.
- b. Determine on-site benefits by deducting gross income without a program from gross income with a program. ^{1/} Increases in income and decreases in costs as a result of the program

^{1/} Additional costs of obtaining the increases in gross income are included under costs (See Phase 5, b, 1.).

should always be carried as benefits and decreases in income and increases in costs should always be carried as costs of the program (See Phase 6 of this Section) to have each properly reflected in the cost-benefit analysis. Increases in income for one class of operating units must not be offset against decreases for another class, but the latter must be counted as a cost of the program.

Phase 9. Calculation of Total Monetary Benefits

Total monetary benefits to whomsoever they may accrue are required by Guiding Principle 6a. This total is needed in Phase 10 for comparison with total cost of the program. Average annual total monetary benefits are computed by adding total average annual benefits computed under Phases 6, 7, and 8.

Phase 10. Comparison of Monetary Benefits with Costs

Two benefit-cost ratios are required for justification purposes. (See Guiding Principles 6a and 6b.) To be recommended by the Department of Agriculture to the Congress for authorization of operations, the program proposed in the survey report must at least meet the following requirements: (a) total benefits to whomsoever they may accrue must be in excess of total cost of the program, and (b) total flood reduction benefits and off-site benefits from water conservation must exceed one-half of the Federal cost of the recommended flood control program, unless intangible benefits are very important. (See Phase 11 and Guiding Principle 6c.)

Total monetary benefits are computed in Phase 9 and total cost of the program in Phase 5. Flood and sediment reduction benefits and off-site benefits from water conservation are calculated in Phase 6 and Federal cost of the program in Phase 5.

Before benefits and costs can be compared they must be converted to a common time basis. This is accomplished by using either average annual values or present worth based on elapsed time from the end of the first year the expenditure is made. In the interest of uniformity, costs and benefits will be calculated on the basis of a 2 percent compound interest rate with the assumption that the benefits accruing to the program will continue indefinitely in a manner to produce the estimated benefits. (See Guiding Principle 7.)

Phase 11. Summary of Intangible or Nonmonetary Benefits

In addition to the tangible benefits which are evaluated in monetary terms, the program will also give rise to intangible benefits of such nature that they elude evaluation in monetary terms (See II, f, 2 of this Chapter). This applies especially to watersheds where, as a result of land misuse, unemployment

and relief have become acute, Governmental revenues reduced, living standards lowered; where the security of communities is threatened by exposure to floods; or where loss of life has occurred.

In addition to bettering these conditions, the restoration and improvement of the resources, in many instances, may create or expand the opportunities for general recreational purposes, and fish and wildlife development.

The effects of land misuse may be reflected in social instability, such as unemployment and relief loads, rural tax delinquency, land abandonment, decreased volume of trade, population migration, and inability of communities to support local governments and institutions. A judicious comparison of past with future trends likely to develop as a result of the program, will permit a qualitative expression of the effects of the program. Similarly, when non-monetary recreational, fish and wildlife benefits are expected to accrue, these should also be treated qualitatively.

Actual examples of the social and economic effects of planned land use programs already in effect in areas similar to the watershed might be cited.

Consideration of the above types of benefits, along with decreased loss of life, where this is a factor, will permit a judgment as to the additional justification for the program over and above the comparison of monetary benefits and costs. (See Guiding Principle 6c.)

V. Preparation of Survey Report

The Survey Report will be prepared in the Regional Office or Forest Experiment Station and is to be a concise and orderly statement of survey findings and recommendations. While brevity and clarity will be expected the report should be prepared in sufficient detail to explain clearly watershed flood problems, measures proposed for their alleviation, the effect of these measures and the expected costs and benefits to accrue from them. The report will be reviewed for the Secretary in Washington by the Solicitor's Office before submission to the Congress. It may, therefore, under certain circumstances be found advisable, during preparation of the report, to obtain comment from the appropriate field representative of the Solicitor. Field comment of the Solicitor's Office, however, will not be obligatory. The report and accompanying appendices will be submitted by the Department of Agriculture to other agencies for review and comment, and to the Congress for examination and decision. A survey report recommending a watershed improvement program is customarily printed as a House or Senate document. If approved by the Congress, the report becomes the Act authorizing flood control operations in the watershed to which it relates. Generally, the appendices are not printed.

