FLOOD DAMAGE ANALYSIS TRAINING

Hydrologic Engineering Center
Training Course on

FLOOD DAMAGE ANALYSIS

using the

HEC FDA Package

12-16 February 1990

Davis, California

Course Objectives

This course is intended to provide Corps water resources professionals with detailed instruction in the use of the flood damage analysis and data management features of the HEC Flood Damage Analysis Package (FDA). The course will include instructions in the features and use of FDA and programs COED (Corps' computer text editor), EAD (Expected Annual Flood Damage Computation computer program), SID (Structure Inventory for Damage Analysis), SIDEDT (editor for SID damage functions and structure files, DSS (the HEC Data Storage System), DSS utilities, such as DSPLAY and DSSUTL, and PIP (Interactive Program for Input of Paired-function Data). Also included will be a discussion of the interface with hydraulics and hydrology data that can be developed from using other HEC hydrologic engineering computer programs.

HEC Instructors

Coordinator: Robert Carl

Shelle Barkin
Vern Bonner
Mike Burnham
Darryl Davis
Arlen Feldman
Harold Kubik
John Peters

Guest Instructors

Robert Daniel	Headquarters, CECW-PD
Richard Hill	Savannah District
Harry Kitch - NO	Headquarters, CECW-P
Gene Senycz	Philadelphia District

FLOOD DAMAGE ANALYSIS
using the HEC FDA Package

12-16 February 1990

Monday, 12 February

8:00- 9:00 a.m.	Introduction
9:00- 9:20 a.m.	Break
9:20-10:20 a.m.	Lecture 1: OVERVIEW OF FLOOD DAMAGE CALCULATIONS Description of the hydrologic, hydraulic, and economic relationships used in flood damage calculations. Discussion of plan formulation and evaluation. (Davis)
10:30-11:30 a.m.	Lecture 2: DESCRIPTION OF THE EXPECTED ANNUAL DAMAGE PROGRAM Development and application of the EAD program; expected annual flood damage computations using the program, including computational techniques and limitations. Analysis and usage of input and output. (Kubik)
11:30- 1:00 p.m.	ICE BREAKER LUNCHEON
1:00- 2:15 p.m.	Lecture 3: DESCRIPTION AND APPLICATION OF THE MICROCOMPUTER VERSION OF THE FDA PACKAGE. Describe the micro-computer version of the FDA Package, the component programs and their purpose. Describe and demonstrate entering input data for the EAD program using COED. Review pre-course COED assignment. Describe the workshop procedures. (Carl)
2:15- 4:15 p.m.	Workshop 1: COMPUTATION OF EXPECTED ANNUAL DAMAGE BY HAND AND WITH THE EAD PROGRAM. (Kubik)
4:15- 5:00 p.m.	Workshop 1 Review (Kubik, Carl)

Tuesday, 13 February

8:00- 8:30 a.m.	REVIEW OF DAY 1 (Kubik, Carl)
8:30- 9:30 a.m.	Lecture 4: AN INTRODUCTION TO THE HECDSS DATA STORAGE SYSTEM Description of the DSS data base system - files, data conventions, and naming conventions. (Peters)
9:30- 9:50 a.m.	Break
9:50-10:35 a.m.	Lecture 5: DESCRIPTION OF DSS PAIRED FUNCTION DATA. DEMONSTRATION IN THE USE OF COMPUTER PROGRAM PIP Definition of paired function data. Types of relationships stored. Conventions for pathname parts. Description of the program PIP; DSS file and DATAFILE files, menus, operation. Defining pathnames, command syntax, executing from the FDA menu program. Demonstration of PIP program. (Carl)
10:45-11:30 p.m.	Lecture 6: USE OF HEC PROGRAMS TO DERIVE MODIFIED FREQUENCY CURVES Use of HEC programs to derive modified frequency curves. Subdividing basins for hydrologic and economic needs. Output from the HEC-1 program. Input data required to write frequency curves to a DSS file. Demonstration using HEC-1 to compute modified frequency curves. (Feldman) — CLASS PHOTO GRAPH —
11:30-12:30 p.m.	Lunch
12:30- 1:30 a.m.	Lecture 7: USE OF HEC-2 TO DERIVE RATING CURVES Computation of both baseline and modified condition rating curves. Coordination with the hydrology for magnitude of discharges for each profile. Capabilities for simulating damage reduction plans involving channel improvement, levees, etc. Input data required to write rating curves to DSS files. Procedures for saving the "TAPE95" or "TAPE96" output results. (Bonner)
1:40- 2:30 p.m.	Lecture 8: USE OF HECDSS-DSPLAY TO CATALOG FILE AND PLOT DATA AND FDA2PO TO STORE RATING CURVES Description and demonstration of the program HECDSS-DSPLAY to catalog a DSS data file. Selecting paired functions and obtaining plots. Use of the FDA2PO program to store rating curves in a DSS datafile. (Carl)
2:30- 4:00 p.m.	Workshop 2: USE OF PIP TO ENTER A FREQUENCY CURVE, FDA2PO TO STORE RATING CURVE, AND DSPLAY TO CATALOG FILE AND DISPLAY DATA (Carl, Barkin)
4:00- 5:00 p.m.	Workshop 2 Review (Carl, Barkin)

Wednesday, 14 February

8:00- 8:30 a.m.	REVIEW OF DAY 2 (Feldman, Hayes, Carl)
8:30- 9:30 a.m.	Lecture 9: INVENTORYING STRUCTURES AND DETERMINING DEPTH-DAMAGE FUNCTIONS Structure inventory techniques. Sampling, determining value of structure and contents. Determining depth-damage functions. Sources of depth-damage functions, references and methodology for determining values. (Richard Hill)
9:30- 9:50 a.m.	Break
9:50-10:50 a.m.	Lecture 10: DEVELOPMENT OF ELEVATION-DAMAGE DATA Overview of data requirements and calculation procedures. Data aggregation and disaggregation. (Burnham)
11:00-12:00 p.m.	Lecture 11: DESCRIPTION OF THE SID COMPUTER PROGRAM. Instructions on the basic features and capabilities of computer program SID. Aggregation of damage. Description of input and output. Flood zone summary output. Overview of the SID options: single event damage, nonstructural measures, future condition analysis. Application with DSS including required input data and the relationship of tabular output to DSS output. (Barkin)
12:00- 1:00 p.m.	Lunch
1:00- 3:30 p.m.	Workshop 3: COMPUTATION OF ELEVATION-DAMAGE AT INDEX LOCATION BY HAND AND USING SID. (Barkin, Burnham)
3:30- 4:30 p.m.	Review Workshop 3: (Barkin, Burnham)

Thursday, 15 February

8:00- 8:30 a.m.	REVIEW OF DAY 3 (Barkin, Burnham)
8:30- 9:30 a.m.	Lecture 12: OCE PERSPECTIVE OF FLOOD DAMAGE ANALYSIS AND FLOOD PLAIN MANAGEMENT PLANNING. (Bob Daniel)
9:30- 9:50 a.m.	Break
9:50-10:40 a.m.	Lecture 13: DESCRIPTION AND DEMONSTRATION OF FDA2PO PROGRAM TO POST-PROCESS HEC-2 RESULTS Description of the FDA2PO program to post-process HEC-2 results. Describe computing the reference flood elevation at all structures and at the index location. Demonstration of the program. (Carl)
10:50-11:30 a.m.	Lecture 14: DESCRIPTION OF ADDITIONAL EAD OPTIONS The DSS linkage with HEC-1, HEC-2, HEC-5, SID and PIP; Writing results to a DSS file; Computation of affluence. (Carl)
11:30-12:30 p.m.	Lunch
12:30- 4:00 p.m.	Workshop 4: APPLICATION OF SID AND EAD TO EVALUATE THE FIVE PLANS (Carl)
4:00- 5:00 p.m.	Workshop 4 Review (Carl, Barkin)

Friday, 16 February

8:00- 9:15 a.m.	Lecture 15: CASE STUDY USING FDA PACKAGE (Gene Senycz)
9:15- 9:30 a.m.	Break
9:30-10:45 a.m.	PLANNING IN A COST-SHARED ENVIRONMENT - PRESENT STATUS AND FUTURE PROJECTIONS. (Harry Kitch, Acting Chief of Planning, Policy and Planning Division, HQUSACE)
10:50-11:30 a.m.	CRITIQUE AND CLOSING DISCUSSIONS

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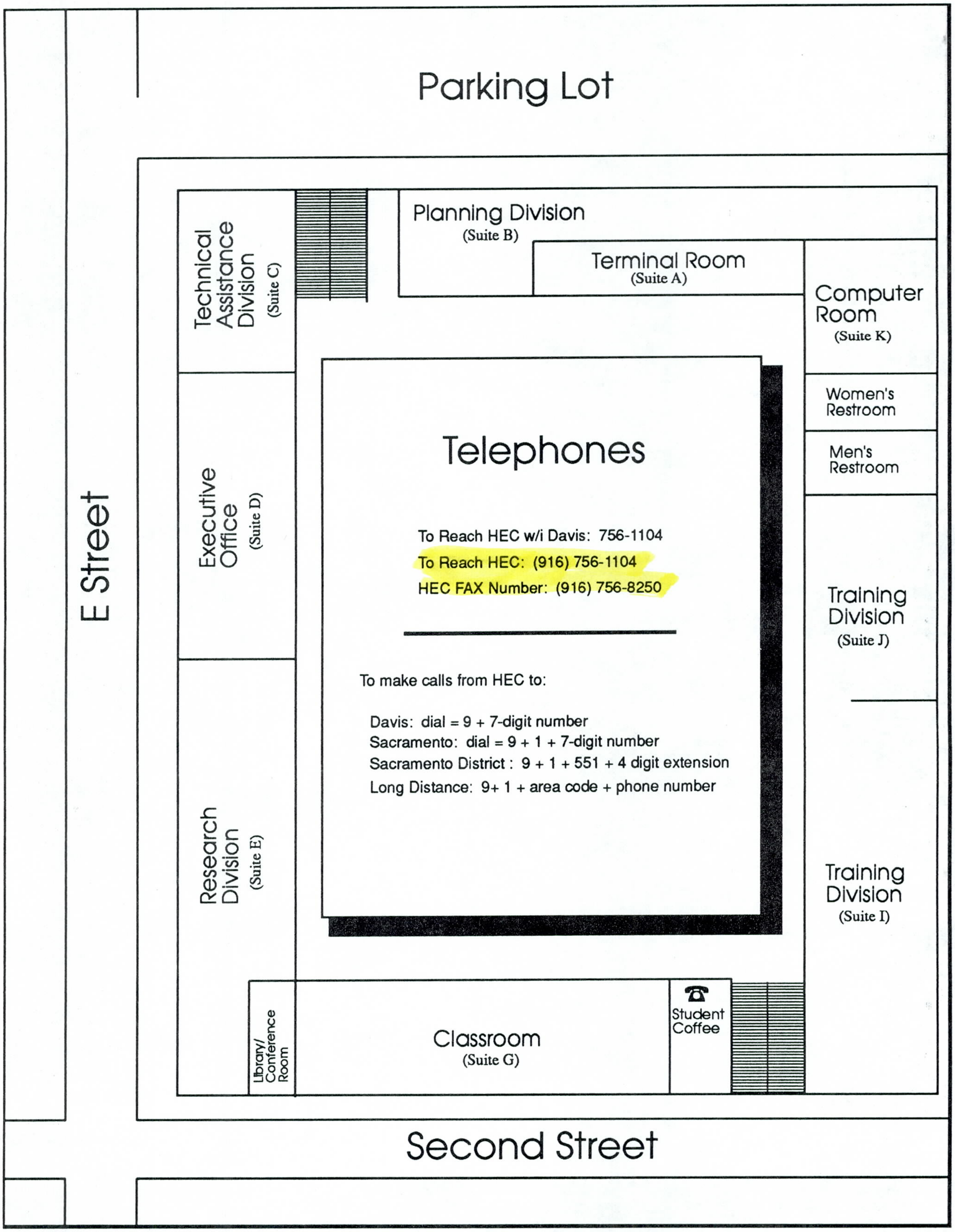
January 1990

1/90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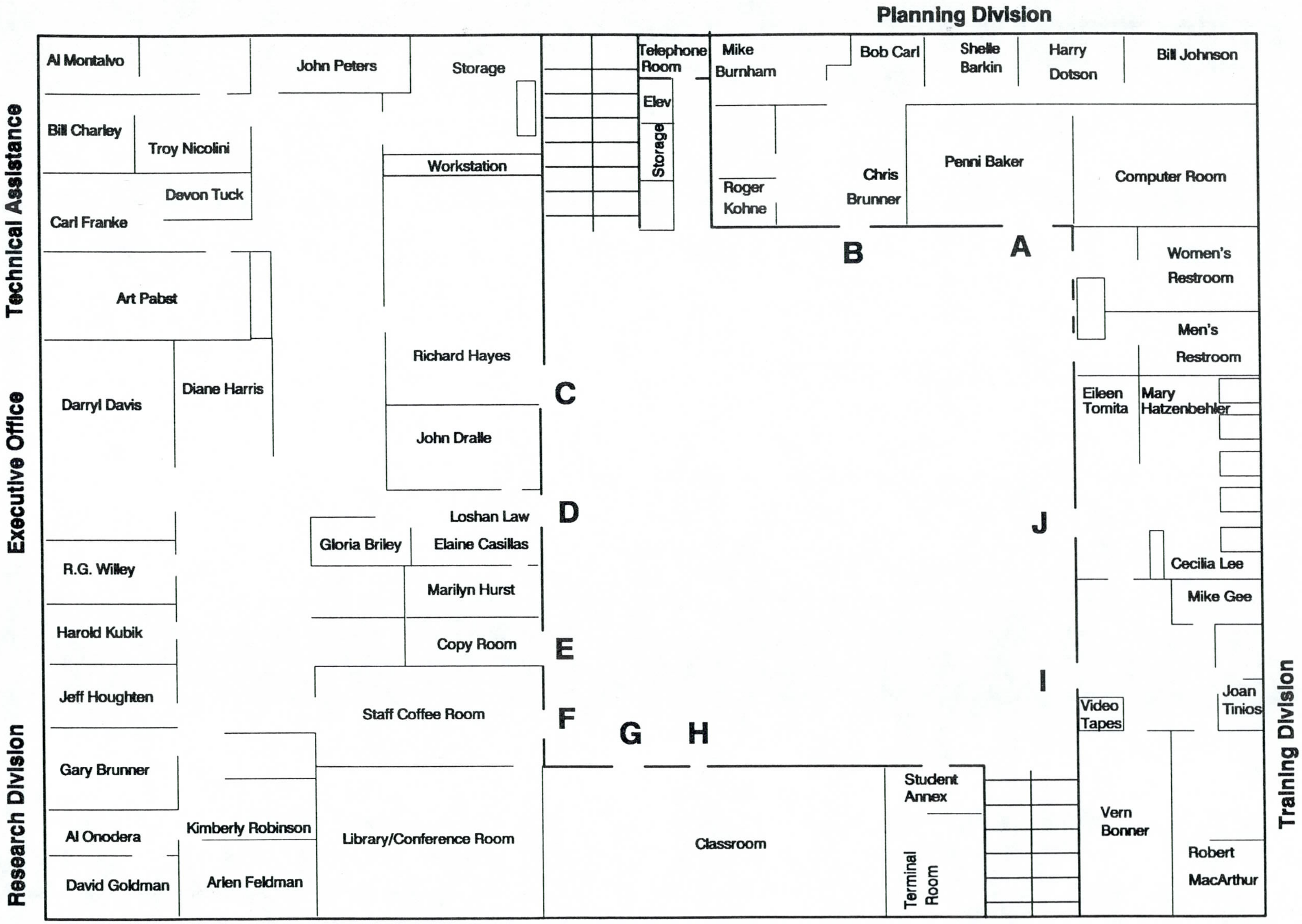

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609 Second Street
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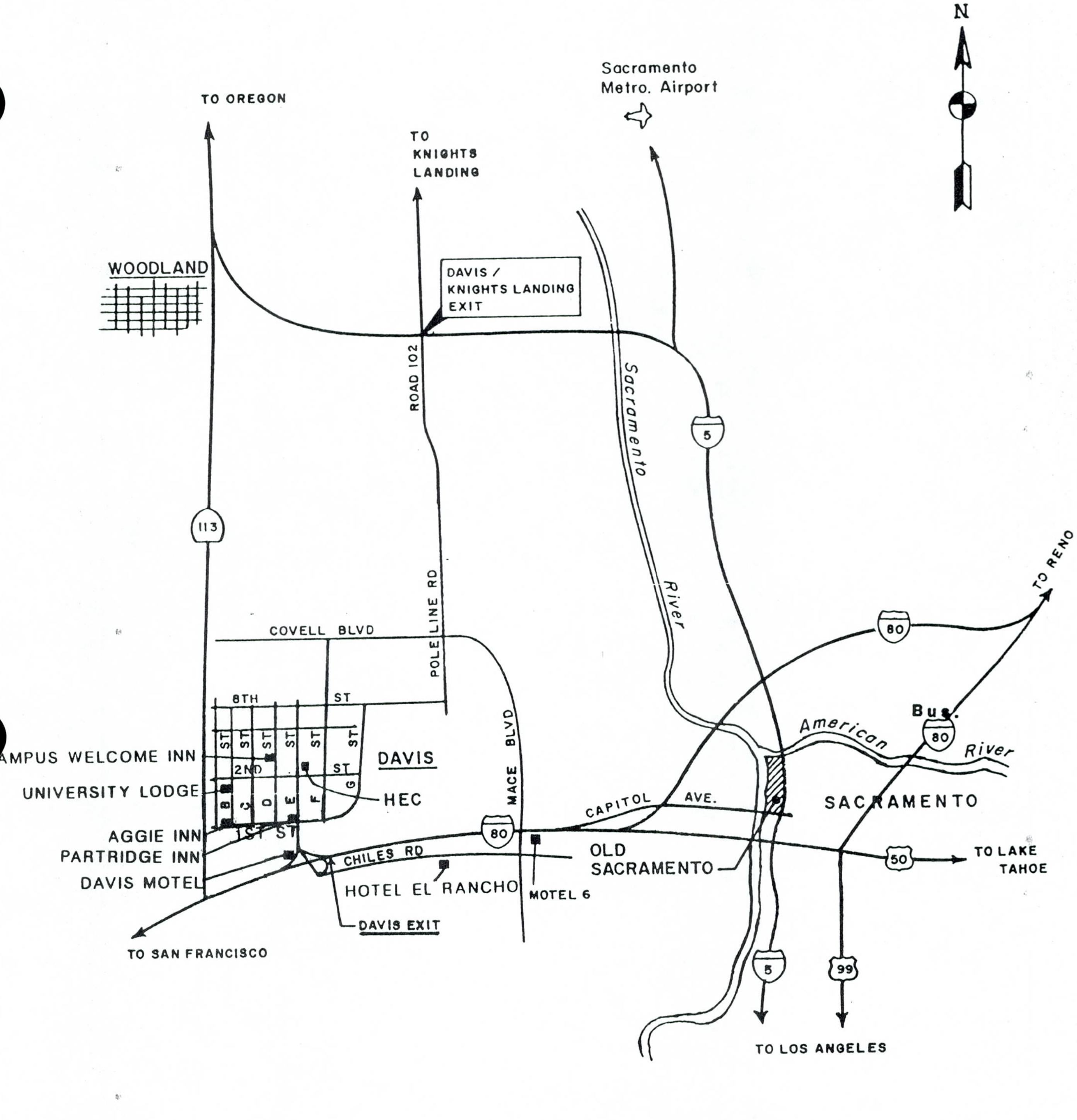
As of: 1 January 1990

(Map not to scale)



SACRAMENTO – DAVIS AREA MAP

Motels in the Davis area:

University Lodge
123 B Street
(916) 756-7890

Campus Welcome Inn
221 D Street
(916) 756-1040

Davis Motel
Interstate 80 & Richards Blvd.
(916) 756-0910

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521 First Street
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Hotel El Rancho
4120 Chiles Road
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Aggie Inn
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January 1990

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		# on Map
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A.J. BUMPS	228 G Street	2
BLUE MANGO	330 G Street	3
CHINA HOUSE	229 G Street	4
CAFE CALIFORNIA	808 2nd Street	5
COLETTE	802 2nd Street	6
CASA HERNANDEZ	1123 Olive Drive	7
PROFESSOR'S PIZZA (Delivery Only)	718 2nd Street	8
MUSTARD SEED (DELI)	231 G Street	9
NOODLE EXPRESS	301 G Street	10
DAIRY QUEEN	909 5th Street	11
CAFFE ITALIA	1121 Richards Blvd.	12
CAFE ROMA	231 E Street	13
FOOD GALLERY	132 E Street	14
JACK-IN-THE-BOX	337 G Street	15
LA BOULANGERIE (6:30 a.m.-5:30 p.m.)	260 Russell Blvd.	16
KENTUCKY FRIED CHICKEN	119 E Street	17
CREPE BRISTRO	234 E Street	18
TOGO'S	715 2nd Street	19
LONDON FISH 'N CHIPS	129 E Street	20
CREME FRAICHE	133 D Street	21
MR. B'S SPORT PAGE	217 E Street	22
ORANGE COURT CAFE (7 a.m.-9 p.m.)	129 E Street	23
ORANGE HUT CHINESE RESTAURANT	226 3rd Street	24
PARAGON	726 2nd Street	25
PEKING RESTAURANT	335 F Street	26
KAMON (JAPANESE RESTAURANT)	129 E Street	27
MOUNTAIN MIKE'S PIZZA	234 G Street	28
BAKER'S SQUARE RESTAURANT	255 2nd Street	29
STEVE'S PLACE (PIZZA, ETC.)	314 F Street	30
(Vacant)	630 G Street	31
TACO BELL	425 G Street	32
MANSION CELLARS PUB & DELI	132 E Street	33
MICHELE	409 2nd Street	36
PISTACHIOS	305 1st Street	37
LA ESPERANZA	200 G Street	38
WOODSTOCK'S PIZZA	219 G Street	39
LAS SALSAS TAQUERIA	132 E Street	34
RISTORANTE MANGIAMO	222 D Street	35
MURDER BURGER	978 Olive Drive	40

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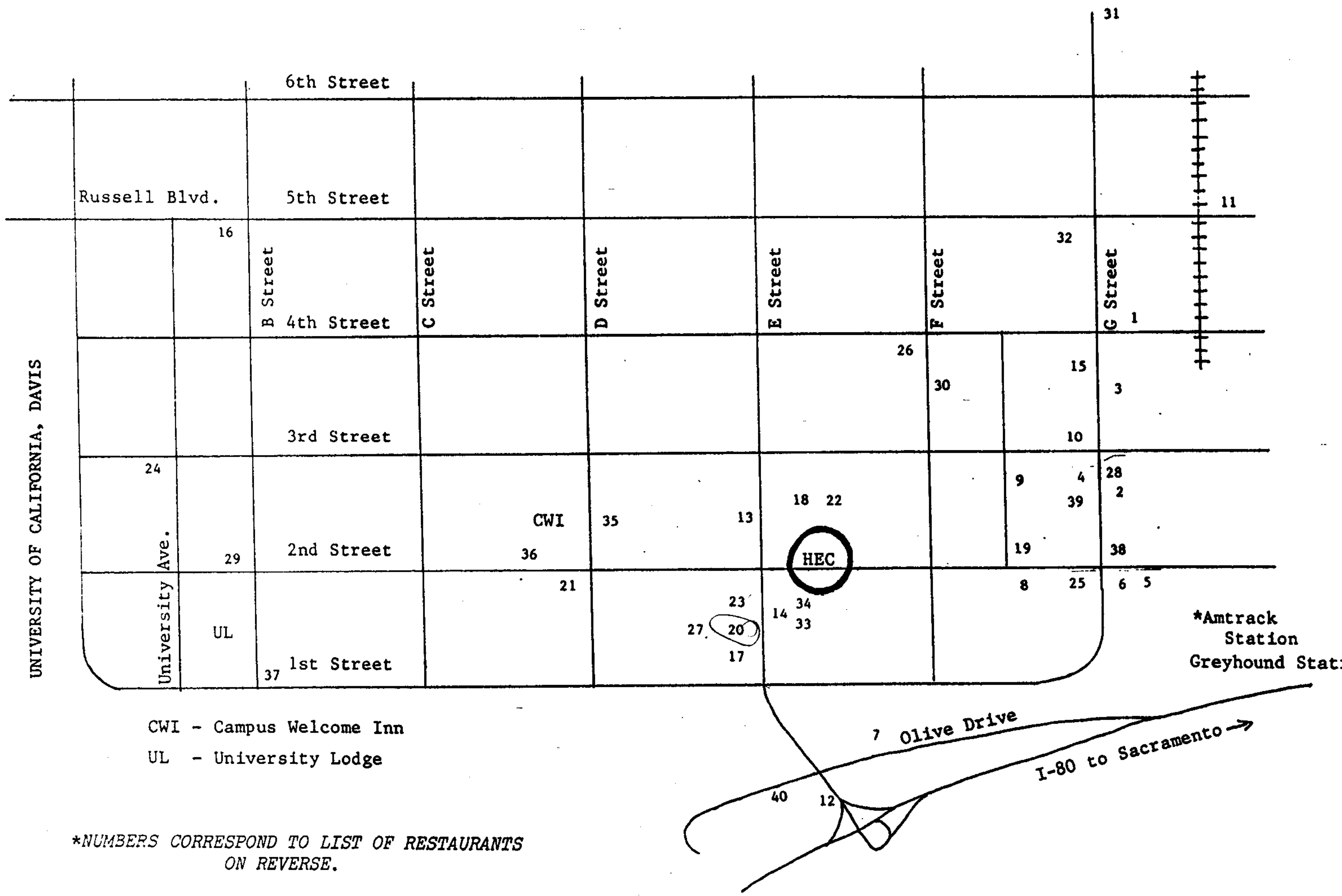
B & L (Bicycle Rental) 610 3rd Street, #756-3540
KIM'S ORIENTAL MARKET - 660 4th Street

*MAP ON REVERSE

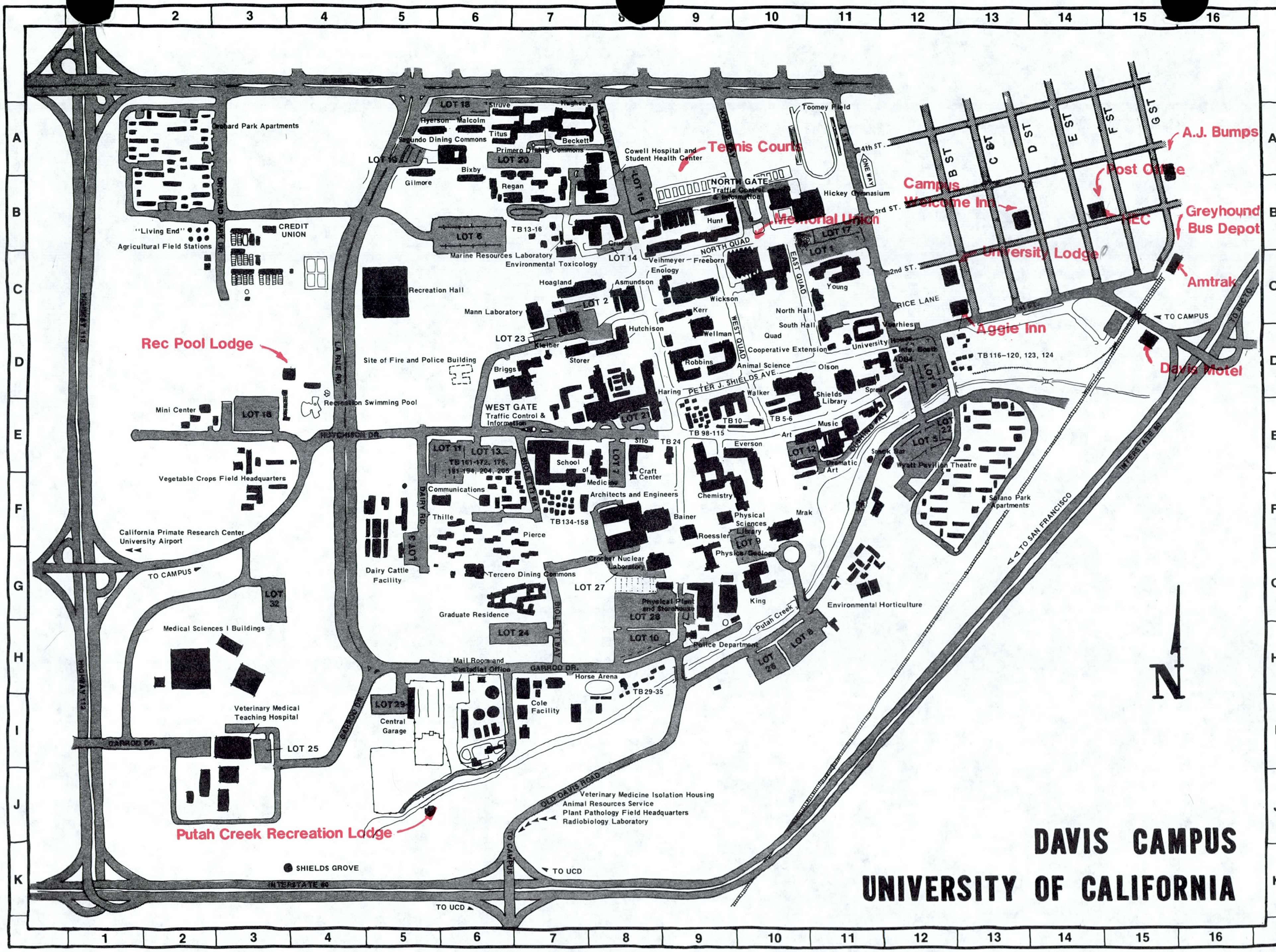
RESTAURANT LOCATIONS IN DAVIS*



CWI - Campus Welcome Inn

UL - University Lodge

**NUMBERS CORRESPOND TO LIST OF RESTAURANTS ON REVERSE.*



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UNIVERSITY OF CALIFORNIA

December 1989

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SCHEDULED FY 1990 TRAINING
THE HYDROLOGIC ENGINEERING CENTER

Course	Coordinator	Date	Cost
Hydrologic Engr/Plan	Willey	23-27 Oct 89	$ 900
Advanced HEC-2	Hayes	13-17 Nov 89	$ 925
Real Time Water Cntrl	Peters	4-15 Dec 89	$1570
Flood Warning/Prep	Dotson	22-26 Jan 90	$1365
Flood Damage Analysis	Carl	12-16 Feb 90	$1165
Sediment Transport	MacArthur	5-16 Mar 90	$1805
Hydrologic Data Mgt	Charley	2- 6 Apr 90	$ 965
Interior Flooding	Dotson	4- 8 Jun 90	$1225
Advanced HEC-1*	Brunner	23-27 Jul 90	$1430

* -- Advanced HEC-1 is a new course for FY 1990. The course will provide instruction on advanced applications of the HEC-1 Flood Hydrograph Package. Emphasis is placed on estimating infiltration, runoff, routing parameters in ungaged areas. Special attention is made to flood simulation in urban and urbanizing areas. The kinematic wave land surface runoff method and various channel and reservoir routing methods (including dam breach) will be applied. Course participants should have a basic HEC-1 course from Flood Plain Hydraulics and Hydrology, Hydrologic Analysis of Floods, or a Basic HEC-1 University short course.

Interested persons may contact the Huntsville Division:

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U.S. Army Engineer Division, Huntsville
Attn: CEHND-TD/Betty Pruitt, Registrar
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THE HYDROLOGIC ENGINEERING CENTER

PUBLICATIONS CATALOG

Publications in this catalog are organized by type of document and general subject categories. Subjects included are: Data Storage System, Economic Analysis, Floodplain Management, Groundwater Hydrology, Hydropower, Miscellaneous, Reservoirs, River Hydraulics, Spatial Data Management, Statistical Hydrology, and Water Quality.

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COMPUTER PROGRAM DOCUMENTATION (CPD)[1]

Users manuals are available for all computer programs and provide instruction in using the program. Programmers manuals are only available for some programs and provide detailed information on the program's organization and logic. The abridged title in parenthesis is provided to assist in ordering and referring to the program.

HEC Number	Title	HEC Price
DATA STORAGE SYSTEM		
CPD-45	HECDSS, User's Guide and Utility Program Manuals, Nov 87, 134 pp.	6.00
	Water Control Software, Data Acquisition, Nov 87, 139 pp. Available to Corps only.	
	Water Control Software, Forecast and Operations, Nov 87, 133 pp. Available to Corps only.	
	Water Control Software, Implementation and Managment, Nov 87, 43 pp. Available to Corps only.	
CPD-53	Interactive Paired-Function Data Input Program for Flood Damage Data (PIP), User's Manual, Jan 86, 30 pp.	3.00
CPD-57	HECDSS, Programmers Manual, Mar 87, 123 pp.	5.50
FLOOD DAMAGE ANALYSIS		
CPD-30	Expected Annual Flood Damage Computation (EAD) Users Manual, Feb 84, 133 pp.	5.00
CPD-35	Damage Reach Stage - Damage Calculation (DAMCAL) Users Manaual, Feb 79, 172 pp.	8.00
CPD-41	Structure Inventory for Damage Analysis (SID) Users Manual,. Jan 82 (revised Jun 87), 402 pp.	12.00
CPD-44	Structure Inventory for Damages Analysis Edit Program (SIDEDT) Users Manual, Dec 83, 77 pp.	4.50
CPD-48	Agricultural Flood Damage Analysis (AGDAM) Provisional, Users Manual, Apr 85, 151 pp.	7.00
CPD-53	Interactive Paired-function Data Input Program For Flood Damage Data (PIP), User's Manual, Jan 86, 30 pp.	3.00
CPD-55	Interactive Nonstructural Analysis Package (PINA) Users Manual (Preliminary), Jul 81, 59 pp.	4.00
CPD-59	Flood-Damage Analysis Package, Users Manual, Apr 88, 165 pp.	8.00
CPD-60	Flood Damage Analysis Package on the Microcomputer, Installation and User's Guide, Jul 88, 633 pp.	4.00

[1]Documentation (1 copy each) is furnished at no charge with computer programs obtained from HEC.

COMPUTER PROGRAM DOCUMENTATION (CPD) (continued)

HEC Number	Title	HEC Price
GROUNDWATER HYDROLOGY		
CPD-29	Finite Element Solution of Steady State Potential Flow Problems (FEMFLO) Users Manual, Nov 70, 76 pp.	4.50
HYDROPOWER		
CPD-38	Hydropower Analysis Using Streamflow Duration Procedures (HYDUR) Users Manual, Sep 82, 146 pp.	6.50
CPD-43	Small-Scale Hydroelectric Power Cost Estimates (HYCOST) Users Manual, Aug 83, 103 pp.	5.50
MISCELLANEOUS		
CPD-36	Fortran Source Inventory and Renumbering (FSIR) Users Manual, Oct 66, 66 pp.	4.50
CPD-37	Fortran Input/Output Conversion (FIOC) User Manual, Jul 66, 20 pp.	2.00
CPD-47	Dredged-Material Disposal Management Model (D2M2) Users Manual, Jul 84, 105 pp.	5.50
CPD-56	COED, Corps of Engineers Editor, Feb 87, 70 pp.	4.50
CPD-58	HECLIB, Programmers Manual, Aug 87, 310 pp.	14.00
RESERVOIRS		
CPD-3a	HEC-3, Reservoir System Analysis for Conservation Users Manual, Mar 81, 110 pp.	6.00
CPD-3P	Programmers Manual, Jan 76, 116 pp.	6.00
CPD-5a	HEC-5, Simulation of Flood Control and Conservation Systems Users Manual, w/o Exhibit 8, Apr 82 (Rev. May 83), 239 pp.	11.00
CPD-5b	Exhibit 8 - Input Description, Jan 89, 117 pp.	6.00
CPD-5Q	Appendix on Water Quality Analysis, Simulation of Flood Control and Conservation Systems, Users Manual, Sep 86, 387 pp.	16.50
CPD-22	Spillway Rating and Flood Routing (SWRFR) Users Manual, Oct 66, 89 pp.	4.50
CPD-23	Spillway Rating - Partial Tainter Gate Openings (SWRPTG) Users Manual, Jul 66, 26 pp.	2.00
CPD-24	Spillway Gate Regulation Curve (SWGRC) Users Manual, Feb 66, 26 pp.	2.00
CPD-25	Reservoir Yield (RESYLD) Users Manual, Aug 66, 36 pp.	3.00
CPD-26	Reservoir Area-Capacity Tables by Conic Method (RESACT) Users Manual, Jul 66, 25 pp.	2.00

COMPUTER PROGRAM DOCUMENTATION (CPD) (continued)

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RESERVOIRS (continued)		
CPD-28	Reservoir Temperature Stratification (RSTEMP) Users Manual, Jan 72, 52 pp.	4.00
	Water Control Software, Forecast and Operations, Nov 87, 133 pp. Available to Corps only.	
	Water Control Software, Implementation and Management, Nov 87, 43 pp. Available to Corps only.	
CPD-49	INCARD, Flow Conversion for HEC-5 Users Manual, Mar 83, 35 pp.	2.00
CPD-50	INFIVE, Interactive Input Preparation Program for HEC-5 Users Manual, Jul 87, 76 pp.	3.00
CPD-51	CKHEC5, Input Data Checking Program for HEC-5 Users Manual, Jun 87, 49 pp.	2.00
RIVER HYDRAULICS		
CPD-2a	HEC-2, Water Surface Profiles Users Manual, Sep 82 (Rev. May 85), 270 pp.	12.00
CPD-2P	Programmers Manual, Sep 82 (Rev. Oct 84), 235 pp.	14.00
CPD-6	HEC-6, Scour and Deposition in Rivers and Reservoirs Users Manual, Mar 77, 149 pp.	7.00
CPD-10	Hydraulics Graphics Package (HGP) Users Manual, Nov 85, 93 pp.	6.00
CPD-15	Geometric Elements from Cross Section Coordinates (GEDA) Users Manual, Oct 81, 57 pp.	4.00
CPD-40	The NWS Dam-Break Flood Forecasting Model (DAMBRK) Preliminary Users Manual, Feb 84, 210 pp.	6.50
CPD-54	Stream Hydraulics Package (SHP) Computer Program Description (Preliminary), Oct 79, 194 pp.	6.50
CPD-61	Preliminary Analysis System for Water Surface Profile (PAS) User's Manual, Jul 88, 75 pp.	4.50
SPATIAL DATA MANAGEMENT		
CPD-33	Resource Information and Analysis (RIA) Users Manual, Nov 81, 142 pp.	6.50
CPD-34	Hydrologic Parameters (HYDPAR) Users Manual, Jul 85, 79 pp.	4.50
CPD-35	Damage Reach Stage - Damage Calculation (DAMCAL) Users Manual, Feb 79, 172 pp.	8.00

COMPUTER PROGRAM DOCUMENTATION (CPD) (continued)

HEC Number	Title	HEC Price
STATISTICAL HYDROLOGY		
CPD-4	HEC-4, Monthly Streamflow Simulation Users Manual, Feb 71, 91 pp.	6.00
CPD-12	Statistical and Graphical Analyses of Stream Water Quality Data (SGSWQ) Users Manual, Jul 87, 85 pp.	5.50
CPD-13	Flood Flow Frequency Analysis (HECWRC) Users Manual, Feb 82, 64 pp.	4.00
CPD-27	Regional Frequency Computation (REGFQ) Users Manual, Jul 72, 39 pp.	4.00
CPD-32	Multiple Linear Regression (MLRP) Users Manual, Sep 70, 27 pp.	2.00
SURFACE WATER HYDROLOGY		
CPD-1a	HEC-1, Flood Hydrograph Package Users Manual, Sep 81 (Rev. Jun 88), 314 pp.	12.00
CPD-1P	Computer Implementation Guide, Jul 85, 18 pp.	N/C
CPD-7	Storage, Treatment, Overflow, Runoff, Model (STORM) Users Manual, Aug 77, 172 pp.	8.00
CPD-16	Basin Rainfall and Snowmelt Computation (BASINC) Users Manual, Jul 66, 24 pp.	2.00
CPD-17	Unit Graph and Hydrograph Computation (UHHC) Users Manual, Jul 66, 31 pp.	2.00
CPD-19	Hydrograph Combining and Routing (HYDCR) Users Manual, Aug 66, 34 pp.	2.00
CPD-20	Streamflow Routing Optimization (SFRO) Users Manual, Nov 66, 34 pp.	2.00
CPD-21	Balanced Hydrograph (BALHYD) Users Manual, Nov 66, 15 pp.	2.00
CPD-31	Interior Drainage Flood Routing (INTDRA) Users Manual, Mar 69 (Rev. Nov 78), 31 pp.	3.00
CPD-34	Hydrologic Parameters (HYDPAR) Users Manual, Jul 85, 79 pp.	4.50
CPD-42	Streamflow Routing Optimization (OPROUT) Users Manual, Jan 82, 64 pp.	2.00
CPD-46	Probable Maximum Storm (Eastern United States) (HMR52) Users Manual, Mar 84, 89 pp.	5.00
WATER QUALITY		
CPD-5Q	Appendix on Water Quality Analysis, Simulation of Flood Control and Conservation Systems, Users Manual, Sep 86, 387 pp.	16.50
CPD-8	Water Quality for River-Reservoir Systems (WQRRS) Users Manual, Oct 78 (Rev. Feb 85), 354 pp.	20.00

COMPUTER PROGRAM DOCUMENTATION (CPD) (continued)

HEC Number	Title	HEC Price
WATER QUALITY (continued)		
CPD-9	Receiving Water Quality Model (RWQM) Users Manual (Draft), Mar 79, 88 pp.	4.50
CPD-11	Thermal Simulation of Lakes (THERMS) Users Manual, Nov 77, 70 pp.	5.50
CPD-12	Statistical and Graphical Analyses of Stream Water Quality Data (SGSWQ) Users Manual, Jul 87, 85 pp.	5.50
CPD-28	Reservoir Temperature Stratification (RSTEMP) Users Manual, Jan 72, 52 pp.	4.00
CPD-52	WEATHER Users Manual, Jan 86, 21 pp.	2.00
WATER SUPPLY		
CPD-39	A Model for Estimating Water Demands (DEMAND) Users Manual, May 77, 128 pp.	6.50

REPORTS ON "HYDROLOGIC ENGINEERING METHODS FOR WATER RESOURCES" DEVELOPMENT" (IHD)

A United States Contribution to the International Hydorlogical Decade

These volumes describe methods and procedures of hydrologic engineering. In some cases appendices have been omitted. These omitted appendices are computer program listings that may be available in computer program documentation.

HEC Number	Title	HEC Price	NTIS Number
DATA STORAGE SYSTEM			
IHD-2	Hydrologic Data Management, (Without Appendices 1 and 2), Apr 72, 77 pp.	4.50	AD-A758 905
GROUNDWATER HYDROLOGY			
IHD-10	Principles of Ground-Water Hydrology, (Without Appendix 7), Apr 72, 284 pp.	13.00	AD-A758 906
RESERVOIRS			
IHD-1	Requirements and General Procedures, (Without Appendices), Oct 71, 123 pp.	6.00	AD-A758 904
IHD-7	Flood Control by Reservoirs, (Without Appendices 1, 2, 3, 4, and 5), Feb 76, 121 pp.	6.00	AD-A052 598
IHD-8	Reservoir Yield, Jan 75, 143 pp.	6.50	AD-A007 107
IHD-9	Reservoir System Analysis for Conservation, Jun 77, 95 pp.	5.00	AD-A052 599
RIVER HYDRAULICS			
IHD-6	Water Surface Profiles, Jul 75, 136 pp.	6.50	AD-A017 435
IHD-12	Sediment Transport, (Without Appendices 6 and 7), Jun 77, 225 pp.	11.00	AD-A052 600
STATISTICAL HYDROLOGY			
IHD-3	Hydrologic Frequency Analysis, Apr 75, 159 pp.	7.00	AD-A017 433
SURFACE WATER HYDROLOGY			
IHD-4	Hydrograph Analysis, (Without Appendices 2 and 3), Oct 73, 64 pp.	4.00	AD-A774 261
IHD-5	Hypothetical Floods, (Without Appendices 1, 2, 3, and 4), Mar 75, 86 pp.	5.00	AD-A017 434
WATER QUALITY			
IHD-11	Water Quality Determinations, (Without Appendix 1), Jul 72, 103 pp.	5.00	AD-A762 109

PROJECT REPORTS (PR)

Project reports describe selected projects conducted at the HEC which may be of general interest.

HEC Number	Title	HEC Price	NTIS Number
HYDROPOWER			
PR-3	Feasibility Studies for Small Scale Hydropower Additions, A Guide Manual, Jul 79, 341 pp.	14.00	DOE/RA-0048
PR-4	National Hydroelectric Power Resources Study, Preliminary Inventory of Hydropower Resources. Volumes are not available from the Hydrologic Engineering Center but may be ordered through the National Technical Information Service.		
	Volume 1, Pacific Northwest Region, Jul 79, 245 pp.		AD-A075 962
	Volume 2, Pacific Southwest Region, Jul 79, 137 pp.		AD-A075 963
	Volume 3, Mid-Continent Region, Jul 79, 239 pp.		AD-A075 964
	Volume 4, Lake Central Region, Jul 79, 215 pp.		AD-A075 965
	Volume 5, Southeast Region, Jul 79, 195 pp.		AD-A075 966
	Volume 6, Northeast Region, Jul 79, 314 pp.		AD-A075 967
PR-7	Potential for Increasing the Output of Existing Hydroelectric Plants, Vol. IX, Jul 81, 230 pp.	10.00	AD-A109 772
PR-8	Data Base Inventory, Vol. XII, Sep 81, 864 pp.	15.00	
WATER QUALITY			
PR-1	Phase 1 Oconee Basin Pilot Study - Trail Creek Test, Sep 75, 74 pp.	11.00	AD-A054 845
PR-2	Chattahoochee River Water Quality Analysis, Apr 78, 239 pp.	11.00	AD-A102 033
PR-5	Pennypack Creek Water Quality Study, Nov 79, 74 pp.	4.50	AD-A102 115
PR-6	Simulation of Streamflow Regulation Effects on the Water Quality of the Allegheny River, Feb 83, 123 pp.	7.00	AD-A130 892
PR-9	Kanawha River Basin Water Quality Modeling, Jul 86, 186 pp.	7.00	

PROJECT REPORTS (PR) (continued)

HEC Number	Title	HEC Price	NTIS Number
WATER SUPPLY			
PR-10	Lessons Learned from the 1986 Drought, Jun 88, 83 pp. This publication is not available outside of the U.S.	4.00	
PR-11	Opportunities for Reservoir Storage Reallocation, Jul 88, 83 pp. This publication is not available outside of the U.S.	4.50	
PR-12	Water Supply and Use Dalton Lake, Georgia, May 86, 118 pp. This publication is not available outside of the U.S.	4.50	

RESEARCH DOCUMENTS (RD)

Research documents describe results from research by the HEC staff and/or by persons from other organizations under contract to the HEC.

HEC Number	Title	HEC Price	NTIS Number
FLOODPLAIN MANAGEMENT			
RD-9	Annotations of Selected Literature on Nonstructural Flood Plain Management Measures, Mar 77, 99 pp.	5.00	AD-A102 184
RD-10	Estimating Costs and Benefits for Nonstructural Flood Control Measures, Oct 75, 120 pp.	6.00	AD-A102 183
RD-11	Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures, Mar 78, 233 pp.	11.00	AD-A102 012
RD-12	Costs of Placing Fill in a Flood Plain, Advance Copy, May 75, 115 pp.	6.00	AD-A102 192
RD-15	National Economic Development Benefits for Nonstructural (Flood Mitigation) Measures, May 86, 81 pp.	4.50	AD-A102 013
RD-18	Flood Preparedness Planning: Metropolitan Phoenix Area, Jan 82, 89 pp.	8.00	AD-A117 813
RD-19	Example Emergency Plan for Blue Marsh Dam and Lake, Aug 83, 96 pp.	5.00	AD-A138 903
RD-20	Example Plan for Evacuation of Reading, Pennsylvania in the Event of Emergencies at Blue Marsh Dam and Lake, Aug 83, 26 pp.	2.50	AD-A138 902
RD-30	General Guidelines for Comprehensive Flood Warning/Preparedness Studies, Oct 88, 31 pp.	3.00	
GROUNDWATER HYDROLOGY			
RD-16	Guide Manual for Preparation of Water Balances, Nov 80 (revised Apr 83), 75 pp.	4.50	AD-A102 014
RD-21	Survey of Conjunctive Use and Artificial Recharge Activity in the United States, Jan 84, 73 pp.	4.50	AD-A139 464
RD-22	A Comparative Analysis of Groundwater Model Formulation: The San Andres-Glorieta Case Study, Jun 84, 75 pp.	5.00	AD-A159 098
RESERVOIRS			
RD-13	Flood Emergency Plans, Jun 80, 58 pp.	4.00	AD-A158 679
RD-17	Emergency Planning for Dams, Bibliography and Abstracts of Selected Publications, Jan 82, 33 pp.	2.00	AD-A117 628

RESEARCH DOCUMENTS (RD) (continued)

HEC Number	Title	HEC Price	NTIS Number
RESERVOIRS (continued)			
RD-19	Example Emergency Plan for Blue Marsh Dam and Lake, Aug 83, 96 pp.	5.00	AD-A138 903
RD-20	Example Plan Evacuation of Reading, Pennsylvania in the Event of Emergencies at Blue Marsh Dam and Lake, Aug 83, 26 pp.	2.50	AD-A138 902
RIVER HYDRAULICS			
RD-5	Guidelines for Calculating and Routing A Dam-Break Flood, Jan 77, 51 pp.	4.00	AD-A102 015
RD-8	Dimensionless Graphs of Floods from Ruptured Dams, Apr 80, 70 pp.	4.50	AD-A102 191
RD-14	Effects of Flood Plain Encroachments on Peak Flow, Sep 80, 58 pp.	4.00	AD-A102 016
RD-26	Accuracy of Computed Water Surface Profiles, Dec 86, 117 pp.	9.00	AD-A176 314
RD-26A	Accuracy of Computed Water Surface Profiles, Commercial Survey Guidelines for Water Surface Profiles, Supplement, Jan 87, 59 pp.	5.00	AD-A180 542
RD-26D	Accuracy of Computed Water Surface Profiles, APPENDIX D - Data Management and Processing Procedures, Feb 87, 117 pp.	5.50	AD-A180 583
SPATIAL DATA MANAGEMENT			
RD-4	An Assessment of Remote Sensing Applications in Hydrologic Engineering, Sep 74, 56 pp.	4.00	AD-A102 036
RD-7	Determination of Land Use from LANDSAT Imagery; Applications to Hydrologic Modeling, Nov 79, 77 pp.	4.50	AD-A102 190
RD-29	Remote Sensing Techniques and Spatial Data Applications, Dec 87, 145 pp.	6.50	AD-A195 809
SURFACE WATER HYDROLOGY			
RD-1	A Cumulus Convection Model Applied to Thunderstorm Rainfall in Arid Regions, Dec 70, 24 pp.	2.00	AD-A950 779
RD-6	Continuous Hydrologic Simulation of the West Branch Dupage River Above West Chicago: An Application of Hydrocomp's HSP, Jul 79, 65 pp.	4.50	AD-A102 189

RESEARCH DOCUMENTS (RD) (continued)

HEC Number	Title	HEC Price	NTIS Number
SURFACE WATER HYDROLOGY (continued)			
RD-23	Modified-Puls Routing in Chuquatonchee Creek, Sep 80, 37 pp.	3.00	AD-A154 285
RD-24	Comparative Analysis of Flood Routing, Sep 80, 122 pp.	6.00	AD-A158 850
WATER SUPPLY			
RD-25	Reservoir Operation During Drought: Case Studies, Aug 86, 144 pp.	7.00	AD-A176 313
RD-27	Elements of Conjunctive Use Water Supply, Mar 88, 227 pp.	11.00	
RD-28	Desktop Techniques for Analyzing Surface-Ground Water Interactions, May 88, 88 pp.	5.00	AD-A196 280

SEMINAR PROCEEDINGS (SP)

Periodically seminars are held on topics of special interest. Specialists from the HEC, Corps field offices, universities and other organizations are invited to attend and present papers. These proceedings are a compendium of papers presented.

HEC Number	Title	HEC Price	NTIS Number
FLOOD DAMAGE ANALYSIS			
SP-19	Flood-Damage Reduction Reconnaissance-Phase Studies, Davis, CA, 9-11 Aug 88, 181 pp.	8.00	AD-A201 926
FLOODPLAIN MANAGEMENT			
SP-8	Nonstructural Flood Plain Management Measures, Fort Belvoir, Virginia, 4-6 May 76, 199 pp.	9.00	AD-A052 607
SP-17	Local Flood Warning - Response System	8.00	AD-A179 753
MISCELLANEOUS			
SP-5	Hydrologic Aspects of Project Planning, Davis, California, 7-9 Mar 72, 169 pp.	7.00	AD-A052 604
SP-6	Analytical Methods in Planning, Davis, California, 26-28 Mar 74, 196 pp.	15.00	AD-A052 605
RESERVOIRS			
SP-1	Reservoir System Analysis, Davis, California, 4-6 Nov 69, 206 pp.	9.00	AD-A052 134
SP-7	Real-Time Water Control Management, Davis, California, 17-19 Nov 75, 348 pp.	15.00	AD-A052 606
RIVER HYDRAULICS			
SP-2	Sediment Transport in Rivers and Reservoirs, Davis, California, 7-9 Apr 70, 218 pp.	10.00	AD-A052 601
SP-13	Two-Dimensional Flow Modeling, Davis, California, 7-9 Jul 81, 280 pp.	12.00	AD-A123 847
SPATIAL DATA MANAGEMENT			
SP-10	Variable Grid Resolution - Issues and Requirements, Davis, California, 18-19 Aug 77, 120 pp.	6.00	AD-A055 542

SEMINAR PROCEEDINGS (SP) (continued)

HEC Number	Title	HEC Price	NTIS Number
SURFACE WATER HYDROLOGY			
SP-3	Urban Hydrology, Davis, California, 1-3 Sep 70, 294 pp.	14.00	AD-A052 602
SP-4	Computer Applications in Hydrology, Davis, California, 23-25 Feb 71, 212 pp.	10.00	AD-A052 603
SP-20	Proceedings of a Workshop on Calibration and Application of Hydrologic Models, Gulf Shores, AL, 18-20 Oct 88, 240 pp.	11.00	
WATER QUALITY			
SP-9	Water Quality Data Collection and Management, Denver, Colorado, 25-26 Jan 77, 142 pp.	6.50	AD-A101 803
SP-11	Water Quality Data Interpretation, Atlanta, Georgia, 8-9 Feb 78, 193 pp.	9.00	AD-A101 802
SP-12	Water Quality Evaluation, Tampa, Florida, 22-24 Jan 80, 236 pp.	11.00	AD-A101 804
SP-14	Attaining Water Quality Goals through Water Management Procedures, Dallas, Texas, 17-18 Feb 82, 282 pp.	12.00	AD-A123 847
SP-15	Applications in Water Quality Control, Portland, Oregon, 31 Jan-1 Feb 84, 233 pp.	10.00	AD-A155 514
SP-16	Water Quality R&D: Successful Bridging Between Theory and Applications, New Orleans, Louisiana, 25-27 Feb 86, 272 pp.	12.00	AD-A170 041
SP-18	Water Quality '88, Charleston, South Carolina 23 - 25 Feb 1988, 444 pp.	22.00	AD-A198 648

TRAINING DOCUMENTS (TD)

Training documents are written to provide instruction on selected topics. Generally they contain examples and explanations to assist the reader.

HEC Number	Title	HEC Price	NTIS Number
FLOOD DAMAGE ANALYSIS			
TD-23	Flood-Damage-Mitigation Plan Selection with Branch-and-Bound Enumeration, Aug 85, 28 pp.	2.00	AD-A159 191
FLOODPLAIN MANAGEMENT			
TD-5	Floodway Determination Using Computer Program HEC-2, Jan 88, 123 pp.	5.00	AD-A106 698
TD-16	Analytical Instruments for Formulating and Evaluating Nonstructural Measures, Jan 82, 55 pp.	5.00	AD-A117 658
HYDROPOWER			
TD-12	Application of the HEC-5 Hydropower Routines, Mar 80, 49 pp.	3.00	AD-A106 705
RESERVOIRS			
TD-3	Reservoir Storage-Yield Procedures, Oct 67, 71 pp.	4.50	AD-A951 551
TD-20	Water Supply Simulation Using HEC-5, Jul 83, 139 pp.	6.50	AD-A158 888
TD-24	Water Quality Modeling of Reservoir System Operations Using HEC-5, Sep 87, 114 pp.	6.00	
TD-25	Stochastic Analysis of Drought Phenomena, Jul 85, 140 pp.	6.50	AD-A160 947
RIVER HYDRAULICS			
TD-5	Floodway Determination Using Computer Program HEC-2, Jan 88, 123 pp.	5.00	AD-A106 698
TD-10	Introduction and Application of Kinematic Wave Routing Techniques Using HEC-1, May 79, 100 pp.	5.00	AD-A106 703
TD-13	Guidelines for the Calibration and Application of Computer Program HEC-6, Feb 81, 38 pp.	3.00	AD-A106 706
TD-18	Application of the HEC-2 Split Flow Option, Apr 82, 62 pp.	4.00	AD-A117 657
TD-26	Computing Water Surface Profiles with HEC-2 on a Personal Computer, Sep 88, 64 pp.	4.00	

TRAINING DOCUMENTS (TD) (continued)

HEC Number	Title	HEC Price	NTIS Number
SPATIAL DATA MANAGEMENT			
TD-2	Guide Manual for the Creation of Grid Cell Data Banks, Jan 88, 74 pp.	4.50	AD-A106 710
TD-19	Application of Spatial Data Management Techniques to HEC-1 Rainfall-Runoff Studies, Oct 83, 72 pp.	4.00	AD-A135 627
TD-22	A Tutorial on Creating a Grid Cell Land Cover Data File from Remote Sensing Data, Jun 85, 72 pp.	4.00	AD-A159 365
STATISTICAL HYDROLOGY			
TD-11	Adoption of Flood Flow Frequency Estimates at Ungaged Locations, Feb 80, 50 pp.	3.00	AD-A106 704
TD-17	Mixed-Population Frequency Analysis, Nov 81, 50 pp.	4.00	AD-A117 627
SURFACE WATER HYDROLOGY			
TD-8	Guidelines for Calibration and Application of STORM, Dec 77, 51 pp.	4.00	AD-A106 701
TD-10	Introduction and Application of Kinematic Wave Routing Techniques Using HEC-1, May 79, 100 pp.	5.00	AD-A106 703
TD-14	Hydrologic Engineering in Planning, Apr 81, 346 pp.	15.00	AD-A117 812
TD-15	Hydrologic Analysis of Ungaged Watersheds with HEC-1, Apr 81, 172 pp.	8.00	AD-A117 614
TD-19	Application of Spatial Data Management Techniques to HEC-1 Rainfall-Runoff Studies, Oct 83, 72 pp.	4.00	AD-A135 627
WATER QUALITY			
TD-24	Water Quality Modeling of Reservoir System Operations, Sep 87, 114 pp.	6.00	AD-A196 429
WATER SUPPLY			
TD-20	Water Supply Simulation Using HEC-5, Aug 85, 139 pp.	6.50	AD-A158 888
TD-25	Stochastic Analysis of Drought Phenomena, Jul 85, 140 pp.	6.50	AD-A160 947

TECHNICAL PAPERS (TP)

Technical papers are written by the staff of the HEC, sometimes in collaboration with persons from other organizations, for presentation at various conferences, meetings, seminars and other gatherings.

HEC Number	Title	HEC Price	NTIS Number
		$ 2.00 Each	
FLOOD DAMAGE ANALYSIS			
TP-43	Hydrologic and Economic Simulation of Flood Control Aspects of Water Resources Systems, Aug 75, 10 pp.		AD-A106 244
TP-57	Flood Damage Assessments Using Spatial Data Management Techniques, May 78, 27 pp.		AD-A106 256
TP-103	Engineering and Economic Considerations in Formulating Nonstructural Plans, Jan 85, 16 pp.		AD-A150 154
TP-125	An Integrated Software Package for Flood Damage Analysis, Feb 89, 23 pp.		
FLOODPLAIN MANAGEMENT			
TP-47	Comprehensive Flood Plain Studies Using Spatial Data Management Techniques, Oct 76, 20 pp.		AD-A106 248
TP-68	Interactive Nonstructural Flood-Control Planning, Jun 80, 12 pp.		AD-A109 764
TP-96	The Hydrologic Engineering Center Experience in Nonstructural Planning, Feb 84, 7 pp.		AD-A141 860
TP-103	Engineering and Economic Considerations in Formulating Nonstructural Plans, Jan 85, 16 pp.		AD-A150 154
TP-109	One-Dimensional Model For Mud Flows, Oct 85, 6 pp.		AD-A160 486
TP-124	Review of the U.S. Army Corps of Engineers Involvement with Alluvial Fan Flooding Problems, Dec 88		AD-A202 119
GROUNDWATER HYDROLOGY			
TP-22	A Finite Difference Method for Analyzing Liquid Flow in Variably Saturated Porous Media, Apr 70, 47 pp.		AD-A951 387
TP-52	Potential Use of Digital Computer Ground Water Models, Apr 78, 38 pp.		AD-A106 251
HYDROPOWER			
TP-24	Hydroelectric Power Analysis in Reservoir Systems, Aug 70, 15 pp.		AD-A951 389
TP-33	System Simulation for Integrated Use of Hydroelectric and Thermal Power Generation, Oct 72, 22 pp.		AD-A104 911

TECHNICAL PAPERS (TP) (continued)

HEC Number	Title	HEC Price	NTIS Number
		$ 2.00 Each	
HYDROPOWER (continued)			
TP-61	Technical Factors in Small Hydropower Planning, Feb 79, 35 pp.		AD-A109 757
TP-65	Feasibility Analysis in Small Hydropower Planning, Aug 79, 20 pp.		AD-A109 761
TP-78	Potential for Increasing the Output of Existing Hydroelectric Plants, Jun 81, 20 pp.		AD-A109 772
TP-79	Potential Energy and Capacity Gains from Flood Control Storage Reallocation at Existing U. S. Hydropower Reservoirs, Jun 81, 18 pp.		AD-A109 787
TP-80	Use of Non-Sequential Techniques in the Analysis of Power Potential at Storage Projects, Jun 81, 18 pp.		AD-A109 788
MISCELLANEOUS			
TP-29	Computer Applications in Continuing Education, Jan 72, 23 pp.		AD-A104 916
TP-49	Experience of HEC in Disseminating Information on Hydrological Models, Jun 77, 9 pp. (Superseded by TP-56.)		
TP-56	Experiences of the Hydrologic Engineering Center in Maintaining Widely Used Hydrologic and Water Resource Computer Models, Nov 78, 16 pp.		AD-A106 255
TP-76	Institutional Support of Water Resource Models, May 80, 23 pp.		AD-A109 770
TP-86	Training the Practitioner: The Hydrologic Engineering Center Program, Oct 81, 20 pp.		AD-A123 568
TP-87	Documentation Needs for Water Resources Models, Aug 82, 16 pp.		AD-A123 558
TP-91	HEC Software Development and Support, Nov 83, 11 pp.		AD-A139 009
TP-94	Dredged-Material Disposal Management Model, Jan 84, 18 pp.		AD-A139 008
TP-98	Evolution in Computer Programs Causes Evolution in Training Needs: The Hydrologic Engineering Center Experience, Jul 84, 20 pp.		AD-A145 601
TP-107	Dredged-Material Disposal System Capacity Expansion, Apr 86, 15 pp.		AD-A171 090

TECHNICAL PAPERS (TP) (continued)

HEC Number	Title	HEC Price	NTIS Number
		$ 2.00 Each	
MISCELLANEOUS (continued)			
TP-117	HEC-1 and HEC-2 Applications on the Microcomputer, Aug 87, 6 pp.		AD-A185 438
TP-120	Technology Transfer of Corps' Hydrologic Models, Sep 88, 7 pp.		AD-A199 653
RESERVOIRS			
TP-3	Methods of Determination of Safe Yield and Compensation Water from Storage Reservoirs, Aug 65, 17 pp.		AD-A950 883
TP-4	Functional Evaluation of a Water Resources System, Jan 67, 28 pp.		AD-A950 884
TP-7	Pilot Study for Storage Requirements for Low Flow Augmentation, Apr 68, 26 pp.		AD-A950 887
TP-9	Economic Evaluation of Reservoir System Accomplishments, May 68, 20 pp.		AD-A950 889
TP-10	Hydrologic Simulation in Water-Yield Analysis, 1964, 20 pp.		AD-A950 890
TP-14	Techniques for Evaluating Long-Term Reservoir Yields, Feb 69, 32 pp.		AD-A950 894
TP-17	Hydrologic Engineering Techniques for Regional Water Resources Planning, Oct 69, 26 pp.		AD-A950 897
TP-23	Uses of Simulation in River Basin Planning, Aug 70, 28 pp.		AD-A951 388
TP-24	Hydroelectric Power Analysis in Reservoir Systems, Aug 70, 15 pp.		AD-A951 389
TP-25	Status of Water Resource Systems Analysis, Jan 71, 13 pp.		AD-A104 915
TP-26	System Relationships for Panama Canal Water Supply, Apr 71, 17 pp. This publication is not available to countries outside of the U.S.		
TP-27	System Analysis of the Panama Canal Water Supply, Apr 71, 13 pp. This publication is not available to countries outside of the U.S.		
TP-28	Digital Simulation of an Existing Water Resources System, Oct 71, 31 pp.		AD-A104 916
TP-30	Drought Severity and Water Supply Dependability, Jan 72, 18 pp.		AD-A104 918

TECHNICAL PAPERS (TP) (continued)

HEC Number	Title	HEC Price	NTIS Number
		$ 2.00 Each	
RESERVOIRS (continued)			
TP-31	Development of System Operation Rules for an Existing System by Simulation, Aug 71, 20 pp.		AD-A104 919
TP-32	Alternative Approaches to Water Resource System Simulation, May 72, 12 pp.		AD-A104 912
TP-33	System Simulation for Integrated Use of Hydroelectric and Thermal Power Generation, Oct 72, 22 pp.		AD-A104 911
TP-34	Optimizing Flood Control Allocation for a Multipurpose Reservoir, Aug 72, 15 pp.		AD-A104 910
TP-36	Evaluation of Drought Effects at Lake Atitlan, Sep 72, 15 pp. <u>This publication is not available to countries outside of the U.S.</u>		
TP-39	A Method for Analyzing Effects of Dam Failures in Design Design Studies, Aug 72, 29 pp.		AD-A104 906
TP-41	HEC-5C, A Simulation Model for System Formulation and Evaluation, Mar 74, 28 pp.		AD-A106 242
TP-43	Hydrologic and Economic Simulation of Flood Control Aspects of Water Resources Systems, Aug 75, 10 pp.		AD-A106 244
TP-44	Sizing Flood Control Reservoir Systems by Systems Analysis, Mar 76, 34 pp.		AD-A106 245
TP-45	Techniques for Real-Time Operation of Flood Control Reservoirs in the Merrimack River Basin, Nov 75, 45 pp.		AD-A106 246
TP-50	Effects of Dam Removal: An Approach to Sedimentation, Oct 77, 36 pp.		AD-A106 250
TP-51	Design of Flood Control Improvements by Systems Analysis: A Case Study, Oct 71, 23 pp.		AD-A106 364
TP-60	Operational Simulation of a Reservoir System with Pumped Storage, Feb 79, 32 pp.		AD-A106 259
TP-63	HEC Contribution to Reservoir System Operation, Aug 79, 28 pp.		AD-A109 759
TP-66	Reservoir Storage Determination by Computer Simulation of Flood Control and Conservation Systems, Oct 79, 10 pp.		AD-A109 762
TP-75	HEC Activities in Reservoir Analysis, Jun 80, 10 pp.		AD-A109 769

TECHNICAL PAPERS (TP) (continued)

HEC Number	Title	HEC Price	NTIS Number
		$ 2.00 Each	
RESERVOIRS (continued)			
TP-79	Potential Energy and Capacity Gains from Flood Control Storage Reallocation at Existing U. S. Hydropower Reservoirs, Jun 81, 18 pp.		AD-A109 787
TP-80	Use of Non-Sequential Techniques in the Analysis of Power Potential at Storage Projects, Jun 81, 18 pp.		AD-A109 788
TP-84	Generalized Real-Time Flood Control System Model, Apr 82, 18 pp.		AD-A114 359
TP-85	Operation Policy Analysis: Sam Rayburn Reservoir, Oct 81, 16 pp.		AD-A123 526
TP-89	A Software System to Aid in Making Real-Time Water Control Decisions, Sep 83, 17 pp.		AD-A138 616
TP-101	Use of Computer Program HEC-5 for Water Supply Analysis, Aug 84, 7 pp.		AD-A146 535
TP-112	New Developments in HEC Programs for Flood Control, Aug 86, 18 pp.		AD-A172 495
TP-119	Multi-Purpose, Multi-Reservoir Simulation on a PC, Aug 88, 18 pp.		
TP-123	Developing and Managing a Comprehensive Reservoir Analysis Model, Nov 88		AD-A202 118
RIVER HYDRAULICS			
TP-11	Survey of Programs for Water Surface Profiles, Aug 68, 35 pp.		AD-A950 891
TP-19	Suspended Sediment Discharge in Streams, Apr 69, 20 pp.		AD-A950 899
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TP-101	Use of Computer Program HEC-5 for Water Supply Analysis, Aug 84, 7 pp.		AD-A146 535

ADMINISTRATIVE DOCUMENTS (AD)

HEC Number	Title	HEC Price
		No Charge
AD1-87	Annual Report, 1987, 27 pages (NTIS No. AD-A200 621).	
AD3-87	Video Tape Loan Library Catalog, July 1987, 58 pages.	
AD4-89	Publications Catalog, February 1989, 26 pages.	
AD5-88	Computer Program Catalog, May 1988, 40 pp.	

OVERVIEW OF FLOOD DAMAGE COMPUTATIONS

DARRYL DAVIS

References

a. Expected Annual Flood Damage Computations Users Manual, Hydrologic Engineering Center, February 1984.

b. Flood Damage Analysis Package - Description, User guidance, and Example, Hydrologic Engineering Center,January 1986.

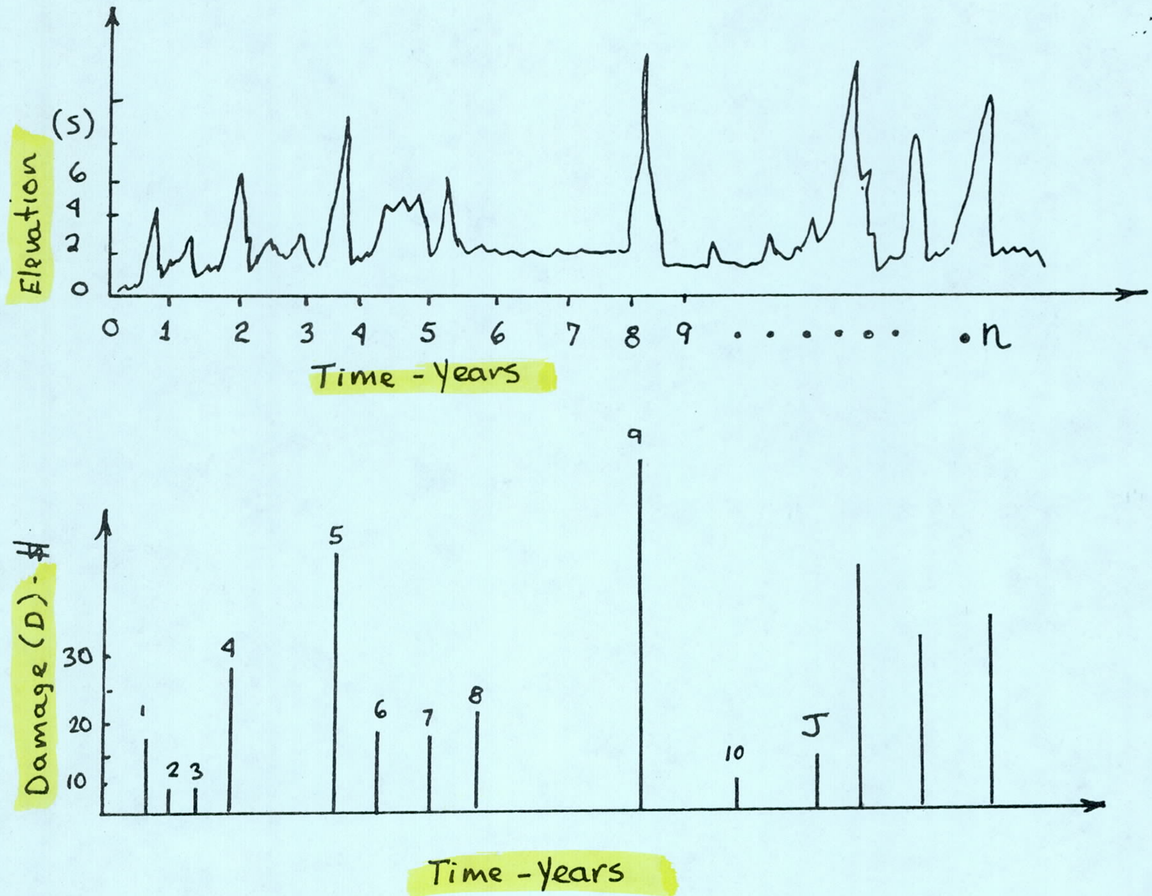
c. SID (Structure Inventory for Damage Analysis Users Manual, Hydrologic Engineering Center, June 1987.

d. ER 1105-2-40 Economic Considerations, Chapter 1 - Procedures for Evaluation of NED Benefits and Costs, 8 January 1982.

NED BENEFIT = DAMAGES (W/O) - DAMAGE (W/)

1. The estimation of damage caused by floods is needed to determine the NED benefits that may accrue to flood damage reduction projects. The goal is to determine the expected value of annual damage for without project conditions and the consequent damage reduction benefits for alternative mitigation plans of interest. In a simple conceptual way, the damage estimation goal is as presented in figure 1. For illustration purposes, the flood threat over a planning horizon may be represented by the time history of flood elevation (or often referred to as stage) shown as the upper time trace in the figure. Transforming this time trace of flood elevations to a time trace of flood damage, and subsequently computing the average (or better termed the 'expected value')for the record period is the analytical goal. Performing the analysis for existing and expected future conditions without proposed mitigation plans yields the 'without' condition flood damage and repeating the analysis for a proposed flood loss mitigation plan results in determining the 'with' condition flood damage. The difference between the without and with conditions is the flood damage reduction benefits - normally expressed as the expected annual benefits.

2. Two alternative computation strategies are commonly used to estimate the annual flood damage. One strategy is termed the 'continuous record' method and it is designed to mimic the conceptual picture presented in figure 1 by computing the damage for a continuous record elevation - hydrograph. The strategy consists of developing and applying computational methods that permit accurately determining the damage consequences of an historic record of flooding. This method is most commonly used for computing agricultural flood damage. The other strategy, often termed the 'frequency' method, is most commonly employed in performing urban flood damage analysis. Flood damage is computed for a range of flood events usually



$$\text{Annual Damage} = \frac{1}{n} \sum_{I=1}^{J} D(J)$$

Where D = Event Damage

J = Event

n = Total years of record

figure 1 General Concept - Damage Computation Goal

ZONE METHOD (L.A.D. Method)

H & H TO STRUCTURE (PROFILE)

INDEX STATION (LOCATION)

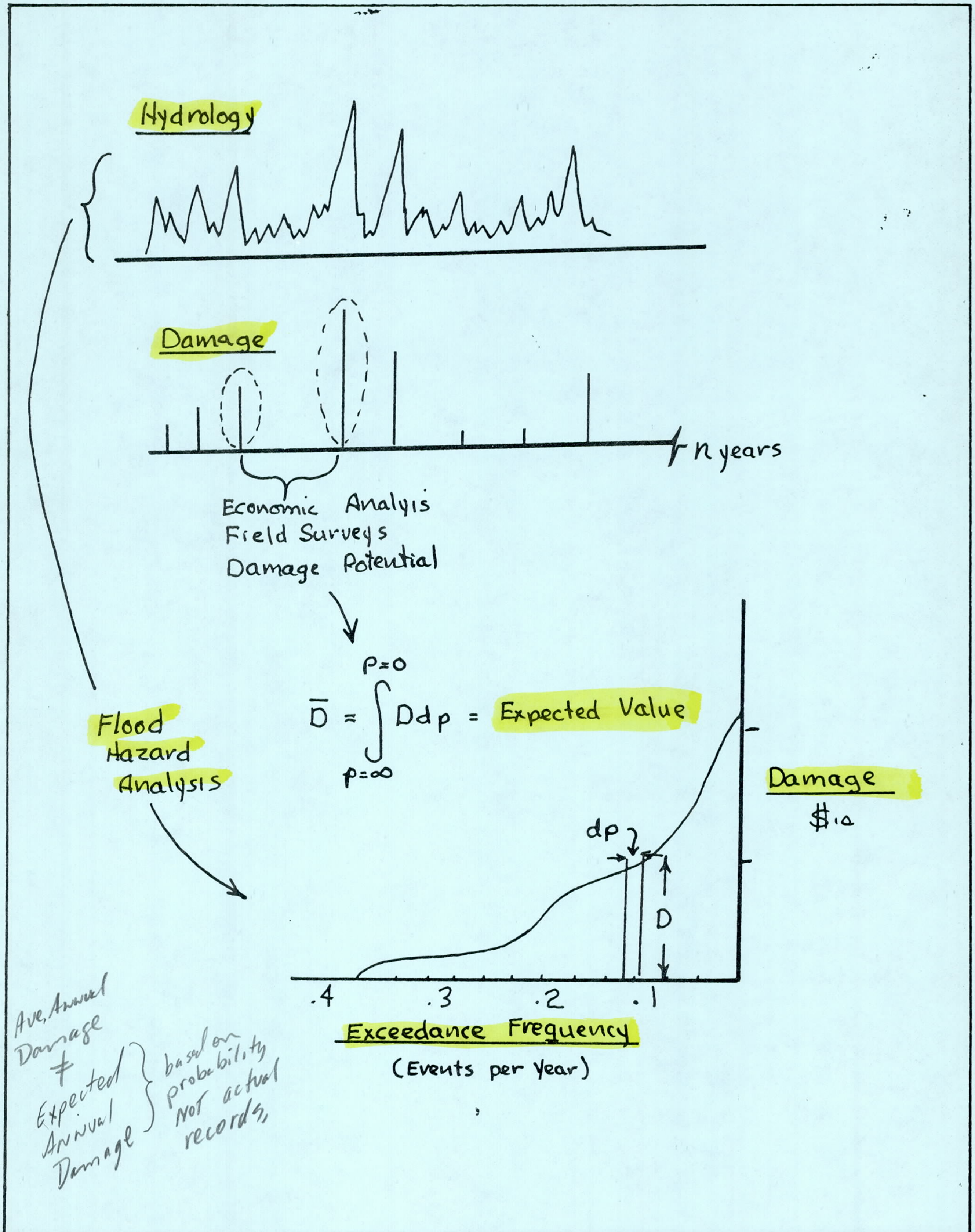


figure 2 Damage by Frequency Method

represented by an exceedance frequency curve and the result is weighted by the appropriate exceedance probability to develop the expected annual value. Figure 2 is a conceptualization of the frequency method for expected annual flood damage computation. The frequency method forms the basis for the HEC Flood Damage Analysis Package.

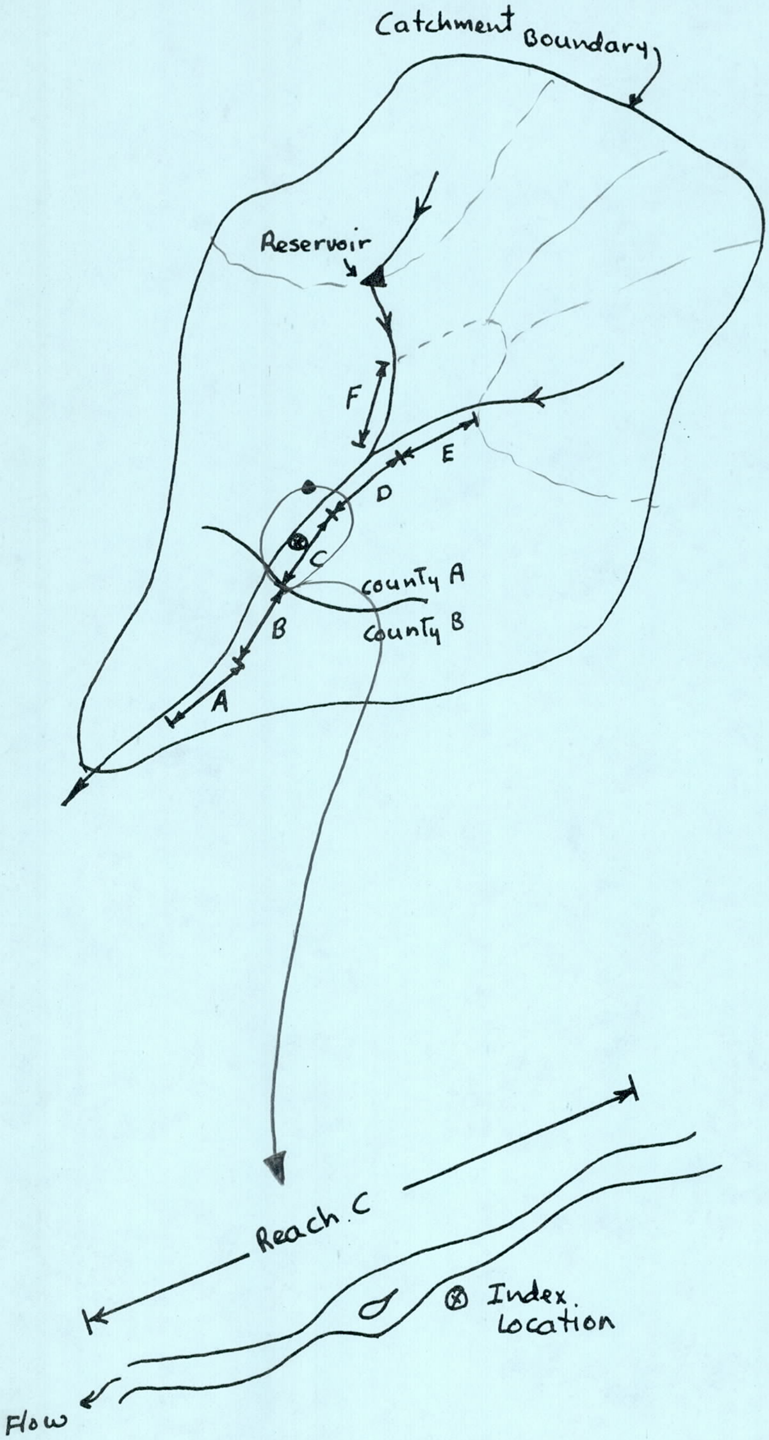
3. The study area should be partitioned into discreet units to facilitate practical analysis needs. Aggregation areas, termed, damage reaches, are defined that enable data to be aggregated at index locations to represent the hydrologic conditions, distribution of flood damage potential, and to accommodate the study of a variety of mitigation alternatives. Figure 3 is a conceptualization of the study area partitioning process.

4. Evaluation functions are developed for each damage reach for the several alternatives of interest. The functions are developed and applied at the adopted index location for the reach. Evaluation functions are needed to represent the flood hazard and frequency and damage potential. The functions for flood hazard and frequency are: flow-exceedance frequency function (commonly referred to as a 'frequency curve' and an elevation-flow function (commonly referred to as a 'rating curve'. These two functions are sometimes combined into an elevation-frequency function (sometimes called a 'stage-frequency' curve). It is best to keep them separate whenever possible to facilitate representing the effects of various mitigation measures.

5. The damage potential is represented by an elevation-damage function often referred to as simply the 'damage curve'. The damage potential function is usually developed by aggregating individual property damage relationships for the damage reach to a single function at the index location. Several functions are often developed to represent categories of damage potential. Figure 4 is a summary of the evaluation relationships used in flood damage analysis. Figure 5 presents conceptually the aggregation of property structure damage functions to an aggregate damage function at the index location. Figure 6 is a summary diagram of the function development, aggregation, computation process.

6. The function formed from the several evaluation functions is a frequency - damage relationship. The function thus formed is termed in statistical terminology, a cumulative distribution function of flood damage. Integration of a cumulative distribution function yields the 'expected value' so that if the functions are formed representing annual values (eg an annual series frequency curve), then the integral is the 'expected annual damage' commonly referred to as the average annual damage.

INDEX (LOCATION) METHOD



Partition Criteria

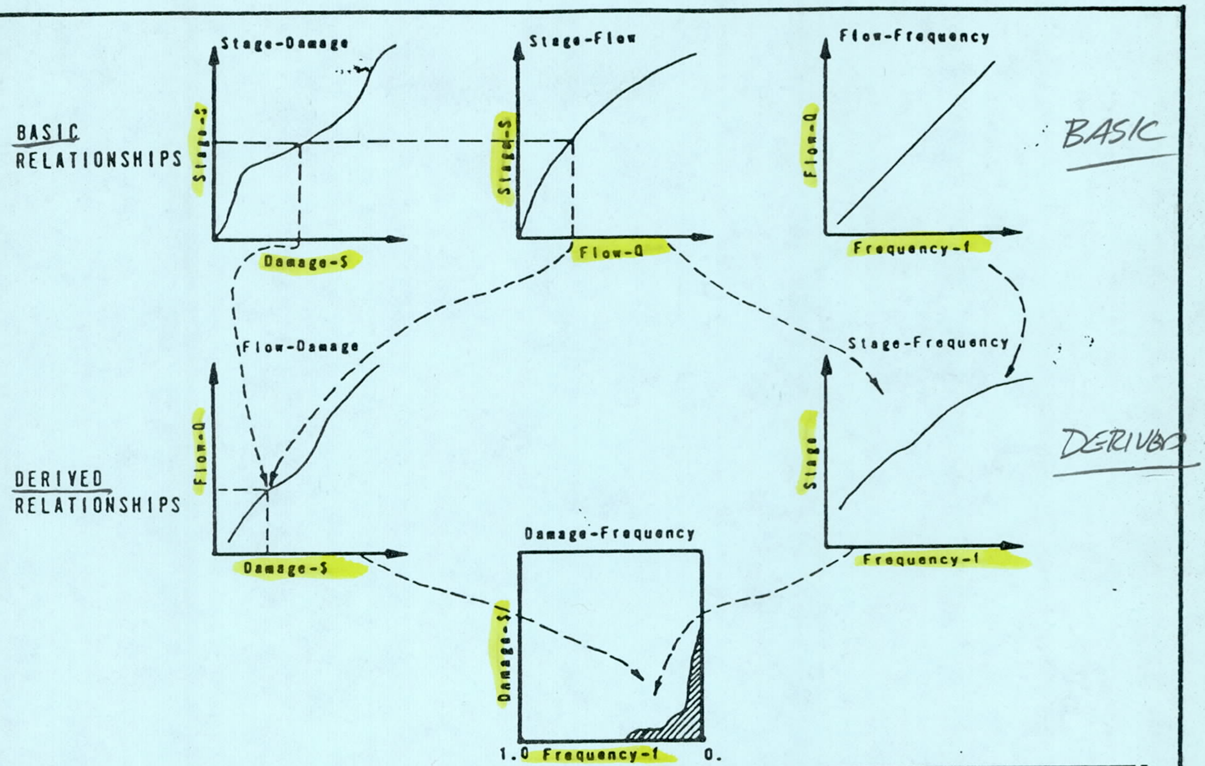
Stream Gages
Catchment Subdivisions
Computation Points
Consistent Profiles
Good Index Location

Damage Potential Distribution
Reporting Boundaries
Previous Studies

Flood Damage Mitigation Measures

"IMPORTANT TO LOGICALLY LAY OUT THE REACHES"

figure 3 Study Area Partitioning



The basic and derived evaluation relationships are shown above. Concepts important to their construction are described herein.

Stage-Flow Relationship: This is a basic hydraulic function that shows for a specific location, the relationship between flow rate and stage. It is frequently referred to as a 'rating curve' and is normally derived from water surface profile computations.

Stage-Damage Relationship: This is the economic counterpart to the stage-flow function and represents the damage which will occur for various river stages. Usually the damage represents an aggregate of the damage which could occur some distance upstream and downstream from the specified location. It is usually developed from field damage surveys.

Flow-Frequency Relationship: This defines the relationship between exceedance frequency and flow at a location. It is the basic function describing the probability nature of stream flow and is commonly determined from either statistical analysis of gaged flow data or through watershed model calculations.

Damage-Frequency Relationship: This relationship is derived by combining the basic relationships using the common parameters stage and flow For example, the damage for a specific exceedance frequency is determined by ascertaining the corresponding flow rate from the flow-frequency function, the corresponding stage from the stage-flow function and finally the corresponding damage from the stage-damage relationship. Any changes which occur in the basic relationships because of watershed development or flood plain management measure implementation will change the damage-frequency function and therefore the expected annual damage that is computed as the integral of the function (area underneath).

Other Functional Relationship: The flow-damage relationship is developed by combining the stage-damage with the stage-flow relationship using stage as the common parameter. The stage frequency relationship is developed by combining the stage-flow with the flow-frequency relationship using flow as the common parameter. The damage-frequency relationship could then be developed as a further combination of these derived relationships.

Figure 4 Basic and Derived Relationships

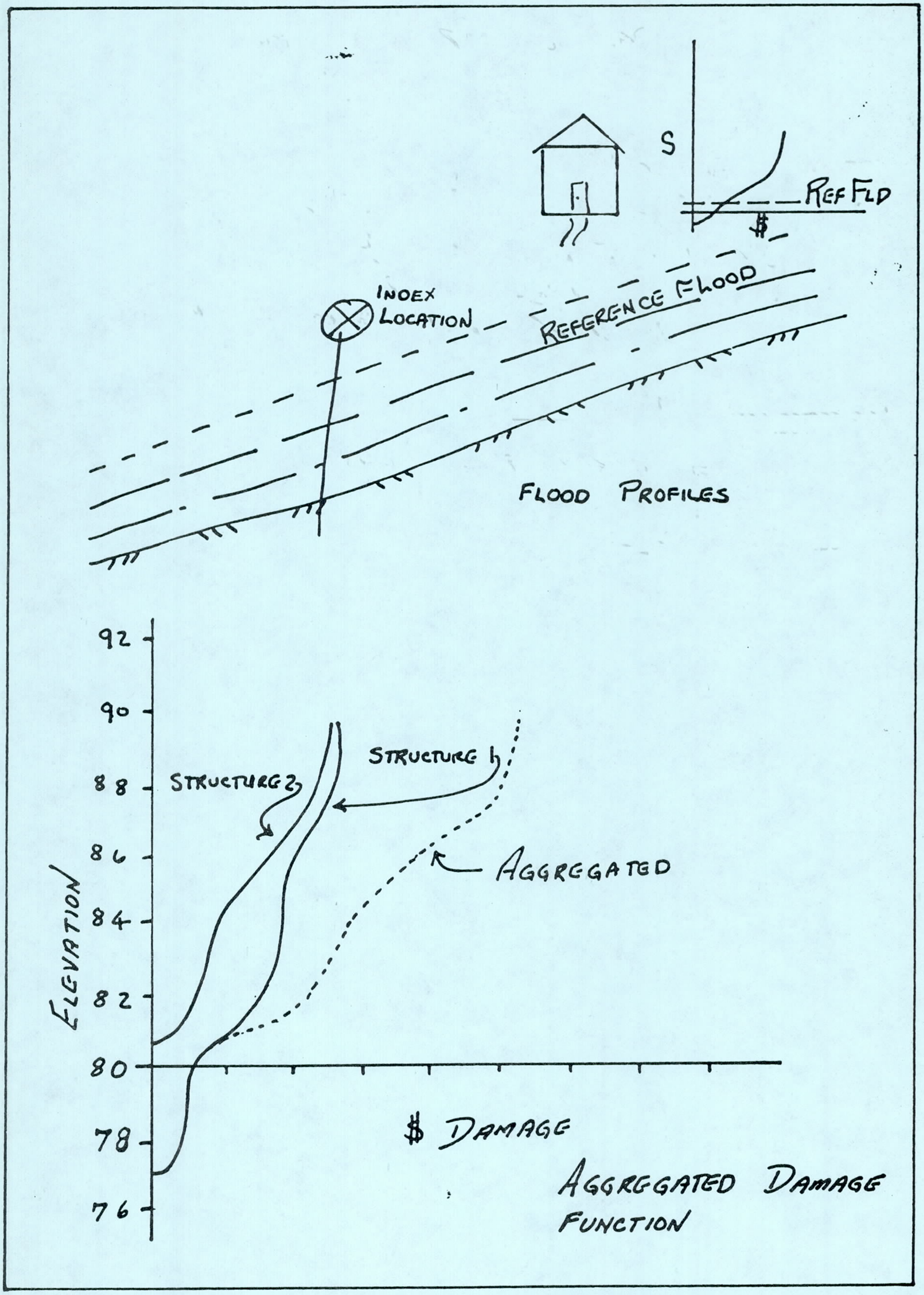


figure 5 Aggregation Concepts

DAMAGE FREQUENCY FUNCTION
INTEGRATION

FORMING FUNCTION ACCURATELY!

- CONVIENT TO WORK from Freq.
- Capture Breaks Accurately
- Define Extremes - Damage threshold and 1.0 Exceedence Frequency.

INTEGRATING FUNCTION!

- common CALCULATION - Integration
- Graphical
- Automated.

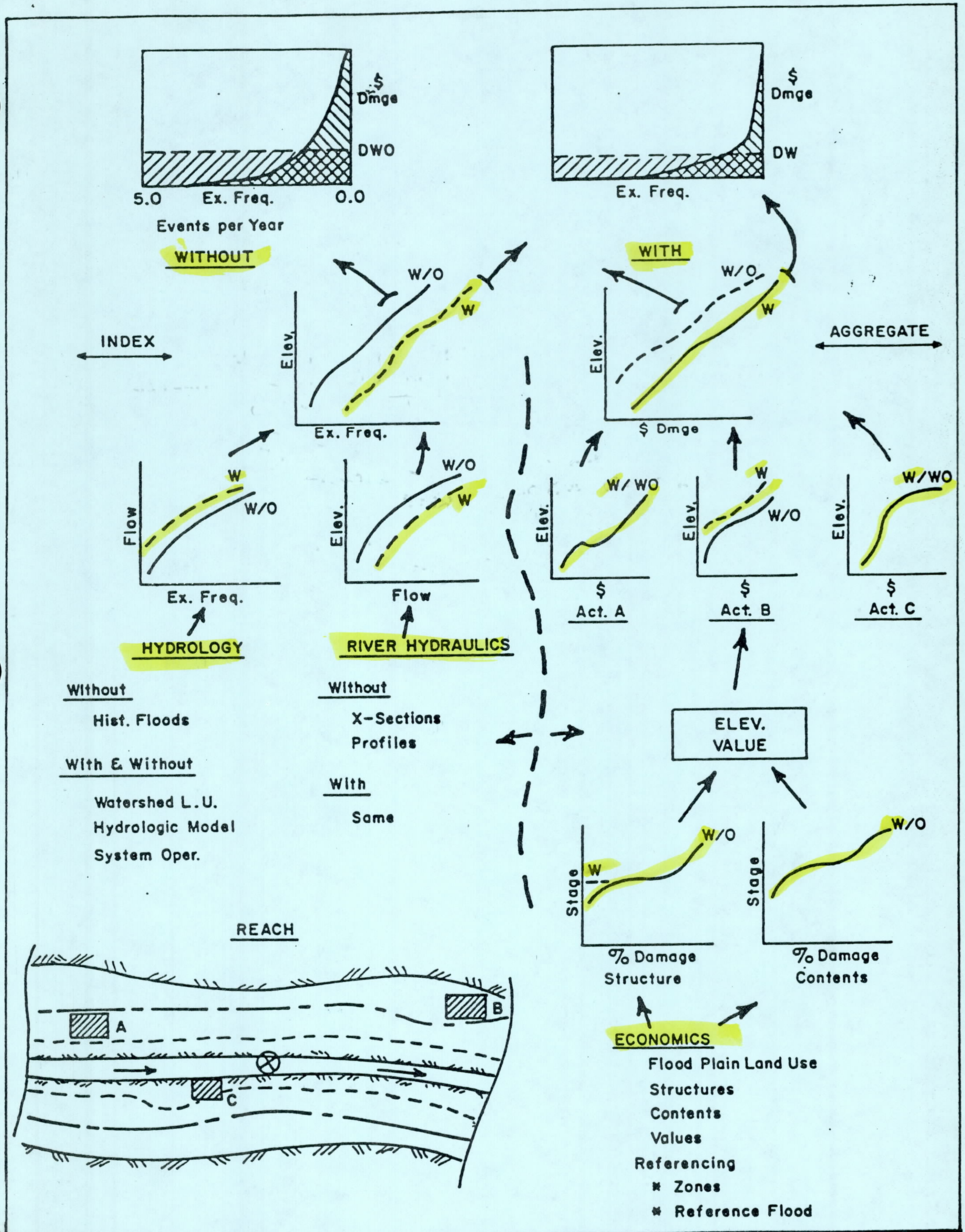


figure 6 Evaluation Function Development

7. The computation of expected annual damage from the damage frequency function is commonly performed by simple numerical integration methods such as planimetering, counting squares, application of rectangular or trapezoidal rules but most commonly by use of computer programs. Figure 7 illustrates several of the integration methods. A few key points are important to the accurate integration of the function. Both ends of the function must be well defined - start the computations before the threshold of damaging floods and continue them systematically to the end of the function, don't stop until "0" exceedance frequency is reached. Be sure to define the function at all points of change throughout and include sufficient computation points to accurately perform the integration. Often times inadequate subdivision is used in the low damage - high frequency area of the function and this can lead to significant error. Weighting a low damage value with a large probability increment can result in a very large incremental contribution to the expected value.

8. The functional relationships defining the flood hazard and frequency and damage potential can and often do change with time and therefore the computed expected value can also change with time as well. This reflects that development within the flood plain may change over time as well as the hydraulic characteristics of the stream from say encroachments, scour and deposition, and morphological changes. The flow-frequency function may change as well because of changes in the watershed runoff characteristics and implementation of flood damage mitigation plans. An equivalent annual value is computed so that residual damage of alternative plans may be compared with investment plans. The equivalent annual damage represents a uniform distribution of annual values and is computed by discounting and amortizng each year's expected annual damage value over a period of analysis. The discounting and amortization takes into account the time value of money. Figure 8 graphically portrays the concept of varying annual damage and equivalence.

Frequency %	Damage 1000 $	Ave Damage	Freq. Increment	Product
50	0	–		0
40	0	2.5	.1	.25
30	5	7.5	.1	.75
20	10	17.5	.1	1.75
10	25	50.0	.05	2.50
5	75	87.5	.02	1.75
3	100	250.0	.01	2.50
2	400	700.0	.01	7.00
1	1000	1750.0	.005	8.75
.5	2500	3750.0	.004	15.00
.1	5000	5000.0	.001	5.00
				45.25

Average End Areas Method

EAD w/ SAME Data ≈ 42.9

GRAPHICAL:

No. of Squares = 80±

Value of square = .005 x $100 = .5

Expected Value = .5 x 80 = 40.0

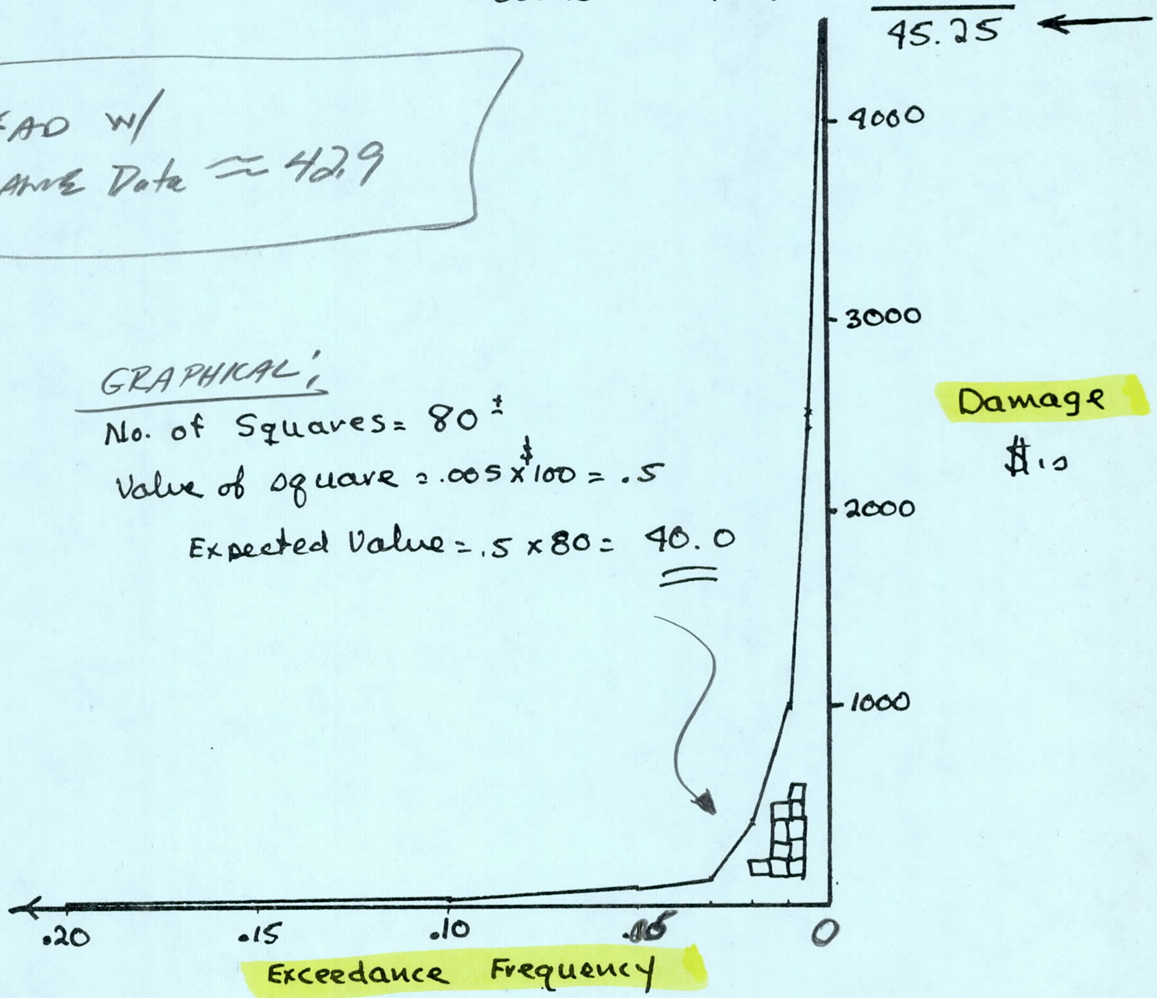
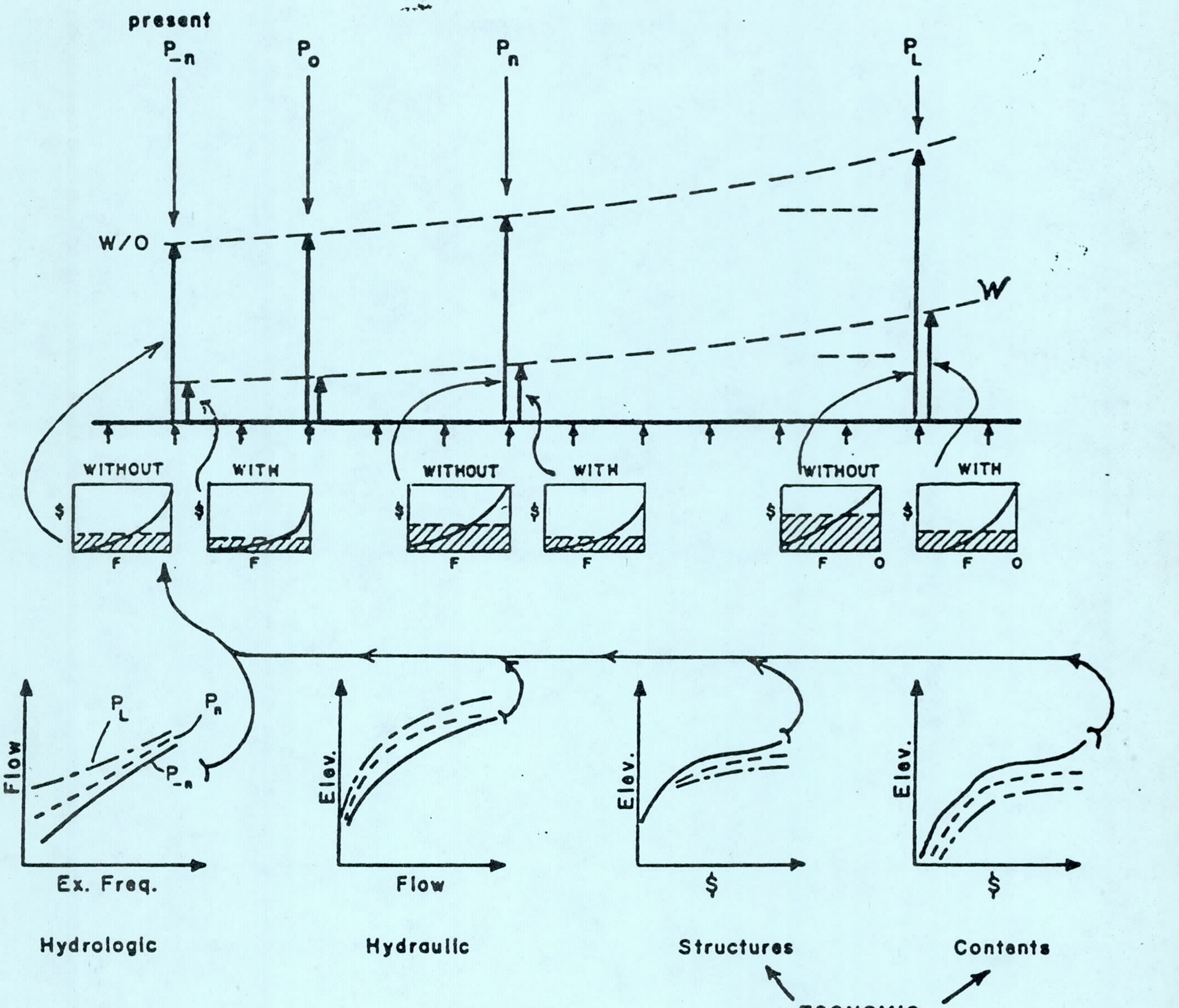


figure 7 Integration Methods



WITHOUT

Similiar Complete Set - **WITH**

Hydrologic Change

1. Urban Development, off Flood Plain.
2. Conveyance Modifications
3. Improvement Works in Basin

Hydraulic Change

1. Improvement Works for Conveyance.
2. Sedimentation
3. Erosion

Economic Change

1. Urban Development on F. P.
   * Add / Subtract Activities
2. Change in Value.
   * Affluence Factor

figure 8 Equivalent Annual Damage

OVERVIEW OF THE EXPECTED ANNUAL DAMAGE PROGRAM
(761-X6-L7580)

HAROLD KUBIK

1. Program Purpose

The basic purpose of the computer program is to compute expected (average) annual flood damages and to allow comparison of flood plain management plans. Particular attention was given to ER 1105-2-351, "Evaluation of Beneficial Contributions to National Economic Development for Flood Plain Management Plans." Only flood damage inundation reduction benefits may be evaluated by the program.

2. General Capability (EAD)

EAD = prob. x damage

a. Three Modes of Operation

(1) Compute flood damages for specific events

(2) Compute expected annual flood damages

(3) Compute equivalent annual flood damages for an analysis period.

b. Damage Categories

The various types of flood damages: urban, agricultural, industrial, services, residential, etc., are computed separately and then totaled. Up to 18 damage categories may be specified.

c. Flood Plain Management Plans

Each flood plain management plan is described by the effect that it has on the input hydrologic, hydraulic, and/or economic relations. If inundation reduction benefits are to be computed, the first plan should be for "without" conditions. Up to 13 plans may be specified.

d. Input Data Years

The input data may be referenced to past or future years. The magnitude of the relations for a particular year are then determined by linear interpolation between the input data years for that relation. Up to nine different input data years are allowed.

L-271/HEK/ 4-84

e. Reach Concept

A reach is a section of flood plain that can be represented by the same flow-frequency and stage-flow relations. Economic data, political boundaries, physical features, etc., may also govern selection of reaches. Data are input on a reach-by-reach basis.

3. Reach Input Data

All data for one flood plain management plan are input (followed by an EP card) and those data are processed and output before the data for the next plan is read.

a. Frequency Data

If expected annual flood damages are computed, the exceedance frequency, expressed as percent chance of exceeding, is input via the FR card. The same FR card data will be applied to all succeeding reaches until another FR card is encountered. Either the corresponding flows (QF card) or stages (SF card) are input for the particular plan. Several sets of QF (or SF) cards may be input, each identified with a different input data year. This relation need not be repeated for each plan if it remains the same. Be sure the first frequency value is below the non-damaging stage (or flow) and that the last value is a very rare event (.1 is usually adequate).

b. Stage-Flow Data (Rating Curve)

Need not be supplied if not needed, i.e., damages known for frequency values. Stages are input on SQ card and flows on QS cards. Several QS cards may be supplied for different input data years. This relation need not be repeated for each plan if it remains the same. Be sure that range of data covers that on the QF (or SF) cards as there is no extrapolation.

c. Stage (or Flow) - Damage Data

Unless the damages are known for the frequency values, either stages (SD card) or flows (QD card) are input and the corresponding damages (DG card). The damages are identified by category number and several sets may be required for different input data years. These relations need not be required for different input data years. These relations need not be repeated for each plan if they remain the same. Be sure that the range of data on the SD (or QD) card covers zero damage and that on the QF (or SF) cards as there is no extrapolation.

d. RV Card

Useful in modifying previous data to generate new relations for a new flood plain management plan. Can be used to evaluate raising all structures in the reach (or subreach) or examine various protection levels.

e. End-of-Data Cards

(1) EP - Denotes end of data for a particular plan

(2) ES - Denotes end of a subreach. Like a reach, but no change in the frequency and/or rating curve relations.

(3) ER - Denotes the end of data for a plan and also the last data for a reach

(4) EJ - Denotes the end of data for a plan, reach, and job and begins the summary output

4. Steps in the Computation of Expected Annual Damages

a. Program keys on input exceedance frequency values.

b. A cubic polynomial fit is made of frequency vs flow (or stage) data and nine additional points are generated (at .1, .2, etc. of the distance) between two adjacent exceedance frequency values.

c. The damage is computed (for a given input data year, if necessary) for each input and generated frequency value by dropping through the necessary relations, e.g., find the stage for the flow corresponding to the frequency value, then find the damage corresponding to the stage. Linear interpolation is used for the stage-flow and stage (or flow) damage relations. Linear interpolation is also used to determine the relations for specific years between those that were input.

d. The exceedance frequency values are converted to exceedance probability by dividing by 100 and a cubic polynomial fit is made of the probability-damage data. The resulting relation is integrated by application of 3-point Gaussian quadrature between each input and generated probability point. The last area is added as a rectangle (damage times the last probability value). The total area is the expected annual value.

5. Computation of Equivalent Annual Flood Damages

The study year, base year, 5 decade years and the end-of-analysis years are added to the input data years as points in time to compute expected annual damages. Then expected annual damages (EAD) are found for each year by linear interpolation, the present worth of EAD for each year is computed at the base year, and then amortized over the period of analysis.

6. Computation of Inundation Reduction Benefits

Various flood plain management plans may be subtracted from each other for comparison purposes.

7. A Look at the Output

a. Input data

b. Damages

c. Expected annual flood damages

d. Equivalent annual flood damages

e. Summary

8. Other Features

a. Can punch damage and EAD data for input into HEC-5

b. Data files generated by DAMCAL, SID, HEC-1, HEC-2, and HEC-5 can be used as input.

References: a. Users Manual, Expected Annual Flood Damage Computation, HEC Computer Program 761-X6-L7580, February 1984.

b. ER 1105-2-351, Evaluation of Beneficial Contribution to National Economic Development for Flood Plain Management Plans, U.S. Army Corps of Engineers, 13 June 1975.

SELECTING FREQUENCY VALUES

EAD PROGRAM

LOW END

- Annual Event Frequency Curve

FR STA1 10 50. 40. 30. 20. etc.

No damage below mean annual flood (usually an urban area)

- Annual Event Frequency Curve

FR STA1 15 95. 90. 80. 70. etc.

Damage can be caused by frequent events

- Partial Duration Frequency Curve

FR STA1 18 200. 150. 100. 90. etc.

