

**DEPARTMENT OF THE ARMY  
U.S. Army Corps of Engineers  
Washington, DC 20314-1000**

EM 1110-2-1417

CECW-EH

Manual  
No. 1110-2-1417

31 August 1994

**Engineering and Design  
FLOOD-RUNOFF ANALYSIS**

**Table of Contents**

Subject	Paragraph	Page	Subject	Paragraph	Page
<b>Chapter 1 Introduction</b>			Construction and Operation . . . . .	3-7	3-7
Purpose . . . . .	1-1	1-1	Reporting Requirements . . . . .	3-8	3-7
Applicability . . . . .	1-2	1-1	Summary . . . . .	3-9	3-8
References . . . . .	1-3	1-1			
Scope and Organization . . . . .	1-4	1-1	<b>Part II Hydrologic Analysis</b>		
Relationship to Other Guidance . . . . .	1-5	1-1	<b>Chapter 4 Rainfall Analysis</b>		
<b>Part I Problem Definition and Selection of Methodology</b>			General . . . . .	4-1	4-1
<b>Chapter 2 Introduction to Flood-Runoff Analysis</b>			Point Rainfall Data . . . . .	4-2	4-1
General . . . . .	2-1	2-1	Rainfall Data From Remote Sensors . . . . .	4-3	4-1
Applications of Flood-Runoff Analysis . . . . .	2-2	2-1	Areal and Temporal Distribution of Rainfall Data . . . . .	4-4	4-5
Nature of Flood Hydrology . . . . .	2-3	2-2			
Data Considerations . . . . .	2-4	2-3	<b>Chapter 5 Snow Analysis</b>		
Approaches to Flood-Runoff Analysis . . . . .	2-5	2-3	General . . . . .	5-1	5-1
<b>Chapter 3 Study Formulation and Reporting</b>			Physical Processes . . . . .	5-2	5-1
General . . . . .	3-1	3-1	Data Requirements, Collection, and Processing . . . . .	5-3	5-2
Overview of Corps Flood Damage Reduction Studies . . . . .	3-2	3-1	Simulating Snow Accumulation . . . . .	5-4	5-3
Planning and Managing the Hydrologic Investigation . . . . .	3-3	3-1	Simulating Snowmelt . . . . .	5-5	5-6
Hydrologic Engineering Analysis Strategy . . . . .	3-4	3-2			
Hydrologic Requirements for Planning Studies . . . . .	3-5	3-3	<b>Chapter 6 Infiltration/Loss Analysis</b>		
Preconstruction Engineering and Design (PED) Phase . . . . .	3-6	3-6	General . . . . .	6-1	6-1
			Gauged versus Ungauged Parameter Estimation . . . . .	6-2	6-5
			Antecedent Moisture Conditions . . . . .	6-3	6-5
			Surface Loss Estimation . . . . .	6-4	6-6
			Infiltration Methods . . . . .	6-5	6-6
			Impervious Areas . . . . .	6-6	6-20
			Method Selection . . . . .	6-7	6-21