Although the appendices accompanying the report are not generally printed with the textual material as a part of the House or Senate Document, they are to be indexed in an orderly manner, by subject matter. They should contain such matter, maps, and tables as are necessary to substantiate the report. Lengthy statistical research data or lengthy tables that are not in direct substantiation of the text are not to be included in the appendices but should be indexed and retained for reference in the origination office.

Following is an outline for the survey report. It is realized that emphasis on various subjects will vary widely between reports on different watersheds but general conformance to the subject headings is expected.

Outline for the Survey Report

A. Authorization

The title page of the report should contain a statement indicating legal authority for the report.

B. Summary and Recommendations

The first section of the report will be a brief and concise summary and will contain the basic recommendations of the report. Recommendations should contain a direct statement that \$_____ are recommended for expenditure by the Federal Government on _____ Watershed for measures in aid of flood control. The outline of topics should follow the outline for the body of the report. Opposite or near the first page of the summary should be a location map showing such features as are needed in the summary. The summary also will contain the three following tables: (1) The cost of various types of works and measures, (2) apportionment of cost among participants as to installation cost and annual cost of operation and maintenance, and (3) comparison of the present worth of benefits and costs.

C. Body of Report

The body of the report should discuss the following subjects in the sequence shown.

1. Purpose and scope
2. Description of watershed
 - a. General description

The general description of the watershed should include a brief description of the area under investigation with sufficient detail to give a general picture of the physical and economic setting in which the flood control program will operate. Particular attention should be given to those features which cause flood damage, which bear on measures for alleviating such damages, and which otherwise influence the flood problem.

3. Flood problems

Since the survey report primarily concerns flood problems, it should carefully describe floods that occur, reasons for them, and damages and other problems caused by them. The following factors should be discussed:

- a. Description of past floods and probabilities of future floods
- b. Sources of floodwaters and sediment
- c. Damages caused by floodwaters and sediment
 - (1) Description
 - (2) Monetary estimates
- d. Social and economic problems arising from floods

4. Past and current activities to alleviate floods and resulting damages

- a. Activities
 - (1) Federal agencies including Department of Agriculture
 - (2) State and local
 - (3) Other
- b. Results achieved and relation to solving the problem

Discuss the results achieved by activities past and present to alleviate flood water and sediment damage, relation to the total problem, and whether the entire problem is being met or would be met without the Department program of waterflow retardation in aid of flood control.

5. Proposed remedial program

- a. Works, measures, and land treatments

Discuss the works, measures, and land treatments to be included in the program, and present estimated amounts of the various types that will be needed, such as:

- (1) Works wholly or partly to accomplish flood control
- (2) Land treatment such as:

Contour farming, terraces, strip cropping, contour furrowing, improved forest management, fire protection.

b. Effect of proposed program

- (1) Discuss the physical effect the program will have in solving the flood and sedimentation problems.
- (2) Discuss the effect of the program on other water uses.

c. Participation of State, and local agencies, and local people.

- (1) Discuss kind and extent of local participation expected in the program.
 - (a) Indicate the kind and amount of participation expected from State, county, and city governmental units; other agencies; and farmers and other operating unit owners and/or operators.
 - (b) Substantiate the percent of participation used in computing costs and benefits from the program.
 - (c) State conditions required by Department of Agriculture as the basis for its cooperation under the program.
- (2) Discuss the factors which may limit participation and the means taken to surmount these difficulties.

6. Cost of program

Discuss the cost of the program and indicate monetary cost:

a. For installation

- (1) Cost of various types of works, measures, and treatments
- (2) Total cost, including both direct and indirect costs
- (3) Cost allocation to various participants, such as, Federal for flood control, State and local governmental units, other agencies, and farmers and other owners and/or operators of operation units.

b. Annual cost of operation and maintenance

- (1) Cost of various types of works, measures and treatments
- (2) Total annual cost
- (3) Cost to be borne by different participants

7. Monetary benefits from program

Discuss the benefits from the program that are measured in monetary terms (including both direct and indirect benefits but not intangible benefits).

a. Total for watershed

Indicate total benefits from the entire program in the watershed and discuss their significance.

b. Flood control and water conservation benefits

Indicate benefits expected to accrue in the watershed from the reduction of flood water and sedimentation and discuss their significance, including both direct and indirect benefits.