Damage can be caused by several events each year

HIGH END

FR . . . 0.5 0.2

FR . . . 0.5 0.2 0.1

No damage reduction should be provided above this value

STAGE-FLOW DATA

EAD PROGRAM

NEEDED WHEN:

FR QF	Flow-Frequency Relations
SQ QS	Rating Curve
SD DG	Stage-Damage Relations
EP	

← First values at or below damaging stage

← Last values at or above last frequency value

NOT NEEDED IF:

FR DG	Damage-Frequency Relations

OR:

FR SF	Stage-Frequency Relations
SD DG	Stage-Damage Relations

OR:

FR QF	Flow-Frequency Relations
QD DG	Flow-Damage Relations

STAGE-FLOW DATA FOR SUB-REACHES

EAD PROGRAM

RATING CURVE NEEDED FOR ONLY FIRST SUB-REACH:

RN	Name of sub-reach
FR QF	Frequency Relations for Plan 1
SQ QS	Rating Curve
SD DG	Stage-Damage Relations for Plan 1
EP	End of Plan 1
QF	Modified frequency relations for Plan 2
ES	End of Plan 2 and sub-reach 1
RN	Name of sub-reach 2
QF	Frequency relations for Plan 1
SD DG	Stage-Damage relations for Plan 1
EP	
. . .	etc.

RATING CURVE MODIFIED FOR SUB-REACHES

EAD PROGRAM

RATING CURVE NEEDED FOR SECOND SUB-REACH:

RN	Name of first sub-reach
FR	
QF	
SQ QS	] Rating Curve for existing conditions
SD	
DG	
EP	End of Plan 1
SQ QS	] Rating Curve as modified by channel improvement
ES	End of Plan 2 and sub-reach 1
RN	Name of sub-reach 2
SQ QS	] Rating Curve for existing conditions (input again)
SD	
DG	
EP	End of Plan 1

. . . etc.

DAMAGE RELATIONS

EAD PROGRAM

DIFFERENT STAGES FOR EACH RELATION:

```
SD                                              ] Relation for
DG          1      0. . . . . .   1380.         ] Damage Category 1
                   ↑ First value should be      ↑ Last value should be above
                     zero damage.                 last frequency value.

SD                 ] Relation for Damage Category 2
DG          2      ]
```

SAME STAGE FOR EACH RELATION:

```
SD            ← Provide just once

DG            1
DG            2
. . .  etc.
```

DAMAGES CHANGE WITH TIME:

```
SD                    ]
DG     1980     1     ]
DG     1995     1     ] Damage for category 1 changes with time
DG     2030     1     ]

SD                    ]
DG              2     ] All categories need not change with time
```

REVISION OF DATA

EAD PROGRAM

RV CARD MUST APPEAR LATER THAN THE RELATION TO BE MODIFIED.

USES:

1. CAN BE USED TO RAISE ONE OR ALL DAMAGE CATEGORIES BY X FEET.

2. CAN MULTIPLY ONE OR ALL DAMAGE CATEGORIES BY A FACTOR.

3. CAN TRUNCATE ALL DAMAGE BELOW A GIVEN FLOW, STAGE, OR FREQUENCY. CANNOT USE FREQUENCY TRUNCATION IF ANY RELATIONS CHANGE WITH TIME.

4. TRUNCATION MAY BE FOR ONLY ONE REACH OR MAY BE APPLIED FOR A GIVEN PLAN TO ALL REACHES.

5. TRUNCATION DOES NOT MODIFY ANY OF THE THREE BASIC INPUT RELATIONS.

END-OF-DATA CARDS

EAD PROGRAM

EP - END OF PLAN, ANOTHER PLAN FOR SAME REACH WILL FOLLOW.

ES - END OF A PLAN AND SUB-REACH, A NEW SUB-REACH WITH SAME FREQUENCY AND/OR RATING CURVE RELATIONS WILL FOLLOW.

ER - END OF A PLAN AND REACH, A NEW FREQUENCY AND, IF APPLICABLE, NEW RATING CURVE RELATIONS WILL FOLLOW.

EJ - END OF PLAN, REACH, AND JOB; EITHER A NEW JOB MAY FOLLOW OR END OF RUN.

NOTE: ENDING CARDS ARE MUTUALLY EXCLUSIVE ! ! !

COOPER CREEK, TEXAS

Flood Damage Analysis Workshop Package

February 1990

The Hydrologic Engineering Center
Water Resources Support Center
U.S. Army Corps of Engineers
609 Second Street
Davis, California 95616-4687

(916) 756-1104

H-784/RDC/90

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COOPER CREEK, TEXAS
Flood Damage Analysis Workshop Package

I. Introduction

A. Purpose of the Workshop Package

This Workshop Package illustrates the application of the HEC Flood Damage Analysis Package. It describes an actual study performed for the city of Denton, Texas by the Ft. Worth District, U.S. Army Corps of Engineers. The Workshop Package also presents a series of workshops that require the analyst to compute relationships by hand and apply HEC's Flood Damage Analysis Package of computer programs in conjunction with HEC's data management system. After completing the workshops, the student will have performed all of the technical procedures which are required to evaluate damage reduction along Cooper Creek. Several structural and nonstructural alternatives are compared by computing Expected Annual Flood Damage and comparing damage reduction associated with each plan. This requires the use of computer programs HEC- 1, HEC-2, HEC-5, SID, DAMCAL, and EAD. All programs are linked through the DSS system. This requires the application of HECDSS utility programs including DSSUTL, DSPLAY, and PIP. Much of the data presented in this appendix was used in the actual study. However, several hypothetical alternatives have been added and some input data has been altered to more fully demonstrate the use of the Package. The reader should not assume that any of the data presented herein represents true fact.

B. Background

The city of Denton in early 1979 requested the Corps to study flooding problems in the city caused by Cooper Creek. In response, the Fort Worth District prepared a reconnaissance report in accordance with the Continuing Authorities program. The information developed from the reconnaissance indicated that the flood problems could be alleviated; consequently, the feasibility study was authorized under Section 205 of the Flood Control Act of 1948.

II. Problem Identification

Intense thunderstorms over a relatively small area cause flooding in the city of Denton. Urbanization and clay soils produce low infiltration and high peak flows from even relatively light rainfalls. Denton County was declared a flood disaster area in 1957 and again in 1974. Another major flood occurred in 1962. Damage included flooded homes and businesses and washed out bridges.

Cooper Creek and its tributaries are largely unimproved streams which have mild slopes and small channel capacities in relationship to their drainage areas. The bridges spanning the creek have limited hydraulic capacities and frequently cause backwater conditions. Brush and other plants tend to grow in the channel and flood plain, further retarding flow and producing higher flood elevations. The watershed is rapidly urbanizing with the newly developed residential subdivisions along the creek subject to flooding. Although actual flooding of houses has been limited to a small number along Cooper Creek, the potential for significant damage exists due to the large number of residences in the flood plain.

III. Description of the Study Area

A. General

The city of Denton is the county seat of Denton County and is located in north central Texas about 36 miles north of Fort Worth and 38 miles northwest of Dallas. Direct freeway access between Denton and Fort Worth and Dallas is provided by Interstate Highway 35. The estimated 1980 population is over 50,000 and it has a corporate area of nearly 31 square miles. The city of Denton and the Cooper Creek watershed lie in the Trinity River Basin. The study area is shown on figure 1.

The study area lies in a region of temperate mean climatological conditions experiencing occasional extremes of temperature and rainfall of relatively short duration. The annual mean rainfall is 32.3 inches. The maximum and minimum annual rainfall during the National Weather Service (NWS) period of record are 51.03 inches occurring in 1932 and 17.91 inches in 1921, respectively. The mean relative humidity is 65 percent, and the average temperature is 65.5 degrees. The record temperature extremes range from a maximum of 113 degrees in June 1980 to a minimum of -8 degrees in February 1899.

B. Flood Plain

Cooper Creek originates north of Denton, flows in a southeasterly direction through the northeast part of the city, and continues to Lewisville Lake. The Cooper Creek watershed is about 6.1 miles long with an average width of about 2.0 miles and contains an area of 10.7 square miles. The creek is a small but well-defined, mostly unimproved channel with several tributaries. The main channel has an approximate average depth of 6 feet, top width of 50 feet, and a slope of 25 feet per mile. The creek is normally dry, with flow occurring only during periods of extended rainfall. Extensive residential development exists in the flood plain on both sides of Cooper Creek from approximately 1/4 mile downstream of Burningtree Lane upstream to Stuart Road in the upper reaches of the study area. There also exists a small pocket of residential development southeast of Mingo Road in the lower reaches of the study area. Commercial development is widely scattered throughout the lower end of the study area and has only minimal flood damage potential. Much of the vegetative cover in the study area is in its natural state except where residential development has encroached upon the creek in the upper end of the study area.

IV. Analysis Procedure

The general analysis procedure used in this Workshop Package is:

- Compute Expected Annual Damage by Hand
- Define available data
- Define damage reaches, index locations, stage/elevation datum.
- Define naming conventions (file and pathname).
- Establish hydrologic and hydraulic information.
- Establish economic relationships.
- Evaluate flood damage reduction plans by computing expected annual damage.

Specifically, the following applications will be performed:

- Flow-frequency data will be generated using HEC-1 and HEC-5.
- Elevation-flow data will be generated using HEC-2.
- Elevation-flood damage information will be computed using both DAMCAL and SID. Only one of the programs would normally be used for a study. Both are used herein for illustrative purposes only.

These procedures will be accomplished for the base condition as well as for the alternative plans. The DSS will act as a data manager to pass results from one program to another. The EAD program will be used to calculate the expected annual damage for the base condition and the alternative plans. The following paragraphs describe the sources of information necessary for each for the featured programs.

V. Data Sources

Rainfall for the various frequency storms was developed using data in National Weather Service Technical Paper 40 (TP 40), National Oceanic and Atmospheric Administration Technical Memorandum NWS Hydro-35, and Corps of Engineers Civil Engineer Bulletin No. 52-8, "Standard Project Flood Determinations". Losses were deducted using the block and uniform loss method. Time to peak was developed for each basin using methodology described in "Synthetic Unit Hydrograph Relationships, Trinity River Tributaries, Fort Worth-Dallas Urban Area" by T.L. Nelson, 1970. Routing of the flood hydrographs was accomplished using modified Puls routing. Figure 2 depicts the schematic for the HEC-1 and HEC-5 simulation input data.

Stream cross-section information for the HEC-2 model was obtained from field surveys. These sections were supplemented with interpolated sections taken from the city of Denton 2-foot topography dated 1974. Figure 3 shows the location of the cross-sections and the index locations used for the SID and DAMCAL runs. Bridge models were developed using field surveys and bridge plans where available. Mannings "n" values were determined from field reconnaissance and aerial photography.

Figure 4 shows the structures inventoried for subsequent analysis with SID. The finished floor elevations of these structures was determined form field surveys. A field reconnaissance was performed to determine the structure types, and a real estate gross appraisal was obtained to determine the value of the structures. The Fort Worth District's Socio- Economic Branch of Planning Division determined the stage-percent damage functions. Damageable property was divided into five categories as shown in Table 1.

Table 1: Damage Categories

Category	Identifier	Description
1	RESIDENT	Residential Structures
2	GAS STAT	Service (Gas) Stations
3	SCHOOL	Schools
4	CHURCH	Churches
5	OTHER	Miscellaneous

The miscellaneous category is established only for computational purposes. It will catch any damage that, due to some error, is not aggregated to the other specific categories. Tables 3 through 6 list the damage function relationships for the above categories. Figure 5 depicts the structure damage functions and figure 6 depicts the content damage functions.

Land use interpretation needed to construct the grid cell data bank that is used by DAMCAL was obtained from field reconnaissance and aerial photography, and the city of Denton 20 year Community Plan published in 1970. A data bank consisting of 0.29 acre grid cells was created to contain the data for the DAMCAL analysis. The grid cells are 125 feet by 100 feet rectangles and number about 5000. Data was encoded into each grid cell for land use type, damage reach boundary, reference flood and topographic elevation, and other pertinent information. Figures @ and @ are line printer maps of the land use and damage reach boundaries, respectively, contained in the grid cell data bank. Grid cell ground elevations were interpolated from the 2 foot topography maps, and the reference flood elevations used were the 50-year exceedance interval flood elevations obtained from an existing condition HEC-2 run.

VI. Plan Selection

A variety of structural and non-structural flood control measures were considered in the Cooper Creek study. Many of the structural measures were ruled out after cursory examination. These plans included detention ponds, levee floodway, and diversion channels. Due to excessive cost, limited right-of-way, and/or lack of easement, only channel improvement measures were studied in detail.

This Workshop Package will consider some hypothetical structural and nonstructural measures in addition to those measures actually studied. This includes detention ponds, gated detention ponds, and diversion channels. Table 2 lists the plans which are analyzed in this series of workshop problems.

Table 2: Damage Reduction Plans

Plan	Identification	Description
1	BASE	Baseline (existing conditions).
2	UNGTD SPILL 650	Ungated reservoir, spillway elevation 650 feet.
3	UNGTD SPILL 655	Ungated reservoir, spillway elevation 655 feet.
No — 4	GATED SPILL 650	Gated reservoir, spillway elevation 650 feet.
5	CHIMP 40FT	Channel Improvement, 40 foot bottom width.
6	FP-2%	Flood proofing, 2 percent chance exceedance.

Figure 9 depicts the HECDSS data files which will be used in this workshop. The programs HEC-1, HEC-2, and HEC-5 may write more data than is actually needed to calculate expected annual damage. Therefore, each of these programs write data to their own HECDSS data file, and then only the necessary data is copied into the master HECDSS data file.

VII. Archiving Procedures

An important portion of the study, following the actual analysis completion, is the permanent storage of study information. The reason for ending work n the study is inconsequential; of importance is the fact that sometime in the future, the information may be needed again.

The most efficient method of archiving the input data, output listings, and intermediate files is to save them on a magnetic tape. Most installations have this capability, and the process is fairly simple. At least two tapes should be made in case one tape is accidentally destroyed. The chances of this happening are slim, but it is better to take the precaution (tapes do not take up much room as far as storage is concerned). It is also recommended that the data on the tapes be verified to be certain that the information is correctly stored.

The above archiving procedure should also be followed by users of Personal Computers also. Data may be stored on floppy diskettes, on backup cassette tapes, or portable mass storage "hard" disks.

Archiving data requires that the analyst not only save the data, but save it in a proper format as well as document data and files in detail. Archived data includes simulation input data (such as HEC-1, HEC-2, SID, etc. input data) as well as data stored in HECDSS data files. HECDSS data files are direct access, unformatted files. The user cannot view the data directly but must instead execute a utility program. To archive the HECDSS data files, the user should archive the file both directly (as a direct access, unformatted file) and indirectly (a generic, human readable ASCII file). The later requires the analyst to execute a data management utility program to transform data into an ASCII format that can later be read by the same utility program and directly stored into a new HECDSS data file.

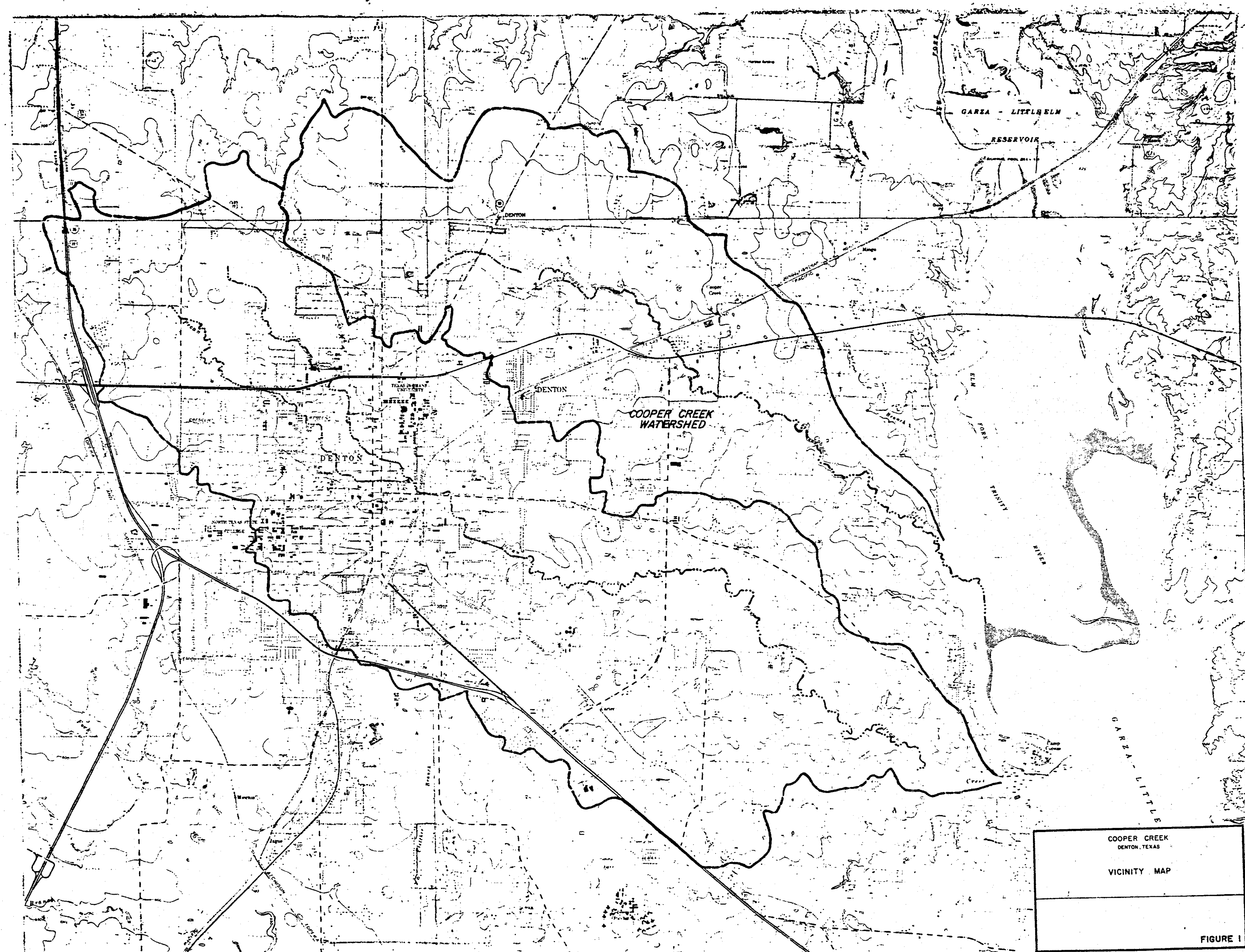
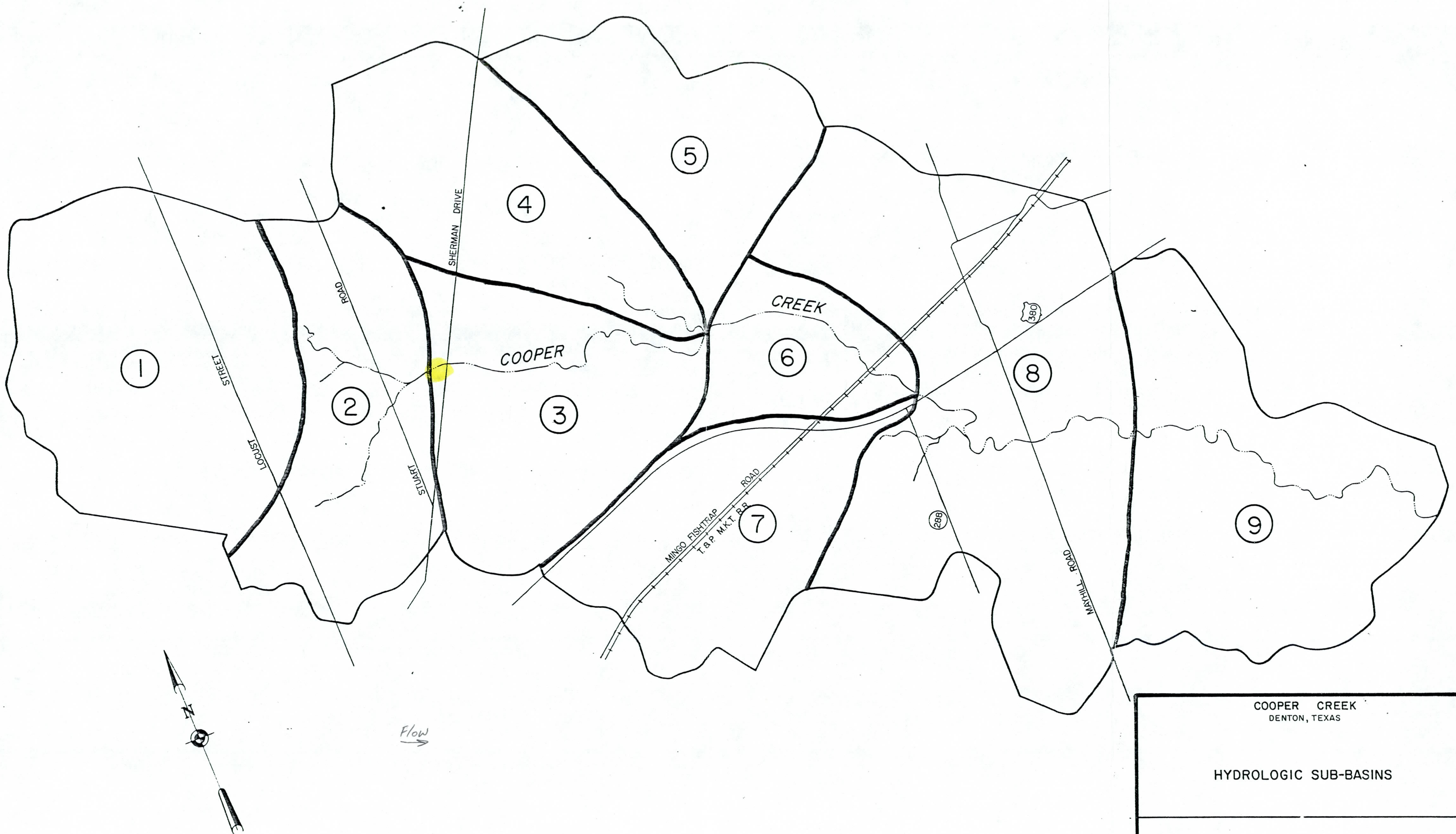

GARZA - LITTLE ELM
RESERVOIR
DENTON
COOPER CREEK
WATERSHED
ELM FORK TRINITY RIVER
GARZA - LITTLE
COOPER CREEK
DENTON, TEXAS
VICINITY MAP

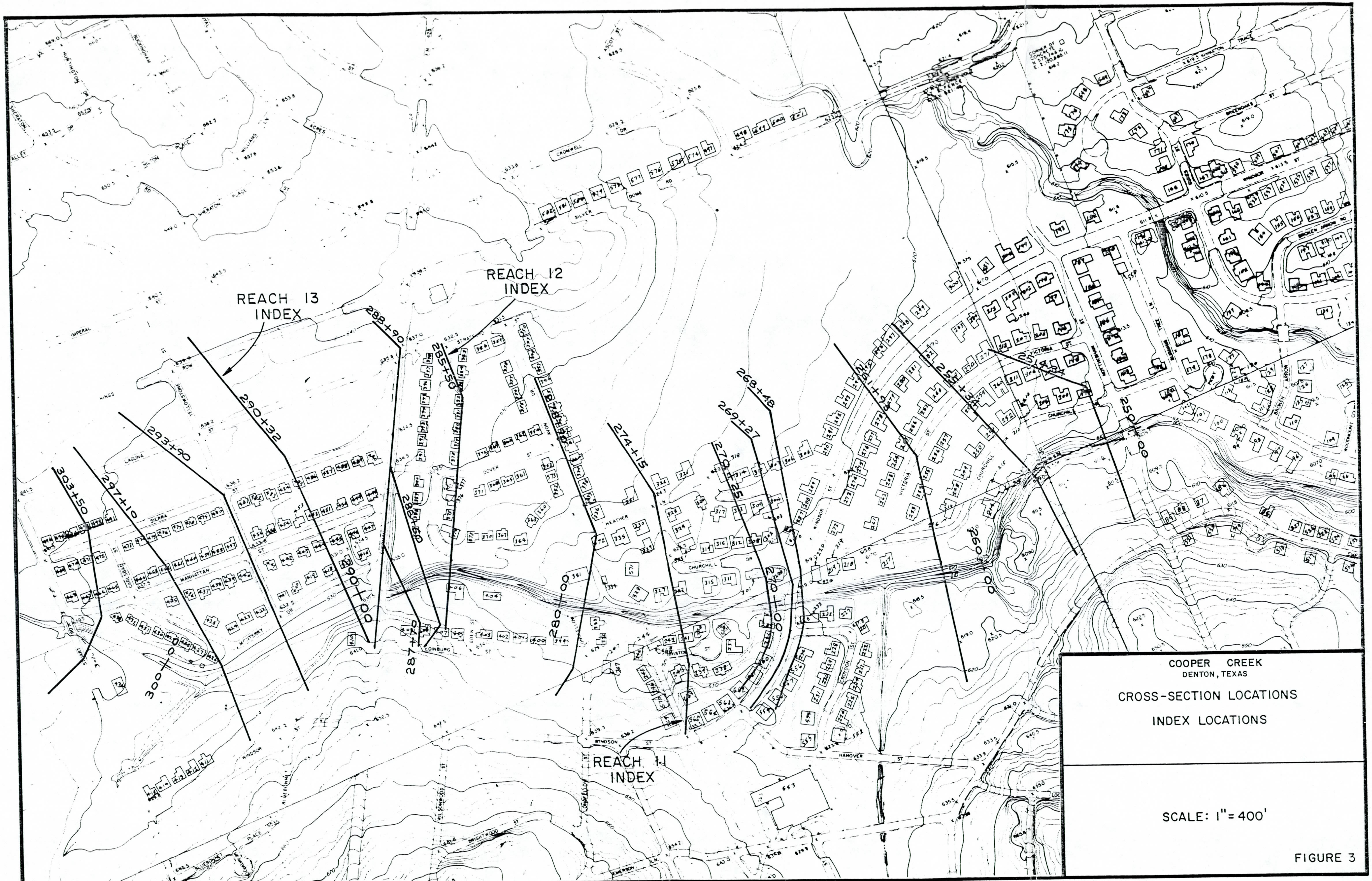
FIGURE 1



COOPER CREEK
DENTON, TEXAS

HYDROLOGIC SUB-BASINS

FIGURE 2

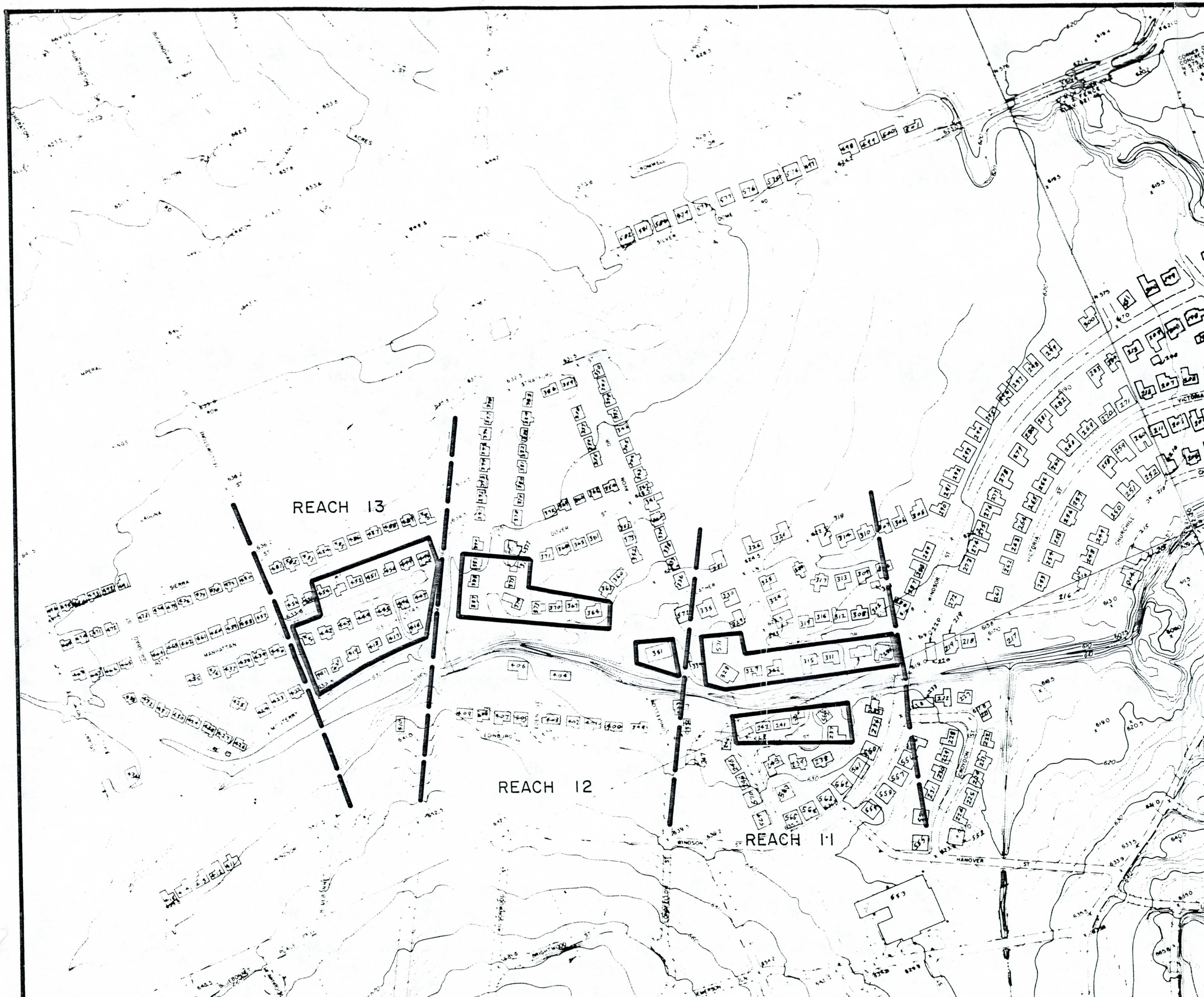


COOPER CREEK
DENTON, TEXAS

CROSS-SECTION LOCATIONS
INDEX LOCATIONS

SCALE: 1" = 400'

FIGURE 3



COOPER CREEK
DENTON, TEXAS

STRUCTURES FOR
SID MODEL

SCALE: 1" = 400'

FIGURE 4

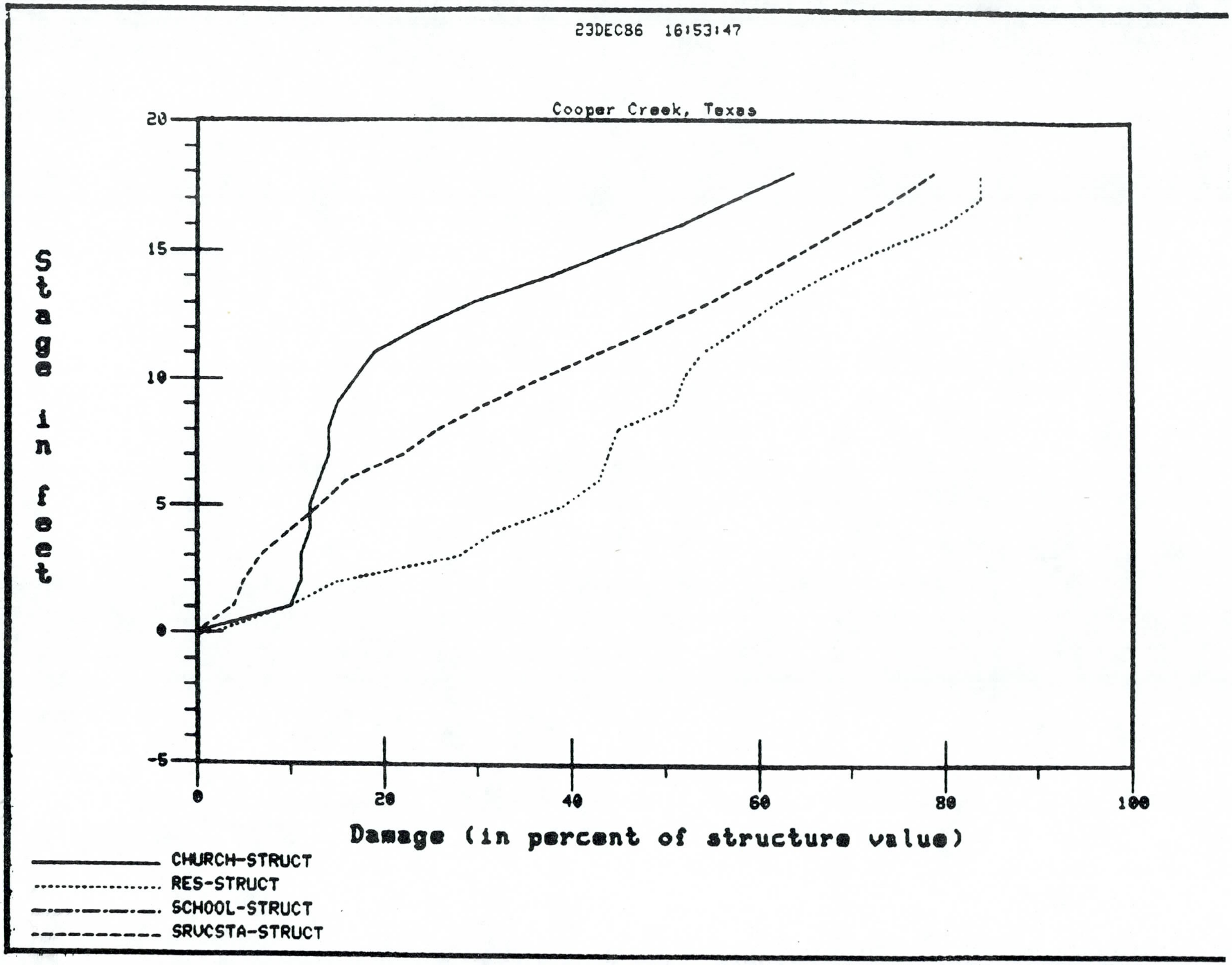


Fig. VIII-5: Structure Damage Functions

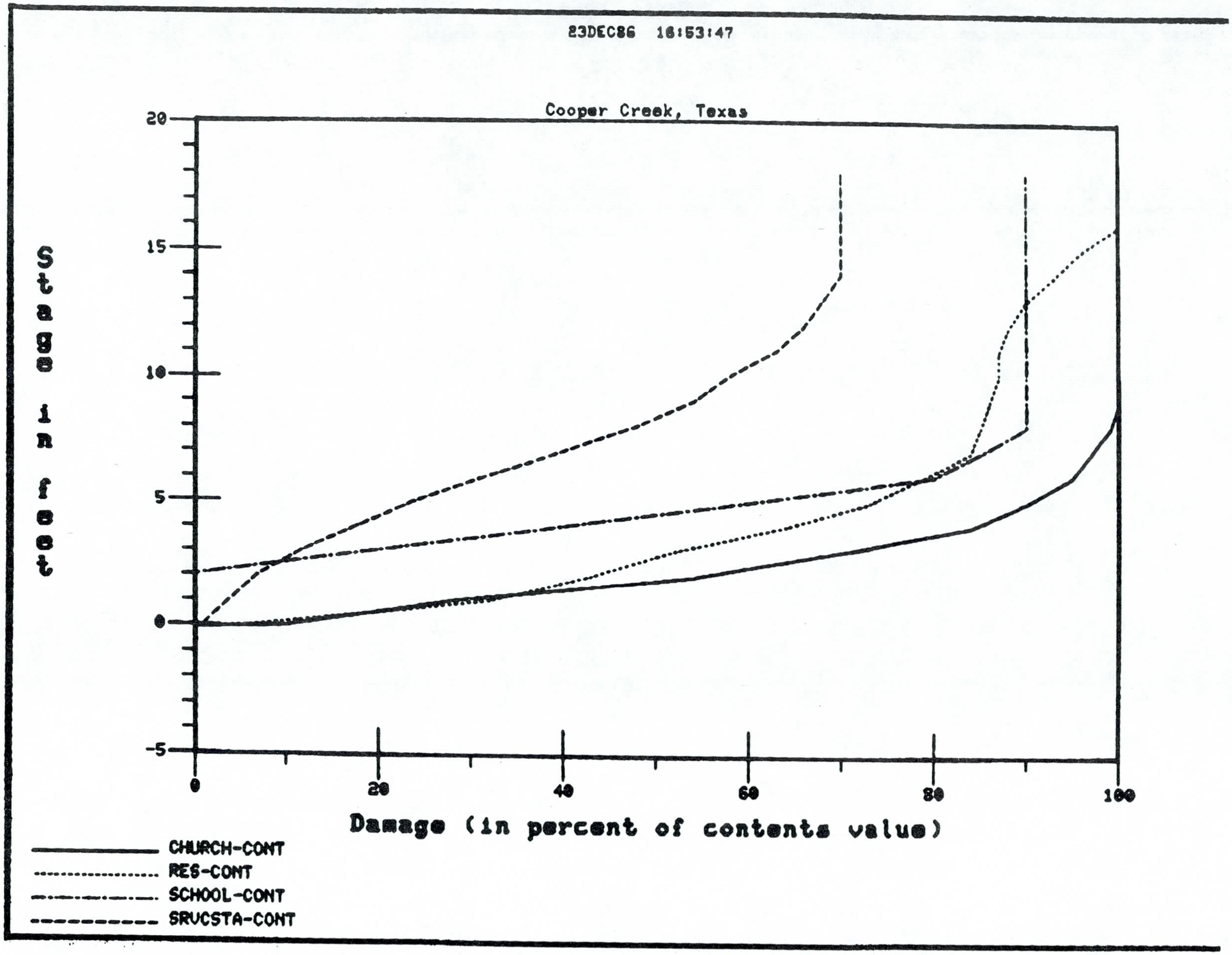


Fig. VIII-6: Content Damage Functions

Figure 7: HECDSS Data File Schematic

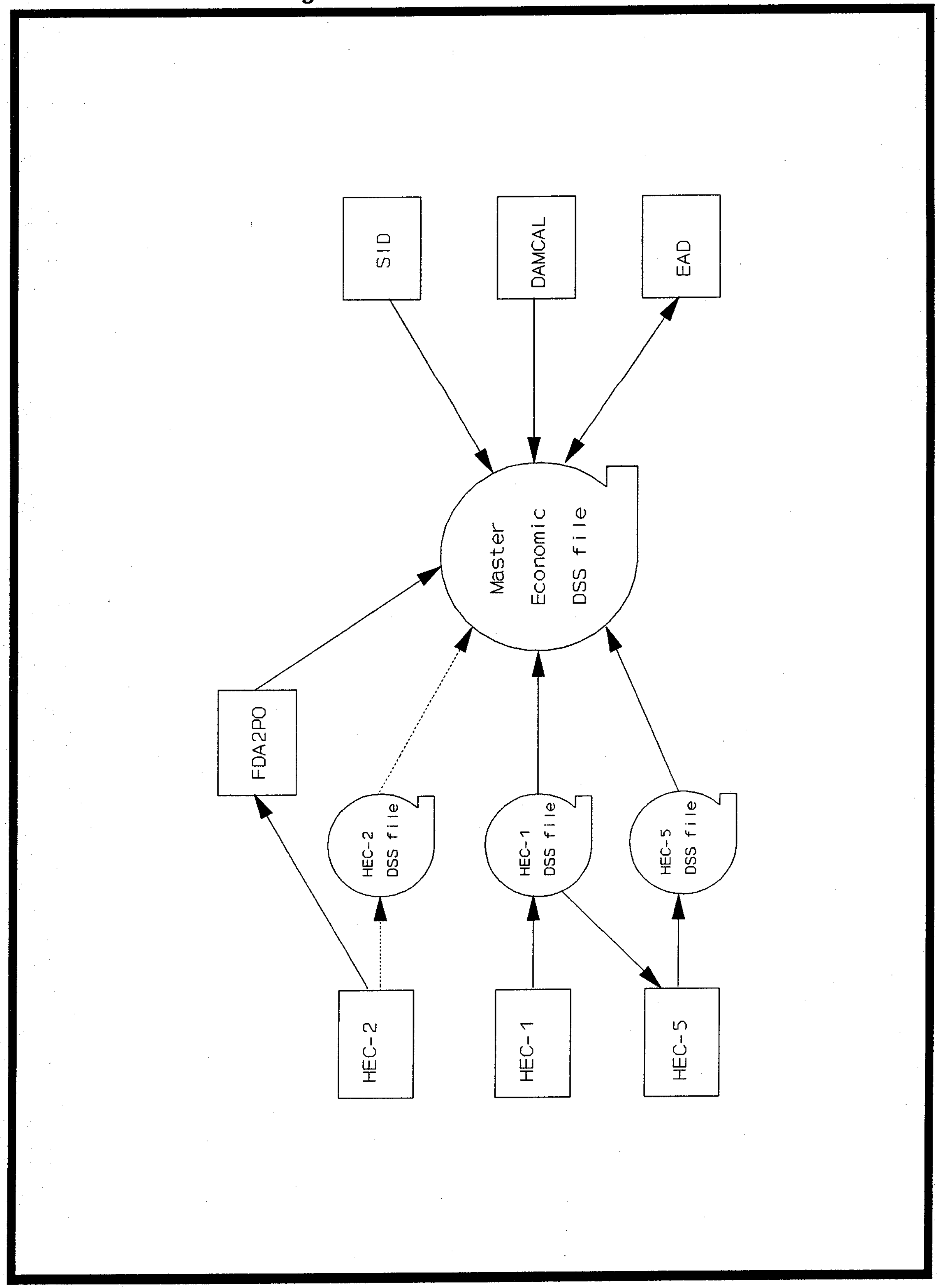


Table 3: Residential Damage Functions

Index	Stage (feet)	RS1 Structure (percent)	RC1 Content (percent)
1	-.1	0	0
2	0.0	2	6
3	1.0	10	32
4	2.0	15	43
5	3.0	28	52
6	4.0	32	64
7	5.0	39	73
8	6.0	43	79
9	7.0	44	84
10	8.0	45	85
11	9.0	51	86
12	10.0	52	87
13	11.0	54	87
14	12.0	58	88
15	13.0	62	90
16	14.0	67	93
17	15.0	73	96
18	16.0	80	100
19	17.0	84	100
20	18.0	84	100

Table 4: Service Station Damage Functions

Index	Stage (feet)	GS1 Structure (percent)	GC1 Content (percent)
1	-.1	0	0
2	0.0	0	1
3	1.0	4	4
4	2.0	5	7
5	3.0	7	12
6	4.0	10	18
7	5.0	13	24
8	6.0	16	32
9	7.0	22	40
10	8.0	26	48
11	9.0	31	54
12	10.0	37	58
13	11.0	43	63
14	12.0	49	66
15	13.0	55	68
16	14.0	60	70
17	15.0	65	70
18	16.0	70	70
19	17.0	75	70
20	18.0	79	70

Table 5: School Damage Functions

Index	Stage (feet)	SS1 Structure (percent)	SC1 Content (percent)
1	-.1	0	0
2	0.0	0	0
3	1.0	10	0
4	2.0	11	0
5	3.0	11	20
6	4.0	12	40
7	5.0	12	60
8	6.0	13	80
9	7.0	14	85
10	8.0	14	90
11	9.0	15	90
12	10.0	17	90
13	11.0	19	90
14	12.0	24	90
15	13.0	30	90
16	14.0	38	90
17	15.0	45	90
18	16.0	52	90
19	17.0	58	90
20	18.0	64	90

Table 6: Church Damage Functions

Index	Stage (feet)	CS1 Structure (percent)	CC1 Content (percent)
1	-.1	0	0
2	0.0	0	10
3	1.0	10	28
4	2.0	11	54
5	3.0	11	70
6	4.0	12	84
7	5.0	12	90
8	6.0	13	95
9	7.0	14	97
10	8.0	14	99
11	9.0	15	100
12	10.0	17	100
13	11.0	19	100
14	12.0	24	100
15	13.0	30	100
16	14.0	38	100
17	15.0	45	100
18	16.0	52	100
19	17.0	58	100
20	18.0	64	100

Table 7: Reach 11 Structures

Street Address	Struct Ident.	Damage Category	Struct Value	Contnt Value	River Loc.	Struct. Ref. El.
2920 BRISTOL ST	237	Residential	70	35	27220	623.4
2919 BRISTOL ST	240	Residential	65	33	27375	624.3
2921 BRISTOL ST	566	Residential	70	35	27265	622.4
3917 BRISTOL ST	241	Residential	65	33	27450	624.8
2915 BRISTOL ST	242	Residential	65	33	27500	624.2
2913 BRISTOL ST	568	Residential	70	35	27555	625.4
1406 CHURCHILL DR	285	Residential	80	40	26910	621.3
1402 CHURCHILL DR	301	Residential	80	40	27070	622.0
1324 CHURCHILL DR	311	Residential	80	40	27180	622.9
1320 CHURCHILL DR	315	Residential	90	45	27290	623.4
1314 CHURCHILL DR	322	Residential	75	38	27400	623.4
1310 CHURCHILL DR	327	Residential	75	38	27530	624.3
1306 CHURCHILL DR	328	Residential	75	38	27660	625.2
1304 CHURCHILL DR	571	School	200	60	27690	622.4

Table 8: Reach 12 Structures

Street Address	Struct Ident.	Damage Category	Struct Value	Contnt Value	River Loc.	Struct. Ref. El.
3105 HEATHER LN.	351	Church	250	80	27970	626.4
3110 HEATHER LN.	364	Residential	70	35	28270	627.6
3114 HEATHER LN.	367	Residential	70	35	28340	628.4
3116 HEATHER LN.	370	Residential	70	35	28415	629.2
3118 HEATHER LN.	373	Residential	70	35	28490	629.5
3202 HEATHER LN.	374	Residential	95	45	28550	629.5
3206 HEATHER LN.	375	Residential	60	30	28570	630.5
3208 HEATHER LN.	376	Residential	60	30	28570	631.2
3205 HEATHER LN.	387	Residential	70	35	28680	630.8
3207 HEATHER LN.	388	Residential	60	30	28680	631.4
3209 HEATHER LN.	389	Residential	60	30	28680	631.8

Table 9: Reach 13 Structures

Street Address	Struct Ident.	Damage Category	Struct Value	Contnt Value	River Loc.	Struct. Ref. El.
1101 MONTERRY ST.	416	Service statn.	150	45	29030	634.9
1021 MONTERRY ST.	417	Residential	60	30	29030	636.6
1013 MONTERRY ST.	418	Residential	75	38	29250	636.7
1009 MONTERRY ST.	419	Residential	60	30	29460	635.7
1005 MONTERRY ST.	420	Residential	60	30	29460	635.6
1001 MONTERRY ST.	421	Residential	75	38	29640	636.3
1000 MANHATTEN	441	Residential	60	30	29640	637.0
1004 MANHATTEN	442	Residential	60	30	29460	636.4
1008 MANHATTEN	443	Residential	60	30	29250	636.0
1014 MANHATTEN	444	Residential	84	42	29250	636.2
1018 MANHATTEN	445	Residential	60	30	29030	635.1
1100 MANHATTEN	446	Residential	75	38	29030	635.2
1104 MANHATTEN	447	Residential	60	30	29030	633.9
1109 MANHATTEN	448	Residential	60	30	29030	635.4
1105 MANHATTEN	449	Residential	60	30	29030	635.3
1101 MANHATTEN	450	Residential	60	30	29030	635.4
1021 MANHATTEN	451	Residential	60	30	29030	635.0
1017 MANHATTEN	452	Residential	60	30	29030	634.9
1013 MANHATTEN	453	Residential	60	30	29250	634.8
1009 MANHATTEN	454	Residential	60	30	29250	635.3

Introductory COED Exercise

Training course on Flood Damage Analysis, 12-16 February 1990.

Introduction

This exercise introduces the analyst to the use of COED to edit a SID structure inventory data file. The methods and commands used in this exercise are typical of those required to edit and manage most data files associated with the FDA programs. COED is invoked in the full screen mode from the FDA menu program. The FDA menu program generates the proper commands to invoke COED in the full screen mode and attach on-line documentation which describes each data field and each record. You will use the existing data file named "EXAMPLE.I". It contains some information for one structure. You will edit that information as well as add data for a second structure. The file "EXAMPLE.I" is listed below:

```
SL RCH 1     R001                       3464.8  3463.8
SD RCH 1     R001 RESDNTLRS1  130RS2   -50
```

Tasks:

1. Invoke the FDA menu program:

   a. From the DOS prompt, type the command "MENUFDA" followed by the "Enter" key.

   b. Press any key to bypass the banner page.

   c. Select the study "FDA COED exercise" by using the cursor keys to highlight the study name and pressing the "Enter" key.

   d. Select the program "SID" by using the cursor keys to highlight the program and pressing the "Enter" key.

   e. Define the structure inventory data file by using the cursor keys to highlight the data file "Structure file", pressing the "?" key, and selecting the data file "EXAMPLE.I" by using the cursor keys to highlight that file and pressing the "Enter" key.

2. Use of COED to edit the file "EXAMPLE.I"

a. Once the FDA menu program is invoked and the structure inventory file name is defined, you are ready to edit that file using COED. Edit the structure inventory file "EXAMPLE.I" by pressing "Alt-E" (pressing and holding down the "Alt" key and then pressing the "E" key). The data in this file is taken from Training Document 21. The file contains data for a residential structure and you will be required to edit that data and then enter data for a commercial structure.

b. Invoke the help function for COED to get information about the "Help Program Information" by pressing the F1 function key and following the instructions listed below or the instructions that COED gives you. The "Help Program Information" is the same information given in Appendix C of the COED manual.

F1 Press the F1 function key to get help about the COED editor.

"Enter" Press the "Enter" key to get the next page of help information for COED.

"Enter" Press the "Enter" key to get the next page of help information which should be an index of help information.

21 Press the "2" key, then the "1" key, and then the "Enter" key to obtain information about the "Help Program Information".

Q Press the "Q" key to exit from the "Help Program Information" mode and return to the help mode.

F1 Press the F1 function key to return to the edit mode.

c. Edit the existing structure input data for SID contained in the file "EXAMPLE.I". The data in this file is taken from Training Document 21. The file contains data for the residential structure and you will be required to edit that data and then enter data for the commercial structure. The table below defines the various values for individual variables and the data columns in which the data should be entered. Allow COED to right or left justify the data.

Structure: Residential structure R001

Record I.D.	Columns	Variable Name	Value
SL	1-2	-	SL
	3-8	IDRCH	RCH 1
	9-16	IBLDG	R001
	33-40	ADJ	3464.8
	41-48	STOPO	3463.8
SD	1-2	-	SD
	3-8	IDRCH	RCH 1
	9-16	IBLDG	R001
	17-24	IDCAT	RESDNTL
	25-27	ID1FS	RS1
	28-32	V1FS	130
	33-35	ID1FC	RS2
	36-40	V1FC	-50

Structure: Commercial structure C001

Record I.D.	Columns	Variable Name	Value
SL	1-2	-	SL
	3-8	IDRCH	RCH 1
	9-16	IBLDG	C001
	33-40	ADJ	3465.9
	41-48	STOPO	3462.4
SD	1-2	-	SD
	3-8	IDRCH	RCH 1
	9-16	IBLDG	C001
	17-24	IDCAT	COMERCL
	25-27	ID1FS	CM1
	28-32	V1FS	60
	33-35	ID1FC	CM2
	36-40	V1FC	250

3. Edit the reference flood elevation for structure R001.

- Use the cursor keys to move to the record containing the SL record for structure R001.
- Repeatedly press and release the "Tab" key to move to column 40 which is the last column in the field for variable "ADJ".
- Verify this and get the "help program information" for this variable by entering "Alt-F1". This should display on the screen a description of the variable "ADJ". If it describes another variable, you are not properly positioned.
- Edit the existing value of 3464.8 to the new value of 3463.75. Use the keys "Backspace", "left arrow", "right arrow", "Del", and the numeric keys to modify this value.

4. Enter data for the commercial structure C001.

- Move the cursor to the bottom of the file by pressing the "End" key twice.
- Invoke the "insert line" mode by pressing the F4 function key. The message "insert line" must appear at the bottom of the screen. This should put the cursor on a blank line below the SD record for building R001 and in column one.
- Begin entering data for structure C001 by entering the characters "SL" in columns one and two.
- Enter the reach identification "RCH 1" by pressing the "Tab" key to move the cursor to column eight and entering "RCH 1".
- Enter the building identification "C001" by pressing the "Tab" key to move the cursor to column sixteen and entering "C001".
- Enter the reference flood elevation of 3465.9 by pressing the "Tab" key three times to move the cursor to column 40 and entering 3465.9.
- Enter the structure reference elevation of 3462.4 by pressing the "Tab" key to move the cursor to column 48 and entering 3462.4.
- Generate the next line by pressing the "Enter" key (you still must be in the "insert line" mode --- the message "insert line" must appear at the bottom of your screen).
- Begin entering data on the SD record by entering SD in columns one and two of the new line.
- Enter the reach identification "RCH 1" by pressing the "Tab" key to move the cursor to column eight and entering "RCH 1".
- Enter the building identification "C001" by pressing the "Tab" key to move the cursor to column sixteen and entering "C001".
- Enter the damage category identification "COMERCL" by pressing the "Tab" key to move the cursor to column 24 and entering "COMERCL".
- Enter the structure's damage potential function identification code "CM1" by pressing the "Tab" key to move the cursor to column 27 and entering "CM1".
- Enter the total value ($60,000) of the structure in thousands of dollars by pressing the "Tab" key to move the cursor to column 32 and entering "60".
- Enter the contents damage potential function identification code "CM2" by pressing the "Tab" key to move the cursor to column 35 and entering "CM2".
- Enter the total value ($250,000) of the contents within the structure in thousands of dollars by pressing the "Tab" key to move the cursor to column 40 and entering "250".

5. Save the changes that you have made and exit to DOS by doing one of the following:

   a. Either enter "FILE" in the line edit mode by:

      - Enter the line-edit mode by pressing the F10 function key.
      - Save your changes and exiting to DOS by typing "FILE" and then pressing the "Enter" key.
      - Look at the screen and notice that COED responds by indicating that your file "EXAMPLE.I" has been edited which means your changes have been made to the file.

   b. Or save your changes from the full-screen mode by:

      - Pressing "Alt-F10" (pressing and holding the "Alt" key and then pressing the "F10" function key).
      - Verify that the changes will be saved in the file "EXAMPLE" by pressing the "Enter" key.
      - Look at the screen and notice that COED responds by indicating that your file "EXAMPLE" has been edited which means your changes have been made to the file.

6. Continue to enter and edit data until you fell fairly proficient at it. Use the COED help function key "F1" or the COED User's Manual to obtain help and information.

7. List of files before and after editing.

   The file EXAMPLE.I is shown below. The first example shows the file as it appears after being extracted from the diskette. The second example shows the file after you have finished editing it.

   The file EXAMPLE.I as extracted from the diskette contains two records:

```
SL RCH 1     R001                  3464.8  3463.8
SD RCH 1     R001 RESDNTLRS1   130RS2  -50
```

   The file EXAMPLE.I after you have modified it should contain four records:

```
SL RCH 1     R001                  3463.75  3463.8
SD RCH 1     R001 RESDNTLRS1   130RS2  -50
SL RCH 1     C001                    3465.9  3462.4
SD RCH 1     C001COMMERCLCM1    60CM2  250
```

COED Commands

Command	Purpose	Examples
COED	Begin edit session	COED MYFILE COED OUTFILE S=132
FS	Go into Full Screen mode	FS
T	Go to Top of file (line zero)	T
B	Go to Bottom of file	B
P	Print line(s)	P (print 1) P 3 (print 3) P A (print all) P * (print to bottom)
N	Go to Next line	N (next line) N 3 (go down 3 lines)
U	Go Up	U 2 (go up 2)
L	Locate a string	L /ABC/
C	Change a string	C /ABC/XYZ/
I	Insert a line	I THIS IS A LINE
I	Input mode	I LINE ONE OF TWO LINE TWO OF TWO $$$
R	Replace a line	R NEW INFORMATION
DE	Delete a line	DE
CL	Show column banner	CL
FILE	Update file and exit	FILE NEWFILE
QU	Quit edit session (nothing saved)	QU

Note: A blank line (just a carriage return) causes the previous command to be repeated.

Full Screen Commands

To enter full screen mode type "FS"
To return to line edit mode press the "COMMAND-LOCK" key (S8).

Key	Description
PAGE UP	Goes up approximately 18 lines.
PAGE DOWN	Goes down approximately 18 lines.
HOME	Pressed once, goes to the top left corner of the screen. Pressed again, goes to the first line in the file.
END	Pressed once, goes to the bottom left corner of the screen. Pressed again, goes to the last line in the file.
INSERT CHARACTER	Toggles you into or out of insert character mode. In insert character mode, whenever characters are pressed, they are inserted to the left of the cursor. New lines are not created by insert character.
DELETE CHARACTER	Deletes characters on the current line. Delete character may be used in two ways: a. Delete highlighted area: Press delete character key, move cursor to highlight string to be deleted, press delete character key again to delete. A string may be highlighted by pressing the return key, End of line key, Beginning of line key, or a regular character (whereby the cursor will index right to that character. b. Delete single characters: Single characters are deleted when the delete key is pressed a second or subsequent time.
DELETE LINE (F3)	Deletes the line the cursor is at.
INSERT LINE (F4)	Toggles into and out of insert line mode. Pressing the insert line key will provide you with a new line. Additional lines are generated by a carriage return, until insert line mode is turned off. If you are at the bottom of the file, a carriage return alone creates a new line (it will not put you into insert line mode, however.)

Function Keys

F1 – function Key Index

Key	Description
BEGINNING OF LINE	Moves the cursor to the left edge of the screen.
END OF LINE	Moves the cursor to the position following the last character on the line.
SCROLL UP	Causes the screen to scroll up.
SCROLL DOWN	Causes the screen to scroll down.
RESTORE	Restores the line you are on, if the previous command was in error: If the last key pressed was 'Delete line', that line will be resorted. If you inadvertently miss-typed characters on the line, are in the process of deleting character (or have deleted characters), restore will return the line to what it was before you positioned the cursor on it. Once you have moved off of the line, it cannot be restored.
COMMAND	Provides an E> to execute one command, then returns to full screen mode. This is useful for doing locates, etc. It will be expanded in a later release.
COMMAND-LOCK	Returns the program to the regular line-edit mode. To return to full screen mode, enter 'FS' again.
← TAB	Tabs to the settings used in line-edit mode.
BACKSPACE	Move back one position and blanks that space.
CARRIAGE RETURN	Puts the cursor on the next line at the left margin. A new line will be generated if either in insert line mode, or if at the bottom of the file.

TAB ⇒ Right
Shift TAB ← Left.

COED KEY PAD KEYS

COED FULL SCREEN KEYS

Home 1	↑ 2	Page Up 3	Scroll Up
← 4	5	→ 6	Scroll Down
End 7	↓ 8	Page Down 9	
Insert Char		Del Char	

Number Lock OFF

Workshop Problem

COMPUTATION OF EXPECTED ANNUAL DAMAGE
(Hand Computation)

PROBLEM DESCRIPTION

The 10.7 sq mi Cooper Creek catchment in Denton, TX has a history of damaging floods due to intense thunderstorms falling on a heavily-urbanized area with soils of low permeability. Major damaging floods occurred in 1957, 1962, and 1974. With increasing urbanization, the risk of damage increases each year.

Cooper Creek and its tributaries are unimproved channels with mild slopes and small capacities relative to the impervious drainage areas. The main channel, which is overgrown with vegetation, is approximately 6 ft deep and 50 ft wide, with a slope of 25 ft/mi. The creek is crossed by a number of small capacity bridges which may constrain discharge and cause backwater.

A channel improvement project has been proposed for reach 11 of Cooper Creek. This project provides for clearing the channel and widening the bottom to 40 ft. The economic efficiency of the alternative is to be evaluated by computing the expected annual damage (EAD) with the improvement and comparing this with the existing-condition EAD to determine inundation-reduction benefit.

TASKS

1. List the functions required to computed the EAD for each alternative.

2. Which of the functions will be modified by the proposed channel improvement?

3 fuctions

3. Complete the table below to determine the damage due to the 1% chance event with existing conditions. Use the existing-condition rating function of Table 1, the existing-condition elevation-damage function of Table 2, and the existing-condition discharge-frequency function of Table 3.

1%-chance discharge, in cfs	5428 cfs
Elevation corresponding to 1%-chance discharge, in feet	624.72'
Damage corresponding to elevation, in $1,000	$53.87

4. Develop a damage-frequency function for existing conditions by completing the Table 4.

5. Use the values in columns 1 and 4 of Table 4 to estimate the EAD. You may do this by plotting the damage-frequency function and counting squares on the graph paper, or you may use principles of geometry.

6. The EAD with channel improvement (in $1,000), is 7.34. What is the inundation-reduction benefit of this alternative?

TABLE 1 - Existing-condition Rating Function
Cooper Creek, Reach 11

Elevation in feet (1)	Discharge in cfs (2)
617.25	303
620.88	1,304
621.44	1,543
622.06	1,817
622.44	2,151
622.95	2,595
623.21	2,896
623.52	3,289
623.73	3,603
623.92	3,892
624.18	4,338
624.38	4,698
625.04	6,125
625.34	6,858
625.42	7,503

TABLE 2 - Existing-condition Elevation-Damage Function
Cooper Creek, Reach 11

Elevation in feet (1)	Damage in $1,000 (2)
617.25	0.00
620.88	0.00
621.44	2.21
622.06	13.31
622.44	19.15
622.95	21.11
623.21	21.64
623.52	23.81
623.73	26.04
623.92	28.67
624.18	37.86
624.38	43.86
625.04	63.29
625.34	70.59
625.42	72.30

TABLE 4 - Existing-condition Damage-Frequency Function
Cooper Creek, Reach 11

Frequency in percent (1)	Δ ÷/100	Discharge in cfs (2)	Elevation in feet (3)	Damage in $1,000 (4)		EAD
99.0	.39	303	617.25	∅	∅	∅
60.0	.10	1304	620.88	∅	1.11	.111
50.0	.10	1543	621.44	2.21	7.76	.776
40.0	.10	1817	622.06	13.31	16.23	1.623
30.0	.10	2151	622.44	19.15	20.13	2.013
20.0	.05	2595	622.95	21.11	21.38	1.069
15.0	.05	2896	623.21	21.64	22.73	1.137
10.0	.03	3289	623.52	23.81	24.93	0.748
7.0	.02	3603	623.73	26.04	27.36	0.547
5.0	.02	3892	623.92	28.67	33.27	0.665
3.0	.01	4338	624.18	37.86	40.86	0.409
2.0	.01	4698	624.38	43.86	48.87	0.488
1.0	.005	5428	624.72	53.87	58.58	0.293
.5	.003	6125	625.04	63.29	66.94	0.201
.2	.001	6858	625.34	70.59	71.45	0.715
.1		7503	625.42	72.30		

Σ = 10.795

Should be 10.16

TABLE 3 - Existing-condition Discharge-Frequency Function
Cooper Creek, Reach 11

Frequency in percent (1)	Discharge in cfs (2)
99.0	303
60.0	1,304
50.0	1,543
40.0	1,817
30.0	2,151
20.0	2,595
15.0	2,896
10.0	3,289
7.0	3,603
5.0	3,892
3.0	4,338
2.0	4,698
1.0	5,428
0.5	6,125
0.2	6,858
0.1	7,503

Workshop Problem

COMPUTATION OF EXPECTED ANNUAL DAMAGE
(Computation with EAD Program)

PROBLEM DESCRIPTION

The Expected Annual Flood Damage computer program is to be used to evaluate economic efficiency of proposed channel improvements for Cooper Creek, Denton, TX. Hydrologic, hydraulic, and economic data have been furnished in a previous workshop problem.

TASKS

1. Show in col. 2 of the table below the input records of the EAD program that accomplish the tasks shown in col. 1.

Task (1)	Input record (2)
Specify titles	TT
Define damage categories ONE per category	CN
Identify alternatives (plans) ONE per plan	PN
Identify damage reach ONE per reach	RN
Specify frequency values (ONE relationship pair)	FR
Specify discharge values for discharge-frequency function	QF
Specify elevation for elevation-discharge function HEC-2 rating curve (ONE relationship pair)	SQ
Specify discharge for elevation-discharge function	QS
Specify elevation for elevation-damage function (ONE relationship pair)	SD
Specify damage for elevation-damage function	DG
Identify the end of data for a plan	EP
Identify the end of data for a job	EJ

2. Prepare input to compute EAD for reach 11 of Cooper Creek. Use the existing-condition discharge-frequency, elevation-discharge, and elevation-damage functions provided previously. Describe two plans: (1) existing condition, and (2) the channel

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modification alternative. Assume that the discharge-frequency and elevation-damage functions are the same with both plans. Use the following elevation-discharge function for the channel modification:

SQ QS,

Plan 2

Elevation (1)	Discharge (2)
616.02	190
619.58	1000
621.58	1800
622.57	2650
623.02	3250
623.56	4100
623.89	4700
624.24	5400
624.90	6900
624.98	7100

3. Execute the program. While you are awaiting the output, answer the questions that follow.

a. If predicted future-condition discharge-frequency functions are available, which records should be added to permit computation of the equivalent annual damage for a 50-yr project life?

Record I.D,

b. What is the purpose of the RV record? How could this record be used to estimate the damage reduction due to raising by 2 ft all structures in reach 11?

c. How should the input be modified if damage is specified as a function of discharge rather than as a function of elevation? QD

d. What is the purpose of the ZR record? USE WHEN DATA ARE TO BE RETRIEVED FROM A FILE by use of HEC data storage system (DSS).

4. Peruse the program output and answer the questions that follow.

a. What is the computed EAD for existing conditions? If this does match the value you computed by hand, explain why. 10.1

b. What is the elevation corresponding to the 1%-chance discharge after channel modification? What is the damage? 7.34

c. What is the computed EAD with the channel modification? What is the expected annual inundation-reduction benefit?

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Workshop Problem Solution

COMPUTATION OF EXPECTED ANNUAL DAMAGE
(Hand Computation) HAROLD KUBIK

1. Hydrologic, hydraulic, and economic functions are required to compute expected annual damage (EAD).

The hydrologic data necessary for computation of expected annual damage must define the probability of flooding. An elevation-frequency function or a discharge-frequency function typically provide this information, although in the case of reservoir flooding, a storage-frequency function may be appropriate. If the frequency function is expected to change with time or with the construction of management measures, the modified frequency function must be defined also.

The economic data define the relationship of water-surface elevation to damage. The damage may be categorized if necessary. The required data may be supplied in alternative forms. For example, the elevation-damage data may be in the form of a generalized elevation vs. percent damage function, which is combined with specific information on each structure or group of structures.

Hydraulic functions are required to link the hydrologic-frequency and economic-damage data. If the probability of flooding is defined with a discharge-frequency function, a rating curve is required to convert discharge to water-surface elevation in the channel. Further, the relationship of water-surface elevation in the channel to water-surface elevation at the damageable property must be defined. If the damage-reduction measures modify the hydraulic relationship, the modified relationship must be defined.

2. The proposed channel improvement will modify the rating function (elevation-discharge).

3. The completed table shows the discharge, elevation, and damage for existing conditions. The 1%-chance discharge is found in Table 3. The corresponding elevation is not given explicitly in Table 1, so linear interpolation is used. The elevation is 624.38 ft for 4698 cfs and 625.04 for 6125 cfs, so the estimated elevation is 624.72 ft for 5428 cfs. Likewise, the damage corresponding to the interpolated elevation of 624.72 ft is not given directly in Table 2, so linear interpolation again is used. The damage, in $1000, is 43.86 for 624.38 ft and 63.29 for 625.04 ft, so the interpolated value for 624.72 ft is 53.80.

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1%-chance discharge, in cfs	5428
Elevation corresponding to 1%-chance discharge, in ft	624.72
Damage corresponding to elevation, in $1000	53.80

4. The completed existing-condition damage-frequency function is given in Table 4. The discharge values in col. 2 are found by referring to the discharge-frequency function. After the values in col. 2 are established, the values in col. 3 are determined from the rating curve, interpolating as necessary. The values in col. 4 are determined from the elevation-damage function.

5. The EAD is estimated by integrating numerically the function defined by cols. 4 and 1. (The frequency values must be divided by 100 to obtain probability values prior to integration.) The resulting EAD estimate, in $1000, is 10.22.

6. If the EAD, in $1000, with channel improvement is 7.34, the inundation-reduction benefit, in $1000, is 10.22-7.34 = 2.88.

TABLE 4. - Existing-condition Damage-frequency Function
Cooper Creek, Reach 11

Frequency, in percent (1)	Discharge, in cfs (2)	Elevation, in ft (3)	Damage, in $1000 (4)
99.00	303	617.25	0.00
60.00	1304	620.88	0.00
50.00	1543	621.44	2.21
40.00	1817	622.06	13.31
30.00	2151	622.44	19.15
20.00	2595	622.95	21.11
15.00	2896	623.21	21.64
10.00	3289	623.52	23.81
7.00	3603	623.73	26.04
5.00	3892	623.92	28.67
3.00	4338	624.18	37.86
2.00	4698	624.38	43.86
1.00	5428	624.72	53.80
0.50	6125	625.04	63.29
0.20	6858	625.34	70.59
0.10	7503	625.42	72.30

2/12/90

Workshop Problem Solution

COMPUTATION OF EXPECTED ANNUAL DAMAGE
(Computation with EAD Program)

1. The completed table below shows the input records of the EAD program that accomplish the tasks indicated in col. 1.

Task (1)	Input record (2)
Specify titles	TT
Define damage categories	CN
Identify alternatives (plans)	PN
Identify damage reach	RN
Specify frequency values	FR
Specify discharge values for discharge-frequency function	QF
Specify elevation for elevation-discharge function	SQ
Specify discharge for elevation-discharge function	QS
Specify elevation for elevation-damage function	SD
Specify damage for elevation-damage function	DG
Identify the end of data for a plan	EP
Identify the end of data for a job	EJ

2. Input for the computer program is included as Fig. 1. One damage category is defined with the CN record (record 2), and two plans are identified with the PN records (records 3 and 4). The RN record, record 5, identifies the reach.

The FR-QF records (records 6-9) define the discharge-frequency function with 16 values. The discharge values on the QF records correspond to the frequency values on the FR records. The frequency values are exceedance values in percent. The values included range from non-damaging discharge to rare-event discharge values, thus defining well the frequency function for subsequent integration. IPLNN in field 2 of the FR record is

```
RECORD
 ORDER         1       2       3       4       5       6       7       8
NUMBER 12345678901234567890123456789012345678901234567890123456789012345678901234567890

     1 TT EAD COMPUTATION FOR COOPER CREEK
     2 CN      1   TOTAL
     3 PN      1EXISTING CONDITION
     4 PN      2CHANNEL MODIFICATION
     5 RN       DAMAGE REACH 11
     6 FRRCH 11      16      99      60      50      40      30      20      15      10
     7 FR      7       5       3       2       1      .5      .2      .1
     8 QFRCH 11             303    1304    1543    1817    2151    2595    2896    3289
     9 QF  3603    3892    4338    4698    5428    6125    6858    7503
    10 SQRCH 11      15  617.25  620.88  621.44  622.06  622.44  622.95  623.21  623.52
    11 SQ623.73  623.92  624.18  624.38  625.04  625.34  625.42
    12 QSRCH 11       1     303    1304    1543    1817    2151    2595    2896    3289
    13 QS  3603    3892    4338    4698    6125    6858    7503
    14 SDRCH 11      15  617.25  620.88  621.44  622.06  622.44  622.95  623.21  623.52
    15 SD623.73  623.92  624.18  624.38  625.04  625.34  625.42
    16 DGRCH 11               0       0    2.21   13.31   19.15   21.11   21.64   23.81
    17 DG 26.04   28.67   37.86   43.86   63.29   70.59   72.30
    18 EP      1
    19 SQRCH 11      10  616.02  619.58  621.58  622.57  623.02  623.56  623.89  624.24
    20 SQ624.90  624.98
    21 QSRCH 11       2     190    1000    1800    2650    3250    4100    4700    5400
    22 QS  6900    7100
    23 EJ      2

READIN --    23 RECORDS WRITTEN TO LOGICAL FILE  8
```

don't need EP or ER only one!

FIG. 1. - EAD Program Input

blank, indicating that the same discharge-frequency function applies for all plans.

The rating curve for plan 1, the existing condition, is described with 15 values on the SQ-QS records (records 10-13). The discharge values on the QS records correspond to the elevation values on the SQ records. The plan number is specified in field 2 of the QS record.

The elevation-damage function is described with the SD-DG records, records 14-17. Field 2 of the DG record is blank, so the program uses the same elevation-damage function for all plans.

Record 18, the EP record, indicates the end of the description of plan 1.

Plan 2 is described with records 19-22. These SQ and QS records define the modified-condition rating function. The discharge-frequency and elevation-damage functions are not re-defined, as these are the same for both plans. The EJ record (record 23) signals the end of the description of plan 2 and the end of job.

3. a. If predicted future-condition discharge-frequency functions are available, additional QF records may be added. In each case, the data year is specified in field 2. To compute equivalent annual damage, the length of the period of analysis, the study year, base year, and dollar year must be specified with the J1 record. The discount rate must be specified with the J2 record. Pages 8 and 9 of the February 1984 version of the users manual for the Expected Annual Flood Damage Computation program explains how the changes are included in EAD calculations in the program. The EAD is computed for each year, using the specified frequency curve, and EAD is interpolated for intermediate decade years. A discounting formula is used to compute the equivalent annual flood damage.

b. The RV record simplifies modification of data to represent the impacts of damage-reduction alternatives. For example, to estimate the damage reduction due to raising by 2 ft all structures in reach 11, the RV record is included with ICRD = SD, IFUNC = 1, and CONST = 2.0. This will case the values on the SD record (elevation for the elevation-damage function) to be modified; 2.0 will be added to all values.

c. If damage is specified as a function of discharge rather than as a function of elevation, the SD records will be replaced with QD records.

d. The ZR record permits retrieval of discharge, elevation, or damage data from the Hydrologic Engineering Center's data storage system, HEC-DSS.

4. In the program output, the input records are printed. Then the frequency-flow-stage-damage function is shown for each plan, and the computed EAD is shown for each category and for the total, as shown below.

++DAMAGE DATA FOR PLAN 1 -- EXISTING CONDITION

	FREQ	FLOW	STAGE	TOTAL	TOTAL	ACC EAD
1	99.00	303.	617.25	.00	.00	10.16
2	60.00	1304.	620.88	.00	.00	10.16
3	50.00	1543.	621.44	2.21	2.21	10.05
4	40.00	1817.	622.06	13.31	13.31	9.29
5	30.00	2151.	622.44	19.15	19.15	7.68
6	20.00	2595.	622.95	21.11	21.11	5.67
7	15.00	2896.	623.21	21.64	21.64	4.60
8	10.00	3289.	623.52	23.81	23.81	3.47
9	7.00	3603.	623.73	26.04	26.04	2.72
10	5.00	3892.	623.92	28.67	28.67	2.18
11	3.00	4338.	624.18	37.86	37.86	1.52
12	2.00	4698.	624.38	43.86	43.86	1.12
13	1.00	5428.	624.72	53.80	53.80	.63
14	.50	6125.	625.04	63.29	63.29	.34
15	.20	6858.	625.34	70.59	70.59	.14
16	.10	7503.	625.42	72.30	72.30	.07
EXP ANNUAL DAMAGE				10.16	10.16	

2.45
1.22

++DAMAGE DATA FOR PLAN 2 -- CHANNEL MODIFICATION

	FREQ	FLOW	STAGE	TOTAL	TOTAL	ACC EAD
1	99.00	303.	616.52	.00	.00	7.34
2	60.00	1304.	620.34	.00	.00	7.34
3	50.00	1543.	620.94	.23	.23	7.34
4	40.00	1817.	621.60	5.07	5.07	7.15
5	30.00	2151.	621.99	12.04	12.04	6.31
6	20.00	2595.	622.51	19.40	19.40	4.72
7	15.00	2896.	622.75	20.36	20.36	3.73
8	10.00	3289.	623.04	21.30	21.30	2.68
9	7.00	3603.	623.24	21.88	21.88	2.04
10	5.00	3892.	623.43	23.16	23.16	1.59
11	3.00	4338.	623.69	25.63	25.63	1.10
12	2.00	4698.	623.89	28.24	28.24	.83
13	1.00	5428.	624.25	40.03	40.03	.50
14	.50	6125.	624.56	49.13	49.13	.28
15	.20	6858.	624.88	58.63	58.63	.12
16	.10	7503.	624.98	61.52	61.52	.06
EXP ANNUAL DAMAGE				7.34	7.34	

The grand summary for all plans for all damage categories is included.

```
  EAD COMPUTATION FOR COOPER CREEK


** GRAND SUMMARY BY CATEGORY **

** FLOOD PLAIN MANAGEMENT PLANS
          1 - EXISTING CONDITION
          2 - CHANNEL MODIFICATION

 GRAND SUMMARY - ALL DAMAGE CATEGORIES
 ----------------------------------------
            . EXPECTED ANNUAL DAMAGE  .
   DAMAGE      BASE    .... PLAN  2....
  CATEGORY  CONDITION  DAMAGE   DAMAGE
             (PLAN  1) W/PLAN  REDUCED
 ----------------------------------------
      TOTAL      10.16     7.34      2.82
 ----------------------------------------

     TOTAL      10.16     7.34      2.82

----------------------------------------
```

a. The program-computed EAD for existing conditions, in $1000, is 10.16. This does not match exactly the value computed by hand in the previous workshop due to to differences in interpolation and integration techniques. The program interpolates to insert additional points in the damage-frequency function prior to integration; no such interpolation was done in the previous exercise. The program uses cubic-spline interpolation, but linear interpolation was used for the solution in the previous workshop.

b. The elevation corresponding to the 1%-chance discharge after channel modification is 624.25 ft, and the corresponding damage, in $1000, is 40.03.

c. The program-computed EAD with the channel modification is 7.34, and the expected annual inundation-reduction benefit is 2.84.

2/13/90

INTRODUCTION TO THE DATA STORAGE SYSTEM (DSS)

- JOHN PETERS -

1. Introduction

Studies associated with water resource planning and flood plain management tend to be data-intensive. One reason is that the physical systems with which we work are often large and complex (e.g., watersheds, precipitation fields, river-reservoir systems), and substantial quantities of data are required for their representation. Another reason is that the investigations themselves are complex, with a variety of interdependent computational elements (e.g., precipitation-runoff simulation, statistical analyses, systems analysis, economic analysis, etc.). The transfer of data generated with one element to another is a significant requirement in such investigations.

Another "water resource" area for which data management is important is real-time water control. Large quantities of hydrometeorological data are received on a continuing basis. Efficient processing and management of this data, and also of data resulting from forecasting and other types of analysis, are critical elements of any system that is devised to support water control activities.

The data management system to be described in this lecture is the HEC Data Storage System (DSS), which has been under development since 1979. It is a system that can be used to store and manage data for water resource planning/management studies as well as real-time applications. Although water resource applications will be used for purposes of illustrating use of DSS, applications for other purposes would be equally valid. This lecture will provide an overview of DSS and an illustration of how it may be used.

2. Function of the Data Storage System

Table 1 provides a list of data types commonly used in water resource investigations. Many of the data items can be classified as either time series data (e.g., discharge or stage hydrographs, precipitation mass curves, etc.); or as paired function data, in which one variable is paired with another (e.g., stage-discharge, discharge-exceedance frequency, etc.). The Data Storage System is well-suited for applications in water resources studies where it is necessary to manage time series, paired-function and other data for which it is generally desirable to deal with blocks of contiguous data.

Methods for transferring data and information to and among computer programs have progressed somewhat as follows: Initially, data was prepared manually, and the transfer of data generated by one program to another was also performed manually, as illustrated in part (a) of Fig. 1. In part (b) of Fig. 1, a utility program automatically generates data in the format required for a second program, thus facilitating the process of data transferral. In part (c) of Fig. 1, data resides in a central repository (data base) for access by any number of applications programs, as well as utility programs (e.g. for data entry or plotting). The latter framework is the basis for the Data Storage System.

There are many proprietary database management systems. The majority of these are intended for business applications and are typically designed for use with items such as personnel records, mailing lists, manufacturing inventories, finance and accounting records, etc.. Although general purpose data bases may be used for storing hydrologic information, in most cases they are inefficient for storing and retrieving time series and other data for which it is normally desired to deal with blocks of data.

3. Components of the Data Storage System

The Data Storage System (DSS) consists of a Fortran library of subroutines that enable transfer of data to and from a data base file; a DSS file to contain the data; and a set of utility programs that facilitate data entry, display, etc.. Subroutines from the library are used in 'applications' programs to retrieve information from, and write information to, the DSS file. See Fig. 2.

The following are some of the applications programs that presently are able to communicate with a DSS file:

AGDAM	HEC-2
CONVRT	HEC-5
DAMCAL	HEC-5Q
DATAST	HMR52
EAD	HYDPAR
EXTRCT	PRECIP
FDA2PO	SID
HEC-1	STATS
HEC1F	

A list of utility programs is provided in Table 2.

4. The DSS File

The DSS file is a "direct access" file. This type of file allows access to any specific section of the file without reading sequentially through the intervening information. Because the file is a binary file, it cannot be viewed with a simple Harris LIST or DISPLAY command. To 'look into' a DSS file it is necessary to use a utility program such as DSSUTL. The DSS file is set up for multiple-user access to enable several users to have concurrent access to the data base.

Data is stored in a DSS file in blocks to enable efficiencies in data storage and retrieval. For example, each block of data for a typical time-series application consists of a record of a time-dependent variable for a day or month or year. By storing data in this manner, an entire year of daily flows (one block of data) can be handled as a single record and accessed by one "read" from the data base.

The DSS is capable of storing any information provided by the user. The data stored is given a name to facilitate its identification and later reference. This name is called the pathname. Standard naming conventions have been developed for regular-interval time series, irregular-interval time series and paired X-Y data. Such conventions automatically control the size of data blocks in a manner transparent to the user. Block-size conventions for regular-interval data are as follows:

Data Interval*	Block Length
5MIN, 10MIN, 15MIN, 30MIN	One day.
1HOUR, 2HOUR, 3HOUR, 4HOUR, 6HOUR, 12HOUR	One month.
1DAY	One year.
1WEEK, 1MON	One decade.
1YEAR	One century.

* The interval as specified in the fifth position (or "E" part) of a pathname.

DSSUTL - DSPLAY

DSS utility programs have been designed to recognize the standard records (i.e., records that are created and labeled with the standard conventions) which enables efficient processing of the data and facilitates, for example, the automatic generation of labels on graphs.

The data in a DSS file is self-documented. That is, there is information stored with the data that describe its type, units, number of data values, time characteristics, etc., so that no additional information outside the data system is required to identify or interpret it. This documentation is stored in a 'header' at the beginning of the data. Fig. 3 illustrates the header information and subsequent data. A missing data element is defined as -901.

5. Accessing DSS Records

a. Pathnames

PATHNAMES MUST BE UNIQUE!

The "keys" to DSS records (i.e., blocks of data) are pathnames. That is, each block of data is referenced by a pathname, and it is necessary to specify that pathname to enable retrieval of the data. The standard convention for regular-interval time series data specifies that the pathname consist of up to 80 characters and be separated into six parts. For discussion, the parts are referenced by the characters A, B, C, D, E and F, and are delimited by a slash "/", so that a pathname would look as follows:

/A/B/C/D/E/F/

For example, a brief description of the pathname parts for regular-interval time-series data is as follows:

Pathname Part		Description
A		River basin or project name.
B		Location, or gage identifier.
C		Data variable, e.g., FLOW, PRECIP, etc..
D	OPTIONAL	FURTHER QUALIFICATION OF DATA Starting date for block of data, such as 01JAN1980 for daily data in 1980.
E		Time interval, e.g., 1DAY, 3HOUR, 1MON, etc..
F		Additional user-defined description to further the data, e.g., PLAN A.

A typical pathname would be:

/RED RIVER/BEND MARINA/FLOW/01JAN1975/1DAY/OBS/

Detailed information on pathname conventions may be found in Appendix C to the Overview and Users Guide, DSS Users Manual.

b. Catalogs

In order to find out what records a DSS file contains, a catalog file can be generated. A catalog file is simply a listing of pathnames for the records in the file (see Fig. 4). The utility programs DSSUTL and DSPLAY both have the capability to generate catalogs.

c. Behind the scenes

The DSS uses a hierarchical or tree-like structure (based upon the data's unique pathname) to store and retrieve data. The DSS software does not sequentially search for data, but uses its pathname to index its position within the file. This technique allows the rapid storage and retrieval of data from the file, regardless of its size.

6. Utility Programs

A number of utility programs will be described and used in this course. Some of the programs are for entering data; others are for editing data, preparing graphical displays, or reports. Two of the most widely used utility programs are DSSUTL and DSPLAY. Capabilities of DSSUTL are as follows:

a. Catalog a DSS file.

b. Write out data from a DSS file in a formatted form.

c. Read in formatted data.

d. Edit data.

e. Tabulate data.

f. Copy data from one DSS file to another.

g. Delete data.

h. Rename data.

i. "Squeeze" dead space from a DSS file.

Some capabilities of the DSPLAY program are as follows:

a. Develop plots of data from standard data records stored in a DSS file.

b. Tabulate data from standard data records stored in a DSS file.

c. Linear, logarithmic or probability scales may be used for plotting. Multiple curves may be plotted. Optional grids, shading and labelling may be used.

d. Data can be edited graphically using either cross-hairs on the display screen, or a digitizer tablet, if available.

References

Hydrologic Engineering Center, 1985. HECDSS Users Guide and Utility Program Manuals. U.S. Army Corps of Engineers, Davis, California.

Pabst, Arthur F., 1984. Data Management for Hydrologic Engineering. In Proceedings of a Conference on Emerging Computer Techniques in Stormwater and Flood Management, 29 October - 4 November, 1983. American Society of Civil Engineers.

TYPES OF DATA USED FOR WATER RESOURCES STUDIES

Time series data

- o **METEOROLOGICAL DATA** (precipitation, temperature, evaporation, etc.)
- o **HYDROGRAPHIC DATA** (river stage and discharge, reservoir elevation, etc.)

Paired data ie: one unit as a function of another

- o **PHYSICAL CHARACTERISTICS** (drainage areas, soil type, land use, river cross sections, reservoir area-elevation-capacity, structure dimensions, etc.)
- o **ECONOMIC DATA** (damage-stage, cost, etc.)
- o **STATISTICAL DATA** (depth-area-duration, exceedance frequency, etc.)
- o **MODEL PARAMETERS** (runoff, reservoir system operation, economic evaluations, etc.)

Table 1. Types of Data Used for Water Resource Studies

Data Entry Programs

GOESLD	Load data from GOES Data Collection Platforms.
DSSIN	Enter bulk quantities of time series data.
DSSITS	Enter irregular-interval time series data.
DSSPD	Enter paired-function data.
DSSTS	Enter regular-interval time series data.
DWINDO	Full-screen data entry and editing.
NWSDSS	Load daily and hourly climatological (e.g., precipitation) data from NWS tapes.
PIP	Enter flood damage paired-function data.
SHFDSS	Load data that is in the Standard Hydrometeorological Exchange Format (SHF). There is also a program DSSSHF that encodes data from a DSS file into the SHF.
WATDSS	Load streamflow data that is in the WATSTORE format.

Programs for Editing, Displaying, etc.

DSPLAY	Graphical and tabular display of data from a DSS file.
DSSUTL	General management and editing of data in a DSS file.
REPGEN	Create reports with data from a DSS or text file.
MATHPK	Perform mathematical transformations or statistical calculations on data stored in a DSS file.
WCCOMP	Provides specialized functional capabilities for processing real-time operational hydrological data.

Table 2. List of DSS Utility Programs

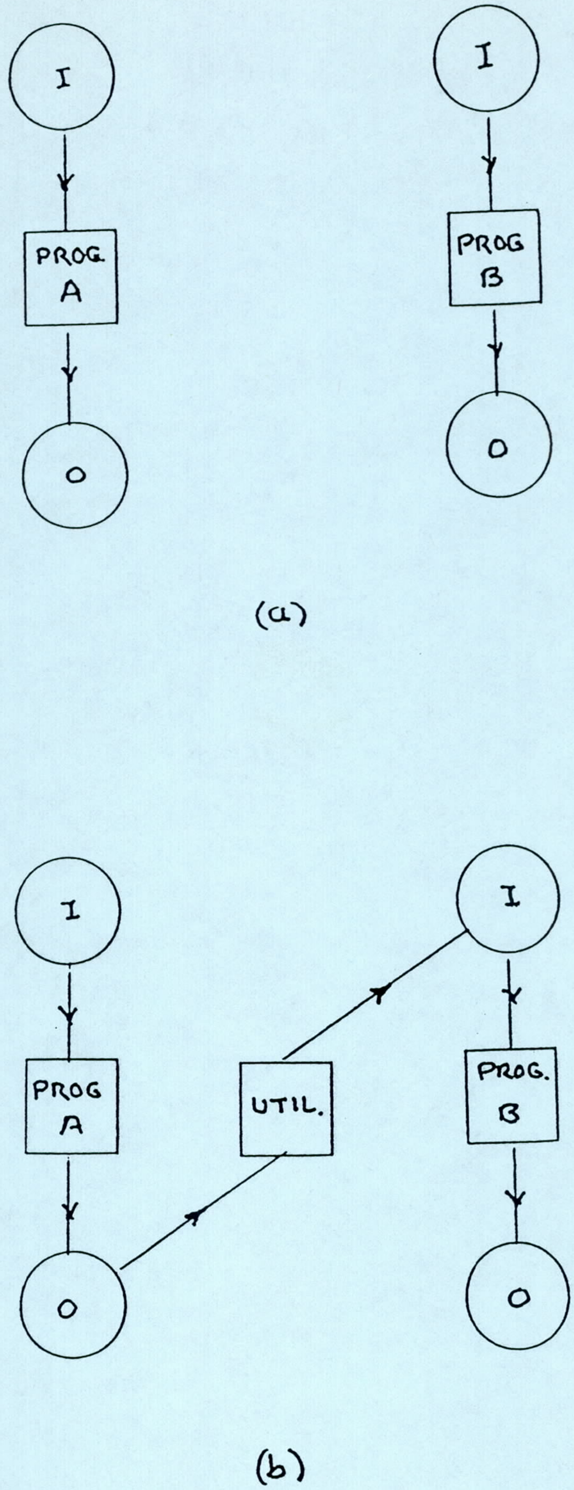
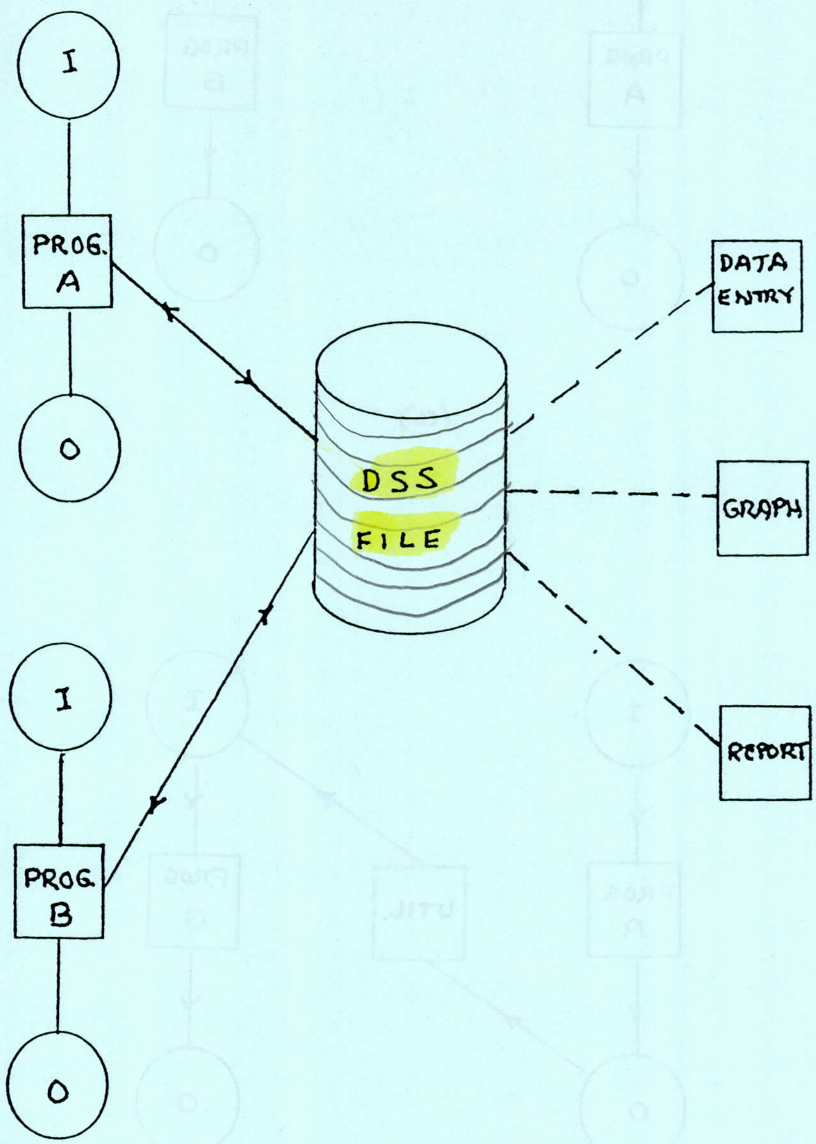


Figure 1. Methods for Data Transfer



(C)

Figure 1 cont'd. Methods for Data Transfer

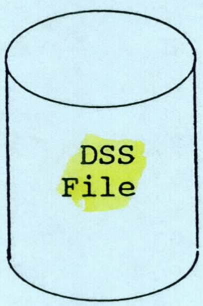
FORTRAN

Library of
DSS
Subroutines

ZOPEN
ZCLOSE
ZPTDTS
ZGTDTS
.
.
.

Applications
Programs

HEC-1
HEC-2
HEC-5
EAD
.
.
.



Utility
Programs

Data Entry
Editor
Graphics
Reports

INFO STORED W/ DATA

THE DSS FILE:

- DIRECT ACCESS
- CAN HAVE MULTIPLE-USER ACCESS
- DATA STORED IN BLOCKS
- DATA IS SELF-DOCUMENTED

Figure 2. Components of the Data Storage System

/KANAWHA/ALIR7/FLOW/01APR1977/3HOUR/M24AFB/
START = 01APR1977, 0300 HRS; (END = 30APR1977, 2400 HRS, NO. DATA = 240)
UNITS = CFS TYPE = INST-VAL

01APR77, 0300;	5237.	5214.	5214.	5237.	5295.	5203.
01APR77, 2100;	3968.	4326.	4776.	4233.	3898.	4049.
02APR77, 1500;	4441.	4568.	4210.	3696.	3565.	3725.
03APR77, 0900;	3818.	3968.	4222.	4314.	4383.	4626.
04APR77, 0300;	4868.	5214.	6298.	10099.	14368.	16257.
04APR77, 2100;	18134.	24033.	27602.	33056.	38599.	41864.
05APR77, 1500;	42541.	41542.	40254.	37482.	33785.	30058.
06APR77, 0900;	26658.	23649.	21007.	18691.	16658.	14871.
07APR77, 0300;	13298.	11911.	10805.	9917.	9115.	8391.
07APR77, 2100;	7737.	7146.	6611.	6127.	5690.	5296.
08APR77, 1500;	4957.	4682.	4448.	4236.	4040.	3857.
09APR77, 0900;	3686.	3525.	3374.	3233.	3100.	2975.
10APR77, 0300;	-901.	-901.	-901.	-901.	-901.	-901.
10APR77, 2100;	-901.	-901.	-901.	-901.	-901.	-901.
11APR77, 1500;	-901.	-901.	-901.	-901.	-901.	-901.
12APR77, 0900;	-901.	-901.	-901.	-901.	-901.	-901.
13APR77, 0300;	-901.	-901.	-901.	-901.	-901.	-901.
13APR77, 2100;	-901.	-901.	-901.	-901.	-901.	-901.
14APR77, 1500;	-901.	-901.	-901.	-901.	-901.	-901.
15APR77, 0900;	-901.	-901.	-901.	-901.	-901.	-901.
16APR77, 0300;	-901.	-901.	-901.	-901.	-901.	-901.
16APR77, 2100;	-901.	-901.	-901.	-901.	-901.	-901.
17APR77, 1500;	-901.	-901.	-901.	-901.	-901.	-901.
18APR77, 0900;	-901.	-901.	-901.	-901.	-901.	-901.
19APR77, 0300;	-901.	-901.	-901.	-901.	-901.	-901.
19APR77, 2100;	-901.	-901.	-901.	-901.	-901.	-901.
20APR77, 1500;	-901.	-901.	-901.	-901.	-901.	-901.
21APR77, 0900;	-901.	-901.	-901.	-901.	-901.	-901.
22APR77, 0300;	-901.	-901.	-901.	-901.	-901.	-901.
22APR77, 2100;	-901.	-901.	-901.	-901.	-901.	-901.
23APR77, 1500;	-901.	-901.	-901.	-901.	-901.	-901.
24APR77, 0900;	-901.	-901.	-901.	-901.	-901.	-901.
25APR77, 0300;	-901.	-901.	-901.	-901.	-901.	-901.
25APR77, 2100;	-901.	-901.	-901.	-901.	-901.	-901.
26APR77, 1500;	-901.	-901.	-901.	-901.	-901.	-901.
27APR77, 0900;	-901.	-901.	-901.	-901.	-901.	-901.
28APR77, 0300;	-901.	-901.	-901.	-901.	-901.	-901.
28APR77, 2100;	-901.	-901.	-901.	-901.	-901.	-901.
29APR77, 1500;	-901.	-901.	-901.	-901.	-901.	-901.
30APR77, 0900;	-901.	-901.	-901.	-901.	-901.	-901.

Figure 3. A DSS Record

```
HECDSS COMPLETE CATALOG OF RECORD PATHNAMES ON FILE  0000P57J DSSF86

SHORT FORM;  CATALOG DATE = 05JAN87, TIME = 10:45:45
NUMBER OF RECORDS =    35

 1  /CALAVERAS/BELLOC/FLOW/01FEB1986/1HOUR/FEB86E/
 2  /CALAVERAS/BELOTA/FLOW/01FEB1986/1HOUR/FEB86E/
 3  /CALAVERAS/BELOTA/FLOW/01JAN1986/1HOUR/OBS/
 4  /CALAVERAS/BELOTA/FLOW/01FEB1986/1HOUR/OBS/
 5  /CALAVERAS/BELOTA/FLOW/01MAR1986/1HOUR/OBS/
 6  /CALAVERAS/BELOTA/PRECIP-INC/01FEB1986/1HOUR/FEB86/
 7  /CALAVERAS/FLM/PRECIP-INC/01JAN1986/1HOUR/OBS/
 8  /CALAVERAS/FLM/PRECIP-INC/01FEB1986/1HOUR/OBS/
 9  /CALAVERAS/FLM/PRECIP-INC/01MAR1986/1HOUR/OBS/
10  /CALAVERAS/NHD/PRECIP-INC/01JAN1986/1DAY/OBS/
11  /CALAVERAS/NHDOF/FLOW/01FEB1986/1HOUR/FEB86E/
12  /CALAVERAS/NHDOF/FLOW/01JAN1986/1HOUR/OBS/
13  /CALAVERAS/NHDOF/FLOW/01FEB1986/1HOUR/OBS/
14  /CALAVERAS/NHDOF/FLOW/01MAR1986/1HOUR/OBS/
15  /CALAVERAS/NHOGAN/ELEVATION/01JAN1986/1HOUR/OBS/
16  /CALAVERAS/NHOGAN/ELEVATION/01FEB1986/1HOUR/OBS/
17  /CALAVERAS/NHOGAN/ELEVATION/01MAR1986/1HOUR/OBS/
18  /CALAVERAS/NHOGAN/FLOW/01FEB1986/1HOUR/FEB86E/
19  /CALAVERAS/NHOGAN/FLOW/01JAN1986/1HOUR/OBS/
20  /CALAVERAS/NHOGAN/FLOW/01FEB1986/1HOUR/OBS/
21  /CALAVERAS/NHOGAN/FLOW/01MAR1986/1HOUR/OBS/
22  /CALAVERAS/NHOGAN/PRECIP-INC/01FEB1986/1HOUR/FEB86/
23  /CALAVERAS/NHOGAN/STOR-ALLOW/01JAN1986/1DAY//
24  /CALAVERAS/NHOGAN/STORAGE/01JAN1986/1HOUR/OBS/
25  /CALAVERAS/NHOGAN/STORAGE/01FEB1986/1HOUR/OBS/
26  /CALAVERAS/NHOGAN/STORAGE/01MAR1986/1HOUR/OBS/
27  /CALAVERAS/PER/PRECIP-INC/01JAN1986/1HOUR/OBS/
28  /CALAVERAS/PER/PRECIP-INC/01FEB1986/1HOUR/OBS/
29  /CALAVERAS/PER/PRECIP-INC/01MAR1986/1HOUR/OBS/
30  /CALAVERAS/RRF/PRECIP-INC/01JAN1986/1HOUR/OBS/
31  /CALAVERAS/RRF/PRECIP-INC/01FEB1986/1HOUR/OBS/
32  /CALAVERAS/RRF/PRECIP-INC/01MAR1986/1HOUR/OBS/
33  /CALAVERAS/SHR/PRECIP-INC/01JAN1986/1HOUR/OBS/
34  /CALAVERAS/SHR/PRECIP-INC/01FEB1986/1HOUR/OBS/
35  /CALAVERAS/SHR/PRECIP-INC/01MAR1986/1HOUR/OBS/
```

Figure 4. A DSS Catalog

Paired Data and FDA Programs

I. Paired Data and the HECDSS Data Storage System

The paired data convention is a set of rules for storing data in a DSS file. Any type of data may be stored, even "time series" data. However, DSS utility programs recognize a separate time series convention which allow them to store data more efficiently and display data in better formats. The rules define the contents of the "header", the data, and the pathname for paired function data.

Paired function data may be conceptualized as a matrix of values. For example:

	col_1	col_2	col_3	col_4	...	col_n
row_1	...	...	...	...	...	...
row_2	...	...	...	...	...	...
row_3	...	...	...	...	...	...
row_4	...	...	...	...	...	...
row_5	...	...	...	...	...	...
row_6	...	...	...	...	...	...
row_7	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
row_n	...	...	...	...	...	...

When used in the DSS system, this matrix of data has certain conventions including the following:

1 The rows of the matrix are called ordinates or values.

2 The columns of the matrix are called vectors --- two vectors form a curve.

3 Paired data convention consists of two variables: one "independent" and one "dependent".

4 There can be only one vector associated with the first variable.

5 DSS documentation sometimes references the data by "curve" which identifies the vector of the second variable (the first variable is always used as a component of the "curve").

6 Either the "dependent" or the "independent" data may be stored first in the matrix (the first variable). DSS documentation refers to the variables in two ways:

   (1) The first variable and the second variable, where the first variable occupies the first storage locations in the matrix and the second variable occupies space after the first variable.

   (2) The independent variable and the dependent variable, where the independent variable is assumed to occupy the first storage locations in the matrix, and the dependent variable the subsequent locations. This may contradict the physical meaning of the variables (e.g. damage is a function of elevation rather than the reverse).

7 Part C of the pathname must contain both variable names separated by a hyphen "-", the first (or independent) variable name entered first and the second (or dependent) variable name entered second. Several of HEC's programs automatically generate part C.

8 The first variable may be plotted on either the horizontal or vertical axis.

9 The header portion of the DSS record contains information about the data including: units (e.g. CFS for cubic-feet-per-second), and the data type or transformation (e.g. PROB for probability).

10 If the data consists of more than one vector for the second variable, the user may define an eight character label for each vector (or "curve").

By adopting a "convention", application programs may write and read to a data file and exchange data in a coherent manner. Computations performed by one program may be used as input to another program. The paired function convention is used extensively in the following areas:

1 The Flood Damage Analysis Package which includes the computer programs: HEC-1, HEC-2, HEC-5, SID, DAMCAL, EAD, and FDA2PO.

2 The MATHPK computer program which performs storage routing (Modified Puls, Working R&D) and table lookup (interpolation).

CONVENTIONS FOR PAIRED FUNCTION DATA

1. This material describes conventions applicable to standard paired function data stored in HEC-DSS. Each single variable may be one of at least three possible types: untransformed, logarithmic, or probabilistic. The first variable may have only one vector. The second variable must have at least one vector and may have more vectors. If the second variable has more than one vector, it is sometimes called a "repeating variable".

2. Each block of data is identified by a pathname consisting of 6 parts. Each part is defined by a separator. The slash (/) character is the default separator. A sample pathname is:

/A/B/C/D/E/F/

3. Part A - Group
This part of the data pathname is for general grouping of data. It may be a study name, watershed name, etc., that would cause all records associated in a certain way to sort together, be copied together, deleted together, or otherwise recognized as a group.

4. Part B - Location
This pathanme part is the basic location identification of the paired function data. It may be a control point, damage reach ID, station ID, or other such identifier.

5. Part C - Parameters
Because paired function data represents a relationship between 2 variables (or parameters), this part should contain the two variable names separated by a hyphen (-). Examples of valid variables are:

ELEVATION-DAMAGE, FREQ-FLOW, ELEV-FLOW, STATION-ELEVATION

In the above examples, ELEVATION, FREQ, ELEV and STATION are referred to as the first (1st) variable, respectively; while DAMAGE, FLOW, FLOW, and ELEVATION are the second (2nd) variable respectively.

6. Part D — OPTIONAL - NOT NEEDED
This part of the pathname is used to provide any further qualifications of the data. It may vary from application to application as appropriate.

7. Part E - Data Year   ONLY NEED - IF WE RUN MORE THAN ONE YEAR
This part of the pathname is used only if the paired function data is representative of a specific point in time such as a forecast for the year 2010 condition.

8. Part F - Qualifier
This part of the pathname identifies the unique qualifier of the data such as the situation, condition, or alternative plan name associated with the paired function data (for example, /GATED RES-400,000AF/ .

9. For plotting purposes, Parts A, B, C, E & F are used for curve labeling. The header information (see next page) will help define the data units, transformation, etc.

HEADER INFORMATION FOR PAIRED FUNCTION DATA

Entry	Type	Length (Chars.)	Word	Use
1	I	-	1	Record type = 2
2	I	-	2	Length of header in words.
3	I	-	3	Number of coordinates (number of values in each vector).
4	I	-	4	Number of times the first variable in parameter name (Part C) repeats. Under the current releases of the HECDSS, this must be set to "1" (one vector of information).
5	I	-	5	Number of times the second variable in parameter name (Part C) repeats (or the number of vectors associated with the second variable).
6	I	-	6	Variable number to appear on the horizontal axis when plotted; i.e. 1 or 2 for first or second variable.
7	C	8	7-10	First variable units of data (CFS, FEET, PERCENT, etc.).
8	C	8	11-14	Second variable units of data ($1000, CFS, etc.).
9	C	4	15-16	First variable data transformation (UNT, LOG, PROB).
10	C	4	17-18	Second variable data transformation (UNT, LOG, PROB).
11-22	C		19-30	Reserved
23	C	8	31-34	Label for first occurence of the repeating variable.
24	C	8	35-38	Label for second occurence of the repeating variable, if present.
.				Label for nth occurence of the repeating variable, if present.
.				
.				
.				

Example: ELEVATION-DAMAGE FUNCTION

	DAMAGE IN $1000	
ELEVATION	S.F. RES	COMMERCIAL
500.0	0.0	0.0
501.0	0.0	0.0
502.0	25.8	0.0
503.0	33.4	125.6
504.0	51.2	323.4
505.0	77.8	525.5
506.0	93.8	655.7
507.0	111.9	753.3
508.0	137.9	809.1
509.0	154.5	846.3
510.0	166.2	869.6
511.0	177.6	878.8
512.0	188.7	883.5
513.0	194.8	883.5
514.0	201.6	883.5
515.0	209.3	883.5
516.0	216.0	883.5
517.0	223.8	883.5

PATHNAME (/A/B/C/D/E/F/):
/JAMES RIVER/DR1/ELEVATION-DAMAGE//1980/FLOOD PROOF PLAN B/

HEADER INFORMATION:

ENTRY	WORD	VALUE
1	1	2
2	2	38
3	3	18
4	4	1
5	5	2
6	6	2 (damage on horizontal axis)
7	7-10	FEET
8	11-14	$1000
9	15-16	UNT
10	17-18	UNT
11-22	19-30	Blank --- unused
23	31-34	S.F. RES
24	35-38	COMMERCL

DATA STORAGE

The actual paired function data is stored in computer memory with the first variable (ELEVATION in this case) occupying the first IHEAD(3) words of memory (in this case, 18), and the second variable (DAMAGE in this case) in the next IHEAD(3) memory words, repeatedly.

II. Conventions and Limitations In Using DSS With the FDA Package

While the user may define the pathname parts in any manner, the following nameing conventions are used in conjunction with the FDA package:

Pathname Part	Description
A	River basin or project identifier.
B	Location, reach, or gage identifier.
C	Data variables.
D	Not used.
E	Year corresponding to data.
F	Alternative name or data variable qualifier.

Example pathnames for frequency curves determined using HEC-1 are shown below:

/SILVER CREEK/RCH 1/FREQ-FLOW//1990/BASE/
/SILVER CREEK/RCH 1/FREQ-FLOW//1990/UNGTD RES/

A pathname cannot exceed 80 characters including the "/" (slash) separators. DSS limits individual parts to 32 characters. Application programs further limit those pathname parts by allowing a limited number of columns of user input. As a result, the following limitations apply to pathname parts when used in Flood Damage Analysis:

Part	Max. number of chars.	
A	14	(if using fixed format)
B	6	
E	4	(if using fixed format)
F	22	(if using fixed format)

Example input to HEC-1 and the EAD programs to write and read data from/to a DSS data file:

Valid example:

```
ZW  A= SILVER CREEK  E=1990   F=BASE
ZR  A=SILVER CREEK B=RCH1 C=QF E=1990 F=  BASE
```

EAD will be able to read frequency curves written to DSS by HEC-1 because leading and trailing blanks of a pathname part are ignored. DSS software will ignore the leading blank before "SILVER CREEK" on the ZW card and the leading blanks before "BASE" on the ZR card.

Invalid example:

PATHNAMES MUST BE VERBATIM.

```
ZW A=SILVER  CREEK E=1990 F=BASE
ZR A=SILVER CREEK B=RCH1 C=QF E=1990 F=BASE
```

EAD will not be able to retrieve the frequency curve written by HEC-1 because the HEC-1 ZW card contains two blank columns between "SILVER" and "CREEK" whereas the EAD ZR card contains only one.

TABLE 2: Location of DSS Pathname Parts [1]
(fixed-format input)

Program	A	B	C	D	E	F
			Pathname Part			
HYDPAR	ZW.1-2	SB-5	AG	NA	ZW.6	ZW.3-5
HEC-1	ZW.1-2	FR.1[2]	AG	NA	ZW.6	ZW.3-5
HEC-2	ZW.1-2	X1.1	AG	NA	ZW.6	ZW.3-5
HEC-5	ZW [3]	ID.1-2	AG	NA	ZW [3]	ZW [3]
SID	ZW.1-2	DR.1	AG	NA	ZW.6	ZW.3-5
DAMCAL	ZW.1-2	DT.1	AG	NA	ZW.6	ZW.3-5
EAD	ZR.1-2	[4]	AG [5]	NA	[6]	ZR.3-5
EAD	ZR.1-2	QF.1	AG	NA	QF.2	ZR.3-5
EAD	ZR.1-2	QS.1	AG	NA	QS.2	ZR.3-5
EAD	ZR.1-2	DG.1	AG	NA	DG.2	ZR.3-5

note:

[1] The part location is identified by the code: "xx.n-m"

where:

xx is the record code identifier entered in columns one and two for an application program (i.e. "ZW").

n-m is the field locations on that record. If only one field is occupied, then "-m" is not entered. Sometimes, partial fields are used. That is documented with the detailed record descriptions.

The code "NA" indicates that part is not used and the code "AG" indicates that part is automatically generated by the applications program.

[2] HEC-1 generates part B from field one of the FR record. If it is blank, then it uses the first field of the preceding KK record.

[3] HEC-5 requires the user to enter "ZWQF" in columns one through four to store flow-frequency data in a DSS file. Parts A, E, and F are entered in a free format style. For example:
ZWQF A=BEDROCK CREEK, E=1990, F=BASE

[4] EAD generates part B from field one of the following records: QF,QS,DG.

[5] EAD automatically generates part C based on the type of record input: QF,QS, or DG.

[6] EAD generates part E from field 2, columns nine through twelve of the following records: QF,QS, or DG.