Subject	Paragraph	Page	Subject	Paragraph	Page				
<b>Chapter 7</b>									
<b>Precipitation Excess - Runoff Transformation</b>									
General . . . . .	7-1	7-1	<b>Chapter 12</b>						
Runoff Subdivision . . . . .	7-2	7-1	<b>Frequency Analysis of Streamflow Data</b>						
Unit Hydrograph Approach . . . . .	7-3	7-1	General . . . . .	12-1	12-1				
Kinematic Wave Approach . . . . .	7-4	7-12	Frequency Analysis Concepts . . . . .	12-2	12-1				
<b>Chapter 8</b>									
<b>Subsurface Runoff Analysis</b>									
General . . . . .	8-1	8-1	Graphical Techniques . . . . .	12-3	12-3				
Event-Oriented Methods . . . . .	8-2	8-1	Numerical Techniques . . . . .	12-4	12-5				
Evapotranspiration . . . . .	8-3	8-5	Special Considerations . . . . .	12-5	12-10				
Continuous Simulation Approach to Subsurface Modeling . . . . .	8-4	8-11	<b>Chapter 13</b>						
Existing Continuous Simulation Models . . . . .	8-5	8-16	<b>Analysis of Storm Events</b>						
Parameter Estimation for Continuous Simulation Models . . . . .	8-6	8-23	Introduction . . . . .	13-1	13-1				
<b>Chapter 9</b>									
<b>Streamflow and Reservoir Routing</b>									
General . . . . .	9-1	9-1	Model Development . . . . .	13-2	13-1				
Hydraulic Routing Techniques . . . . .	9-2	9-2	Model Calibration . . . . .	13-3	13-2				
Hydrologic Routing Techniques . . . . .	9-3	9-5	Simulation of Frequency-Based Design Floods . . . . .	13-4	13-3				
Applicability of Routing Techniques . . . . .	9-4	9-21	Simulation of Standard Project and Probable Maximum Floods . . . . .	13-5	13-5				
<b>Chapter 10</b>									
<b>Multisubbasin Modeling</b>									
General . . . . .	10-1	10-1	<b>Chapter 14</b>						
General Considerations for Selecting Basin Components . . . . .	10-2	10-1	<b>Period-of-Record Analysis</b>						
Selection of Hydrograph Computation Locations . . . . .	10-3	10-2	General . . . . .	14-1	14-1				
Calibration of Individual Components . . . . .	10-4	10-4	Simulation Requirements . . . . .	14-2	14-1				
Calibration of Multisubbasin Model . . . . .	10-5	10-4	Model Calibration . . . . .	14-3	14-1				
Verification of the Multisubbasin Model . . . . .	10-6	10-5	Applications . . . . .	14-4	14-4				
<b>Part III Methods for Flood-Runoff Analysis</b>									
<b>Chapter 11</b>									
<b>Simplified Techniques</b>									
Introduction . . . . .	11-1	11-1	<b>Chapter 15</b>						
Rational Method . . . . .	11-2	11-1	<b>Data Collection and Management</b>						
Regional Frequency Analysis . . . . .	11-3	11-1	General . . . . .	15-1	15-1				
Envelope Curves . . . . .	11-4	11-5	Data Management Concepts . . . . .	15-2	15-1				
Rainfall Data Sources . . . . .	11-5	11-6	Geographic Information Systems . . . . .	15-3	15-1				
<b>Chapter 16</b>									
<b>Ungauged Basin Analysis</b>									
General . . . . .	16-1	16-1	Data Acquisition and Use . . . . .	15-4	15-2				
Loss-Model Parameter Estimates . . . . .	16-2	16-2	<b>Chapter 17</b>						
Runoff-Model Parameter Estimates . . . . .	16-3	16-3	<b>Development of Frequency-Based Estimates</b>						
Routing-Model Parameter Estimates . . . . .	16-4	16-4	Introduction . . . . .	17-1	17-1				
Statistical-Model Parameter Estimates . . . . .	16-5	16-5	Choice of Methodology . . . . .	17-2	17-1				
Reliability of Estimates . . . . .	16-6	16-6							

<b>Subject</b>	<b>Paragraph</b>	<b>Page</b>	<b>Subject</b>	<b>Paragraph</b>	<b>Page</b>
Hypothetical Storm Frequency . . . . .	17-3	17-2	Evaluating Reservoir and Detention Basins . . . . .	18-4	18-4
Transfer of Frequency Information with Hypothetical Events . . . . .	17-4	17-3	Evaluating Channel Alterations and Levees . . . . .	18-5	18-8
Development of Future-Condition Frequency Estimates . . . . .	17-5	17-3	Evaluating Other Alternatives . . . . .	18-6	18-10
Adjustment of Peak Discharges to Represent Stationary Conditions . . .	17-6	17-4			
<b>Chapter 18</b>			<b>Appendix A</b>		
<b>Evaluating Change</b>			<b>References</b>		
General . . . . .	18-1	18-1			
Evaluating Catchment and Conveyance-System Change . . . . .	18-2	18-1	<b>Appendix B</b>		
Procedure for Evaluating Damage- Reduction Plans . . . . .	18-3	18-3	<b>Hydrologic Engineering Management Plan for</b> <b>Flood Damage Reduction Feasibility-Phase</b> <b>Studies</b>		