8. Comparison of monetary benefits and costs of program

Indicate the amounts of benefits and costs of the program in the entire watershed under survey, and discuss their relationship, on the following bases:

a. Total monetary benefits and total costs

(1) Present worth

(2) Average annual

b. Federal flood control and water conservation benefits and Federal Flood Control costs.

(1) Present worth

(2) Average annual

9. Intangible or non-monetary benefits

Describe fully and discuss significance of any intangible or non-monetary benefits, particularly those that relate to public safety, that are of importance in the watershed. If relationships between benefits and costs of the program are not great enough to warrant recommendation that the program be conducted, but if intangible benefits are sufficiently significant to recommend the program, this must be discussed carefully to fully substantiate such recommendations.

D. Appendices of the Report

The major purpose of the Appendices is to furnish supporting data for the main body of the report. They should be factual.

They should be written in such a manner as to permit a clear understanding of the processes by which given report conclusions or results were arrived at. They should especially be designed to facilitate the intended interpretation of the program recommendations--and limitations--by those action agencies who subsequently will be responsible for carrying them out, perhaps under greatly changed conditions of land use, cover, or legislative or administrative procedures.

Appendices should be arranged and indexed so as to permit ready reference to any significant phase of the survey report the reviewer may wish to pursue further. To the extent possible, stress should be placed on the use of maps, charts and tables in preference to lengthy textual matter. However, although care should be used in preparing the text, it need not be given the same degree of editorial treatment as that required for the report.

The appendices should not include the details of basic research data obtained from sources other than the survey itself. Only the results and the methodology of their application to survey computations should be shown, except that sample calculations may be included to illustrate the methods of analysis applied.

In brief, the Appendices should not be considered a catch-all for the field measurements and other detailed information collected by the survey. Only material necessary to explain the more essential report findings or recommendations properly belongs there.

Outline of Appendix Headings

Appendix headings and subheadings need not closely conform with or follow the same pattern as that followed in the main report. In addition to a list of selected references, they should include pertinent material on at least the following subjects:

1. Physical Factors (includes descriptive and analytical material on climate, geology, soils, plant cover, which bear directly on the flood, sediment and erosion problems and their alleviation.)
2. Land and Water Economy (ownership, legislative factors, operating practices and returns, existing land and water developments, which affect or are affected by the flood program, and which must be considered in program development.)
3. Hydrology (includes analyses of precipitation - run-off relations; bases for various subdivisions of watershed and of stream reaches for analytical and program development purposes; bases for damage-stage determinations; bases for soil-cover complex classification.)

4. Damages (includes methodology and sample computations employed in arriving at different types, quantities, and distribution of physical and monetary damages, respectively; methodology for arriving at ratio of indirect to direct monetary damages.)
5. Plan of Improvement (includes evidence supporting character and extent of recommended program as against others considered; effects of relation of proposed program to other existing programs of the Department and other public agencies, as well as known projected programs considered likely to affect the flood problem or the remedial program; reasons for public acquisition, where recommended; bases for program costs.)
6. Program Appraisal (includes major results of analyses of physical and economic program effects — Physical: flood, sediment, erosion reduction; changes in crop or other fields; changes in streamflow distribution, groundwater levels; Economic: downstream costs and returns as influenced by flood and sediment reductions and by water conservation. Upland costs and returns; ratios of indirect or direct benefits; methods for converting costs and monetary benefits to average annual equivalents for ratio determinations. Itemized description and classification of intangible or non-monetary benefits, should be included only where such benefits are used to justify an otherwise unfavorable report.
7. Bibliography (includes references to research, historical, and other data obtained from secondary sources.)

The above headings are suggestive only. In given cases, one or more of the features covered under the above listed major headings may be so important as to warrant treatment under a separate section: as for example, soil conditions, sedimentation problems, institutional factors, or administrative arrangements.