III. The Interactive Paired-Function Data Input Program For Flood Damage Data (PIP)

PIP is designed to assist in inserting and storing flood damage paired- function data in the HECDSS. By using PIP, a person can enter data directly from a keyboard into a DSS file. The program is menu-driven to assist users during execution and includes on-line help instructions. The type of data the PIP processes is called "paired-function" data. A paired-function is an x-y relationship with either:

(1) one independent variable and one dependent variable, such as an elevation-flow curve; or

(2) one independent variable and more than one dependent variable, such as an elevation-damage function where one set of elevations are defined for more than one damage category.

DON'T NEED PIP IF YOU USE SID

The six (6) paired-functions that may be input using PIP are:

1. elevation-damage data (ELEVATION-DAMAGE)
2. elevation-flow data (ELEV-FLOW)
3. exceedance frequency-elevation data (FREQ-ELEV)
4. exceedance frequency-flow data (FREQ-FLOW)
5. flow-damage data (FLOW-DAMAGE)
6. exceedance frequency-damage data (FREQ-DAMAGE)

The following example demonstrates the use of the PIP computer program. All of the user's responses are underlined.

```
*****************************************************************
*  PIP - Paired-function data Input Program for HECDSS          *
*  Version date: October 1, 1989                                *
*  IBM-PC Compatible (MS)                                       *
*  Rundate 10JAN90     Time 19:55:57                            *
*****************************************************************


   O P E N I N G   M E N U

      0  EXIT PROGRAM

      1  GENERAL HELP MENU

      2  PATHNAME MENU

      3  DATA ENTRY MENU

      4  DATA-FILE MENU

Enter: item number or (H)elp> 1
                         G E N E R A L   H E L P   M E N U

                                                         OTHER MENUS

   0  EXIT PROGRAM          :  3  SAVE AND EDIT DATAFILE :  5  PATHNAME MENU
                            :                            :
   1  SET HELP LEVEL        :  4  DATA-FILE STRUCTURE    :  6  DATA ENTRY MENU
                            :                            :
   2  GENERAL INSTRUCTIONS  :                            :  7  DATA-FILE MENU

Enter: item number or (H)elp> 1
  Help levels:

    0  All data entry instructions displayed
    1  All data entry instructions suppressed

  Current help level is 0
Enter space or new help level (0 or 1)> 1
  Current help level is now 1

                         G E N E R A L   H E L P   M E N U

                                                         OTHER MENUS

   0  EXIT PROGRAM          :  3  SAVE AND EDIT DATAFILE :  5  PATHNAME MENU
                            :                            :
   1  SET HELP LEVEL        :  4  DATA-FILE STRUCTURE    :  6  DATA ENTRY MENU
                            :                            :
   2  GENERAL INSTRUCTIONS  :                            :  7  DATA-FILE MENU

Enter: item number or (H)elp> 5
```

```
          P A T H N A M E   M E N U
                                               OTHER MENUS

     0  EXIT PROGRAM                       :  3  GENERAL HELP MENU
                                           :
     1  SET PROJECT NAME (part A)          :  4  DATA ENTRY MENU
                                           :
     2  SET ALTERNATIVE NAME (part F)      :  5  DATA-FILE MENU

Enter: item number or (H)elp> 1

 Current Project name:
Enter Project name (max 32 characters)> COOPER CREEK
Enter: item number or (H)elp> 2

 Current Alternative name:
Enter Alternative name (max 32 characters)> BASE
Enter: item number or (H)elp> 4

          D A T A   E N T R Y   M E N U
                                           OTHER MENUS

     0  EXIT PROGRAM                  :  4  GENERAL HELP MENU
                                      :
     1  SET LOCATION (part B)         :  5  PATHNAME MENU
                                      :
     2  SET DATA YEAR (part E)        :  6  DATA-FILE MENU
                                      :
     3  SELECT DATA TYPE              :

Enter: item number or (H)elp> 1

 Current location:
Enter location (max 6 characters> 3
Enter: item number or (H)elp> 3

              D A T A   T Y P E   M E N U
                                                      OTHER MENUS

     0  EXIT PROGRAM      :  4  FREQ-FLOW          :  8  GENERAL HELP MENU
                          :                        :
     1  ELEVATION-DAMAGE  :  5  FLOW-DAMAGE        :  9  PATHNAME MENU
                          :                        :
     2  ELEV-FLOW         :  6  FREQ-DAMAGE        : 10  DATA ENTRY MENU
                          :                        :
     3  FREQ-ELEV         :  7  DISPLAY PATHNAME   : 11  DATA-FILE MENU

Enter: item number or (H)elp> 4
Enter FREQUENCY-FLOW> 99 515
Enter FREQUENCY-FLOW> 50 1675
Enter FREQUENCY-FLOW> 20 2579
Enter FREQUENCY-FLOW> 10 3236
Enter FREQUENCY-FLOW> 4 4140
Enter FREQUENCY-FLOW> 2 4790
Enter FREQUENCY-FLOW> 1 5430
```

Enter FREQUENCY-FLOW> **.2 6889**

Enter FREQUENCY-FLOW> **.01 9219**

Enter FREQUENCY-FLOW> **"Enter" key pressed**

Do you want to display the data?
(You cannot edit the data without displaying it)

Display? (Y or N)> **Y**

Data display

Point	FREQUENCY	FLOW
1	99.00	515.00
2	50.00	1675.00
3	20.00	2579.00
4	10.00	3236.00
5	4.00	4140.00
6	2.00	4790.00
7	1.00	5430.00
8	.20	6889.00
9	.01	9219.00

Do you want to edit the data? (Y or N)> **N**

```
          D A T A   E N T R Y   M E N U

                                         OTHER MENUS

  0  EXIT PROGRAM              :   4  GENERAL HELP MENU
                               :
  1  SET LOCATION (part B)     :   5  PATHNAME MENU
                               :
  2  SET DATA YEAR (part E)    :   6  DATA-FILE MENU
                               :
  3  SELECT DATA TYPE          :
```

Enter: item number or (H)elp> **1**

Current location: 3

Enter location (max 6 characters> **27415.**

Enter: item number or (H)elp> **3**

```
                 D A T A   T Y P E   M E N U

                                                  OTHER MENUS

  0  EXIT PROGRAM      :  4  FREQ-FLOW         :  8  GENERAL HELP MENU
                       :                       :
  1  ELEVATION-DAMAGE  :  5  FLOW-DAMAGE       :  9  PATHNAME MENU
                       :                       :
  2  ELEV-FLOW         :  6  FREQ-DAMAGE       : 10  DATA ENTRY MENU
                       :                       :
  3  FREQ-ELEV         :  7  DISPLAY PATHNAME  : 11  DATA-FILE MENU
```

Enter: item number or (H)elp> **2**

Enter ELEVATION-FLOW> **616.77 190**

Enter ELEVATION-FLOW> **620.17 1000**

Enter ELEVATION-FLOW> **622.04 1800**

Enter ELEVATION-FLOW> **623.01 2650**

Enter ELEVATION-FLOW> **623.5 3250**

Enter ELEVATION-FLOW> **624.05 4100**

Enter ELEVATION-FLOW> **624.38 4700**

```
Enter ELEVATION-FLOW> 625.42
Enter ELEVATION-FLOW> "Enter" key pressed
  Do you want to display the data?
 (You cannot edit the data without displaying it)

Display? (Y or N)> Y
  Data display
  Point      ELEVATION          FLOW
     1          616.77        190.00
     2          620.17       1000.00
     3          622.04       1800.00
     4          623.01       2650.00
     5          623.50       3250.00
     6          624.05       4100.00
     7          624.38       4700.00
     8          625.42           .00
Do you want to edit the data? (Y or N)> Y


 You may:
      (C)hange
      (D)elete
      (I)nsert
      (L)ist data
   or e(X)it and return to data display.

Enter: Action code (C,D,I,L,X), Point no., New values> I 7
 Current values:   Point no.     ELEVATION     FLOW
                           7        624.38       4700.00

Enter new ELEVATION>  625.36 6900

Enter: Action code (C,D,I,L,X), Point no., New values> L,,
 Range set to: 1-9
  Point      ELEVATION          FLOW
     1          616.77        190.00
     2          620.17       1000.00
     3          622.04       1800.00
     4          623.01       2650.00
     5          623.50       3250.00
     6          624.05       4100.00
     7          624.38       4700.00
     8          625.36       6900.00
     9          625.42           .00

Enter: Action code (C,D,I,L,X), Point no., New values> C
Enter point no.> 8
 Current values:   Point no.     ELEVATION     FLOW
                           8        625.36       6900.00

Enter new ELEVATION>  "Enter" key pressed
 Value of ELEVATION retained:      625.36
Enter new FLOW     > "Enter" key pressed
 Value of FLOW      retained:    6900.00

 New values:   Point no.     ELEVATION     FLOW
                       8        625.36       6900.00
```

```
Enter: Action code (C,D,I,L,X), Point no., New values> C 9
 Current values:   Point no.      ELEVATION      FLOW
                           9        625.42              .00

Enter new ELEVATION>  "Enter" key pressed
 Value of ELEVATION retained:       625.42
Enter new FLOW      >  7100

 New values:   Point no.    ELEVATION    FLOW
                       9      625.42      7100.00


Enter: Action code (C,D,I,L,X), Point no., New values> L,,
 Range set to: 1-9
  Point       ELEVATION            FLOW
     1         616.77          190.00
     2         620.17         1000.00
     3         622.04         1800.00
     4         623.01         2650.00
     5         623.50         3250.00
     6         624.05         4100.00
     7         624.38         4700.00
     8         625.36         6900.00
     9         625.42         7100.00

Enter: Action code (C,D,I,L,X), Point no., New values> X
  Do you want to display the data?
 (You cannot edit the data without displaying it)

Display? (Y or N)>  Y
  Data display
  Point       ELEVATION            FLOW
     1         616.77          190.00
     2         620.17         1000.00
     3         622.04         1800.00
     4         623.01         2650.00
     5         623.50         3250.00
     6         624.05         4100.00
     7         624.38         4700.00
     8         625.36         6900.00
     9         625.42         7100.00
Do you want to edit the data? (Y or N)>  Y


 You may:
      (C)hange
      (D)elete
      (I)nsert
      (L)ist data
   or e(X)it and return to data display.

Enter: Action code (C,D,I,L,X), Point no., New values> I 7
 Current values:   Point no.      ELEVATION      FLOW
                           7        624.38        4700.00

Enter new ELEVATION>  624.73 5400

Enter: Action code (C,D,I,L,X), Point no., New values> L,,
 Range set to: 1-10
  Point       ELEVATION            FLOW
     1         616.77          190.00
     2         620.17         1000.00
     3         622.04         1800.00
     4         623.01         2650.00
```

```
     5          623.50         3250.00
     6          624.05         4100.00
     7          624.38         4700.00
     8          624.73         5400.00
     9          625.36         6900.00
    10          625.42         7100.00

Enter: Action code (C,D,I,L,X), Point no., New values> X
  Do you want to display the data?
 (You cannot edit the data without displaying it)

Display? (Y or N)> N

            D A T A   E N T R Y   M E N U

                                               OTHER MENUS

     0  EXIT PROGRAM               :   4  GENERAL HELP MENU
                                   :
     1  SET LOCATION (part B)      :   5  PATHNAME MENU
                                   :
     2  SET DATA YEAR (part E)     :   6  DATA-FILE MENU
                                   :
     3  SELECT DATA TYPE           :

Enter: item number or (H)elp> 1

 Current location: 27415.
Enter location (max 6 characters> SID11
Enter: item number or (H)elp> 2

 Current input data year:
Enter input data year (max 4 digits)> 1990
Enter: item number or (H)elp> 3

                    D A T A   T Y P E   M E N U

                                                          OTHER MENUS

     0  EXIT PROGRAM      :  4  FREQ-FLOW         :  8  GENERAL HELP MENU
                          :                       :
     1  ELEVATION-DAMAGE  :  5  FLOW-DAMAGE       :  9  PATHNAME MENU
                          :                       :
     2  ELEV-FLOW         :  6  FREQ-DAMAGE       : 10  DATA ENTRY MENU
                          :                       :
     3  FREQ-ELEV         :  7  DISPLAY PATHNAME  : 11  DATA-FILE MENU

Enter: item number or (H)elp> 1
Enter damage category name (max 8 characters)> RESIDENT
ENTER ELEVATION-DAMAGE> 615 0
ENTER ELEVATION-DAMAGE> 616 0
ENTER ELEVATION-DAMAGE> 617 0
ENTER ELEVATION-DAMAGE> 618 0
ENTER ELEVATION-DAMAGE> 619 0
ENTER ELEVATION-DAMAGE> 620 0
ENTER ELEVATION-DAMAGE> 621 0
ENTER ELEVATION-DAMAGE> 622 0
ENTER ELEVATION-DAMAGE> 623 .56
```

```
ENTER ELEVATION-DAMAGE> 624 66.54
ENTER ELEVATION-DAMAGE> 625 228.75
ENTER ELEVATION-DAMAGE> 626 367.46
ENTER ELEVATION-DAMAGE> 627 505.37
ENTER ELEVATION-DAMAGE> 628 619.42
ENTER ELEVATION-DAMAGE> 629 716.96
ENTER ELEVATION-DAMAGE> 630 785.24
ENTER ELEVATION-DAMAGE> 631 821.7
ENTER ELEVATION-DAMAGE> 632 851.31
ENTER ELEVATION-DAMAGE> "Enter" key pressed
  Do you want to display the data?
 (You cannot edit the data without displaying it)

Display? (Y or N)> Y
  Data display
  Damage Category = RESIDENT

  Point      ELEVATION         DAMAGE
      1        615.00             .00
      2        616.00             .00
      3        617.00             .00
      4        618.00             .00
      5        619.00             .00
      6        620.00             .00
      7        621.00             .00
      8        622.00             .00
      9        623.00             .56
     10        624.00           66.54
     11        625.00          228.75
     12        626.00          367.46
     13        627.00          505.37
     14        628.00          619.42
     15        629.00          716.96
     16        630.00          785.24
     17        631.00          821.70
     18        632.00          851.31
Do you want to edit the data? (Y or N)> N
Enter damage category name (max 8 characters)> SCHOOL
ELEVATION = 615.00   ENTER DAMAGE> 0
ELEVATION = 616.00   ENTER DAMAGE> 0
ELEVATION = 617.00   ENTER DAMAGE> 0
ELEVATION = 618.00   ENTER DAMAGE> 0
ELEVATION = 619.00   ENTER DAMAGE> 0
ELEVATION = 620.00   ENTER DAMAGE> 0
ELEVATION = 621.00   ENTER DAMAGE> 0
ELEVATION = 622.00   ENTER DAMAGE> 12.2
ELEVATION = 623.00   ENTER DAMAGE> 21.2
ELEVATION = 624.00   ENTER DAMAGE> 29.32
ELEVATION = 625.00   ENTER DAMAGE> 42.54
ELEVATION = 626.00   ENTER DAMAGE> 55.32
ELEVATION = 627.00   ENTER DAMAGE> 68.54
ELEVATION = 628.00   ENTER DAMAGE> 77.05
ELEVATION = 629.00   ENTER DAMAGE> 80.83
ELEVATION = 630.00   ENTER DAMAGE> 83.22
```

```
ELEVATION = 631.00   ENTER DAMAGE> 86.44
ELEVATION = 632.00   ENTER DAMAGE> 90.44
  Do you want to display the data?
 (You cannot edit the data without displaying it)

Display? (Y or N)> "Enter" key pressed
  Do you want to display the data?
 (You cannot edit the data without displaying it)

Display? (Y or N)> Y
  Data display
  Damage Category = SCHOOL

  Point      ELEVATION          DAMAGE
      1         615.00             .00
      2         616.00             .00
      3         617.00             .00
      4         618.00             .00
      5         619.00             .00
      6         620.00             .00
      7         621.00             .00
      8         622.00           12.20
      9         623.00           21.20
     10         624.00           29.32
     11         625.00           42.54
     12         626.00           55.32
     13         627.00           68.54
     14         628.00           77.05
     15         629.00           80.83
     16         630.00           83.22
     17         631.00           86.44
     18         632.00           90.44
Do you want to edit the data? (Y or N)> N
Enter damage category name (max 8 characters)> "Enter" key pressed

            D A T A   E N T R Y   M E N U

                                          OTHER MENUS

     0  EXIT PROGRAM               :   4  GENERAL HELP MENU
                                   :
     1  SET LOCATION (part B)      :   5  PATHNAME MENU
                                   :
     2  SET DATA YEAR (part E)     :   6  DATA-FILE MENU
                                   :
     3  SELECT DATA TYPE           :

Enter: item number or (H)elp> 0
Do you want to save your data? (Y or N)> Y

 Current DSS filename: COOP.DSS
Enter DSS filename> COOP.DSS

  ** HECDSS File system read **
    -----DSS---ZOPEN; Existing File Opened - Unit:  71  File: COOP.DSS
 -----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/3/FREQ-FLOW///BASE/
 -----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/27415./ELEV-FLOW///BASE/
 -----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/SID11/ELEVATION-DAMAGE//1990/BASE/
    -----DSS---ZCLOSE Unit: 71
             Number of Records:      3
             File Size:       2.8  Kbytes
             Percent Inactive:    .00
```

Below, the file "DATAFILE" is listed. Every time PIP is executed and some function is entered by the user, the data is written to this file.

```
/COOPER CREEK/3/FREQ-FLOW///BASE/

 9  1  1  1 "PERCENT " "CFS      " "PROB" "UNT "

      99.00      515.00
      50.00     1675.00
      20.00     2579.00
      10.00     3236.00
       4.00     4140.00
       2.00     4790.00
       1.00     5430.00
        .20     6889.00
        .01     9219.00
/COOPER CREEK/27415./ELEV-FLOW///BASE/

10  1  1  2 "FEET     " "CFS      " "UNT " "UNT "

     616.77      190.00
     620.17     1000.00
     622.04     1800.00
     623.01     2650.00
     623.50     3250.00
     624.05     4100.00
     624.38     4700.00
     624.73     5400.00
     625.36     6900.00
     625.42     7100.00
/COOPER CREEK/SID11/ELEVATION-DAMAGE//1990/BASE/

18  1  2  2 "FEET     " "$1000    " "UNT " "UNT "
"RESIDENT""SCHOOL  "
     615.00         .00         .00
     616.00         .00         .00
     617.00         .00         .00
     618.00         .00         .00
     619.00         .00         .00
     620.00         .00         .00
     621.00         .00         .00
     622.00         .00       12.20
     623.00         .56       21.20
     624.00       66.54       29.32
     625.00      228.75       42.54
     626.00      367.46       55.32
     627.00      505.37       68.54
     628.00      619.42       77.05
     629.00      716.96       80.83
     630.00      785.24       83.22
     631.00      821.70       86.44
     632.00      851.31       90.44
```

ARLEN FELDMAN

Use of HEC Programs to Derive Modified Frequency Curves

1. Purpose of this discussion:

    Describe frequency curve computation methods.
    Discuss approaches for deriving modified frequency curves.
    Present pertinent HEC computer programs (models).
    Show how HEC-1 is used to compute modified frequencies for with-project conditions.
    Discuss HEC-1 input and output and connections with DSS.

2. HEC computer programs for use in modified frequency curve computation.

    HEC-1: Rainfall/snowmelt runoff computations for river basins
    HEC-2: Water surface profile computations in rivers (HEC-2 is discussed in another lecture)
    HEC-5: Reservoir system simulation for river basins
    HECWRC: Flood frequency computation from peak streamflows

3. Review of methods for flood frequency computation

    A. Analysis of historical streamflow records at sites of interest

    Peak flows (annual or partial duration)
    Stationary record?
    WRC Bulletin 17 Log-Pearson Type III frequency analysis (HECWRC)
    See Figure 1 for example of HECWRC analysis.

    B. Statistical analysis of regional streamflows

    USGS or other regression equations for rural/urban areas

    USGS Water Supply Paper No. 2207, "Flood Characteristics of Urban Watersheds in the United States," has good information for both rural and urban watersheds.

    An example of regional streamflow statistical analysis is the work of Stankowski, 1974. He used 103 stations in New Jersey with a total of 2,800 station years of record. Analysis was limited to basins less than 1,000 square miles and those not significantly affected by regulation or diversion. His generalized equation for the 1% flood is:

INPUT

FINAL RESULTS

-PLOTTING POSITIONS- COLUMBIA RIVER AT THE DALLES

HISTORICAL PEAKS

EVENTS ANALYZED				ORDERED EVENTS			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	WEIBULL PLOT POS
0	0	1858	563000.	1	1894	1246000.	.0083
0	0	1859	847000.	2	1948	1078000.	.0165
0	0	1860	668000.	3	1974	1074000.	.0248
0	0	1861	618000.	4	1972	1053000.	.0331
0	0	1862	948000.	5	1956	972000.	.0413
0	0	1863	777000.	6	1876	958000.	.0496
0	0	1864	654000.	7	1862	948000.	.0579
0	0	1865	714000.	8	1880	915000.	.0661
0	0	1866	839000.	9	1887	899000.	.0744
0	0	1867	671000.	10	1882	885000.	.0826
0	0	1972	1053000.	115	1941	353000.	.9504
0	0	1973	454000.	116	1977	342000.	.9587
0	0	1974	1074000.	117	1931	338000.	.9669
0	0	1975	732000.	118	1869	328000.	.9752
0	0	1976	685000.	119	1889	306000.	.9835
0	0	1977	342000.	120	1926	303000.	.9917

HEC WRC

FINAL RESULTS

-FREQUENCY CURVE- COLUMBIA RIVER AT THE DALLES

FLOW,CFS			CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	.05 LIMIT	.95 LIMIT
1230000.	1250000.	.002	1350000.	1140000.
1160000.	1180000.	.005	1270000.	1080000.
1110000.	1120000.	.010	1200000.	1040000.
1050000.	1060000.	.020	1130000.	985000.
984000.	989000.	.040	1060000.	927000.
886000.	888000.	.100	941000.	840000.
796000.	797000.	.200	839000.	759000.
637000.	637000.	.500	665000.	610000.
496000.	495000.	.800	520000.	471000.
431000.	429000.	.900	455000.	404000.
381000.	378000.	.950	406000.	354000.
298000.	294000.	.990	324000.	270000.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	5.7960	HISTORIC EVENTS	0
STANDARD DEVIATION	.1228	HIGH OUTLIERS	0
COMPUTED SKEW	-.4591	LOW OUTLIERS	0
GENERALIZED SKEW	.0000	ZERO OR MISSING	0
ADOPTED SKEW	-.4000	SYSTEMATIC EVENTS	120

Figure 1. Example HECWRC Frequency Curve Results

REGIONAL STREAMFLOW STATISTICS

USGS "WSP # 2207" water supply paper

$$Q_{100} = 136A^{0.84} S^{0.26} St^{-0.51} I^{0.14}$$

where Q_{100} = 1% peak flow

A = basin area

S = main channel slope

St = surface storage index

I = Impervious cover index

$$I = 0.117D^{0.792-0.039\log D}$$

D = population density in persons per square mile

C. Design storm runoff simulation.

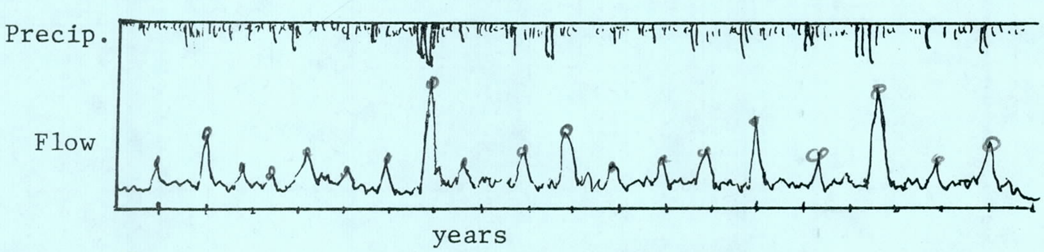
HEC-1 model of river basin

Set antecedent moisture conditions.
Apply design storms (TP-40, NOAA Atlas, etc.).
Compute runoff throughout river basin.

Assume runoff frequency equals rainfall frequency.

D. Historical rainfall runoff simulation

Period of record precipitation
Continuous watershed model (e.g., SSARR, HSPF or NWS-Sacramento) to compute runoff
Traditional peak streamflow frequency analysis, see A above
Can also analyze annual max storms with HEC-1 type model



E. Having the above estimates of frequency curves, the hydrologic engineer must then use professional judgment to make the best estimate of the frequency curves at the desired locations, see Figure 2.

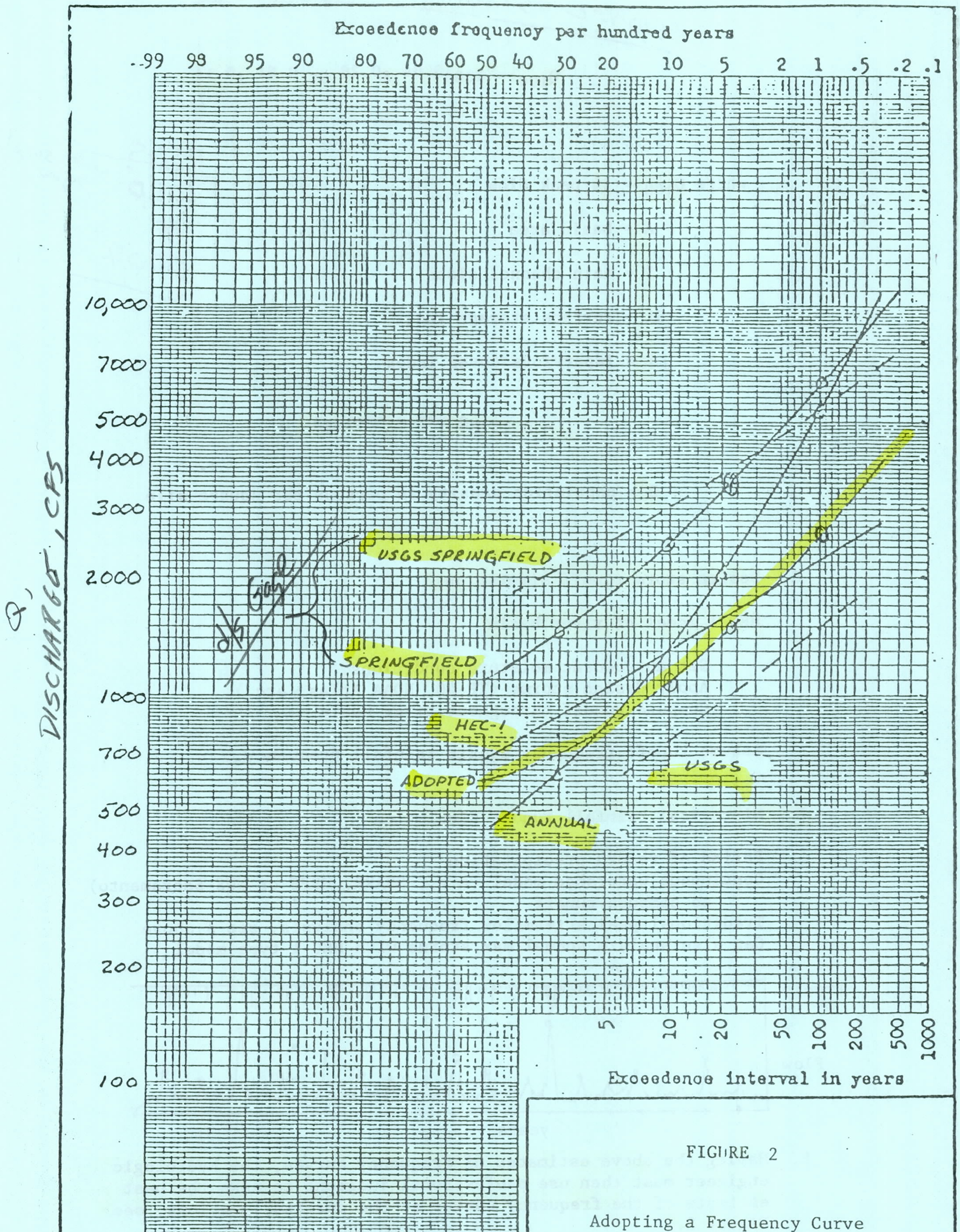


FIGURE 2

Adopting a Frequency Curve

Corps of Engineers

Prepared: Date:

4. Computation of flow-frequency curve for with-project conditions.

Why must a model be used?

What types of projects affect flow frequency?

Compute runoff (and frequency) for with-project conditions.

Design-storm approach
Period-of-record precipitation-runoff simulation

5. General capabilities of HEC-1.

A. Computes runoff from rainfall or snowmelt throughout a river basin, see Figure 3.

Delineate subbasins and river reaches for hydrologic, hydraulic, and economic needs.

Determine subbasin average rainfall.

Transform rainfall to runoff.

Route flows downstream and combine with other tributaries.

Computes hydrographs throughout river basin.

B. Summarizes peak flows at every location.

C. Can simulate multiple storms simultaneously.

D. Can simulate with/without project conditions simultaneously.

E. When flood frequency curve is given, it computes modified frequency curve using C and D above.

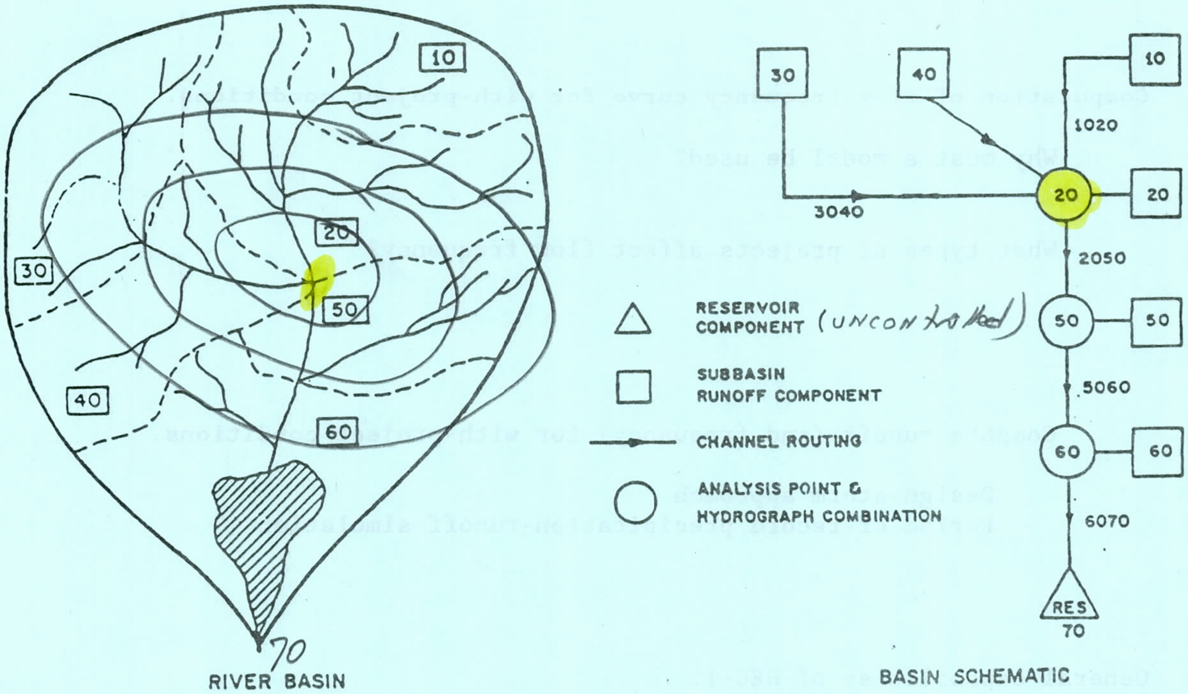


Figure 3. Example HEC-1 Representation of a River Basin

6. Modified frequency curve computation using HEC-1.

   A. Set up HEC-1 model for river basin.

   B. Calibrate model using historical storms for existing (without project) conditions.

   C. Provide the existing condition flow-frequency curve.

   D. Use the Multistorm option to simulate a range of floods.

   E. Use the Multiplan option to simulate with- and without-project scenarios.

   F. Simulate rainfall runoff for various storms and plans.

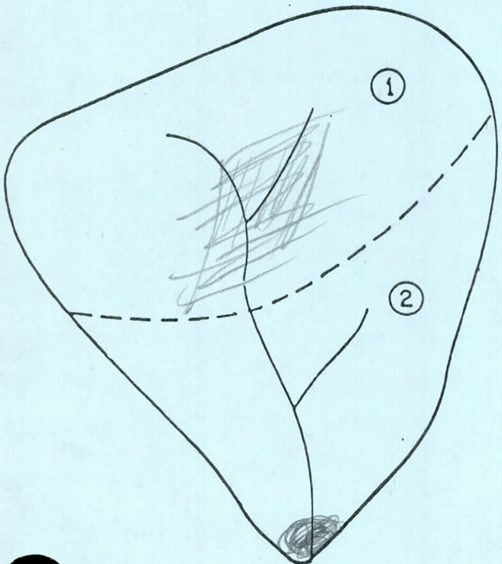
   G. Compute frequency curves, see Figure 4.

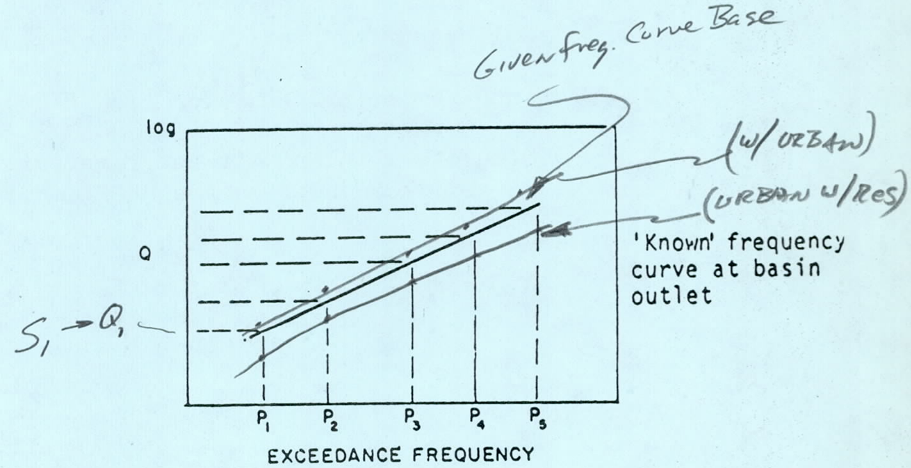
      Compute frequency of existing condition peak flows from input existing condition frequency curve.

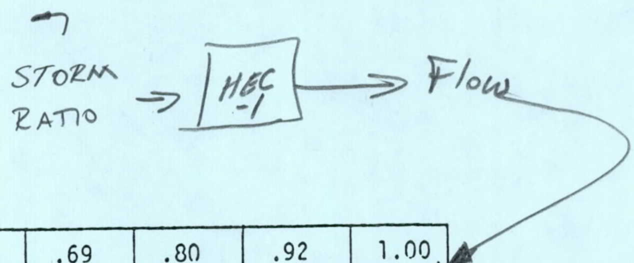
      Compute modified flows do to projects.

      Assume same storm produces runoff of the same frequency under existing and with-project conditions.

   H. Output resulting modified frequency curve to DSS.







	#1				
Storm Ratio	.58	.69	.80	.92	1.00
Q for Existing Conditions (Plan 1) EXISTING	Q_1 4613	5898	7238	8747	9766
Exceedance Frequencies*	P_1	P_2	P_3	P_4	P_5
Q for Plan 2 (URBAN)	5345	6731	8163	9772	10857
Q for Plan 3 (URBAN w/ RES)	3782	4718	5684	6780	7523

*Exceedance frequencies obtained from 'known' frequency curve for existing conditions.

Figure 4. Determination of Frequency Curves for Modified Conditions

7. Use HEC-5 if reservoirs are regulated for downstream flood conditions.

Obtain reservoir inflows for hydrologic analysis (HEC-1).

Calibrate reservoir system operation, see Figure 5.

Input existing condition flow-frequency curve.

Simulate with and without reservoir conditions for several storms in a like manner to the HEC-1 modified frequency curve above.

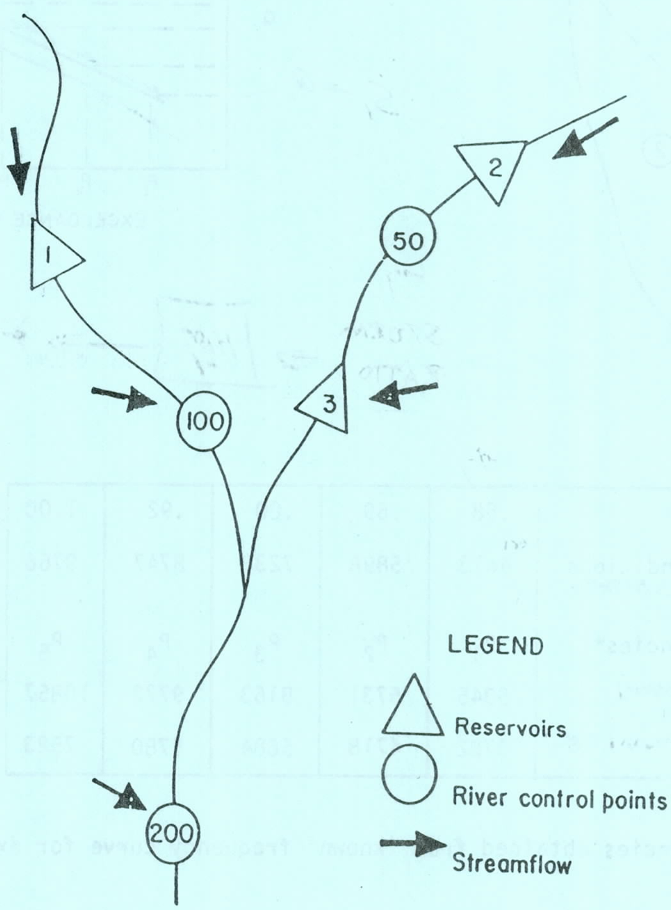


Figure 5. HEC-5 Reservoir System

8. HEC-1 input data with annotations, see Figure 6.

9. HEC-1 output data with annotations, see Figure 7.

```
          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

*** FREE ***

          *DIAGRAM
          ID        COOPER CREEK     DENTON, TEXAS
          ID        INPUT DECK COOAA.1,   THREE PLANS
          ID        BASE CONDITION, RESERVOIR WITH SPILLWAY AT 650 & 655
          IT      15 23JUN83    0000
          JR    PREC     .15      .4     .55     .65      .8      .9       1     1.2     1.5
          JP       3
          IO       5

          KK       1 ---> SUBBASIN #1: COOPER CR BELOW TRIB C-6 LOCAL
          PB 12.0048
          PI  0.0199  0.0201  0.0204  0.0205  0.0209  0.0210  0.0214  0.0216  0.0219  0.0221
          PI  0.0226  0.0228  0.0232  0.0234  0.0239  0.0242  0.0247  0.0250  0.0256  0.0259
          PI  0.0265  0.0269  0.0276  0.0279  0.0287  0.0291  0.0300  0.0305  0.0315  0.0320
          PI  0.0331  0.0337  0.0975  0.0978  0.0985  0.0989  0.0994  0.0998  0.1008  0.1013
          PI  0.1025  0.0131  0.1046  0.1054  0.1072  0.1083  0.1102  0.1106  0.1134  0.1235
          PI  0.1391  0.1401  0.1426  0.1446  0.1496  0.1527  0.1602  0.1650  0.3370  0.3534
          PI  0.4119  0.6566  0.9268  2.2582  0.7213  0.3768  0.1706  0.1562  0.1470  0.1407
          PI  0.1376  0.1120  0.1094  0.1063  0.1038  0.1019  0.1003  0.0992  0.0982  0.0972
          PI  0.0325  0.0310  0.0296  0.0283  0.0272  0.0262  0.0253  0.0244  0.0237  0.0230
          PI  0.0223  0.0217  0.0212  0.0207  0.0202  0.0198
          BA    1.34       0
          LU   0.813   0.083   39.18
          US   0.607   0.719

          KK      1B ---> RESERVOIR
          KP       1
          RN
          ZW   A=COOPER CR B=1B C=FLOW F=UNGTD RES-INFLOW
          KP       2
          RS       1    ELEV      -1       0
          SL     640     7.1      .7      .5
          SS     650      50     2.8     1.5
          SV       0      20     150     300     500     800    2000   10000
          SE     635     640     650     655     660     665     670     675
          ZW   A=COOPER CR B=1B C=FLOW F=UNGTD RES OUT-650
          KP       3
          RS       1    ELEV      -1       0
          SL     640     7.1      .7      .5
          SS     655      50     2.8     1.5
          SV       0      20     150     300     500     800    2000   10000
          SE     635     640     650     655     660     665     670     675
          ZW   A=COOPER CR B=1B C=FLOW F=UNGTD RES OUT-655

          KK      1A ---> ROUTING THROUGH SUBAREA 2
          RS       1    STOR       0       0
          SV       0     1.3    2.11    2.88    4.08    5.13    6.60    7.99    9.28   11.02
          SV   15.46   26.38   37.82   73.85  120.73     155  183.79  219.61  302.42  378.80
          SQ       0      28      56      84     140     196     280     364     448     560
```

Handwritten annotations:

- Storm ratio's used to define modified frequency curve (line 5, JR)
- 3 Plans: Base, 650', 655' (line 6, JP)
- Hydrology for Subbasin #1 (lines 8–22)
- Routing through proposed reservoir (line 23, KK 1B)
- PLAN 1: Baseline (line 24, KP 1)
- PLAN 2: Spillway crest at 650' (line 27, KP 2)
- PLAN 3: Spillway crest at 655' (line 34, KP 3)

Figure 6. HEC-1 Input for Cooper Creek

HEC-1 INPUT

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10
```

{ H & H data for rest of basin

```
 115          KK       8 SUBBASIN #8: COOPER CR BELOW TRIBS C-2 AND C-1 LOCAL
 116          PB 12.0048
 117          BA     1.66        0
 118          LU    0.845    0.089     45.6
 119          US    0.547    0.719

 120          KK      8B ---> COMBINE BETWEEN 7 & 8
 121          HC       2
```

end of H & H data

Economics

```
 122          EC

 123          PN       1 BASE
 124          ZW    A=COOPER CR E=1980 F=BASELINE

 125          PN       2 RESERVOIR WITH SPILLWAY CREST AT ELEVATION 650
 126          ZW    A=COOPER CR E=1980 F=UNGTD RES 650

 127          PN       3 RESERVOIR WITH SPILLWAY CREST AT ELEVATION 655
 128          ZW    A=COOPER CR E=1980 F=UNGTD 655
```

Plan names and DSS write Commands

```
 129          KK      2A, ROUTING THROUGH SUBAREA 3

 130          FR               10       99    20.31    10.01     3.16     1.53      .65      .31      .12
 131          FR      .05     .01

 132          QF                       310     1591     1999     2652     3130     3697     4146     4678
 133          QF     5893     7395
```

← Location for frequency computation

Base condition frequency curve

```
 134          KK      3B, COMBINE BETWEEN 2 & 3

 135          FR               10       99    25.16    11.67     3.81     1.61      .69      .31      .11
 136          FR      .05     .01

 137          QF                       600     2469     3099     4144     4915     5819     6534     7358
 138          QF     9215    11500

 139          ZZ
```

← Location for frequency computation

Base condition frequency curve

```
*******************************************
*                                         *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)      *
*          FEBRUARY 1981                  *
*        REVISED 03 NOV 87                *
*                                         *
* RUN DATE 11 APR 88     TIME    8:16:29  *
*                                         *
*******************************************
```

```
*******************************************
*                                         *
*  U.S. ARMY CORPS OF ENGINEERS           *
*  THE HYDROLOGIC ENGINEERING CENTER      *
*        609 SECOND STREET                *
*     DAVIS, CALIFORNIA 95616             *
*  (916) 440-3285 OR (FTS) 448-3285       *
*                                         *
*******************************************
```

```
                    COOPER CREEK      DENTON, TEXAS
                    INPUT DECK COOAA.1,  THREE PLANS
                    BASE CONDITION, RESERVOIR WITH SPILLWAY AT 650 & 655

  7 IO        OUTPUT CONTROL VARIABLES
                IPRNT          5  PRINT CONTROL
                IPLOT          0  PLOT CONTROL
                QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT        HYDROGRAPH TIME DATA
                 NMIN         15  MINUTES IN COMPUTATION INTERVAL
                IDATE    23JUN83  STARTING DATE
                ITIME       0000  STARTING TIME
                   NQ        101  NUMBER OF HYDROGRAPH ORDINATES
               NDDATE    24JUN83  ENDING DATE
               NDTIME       0100  ENDING TIME
                ICENT         19  CENTURY MARK

           COMPUTATION INTERVAL     0.25 HOURS
                TOTAL TIME BASE    25.00 HOURS

    JP        MULTI-PLAN OPTION
                NPLAN          3  NUMBER OF PLANS

    JR        MULTI-RATIO OPTION
              RATIOS OF PRECIPITATION
            0.15    0.40    0.55    0.65    0.80    0.90    1.00    1.20    1.50
          -----DSS---ZOPEN EXISTING FILE OPENED    71  0000M01*COODSS
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/1B/FLOW/22JUN1983/15MIN/UNGTD RES-INFLOW+1/
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/1B/FLOW/23JUN1983/15MIN/UNGTD RES-INFLOW+1/
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/1B/FLOW/24JUN1983/15MIN/UNGTD RES-INFLOW+1/

-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/1B/FLOW/22JUN1983/15MIN/UNGTD RES OUT-650+1/
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/1B/FLOW/23JUN1983/15MIN/UNGTD RES OUT-650+1/
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/1B/FLOW/24JUN1983/15MIN/UNGTD RES OUT-650+1/

-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/1B/FLOW/22JUN1983/15MIN/UNGTD RES OUT-655+1/
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/1B/FLOW/23JUN1983/15MIN/UNGTD RES OUT-655+1/
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/1B/FLOW/24JUN1983/15MIN/UNGTD RES OUT-655+1/
```

Handwritten annotations: "Storm Ratios" (arrow to ratios); "DSS write of reservoir routing"; "Base"; "650' spillway"; "655' spillway"; ditto marks ("").

Figure 7. HEC-1 Output for Cooper Creek

H & H Summary

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIO 1 0.15	RATIO 2 0.40	RATIO 3 0.55	RATIO 4 0.65	RATIO 5 0.80	RATIO 6 0.90	RATIO 7 1.00	RATIO 8 1.20	RATIO 9 1.50
					RATIOS APPLIED TO PRECIPITATION								
HYDROGRAPH AT	1	1.34	1	FLOW	522.	1523.	2110.	2502.	3089.	3480.	3872.	4655.	5830.
Subbasin #1 Runoff				TIME	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
			2	FLOW	522.	1523.	2110.	2502.	3089.	3480.	3872.	4655.	5830.
				TIME	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
			3	FLOW	522.	1523.	2110.	2502.	3089.	3480.	3872.	4655.	5830.
				TIME	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
ROUTED TO	1B	1.34	1	FLOW	522.	1523.	2110.	2502.	3089.	3480.	3872.	4655.	5830.
Routing through proposed Reservoir				TIME	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50	16.50
			2	FLOW	77.	366.	882.	1237.	1795.	2096.	2382.	2971.	3794.
				TIME	17.75	17.50	17.25	17.00	17.00	17.00	17.00	17.00	17.00
			3	FLOW	77.	137.	160.	359.	795.	1122.	1494.	2094.	2913.
				TIME	17.75	18.50	19.25	18.00	17.50	17.25	17.25	17.25	17.00
			** PEAK STAGES IN FEET **										
			1	STAGE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				TIME	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
			2	STAGE	643.71	651.35	652.97	653.91	655.15	655.75	656.31	657.32	658.7
				TIME	17.75	17.50	17.25	17.00	17.00	17.00	17.00	17.00	17.00
			3	STAGE	643.71	651.94	655.08	656.22	657.67	658.56	659.42	660.67	662.23
				TIME	17.75	18.50	19.25	18.00	17.50	17.25	17.25	17.25	17.00
ROUTED TO	1A	1.34	1	FLOW	471.	1295.	1721.	1958.	2375.	2729.	3057.	3718.	4785.
				TIME	16.75	16.75	16.75	16.75	16.75	16.75	16.75	16.75	16.75
			2	FLOW	76.	356.	845.	1119.	1612.	1834.	2058.	2568.	3332.
				TIME	18.25	17.75	17.50	17.50	17.50	17.50	17.50	17.50	17.25
			3	FLOW	76.	137.	160.	355.	778.	1038.	1372.	1868.	2596.
				TIME	18.25	18.75	19.50	18.25	17.75	17.75	17.75	17.75	17.75
			** PEAK STAGES IN FEET **										
			1	STAGE	627.20	629.85	631.18	631.86	632.89	633.41	633.90	634.87	636.07
				TIME	16.75	16.75	16.75	16.75	16.75	16.75	16.75	16.75	16.75
			2	STAGE	625.07	626.74	628.45	629.27	630.86	631.50	632.15	633.17	634.31
				TIME	18.25	17.75	17.50	17.50	17.50	17.50	17.50	17.50	17.25
			3	STAGE	625.07	625.59	625.73	626.73	628.23	629.03	630.10	631.60	633.22
				TIME	18.25	18.75	19.50	18.25	17.75	17.75	17.75	17.75	17.75
HYDROGRAPH AT	2	1.03	1	FLOW	374.	1336.	1950.	2360.	2974.	3384.	3794.	4613.	5842.
				TIME	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25
			2	FLOW	374.	1336.	1950.	2360.	2974.	3384.	3794.	4613.	5842.
				TIME	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25
			3	FLOW	374.	1336.	1950.	2360.	2974.	3384.	3794.	4613.	5842.
				TIME	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25

Flood Damage (Frequency) Summary

```
               ***************
               *             *
129 KK         *      2A     *          , ROUTING THROUGH SUBAREA 3
               *             *
               ***************
```

Location of interest (corresponds to H&H location)

NO DAMAGE DATA (QD OR SD CARDS) FOR THIS LOCATION,
SO DAMAGES WILL NOT BE CALCULATED.

Input Base

FR	PERCENT EXCEEDANCE	99.0	20.3	10.0	3.2	1.5	0.7	0.3	0.1	0.1	0.0
QF	PEAK FLOW	310.	1591.	1999.	2652.	3130.	3697.	4146.	4678.	5893.	7395.

```
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/2A/FREQ-FLOW//1980/BASELINE/
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/2A/FREQ-FLOW//1980/UNGTD RES 650/
-----DSS---ZWRITE FILE  71, VERS.   2   /COOPER CR/2A/FREQ-FLOW//1980/UNGTD 655/
```

DSS write commands for frequency curves

FREQUENCY-FLOW TABLE FOR PLAN 1 "Base"

FREQUENCY	68.83	11.90	3.42	1.73	0.62	0.29	0.12	0.06	0.01
PEAK FLOW	575.	1912.	2598.	3041.	3724.	4185.	4678.	5701.	7256.

Frequency Curves written to DSS

FREQUENCY-FLOW TABLE FOR PLAN 2 "650' Spillway elev."

FREQUENCY	68.83	11.90	3.42	1.73	0.62	0.29	0.12	0.06	0.01
PEAK FLOW	297.	1095.	1621.	2056.	2725.	3174.	3638.	4528.	5845.

"

FREQUENCY-FLOW TABLE FOR PLAN 3 "655' Spillway elev."

FREQUENCY	68.83	11.90	3.42	1.73	0.62	0.29	0.12	0.06	0.01
PEAK FLOW	297.	1095.	1589.	1920.	2387.	2689.	3011.	3807.	5199.

"

Similar to above for location 3B