APPENDIX



APPENDIX

A CONSOLIDATION OF THE PORTIONS OF THE FLOOD CONTROL ACTS
WHICH APPLY DIRECTLY TO THE DEPARTMENT OF AGRICULTURE, EX-
CEPT THE PARTS WHICH ENUMERATE THE WATERSHEDS OR PORTIONS
OF WATERSHEDS AUTHORIZED FOR PRELIMINARY EXAMINATION AND
SURVEY.

AS OF JANUARY 1, 1947

TITLE 33--NAVIGATION AND NAVIGABLE WATERS

FLOOD CONTROL

AND

ADDITIONAL AUTHORIZATIONS

TITLE 33--NAVIGATION AND NAVIGABLE WATERS

FLOOD CONTROL

§ 701a. Flood control generally; declaration of policy.—It is hereby recognized that destructive floods upon the rivers of the United States, upsetting orderly processes and causing loss of life and property, including the erosion of lands, and impairing and obstructing navigation, highways, railroads, and other channels of commerce between the States, constitute a menace to national welfare; that it is the sense of Congress that flood control on navigable waters or their tributaries is a proper activity of the Federal Government in cooperation with States, their political subdivisions, and localities thereof; that investigations and improvements of rivers and other waterways, including watersheds thereof, for flood-control purposes are in the interest of the general welfare; that the Federal Government should improve or participate in the improvement of navigable waters or their tributaries, including watersheds thereof, for flood-control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs, and if the lives and social security of people are otherwise adversely affected. (June 22, 1936, ch. 688 § 1, 49 Stat. 1570.)

§ 701a.—Same; definition of "flood control"; jurisdiction of Federal investigations.—The words "flood control" as used in section 701 of this title, shall be construed to include channel and major drainage improvements, and the Federal investigations and improvements of rivers and other waterways for flood control and allied purposes shall be under the jurisdiction of and shall be prosecuted by the War Department under the direction of the Secretary of War and supervision of the Chief of Engineers, and Federal investigations of watersheds and measures for run-off and water-flow retardation and soil-erosion prevention on watersheds shall be under the jurisdiction of and shall be prosecuted by the Department of Agriculture under the direction of the Secretary of Agriculture, except as otherwise provided by Act of Congress. (Dec. 22, 1944, ch. 665, § 2, 58 Stat. 839.)

§ 701b. Same; supervision of Secretary of War and Secretary of Agriculture; reclamation projects unaffected.—/ Repetitive language omitted. . . . and that in their reports upon examinations and surveys, the Secretary of War and the Secretary of Agriculture shall be guided as to flood-control measures by the principles set forth in section 701a of this title in the determination of the Federal interests involved; Provided, That the foregoing grants of authority shall not interfere with investigations and river improvements incident to reclamation projects that may not be in progress or may be hereafter undertaken by the Bureau of Reclamation of the Interior Department pursuant to general or specific authorization of law. (June 22, 1936, ch. 688, § 2, 49 Stat. 1570; June 28, 1938, ch. 749, § 1, 52 Stat. 1215; Aug. 18, 1941, ch. 377, § 1, 55 Stat. 638)

§ 701b-1. Transfer of jurisdiction in certain cases to Department of Agriculture.—In order to effectuate the policy declared in sections 701a and 701b of this title, and to correlate the program for the improvement of rivers and other waterways by the Department of War with the program for the improvement of watersheds by the Department of Agriculture, works of improvement for measures of run-off and water-flow retardation and soil-erosion prevention on the watersheds of waterways, for which works of improvements for the benefit of navigation and the control of destructive floodwaters and other provisions have been adopted and authorized to be prosecuted under the direction of the Secretary of War and supervision of the Chief of Engineers, are hereby authorized to be prosecuted by the Department of Agriculture under the direction of the Secretary of Agriculture and in accordance with plans approved by him. The Secretary of Agriculture is hereby authorized in his discretion to undertake such emergency measures for run-off retardation and soil-erosion prevention as may be needed to safeguard lives and property from floods and the products of erosion on any watershed whenever fire or any other natural element or force has caused a sudden impairment of that watershed: Provided; That not to exceed \$100,000 out of any funds heretofore or hereafter appropriated for the prosecution by the Secretary of Agriculture of works of improvement or measures for run-off and waterflow retardation and soil-erosion prevention on watersheds may be expended during any one fiscal year for such emergency measures. For prosecuting said work and measures there is hereby authorized to be appropriated the sum of \$10,000,000, to be expended at the rate of \$2,000,000 per annum during the five-year period ending June 30, 1944 [The Act of Dec. 22, 1944 provided that the balance remaining from this authorization of \$10,000,000 . . . "is hereby reauthorized to be expended during the post-war period by the Department of Agriculture for the prosecution of the work authorized in section 13" of the 1944 Act.]: Provided, That such works and measures which are herein authorized to be prosecuted by the Department of Agriculture may be carried out on the watersheds of the Rio Grande and Pecos Rivers subject to the provision in section 701b of this title. (June 28, 1938, ch. 795, § 7, 52 Stat. 1225; Dec. 22, 1944, ch. 665, § 15, 58 Stat. 907.)

§ 701b-2. Same; cooperation by Secretaries of War and Agriculture expenditures.—In carrying out the purposes of sections 701a, 701b, 701c, 701d, 701e, 701f, and 701h of this title, as amended and supplemented, the Secretary of War and the Secretary of Agriculture are hereby authorized to cooperate with institutions, organizations, and individuals, and to utilize the services of Federal, State, and other public agencies, and to pay by check to the cooperating public agency, either in advance or upon the furnishing or performance of said services, all or part of the estimated or actual cost thereof, and to make expenditures for personal services and rent in the

District of Columbia and elsewhere, for purchase of reference and law books and periodicals, for printing and binding, for the purchase, exchange, operation, and maintenance of motor-propelled passenger-carrying vehicles and motor boats for official use, and for other necessary expenses. The provisions of this section shall be applicable to any funds heretofore appropriated for the prosecution by the Secretary of Agriculture of works of improvement for measures of run-off and water-flow retardation and soil-erosion prevention upon watersheds. (June 23, 1938, ch. 795, § 5, 52 Stat. 1223; Aug. 18, 1941, ch. 377, § 8, 55 Stat. 650.)

§ 701c. Same; rights-of-way, easements, etc.; acquisition by local authorities; maintenance and operation; protection of United States from liability for damages; requisites to run-off and water-flow retardation and soil erosion prevention assistance.---. . . (d) as a condition to the extending of any benefits, in prosecuting measures for run-off and water-flow retardation and soil-erosion prevention authorized by Act of Congress pursuant to the policy declared in section 701a of this title, to any lands not owned or controlled by the United States or any of its agencies, the Secretary of Agriculture may, insofar as he may deem necessary for the purposes of such Acts, require--

(1) The enactment and reasonable safeguards for the enforcement of State and local laws imposing suitable permanent restrictions on the use of such lands and otherwise providing for run-off and water-flow retardation and soil-erosion prevention;

(2) Agreements or covenants as to the permanent use of such lands; and

(3) Contributions in money, services, materials, or otherwise to any operations conferring such benefits. (June 22, 1936, ch. 688, § 3, 49 Stat. 1571; Aug. 28, 1937, ch. 877, § 4, 50 Stat. 877.)

§ 701e. Same; effect of act of June 22, 1936, on provisions for Mississippi River and other projects.---. . . The authority conferred by . . . /this Act/ . . . and any funds appropriated pursuant thereto for expenditure are supplemental to all other authority and appropriations relating to the departments or agencies concerned, and nothing in . . . /This Act/ . . . shall be construed to limit or retard any department or agency in carrying out similar and related activities heretofore or hereafter authorized, or to limit the exercise of powers conferred on any department or agency by other provisions of law is l/ carrying out similar and related activities. (June 22, 1936, ch. 688, § 8, 49 Stat. 1596.)

l/ So in original. Probably should read "in".