```
              **************
              *            *
 134 KK       *      3B    *       , COMBINE BETWEEN 2 & 3
              *            *
              **************
```

NO DAMAGE DATA (QD OR SD CARDS) FOR THIS LOCATION,
SO DAMAGES WILL NOT BE CALCULATED.

FR PERCENT EXCEEDANCE

99.0 25.2 11.7 3.8 1.6 0.7 0.3 0.1
0.1 0.0

QF PEAK FLOW

600. 2469. 3099. 4144. 4915. 5819. 6534. 7358.
9215. 11500.

-----DSS---ZWRITE FILE 71, VERS. 2 /COOPER CR/3B/FREQ-FLOW//1980/BASELINE/
-----DSS---ZWRITE FILE 71, VERS. 2 /COOPER CR/3B/FREQ-FLOW//1980/UNGTD RES 650/
-----DSS---ZWRITE FILE 71, VERS. 2 /COOPER CR/3B/FREQ-FLOW//1980/UNGTD 655/

FREQUENCY-FLOW TABLE FOR PLAN 1

FREQUENCY	77.45	14.01	4.14	1.85	0.66	0.29	0.11	0.06	0.01
PEAK FLOW	922.	2966.	4059.	4772.	5862.	6594.	7358.	8923.	11291.

FREQUENCY-FLOW TABLE FOR PLAN 2

FREQUENCY	77.45	14.01	4.14	1.85	0.66	0.29	0.11	0.06	0.01
PEAK FLOW	666.	2149.	3082.	3787.	4863.	5582.	6318.	7750.	9880.

FREQUENCY-FLOW TABLE FOR PLAN 3

FREQUENCY	77.45	14.01	4.14	1.85	0.66	0.29	0.11	0.06	0.01
PEAK FLOW	665.	2149.	3049.	3651.	4525.	5098.	5691.	7029.	9234.

*** NORMAL END OF HEC-1 ***

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NO. RECORDS= 87
FILE SIZE= 23813 WORDS, 213 SECTORS
PERCENT INACTIVE= 0.00

closing DSS

CHAPTER 7

HYDROGRAPH ANALYSIS IN URBAN AREAS

Introduction

The objective of analyzing urban runoff is to develop quantitative information on the volume and rates of runoff for use in planning and design of urban water management systems, or to provide information for other planning functions on the flood hazard potential of the urban area.

Urbanization affects the physical characteristics of a watershed and may result in significant changes to the shape of the hydrograph (volume, peak and time to peak). Methods of analysis depend upon the objectives of the study (storm drainage, flood control, pollutant control), the expected availability of information, time and funds, and the technology available for performing the analysis.

Effects of Urbanization

Urbanization of a watershed often results in significant changes to the physical characteristics that increase the volume of runoff, and reduces travel times, causing quicker and higher peak discharges. Other effects may be water quality degradation due to man's activities, and a reduction of groundwater recharge. The following physical changes of a basin generally occur with urbanization:

- Pervious surface is modified
- Depression storage is significantly reduced
- Impervious areas are increased
- Channels are widened, straightened, and smoothed
- Secondary drainage systems are constructed
- Natural storage is reduced

Each of these land use changes may or may not individually have a major effect on the hydrograph, however, when they are combined their is a greater volume of runoff and quicker and higher peaks to the hydrograph usually result.

Hydrograph Volume: Urbanization typically results in land use modifications that reduce the watershed's losses, thereby increasing the rainfall excess and volume of runoff. The modifications include increases in impervious surfaces, reduction of depression storage areas, and the reduction of natural vegetation cover. Impervious surfaces are roofs, streets and roads, parking lots, etc., which prohibit infiltration. Depression storage areas may be natural swales, sinks, swamps, marshes, etc., which trap runoff in isolated storage areas that do not contribute to the runoff of the watershed's major conveyance system. These areas are often filled or drained by secondary drainage systems when urbanization occurs.

Timing of the Hydrograph: The time to peak of a hydrograph may be significantly reduced by urbanization factors such as decreased land surface, channel roughness, natural flood plain storage, and channel modifications, etc., which result in higher and quicker peak discharges. However, the higher peak discharges may have a beneficial effect in some circumstances. The urbanization of the lower portion of the watershed may allow those flows to pass more quickly out of the system, prior to being appreciably affected by the upper reach runoff. Another situation is the confluence of two hydrologically similar tributaries which results in simultaneous peak discharges occurring at their confluence. If one tributary becomes urbanized its hydrograph would peak quicker and cause a reduced combined flow below their confluence.

Peak Discharges: The primary concern of hydrologists when urbanization occurs is increases in peak discharges and corresponding flood heights. This is the result of reduced travel time of the hydrograph, reduction in natural storage and increase in the volume of runoff.

Development of a Watershed

To illustrate the effects of urbanization on the hydrologic response of a watershed, a hypothetical sequence of development may be used. Under natural conditions the basin has a meandering stream, and a land cover of natural vegetation. Losses in the basin are largely due to depression storage, interception, transpiration, and infiltration. The runoff response is slow because of the meandering stream and the roughness of the land surface and channel. The hydrograph at the outlet has a flat, rounded peak, reflecting the large amount of natural storage and slow response time of the system as shown in Figure 7.1.

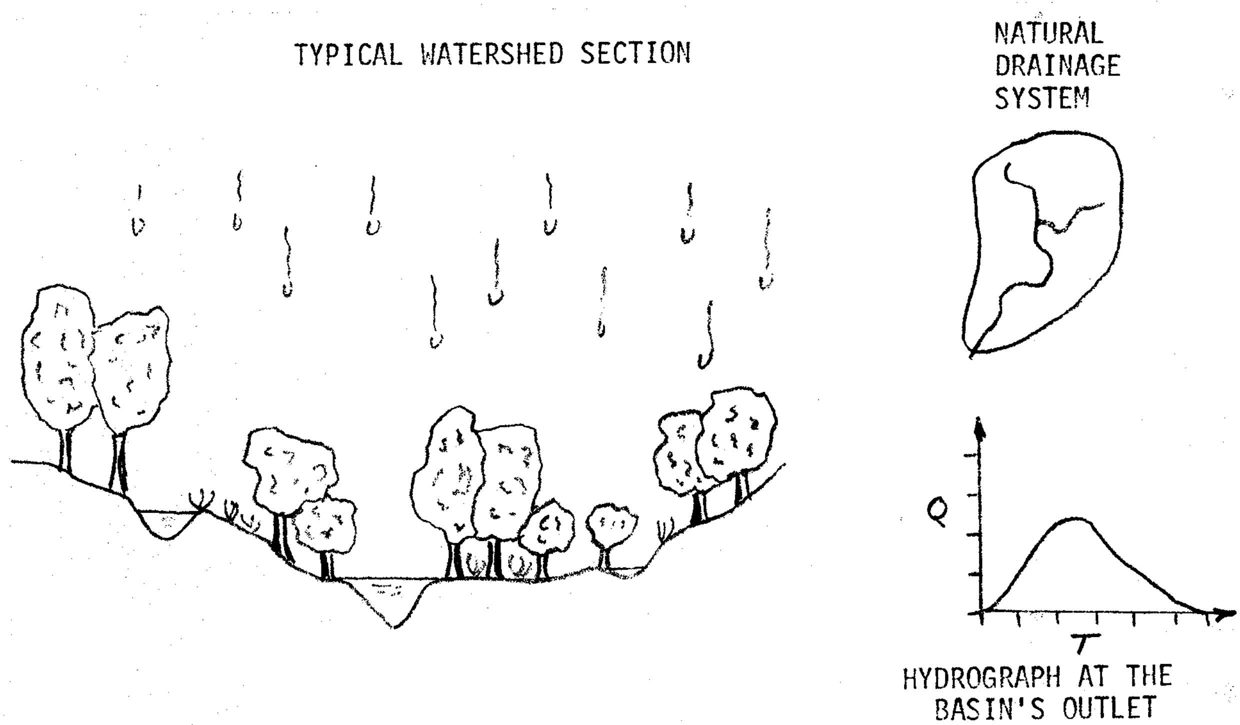


Figure 7.1 NATURAL WATERSHED RESPONSE

Modification of Pervious Surfaces: In this condition the land surface has been graded and cleared with grass planted prior to urban development. Depression storage has been reduced along with some interception and transpiration losses resulting in an increase in volume of runoff. The overall roughness of the land surface has also been reduced causing a quicker travel time of the runoff. With the exception of depression storage, the natural storage in the system has been preserved. The overall effect on the hydrograph will be a slightly quicker and higher peak and a small increase in volume as shown in Figure 7.2.

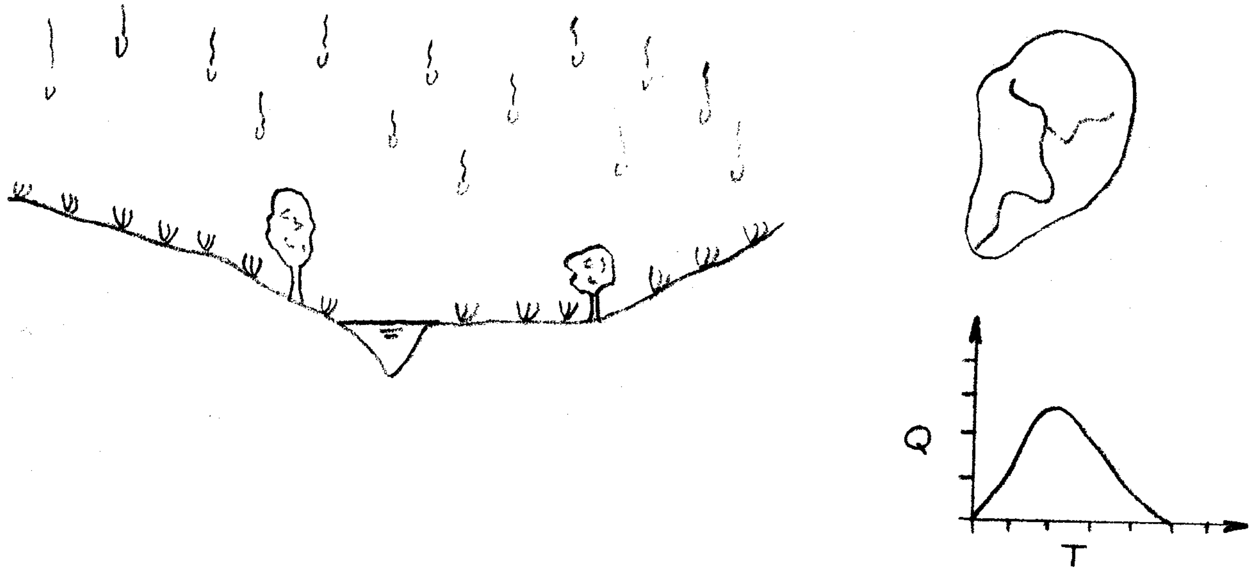


Figure 7.2 PERVIOUS SURFACE RESPONSE

Increase in Impervious Surfaces: Next in the sequence, urbanization (houses, streets, industrial and commercial development) has occurred with a large increase in the amount of impervious surfaces. The primary result will be a significant increase in the volume of runoff due to the reduction of infiltration losses as shown in Figure 7.3. Other effects will be a quicker runoff of water over land surfaces (due to reduced roughness of the basin) into the channel conveyance system causing a higher peak discharge. Natural storage has again been preserved, maintaining the basic response time of the major conveyance system.

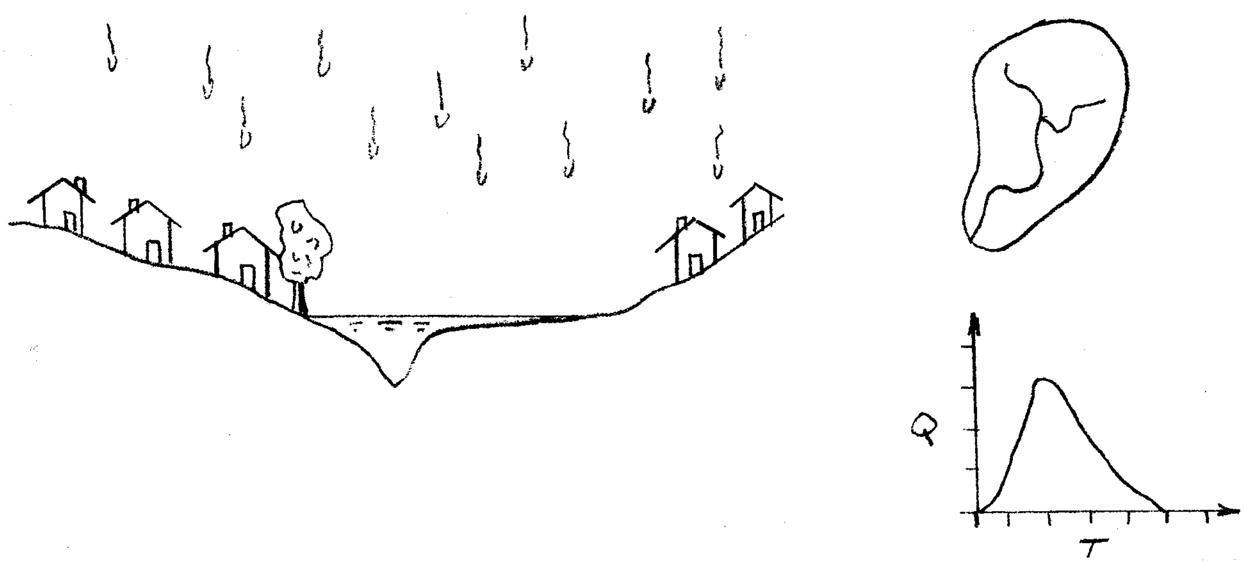


Figure 7.3 IMPERVIOUS SURFACE RESPONSE

Channel Modifications: In this phase of development extensive channel modifications have occurred by straightening, modifying the channel geometry by increasing its capacity, and reducing the roughness of its sides. The straightening of the channel, which increases the steepness of its slope, will have the most adverse effect on the shape of the hydrograph by reducing the travel time of the system and causing quicker and higher peaks as shown in Figure 7.4. Reducing the channel roughness will have a similar effect. (Maintenance of straightened and over-sized channels often becomes an expensive and major problem).

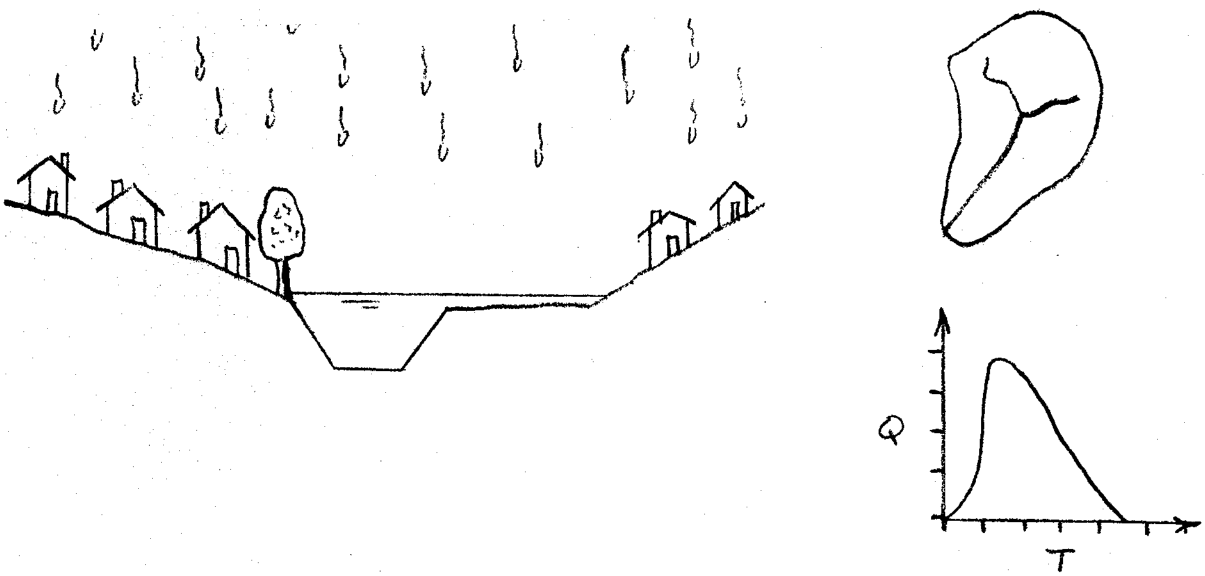


Figure 7.4 MODIFIED CHANNEL RESPONSE

Secondary Drainage Systems: The implementation of secondary storm sewers provide an expedient mechanism of removing storm runoff from local areas into the major conveyance system. The secondary system increases the drainage density of the basin and results in quicker travel times of overland flow and reductions in depression storage areas. The result is higher peak discharges and if depression storage is great, a larger volume of runoff as shown in Figure 7.5. The effect of secondary systems on major floods is small since most of the runoff is overland and not through the overtaxed secondary system.

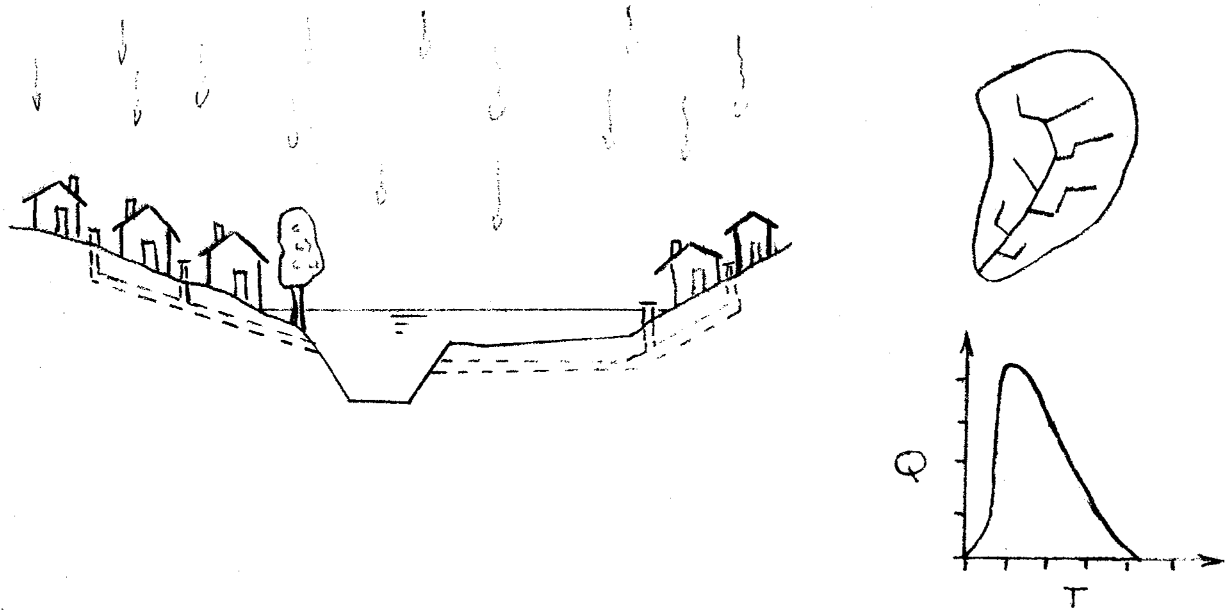


Figure 7.5 DRAINAGE SYSTEM RESPONSE

Reduction of Natural Storage: The reduction of natural storage by landfills, levees, or flood walls may significantly increase flood heights. The effects of flood hydrographs translating throughout the watershed with extensive reduction in vally storage will be increases in peak discharges and consequently flood heights as shown in Figure 7.6.

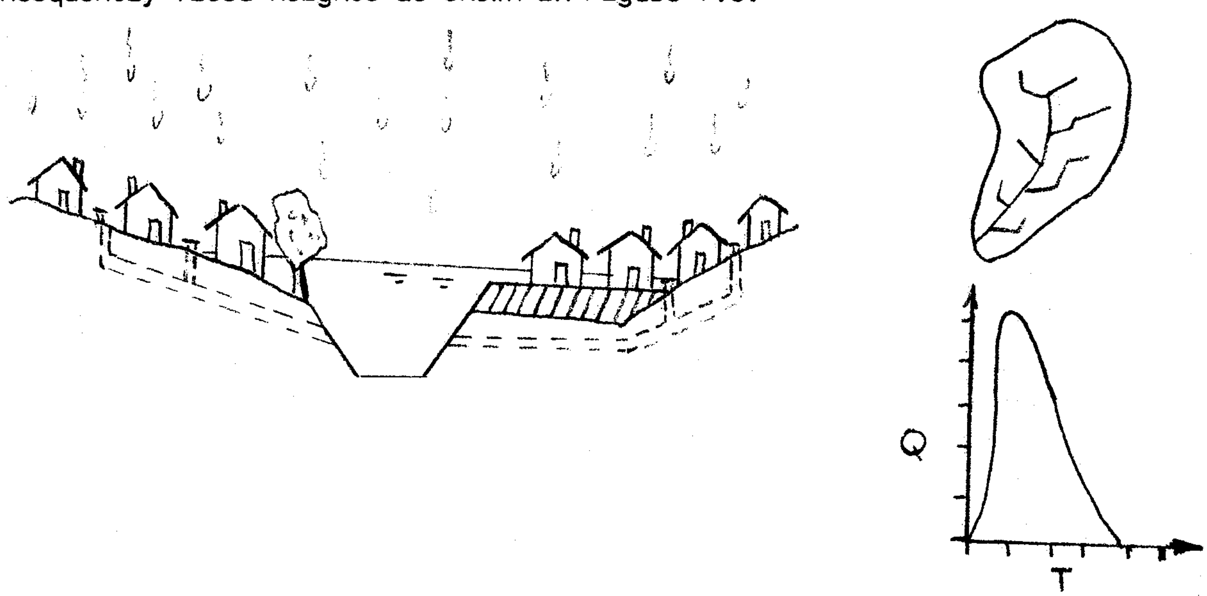


Figure 7.6 STORAGE REDUCTION IMPACT

Impact of Urbanization

The relative effect of urbanization depends on the original characteristics of the basin, and the location and extent of the land use changes. For steep watersheds with little natural storage and highly impervious soils, it may have little effect on the hydrograph. Urbanization of small portions of the watershed usually have insignificant effects on the watershed's runoff. Urbanization occurring in the lower reaches of a basin may have a slightly beneficial effect by allowing the flows to pass prior to the major flow's arrival from the upstream reaches of the basin.

Urbanization has a much greater effect on lower and moderate discharges than on higher discharges. The more frequent floods peak discharges may be increased from two to five times whereas lesser frequency flows may be only slightly altered. The reasons urbanization has a lesser effect on very large events are:

- Depression storage areas are filled
- Secondary systems become overtaxed resulting in overland flow
- Much of the flow is overbank and is not affected by the channel modifications

Evaluation of Urban Runoff

The technique selected for evaluating urban runoff is dependent upon the study objective, availability of information, time and funds, and the technology available for performing the analysis. The study objectives should define the output information needed from the analysis. For example:

Objective	Probable Information Need
Storm drainage	Peak flow rates for design condition for small areas
"Major" storm drainage	Flow rates and volumes for larger areas for design condition
Flood control	Same as above for range of events

Stormwater quality control	Volumes, rates for all areas for many events
Receiving water quality quality analysis	Volumes, rates for discharge points for selected events

Since few streamflow gages generally exist in locations of interest in urban watersheds, and long-term records must be correlated with changes in urbanization, pertinent recorded streamflow data is almost nonexistent. Therefore, techniques described in Chapter 6, Hydrograph Analysis of Ungaged Watersheds, are commonly used. Their use may be summarized as:

- Direct Transfer of Data - This technique is not often used in urban areas because of the dissimilarity of physical characteristics of the watershed
- Simplified Equations (Rational Method) - peak flows
- Multiple Regression relationships - peak flows
- Rainfall-runoff models - hydrograph analysis simulations, peak flows, volumes

QUESTIONS

CHAPTER 7

HYDROGRAPH ANALYSIS OF URBAN AREAS

1. What changes to a watershed may occur with urbanization?

2. What is the general effect of urbanization on the peak, time to peak, and volume of the hydrograph?

3. Describe the effects of the following urbanization modifications on the annual flood event and a rare major flood event. What are your conclusions as to the overall effect of urbanization on both flood hydrographs?

   a. Storm sewers (10-year frequency design).

   b. Impervious surfaces.

   c. Channel straightening.

   d. Extensive flood plain fills.

4. Compare the effects of urbanization on the upper portions of a watershed with that of urbanization occurring in the lower portions of the watershed.

DISCUSSION TO QUESTIONS
CHAPTER 7
HYDROGRAPH ANALYSIS OF URBAN AREAS

1. Changes that often occur to an urbanizing watershed are an increase in impervious areas, a reduction in depression storage in the system, a reduction in natural flood plain storage and straightening, smoothing, and widening of channels.

2. The general results of urbanization on the hydrograph are quicker and higher peak flows and an increase in overall volume.

3. The effect of urbanization on the annual and rare flood events depending on the modification would be:

   a. The implementation of a 10-year frequency storm sewer would provide a satisfactory conveyance system for the annual event and would have little effect on the rarer event.

   b. The increase of impervious surfaces would typically greatly affect the annual event and have little results on the peak discharges of the rare event.

   c. Channel straightening would probably not change the annual or rare event drastically, but could have significant results on intermediate floods.

   d. Flood plain fills would not alter the annual flood since it would probably be contained in the banks of the channel. The discharges of the event could be increased due to reduction in natural storage areas.

4. Urbanization in the upper portions of the basin may increase flood hydrograph peaks at the outlet of a watershed since runoff would be greater and quicker. Urbanization of the lower reaches of a watershed may have a slightly beneficial result by allowing the system to partially drain before arrival of the upper watershed runoff.

CHAPTER 8
FLOOD HYDROGRAPH ROUTING

General Concepts

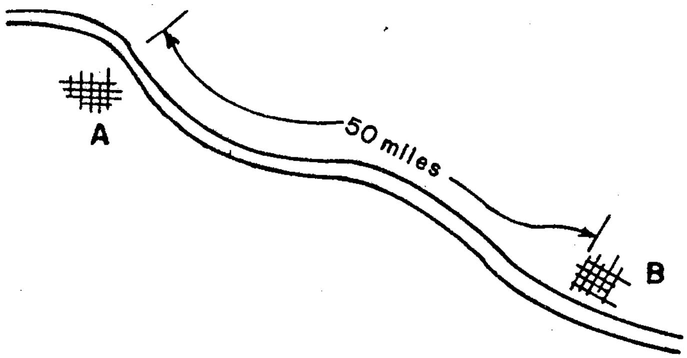
Routing refers to the engineering procedure of tracing the movement of water throughout a hydrologic system, which may be composed of natural streams and lakes or man-made conveyance channels and reservoirs in addition to the natural channels. The basic scientific principles associated with routing are conservation of mass and energy. In the case of water flow in natural systems, the conservation of mass (which includes, volume conservation and time continuity) is normally the dominant factor. Channel routing is concerned with timing and energy conservation, whereas reservoir routing is almost extensively concerned with volume.

The routing of flood hydrographs is required to ascertain the effect of changes within the system on downstream flows and to compute flow at desired ungaged locations throughout the system using known flows (See Figure 8.1). Routing studies are required to:

- Translate gaged historic events to intermediate locations where gages do not exist
- Compute streamflow at downstream locations for synthetic (nonhistoric) events
- Predict the effects of man-made works on downstream flows

  Reservoirs are designed to modify the time distribution of the system's storage and consequently also modify streamflows.

  Channel modifications, levees, floodwalls, etc., also modify the time distribution of system storage and therefore modify streamflow. These effects can be significant and should not be ignored (although they often are).



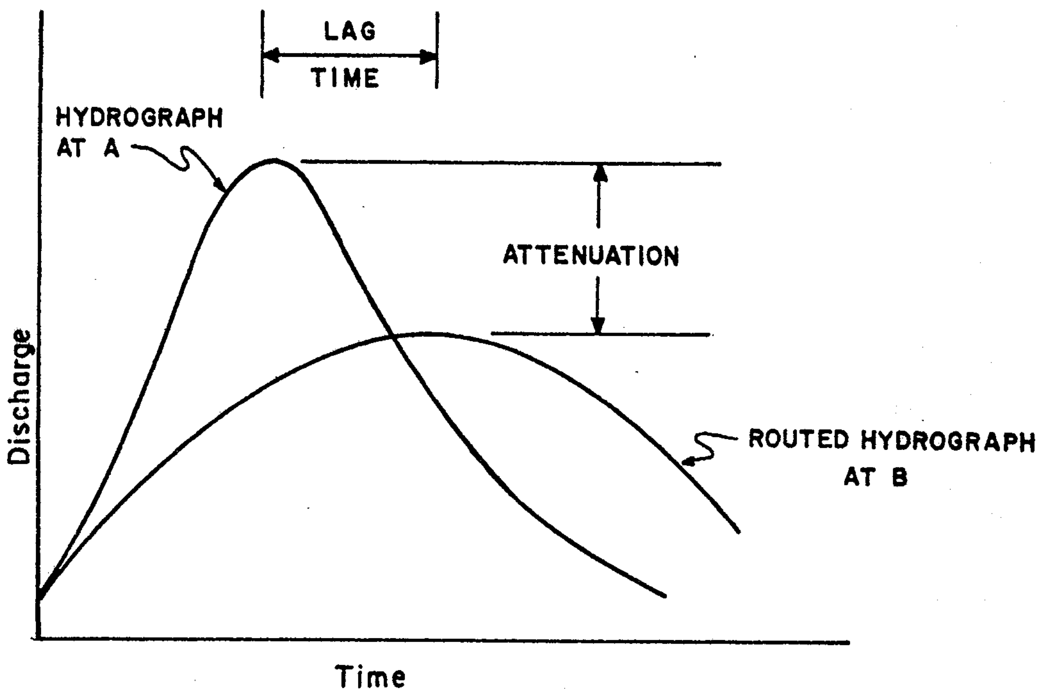
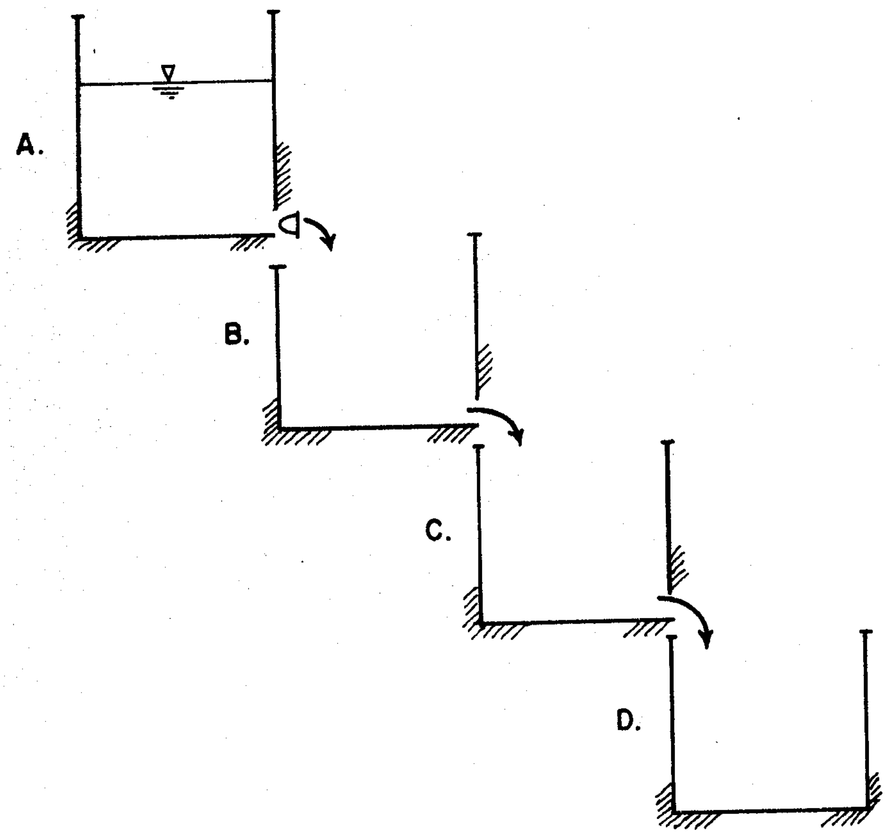


Figure 8.1 FLOOD HYDROGRAPH ROUTING

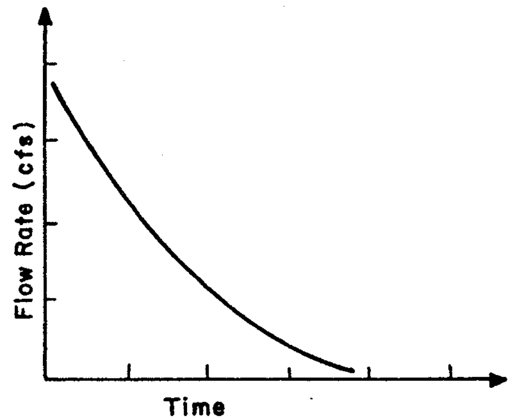
Routing Concepts

The basic process of routing (in terms of volume conservation and the effects of storage on timing) can be examined by analogy with a series of buckets each with a hole (orifice) to let the water runout. These orifices may be of different sizes. This is illustrated below:



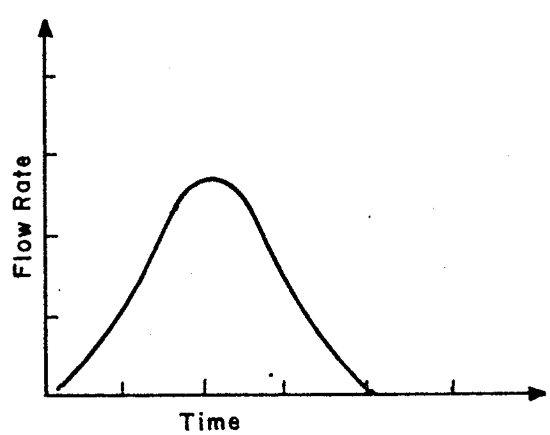
o Begin by assuming bucket A to be full and its orifice plugged, bucket B empty and its orifice unplugged, bucket C with its orifice unplugged, and bucket D with no outlet.

o Remove the plug for A and observe that the rate of outflow decreases as the level drops. The time trace of the outflow is illustrated in the following sketch:

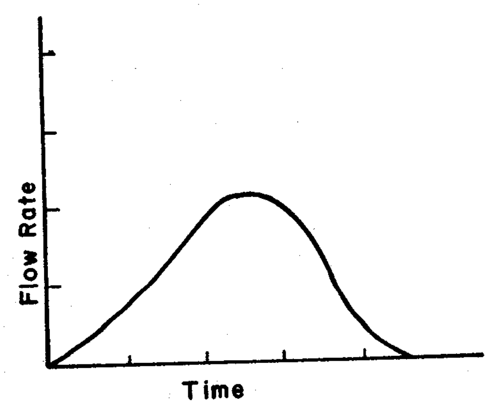


When all the water has run out of A, the volume of water which has passed through the orifice must be equal to that which was initially contained within A. The area beneath the curve in the plot (integrated area) must be this volume.

Now look at bucket B. If the orifice were large enough, flow would pass out of B at essentially the same rate it flows in. Since reservoirs and stream channels have restricted conveyance capacities - the water will not flow out as rapidly as it flows in - there will be temporary storage of some water in B. This is analogous to the passage of a flood hydrograph through a river reach. The outflow from B is shown below; note that the volume (area under the curve in the plot) must be equal to the original volume in A.



A similar temporary-storage phenomena will occur for C (different from B). The outflow from C may be sketched as:



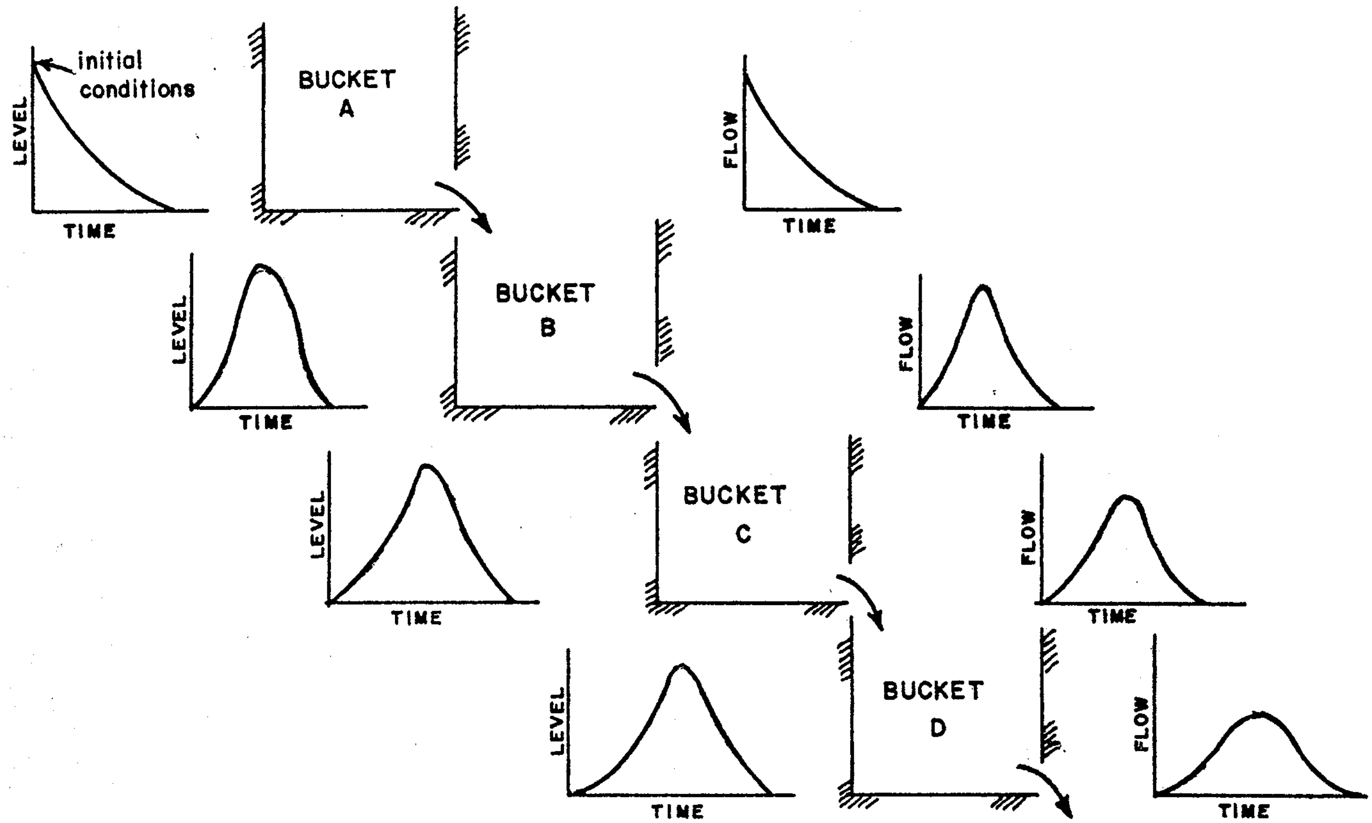
Bucket D catches and retains (orifice is plugged) all the water released from C. It must be equal to the original volume in A. Volume has been conserved, but the time distributions of flow and of volume in each bucket was different - the results of differences in conveyance characteristics (orifice) and the storage relationships (container shape).

Plots of the levels in the bucket are similar to plots of the flow rates. Figure 8.2 shows time traces of water levels and discharges for the system.

The effects of many physical works can be examined by analogy with the buckets. In Figure 8.3 the natural system conditions are shown. Using bucket C, the effect of providing a storage reservoir (control on the orifice) is shown in Figure 8.4, building a levee (reducing the size of the bucket) in Figure 8.5, and modifying the channel conveyance (enlarging the orifice) in Figure 8.6.

Routing Techniques

Many techniques have been developed for performing the computations necessary to route flows through reservoirs and stream reaches. Each technique attempts to capture particular aspects of the fundamental concepts involved. Reservoir routing procedures are concerned almost exclusively with



NOTE: The volume of flow passing through each bucket is constant

Figure 8.2 TIME TRACE OF BUCKET LEVELS AND DISCHARGES

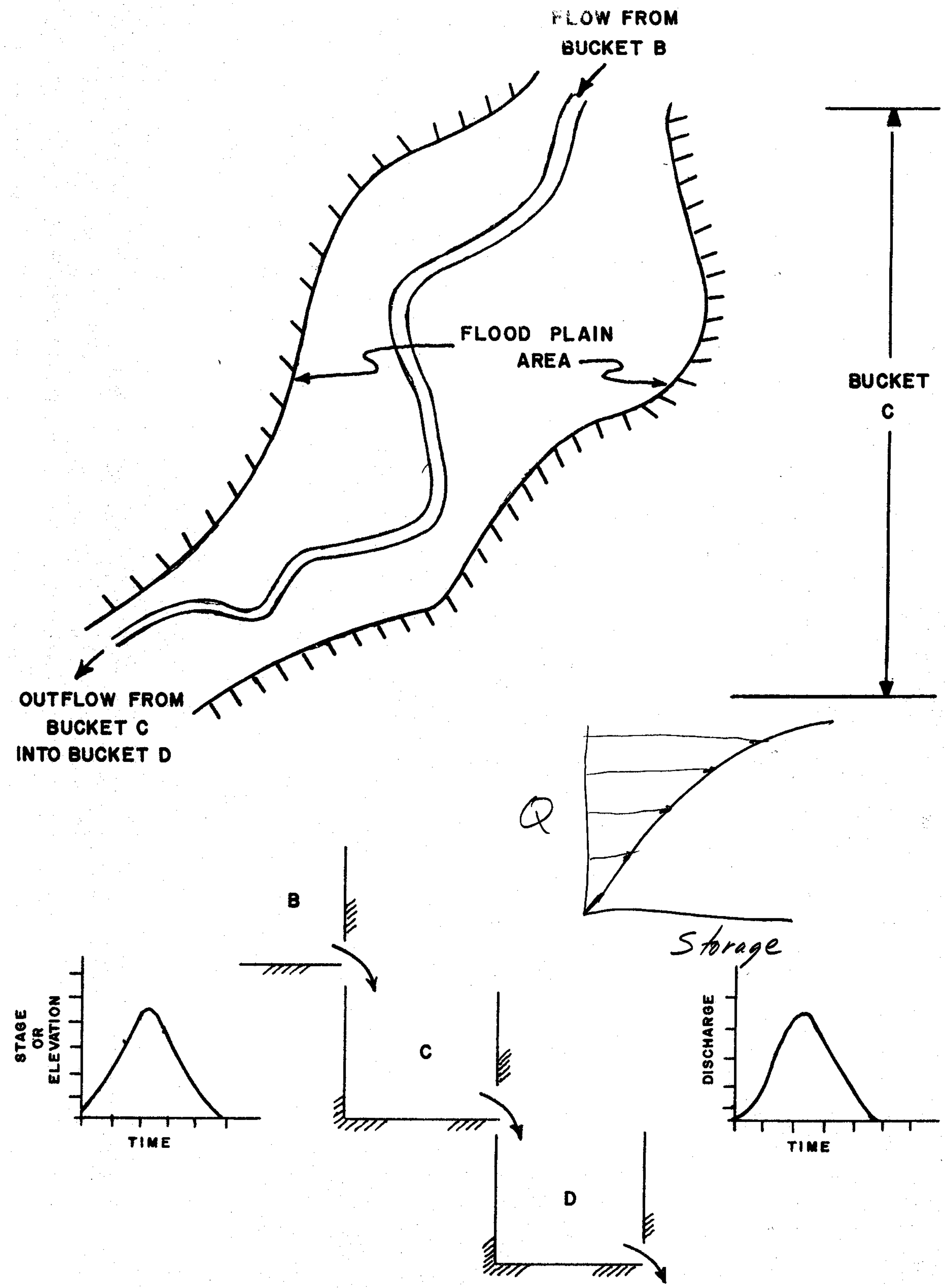


Figure 8.3 NATURAL SYSTEM CONDITIONS

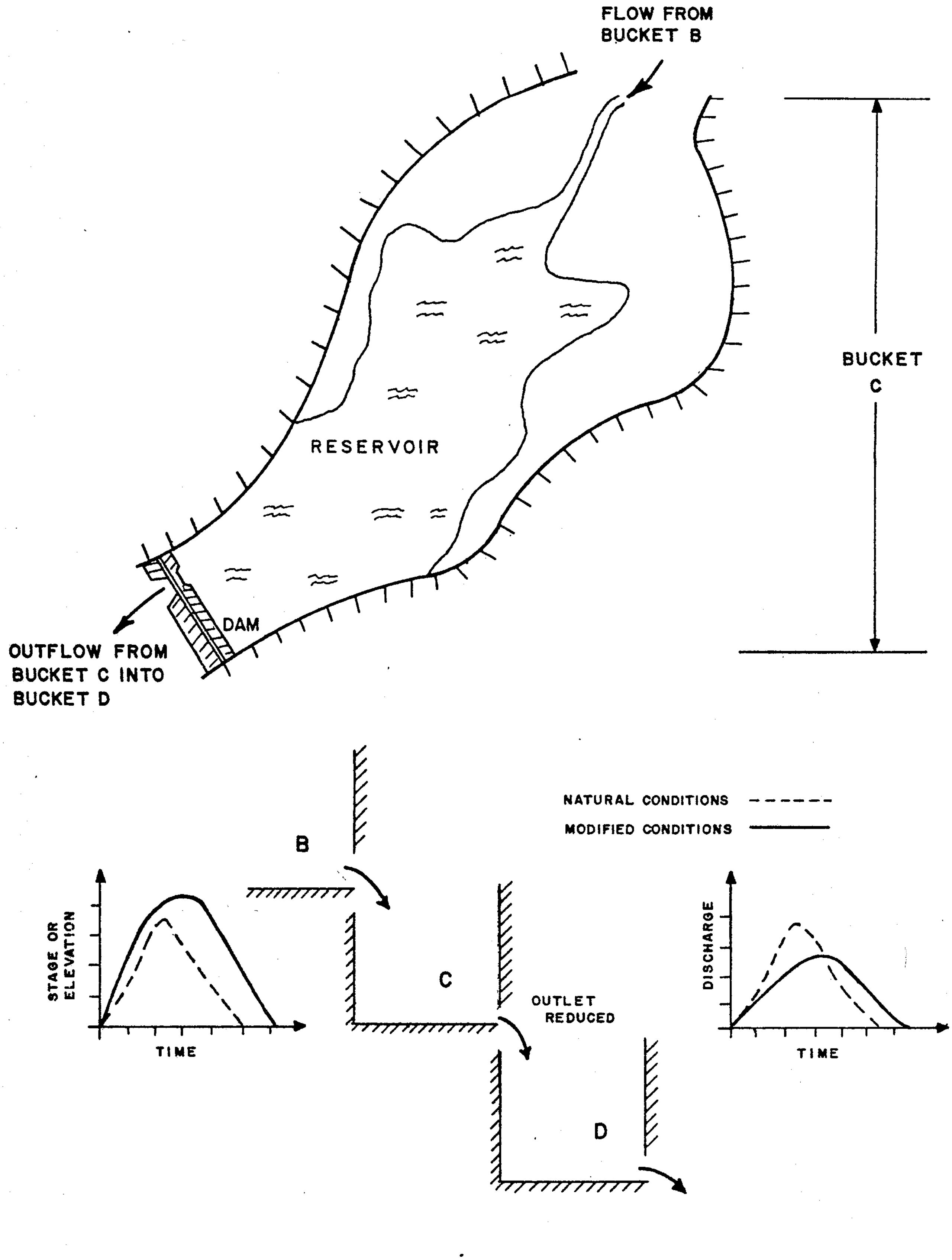


Figure 8.4 REPRESENTATION OF A RESERVOIR

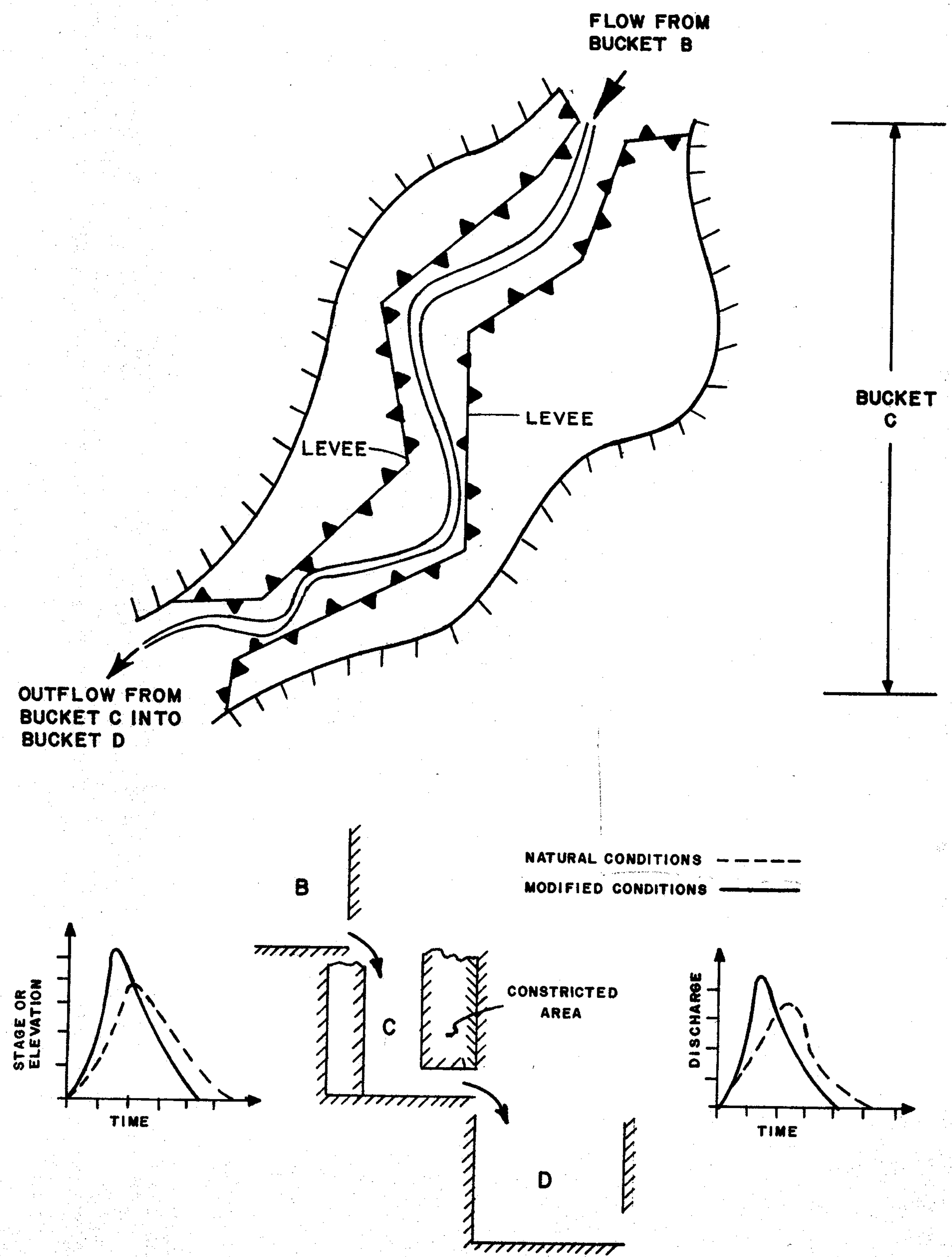


Figure 8.5 REPRESENTATION OF A LEVEE SYSTEM

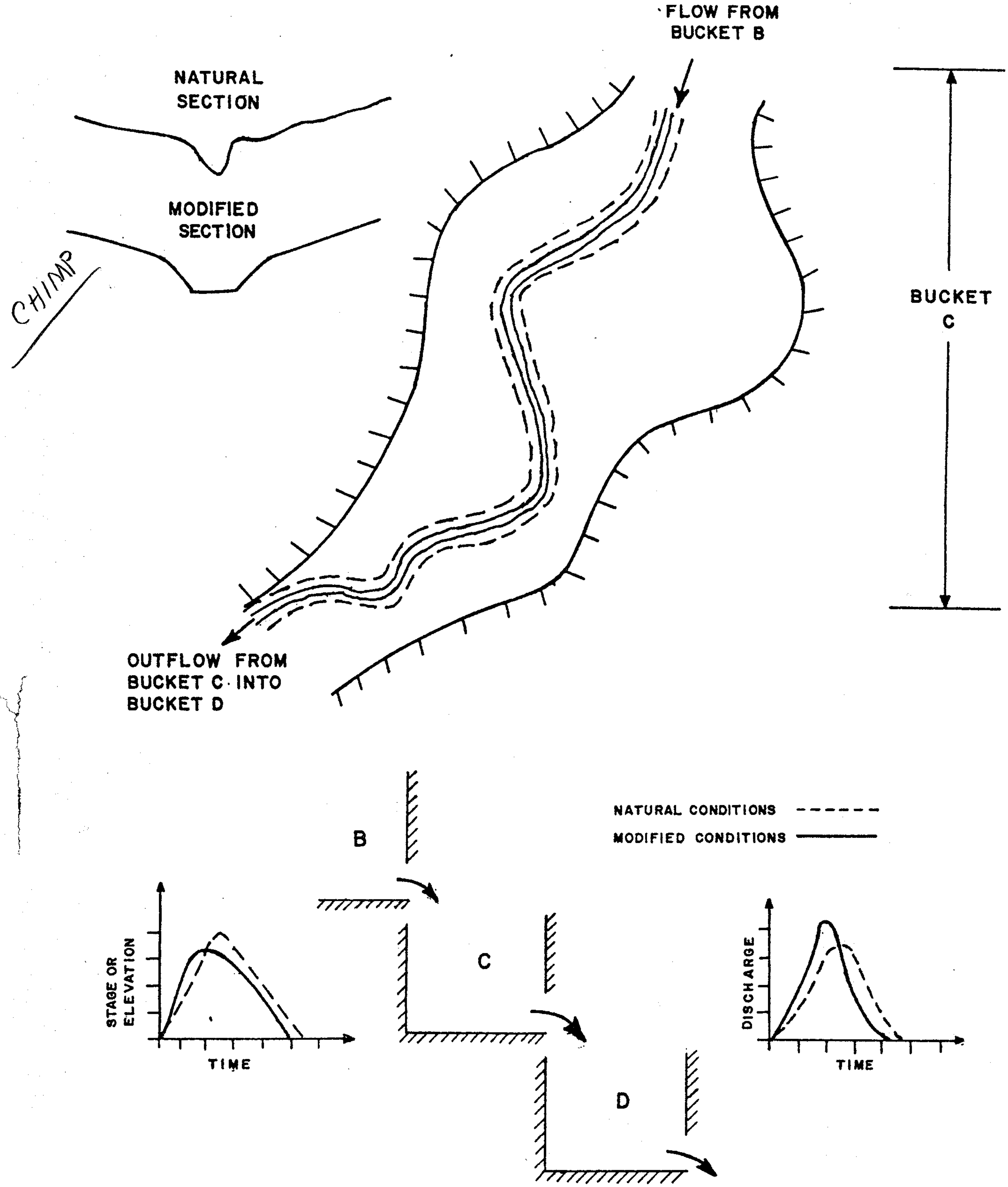


Figure 8.6 REPRESENTATION OF CHANNEL MODIFICATIONS

volume conservation for the reservoir inflow, outflow, and pool storage. Streamflow routing is concerned with volume, energy, and in some instances, momentum conservation, as well as timing. Reservoir routing procedures, when applied correctly, can be used for streamflow routing. Hydrologic methods refer to those techniques concerned primarily with volume and timing, and hydraulic methods to those techniques concerned with conservation of energy and momentum as well.

Conservation studies require routing based on long-term accounting of volumes (say 30 years of record). Studies of reservoir yields are usually based on long time intervals of weeks or months. However, hydropower investigations require shorter time intervals, usually of several hours.

Each of the techniques yields reasonable results where the assumptions used in development hold. From the viewpoint of the planner, it is essential that the methods used be compatible with the alternatives to be evaluated, i.e., the method must be responsive to rational adjustments for the proposed alternatives. For example, evaluation of the effects of a channel enlargement on downstream flow cannot rationally be determined by averaging and lagging methods. Application of the Modified Puls Method would be an acceptable alternative. However, it requires developing storage-outflow relations by water surface profile calculations.

A list of the various routing techniques are shown in Table 8.1.

Routing techniques are often referred to as linear or nonlinear.

- Linear routing methods refer to a group of techniques that are based on an assumption of a straight line relationshp between storage and flow in a reach. The most common linear technique is termed the Muskingum Method; other more simplified methods (averaging and lagging) include the Tatum and Straddle-Stagger.

- Nonlinear methods permit a more general (curved line) relationship between storage and flow, but generally do not include the dynamic effects of inertia (momentum conservation).

Table 8.1

HYDRAULIC AND HYDROLOGIC ROUTING TECHNIQUES

Abbreviations	Title	Type
V	Unsteady flow using St. Venant Equations	Hydraulic Method
K	Kinematic wave approximation of St. Venant Equations	Hydraulic Method
D	Diffusion approximation of St. Venant Equations	Hydraulic Method
RD	Working R&D	Hydrologic Method
MP	Modified Puls	Hydrologic Method
MU	Muskingham	Hydrologic Method
T	Tatum	Hydrologic Method
SS	Straddle-Stagger	Hydrologic Method
MB	Combination of steady-state backwater computations and Modified Puls or R&D	Hydrologic Method

QUESTIONS

CHAPTER 8

FLOOD HYDROGRAPH ROUTING

1. What is the main function of stream routing and reservoir routing?

2. What effect does routing have on the peak, time to peak, and volume of the hydrograph as a flood moves downstream?

3. Using the concepts of the system of buckets presented in this chapter illustrate and describe what modifications (orifice or bucket size) to bucket B correspond to the following land use changes.

   a. Flood plain fills.

   b. The development of a large log jam on a stream.

DISCUSSION OF QUESTIONS

CHAPTER 8

FLOOD HYDROGRAPH ROUTING

1. The purpose of stream or channel routing is to translate hydrographs from one location to another in the system. Reservoir routing serves the same purpose by translating hydrographs through a reservoir, however, the resulting modifications to the downstream hydrographs are usally more severe.

2. The routing of hydrographs through a desired channel reach or reservoir will result in a lower peak discharge occurring later in time. There is no change in the volume of a hydrograph during the routing process.

3. Using the concepts of the system of buckets the following conditions would occur:

   a. Flood plain fills - The encroachment into the flood plain by fills would have the same characteristics as the implementation of the levee system illustrated in Figure 8.5. The bucket area would be constricted, thus the modified-condition hydrograph would have a higher peak and would occur earlier.

   b. Log jam - The development of a large log jam on a stream would be similar to the effects of the reservoir shown in Figure 8.4. The outlet of bucket B would be smaller and the resulting hydrograph would have a lower peak discharge, occurring later in time.

CHAPTER 9
DESIGN FLOODS

Types of Design Floods

A design flood is the runoff hydrograph that is selected as a standard against which performance of a facility may be evaluated. A design storm is the precipitation event that results in the design flood's runoff. Design floods typically refer to:

- Spillway design flood - the flood selected for sizing and operating the spillway of a reservoir
- Reservoir design flood - the flood selected for sizing and operating the flood control features of a reservoir
- Project design flood - the flood selected for sizing and operating a project. The project could be a reservoir, levee, interior drainage facility, navigation lock, or even a bridge.

The design flood may be any flood the decision-maker chooses to define as a performance target for a facility. Floods that may be selected are:

- Probable Maximum Flood - The spillway design flood for reservoirs whose failure would be disastrous to downstream areas. In rare cases, where loss of life and property is great, it may be selected as the project design flood
- Standard Project Flood - May be the design flood for major reservoirs or local protection projects if it can be economically justified
- Specific exceedance interval floods such as 10-, 20-, 50-year, etc. These floods are common means of designating "degree of protection" and also of specifying performance standards for storm drainage facilities, and minor local protection projects.
- Historic floods such as the "Flood of '43," may be used as the design flood on major projects if it exceeds the normal design flood limits and has occurred within memory of local residents.

Concepts of a Design Flood: The concept making use of a design storm or flood is based on the philosophy that one can preselect the performance criteria one wishes for water resources facilities. It is considered to be dependent upon many factors besides hydrologic factors such as:

- Economics - must be justified
- Institutional - we will not build facilities that will not protect against the design flood (N-year event)
- Political - must be accepted by interested publics, etc.
- Environmental
- Social

The basic traditional Corps philosophy has been that major flood control works should have Standard Project Flood protection if it can be justified. However, the more recent concepts and policies are tending to be less based on design storms and floods than in examining the performance of a number of systems and for a wide range of storm and flood events. The system is selected from this information rather than a storm being selected and the facilities following. Many other considerations are emphasized in planning the facilities rather than focusing on just the design-flood event. Alternatives to preselection of a design flood are period-of-record analysis and analysis of a range of events to develop "average" evaluations.

CHAPTER 10
INTRODUCTION TO FLUVIAL HYDRAULICS

General

Fluvial hydraulics is the technical subject area concerned with the flow of water in natural river and streams. For the purpose of technical analysis, a conceptual distinction in the hydrologic system between the 'overland flow' component and the 'channel flow' component is useful. In addition, a further distinction is made between technical analysis related to computing flow rates by aggregating hydrographs and accounting for natural stream storage (referred to as routing elsewhere in this manual) and the technical analysis related to determination of stage (water surface elevations) from flow which is generally referred to as hydraulics. Fluvial hydraulics, therefore, has as its main focus the estimation of stage for flow rates of interest in natural channels.

If it were possible, one would simply measure the flow rate for a range of elevations at all locations of interest and use the relationship (a rating curve) for subsequent elevation determinations. Because this is not usually possible, analytic computation methods are normally employed. Computation methods which assume fixed channel boundaries come under "rigid boundary hydraulcs" and those accounting for the mobile nature of the streambed as "Mobil Boundary Hydraulics".

Geomorphology

Natural streams have acquired their present form from long-term processes involving land surface erosion, stream channel incisement, and streamflow. Streams, in fact, are either in a natural equilibrium with the determining factors, or are slowly adjusting toward an equilibrium condition. Disregarding long-term climatic and geologic changes, the factors involved in determining the equilibrium are 1) a streams capability to transport sediment; 2) the particle sizes of sediment; and 3) the available supply of sediment. Streams are continually adjusting themselves toward equilibrium so that when natural events (such as forest fires) or human activities (such as engineering works) alter one of the factors, a stream begins to adjust to accommodate the changed conditions. In many instances, the adjustments are of significance and must be directly accounted for in studies (such as long-term increases in river stage due to sediment deposition), and, in many others, the changes are not important. Because of this latter situation (small potential adjustments) and the overall complexity of considering the effects of change in all situations, there has developed two directions of technical analysis, 1) mobile and 2) rigid boundary hydraulics.

Mobile Boundary Hydraulics

The mobile boundary view of natural stream hydraulics recognizes that there is a changing relationship between streamflow and channel geometry that is a complex function of sediment supply, transport potential and grain size. This technical analysis viewpoint is generally referred to as "sediment transport analysis". Technology for mobile boundary hydraulics continues to be under development and is presently at a much lower level than rigid boundary hydraulics. Because of the complex specialty nature of the analysis, widespread capability to perform studies is generally not available. This general subject will be discussed in more detail in Chapter 15.

Rigid Boundary Hydraulics

The rigid boundary view bases the perceptions and analysis of natural streams on the idea that, for a specific analysis, the stream geometry can be considered as fixed (rigid) and, therefore, one can concentrate upon the physics of the flow field. Virtually all water surface profile determinations, such as for flood insurance studies, are based on rigid boundary hydraulic concepts. The governing principles used in analysis are derived from well established laws of physics, and the analytical techniques and tools are highly developed. Conservation of energy (continuous accounting of energy additions to flow e.g., elevation drop, and energy extractions from flow e.g., "head losses") is the dominant concept and is highly developed conceptually and analytically. Chapters 11, 12 and 13 discuss the general concepts involved and relate them to analysis needs and important concerns during planning studies.

Unsteady Flow

The literal meaning of unsteady flow is flow that changes with time. The transient or unsteady nature of flow is acknowledged since streamflow is seldom constant over any significant period of time. "Unsteady" flow as used by the profession generally refers to a broader classification of changing flow than just flood routing. Changes are sufficiently rapid such that inertial forces are of importance in such instances as the sudden release or stoppage of flow.

It is common practice by hydraulic engineers to perform simplified unsteady flow analysis (termed flood routing) to determine the peak flows at various points downstream, and then to perform steady flow water profile analysis to determine elevations corresponding to the peak flow rates.

Chapter 14 will introduce the notion of inertia, discuss the basic principles involved, and describe instances where this specialized type of analysis is important.

Planning Interface

Fluvial hydraulics is an area of technical analysis that is required to determine water surface elevation information (as contrasted with peak flow information) and, in certain instances, sediment volumes that are needed in many water resources management studies. Fluvial hydraulic computations are required to provide the following types of information.

- Flood Control
  - Flood elevations and depths
  - Levee heights
  - Rights-of-way limits
  - Sizing of channel works

- Water Supply
  - Diversion elevations
  - Sizing conveyance canals

- o Navigation
  - Maximum/minimum flow depths
  - Annual maintenance dredging requirement

- o Hydropower
  - Powerhouse tailwater elevations

In some studies, fluvial hydraulics might dominate the technical analysis, such as hydrologic studies for extensive channel modification projects, while in others, such as water supply, fluvial hydraulics might play a minor role. The manpower and time resources that can easily be consumed in studies of this type demand that planners be at least casually familiar with the basic principles and fairly specific as to the scope and detail of analysis required to meet identified planning objectives.

CHAPTER 11

STEADY FLOW RIGID BOUNDARY HYDRAULICS

Introduction

The flow rate in natural streams varies in time, the channel boundaries do not remain rigid but distort with the passage of flood events, and the energy losses and other dominating flow phenomena are complex and only partially understood. One can observe most of the complexities of natural streamflow by standing on a stream bank and observing flow as it passes. One will note that the channel is apparently irregular; it is narrower at some points than others. Surface eddies are visible, and it can be observed that the flow velocity along the boundaries is certainly much different that the flow velocity in the center of the channel. Turbulence seems to be generated at all discontinuities in the flow and at all obstructions. White water will be noted here and there, and a variety of surface wave patterns will be evident. If one watches the stream bank long enough, the water level will be observed to fluctuate and the bank may cave or slough periodically.

It has been the practice of the profession to considerably simplify this view of the flow process so that reasonably systematic analysis of the complex phenomena is possible. In order to reduce the phenomena observed to a manageable technical task, the following series of simplifying assumptions are useful.

- Steady flow - the flow rate is taken as fixed so that the water level does not fluctuate with time (in the span of interest)
- Rigid boundary - the cross section is stable in geometric shape (for the time period of interest)
- One dimensional - the water surface elevation across the channel is horizontal and the flow velocity is in a single direction.
- Constant fluid properties - the sediment content of the flow does not alter the fluid properties and governing equations.

Assuming these assumptions are reasonable, and in many instances these assumptions are in fact completely satisfactory, the scientific principles that apply to the determination of the water surface elevations and energy losses are very well developed and can be derived from Newton's laws. The ability to found the analysis on a firm principle of physics is important since it allows extrapolation with more confidence to unmeasured conditions.

Evaluation of flow in open channels is dominated almost entirely by analysis of energy conservation, and to a lesser extent by the determination of flow continuity.

Continuity

Continuity is the engineering principle which states that mass (stream flow volume) is conserved. Mass conservation in a volumetric sense would mean that for a given reach of the stream, the amount of volume passing at one point will also pass another provided that changes in storage between the points are properly accounted for. In water surface profile and river hydraulic determinations, the governing statement of the principle of continuity is:

$$Q = AxV$$

where

Q = volumetric flow rate in ft.^{3}/sec.
A = cross sectional area in ft.^{2}
V = mean flow velocity in ft./sec.

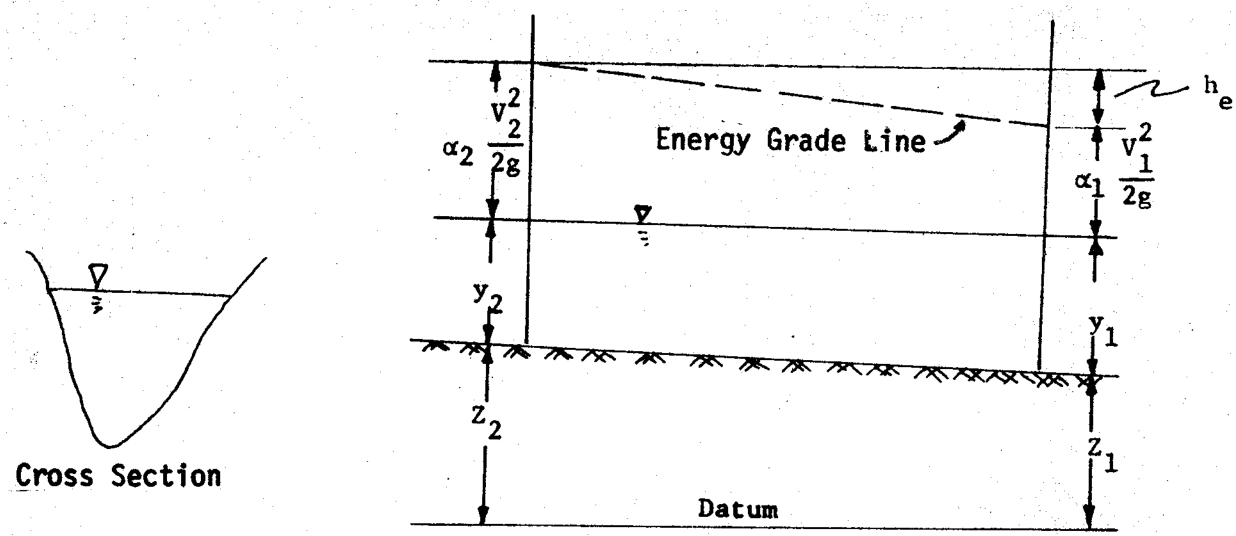
The equation states that the volumetric flow rate Q is equal to the product of the velocity of flow and the area through which the flow is passing. Although the statement of continuity can be viewed as quite simple, an important basic understanding of flow can be derived from this simple relationship. For example, suppose 10,000 cfs were flowing at a location where the flow area is 1,000 sq. ft. The mean velocity can be computed as 10 feet per second. If the flow now is increased to 15,000 cfs, what must change? The equation says one (A or V) or both must increase. Do we know which? Without further information we cannot tell, but we suspect that the velocity will not increase drastically (a pretty fair assumption) so that the flow ara (A) will probably increase to a little less than 1,500 sq. ft. and provide us with a means for estimating the new flow depth if we know the flow geometry. Other similar observations based on changing velocity and changing cross section area can provide some insight into flow within stream channels. One must be careful, however, to not consider the continuity relationships alone but integrate the conclusions with full consideration of conservation of energy as well.

Conservation of Energy

Energy conservation, stated in a scientific principle, says that in proceeding from one point in a stream system to another, system energy must be continuously accounted for. The mathematical statement of energy conservation is called the Bernoulli equation and is: the sum of the kinetic energy (due to motion) plus the potential energy (due to height) at a location is equal to the sum of the kinetic plus potential energies at another location plus or minus the energy additions or substractions from the system. Figure 11.1 defines the statement of energy conservation.

A few definitions need mentioning so that the nomenclature that is common among hydraulic engineers can be used in discussions by planners. The sum of the depth plus the kinetic energy (which is termed the velocity head) is defined as the "specific energy" at a given point. The specific energy, when added to the elevation of the channel invert is called the "total head" and in the definition sketch, Figure 11.1, the total head at a point is defined as H. An imaginary line tracing the total head linearally along the channel has been given the label the "total energy line" or at times the "energy grade line".

There is considerable difference between viewing the energy conservation principle as it occurs in a closed pipleine system and as it occurs in an open channel. The key difference is that open channels have another degree of freedom in that the water surface can locate itself with respect to the energy content of the fluid. In a pipeline, if one introduces energy loss at a point, all locations upstream from that point will encounter an increase in



$$Z_2 + y_2 + \alpha_2 \frac{V_2^2}{2g} = Z_1 + y_1 + \alpha_1 \frac{V_1^2}{2g} + h_e$$

$$\text{Let } H = Z + y + \alpha\frac{V^2}{2g}$$

$$H_2 = H_1 + h_e$$

where

$z+y$ = water surface elevation in ft.

$\alpha \frac{V^2}{2g}$ = velocity head in ft.

h_e = energy loss in ft.

H = total head in ft.

Figure 11.1 OPEN CHANNEL ENERGY RELATIONSHIPS

pressure that is a result of the energy loss. In an open channel flow situation, this is not the case. For example, if an obstruction is placed in the flow and generates an energy loss (h_e in Figure 11.1) there is some distance upstream where this energy loss is no longer reflected in the position of the total energy line, and thus the flow depth at that distance is unaffected. The flow conditions will adjust to the local increase in energy loss by an increase in water level upstream. This will allow the flow to gain the energy required to overcome the energy loss, but the increase will gradually decrease in the upstream direction. It is this complication, the freedom in the location of the water surface, that makes open channel hydraulics both a complicated and interesting technical subject.

At this point, another simplification will be introduced so that some basic principles can be discussed in simple terms that will relate quite nicely to the more complicated natural situation: the notion of a prismatic channel. Prismatic refers to a situation in which cross section shape and bottom slope remain constant through the reach of interest. Assuming a prismatic channel and observing the equation and definition sketch previously discussed, one would note the following: the flow depth and velocity head would remain constant between the two locations; the total energy line and the water surface would parallel the channel bottom; and a flow condition that is termed "uniform flow" would occur. In the case of uniform flow, energy would be consumed by losses at exactly the same rate as it would be provided by the drop in channel bottom. It should be noted that natural and other open channels gain their energy from gravity (the change in ground elevation), consume energy in boundary friction, and impact losses from obstacles. With the introduction of the prismatic channel concept, one may speak of classifying flow in terms of profile types and energy levels.

Flow Classifications

The observation of major distinctions in the character of flow is essential for analysis of flow conditions and an understanding of the nature of flow. The analysis framework has already been classified as steady flow. Further distinction is needed between the two concepts "supercritical" and "subcritical" flow. These terms relate to a theoretical conception of the energy state of flow. In a practical sense, it can be said that supercritical flow is occurring if the flow velocity is more rapid than the velocity of a small surface wave as may be caused by throwing a rock into the stream. Flow at velocities that are less than the speed of this surface disturbance would result in flow conditions called subcritical. The nature of flow conditions and profiles are quite different between these two situations. In the large majority of flow situations in natural channels, flow exists in a subcritical state. Flow could exist in a supercritical state in man-made channels such as concrete lined chutes and perchaps in very steep mountain streams.

A significant aspect related to flow classification is that the flow profile cannot cross the critical condition (transition between subcritical and supercritical) without a very specific and definable set of conditions occurring. For example, to pass from supercritical flow to subcritical flow, a phenomenon termed a "hydraulic jump" (or as might be observed in a steep mountain channel a "standing wave") accompanied by considerable turbulence would have to occur. These conditions naturally generate tremendous energy losses and greatly complicated flow pattern.

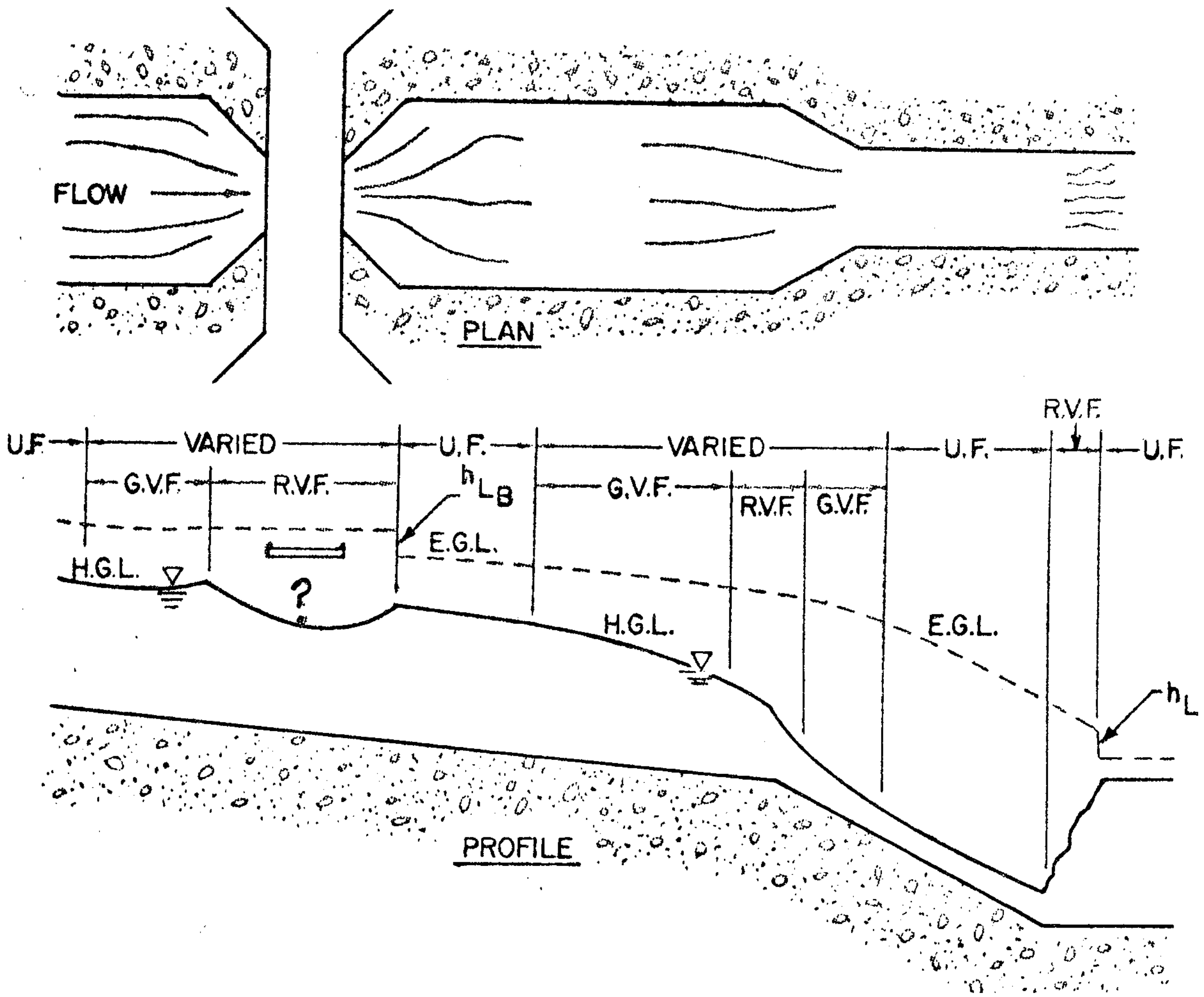
Another classification of flow results from the distinction between "varied flow" and "uniform flow". Uniform flow as we stated previously characteristically occurs in prismatic channels and is a useful reference point since all flow given sufficient distance over which it may occur would tend toward the uniform flow condition. On the other hand, all flow other than that classified as uniform is classified as "varied" in which the depths and velocities vary along the stream channels. Varied flow can occur when the flow is interrupted, such as by bridges, or when the flow field changes, such as by a change in flow rate or change in channel geometry. Within the varied flow definition, "gradually varied" flow refers to the normal situation that is observed in nature where there is a gradual change in depth and velocity along the channel. In this instance, the general energy equation that was defined previously and the general notions related to it continue to apply. The other category of varied flow is termed "rapidly varied" flow, and it is the flow condition that occurs in the vicinity of obstacles such as within the opening of bridges or other features that greatly constrict the flow. Rapidly varied flow occurs when the pressure that is exerted within the flow field is nonhydrostatic, meaning that if one were to place a pressure measuring device within the flow field it would not reflect pressure as being simply a straight forward relationship with depth. Figure 11.2 provides an overview of the classifications of the flow in the "varied" categories and also illustrates the conditions whereby critical flow can occur.

It should be once again emphasized, however, that in natural streams, the dominant flow condition is subcritical and in the absence of constructing structures the flow may be assumed to be gradually varied. The classic term "backwater" that is often referred to relates to the condition in which the water surface elevation is raised above the normal condition by a downstream obstruction which creates a higher water level or an energy loss. In the above sketch the condition occurring immediately upstream of the bridge is the "backwater" condition.

The specific reaction or water surface profile change that results from management works such as levees, bridges, and channel improvements is dependent upon the class and type of flow. Conclusions drawn from placing control measures within supercritical flow would not apply for the placement of the same controls in a subcritical flow situation. Some general notions related to changes in water surface elevation that might occur can be obtained from observing the sketch and studying similar situations for man-made management works. Chapter 13 contains a more detailed description of water surface profile types and the changes that can occur in the vicinity of management works.

Relationship to Natural Channels

The primary conceptual change in moving from the study of prismatic channel hydraulics to natural streams hydraulics is casued by variations in cross sections and the varying rate of drop of the channel invert. The sketch below illustrates the conditions that occur in a natural channel. Figure 11.3 is a profile view of a natural stream. The "n" refers to the uniform flow depth called "normal depth" for a given discharge and the "c"



The abbreviations in the previous figure are:

U.F. = Uniform flow

G.V.F. = Gradually Varied Flow

R.V.F. = Rapidly Varied Flow

E.G.L. = Energy Grade Line

h_{L_B} = Head loss due to bridge

H.G.L. = Hydraulic Grade Line

h_{L_j} = Head loss due to jump

Figure 11.2 FLOW CLASSIFICATIONS

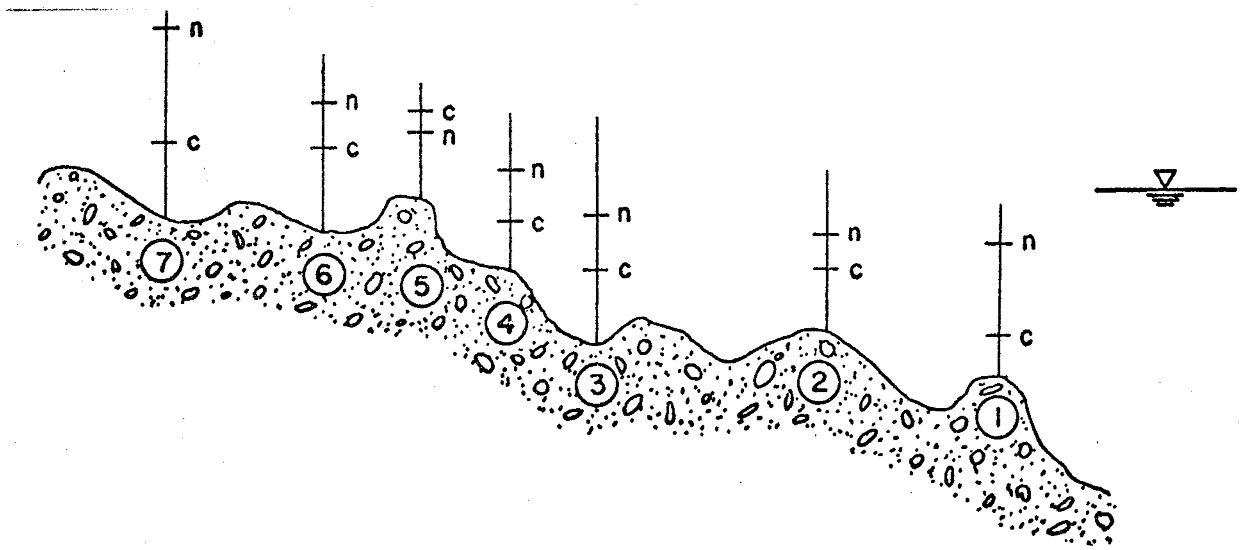


Figure 11.3 NATURAL STREAM PROFILE

refers to critical depth for the same given discharge. Note that they have a varying relationship to one another along the profile.

The significant point is that in nature, there is no such condition as uniform flow. There never exists a complete balance (in theoretical sense) between the rate in which energy is being consumed and the rate at which it is being added by drop in the channel bottom. However, over a given distance the rise and fall in the channel bottom and the fluctuations in cross section areas will give rise to conditions that approximate a uniform flow condition so that the notion that flow is always attempting to adjust to a "normal" situation can generally be applied. For instance, in the above sketch it could be possible that the flow profile would be similar to a gradually varied flow profile that is increasing in depth in a downstream direction, similar to what was termed "backwater" in the case of the prismatic channel upstream of the bridge in a previous sketch. The changing relationship between the critical depth and normal depth along the channel gives rise to a number of computational difficulties in defining a water surface elevation and also in completely relying upon generalizations as to the behavior of the profile in a natural channel. The general notions discussed thus far will by and large be valid in the general case, but there must always be a thorough analysis of the energy balance before definite conclusions can be drawn in a particular project situation.

Energy Loss

The predominant concern of the hydraulic engineer in analysis of the conditions of flow and determination of water surface elevations is the continuous accounting of the energy state of the flow, which is dominated by the determination of "energy losses". Energy losses consist of the loss in energy in the system that is consumed by boundary friction and by internal turbulence generated by discontinuities in the boundaries.

Friction Loss

Boundary friction generates energy losses by internal fluid shear between water particles moving with respect to each other. Since flow is not moving at the channel boundary, but is moving at some distance away, shear must exist. A number of mathematical equations are in current use that model the friction energy loss phenomenon. All equations basically have the components of a factor that describes the rate of energy loss, a relationship for accounting for boundary roughness, a measure of the amount of boundary that is within contact of the flow, and the flow velocity. The standard that has been used by the profession for many years is the Manning Equation that is defined as:

$$Q = AV = \frac{1.5}{n} AR^{2/3} S_f^{1/2}$$

where

Q = flow rate in cubic feet per second

n = Manning roughness coefficient

A = flow area in square feet

R = hydraulic radius (A/WP) in ft.

WP = wetted perimeter in ft.

S_f = rate of energy loss in ft./ft. due to friction (slope of energy line)

The Manning equation in its usual form shows the computation of the flow rate Q as a function of the boundary roughness, flow area, channel shape,and rate of energy loss. For computation of water surface elevations in the usual case, the equation is solved iteratively to determine the rate of energy loss so that energy may be balanced between adjacent locations. The normal situation is that the downstream water surface elevation is known (elevation is known at a control point) and other elevations are to be determined so that water surface elevation and energy loss are both unknown requiring an interactive solution. The equation is applied conceptually to selected strips along the channel so that account can be taken of the varying nature of boundary and the flow velocity change laterally across the channel.

An example illustrating the nature of the Manning equation when applied to natural streams is contained in Chapter 12.

<u>Other Energy Losses</u>

The other energy losses that must be accounted for in energy conservation computations are those that occur because of major disturbances in the flow such as those caused by bridges, wing dam constructions, and flood plain fill. The major conceptual components generating energy loss are the contractions of the flow field upstream of the obstruction, the expansion that occurs downstream of the obstruction, and the losses generated by impact with the obstruction itself. A dominate loss that occurs in such structures as bridges results from the expanding portion of flow downstream. It seems that flow can efficiently contract (in terms of energy conservation) but is incapable of expanding without the generation of significant energy losses.

Obstructions in flow generally cause local changes in water surface elevations that are of interest in a planning situation. For example, the introduction of a bridge or, for that matter, an encroached channel condition at a given point, will generally raise the water surface elevation for some distance above that point. If the flow is subcritical, which is the usual case, the encroachment will not cause any change in water surface elevations downstream. Another situation, in which encroachments along the stream channels change the natural storage and flow rates, is discussed in a previous chapter related to streamflow routing.

Summary

The flow in natural channels can be analyzed by well founded scientific principles assuming that specific conditions can be imposed, such as steady flow and rigid boundaries. The nature of the response of water surface elevations, flows, and velocities is not mysterious but rather straight forward, and is generally well understood by the practicing profession. The predominant principles that are involved in determining the flow in a specific situation are that of volume, continuity and energy conservation. For energy conservation, the major concern is the analysis of energy losses between locations in the system.

QUESTIONS

CHAPTER 11

STEADY FLOW RIGID BOUNDARY HYDRAULICS

1. In a typical natural channel would one expect the water surface elevation to increase if the flow rate were to increase? The water surface to increase if the cross sectional area were decreased? Why?

2. When would an increase in flow rate result in a lower surface elevation?

3. What is the predominant feature that provides energy to flow in natural channels? Discuss the situation that would occur if a bridge were introduced into a natural channel that was experiencing subcritical flow? What would occur upstream and what would the conditions be downstream?

4. What term in the energy equation would the modification of the geometry of a natural channel impact upon? Is this the only term affected?

5. What major notions of river hydraulics are of predominant concern to planners?

DISCUSSION TO QUESTIONS

CHAPTER 11

STEADY FLOW RIGID BOUNDARY HYDRAULICS

1. Yes, because the increased flow would occupy a greater flow area; yes, because a decreased cross section area would require compensation by increased depth to maintain the needed flow area.

2. Expect the water surface elevation to increase in virtually every case.

3. The drop in land surface (channel) elevation. Introducing a bridge to the flow would generate increased energy loss. The upstream level would rise for a distance upstream and no change would be induced downstream.

4. Modifying geometry would directly change the velocity head term ($V^2/2g$) which would incidentally affect both the energy loss term and water surface elevation.

5. A question to reflect upon!

CHAPTER 12

WATER SURFACE PROFILE COMPUTATION

Introduction

The operational conversion of flow rate to water surface elevation is a task performed by the hydraulic engineer. In many hydrologic studies, this task consumes a major proportion of the analytical efforts. The alternatives that are available for conversion of flow rate to water surface elevation range from extrapolation and adjustment of observed high water marks, to the detailed analytical computation of water surface profiles, referred to by many as "backwater computations". Computation methodologies range from techniques that are very simple (extensions of prismatic concepts) to the more complete natural stream standard step backwater analysis which is normally performed in Corps of Engineers studies. The subject to be discussed in this chapter is the latter which comprises the operational application of the principles described in the pervious chapter. The framework for the analysis is to determine water surface elevation profiles for specific flow rates at specific points, where the flow rates have been developed by hydrologic analysis.

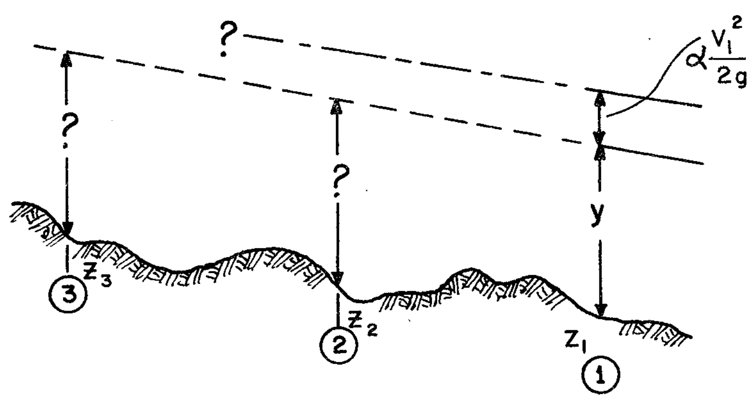
General Process

The overall process includes preparation work and actual computations. The preparation work consists of:

1. Assembly of flow and geometric data from hydrologic computations and field surveys.
2. Estimation of energy loss calibration coefficients. These coefficients may be determined by trail computations designed to reproduce observed streamflow high water marks. The coefficients are adjusted until an observed profile is matched, which is the desired condition. In the absence of observed data, the coefficients may be derived from experience, from handbooks supplemented by field observations, or perhaps transferred from similar stream reaches with known coefficients.

The production aspect involves the computation of the desired water surface profile. The production phase is usually a small part of the overall process with a relatively large amount of effort required to assemble and process flow and geometry data and calibrate the resistance coefficients for computations. Once these above items are accomplished, the processing is generally a simple final step requiring only checking for consistency and discontinuities in the computed profile.

The sketch below defines the conditions that may exist for a typical water surface profile determination.



Flow conditions are known or assumed at a location in the stream (location 1), and it is desired to determine the flow conditions (including water surface elevation) at other locations such as locations 2 and 3. The general computational process is as follows:

1. Based on known water surface elevation, compute flow condition and energy level at location 1.
2. Assume water surface elevation at location 2 and compute energy level and flow conditions at location 2.
3. Compute water surface elevation at location 2 using the known conditions at location 1 and the rates of energy loss computed in step 2.

4. Compare the water surface elevation computed in step 3 with the assumed water surface elevation in step 2.

5. Repeat steps 2 through 4 if elevations are not within a tolerable error.

The recursive application of this methodology is performed by continuously stepping from one location in a stream to another. The computations are quite repetitive, the solution techniques are well defined, and the number processing aspect of the process are quite demanding. Therefore, the procedure is a very logical candidate for computerization, and at the present time, virtually all water surface profiles are computed with the aid of the electronic digital computer.

Example

As an aid in bringing together principles and concepts discussed thus far and to provide a bit of the flavor of the numerical operations required to determine water surface elevation profiles in natural channels, the example contained in Table 12.1 will be discussed in some detail. The example requires the computation of the water surface elevation at location 2 (labeled River Mile 1.5) with conditions known at location 1 (labeled River Mile 1.0). Sketches in the lower portion of the figure show the channel geometry for the two locations. Idealized geometry is used to simplify the arithmetic associated with determining the geometric elements.

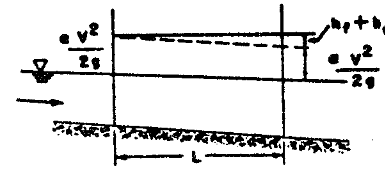
The initial columns of the table are for recording assumed and computed conditions for the comparisons that were described in the computation process. The table heading labeled A, $R^{2/3}$, and n are hydraulic geometry elements required for the computation of the rate of energy loss. The columns labeled K and K introduce the concept of conveyance, which is a function of the hydraulic geometry and Manning's n from the Manning Equation and is a measure of the flow carrying capacity of a portion of the channel. The remainder of the table is designed to cause systematic computations of the energy loss due to friction h_f, the kinetic energy (defined as $V^2/2g$) and finally expansion and contraction energy losses that will be described

Table 12.1 WATER-SURFACE PROFILE CALCULATIONS

PROJECT: STANDARD STEP EXAMPLE

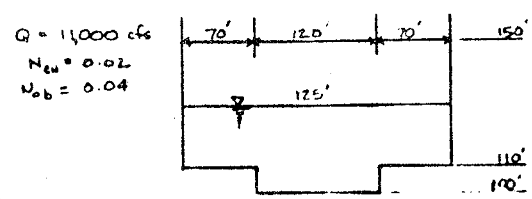
Q =

C_e = 0.3 C_c = 0.1

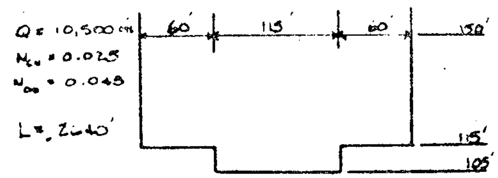


CROSS SECTION NO.	WATER SURFACE ELEVATION ASSUMED	WATER SURFACE ELEVATION COMPUTED	AREA A	HYDRAULIC RADIUS R	$R^{2/3}$	n	10^3 K	$\bar{K}$	$\bar{S}_f$	L	h_f	10^9 K^3/A^2	α	V	$\alpha \frac{V^2}{2g}$	$\Delta(\alpha \frac{V^2}{2g})$	h_o	Δ(WATER SURFACE ELEVATION)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1.0	125.0		1050	12.35	5.35	0.04	209.0					8.3						
Q =	11,000		3000	21.40	7.70	0.02	1730.0					575.4						
			1050	12.35	5.35	0.04	209.0					8.4						
		TOTAL	5100				2148.0					592.1	1.53	2.16	0.11			
1.5	126.1	125.06	666	9.37	4.41	0.045	97.0					2.05						
Q = 10500			2426	18.00	6.85	0.025	988.0					163.90						
			666	9.37	4.41	0.045	97.0					2.05						
		TOTAL	3758				1182.0	1665	.00003	2640	0.10	168.00	1.44	2.79	0.17	-0.06	0.02	+0.06
	125.0	125.04	600	8.6	4.2	0.045	83.0					1.58						
			2300	17.0	6.1	0.025	911.6					144.60						
			600	8.6	4.2	0.045	83.0					1.58						
		TOTAL	3500				1077.6	1612.8	.00004	2640	0.11	147.76	1.47	3.02	0.20	-0.09	0.02	+0.04

X-SECTION 1.0



X-SECTION 1.5



(8) $K = \frac{1.486\ AR^{2/3}}{n}$

(9) $\bar{K} = \frac{K_{upstream} + K_{downstream}}{2}$

(10) $\bar{S}_f = (\frac{Q}{\bar{K}})^2$

(12) $h_f = L\ \bar{S}_f$

(14) $\alpha = \frac{(A_T)^2\ \Sigma\ (K_i^3/A_i^2)}{(K_T)^3}$

where: i = incremental value

T = total value

(15) $V = Q/A_T$

(17) $\Delta(\alpha \frac{V^2}{2g}) = (\alpha \frac{V^2}{2g})_{downstream} - (\alpha \frac{V^2}{2g})_{upstream}$

(18a) $h_o = C_e\ |\Delta(\alpha \frac{V^2}{2g})|$ for $\Delta(\alpha \frac{V^2}{2g}) < 0$

(18b) $h_o = C_c\ |\Delta(\alpha \frac{V^2}{2g})|$ for $\Delta(\alpha \frac{V^2}{2g}) > 0$

(19) Δ (water surface elevation) = $\Delta(\alpha \frac{V^2}{2g}) + h_f + h_o$

subsequently. Note also the general horizontal layout of information and processing for a subdivision of the channel into three components. This is for the purpose (described in Chapter 11) of including the individual transport characteristics of each element of the cross section so that a more accurate determination of the rate of energy loss and kinetic energy can be made. In many computerized computations, up to 20 subdivisions of the cross section can be defined.

Example Computation: The known water surface elevation at (1) is 125.0 and the flow rate is 11,000 cfs. For an elevation of 125.0 the cross sectional flow area for the 3 elements are 1,050, 3,000, and 1,050 totaling 5,100 sq. ft. The hydraulic radius (R) is similarly computed and raised to the two thirds power (5.35, 7.70 and 5.35). Note that all pertinent mathmetical equations are shown at the bottom of the page. The hydraulic elements A, $R^{2/3}$ and n are then brought together to compute the conveyance for the elements of the cross section (209, 1,730, and 209 totaling 2,148). The distribution of conveyance within a cross section (k values) are then formed into a relationship for determining the velocity head coefficient ($\alpha =$ 1.5) and multiplied times the velocity head to yield the kinetic energy of .11 ft. Known conditions have now been defined.

The first estimate of the water surface elevation at location (2) is assumed to be 126.1. The above process that was required for computing the conditions at location (1) is then repeated for the water surface elevation 126.1. The concluding effort is the computation of the average conveyance K (1,665), the energy loss due to friction (0.1) and the balance in the energy relationship showing a change in water surface of +.06 feet, (.10 - .06 + .02), the column shown as WS. The computed elevation is thus 125.06 compared to the assumed 126.1, which is not within the tolerance of .05 ft. Another cycle is then repeated for an assumed elevation 125.0 and the computed elevation (125.04) is within the allowable tolerance, and we conclude that the water surface elevation of location (2) is 125.04 feet).

Note that even though the flow is proceeding from left to right in the sketch, that the water surface elevation is almost the same at both locations. How has this occurred? Note that the velocity has increased from

(1) to (2) which means that the flow is slowing down and thus the depth is increasing in a relative sense in the downstream direction. This illustrates the complex interaction accommodated by the energy principle allowing changes in water surface elevation, velocity head, and energy loss to be adjusted for specific flow conditions.

Data Requirements

The example should bring to mind questions regarding the overall requirement for information to facilitate the detailed computations. The stream reaches to encompass the area of concern and the evaluation conditions (such as encroachments) that are desired, and the flow rates that are of interest need specific definition. The class of the flow must be determined so that computations can proceed systematically. Most computational procedures require that the flow class be defined (either supercritical or subcritical) or computations will cease somewhere during the middle of the process. The initial condition (staring water surface elevation and location) is needed. Other needed data include calibration information (the horizontal distribution of channel roughness at all locations of interest, and the energy loss relationships for all obstructions such as bridges and changes in channel geometry) and finally the geometric data that is required to describe the hydraulic flow field. The geometric data is comprised of channel geometry (cross section data) and flow length between locations of interest. Because of the expense and importance of defining the hydraulic geometry it will be discussed further.

Geometric Data: Detailed cross sectional geometry is required to provide a numerical description of the flow field. The data must describe the river channel and flood plain so that the flow conditions can be modeled. In general, geometric data is required at all locations where significant changes in the hydraulic regime of the stream would occur such as where there is appreciable change in cross sectional area, or an appreciable change in the channel roughness characteristics, or a significant change in channel slope, or where major tributaries intersect. Other locations where cross sections generally should be obtained are:

- Above, below and within bridges
- At the head and tail of constricted sections such as levees
- At all control sections such as gaging stations

It is essential that the flow be described accurately which requires that cross section geometry be taken normal to the flow lines, and not necessarily perpendicular to the main stream channel. Where energy losses are occurring rapidly, such as in urban areas with many bridges and other obstructions, cross sections are required more frequently. Cross section data acquisition is expensive and there are trade-offs between the quality of the computed results and the completeness of the data collection and geometric description of the flow field.

Some specific guidelines that may be of interest (and probably should not be used to hold some hydraulic engineer's hand to the fire) are in Beasley [2]. The guideline is as follows:

"Maximum length between cross sections should not exceed a half mile for wide flood plains and slopes less than 2 feet per mile, 1,800 feet for slopes less than 3 feet per mile and 1,200 feet for slopes greater than 3 feet per mile."

In addition the computations that result will basically dictate the requirements and indicate the degree to which the overall analytical procedure assumptions and analysis techniques are being met. For instance, if the rate of energy loss between adjacent sections changes by more than 100% then the methods used are poor approximations and more cross sections are needed. Also, if the distribution of flow from once location to other changes substantially, such as from 50% within the channel at one cross section to only 10% within the channel at the next cross section, then more definition of the flow geometry is required.

Energy Loss Coefficients: The energy loss coefficients for friction and obstruction losses in an ideal sense should be determined from computations to reconstitute observed field data (highwater marks). Data for calibration of channel roughness coefficients is usually available for major streams, but seldom available for small channels and is almost never available for the many constrictions in bridges that occur throughout the system. As a consequence, local experience should be exercised for the determination of channel roughness and a number of general guides have been prepared to assist hydraulic engineers in these determinations. Expansion and contraction coefficients that predominate in bridge type computations (discussed in the next chapter) generally are determined from handbooks and have a significant impact on the computations in the vicinity of bridges.

Sensitivity of Water Surface Profile Data

A question that often arises to those who must spend large amounts of time and energy collecting data and processing results is: How much difference does it make to have accurate and large amounts of data? On the other hand, how much confidence can one have in results that are determined based on a limited set of data? These questions generally relate to the amount of stream geometry data available, which can be directly controlled by the amount of field surveys. It is obvious that the accuracy of the cross section data as well as the longitudinal frequency with which cross sections are obtained have a direct impact on the accuracy of the computed results. Another element less subject to field measurement is the amount and distribution of channel roughness as reflected by the Manning roughness coefficient.

Most studies of accuracy attempt to isolate random and systematic error in cross sections, for example, by comparing USGS quadrangle cross section type data with field surveys. For cross section data, it seems that in selected studies referenced in the literature, differences of up to 1 to 4 feet in computed water surface elevations can occur when comparing results from field surveys to cross section data obtained from standard 7-1/2 minute USGS quandrangle sheets. Differences in cross section spacing can result in a range of small differences computed elevations to very large differences, if the rates of energy loss are significant. Differences of over 4 feet in computed elevations have been observed in published results. The results for the energy loss coefficients (expansion and contraction) seem to be relatively insensitive in computation of profiles, but can be significant near bridges. Also an interesting observation is that profiles are not especially sensitive to differences in flow rate, indicating that the precise determination of flow rates is not always required for reasonable delineation of water surface elevations.

Included in Appendix B is an HEC paper that shows the results of a specific sensitivity study that was performed to develop a quantative comparison of the resulting differences in computed water surface elevations. A study of this example should provide some background for judging the reliability and utility of water surface profiles computed from varying data and varying assumptions.

QUESTIONS

CHAPTER 12

WATER SURFACE PROFILE COMPUTATION

1. Must the water surface elevation always decrease in the downstream direction? Explain your answer.

2. Given a flow rate, can the water surface elevation at an arbitrary point in a natural channel be directly determined by observation of the geometry at the location alone? Can it be determined approximately by this observation? What is the assumption that is made for this determination?

3. What types of studies would warrant the detailed computation of profiles as discussed in this particular chapter? What are the alternatives to detailed computations and where would they be appropriate and defendable?

4. Under what condition would a two-foot error in the computation of the 100-year flood level (assuming the correct flow is exactly known) be of major significance in a planning study?

DISCUSSION TO QUESTIONS

CHAPTER 12

WATER SURFACE PROFILE COMPUTATION

1. No, discontinuities in the profiles can occur from abrupt changes such as at a hydraulic jump or rapid increase in flow areas. The usual notion of water level decreasing in the downstream direction is, however, valid.

2. No, not without some simplifying assumptions. It can be determined approximately by assuming flow to be occurring in the "normal" state (rate of energy loss just balanced by fall in channel invert), and assuming the energy gradient can be determined from the ground slope. The Manning formula would then be used to compute the elevation.

3. With the increased refinement is computer technology and automated means of acquiring geometric data, there is less need for shortcut methods. Certainly most survey and local project investigations require reasonably accurate profile data. Perhaps some reconnaissance studies may not require detailed profiles. An alternative to profile computation is projection by map studies of observed high water marks and gaged rating relationships.

4. The point of this question is to cause reflection on the part of the reader as to his perception of the accuracy of profile computations. A two-foot error should not be expected to be a common occurrence but is by no means especially rare.

VERN BONNER

USE OF HEC-2 TO DERIVE RATING CURVES

OVERVIEW OF MATERIAL

* What is HEC-2 and what are its basic assumptions?
* What data are required to define base conditions?
* What are the primary impacts of channel flood reduction measures?
* How do we develop the base and modified rating curves?

1. HEC-2 WATER SURFACE PROFILES PROGRAM

HEC-2 is the Corps' primary tool for the determination of water surface profiles in natural and improved channels. Like HEC-1, it is a generalized computer program which is intended for application in a wide variety of stream analysis situations.

HEC-2 provides the capability to convert steady flow discharges (peak flows) computed by HEC-1 into water surface elevations, rating curves, depths and floodplain inundated areas. The hydraulic effects of bridges, floodplain fills, levees, bypasses, channel improvements, and ice may be simulated with HEC-2. Also, HEC-2 can be used to develop discharge-storage relationships to use in storage-based channel routing procedures in HEC-1 and HEC-5, the reservoir simulation program.

Figure 1 illustrates the use of HEC-2, along with the family of programs available for flood damage calculations.

2. BASIC ASSUMPTIONS FOR HEC-2 PROFILE CALCULATIONS

a. Flow is gradually varied - flow depths and velocity change gradually over distance.

b. Flow is steady - the discharge does not change with time

c. Flow is one dimensional - the total water energy is a constant in a cross section and the velocity components are in the direction of the flow.

d. The river is of small slope, less than 1:10

e. The channel boundary is rigid, not changing with flow.

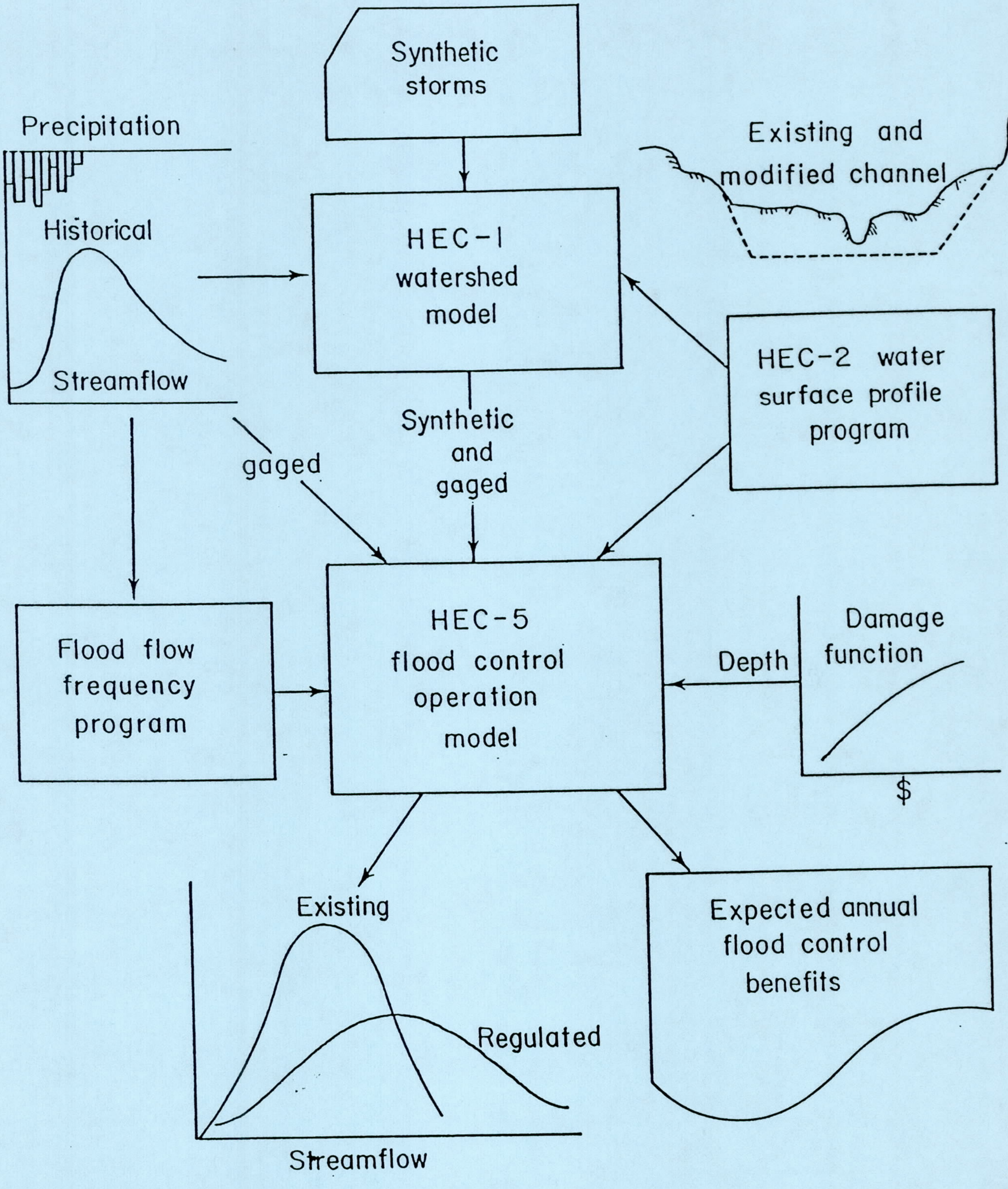


FIGURE 1

The use of computer programs HEC-1, HEC-2 and HEC-5 for Flood Plain Management Planning

3. DATA REQUIREMENTS FOR WATER SURFACE PROFILE CALCULATIONS

a. Flow - usually a flood peak discharge estimated by statistical analysis of observed data or by rainfall-runoff calculations.

If planned future conditions effect the peak flow values, these must be estimated and provided to the profile calculation process.

b. Starting water surface elevation - ideally based on stable control location. If unknown, starting location should be moved downstream from study area.

c. Cross sections - should be sufficient for the range of discharges expected and cover the entire study reach.

Program **PAS** is available to assist in determining study requirements and estimated cost of data collection.

d. Reach lengths - defining the distance between cross sections along the expected flow path.

There may be significant differences in the flow path for smaller floods than those for the larger floods.

e. Loss coefficients - Manning's "n" values are the primary coefficients; however, contraction, expansion, and bridge loss coefficients are usually required.

The computed profile is dependent on these coefficients; therefore, the values for existing conditions should be calibrated with observed historical flood events. Ref: "Accuracy of Computed Water Surface Profiles, HEC RD-26, December 1986.

The estimated coefficients for extreme floods and for modified conditions are important to the project. The estimation of the values should be documented and supported.

Required channel maintenance for the assumed coefficients under modified conditions must also be documented and supported in OM&R costs and the LCA.

f. Flow regime - usually subcritical, which means that changes in the channel will affect the water surface elevations upstream from the change. For example, a bridge, which causes an added energy loss, will cause a higher water surface elevation some distance upstream from the bridge.

4. CHANNEL FLOOD REDUCTION MEASURES

a. Channel Modifications

Clearing the channel reduces energy loss and produces a lower water surface profile for the same flow. This is usually modeled by reducing the loss coefficient for the channel.

Similarly, modifying bridges to increase flow capacity will reduce the local losses.

Channel improvements provide a more efficient cross section and usually reduced channel roughness. The primary result is a lower water surface elevation for the same discharge. A secondary impact may be less attenuation of the flood hydrograph in the improved reach; therefore a higher discharge.

HEC-2 has the CHIMP routine to provide easy preliminary modeling of the improved channel section and the resulting water surface profiles. HEC-2 can also be used to develop storage-discharge relationships, for the improved channel, to model the routing effects.

b. Levees and Floodwalls

Levees and Floodwalls contain the flow. The water surface profile will be higher when the flow is contained and there will be less attenuation of the flood hydrograph as it moves through the controlled reach.

HEC-2 has Encroachment options that can be used to simulate floodwall or levees for preliminary analysis. Usually more detailed cross sections will be used for the final analysis.

Flood profiles are also required for events that exceed the height levees and floodwalls. These analysis may require more complex models to evaluate flood overflow and residual flooding.

c. Diversions and Bypasses

Diversions reduce the flow downstream from the point of diversion. HEC-2 can be used to compute the profile based on the flow remaining in the channel.

The HEC-2 Split Flow option can be used to compute the lateral overflow based on the water surface elevation in the channel. Ref: "Application of the HEC-2 Split Flow Option," HEC TD-18.

5. DEVELOPING RATING CURVES FOR BASE AND MODIFIED CONDITIONS

a. Develop the existing conditions model with HEC-2.

Locations where rating curves are required must be known because cross sections will be required at those locations. Water surface elevations are only computed at cross-section locations.

b. Calibrate the model for historical flood events.

c. Define the range of discharges for study purposes. The discharges should range from low, non-damaging discharges up to the maximum value.

The discharge can change at any cross section in the model

Discharges may be different for future conditions.

d. Compute water surface profiles for the entire range of flows. These results must be carefully reviewed. Just because the model successfully worked for one discharge profile does not mean that it is adequate for all profiles.

e. Plot profiles for review and evaluation

f. Save input, output and binary (TAPE95) files. Careful labelling of the files and what they represent will reduce the chance for errors and incorrect use of the information.

HEC-2 has Title, Comments, and Remarks input options to allow program users to annotate the model data and assumptions.

g. TAPE95 is the input to **FDA2PO** Program, which provides for writing rating curves to HEC-DSS files.

h. Repeat the process for alternative plans. Remember to carefully review all data for each plan to ensure that the information is consistent.

BOB CARL.

USE OF THE FDA2PO PROGRAM TO STORE RATING CURVES

Program Purpose

The FDA2PO program post-processes computed results from HEC-2. It allows you to store rating curves in a HECDSS data file and / or compute reference flood elevations for each structure. This method of storing rating curves is an alternative to storing them directly with HEC-2. At this time, the personal computer version of HEC-2 does not contain the HECDSS capability although it will at a later date. Thus, the FDA2PO program provides the only automatic method of storing elevation-flow rating curves in a HECDSS data file on the personal computer. The FDA2PO program allows you to select the cross-sections at which you desire to store the curves rather than storing curves for all sections as is currently done by HEC-2 in the Harris version. The computation of the reference flood elevations requires that you supply a SID structure file containing "SL", "SD", and "SO" records and a SID input data file containing the reach identification records "DR".

The FDA2PO program processes results from either "TAPE95" or "TAPE96" output from a HEC-2 execution. The "TAPE95" file is a binary disk file to which HEC-2 writes computed results. It is a "binary" or "unformatted" file (not readable using the DOS "TYPE" command). It must be created with the current version of the HEC-2 program and not older versions so that it will be compatible (and readable) by the FDA2PO program. The "TAPE96" file is the archive output file from HEC-2. It is written in an ASCII (or readable) format. This file can be created on another computer system (such as the Harris) and downloaded to the personal computer where the FDA2PO program can process it and store rating curves and structure reference elevations in a HECDSS file on the personal computer. It is far more efficient to use the "TAPE95" file - it requires about fifty percent less processing time. However, program versions of the HEC-2 and FDA2PO must match and you can not look at the file using the DOS command "TYPE".

File Assignments

If you use the menu program to execute the programs, you need not worry about these keywords. However, if you execute on the Harris or don't use the menu program, you need to know these keywords. To determine the current definition, enter the command:

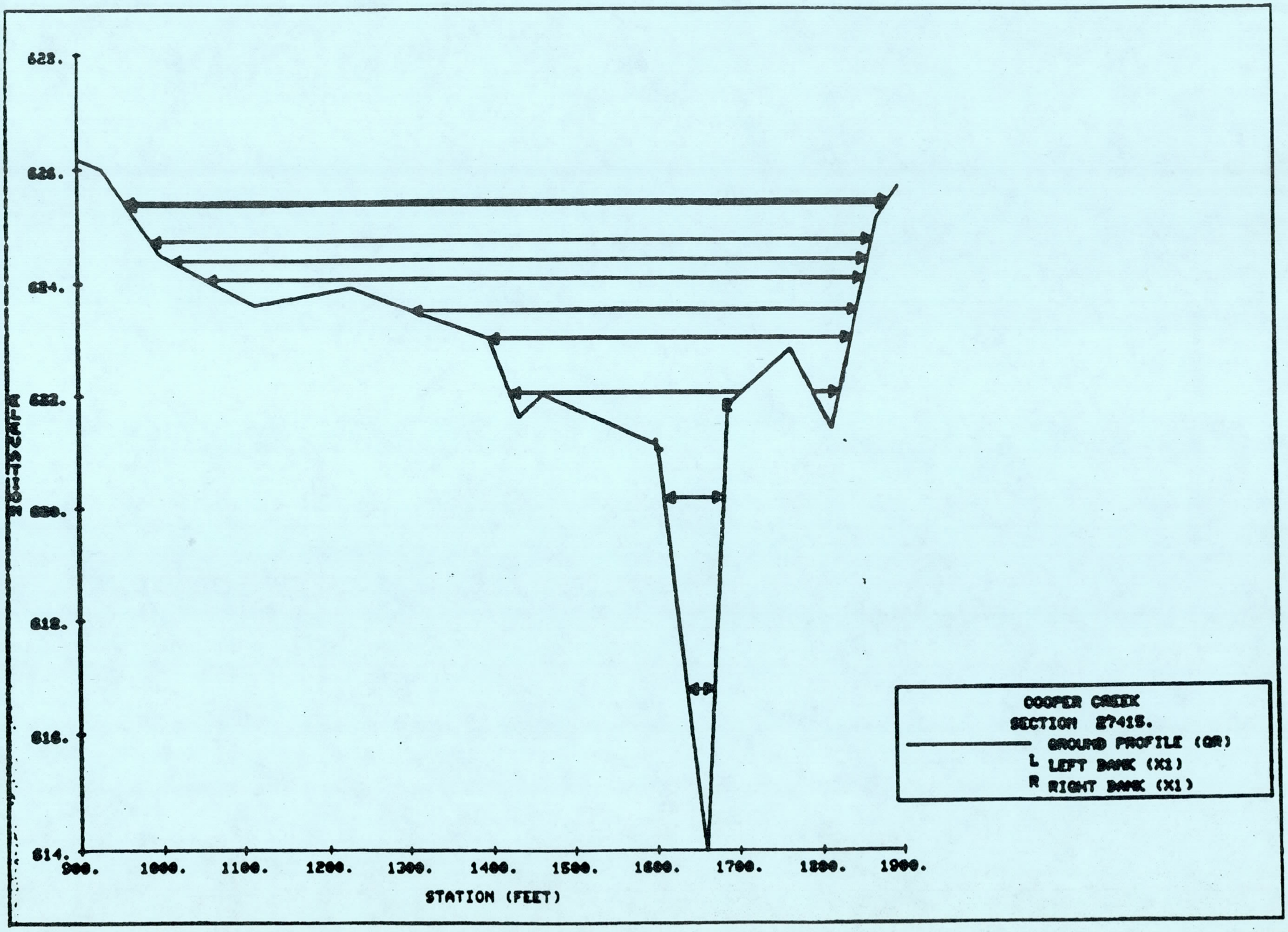
FDA2PO ?

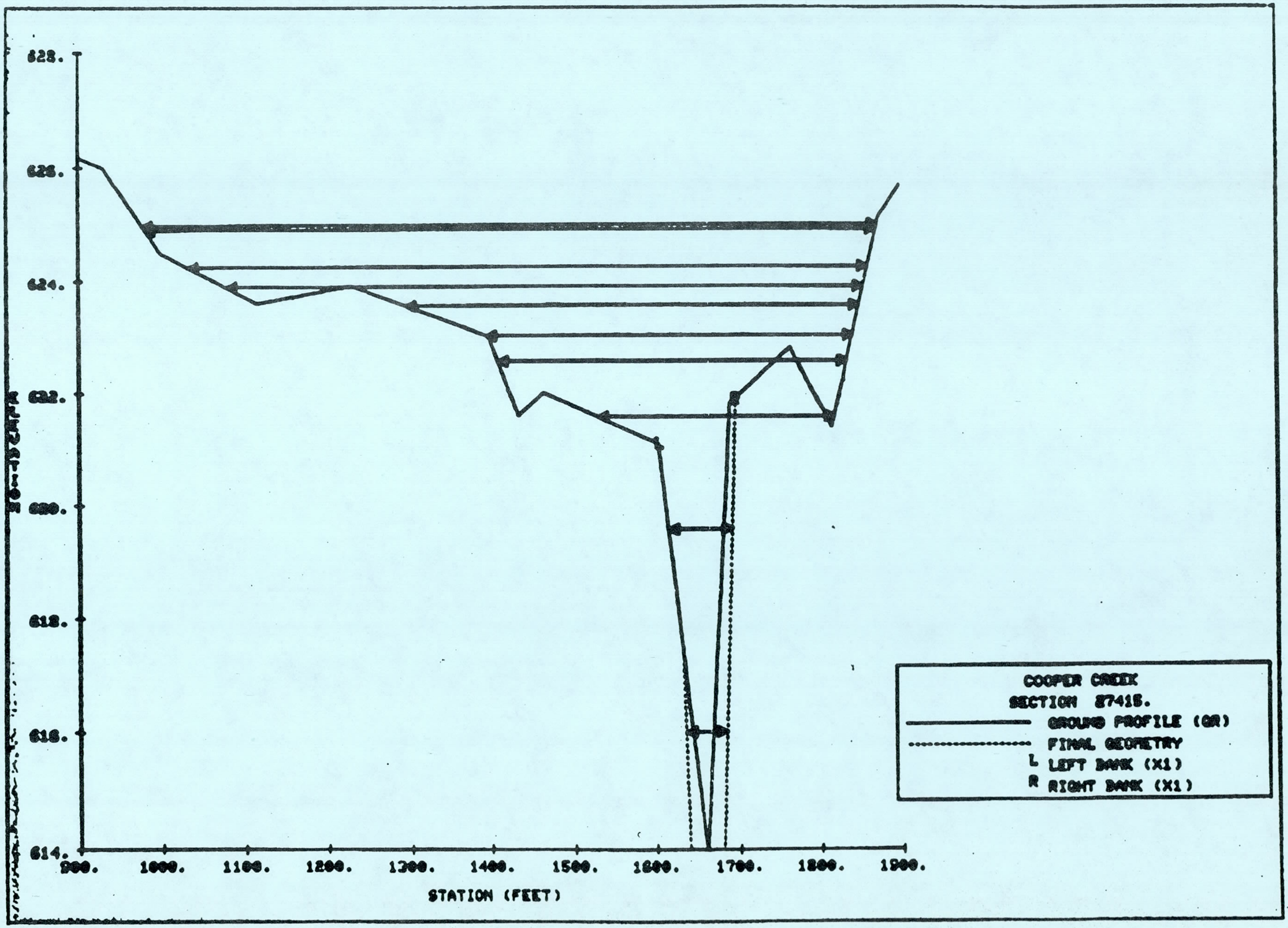
The resulting output should look similar to the following:

```
Post-Process HEC-2 for ref. flood - dated January 21, 1988
  UNIT      KEYWORD        *ABREV    **MAX   DEFAULT
    5       IN             I           64    CON
    6       OUT            O           64    CON
  NOP       F95            F           64    SCRATCH.031
  NOP       F96            F96         64    SCRATCH.001
  NOP       DR             D           64    SCRATCH.002
  NOP       SIN            S           64    SCRATCH.003
  NOP       SOUT           SO          64    SCRATCH.004
  NOP       DSS            DS          64    SCRATCH.032
  NOP       DRN            DRN         64    SCRATCH.005
  * ABREV - SHORTEST ABBREVIATION ALLOWED FOR KEYWORD
  ** MAX - MAXIMUM # OF CHARACTERS FOR FILENAME (OR STRING)
Stop - Program terminated.
```

The user should enter filenames for the keywords as follows:

Keyword	Description
F95 or F96	File which contains the results from HEC-2 (one of these is required for all calculations).
DR	File contains input data for the SID program including the DR records (required for calculation of reference flood elevations)
SIN	File contains the original structure records (SL, SD, and SO) for SID (required for all executions).
SOUT	File will contain the same structure records as the SIN file after they are modified with the computed reference flood elevation in field SL.5 and the translated first floor elevation in field SO.10 (required for calculation of reference flood elevations).
DSS	File is the HECDSS data file to which rating curves are written (required for storage of rating curves).


628.
614.
900.
1000.
1100.
1200.
1300.
1400.
1500.
1600.
1700.
1800.
1900.
STATION (FEET)
COOPER CREEK
SECTION 27415.
GROUND PROFILE (GR)
L LEFT BANK (X1)
R RIGHT BANK (X1)


628.
626.
624.
622.
620.
618.
616.
614.
900.
1000.
1100.
1200.
1300.
1400.
1500.
1600.
1700.
1800.
1900.
STATION (FEET)
COOPER CREEK
SECTION 27415.
GROUND PROFILE (GR)
FINAL GEOMETRY
L LEFT BANK (X1)
R RIGHT BANK (X1)

Rating Curve Calculation

To store rating curve(s) in a HECDSS data file, you must have SID input data containing the structure records SL, SD, and SO. You must also have the computed results from HEC-2 written on either "TAPE95" or "TAPE96". The HEC-2 results must be for several profiles of increasing discharge spanning the range of desired exceedance frequencies. The FDA2PO program prompts the user to identify the damage index locations by cross-section index number. For example, if there are 50 cross-sections, the user might identify cross-section 14 as the section coinciding with the damage index location. The user may identify the cross-section using the river mile (which is defined in field one of the X1 record of the HEC-2 input) by entering the code S={river mile}. For example, if cross-section 14 is at river mile 56.78 and it is the index location, the user may identify it by entering "S=56.78". The FDA2PO program uses the structure data to determine the number of reaches for which rating curves must be defined. If the HEC-2 results span more damage reaches than those defined in the SID structure file, the user needs to run FDA2PO several times, each time specifying a new structure file.

Before storing the rating curves in the HECDSS data file, FDA2PO prompts the user to define the pathname parts A, E, and F. FDA2PO utilizes the six character reach identification from the SL records as part B of the pathname. One record will be written to the HECDSS data file for each reach. Each record contains one elevation-discharge rating curve.

Example Execution of FDA2PO

The following pages illustrate a simple execution of the FDA2PO program. The data consists of three reaches in the Cooper Creek watershed. It includes only the storage of rating curves for the three reaches and not the reference flood elevations. The damage index locations are:

Reach	River Location (in feet)
REACH 11	27415
REACH 12	28550
REACH 13	29032

The river location is the cross-section "number" entered in field 1 of the HEC-2 input data. The program output and the user input are in normal font whereas the explanatory messages are in italics.

{The following is the output from FDA2PO as it processes HEC-2 output which has been stored on "TAPE95". Like this paragraph, explanations of the output not written by FDA2PO appear within brackets and in italics.}

```
Number of sections from File95 header:     17.

Process profile  1.
Process profile  2.
Process profile  3.
Process profile  4.
Process profile  5.
Process profile  6.
Process profile  7.
Process profile  8.
Process profile  9.
Process profile 10.
```

{The abover information is output by FDA2PO as it reads results for each water surface profile calculation. The number of cross-sections (17 in this case) should agree with the user's HEC-2 input data. If it does not agree, then the "TAPE95" is either wrong or it was generated with the a version of HEC-2 that is incompatible with the FDA2PO post-processor.}

{The following output displays the computed water surface elevations. In this case, there are 10 profiles. The water surface elevation for the tenth profile is located in the second line below the column titled "Profile 5". The "Cum dist." is simply the cumulative distance (in feet) of each cross-section from the first section. The "Section no." is the river mile entered in field one of the X1 record in the HEC-2 input data file.}

There were 10 profiles, 17 sections, and 0 tributaries.

Section no.	Cum dist.	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
25534.000	0.	607.55	609.53	611.45	612.89	613.69
		614.53	615.16	615.68	616.72	617.01
26193.000	659.	612.25	614.39	615.82	616.97	617.63
		618.36	618.86	619.32	620.23	620.45
26848.000	1314.	615.49	618.65	620.03	620.81	621.23
		621.69	621.99	622.28	622.86	622.98
26900.000	1366.	615.58	618.82	620.26	621.15	621.59
		622.05	622.35	622.62	623.16	623.26
26954.000	1420.	615.59	618.84	620.83	621.76	622.08
		622.44	622.66	622.88	623.38	623.47
27025.000	1491.	615.69	618.99	620.92	621.78	622.07
		622.40	622.61	622.81	623.26	623.37

27415.000	1881.	616.77	620.17	622.04	623.01	623.50
		624.05	624.38	624.73	625.36	625.42
27890.000	2356.	619.94	622.75	624.13	624.95	625.37
		625.87	626.15	626.45	627.01	627.08
28550.000	3016.	623.82	626.54	628.06	629.13	629.67
		630.29	630.61	630.91	631.46	631.53
28660.000	3126.	625.01	627.24	628.69	629.68	630.19
		630.78	631.07	631.45	632.21	632.27

>

Section no.	Cum dist.	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
28770.000	3236.	625.86	628.55	629.99	631.00	631.45
		631.99	632.30	632.60	633.54	633.75
28860.000	3326.	626.14	629.08	630.68	631.84	632.55
		633.49	634.15	634.91	636.04	636.09
28932.000	3398.	626.14	629.11	630.73	634.28	635.04
		635.47	635.73	635.99	636.48	636.52
29032.000	3498.	626.82	629.69	631.53	634.77	635.28
		635.74	636.01	636.28	636.80	636.83
29390.000	3856.	629.53	630.41	632.57	634.90	635.40
		635.87	636.16	636.44	636.97	637.14
29710.000	4176.	630.53	631.69	633.62	635.10	635.58
		636.04	636.34	636.63	637.17	637.46
30350.000	4816.	633.25	634.60	636.82	637.13	637.54
		637.99	638.32	638.60	639.44	640.26

Do you want to store rating curves in a DSS data file? (y/n): y

{User responds by entering "y" to indicate that rating curves will be stored in a HECDSS data file. FDA2PO recognizes either lower or upper case letters.}

Do you want to compute reference flood elevations? (y/n): n

{User responds by entering "n" to indicate that reference flood elevations will not be computed at each structure and at the index locations.}

```
There are   3 reach(es) in the structure file:
   Index   I.D.   Index   I.D.   Index   I.D.   Index   I.D.   Index   I.D.
--------------------------------------------------------------------------
       1  SID11       2  SID12       3  SID13
```

{The above reach information is read from the "SIN" (or SID input structure) file. FDA2PO displays this message after it has read all of the structure data contained in the SID structure file.}

```
For each damage reach from SID,  you must identify the
following:
(1)   The cross-section which corresponds to the index
      location.
(2)   The index number of the profile which will be used
      for the reference flood.
(3)   An edited river mile for the index location.


To eliminate a damage reach from consideration, enter a "d"
when prompted for the section number.
To get a list of cross-sections, enter "L" when prompted
for the section number.

Damage reach  SID11, Identify the cross-section at the index location > L
```

{The user has entered the character "L" to obtain a listing of all of the HEC-2 cross-sections. Two numbers appear for each cross-section: (1) The first number is the integer index which ranges from one through the number of sections, and (2) The second number is the river mile associated with that section as defined in field one of the HEC-2 X1 record.}

17 Cross-sections

IDX	Section	IDX	Section	IDX	Section	IDX	Section	IDX	Section
1	25534.000	5	26954.000	9	28550.000	13	28932.000	17	30350.000
2	26193.000	6	27025.000	10	28660.000	14	29032.000		
3	26848.000	7	27415.000	11	28770.000	15	29390.000		
4	26900.000	8	27890.000	12	28860.000	16	29710.000		

```
Damage reach  SID11, Identify the cross-section at the index location > 7

Damage reach  SID12, Identify the cross-section at the index location > s=28550

Damage reach  SID13, Identify the cross-section at the index location > s=29032
```

{The user has defined cross-section seven (river location 27415.0) as the damage index location for reach "SID11". It is defined using the index number. For reaches "SID12" and "SID13", the cross-sections are defined using the "cross-section number" as entered on the X1 record of the HEC-2 input data. This is done by entering the characters "s=" before the actual section number. FDA2PO will store three rating curves in the HECDSS data file, one for each reach.}

```
-----DSS---ZOPEN; Existing File Opened - Unit:  71  File: COOPER.DSS

Enter one of the following:
 (1)  The pathname part(s) in the format:
         A=pathname part A, E=pathname part E, F=pathname part F
 (2)  The pathname part when prompted.
 (3)  The command "EXIT" or press the "Enter" key to store
      the rating curves in the HECDSS data file.
 (4)  A "?" go get this message.


Study name - pathname part A ().
Data year - pathname part E ().
Alternative or plan - pathname part F ().

Study name - part A - () > COOPER CREEK


Study name - pathname part A (COOPER CREEK).
Data year - pathname part E ().
Alternative or plan - pathname part F ().

Data year - part E - () >


Study name - pathname part A (COOPER CREEK).
```

```
Data year - pathname part E ().
Alternative or plan - pathname part F ().

Alternative or plan - part F () > BASE


Study name - pathname part A (COOPER CREEK).
Data year - pathname part E ().
Alternative or plan - pathname part F (BASE).
```

{In the above section, the FDA2PO program opens the HECDSS data file and prompts the user for the pathname parts A, E, and F. The user did not enter part E. A blank part is defined by simply pressing the "Enter" key when prompted by FDA2PO for a pathname part.}

```
Store rating curves and exit? (y/n) > Y

-----DSS---ZWRITE Unit  71; Vers.    5:  /COOPER CREEK/SID11/ELEV-FLOW//BASE/
-----DSS---ZWRITE Unit  71; Vers.    5:  /COOPER CREEK/SID12/ELEV-FLOW//BASE/
-----DSS---ZWRITE Unit  71; Vers.    5:  /COOPER CREEK/SID13/ELEV-FLOW//BASE/
   -----DSS---ZCLOSE Unit: 71
              Number of Records:      6
              File Size:      4.4  Kbytes
              Percent Inactive:   .00
```

{The final user response of "y" triggers the storage of all (in this case three) rating curves in the HECDSS data file as indicated above. At this point, FDA2PO terminates processing.}

OVERVIEW OF DSSUTL AND DSPLAY

DSSUTL is a HECDSS utility program which allows the user to:

- Determine the pathnames associated with data stored in a DSS data file.
- Rename pathnames.
- Look at (or tabulate) data stored in the file.
- Copy data from one DSS file to another.
- Write / Read data to /from an ASCII file for transfer of data between dissimiliar computers.
- Edit data.

DSPLAY is a HECDSS utility program which allows the user to:

- Determine the pathnames associated with data stored in a DSS data file.

- Plot data stored in the DSS data file.
  - Tektronix 4010 & 4100 series CRT.
  - HP 7475 Pen Plotter.
  - Tektronix emulation packages.
  - MS-DOS Personal Computers (mono, EGA).

- Tabulate data stored in the DSS data file.

User Input Commands

Programs are "command" driven - they are not menu driven. Input consists of a command, option(s), and parameter(s) in the following format:

Command.Option(s), Parameter(s)

An example user command is one that catalogs the DSS data file (lists the pathnames associated with data stored in the data file):

CA.NFS O=ABCFED

The above command is the catalog command (abbreviated CA). Three options have been entered: "N" to obtain a new catalog list, "F" to list in the full format, and "S" to suppress listing the catalog to the screen. The parameter "O=ABCFED" indicates the sort order which is used to generate a sorted catalog list.

Pathname references

Pathnames may be referenced by either the "REF NO.", the full pathname, or updating the existing pathname. Examples:

23
/COOPER CREEK/SID11/ELEVATION-DAMAGE///BASE/
F=FP-3 FT

MOST IMPORTANT DSSUTL COMMANDS

CATALOG (CA)

- Determine the pathnames associated with data stored in a DSS data file.
- After data has been added to a DSS data file, a "new" catalog list must be obtained to accurately reflect the DSS file.
- Command is "CA.N".
- Command "CA.A" gives abbreviated listing which fits on 80 column screen.

DISPLAY PATHNAMES (DP)

- Lists pathnames that meet certain character mask. This is the "selective catalog" feature of the HECDSS.
- Useful to determine all pathnames associated with a certain location, plan, or type of data.
- Command to list all frequency-discharge curves:

```
DP C=FREQ-FLOW
```

RENAME (RN)

- Rename pathnames.
- Allows user to change the pathname label associated with data in the file.
- Useful if a label has been used which is inconsistent with other labels used for the same location or same plan.
- Command to change all pathname labels containing "BASELINE" as part F to "BASE":

```
RN F=BASELINE
F=BASE
```

COPY (CO)

- Copy data from one DSS file to another.
- Allows the user to copy data from the hydrology & hydraulics DSS data base into the Economic DSS data base.
- Allows the user to copy rating curves for only the desired locations from the HEC-2 DSS data file into the Economic DSS data file.
- Command to copy all frequency-discharge curves from the currently opened DSS data file named COO1.DSS (the HEC-1 DSS data file) into the Economic DSS data file named COOE.DSS:

  CO COOE.DSS C=FREQ-FLOW

WRITE DATA (WR)
READ DATA (RE)

- Write/Read data to/from an ASCII file.
- Allows the user to transfer data between dissimiliar computers.
- Command to write all frequency-discharge curves from the currently opened DSS data file into the ASCII file "QFDATA":

  WR,QFDATA, C=FREQ-FLOW

- Command to read the frequency-discharge curves (or any other DSSUTL compatible data) from the ASCII file "QFDATA" into the currently opened DSS data file:

  RE,QFDATA

EDIT (ED)

- Edit data stored in DSS data file.
- Allows the user to modify data already entered into the DSS data file.
- Operational only on the Harris ("chains" into COED for editing).
- On the PC, "WRite data" to an ASCII file, exit DSSUTL, invoke COED, execute DSSUTL, and "REad data" from an ASCII file.

MOST IMPORTANT DSPLAY COMMANDS

CATALOG (CA)

- Determine the pathnames associated with data stored in a DSS data file.
- After data has been added to a DSS data file, a "new" catalog list must be obtained to accurately reflect the DSS file.
- Command is "CA.N" for new catalog.
- Command "CA.A" gives abbreviated listing which fits on 80 column screen.

DISPLAY PATHNAMES (DP)

- Lists pathnames that meet certain character mask.
- Useful to determine all pathnames associated with a certain location, plan, or type of data.
- Command to list all frequency-discharge curves:

```
DP C=FREQ-FLOW
```

PATH (PA)

- Defines pathname and causes DSPLAY to retrieve data from the currently opened DSS data file and store in the program's memory.
- Data from other DSS files may be retrieved by "OPening" another DSS file and issuing the "PAth" command.
- Example "PAth" commands:

```
PA 23
PA /COOPER CREEK/SID11/ELEVATION-DAMAGE///BASE/
PA F=FP-3 FT
```

TABULATE (TA)

- Tabulate data which has already been retrieved (using the "PAth" command).
- Tabulate command may contain pathname references in the "index number" format:

  TA 1

- Example sequence to tabulate data for one pathname:

  PA 1
  TA 1

PLOT (PL)

- Plots data which has already been retrieved using the "PAth" command on desired device:
  - Tektronix 4010 & 4100 series CRT.
  - HP 7475 Pen Plotter.
  - Tektronix emulation packages.
  - MS-DOS Personal Computers (mono, EGA).
- PLot command may contain pathname references in the "index number" format:

  PL 1

- Example sequence to plot data for two pathnames:

  PA 1
  PA 3
  TA 1

- DSPLAY has many commands which control the format of the plot.

- Several command are of particular importance to the FDA Package and paired function data. They include:

AXis — Defines the type of plot axis. A specification is entered for each "vector". For example, a frequency-discharge curve from HEC-1 contains two vectors: frequency and discharge. To plot the log of discharge versus exceedance frequency, enter:

```
AX,LIN,LOG
```

The "LIN" defines the frequency axis as linear in terms of probability and the "LOG" defines the discharge axis as base 10 logarithmic.

CUrve — Defines the vectors (or curves) which will be plotted. This command allows the user to plot a subset of data stored in one pathname. One typical example of this is the ELEVATION-DAMAGE function stored by SID. It contains an elevation-damage function for all damage categories. If the user wishes to plot only the second damage category, then the "CUrve,2" command must be entered <u>before</u> the "PAth" command is entered. An example sequence of user input required to plot the second and third damage category elevation-damage functions is:

```
AX,LIN,LIN,LIN
CU,2,3
PA /COOPER CREEK/SID11/ELEVATION-DAMAGE//BASE/
PA F=FP-3 FT
PL
```

HECDSS Complete Catalog of Record Pathnames for DSS File: COOPER.DSS

Catalog Date: 05MAY88 at 14:38; File Created on 05MAY88; DSS Version 5-BE
Number of Records: 12
Pathnames Not Sorted

Ref. No.	Prog	Last Written Date	Last Written Time	Ver	Head	Data	Record Pathname
1	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CR/2A/FREQ-FLOW///BASE/
2	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CR/2A/FREQ-FLOW///UNGTD SPILL 650/
3	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CR/2A/FREQ-FLOW///UNGTD SPILL 655/
4	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CR/3B/FREQ-FLOW///BASE/
5	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CR/3B/FREQ-FLOW///UNGTD SPILL 650/
6	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CR/3B/FREQ-FLOW///UNGTD SPILL 655/
7	SID	05MAY88	14:38:06	1	50	216	/COOPER CREEK/RCH11/ELEVATION-DAMAGE///BASE/
8	SID	05MAY88	14:38:06	1	50	216	/COOPER CREEK/RCH12/ELEVATION-DAMAGE///BASE/
9	SID	05MAY88	14:38:06	1	50	216	/COOPER CREEK/RCH13/ELEVATION-DAMAGE///BASE/
10	SID	05MAY88	14:38:30	1	50	228	/COOPER CREEK/RCH11/ELEVATION-DAMAGE///FP-2%/
11	SID	05MAY88	14:38:30	1	50	228	/COOPER CREEK/RCH12/ELEVATION-DAMAGE///FP-2%/
12	SID	05MAY88	14:38:30	1	50	228	/COOPER CREEK/RCH13/ELEVATION-DAMAGE///FP-2%/

PA. 1 - Pathname Ref #1

PA. 3 - Pathname Ref #3

PL - PLOT

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Workshop

Bob Carl

PAIRED DATA, PIP, FDA2PO, DSSUTL, AND DSPLAY PROGRAMS

Objectives

This workshop provides the participant with experience in applying the "paired function convention" as defined for the Hydrologic Engineering Center's Data Storage System (HECDSS). The participant must:

- Enter frequency functions into a DSS data file using the interactive program "PIP".
- Store rating curves in the DSS data file using the interactive HEC-2 post-processor program FDA2PO.
- "REad" data from a HECDSS-DSSUTL compatible ASCII file and store the data in a DSS file.
- Catalog the DSS data file using HECDSS-DSPLAY.
- Tabulate data in the DSS data file using HECDSS-DSPLAY.
- Plot data in the DSS data file using HECDSS-DSPLAY

Background

This workshop demonstrates the capabilities of the following:

- PIP program, paired data input program
- FDA2PO program, the HEC-2 post-processor program
- DSSUTL program, the HECDSS utility program for managing HECDSS data files.
- DSPLAY program, the HECDSS utility program for accessing and displaying data in a DSS data file.

It also familiarizes the workshop participant with the paired data convention in conjunction with the HECDSS data management system.

The workshop participant will enter frequency-discharge functions for Cooper Creek reaches 11, 12, and 13 directly into the master economic DSS data file. These frequency functions represent baseline conditions. They will later be inserted into the HEC-1 and HEC-5 input data sets. Although HEC-1 and HEC-5 cannot read frequency functions from a DSS data file, they must interpolate a new baseline condition frequency function using the user defined baseline frequency function and ratios of flow or precipitation. By entering the baseline frequency function into the DSS data file, the participant will later compare the HEC-1 / HEC-5 interpolated baseline frequency function with the original user defined function.

The participant will also store elevation-discharge rating curves in the DSS data file using the HEC-2 post-processor program FDA2PO. These rating curves represent baseline conditions. A similar application of FDA2PO is required to store modified rating curves in the DSS data file. The modified curves are computed to evaluate the channel modification or channel improvement damage reduction measure.

The participant will read an ASCII formatted file into the DSS data file using the DSSUTL. This file contains frequency-discharge curves computed by HEC-1. The file is formatted in the DSSUTL compatible structure.

Finally, the participant will invoke the HECDSS-DSPLAY program to verify that the proper relationships are stored in the DSS data file. This program allows the user to catalog (or list) all of the pathnames associated with data in the DSS data file. It also allows the user to examine the data in tabular or graphical form.

Tasks

(1) Enter the frequency-discharge functions for Cooper Creek damage reaches 11, 12, and 13. Cooper Creek reaches 11 and 12 use the frequency function at control point 3B and reach 13 uses the frequency function at control point 2A.

(a) To execute PIP, enter: MENUFDA to run the FDA menu program. Select the PIP program and define the DSS data file to be "COO.DSS".

(b) The participant must define DSS pathname parts A, B, and F. You should slightly modify your pathname part F for base (plan 1) conditions. HEC-1 will write another, different base condition frequency function to the DSS data file and you will need to distinguish between the two. To maintain uniformity with the output from HEC-1, use the HEC-1 control point identifiers as part B of the HECDSS pathname (2A and 3B).

(c) The Frequency-discharge function for control point 2A is listed below. Write the pathname parts which you selected in the spaces below.

Pathname part A (Project Name): COOPER CREEK

Pathname part B (Location): CP 2A

Pathname part F (Alternative): BASE TEST

Index	Frequency (%)	Discharge (cfs)
1	99.00	310
2	20.31	1,591
3	10.01	1,999
4	3.16	2,652
5	1.53	3,130
6	.65	3,697
7	.31	4,146
8	.12	4,678
9	.05	5,893
10	.01	7,395

(d) The Frequency-discharge function for control point 3B is listed below. Write the pathname parts which you selected in the spaces below.

Pathname part A (Project Name): COOPER CREEK

Pathname part B (Location): CP 3B

Pathname part F (Alternative): BASE TEST

Index	Frequency (%)	Discharge (cfs)
1	99.00	600
2	25.16	2,469
3	11.67	3,099
4	3.81	4,144
5	1.61	4,915
6	.69	5,819
7	.31	6,534
8	.11	7,358
9	.05	9,215
10	.01	11,500

(e) Exit the PIP program and save your data in the DSS data file. Use the file "COO.DSS" as the DSS file. From the "Define Data File" menu, list the file "DATAFILE". Verify that you have correctly entered the frequency functions. (If you have incorrectly entered data, you may invoke COED to modify the file, and then execute PIP to re-enter the data in the DSS data file).

(2) Store rating curves in the DSS data file using the interactive HEC-2 post-processor program FDA2PO. When operating on the Harris, you may write rating curves directly to the DSS file from HEC-2. However, HEC-2 writes a rating curve for every cross-section rather than just those you wish to store. For this workshop, the "TAPE95" results from HEC-2 for base conditions have been saved in the file "P1.295". A "dummy" set of structures for SID has been entered in the file "DUMMY.I". (You do not need to enter a file name for the "DR" file - the SID input data file which contains the "DR" reach identification records).

(a) Write your selection for the pathname parts in the tables below.

Pathname Part A: COOPER CREEK

Pathname Part F: BASE TEST

Reach	Cross-section	Pathname Part B
11	274+15	27415
12	285+50	28550
13	290+32	29032

(b) Execute the FDA2PO program by entering: MENUFDA and selecting the FDA2PO program. You must define the following files:

- File 95 (HEC-2 binary results) (P1.295)
- Input SID structure file (DUMMY.I)
- Output SID structure file (TEMP.I)
- HECDSS file (COO.DSS)

Do not calculate the reference flood elevations.

(c) Execute the FDA2PO program again for plan 5, the channel improvement. You must define the following files:

- File 95 (HEC-2 binary results) (P5.295)
- Input SID structure file (DUMMY.I)
- Output SID structure file (TEMP.I)
- HECDSS file (COO.DSS)
- Macro file (FDA2PO.MAC)

Do not calculate the reference flood elevations. Instead of entering FDA2PO commands from the keyboard, press the "Enter" key until you receive the prompt:

Do you want to store rating curves in a DSS data file?

At that point, you will run a "PREAD" macro by typing the command **"!RUN PLAN5"**.

(3) "REad" data from a HECDSS-DSSUTL compatible ASCII file and store the data in a DSS file. In this operation, you will store data in the DSS file which has been previously written by DSSUTL into an ASCII (or "human readable") file.
For normal operations on the Harris, the analyst would directly write the computed frequency curves from HEC-1 (or HEC-5) into a DSS file. If the economic DSS file is different than the H&H DSS data file, the user would invoke the "COpy" command from DSSUTL to copy data associated with pathnames from one DSS file to another.

However, in this case, it is assumed that the H&H work is done on a different computer than the economic analyses. To transfer data between computers, the user "Writes Data" using DSSUTL to an ASCII file from a DSS file on the H&H machine. Then, the analyst performing the economic analysis invokes DSSUTL (as you will do in this workshop) to read that data from the ASCII file into the economic DSS file. A typical application is to write all frequency-discharge curves to the ASCII file. To write frequency-discharge curves from the currently opened DSS file to the file named QFDATA, the analyst enters the DSSUTL command: WD,QFDATA,C=FREQ-FLOW

For this workshop, frequency data computed by HEC-1 has been written from a DSS file into the ASCII file named QFDATA.

(a) Look at the HECDSS-DSSUTL compatible ASCII file named QFDATA by "LIsting" the file. For example, enter: LIST QFDATA

(b) Execute the DSSUTL program by entering: MENUFDA to invoke the FDA menu program, select DSSUTL, and define the HECDSS file as "COO.DSS".

(c) Read all of the data stored in the file QFDATA and store it in the DSS file by entering: RE,QFDATA

(d) Exit DSSUTL by entering "FI" or "FINISH".

(4) Catalog the DSS data file using HECDSS-DSPLAY. This operation could have been performed using the DSSUTL program. However, we also wish to plot the data so the HECDSS-DSPLAY program is invoked.

(a) Execute the DSPLAY program by entering: MENUFDA to execute the FDA menu program, select the DSPLAY program, and define the HECDSS data file as "COO.DSS".

(b) Get a catalog of all pathnames which correspond to data stored in the DSS file. Since you have just entered data into the file, there is not a current catalog list available. You must obtain a new catalog by entering:

CA.N

(c) Get an abbreviated catalog list by entering:

CA.A

(5) Tabulate data in the DSS data file using HECDSS-DSPLAY. To tabulate (or plot data) the data is first retrieved from the DSS file. This is done through the use of the "PAth" command which defines the desired records.

(a) Execute DSPLAY (if not executing already).

(b) Use the same HECDSS filename as you have previously used in this workshop "COO.DSS".

(c) Get a list of frequency-discharge pathnames by entering:

DP C=FREQ-FLOW

(d) Tabulate the base condition and modified condition frequency curves for control point 3B.

(e) Compare the original base condition frequency curve (the one you entered using PIP) with the interpolated base condition frequency curve as computed by HEC-1.

(6) Plot data in the DSS data file using HECDSS-DSPLAY. To plot data, the data is first retrieved from the DSS file. This is done through the use of the "PAth" command which defines the desired records.

(a) Execute DSPLAY (if not executing already).

(b) Use the same HECDSS filename as you have previously used in this workshop.

(c) Define the vertical axis as logarithmic by entering the command:

AX,LIN,LOG,LOG,LOG

(d) Get a list of frequency-discharge pathnames by entering:

DP C=FREQ-FLOW

(e) Plot the base condition and modified condition frequency curves for control point 3B. Use the results from the previous command to define the desired pathnames. Example user input is:

PA 4,5,6
PL

(f) Compare the original base condition frequency curve (the one you entered using PIP) with the interpolated base condition frequency curve as computed by HEC-1.

(7) Perform tasks five and six again accessing the rating curves instead of the frequency curves.

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Bob Carl.

Workshop Solution

PAIRED DATA, PIP, FDA2PO, DSSUTL, AND DSPLAY PROGRAMS

Tasks

(1) Enter the frequency-discharge functions for Cooper Creek damage reaches 11, 12, and 13. Cooper Creek reaches 11 and 12 use the frequency function at control point 3B and reach 13 uses the frequency function at control point 2A.

(a) To execute PIP, enter: MENUFDA to run the FDA menu program. Select the PIP program and define the DSS data file to be "COO.DSS".

(b) The participant must define DSS pathname parts A, B, and F. You should slightly modify your pathname part F for base (plan 1) conditions. HEC-1 will write another, different base condition frequency function to the DSS data file and you will need to distinguish between the two. To maintain uniformity with the output from HEC-1, use the HEC-1 control point identifiers as part B of the HECDSS pathname (2A and 3B).

(c) The Frequency-discharge function for control point 2A is listed below. Write the pathname parts which you selected in the spaces below.

Pathname part A (Project Name): COOPER CREEK

Pathname part B (Location): 2A

Pathname part F (Alternative): BASE-ORIGINAL

Index	Frequency (%)	Discharge (cfs)
1	99.00	310
2	20.31	1,591
3	10.01	1,999
4	3.16	2,652
5	1.53	3,130
6	.65	3,697
7	.31	4,146
8	.12	4,678
9	.05	5,893
10	.01	7,395

Best Estimate Existing Condition Frequency Curve

(d) The Frequency-discharge function for control point 3B is listed below. Write the pathname parts which you selected in the spaces below.

Pathname part A (Project Name): COOPER CREEK

Pathname part B (Location): 3B

Pathname part F (Alternative): BASE-ORIGINAL

Index	Frequency (%)	Discharge (cfs)
1	99.00	600
2	25.16	2,469
3	11.67	3,099
4	3.81	4,144
5	1.61	4,915
6	.69	5,819
7	.31	6,534
8	.11	7,358
9	.05	9,215
10	.01	11,500

(e) Exit the PIP program and save your data in the DSS data file. Use the file "COO.DSS" as the DSS file. From the "Define Data File" menu, list the file "DATAFILE". Verify that you have correctly entered the frequency functions. (If you have incorrectly entered data, you may invoke COED to modify the file, and then execute PIP to re-enter the data in the DSS data file).

PIP Program: user input and program output.

```
*****************************************************************
*  PIP - Paired-function data Input Program for HECDSS         *
*  Version date: October 1, 1989                               *
*  IBM-PC Compatible (MS)                                      *
*  Rundate 16JAN90     Time 15:12:56                           *
*****************************************************************


        O P E N I N G   M E N U

          0  EXIT PROGRAM

          1  GENERAL HELP MENU

          2  PATHNAME MENU

          3  DATA ENTRY MENU

          4  DATA-FILE MENU


Enter: item number or (H)elp> 1

                        G E N E R A L   H E L P   M E N U

                                                          OTHER MENUS

    0  EXIT PROGRAM         :  3  SAVE AND EDIT DATAFILE :  5  PATHNAME MENU
                            :                            :
    1  SET HELP LEVEL       :  4  DATA-FILE STRUCTURE    :  6  DATA ENTRY MENU
                            :                            :
    2  GENERAL INSTRUCTIONS :                            :  7  DATA-FILE MENU


Enter: item number or (H)elp> 1
  Help levels:

    0  All data entry instructions displayed
    1  All data entry instructions suppressed

  Current help level is 0
Enter space or new help level (0 or 1)> 1
  Current help level is now 1
```

```
                    G E N E R A L   H E L P   M E N U
                                                              OTHER MENUS

  0  EXIT PROGRAM           :  3  SAVE AND EDIT DATAFILE :  5  PATHNAME MENU
                            :                            :
  1  SET HELP LEVEL         :  4  DATA-FILE STRUCTURE    :  6  DATA ENTRY MENU
                            :                            :
  2  GENERAL INSTRUCTIONS   :                            :  7  DATA-FILE MENU

Enter: item number or (H)elp> 5
```

```
               P A T H N A M E   M E N U
                                                 OTHER MENUS

  0  EXIT PROGRAM                     :  3  GENERAL HELP MENU
                                      :
  1  SET PROJECT NAME (part A)        :  4  DATA ENTRY MENU
                                      :
  2  SET ALTERNATIVE NAME (part F)    :  5  DATA-FILE MENU

Enter: item number or (H)elp> 1

 Current Project name:
Enter Project name (max 32 characters)> COOPER CREEK
Enter: item number or (H)elp> 2

 Current Alternative name:
Enter Alternative name (max 32 characters)> BASE-ORIGINAL
Enter: item number or (H)elp> 4
```

```
            D A T A   E N T R Y   M E N U
                                              OTHER MENUS

  0  EXIT PROGRAM                :  4  GENERAL HELP MENU
                                 :
  1  SET LOCATION (part B)       :  5  PATHNAME MENU
                                 :
  2  SET DATA YEAR (part E)      :  6  DATA-FILE MENU
                                 :
  3  SELECT DATA TYPE            :

Enter: item number or (H)elp> 1

 Current location:
Enter location (max 6 characters> 2A
Enter: item number or (H)elp> 3
```

```
                    D A T A   T Y P E   M E N U
                                                      OTHER MENUS

    0 EXIT PROGRAM      : 4 FREQ-FLOW          :  8 GENERAL HELP MENU
                        :                      :
    1 ELEVATION-DAMAGE  : 5 FLOW-DAMAGE        :  9 PATHNAME MENU
                        :                      :
    2 ELEV-FLOW         : 6 FREQ-DAMAGE        : 10 DATA ENTRY MENU
                        :                      :
    3 FREQ-ELEV         : 7 DISPLAY PATHNAME   : 11 DATA-FILE MENU

Enter: item number or (H)elp> 4
Enter FREQUENCY-FLOW> 99 310
Enter FREQUENCY-FLOW> 20.31 1591
Enter FREQUENCY-FLOW> 10.01 1999
Enter FREQUENCY-FLOW> 3.16 2652
Enter FREQUENCY-FLOW> 1.53 3130
Enter FREQUENCY-FLOW> .65 3697
Enter FREQUENCY-FLOW> .31 4146
Enter FREQUENCY-FLOW> .12 4678
Enter FREQUENCY-FLOW> .05 5893
Enter FREQUENCY-FLOW> .01 7395
Enter FREQUENCY-FLOW> "Enter" key pressed
 Do you want to display the data?
 (You cannot edit the data without displaying it)

Display? (Y or N)> Y
 Data display
 Point      FREQUENCY          FLOW
     1          99.00        310.00
     2          20.31       1591.00
     3          10.01       1999.00
     4           3.16       2652.00
     5           1.53       3130.00
     6            .65       3697.00
     7            .31       4146.00
     8            .12       4678.00
     9            .05       5893.00
    10            .01       7395.00
Do you want to edit the data? (Y or N)> N

                D A T A   E N T R Y   M E N U
                                               OTHER MENUS

    0 EXIT PROGRAM                   :  4 GENERAL HELP MENU
                                     :
    1 SET LOCATION (part B)          :  5 PATHNAME MENU
                                     :
    2 SET DATA YEAR (part E)         :  6 DATA-FILE MENU
                                     :
    3 SELECT DATA TYPE               :

Enter: item number or (H)elp> 1

 Current location: 2A
Enter location (max 6 characters> 3B
```

```
Enter: item number or (H)elp> 3

                    D A T A   T Y P E   M E N U

                                                  OTHER MENUS

  0  EXIT PROGRAM      :  4  FREQ-FLOW        :  8  GENERAL HELP MENU
                       :                      :
  1  ELEVATION-DAMAGE  :  5  FLOW-DAMAGE      :  9  PATHNAME MENU
                       :                      :
  2  ELEV-FLOW         :  6  FREQ-DAMAGE      : 10  DATA ENTRY MENU
                       :                      :
  3  FREQ-ELEV         :  7  DISPLAY PATHNAME : 11  DATA-FILE MENU

Enter: item number or (H)elp> 4
Enter FREQUENCY-FLOW> 99 600
Enter FREQUENCY-FLOW> 25.16 2469
Enter FREQUENCY-FLOW> 11.67 3099
Enter FREQUENCY-FLOW> 3.81 4144
Enter FREQUENCY-FLOW> 1.61 4915
Enter FREQUENCY-FLOW> .69 5819
Enter FREQUENCY-FLOW> .31 6534
Enter FREQUENCY-FLOW> .11 7358
Enter FREQUENCY-FLOW> .05 9215
Enter FREQUENCY-FLOW> .01 11500
Enter FREQUENCY-FLOW> "Enter" key pressed
 Do you want to display the data?
 (You cannot edit the data without displaying it)

Display? (Y or N)> Y
 Data display
 Point    FREQUENCY       FLOW
    1        99.00       600.00
    2        25.16      2469.00
    3        11.67      3099.00
    4         3.81      4144.00
    5         1.61      4915.00
    6          .69      5819.00
    7          .31      6534.00
    8          .11      7358.00
    9          .05      9215.00
   10          .01     11500.00
Do you want to edit the data? (Y or N)> N

              D A T A   E N T R Y   M E N U

                                       OTHER MENUS

  0  EXIT PROGRAM              :  4  GENERAL HELP MENU
                               :
  1  SET LOCATION (part B)     :  5  PATHNAME MENU
                               :
  2  SET DATA YEAR (part E)    :  6  DATA-FILE MENU
                               :
  3  SELECT DATA TYPE          :

Enter: item number or (H)elp> 0
Do you want to save your data? (Y or N)> Y
```

```
Current DSS filename: COO.DSS
Enter DSS filename> COO.DSS

 ** HECDSS File system read **
   -----DSS---ZOPEN;      New File Opened - Unit:  71  File: COO.DSS
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/2A/FREQ-FLOW///BASE-ORIGINAL/
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/
   -----DSS---ZCLOSE Unit: 71
              Number of Records:     2
              File Size:        2.3  Kbytes
              Percent Inactive:  .00
```

Listing of the file "DATAFILE".

```
/COOPER CREEK/2A/FREQ-FLOW///BASE-ORIGINAL/

10   1   1   1 "PERCENT " "CFS       " "PROB" "UNT "

     99.00    310.00
     20.31   1591.00
     10.01   1999.00
      3.16   2652.00
      1.53   3130.00
       .65   3697.00
       .31   4146.00
       .12   4678.00
       .05   5893.00
       .01   7395.00
/COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/

10   1   1   1 "PERCENT " "CFS       " "PROB" "UNT "

     99.00    600.00
     25.16   2469.00
     11.67   3099.00
      3.81   4144.00
      1.61   4915.00
       .69   5819.00
       .31   6534.00
       .11   7358.00
       .05   9215.00
       .01  11500.00
```

(2) Store rating curves in the DSS data file using the interactive HEC-2 post-processor program FDA2PO. When operating on the Harris, you may write rating curves directly to the DSS file from HEC-2. However, HEC-2 writes a rating curve for every cross-section rather than just those you wish to store. For this workshop, the "TAPE95" results from HEC-2 for base conditions have been saved in the file "P1.295". A "dummy" set of structures for SID has been entered in the file "DUMMY.I". (You do not need to enter a file name for the "DR" file - the SID input data file which contains the "DR" reach identification records).

(a) Write your selection for the pathname parts in the tables below.

Pathname Part A: COOPER CREEK

Pathname Part F: BASE

Reach	Cross-section	Pathname Part B
11	274+15	RCH11
12	285+50	RCH12
13	290+32	RCH13

from SID STRUCTURES

(b) Execute the FDA2PO program by entering: MENUFDA and selecting the FDA2PO program. You must define the following files:

- File 95 (HEC-2 binary results) (P1.295)
- Input SID structure file(DUMMY.I)
- Output SID structure file (TEMP.I)
- HECDSS file (COO.DSS)

Do not calculate the reference flood elevations.

FDA2PO Program: Input and Output For Plan 1.

```
Number of sections from File95 header:    17.

Process profile  1.
Process profile  2.
Process profile  3.
Process profile  4.
Process profile  5.
Process profile  6.
Process profile  7.
Process profile  8.
Process profile  9.
Process profile 10.

There were 10 profiles,  17 sections, and 0 tributaries.
--------------------------------------------------------------------
```

Section no.	Cum dist.	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
25534.000	0.	607.55	609.53	611.45	612.89	613.69
		614.53	615.16	615.68	616.72	617.01
26193.000	659.	612.25	614.39	615.82	616.97	617.63
		618.36	618.86	619.32	620.23	620.45
26848.000	1314.	615.49	618.65	620.03	620.81	621.23
		621.69	621.99	622.28	622.86	622.98
26900.000	1366.	615.58	618.82	620.26	621.15	621.59
		622.05	622.35	622.62	623.16	623.26
26954.000	1420.	615.59	618.84	620.83	621.76	622.07
		622.41	622.60	622.80	623.20	623.27
27025.000	1491.	615.69	618.99	620.92	621.78	622.06
		622.37	622.55	622.72	623.07	623.14
27415.000	1881.	616.77	620.17	622.04	623.01	623.50
		624.05	624.39	624.74	625.40	625.47
27890.000	2356.	619.94	622.75	624.13	624.95	625.37
		625.87	626.15	626.44	627.00	627.07
28550.000	3016.	623.82	626.54	628.06	629.13	629.67
		630.29	630.60	630.91	631.47	631.54
28660.000	3126.	625.01	627.24	628.69	629.68	630.19
		630.77	631.07	631.45	632.21	632.27

> **"Enter" key pressed**

Section no.	Cum dist.	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
28770.000	3236.	625.86	628.55	629.99	631.00	631.45
		631.99	632.30	632.60	633.54	633.75
28860.000	3326.	626.14	629.08	630.68	631.84	632.56
		633.49	634.15	634.91	636.04	636.09
28932.000	3398.	626.14	629.11	630.73	634.28	635.04
		635.47	635.73	635.99	636.41	636.45
29032.000	3498.	626.82	629.69	631.53	634.77	635.28
		635.74	636.01	636.28	636.75	636.78
29390.000	3856.	629.53	630.41	632.57	634.90	635.40
		635.87	636.16	636.44	636.93	637.10
29710.000	4176.	630.53	631.69	633.62	635.10	635.58
		636.04	636.34	636.63	637.14	637.43
30350.000	4816.	633.25	634.60	636.82	637.13	637.54
		637.99	638.32	638.60	639.44	640.27

Do you want to store rating curves in a DSS data file?
(y/n): **Y**

Do you want to compute reference flood elevations?
(y/n): **N**

There are 3 reach(es) in the structure file:

Index	I.D.	Index	I.D.	Index	I.D.	Index	I.D.	Index	I.D.
1	RCH11	2	RCH12	3	RCH13				

For each damage reach from SID, you must identify the following:
(1) The cross-section which corresponds to the index location.
(2) The index number of the profile which will be used for the reference flood.
(3) An edited river mile for the index location.

To eliminate a damage reach from consideration, enter a "d" when prompted for the section number.
To get a list of cross-sections, enter "L" when prompted for the section number.

```
Damage reach  RCH11,
Identify the cross-section at the index location (1-17)>  L

                    17 Cross-sections
---------------------------------------------------------------------
 IDX   Section  IDX   Section  IDX   Section  IDX   Section  IDX   Section
---------------------------------------------------------------------
   1  25534.000   5  26954.000   9  28550.000  13  28932.000  17  30350.000
   2  26193.000   6  27025.000  10  28660.000  14  29032.000
   3  26848.000   7  27415.000  11  28770.000  15  29390.000
   4  26900.000   8  27890.000  12  28860.000  16  29710.000

Damage reach  RCH11,
Identify the cross-section at the index location (1-17)>  7

Damage reach  RCH12,
Identify the cross-section at the index location (1-17)>  9

Damage reach  RCH13,
Identify the cross-section at the index location (1-17)>  14
   -----DSS---ZOPEN; Existing File Opened - Unit:  71  File: COO.DSS

Enter one of the following:
 (1)  The pathname part(s) in the format:
         A=pathname part A, E=pathname part E, F=pathname part F
 (2)  The pathname part when prompted.
 (3)  The command "EXIT" or press the "Enter" key to store
      the rating curves in the HECDSS data file.
 (4)  A "?" go get this message.


Study name - pathname part A ().
Data year - pathname part E ().
Alternative or plan - pathname part F ().

Study name - part A - () >  COOPER CREEK

Study name - pathname part A (COOPER CREEK).
Data year - pathname part E ().
Alternative or plan - pathname part F ().

Data year - part E - () >  "Enter" key pressed

Study name - pathname part A (COOPER CREEK).
Data year - pathname part E ().
Alternative or plan - pathname part F ().

Alternative or plan - part F () >  BASE

Study name - pathname part A (COOPER CREEK).
Data year - pathname part E ().
Alternative or plan - pathname part F (BASE).

Store rating curves and exit? (y/n) >  Y
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/RCH11/ELEV-FLOW///BASE/
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/RCH12/ELEV-FLOW///BASE/
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/RCH13/ELEV-FLOW///BASE/
   -----DSS---ZCLOSE Unit: 71
            Number of Records:      3
            File Size:      2.3  Kbytes
            Percent Inactive:   .00
```

```
There are   3 reach(es) in the structure file:
   Index   I.D.   Index   I.D.   Index   I.D.   Index   I.D.   Index   I.D.
-------------------------------------------------------------------------------
       1  RCH11       2  RCH12       3  RCH13


For each damage reach from SID,  you must identify the
following:
(1)   The cross-section which corresponds to the index
      location.
(2)   The index number of the profile which will be used
      for the reference flood.
(3)   An edited river mile for the index location.


To eliminate a damage reach from consideration, enter a "d"
when prompted for the section number.
To get a list of cross-sections, enter "L" when prompted
for the section number.


Damage reach  RCH11,
Identify the cross-section at the index location (1-17)> L

                      17 Cross-sections
-------------------------------------------------------------------------------
  IDX   Section  IDX   Section  IDX   Section  IDX   Section  IDX   Section
-------------------------------------------------------------------------------
    1 25534.000   5 26954.000   9 28550.000  13 28932.000  17 30350.000
    2 26193.000   6 27025.000  10 28660.000  14 29032.000
    3 26848.000   7 27415.000  11 28770.000  15 29390.000
    4 26900.000   8 27890.000  12 28860.000  16 29710.000

Damage reach  RCH11,
Identify the cross-section at the index location (1-17)> S=27415

Damage reach  RCH12,
Identify the cross-section at the index location (1-17)> S=28550

Damage reach  RCH13,
Identify the cross-section at the index location (1-17)> S=29032
   -----DSS---ZOPEN; Existing File Opened - Unit:  71  File: COO.DSS

Enter one of the following:
 (1)  The pathname part(s) in the format:
           A=pathname part A, E=pathname part E, F=pathname part F
 (2)  The pathname part when prompted.
 (3)  The command "EXIT" or press the "Enter" key to store
      the rating curves in the HECDSS data file.
 (4)  A "?" go get this message.


Study name - pathname part A ().
Data year - pathname part E ().
Alternative or plan - pathname part F ().

Study name - part A - () > COOPER CREEK

Study name - pathname part A (COOPER CREEK).
Data year - pathname part E ().
Alternative or plan - pathname part F ().

Data year - part E - () > "Enter" key pressed
```

```
Study name - pathname part A (COOPER CREEK).
Data year - pathname part E ().
Alternative or plan - pathname part F ().

Alternative or plan - part F () > CHIMP 40FT

Study name - pathname part A (COOPER CREEK).
Data year - pathname part E ().
Alternative or plan - pathname part F (CHIMP 40FT).