§ 701f: Same; authorization; payment of employees from funds of Works Progress Administration.—. . . the sum of \$10,000,000 is authorized to be appropriated and expended in equal amounts by the Departments of War and Agriculture for carrying out any examinations and surveys provided for in . . . the . . . Act [of June 22, 1936] and other Acts of Congress . . . (June 22, 1936, ch. 688, § 9, 49 Stat. 1596.)

§ 701f-1. Same; authorization.—. . . the sum of \$10,000,000 additional is authorized to be appropriated and expended in equal amounts by the Departments of War and Agriculture for carrying out any examinations and surveys provided for in . . . [the Act of June 28, 1938] and any other Acts of Congress, to be prosecuted by said Departments. . . . (June 28, 1938, ch. 795, § 9, 52 Stat. 1226.)

ADDITIONAL AUTHORIZATIONS

Act Aug. 18, 1941, ch. 377, § 10, 55 Stat. 651, provided as follows: "Sec. 10 . . . the sum of \$10,000,000 additional is authorized to be appropriated and expended in equal amounts by the Departments of War and Agriculture for carrying out any examinations and surveys provided for in this Act and any other Acts of Congress to be prosecuted by said Departments. There is also hereby authorized to be appropriated for expenditures by the Department of Agriculture in carrying on works of improvement of the character specified in section 7 of the Flood Control Act of June 28, 1938 (Title 33, § 701b-1), and which the Department is not otherwise authorized to undertake, such additional sums, not to exceed \$5,000,000, as may be necessary for that purpose. All appropriations necessary for operation and maintenance of flood-control works authorized by law to be operated and maintained by the United States are hereby authorized."

Act of Dec. 22, 1944, ch. 665 § 10, 58 Stat. 891, provided as follows: "SEC. 12. . . . the sum of \$10,000,000 additional is authorized to be appropriated and expended in equal amounts by the Departments of War and Agriculture for carrying out any examination or survey provided for in this Act and any other Acts of Congress, to be prosecuted by said Departments"

Act of July 24, 1946 (Public Law 526 - 79th Congress, 2nd Sess.) provided as follows: "SEC. 15 the sum of \$10,000,000 additional is authorized to be appropriated and expended in equal amounts by the Departments of War and Agriculture for carrying out any examination or survey provided for in this Act and any other Acts of Congress to be prosecuted by said Departments" and "SEC. 17. That the \$5,000,000 authorized to be appropriated in section 10 of the Flood Control Act approved August 18, 1941, is reauthorized to be appropriated, and the

sum of \$20,000,000 additional is authorized to be appropriated, for expenditure by the Department of Agriculture for the prosecution of the works of improvement authorized to be carried out by that Department by the Flood Control Act of December 22, 1944."

The Flood Control Acts authorize the Department of Agriculture to make preliminary examinations and surveys for run-off and waterflow retardation and soil-erosion prevention on the watersheds of nearly all waterways and localities which the War Department is authorized to investigate for flood control and allied purposes. The exact wording from the various Acts making such authorizations is not included here, but a list of "Localities and Watersheds Authorized for Preliminary Examination and Survey by the War Department and the Department of Agriculture under Flood Control Legislation" has been compiled and is available from the Office of the Secretary of Agriculture.

The 1944 Flood Control Act authorized works of improvement as follows: "SEC. 13. That the following works of improvement for run-off and waterflow retardation, and soil-erosion prevention, are hereby adopted and authorized in the interest of the national security and with a view toward an adequate reservoir of useful and worthy public works for the post-war construction program to be prosecuted by the Department of Agriculture, under the direction of the Secretary of Agriculture, in accordance with the plans of the respective reports hereinafter designated and subject to the conditions set forth there: Provided, That the necessary plans and preliminary work may be prosecuted during the war with funds from appropriations heretofore or hereafter made for such works so as to be ready for rapid inauguration of post-war construction: Provided further, That when the existing critical situation with respect to materials, equipment, and manpower, no longer exists and in any event not later than immediately following the cessation of hostilities in the present war, the projects herein shall be initiated as expeditiously and prosecuted as vigorously as may be consistent with budgetary requirements: Provided further, That nothing in this section shall be construed as approving or authorizing the acquisition of any land by the Federal Government until the legislature of the State in which the land lies shall have consented to the acquisition of lands by the United States for the purposes within the scope of this section: Provided further, That there shall be paid annually to the county in which any lands acquired under this section may lie, a sum equal to 1 per centum of the purchase price paid for the lands acquired in that county or, if not acquired by purchase, 1 per centum of their valuation at the time of their acquisition.