Store rating curves and exit? (y/n) > Y
-----DSS---ZWRITE Unit  71; Vers.   2:  /COOPER CREEK/RCH11/ELEV-FLOW///CHIMP 40FT/
-----DSS---ZWRITE Unit  71; Vers.   2:  /COOPER CREEK/RCH12/ELEV-FLOW///CHIMP 40FT/
-----DSS---ZWRITE Unit  71; Vers.   2:  /COOPER CREEK/RCH13/ELEV-FLOW///CHIMP 40FT/
   -----DSS---ZCLOSE Unit: 71
              Number of Records:      8
              File Size:        3.9  Kbytes
              Percent Inactive:   .00
```

(3) "REad" data from a HECDSS-DSSUTL compatible ASCII file and store the data in a DSS file. In this operation, you will store data in the DSS file which has been previously written by DSSUTL into an ASCII (or "human readable") file.

For normal operations on the Harris, the analyst would directly write the computed frequency curves from HEC-1 (or HEC-5) into a DSS file. If the economic DSS file is different than the H&H DSS data file, the user would invoke the "COpy" command from DSSUTL to copy data associated with pathnames from one DSS file to another.

However, in this case, it is assumed that the H&H work is done on a different computer than the economic analyses. To transfer data between computers, the user "Writes Data" using DSSUTL to an ASCII file from a DSS file on the H&H machine. Then, the analyst performing the economic analysis invokes DSSUTL (as you will do in this workshop) to read that data from the ASCII file into the economic DSS file. A typical application is to write all frequency-discharge curves to the ASCII file. To write frequency-discharge curves from the currently opened DSS file to the file named QFDATA, the analyst enters the DSSUTL command: WD,QFDATA,C=FREQ-FLOW

For this workshop, frequency data computed by HEC-1 has been written from a DSS file into the ASCII file named QFDATA.

(a) Look at the HECDSS-DSSUTL compatible ASCII file named QFDATA by "LIsting" the file. For example, enter: LIST QFDATA

```
/COOPER CREEK/2A/FREQ-FLOW///BASE/
PD   VER=  2   PROG=HEC1  DATE=07JAN87  08:37:39  NO. DATA=   18
 HEADER L.=  30, # DATA PAIRS=   9, # X CURVES=  1, # Y CURVES=  1, HORIZ=  1
PERCENT CFS     PROBUNT

   68.8338   11.9025    3.4233    1.7257    0.6243    0.2907    0.1200    0.0568
    0.0123
   575.358  1911.701  2598.420  3041.090  3724.289  4184.816  4677.819  5700.795
  7256.249
END DATA
/COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 650/
PD   VER=  2   PROG=HEC1  DATE=07JAN87  08:37:39  NO. DATA=   18
 HEADER L.=  30, # DATA PAIRS=   9, # X CURVES=  1, # Y CURVES=  1, HORIZ=  1
PERCENT CFS     PROBUNT

   68.8338   11.9025    3.4233    1.7257    0.6243    0.2907    0.1200    0.0568
    0.0123
   297.069  1095.282  1621.446  2055.638  2724.898  3173.568  3638.031  4528.230
  5844.744
END DATA
/COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 655/
PD   VER=  2   PROG=HEC1  DATE=07JAN87  08:37:39  NO. DATA=   18
 HEADER L.=  30, # DATA PAIRS=   9, # X CURVES=  1, # Y CURVES=  1, HORIZ=  1
PERCENT CFS     PROBUNT

   68.8338   11.9025    3.4233    1.7257    0.6243    0.2907    0.1200    0.0568
    0.0123
   296.958  1095.271  1588.796  1920.003  2386.723  2688.958  3010.655  3807.386
  5199.402
END DATA
/COOPER CREEK/3B/FREQ-FLOW///BASE/
PD   VER=  2   PROG=HEC1  DATE=07JAN87  08:37:39  NO. DATA=   18
 HEADER L.=  30, # DATA PAIRS=   9, # X CURVES=  1, # Y CURVES=  1, HORIZ=  1
PERCENT CFS     PROBUNT

   77.4506   14.0120    4.1362    1.8482    0.6628    0.2889    0.1100    0.0564
    0.0126
   922.   2966.   4059.   4772.   5862.   6594.   7358.   8923.  11291.
END DATA
/COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/
PD   VER=  2   PROG=HEC1  DATE=07JAN87  08:37:39  NO. DATA=   18
 HEADER L.=  30, # DATA PAIRS=   9, # X CURVES=  1, # Y CURVES=  1, HORIZ=  1
PERCENT CFS     PROBUNT

   77.4506   14.0120    4.1362    1.8482    0.6628    0.2889    0.1100    0.0564
    0.0126
   665.558  2149.156  3081.835  3787.036  4862.812  5582.492  6317.965  7750.184
  9879.728
END DATA
/COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 655/
PD   VER=  2   PROG=HEC1  DATE=07JAN87  08:37:39  NO. DATA=   18
```

```
HEADER L.=  30, # DATA PAIRS=   9, # X CURVES=  1, # Y CURVES=  1, HORIZ=  1
PERCENT CFS     PROBUNT

   77.4506   14.0120    4.1362    1.8482    0.6628    0.2889    0.1100    0.0564
    0.0126
   665.447  2149.145  3049.184  3651.402  4524.637  5097.882  5690.589  7029.341
  9234.387
END FILE
```

(b) Execute the DSSUTL program by entering: MENUFDA to invoke the FDA menu program, select DSSUTL, and define the HECDSS file as "COO.DSS".

(c) Read all of the data stored in the file QFDATA and store it in the DSS file by entering: RE,QFDATA

(d) Exit DSSUTL by entering "FI" or "FINISH".

```
   DSSUTL  -  Version 4.6.4;  August 1989
   DSS Version: 5-DA

Enter DSS File Name or Postion Cursor to Name
FILE = COO.DSS

   -----DSS---ZOPEN; Existing File Opened - Unit:  71  File: COO.DSS

U>RE QFDATA
Reading Data from File QFDATA
--ZWRITE: /COOPER CREEK/2A/FREQ-FLOW///BASE/
--ZWRITE: /COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 650/
--ZWRITE: /COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 655/
--ZWRITE: /COOPER CREEK/3B/FREQ-FLOW///BASE/
--ZWRITE: /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/
--ZWRITE: /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 655/
U>FI
   -----DSS---ZCLOSE Unit: 71
              Number of Records:      14
              File Size:       6.1  Kbytes
              Percent Inactive:    .00
STOP
```

(4) Catalog the DSS data file using HECDSS-DSPLAY. This operation could have been performed using the DSSUTL program. However, we also wish to plot the data so the HECDSS-DSPLAY program is invoked.

(a) Execute the DSPLAY program by entering: MENUFDA to execute the FDA menu program, select the DSPLAY program, and define the HECDSS data file as "COO.DSS".

(b) Get a catalog of all pathnames which correspond to data stored in the DSS file. Since you have just entered data into the file, there is not a current catalog list available. You must obtain a new catalog by entering:

CA.N

(c) Get an abbreviated catalog list by entering:

CA.A

DSPLAY Output For CAtalogue Command.

```
Enter DSS File Name or FINISH or Position Cursor to Name
FILE = COO.DSS

  -----DSS---ZOPEN; Existing File Opened - Unit:  71  File: COO.DSS

Enter Command  HELP for list of vallid commands
D>CA.N
Catalog File: COO.DSC

    HECDSS Complete Catalog of Record Pathnames for DSS File: COO.DSS

    Catalog Date: 17JAN90 at 10:30;  File Created on 17JAN90;  DSS Version 5-CB
    Number of Records:    14
    Pathnames Not Sorted
```

Ref. No.	Prog	Last Written Date	Time	Ver	Head	Data	Record Pathname
1	PIP	17JAN90	10:08:26	1	34	40	/COOPER CREEK/2A/FREQ-FLOW///BASE-ORIGINAL/
2	PIP	17JAN90	10:08:26	1	34	40	/COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/
3	F2PO	17JAN90	10:11:10	1	18	40	/COOPER CREEK/RCH11/ELEV-FLOW///BASE/
4	F2PO	17JAN90	10:11:10	1	18	40	/COOPER CREEK/RCH12/ELEV-FLOW///BASE/
5	F2PO	17JAN90	10:11:10	1	18	40	/COOPER CREEK/RCH13/ELEV-FLOW///BASE/
6	F2PO	17JAN90	10:11:13	1	18	40	/COOPER CREEK/RCH11/ELEV-FLOW///CHIMP 40FT/
7	F2PO	17JAN90	10:11:13	1	18	40	/COOPER CREEK/RCH12/ELEV-FLOW///CHIMP 40FT/
8	F2PO	17JAN90	10:11:13	1	18	40	/COOPER CREEK/RCH13/ELEV-FLOW///CHIMP 40FT/
9	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/2A/FREQ-FLOW///BASE/
10	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 650/
11	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 655/
12	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/3B/FREQ-FLOW///BASE/
13	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/

<u>CA.A</u>

```
 1  /COOPER CREEK/2A/FREQ-FLOW///BASE-ORIGINAL/
 2  /COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/
 3  /COOPER CREEK/RCH11/ELEV-FLOW///BASE/
 4  /COOPER CREEK/RCH12/ELEV-FLOW///BASE/
 5  /COOPER CREEK/RCH13/ELEV-FLOW///BASE/
 6  /COOPER CREEK/RCH11/ELEV-FLOW///CHIMP 40FT/
 7  /COOPER CREEK/RCH12/ELEV-FLOW///CHIMP 40FT/
 8  /COOPER CREEK/RCH13/ELEV-FLOW///CHIMP 40FT/
 9  /COOPER CREEK/2A/FREQ-FLOW///BASE/
10  /COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 650/
```

```
11  /COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 655/
12  /COOPER CREEK/3B/FREQ-FLOW///BASE/
13  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/
14  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 655/
```

<u>FI</u>

```
-----DSS---ZCLOSE Unit: 71
           Number of Records:      14
           File Size:        6.1  Kbytes
           Percent Inactive:     .00
Stop - Program terminated.
```

(5) Tabulate data in the DSS data file using HECDSS-DSPLAY. To tabulate (or plot data) the data is first retrieved from the DSS file. This is done through the use of the "PAth" command which defines the desired records.

(a) Execute DSPLAY (if not executing already).

(b) Use the same HECDSS filename as you have previously used in this workshop "COO.DSS".

(c) Get a list of frequency-discharge pathnames by entering:

DP C=FREQ-FLOW

(d) Tabulate the base condition and modified condition frequency curves for control point 3B.

(e) Compare the original base condition frequency curve (the one you entered using PIP) with the interpolated base condition frequency curve as computed by HEC-1.

```
Enter DSS File Name or FINISH or Position Cursor to Name
FILE = COO.DSS

  -----DSS---ZOPEN; Existing File Opened - Unit:  71  File: COO.DSS

D>DP C=FREQ-FLOW
Catalog File: COO.DSC
    1  /COOPER CREEK/2A/FREQ-FLOW///BASE-ORIGINAL/
    2  /COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/
    9  /COOPER CREEK/2A/FREQ-FLOW///BASE/
   10  /COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 650/
   11  /COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 655/
   12  /COOPER CREEK/3B/FREQ-FLOW///BASE/
   13  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/
   14  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 655/

D>PA 12 13 14

  /COOPER CREEK/3B/FREQ-FLOW///BASE/
  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/
  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 655/

D>TA

17JAN90    10:42:55                                             PAGE     1

/COOPER CREEK/3B/FREQ-FLOW///BASE/


                FLOW IN  CFS

 NO     FREQ

   1       77.451      922.000
   2       14.012     2966.000
   3        4.136     4059.000
   4        1.848     4772.000
   5         .663     5862.000
   6         .289     6594.000
   7         .110     7358.000
   8         .056     8923.000
   9         .013    11291.000

T>PA 2 12

  /COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/
  /COOPER CREEK/3B/FREQ-FLOW///BASE/

D>TA
```

```
17JAN90    10:42:55                                              PAGE      1

/COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/

                        FLOW IN  CFS

 NO      FREQ

  1        99.000       600.000
  2        25.160      2469.000
  3        11.670      3099.000
  4         3.810      4144.000
  5         1.610      4915.000
  6          .690      5819.000
  7          .310      6534.000
  8          .110      7358.000
  9          .050      9215.000
 10          .010     11500.000
T>FI
   -----DSS---ZCLOSE Unit: 71
                Number of Records:       14
                File Size:          6.1  Kbytes
                Percent Inactive:      .00^[[0m^[[37;40m
Stop - Program terminated.
```

(6) Plot data in the DSS data file using HECDSS-DSPLAY. To plot data, the data is first retrieved from the DSS file. This is done through the use of the "PAth" command which defines the desired records.

(a) Execute DSPLAY (if not executing already).

(b) Use the same HECDSS filename as you have previously used in this workshop.

(c) Define the vertical axis as logarithmic by entering the command:

AX,LIN,LOG,LOG,LOG

(d) Get a list of frequency-discharge pathnames by entering:

DP C=FREQ-FLOW

(e) Plot the base condition and modified condition frequency curves for control point 3B. Use the results from the previous command to define the desired pathnames. Example user input is:

```
PA 4,5,6
PL
```

(f) Compare the original base condition frequency curve (the one you entered using PIP) with the interpolated base condition frequency curve as computed by HEC-1.

```
Enter DSS File Name or FINISH or Position Cursor to Name
FILE = COO.DSS

 -----DSS---ZOPEN; Existing File Opened - Unit:  71  File: COO.DSS

D>AX,LIN,LOG,LOG,LOG
D>DP C=FREQ-FLOW

Catalog File: COO.DSC
    1  /COOPER CREEK/2A/FREQ-FLOW///BASE-ORIGINAL/
    2  /COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/
    9  /COOPER CREEK/2A/FREQ-FLOW///BASE/
   10  /COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 650/
   11  /COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 655/
   12  /COOPER CREEK/3B/FREQ-FLOW///BASE/
   13  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/
   14  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 655/

 CU 1

D>PA 12 13 14

  /COOPER CREEK/3B/FREQ-FLOW///BASE/
  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/
  /COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 655/

D>PL

PA 2 12

  /COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/
  /COOPER CREEK/3B/FREQ-FLOW///BASE/

D>PL

FI

 -----DSS---ZCLOSE Unit: 71
          Number of Records:     14
          File Size:      6.1  Kbytes
          Percent Inactive:    .00^[[0m^[[37;40m
Stop - Program terminated.
```

Figure 1: Comparison of Frequency Curves For Plans 1,2, and 3

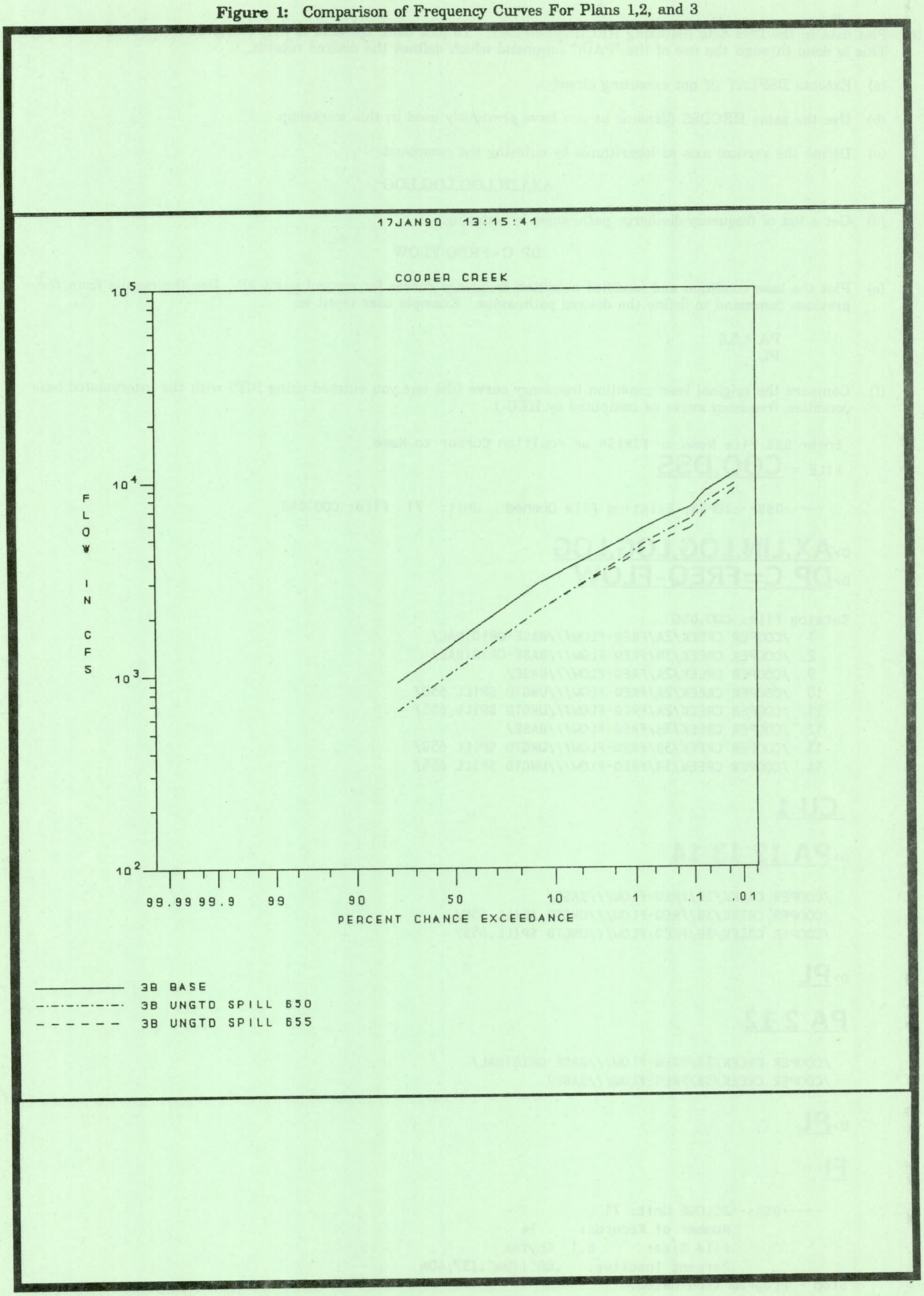
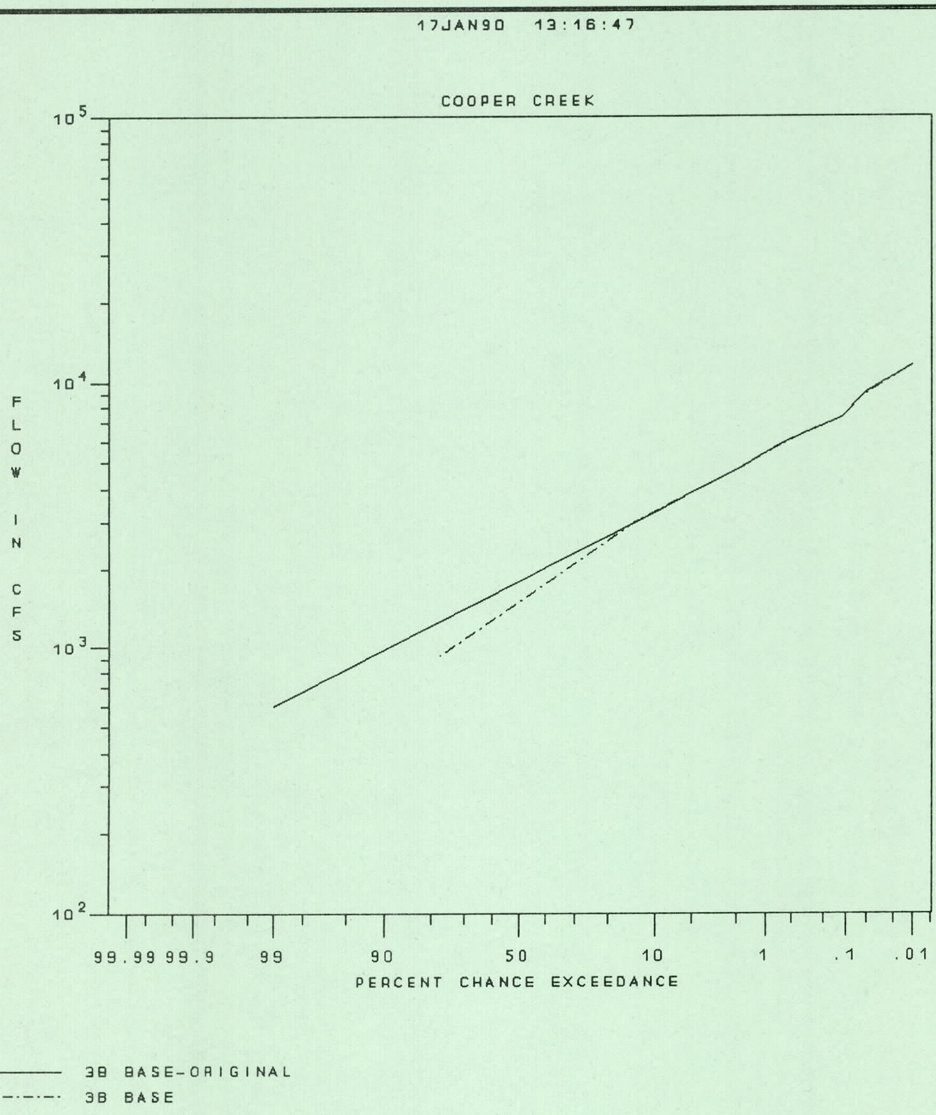


Figure 2: Comparison of Base Condition Frequency Curves



(7) Perform tasks five and six again accessing the rating curves instead of the frequency curves.

Richard Hill
2/14/90

SAMPLING AND INVENTORY TECHNIQUES

<u>SAMPLING</u> The high cost of doing business is a universal theme within the Corps these days. One of the direct impacts of high overhead rates is the resulting squeeze on our project analysis and reporting process. As study managers try to allocate their scarce resources among many competing users, trade-offs must be made in order to optimize the study quality vs. cost equation. One of the methods which may help to minimize this problem is the use of sampling. More and more districts are resorting to sampling of flood plain populations rather than collecting data on each structure. With proper attention to sample design, this can be not only cost-effective, but also a reliable method of data collection with minimal risk of degraded accuracy of the final benefit estimate.

In order to design a sound sample, the first thing the economist should do is to think about the problem. A quick tour of the flood plain will usually help focus on the necessary parameters of the sample. For example, if the flood plain property is largely residential mixed with some commercial property, the bulk of your effort should probably be focused on the non-residential sector. Neighborhoods tend to be relatively homogenous in terms of structure type, size, construction, age, and value, which provide convenient parameters for sample stratification. Thus it may not be necessary to build an exhaustive data base of these statistics. The characteristic most likely to vary significantly in a densely developed residential area is elevation. Thus, more of your scarce study money could be devoted to collecting elevations and relatively little to the other residential characteristics which can be reliably sampled. A good text in statistics will provide good guidelines to sample size compared to population size. The larger the sample you can afford, the more reliable your benefit calculations will be, but diminishing returns will eventually set in. The use of confidence interval estimates will help you decide when you have sampled enough activities to be relatively confident in your answer.

A great deal of information can be gathered quickly from two sources, which will also help you define the parameters for your sample design. These two sources are aerial photographs of the flood plain, and county tax assessor property records. Contiguous areas of similar property can be identified very quickly from aerial photographs, which will point you toward the areas where you can expect reasonable success from sampling. If controlled aerials (rectified to eliminate horizontal distortion and with vertical references established) are available, you may also find that elevation can be sampled with minimal effect on overall study accuracy. In coastal areas or other areas of low vertical relief, the differences in elevation may be gradual enough that the use of two foot contours from aerial photos will be sufficiently accurate to enable further analysis. Of course when you use this method, it is imperative to do some neighborhood sampling to determine the typical foundation height from the existing grade. The county tax assessor maintains detailed property records which can be an extremely valuable resource for flood plain inventory purposes. Not only is the assessed value of the property shown (both land and improvements), but age, size, construction type etc. are also typically recorded. Many counties now have this information filed electronically and can also provide annotated plat maps fairly easily. When these plat maps are overlaid on aerial photos, most of the information necessary for a detailed analysis is then in one place. Unfortunately, this kind of coordination and availability of data is rare in our version of the real world. One word of caution is that you should generally not rely on the assessed value for damage calculations, but try to get a factor to update these to current market value. Either your Real Estate Division or local realtors can provide you with a lot of help here.

SURVEY METHODS Once the parameters of the flood plain inventory samples have been decided upon, the use of random number tables can quickly give you a true random sample within your sample areas (either geographically or otherwise). This will produce a cross between a convenience sample and a true random sample. Armed with a list of addresses to inspect, the field team can efficiently go about the task of data collection. In a recon level study, the "windshield" survey is appropriate in most instances, assuming that the field party is experienced enough to estimate property values reasonably accurately. Local realtors can provide comparable sales in many cases, or you can look at current listings to get a feel for the market in the flood plain of interest. If you are involved in a feasibility investigation, however, much greater data accuracy is called for, along with a detailed audit trail of how and why the information was collected. If you devoted some time to sample design, you should have a good idea of the most critical parameters, and can spend most of your field effort collecting those data. Personal interviews tend to be the most productive data sources, but experience has shown that even these aren't always a reliable source of value/damage information. Many people are unable to provide damage data because they weren't in the flooded property when it last flooded. Many commercial establishments are reluctant to provide detailed financial data to the government for fear that it will be given to IRS. Assurances that no individual property values will be released, only aggregates, usually will result in more candid information. Thus, you should be prepared to find external sources of this information, or estimates of it, in the event that interviews don't prove productive. In general, the more often and the more recently an area has flooded, the more useful information you will obtain from field interviews.

Elevation measurements are normally a key parameter of the flood damage calculation. In areas of slight vertical relief, it is common for tenths of a foot to produce significant differences in the total damage estimate. This is one area where judgement developed from experience will be very helpful. The use of topographic mapping may prove satisfactory, supplemented with field validation of foundation height as previously mentioned, but actual elevation measurements to the nearest tenth foot are preferable. The use of a hand level will provide a quick, cheap, relatively accurate measurement of structure elevations. It should be recognized, however, that the error inherent in hand level measurement tends to be fairly high. Therefore, if you need feasibility level accuracy, have levels shot with a tripod mounted instrument. If it is too expensive to shoot every structure - sample! This is an area where sampling can pay big dividends. If, for example, an entire street in a neighborhood is relatively uniform in elevation, shoot only a few structures and move on. The results can be interpolated for the other structures on the street with minimal error. This is an area where your prior planning will be well justified. Many times an accuracy of only a half-foot or so will provide just as reliable an answer as one-tenth foot accuracy. If you have done some rough calculations on a small sample in advance, you will be in a position to better judge the level of accuracy absolutely necessary. In any event, each dollar you don't spend on having elevations shot is a dollar you can use elsewhere in your economic analysis - always pay yourself well for a good analysis!

STRUCTURE INVENTORIES Many of the points previously raised apply to collecting inventory data on flood plain structures. The keys to the flood plain structure inventory are the number of structures and their value (including contents). These two pieces of data have the most direct bearing on total flood damages of all the data you will collect.

As previously mentioned, the market value of structures can be obtained from several real estate sources, including tax assessors, realtors, appraisers, and the District Real Estate Division. When approaching these people for appraisals of the flood plain properties, it is important to indicate that the value you need is the current fair market value for the property - remembering that only the structure (and contents) will generally accrue direct inundation losses. The value of the land itself may be temporarily impacted by flood events, but except for physical loss of land, the land price will probably be in long term equilibrium. Appraisers are frequently uncomfortable dealing with "gross" appraisals since their professional ethics require a much more detailed appraisal in a sale than we would typically need for a benefit analysis. It is worth spending some time with the appraiser, however, to learn as much of his business as you can, as well as to persuade him that "neighborhood gross appraisals" are adequate for your purposes. Because of the relative homogeneity of neighborhoods, a range of values, or a value per square foot can be applied uniformly to a large number of properties in a contiguous area without undue error. The use of Marshall-Swift or similar appraisal guidelines will provide an excellent source of valuation statistics. It is recommended that this publication be obtained for permanent use in the District's economics shop.

Commercial properties tend to exhibit similarities in certain business, which can be exploited in a sam;ling scheme. Fast food restaurants, for example, tend to be very uniform in size and value. Therefore only a limited sample may produce values for several properties in a study area. Other types of businesses will also tend to be very similar, making your sample both easier and more reliable. Industrial concerns, however, call for individual investigations and personal interviews. If you can get the plant manager to walk around with you, you should come away with an excellent view of the damage potential of the business. Prearranged interview appointments will probably get you more "face time" than just showing up at the door, however.

Determining the value of contents subject to flood damage in a particular structure is a much more involved problem than getting the structure value. Possible methods of gathering this data include:

- Guess
- Find statistics on comparable structures elsewhere
- Use industry standards
- Interview
- Questionnaire

With experience, you should be able to estimate accurately enough for a recon what the damageable contents will be for most types of structures. If you don't have this much experience, or the study demands greater detail, the other methods are indicated. You will be able to find a great deal of information externally from industry publications, in the library, by talking to owners of similar properties, etc. In the case of residential property in particular, there are rules of thumb which will prove quite valuable. For example, the standard contents/structure ratio for homeowners insurance policies and in the fire insurance business, is 0.50. Various Districts have spent a great deal of time trying to document this ratio for residential properties in their areas. The variances have been so large, however, that it seems to make sense to just use 50 percent and get on with the study. Many Districts have standardized on this ratio, so if you use a lower ratio, in the absence of hard data you are only giving up benefits which are probably there. Proving a ratio higher than 50 percent, conversely, has been very frustrating to those Districts which have tried. Because this situation may be more common in low value structures, it is quite difficult to convince reviewers that these low income flood plain residents would insure their contents beyond 50 percent - if they could convince the insurance agency that it is justified. Most flood plains will probably show residential contents averaging 30-50 percent of the structure value.

Non-residential contents are much more problematic because businesses vary so much more than residences. The exceptions, however, are in fast food and other businesses which tend to be very uniform for each location. Reliance on sample data for these firms is probably entirely adequate. In the case of industrial or heavy commercial firms, however, on-site inspections and interviews are called for. In these inspections, pay particular attention to how the firm's inventory and/or equipment is located or stored. Many warehouses tend to stack items quite high, which will limit the damage potential from frequent floods. The problem is to assign a value at various depths. This is where it is vital to spend some time with the manager of the operation if at all possible. Industrial firms tend to have very expensive equipment at their plants, but often this equipment does not suffer great flood damage - only cleaning expense, drying of motors, etc.

DEPTH - DAMAGE FUNCTIONS The previous discussion on inventory methods also addressed several points which are included in the subject of depth-damage functions. Probably no parameter of the flood damage calculation problem has been given less study and deserves it more. The damage susceptibility of different types of property is highly variable because there are so many components involved. Construction type, age, flood characteristics, and many other factors all heavily influence how a given structure responds to flooding. Several Districts have come up with depth-damage coefficients for their own use, drawing heavily on historical flood damages. As construction methods, materials, and lifestyles change, however, we can expect the need for updated coefficients to grow.

If you want to determine these coefficients for your own District or a particular study, you should count on having a reasonable sample size for each type of structure you intend to estimate damages for later on. Small sample sizes have been the principal weakness in non-residential damage coefficients, historically. Because there are so many more residential structures, these coefficients have been developed to a much higher degree of reliability. So, how do you grow your own?

- Build a multivariate regression model
- Do post flood damage assessments and aggregate damages
- Interview a reasonable sample of property owners to develop synthetic damages

The modeling approach also depends upon the data from field interviews and actual flood damages, so it probably represents the best answer to the problem. Unfortunately, it also requires the most data, and that is often hard to come by. If your District does post flood surveys on a regular basis, and there has been quite a bit of flooding, there may be enough data to develop reliable coefficients. It may not be on a comparable basis, though, which will force you to make adjustments which reduce the validity of your answers. Finally, you can go interview people. In the case of people who haven't flooded (recently, at least) it may be difficult to obtain historical damage data. This is where your interview skills become important. If you are to develop accurate coefficients, you need to isolate the damageable components of the property, structure and contents separately. The percent of total value which is subject to damage at a given interval, two feet is suggested, will need to be built for each property. From this relationship, you can interpolate for smaller increments. The important point is that nothing must be either overlooked or overstated. If you don't know, ask how having flood water on a piece of inventory would be handled post flood. For example, if water touches a shelf in a grocery, all foodstuffs on that shelf should be thrown away. If flood water covers the dashboard on a car, the insurance practice is to total the car - less than that it will only be repaired. So you can see that it is vitally important to understand how the individual property will be affected by floods of every given depth possible. Once you have collected this kind of data for a reasonable sample size, you can compute mean damage factors for each depth increment. Ideally, you should do statistical reliability testing on the sample before using these coefficients.

Many times, it just isn't practical to go to the level of effort just described. This is frustratingly common. Methods of dealing with this situation are only limited by your knowledge and creativity. One practical method is to aggregate several categories with limited data into fewer, broad categories. It may be much more representative to just talk about commercial property, or industrial property than to try to isolate individual businesses, in the absence of reliable data, or small samples. Using square foot estimates of damage developed in other studies or categories of property may be useful in this situation, also. The goal is to increase the statistical reliability of the answer without having to collect additional data, which may or may not even be available.

Where can you find acceptable depth-damage coefficients? Several Districts, the Institute for Water Resources, Flood Insurance Administration, Federal Emergency Management Agency, and state and local planning agencies may all be able to help. Stuart Davis of the IWR has done the most exhaustive studies that

I'm aware of. His studies included numerous major floods in several parts of the countries, and he had access to the raw data tapes from the FIA Claims Files. The following Districts have also done good work in developing these factors, but there are probably many more which deserve mention which I'm unaware of:

- Tulsa
- Ft Worth
- Galveston
- Mobile
- Jacksonville
- Savannah
- Wilmington
- Vicksburg
- New Orleans

Again this represents only partial knowledge, so the Division Economist would be a good starting point in your region. The Gulf Engineers and Consultants (ex-Gulf South Research Institute) has also done several depth-damage surveys in the southern states, and have produced an excellent set of coefficients. So, as you can see, there is a wealth of information available - in fact there is probably more good, but unknown, research available than I have described here. The process of ferreting out this data, applying what you can, then developing your own supplemental data will probably give the most professional and least costly solution problem. Good Hunting.

2/14/90

Richard Hill
~~ARLEN FELDMAN~~

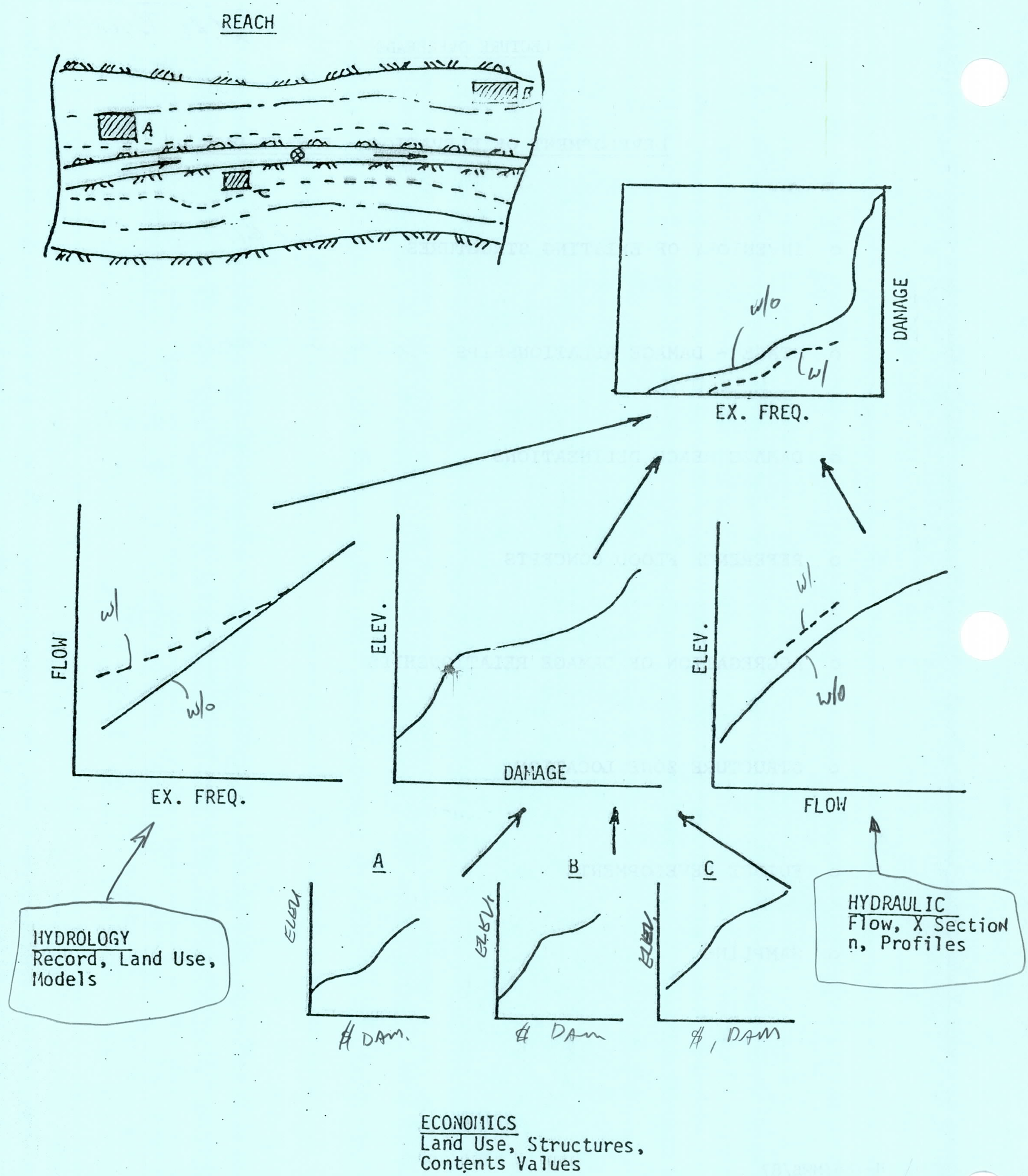
Mike Burnham

LECTURE OVERHEADS

DEVELOPMENT OF ELEVATION - DAMAGE DATA

- o INVENTORY OF EXISTING STRUCTURES - Richard Hill
- o STAGE - DAMAGE RELATIONSHIPS - Mike Burnham
- o DAMAGE REACH DELINEATIONS
- o REFERENCE FLOOD CONCEPTS
- o AGGREGATION OF DAMAGE RELATIONSHIPS
- o STRUCTURE ZONE LOCATION
- o FUTURE DEVELOPMENT
- o SAMPLING

H-786/MWB/87



Schematic of Flood Damage Computation Process

DAMAGE REACH DELINEATION

o Changes to discharge - frequency relationships

- Stream system topology
- Future land use development or project induced changes.

W.S. profiles & damage reaches must be consistent. - NOT vary greatly.

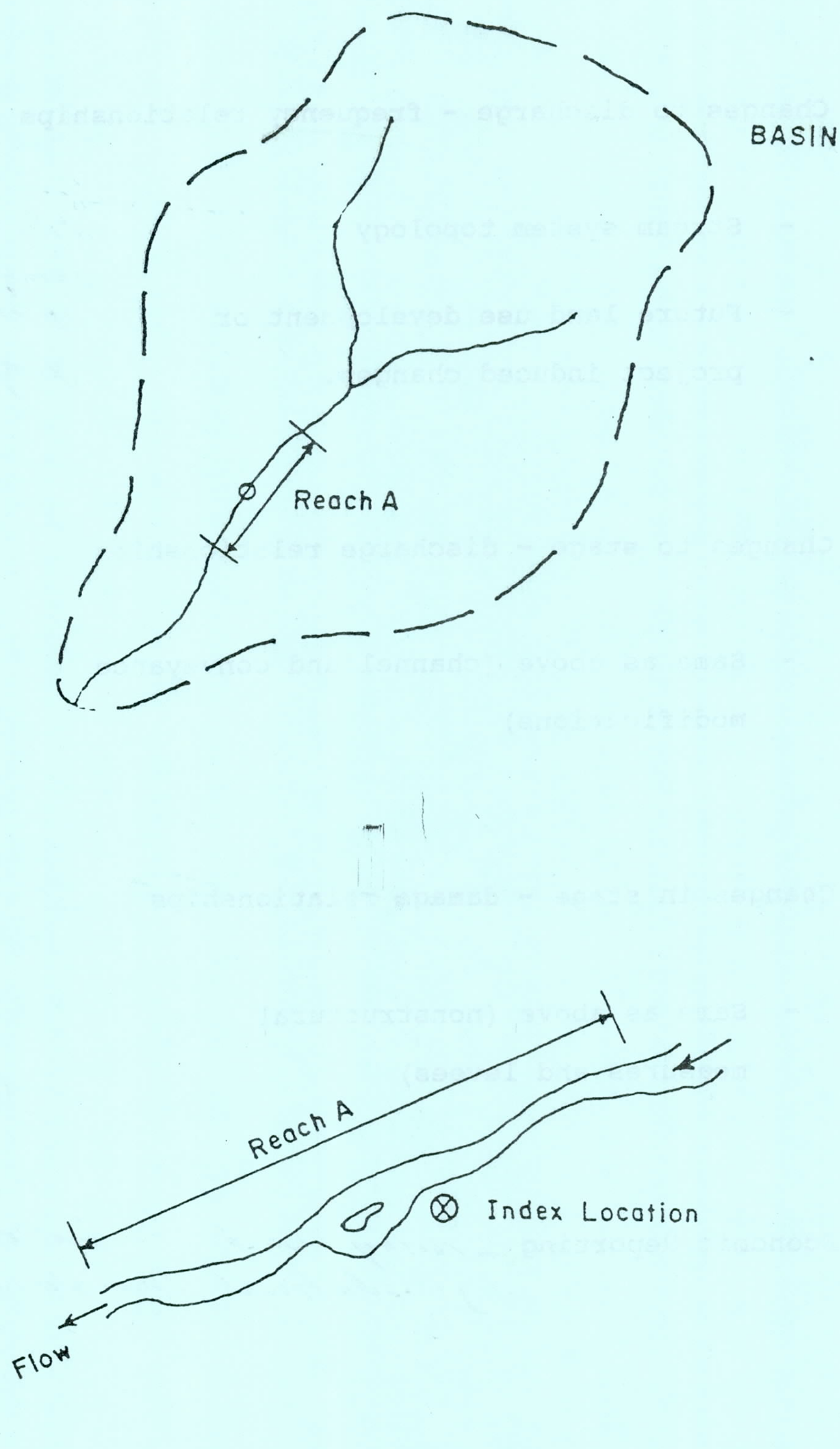
o Changes to stage - discharge relationships

- Same as above (channel and conveyance modifications)

o Changes in stage - damage relationships

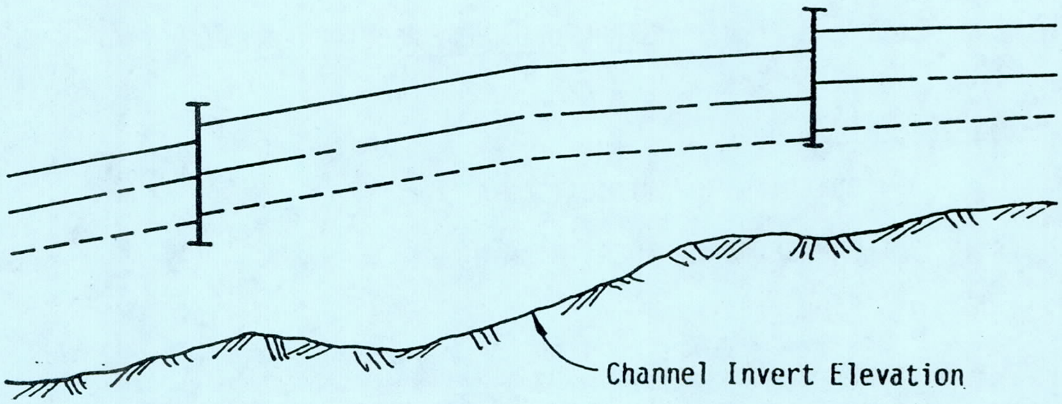
- Same as above (nonstructural measures and levees)

o Economic Reporting - may want to break down into jurisdictional boundaries

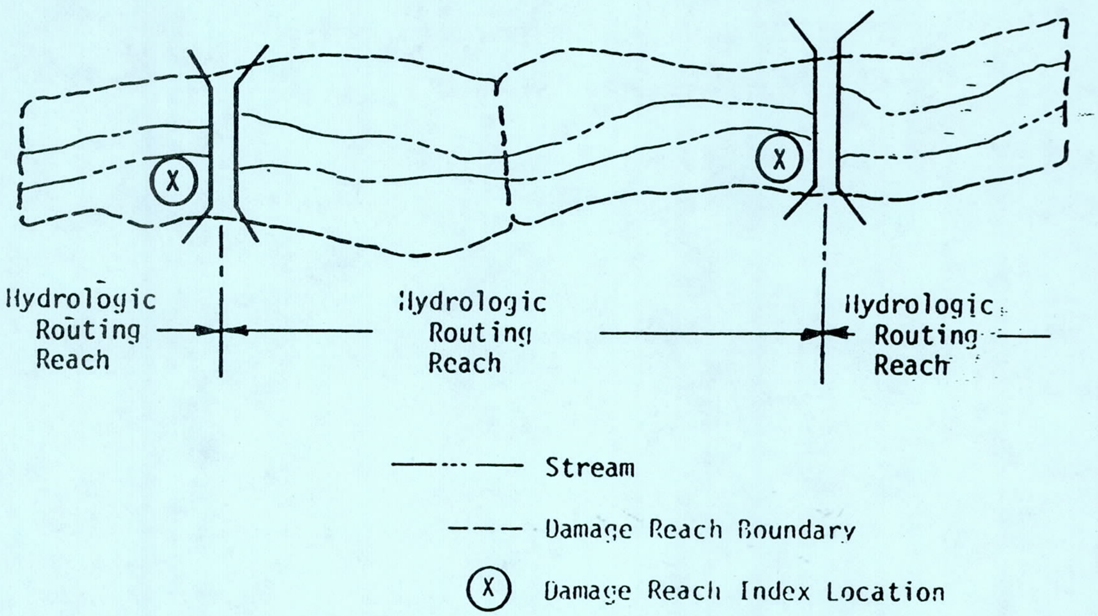


DAMAGE REACH CONCEPT

WATER SURFACE PROFILES



DAMAGE REACH DELINEATION



DAMAGE REACH DELINEATIONS

STRUCTURE DATA REQUIREMENTS

IDENTIFICATION DATA

1) BUILDING IDENTIFICATION

2) DAMAGE REACH IDENTIFICATION

3) DAMAGE CATEGORY

LOCATION

1) REFERENCE ELEVATION OF STRUCTURE

2) REFERENCE FLOOD ELEVATION AT STRUCTURE

3) LOCATION COORDINATES (OPTIONAL)

DAMAGE

1) STAGE-DAMAGE RELATIONSHIP FOR EACH TYPE (STRUCTURE, CONTENTS, OTHER)

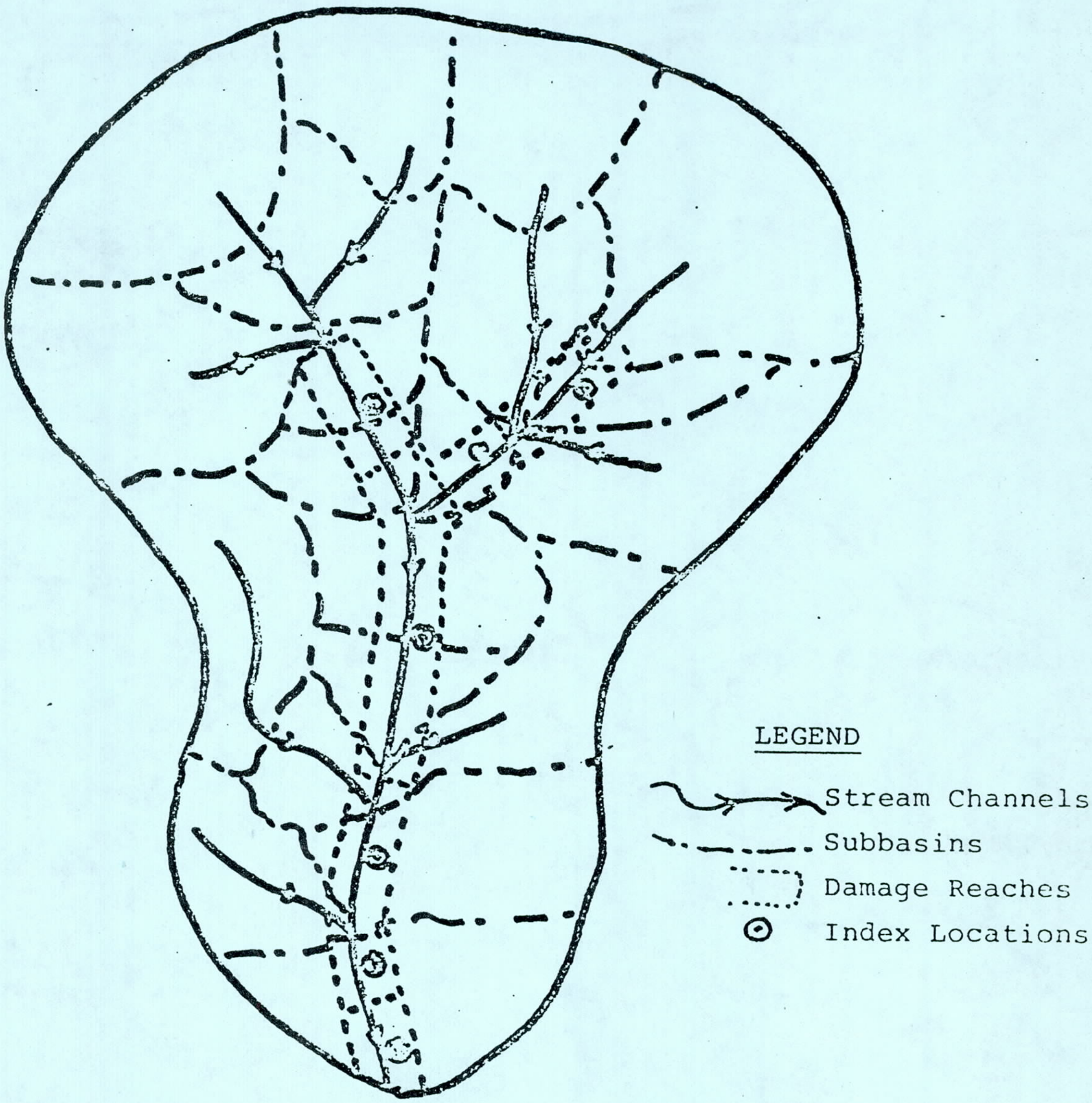
2) TOTAL VALUE OF EACH DAMAGE TYPE

Subbasins

- Logic Breaks
- Gages
- Index Areas of Interest
- Size Capture Changes
- Physical Works

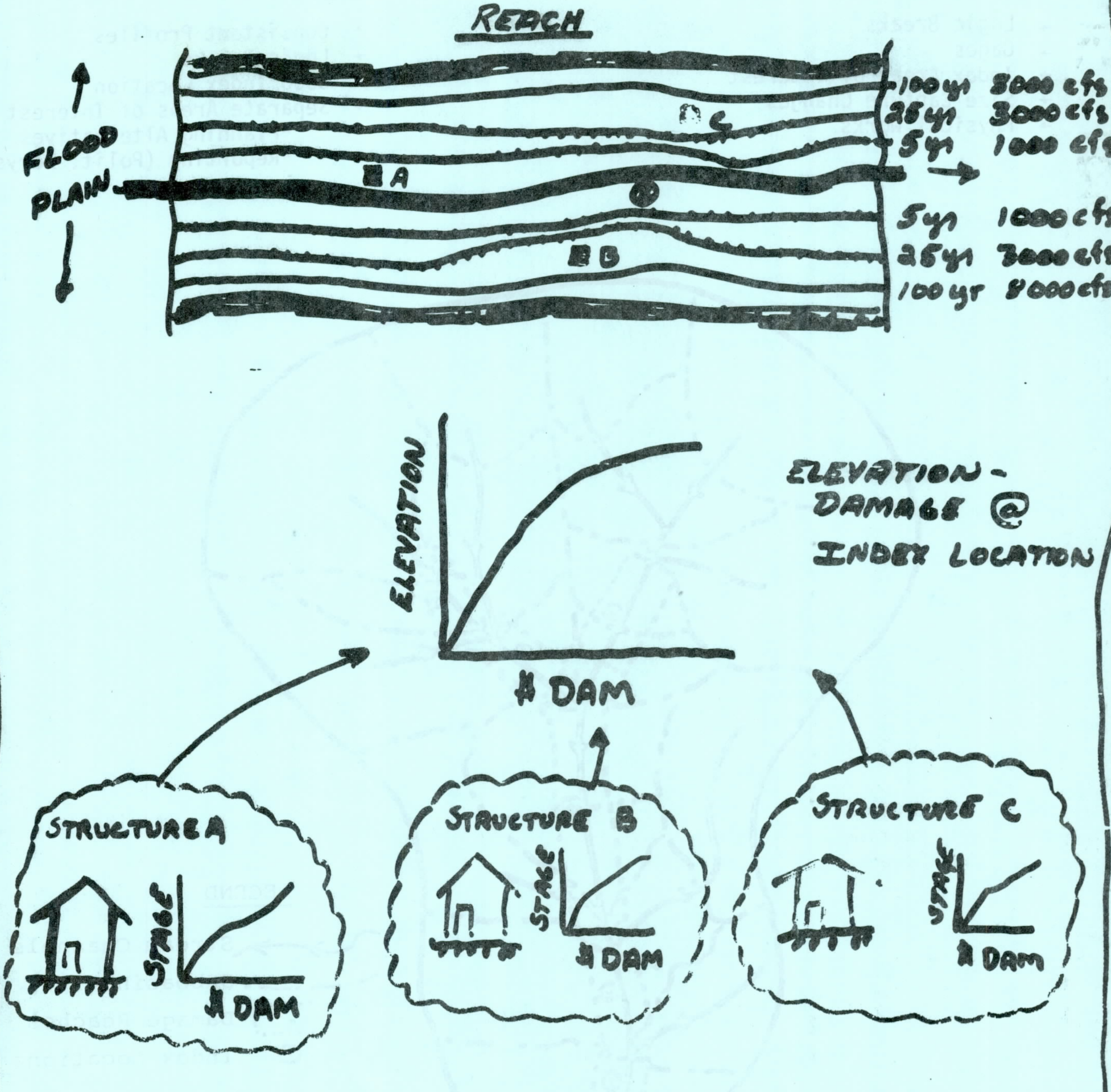
Damage Reaches

- Consistent Profiles
- Logic Breaks
- Good Index Location
- Separate Areas of Interest
  - *Planning Alternatives
  - *Reporting (Polit. Bdrys)



System Layout Concepts

STAGE - DAMAGE RELATIONSHIP



STRUCTURE INVENTORY FIELD SURVEY PROCEDURES

- o Review Previous Studies - Other Data
- o Define Objectives - Potential Alternatives
- o Estimate Damage Reaches on Maps
  - Profiles
  - Economic Reporting
  - Alternatives
- o Initial Field Recon
  - Interviews (High Water Marks/Nature of Damage)
  - Identify Types of Structures
  - Structure Values for Real Estate, etc.
  - Photographs
- o Determine Study Information Requirements
  - Level of Detail of Damage Data
  - Structure Inventory (Exhaustive or Samples)
  - Establish Damage Categories
  - Finalize Damage Reaches
  - Define Unique Structures/Features
  - Develop General Classes of Stage-Damage Functions, FIA, etc.)
- o Second Field Survey/Aerial Photos
  - Determine Structure Values and Associated Damage Functions
  - Define Structure Elevations (Field Survey, Topo)
  - Determine Information for Unique Structures

STRUCTURE DATA REQUIREMENTS

O Identification Data

- Building Identification
- Damage Reach ID
- Damage Category

o Location

- Reference Flood Elevation
- Reference Structure Elevation
- Location Coordinates (Opt)

o Damage

- Stage-damage Relationships (Structure, Contents, etc.)
- Value of Each Damage Type

STRUCTURE CLASSIFICATION

- Determined from previous studies, initial assessment of study area.

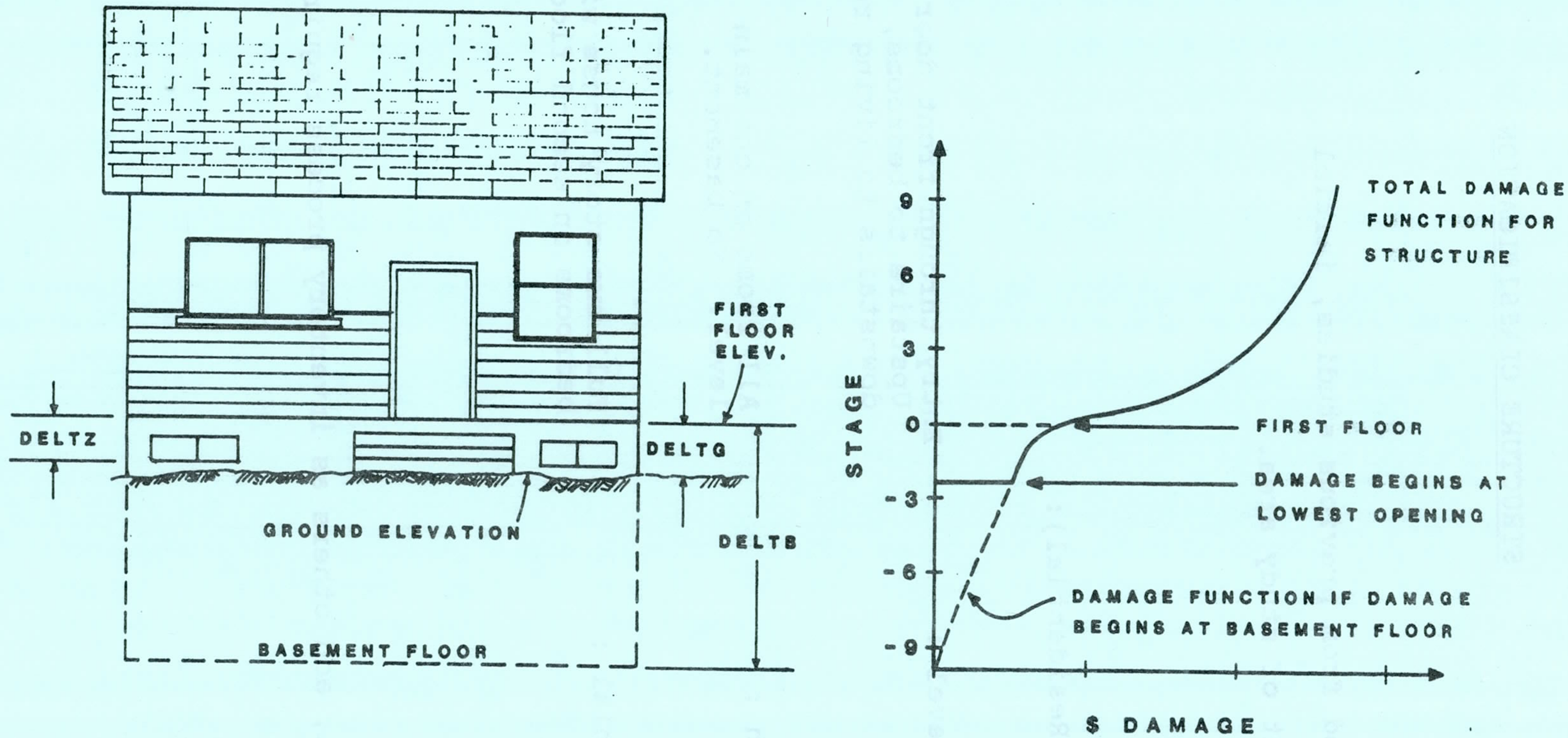
- Example (Residential):

  - Bi-level : Entry through front door. Upstairs to bedrooms, downstairs to living room.

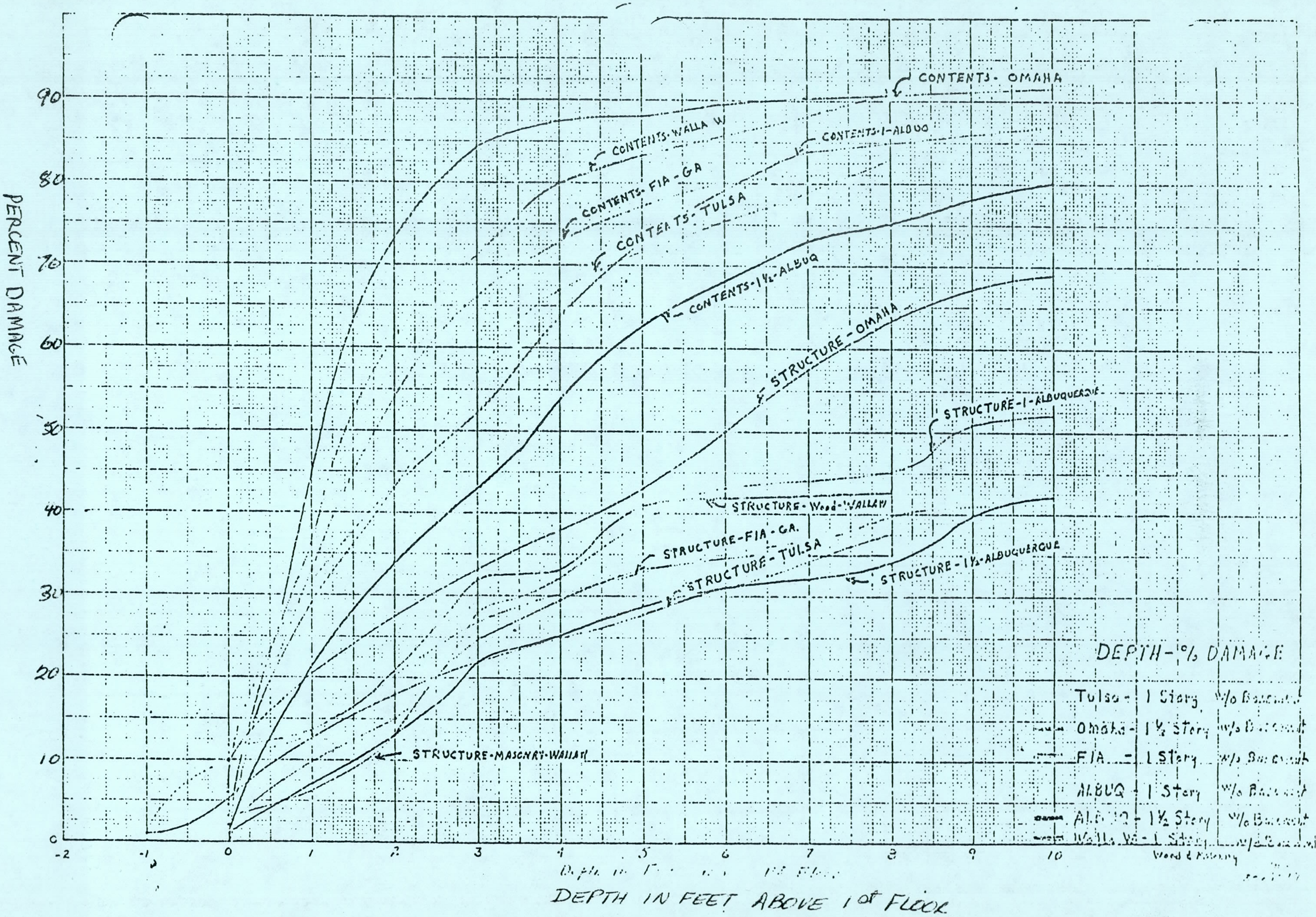
  - Ranch : All rooms on one main level. No basement.

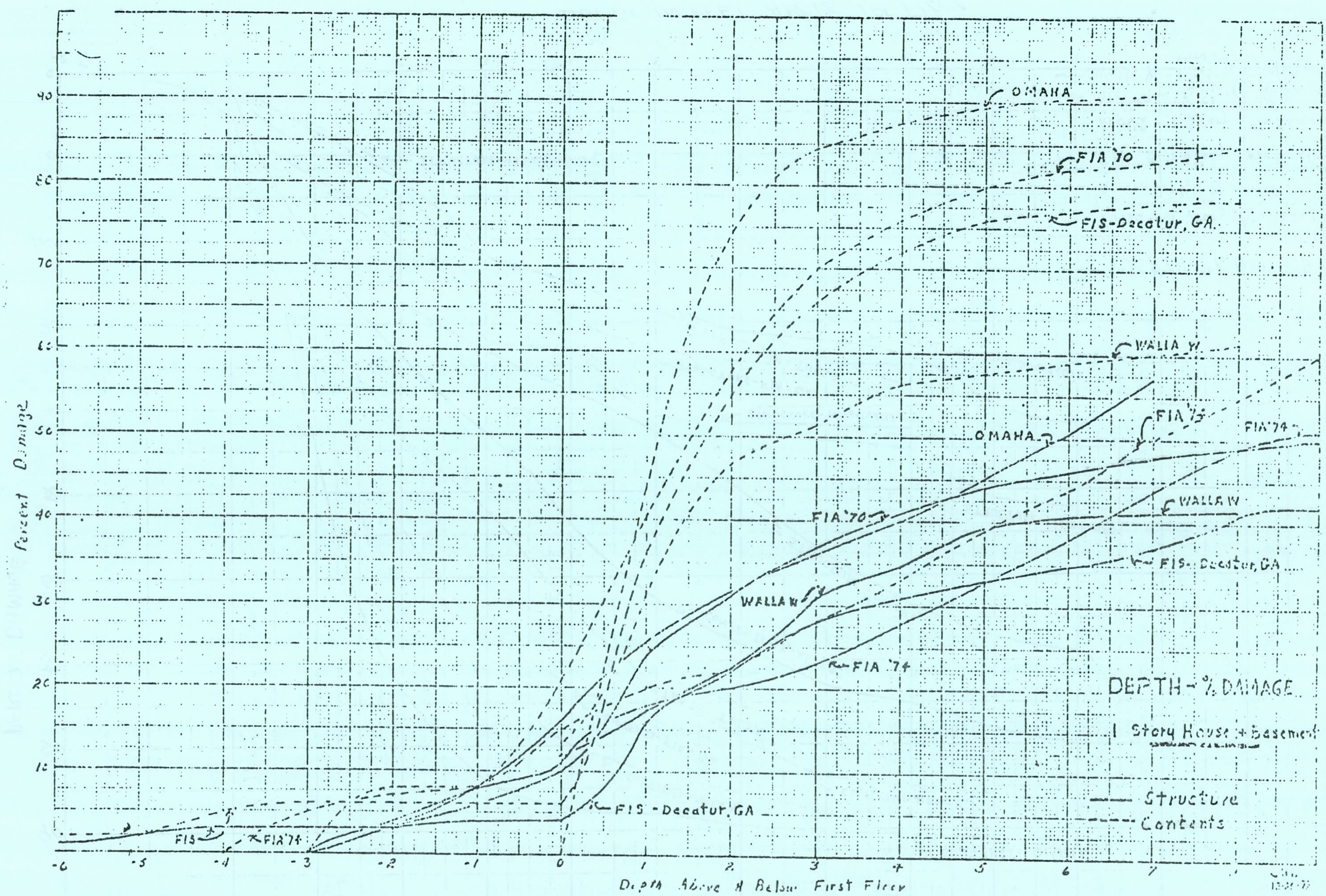
  - Colonial : Full two-story house with bedrooms on second floor.

Continue, add others as inventory process requires.



Damage Function Construction Concepts


PERCENT DAMAGE
90
80
70
60
50
40
30
20
10
0
-2
-1
0
1
2
3
4
5
6
7
8
9
10
CONTENTS - OMAHA
CONTENTS - WALLA W
CONTENTS - 1 - ALBUQ
CONTENTS - FIA - GA
CONTENTS - TULSA
CONTENTS - 1½ - ALBUQ
STRUCTURE - OMAHA
STRUCTURE - 1 - ALBUQUERQUE
STRUCTURE - Wood - WALLA W
STRUCTURE - FIA - GA.
STRUCTURE - TULSA
STRUCTURE - 1½ - ALBUQUERQUE
STRUCTURE - MASONRY - WALLA W
DEPTH - % DAMAGE
Tulsa - 1 Story
Omaha - 1½ Story
FIA - 1 Story
ALBUQ - 1 Story
1½ Story
Wood & Masonry
DEPTH IN FEET ABOVE 1st FLOOR



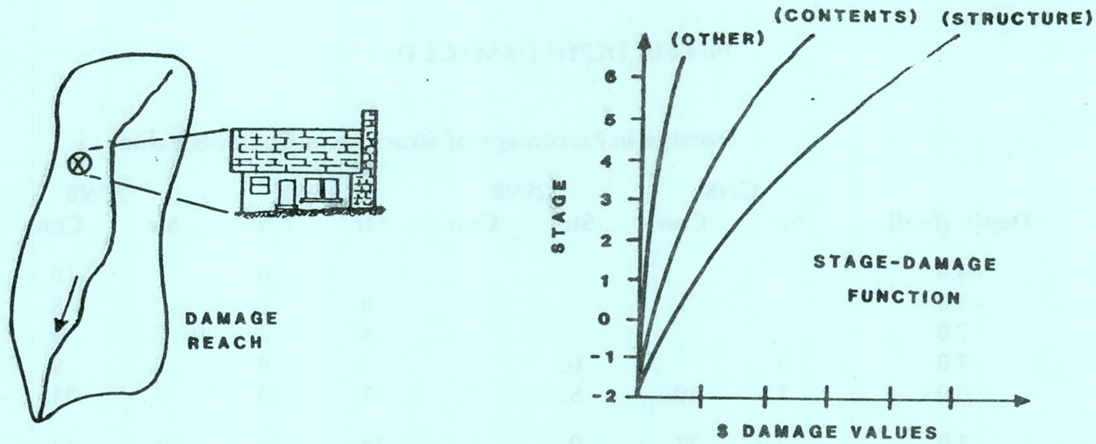
DEPTH - % DAMAGE
1 Story House + Basement
Structure
Contents
Percent Damage
Depth Above & Below First Floor
OMAHA
FIA 70
FIS-Decatur, GA.
WALLA W.
FIA 73
FIA 74
FIS
FIA 74
FIS - Decatur, GA

1974 FIA DEPTH-DAMAGE DATA[1]

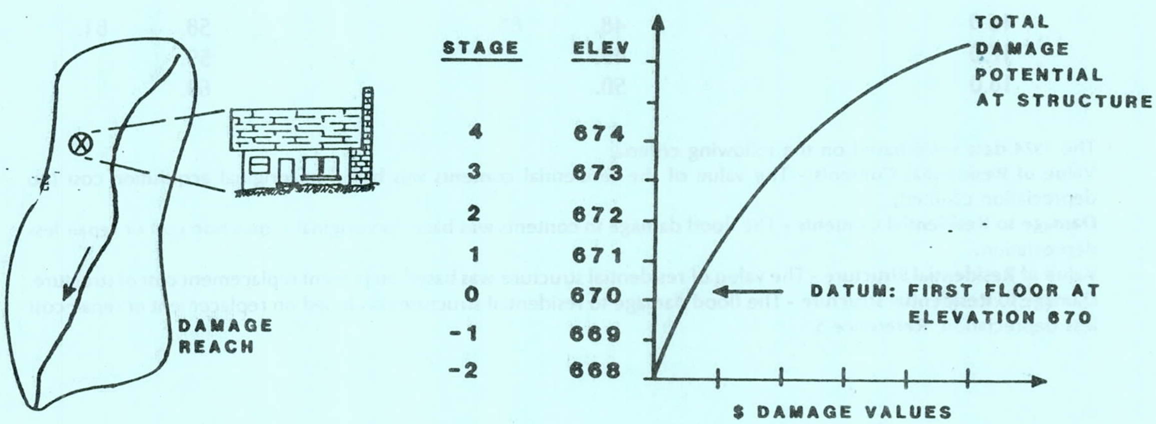
Damage in Percentage of Structure or Contents Value

	1SNB		2SNB		1SWB		2SWB	
Depth (feet)	**Str**	**Con**	**Str**	**Con**	**Str**	**Con**	**Str**	**Con**
-4.0						0.		0.
-3.0					0.	5.	0.	5.
-2.0					4.	7.	3.	6.
-1.0	0.		0.		8.	8.	5.	9.
0.0	7.	10.	5.	7.	11.	15.	7.	11.
1.0	10.	17.	9.	9.	18.	20.	11.	17.
2.0	14.	23.	13.	17.	20.	22.	17.	22.
3.0	26.	29.	18.	22.	23.	28.	22.	28.
4.0	28.	35.	20.	28.	28.	33.	28.	33.
5.0	29.	40.	22.	33.	33.	39.	33.	39.
6.0	41.	45.	24.	39.	38.	44.	35.	44.
7.0	43.	50.	26.	44.	44.	50.	38.	49.
8.0	44.	55.	31.	50.	49.	55.	40.	55.
9.0	45.	60.	36.	55.	51.	60.	44.	61.
10.0	46.		38.	58.	53.		46.	64.
11.0	47.		40.	65.	55.		48.	71.
12.0	48.		42.	72.	57.		50.	76.
13.0	49.		44.	78.	59.		52.	78.
14.0	50.		46.	79.	60.		54.	79.
15.0			47.	80.			56.	80.
16.0			48.	81.			58.	81.
17.0			49.				59.	
18.0			50.				60.	

[1] The 1974 data were based on the following criteria:
Value of Residential Contents - The value of the residential contents was based on original acquisition cost (no depreciation claimed).
Damage to Residential Contents - The flood damage to contents was based on original acquisition cost or repair less depreciation.
Value of Residential Structure - The value of residential structure was based on present replacement cost of structure.
Damage to Residential Structure - The flood damage to residential structure was based on replacement or repair cost less depreciation. Reference 5.



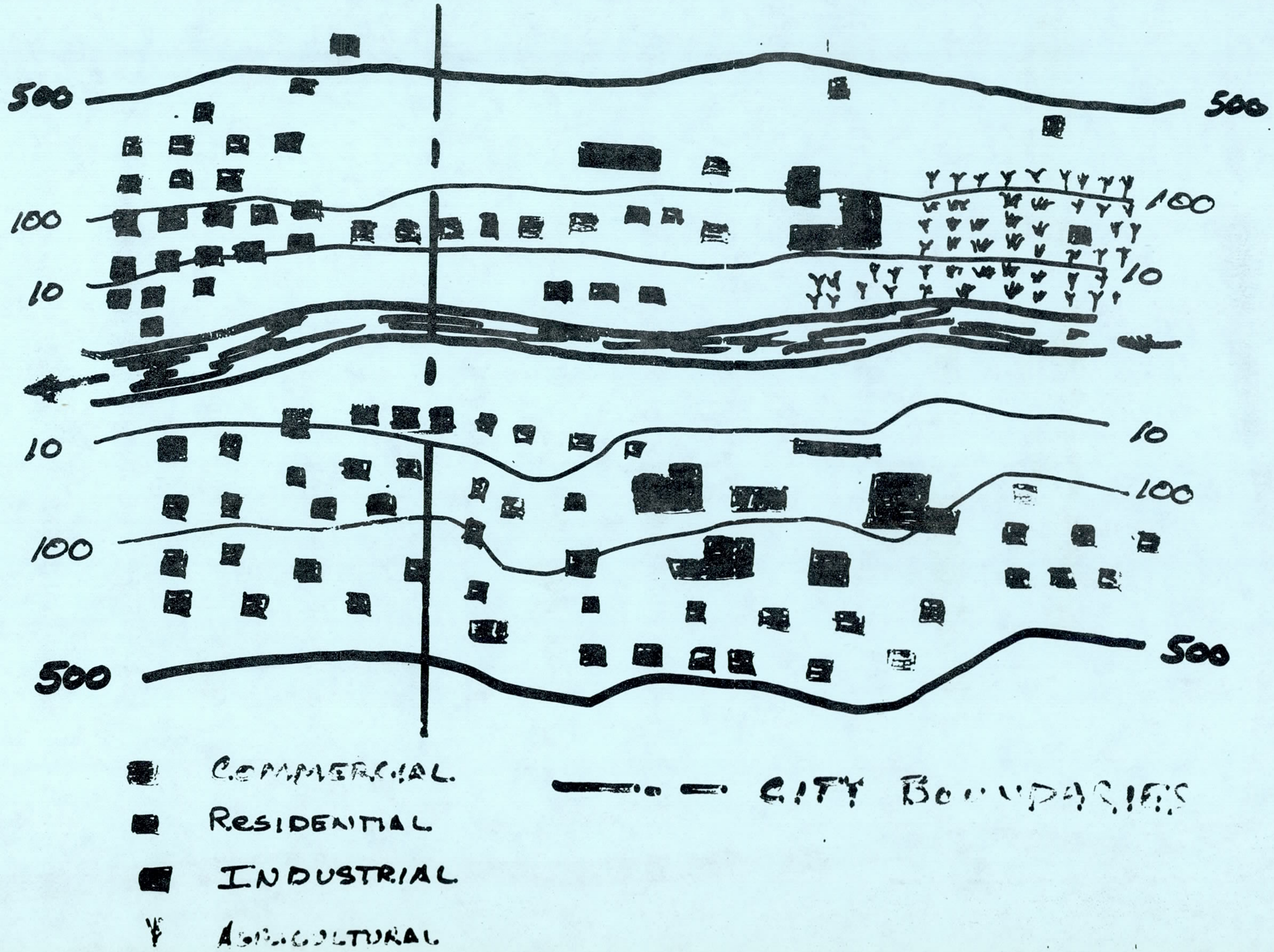
(a) Damage Category (single family residential, heavy industrial, strip commercial, etc.) stage-damage functions.



(b) Conversion of stage to elevation based on reference datum associated with the structure.

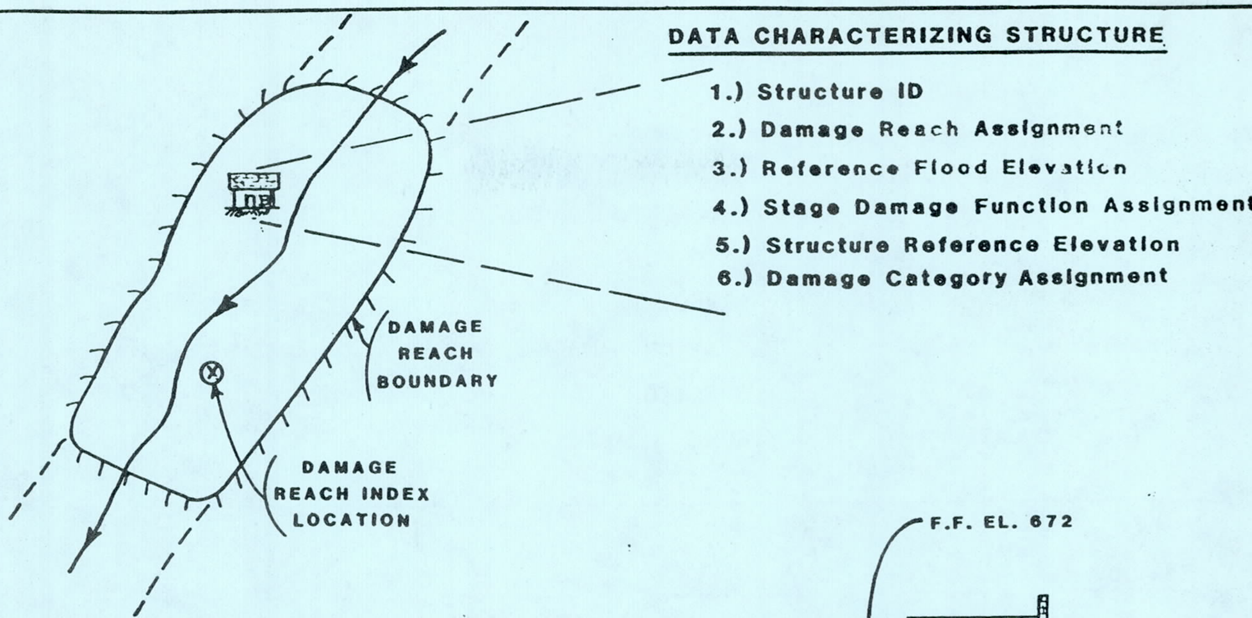
Elevation-Damage Function Development at Structure

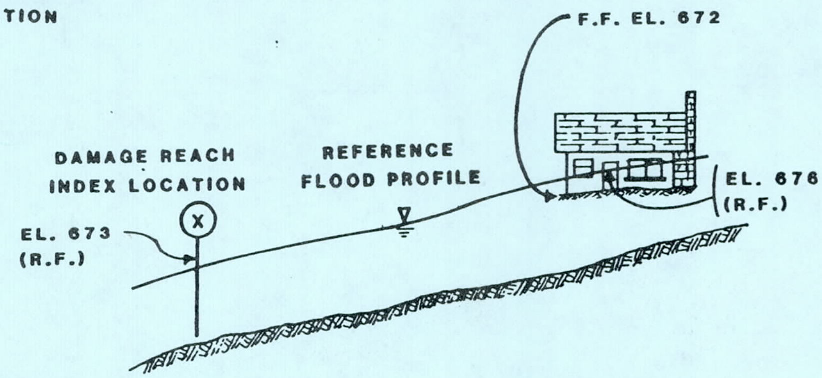
STUDY AREA


500
100
10
COMMERCIAL
RESIDENTIAL
INDUSTRIAL
CITY BOUNDARIES

PROCEDURES FOR AGGREGATING DAMAGE FUNCTION

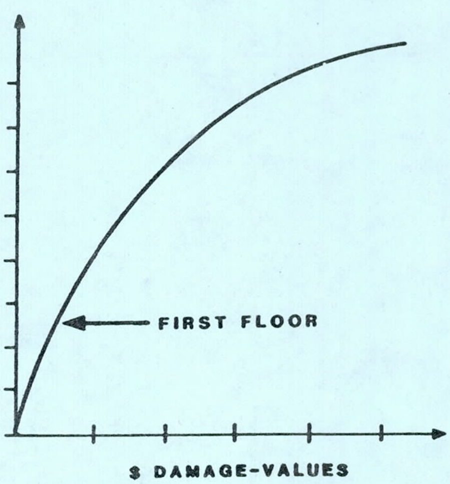
- REFERENCE FLOOD CONCEPT "Damage Reach Index Location"
  - (1) DEVELOP ELEVATION-DAMAGE FUNCTION AT STRUCTURE
  - (2) TRANSLATE FUNCTION TO DAMAGE REACH INDEX LOCATION (ACCOUNT FOR SLOPE IN PROFILE)
  - (3) AGGREGATE INTO APPROPRIATE DAMAGE CATEGORY
- FLOOD ZONE CONCEPT LA District Econ
  - (1) DETERMINE RANGE OF FLOOD ZONES
  - (2) DETERMINE APPROPRIATE ZONE OF STRUCTURES
  - (3) AGGREGATE BY REACH
- ANALYSIS AT STRUCTURE "Structure x Structure Analysis"
  - (1) DETERMINE ELEVATION-DAMAGE FUNCTION AT STRUCTURE
  - (2) TRANSLATE HYDROLOGIC/HYDRAULIC DATA TO STRUCTURE





Elevation Scale adjusted -3 feet (676-673) for slope in water surface profile.

VALUES AT STRUCTURE		ADJUSTED ELEVATION AT DAMAGE REACH INDEX LOCATION
STAGE	ELEVATION	
4	676	673
3	675	672
2	674	671
1	673	670
0	672	669
-1	671	668
-2	670	667



Translation of Structure Elevation-Damage Function to Index Location

DAMAGE AGGREGATION PROCESS

STRUCTURE A ELEVATION-DAMAGE FUNCTION AT INDEX LOCATION		+	STRUCTURE B ELEVATION-DAMAGE FUNCTION AT INDEX LOCATION		=	TOTAL FUNCTION AT DAMAGE REACH INDEX LOCATION	
Elevation	Damage ($\$ \times 10^3$)		Elevation	Damage ($\$ \times 10^3$)		Elevation	Damage ($\$ \times 10^3$)
			662	0		662	0
			663	1.1		663	1.1
			664	4.7		664	4.7
			665	5.2		665	5.2
			666	10.7		666	10.7
667	0		667	12.3		667	12.3
668	0.8		668	14.2		668	15.0
669	1.2		669	17.6		669	18.8
670	2.0		670	20.3		670	22.3
671	3.6		671	35.0		671	38.6
672	5.0		672	37.4		672	42.+
673	7.0		673	41.0		673	48.0

AGGREGATED DAMAGE FUNCTIONS
AT THE INDEX LOCATION
($1,000's)

Elev m.s.l	Single Family Residential	Multi-Family Residential	Public Facilities	Heavy Industrial	Unimproved Pasture	Total Damage
654	0.0	0.0	0.0	0.0	0.0	0.0
655	0.5	0.0	0.1	0.0	0.0	0.6
656	1.2	0.0	0.4	0.0	0.0	1.6
657	1.4	0.0	0.4	0.0	0.1	1.9
658	1.5	0.0	0.4	0.0	0.1	2.0
659	1.6	0.0	0.4	0.0	0.1	2.1
660	1.9	0.0	0.4	0.0	0.1	2.4
661	2.4	0.0	0.4	0.0	0.1	2.9
662	2.8	1.1	0.4	1.2	0.2	5.7
663	3.1	5.5	0.4	1.2	0.2	10.4
664	3.2	14.7	0.4	20.4	0.2	38.9
665	3.4	19.9	0.4	86.1	0.3	110.1
666	3.7	26.8	0.4	175.9	0.3	207.1
667	4.0	36.4	0.4	267.5	0.3	308.6
668	4.2	47.9	0.4	325.1	0.4	378.0
669	4.4	71.6	0.4	372.2	0.4	449.0
670	4.4	71.6	0.4	420.6	0.4	497.4
671	4.6	91.0	0.5	422.8	0.5	519.4

SHELLE BARKIN

Introduction to SID

- Program Features
- Input
- Output Options
- SIDEDT

The Hydrologic Engineering Center

SID Program Features

- Develop Elevation-Damage Functions by:
  - damage category
  - damage reach
- Transfer Functions to EAD

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Develop Elevation-Damage Function

1. • Develop Stage-Damage Functions at Individual Structures
2. • Convert Stage Values to Elevation
3. • Move Structure to Index Location
4. • Aggregate By Damage Category and Reach

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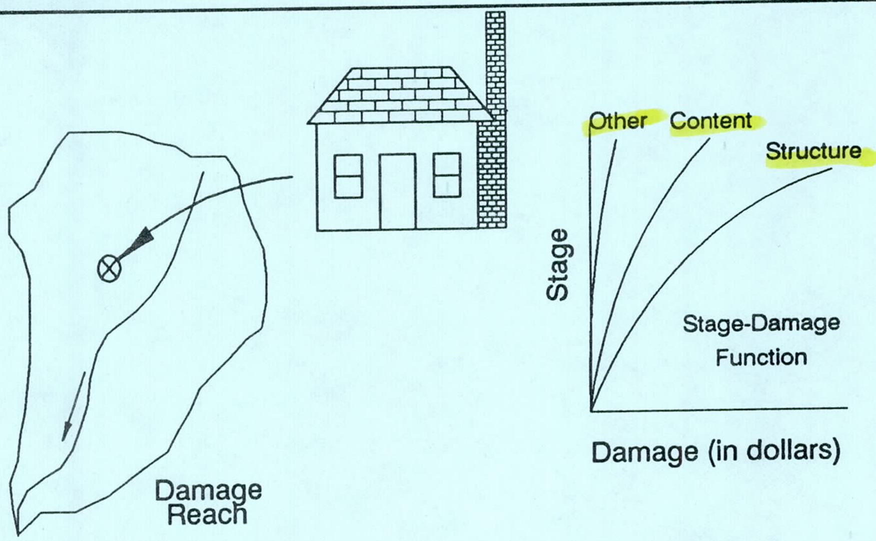
Develop Stage-Damage Function

#1



Generalized stage-damage functions, i.e., single family residential, heavy industrial, strip commercial, etc.

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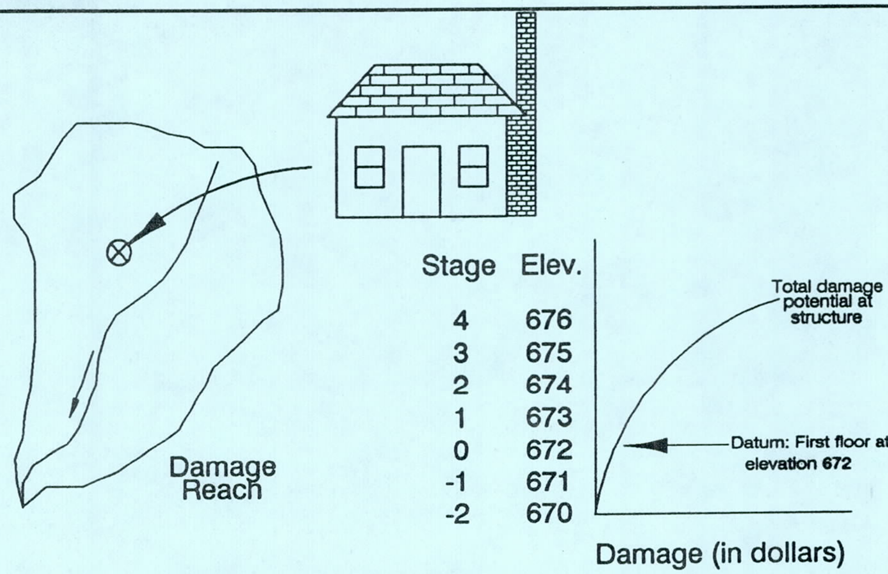
#2

Convert Stage Values to Elevation



Stage	Elev.
4	676
3	675
2	674
1	673
0	672
-1	671
-2	670

Conversion of stage to elevation based on reference datum associated with the structure.

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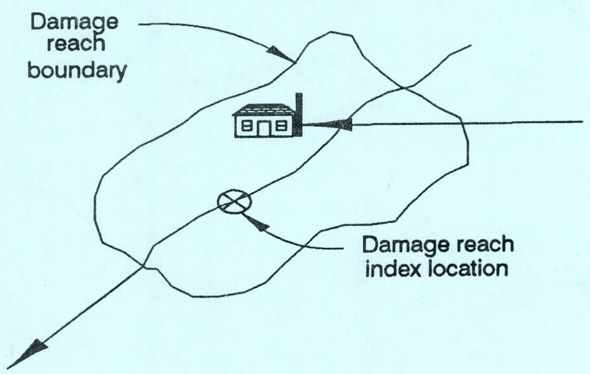
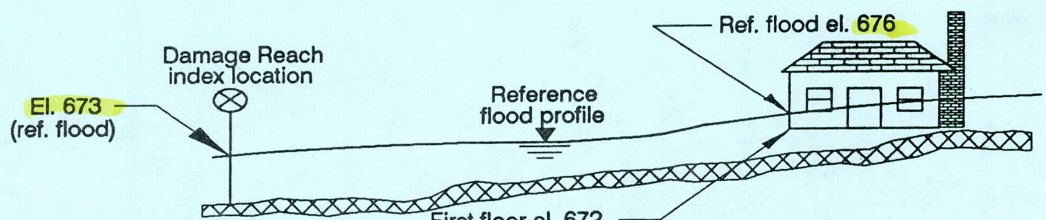
#3

Move Structure to Index Location



Data Characterizing Structure

- Structure I.D.
- Damage reach assignment
- Reference flood elevation
- Stage-damage function assignment
- Structure reference elevation
- Damage category assignment



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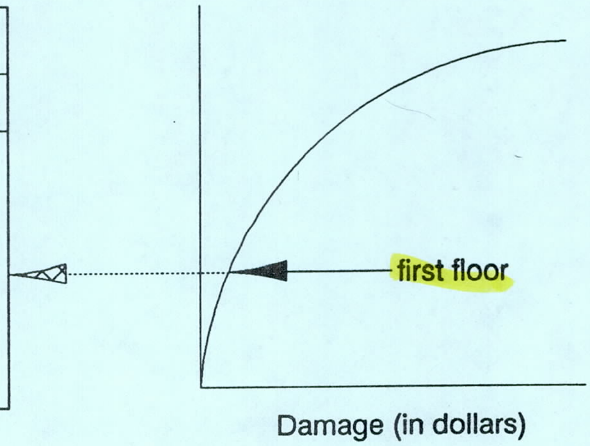
Move Structure to Index Location

Elevation scale adjusted -3 feet (676-673) for slope in reference flood water surface profile.

Values at structure		Value at index
stage	elevation	adjusted elevation
4	676	673
3	675	672
2	674	671
1	673	670
0	672	669
-1	671	668
-2	670	667



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Aggregate Damage Functions

Structure A Elevation-Damage Function at Index Location + Structure B Elevation-Damage Function at Index Location = Total Function At Damage Reach Index Location

Structure A Elevation	Structure A Damage ($1000)	Structure B Elevation	Structure B Damage ($1000)	Total Elevation	Total Damage ($1000)
....	....	662	0	662	0
....	....	663	1.1	663	1.1
....	....	664	4.7	664	4.7
....	....	665	5.2	665	5.2
....	....	666	10.7	666	10.7
667	0	667	12.3	667	12.3
668	0.8	668	14.2	668	15.0
669	1.2	669	17.6	669	18.8
670	2.0	670	20.3	670	22.3
671	3.6	671	35.0	671	38.6
672	5.0	672	37.4	672	42.4
673	7.0	673	41.0	673	48.0

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Basic HEC Input Format

- Each record contains 11 fields
  - Field 0 (col 1-2) - Record Identifier
  - Field 1 (col 3-8) -
  - Fields 2-10 (multiples of 8)
- Numbers are right-justified
- Characters are left-justified

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Input (COED)

- Job Control
- Depth-Damage Functions
- Damage Categories
- Damage Reaches
- Structures

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Job Control

- Title Records
- Job Records
- DSS Record

-T1
-T2
-T3
J1 - J9
Fill Out Completely

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Job Records

- Define Analysis Specifications
  - J1 and J2 Records
- Specify Nonstructural Analysis
  - J3 - J9 Records and OA Record

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J1 Record - Required

P.179 S/D Manual

NON-STRUCTURAL

J1	IPOL	IPROF	IEVAC	blank	IPRNT
0	1	2	3	4	5

SINGLE EVENT Damage @ an elev.

ITRCE	blank	ITYPE	IAG	ISAMP
6	7	8	9	10

J1.8

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J2 Record - Required

P.182

J2	NODF	NODC	NODR	AGG	NFILE
0	1	2	3	4	5

18 Blank

IMAGE	IELV	IMARK	NDFILE	blank
6	7	8	9	10

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DSS Record

P.192

ZW A=Cooper Creek F=Base Condition

- Transfers Elevation-Damage Function to DSS File

required for SID => EAD

- ZW Record
  - Specifies DSS Pathname
    - Part A - Project
    - Part E - Data Year
    - Part F - Alternative

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Stage-Damage Functions

P193

- Stage-Percent Damage Function
  - DF, DP, PC Records
- Stage-Direct Dollar Damage Function
  - DF, DP, DD Records
- Maximum Number
  - Sequential File - 50 (LIMIT # categories of damage)
  - Direct Access File - 2000 (PC version - 485)
- 3 Character Identifier

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DF Record - Required

P.193

DF	IT	NSTAG	~~IDFILE~~ IDF	~~blank~~ IDFILE	blank
0	1 (6-8)	2	3	4	5

blank	blank	blank	blank	blank
6	7	8	9	10

IF <10, only one DP Record

IF ≥10 ∴ 2 DP records?

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DP Record - Required

P.194

DP	SAGE	SAGE	SAGE	SAGE	SAGE
0	1	2	3	4	5

SAGE	SAGE	SAGE	SAGE	SAGE
6	7	8	9	10

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PC Record - Optional

P. 195

Percent Damage

PC	PERCNT	PERCNT	PERCNT	PERCENT	PERCNT
0	1	2	3	4	5

PERCNT	PERCNT	PERCNT	PERCNT	PERCNT
6	7	8	9	10

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Must have PC or DD

DD Record - Optional

P. 195

Direct Dollars

in Thousands of $

DD	PERCNT	PERCNT	PERCNT	PERCNT	PERCNT
0	1	2	3	4	5

PERCNT	PERCNT	PERCNT	PERCNT	PERCNT
6	7	8	9	10

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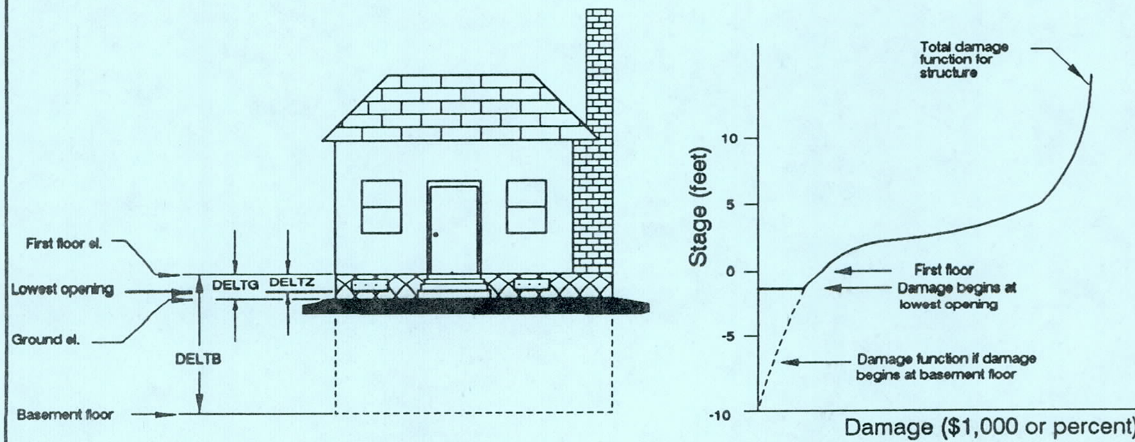
Stage-Damage Functions



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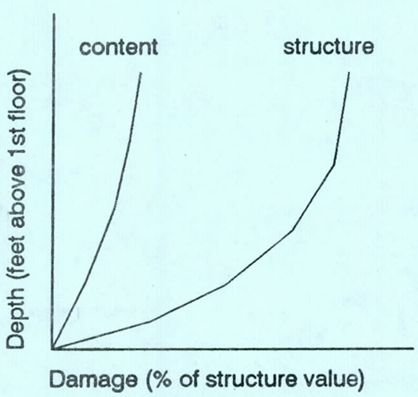
Damage Function Input Options



Stage-percent damage functions

If STOPO (SL.6)=0, functions must be elevation-damage

Stage values	=	DP Records
Damage Function Option	=	IDF (DF.3)=0
Percent Damage Values	=	PC Records
Structure Value	=	V1FS (SD.4)
Content Value	=	V1FC (SD.5)
Other Value	=	V1FO (SD.6)

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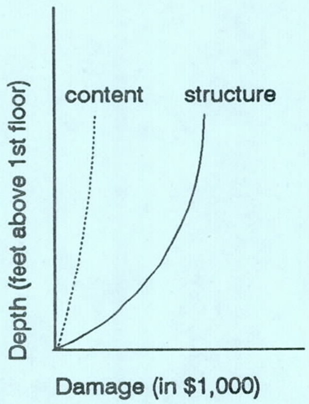
Damage Function Input Options



Stage-dollar damage functions

If STOPO (SL.6)=0, functions must be elevation-damage

Stage values	=	DP Records
Damage Function Option	=	IDF (DF.3)=1
Percent Damage Values	=	~~PC~~ Records
Structure Value	=	V1FS (SD.4)
Content Value	=	V1FC (SD.5)
Other Value	=	V1FO (SD.6)

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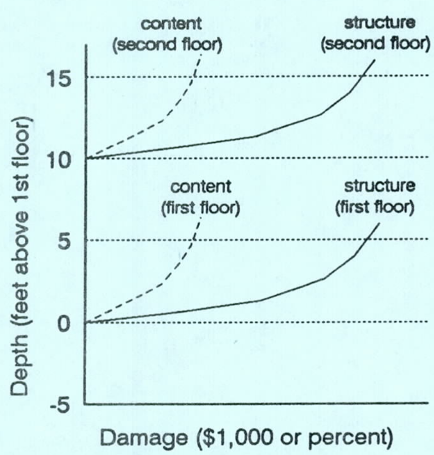
Damage Function Input Options



Stage-Damage Functions by Floor Level

If STOPO (SL.6)=0, functions must be elevation-damage

Stage values	=	DP Records
Damage Function Option	=	IDF (DF.3)
Percent Damage Values	=	PC Records
Direct Damage Values	=	DD Records
Structure Content and "Other" Values For Each Floor	=	SO Record

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Damage Categories

- Consolidates Damage Potential To Structure, Contents, and Other
  - DC Record (Required)
  - CC Record (Optional)
- 8 Character Identifier

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DC Record - Required

P. 196

Required for each Damage Category

DC	blank	JDCT	POLMX	PRFMX	TITDC
0	1	2	3	4	5

TITDC	TITDC	TITDC	TITDC	TITDC
6	7	8	9	10

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Damage Reaches

- **Define Limits of Consistent Data**
  - Water Surface Elevation (DR)
  - Title (DT)
  - Single Event Analysis Water Surface Elevation (SE)
  - Scaling Adjustments to Damage Functions (D3)
  - Single Event Title (ST)
  - Single Event Damage Category Output Consolidation (AC)
  - Single Event Damage Reach Output Consolidation (AR)

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DR Record - Required

DR	JDR	REFFLD	POLELV	PROELV	EVCELV
0	1	2	3	4	5

STRELV	ELINTR	IDPRT	ID3	blank
6	7	8	9	10

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DT Record - Required

P. 139

DT	DTITLE

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SE Record - Optional

SE	SINGLE	SINGLE	SINGLE	SINGLE	SINGLE
0	1	2	3	4	5

SINGLE	SINGLE	SINGLE	SINGLE	SINGLE
6	7	8	9	10

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~~SE~~ ST Record - Optional

P. 201

ST	SEVTIT	SEVTIT	SEVTIT	SEVTIT	SEVTIT
0	1	2	3	4	5

SEVTIT	SEVTIT	SEVTIT	SEVTIT	SEVTIT
6	7	8	9	10

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Structures

- Identification Data
- Location Data
- Damage Data

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Structure Identification Data

- Building Identifier
  - 8 characters
- Damage Reach Identifier
  - 6 characters
- Damage Category Identifier
  - 8 characters

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Structure Location Data

1st Floor

- Reference Elevation at Structure
- Reference Flood Elevation at Structure
- Location Coordinates

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SL Record - Required

P. 204

SL	IDRCH	IBLDG	ROWN	COLE	ADJ
0	1	2	3	4	5

STOPO	DELTZ	DELTB	DELTG	*	**
6	7	8	9	10	

*IFUNC (73-74)

**NEWSTR (75)

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Structure Damage Data

P. 206

- Stage-Damage Curve for:
  - Structure
  - Contents
  - Other
- Dollar Value for:
  - Structure
  - Contents
  - Other

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SD Record - Required

P. 206

SD	IDRCH	IBLDG	IDCAT	ID1FS	V1FS	ID1FC	V1FC
0	1	2	3		4		5
					STRUCTURE		CONTENTS

ID1FO	V1FO	IADDR	IADDR	IADDR	IADDR
	6	7	8	9	10
	OTHER				

ES - END OF STRUCTURES (P. 213)

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Nonstructural Measures

- Flood Proofing
- Raising of Structure and Contents
- Relocation of Structures

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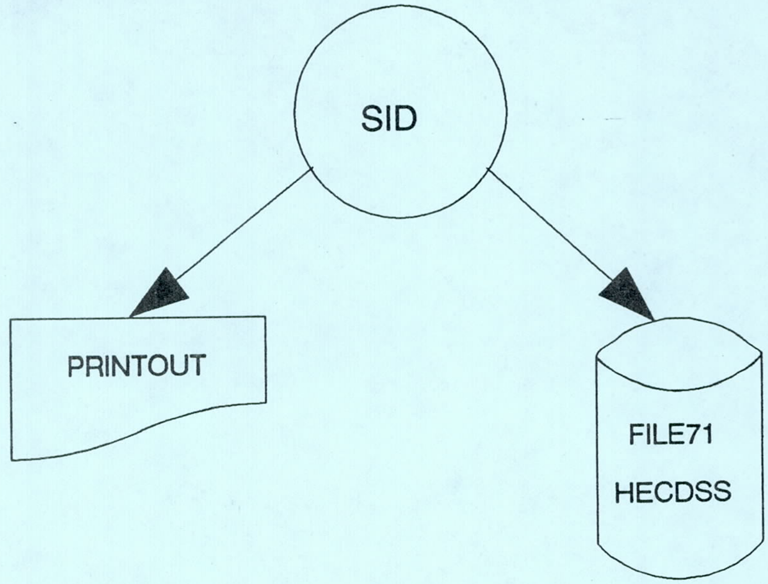
Output Options



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Output Options

- Banner Page
- Input Listing
- Stage-Damage Functions
- Damage Categories
- Index Location Summary
- Single Event Information

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Output Options

- Structure Inventory Data Summary
- Trace Output
- Nonstructural Analysis Summary
- Flood Zone Summary Tables
- Damage Reach Aggregation Summaries

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SIDEDT Program Features

- Helps Correct Errors in a Structure Inventory File or a Stage-Damage Function File
- Provides a Wide Range of Data Base Management Operations to Aid in File Management

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WORKSHOP PROBLEM

DEVELOPMENT OF AGGREGATED ELEVATION-DAMAGE DATA AT DAMAGE REACH INDEX LOCATIONS

Purpose

This problem requires course participants to manually aggregate structure elevation-damage data to a damage reach index location and to use the SID program to perform the same analysis. Though only two structures are used to minimize the calculations and data entry while demonstrating the analysis process, the logic and procedures are the same for a large basin with tens of thousands of structures and several hundred damage reaches.

Problem Description

A Corps of Engineers' feasibility study along Cooper Creek, located in the City of Denton, Texas, requires analysis of the flood damage potential of several damage reaches. Figure 1 depicts the stream reach of interest for this workshop, damage reach 11. The following paragraphs describe the analyses performed to date by the various disciplines involved in the study.

* Hydraulic Analysis. Detailed water surface profiles (HEC-2) have been developed for a range of flood flow rates. Figure 2 shows the elevation-discharge function (rating curve) developed at the damage reach 11 index location from the water surface profile analysis for the existing without project condition.

* Hydrologic Analysis. A result of the hydrologic analysis is the discharge-frequency function for the damage reach 11 index location shown in Figure 3. These relationships were developed using a rainfall-runoff model (HEC-1) calibrated using USGS flow-frequency regression equations and field survey high water marks.

* Flood Damage Potential Data. The structures to be analyzed are located in damage reach 11 and include a school (structure no. 571) and a single family residential structure (structure no. 311). The stage-percent damage functions and other pertinent information of the two structures and their contents are shown in Table 1. The stage-percent damage function for the school was obtained from a specific damage potential survey for the structure. The stage-damage function for the residential structure is the general relationship developed for the specific category of residential structures.

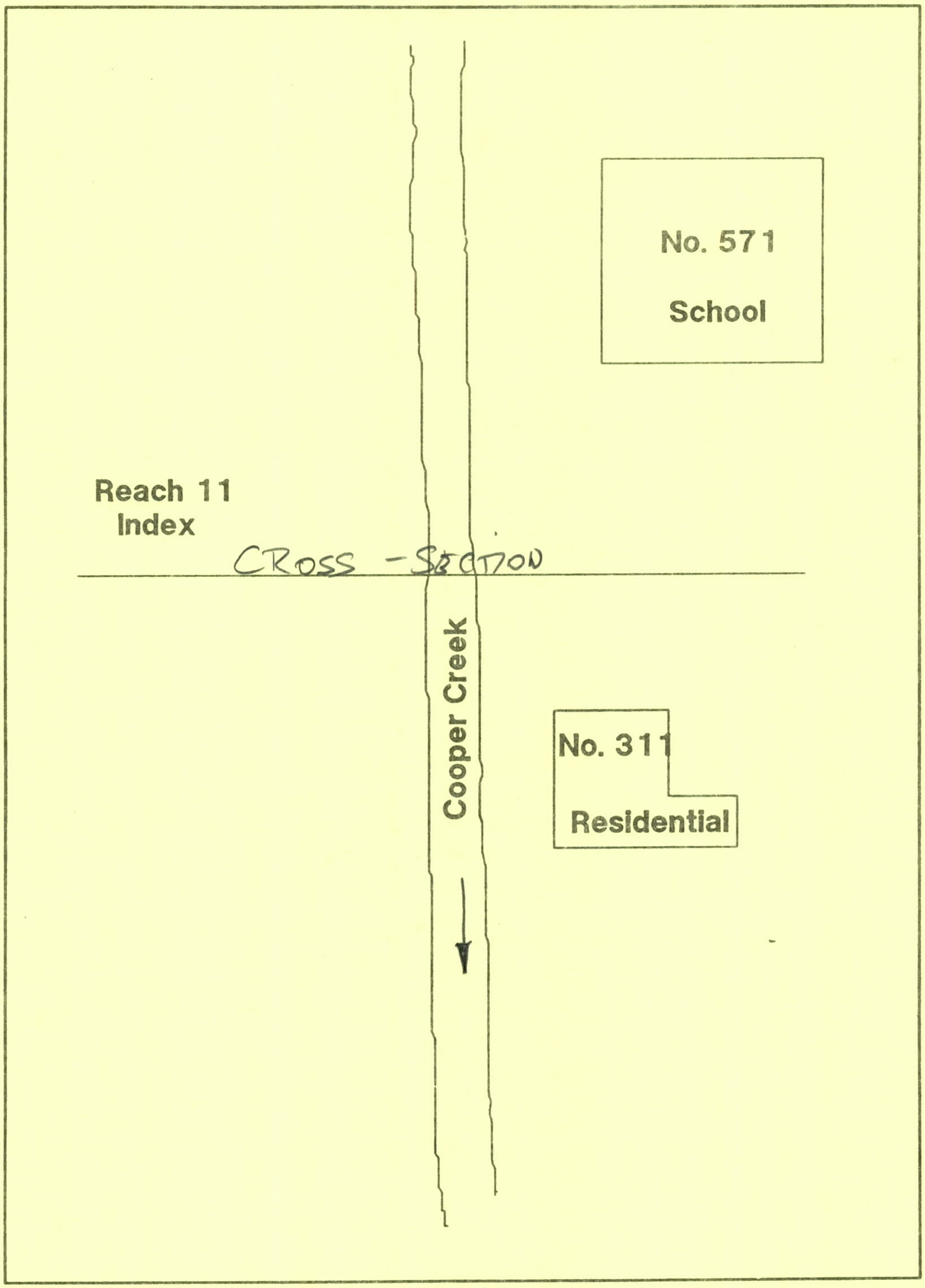


Figure 1 - Cooper Creek Structures

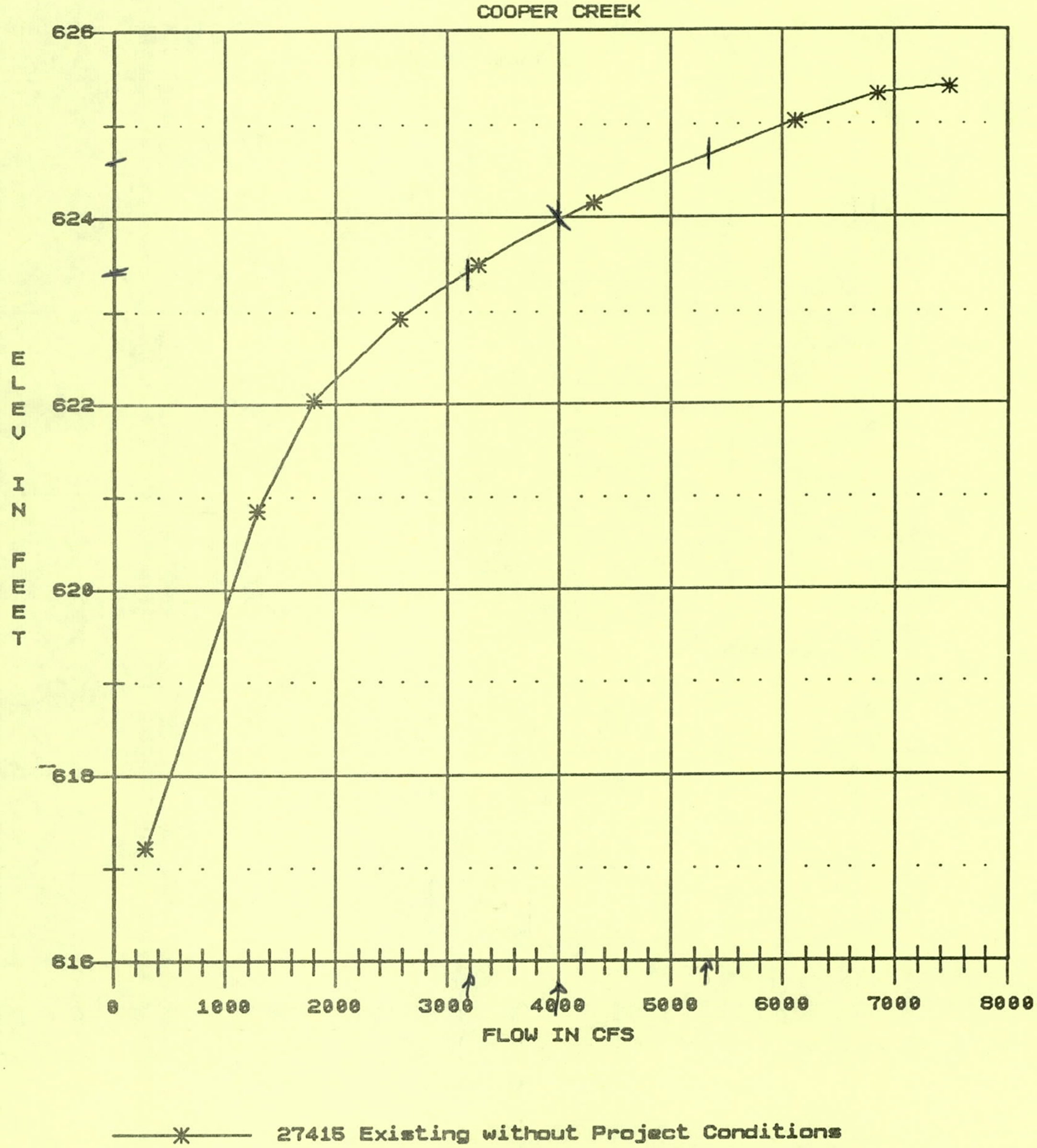


Figure 2 - Cooper Creek Rating Curve

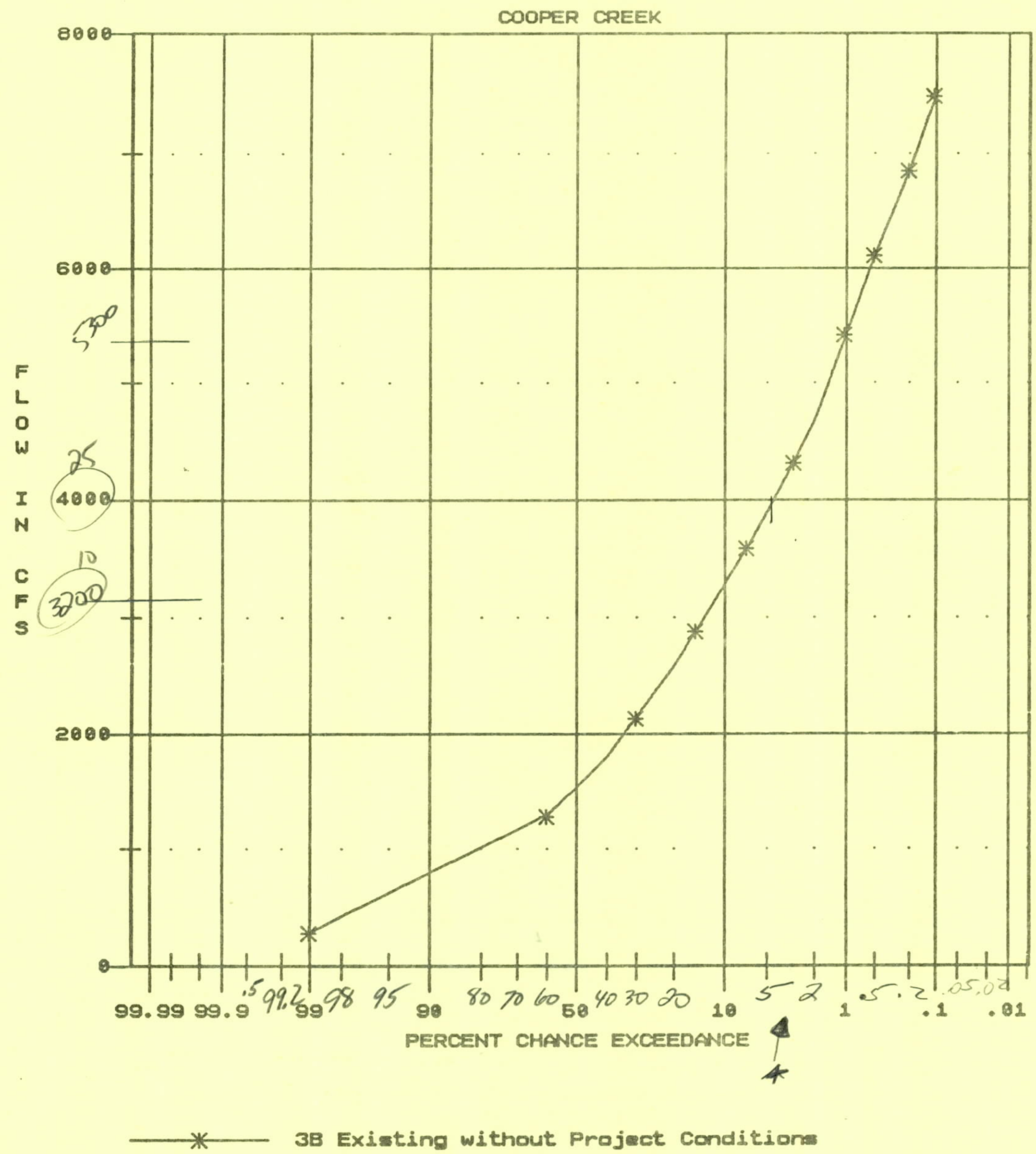


Figure 3 - Cooper Creek Frequency Curve

TABLE 1
STAGE-PERCENT DAMAGE FUNCTIONS

Structure No. 311
Single-Family Residential Structure

Stage (feet)	RS1 Structure (percent)	RC1 Contents (percent)	
-1	0	0	
0	2	6	
1	10	32	Structure Value = $80,000
2	15	43	
3	28	52	
4	32	64	Content Value = $40,000
5	39	73	
6	43	79	
7	44	84	First Floor Elevation = 623 ft. (0 stage)
8	45	85	
9	51	86	
10	52	87	
11	54	87	Reference Flood Elevation = 623 ft.
12	58	88	
13	62	90	
14	67	93	
15	73	96	

Structure No. 571
School

Stage (feet)	SS1 Structure (percent)	SC1 Contents (percent)	
0	0		
1	10		Structure Value = $200,000
2	11	0	
3	11	20	
4	12	40	Content Value = $60,000
5	12	60	
6	13	80	
7	14	85	First Floor Elevation = 622 ft.
8	14	90	
9	15		
10	17		Reference Flood Elevation = 625 ft.
11	19		
12	24		
13	30		
14	38		
15	45		

Problems

1. Aggregation of Structure Elevation-Damage Functions to Index Location By Hand.

a. Develop the elevation-dollar damage function for each structure and associated contents in one foot intervals. Use TABLE 2. Each function will represent the damage function at the structure location.

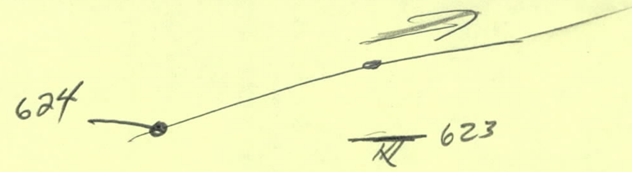
TABLE 2

STRUCTURE No. 311
SINGLE FAMILY RESIDENTIAL

Stage (feet)	% Damage Structure ($80,000)	% Damage Contents ($40,000)	Elevation M.S.L.	$ Damage Structure	$ Damage Contents	Total $ Damage
-1	0	0	622	Ø	Ø	Ø
0	2	6	623	1600	2400	4000
1	10	32	624	8000	12,800	20800
2	15	43	625	12,000	17,200	29,200
3	28	52	626	22,400	20,800	43 200
4	32	64	627	25,600	25,600	51200
5	39	73	628	31,200	29,200	60,400
6	43	79	629	34,400	31,600	66,000
7	44	84	630	35,200	33,600	68,800

STRUCTURE No. 571
SCHOOL

Stage (feet)	% Damage Structure ($200,000)	% Damage Contents ($60,000)	Elevation M.S.L.	$ Damage Structure (x 1000 $)	$ Damage Contents (x 1000)	Total $ Damage (x 1000)
0	0	0	622	0	Ø	Ø
1	10	0	623	20	0	20
2	11	0	624	22	0	22
3	11	20	625	22	12	34
4	12	40	626	24	24	48
5	12	60	627	24	36	60
6	13	80	628	26	48	74
7	14	85	629	28	51	79
8	14	90	630	28	54	82

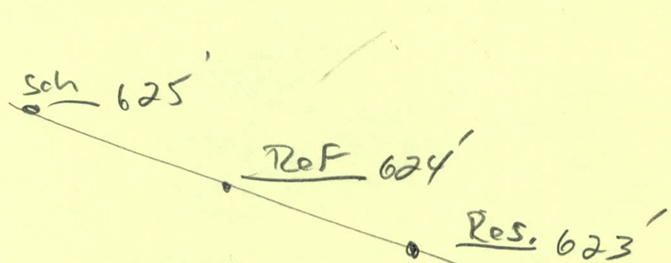


b. Aggregate the elevation-damage functions (in one foot intervals) of each structure and its contents to the damage reach index location (reach 11). Use the reference flood concept to account for the difference in elevations due to the slope in water surface profile. The reference flood elevation at the damage reach index location is 624 ft. Use TABLE 3.

TABLE 3

AGGREGATION OF DAMAGE TO DAMAGE REACH 11 INDEX LOCATION

Elevation Index Loc. M.S.L	Damage to No. 311 ($ x 1000)			Damage to No. 571 ($ x 1000)			Total $ Damage
	Structure	Contents	Total	Structure	Contents	Total	
620	—	—	—	—	—	—	—
621	—	—	—	∅	∅	∅	0
622	—	—	—	20	0	20	20
623	∅	∅	∅	22	0	22	22
624	1.6	2.4	4.0	22	12	34	38
625	8.0	12.8	20.8	24	24	48	68.8
626	12.0	17.2	29.2	24	36	60	89.2
627	22.4	20.8	43.2	26	48	74	117.2
628	25.6	25.6	51.2	28	51	79	130.2
629	31.2	29.2	60.4	28	54	82	142.4
630	34.4	31.6	66.0				
631	35.2	33.6	68.8				
632							
633							



RoF = Res + 1'

Res = RoF − 1'

Sch = RoF + 1

∴ RoF = Sch − 1

c. Based on available discharge-elevation (rating curve) and discharge-frequency (frequency curve) data, estimate the damage to the residential structure and school (including contents) for the 1-, 4-, and 10-percent chance flood events. Complete TABLE 4.

TABLE 4

DAMAGE ESTIMATES FOR SPECIFIC FLOOD EVENTS

Flood Event % Chance	Elevation	$ Damage No. 311	$ Damage No. 571	Total Damage
10 (10 year)	623.5'	2	~~30~~ 28	30
4 (25 year)	624.0'	4	34	38
1 (100 year)	624.6'	14.1	42.4	56.5

d. Go to next page.

Q 100

Q 25

Q 10

2. Basic Application of SID Computer Program.

a. Use the FDA package to complete the input for the SID computer program to compute the elevation-damage function for damage reach 11.

1. Start the FDA program by typing MENUFDA followed by a return (use the <ENTER> key).

2. Select the study name Cooper Creek. Then select the SID program option.

3. Using the stage-percent damage function data provided in TABLE 1 together with the information provided in task 1 of this workshop, complete the SID input data located in file, COOPBASE.S. Remember that the reference flood elevation at index location damage reach 11 is 624 ft. To start the COED program, select the input file name and press the <ALT> key together with the letter E. When you are done editing, to save your file, press the <ALT> key together with the <F10> function key.

a. Complete the entry of the DP and DC records for the damage functions, RS1 and RC1.

b. Enter the reference flood elevation (REFFLD - DR.2) and the starting tabular elevation (STRELV - DR.6) for damage reach 11 on the DR record. The starting tabular elevation identifies where to begin the elevation-damage computations for a particular damage reach. Complete the damage reach title record (DTITLE - DT.1-10)

c. Enter the structure inventory data for the single-family residence on the SL and SD records. Enter the reference flood elevation at the structure in SL.5 (ADJ) and the first-floor elevation of the structure in SL.6 (STOPO). Complete the SD record by filling in values for the structure damage function (SD.4 (25-27) - ID1FS) and the total value of the structure in thousands of dollars (SD.4 (28-32) - V1FS). Do the same thing for the contents damage function (SD.5 (33-35) - ID1FC) and total value of the contents (SD.5 (36-40) - V1FC).

4. Execute the program with your input data by pressing the <ALT> key together with the letter X.

b. After the program terminates, list the output file on the computer console by highlighting the output filename from the FDA menu and pressing the <ALT> key together with the letter L. Use the output to answer the following questions concerning the SID output results.

1. What elevation did you specify for the starting elevation for tabulation of the elevation-damage function? How did you determine the starting elevation? What are the consequences of specifying a starting elevation above the zero damage point?

620' - Safety below the ∅ damage el.
- Won't get all of damages.

2. What aggregation interval did you select for the damage reach? Why? What are the consequences of specifying a smaller or larger interval?

- Choice of 1 foot - got half foot

c. The SID program may be used to calculate inundation damage values associated with user-defined single flood events. Modify the SID input data created in Task 1 to include the calculation for the events of 1-, 4-, and 10-percent chance exceedance. Rerun the SID program with this new input file.

1. Use COED to modify the file COOPSING.S.

2. Enter the number of single events in J1.8 (ITYPE) on the J1 record. 3

3. Enter elevations for the single events on the SE record in fields 1,2 and 3. Enter corresponding titles for each single event on the ST record.

4. Save the file and rerun SID to complete the following table.

Damage Reach 11

Event (occurrence)	Elevation (feet)	Total Damage (thousands)
1-percent chance	624.7 (624.6)	59.6 (56.5)
4-percent chance	624.1 (624.0)	41.1 (38)
10-percent chance	623.5 (623.5)	30.0 (30)

5. In what flood zones are the two structures located?

0-10 flood zone

2/14/90

WORKSHOP SOLUTION

DEVELOPMENT OF AGGREGATED ELEVATION-DAMAGE DATA AT DAMAGE REACH INDEX LOCATIONS

Purpose

This problem was designed to familiarize course participants with the analytical procedures required to aggregate elevation-damage data to damage reach index locations. The techniques were first applied manually for two structures in order to better understanding of the calculations performed by the SID computer program.

Problems

1. Aggregation of Structure Elevation-Damage Functions to Index Location By Hand.

a. Develop the elevation-dollar damage function for each structure and associated contents in one foot intervals. Use TABLE 2. Each function will represent the damage function at the structure location.

TABLE 2

STRUCTURE No. 311
SINGLE FAMILY RESIDENTIAL

Stage (feet)	% Damage Structure	% Damage Contents	Elevation M.S.L.	$ Damage Structure	$ Damage Contents	Total $ Damage
-1	0	0	622	0	0	0
0	2	6	623	1,600	2,400	4,000
1	10	32	624	8,000	12,800	20,800
2	15	43	625	12,000	17,200	29,200
3	28	52	626	22,400	20,800	43,200
4	32	64	627	25,600	25,600	51,200
5	39	73	628	31,200	29,200	60,400
6	43	79	629	34,400	31,600	66,000
7	44	84	630	35,200	33,600	68,800

TABLE 2 (CONT.)
STRUCTURE No. 571
SCHOOL

Stage (feet)	% Damage Structure	% Damage Contents	Elevation M.S.L.	$ Damage Structure	$ Damage Contents	Total $ Damage
-1	0	0	621	0	0	0
0	0	0	622	0	0	0
1	10	0	623	20,000	0	20,000
2	11	0	624	22,000	0	22,000
3	11	20	625	22,000	12,000	34,000
4	12	40	626	24,000	24,000	48,000
5	12	60	627	24,000	36,000	60,000
6	13	80	628	26,000	48,000	74,000
7	14	85	629	28,000	51,000	79,000
8	14	90	630	28,000	54,000	82,000

b. Aggregate the elevation-damage functions (in one foot intervals) of each structure and its contents to the damage reach 11 index location. Use the reference flood concept to account for the difference in elevations due to the slope in water surface profile. The reference flood elevation at the damage reach index location is 624 ft. Use TABLE 3.

TABLE 3

AGGREGATION OF DAMAGE TO
DAMAGE REACH INDEX LOCATION (No. 11)

Elevation Index Loc. M.S.L	Damage to No. 311			Damage to No. 571			Total $ Damage
	Structure	Contents	Total	Structure	Contents	Total	
621	0	0	0	0	0	0	0
622	0	0	0	20,000	0	20,000	20,000
623	0	0	0	22,000	0	22,000	22,000
624	1,600	2,400	4,000	22,000	12,000	34,000	38,000
625	8,000	12,800	20,000	24,000	24,000	48,000	68,800
626	12,000	17,200	29,200	24,000	36,000	60,000	89,200
627	22,400	20,800	43,200	26,000	48,000	74,000	117,200
628	25,600	25,600	51,200	28,000	51,000	79,000	130,200
629	31,200	29,200	60,400	28,000	54,000	82,000	142,400

c. Based on available discharge-elevation and discharge-frequency function data, estimate the damage to the residential structure and school (including contents) for the 1-, 4-, and 10-percent chance flood events. Complete TABLE 4.

TABLE 4

DAMAGE ESTIMATES FOR
SPECIFIC FLOOD EVENTS

Flood Event % Chance	Elevation	$ Damage No. 311	No. 571	Total
10 (10 year)	623.5	2,000	28,000	30,000
4 (25 year)	624.1	5,600	35,400	41,000
1 (100 year)	624.7	15,800	43,800	59,600

2. Basic Application of SID Computer Program.

a. Use the FDA package to complete the input for the SID computer program to compute the elevation-damage function for damage reach 11.

1. Start the FDA program by typing MENUFDA followed by a return (use the <ENTER> key).

2. Select the study name Cooper Creek. Then select the SID program option.

3. Using the stage-percent damage function data provided in TABLE 1 together with the information provided in task 1 of this workshop, complete the SID input data located in file, COOPBASE.S. Remember that the reference flood elevation at index location damage reach 11 is 624 ft. To start the COED program, select the input file name and press the <ALT> key together with the letter E. When you are done editing, to save your file, press the <ALT> key together with the <F10> function key.

a. Complete the entry of the DP and DC records for the damage functions, RS1 and RC1.

b. Enter the reference flood elevation (REFFLD - DR.2) and the starting tabular elevation (STRELV - DR.6) for damage reach 11 on the DR record. The starting tabular elevation identifies where to begin the elevation-damage computations for a particular damage reach. Complete the damage reach title record (DTITLE - DT.1-10)

c. Enter the structure inventory data for the single-family residence on the SL and SD records. Enter the reference flood elevation at the structure in SL.5 (ADJ) and the first-floor elevation of the structure in SL.6 (STOPO). Complete the SD record by filling in values for the structure damage function (SD.4 (25-27) - ID1FS) and the total value of the structure in thousands of dollars (SD.4 (28-32) - V1FS). Do the same thing for the contents damage function (SD.5 (33-35) - ID1FC) and total value of the contents (SD.5 (36-40) - V1FC).

4. Execute the program with your input data by pressing the <ALT> key together with the letter X.

b. After the program terminates, list the output file on the computer console by highlighting the output filename from the FDA menu and pressing the <ALT> key together with the letter L. Use the output to answer the following questions concerning the SID output results.

1. What elevation did you specify for the starting elevation for tabulation of the elevation-damage function? How did you determine the starting elevation? What are the consequences of specifying a starting elevation above the zero damage point?

Starting elevations are typically initially estimated by the start of damage elevations of structures near the index location. Starting elevations for the initial SID execution are generally purposefully set low to assure that the zero damage point is defined. Because the lowest zero damage elevation for the 2 structures (311 and 571) is 622.0 feet, initially set the starting elevation to 621.0. After inspection of starting elevations and other data from the initial program execution, adjustments may be made. This process typically takes a minimum of two computer runs. If the zero damage location is not at or above the initial starting elevation at the index location, the resulting expected annual damage computations will not be accurate.

2. What aggregation interval did you select for the damage reach? Why? What are the consequences of specifying a smaller or larger interval?

This solution specifies an aggregation interval of 1.0 feet. A smaller interval may have been selected, such as .5 feet, as long as the computed elevation-damage function covers the flooded area from the zero damage point through the entire range of single events. The one constraint to remember is that the EAD program can only read the first 18 elevation-damage points, so be sure to capture the range of damage potential with 18 points.

c. The SID program may be used to calculate inundation damage values associated with user-defined single flood events. Modify the SID input data created in Task 1 to include the calculation for the events of 1-, 4-, and 10-percent chance exceedance. Rerun the SID program with this new input file.

MODIFIED SID INPUT DATA

```
T1       COOPER CREEK     DENTON, TEXAS
T2
T3       BASE CONDITION WITH 3 SINGLE EVENTS
J1      0       0                                            3
                                                  (3 single events)
SE 623.5   624.1   624.7 }
ST 10 YR   25 YR  100 YR } - -> records to follow DT record
                                (before SL records)
```

1. Use the SID output to complete the following table.

Damage Reach 11

Event (occurrence)	Elevation (feet)	Total Damage (thousands)
1-percent chance	624.7	59.6
4-percent chance	624.1	41.1
10-percent chance	623.5	30.0

2. In what flood zones are the two structures located?

The school, structure 571, will be flooded by the 10-percent chance event. The residential structure, 311, lies between the 10-percent chance event and the 4-percent chance event.

```
1           ***********************************************************
            *       Structure Inventory for Damage Analysis          *
            *       Users Manual (June 1987)                         *
            *       Version  June 7, 1988                            *
            *       IBM-PC Compatible (MS)                           *
            *       Run date 31MAR89   time 14:25:02                 *
            ***********************************************************


                          SSSSSSSS   IIIIIIII   DDDDDDD
                          SS            II      DD     DD
                          SS            II      DD     DD
                          SSSSSSSS      II      DD     DD
                                SS      II      DD     DD
                                SS      II      DD     DD
                          SSSSSSSS   IIIIIIII   DDDDDDD


                      *****************************************
                      *  U.S. Army Corps of Engineers         *
                      *  The Hydrologic Engineering Center    *
                      *  609 Second Street, Suite B           *
                      *  Davis, California 95616              *
                      *  (916) 551-1748                       *
                      *****************************************
1 List of Input Records for This Run


 T1    COOPER CREEK          DENTON, TEXAS
 T2    DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
 T3    EXISTING WITHOUT PROJECT CONDITION
 J1
 J2       4       4       1       1       0       1
 DF     RS1      17
 DP      -1       0       1       2       3       4       5       6       7       8
 DP       9      10      11      12      13      14      15
 PC       0       2      10      15      28      32      39      43      44      45
 PC      51      52      54      58      62      67      73
 DF     RC1      17
 DP      -1       0       1       2       3       4       5       6       7       8
 DP       9      10      11      12      13      14      15
 PC       0       6      32      43      52      64      73      79      84      85
 PC      86      87      87      88      90      93      96
 DF     SS1      16
 DP       0       1       2       3       4       5       6       7       8       9
 DP      10      11      12      13      14      15
 PC       0      10      11      11      12      12      13      14      14      15
 PC      17      19      24      30      38      45
 DF     SC1       7
 DP       2       3       4       5       6       7       8
 PC       0      20      40      60      80      85      90
 DC        RESIDENT                    RESIDENTIAL
 DC        SCHOOL                      SCHOOL
 DC        RESIDCON                    RESIDENTIAL CONTENTS
 DC        SCHOLCON                    SCHOOL CONTENTS
 CC       1RESIDCONRESIDENT
 CC       1SCHOLCONSCHOOL
 DR RCH11      624                             621.0     1.0
 DT        DAMAGE REACH 11 INDEX LOCATION
 SL RCH11      311                    623.0    623.0
 SD RCH11      311RESIDENTRS1    80RC1    40
 SL RCH11      571                    625.0    622.0
 SD RCH11      571SCHOOL  SS1   200SC1    60
 ES
1
     COOPER CREEK          DENTON, TEXAS
     DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
     EXISTING WITHOUT PROJECT CONDITION



 J1      0       0       0       0       0       0       0       0       0       0

 This job will perform the following
 -------------------------------------------------------------------------------

 IPOL    =      0, No raise-to-target elevation analysis to be considered for
```

this computer run

IPROF = 0, No flood proofing analysis to be considered for this computer run

IEVAC = 0, No structure relocation will be considered for this computer run

IPRNT = 0, Normal Output

ITRACE = 0, No trace output

ITYPE = 0, Single event damage will not be calculated

IAG = 0, No aggregation of single event damage

ISAMP = 0, No sampling conversion

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

```
J2    4    4    1   1.00    0    1    0    0    0
```

Job Processing Information

NODF = 4 Number of Damage Functions

NODC = 4 Number of Damage Categories

NODR = 1 Number of Damage Reaches

AGG = 1.00, Aggregation interval (in feet)

NFILE = 0, Structure information file

IMAGE = 1, Images of input records will be listed and echoed as read

IELV = 18, The number of elevations to be calculated for the elevation-damage relationships

IMARK = 0, The structure value only will be used in the structure value flood zone summary

NDFILE = 0, Damage function file

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

DF	RS1	17	0	0						
DP	-1.0	.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
DP	9.0	10.0	11.0	12.0	13.0	14.0	15.0	.0	.0	.0
PC	.0	2.0	10.0	15.0	28.0	32.0	39.0	43.0	44.0	45.0
PC	51.0	52.0	54.0	58.0	62.0	67.0	73.0	.0	.0	.0
DF	RC1	17	0	0						
DP	-1.0	.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
DP	9.0	10.0	11.0	12.0	13.0	14.0	15.0	.0	.0	.0
PC	.0	6.0	32.0	43.0	52.0	64.0	73.0	79.0	84.0	85.0
PC	86.0	87.0	87.0	88.0	90.0	93.0	96.0	.0	.0	.0
DF	CS1	16	0	0						
DP	.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
DP	10.0	11.0	12.0	13.0	14.0	15.0	.0	.0	.0	.0
PC	.0	10.0	11.0	11.0	12.0	12.0	13.0	14.0	14.0	15.0
PC	17.0	19.0	24.0	30.0	38.0	45.0	.0	.0	.0	.0
DF	SC1	7	0	0						
DP	2.0	3.0	4.0	5.0	6.0	7.0	8.0	.0	.0	.0
PC	.0	20.0	40.0	60.0	80.0	85.0	90.0	.0	.0	.0

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

Stage Damage Functions

RS1

Stage	Percent Damage
-1.00	.00
.00	2.00
1.00	10.00
2.00	15.00
3.00	28.00
4.00	32.00
5.00	39.00
6.00	43.00
7.00	44.00
8.00	45.00
9.00	51.00
10.00	52.00
11.00	54.00
12.00	58.00
13.00	62.00
14.00	67.00
15.00	73.00
9999.00	73.00

RC1

Stage	Percent Damage
-1.00	.00
.00	6.00
1.00	32.00
2.00	43.00
3.00	52.00
4.00	64.00
5.00	73.00
6.00	79.00
7.00	84.00
8.00	85.00
9.00	86.00
10.00	87.00
11.00	87.00
12.00	88.00
13.00	90.00
14.00	93.00
15.00	96.00
9999.00	96.00

SS1

Stage	Percent Damage
.00	.00
1.00	10.00
2.00	11.00
3.00	11.00
4.00	12.00
5.00	12.00
6.00	13.00
7.00	14.00
8.00	14.00
9.00	15.00
10.00	17.00
11.00	19.00
12.00	24.00
13.00	30.00
14.00	38.00
15.00	45.00
9999.00	45.00
9999.00	45.00

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

Stage Damage Functions

SC1

Stage	Percent Damage
2.00	.00
3.00	20.00
4.00	40.00
5.00	60.00
6.00	80.00
7.00	85.00
8.00	90.00
9999.00	90.00

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

```
DC      RESIDENT     .00     .00RESIDENTIAL
DC      SCHOOL       .00     .00SCHOOL
DC      RESIDCON     .00     .00RESIDENTIAL CONTENTS
DC      SCHOLCON     .00     .00SCHOOL CONTENTS
```

Damage Categories

Damage Cat.	Damage Category Title	POLMAX	PRFMAX
RESIDENT	RESIDENTIAL	.00	.00
SCHOOL	SCHOOL	.00	.00
RESIDCON	RESIDENTIAL CONTENTS	.00	.00
SCHOLCON	SCHOOL CONTENTS	.00	.00
OTHER	OTHER DAMAGE CATEGORIES	.00	.00

```
CC      1RESIDCONRESIDENT
CC      1SCHOLCONSCHOOL
```

Content Category	Contents from structures of the following categories will be used for the content category
RESIDCON	RESIDENT
SCHOLCON	SCHOOL

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

```
DR RCH11   624.0      .0      .0      .0   621.0     1.0      .0      .0      .0
DT      DAMAGE REACH 11 INDEX LOCATION
```

Damage Reach Index Location Summary

Reach I.D.	Ref Flood Elev	Policy Flood Elev	Flood Proof Elev	Reloc-ation Elev	Start Damage Elev	Damage Elev Incr	Print Option Flag	Samplng Functn Flag
RCH11	624.00	.00	.00	.00	621.00	1.00	0	0

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

```
SL RCH11     311                  623.0   623.0
SD RCH11     311RESIDENTRS1   80RC1   40
```

Structure I.D.= 311 Ref. flood elev.= 623.00
Structure reference elevation = 623.00
Damage reach RCH11 Reference elev. at index = 624.00
Damage category RESIDENT

	Structure	Contents	Other	Total
Total Value	80000.	40000.	0.	120000.
Damage Function	RS1	RC1		

Stage	Index Elev	Structure	Contents	Other	Total
-1.00	623.00	0.	0.	0.	0.
-.50	623.50	800.	1200.	0.	2000.
.00	624.00	1600.	2400.	0.	4000.
.50	624.50	4800.	7600.	0.	12400.
1.00	625.00	8000.	12800.	0.	20800.
1.50	625.50	10000.	15000.	0.	25000.
2.00	626.00	12000.	17200.	0.	29200.
2.50	626.50	17200.	19000.	0.	36200.
3.00	627.00	22400.	20800.	0.	43200.
3.50	627.50	24000.	23200.	0.	47200.
4.00	628.00	25600.	25600.	0.	51200.
4.50	628.50	28400.	27400.	0.	55800.
5.00	629.00	31200.	29200.	0.	60400.
5.50	629.50	32800.	30400.	0.	63200.
6.00	630.00	34400.	31600.	0.	66000.
6.50	630.50	34800.	32600.	0.	67400.
7.00	631.00	35200.	33600.	0.	68800.
7.50	631.50	35600.	33800.	0.	69400.
8.00	632.00	36000.	34000.	0.	70000.
8.50	632.50	38400.	34200.	0.	72600.
9.00	633.00	40800.	34400.	0.	75200.
9.50	633.50	41200.	34600.	0.	75800.
10.00	634.00	41600.	34800.	0.	76400.
10.50	634.50	42400.	34800.	0.	77200.
11.00	635.00	43200.	34800.	0.	78000.
11.50	635.50	44800.	35000.	0.	79800.
12.00	636.00	46400.	35200.	0.	81600.
12.50	636.50	48000.	35600.	0.	83600.
13.00	637.00	49600.	36000.	0.	85600.

13.50	637.50	51600.	36600.	0.	88200.
14.00	638.00	53600.	37200.	0.	90800.
14.50	638.50	56000.	37800.	0.	93800.
15.00	639.00	58400.	38400.	0.	96800.

Contents damage for this structure was placed in content category RESIDCON

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

```
SL RCH11      571                    625.0   622.0
SD RCH11      571SCHOOL  SS1  200SC1   60
```

Structure I.D.= 571

Ref. flood elev.= 625.00
Structure reference elevation = 622.00
Reference elev. at index = 621.00

Damage reach RCH11
Damage category SCHOOL

	Structure	Contents	Other	Total
Total Value	200000.	60000.	0.	260000.
Damage Function	SS1	SC1		

Stage	Index Elev	Structure	Contents	Other	Total
.00	621.00	0.	0.	0.	0.
.50	621.50	10000.	0.	0.	10000.
1.00	622.00	20000.	0.	0.	20000.
1.50	622.50	21000.	0.	0.	21000.
2.00	623.00	22000.	0.	0.	22000.
2.50	623.50	22000.	6000.	0.	28000.
3.00	624.00	22000.	12000.	0.	34000.
3.50	624.50	23000.	18000.	0.	41000.
4.00	625.00	24000.	24000.	0.	48000.
4.50	625.50	24000.	30000.	0.	54000.
5.00	626.00	24000.	36000.	0.	60000.
5.50	626.50	25000.	42000.	0.	67000.
6.00	627.00	26000.	48000.	0.	74000.
6.50	627.50	27000.	49500.	0.	76500.
7.00	628.00	28000.	51000.	0.	79000.
7.50	628.50	28000.	52500.	0.	80500.
8.00	629.00	28000.	54000.	0.	82000.
8.50	629.50	29000.	54000.	0.	83000.
9.00	630.00	30000.	54000.	0.	84000.
9.50	630.50	32000.	54000.	0.	86000.
10.00	631.00	34000.	54000.	0.	88000.
10.50	631.50	36000.	54000.	0.	90000.
11.00	632.00	38000.	54000.	0.	92000.
11.50	632.50	43000.	54000.	0.	97000.
12.00	633.00	48000.	54000.	0.	102000.
12.50	633.50	54000.	54000.	0.	108000.
13.00	634.00	60000.	54000.	0.	114000.
13.50	634.50	68000.	54000.	0.	122000.
14.00	635.00	76000.	54000.	0.	130000.
14.50	635.50	83000.	54000.	0.	137000.
15.00	636.00	90000.	54000.	0.	144000.

Contents damage for this structure was placed in content category SCHOLCON

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

ES

1

COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

Damage Reach RCH11

There were no modifications to any buildings in this damage reach

1
COOPER CREEK DENTON, TEXAS
DEVELOP ELEVATION-DAMAGE DATA WORKSHOP
EXISTING WITHOUT PROJECT CONDITION

Damage Reach RCH11
DAMAGE REACH 11 INDEX LOCATION
(Damages are in $1,000)

Damage Categories

Elevation	RESIDENT	SCHOOL	RESIDCON	SCHOLCON	OTHER						Total
621.00	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
622.00	.0	20.0	.0	.0	.0	.0	.0	.0	.0	.0	20.0
623.00	.0	22.0	.0	.0	.0	.0	.0	.0	.0	.0	22.0
624.00	1.6	22.0	2.4	12.0	.0	.0	.0	.0	.0	.0	38.0
625.00	8.0	24.0	12.8	24.0	.0	.0	.0	.0	.0	.0	68.8
626.00	12.0	24.0	17.2	36.0	.0	.0	.0	.0	.0	.0	89.2
627.00	22.4	26.0	20.8	48.0	.0	.0	.0	.0	.0	.0	117.2
628.00	25.6	28.0	25.6	51.0	.0	.0	.0	.0	.0	.0	130.2
629.00	31.2	28.0	29.2	54.0	.0	.0	.0	.0	.0	.0	142.4
630.00	34.4	30.0	31.6	54.0	.0	.0	.0	.0	.0	.0	150.0
631.00	35.2	34.0	33.6	54.0	.0	.0	.0	.0	.0	.0	156.8
632.00	36.0	38.0	34.0	54.0	.0	.0	.0	.0	.0	.0	162.0
633.00	40.8	48.0	34.4	54.0	.0	.0	.0	.0	.0	.0	177.2
634.00	41.6	60.0	34.8	54.0	.0	.0	.0	.0	.0	.0	190.4
635.00	43.2	76.0	34.8	54.0	.0	.0	.0	.0	.0	.0	208.0
636.00	46.4	90.0	35.2	54.0	.0	.0	.0	.0	.0	.0	225.6
637.00	49.6	90.0	36.0	54.0	.0	.0	.0	.0	.0	.0	229.6
638.00	53.6	90.0	37.2	54.0	.0	.0	.0	.0	.0	.0	234.8

Damage category RESIDENT identified as RESIDENTIAL
Damage category SCHOOL identified as SCHOOL
Damage category RESIDCON identified as RESIDENTIAL CONTENTS
Damage category SCHOLCON identified as SCHOOL CONTENTS
Damage category OTHER identified as OTHER DAMAGE CATEGORIES

Elapsed CPU time is 2 seconds or .033 minutes.

2/15/90

Bob Carl

USE OF THE FDA2PO PROGRAM TO REFERENCE FLOOD ELEVATIONS

Program Purpose

The FDA2PO program post-processes computed results from HEC-2. It allows you to:

- o store rating curves in a HECDSS data file and / or
- o compute reference flood elevations for each structure.

The FDA2PO program provides the only means of automatically computing reference flood elevations. The computation of the reference flood elevations requires that you supply a SID structure file containing "SL", "SD", and "SO" records and a SID input data file containing the reach identification records "DR".

The FDA2PO program processes results from either "TAPE95" or "TAPE96" output from a HEC-2 execution. The "TAPE95" file is a binary disk file to which HEC-2 writes computed results. It is a "binary" or "unformatted" file (not readable using the DOS "TYPE" command). It must be created with the current version of the HEC-2 program and not older versions so that it will be compatible (and readable) by the FDA2PO program. The "TAPE96" file is the archive output file from HEC-2. It is written in an ASCII (or readable) format. This file can be created on another computer system (such as the Harris) and downloaded to the personal computer where the FDA2PO program can process it and store rating curves and structure reference elevations in a HECDSS file on the personal computer. It is far more efficient to use the "TAPE95" file - it requires about fifty percent less processing time. However, program versions of the HEC-2 and FDA2PO must match and you can not look at the file using the DOS command "TYPE".

File Assignments

If you use the menu program to execute the programs, you need not worry about these keywords. However, if you execute on the Harris or don't use the menu program, you need to know these keywords. To determine the current definition, enter the command:

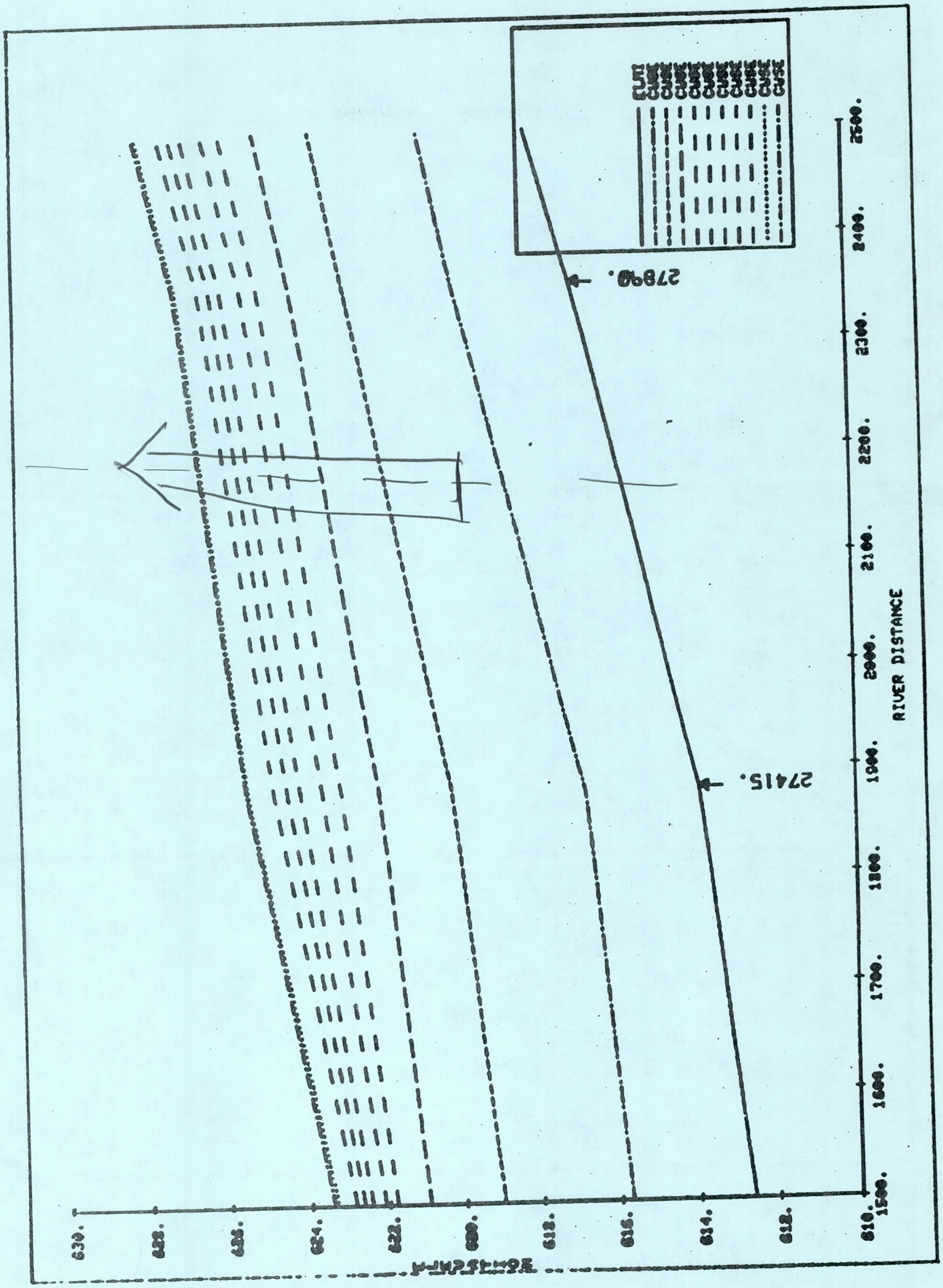
FDA2PO ?

The resulting output should look similar to the following:

```
Post-Process HEC-2 for ref. flood - dated January 21, 1988
  UNIT     KEYWORD        *ABREV    **MAX   DEFAULT
     5     IN             I          64     CON
     6     OUT            O          64     CON
   NOP     F95            F          64     SCRATCH.031
   NOP     F96            F96        64     SCRATCH.001
   NOP     DR             D          64     SCRATCH.002
   NOP     SIN            S          64     SCRATCH.003
   NOP     SOUT           SO         64     SCRATCH.004
   NOP     DSS            DS         64     SCRATCH.032
   NOP     DRN            DRN        64     SCRATCH.005
 * ABREV - SHORTEST ABBREVIATION ALLOWED FOR KEYWORD
 ** MAX - MAXIMUM # OF CHARACTERS FOR FILENAME (OR STRING)
Stop - Program terminated.
```

The user should enter filenames for the keywords as follows:

Keyword	Description
F95 or F96	File which contains the results from HEC-2 (one of these is required for all calculations).
DR	File contains input data for the SID program including the DR records (required for calculation of reference flood elevations)
SIN	File contains the original structure records (SL, SD, and SO) for SID (required for all executions).
SOUT	File will contain the same structure records as the SIN file after they are modified with the computed reference flood elevation in field SL.5 and the translated first floor elevation in field SO.10 (required for calculation of reference flood elevations).
DSS	File is the HECDSS data file to which rating curves are written (required for storage of rating curves).


RIVER DISTANCE
1500.
1600.
1700.
1800.
1900.
2000.
2100.
2200.
2300.
2400.
2500.
610.
612.
614.
616.
618.
620.
622.
624.
626.
628.
630.
27415.
27890.

PROJECT	Page __ of __	COMPUTED BY	DATE
SUBJECT		CHECKED BY	DATE

STRUCTURE #571
FIRST FLOOR ELEV 622.4'
RIVER LOCATION 276+90

ADJACENT CROSS-SECTIONS

CROSS-SECTION	PROFILE 7 CWSEL
274+15	624.38
278+90	626.15

REF. FLOOD ELEV @ STRUCTURE # 571

$$ADJ = 624.38 + (626.15 - 624.38) \times \frac{(27690 - 27415)}{(27890 - 27415)}$$

$$= 624.38 + 1.77 \times \left(\frac{275}{475}\right)$$

$$= 624.38 + 1.02$$

$$= 625.40$$

FIRST FLOOR ELEVATION ADJUSTMENT

$$\Delta \text{ REF. FLOOD} = EL_{INDEX} - EL_{\#571}$$

$$= 624.38 - 625.40$$

$$= -1.02$$

$$EL_{\#571\ FF@INDEX} = EL_{\#571FF} + \Delta \text{REF. FLOOD}$$

$$= 622.4 - 1.02$$

$$= 621.38$$

Calculation of Reference Flood

In the past, the user must enter the reference flood elevation for each structure in field SL.5 of the SID input data file for every structure. Now, the user may automatically compute this elevation using the results from HEC-2 and the HEC-2 post-processor program FDA2PO. To facilitate this, the user must identify the river river location (such as river mile) associated with each structure. The FDA2PO program uses the river location to interpolate the computed water surface elevation from the HEC-2 calculated water surface profile and stores it in field SL.5 of the SID structure input data stream. The river location of the structure is entered in field SO.9. The units and reference locations must be the same in both field one of the X1 record for HEC-2 and in field nine of the SO record for SID.

To compute the reference flood elevations, you must have SID input data containing the DR reach record(s) and the structure records SL, SD, and SO. You must also have the computed results from HEC-2 written on either "TAPE95" or "TAPE96" and one of the profiles calculated by HEC-2 must be acceptable as the reference flood. The structure records and the DR records may exist in the same file but you will have to specify that same file name for both the DR file and the input structure file. Field 2 of the DR record will be over written by the calculated reference flood elevation at the index location. The structure data must contain SO records with the river location entered in field nine. The FDA2PO program will use the reference flood water surface profile to:

(1) calculate the structures first floor elevation after transforming it to the index location and writing that elevation in field ten of the SO record.

(2) calculate the reference flood elevation at the structure by interpolating the profile at the river mile entered by the user in field nine of the SO record. The FDA2PO program assumes that the cross-section number entered in field one of the HEC-2 input data file is expressed in the same units and uses the same reference as the river locations entered in field nine of the SO records. The river location (or river mile) is used to interpolate the reference flood elevation. The calculated elevation is written in field five of the SL record. The FDA2PO program writes all of the records to a new file to allow the user to compare the modified records with the original records.

(3) calculate the reference flood elevation at the index location by interpolating the profile at the river location associated with the cross-section that the user defines as the index location when prompted by the FDA2PO program. The FDA2PO program allows the user to redefine the river mile associated with the index location. This is desirable if none of the sections coincide with the index location. The calculated elevation is written in field two of the DR records and will overwrite any existing value.

Example Execution of FDA2PO

The following pages illustrate a simple execution of the FDA2PO program. The data consists of three reaches in the Cooper Creek watershed. It includes only the calculation of the reference flood elevations at each structure and at the index locations. Profile seven represents the reference flood water surface profile. The damage index locations are:

Reach	River Location (in feet)
REACH 11	27415
REACH 12	28550
REACH 13	29032

The river location is the cross-section "number" entered in field 1 of the HEC-2 input data. The program output and the user input are in normal font whereas the explanatory messages are in italics.

{Two files are shown below. The first file contains the DR records for reaches 11, 12, and 13. The DR records do <u>*not*</u> *contain the reference flood elevation in field two. The FDA2PO program modifies the DR records by calculating the reference flood elevation at the damage index locations and storing it in field two (columns 9 through 16). The second file contains the SID structure records. The FDA2PO program will modify the SL records by calculating the reference flood elevations at each structure and storeing it in field five (columns 33 through 40). It wil also modify the SO record by calculating the structure first floor elevation after it has been transposed to the index location.}*

```
T1      COOPER CREEK     DENTON, TEXAS
T2      INPUT DECK PLAN1.S
T3      BASE CONDITION - ALSO USED FOR CHANNEL IMP., RES ALT.
J1                                                          8
J2    8       4       3       1       1       2                     2
ZW A=COOPER CREEK F=BASE
DC      RESIDENT                        RESIDENTIAL
DC      GAS STAT                        SERVICE STATION
DC      SCHOOL                          SCHOOL
DC      CHURCH                          CHURCHES
DR SID11                                  621.25    .25
DT      WINDSOR STREET(STATION 26927) TO STATION 27890      INDEX 27415
SE 620.2   622.0   623.0   623.5   624.1   624.4   624.7   625.4
DR SID12                                  629       .25
DT      STATION 27890 TO SHERMAN DRIVE(STATION 28896)       INDEX 28550
SE 626.5   628.1   629.1   629.7   630.3   630.6   630.9   631.5
DR SID13                                  633       .25
DT      STATION 28896 TO 29390    INDEX 29032
SE 629.7   631.5   634.8   635.3   635.7   636.0   636.3   636.8
ST  1 YR    2 YR    5 YR   10 YR   25 YR   50 YR  100 YR  500 YR
ES
```

SL	SID11	237					623.4		1
SD	SID11	237RESIDENT	1	70	2	35		2920 BRISTOL ST	
SO	SID11	237							27220
SL	SID11	240					624.3		1
SD	SID11	240RESIDENT	1	65	2	32.5		2919 BRISTOL ST	
SO	SID11	240							27375
SL	SID11	566					622.4		1
SD	SID11	566RESIDENT	1	70	2	35.0		2921 BRISTOL ST	
SO	SID11	566							27265
SL	SID11	241					624.8		1
SD	SID11	241RESIDENT	1	65	2	32.5		3917 BRISTOL ST	
SO	SID11	241							27450
SL	SID11	242					624.2		1
SD	SID11	242RESIDENT	1	65	2	32.5		2915 BRISTOL ST	
SO	SID11	242							27500
SL	SID11	568					625.4		1
SD	SID11	568RESIDENT	1	70	2	35.0		2913 BRISTOL ST	
SO	SID11	568							27555
SL	SID11	285					621.3		1
SD	SID11	285RESIDENT	1	80	2	40.0		1406 CHURCHILL ST.	
SO	SID11	285							26909
SL	SID11	301					622.0		1
SD	SID11	301RESIDENT	1	80	2	40.0		1402 CHURCHILL ST.	
SO	SID11	301							27070
SL	SID11	311					622.9		1
SD	SID11	311RESIDENT	1	80	2	40.0		1324 CHURCHILL DR.	
SO	SID11	311							27180
SL	SID11	315					623.4		1
SD	SID11	315RESIDENT	1	90	2	45.0		1320 CHURCHILL DR.	
SO	SID11	315							27290
SL	SID11	322					623.4		1
SD	SID11	322RESIDENT	1	75	2	37.5		1314 CHURCHILL DR.	
SO	SID11	322							27400
SL	SID11	327					624.3		1
SD	SID11	327RESIDENT	1	75	2	37.5		1310 CHURCHILL DR.	
SO	SID11	327							27530
SL	SID11	328					625.2		1
SD	SID11	328RESIDENT	1	75	2	37.5		1306 CHURCHILL DR.	
SO	SID11	328							27660
SL	SID11	571					622.4		1
SD	SID11	571SCHOOL	5	200	6	60.0		1304 CHURCHILL DR.	
SO	SID11	571							27690
SL	SID12	351					626.4		1
SD	SID12	351CHURCH	7	250	8	80.0		3105 HEATHER LN.	
SO	SID12	351							27970
SL	SID12	364					627.6		1
SD	SID12	364RESIDENT	1	70	2	35.0		3110 HEATHER LN.	
SO	SID12	364							28270
SL	SID12	367					628.4		1
SD	SID12	367RESIDENT	1	70	2	35.0		3114 HEATHER LN.	
SO	SID12	367							28340
SL	SID12	370					629.2		1

SD	SID12	370RESIDENT	1	70	2	35.0		3116 HEATHER LN.		
SO	SID12	370							28415	
SL	SID12	373					629.5			1
SD	SID12	373RESIDENT	1	70	2	35.0		3118 HEATHER ST.		
SO	SID12	373							28490	
SL	SID12	374					629.5			1
SD	SID12	374RESIDENT	1	95	2	45.0		3202 HEATHER LN.		
SO	SID12	374							28550	
SL	SID12	375					630.5			1
SD	SID12	375RESIDENT	1	60	2	30.0		3206 HEATHER LN.		
SO	SID12	375							28570	
SL	SID12	376					631.2			1
SD	SID12	376RESIDENT	1	60	2	30.0		3208 HEATHER LN.		
SO	SID12	376							28570	
SL	SID12	387					630.8			1
SD	SID12	387RESIDENT	1	70	2	35.0		3205 HEATHER LN.		
SO	SID12	387							28680	
SL	SID12	388					631.4			1
SD	SID12	388RESIDENT	1	60	2	30.0		3207 HEATHER LN.		
SO	SID12	388							28680	
SL	SID12	389					631.8			1
SD	SID12	389RESIDENT	1	60	2	30.0		3209 HEATHER LN.		
SO	SID12	389							28680	
SL	SID13	416					634.9			1
SD	SID13	416GAS STAT	3	150	4	45.0		1101 MONTERRY ST.		
SO	SID13	416							29030	
SL	SID13	417					636.6			1
SD	SID13	417RESIDENT	1	60	2	30.0		1021 MONTERRY ST.		
SO	SID13	417							29030	
SL	SID13	418					636.7			1
SD	SID13	418RESIDENT	1	75	2	37.5		1013 MONTERRY ST.		
SO	SID13	418							29250	
SL	SID13	419					635.7			1
SD	SID13	419RESIDENT	1	60	2	30.0		1009 MONTERRY ST.		
SO	SID13	419							29460	
SL	SID13	420					635.6			1
SD	SID13	420RESIDENT	1	60	2	30.0		1005 MONTERRY ST.		
SO	SID13	420							29460	
SL	SID13	421					636.3			1
SD	SID13	421RESIDENT	1	75	2	37.5		1001 MONTERRY ST.		
SO	SID13	421							29640	
SL	SID13	441					637.0			1
SD	SID13	441RESIDENT	1	60	2	30.0		1000 MANHATTEN		
SO	SID13	441							29640	
SL	SID13	442					636.4			1
SD	SID13	442RESIDENT	1	60	2	30.0		1004 MANHATTEN		
SO	SID13	442							29460	
SL	SID13	443					636.0			1
SD	SID13	443RESIDENT	1	60	2	30.0		1008 MANHATTEN		
SO	SID13	443							29250	
SL	SID13	444					636.2			1
SD	SID13	444RESIDENT	1	84	2	42.0		1014 MANHATTEN		

```
SO SID13      444                                              29250
SL SID13      445                           635.1                   1
SD SID13      445RESIDENT  1   60  2 30.0            1018 MANHATTEN
SO SID13      445                                              29030
SL SID13      446                           635.2                   1
SD SID13      446RESIDENT  1   75  2 37.5            1100 MANHATTEN
SO SID13      446                                              29030
SL SID13      447                           633.9                   1
SD SID13      447RESIDENT  1   60  2 30.0            1104 MANHATTEN
SO SID13      447                                              29030
SL SID13      448                           635.4                   1
SD SID13      448RESIDENT  1   60  2 30.0            1109 MANHATTEN
SO SID13      448                                              29030
SL SID13      449                           635.3                   1
SD SID13      449RESIDENT  1   60  2 30.0            1105 MANHATTEN
SO SID13      449                                              29030
SL SID13      450                           635.4                   1
SD SID13      450RESIDENT  1   60  2 30.0            1101 MANHATTEN
SO SID13      450                                              29030
SL SID13      451                           635.0                   1
SD SID13      451RESIDENT  1   60  2 30.0            1021 MANHATTEN
SO SID13      451                                              29030
SL SID13      452                           634.9                   1
SD SID13      452RESIDENT  1   60  2 30.0            1017 MANHATTEN
SO SID13      452                                              29030
SL SID13      453                           634.8                   1
SD SID13      453RESIDENT  1   60  2 30.0            1013 MANHATTEN
SO SID13      453                                              29250
SL SID13      454                           635.3                   1
SD SID13      454RESIDENT  1   60  2 30.0            1009 MANHATTEN
SO SID13      454                                              29250
```

{The following is the output from FDA2PO as it processes HEC-2 output which has been stored on "TAPE95". Like this paragraph, explanations of the output not written by FDA2PO appear within brackets and in italics.}

```
Number of sections from File95 header:    17.

Process profile  1.
Process profile  2.
Process profile  3.
Process profile  4.
Process profile  5.
Process profile  6.
Process profile  7.
Process profile  8.
Process profile  9.
Process profile 10.
```

{The above information is output by FDA2PO as it reads results for each water surface profile calculation. The number of cross-sections (17 in this case) should agree with the user's HEC-2 input data. If it does not agree, then the "TAPE95" is either wrong or it was generated with a version of HEC-2 that is incompatible with the FDA2PO post-processor.}

{The following output displays the computed water surface elevations. In this case, there are 10 profiles. The water surface elevation for the tenth profile is located in the second line below the column titled "Profile 5". The "Cum dist." is simply the cumulative distance (in feet) of each cross-section from the first section. The "Section no." is the river location (or river mile) entered in field one of the X1 record in the HEC-2 input data file.}

There were 10 profiles, 17 sections, and 0 tributaries.

Section no.	Cum dist.	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
25534.000	0.	607.55	609.53	611.45	612.89	613.69
		614.53	615.16	615.68	616.72	617.01
26193.000	659.	612.25	614.39	615.82	616.97	617.63
		618.36	618.86	619.32	620.23	620.45
26848.000	1314.	615.49	618.65	620.03	620.81	621.23
		621.69	621.99	622.28	622.86	622.98
26900.000	1366.	615.58	618.82	620.26	621.15	621.59
		622.05	622.35	622.62	623.16	623.26
26954.000	1420.	615.59	618.84	620.83	621.76	622.08
		622.44	622.66	622.88	623.38	623.47
27025.000	1491.	615.69	618.99	620.92	621.78	622.07
		622.40	622.61	622.81	623.26	623.37

27415.000	1881.	616.77	620.17	622.04	623.01	623.50
		624.05	624.38	624.73	625.36	625.42
27890.000	2356.	619.94	622.75	624.13	624.95	625.37
		625.87	626.15	626.45	627.01	627.08
28550.000	3016.	623.82	626.54	628.06	629.13	629.67
		630.29	630.61	630.91	631.46	631.53
28660.000	3126.	625.01	627.24	628.69	629.68	630.19
		630.78	631.07	631.45	632.21	632.27

>

Section no.	Cum dist.	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
28770.000	3236.	625.86	628.55	629.99	631.00	631.45
		631.99	632.30	632.60	633.54	633.75
28860.000	3326.	626.14	629.08	630.68	631.84	632.55
		633.49	634.15	634.91	636.04	636.09
28932.000	3398.	626.14	629.11	630.73	634.28	635.04
		635.47	635.73	635.99	636.48	636.52
29032.000	3498.	626.82	629.69	631.53	634.77	635.28
		635.74	636.01	636.28	636.80	636.83
29390.000	3856.	629.53	630.41	632.57	634.90	635.40
		635.87	636.16	636.44	636.97	637.14
29710.000	4176.	630.53	631.69	633.62	635.10	635.58
		636.04	636.34	636.63	637.17	637.46
30350.000	4816.	633.25	634.60	636.82	637.13	637.54
		637.99	638.32	638.60	639.44	640.26

Do you want to store rating curves in a DSS data file? (y/n): n

{User responds by entering "n" to indicate that rating curves will <u>not</u> be stored in a HECDSS data file. FDA2PO recognizes either lower or upper case letters.}

Do you want to compute reference flood elevations? (y/n): y

{User rwspnds by entering "y" to indicate that reference flood elevations will be computed at each structure and at the index locations.}

Note, file R11AM.I already exists!

Do you want to overwrite it? (y/n) y

There are 3 reach(es) in the structure file:

Index I.D. Index I.D. Index I.D. Index I.D. Index I.D.

....

```
1 SID11        2 SID12        3 SID13
```

{The file R11AM.I is the "SOUT" or output structure file. It will contain the structure data after the computed reference flood elevations have been written on the SL records. If the file already exists as it does in this case, the FDA2PO asks the user to verify that it will be overwritten. The above reach information is read from the "SIN" (or SID input structure) file. FDA2PO displays this message after it has read all of the structure data contained in the SID structure file.}

```
Eliminate any cross-sections? (y/n)  n
```

{FDA2PO allows the user to eliminate any cross-sections from the reference flood interpolation procedure. For this example, none of the sections are eliminated.)

```
For each damage reach from SID,  you must identify the
following:
(1)   The cross-section which corresponds to the index
      location.
(2)   The index number of the profile which will be used
      for the reference flood.
(3)   An edited river mile for the index location.


To eliminate a damage reach from consideration, enter a "d"
when prompted for the section number.
To get a list of cross-sections, enter "L" when prompted
for the section number.

Damage reach  SID11, Identify the cross-section at the index location > 7
```

{The user has defined cross-section seven (river location 27415.0) as the damage index location ofr reach "SID11". It is defined using the index number. A DR record with the reach I.D. of SID11 must exist in the SID input data file (keyword DR) so that the computed reference flood elevation at the index location can be written.}

```
Damage reach  SID11, Identify the profile to use as the reference flood > (1-10)> 7
```

{The user has defined profile seven as the reference flood water surface profile. FDA2PO prompts the user with "(1-10)" to indicate that there are ten possible profiles as computed by HEC-2. This profile will be used to compute reference flood elevations at all structures and at the index locaiton for this reach.}

```
Damage reach  SID11.  Redefine the index location river mile
(or press Enter to retain the current definition).

 SID11(27415.000) >
```

{The user has pressed the "Enter" key to indicate that the river location 27415.0 will be used for the index point location for reach SID11.}

```
Damage reach  SID12, Identify the cross-section at the index location >

Damage reach  SID12, Identify the profile to use as the reference flood > (1-10)>

Damage reach  SID12.  Redefine the index location river mile
(or press Enter to retain the current definition).

 SID12(28550.000) >

Damage reach  SID13, Identify the cross-section at the index location >

Damage reach  SID13, Identify the profile to use as the reference flood > (1-10)>

Damage reach  SID13.  Redefine the index location river mile
(or press Enter to retain the current definition).

 SID13(29032.000) >
```

{The user enters similiar responses for the other two reaches. At this point, the FDA2PO program processes all of the structures for all of the reaches. It computes the reference flood elevation at each structure and at each damage reach index location. At this point, FDA2PO terminates processing.}

{The following is a list of the original file containing the SID DR records after FDA2PO has modified the reference flood elevation.}

```
T1      COOPER CREEK    DENTON, TEXAS
T2      INPUT DECK PLAN1.S
T3      BASE CONDITION - ALSO USED FOR CHANNEL IMP., RES ALT.
J1                                                                  8
J2   8       4       3       1       1       2                          2
ZW A=COOPER CREEK F=BASE
DC      RESIDENT                        RESIDENTIAL
DC      GAS STAT                        SERVICE STATION
DC      SCHOOL                          SCHOOL
DC      CHURCH                          CHURCHES
DR SID11  624.38                          621.25      .25
DT      WINDSOR STREET(STATION 26927) TO STATION 27890      INDEX 27415
SE 620.2   622.0   623.0   623.5   624.1   624.4   624.7   625.4
DR SID12  630.61                            629       .25
DT      STATION 27890 TO SHERMAN DRIVE(STATION 28896)       INDEX 28550
SE 626.5   628.1   629.1   629.7   630.3   630.6   630.9   631.5
DR SID13  636.01                            633       .25
DT      STATION 28896 TO 29390   INDEX 29032
SE 629.7   631.5   634.8   635.3   635.7   636.0   636.3   636.8
ST  1 YR    2 YR    5 YR   10 YR   25 YR   50 YR  100 YR  500 YR
ES
```

{The following is a list of the output SID structure file containing the modified records including the structure reference flood elevations and the transformed first floor elevations.}

```
SL SID11      237                 623.50    623.4                   1
SD SID11      237RESIDENT  1   70  2  35            2920 BRISTOL ST
SO SID11      237                                           27220  624.29
SL SID11      240                 624.20    624.3                   1
SD SID11      240RESIDENT  1   65  2 32.5           2919 BRISTOL ST
SO SID11      240                                           27375  624.48
SL SID11      566                 623.70    622.4                   1
SD SID11      566RESIDENT  1   70  2 35.0           2921 BRISTOL ST
SO SID11      566                                           27265  623.08
SL SID11      241                 624.51    624.8                   1
SD SID11      241RESIDENT  1   65  2 32.5           3917 BRISTOL ST
SO SID11      241                                           27450  624.67
SL SID11      242                 624.70    624.2                   1
SD SID11      242RESIDENT  1   65  2 32.5           2915 BRISTOL ST
SO SID11      242                                           27500  623.88
SL SID11      568                 624.91    625.4                   1
SD SID11      568RESIDENT  1   70  2 35.0           2913 BRISTOL ST
SO SID11      568                                           27555  624.88
```

SL	SID11	285			622.40	621.3		1	
SD	SID11	285RESIDENT	1	80	2 40.0		1406 CHURCHILL ST.		
SO	SID11	285						26909	623.28
SL	SID11	301			622.81	622.0		1	
SD	SID11	301RESIDENT	1	80	2 40.0		1402 CHURCHILL ST.		
SO	SID11	301						27070	623.57
SL	SID11	311			623.31	622.9		1	
SD	SID11	311RESIDENT	1	80	2 40.0		1324 CHURCHILL DR.		
SO	SID11	311						27180	623.97
SL	SID11	315			623.81	623.4		1	
SD	SID11	315RESIDENT	1	90	2 45.0		1320 CHURCHILL DR.		
SO	SID11	315						27290	623.97
SL	SID11	322			624.32	623.4		1	
SD	SID11	322RESIDENT	1	75	2 37.5		1314 CHURCHILL DR.		
SO	SID11	322						27400	623.47
SL	SID11	327			624.81	624.3		1	
SD	SID11	327RESIDENT	1	75	2 37.5		1310 CHURCHILL DR.		
SO	SID11	327						27530	623.87
SL	SID11	328			625.30	625.2		1	
SD	SID11	328RESIDENT	1	75	2 37.5		1306 CHURCHILL DR.		
SO	SID11	328						27660	624.29
SL	SID11	571			625.41	622.4		1	
SD	SID11	571SCHOOL	5	200	6 60.0		1304 CHURCHILL DR.		
SO	SID11	571						27690	621.38
SL	SID12	351			626.69	626.4		1	
SD	SID12	351CHURCH	7	250	8 80.0		3105 HEATHER LN.		
SO	SID12	351						27970	630.32
SL	SID12	364			628.72	627.6		1	
SD	SID12	364RESIDENT	1	70	2 35.0		3110 HEATHER LN.		
SO	SID12	364						28270	629.49
SL	SID12	367			629.19	628.4		1	
SD	SID12	367RESIDENT	1	70	2 35.0		3114 HEATHER LN.		
SO	SID12	367						28340	629.82
SL	SID12	370			629.70	629.2		1	
SD	SID12	370RESIDENT	1	70	2 35.0		3116 HEATHER LN.		
SO	SID12	370						28415	630.11
SL	SID12	373			630.20	629.5		1	
SD	SID12	373RESIDENT	1	70	2 35.0		3118 HEATHER ST.		
SO	SID12	373						28490	629.91
SL	SID12	374			630.61	629.5		1	
SD	SID12	374RESIDENT	1	95	2 45.0		3202 HEATHER LN.		
SO	SID12	374						28550	629.50
SL	SID12	375			630.69	630.5		1	
SD	SID12	375RESIDENT	1	60	2 30.0		3206 HEATHER LN.		
SO	SID12	375						28570	630.42
SL	SID12	376			630.69	631.2		1	
SD	SID12	376RESIDENT	1	60	2 30.0		3208 HEATHER LN.		
SO	SID12	376						28570	631.12
SL	SID12	387			631.29	630.8		1	
SD	SID12	387RESIDENT	1	70	2 35.0		3205 HEATHER LN.		
SO	SID12	387						28680	630.11

SL SID12	388			631.29	631.4				1
SD SID12	388RESIDENT	1	60	2 30.0		3207 HEATHER LN.			
SO SID12	388						28680	630.71	
SL SID12	389			631.29	631.8				1
SD SID12	389RESIDENT	1	60	2 30.0		3209 HEATHER LN.			
SO SID12	389						28680	631.11	
SL SID13	416			636.00	634.9				1
SD SID13	416GAS STAT	3	150	4 45.0		1101 MONTERRY ST.			
SO SID13	416						29030	634.91	
SL SID13	417			636.00	636.6				1
SD SID13	417RESIDENT	1	60	2 30.0		1021 MONTERRY ST.			
SO SID13	417						29030	636.61	
SL SID13	418			636.10	636.7				1
SD SID13	418RESIDENT	1	75	2 37.5		1013 MONTERRY ST.			
SO SID13	418						29250	636.61	
SL SID13	419			636.20	635.7				1
SD SID13	419RESIDENT	1	60	2 30.0		1009 MONTERRY ST.			
SO SID13	419						29460	635.51	
SL SID13	420			636.20	635.6				1
SD SID13	420RESIDENT	1	60	2 30.0		1005 MONTERRY ST.			
SO SID13	420						29460	635.41	
SL SID13	421			636.30	636.3				1
SD SID13	421RESIDENT	1	75	2 37.5		1001 MONTERRY ST.			
SO SID13	421						29640	636.01	
SL SID13	441			636.30	637.0				1
SD SID13	441RESIDENT	1	60	2 30.0		1000 MANHATTEN			
SO SID13	441						29640	636.71	
SL SID13	442			636.20	636.4				1
SD SID13	442RESIDENT	1	60	2 30.0		1004 MANHATTEN			
SO SID13	442						29460	636.21	
SL SID13	443			636.10	636.0				1
SD SID13	443RESIDENT	1	60	2 30.0		1008 MANHATTEN			
SO SID13	443						29250	635.91	
SL SID13	444			636.10	636.2				1
SD SID13	444RESIDENT	1	84	2 42.0		1014 MANHATTEN			
SO SID13	444						29250	636.11	
SL SID13	445			636.00	635.1				1
SD SID13	445RESIDENT	1	60	2 30.0		1018 MANHATTEN			
SO SID13	445						29030	635.11	
SL SID13	446			636.00	635.2				1
SD SID13	446RESIDENT	1	75	2 37.5		1100 MANHATTEN			
SO SID13	446						29030	635.21	
SL SID13	447			636.00	633.9				1
SD SID13	447RESIDENT	1	60	2 30.0		1104 MANHATTEN			
SO SID13	447						29030	633.91	
SL SID13	448			636.00	635.4				1
SD SID13	448RESIDENT	1	60	2 30.0		1109 MANHATTEN			
SO SID13	448						29030	635.41	
SL SID13	449			636.00	635.3				1
SD SID13	449RESIDENT	1	60	2 30.0		1105 MANHATTEN			
SO SID13	449						29030	635.31	

```
SL SID13     450              636.00  635.4                    1
SD SID13     450RESIDENT  1   60  2 30.0           1101 MANHATTEN
SO SID13     450                                          29030  635.41
SL SID13     451              636.00  635.0                    1
SD SID13     451RESIDENT  1   60  2 30.0           1021 MANHATTEN
SO SID13     451                                          29030  635.01
SL SID13     452              636.00  634.9                    1
SD SID13     452RESIDENT  1   60  2 30.0           1017 MANHATTEN
SO SID13     452                                          29030  634.91
SL SID13     453              636.10  634.8                    1
SD SID13     453RESIDENT  1   60  2 30.0           1013 MANHATTEN
SO SID13     453                                          29250  634.71
SL SID13     454              636.10  635.3                    1
SD SID13     454RESIDENT  1   60  2 30.0           1009 MANHATTEN
SO SID13     454                                          29250  635.21
```

EXPANDED CAPABILITIES OF THE EAD PROGRAM

Use of HECDSS with the EAD program

When using HECDSS in the EAD program, always:

- Insert one set of FR records and don't change the values of exceedance frequency in the middle of the study.
- Always insert the plan number on the applicable "end" record (the EP, ES, ER, or EJ records).

Damage Category Names

Damage category names are extremely important when using the HECDSS option. The EAD program compares the category names stored in the DSS data file with those entered on CN records --- they must match or else the damage data will not be retrieved. If computing aggregated elevation-damage data using SID, the user must enter category names (variable JDCT, field DC.2) identical to those used on the EAD record "CN".

Use of EAD input data records for HECDSS

Since the initial release of the linked SID and EAD programs on the Harris, there have been three major changes or additions to the user input associated with the HECDSS data storage system. The changes influence the existing ZR and DZ records and the addition of the ZW record. The ZR record facilitates retrieval of data from a DSS data file, the ZW record facilitates storage of results in a DSS data file, and the DZ record facilitates combining two or more damage categories into one for EAD processing.

ZR records

Previously, the user entered a pair of records to retrieve data from the HECDSS data file. This is documented in the EAD user's manual. The current implementation still accepts this method of input. However, it also accepts a new method of input that is more compatible with other HEC programs. Using the new method, the user inserts a ZR record at each location in the input data stream at which location data is needed (rather than at the front of the input data stream). All of the pathname parts are entered in a free-format style and each part is preceded by the part identification (A through F) and an equal sign. Part C defines the parameters. It is defined by entering the complete pathname part or by entering a special code. When using this method, the user must always enter a plan number in field one of the EP, ES, ER, and EJ records. A skeleton EAD input data stream is shown below to illustrate use of the ZR record to retrieve frequency-flow, an elevation-flow, and an elevation-damage functions for base condition for one reach.

Sample Input

```
TT
J1 ...
CN      2RESIDENTL COMERCL
PN      1 BASE CONDITION
RN REACH 1
FR  RCH1        3 ·      90       50       1
ZR A=SILVER CREEK B=RCH 1 C=QF F=BASELINE
ZR A=SILVER CREEK B=RCH 1 C=QS F=BASELINE
ZR A=SILVER CREEK B=RCH 1 C=SD F=BASELINE
EJ      1
```

The above ZR records contain the special code for part C of the pathname. Each code represents the two character record identifier which is normally placed in columns one and two when you are entering functions directly in the input stream (as opposed to retrieving data from a HECDSS data file). You may use either the special two character code or the full part C of the pathname. The table below describes the functions that can be retrieved from a HECDSS data file and the associated code for part C of the pathname.

Function	Code
elevation-flow (rating)	QS
frequency-flow	QF
frequency-elevation	SF
elevation-damage	SD (or DG)
flow-damage	QD
frequency-damage	DF

Storing Matrices In the HECDSS File

Computed results are written to a HECDSS data file by entering "ZW" records with a coded pathname part C. Parts B and E are automatically determined by the program and should not be entered by the user. In some cases, the EAD program also determines part F. The matrices written to the HECDSS data file are somewhat paired data convention, but not entirely. For example, the frequency-damage matrix contains not only damage data but also frequency-elevation and frequency-flow data. The category-expected annual damage function contains damage category names that are character in nature. The current standard data conventions of the HECDSS system do not automatically facilitate display of these types of data. Thus, the use of DSSUTL and DSPLAY to tabulate or plot the matrices is awkward and confusing but they can be utilized. Currently, EAD can store four different types of tabular output in a HECDSS data file. Those matrices and their associated pathname part C codes are shown in Table 1. Each output matrix is conceptually shown in the following pages.

Type of Matrices

Table 1: Matrices Stored In HECDSS File

Part C Code	Matrix Description
FREQ-DAMAGE	Frequency-Damage including: • Frequency-Flow • Frequency-stage • Frequency-damage for each category • Total Frequency-damage for all categories • Accumulated expected annual damage. This output coincides exactly with the frequency-damage table the EAD writes to the output file for each plan and each reach.
REACH-EAD	The expected annual damage for each plan by reach.
CATEGORY-EAD	The expected annual damage for each plan by category.
PLAN-EAD	The expected annual damage for each plan.

There are basically two types of data that may be stored in a HECDSS data file:

- **Expected annual damage versus either reach or category or plan.**
- **Damage versus exceedance frequency.**

The content of each of these functions are described below. The example pathname strings contain upper and lower case characters. The lower case letters are pathname parts that either the EAD program determines or that the user defines. The parts in upper case letters are fixed for a particular type of function. When the discussion includes the terminology "curve", it refers to the concept of curve as used in the HECDSS - DSPLAY and DSSUTL programs and the paired function convention data.

Expected Annual Damage or Equivalent Annual Damage

Expected annual damage appears in the output of three matrices for each reach, damage category, and plan as indicated by their associated pathname part C as follows:

- REACH-EAD
- CATEGORY-EAD
- PLAN-EAD

The following sections describe these three matrices in detail.

REACH-EAD

For each damage category, one HECDSS record is written for each damage category and each discount rate and one record is written containing the total damage in all categories for each plan, reach, and discount rate.

Number of curves	NPLAN+1
Number of vectors	NPLAN+2
Number of ordinates (rows)	NREACH+1

Each vector contains the following information:

Vector	Curve	Description
1	na	First four characters of reach name.
2	1	Last two characters of reach name.
3	2	Plan 1 (or base condition) expected annual damage.
3 thru NPLAN+2	2 thru NPLAN+1	Expected annual damage for each plan.

Each ordinate is the expected annual damage associated with one reach. The ordinate "NREACH+1" is the total expected annual damage for a given plan. The user should define pathname parts A and C on the ZW record and may define part F. An example user entry is:

ZW A=SILVER CREEK C=REACH-EAD

For each execution of the EAD program, one record is written to the HECDSS data file for each damage category and each discount rate. The format of these records is shown in Table 2.

Table 2: Schematic of REACH-EAD Matrix

Each Category /basin/category/REACH-EAD//discount rate/qualifier/
Example: /SILVER CREEK/RESIDNTL/REACH-EAD/6.375%///

```
Reach     Base    Plan 2  Plan 3  Plan 4

DR 1      ......  ......  ......  ......
DR 2      ......  ......  ......  ......
...
RESIDNTL  ......  ......  ......  ......     (total EAD for each plan for RESIDNTL)
```

Each Job /basin/ALL CATEGORIES/REACH-EAD//discount rate/qualifier/
Example: /SILVER CREEK/ALL CATEGORIES/REACH-EAD//6.375%//

```
Reach     Base    Plan 2  Plan 3  Plan 4

DR 1      ......  ......  ......  ......
DR 2      ......  ......  ......  ......
...
TOTAL     ......  ......  ......  ......     (total EAD for each plan for all categories)
```

CATEGORY-EAD

For each EAD job, one record is written which contains the expected annual damage for each plan versus damage category. Each record contains the following:

Number of curves	NPLAN+1
Number of vectors	NPLAN+2
Number of ordinates (rows)	NCAT+1

Each vector contains the following information:

Vector	Curve	Description
1	na	First four characters of damage category name.
2	1	Last four characters of damage category name.
3	2	Plan 1 (or base condition) expected annual damage.
3 thru NPLAN+2	2 thru NPLAN+1	Expected annual damage for each plan.

Each ordinate is the expected annual damage associated with one damage category. The ordinate "NCAT+1" is the total expected annual damage for a given plan. The user should define pathname parts A and C on the ZW record and may define part F. An example user entry is:

ZW A=SILVER CREEK C=CATEGORY-EAD F=PLANS 1,32-45

The CATEGORY-EAD function is stored in a modified paired function convention format. Each vector (curve) is the expected annual damage for a given plan. Each ordinate (row) is the expected annual damage for a given damage category and the last ordinate of each curve is the total damage for a given category. Table 3 illustrates the format of these records.

Table 3: Schematic of CATEGORY-EAD Matrix

Each Job /basin/ALL REACHES/CATEGORY-EAD//discount rate/qualifier/

Example: /SILVER CREEK/ALL REACHES/CATEGORY-EAD//6.375%/PLANS 1,32-45/

category	Base	Plan 32	Plan 33	Plan 34	....
RESIDNTL	......	......	......	......	......
COMMERCL	......	......	......	......	......
......	......	......	......	......	......
TOTAL	......	......	......	......	......

PLAN-EAD

For each EAD job, one record is written which contains the expected annual damage for each plan. The PLAN-EAD matrix is stored in true paired data convention format. This record contains the following:

Number of curves	1
Number of vectors	2
Number of ordinates (rows)	NPLAN

Each vector contains the following information:

Vector	Curve	Description
1	na	Plan number as entered in the first field of the PN record.
2	1	For each plan, the total expected annual damage for all reaches and damage categories.

The user should define pathname part A on the ZW record and may define parts B and F. An example user entry is:

ZW A=SILVER CREEK C=PLAN-EAD

Table 4 illustrates the format of these records.

Table 4: Schematic of PLAN-EAD Matrix

Each Job /basin/location/PLAN-EAD//discount rate/qualifier/
Example: /SILVER CREEK//PLAN-EAD//6.375%//

Plan	EAD
1	......
2	......
3	......
4	......
5	......
6	......

Damage-Frequency Matrix

The Damage-Frequency Matrix appears in the output of one matrix for each reach, damage category, and plan as indicated by their associated pathname part C: FREQ-DAMAGE. The following section describes this matrix in detail.

FREQUENCY-DAMAGE

The EAD program writes one record to the HECDSS data file for each damage reach, each plan, and each data year. Each record contains not only frequency-damage but frequency-flow and frequency-stage as well. Specifically, each record contains the following:

Number of curves	NCAT+4
Number of vectors	NCAT+5
Number of ordinates (rows)	NFRQ

Each vector contains the following information:

Vector	Curve	Description
1	na	Exceedance frequency values entered on the FR records.
2	1	Flow corresponding to frequency.
3	2	Elevation (stage) corresponding to frequency.
4 thru NCAT+3	3 thru NCAT+2	Damage corresponding to frequency for each damage category.
NCAT+4	NCAT+3	Total damage for all categories corresponding to frequency.
NCAT+5	NCAT+4	Accumulated expected annual damage corresponding to frequency.

The user should define pathname parts A and C and may define additions to part F. The EAD program defines part F using the plan number in the format "PLAN i" where "i" is the plan number (1-99) entered in the first field of the PN record. An example user entry is:

ZW A=SILVER CREEK C=FREQ-DAMAGE

There are two options for storing this data:

- The user may store only the computed data points which correspond to the frequencies entered on the FR records.
- The user may store all of the computed data points which are used in the computation of expected annual damage. These include the nine frequency points which are inserted by the EAD program between each of the user specified exceedance frequencies.

Table 5 illustrates the format of these records.

Table 5: Schematic of FREQUENCY-DAMAGE Matrix

Each reach, plan, and year:
/basin/reach/FREQ-DAMAGE//year/plan-qualifier/

Example:
/SILVER CREEK/DR 1/FREQ-DAMAGE//1985/PLAN 32-PLANS 1,32-45/

frequency	flow	stage	cat. $_1$	cat. $_2$	cat. $_i$	cat. $_n$	total	acc ead
......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......

Affluence Factor

An increase or decrease in the value of the contents in residential structures during a period of analysis can be taken into account in the computation of expected annual damage by one of two methods:

- Use of the RV record to modify the input damage matrix by multiplying the damage vector by some factor.
- Use of the RC record to define the annual rate increase in the damage vector and maximum value expressed as a percentage.

Use of the RV Record

In the first method, the change in the value of the contents is computed by invoking the RV record to specify the affluence factor as a ratio (1.04 indicates a 4 percent affluence factor), the damage category (residential contents), and the input data years to which it applies. This factor can be applied to each plan with a damage category for residential contents. It is required that the maximum level for the value of contents (expressed as a percentage of the value of structure) be determined by the analyst. The program does not automatically determine to which year it applies. The effect of affluence is displayed in the equivalent annual damage for the residential contents category and the total damage for each year. The EAD program has computed affluence using this method for a number of years. It is a fairly simplistic computation and requires the user to monitor the calculations for correctness.

Use of the RC Record

The second method was implemented with the February 1987 version of the program. For this method, the change in the value of the contents is computed by invoking RC records to define the economic year, the rate of affluence, and the maximum value of the contents as a function of the structure value.

Federal regulations permit projecting changes in the value of certain damage during the period of analysis. The most common projections are for increased value of household contents. Such an increase or a decrease may be computed automatically by specifying on RC records the appropriate annual rates of change for any previously defined damage category. The program then computes the appropriate increase or decrease for specified stage-damage or discharge-damage matrices. Nine annual rates of change can be specified, beginning with the economic base year and ending with the final year of the study, (IBASYR+IPOA-1). They must correspond with the input data years specified on the DY record.

Figure 1 illustrates the manner in which the specified rates are used to update the stage-damage or discharge-damage matrix for each year of the computations. The damage matrix for the economic base year is entered by the user to the EAD program on "DG" records. If only one rate of change is used, the modified damage values for any year, T, are computed by multiplying all damage vectors for the appropriate stage-damage or discharge-damage matrix for the economic base year by the parameter "FACTOR" shown in Figure 1.

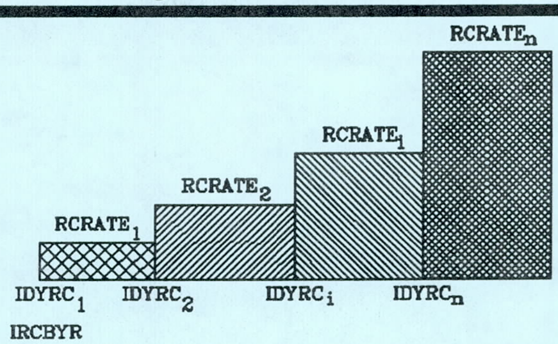
If more than one rate of change is specified, the following steps are performed:

(1) Determine the rate for each year.

(2) Compute the "future value" factor for each year.

(3) Multiply the damage function by the "future value" factor at each analysis year.

Figure 1: Rate of Affluence



$$FACTOR = \left(1 + \frac{RCRATE(1)}{100}\right)^{(T-IECONYR+1)}$$

where:

RCRATE(1)	Projected rate of change, in percent, after and including the economic base year.
IECONYR	Economic base year of computation.
T	Current year of computation

The user may impose a lower or upper bound on the damage functions computed automatically by the program. For example, to conform to current Corps of Engineers regulations, the projected value of household goods for a structure may not exceed an upper bound of 75 percent of the structure value. This limitation is imposed by setting DGRCMX (RC.6) equal to the percent of structure value of this upper bound. The maximum damage value of each stage-damage or discharge-damage function (which is subsequently computed by scaling the base-year function) is compared to this bound. If the bound is exceeded, the computed factor is reduced, so the maximum value of the computed function equals the specified bound.

Test Example 4 Computation of Affluence Using RC Records

Features of this example:

- One reach.
- Four damage categories: Residential Structure, Residential Content, Commercial, and Public.
- One flood plain management plan: Natural conditions.
- The Residential Content Damage Category is increasing in value during the projects serviceable life according to the following rates:

Year	Rate (annual percent)
1984	1.35
1990	1.50
2000	2.50
2015	2.70
2034	2.80

- The period of analysis is 50 years.
- The study year is 1983, the base year is 1985, and the economic base year (the year in which the stage-damage matrices apply) is 1983.
- The value of the residential contents at the beginning of the economic base year (1983) is 30% of the structure value.
- During the period of analysis, the residential contents cannot exceed 60% of the value of the structure.

Description of This Example:

The period of analysis of 50 years and the start of the period of analysis of 1985 are required on the **J1** record.

The discount rate of 5% is required on the **J2** record. The discount rate is used both for discounting (single payment present worth factor) as well as the amortization (capital recovery factor equation).

The four damage category names must be entered on the **CN** record.

The one plan must be entered on the **PN** record.

The appropriate data years must be entered on the **DY** record. In this case, the analyst must enter 1983 (the study and economic base year), 1984 (the first year of the affluence rate of 1.35%), 1985 (the period of analysis base year), 1990, 2000, 2015, and 2034 (the years in which the affluence rate changes). The EAD program uses the rate of change in the residential content value for all years subsequent to and including the corresponding year. For example, the rate of 2.5% and the year 2000 is used as the annual rate from 2000 through 2014.

The **FR**, **SF**, **SD**, and **DG** records are entered in the usual manner. The stage-damage matrix is entered for the year 1983. If there is projected development, then the analyst must enter additional DG records representing and increase in damage due to the construction of additional structures in the flood plain.

One **RC** record is entered for each affluence growth rate. In this case, there are five different rates for the growth in content value. The content value for the economic year (30% in 1983) and the maximum allowable content value (60%) are entered on the first RC record. The same values may be entered on any of the RC records --- The EAD program uses the last one entered.

In any given year, all structures in the residential content category are valued at the same percentage of the value of the structure. For example, in 1983, all residential structures have contents which are valued at 30% of the structure value; a $100,000 house contains contents worth $30,000 and a $200,000 house contains contents worth $60,000. By looking at the EAD output, the analyst can determine that in the year 1990, all residential structures contain contents which are 33% of the structure value. This is computed by taking the content value in the economic base year (30%) and multiplying it by the "adjusted factor" of 1.10004. If development is occurring, new structures do **not** contain contents that are 30% of the structure value but rather contain contents that are valued at the percentage computed using the affluence growth rate (33% for 1990).

In the affluence table output, the column entitled "UNADJUSTED FACTOR" is the computed affluence factor based on user input growth rates. To determine the content value as a function of the structure value in any given year, this factor is multiplied by the content value (in percent) which is observed in the economic base year (30% in 1973). For example, in the year 2000, contents are 38.7% of the structure value (multiply 30% by 1.28922). The maximum allowable factor is 2.0 (the maximum content value is 60% of the structure value; the content value is 30% of the structure value in the base economic year of 1973; divide 60% by 30%). The column entitled "ADJUSTED FACTOR" contains the actual factor used in computing the content value and it reflects the maximum limit of 60%.

```
++++++++++++++++++++++++++++++++++++++++++++
+ Expected Annual Flood Damage Computation +
+ 761-X6-L7580        IBM-PC Compatible    +
+ Version Date        December 1, 1988     +
++++++++++++++++++++++++++++++++++++++++++++


** LIST OF RECORDS READ BY READIN **
RECORD
 ORDER         1         2         3         4         5         6         7         8
NUMBER 12345678901234567890123456789012345678901234567890123456789012345678901234567890

     1 TT      TEST NO. 4 -- AFFLUENCE CALCULATION FOR RESIDENTIAL CONTENTS
     2 TT      FIVE RATES OF GROWTH IN AFFLUENCE (1984, 1990, 2000, 2015, 2034)
     3 TT      ECONOMIC BASE YEAR IS 1983
     4 TT      PERIOD OF ANALYSIS BASE YEAR IS 1985
     5 TT      DAMAGE IN $1,000
     6 TT      MARCH 1989
     7 J1     50    1983      1985
     8 J2      5
     9 CN      4RESIDNTLRES-CONTCOMM     PUBLIC
    10 PN      1BASE CONDITION
    11 DY      7    1983      1984      1985      1990      2000      2015      2034
    12 RN    REACH 1
    13 FR    RCH1      3        90        50         1
    14 SF    RCH11983 1        835       855       880
    15 SD    RCH1      3       850       860       880
    16 DG    RCH11983 1 1        0       333      1667
    17 DG    RCH11983 1 2        0       100       500
    18 DG    RCH11983 1 3        0       200      1200
    19 DG    RCH11983 1 4        0        50       175
    20 RC    RES-CONT         1984      1.35        30        60                1983
    21 RC    RES-CONT         1990       1.5
    22 RC    RES-CONT         2000       2.5
    23 RC    RES-CONT         2015       2.7
    24 RC    RES-CONT         2034       2.8
    25 EJ      1


READIN --     25 RECORDS WRITTEN TO LOGICAL FILE  8
```

```
++++++++++++++++++++++++++++++++++++++++++++
+ Expected Annual Flood Damage Computation +
+ 761-X6-L7580      IBM-PC Compatible      +
+ Version Date      December 1, 1988       +
++++++++++++++++++++++++++++++++++++++++++++


TT      TEST NO. 4 -- AFFLUENCE CALCULATION FOR RESIDENTIAL CONTENTS
TT      FIVE RATES OF GROWTH IN AFFLUENCE (1984, 1990, 2000, 2015, 2034)
TT      ECONOMIC BASE YEAR IS 1983
TT      PERIOD OF ANALYSIS BASE YEAR IS 1985
TT      DAMAGE IN $1,000
TT      MARCH 1989

**JOB RECORD**
      IPOA  ISTDYR  IBASYR   IDMTH  IDOLYR    NHIS   NDMTH  NDOLYR
J1      50    1983    1985       0       0       0       0       0

   RATE(1) RATE(2) RATE(3)    CPLI
J2  5.0000   .0000   .0000  1.0000

**DAMAGE CATEGORY NAMES**
CN   4  RESIDNTLRES-CONTCOMM    PUBLIC

**FLOOD PLAIN MANAGEMENT PLAN NAMES**
PN   1  BASE CONDITION

**INPUT DATA YEARS**
     NDYRS   IDYRS
DY       7    1983    1984    1985    1990    2000    2015    2034

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


REACH    1, REACH NAME -
RN  REACH 1

++++ INPUT DATA ++++

**FREQUENCIES**
FR  RCH1        3   90.00   50.00    1.00

**FLOOD STAGES**
SF  RCH11983 1    835.00  855.00  880.00

**STAGES FOR DAMAGE DATA**
SD  RCH1        3  850.00  860.00  880.00

**FLOOD DAMAGE DATA**
DG  RCH11983 1 1     .00  333.00 1667.00

**FLOOD DAMAGE DATA**
DG  RCH11983 1 2     .00  100.00  500.00

**FLOOD DAMAGE DATA**
DG  RCH11983 1 3     .00  200.00 1200.00

**FLOOD DAMAGE DATA**
DG  RCH11983 1 4     .00   50.00  175.00

**AFFLUENCE DATA**
             CNMRC   IDYRC  RCRATE  RCRTIO  DGRCMX  DGRCMN  IRCBYR
RC        RES-CONT    1984    1.35   30.00   60.00     .00    1983
             CNMRC   IDYRC  RCRATE  RCRTIO  DGRCMX  DGRCMN  IRCBYR
RC        RES-CONT    1990    1.50   30.00   60.00     .00    1983
             CNMRC   IDYRC  RCRATE  RCRTIO  DGRCMX  DGRCMN  IRCBYR
RC        RES-CONT    2000    2.50   30.00   60.00     .00    1983
```

	CNMRC	IDYRC	RCRATE	RCRTIO	DGRCMX	DGRCMN	IRCBYR
RC	RES-CONT	2015	2.70	30.00	60.00	.00	1983
	CNMRC	IDYRC	RCRATE	RCRTIO	DGRCMX	DGRCMN	IRCBYR
RC	RES-CONT	2034	2.80	30.00	60.00	.00	1983

AFFLUENCE FACTORS FOR DAMAGE CATEGORY 2 (RES-CONT).

ECONOMIC YEAR OF DAMAGE DATA..................	1983
COMPUTATIONAL YEAR............................	2034
RATIO OF CONTENTS TO STRUC ECON YR (%).........	30.00
MAX RATIO OF CONTENTS TO STRUC COMP YR (%).....	60.00
MIN RATIO OF CONTENTS TO STRUC COMP YR (%).....	.00

USER DEFINED RATES - 5 YEARS

YEAR	RATE (%)	MAX RATIO (%)	MIN RATIO (%)
1984	1.350	60.000	.000
1990	1.500	60.000	.000
2000	2.500	60.000	.000
2015	2.700	60.000	.000
2034	2.800	60.000	.000

YEAR	RATE (%)	UNADJUSTED FACTOR	ADJUSTED FACTOR	MAXIMUM FACTOR	MINIMUM FACTOR
1983	1.350	1.01350	1.01350	2.00000	.00000
1984	1.350	1.02718	1.02718	2.00000	.00000
1985	1.350	1.04105	1.04105	2.00000	.00000
1986	1.350	1.05510	1.05510	2.00000	.00000
1987	1.350	1.06935	1.06935	2.00000	.00000
1988	1.350	1.08378	1.08378	2.00000	.00000
1989	1.350	1.09841	1.09841	2.00000	.00000
1990	1.500	1.11489	1.11489	2.00000	.00000
1991	1.500	1.13161	1.13161	2.00000	.00000
1992	1.500	1.14859	1.14859	2.00000	.00000
1993	1.500	1.16582	1.16582	2.00000	.00000
1994	1.500	1.18330	1.18330	2.00000	.00000
1995	1.500	1.20105	1.20105	2.00000	.00000
1996	1.500	1.21907	1.21907	2.00000	.00000
1997	1.500	1.23736	1.23736	2.00000	.00000
1998	1.500	1.25592	1.25592	2.00000	.00000
1999	1.500	1.27475	1.27475	2.00000	.00000
2000	2.500	1.30662	1.30662	2.00000	.00000
2001	2.500	1.33929	1.33929	2.00000	.00000
2002	2.500	1.37277	1.37277	2.00000	.00000
2003	2.500	1.40709	1.40709	2.00000	.00000
2004	2.500	1.44227	1.44227	2.00000	.00000
2005	2.500	1.47832	1.47832	2.00000	.00000
2006	2.500	1.51528	1.51528	2.00000	.00000
2007	2.500	1.55316	1.55316	2.00000	.00000
2008	2.500	1.59199	1.59199	2.00000	.00000
2009	2.500	1.63179	1.63179	2.00000	.00000
2010	2.500	1.67259	1.67259	2.00000	.00000
2011	2.500	1.71440	1.71440	2.00000	.00000
2012	2.500	1.75726	1.75726	2.00000	.00000
2013	2.500	1.80120	1.80120	2.00000	.00000
2014	2.500	1.84622	1.84622	2.00000	.00000
2015	2.700	1.89607	1.89607	2.00000	.00000
2016	2.700	1.94727	1.94727	2.00000	.00000
2017	2.700	1.99984	1.99984	2.00000	.00000
2018	2.700	2.05384	2.00000	2.00000	.00000
2019	2.700	2.10929	2.00000	2.00000	.00000
2020	2.700	2.16624	2.00000	2.00000	.00000
2021	2.700	2.22473	2.00000	2.00000	.00000
2022	2.700	2.28480	2.00000	2.00000	.00000

2023	2.700	2.34649	2.00000	2.00000	.00000
2024	2.700	2.40984	2.00000	2.00000	.00000
2025	2.700	2.47491	2.00000	2.00000	.00000
2026	2.700	2.54173	2.00000	2.00000	.00000
2027	2.700	2.61036	2.00000	2.00000	.00000
2028	2.700	2.68084	2.00000	2.00000	.00000
2029	2.700	2.75322	2.00000	2.00000	.00000
2030	2.700	2.82756	2.00000	2.00000	.00000
2031	2.700	2.90390	2.00000	2.00000	.00000
2032	2.700	2.98231	2.00000	2.00000	.00000
2033	2.700	3.06283	2.00000	2.00000	.00000
2034	2.800	3.14859	2.00000	2.00000	.00000

**END OF INPUT DATA FOR PLAN 1 **
EJ++

++DAMAGE DATA FOR PLAN 1 AND YEAR 1983 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	698.64
2	50.00	-1.	855.00	166.50	50.67	100.00	25.00	342.17	673.28
3	1.00	-1.	880.00	1667.00	506.75	1200.00	175.00	3548.75	35.49

EXP ANNUAL DAMAGE, YEAR 1983 332.48 101.11 224.54 40.51 698.64

++DAMAGE DATA FOR PLAN 1 AND YEAR 1985 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	701.39
2	50.00	-1.	855.00	166.50	52.05	100.00	25.00	343.55	675.93
3	1.00	-1.	880.00	1667.00	520.52	1200.00	175.00	3562.52	35.63

EXP ANNUAL DAMAGE, YEAR 1985 332.48 103.86 224.54 40.51 701.39

++DAMAGE DATA FOR PLAN 1 AND YEAR 1994 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	715.58
2	50.00	-1.	855.00	166.50	59.17	100.00	25.00	350.67	689.59
3	1.00	-1.	880.00	1667.00	591.65	1200.00	175.00	3633.65	36.34

EXP ANNUAL DAMAGE, YEAR 1994 332.48 118.06 224.54 40.51 715.58

++DAMAGE DATA FOR PLAN 1 AND YEAR 2004 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	741.41
2	50.00	-1.	855.00	166.50	72.11	100.00	25.00	363.61	714.47
3	1.00	-1.	880.00	1667.00	721.13	1200.00	175.00	3763.13	37.63

EXP ANNUAL DAMAGE, YEAR 2004 332.48 143.89 224.54 40.51 741.41

++DAMAGE DATA FOR PLAN 1 AND YEAR 2014 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	781.72
2	50.00	-1.	855.00	166.50	92.31	100.00	25.00	383.81	753.27
3	1.00	-1.	880.00	1667.00	923.11	1200.00	175.00	3965.11	39.65

EXP ANNUAL DAMAGE, YEAR 2014 332.48 184.19 224.54 40.51 781.72

++DAMAGE DATA FOR PLAN 1 AND YEAR 2024 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	797.06
2	50.00	-1.	855.00	166.50	100.00	100.00	25.00	391.50	768.05
3	1.00	-1.	880.00	1667.00	1000.00	1200.00	175.00	4042.00	40.42

EXP ANNUAL DAMAGE, YEAR 2024 332.48 199.53 224.54 40.51 797.06

++DAMAGE DATA FOR PLAN 1 AND YEAR 2034 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	797.06
2	50.00	-1.	855.00	166.50	100.00	100.00	25.00	391.50	768.05
3	1.00	-1.	880.00	1667.00	1000.00	1200.00	175.00	4042.00	40.42

EXP ANNUAL DAMAGE, YEAR 2034 332.48 199.53 224.54 40.51 797.06

++DAMAGE DATA FOR PLAN 1 AND YEAR 1984 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	700.00
2	50.00	-1.	855.00	166.50	51.36	100.00	25.00	342.86	674.59
3	1.00	-1.	880.00	1667.00	513.59	1200.00	175.00	3555.59	35.56

EXP ANNUAL DAMAGE, YEAR 1984 332.48 102.48 224.54 40.51 700.00

++DAMAGE DATA FOR PLAN 1 AND YEAR 1990 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	708.75
2	50.00	-1.	855.00	166.50	55.74	100.00	25.00	347.24	683.02
3	1.00	-1.	880.00	1667.00	557.45	1200.00	175.00	3599.45	35.99

EXP ANNUAL DAMAGE, YEAR 1990 332.48 111.23 224.54 40.51 708.75

++DAMAGE DATA FOR PLAN 1 AND YEAR 2000 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	727.88
2	50.00	-1.	855.00	166.50	65.33	100.00	25.00	356.83	701.44
3	1.00	-1.	880.00	1667.00	653.31	1200.00	175.00	3695.31	36.95

EXP ANNUAL DAMAGE, YEAR 2000 332.48 130.36 224.54 40.51 727.88

++DAMAGE DATA FOR PLAN 1 AND YEAR 2015 -- BASE CONDITION

	FREQ	FLOW	STAGE	RESIDNTL	RES-CONT	COMM	PUBLIC	TOTAL	ACC EAD
1	90.00	-1.	835.00	.00	.00	.00	.00	.00	786.69
2	50.00	-1.	855.00	166.50	94.80	100.00	25.00	386.30	758.06
3	1.00	-1.	880.00	1667.00	948.04	1200.00	175.00	3990.04	39.90

EXP ANNUAL DAMAGE, YEAR 2015 332.48 189.17 224.54 40.51 786.69

* *

TEST NO. 4 -- AFFLUENCE CALCULATION FOR RESIDENTIAL CONTENTS
FIVE RATES OF GROWTH IN AFFLUENCE (1984, 1990, 2000, 2015, 2034)
ECONOMIC BASE YEAR IS 1983

** EXPECTED ANNUAL FLOOD DAMAGE **

** FOR REACH 1 = REACH 1

** WITH PLAN 1 = BASE CONDITION

** INPUT DATA YEARS = 1983 1984 1985 1990 2000 2015 2034

** PERIOD OF ANALYSIS = 50 YEARS

** DISCOUNT RATE = 5.0000 PERCENT

DAMAGE CATEGORIES	STUDY YEAR 1983	BASE YEAR 1985	.... DECADE YEARS 10 1994	20 2004	30 2014	40 2024	50 2034	END OF PERIOD 2034	EQUIVALENT ANNUAL DAMAGE
1RESIDNTL	332.48	332.48	332.48	332.48	332.48	332.48	332.48	332.48	332.47
2RES-CONT	101.11	103.86	118.06	143.89	184.19	199.53	199.53	199.53	137.50
3COMM	224.54	224.54	224.54	224.54	224.54	224.54	224.54	224.54	224.54
4PUBLIC	40.51	40.51	40.51	40.51	40.51	40.51	40.51	40.51	40.51
TOTAL	698.64	701.39	715.58	741.41	781.72	797.06	797.06	797.06	735.02

* *

```
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       TEST NO. 4 -- AFFLUENCE CALCULATION FOR RESIDENTIAL CONTENTS
       FIVE RATES OF GROWTH IN AFFLUENCE (1984, 1990, 2000, 2015, 2034)
       ECONOMIC BASE YEAR IS 1983


 ** SUMMARY OF REACH NAMES  **

  NO    ID    . . NAME . . .
 ---------------------------------------------------------------------------
   1  RCH1     REACH 1

 ---------------------------------------------------------------------------
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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       TEST NO. 4 -- AFFLUENCE CALCULATION FOR RESIDENTIAL CONTENTS
       FIVE RATES OF GROWTH IN AFFLUENCE (1984, 1990, 2000, 2015, 2034)
       ECONOMIC BASE YEAR IS 1983

 ** GRAND SUMMARY BY CATEGORY **

 ** INPUT DATA YEARS    = 1983  1984  1985  1990  2000  2015  2034

 PERIOD OF ANALYSIS =   50 YEARS

 ** DISCOUNT RATE       = 5.0000 PERCENT

 ** FLOOD PLAIN MANAGEMENT PLANS
       1 - BASE CONDITION

 GRAND SUMMARY - ALL DAMAGE CATEGORIES
 ---------------------


             EQUIVALENT ANNUAL DAMAGE

  DAMAGE     BASE
 CATEGORY   CONDITION
            (PLAN  1)
 ---------------------

  RESIDNTL    332.47
  RES-CONT    137.50
  COMM        224.54
  PUBLIC       40.51
 ---------------------


     TOTAL    735.02

 ---------------------

 READIN --  NO RECORDS READ FROM USER INPUT
```

Calculation Progress Message

On the personal computer, the EAD program issues a message indicating the status of calculations. Sometimes, it may seem that your computer is "hung" - nothing is being processed. To help alleviate this problem, the program issues a message at the conclusion of the computation of expected annual damage for every plan. On faster machines and for simple computations, this message appears frequently (once every five seconds or less). On slower machines or especially if you are calculating equivalent annual damage, this message may appear infrequently (once every minute or two).

File Assignments

The keywords used to assign files when the program is executed have been changed since the first release of the SID and EAD programs. If you use the menu program to execute the programs, you need not worry about these keywords. However, if you execute on the Harris or don't use the menu program, you need to know these keywords. To determine the current definition, enter the command:

```
EAD ?
```

The results from this command should look similar to the following:

```
EAD - Version date: December 15, 1987

   UNIT      KEYWORD          *ABREV     **MAX   DEFAULT
     5       IN               I          64      CON
     6       OUT              O          64      CON
     7       PUNCH            P          64      SCRATCH.001
    29       TRACE            T          64      SCRATCH.002
     8       FILE8            F          64      SCRATCH.008
     9       FILE9            FILE9      64      SCRATCH.009
   NOP       DSSFILE          D          64      SCRATCH.031

   * ABREV - SHORTEST ABBREVIATION ALLOWED FOR KEYWORD
   ** MAX - MAXIMUM # OF CHARACTERS FOR FILENAME (OR STRING)
Stop - Program terminated.
```

Notice that use of the old keyword "INPUT" is invalid and has been shortened to "IN" or just "I". An example user entry to execute the program on the Harris (or on the personal computer if you are not using the menu program) may look like the following:

HLIB*EAD I=SLV01.E O=SLV01.EO DSS=SILVER.DSS

APPLICATION OF FDA2PO
(COMPUTING REFERENCE FLOOD ELEVATIONS)

Workshop Problem

Problem Purpose

The objective of this workshop problem is give class participants experience in using the FDA2PO program to compute reference flood elevations by postprocessing calculated results from HEC-2.

Problem Description

The SID input data file simulates the base condition elevation-damage relationships for three reaches. There is a separate structure file which contains data for all of the structures in reaches 11, 12, and 13. They do not contain the reference flood elevations for each structure and at the index location.

The following files are used in this workshop:

HEC-2 "TAPE95" computed results	P1.295
SID input data file for Plan 1	PLAN1.S
SID structure file (input, without ref elev)	BASE.I
SID structure file (output, with computed ref elev)	COOP.I

Table 1 contains a list of the structure file "BASE.I". Notice that the SL records do not contain the reference flood elevations. However, field nine of the SO records already contain the "station" (or river location) of each structure. Table 2 contains a listing of the SID input data (which does not contain the damage function or structure inventory data). Field 2 of the DR records in the SID input data file do not contain the reference flood elevations for each reach.

In this workshop, we will not store rating curves for the damage index locations in the HECDSS data file. They have already been stored in the previous FD2PO workshop.

Table 1 Structure Inventory

SL	RCH11	237			623.4		1
SD	RCH11	237RESIDENTRS1	70RC1	35		2920 BRISTOL ST	
SO	RCH11	237				27220	
SL	RCH11	240			624.3		1
SD	RCH11	240RESIDENTRS1	65RC1	32.5		2919 BRISTOL ST	
SO	RCH11	240				27375	
SL	RCH11	566			622.4		1
SD	RCH11	566RESIDENTRS1	70RC1	35.0		2921 BRISTOL ST	
SO	RCH11	566				27265	
SL	RCH11	241			624.8		1
SD	RCH11	241RESIDENTRS1	65RC1	32.5		3917 BRISTOL ST	
SO	RCH11	241				27450	
SL	RCH11	242			624.2		1
SD	RCH11	242RESIDENTRS1	65RC1	32.5		2915 BRISTOL ST	
SO	RCH11	242				27500	
SL	RCH11	568			625.4		1
SD	RCH11	568RESIDENTRS1	70RC1	35.0		2913 BRISTOL ST	
SO	RCH11	568				27555	
SL	RCH11	285			621.3		1
SD	RCH11	285RESIDENTRS1	80RC1	40.0		1406 CHURCHILL ST.	
SO	RCH11	285				26909	
SL	RCH11	301			622.0		1
SD	RCH11	301RESIDENTRS1	80RC1	40.0		1402 CHURCHILL ST.	
SO	RCH11	301				27070	
SL	RCH11	311			622.9		1
SD	RCH11	311RESIDENTRS1	80RC1	40.0		1324 CHURCHILL DR.	
SO	RCH11	311					
SL	RCH11	315			623.4		1
SD	RCH11	315RESIDENTRS1	90RC1	45.0		1320 CHURCHILL DR.	
SO	RCH11	315				27290	
SL	RCH11	322			623.4		1
SD	RCH11	322RESIDENTRS1	75RC1	37.5		1314 CHURCHILL DR.	
SO	RCH11	322				27400	
SL	RCH11	327			624.3		1
SD	RCH11	327RESIDENTRS1	75RC1	37.5		1310 CHURCHILL DR.	
SO	RCH11	327				27530	
SL	RCH11	328			625.2		1
SD	RCH11	328RESIDENTRS1	75RC1	37.5		1306 CHURCHILL DR.	
SO	RCH11	328				27660	
SL	RCH11	571			622.4		1
SD	RCH11	571SCHOOL SS1	200SC1	60.0		1304 CHURCHILL DR.	
SO	RCH11	571				27690	
SL	RCH12	351			626.4		1
SD	RCH12	351CHURCH CS1	250CC1	80.0		3105 HEATHER LN.	
SO	RCH12	351				27970	
SL	RCH12	364			627.6		1
SD	RCH12	364RESIDENTRS1	70RC1	35.0		3110 HEATHER LN.	
SO	RCH12	364				28270	
SL	RCH12	367			628.4		1
SD	RCH12	367RESIDENTRS1	70RC1	35.0		3114 HEATHER LN.	
SO	RCH12	367				28340	
SL	RCH12	370			629.2		1
SD	RCH12	370RESIDENTRS1	70RC1	35.0		3116 HEATHER LN.	
SO	RCH12	370				28415	
SL	RCH12	373			629.5		1
SD	RCH12	373RESIDENTRS1	70RC1	35.0		3118 HEATHER ST.	
SO	RCH12	373				28490	
SL	RCH12	374			629.5		1
SD	RCH12	374RESIDENTRS1	95RC1	45.0		3202 HEATHER LN.	
SO	RCH12	374				28550	
SL	RCH12	375			630.5		1
SD	RCH12	375RESIDENTRS1	60RC1	30.0		3206 HEATHER LN.	
SO	RCH12	375				28570	
SL	RCH12	376			631.2		1
SD	RCH12	376RESIDENTRS1	60RC1	30.0		3208 HEATHER LN.	
SO	RCH12	376				28570	

SL	RCH12	387		630.8		1
SD	RCH12	387RESIDENTRS1	70RC1 35.0		3205 HEATHER LN.	
SO	RCH12	387			28680	
SL	RCH12	388		631.4		1
SD	RCH12	388RESIDENTRS1	60RC1 30.0		3207 HEATHER LN.	
SO	RCH12	388			28680	
SL	RCH12	389		631.8		1
SD	RCH12	389RESIDENTRS1	60RC1 30.0		3209 HEATHER LN.	
SO	RCH12	389			28680	
SL	RCH13	416		634.9		1
SD	RCH13	416GAS STATGS1	150GC1 45.0		1101 MONTERRY ST.	
SO	RCH13	416			29030	
SL	RCH13	417		636.6		1
SD	RCH13	417RESIDENTRS1	60RC1 30.0		1021 MONTERRY ST.	
SO	RCH13	417			29030	
SL	RCH13	418		636.7		1
SD	RCH13	418RESIDENTRS1	75RC1 37.5		1013 MONTERRY ST.	
SO	RCH13	418			29250	
SL	RCH13	419		635.7		1
SD	RCH13	419RESIDENTRS1	60RC1 30.0		1009 MONTERRY ST.	
SO	RCH13	419			29460	
SL	RCH13	420		635.6		1
SD	RCH13	420RESIDENTRS1	60RC1 30.0		1005 MONTERRY ST.	
SO	RCH13	420			29460	
SL	RCH13	421		636.3		1
SD	RCH13	421RESIDENTRS1	75RC1 37.5		1001 MONTERRY ST.	
SO	RCH13	421			29640	
SL	RCH13	441		637.0		1
SD	RCH13	441RESIDENTRS1	60RC1 30.0		1000 MANHATTEN	
SO	RCH13	441			29640	
SL	RCH13	442		636.4		1
SD	RCH13	442RESIDENTRS1	60RC1 30.0		1004 MANHATTEN	
SO	RCH13	442			29460	
SL	RCH13	443		636.0		1
SD	RCH13	443RESIDENTRS1	60RC1 30.0		1008 MANHATTEN	
SO	RCH13	443			29250	
SL	RCH13	444		636.2		1
SD	RCH13	444RESIDENTRS1	84RC1 42.0		1014 MANHATTEN	
SO	RCH13	444			29250	
SL	RCH13	445		635.1		1
SD	RCH13	445RESIDENTRS1	60RC1 30.0		1018 MANHATTEN	
SO	RCH13	445			29030	
SL	RCH13	446		635.2		1
SD	RCH13	446RESIDENTRS1	75RC1 37.5		1100 MANHATTEN	
SO	RCH13	446			29030	
SL	RCH13	447		633.9		1
SD	RCH13	447RESIDENTRS1	60RC1 30.0		1104 MANHATTEN	
SO	RCH13	447			29030	
SL	RCH13	448		635.4		1
SD	RCH13	448RESIDENTRS1	60RC1 30.0		1109 MANHATTEN	
SO	RCH13	448			29030	
SL	RCH13	449		635.3		1
SD	RCH13	449RESIDENTRS1	60RC1 30.0		1105 MANHATTEN	
SO	RCH13	449			29030	
SL	RCH13	450		635.4		1
SD	RCH13	450RESIDENTRS1	60RC1 30.0		1101 MANHATTEN	
SO	RCH13	450			29030	
SL	RCH13	451		635.0		1
SD	RCH13	451RESIDENTRS1	60RC1 30.0		1021 MANHATTEN	
SO	RCH13	451			29030	
SL	RCH13	452		634.9		1
SD	RCH13	452RESIDENTRS1	60RC1 30.0		1017 MANHATTEN	
SO	RCH13	452			29030	
SL	RCH13	453		634.8		1
SD	RCH13	453RESIDENTRS1	60RC1 30.0		1013 MANHATTEN	
SO	RCH13	453			29250	
SL	RCH13	454		635.3		1
SD	RCH13	454RESIDENTRS1	60RC1 30.0		1009 MANHATTEN	
SO	RCH13	454			29250	

SID Input Data (without damage functions and structures)