"Los Angeles River Basin

"The program on the Los Angeles River watershed is hereby approved substantially in accordance with the recommendation of the Under

Secretary of Agriculture in House Document Numbered 426, Seventy-seventh Congress, first session, at an estimated cost to the United States of \$8,380,000.

"Santa Ynez River Watershed

"The program on the Santa Ynez River watershed is hereby approved substantially in accordance with the recommendation of the Acting Secretary of Agriculture in House Document Numbered 518, Seventy-eighth Congress, first session, at an estimated cost to the United States of \$434,000.

"Trinity River Basin (Texas)

"The program on the Trinity River watershed is hereby approved substantially in accordance with the recommendation of the Secretary of Agriculture in House Document Numbered 708, Seventy-seventh Congress, second session, at an estimated cost to the United States of \$32,000,000.

"Little Tallahatchie River Watershed

"The program on the Little Tallahatchie River watershed is hereby approved substantially in accordance with the recommendation of the Acting Secretary of Agriculture in House Document Numbered 892, Seventy-seventh Congress, second session, at an estimated cost to the United States of \$4,221,000.

"Yazoo River Watershed

"The program on the Yazoo River watershed is hereby approved substantially in accordance with the recommendation of the Acting Secretary of Agriculture in House Document Numbered 564, Seventy-eighth Congress, second session, at an estimated cost to the United States of \$21,700,000.

"Coosa River Watershed (Above Rome, Georgia)

"The program on the Coosa River watershed above Rome, Georgia, is hereby approved substantially in accordance with the recommendation of the Acting Secretary of Agriculture in House Document Numbered 236, Seventy-eighth Congress, first session, at an estimated cost to the United States of \$1,233,000.

"Little Sioux River Watershed

"The program on the Little Sioux River watershed is hereby approved substantially in accordance with the recommendation of the Assistant Secretary of Agriculture in House Document Numbered 268, Seventy-eighth Congress, first session, at an estimated cost to the United States of \$4,280,000.

"Potomac River Watershed

"The program on the Potomac River watershed is hereby approved substantially in accordance with the recommendation of the Assistant Secretary of Agriculture in House Document Numbered 269, Seventy-eighth Congress, first session, at an estimated cost to the United States of \$859,000.

"Buffalo Creek Watershed (New York)

"Buffalo, Cayuga, and Cazenovia Creeks

"The program on the watershed of Buffalo Creek and its tributaries, Cayuga and Cazenovia Creeks, is hereby approved substantially in accordance with the recommendation of the Acting Secretary of Agriculture in House Document Numbered 574, Seventy-eighth Congress, second session, at an estimated cost to the United States of \$739,000."

(The 1946 Flood Control Act amended Sec. 13 of the 1944 Flood Control Act as follows:

"SEC. 16. That the program on the watershed of Buffalo Creek and its tributaries authorized in section 13 of the Flood control Act of December 22, 1944, is hereby amended to authorize the Secretary of Agriculture to include and prosecute works for the stabilization of stream banks such as described in House Document Numbered 574, Seventy-eighth Congress, second session, at an estimated additional cost of \$1,842,400.")

"Colorado River Watershed (Texas)

"The program on those portions of the Colorado River watershed included in the watersheds of Pecan Bayou, San Saba River, Brady Creek, and the area tributary to the main stream of the Colorado River below its confluence with the Concho River and above the mouth of Pecan Bayou, is hereby approved substantially in accordance with the recommendation of the Assistant Secretary of Agriculture in House Document Numbered 270, Seventy-eighth Congress, first session, at an estimated cost to the United States of \$2,693,000.

"Washita River Watershed

"The program on the Washita River watershed is hereby approved substantially in accordance with the recommendation of the Under Secretary of Agriculture in House Document Numbered 275, Seventy-eighth Congress, first session, at an estimated cost to the United States of \$11,243,000."

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