```
T1      COOPER CREEK      DENTON, TEXAS
T2      INPUT DECK PLAN1.S
T3      BASE CONDITION - ALSO USED FOR CHANNEL IMP., RES ALT.
J1                                                             8
J2
ZW
DC
DC
DC
DC
DR RCH11
DT      WINDSOR STREET(STATION 26927) TO STATION 27890       INDEX 27415
SE 620.2   622.0   623.0   623.5   624.1  624.38   624.7   625.4
DR RCH12
DT      STATION 27890 TO SHERMAN DRIVE(STATION 28896)        INDEX 28550
SE 626.5   628.1   629.1   629.7   630.3   630.61  630.9   631.5
DR RCH13
DT      STATION 28896 TO 29390   INDEX 29032
SE 629.7   631.5   634.8   635.3   635.7  636.01   636.3   636.8
ST  1 YR    2 YR    5 YR   10 YR   25 YR   50 YR  100 YR  500 YR
ES
```

Tasks

1. Determine the cross-section I.D. for the damage index locations for reaches 11, 12, and 13. For Cooper Creek, the cross-section I.D. and river location are the same. Using the handout on Cooper Creek, fill in the table below:

Damage reach	Cross section I.D.
RCH 11	274+15
RCH 12	285+50
RCH 13	[290+32]

274+15
270+25
3/390
130
+270+25
271+55

2. The river location for structure #311 in reach 11 has been omitted from the structure inventory. From page 15 of the Cooper Creek handout, determine the "River Loc." for this structure and enter it in the structure inventory file (BASE.I).

   Structure #311   River Location 271+55

3. Execute the FDA2PO program by entering "MENUFDA", selecting the FDA2PO program, and defining the data files. Assign the files as listed on page 1 of this workshop problem. Do not store the rating curves in the HECDSS data file unless you wish to overwrite the existing ones. The 7th profile is used as the reference flood water surface profile.

4. List the modified SID data files PLAN1.S and COOP.I to answer the following questions.

   a. What are the reference flood elevations at the following damage index points?

   Reach 11 624.4

   Reach 12 630.6

   Reach 13 630.0

   b. What are the reference flood elevations and the transformed first floor elevations at the following structures?

Structure Identification	Reference Flood Elevation	Transformed First Elevation
#311 reach 11	623.2	624.1
#416 reach 13	636.0	634.9

APPLICATION OF SID WITH THE EXPANDED CAPABILITIES (DSS AND FUNCTION / STRUCTURE FILES)

Workshop Problem

Problem Purpose

The objective of this workshop problem is to introduce class participants to the data management aspects of flood damage computation. The class will become familiar with separate sequential structure and damage function files, and the HEC Data Storage System (DSS) direct access files. The emphasis is on SID data input, file manipulation, and job control language (JCL) for program exection.

Problem Description

The SID input data file simulates the base condition elevation-damage relationships for three reaches. Single event flood damage will be calculated for eight different elevations. These elevations have a corresponding frequency which was derived from the flow-frequency and water surface profile analyses. A listing of the file appears in Table 1. The Corps text editor COED is used to edit the ZW record to write computed elevation-damage functions from SID to a DSS data file so that they may be automatically transferred to the Expected Annual Damage computation (EAD) computer program.

The SID input data file will then be modified to simulate floodprofing all residential structures to the 2 percent chance exceedance level. The ZW record is modified to generate a new pathname which is associated with the modified elevation-damage matrices.

The following files are used in this workshop:

SID input data file for Plan 1	PLAN1.S
SID output results for Plan 1	PLAN1.SO
SID JCL file for Plan 1	J1.SID
SID input data file for Plan 6 (floodproofing)	PLAN6.S
SID output results for Plan 6 (floodproofing)	PLAN6.SO
SID JCL file for Plan 6	J6.SID
SID structure file	COOP.I
SID sequential damage function file	COOP.F
HECDSS data file	COO.DSS

On the Harris, the SID JCL file looks similiar to the following:

```
$JOB GPxx GPxx P=4 OUT=PLAN1.SO
HLIB*SID I=PLAN1.S S=COOP.I D=COOP.F DSS=COO.DSS
```

The damage functions (or depth damage relationships) and the structure inventory records are stored in separate sequential files. The SID input data must be modified to reflect this.

Tasks

1. Edit the SID input data file for the base condition. Most of the input is supplied. You need to enter data on the J2, ZW, DC, and DR records. **Answering the following questions will help you complete your input.**

   a. How many damage functions are there? ___8___ P.7
   Enter this number in the appropriate field of the J2 record.

   b. How many damage categories are there? ___~~8~~ 4___
   Enter this number in the appropriate field of the J2 record.

   c. What are the damage category names? Enter them in the spaces provided below. You must use 8 or less characters to define each damage category name.

Category number	Name
1	RESIDENT
2	GAS STAT
3	SCHOOL
4	CHURCH

   Enter the above names on the appropriate DC records.

   d. How many damage reaches are there? ___3___
   Enter this number in the appropriate field of the J2 record.

   e. What are the damage reach names? Enter them in the spaces provided below. You must use 6 or less characters to define each damage reach name.

Reach number	Name
1	RCH 11
2	RCH 12
3	RCH13

   f. Structure data is not included with the SID input data file which contains the job specification records. Modify the J2 record to reflect this.

g. Damage functions (depth-damage data) are not included with the SID input data file which contains the job specification records. They are resident on disk (unit 12) in record image format. Modify the J2 record to reflect this.

h. The aggregated elevation-damage relationship must be stored in the HECDSS data file.

What is part A of the HECDSS pathname? A= COOPER CREEK

What is part E of the HECDSS pathname? BLANK

What is part F of the HECDSS pathname? F= BASE

Enter the HECDSS pathname parts on the ZW record.

i. For each reach, you must define the parameters which control the elevation ordinates (and the associated damage) used for printout and storage in the HECDSS data file. The starting elevation is the elevation at which the tabulation begins. The Tabulation Increment controls the difference between tabulation intervals. For example, if the starting elevation is 200 feet and the increment is 0.5 foot, the elevation-damage relationship would start at 200, the second ordinate would be elevation 200.5, the third ordinate wuld be elevation 201.0, etc. Fill out the table below and modify the appropriate DR records in the SID input data file.

Reach Identification	Starting Elevation	Tabulation Increment
RCH11	~~619~~ 621	~~0.5~~ 1
RCH12	~~625~~ 629	~~0.5~~ 1
RCH13	~~628~~ 633	~~0.5~~ 1

j. Calculate the aggregated elevation-damage relationship for the base condition by either:

- On the **Harris**, submiting a "batch" or control-point job using your edited SID input data set and the appropriate JCL file.
- On the **Personal Computer (MS-DOS)**, execute the program by pressing and holding the "Alt" key and the pressing the "X" key.

2. Create and edit the SID input data file for Plan 6. For Plan 6, we will floodproof ALL residential structures in reaches 11, 12, and 13 to the 2% chance exceedance frequency level. Copy your base condition SID input data file (PLAN1.S) into a new file which will be used for Plan 6. To do this, enter the following JCL:

COPY PLAN1.S PLAN6.S   From DOS

Most of the input remains the same for Plan 6. You need to enter data on the J1, J5, ZW, and DR records. Answering the following questions will help you complete your input.

a. What variable on the J1 record allows us to specify the floodproofing operation?
Enter the variable name: IPROF =1

b. To floodproof all residential structures to the elevation associated with the 2% chance exceedance frequency water surface profile elevation, what value do we give the variable defined by the previous question? J5

Enter value: RESIDENT

c. Which SID input record is used to define the damage categories which are subject to floodproofing?

Enter record I.D.: F = FLOODPROOF 50-YEAR

Add this record to the SID input data file and enter the appropriate values.

d. When storing the elevation-damage relationships for Plan 6 in the HECDSS data file, we must define a different pathname for it as compared to the base condition plan. Define your pathname parts below:

What is part A of the HECDSS pathname? A = COOPER CREEK

What is part E of the HECDSS pathname? BLANK

What is part F of the HECDSS pathname? F = ~~PLAN 6~~ FLOOD PROOF 50-YEAR

Enter the HECDSS pathname parts on the ZW record.

e. Which variable on the DR record allows us to define the elevation to which the structures are floodproofed?

Enter variable name: PROELV

The 2% chance exceedance elevations are entered on the SE records of the SID input data file and are used to compute single flood event damage (field J1.8, variable ITYPE, is non-zero). Look at the SE and ST records and fill out the table below.

Reach Name	Elevation of 2 percent chance exceedance event
RCH11	624.38
RCH12	630.6
RCH13	636.0

Enter these values in the appropriate field of the DR records.

f. To compute a modified elevation-damage relationship, do one of the following:

- On the Harris, submit the "batch" (or control point) job using the input data stored in the file PLAN6.S using the JCL file J6.SID.
- On the **Personal Computer (MS-DOS)**, execute the program by pressing and holding the "Alt" key and the pressing the "X" key.

3. Verify that both SID jobs executed properly. Peruse the output by listing or displaying at your terminal, or by spooling it to the printer (if available). Answer the following questions and perform the following tasks.

a. How much damage is associated with the 2% chance exceedance event **for the base condition**? Fill in the following table **for the base condition.**

Single Event Damage (in $1,000)

Damage Category

Reach Name	Residential	Service Station	Schools	Churches	Total
RCH13	175.2	7.9	∅	∅	183.1
RCH12	98.0	∅	∅	19.0	117.0
RCH11	123.6	∅	33.9	∅	157.5

b. Use DSPLAY (and DSSUTL, if you wish) to tabulate and plot the elevation-damage curves for base and floodproofing plans for each reach. Do they seem reasonable?

	BASE	Plan
11	24	40
12	25	46
13	26	42

Table 1 Damage Function File

File: COOP.F

DF	RS1	20									
DP	-.1	0	1	2	3	4	5	6	7	8	
DP	9	10	11	12	13	14	15	16	17	18	
PC	0	2	10	15	28	32	39	43	44	45	
PC	51	52	54	58	62	67	73	80	84	84	
DF	RC1	20									
DP	-.1	0	1	2	3	4	5	6	7	8	
DP	9	10	11	12	13	14	15	16	17	18	
PC	0	6	32	43	52	64	73	79	84	85	
PC	86	87	87	88	90	93	96	100	100	100	
DF	GS1	20									
DP	-.1	0	1	2	3	4	5	6	7	8	
DP	9	10	11	12	13	14	15	16	17	18	
PC	0	0	4	5	7	10	13	16	22	26	
PC	31	37	43	49	55	60	65	70	75	79	
DF	GC1	20									
DP	-.1	0	1	2	3	4	5	6	7	8	
DP	9	10	11	12	13	14	15	16	17	18	
PC	0	1	4	7	12	18	24	32	40	48	
PC	54	58	63	66	68	70	70	70	70	70	
DF	SS1	20									
DP	-.1	0	1	2	3	4	5	6	7	8	
DP	9	10	11	12	13	14	15	16	17	18	
PC	0	0	10	11	11	12	12	13	14	14	
PC	15	17	19	24	30	38	45	52	58	64	
DF	SC1	20									
DP	-.1	0	1	2	3	4	5	6	7	8	
DP	9	10	11	12	13	14	15	16	17	18	
PC	0	0	0	0	20	40	60	80	85	90	
PC	90	90	90	90	90	90	90	90	90	90	
DF	CS1	20									
DP	-.1	0	1	2	3	4	5	6	7	8	
DP	9	10	11	12	13	14	15	16	17	18	
PC	0	0	10	11	11	12	12	13	14	14	
PC	15	17	19	24	30	38	45	52	58	64	
DF	CC1	20									
DP	-.1	0	1	2	3	4	5	6	7	8	
DP	9	10	11	12	13	14	15	16	17	18	
PC	0	10	28	54	70	84	90	95	97	99	
PC	100	100	100	100	100	100	100	100	100	100	

Table 2 Structure Inventory

File: COOP.I

SL	RCH11	237	623.5	623.4	1
SD	RCH11	237RESIDENTRS1	70RC1 35		2920 BRISTOL ST
SO	RCH11	237			27220 624.3
SL	RCH11	240	624.2	624.3	1
SD	RCH11	240RESIDENTRS1	65RC1 32.5		2919 BRISTOL ST
SO	RCH11	240			27375 624.5
SL	RCH11	566	623.7	622.4	1
SD	RCH11	566RESIDENTRS1	70RC1 35.0		2921 BRISTOL ST
SO	RCH11	566			27265 623.1
SL	RCH11	241	624.5	624.8	1
SD	RCH11	241RESIDENTRS1	65RC1 32.5		3917 BRISTOL ST
SO	RCH11	241			27450 624.7
SL	RCH11	242	624.7	624.2	1
SD	RCH11	242RESIDENTRS1	65RC1 32.5		2915 BRISTOL ST
SO	RCH11	242			27500 623.9
SL	RCH11	568	624.9	625.4	1
SD	RCH11	568RESIDENTRS1	70RC1 35.0		2913 BRISTOL ST
SO	RCH11	568			27555 624.9
SL	RCH11	285	622.4	621.3	1
SD	RCH11	285RESIDENTRS1	80RC1 40.0		1406 CHURCHILL ST.
SO	RCH11	285			26909 623.3
SL	RCH11	301	622.8	622.0	1
SD	RCH11	301RESIDENTRS1	80RC1 40.0		1402 CHURCHILL ST.
SO	RCH11	301			27070 623.6
SL	RCH11	311	623.3	622.9	1
SD	RCH11	311RESIDENTRS1	80RC1 40.0		1324 CHURCHILL DR.
SO	RCH11	311			27180 624.0
SL	RCH11	315	623.8	623.4	1
SD	RCH11	315RESIDENTRS1	90RC1 45.0		1320 CHURCHILL DR.
SO	RCH11	315			27290 624.0
SL	RCH11	322	624.3	623.4	1
SD	RCH11	322RESIDENTRS1	75RC1 37.5		1314 CHURCHILL DR.
SO	RCH11	322			27400 623.5
SL	RCH11	327	624.8	624.3	1
SD	RCH11	327RESIDENTRS1	75RC1 37.5		1310 CHURCHILL DR.
SO	RCH11	327			27530 623.9
SL	RCH11	328	625.3	625.2	1
SD	RCH11	328RESIDENTRS1	75RC1 37.5		1306 CHURCHILL DR.
SO	RCH11	328			27660 624.3
SL	RCH11	571	625.4	622.4	1
SD	RCH11	571 SCHOOLSS1	200SC1 60.0		1304 CHURCHILL DR.
SO	RCH11	571			27690 621.4
SL	RCH12	351	626.7	626.4	1
SD	RCH12	351 CHURCHCS1	250CC1 80.0		3105 HEATHER LN.
SO	RCH12	351			27970 630.3
SL	RCH12	364	628.7	627.6	1
SD	RCH12	364RESIDENTRS1	70RC1 35.0		3110 HEATHER LN.
SO	RCH12	364			28270 629.5
SL	RCH12	367	629.2	628.4	1
SD	RCH12	367RESIDENTRS1	70RC1 35.0		3114 HEATHER LN.
SO	RCH12	367			28340 629.8
SL	RCH12	370	629.7	629.2	1
SD	RCH12	370RESIDENTRS1	70RC1 35.0		3116 HEATHER LN.
SO	RCH12	370			28415 630.1
SL	RCH12	373	630.2	629.5	1
SD	RCH12	373RESIDENTRS1	70RC1 35.0		3118 HEATHER ST.
SO	RCH12	373			28490 629.9
SL	RCH12	374	630.6	629.5	1
SD	RCH12	374RESIDENTRS1	95RC1 45.0		3202 HEATHER LN.
SO	RCH12	374			28550 629.5
SL	RCH12	375	630.7	630.5	1
SD	RCH12	375RESIDENTRS1	60RC1 30.0		3206 HEATHER LN.
SO	RCH12	375			28570 630.4
SL	RCH12	376	630.7	631.2	1
SD	RCH12	376RESIDENTRS1	60RC1 30.0		3208 HEATHER LN.
SO	RCH12	376			28570 631.1
SL	RCH12	387	631.3	630.8	1
SD	RCH12	387RESIDENTRS1	70RC1 35.0		3205 HEATHER LN.
SO	RCH12	387			28680 630.1
SL	RCH12	388	631.3	631.4	1

SD	RCH12	388RESIDENTRS1	60RC1 30.0		3207 HEATHER LN.		
SO	RCH12	388				28680	630.7
SL	RCH12	389	631.3	631.8	1		
SD	RCH12	389RESIDENTRS1	60RC1 30.0		3209 HEATHER LN.		
SO	RCH12	389				28680	631.1
SL	RCH13	416	636.0	634.9	1		
SD	RCH13	416GAS STATGS1	150GC1 45.0		1101 MONTERRY ST.		
SO	RCH13	416				29030	634.9
SL	RCH13	417	636.0	636.6	1		
SD	RCH13	417RESIDENTRS1	60RC1 30.0		1021 MONTERRY ST.		
SO	RCH13	417				29030	636.6
SL	RCH13	418	636.1	636.7	1		
SD	RCH13	418RESIDENTRS1	75RC1 37.5		1013 MONTERRY ST.		
SO	RCH13	418				29250	636.6
SL	RCH13	419	636.2	635.7	1		
SD	RCH13	419RESIDENTRS1	60RC1 30.0		1009 MONTERRY ST.		
SO	RCH13	419				29460	635.5
SL	RCH13	420	636.2	635.6	1		
SD	RCH13	420RESIDENTRS1	60RC1 30.0		1005 MONTERRY ST.		
SO	RCH13	420				29460	635.4
SL	RCH13	421	636.3	636.3	1		
SD	RCH13	421RESIDENTRS1	75RC1 37.5		1001 MONTERRY ST.		
SO	RCH13	421				29640	636.0
SL	RCH13	441	636.3	637.0	1		
SD	RCH13	441RESIDENTRS1	60RC1 30.0		1000 MANHATTEN		
SO	RCH13	441				29640	636.7
SL	RCH13	442	636.2	636.4	1		
SD	RCH13	442RESIDENTRS1	60RC1 30.0		1004 MANHATTEN		
SO	RCH13	442				29460	636.2
SL	RCH13	443	636.1	636.0	1		
SD	RCH13	443RESIDENTRS1	60RC1 30.0		1008 MANHATTEN		
SO	RCH13	443				29250	635.9
SL	RCH13	444	636.1	636.2	1		
SD	RCH13	444RESIDENTRS1	84RC1 42.0		1014 MANHATTEN		
SO	RCH13	444				29250	636.1
SL	RCH13	445	636.0	635.1	1		
SD	RCH13	445RESIDENTRS1	60RC1 30.0		1018 MANHATTEN		
SO	RCH13	445				29030	635.1
SL	RCH13	446	636.0	635.2	1		
SD	RCH13	446RESIDENTRS1	75RC1 37.5		1100 MANHATTEN		
SO	RCH13	446				29030	635.2
SL	RCH13	447	636.0	633.9	1		
SD	RCH13	447RESIDENTRS1	60RC1 30.0		1104 MANHATTEN		
SO	RCH13	447				29030	633.9
SL	RCH13	448	636.0	635.4	1		
SD	RCH13	448RESIDENTRS1	60RC1 30.0		1109 MANHATTEN		
SO	RCH13	448				29030	635.4
SL	RCH13	449	636.0	635.3	1		
SD	RCH13	449RESIDENTRS1	60RC1 30.0		1105 MANHATTEN		
SO	RCH13	449				29030	635.3
SL	RCH13	450	636.0	635.4	1		
SD	RCH13	450RESIDENTRS1	60RC1 30.0		1101 MANHATTEN		
SO	RCH13	450				29030	635.4
SL	RCH13	451	636.0	635.0	1		
SD	RCH13	451RESIDENTRS1	60RC1 30.0		1021 MANHATTEN		
SO	RCH13	451				29030	635.0
SL	RCH13	452	636.0	634.9	1		
SD	RCH13	452RESIDENTRS1	60RC1 30.0		1017 MANHATTEN		
SO	RCH13	452				29030	634.9
SL	RCH13	453	636.1	634.8	1		
SD	RCH13	453RESIDENTRS1	60RC1 30.0		1013 MANHATTEN		
SO	RCH13	453				29250	634.7
SL	RCH13	454	636.1	635.3	1		
SD	RCH13	454RESIDENTRS1	60RC1 30.0		1009 MANHATTEN		
SO	RCH13	454				29250	635.2

```
T1      COOPER CREEK      DENTON, TEXAS
T2      INPUT DECK PLAN1.S
T3      BASE CONDITION - ALSO USED FOR CHANNEL IMP., RES ALT.
J1                                                              8
```

J2 NODF	NODC	NODR	AGG	NFILE	IMAGE	IELV	IMARK	NDFILE

ZW__________

DC __________

DC __________

DC __________

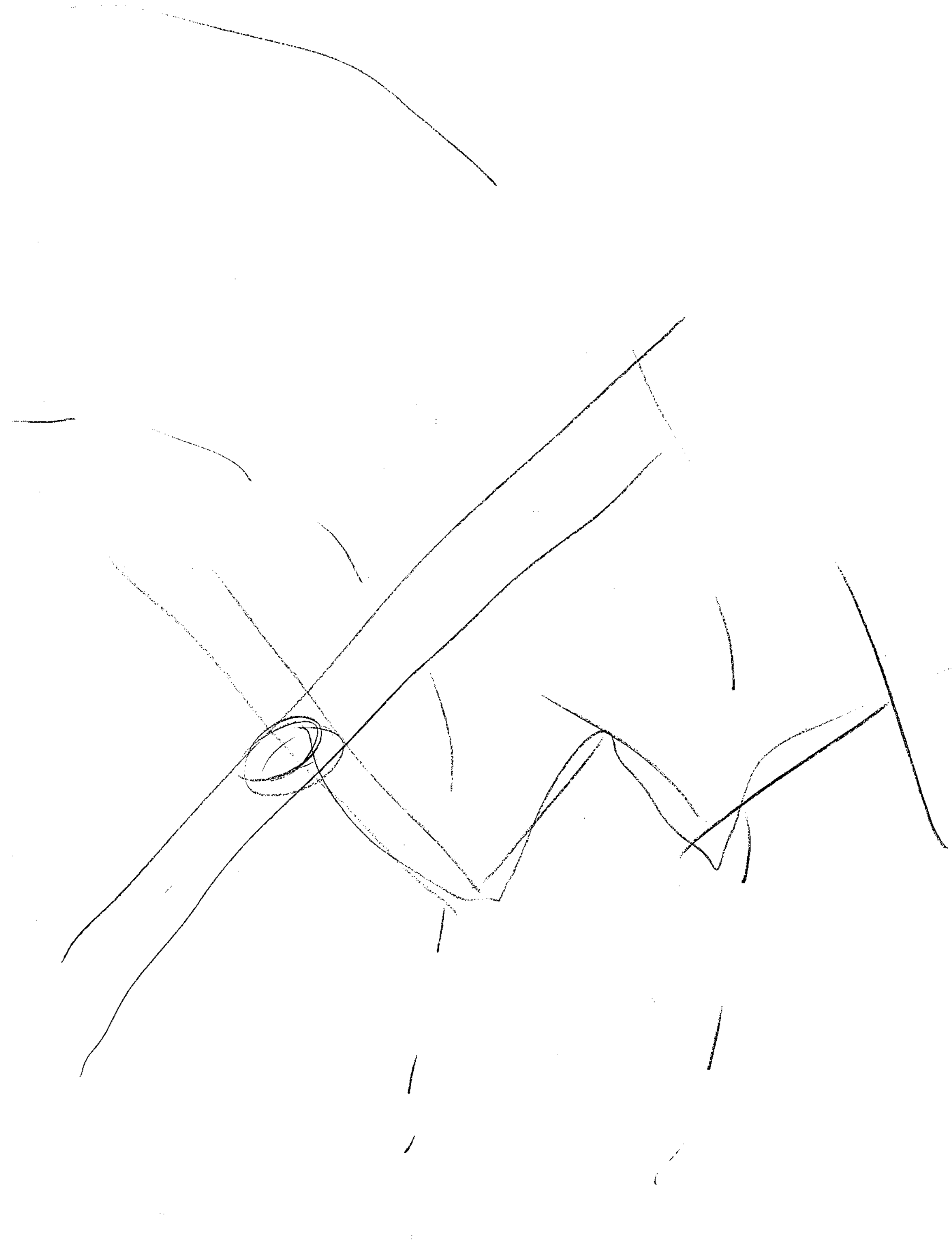
DC __________

```
DR RCH11    624.4
DT       WINDSOR STREET(STATION 26927) TO STATION 27890        INDEX 27415
SE 620.2   622.0   623.0   623.5   624.1  624.38   624.7   625.4

DR RCH12    630.6
DT       STATION 27890 TO SHERMAN DRIVE(STATION 28896)         INDEX 28550
SE 626.5   628.1   629.1   629.7   630.3  630.61   630.9   631.5

DR RCH13    636.0
DT       STATION 28896 TO 29390   INDEX 29032
SE 629.7   631.5   634.8   635.3   635.7  636.01   636.3   636.8
ST  1 YR    2 YR    5 YR   10 YR   25 YR   50 YR  100 YR  500 YR
ES
```

```
TT      American River Study
TT      November 1989;  Damage in millions of dollars
TT      Master EAD Run --- All damage reaches
J1   100     1989     2001     1989        0        0
J2 8.875     .000     .000    1.000
CN    12      RES    RES-C      OFF     COMM       MH     MH-C      IND      PUB    ROADS
CN         EMRGNC     AUTO    OTHER
PN     1 EXISTING
DY     6     1989     1995     2000     2010     2020     2045
PP                       3        0        0
RN NATOMAS;  SOUTHERN NATOMAS
ZW    A=NATOMAS  C=FREQ-DAMAGE
FR   1NA       17       20       10   9.0909   1.6667   1.4286     1.25   1.1111      1.0
FR .9091    .8333    .7692    .6667    .6250    .6211    .5000    .4975    .2500
ZR A=NATOMAS B=1NA C=SF E=1989 F=EXISTING
RV    FR     1989        1     1989                 3     1.67
ZR   C=SD
ZR   C=SD  E=2045
ZR   C=SD  E=1989 F=EXISTING ROAD
ZR   C=SD  F=EXISTING EMERGENCY
ZR   C=SD  F=EXISTING AUTO
ER     1
RN NATOMAS;  MID NATOMAS
ZW    A=NATOMAS  C=FREQ-DAMAGE
ZR A=NATOMAS B=2NA C=SF E=1989 F=EXISTING
RV    FR     1989        1     1989                 3     1.67
ZR   C=SD
ZR   C=SD  E=2045
ZR   C=SD  E=1989  F=EXISTING ROAD
ZR   C=SD  F=EXISTING EMERGENCY
ZR   C=SD  F=EXISTING AUTO
ER     1
RN NATOMAS;  AIRPORT & VICINITY
ZW    A=NATOMAS  C=FREQ-DAMAGE
ZR A=NATOMAS B=3NA C=SF E=1989 F=EXISTING
RV    FR     1989        1     1989                 3     1.67
ZR   C=SD
ZR   C=SD  E=2045
ZR   C=SD  E=1989 F=EXISTING ROAD
ZR   C=SD  F=EXISTING EMERGENCY
ZR   C=SD  F=EXISTING AUTO
ER     1
RN NATOMAS;  NORTHERN NATOMAS
ZW    A=NATOMAS  C=FREQ-DAMAGE
ZR A=NATOMAS B=4NA C=SF E=1989 F=EXISTING
RV    FR     1989        1     1989                 3     1.67
ZR   C=SD
ZR   C=SD  E=2045
ZR   C=SD  E=1989  F=EXISTING ROAD
ZR   C=SD  F=EXISTING EMERGENCY
ZR   C=SD  F=EXISTING AUTO
ER     1
RN DRY CREEK;  KEYS RD TO SANKY RD
ZW    A=DRY CREEK  C=FREQ-DAMAGE
ZR A=DRY CREEK B=5KS C=SF E=1989 F=EXISTING
```



Workshop Problem

APPLICATION OF THE EAD PROGRAM WITH EXPANDED CAPABILITIES

Purpose

The purpose of the workshop is to give the class participant experience in using some of the "expanded" capabilities of the EAD program including:

- Reading data from a DSS data file
- Writing data to a DSS data file

Problem Description

We wish to compute expected annual damage for reaches 11, 12, and 13 in the Cooper Creek Basin. We will use the DSS system to retrieve pertinent functions for input to the EAD program. The specific files that we will use are:

EAD input data file	COOP.E
EAD output results	COOP.EO
~~EAD JCL file . . . .~~	~~J.EAD~~
HECDSS data file	COO.DSS

Frequency-discharge curves have already been computed by HEC-1 and stored in the DSS file. The curves have been computed for the base condition, and two alternative ungated reservoirs - one having a spillway elevation of 650 feet and one of 655 feet.

The elevation-flow rating curves have already been computed using HEC-2 and stored in the DSS file. The curves have been computed for the base condition, and one channel improvement measure. The bottom width of the channel improvement is 40 feet.

The elevation-damage functions were computed in the previous workshop using the SID program and they were stored in the DSS file. The functions were computed for base condition and one floodproofing plan. All structures were floodproofed to the 2% chance exceedance elevation.

The objective of this workshop is to compute expected annual damage for reaches 11, 12, and 13, and plans 1,2,3,5, and 6 as outlined in the handout on Cooper Creek.

Tasks

1. Edit the EAD input data file to retrieve frequency-flow, elevation- flow, and elevation damage relationships from the DSS data file and compute expected annual damage for reaches 11, 12, and 13, and for plans 1,2,3,5, and 6.

   a. The enclosed catalog listing documents the pathnames contained in the DSS data file. You may use it to help you determine pathname parts. The list below may also help you to determine pathname parts.

      Part A:
      All Pathnames
      A=COOPER CREEK

      Part B:
      HEC-1
      B=2A (reach 13)
      B=3B (reaches 11 & 12)

      HEC-2
      B=RCH11 (reach 11)
      B=RCH12 (reach 12)
      B=RCH13 (reach 13)

      SID
      B=RCH11 (reach 11)
      B=RCH12 (reach 12)
      B=RCH13 (reach 13)

      Part E:
      All programs, part left blank
      E=*[blank]*

      Part F:
      All programs
      F=BASE (plan 1)
      F=UNGTD SPILL 650 (plan 2)
      F=UNGTD SPILL 655 (plan 3)
      F=CHIMP 40FT (plan 5)
      F=FP-2% (plan 6)

   b. The damage category names correspond to those used in the SID workshop. Enter those same names on the CN record.

   c. Enter the proper ZR records to retrieve the functions from the DSS data file "COO.DSS". The input data file COOP.E already contains complete ZR records for all plans and reaches except for the plan 1 (base condition) and plan 6 (floodproofing plan).

   d. Enter the proper ZW records to write the following data to the DSS data file:

      REACH-EAD
      FREQ-DAMAGE
      PLAN-EAD

   d. We will <u>not</u> compute the equivalent expected annual damage.

e. Execute the EAD program with your data (On the Harris, submit your EAD run by entering "IJ J.EAD").

The input data file for the EAD program is listed below. All of the necessary input data is entered except for:

- Damage category names on the CN record.
- Exceedance probabilities on the FR records.
- DONE Information on the ZW records to write results to the DSS data file.
- Information on the ZR records to retrieve the following information:

Reach	Plan
11	BASE (all information)
11	2% floodproofing (plan 6)
11,12,13	All information for retrieving the elevation-damage curves.

The required records are supplied below. You only need enter the necessary information as described above.

```
TT      COOPER CREEK    DENTON, TEXAS
TT      INPUT DECK COOP.E
TT      DSS UTILIZATION = HEC-1, HEC-2, SID  =  FIVE PLANS
TT
TT
```

ZW A= COOPER CREEK C= REACH - EAD

ZW A= COOPER CREEK C= PLAN - EAD

ZW.E A= COOPER CREEK C= FREQ - DAMAGE

TT
TT

CN									
4	RESIDENT	GAS STAT	SCHOOL	CHURCH					
NCAT	$NMCAT_1$	$NMCAT_2$	$NMCAT_3$	$NMCAT_4$	$NMCAT_5$	$NMCAT_6$	$NMCAT_i$		

```
TT
PN    1        EXISTING COND. - USES BASE QF,QS,DG DATA
PN    2        RESERVOIR - USES BASE QS,DG DATA - UNGTD RES (650) QF DATA
PN    3        RESERVOIR - USES BASE QS,DG DATA - UNGTD RES (655) QF DATA
PN    5        CHANNEL - USES BASE QF,DG DATA - CHANNEL QS DATA
PN    6        FLOOD-PROOFING-USES BASE QF,QS DATA-FLOODPROOFING DG DATA
RN      DAMAGE REACH 11
```

FR									
RCH11	8	99	50	20	10	4	2	1	0.2
IRCH	NFRQ	$FREQ_1$	$FREQ_2$	$FREQ_3$	$FREQ_4$	$FREQ_5$	$FREQ_6$	$FREQ_7$	$FREQ_8$

FR									
$FREQ_9$	$FREQ_{10}$	$FREQ_{11}$	$FREQ_{12}$	$FREQ_{13}$	$FREQ_{14}$	$FREQ_{15}$	$FREQ_{16}$	$FREQ_{17}$	$FREQ_{18}$

ZR A= COOPER CREEK B= RCH11 C= QF E= — F= BASE

ZR A= 〃 B= 〃 C= QS E= F= BASE

ZR A= 〃 B= 〃 C= SD E= F= BASE

EP 1

```
ZR A=COOPER CREEK   B=3B       C=QF       F=UNGTD SPILL 650
EP      2
ZR A=COOPER CREEK   B=3B       C=QF       F=UNGTD SPILL 655
EP      3
ZR A=COOPER CREEK   B=3B       C=QF       F=BASE
ZR                  B=RCH11    C=QS       F=CHIMP 40FT
EP      5
```

ZR A= B= C= E= F=

ZR A= B= C= E= F=

```
ER      6
RN        DAMAGE REACH 12
ZR                  B=3B       C=QF       F=BASE
ZR                  B=RCH12    C=QS       F=BASE
```

ZR A= B= C= E= F=

```
EP      1
ZR                  B=3B       C=QF       F=UNGTD SPILL 650
EP      2
ZR                  B=3B       C=QF       F=UNGTD SPILL 655
EP      3
ZR                  B=3B       C=QF       F=BASE
ZR                  B=RCH12    C=QS       F=CHIMP 40FT
EP      5
ZR                  B=RCH12    C=QS       F=BASE
```

ZR A= B= C= E= F=

```
ER      6
```

```
RN        DAMAGE REACH 13
ZR                        B=2A        C=QF        F=BASE
ZR                        B=RCH13     C=QS        F=BASE
```

ZR	A=	B=	C=	E=	F=
EP	1				
ZR		B=2A	C=QF		F=UNGTD SPILL 650
EP	2				
ZR		B=2A	C=QF		F=UNGTD SPILL 655
EP	3				
ZR		B=2A	C=QF		F=BASE
ZR		B=RCH13	C=QS		F=CHIMP 40FT
EP	5				
ZR		B=RCH13	C=QS		F=BASE

ZR	A=	B=	C=	E=	F=

EJ 6

HECDSS Complete Catalog of Record Pathnames for DSS File: COO.DSS

Catalog Date: 30JAN90 at 14:24; File Created on 17JAN90; DSS Version 5-CB
Number of Records: 47
Pathnames Not Sorted

Ref. No.	Prog	Last Written Date	Time	Ver	Head	Data	Record Pathname
1	PIP	17JAN90	11:41:59	1	34	40	/COOPER CREEK/2A/FREQ-FLOW///BASE-ORIGINAL/
2	PIP	17JAN90	11:41:59	1	34	40	/COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/
3	F2PO	23JAN90	15:28:15	4	18	40	/COOPER CREEK/RCH11/ELEV-FLOW///BASE/
4	F2PO	23JAN90	15:28:15	4	18	40	/COOPER CREEK/RCH12/ELEV-FLOW///BASE/
5	F2PO	23JAN90	15:28:15	4	18	40	/COOPER CREEK/RCH13/ELEV-FLOW///BASE/
6	F2PO	17JAN90	11:42:06	1	18	40	/COOPER CREEK/RCH11/ELEV-FLOW///CHIMP 40FT/
7	F2PO	17JAN90	11:42:06	1	18	40	/COOPER CREEK/RCH12/ELEV-FLOW///CHIMP 40FT/
8	F2PO	17JAN90	11:42:06	1	18	40	/COOPER CREEK/RCH13/ELEV-FLOW///CHIMP 40FT/
9	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/2A/FREQ-FLOW///BASE/
10	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 650/
11	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 655/
12	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/3B/FREQ-FLOW///BASE/
13	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/
14	HEC1	07JAN87	08:37:39	2	18	36	/COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 655/
15	SID	23JAN90	15:46:51	12	82	280	/COOPER CREEK/RCH11/FF FLD ZONE-NO. STRUC///BASE/
16	SID	23JAN90	15:46:51	12	82	280	/COOPER CREEK/RCH12/FF FLD ZONE-NO. STRUC///BASE/
17	SID	23JAN90	15:46:51	12	82	280	/COOPER CREEK/RCH13/FF FLD ZONE-NO. STRUC///BASE/
18	SID	23JAN90	15:46:51	12	82	280	/COOPER CREEK/RCH11/ZERO DMG ZONE-NO. STRUC///BASE/
19	SID	23JAN90	15:46:51	12	82	280	/COOPER CREEK/RCH12/ZERO DMG ZONE-NO. STRUC///BASE/
20	SID	23JAN90	15:46:51	12	82	280	/COOPER CREEK/RCH13/ZERO DMG ZONE-NO. STRUC///BASE/
21	SID	23JAN90	15:46:51	12	82	280	/COOPER CREEK/RCH11/FF FLD ZONE-STRUC VALUE///BASE/
22	SID	23JAN90	15:46:51	12	82	280	/COOPER CREEK/RCH12/FF FLD ZONE-STRUC VALUE///BASE/
23	SID	23JAN90	15:46:51	12	82	280	/COOPER CREEK/RCH13/FF FLD ZONE-STRUC VALUE///BASE/
24	SID	23JAN90	15:40:06	5	50	216	/COOPER CREEK/RCH11/ELEVATION-DAMAGE///BASE/
25	SID	23JAN90	15:40:06	5	50	216	/COOPER CREEK/RCH12/ELEVATION-DAMAGE///BASE/
26	SID	23JAN90	15:40:06	5	50	216	/COOPER CREEK/RCH13/ELEVATION-DAMAGE///BASE/
27	SID	30JAN90	10:19:20	19	82	280	//RCH11/FF FLD ZONE-NO. STRUC////
28	SID	30JAN90	10:19:20	19	82	280	//RCH12/FF FLD ZONE-NO. STRUC////
29	SID	30JAN90	10:19:20	19	82	280	//RCH13/FF FLD ZONE-NO. STRUC////
30	SID	30JAN90	10:19:20	19	82	280	//RCH11/ZERO DMG ZONE-NO. STRUC////
31	SID	30JAN90	10:19:20	19	82	280	//RCH12/ZERO DMG ZONE-NO. STRUC////
32	SID	30JAN90	10:19:20	19	82	280	//RCH13/ZERO DMG ZONE-NO. STRUC////
33	SID	30JAN90	10:19:20	19	82	280	//RCH11/FF FLD ZONE-STRUC VALUE////
34	SID	30JAN90	10:19:20	19	82	280	//RCH12/FF FLD ZONE-STRUC VALUE////
35	SID	30JAN90	10:19:20	19	82	280	//RCH13/FF FLD ZONE-STRUC VALUE////
36	SID	30JAN90	10:28:57	2	82	280	/COOPER CREEK/RCH11/FF FLD ZONE-NO. STRUC///FP-2%/
37	SID	30JAN90	10:28:57	2	82	280	/COOPER CREEK/RCH12/FF FLD ZONE-NO. STRUC///FP-2%/
38	SID	30JAN90	10:28:57	2	82	280	/COOPER CREEK/RCH13/FF FLD ZONE-NO. STRUC///FP-2%/
39	SID	30JAN90	10:28:57	2	82	280	/COOPER CREEK/RCH11/ZERO DMG ZONE-NO. STRUC///FP-2%/
40	SID	30JAN90	10:28:57	2	82	280	/COOPER CREEK/RCH12/ZERO DMG ZONE-NO. STRUC///FP-2%/
41	SID	30JAN90	10:28:57	2	82	280	/COOPER CREEK/RCH13/ZERO DMG ZONE-NO. STRUC///FP-2%/
42	SID	30JAN90	10:28:57	2	82	280	/COOPER CREEK/RCH11/FF FLD ZONE-STRUC VALUE///FP-2%/
43	SID	30JAN90	10:28:57	2	82	280	/COOPER CREEK/RCH12/FF FLD ZONE-STRUC VALUE///FP-2%/
44	SID	30JAN90	10:28:57	2	82	280	/COOPER CREEK/RCH13/FF FLD ZONE-STRUC VALUE///FP-2%/
45	SID	30JAN90	10:28:57	1	50	228	/COOPER CREEK/RCH11/ELEVATION-DAMAGE///FP-2%/
46	SID	30JAN90	10:28:57	1	50	228	/COOPER CREEK/RCH12/ELEVATION-DAMAGE///FP-2%/
47	SID	30JAN90	10:28:57	1	50	228	/COOPER CREEK/RCH13/ELEVATION-DAMAGE///FP-2%/

2. Do the following tasks. On the Harris, you can do them while waiting for the EAD execution to complete.

   a. Use DSPLAY to compare the frequency curves computed by HEC-1 with the original base condition frequency curve. (In the FDA course, you entered it with the PIP program on Tuesday. Otherwise, the original curve was entered by the instructor.) The original curve is entered using pathname part F of "BASE-ORIGINAL". Use the logrithmic transformation for each "curve":

      On the Harris, execute DSPLAY by entering:
      $MO PS=500
      HLIB*DSPLAY

      The following is a schematic of the DSPLAY input data:
      (enter DSS file name)
      AX,LIN,LOG,LOG,LOG
      PA,i_1
      PA,i_2
      PA,...
      PL

      How do the two baseline condition curves compare?

   b. Use DSPLAY to plot the residential elevation-damage function for reaches 11, 12, and 13 for baseline conditions on the same plot. (Use the "CUrve" command). Don't forget to remove the logarithmic transformation you declared above.

      AX,LIN,LIN,LIN,LIN
      CU,1
      PA,i_1
      PA,i_2
      PA,i_3
      PL

   c. Use DSPLAY to plot damage for all categories for reach 11 for baseline conditions.

   d. What is the damage associated with the elevation of 625 in reach 11 for residential properties?

   e. Does the elevation-damage function for residential properties extend to a low enough elevation for reach 11?

3. When your EAD execution terminates (successfully we hope), check the output file (COOP.EO) to see if you have a successful run. On the Harris, get a printout by entering:

PRINT COOP.EO

If unsuccessful, correct any errors and resubmit.

Look at your EAD output and answer the following questions:

a. What is the residential expected annual damage for plan 3 in reach 12?

b. Which damage reach had the most reduction in residential expected annual damage for plan 5 (the channel improvement plan)?

c. Did you have any expected annual damage associated with the "OTHER" (or "mistakes") damage category?

d. Which plan produced the most reduction in expected annual damage for all three reaches?

e. Which plan produced the least reduction in expected annual damage for all three reaches?

f. Does the rating curve computed using HEC-2 extend below the lowest (most frequent) discharge value on the frequency function and above the highest (least frequent) discharge value on the frequency function for reach 11?

g. Does the elevation-damage function for residential properties extend to a high enough elevation for reach 11 (look at the frequency function)?

4. Review the computed results written to the DSS file by the EAD program by using the DSSUTL or DSPLAY programs.

a. Plot and tabulate the PLAN-EAD results (remember to get a new catalog listing "CA.N" and the "DP" display pathnames command. Compare this with the summary table in the EAD output.

b. Tabulate and plot the FREQ-DAMAGE data for residential damage in reaches 11, 12, and 13 for Plan 5. (You will need to know the "curve" associated with residential damage).

c. Tabulate and plot the FREQ-DAMAGE data for residential damage in reach 11 for plans 1 and 6 (Base and floodproofing). Do the curves seem reasonable?

Workshop Solution

APPLICATION OF SID WITH THE EXPANDED CAPABILITIES (DSS AND FUNCTION / STRUCTURE FILES)

Tasks

1. Edit the SID input data file for the base condition. Most of the input is supplied. You need to enter data on the J2, ZW, DC, and DR records. **Answering the following questions will help you complete your input.**

   a. How many damage functions are there? 8
   Enter this number in the appropriate field of the J2 record.

   b. How many damage categories are there? 4
   Enter this number in the appropriate field of the J2 record.

   c. What are the damage category names? Enter them in the spaces provided below. You must use 8 or less characters to define each damage category name.

Category number	Name
1	RESIDENT
2	GAS STAT
3	SCHOOL
4	CHURCH

   Enter the above names on the appropriate DC records.

   d. How many damage reaches are there? 3
   Enter this number in the appropriate field of the J2 record.

   e. What are the damage reach names? Enter them in the spaces provided below. You must use 6 or less characters to define each damage reach name.

Reach number	Name
1	RCH11
2	RCH12
3	RCH13

   f. Structure data is not included with the SID input data file which contains the job specification records. Modify the J2 record to reflect this.

   Define variable NFILE, field J2.5 to be "1".

g. Damage functions (depth-damage data) are not included with the SID input data file which contains the job specification records. They are resident on disk (unit 12) in record image format. Modify the J2 record to reflect this.

Define variable NDFILE, field J2.9 to be "2".

h. The aggregated elevation-damage relationship must be stored in the HECDSS data file.

What is part A of the HECDSS pathname? COOPER CREEK

What is part E of the HECDSS pathname? -

What is part F of the HECDSS pathname? BASE

Enter the HECDSS pathname parts on the ZW record.

i. For each reach, you must define the parameters which control the elevation ordinates (and the associated damage) used for printout and storage in the HECDSS data file. The starting elevation is the elevation at which the tabulation begins. The Tabulation Increment controls the difference between tabulation intervals. For example, if the starting elevation is 200 feet and the increment is 0.5 foot, the elevation-damage relationship would start at 200, the second ordinate would be elevation 200.5, the third ordinate wuld be elevation 201.0, etc. Fill out the table below and modify the appropriate DR records in the SID input data file.

Reach Identification	Starting Elevation	Tabulation Increment
RCH11	620	0.5
RCH12	626.5	0.5
RCH13	633.0	0.5

j. Calculate the aggregated elevation-damage relationship for the base condition by either:

- On the **Harris**, submiting a "batch" or control-point job using your edited SID input data set and the appropriate JCL file.
- On the **Personal Computer (MS-DOS)**, execute the program by pressing and holding the "Alt" key and the pressing the "X" key.

2. Create and edit the SID input data file for Plan 6. For Plan 6, we will floodproof ALL residential structures in reaches 11, 12, and 13 to the 2% chance exceedance frequency level. Copy your base condition SID input data file (PLAN1.S) into a new file which will be used for Plan 6. To do this, enter the following JCL:

COPY PLAN1.S PLAN6.S

Most of the input remains the same for Plan 6. You need to enter data on the J1, J5, ZW, and DR records. Answering the following questions will help you complete your input.

a. What variable on the J1 record allows us to specify the floodproofing operation? Enter the variable name:

IPROF

b. To floodproof all residential structures to the elevation associated with the 2% chance exceedance frequency water surface profile elevation, what value do we give the variable defined by the previous question?

Enter value: 1

c. Which SID input record is used to define the damage categories which are subject to floodproofing?

Enter record I.D.: J5

Add this record to the SID input data file and enter the appropriate values.

d. When storing the elevation-damage relationships for Plan 6 in the HECDSS data file, we must define a different pathname for it as compared to the base condition plan. Define your pathname parts below:

What is part A of the HECDSS pathname? COOPER CREEK

What is part E of the HECDSS pathname? -

What is part F of the HECDSS pathname? FP-2%

Enter the HECDSS pathname parts on the ZW record.

e. Which variable on the DR record allows us to define the elevation to which the structures are floodproofed?

Enter variable name: PROELV

The 2% chance exceedance elevations are entered on the SE records of the SID input data file and are used to compute single flood event damage (field J1.8, variable ITYPE, is non-zero). Look at the SE and ST records and fill out the table below.

Reach Name	Elevation of 2 percent chance exceedance event
RCH11	624.38
RCH12	630.61
RCH13	636.01

Enter these values in the appropriate field of the DR records.

f. To compute a modified elevation-damage relationship, do one of the following:

- On the Harris, submit the "batch" (or control point) job using the input data stored in the file PLAN6.S using the JCL file J6.SID.

- On the **Personal Computer (MS-DOS)**, execute the program by pressing and holding the "Alt" key and the pressing the "X" key.

3. Verify that both SID jobs executed properly. Peruse the output by listing or displaying at your terminal, or by spooling it to the printer (if available). Answer the following questions and perform the following tasks.

a. How much damage is associated with the 2% chance exceedance event **for the base condition**? Fill in the following table **for the base condition**.

Single Event Damage (in $1,000)

Damage Category

Reach Name	Residential	Service Station	Schools	Churches	Total
RCH11	127.9	0.0	33.9	0.0	161.7
RCH12	100.9	0.0	0.0	20.2	121.1
RCH13	176.8	8.0	0.0	0.0	184.9

b. Use DSPLAY (and DSSUTL, if you wish) to tabulate and plot the elevation-damage curves for base and floodproofing plans for each reach. Do they seem reasonable?

SID Input Data (Base Condition, PLAN1.S)

```
T1       COOPER CREEK     DENTON, TEXAS
T2       INPUT DECK PLAN1.S
T3       BASE CONDITION - ALSO USED FOR CHANNEL IMP., RES ALT.
J1                                                                    8
J2      8       4       3               1                                       2
DC       RESIDENT                 RESIDENTIAL
DC       GAS STAT                 GAS STATIONS
DC         SCHOOL                 SCHOOLS
DC         CHURCH                 CHURCHES
DR RCH11   624.4                               620       .5
DT       WINDSOR STREET(STATION 26927) TO STATION 27890       INDEX 27415
SE 620.2   622.0   623.0   623.5   624.1  624.38   624.7   625.4
DR RCH12   630.6                             626.5       .5
DT       STATION 27890 TO SHERMAN DRIVE(STATION 28896)        INDEX 28550
SE 626.5   628.1   629.1   629.7   630.3  630.61   630.9   631.5
DR RCH13   636.0                             629.5       .5
DT       STATION 28896 TO 29390   INDEX 29032
SE 629.7   631.5   634.8   635.3   635.7  636.01   636.3   636.8
ST  1 YR    2 YR    5 YR   10 YR   25 YR   50 YR  100 YR  500 YR
ES
```

SID Input Data (Flood Proofing Condition, PLAN6.S)

```
T1       COOPER CREEK     DENTON, TEXAS
T2       INPUT DECK PLAN6.S
T3       FLOODPROOFING TO 2%
J1              1                                                     8
J2      8       4       3               1                                       2
J5      1RESIDENT
ZW  A=COOPER CREEK  E=  F=FP-2%
DC       RESIDENT                 RESIDENTIAL
DC       GAS STAT                 GAS STATIONS
DC         SCHOOL                 SCHOOLS
DC         CHURCH                 CHURCHES
DR RCH11   624.4           624.38              620       .5
DT       WINDSOR STREET(STATION 26927) TO STATION 27890       INDEX 27415
SE 620.2   622.0   623.0   623.5   624.1  624.38   624.7   625.4
DR RCH12   630.6           630.61            626.5       .5
DT       STATION 27890 TO SHERMAN DRIVE(STATION 28896)        INDEX 28550
SE 626.5   628.1   629.1   629.7   630.3   630.61  630.9   631.5
DR RCH13   636.0           636.01            629.5       .5
DT       STATION 28896 TO 29390   INDEX 29032
SE 629.7   631.5   634.8   635.3   635.7  636.01   636.3   636.8
ST  1 YR    2 YR    5 YR   10 YR   25 YR   50 YR  100 YR  500 YR
ES
```

COOPER CREEK DENTON, TEXAS
INPUT DECK PLAN1.S
BASE CONDITION - ALSO USED FOR CHANNEL IMP., RES ALT.

Damage Reach RCH11
WINDSOR STREET(STATION 26927) TO STATION 27890 INDEX 27415
(Damages are in $1,000)

Damage Categories

Elevation	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER						Total
620.00	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
620.50	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
621.00	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
621.50	.0	.0	2.4	.0	.0	.0	.0	.0	.0	.0	2.4
622.00	.0	.0	12.0	.0	.0	.0	.0	.0	.0	.0	12.0
622.50	.0	.0	19.8	.0	.0	.0	.0	.0	.0	.0	19.8
623.00	.0	.0	21.2	.0	.0	.0	.0	.0	.0	.0	21.2
623.50	19.2	.0	23.4	.0	.0	.0	.0	.0	.0	.0	42.6
624.00	69.5	.0	29.2	.0	.0	.0	.0	.0	.0	.0	98.7
624.50	148.2	.0	35.4	.0	.0	.0	.0	.0	.0	.0	183.6
625.00	230.3	.0	42.4	.0	.0	.0	.0	.0	.0	.0	272.7
625.50	300.6	.0	49.2	.0	.0	.0	.0	.0	.0	.0	349.7
626.00	367.2	.0	55.2	.0	.0	.0	.0	.0	.0	.0	422.4
626.50	437.1	.0	61.4	.0	.0	.0	.0	.0	.0	.0	498.5
627.00	505.5	.0	68.4	.0	.0	.0	.0	.0	.0	.0	573.9
627.50	565.6	.0	74.3	.0	.0	.0	.0	.0	.0	.0	639.9
628.00	619.3	.0	77.0	.0	.0	.0	.0	.0	.0	.0	696.3
628.50	670.2	.0	79.3	.0	.0	.0	.0	.0	.0	.0	749.4
(1 YR)											
620.20	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
(2 YR)											
622.00	.0	.0	12.0	.0	.0	.0	.0	.0	.0	.0	12.0
(5 YR)											
623.00	.0	.0	21.2	.0	.0	.0	.0	.0	.0	.0	21.2
(10 YR)											
623.50	19.2	.0	23.4	.0	.0	.0	.0	.0	.0	.0	42.6
(25 YR)											
624.10	84.8	.0	30.4	.0	.0	.0	.0	.0	.0	.0	115.2
(50 YR)											
624.38	127.9	.0	33.9	.0	.0	.0	.0	.0	.0	.0	161.7
(100 YR)											
624.70	180.9	.0	38.2	.0	.0	.0	.0	.0	.0	.0	219.1
(500 YR)											
625.40	287.2	.0	47.9	.0	.0	.0	.0	.0	.0	.0	335.1

Workshop Solution

APPLICATION OF THE EAD PROGRAM WITH EXPANDED CAPABILITIES

Tasks

1. Edit the EAD input data file to retrieve frequency-flow, elevation- flow, and elevation damage relationships from the DSS data file and compute expected annual damage for reaches 11, 12, and 13, and for plans 1,2,3,5, and 6.

```
TT       COOPER CREEK    DENTON, TEXAS
TT       INPUT DECK COOP.E
TT       DSS UTILIZATION = HEC-1, HEC-2, SID  =  FIVE PLANS
TT
ZW  A=COOPER CREEK C=REACH-EAD
ZW  A=COOPER CREEK C=PLAN-EAD
ZW.E  A=COOPER CREEK C=FREQ-DAMAGE
TT
TT
CN      5RESIDENTGAS STAT  SCHOOL  CHURCH   OTHER
TT
PN      1         EXISTING COND. - USES BASELINE QF,QS,DG DATA
PN      2         RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
PN      3         RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
PN      5         CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
PN      6         FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA
TT
RN       DAMAGE REACH 11
FR              16       99       60       50       40       30       20       15       10
FR      7        5        3        2        1       .5       .2       .1
ZR  A=COOPER CREEK B=3B    C=QF F=BASE
ZR                 B=RCH11 C=QS
ZR                         C=SD
EP      1
ZR A=COOPER CREEK B=3B    C=QF F=UNGTD SPILL 650
EP      2
ZR A=COOPER CREEK B=3B    C=QF F=UNGTD SPILL 655
EP      3
ZR A=COOPER CREEK B=3B    C=QF F=BASE
ZR                B=RCH11 C=QS F=CHIMP 40FT
EP      5
ZR                B=RCH11 C=QS F=BASE
ZR                        C=SD F=FP-2%
ER      6
```

```
RN      DAMAGE REACH 12
ZR                      B=3B    C=QF F=BASE
ZR                      B=RCH12 C=QS F=BASE
ZR                              C=SD
-----------------------------------------------------------------
EP      1
ZR                      B=3B    C=QF F=UNGTD SPILL 650
EP      2
ZR                      B=3B    C=QF F=UNGTD SPILL 655
EP      3
ZR                      B=3B    C=QF F=BASE
ZR                      B=RCH12 C=QS F=CHIMP 40FT
EP      5
ZR                      B=RCH12 C=QS F=BASE
ZR                              C=SD F=FP-2%
-----------------------------------------------------------------
ER      6
RN      DAMAGE REACH 13
ZR                      B=2A    C=QF F=BASE
ZR                      B=RCH13 C=QS F=BASE
ZR                              C=SD
-----------------------------------------------------------------
EP      1
ZR                      B=2A    C=QF F=UNGTD SPILL 650
EP      2
ZR                      B=2A    C=QF F=UNGTD SPILL 655
EP      3
ZR                      B=2A    C=QF F=BASE
ZR                      B=RCH13 C=QS F=CHIMP 40FT
EP      5
ZR                      B=RCH13 C=QS F=BASE
ZR                              C=SD F=FP-2%
-----------------------------------------------------------------
EJ      6
```

HECDSS Complete Catalog of Record Pathnames for DSS File: COO.DSS

Catalog Date: 30JAN90 at 16:26; File Created on 17JAN90; DSS Version 5-DA
Number of Records: 69
Pathnames Not Sorted

Ref. No.	Prog	Last Written Date	Time	Ver	Head	Data	Record Pathname
1	PIP	17JAN90	11:41:59	1	34	40	/COOPER CREEK/2A/FREQ-FLOW///BASE-ORIGINAL/
2	PIP	17JAN90	11:41:59	1	34	40	/COOPER CREEK/3B/FREQ-FLOW///BASE-ORIGINAL/
3	F2PO	23JAN90	15:28:15	1	18	40	/COOPER CREEK/RCH11/ELEV-FLOW///BASE/
4	F2PO	23JAN90	15:28:15	1	18	40	/COOPER CREEK/RCH12/ELEV-FLOW///BASE/
5	F2PO	23JAN90	15:28:15	1	18	40	/COOPER CREEK/RCH13/ELEV-FLOW///BASE/
6	F2PO	17JAN90	11:42:06	1	18	40	/COOPER CREEK/RCH11/ELEV-FLOW///CHIMP 40FT/
7	F2PO	17JAN90	11:42:06	1	18	40	/COOPER CREEK/RCH12/ELEV-FLOW///CHIMP 40FT/
8	F2PO	17JAN90	11:42:06	1	18	40	/COOPER CREEK/RCH13/ELEV-FLOW///CHIMP 40FT/
9	HEC1	30JAN90	16:06:54	1	34	36	/COOPER CREEK/2A/FREQ-FLOW///BASE/
10	HEC1	07JAN87	08:37:39	1	18	36	/COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 650/
11	HEC1	07JAN87	08:37:39	1	18	36	/COOPER CREEK/2A/FREQ-FLOW///UNGTD SPILL 655/
12	HEC1	30JAN90	16:06:54	1	34	36	/COOPER CREEK/3B/FREQ-FLOW///BASE/
13	HEC1	07JAN87	08:37:39	1	18	36	/COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 650/
14	HEC1	07JAN87	08:37:39	1	18	36	/COOPER CREEK/3B/FREQ-FLOW///UNGTD SPILL 655/
15	SID	23JAN90	15:46:51	1	82	280	/COOPER CREEK/RCH11/FF FLD ZONE-NO. STRUC///BASE/
16	SID	23JAN90	15:46:51	1	82	280	/COOPER CREEK/RCH12/FF FLD ZONE-NO. STRUC///BASE/
17	SID	23JAN90	15:46:51	1	82	280	/COOPER CREEK/RCH13/FF FLD ZONE-NO. STRUC///BASE/
18	SID	23JAN90	15:46:51	1	82	280	/COOPER CREEK/RCH11/ZERO DMG ZONE-NO. STRUC///BASE/
19	SID	23JAN90	15:46:51	1	82	280	/COOPER CREEK/RCH12/ZERO DMG ZONE-NO. STRUC///BASE/
20	SID	23JAN90	15:46:51	1	82	280	/COOPER CREEK/RCH13/ZERO DMG ZONE-NO. STRUC///BASE/
21	SID	23JAN90	15:46:51	1	82	280	/COOPER CREEK/RCH11/FF FLD ZONE-STRUC VALUE///BASE/
22	SID	23JAN90	15:46:51	1	82	280	/COOPER CREEK/RCH12/FF FLD ZONE-STRUC VALUE///BASE/
23	SID	23JAN90	15:46:51	1	82	280	/COOPER CREEK/RCH13/FF FLD ZONE-STRUC VALUE///BASE/
24	SID	23JAN90	15:40:06	1	50	216	/COOPER CREEK/RCH11/ELEVATION-DAMAGE///BASE/
25	SID	23JAN90	15:40:06	1	50	216	/COOPER CREEK/RCH12/ELEVATION-DAMAGE///BASE/
26	SID	23JAN90	15:40:06	1	50	216	/COOPER CREEK/RCH13/ELEVATION-DAMAGE///BASE/
27	SID	30JAN90	10:19:20	1	82	280	//RCH11/FF FLD ZONE-NO. STRUC////
28	SID	30JAN90	10:19:20	1	82	280	//RCH12/FF FLD ZONE-NO. STRUC////
29	SID	30JAN90	10:19:20	1	82	280	//RCH13/FF FLD ZONE-NO. STRUC////
30	SID	30JAN90	10:19:20	1	82	280	//RCH11/ZERO DMG ZONE-NO. STRUC////
31	SID	30JAN90	10:19:20	1	82	280	//RCH12/ZERO DMG ZONE-NO. STRUC////
32	SID	30JAN90	10:19:20	1	82	280	//RCH13/ZERO DMG ZONE-NO. STRUC////
33	SID	30JAN90	10:19:20	1	82	280	//RCH11/FF FLD ZONE-STRUC VALUE////
34	SID	30JAN90	10:19:20	1	82	280	//RCH12/FF FLD ZONE-STRUC VALUE////
35	SID	30JAN90	10:19:20	1	82	280	//RCH13/FF FLD ZONE-STRUC VALUE////
36	SID	30JAN90	10:28:57	1	82	280	/COOPER CREEK/RCH11/FF FLD ZONE-NO. STRUC///FP-2%/
37	SID	30JAN90	10:28:57	1	82	280	/COOPER CREEK/RCH12/FF FLD ZONE-NO. STRUC///FP-2%/
38	SID	30JAN90	10:28:57	1	82	280	/COOPER CREEK/RCH13/FF FLD ZONE-NO. STRUC///FP-2%/
39	SID	30JAN90	10:28:57	1	82	280	/COOPER CREEK/RCH11/ZERO DMG ZONE-NO. STRUC///FP-2%/
40	SID	30JAN90	10:28:57	1	82	280	/COOPER CREEK/RCH12/ZERO DMG ZONE-NO. STRUC///FP-2%/
41	SID	30JAN90	10:28:57	1	82	280	/COOPER CREEK/RCH13/ZERO DMG ZONE-NO. STRUC///FP-2%/
42	SID	30JAN90	10:28:57	1	82	280	/COOPER CREEK/RCH11/FF FLD ZONE-STRUC VALUE///FP-2%/
43	SID	30JAN90	10:28:57	1	82	280	/COOPER CREEK/RCH12/FF FLD ZONE-STRUC VALUE///FP-2%/
44	SID	30JAN90	10:28:57	1	82	280	/COOPER CREEK/RCH13/FF FLD ZONE-STRUC VALUE///FP-2%/
45	SID	30JAN90	10:28:57	1	50	228	/COOPER CREEK/RCH11/ELEVATION-DAMAGE///FP-2%/
46	SID	30JAN90	10:28:57	1	50	228	/COOPER CREEK/RCH12/ELEVATION-DAMAGE///FP-2%/
47	SID	30JAN90	10:28:57	1	50	228	/COOPER CREEK/RCH13/ELEVATION-DAMAGE///FP-2%/
48	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 1/
49	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 2/
50	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 3/
51	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 5/
52	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 6/
53	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 1/
54	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 2/
55	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 3/
56	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 5/
57	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 6/

58	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 1/
59	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 2/
60	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 3/
61	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 5/
62	EAD	30JAN90	14:49:09	1	66	3020	/COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 6/
63	EAD	30JAN90	14:49:09	1	50	42	/COOPER CREEK/RESIDENT/REACH-EAD////
64	EAD	30JAN90	14:49:09	1	50	42	/COOPER CREEK/GAS STAT/REACH-EAD////
65	EAD	30JAN90	14:49:09	1	50	42	/COOPER CREEK/SCHOOL/REACH-EAD////
66	EAD	30JAN90	14:49:09	1	50	42	/COOPER CREEK/CHURCH/REACH-EAD////
67	EAD	30JAN90	14:49:09	1	50	42	/COOPER CREEK/OTHER/REACH-EAD////
68	EAD	30JAN90	14:49:09	1	50	42	/COOPER CREEK/ALL CATEGORIES/REACH-EAD////
69	EAD	30JAN90	14:49:09	1	18	20	/COOPER CREEK//PLAN-EAD////

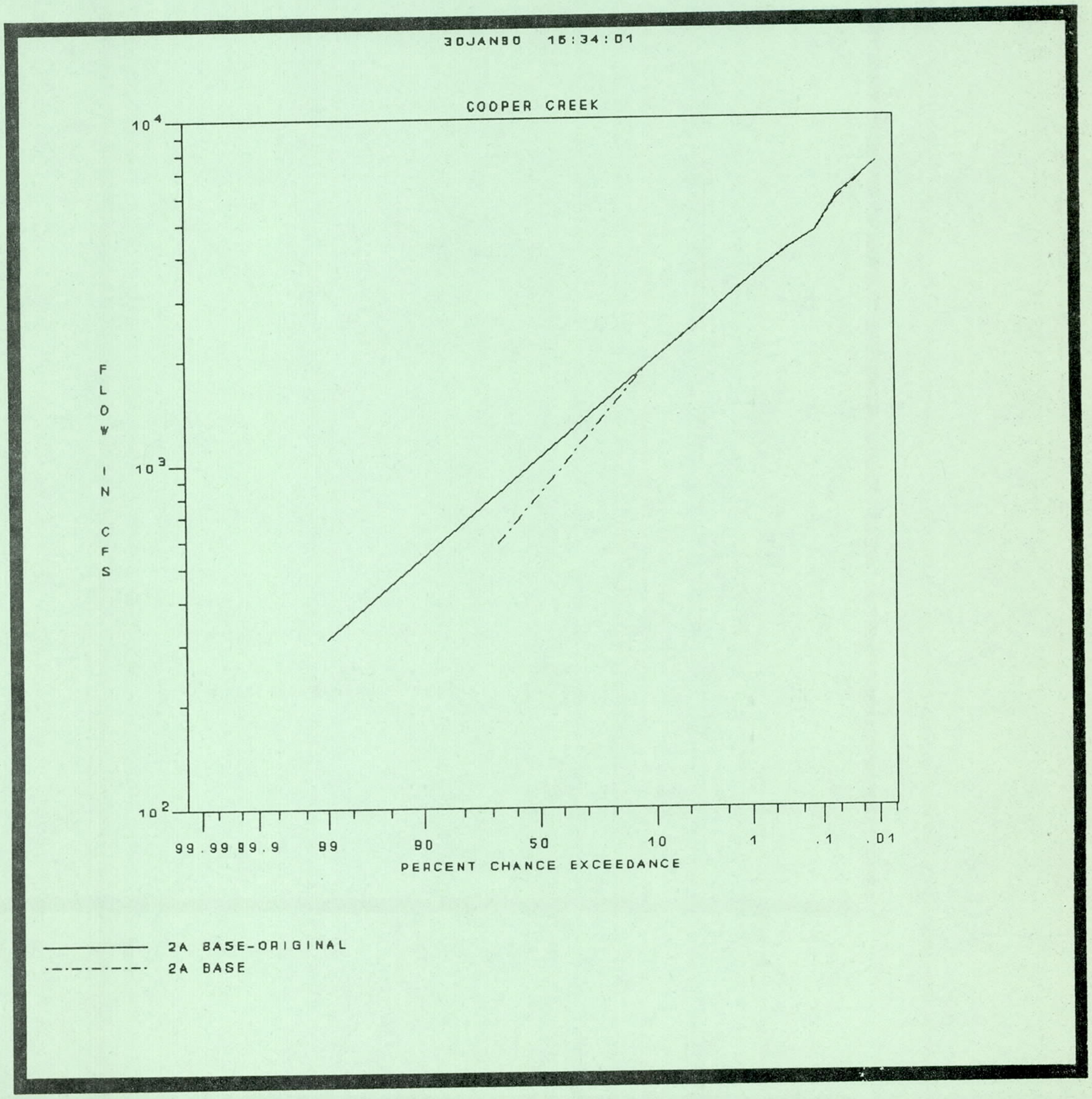
2. Do the following tasks. On the Harris, you can do them while waiting for the EAD execution to complete.

   a. Use DSPLAY to compare the frequency curves computed by HEC-1 with the original base condition frequency curve. (In the FDA course, you entered it with the PIP program on Tuesday. Otherwise, the original curve was entered by the instructor.) The original curve is entered using pathname part F of "BASE-ORIGINAL". Use the logrithmic transformation for each "curve":

   How do the two baseline condition curves compare?

To plot discharge on a logrithmic axis, use the "AX" command. The first parameter "LIN" applies to the first variable "FREQ" and the remaining to the second variable "FLOW". Typical DSPLAY commands:

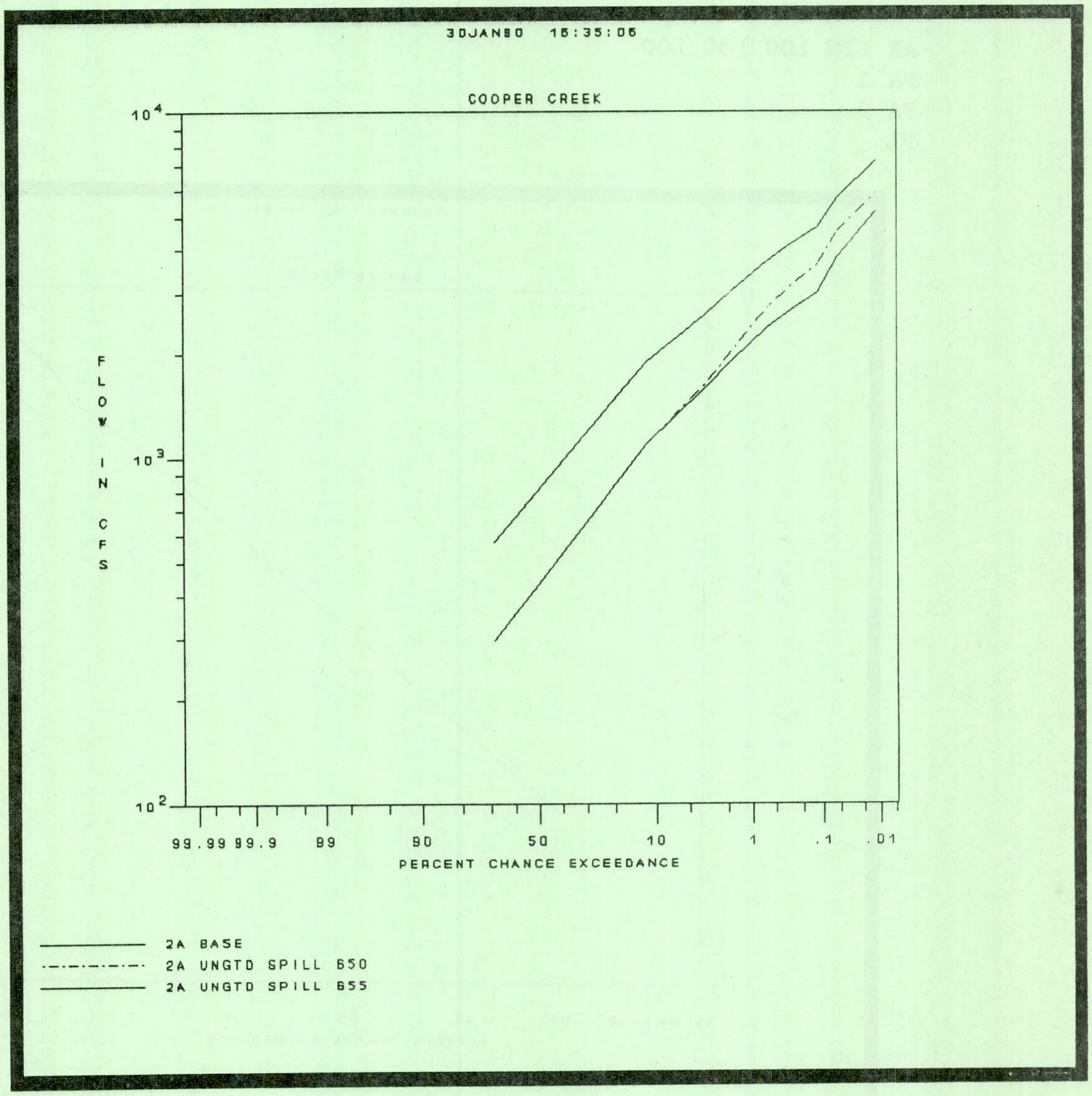
```
AX LIN LOG LOG LOG
PA 1
PA 9
PL
```



There appears to be an error in the interpolation performed by HEC-1 for the first discharge ordinate.

To compare the flow-frequency curves for three plans, the following DSPLAY commands are entered:

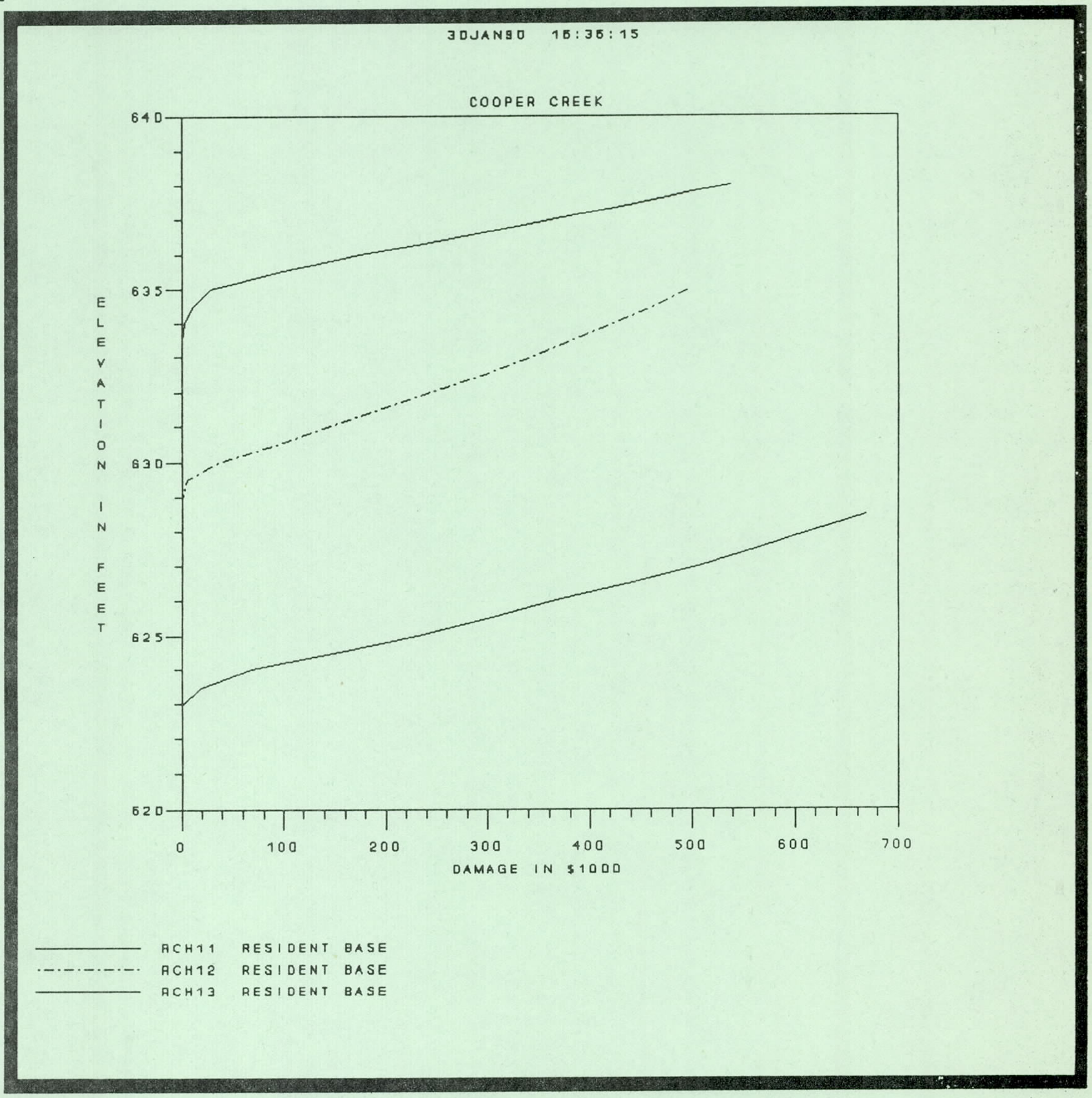
```
AX LIN LOG LOG LOG
PA 9
PA 10
PA 11
PL
```



b. Use DSPLAY to plot the residential elevation-damage function for reaches 11, 12, and 13 for baseline conditions on the same plot. (Use the "CUrve" command). Don't forget to remove the logarithmic transformation you declared above.

To reset the axis definition from logarithmic to linear, enter the AXis command with the parameters "LIN". To compare the elevation-damage functions for three reaches, the following DSPLAY commands are entered:

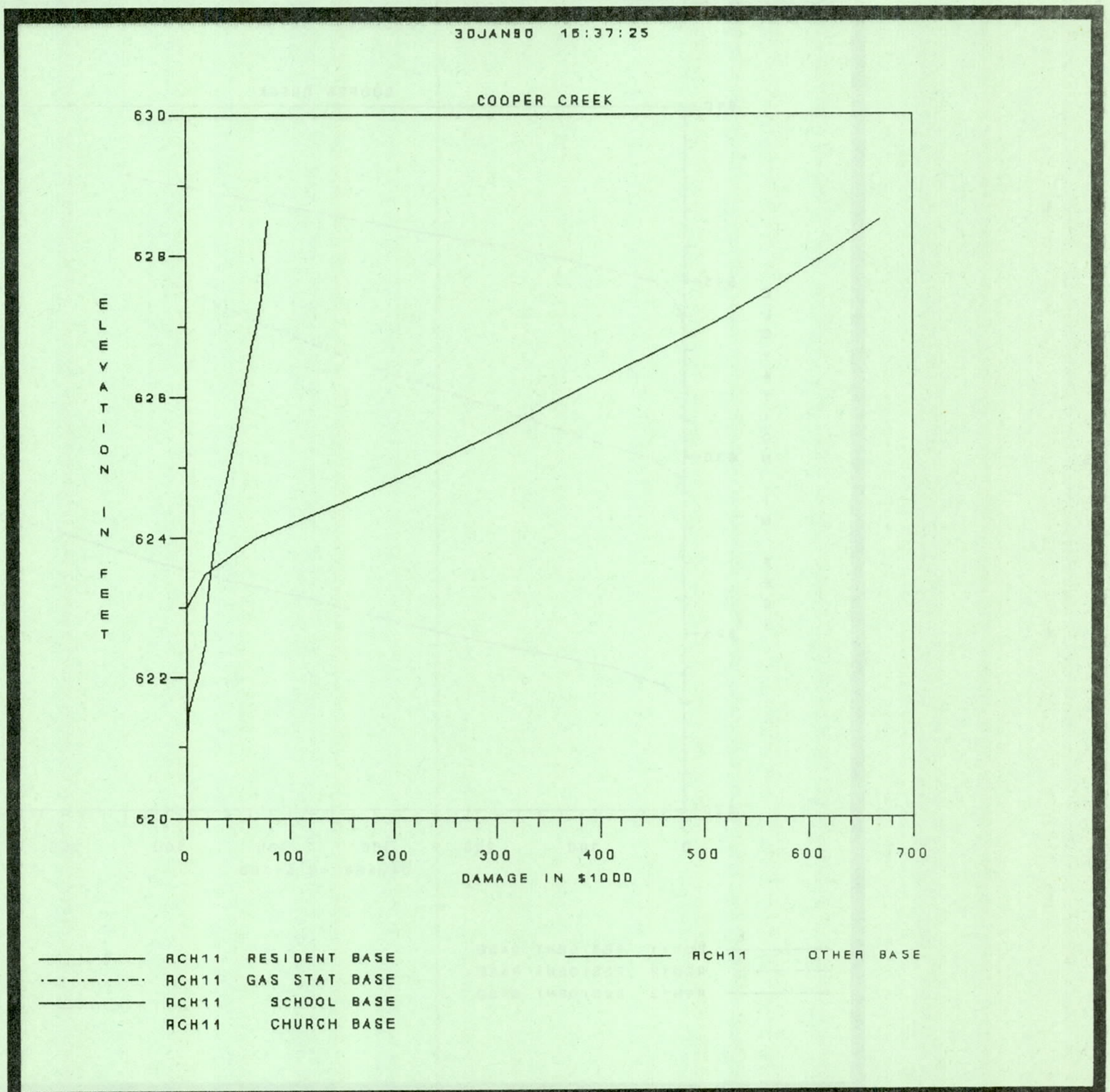
```
AX LIN LIN LIN LIN LIN LIN LIN
CU 1
PA 24 25 26
PL
```



c. Use DSPLAY to plot damage for all categories for reach 11 for baseline conditions.

Since the last plot required only curve 1, you must first reset the curve selection to include all curves. DSPLAY plots a maximum 7 curves. Typical DSPLAY commands required to plot elevation-damage:

```
AX LIN LIN LIN LIN LIN LIN LIN
CU 1 2 3 4 5 6 7
PA 24
PL
```



d. What is the damage associated with the elevation of 625 in reach 11 for residential properties?

Tabulate /COOPER CREEK/RCH11/ELEVATION-DAMAGE///BASE/ and look at curve 1 to determine that the damage at elevation 625 is $230,000.

e. Does the elevation-damage function for residential properties extend to a low enough elevation for reach 11?

Yes, in fact, it starts at too low of an elevation. The starting elevation should be raised to the highest possible elevation without encountering damage. In this case, it would be elevation 621 instead of elevation 620.

3. When your EAD execution terminates (successfully we hope), check the output file (COOP.EO) to see if you have a successful run. On the Harris, get a printout by entering:

PRINT COOP.EO

If unsuccessful, correct any errors and resubmit.

Look at your EAD output and answer the following questions:

a. What is the residential expected annual damage for plan 3 in reach 12?

One way to determine this is to look at the end of the EAD output for the summary table entitled:

" EXPECTED ANNUAL DAMAGE SUMMARY BY REACH ****

and sub-titled:

"SUMMARY FOR DAMAGE CATEGORY 1 - RESIDENT"

From this table, it can be determined that it is $1,980.

b. Which damage reach had the most reduction in residential expected annual damage for plan 4 (the channel improvement plan)?

From the same summary table, it can be determined that it is RCH11.

c. Did you have any expected annual damage associated with the "OTHER" (or "mistakes") damage category?

No, there shouldn't be any damage associated with "other".

d. Which plan produced the most reduction in expected annual damage for all three reaches?

One way to determine this is to look at the end of the EAD output for the summary table entitled:

"** GRAND SUMMARY BY CATEGORY **"

and sub-titled:

"GRAND SUMMARY - ALL DAMAGE CATEGORIES"

From this table, it can be determined that it is plan 3, the ungated reservoir with a spillway elevation of 655 feet.

e. Which plan produced the least reduction in expected annual damage for all three reaches?

From the same table used to answer the previous question, plan 5, the channel improvement produced the least reduction.

f. Does the rating curve computed using HEC-2 extend below the lowest (most frequent) discharge value on the frequency function and above the highest (least frequent) discharge value on the frequency function for reach 11?

No, it does not extend high enough. To determine this, do the following: (1) Find the least and most frequent frequencies (.10% and 99%); (2) Compute the corresponding flow (7,503 cfs and 303 cfs); (3) Compute the corresponding stages using the rating curve --- the lowest and highest discharge points on the rating curve are 190 cfs and 7,100 cfs). In this case, the rating curve extends to 7,100 cfs but we need it to include the .10% chance exceedance frequency discharge of 7,503 cfs.

The rating curves start and end as follows:

Base Condition		Channel Improvement Condition	
Elevation	Discharge	Elevation	Discharge
616.77	190	623.64	190
625.47	7,100	631.29	7,100

The three frequency curves start and end as follows:

Frequency	Plan 1 Flow	Plan 2 Flow	Plan 3 Flow
99.0	303	228	225
0.1	7,503	6,454	5,809

The ELEVATION-FLOW functions (or rating curves) for plans 1 and 5 extend to elevation 625.42 and 624.98 respectively. This elevation should be greater than that associated with the least frequent value of exceedance frequency. We have entered the value "0.1" on the FR records. From the EAD output, we can see that the corresponding discharge for an exceedance frequency of 0.1 percent is 7,503 cfs. The highest elevation in the base condition rating curve is 625.42 and has a corresponding discharge of 7,100 cfs. The rating curve does not extend high enough.

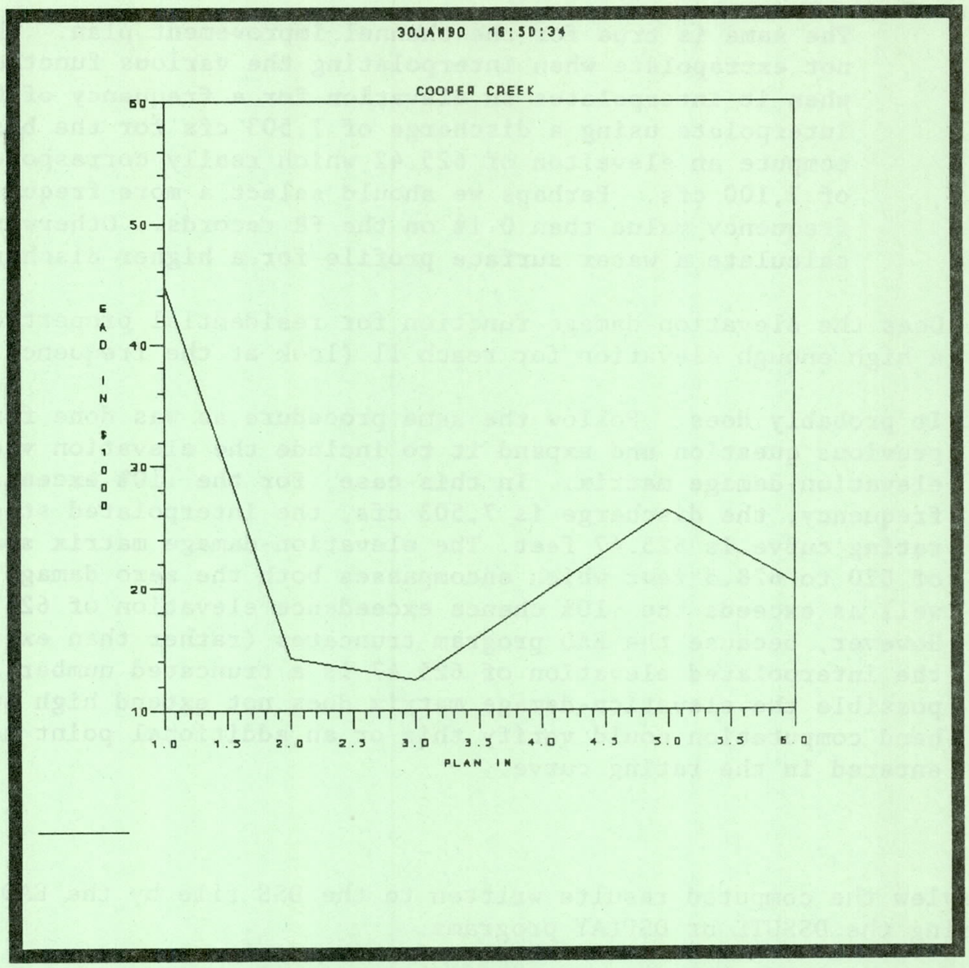
The same is true for the channel improvement plan. The EAD program does not extrapolate when interpolating the various functions. As a result, when it interpolates an elevation for a frequency of 0.1%, it will interpolate using a discharge of 7,503 cfs for the base condition and compute an elevaiton of 625.42 which really corresponds to a discharge of 7,100 cfs. Perhaps we should select a more frequent exceedance frequency value than 0.1% on the FR records. Otherwise, we should calculate a water surface profile for a higher discharge.

g. Does the elevation-damage function for residential properties extend to a high enough elevation for reach 11 (look at the frequency function)?

It probably does. Follow the same procedure as was done for the previous question and expand it to include the elevation vector in the elevation-damage matrix. In this case, for the .10% exceedance frequency, the discharge is 7,503 cfs, the interpolated stage from the rating curve is 625.47 feet. The elevation-damage matrix spans the range of 620 to 628.5 feet which encompasses both the zero damage point as well as exceeds the .10% chance exceedance elevation of 625.47 feet. However, because the EAD program truncates (rather than extrapolates), the interpolated elevation of 625.47 is a truncated number so that it is possible the elevation-damage matrix does not extend high enough. A hand computation could verify this or an additional point could be entered in the rating curve.

4. Review the computed results written to the DSS file by the EAD program by using the DSSUTL or DSPLAY programs.

a. Plot and tabulate the PLAN-EAD results (remember to get a new catalog listing "CA.N" and the "DP" display pathnames command. Compare this with the summary table in the EAD output.



30JAN90 16:50:34 PAGE 1

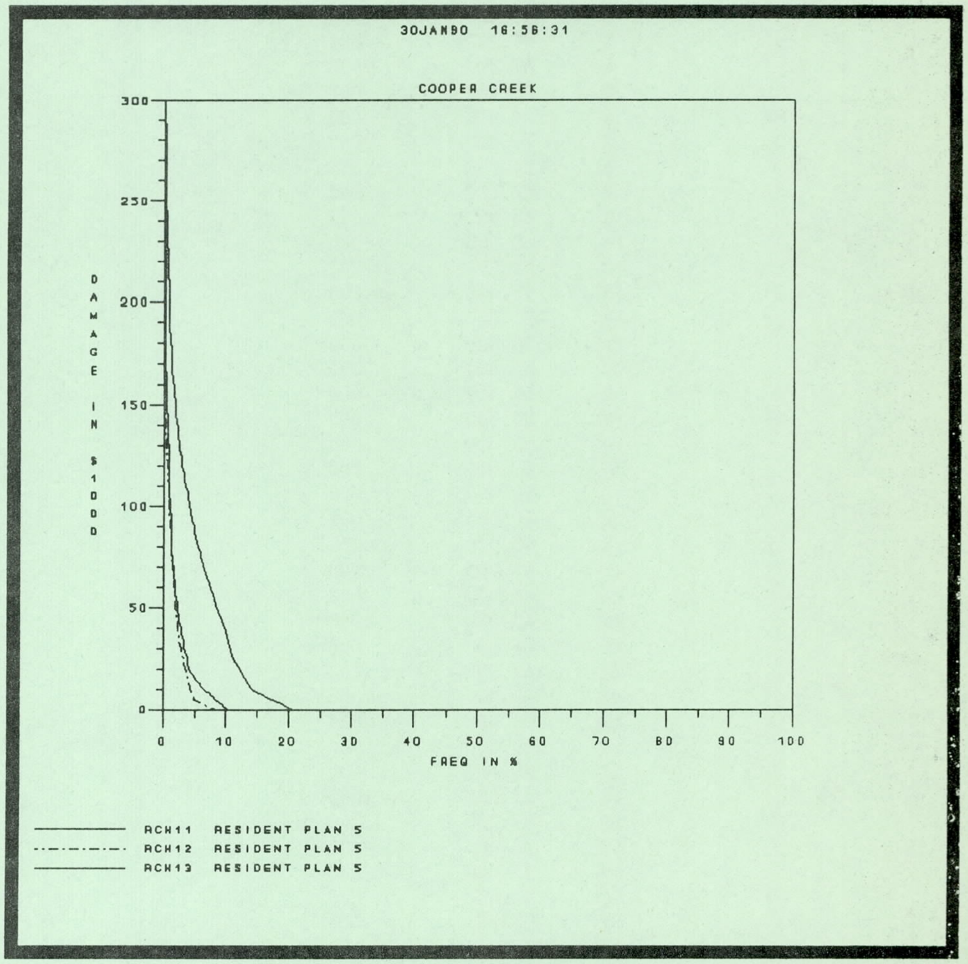
/COOPER CREEK//PLAN-EAD////

EAD IN $1000

NO	PLAN	
1	1.000	44.945
2	2.000	14.404
3	3.000	12.479
4	5.000	26.332
5	6.000	20.392

b. Tabulate and plot the FREQ-DAMAGE data for residential damage in reaches 11, 12, and 13 for Plan 5. (You will need to know the "curve" associated with residential damage).

Residential damage is "curve 3". Curve 1 is the flow corresponding to frequency and curve 2 is the interpolated stage (or elevation) corresponding to frequency.



/COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
1	99.000	.000
2	95.100	.000
3	91.200	.000
4	87.300	.000
5	83.400	.000
6	79.500	.000
7	75.600	.000
8	71.700	.000
9	67.800	.000
10	63.900	.000
11	60.000	.000
12	59.000	.000
13	58.000	.000
14	57.000	.000
15	56.000	.000
16	55.000	.000
17	54.000	.000
18	53.000	.000
19	52.000	.000
20	51.000	.000
21	50.000	.000
22	49.000	.000
23	48.000	.000
24	47.000	.000
25	46.000	.000
26	45.000	.000
27	44.000	.000
28	43.000	.000
29	42.000	.000
30	41.000	.000
31	40.000	.000
32	39.000	.000
33	38.000	.000
34	37.000	.000
35	36.000	.000
36	35.000	.000
37	34.000	.000
38	33.000	.000
39	32.000	.000
40	31.000	.000
41	30.000	.000
42	29.000	.000
43	28.000	.000
44	27.000	.000
45	26.000	.000
46	25.000	.000
47	24.000	.000
48	23.000	.000

/COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
49	22.000	.000
50	21.000	.000
51	20.000	.000
52	19.500	.000
53	19.000	.000
54	18.500	.000
55	18.000	.000
56	17.500	.000
57	17.000	.000
58	16.500	.000
59	16.000	.000
60	15.500	.000
61	15.000	.000
62	14.500	.000
63	14.000	.000
64	13.500	.000
65	13.000	.000
66	12.500	.000
67	12.000	.000
68	11.500	.000
69	11.000	.000
70	10.500	.485
71	10.000	1.602
72	9.700	2.271
73	9.400	2.953
74	9.100	3.648
75	8.800	4.360
76	8.500	5.091
77	8.200	5.840
78	7.900	6.615
79	7.600	7.418
80	7.300	8.254
81	7.000	9.125
82	6.800	9.730
83	6.600	10.348
84	6.400	10.982
85	6.200	11.636
86	6.000	12.310
87	5.800	13.005
88	5.600	13.727
89	5.400	14.474
90	5.200	15.251
91	5.000	16.061
92	4.800	16.909
93	4.600	17.794
94	4.400	18.719
95	4.200	20.509
96	4.000	23.181

/COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
97	3.800	25.761
98	3.600	28.377
99	3.400	31.147
100	3.200	34.089
101	3.000	37.221
102	2.900	38.867
103	2.800	40.550
104	2.700	42.289
105	2.600	44.088
106	2.500	45.967
107	2.400	47.933
108	2.300	50.009
109	2.200	52.208
110	2.100	54.566
111	2.000	57.103
112	1.900	59.639
113	1.800	62.379
114	1.700	65.345
115	1.600	68.563
116	1.500	73.494
117	1.400	79.394
118	1.300	85.764
119	1.200	92.644
120	1.100	100.033
121	1.000	107.681
122	.950	111.381
123	.900	115.301
124	.850	119.462
125	.800	123.872
126	.750	128.551
127	.700	133.509
128	.650	138.755
129	.600	144.300
130	.550	150.215
131	.500	156.582
132	.470	160.532
133	.440	164.602
134	.410	168.813
135	.380	173.214
136	.350	177.866
137	.320	182.859
138	.290	188.313
139	.260	194.419
140	.230	201.467
141	.200	209.919
142	.190	213.127
143	.180	216.265
144	.170	219.614

/COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
145	.160	223.233
146	.150	226.200
147	.140	226.200
148	.130	226.200
149	.120	226.200
150	.110	226.200
151	.100	226.200

/COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
1	99.000	.000
2	95.100	.000
3	91.200	.000
4	87.300	.000
5	83.400	.000
6	79.500	.000
7	75.600	.000
8	71.700	.000
9	67.800	.000
10	63.900	.000
11	60.000	.000
12	59.000	.000
13	58.000	.000
14	57.000	.000
15	56.000	.000
16	55.000	.000
17	54.000	.000
18	53.000	.000
19	52.000	.000
20	51.000	.000
21	50.000	.000
22	49.000	.000
23	48.000	.000
24	47.000	.000
25	46.000	.000
26	45.000	.000
27	44.000	.000
28	43.000	.000
29	42.000	.000
30	41.000	.000
31	40.000	.000
32	39.000	.000
33	38.000	.000
34	37.000	.000
35	36.000	.000
36	35.000	.000
37	34.000	.000
38	33.000	.000
39	32.000	.000
40	31.000	.000
41	30.000	.000
42	29.000	.000
43	28.000	.000
44	27.000	.000
45	26.000	.000
46	25.000	.000
47	24.000	.000
48	23.000	.000

/COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
49	22.000	.000
50	21.000	.000
51	20.000	.000
52	19.500	.000
53	19.000	.000
54	18.500	.000
55	18.000	.000
56	17.500	.000
57	17.000	.000
58	16.500	.000
59	16.000	.000
60	15.500	.000
61	15.000	.000
62	14.500	.000
63	14.000	.000
64	13.500	.000
65	13.000	.000
66	12.500	.000
67	12.000	.000
68	11.500	.000
69	11.000	.000
70	10.500	.000
71	10.000	.000
72	9.700	.000
73	9.400	.000
74	9.100	.000
75	8.800	.210
76	8.500	.517
77	8.200	.833
78	7.900	1.159
79	7.600	1.497
80	7.300	1.849
81	7.000	2.216
82	6.800	2.469
83	6.600	2.730
84	6.400	2.997
85	6.200	3.273
86	6.000	3.556
87	5.800	3.849
88	5.600	4.152
89	5.400	4.467
90	5.200	4.794
91	5.000	5.135
92	4.800	6.515
93	4.600	8.690
94	4.400	10.962
95	4.200	13.344
96	4.000	15.850

/COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
97	3.800	18.104
98	3.600	20.305
99	3.400	22.638
100	3.200	25.118
101	3.000	27.760
102	2.900	29.141
103	2.800	30.563
104	2.700	32.027
105	2.600	33.543
106	2.500	35.124
107	2.400	37.287
108	2.300	40.332
109	2.200	43.567
110	2.100	47.026
111	2.000	50.760
112	1.900	54.094
113	1.800	57.677
114	1.700	61.563
115	1.600	65.769
116	1.500	70.330
117	1.400	75.266
118	1.300	80.594
119	1.200	86.343
120	1.100	92.334
121	1.000	97.982
122	.950	100.284
123	.900	102.726
124	.850	105.315
125	.800	108.062
126	.750	110.975
127	.700	114.058
128	.650	117.325
129	.600	120.774
130	.550	124.407
131	.500	128.205
132	.470	130.562
133	.440	132.986
134	.410	135.501
135	.380	138.126
136	.350	140.968
137	.320	144.153
138	.290	147.631
139	.260	151.528
140	.230	156.018
141	.200	161.408
142	.190	163.451
143	.180	165.317
144	.170	167.314

/COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
145	.160	169.461
146	.150	171.230
147	.140	171.230
148	.130	171.230
149	.120	171.230
150	.110	171.230
151	.100	171.230

/COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
1	99.000	.000
2	95.100	.000
3	91.200	.000
4	87.300	.000
5	83.400	.000
6	79.500	.000
7	75.600	.000
8	71.700	.000
9	67.800	.000
10	63.900	.000
11	60.000	.000
12	59.000	.000
13	58.000	.000
14	57.000	.000
15	56.000	.000
16	55.000	.000
17	54.000	.000
18	53.000	.000
19	52.000	.000
20	51.000	.000
21	50.000	.000
22	49.000	.000
23	48.000	.000
24	47.000	.000
25	46.000	.000
26	45.000	.000
27	44.000	.000
28	43.000	.000
29	42.000	.000
30	41.000	.000
31	40.000	.000
32	39.000	.000
33	38.000	.000
34	37.000	.000
35	36.000	.000
36	35.000	.000
37	34.000	.000
38	33.000	.000
39	32.000	.000
40	31.000	.000
41	30.000	.000
42	29.000	.000
43	28.000	.000
44	27.000	.000
45	26.000	.000
46	25.000	.000
47	24.000	.000
48	23.000	.000

/COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
49	22.000	.000
50	21.000	.041
51	20.000	1.507
52	19.500	2.265
53	19.000	3.039
54	18.500	3.613
55	18.000	4.134
56	17.500	4.880
57	17.000	5.642
58	16.500	6.422
59	16.000	7.219
60	15.500	8.034
61	15.000	8.868
62	14.500	9.726
63	14.000	10.706
64	13.500	13.215
65	13.000	15.807
66	12.500	18.480
67	12.000	21.232
68	11.500	24.065
69	11.000	26.970
70	10.500	33.098
71	10.000	39.268
72	9.700	41.615
73	9.400	43.987
74	9.100	46.382
75	8.800	48.818
76	8.500	51.302
77	8.200	53.835
78	7.900	56.440
79	7.600	59.126
80	7.300	61.917
81	7.000	64.821
82	6.800	66.821
83	6.600	68.845
84	6.400	70.910
85	6.200	73.015
86	6.000	75.185
87	5.800	77.427
88	5.600	79.758
89	5.400	82.194
90	5.200	84.759
91	5.000	87.485
92	4.800	90.357
93	4.600	93.381
94	4.400	96.914
95	4.200	100.974
96	4.000	104.526

/COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

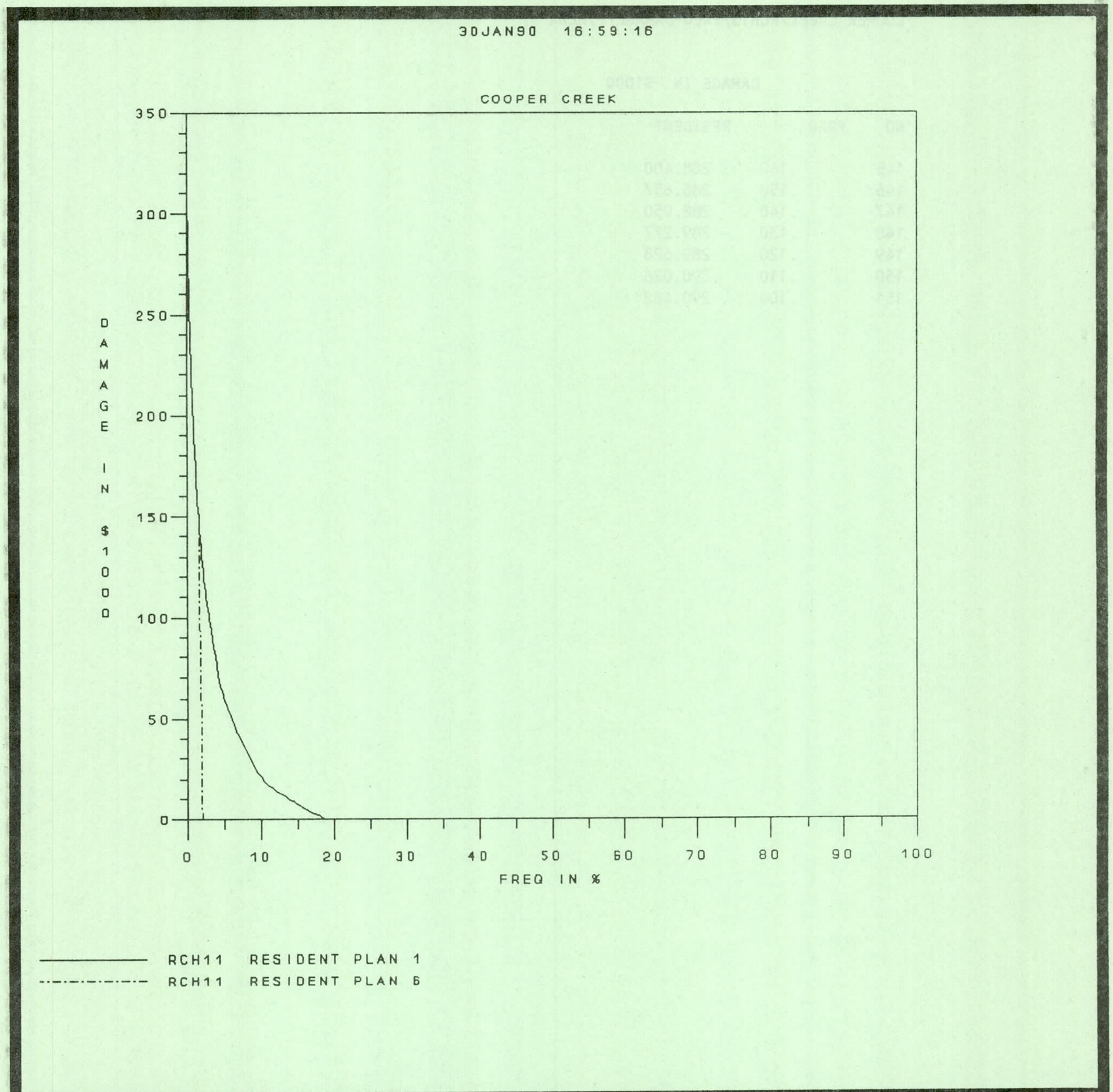
NO	FREQ	RESIDENT
97	3.800	107.249
98	3.600	110.148
99	3.400	113.271
100	3.200	116.628
101	3.000	120.268
102	2.900	122.230
103	2.800	124.299
104	2.700	126.475
105	2.600	128.779
106	2.500	131.199
107	2.400	133.746
108	2.300	136.411
109	2.200	139.212
110	2.100	142.130
111	2.000	145.175
112	1.900	148.229
113	1.800	151.440
114	1.700	154.856
115	1.600	158.496
116	1.500	162.381
117	1.400	166.548
118	1.300	171.028
119	1.200	175.999
120	1.100	181.906
121	1.000	188.342
122	.950	191.890
123	.900	195.659
124	.850	199.649
125	.800	203.881
126	.750	208.377
127	.700	213.149
128	.650	218.229
129	.600	223.630
130	.550	229.371
131	.500	235.466
132	.470	239.279
133	.440	243.224
134	.410	247.313
135	.380	251.622
136	.350	256.195
137	.320	261.133
138	.290	266.682
139	.260	273.223
140	.230	280.864
141	.200	287.522
142	.190	287.709
143	.180	287.920
144	.170	288.154

/COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 5/

DAMAGE IN $1000

NO	FREQ	RESIDENT
145	.160	288.400
146	.150	288.657
147	.140	288.950
148	.130	289.277
149	.120	289.628
150	.110	290.026
151	.100	290.482

Tabulate and plot the FREQ-DAMAGE data for residential damage in reach 11 for plans 1 and 6 (Base and floodproofing). Do the curves seem reasonable?



```
**********************************************************
*        Expected Annual Flood Damage Program            *
*        Users Manual (March 1989)                       *
*        Version  October 1, 1989                        *
*        IBM-PC Compatible                               *
*        Run date 30JAN90    time 14:49:09               *
**********************************************************


            EEEEEEEE       AA       DDDDDDDD
            E            AA  AA     DD       DD
            E           AA    AA    DD       DD
            EEEEE      AA      AA   DD       DD
            E          AAAAAAAAAA   DD       DD
            E          AA      AA   DD       DD
            EEEEEEEE   AA      AA   DDDDDDDD

         *****************************************
         * U.S. Army Corps of Engineers          *
         * The Hydrologic Engineering Center     *
         * 609 Second Street, Suite B            *
         * Davis, California 95616               *
         * (916) 756-1104                        *
         *****************************************


+++++++++++++++++++++++++++++++++++++++++++++
+ Expected Annual Flood Damage Computation +
+ 761-X6-L7580      IBM-PC Compatible       +
+ Version Date      October 1, 1989         +
+++++++++++++++++++++++++++++++++++++++++++++


** LIST OF RECORDS READ BY READIN **
RECORD
 ORDER          1         2         3         4         5         6         7         8
NUMBER 12345678901234567890123456789012345678901234567890123456789012345678901234567890

     1 TT       COOPER CREEK    DENTON, TEXAS
     2 TT       INPUT DECK COOP.E
     3 TT       DSS UTILIZATION = HEC-1, HEC-2, SID  =  FIVE PLANS
     4 TT
     5 ZW  A=COOPER CREEK C=REACH-EAD
     6 ZW  A=COOPER CREEK C=PLAN-EAD
     7 ZW.E  A=COOPER CREEK C=FREQ-DAMAGE
     8 TT
     9 TT
    10 CN      5RESIDENTGAS STAT  SCHOOL  CHURCH   OTHER
    11 TT
    12 PN      1         EXISTING COND. - USES BASELINE QF,QS,DG DATA
    13 PN      2         RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
    14 PN      3         RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
    15 PN      5         CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
    16 PN      6         FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA
    17 TT
    18 RN       DAMAGE REACH 11
    19 FR              16        99        60        50        40        30        20        15        10
    20 FR       7       5         3         2         1        .5        .2        .1
    21 ZR   A=COOPER CREEK B=3B    C=QF F=BASE
    22 ZR                  B=RCH11 C=QS
    23 ZR                          C=SD
    24 EP       1
    25 ZR  A=COOPER CREEK B=3B    C=QF F=UNGTD SPILL 650
    26 EP       2
    27 ZR  A=COOPER CREEK B=3B    C=QF F=UNGTD SPILL 655
    28 EP       3
    29 ZR  A=COOPER CREEK B=3B    C=QF F=BASE
    30 ZR                 B=RCH11 C=QS F=CHIMP 40FT
```

```
31 EP     5
32 ZR               B=RCH11 C=QS F=BASE
33 ZR                       C=SD F=FP-2%
34 ER     6
35 RN      DAMAGE REACH 12
36 ZR               B=3B    C=QF F=BASE
37 ZR               B=RCH12 C=QS F=BASE
38 ZR                       C=SD
39 EP     1
40 ZR               B=3B    C=QF F=UNGTD SPILL 650
41 EP     2
42 ZR               B=3B    C=QF F=UNGTD SPILL 655
43 EP     3
44 ZR               B=3B    C=QF F=BASE
45 ZR               B=RCH12 C=QS F=CHIMP 40FT
46 EP     5
47 ZR               B=RCH12 C=QS F=BASE
48 ZR                       C=SD F=FP-2%
49 ER     6
50 RN      DAMAGE REACH 13
51 ZR               B=2A    C=QF F=BASE
52 ZR               B=RCH13 C=QS F=BASE
53 ZR                       C=SD
54 EP     1
55 ZR               B=2A    C=QF F=UNGTD SPILL 650
56 EP     2
57 ZR               B=2A    C=QF F=UNGTD SPILL 655
58 EP     3
59 ZR               B=2A    C=QF F=BASE
60 ZR               B=RCH13 C=QS F=CHIMP 40FT
61 EP     5
62 ZR               B=RCH13 C=QS F=BASE
63 ZR                       C=SD F=FP-2%
64 EJ     6

READIN --     64 RECORDS WRITTEN TO LOGICAL FILE  8
```

```
++++++++++++++++++++++++++++++++++++++++++++
+ Expected Annual Flood Damage Computation +
+ 761-X6-L7580      IBM-PC Compatible      +
+ Version Date      October 1, 1989        +
++++++++++++++++++++++++++++++++++++++++++++


TT       COOPER CREEK    DENTON, TEXAS
TT       INPUT DECK COOP.E
TT       DSS UTILIZATION = HEC-1, HEC-2, SID  =  FIVE PLANS
TT
TT
TT

**DAMAGE CATEGORY NAMES**
CN   5  RESIDENTGAS STAT  SCHOOL  CHURCH   OTHER
TT

**FLOOD PLAIN MANAGEMENT PLAN NAMES**
PN   1          EXISTING COND. - USES BASELINE QF,QS,DG DATA
PN   2          RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
PN   3          RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
PN   5          CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
PN   6          FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA
TT

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++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


REACH    1, REACH NAME -
RN       DAMAGE REACH 11

++++ INPUT DATA ++++

**FREQUENCIES**
FR           16   99.00   60.00   50.00   40.00   30.00   20.00   15.00   10.00
    7.00    5.00    3.00    2.00    1.00     .50     .20     .10
   -----DSS---ZOPEN; Existing File Opened - Unit:  71  File: COO.DSS

** HECDSS DATA FILE OPENED: COO.DSS

** FREQUENCIES READ FROM HECDSS FILE **
FR    3B      9   77.45   14.01    4.14    1.85     .66     .29     .11     .06
     .01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF    3B    1 0      922.   2966.   4059.   4772.   5862.   6594.   7358.   8923.
  11291.

** INTERPOLATED FLOOD PEAKS **
QF    3B    1 0      303.   1304.   1544.   1818.   2151.   2595.   2896.   3290.
   3603.   3893.   4338.   4697.   5428.   6124.   6858.   7503.

** STAGES FOR RATING CURVE READ FROM HECDSS FILE **
SQ RCH11      10  616.77  620.17  622.04  623.01  623.50  624.05  624.39  624.74
  625.40  625.47

** FLOWS FOR RATING CURVE READ FROM HECDSS FILE **
QS RCH11    1 0      190.   1000.   1800.   2650.   3250.   4100.   4700.   5400.
   6900.   7100.

** STAGES FOR DAMAGE DATA READ FROM HECDSS FILE **
SD RCH11      18  620.00  620.50  621.00  621.50  622.00  622.50  623.00  623.50
  624.00  624.50  625.00  625.50  626.00  626.50  627.00  627.50  628.00  628.50

** FLOOD DAMAGE DATA READ FROM HECDSS FILE **

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  1   (RESIDENT)
DG RCH11    1 0 1      0.      0.      0.      0.      0.      0.      0.     19.
     69.    148.    230.    301.    367.    437.    505.    566.    619.    670.
```

```
DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  2   (GAS STAT)
DG RCH11    1 0 2      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  3   ( SCHOOL)
DG RCH11    1 0 3      0.       0.       0.       2.      12.      20.      21.      23.
     29.      35.      42.      49.      55.      61.      68.      74.      77.      79.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  4   ( CHURCH)
DG RCH11    1 0 4      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  5   (  OTHER)
DG RCH11    1 0 5      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.

**END OF INPUT DATA FOR PLAN  1 **
EP++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 1/

++DAMAGE DATA FOR PLAN 1 --         EXISTING COND. - USES BASELINE QF,QS,DG DATA
```

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	303.	617.25	.00	.00	.00	.00	.00	.00	19.11
2	60.00	1304.	620.88	.00	.00	.00	.00	.00	.00	19.11
3	50.00	1544.	621.44	.00	.00	2.10	.00	.00	2.10	19.03
4	40.00	1818.	622.06	.00	.00	12.87	.00	.00	12.87	18.31
5	30.00	2151.	622.44	.00	.00	18.86	.00	.00	18.86	16.73
6	20.00	2595.	622.95	.00	.00	21.05	.00	.00	21.05	14.71
7	15.00	2896.	623.21	7.99	.00	22.12	.00	.00	30.11	13.47
8	10.00	3290.	623.52	21.29	.00	23.64	.00	.00	44.93	11.64
9	7.00	3603.	623.73	42.02	.00	26.03	.00	.00	68.06	9.96
10	5.00	3893.	623.92	61.13	.00	28.24	.00	.00	89.37	8.40
11	3.00	4338.	624.19	98.88	.00	31.53	.00	.00	130.41	6.25
12	2.00	4697.	624.39	130.61	.00	34.04	.00	.00	164.65	4.79
13	1.00	5428.	624.75	189.94	.00	38.98	.00	.00	228.91	2.87
14	.50	6124.	625.06	238.75	.00	43.21	.00	.00	281.96	1.60
15	.20	6858.	625.38	283.96	.00	47.56	.00	.00	331.52	.69
16	.10	7503.	625.47	296.83	.00	48.80	.00	.00	345.63	.35
EXP ANNUAL DAMAGE				9.48	.00	9.62	.00	.00	19.11	

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


REACH    1, REACH NAME -
RN       DAMAGE REACH 11

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **
FR     3B         9  77.45    14.01     4.14     1.85      .66      .29      .11      .06
      .01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF     3B    1 0      666.    2149.    3082.    3787.    4863.    5582.    6318.    7750.
   9880.

** INTERPOLATED FLOOD PEAKS **
QF     3B    1 0      228.     931.    1099.    1293.    1534.    1864.    2095.    2409.
   2675.    2930.    3351.    3713.    4434.    5122.    5839.    6454.

**END OF INPUT DATA FOR PLAN  2 **
EP++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 2/

++DAMAGE DATA FOR PLAN 2 -- RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	228.	616.93	.00	.00	.00	.00	.00	.00	8.26
2	60.00	931.	619.88	.00	.00	.00	.00	.00	.00	8.26
3	50.00	1099.	620.40	.00	.00	.00	.00	.00	.00	8.26
4	40.00	1293.	620.85	.00	.00	.00	.00	.00	.00	8.26
5	30.00	1534.	621.42	.00	.00	1.99	.00	.00	1.99	8.19
6	20.00	1864.	622.11	.00	.00	13.70	.00	.00	13.70	7.43
7	15.00	2095.	622.37	.00	.00	17.85	.00	.00	17.85	6.65
8	10.00	2409.	622.73	.00	.00	20.47	.00	.00	20.47	5.67
9	7.00	2675.	623.03	1.11	.00	21.33	.00	.00	22.43	5.04
10	5.00	2930.	623.24	9.06	.00	22.24	.00	.00	31.30	4.51
11	3.00	3351.	623.56	25.33	.00	24.11	.00	.00	49.44	3.75
12	2.00	3713.	623.80	49.27	.00	26.87	.00	.00	76.13	3.13
13	1.00	4434.	624.24	107.33	.00	32.20	.00	.00	139.52	2.11
14	.50	5122.	624.60	164.96	.00	36.86	.00	.00	201.82	1.27
15	.20	5839.	624.93	219.58	.00	41.49	.00	.00	261.07	.58
16	.10	6454.	625.20	259.08	.00	45.17	.00	.00	304.24	.30
EXP ANNUAL DAMAGE				3.23	.00	5.04	.00	.00	8.26	

++

REACH 1, REACH NAME -
RN DAMAGE REACH 11

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **
FR 3B 9 77.45 14.01 4.14 1.85 .66 .29 .11 .06
.01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF 3B 1 0 665. 2149. 3049. 3651. 4525. 5098. 5691. 7029.
9234.

** INTERPOLATED FLOOD PEAKS **
QF 3B 1 0 225. 934. 1103. 1298. 1539. 1867. 2095. 2406.
2666. 2909. 3286. 3590. 4180. 4731. 5301. 5809.

**END OF INPUT DATA FOR PLAN 3 **
EP++
-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 3/

++DAMAGE DATA FOR PLAN 3 -- RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	225.	616.92	.00	.00	.00	.00	.00	.00	7.67
2	60.00	934.	619.89	.00	.00	.00	.00	.00	.00	7.67
3	50.00	1103.	620.41	.00	.00	.00	.00	.00	.00	7.67
4	40.00	1298.	620.87	.00	.00	.00	.00	.00	.00	7.67
5	30.00	1539.	621.43	.00	.00	2.05	.00	.00	2.05	7.60
6	20.00	1867.	622.11	.00	.00	13.76	.00	.00	13.76	6.82
7	15.00	2095.	622.37	.00	.00	17.86	.00	.00	17.86	6.03
8	10.00	2406.	622.73	.00	.00	20.46	.00	.00	20.46	5.05
9	7.00	2666.	623.02	.83	.00	21.30	.00	.00	22.12	4.43
10	5.00	2909.	623.22	8.40	.00	22.16	.00	.00	30.57	3.91
11	3.00	3286.	623.52	21.03	.00	23.61	.00	.00	44.64	3.17
12	2.00	3590.	623.72	41.11	.00	25.93	.00	.00	67.04	2.62
13	1.00	4180.	624.10	84.95	.00	30.42	.00	.00	115.37	1.76
14	.50	4731.	624.41	133.32	.00	34.26	.00	.00	167.58	1.06
15	.20	5301.	624.69	179.75	.00	38.11	.00	.00	217.86	.49
16	.10	5809.	624.92	217.41	.00	41.30	.00	.00	258.71	.26
EXP ANNUAL DAMAGE				2.66	.00	5.01	.00	.00	7.67	

++

```
REACH    1, REACH NAME -
RN       DAMAGE REACH 11

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **
FR    3B        9  77.45   14.01    4.14    1.85     .66     .29     .11     .06
     .01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF    3B   1 0       922.   2966.   4059.   4772.   5862.   6594.   7358.   8923.
  11291.

** INTERPOLATED FLOOD PEAKS **
QF    3B   1 0       303.   1304.   1544.   1818.   2151.   2595.   2896.   3290.
   3603.   3893.   4338.   4697.   5428.   6124.   6858.   7503.

** STAGES FOR RATING CURVE READ FROM HECDSS FILE **
SQ RCH11       10  616.02  619.58  621.58  622.57  623.02  623.55  623.88  624.23
  624.89  624.97

** FLOWS FOR RATING CURVE READ FROM HECDSS FILE **
QS RCH11   1 0       190.   1000.   1800.   2650.   3250.   4100.   4700.   5400.
   6900.   7100.

**END OF INPUT DATA FOR PLAN  5 **
EP++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 5/

++DAMAGE DATA FOR PLAN 5 --         CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
```

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	303.	616.52	.00	.00	.00	.00	.00	.00	10.83
2	60.00	1304.	620.34	.00	.00	.00	.00	.00	.00	10.83
3	50.00	1544.	620.94	.00	.00	.00	.00	.00	.00	10.83
4	40.00	1818.	621.60	.00	.00	4.33	.00	.00	4.33	10.68
5	30.00	2151.	621.99	.00	.00	11.75	.00	.00	11.75	9.89
6	20.00	2595.	622.50	.00	.00	19.85	.00	.00	19.85	8.33
7	15.00	2896.	622.75	.00	.00	20.52	.00	.00	20.52	7.33
8	10.00	3290.	623.04	1.60	.00	21.38	.00	.00	22.99	6.27
9	7.00	3603.	623.24	9.13	.00	22.25	.00	.00	31.37	5.46
10	5.00	3893.	623.42	16.06	.00	23.04	.00	.00	39.10	4.76
11	3.00	4338.	623.68	37.22	.00	25.48	.00	.00	62.70	3.80
12	2.00	4697.	623.88	57.10	.00	27.77	.00	.00	84.87	3.07
13	1.00	5428.	624.24	107.68	.00	32.23	.00	.00	139.91	2.00
14	.50	6124.	624.55	156.58	.00	36.15	.00	.00	192.73	1.18
15	.20	6858.	624.88	209.92	.00	40.67	.00	.00	250.59	.53
16	.10	7503.	624.97	226.20	.00	42.05	.00	.00	268.25	.27
EXP ANNUAL DAMAGE				3.76	.00	7.07	.00	.00	10.83	

```
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REACH    1, REACH NAME -
RN       DAMAGE REACH 11

++++ INPUT DATA ++++

** STAGES FOR RATING CURVE READ FROM HECDSS FILE **
SQ RCH11       10  616.77  620.17  622.04  623.01  623.50  624.05  624.39  624.74
  625.40  625.47

** FLOWS FOR RATING CURVE READ FROM HECDSS FILE **
QS RCH11   1 0       190.   1000.   1800.   2650.   3250.   4100.   4700.   5400.
   6900.   7100.

WARNING, TOO MANY POINTS IN DAMAGE RELATIONSHIP STORED IN HECDSS FILE
LIMITED TO:  18 POINTS
```

```
RELATIONSHIP TRUNCATED

** STAGES FOR DAMAGE DATA READ FROM HECDSS FILE **
SD RCH11       19  620.00  620.50  621.00  621.50  622.00  622.50  623.00  623.50
  624.00  624.38  624.50  625.00  625.50  626.00  626.50  627.00  627.50  628.00
  628.50

** FLOOD DAMAGE DATA READ FROM HECDSS FILE **

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  1   (RESIDENT)
DG RCH11    1 0 1     0.      0.      0.      0.      0.      0.      0.      0.
     0.      0.    148.    230.    301.    367.    437.    505.    566.    619.
   670.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  2   (GAS STAT)
DG RCH11    1 0 2     0.      0.      0.      0.      0.      0.      0.      0.
     0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
     0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  3   (  SCHOOL)
DG RCH11    1 0 3     0.      0.      0.      2.     12.     20.     21.     23.
    29.     34.     35.     42.     49.     55.     61.     68.     74.     77.
    79.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  4   (  CHURCH)
DG RCH11    1 0 4     0.      0.      0.      0.      0.      0.      0.      0.
     0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
     0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  5   (   OTHER)
DG RCH11    1 0 5     0.      0.      0.      0.      0.      0.      0.      0.
     0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
     0.

**END OF INPUT DATA FOR PLAN  6 **
ER++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/RCH11/FREQ-DAMAGE///PLAN 6/

++DAMAGE DATA FOR PLAN 6 --         FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA
```

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	303.	617.25	.00	.00	.00	.00	.00	.00	13.37
2	60.00	1304.	620.88	.00	.00	.00	.00	.00	.00	13.37
3	50.00	1544.	621.44	.00	.00	2.10	.00	.00	2.10	13.29
4	40.00	1818.	622.06	.00	.00	12.87	.00	.00	12.87	12.57
5	30.00	2151.	622.44	.00	.00	18.86	.00	.00	18.86	10.99
6	20.00	2595.	622.95	.00	.00	21.05	.00	.00	21.05	8.97
7	15.00	2896.	623.21	.00	.00	22.12	.00	.00	22.12	7.89
8	10.00	3290.	623.52	.00	.00	23.64	.00	.00	23.64	6.75
9	7.00	3603.	623.73	.00	.00	26.03	.00	.00	26.03	6.01
10	5.00	3893.	623.92	.00	.00	28.24	.00	.00	28.24	5.47
11	3.00	4338.	624.19	.00	.00	31.49	.00	.00	31.49	4.87
12	2.00	4697.	624.39	10.10	.00	33.96	.00	.00	44.07	4.54
13	1.00	5428.	624.75	189.94	.00	38.98	.00	.00	228.91	2.87
14	.50	6124.	625.06	238.75	.00	43.21	.00	.00	281.96	1.60
15	.20	6858.	625.38	283.96	.00	47.56	.00	.00	331.52	.69
16	.10	7503.	625.47	296.83	.00	48.80	.00	.00	345.63	.35
EXP ANNUAL DAMAGE				3.75	.00	9.62	.00	.00	13.37	

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REACH   2, REACH NAME -
RN      DAMAGE REACH 12

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **
FR    3B       9  77.45   14.01    4.14    1.85     .66     .29     .11     .06
     .01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF    3B   1 0      922.   2966.   4059.   4772.   5862.   6594.   7358.   8923.
  11291.

** INTERPOLATED FLOOD PEAKS **
QF    3B   1 0      303.   1304.   1544.   1818.   2151.   2595.   2896.   3290.
   3603.   3893.   4338.   4697.   5428.   6124.   6858.   7503.

** STAGES FOR RATING CURVE READ FROM HECDSS FILE **
SQ RCH12      10  623.82  626.54  628.06  629.13  629.67  630.29  630.60  630.91
  631.47  631.54

** FLOWS FOR RATING CURVE READ FROM HECDSS FILE **
QS RCH12   1 0      190.   1000.   1800.   2650.   3250.   4100.   4700.   5400.
   6900.   7100.

** STAGES FOR DAMAGE DATA READ FROM HECDSS FILE **
SD RCH12      18  626.50  627.00  627.50  628.00  628.50  629.00  629.50  630.00
  630.50  631.00  631.50  632.00  632.50  633.00  633.50  634.00  634.50  635.00

** FLOOD DAMAGE DATA READ FROM HECDSS FILE **

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  1   (RESIDENT)
DG RCH12   1 0 1      0.      0.      0.      0.      0.      0.      5.     36.
     90.    140.    193.    244.    295.    342.    385.    427.    464.    498.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  2   (GAS STAT)
DG RCH12   1 0 2      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  3   (  SCHOOL)
DG RCH12   1 0 3      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  4   (  CHURCH)
DG RCH12   1 0 4      0.      0.      0.      0.      0.      0.      0.      0.
     16.     36.     52.     64.     73.     80.     86.     93.     98.    101.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  5   (   OTHER)
DG RCH12   1 0 5      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

**END OF INPUT DATA FOR PLAN  1 **
EP++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 1/

++DAMAGE DATA FOR PLAN 1 -- EXISTING COND. - USES BASELINE QF,QS,DG DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	303.	624.20	.00	.00	.00	.00	.00	.00	8.05
2	60.00	1304.	627.12	.00	.00	.00	.00	.00	.00	8.05
3	50.00	1544.	627.57	.00	.00	.00	.00	.00	.00	8.05
4	40.00	1818.	628.08	.00	.00	.00	.00	.00	.00	8.05
5	30.00	2151.	628.50	.00	.00	.00	.00	.00	.00	8.05
6	20.00	2595.	629.06	.64	.00	.00	.00	.00	.64	8.05
7	15.00	2896.	629.35	3.72	.00	.00	.00	.00	3.72	7.94
8	10.00	3290.	629.70	17.63	.00	.00	.00	.00	17.63	7.52
9	7.00	3603.	629.93	31.62	.00	.00	.00	.00	31.62	6.80
10	5.00	3893.	630.14	50.78	.00	.00	4.33	.00	55.11	5.98
11	3.00	4338.	630.41	80.27	.00	.00	13.04	.00	93.31	4.50
12	2.00	4697.	630.60	99.69	.00	.00	19.75	.00	119.44	3.44
13	1.00	5428.	630.92	131.71	.00	.00	32.36	.00	164.07	2.05
14	.50	6124.	631.18	159.22	.00	.00	41.54	.00	200.75	1.15
15	.20	6858.	631.46	188.77	.00	.00	50.65	.00	239.41	.50
16	.10	7503.	631.54	197.22	.00	.00	52.96	.00	250.19	.25
EXP ANNUAL DAMAGE				7.01	.00	.00	1.04	.00	8.05	

++

REACH 2, REACH NAME -
RN DAMAGE REACH 12

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **
FR 3B 9 77.45 14.01 4.14 1.85 .66 .29 .11 .06
.01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF 3B 1 0 666. 2149. 3082. 3787. 4863. 5582. 6318. 7750.
9880.

** INTERPOLATED FLOOD PEAKS **
QF 3B 1 0 228. 931. 1099. 1293. 1534. 1864. 2095. 2409.
2675. 2930. 3351. 3713. 4434. 5122. 5839. 6454.

**END OF INPUT DATA FOR PLAN 2 **
EP++
-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 2/

++DAMAGE DATA FOR PLAN 2 -- RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	228.	623.95	.00	.00	.00	.00	.00	.00	2.72
2	60.00	931.	626.31	.00	.00	.00	.00	.00	.00	2.72
3	50.00	1099.	626.73	.00	.00	.00	.00	.00	.00	2.72
4	40.00	1293.	627.10	.00	.00	.00	.00	.00	.00	2.72
5	30.00	1534.	627.55	.00	.00	.00	.00	.00	.00	2.72
6	20.00	1864.	628.14	.00	.00	.00	.00	.00	.00	2.72
7	15.00	2095.	628.43	.00	.00	.00	.00	.00	.00	2.72
8	10.00	2409.	628.83	.00	.00	.00	.00	.00	.00	2.72
9	7.00	2675.	629.15	1.60	.00	.00	.00	.00	1.60	2.71
10	5.00	2930.	629.38	4.04	.00	.00	.00	.00	4.04	2.66
11	3.00	3351.	629.74	20.36	.00	.00	.00	.00	20.36	2.47
12	2.00	3713.	630.01	36.81	.00	.00	.21	.00	37.02	2.19
13	1.00	4434.	630.46	85.63	.00	.00	14.63	.00	100.26	1.52
14	.50	5122.	630.79	118.42	.00	.00	27.13	.00	145.54	.91
15	.20	5839.	631.07	147.71	.00	.00	37.99	.00	185.70	.42
16	.10	6454.	631.30	172.50	.00	.00	45.63	.00	218.13	.22
EXP ANNUAL DAMAGE				2.37	.00	.00	.36	.00	2.72	

++

REACH 2, REACH NAME -
RN DAMAGE REACH 12

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **

```
FR    3B        9  77.45   14.01    4.14    1.85     .66     .29     .11     .06
     .01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF    3B   1 0      665.   2149.   3049.   3651.   4525.   5098.   5691.   7029.
   9234.

** INTERPOLATED FLOOD PEAKS **
QF    3B   1 0      225.    934.   1103.   1298.   1539.   1867.   2095.   2406.
   2666.   2909.   3286.   3590.   4180.   4731.   5301.   5809.
```

**END OF INPUT DATA FOR PLAN 3 **

EP++

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 3/

++DAMAGE DATA FOR PLAN 3 -- RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	225.	623.94	.00	.00	.00	.00	.00	.00	2.24
2	60.00	934.	626.32	.00	.00	.00	.00	.00	.00	2.24
3	50.00	1103.	626.73	.00	.00	.00	.00	.00	.00	2.24
4	40.00	1298.	627.10	.00	.00	.00	.00	.00	.00	2.24
5	30.00	1539.	627.56	.00	.00	.00	.00	.00	.00	2.24
6	20.00	1867.	628.14	.00	.00	.00	.00	.00	.00	2.24
7	15.00	2095.	628.43	.00	.00	.00	.00	.00	.00	2.24
8	10.00	2406.	628.82	.00	.00	.00	.00	.00	.00	2.24
9	7.00	2666.	629.14	1.52	.00	.00	.00	.00	1.52	2.23
10	5.00	2909.	629.36	3.84	.00	.00	.00	.00	3.84	2.18
11	3.00	3286.	629.70	17.46	.00	.00	.00	.00	17.46	2.01
12	2.00	3590.	629.92	31.01	.00	.00	.00	.00	31.01	1.78
13	1.00	4180.	630.33	71.42	.00	.00	10.43	.00	81.85	1.26
14	.50	4731.	630.61	101.21	.00	.00	20.35	.00	121.55	.76
15	.20	5301.	630.86	126.30	.00	.00	30.23	.00	156.53	.35
16	.10	5809.	631.06	146.50	.00	.00	37.62	.00	184.11	.18
EXP ANNUAL DAMAGE				1.98	.00	.00	.26	.00	2.24	

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REACH   2, REACH NAME -
RN      DAMAGE REACH 12

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **
FR   3B       9  77.45   14.01    4.14    1.85     .66     .29     .11     .06
     .01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF   3B   1 0     922.   2966.   4059.   4772.   5862.   6594.   7358.   8923.
  11291.

** INTERPOLATED FLOOD PEAKS **
QF   3B   1 0     303.   1304.   1544.   1818.   2151.   2595.   2896.   3290.
   3603.   3893.   4338.   4697.   5428.   6124.   6858.   7503.

** STAGES FOR RATING CURVE READ FROM HECDSS FILE **
SQ RCH12      10 623.64  625.59  626.94  628.18  628.87  629.68  630.14  630.57
  631.22  631.29

** FLOWS FOR RATING CURVE READ FROM HECDSS FILE **
QS RCH12  1 0     190.   1000.   1800.   2650.   3250.   4100.   4700.   5400.
   6900.   7100.

**END OF INPUT DATA FOR PLAN  5 **
EP++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 5/

++DAMAGE DATA FOR PLAN 5 --        CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
```

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	303.	623.91	.00	.00	.00	.00	.00	.00	3.26
2	60.00	1304.	626.10	.00	.00	.00	.00	.00	.00	3.26
3	50.00	1544.	626.51	.00	.00	.00	.00	.00	.00	3.26
4	40.00	1818.	626.97	.00	.00	.00	.00	.00	.00	3.26
5	30.00	2151.	627.45	.00	.00	.00	.00	.00	.00	3.26
6	20.00	2595.	628.10	.00	.00	.00	.00	.00	.00	3.26
7	15.00	2896.	628.47	.00	.00	.00	.00	.00	.00	3.26
8	10.00	3290.	628.91	.00	.00	.00	.00	.00	.00	3.26
9	7.00	3603.	629.21	2.22	.00	.00	.00	.00	2.22	3.23
10	5.00	3893.	629.49	5.14	.00	.00	.00	.00	5.14	3.16
11	3.00	4338.	629.86	27.76	.00	.00	.00	.00	27.76	2.85
12	2.00	4697.	630.14	50.76	.00	.00	4.33	.00	55.09	2.47
13	1.00	5428.	630.58	97.98	.00	.00	19.08	.00	117.06	1.65
14	.50	6124.	630.88	128.20	.00	.00	30.98	.00	159.18	.96
15	.20	6858.	631.20	161.41	.00	.00	42.22	.00	203.62	.43
16	.10	7503.	631.29	171.23	.00	.00	45.24	.00	216.47	.22
EXP ANNUAL DAMAGE				2.82	.00	.00	.44	.00	3.26	

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REACH   2, REACH NAME -
RN      DAMAGE REACH 12

++++ INPUT DATA ++++

** STAGES FOR RATING CURVE READ FROM HECDSS FILE **
SQ RCH12        10  623.82  626.54  628.06  629.13  629.67  630.29  630.60  630.91
  631.47  631.54

** FLOWS FOR RATING CURVE READ FROM HECDSS FILE **
QS RCH12   1 0      190.   1000.   1800.   2650.   3250.   4100.   4700.   5400.
   6900.   7100.

WARNING, TOO MANY POINTS IN DAMAGE RELATIONSHIP STORED IN HECDSS FILE
LIMITED TO:  18 POINTS
RELATIONSHIP TRUNCATED

** STAGES FOR DAMAGE DATA READ FROM HECDSS FILE **
SD RCH12        19  626.50  627.00  627.50  628.00  628.50  629.00  629.50  630.00
  630.50  630.61  631.00  631.50  632.00  632.50  633.00  633.50  634.00  634.50
  635.00

** FLOOD DAMAGE DATA READ FROM HECDSS FILE **

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  1   (RESIDENT)
DG RCH12   1 0 1      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.    140.    193.    244.    295.    342.    385.    427.    464.
    498.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  2   (GAS STAT)
DG RCH12   1 0 2      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
      0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  3   (  SCHOOL)
DG RCH12   1 0 3      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
      0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  4   (  CHURCH)
DG RCH12   1 0 4      0.      0.      0.      0.      0.      0.      0.      0.
     16.     20.     36.     52.     64.     73.     80.     86.     93.     98.
    101.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  5   (   OTHER)
DG RCH12   1 0 5      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
      0.

**END OF INPUT DATA FOR PLAN  6 **
ER+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
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-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH12/FREQ-DAMAGE///PLAN 6/

++DAMAGE DATA FOR PLAN 6 -- FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	303.	624.20	.00	.00	.00	.00	.00	.00	3.11
2	60.00	1304.	627.12	.00	.00	.00	.00	.00	.00	3.11
3	50.00	1544.	627.57	.00	.00	.00	.00	.00	.00	3.11
4	40.00	1818.	628.08	.00	.00	.00	.00	.00	.00	3.11
5	30.00	2151.	628.50	.00	.00	.00	.00	.00	.00	3.11
6	20.00	2595.	629.06	.00	.00	.00	.00	.00	.00	3.11
7	15.00	2896.	629.35	.00	.00	.00	.00	.00	.00	3.11
8	10.00	3290.	629.70	.00	.00	.00	.00	.00	.00	3.11
9	7.00	3603.	629.93	.00	.00	.00	.00	.00	.00	3.11
10	5.00	3893.	630.14	.00	.00	.00	4.33	.00	4.33	3.08
11	3.00	4338.	630.41	.00	.00	.00	13.04	.00	13.04	2.91
12	2.00	4697.	630.60	.00	.00	.00	19.75	.00	19.75	2.75
13	1.00	5428.	630.92	110.57	.00	.00	32.36	.00	142.93	2.03
14	.50	6124.	631.18	159.22	.00	.00	41.54	.00	200.75	1.15
15	.20	6858.	631.46	188.77	.00	.00	50.65	.00	239.41	.50
16	.10	7503.	631.54	197.22	.00	.00	52.96	.00	250.19	.25
EXP ANNUAL DAMAGE				2.07	.00	.00	1.04	.00	3.11	

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REACH   3, REACH NAME -
RN      DAMAGE REACH 13

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **
FR    2A        9  68.83   11.90    3.42    1.73     .62     .29     .12     .06
     .01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF    2A    1 0       575.   1912.   2598.   3041.   3724.   4185.   4678.   5701.
   7256.

** INTERPOLATED FLOOD PEAKS **
QF    2A    1 0       127.    698.    852.   1033.   1256.   1555.   1757.   2020.
   2216.   2389.   2679.   2944.   3410.   3863.   4375.   4872.

** STAGES FOR RATING CURVE READ FROM HECDSS FILE **
SQ RCH13        10  626.82  629.69  631.53  634.77  635.28  635.74  636.01  636.28
  636.75  636.78

** FLOWS FOR RATING CURVE READ FROM HECDSS FILE **
QS RCH13    1 0       100.    300.   1050.   1600.   2000.   2500.   2950.   3400.
   4350.   5900.

** STAGES FOR DAMAGE DATA READ FROM HECDSS FILE **
SD RCH13        18  629.50  630.00  630.50  631.00  631.50  632.00  632.50  633.00
  633.50  634.00  634.50  635.00  635.50  636.00  636.50  637.00  637.50  638.00

** FLOOD DAMAGE DATA READ FROM HECDSS FILE **

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  1   (RESIDENT)
DG RCH13    1 0 1       0.      0.      0.      0.      0.      0.      0.      0.
      0.      4.     11.     29.     95.    175.    265.    361.    450.    538.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  2   (GAS STAT)
DG RCH13    1 0 2       0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      1.      5.      8.     10.     11.     14.     17.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  3   (  SCHOOL)
DG RCH13    1 0 3       0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  4   (  CHURCH)
DG RCH13    1 0 4       0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  5   (   OTHER)
DG RCH13    1 0 5       0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

**END OF INPUT DATA FOR PLAN  1 **
EP++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 1/

++DAMAGE DATA FOR PLAN 1 -- EXISTING COND. - USES BASELINE QF,QS,DG DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	127.	627.21	.00	.00	.00	.00	.00	.00	17.79
2	60.00	698.	630.67	.00	.00	.00	.00	.00	.00	17.79
3	50.00	852.	631.05	.00	.00	.00	.00	.00	.00	17.79
4	40.00	1033.	631.49	.00	.00	.00	.00	.00	.00	17.79
5	30.00	1256.	632.75	.00	.00	.00	.00	.00	.00	17.79
6	20.00	1555.	634.51	10.95	.03	.00	.00	.00	10.98	17.55
7	15.00	1757.	634.97	27.69	1.17	.00	.00	.00	28.86	16.41
8	10.00	2020.	635.29	67.66	3.37	.00	.00	.00	71.03	14.01
9	7.00	2216.	635.47	91.46	4.68	.00	.00	.00	96.14	11.52
10	5.00	2389.	635.63	116.29	5.70	.00	.00	.00	121.99	9.36
11	3.00	2679.	635.85	150.00	7.02	.00	.00	.00	157.02	6.57
12	2.00	2944.	636.01	175.87	8.01	.00	.00	.00	183.88	4.88
13	1.00	3410.	636.29	226.54	8.86	.00	.00	.00	235.40	2.81
14	.50	3863.	636.51	266.99	9.54	.00	.00	.00	276.53	1.54
15	.20	4375.	636.75	313.04	10.37	.00	.00	.00	323.41	.65
16	.10	4872.	636.76	314.70	10.40	.00	.00	.00	325.10	.33
EXP ANNUAL DAMAGE				17.03	.75	.00	.00	.00	17.79	

++

REACH 3, REACH NAME -
RN DAMAGE REACH 13

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **
FR 2A 9 68.83 11.90 3.42 1.73 .62 .29 .12 .06
.01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF 2A 1 0 297. 1095. 1621. 2056. 2725. 3174. 3638. 4528.
5845.

** INTERPOLATED FLOOD PEAKS **
QF 2A 1 0 62. 364. 449. 550. 680. 862. 991. 1170.
1312. 1447. 1694. 1958. 2416. 2861. 3356. 3811.

**END OF INPUT DATA FOR PLAN 2 **
EP+++
-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 2/

++DAMAGE DATA FOR PLAN 2 -- RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	62.	626.82	.00	.00	.00	.00	.00	.00	3.42
2	60.00	364.	629.84	.00	.00	.00	.00	.00	.00	3.42
3	50.00	449.	630.05	.00	.00	.00	.00	.00	.00	3.42
4	40.00	550.	630.30	.00	.00	.00	.00	.00	.00	3.42
5	30.00	680.	630.62	.00	.00	.00	.00	.00	.00	3.42
6	20.00	862.	631.07	.00	.00	.00	.00	.00	.00	3.42
7	15.00	991.	631.39	.00	.00	.00	.00	.00	.00	3.42
8	10.00	1170.	632.24	.00	.00	.00	.00	.00	.00	3.42
9	7.00	1312.	633.08	.00	.00	.00	.00	.00	.00	3.42
10	5.00	1447.	633.87	2.93	.00	.00	.00	.00	2.93	3.40
11	3.00	1694.	634.89	24.84	.98	.00	.00	.00	25.82	3.14
12	2.00	1958.	635.22	58.30	2.86	.00	.00	.00	61.16	2.76
13	1.00	2416.	635.66	120.28	5.86	.00	.00	.00	126.14	1.87
14	.50	2861.	635.96	167.75	7.72	.00	.00	.00	175.47	1.11
15	.20	3356.	636.26	220.82	8.77	.00	.00	.00	229.59	.52
16	.10	3811.	636.48	262.23	9.46	.00	.00	.00	271.70	.27
EXP ANNUAL DAMAGE				3.27	.14	.00	.00	.00	3.42	

++

REACH 3, REACH NAME -
RN DAMAGE REACH 13

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **

```
FR    2A        9  68.83   11.90    3.42    1.73     .62     .29     .12     .06
     .01
```

** FLOOD PEAKS READ FROM HECDSS FILE **

```
QF    2A   1 0       297.   1095.   1589.   1920.   2387.   2689.   3011.   3807.
   5199.
```

** INTERPOLATED FLOOD PEAKS **

```
QF    2A   1 0        60.    364.    451.    554.    685.    866.    994.   1168.
   1307.   1434.   1649.   1849.   2176.   2479.   2811.   3151.
```

**END OF INPUT DATA FOR PLAN 3 **

EP++

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 3/

++DAMAGE DATA FOR PLAN 3 -- RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	60.	626.82	.00	.00	.00	.00	.00	.00	2.57
2	60.00	364.	629.85	.00	.00	.00	.00	.00	.00	2.57
3	50.00	451.	630.06	.00	.00	.00	.00	.00	.00	2.57
4	40.00	554.	630.31	.00	.00	.00	.00	.00	.00	2.57
5	30.00	685.	630.63	.00	.00	.00	.00	.00	.00	2.57
6	20.00	866.	631.08	.00	.00	.00	.00	.00	.00	2.57
7	15.00	994.	631.39	.00	.00	.00	.00	.00	.00	2.57
8	10.00	1168.	632.23	.00	.00	.00	.00	.00	.00	2.57
9	7.00	1307.	633.04	.00	.00	.00	.00	.00	.00	2.57
10	5.00	1434.	633.80	2.31	.00	.00	.00	.00	2.31	2.56
11	3.00	1649.	634.84	22.78	.83	.00	.00	.00	23.62	2.35
12	2.00	1849.	635.09	40.17	1.87	.00	.00	.00	42.04	2.06
13	1.00	2176.	635.44	86.59	4.41	.00	.00	.00	91.00	1.40
14	.50	2479.	635.72	129.48	6.22	.00	.00	.00	135.70	.84
15	.20	2811.	635.93	162.84	7.53	.00	.00	.00	170.37	.39
16	.10	3151.	636.13	198.50	8.39	.00	.00	.00	206.90	.21
EXP ANNUAL DAMAGE				2.46	.11	.00	.00	.00	2.57	

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REACH   3, REACH NAME -
RN      DAMAGE REACH 13

++++ INPUT DATA ++++

** FREQUENCIES READ FROM HECDSS FILE **
FR    2A        9  68.83   11.90    3.42    1.73     .62     .29     .12     .06
      .01

** FLOOD PEAKS READ FROM HECDSS FILE **
QF    2A   1 0      575.   1912.   2598.   3041.   3724.   4185.   4678.   5701.
   7256.

** INTERPOLATED FLOOD PEAKS **
QF    2A   1 0      127.    698.    852.   1033.   1256.   1555.   1757.   2020.
   2216.   2389.   2679.   2944.   3410.   3863.   4375.   4872.

** STAGES FOR RATING CURVE READ FROM HECDSS FILE **
SQ RCH13       10 626.82 629.20 631.01 633.93 635.06 635.55 635.82 636.07
  636.62  636.66

** FLOWS FOR RATING CURVE READ FROM HECDSS FILE **
QS RCH13    1 0     100.    300.   1050.   1600.   2000.   2500.   2950.   3400.
   4350.   5900.

**END OF INPUT DATA FOR PLAN  5 **
EP++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
-----DSS---ZWRITE Unit  71; Vers.    1:  /COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 5/

++DAMAGE DATA FOR PLAN 5 --        CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
```

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	127.	627.15	.00	.00	.00	.00	.00	.00	12.25
2	60.00	698.	630.16	.00	.00	.00	.00	.00	.00	12.25
3	50.00	852.	630.53	.00	.00	.00	.00	.00	.00	12.25
4	40.00	1033.	630.96	.00	.00	.00	.00	.00	.00	12.25
5	30.00	1256.	632.10	.00	.00	.00	.00	.00	.00	12.25
6	20.00	1555.	633.69	1.51	.00	.00	.00	.00	1.51	12.24
7	15.00	1757.	634.37	8.87	.00	.00	.00	.00	8.87	11.99
8	10.00	2020.	635.08	39.27	1.82	.00	.00	.00	41.09	10.97
9	7.00	2216.	635.27	64.82	3.22	.00	.00	.00	68.04	9.35
10	5.00	2389.	635.44	87.49	4.46	.00	.00	.00	91.94	7.76
11	3.00	2679.	635.66	120.27	5.86	.00	.00	.00	126.13	5.59
12	2.00	2944.	635.81	145.17	6.83	.00	.00	.00	152.01	4.20
13	1.00	3410.	636.08	188.34	8.22	.00	.00	.00	196.56	2.49
14	.50	3863.	636.34	235.47	9.01	.00	.00	.00	244.48	1.40
15	.20	4375.	636.62	287.52	9.91	.00	.00	.00	297.43	.60
16	.10	4872.	636.63	290.48	9.96	.00	.00	.00	300.45	.30
EXP ANNUAL DAMAGE				11.73	.52	.00	.00	.00	12.25	

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REACH   3, REACH NAME -
RN      DAMAGE REACH 13

++++ INPUT DATA ++++

** STAGES FOR RATING CURVE READ FROM HECDSS FILE **
SQ RCH13      10  626.82  629.69  631.53  634.77  635.28  635.74  636.01  636.28
  636.75  636.78

** FLOWS FOR RATING CURVE READ FROM HECDSS FILE **
QS RCH13   1 0      100.    300.   1050.   1600.   2000.   2500.   2950.   3400.
   4350.   5900.

WARNING, TOO MANY POINTS IN DAMAGE RELATIONSHIP STORED IN HECDSS FILE
LIMITED TO:  18 POINTS
RELATIONSHIP TRUNCATED

** STAGES FOR DAMAGE DATA READ FROM HECDSS FILE **
SD RCH13      19  629.50  630.00  630.50  631.00  631.50  632.00  632.50  633.00
  633.50  634.00  634.50  635.00  635.50  636.00  636.01  636.50  637.00  637.50
  638.00

** FLOOD DAMAGE DATA READ FROM HECDSS FILE **

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  1   (RESIDENT)
DG RCH13   1 0 1      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.    265.    361.    450.
    538.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  2   (GAS STAT)
DG RCH13   1 0 2      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      1.      5.      8.      8.     10.     11.     14.
     17.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  3   (  SCHOOL)
DG RCH13   1 0 3      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
      0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  4   (  CHURCH)
DG RCH13   1 0 4      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
      0.

DATA BELOW WILL BE AGGREGATED TO DAMAGE CATEGORY  5   (   OTHER)
DG RCH13   1 0 5      0.      0.      0.      0.      0.      0.      0.      0.
      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
      0.

**END OF INPUT DATA FOR PLAN  6 **
EJ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
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-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RCH13/FREQ-DAMAGE///PLAN 6/

++DAMAGE DATA FOR PLAN 6 -- FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA

	FREQ	FLOW	STAGE	RESIDENT	GAS STAT	SCHOOL	CHURCH	OTHER	TOTAL	ACC EAD
1	99.00	127.	627.21	.00	.00	.00	.00	.00	.00	3.92
2	60.00	698.	630.67	.00	.00	.00	.00	.00	.00	3.92
3	50.00	852.	631.05	.00	.00	.00	.00	.00	.00	3.92
4	40.00	1033.	631.49	.00	.00	.00	.00	.00	.00	3.92
5	30.00	1256.	632.75	.00	.00	.00	.00	.00	.00	3.92
6	20.00	1555.	634.51	.00	.03	.00	.00	.00	.03	3.92
7	15.00	1757.	634.97	.00	1.17	.00	.00	.00	1.17	3.88
8	10.00	2020.	635.29	.00	3.37	.00	.00	.00	3.37	3.77
9	7.00	2216.	635.47	.00	4.68	.00	.00	.00	4.68	3.65
10	5.00	2389.	635.63	.00	5.70	.00	.00	.00	5.70	3.54
11	3.00	2679.	635.85	.00	7.02	.00	.00	.00	7.02	3.42
12	2.00	2944.	636.01	.00	8.02	.00	.00	.00	8.02	3.34
13	1.00	3410.	636.29	149.66	8.87	.00	.00	.00	158.53	2.61
14	.50	3863.	636.51	266.99	9.54	.00	.00	.00	276.53	1.54
15	.20	4375.	636.75	313.04	10.37	.00	.00	.00	323.41	.65
16	.10	4872.	636.76	314.70	10.40	.00	.00	.00	325.10	.33
EXP ANNUAL DAMAGE				3.16	.75	.00	.00	.00	3.92	

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* *

COOPER CREEK   DENTON, TEXAS
INPUT DECK COOP.E
DSS UTILIZATION = HEC-1, HEC-2, SID = FIVE PLANS

** SUMMARY OF REACH NAMES **

NO	ID	. . NAME . . .
1	RCH11	DAMAGE REACH 11
2	RCH12	DAMAGE REACH 12
3	RCH13	DAMAGE REACH 13

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* *

COOPER CREEK   DENTON, TEXAS
INPUT DECK COOP.E
DSS UTILIZATION = HEC-1, HEC-2, SID = FIVE PLANS

** EXPECTED ANNUAL DAMAGE SUMMARY BY REACH **

** FLOOD PLAIN MANAGEMENT PLANS

1 - EXISTING COND. - USES BASELINE QF,QS,DG DATA
2 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
3 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
5 - CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
6 - FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA

SUMMARY FOR DAMAGE CATEGORY 1 - RESIDENT

. . . . EXPECTED ANNUAL DAMAGE

REACH NO	ID	BASE CONDITION (PLAN 1)	.... PLAN 2.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 3.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 5.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 6.... DAMAGE W/PLAN	DAMAGE REDUCED
1	RCH11	9.48	3.23	6.26	2.66	6.82	3.76	5.72	3.75	5.74
2	RCH12	7.01	2.37	4.65	1.98	5.03	2.82	4.19	2.07	4.94
3	RCH13	17.03	3.27	13.76	2.46	14.57	11.73	5.30	3.16	13.87
RESIDENT		33.53	8.87	24.66	7.11	26.42	18.31	15.22	8.98	24.55

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/RESIDENT/REACH-EAD////

* *

COOPER CREEK DENTON, TEXAS
INPUT DECK COOP.E
DSS UTILIZATION = HEC-1, HEC-2, SID = FIVE PLANS

** EXPECTED ANNUAL DAMAGE SUMMARY BY REACH **

** FLOOD PLAIN MANAGEMENT PLANS
1 - EXISTING COND. - USES BASELINE QF,QS,DG DATA
2 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
3 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
5 - CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
6 - FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA

SUMMARY FOR DAMAGE CATEGORY 2 - GAS STAT

. . . . EXPECTED ANNUAL DAMAGE

REACH NO	ID	BASE CONDITION (PLAN 1)	.... PLAN 2.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 3.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 5.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 6.... DAMAGE W/PLAN	DAMAGE REDUCED
1	RCH11	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	RCH12	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	RCH13	.75	.14	.61	.11	.64	.52	.24	.75	.00
GAS STAT		.75	.14	.61	.11	.64	.52	.24	.75	.00

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/GAS STAT/REACH-EAD////

* *

COOPER CREEK DENTON, TEXAS
INPUT DECK COOP.E
DSS UTILIZATION = HEC-1, HEC-2, SID = FIVE PLANS

** EXPECTED ANNUAL DAMAGE SUMMARY BY REACH **

** FLOOD PLAIN MANAGEMENT PLANS
1 - EXISTING COND. - USES BASELINE QF,QS,DG DATA
2 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
3 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
5 - CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
6 - FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA

SUMMARY FOR DAMAGE CATEGORY 3 - SCHOOL

. . . . EXPECTED ANNUAL DAMAGE

REACH NO	REACH ID	BASE CONDITION (PLAN 1)	.... PLAN 2.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 3.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 5.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 6.... DAMAGE W/PLAN	DAMAGE REDUCED
1	RCH11	9.62	5.04	4.59	5.01	4.62	7.07	2.56	9.62	.00
2	RCH12	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	RCH13	.00	.00	.00	.00	.00	.00	.00	.00	.00
	SCHOOL	9.62	5.04	4.59	5.01	4.62	7.07	2.56	9.62	.00

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/SCHOOL/REACH-EAD////

* *

COOPER CREEK   DENTON, TEXAS
INPUT DECK COOP.E
DSS UTILIZATION = HEC-1, HEC-2, SID = FIVE PLANS

** EXPECTED ANNUAL DAMAGE SUMMARY BY REACH **

** FLOOD PLAIN MANAGEMENT PLANS
1 - EXISTING COND. - USES BASELINE QF,QS,DG DATA
2 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
3 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
5 - CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
6 - FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA

SUMMARY FOR DAMAGE CATEGORY 4 - CHURCH

. . . . EXPECTED ANNUAL DAMAGE

REACH NO	REACH ID	BASE CONDITION (PLAN 1)	.... PLAN 2.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 3.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 5.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 6.... DAMAGE W/PLAN	DAMAGE REDUCED
1	RCH11	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	RCH12	1.04	.36	.68	.26	.78	.44	.60	1.04	.00
3	RCH13	.00	.00	.00	.00	.00	.00	.00	.00	.00
	CHURCH	1.04	.36	.68	.26	.78	.44	.60	1.04	.00

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/CHURCH/REACH-EAD////

* *

COOPER CREEK DENTON, TEXAS
INPUT DECK COOP.E
DSS UTILIZATION = HEC-1, HEC-2, SID = FIVE PLANS

** EXPECTED ANNUAL DAMAGE SUMMARY BY REACH **

** FLOOD PLAIN MANAGEMENT PLANS
1 - EXISTING COND. - USES BASELINE QF,QS,DG DATA
2 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
3 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
5 - CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
6 - FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA

SUMMARY FOR DAMAGE CATEGORY 5 - OTHER

. . . . EXPECTED ANNUAL DAMAGE

REACH NO	REACH ID	BASE CONDITION (PLAN 1)	.... PLAN 2.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 3.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 5.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 6.... DAMAGE W/PLAN	DAMAGE REDUCED
1	RCH11	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	RCH12	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	RCH13	.00	.00	.00	.00	.00	.00	.00	.00	.00
	OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/OTHER/REACH-EAD////

* *

COOPER CREEK DENTON, TEXAS
INPUT DECK COOP.E
DSS UTILIZATION = HEC-1, HEC-2, SID = FIVE PLANS

** EXPECTED ANNUAL DAMAGE SUMMARY BY REACH **

** FLOOD PLAIN MANAGEMENT PLANS
1 - EXISTING COND. - USES BASELINE QF,QS,DG DATA
2 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
3 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
5 - CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
6 - FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA

GRAND SUMMARY - ALL DAMAGE CATEGORIES

. . . . EXPECTED ANNUAL DAMAGE

REACH NO	REACH ID	BASE CONDITION (PLAN 1)	.... PLAN 2.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 3.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 5.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 6.... DAMAGE W/PLAN	DAMAGE REDUCED
1	RCH11	19.11	8.26	10.84	7.67	11.44	10.83	8.28	13.37	5.74
2	RCH12	8.05	2.72	5.33	2.24	5.81	3.26	4.80	3.11	4.94
3	RCH13	17.79	3.42	14.37	2.57	15.22	12.25	5.54	3.92	13.87
	TOTAL	44.94	14.40	30.54	12.48	32.47	26.33	18.61	20.39	24.55

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK/ALL CATEGORIES/REACH-EAD////

* *

COOPER CREEK   DENTON, TEXAS
INPUT DECK COOP.E
DSS UTILIZATION = HEC-1, HEC-2, SID = FIVE PLANS

** GRAND SUMMARY BY CATEGORY **

** FLOOD PLAIN MANAGEMENT PLANS
1 - EXISTING COND. - USES BASELINE QF,QS,DG DATA
2 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (650) QF DATA
3 - RESERVOIR - USES BASELINE QS,DG DATA - UNGTD RES (655) QF DATA
5 - CHANNEL - USES BASELINE QF,DG DATA - CHANNEL QS DATA
6 - FLOOD-PROOFING-USES BASELINE QF,QS DATA-FLOODPROOFING DG DATA

GRAND SUMMARY - ALL DAMAGE CATEGORIES

. . . . EXPECTED ANNUAL DAMAGE

DAMAGE CATEGORY	BASE CONDITION (PLAN 1)	.... PLAN 2.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 3.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 5.... DAMAGE W/PLAN	DAMAGE REDUCED	.... PLAN 6.... DAMAGE W/PLAN	DAMAGE REDUCED
RESIDENT	33.53	8.87	24.66	7.11	26.42	18.31	15.22	8.98	24.55
GAS STAT	.75	.14	.61	.11	.64	.52	.24	.75	.00
SCHOOL	9.62	5.04	4.59	5.01	4.62	7.07	2.56	9.62	.00
CHURCH	1.04	.36	.68	.26	.78	.44	.60	1.04	.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL	44.94	14.40	30.54	12.48	32.47	26.33	18.61	20.39	24.55

-----DSS---ZWRITE Unit 71; Vers. 1: /COOPER CREEK//PLAN-EAD////

READIN -- NO RECORDS READ FROM USER INPUT

++++++++++++++++
END OF RUN
EAD PROGRAM STOP
++++++++++++++++
-----DSS---ZCLOSE Unit: 71
Number of Records: 69
File Size: 133.7 Kbytes
Percent Inactive: .00

Elapsed CPU time is 26 seconds or .433 minutes.

2/16/90

SCHUYLKILL RIVER AT READING

(A CASE STUDY IN THE USE OF SID AND EAD SOFTWARE)

FEBRUARY 1990

BY

Gene Senycz, Regional Economist
Philadelphia District

L-1309/90

SCHUYLKILL RIVER
(A CASE STUDY IN THE USE OF SID AND EAD)

OVERVIEW

The major purpose of the Schuylkill River Basin Limited Reconnaissance Study is to identify areas within the Schuylkill River Basin which warrant further consideration with regards to structural and non - structural solutions to flooding problems. A secondary purpose of the analysis is to update flood damages prevented from Blue Marsh Dam which became operational in 1979.

GENERAL EXTENT OF PROBLEM

The last study in the Schuylkill River Basin, was a 1980 report which investigated nine areas considered to be representative of main stem communities subject to flooding problems. The nine areas selected for investigation were the City of Reading, Spring City, Royersford, Phoenixville, Upper Providence, Bridgeport, Norristown, Conshohoken and Manayunk (see figure 1 for location). The 1980 economic analysis found no structural solutions at any of the nine locations which were economically justified. The benefit - cost ratio for a floodwall alternative was 0.2 to 1 at Reading.

The Limited Recon Study will address all nine areas with specific emphasis on the City of Reading. An attempt will be made to use revised average annual damages at Reading to pro rate average annual damages at the other damage centers from the 1980 report to see if new methods and conditions have made structural alternatives more economically viable.

A stage - damage curve was to be developed for the City of Reading based on current methods and conditions. Revised average annual benefits were to be developed utilizing the same stage - frequency information as the 1980 report with the revised stage - damage information. Average annual costs for the floodwall were updated and a revised benefit - cost ratio was developed. In addition, levels of protection other than the 100 year frequency were to be investigated. Finally, the effects of Blue Marsh Dam were to be estimated.

STUDY AREA

The Schuylkill River basin is located in Southeastern Pennsylvania, entirely within the boundaries of that Commonwealth. The basin is about 93 miles long and averages about 21 miles in width. Rising in the Appalachian Mountains in Schuylkill County, the Schuylkill River flows in a generally southeasterly direction to its confluence with the Delaware River and drains an area of 1,916 square miles. The headwaters region is characterized by steep and narrow valleys. The valley walls reach elevations of as much as 1,050 feet above the stream beds. At approximately 25 miles below its source, the river cuts a gap through the Blue

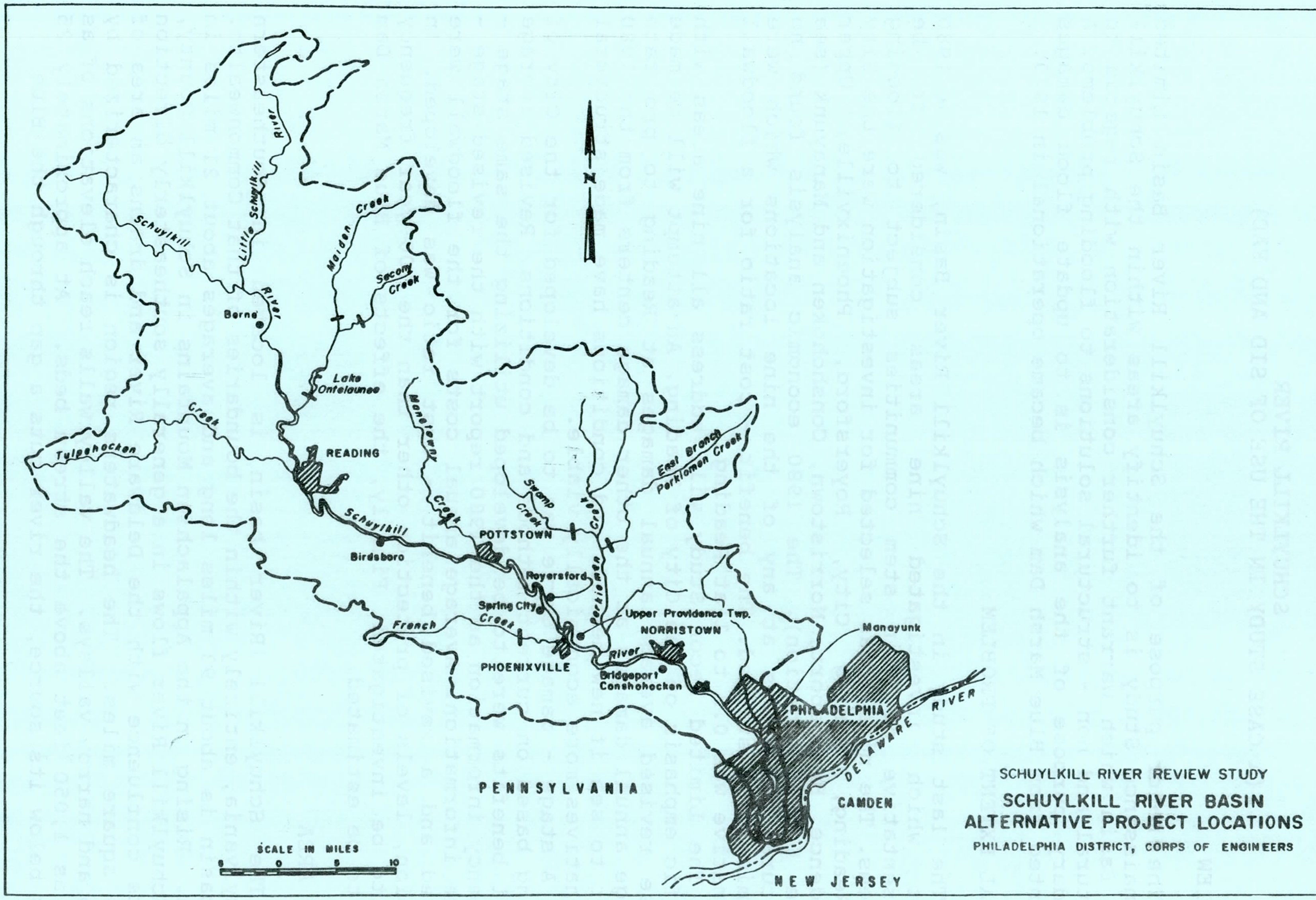

SCHUYLKILL RIVER REVIEW STUDY
SCHUYLKILL RIVER BASIN
ALTERNATIVE PROJECT LOCATIONS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
N
Schuylkill
Little Schuylkill River
Maiden Creek
Second Creek
Berne
River
Lake Ontelaunee
Tulpehocken
Creek
READING
Manatawny
Creek
Schuylkill
Birdsboro
POTTSTOWN
Swamp Creek
Perkiomen Creek
East Branch Perkiomen Creek
Royersford
Spring City
French Creek
Upper Providence Twp.
NORRISTOWN
Manayunk
PHOENIXVILLE
River
Bridgeport
Conshohocken
PHILADELPHIA
DELAWARE RIVER
PENNSYLVANIA
CAMDEN
NEW JERSEY
SCALE IN MILES
5 0 5 10

FIGURE 1

2

Mountain Range. Below this point, the region is a much more gentle country with the low hills and rolling terrain typical of southeastern Pennsylvania. Immediately before its confluence with the Delaware River, the region is one of low relief with much tidal marshlands. There are no large natural lakes in the watershed.

The Schuylkill River basin has a modified continental type climate. Warm humid summers, moderately cold winters, and ample rain distributed throughout the year are characteristic of the region. Much of the study area is covered by weather systems which bring warm air from the south and cold air from the north. Variations in temperature and frequent changes in the weather are more common in winter and spring than in summer and fall. Valleys and mountains exert a great influence on the weather. Local variations in temperature are caused by these differences in topography. The average annual precipitation ranges from 40 inches in Philadelphia to 50 inches in Pottsville. Precipitation in the Schuylkill River basin is well distributed throughout the year with only a two-inch difference between the wettest month, August, and the driest month, October. Thunderstorms are responsible for the largest amount of short period rainfall. They are also the most frequent and most damaging storms of the study area. There are, on the average, approximately 30 thunderstorms a year and they occur most frequently between April and September. Wind and heavy rains caused by hurricanes occasionally affect the Schuylkill River basin. The period between July and October has the highest incident of hurricanes or storms which are remnants of hurricanes. Only a few small tornadoes have been reported. Floods can occur any time of the year, but hurricane caused flooding in the fall and flooding caused by a combination of precipitation and snowmelt in the spring have been proven to be the most severe.

Historically, floods have been recorded in the area since 1757. All types of development including residential, commercial, industrial and public property have been affected. The flow of record for most of the area was caused by rainfall associated with Hurricane Agnes during June 1972 and caused millions of dollars of damage in the area (as shown in Table 1). The Federal government, the Commonwealth of Pennsylvania and local agencies have constructed flood control improvements along the river and its tributaries. These projects have reduced the potential for flood damages but much of the basin is still subject to recurrent flooding problems.

TABLE 1

MAJOR FLOOD FOR SELECTION DAMAGE CENTERS
Schuylkill River Basin
(Dec 72 Price Level)

LOCATION	DAMAGES (thousands of dollars) Aug 1933 1/	Mar 1936 1/	Aug 1955 2/	Jun 1972 3/4/
Reading	665.7	2.1	7.0	29,717.0
Birdsboro	127.5	1.2	28.2	4,648.5
Spring City	24.4	-	1.0	2,905.9
Royersford	57.9	0.2	0.5	4,615.8
Upper Providence Township	-	-	-	5,647.9
Phoenixville	19.8	-	3.4	5,674.7
Norristown	121.6	2.1	see below	6,679.7
Bridgeport	152.2	1.5	42.0	2,048.8
Conshohocken	14.7	0.2	see below	4,779.7
Manayunk	48.0	-	186.2	included in Philadelphia
Philadelphia	81.4	-	162.8	8,564.8

Footnotes:

1/ Source: Table 3, Appendix D, Volume III, House Document No. 522, 87th Congress, 2d Session

2/ Source: Table 4, Appendix D, Volume III, House Document No. 522, 87th Congress, 2d Session

3/ Source: Final Report, Schuylkill River Basin, Post Hurricane Agnes, Flood Damage Survey, December 1972

4/ Source: Selected major damage areas only.

METHODOLOGY

A study area of this size required a methodical approach for identification, collection of data and analysis of flood prone units. A basic schematic of the approach which was adopted is presented in Figure 2. This process was initiated with a research of all available data in order to, first, identify the extent of the problem areas; and, then, to define the general scope of the effort to be required. Next, the entire study area was divided into damage reaches which would be the basic units for cataloging and building economic models for estimating inundation damages. A system for collecting, assimilating, and managing the data was developed. This was followed with an inventory of the entire flood plain. Data collected in the inventory was supplemented by follow-up mail questionnaires, phone calls, and selected interviews, as required. All this information was prepared and processed for input to the damage inundation models. As the data was being collected as processed, methodologies were being developed for maximizing the use of attainable data. Adaption of standardized models and development of new ones translated these methodologies into working procedures. Finally, flood damage potential could be analyzed in order to define current and future flood water and flood plain management problems and needs.

DELINEATION OF FLOOD DAMAGE REACHES. A 1989 inventory of the structures within the 500 year flood plain was done at the Schuylkill River in Reading. To facilitate the inventory, the flood plain was divided into 13 discrete reaches based on a combination of hydraulic, hydrologic physical and/or political factors such as bridges, creeks, and drainage or township boundaries. These damage reaches were designated as shown for the sample on Figure 3. Reach (numerical) identification was constructed in compliance with political boundaries. The first two digits identify the county and state; the second two digits, the municipality; and the third two, an assigned number.

This refinement in dividing and identifying reaches was done in order to collect and manage the data in such a manner that it served as the basic unit for constructing economic models and performing the analyses. These units can then be combined, accumulated, summarized and reported in the selected manner as required.

INVENTORY OF STRUCTURES. The "field inventory" was structured for basin identification and description through visual inspection and readily available information without the use of questionnaires or formal interviews. Survey teams were sent into the field to collect the data and paid particular attention where:

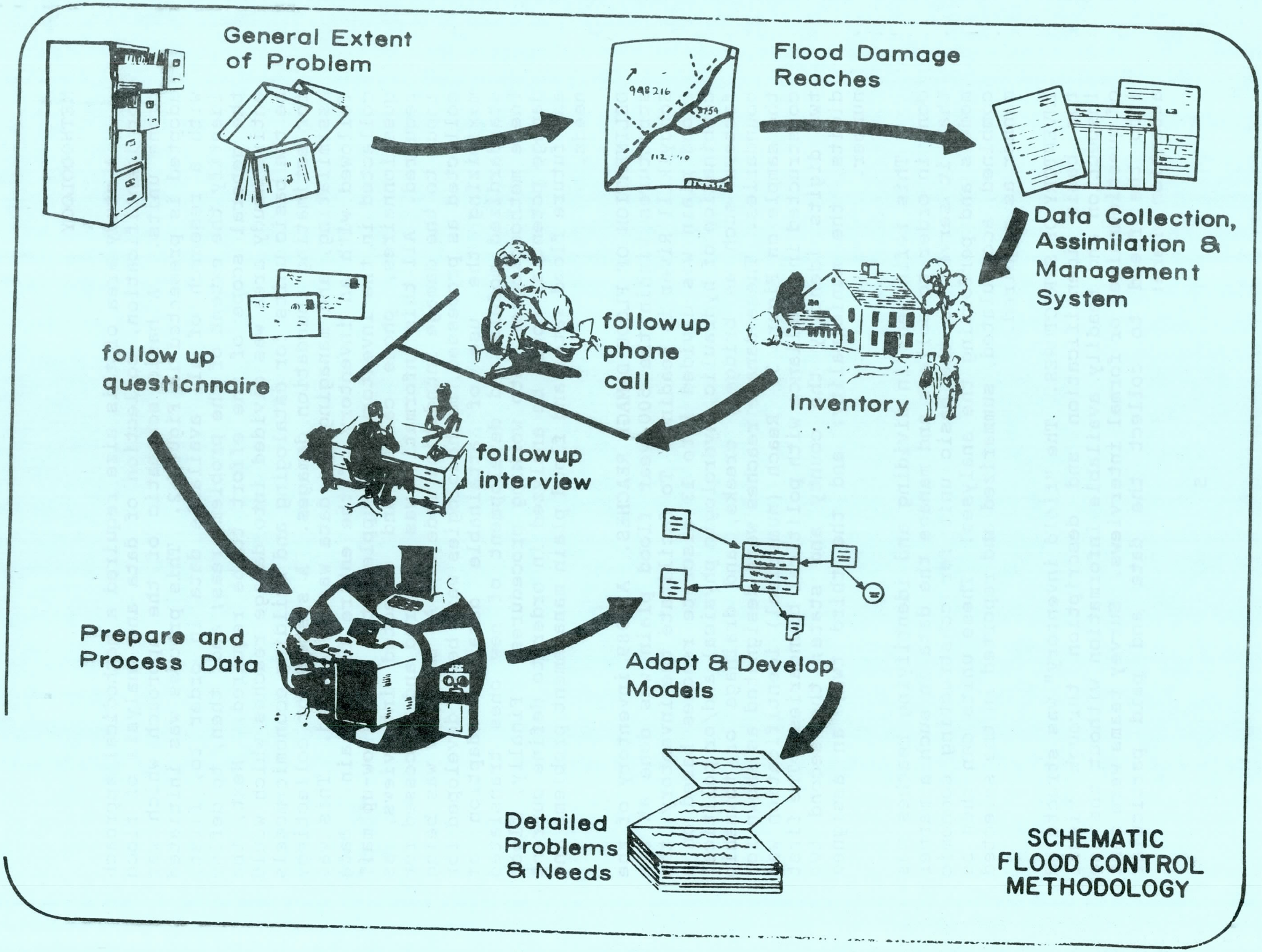
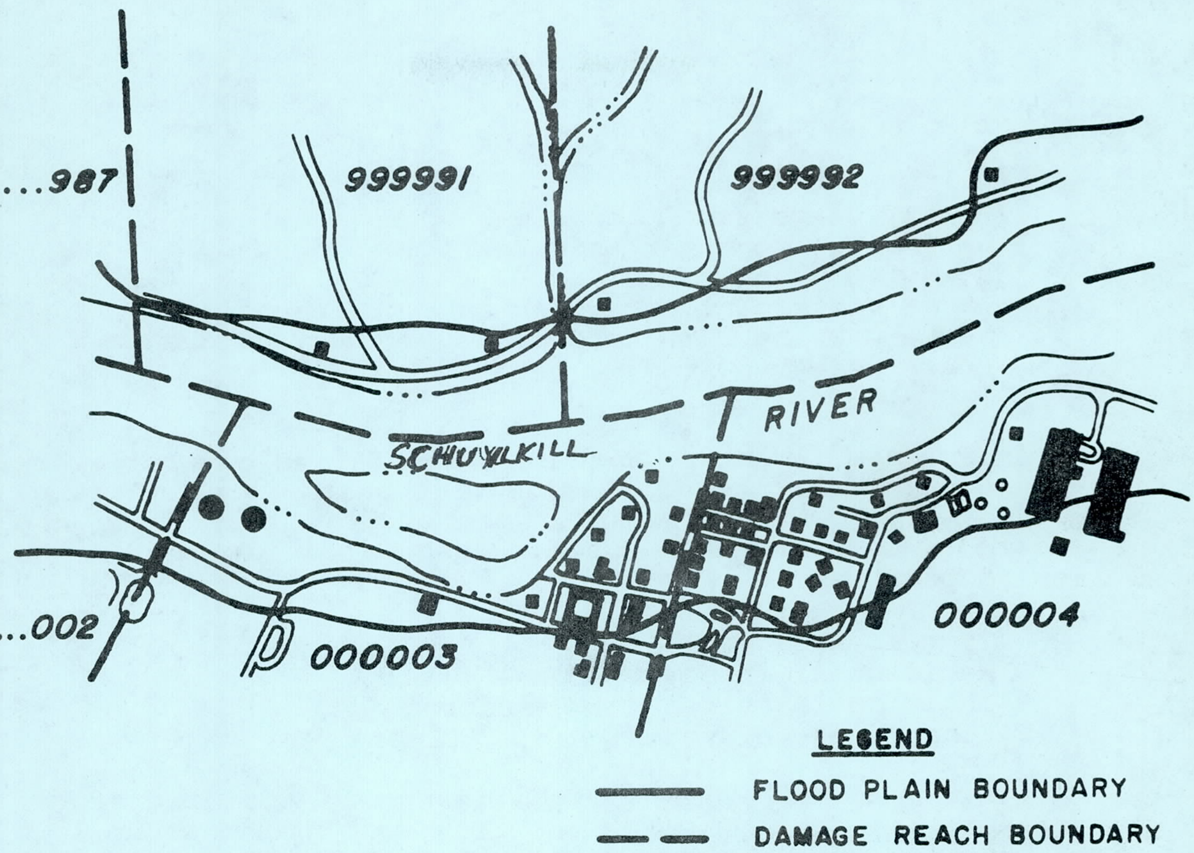
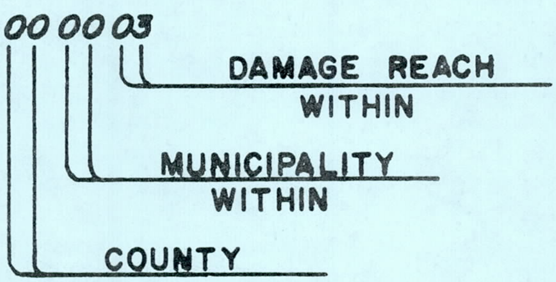

General Extent of Problem
Flood Damage Reaches
Data Collection, Assimilation & Management System
Inventory
followup phone call
follow up questionnaire
followup interview
Prepare and Process Data
Adapt & Develop Models
Detailed Problems & Needs
SCHEMATIC FLOOD CONTROL METHODOLOGY

FIGURE 2





FLOOD DAMAGE REACH DELINEATION

FIGURE 3

- All or part of the structure was hidden from view or was inaccessible.

- Highly congested urban areas where structures were close together and traffic was heavy.

- Large commercial establishments or industrial centers where cars were not allowed or guided tours were required.

An individual inventory data form was filled out for every non-residential structure. Residential units were listed on summary sheets. The different types of inventory forms are listed below and they will be discussed individually in the following paragraphs.

Typical Residential
Residential Inventory Form
Individual Residential-Historic
Commercial-Industrial-Public-Order

The primary objective of the inventory and, therefore, function of these forms was to identify every flood prone unit within the 500 year floodplain. The intent was to gather what was readily available and to later assess the voids and determine what further efforts would be needed.

<u>Inventory Forms</u>. The inventory forms were assigned and first used in the field. They then required follow-up entrees in the office. Control of the forms and data was maintained by assigning each unit an individual identification number. The identification was completed with its address, the map on which it can be located; and the damage reach in which it lies. Two items of information which are used for the economics are the type of construction and the disaggregated values of its lands and improvements. Stage and elevation data entries spatially fix the unit. The elevation of the reference flood and reference point were entered. The reference point is normally the first floor level. Then the stages of the zero damage point, basement and ground are referenced above or below the reference point or is entered as an elevation, whichever is available. The size of the structures were also ascertained.

The forms also allowed the opportunity for the team to document significant or distinguishable information and supplemental data such as:

- Description of additional significant items on property such as large garages, heavy equipment, outside storage, etc.

- Approximate number of windows and doors located on basement and first floor as well as their average size and stage above or below the first floor.

- Attachment of photographs. Photographs were taken of most units except for normal residencies. Only selected photographs were taken of these.

Typical Residential Form. Since most of the residential units were similar or common throughout the entire basin, one of these units was inventoried and photographed and the information was recorded on a "typical" data form. "Typical" varied according to size, number of stories, and construction type. Each "typical" was assigned a different code and, as the floodplain was inventoried, the residential structures were assigned and related to their respective "Typical".

Residential Inventory Form. This form was used to list and identify groups of homes on one or more streets. Since the stage damage curves for the normal residential units are computed from typical curves, a typical residential code is assigned as well as typical structure and content stage percentage curves. Specific physical data recorded includes, first floor elevations, zero damage elevations, and whether it has a basement. (see Attachment 1)

Industrial/Commercial-Public-Other Forms. These forms essentially covers all other flood prone units. These are designed for units which are too individualistic to group together. They are usually the units which, once flooded, result in greater flood damages and related costs. They are also the ones which cannot be easily generalized in applying nonstructural measures (see Attachment 2 and 3).

INDUSTRIAL DAMAGES. Industrial activities were computed on an individual basis. The wide range of sizes and diversified plants made it impractical to develop a generalized procedure for estimating damages. In addition, for those reaches which include industrial activities, the large percentage of industrial flood damage to total damages highlights the importance of collecting site-specific data to insure the accuracy of estimated flood damages. The inventory identified all significant activities with a ZDE (zero damage elevation) below the 100 frequency.

All of the firms were then prioritized according to damage potential primarily based on their size (structure and content assets) and their zero damage elevation and frequency. Damage survey teams then interviewed and inspected the top firms. This was done to assure their accuracy since these firms often represented a major portion of the damages in their respective damage reaches. (see Attachment 4 for questionnaire)

For those firms which refused to cooperate, conservative stage-damage relationships were developed by modifying those similar industries in the study area or from past studies. A vacant facility with no definite plans was assigned the activity which last occupied it. Abandoned facilities were ignored and treated as open spaces.

Structural value was estimated on the building square footage multiplied by a value based on Marshall and Swift building costs.

If a business had several buildings; then each building had its on structure and content curves. If a company with several building experienced a business loss, only the main building would have a business loss curve.

Business losses were set up with various stages having the appropriate dollar values to represent the business loss at each stage. A business must be shut down due to flooding to experience business loss. The three contributors to the business losses were:

- Those sales that were not transferable (excluding foreign markets) or deferable (a unique product).
- The fixed overhead of the business, which includes: depreciation, insurance, taxes, salaries, rent or mortgage, etc.
- Employee wages lost from lay-offs due to flooding (excluding those employees used in cleanup operations which were included in the structure cost category).

Product transferability or deferability was the key to business loss. If the facility did not meet this criteria, then no business loss, no matter what the fixed overhead costs and lost wages were incurred.

COMMERCIAL DAMAGE

Structural losses were estimated on square footage times a value based on Marshall and Swift. Content losses were usually estimated by combination procedure utilizing an automated library of stage-damage (percentage) curves in conjunction with total damageable content value obtained from interviews or estimated from regression equations relating square footage to damage potential. Business losses were generally not quantified since they were, for the most part, either transferable or deferable. For those few instances where a case could be made for a unique product or market, business losses were tabulated. For units which were either too large or unique to generalize, individual curves were developed through damage surveys and field inspections.

Vacant businesses were assigned the activity which last occupied that structure. A vacant unit was defined as presently being unoccupied but probably would be occupied within a short period of time (within 1 year). The building had to be structurally sound, but might need minor repair to restore it to a usable condition. The unit was coded as being occupied by its previous activity and was included in the damage computations. On the other hand, an abandoned unit was defined as a structure which was unoccupied under existing conditions and was in such disrepair and decay that it could not be ignored and not included in the data base.

RESIDENTIAL DAMAGES. Generalized or typical residential structures were used to determine damages. Typical units vary with respect to structural type, construction material and square footage. Typical stage-damage curves were developed by adjusting 1974 Flood Insurance Administration (FIA) curves to better reflect differences with the type of units predominant in the Schuylkill River Basin. Previous detailed damage surveys within the Schuylkill River Basin were utilized for this comparison. The most consistent differences were for damages below the first floor. Below the first floor, FIA damages and related costs were consistently conservative. This is due in large part to the fact that FIA curves are truncated at 3 feet below first floor (-3 stage). This does not present a complete estimate since documented damages and field inventories indicate that damages often incurred below this stage.

Structural value was based on replacement costs for typical structures in the Schuylkill River Basin. This information was provided by Philadelphia District design and cost engineers.

Content value was determined by a regression equation relating value of contents to value of structure. This procedure compared favorably with a comparison which was made with detailed damaged surveys for residential units of similar characteristics. The effect of the increasing real value of residential contents in the future, or affluence, was not evaluated at this time.

PUBLIC. The inventory sheets for the public land use category were reviewed to determine their susceptibility to flooding. Their 100 year reference flood elevation relative to their zero damage elevation (ZDE) was used as an indicator of this susceptibility. Those units with their ZDE below the 100 year reference flood were given priority and analyzed in detail including any necessary interviews and field inspections. A more generalized approach was used for those units (non-priority) with a ZDE above the reference flood and with a "suitable match." A "suitable match" meant that information from their questionnaires indicated a standard typical curve could be used. The typical curves are composites of previous detailed damage surveys which included interviews and site inspections.

UTILITIES. This category includes all those plants and associated facilities for power generation, telephone, municipal water supply and waste-water treatment. It does not include their business offices. The basic method of analysis was generally similar for all types of utility with the methodology for the power generating facilities varying the most. This basic methodology was one of the developing preliminary curves from published literature. These were based on plant capacities. These were then modified with information from local agencies or consultants and, then, finalized with information received from questionnaires and interviews. This process leads to establishing the shapes of the curves from a more universal
data base, but then fixing its magnitude (elevation and expected damages) for critical threshold points on these curves with site specific data.

ROADS AND RAILROADS. Estimates for transportation damages were computed using field data; aerial, topographic and highway mapping; information from knowledgeable sources; and repair and replacement cost estimates. Comparisons with historic documentation of actual damages and losses were made as a check. Most of the losses were to primary and secondary highways, rail bedding and bridges. Business losses were assumed to be either transferable or deferable. Loss of time and increased expense of normal vehicular operations due to detours are also included.

EMERGENCY COSTS. Emergency costs were based on historical information from the 1972 flood in the Schuylkill River Basin. Although there have been damages over the last 30 years in the flood plain the majority of structures and community distributions remain relatively the same. The relationship of physical damages to emergency costs from the 1972 event were, therefore, applied to current physical damages to estimate existing emergency costs.

DEVELOP MODELS

SID. The Structure Inventory for Damage Analysis computer program (SID) was used for the systematic collection, management and processing of data related to structures subject to flooding. 1/ The primary function of the program is to generate elevation-damage function which can be further processed by EAD (EAD is discussed in the following section). SID has the capability to compute damages by category and reach for specific flood events (individually).

Aggregation of elevation-damages by category and reach to an index location within each reach constitutes the fundamental analytic capability of the SID program. The aggregates are derived by summing stage-damages of individual structures, by damage category and reach considering the structure elevation and nature of the flood profiles. The basis process is:

- Stage-damages are developed for individual structures either from the appropriate typical (generalized) stage percentage damage relationship or from direct dollar damage relationship for each unit.
- The stage values are converted to elevation by equating zero stage to a specific elevation (first floor elevation).
- The next step in the aggregation process was to adjust or "translate" the elevation scale for each structure to correspond to the datum at the index location. This adjustment was required to account for the slope of the water surface profile throughout the damage reach. The reference flood concept is used in the adjustment process. A reference flood is defined as a flood profile representative of the range of flood profiles that are expected to occur. Flood profiles from both historic events and computed profiles from hypothetical or standard events (i.e., 100-year event) were used.

1/ Structure Inventory for Damage Analysis (SID) Computer Program; Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers Davis, California; January 1982.

- The difference between the reference flood water surface elevation at the structure and the reference flood water surface elevation at the index location is computed and the elevation scale adjusted.
- The final step is to sum elevation-damage functions for each reach at the respective index location. Aggregates are formed by summing adjusted elevation-damages of each structure with those of other structures assigned to the same damage category and reach.

A partial sample SID input file used for the Reading area is displayed in attachment 5. The reference flood used was the FIA 100 year. Every reach was aggregated to the same index location. This was because the H + H was only available at one point. In future studies each reach will have its own unique index location. Attachment 6 shows the SID output file which displays the number of structures by flood zone and aggregated single event damages for all reaches by land use category.

EAD. The Expected Annual Flood Damage Computation (EAD) program is used for the computation of average annual damages 1/. EAD is based on the principle that flood damage to an individual structure, group of structures, or flood plain reach can be estimated by determining the dollar value of flood damage for different depths of flooding and by estimating the percent chance of exceedence of each flood depth. To compute the average damage which can be expected in a year, the damage corresponding to each depth of flooding was weighted by the percent chance of each depth occurring (damage caused by rare events is weighted less). The sum of the weighted damage represents the expected annual flood damage. If the damage and frequency relationships remain unchanged each year, then the expected annual value represents the damage which can be expected to occur during any one year.

To compare the magnitude of damage of alternative plans or to compare damage with costs, an equivalent annual value was computed. This equivalent value represents a uniform distribution (the same each year) of annual damage value over a period of analysis. The discounting and amortization takes into account the time value associated with damage values.

1/ Expected Annual Flood Damage Computation; Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers, Davis, California, June 1977.

Expected annual damage is the frequency weighted sum of damage for the full range of damaging flood events and can be viewed as what might be expected to occur in any present or future year. It represents the annual damage for a particular set of hydrologic, hydraulic and damage conditions. In the computer program expected annual damage is computed for each input data year, the study year, the base year and each decade year. Each damage value is then weighted according to its percent chance of occurrence. Within the period of analysis, expected annual damage is computed for each year. This is done by first computing expected annual damage for the base year, each decade year (every 10 years from the beginning of operation), and for each input data year. Stage, flow, and damage data for each input data year are used to compute similar data for the base and decade years. Between any pair of input data years the stage, flow, and damage data are assumed to be the same as for the last or single input data year. The equivalent annual flood damage is computed by discounting back each expected annual damage to the base year and then amortizing the total over the period of analysis.

A partial EAD input file is shown for the Reading area in attachment 7. As shown in the input file, three plans were analyzed. In addition, an RV card was used to truncate the stage damage curve at elevation 200 which was the estimated top of bank elevation. Attachment 8 displays the EAD output file. The expected annual damages for each reach and plan are summarized. As shown in attachment 8, the base or natural condition has approximately $2,500,000 of average annual damages in the Reading area. The effects of the Blue Marsh Dam, plan 2, was to reduce the average annual damages by about $1,000,000 to $1,500,000. The floodwall, that provides 100 year level of protection in 5 of the 13 reaches, reduces average annual damages by about $600,000. The benefit - cost ratio for the floodwall is estimated at 0.6 as opposed to 0.2 in the 1980 report.

POTENTIAL FLOOD DAMAGES

Potential flood damages by damage category that are associated with the occurrence of a particular event i.e., 2 year, 10 year, 20 year, 50 year, 100 year, and 500 year were then calculated. The procedure basically translates and accumulates potential damages for each damage reach by category (commercial, industrial, residential, etc.) utilizing the SID model.

For natural conditions, a 10 year flood along the main stem would cause approximately $500,000 in damages. This reflects relatively high zero damage elevations for much of the development in the flood plain. Major damages do not occur until closer to a 50-year flood event ($24 million). However, the damage potential increases considerably to $47 million, $76 million, and $114 million for the 100-year, 1972 Agnes event and SPF events, respectively. The number of units in the 100 year flood, the 1972 Agnes flood and the Standard Project Flood (SPF) plains are 293, 498 and 1014 respectively. The recurrent or equivalent average annual damages (AAD) for natural (unregulated) conditions is divided by each land use type. The AAD's are computed by the Equivalent Annual Damage (EAD) Computer Model. Residential structures (Res) and content (Rescon) damages were aggregated separately in order to allow separate computation of affluence or other growth factors. The major portion of the AAD would occur to industrial (59%), residential (7%), commercial (11%), transportation (10%), and utility (6%). The other land use types including railroads (RLS), emergency costs (EMR) and public (PUB) account for four percent or less.

HISTORICAL COMPARISON AND MODEL VERIFICATION. A comparison of historic damages was made on the Schuylkill River at Reading using hydrology developed in the 1980 report and revised 1989 hydrology. Stage-damage curves were developed from information gathered in 1972 damage survey taken after the flood of 1972 and from the 1989 structure inventory information.

As shown in Table 2 the frequency damage curves for the 1980 floodplain and the 1989 floodplain with 1980 H + H are fairly similar. Only the 50 and 100 year events are substantially different. This may be due in part to the fact that the 1980 damage curve was based on only two points. The zero damage elevation which was approximately a 5 year event and the Agnes elevation which was about a 200 year event. The remaining frequencies were either interpolated or extrapolated from these points. The 1989 damage curve was based on an in depth inventory and damage assessment for each stage and is therefor more reliable for the entire frequency range. The one frequency where both curves give accurate estimates is the 200 year event. As shown in Table 2, the 1989 floodplain has a $38,600,000 damage estimate versus $30,700,000 for the 1980 floodplain. This increase of about $8,000,000 can be attributed to new commercial and industrial activities within the floodplain since 1980. In addition, activities within the floodplain have increased their damage suseptablity by installing electronic equipment such as computers. Even with these developments the average annual damages from 1980 to 1989 increased only from $560,000 to $794,000. The major difference between average annual damages estimated under 1980 conditions and 1989 conditions were the stage - frequency curves. Based on 1989 rating curves there was about a 2 foot increase in stage from 1980 to 1989 for frequencies up to a 100 year event. This is due in part to more years of data being available with higher stage readings. Based on 1989 floodplain and H + H, average annual damages were estimated at $1,330,000. This

TABLE 2

COMPARISON OF 1980 AND 1989 FLOODPLAINS
REACHES 010109-010113
SCHUYLKILL RIVER AT READING
OCTOBER 1989 P.L.

	DAMAGES ($1,000'S)		
FREQ	1980 FLOODPLAIN	1989 FLOODPLAIN 1980 H + H	1989 FLOODPLAIN 1989 H + H 1>
95	0.00	0.00	
20	0.00	0.00	
10	202.86	256.60	
5	1164.09	1143.12	
2	5039.93	12234.53	
1	14655.15	24351.82	
0.5	30,661.44	38,625.48	
0.2	61418.37	57838.74	
EXPECTED ANNUAL DAMAGES	558.96 →	793.59 →	1329.77

1> Approximately a two foot increase in stage from 1980 to 1989 for frequencies up to a 100 year event.

NEED TO PERIODICALLY UPDATE HYDROLOGY.

represents greater than a two fold increase since 1980, most of which can be attributed to the revised H + H.

The ultimate use of this data was to assess existing and future flood damages and benefits attributable to the existing dam and floodwall. Although historic flood damage and flood cost information was also collected, in must cases, it was only used for comparative purposes since this data did not necessarily reflect existing assets or existing potential flood damages and costs.

URBANIZATION. Increased urbanization will occur in non-flood plain lands. Future developments will increase imperviousness; which, in turn increases storm water runoff resulting in greater streamflows, shorter times of concentration, and higher flood stages. This phenomenon is significant and often critical to smaller stream subject to flash flooding. The extent of urbanization in the watershed below Blue Marsh Dam is not projected to be significant in magnitude for a river of the size of the Schuylkill. Its increased runoff potential is not significant to the portion of the main stem being investigated. Urbanization is more of a concern for some of the smaller more developed watersheds of the tributaries of the Schuylkill River. However, the effects of urbanization will be addressed at the next stage of study.

FUTURE WORK

The plan for a floodwall providing 100 year level of protection in 5 of 13 reaches in Reading was unjustified. Further analysis will address lower levels of protection and possibly shortening the project length. All reaches will be revised for updated H + H. As an alternative approach, structures will be coded by river mile and have SID read in reference flood from the HEC-2 using the FDA2PO computer program. Several reference floods will be run to see if there is a significant changes within the without condition and between plans. The effects of urbanization will be investigated for future decades. Finally, the floodwall plan will address the potential for induced damages on the reaches opposite the floodwall.

In addition to the Reading area, the remaining eight damage centers downstream will be investigated for local structural solutions. Finally, the entire main stem will be addressed to see if adding or modifying impoundments would be feasible.

SUMMARY OF THINGS TO REMEMBER

1. Get best available mapping with minimum of 4 foot contour intervals. If this is not possible get survey crew to shoot elevations of critical structures and top of bank.

2. Make field trip to area as soon as possible to get a feel for area and see what is the damage categories which should be considered.

3. Check zero damage elevation structure. Does it make sense?

4. Make sure that there are no negative numbers in your SID and EAD output files.

GET COPY

5. Refer to IWR report 88-R-2 dated March 1988 on procedures for developing urban flood damages.

6. Make sure reaches which should have damages do and vice versa.

7. In the input file for EAD make sure that you have a frequency which is less than the zero damage elevation since EAD will truncate stage damage curve at lowest frequency elevation (see attachment 9 for example).

8. Try to calibrate the EAD model with historical events.

9. Spend the time and money on structures that are subject to more frequent flooding such as all structures with a zero damage elevation or first floor less than the 100 year frequency.

10. Have a checklist of all damage categories you wish to investigate.

11. Make sure to run SIDEDIT whenever you change the damage function file when you have greater than 50 damage functions.

12. Divide total average annual damages by the number of structures by land use category. Does this make sense?

13. Can use SID and EAD for coastal storm damage analysis as well as fluvial.

✓

RESIDENTIAL INVENTORY FORM

STUDY: Schuylkill River Basin - Reading

DATE 10/10/89

STREET(S) Third St

PREPARED BY PTP

TOWN/STATE Reading PA

DAMAGE REACH 010112 AERIAL

ZIP

DAMAGE CATEGORY

STRUCTURE ID NUMBER	HOUSE NUMBER	TYPICAL CODE	STRUCTURE TYPE CODE	CONST TYPE CODE	ELEVATIONS REF FLD	ELEVATIONS REF PT	STAGE WRT REF PT ZD	STAGE WRT REF PT BSMNT	GROUND ELEVATION	NOTES
R085	357	R	207	207	208.3	208	-1.5	-8	206.5	2 STOR ROW
R086	355	R	207	208	↓	210	-2.5	↓	206.5	↓
R087	353	R	207	208		210	-2.5		206.5	
R088	351	R	207	208		210	-2.5		207	
R089	349	R	207	208		210	-2.5		207	
R090	347	R	207	208		210	-2.5		207	
R091	345	R	207	208		210	-2.5		207.5	
R092	343	R	207	208		211	-2.5		207.5	
R093	341	R	207	208		211	-2.5		207.5	
R094	339	R	207	208		211.5	-2.5		207.5	
R095	337	R	207	208		211.5	-2.5		208	
R096	335	R	207	208		211.5	-2.5		207	
R097	333	R	207	208		211.5	-2.5		208	
R098	331	R	207	208	↓	211.5	-2.5	↓	208	↓

ATTACHMENT 1 (20)

FIELD INVENTORY FORM

FLOOD PLAIN STRUCTURES

INDUSTRIAL

STUDY: SCHUYLKILL RIVER RECONNIASSANCE STUDY - Reading

DAMAGE REACH ID 01012

DATE 9/26

STRUCTURE ID I5

PREPARED BY TEK

DAMAGE CATEGORY IND

SA CARD

NAME OF BUSINESS AND/OR RESIDENT (COL 17-32)		
EASTERN MACHINE PRODUCTS - MAIN PLANT + OFFICES		
STREET (COL33-56)		
401 RIVER FRONT DR.		
CITY/TOWN (COL 57-69)	STATE (COL 70-71)	ZIP CODE (COL 72-80)
READING	PA	19603

SL

REFERENCE FLD ELEV (RFE) (COL 33-40)	FIRST FLOOR ELEV (FFE) (COL 41-48)	ZDE WRT FFE (COL 49-56)	GROUND ELEV
208.5	205.5	±0	202.5

SD CARD

IF RESIDENTIAL ENTER TYPICAL CODE

	1/ STRUCTURE	1/ CONTENT	1/ "OTHER"
CURVE ID	D01 (COL 25-27)	D02 (COL 33-35)	D03 (COL 41-43)
VALUE ($000)	490 (COL 28-32)	1650 (COL 36-40)	87 (COL 44-48)

TYPE OF BUSINESS (COL 70-80)

Metal fabricating - Job Shop.

SS CARD

STRUCTURE TYPE CODE (COL 23-24)	CONSTRUCTION TYPE CODE: STRUCTURE (COL 25-26)	CONSTRUCTION TYPE CODE: BASEMENT (COL 35-36)	# OF FLOORS (COL 27-28)	BASEMENT Y OR N (COL 29-30)	FIRST FLOOR AREA (FT X FT): (100×300) + (120×200) + (150×120); AREA IN HUNDREDS OF FT² (COL 61-64)
			1	N	660

CONSTRUCTION QUALITY ☐ LOW ☒ MEDIUM ☐ HIGH

INTERVIEW ☒ YES ☐ NO

LIBRARY FUNCTION AVAILABLE FOR

STRUCTURE ☒ YES ☐ NO

CONTENT ☒ YES ☐ NO

1/ OFFICE DATA

ATTACHMENT 2

B

FIELD INVENTORY FORM

FLOOD PLAIN STRUCTURES

COMMERCIAL-PUBLIC-SEMIPUBLIC-OTHER

STUDY: SCHUYLKILL RIVER RECONNAISSANCE STUDY

DAMAGE REACH ID 010112

DATE 10/11/89 **STRUCTURE ID** C15

PREPARED BY TEK **DAMAGE CATEGORY** COM

SA CARD

NAME OF BUSINESS AND/OR RESIDENT (COL 17-32)
McDonough Company

STREET (COL33-56)
530 Riverfront Drive

CITY/TOWN (COL 57-69)	STATE (COL 70-71)	ZIP CODE (COL 72-80)
Reading	PA	

SL CARD

REFERENCE FLD ELEV (RFE) (COL 33-40)	FIRST FLOOR ELEV (FFE) (COL 41-48)	ZDE WRT FFE (COL 49-56)	GROUND ELEV
208.1	204.5	±0	204.0'

SD CARD

IF RESIDENTIAL ENTER TYPICAL CODE: ☐

	1/ STRUCTURE	1/ CONTENT	1/ "OTHER"
CURVE ID	X01 (COL 25-27)	PAA (COL 33-35)	(COL 41-43)
VALUE ($000)	757.1 (COL 28-32)	374.3 (COL 36-40)	(COL 44-48)

TYPE OF BUSINESS (COL 70-80)
Distribution – Packaging Materials –

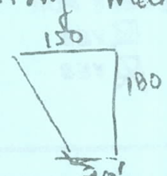
SS CARD

STRUCTURE TYPE CODE (COL 23-24)	CONSTRUCTION TYPE CODE: STRUCTURE (COL 25-26)	CONSTRUCTION TYPE CODE: BASEMENT (COL 35-36)	# OF FLOORS (COL 27-28)	BASEMENT Y OR N (COL 29-30)	FIRST FLOOR AREA (FT X FT) / AREA IN HUNDREDS OF FT² (COL 61-64)
	3		1	N	150' × 180 / 216

CONSTRUCTION QUALITY ☐ LOW ☐ MEDIUM ☒ HIGH

INTERVIEW ☐ YES ☐ NO

1 story masonry industrial/commercial bldg.



– 4' – loading dock
No damage

LIBRARY FUNCTION AVAILABLE FOR

STRUCTURE ☒ YES ☐ NO

CONTENT ☒ YES ☐ NO

1/ OFFICE DATA

ATTACHMENT 3

Structure: Marshall – Good Type C dist. @ $33.97/ft²

Contents: Phila. Library: $13.33/ft² × 1.4 ≈ $19.0/ft²

SCHUYLKILL RIVER BASIN LIMITED RECONNAISSANCE STUDY
FLOOD CONTROL STRUCTURE INVENTORY AND DAMAGE SURVEY

APARTMENT, COMMERCIAL & INDUSTRIAL, GOVERNMENT TRANSPORTATION, AND UTILITIES FLOOD DAMAGE QUESTIONNAIRE

The Schuylkill River Basin Limited Reconnaissance Study project was authorized by the Congress to investigate the potential of reducing flood damages within the Schuylkill River Basin. The Corps of Engineers is using this survey to obtain information to aid in formulating the most economic, environmental, and socially acceptable plan in accordance with the Water Resources Council's Principles and Guidelines. Individual responses will be collected and tabulated by type of response, but will not be filed or published by names of individuals surveyed. Individual responses will be retained in our files as back-up data, and after 10 years retired to the Records Center. Only the tabulated totals of the types of responses will be published in a report which will be circulated to other Federal and State Water and Land Management Agencies for planning purposes.

Answers to these questions are voluntary, and there is no effect in not responding. Your response, however, will be appreciated and aid the planning effort.

ATTACHMENT 4

SCHUYLKILL RIVER BASIN LIMITED RECONNAISSANCE STUDY
FLOOD CONTROL STRUCTURE INVENTORY AND DAMAGE SURVEY

APARTMENT, COMMERCIAL & INDUSTRIAL, GOVERNMENT
TRANSPORTATION, AND UTILITIES
FLOOD DAMAGE QUESTIONNAIRE

1. What is your address (or township, range, and section)?

2. How long have you been at this address?

3. What is the size of your property?
   Square footage under one roof ____. Site acreage ____. # of Floors ____

4. Other than principal structure, are there any other highly damageable items on your property?

   (1) Moveable (cars, trucks, trailers, etc.).

   (2) Not readily moveable (landscaping, electrical equipment, trailer on blocks, etc.).

5. While at this location, approximately how many times did this (type of facility) experience flood damage as a result of flooding from the Schuylkill River? List dates if possible.

6. If this is a multi-unit structure, how many units (both residential, industrial, or commercial) are there? ____

   a. How many units are on the ground floor? ____

   b. How many (if any) living quarters units are partly or wholly below ground level? ____

7. Does the structure have a basement? ____

   Note the number of subbasements, if any. ____

   If there is a basement and its square footage is less than the ground floor, how many square feet? ____

   How many stories are above grade? ____

ATTATCHMENT 4

8. If you are flooded and you are shut down for a period of time, are profits transferrable to another USA competitor or deferable to a later date?

9. What is your estimate of the market value of this (type of facility)

		Market Value	Replacement Cost
Structure	______	______	______
Contents	______	______	______
Land	______	______	______

10. Based on past experience, or your best estimate, please furnish damage estimates for the following depths of flooding above or below your first floor (with) (without) flood warning.

Depth of flooding (below) (above) first floor (ft.)		Dmge to Structure ($)	Dmge to Contents	Other 1/ Dmge	Dmge vehicles	Profit 2/ Loss
Zero Damage	____	______	______	____	______	____
Minor Damage	____	______	______	____	______	____
Significant Dmge	____	______	______	____	______	____
Total Damage	____	______	______	____	______	____

1/ Break out shutdown time, business cost, and emergency costs (sandbagging truck rental, storage, etc.).
2/ Complete if answer to 8 is "yes".

11. For the (last) (most serious flood event) or (flood of ...) please estimate the number of person-days spent away from the job because of flooding problems.________________________________

(a) Number of days lost from work __________

(b) Estimate the effect of flooding on employees income due to missing days of work __________________________

(c) Estimated increase in transportation costs due to flooding
____

(d) To what extent will the lost income reflected in (b) above be made up in this facility or elsewhere? ______________

12. During the past floods, have you experienced a disruption of utilities (water, gas, electricity, etc.)? (List names of utilities)

13. Do you know other businesses which would be adversely affected if your business were to close down during flooding? This could be businesses that supply inputs to you or business to which you supply products. If your business was closed down due to flooding, would they have alternatives which will allow them to continue production at their current levels?

14. While at this location:

(a) What was the deepest flooding experienced? (Check one)

___ Basement ______ inches
___ First Floor ______ inches
___ Ground Floor ______ inches
___ Second Floor ______ inches
___ Other ______

(b) Date of flooding?

(c) Location where depth was measured?

ATTATCHMENT 4

15. How did the water enter?
(Check each that applies)

(a) _____ Through windows or doors from street, river, creek or stream overflow.

(b) ____ Sewer backup due to clogged sewer line between building and street.

(c) ____ Sewer backup - no obstruction in sewer line between building and street.

(d) ____ Seepage through cracks in walls or floors

(e) ____ Don't know

(f) ____ Other (Please specify)

16. Before you moved to this location, what, if anything, had been done to reduce flood damage?

17. While at this present location, what, if anything, have you or others done to flood proof it?

Describe each flood proofing measure, including how effective and limits of effectiveness (water height, duration of flooding, etc.).

(a) Measures ______ ________ ________ ________

(b) Effectiveness ______ ________ ________ ________

(c) Flood Proof Height ______ ________ ________ ________

Note: Flood Proof Height relative to first floor.

18. If you do take measures to minimize your flood damages, please estimate a dollar amount or a percentage by which you decrease your potential flood damages. ________________________________

19. If the flood threat were eliminated by structural measures,

- would decisions to purchase new equipment, build new buildings or expand capacity be different?

- Would you still make the same plans regarding new locations?

(Explain each response)

20. Flood Warning

Is your area protected by some type of:

(a) Flood warning system Yes___ No ___

If "yes", how much warning did you receive? _______ Hours.

(b) Temporary evacuation plan Yes ___ No ___

If so, please describe: ________________________
Please evaluate the effectiveness of this (system) (plan).

21. Do you feel that the above described flood warning/preparedness plan has reduced your past flood losses?

(a) ___Yes How? ________________________

(b) ___No

If so, by how much have your flood losses been reduced for specific floods?

Flood Date	Reduction in Losses				
	0%	5-10%	10-25%	25-50%	50% or greater

ATTATCHMENT 4

22. How many hours of warning would you need to take practical emergency measures to protect your employees and minimize physical losses?
____

23. What is the average annual employment? _______________

24. What is the average annual wage, including fringe benefits?

25. Has the threat of flooding influenced decisions regarding:

   - purchases of new production equipment?

   - construction of new buildings?

   - expansion of production or sales capacity?

   (If "yes", explain each) ____

26. Do you take any measure to minimize your flood damages once flood stage or flooding conditions appear imminent? ________ If so, do you: (please identify major items)

(a) ____________________ Move items from basement to first floor;

(b) ____________________ Move items from basement to second floor or higher;

(c) __________________ Move items from first floor to second floor or higher;

(d) ____________________ Evacuate items from the building;

(e) ____________________ Other (please identify) __________________________

Can you always count on labor being available for your flood fight activities?

SID INPUT FILE ATTACHMENT 5

```
T1   SCHUYLKILL RIVER RECONNAISSANCE STUDY
T2   READING FLOOD DAMAGE - BASE CONDITION
T3   OCTOBER 1989
J1      0        0        0                 3        0                 9        2        0
J2    431        9       13        2        0        2       18        1       92
ZW A=READING E=1989 F=BASE
DC            RES                            RESIDENTIAL STRUCTURE
DC         RESCON                            RESIDENTIAL CONTENT
DC            COM                            COMMERCIAL
DC            PUB                            PUBLIC
DC            IND                            INDUSTRIAL
DC            RDS                            ROADWAYS
DC            RLS                            RAILWAYS
DC           UTL                             UTILITY
DC            EMR                            EMERGENCY
CC        1  RESCON       RES
DR010101     210.3                                   194.0
DT   WEST SIDE SCHUYLKILL R.-TULPEHOCKEN CR. TO CONRAIL RR BRIDGE
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010102     210.3                                   196.0
DT   WEST SIDE SCHUYLKILL R.-CONRAIL RR BRIDGE TO BUTTONWOOD ST.
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010103     210.3                                   198.0
DT   WEST SIDE SCHUYLKILL R.-BUTTONWOOD ST. TO PENN ST.
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010104     210.3                                   196.0
DT   WEST SIDE SCHUYLKILL R.-PENN ST. TO CUMRU TWP. LIMIT
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010105     210.3                                   198.0
DT   WEST SIDE SCHUYLKILL R.-CUMRU TWP. LIMIT TO RT. 222 BR.
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010106     210.3                                   196.0
DT   WEST SIDE SCHUYLKILL R.-RT. 222 BR. TO RT 422 BRIDGE
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010107     210.3                                   192.0
DT   WEST SIDE SCHUYLKILL R.-RT 422 BRIDGE TO FRITZ ISLAND
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010108     210.3                                   205.0
DT   EAST SIDE SCHUYLKILL R.-TULPEHOCKEN CR. TO CONRAIL RR BRIDGE
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010109     210.3                                   200.0
DT   EAST SIDE SCHUYLKILL R.-CONRAIL RR BRIDGE TO BUTTONWOOD ST.
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010110     210.3                                   194.0
DT   EAST SIDE SCHUYLKILL R.-BUTTONWOOD ST. TO PENN ST.
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010111     210.3                                   194.0
DT   EAST SIDE SCHUYLKILL R.-USGS GAGE TO SPRUCE ST.
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010112     210.3                                   194.0
DT   EAST SIDE SCHUYLKILL R.-SPRUCE ST. TO BINGAMAN ST.
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
DR010113     210.3                                   194.0
DT   EAST SIDE SCHUYLKILL R.-BINGAMAN ST. TO RT 422 BRIDGE
SE 192.7     197.1    199.8    201.8    204.4    208.2    211.9    215.1    220.7
ST1.05YR      2 YR     5 YR    10 YR    20 YR    50 YR   100 YR   200 YR   500 YR
AR       1  AGRCH1   AGRCH1   AGRCH1   AGRCH1   AGRCH1   AGRCH1   AGRCH1   AGRCH1   AGRCH1
ARAGRCH1    AGRCH1   AGRCH1   AGRCH1   AGRCH1
SL010101      RD58                      213.5    204.0    -5.0                 2
SD010101      RD58        RDSPRD 66.0
SS010101      RD58          0 0 0                                     0
SA010101      RD58        US RT 422                                READING,PA
SL010102      RD59                      212.4    206.0    -5.0                 2
SD010102      RD59        RDSPRD 35.3
SS010102      RD59          0 0 0                                     0
SA010102      RD59        US RT 422                                READING,PA
SL010103      RD60                      211.1    204.0    -5.0                 2
```

ATTACHMENT 6 (31)

Number of Structures in Flood Zones
(Based on Zero Damage Elevations)

Flood Zone

Dmg Rch	Zero TO 1.05YR	1.05YR TO 2 YR	2 YR TO 5 YR	5 YR TO 10 YR	10 YR TO 20 YR	20 YR TO 50 YR	50 YR TO 100 YR	100 YR TO 200 YR	200 YR TO 500 YR	ABOVEMAX		Total
010101	0	1	0	0	0	0	0	0	0	0	0	1
010102	0	0	1	0	0	0	0	0	0	0	0	1
010103	0	0	1	1	0	0	1	0	0	0	0	3
010104	0	0	1	2	0	18	2	0	1	0	0	24
010105	0	0	0	0	0	2	8	4	27	5	0	46
010106	0	0	0	0	0	0	2	1	2	0	0	5
010107	0	0	0	0	0	1	0	0	0	0	0	1
010108	0	0	0	0	0	0	0	0	0	0	0	0
010109	0	0	0	0	0	0	0	0	0	0	0	0
010110	0	1	1	0	1	3	1	1	5	1	0	14
010111	0	4	3	3	6	27	79	81	81	0	0	284
010112	0	2	1	0	2	8	82	47	220	4	0	366
010113	0	0	1	2	2	8	15	71	180	6	0	285
Total	0	8	9	8	11	67	190	205	516	16	0	1030

Aggregated Single Event Damage

Aggregated Damage Reach AGRCH1
Includes Damage Reaches
010101 010102 010103 010104 010105
010106 010107 010108 010109 010110
010111 010112 010113

(Damage in $1,000)

Damage Categories

Single Event	RES	RESCON	COM	PUB	IND	RDS	RLS	UTL	EMR	OTHER	Total
1.05YR	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2 YR	.0	.0	.0	.0	.0	8.8	20.3	.0	5.1	.0	34.2
5 YR	.0	.0	.0	.0	.0	58.6	41.2	.0	23.2	.0	122.9
10 YR	.0	.0	.0	.0	96.8	109.7	56.6	130.0	112.4	.0	505.6
20 YR	.0	.0	12.0	.0	1212.0	208.7	86.7	407.1	326.0	.0	2252.4
50 YR	77.6	63.1	1951.1	118.0	19757.2	361.6	121.2	1143.2	513.8	.0	24106.9
100 YR	677.7	492.0	4968.1	852.4	31976.6	5567.6	125.9	2481.3	841.2	.0	47982.8
200 YR	2638.6	1725.3	11192.7	4575.5	37496.6	12793.1	132.9	4360.7	1192.1	.0	76107.6
500 YR	13010.0	8571.9	18223.7	7716.5	46276.8	13408.1	134.9	5387.5	1236.0	.0	113965.4

SID OUTPUT

```
TT       SCHULYKILL RIVER AT READING
TT       EXPECTED ANNUAL DAMAGE
TT       OCTOBER 1989 PRICE LEVEL
TT       DAMAGES IN THOUSAND DOLLARS
J1     50      1989     1993 10 1989
J2 8.875
CN      9        RES  RESCON       COM       PUB       IND       RDS       RLS       UTL       EMR
PN      1        WITHOUT PROJECT - NATURAL CONDITIONS
PN      2        WITHOUT PROJECT - EXISTING CONDITIONS WITH BLUE MARSH OPERATIONAL
PN      3        WITH PROJECT - FLOODWALL w/100 PROTECTION IN REACHES 010109-010113
DY      1      1989
RN 010101
FR               9      95.0      50.0      20.0      10.0       5.0       2.0       1.0       0.5
FR     .2
SF               1     193.0     197.6     201.0     203.3     206.5     210.8     214.1     217.6
SF 223.8
ZR A=READING B=010101 C=ELEVATION-DAMAGE E=1989 F=BASE
RV     SD      1989         1      1989                  3       200
EP      1
SF               2     192.7     197.1     199.8     201.8     204.4     208.2     211.9     215.1
SF 220.7
RV     SD      1989         2      1989                  3       200
EP      2
SF               3     192.7     197.1     199.8     201.8     204.4     208.2     211.9     215.1
SF 220.7
RV     SD      1989         3      1989                  3       200
ER      3
RN 010102
SF               1     193.0     197.6     201.0     203.3     206.5     210.8     214.1     217.6
SF 223.8
ZR A=READING B=010102 C=ELEVATION-DAMAGE E=1989 F=BASE
RV     SD      1989         1      1989                  3       200
EP      1
SF               2     192.7     197.1     199.8     201.8     204.4     208.2     211.9     215.1
SF 220.7
RV     SD      1989         2      1989                  3       200
EP      2
SF               3     192.7     197.1     199.8     201.8     204.4     208.2     211.9     215.1
SF 220.7
RV     SD      1989         3      1989                  3       200
ER      3
RN 010109
SF               1     193.0     197.6     201.0     203.3     206.5     210.8     214.1     217.6
SF 223.8
ZR A=READING B=010109 C=ELEVATION-DAMAGE E=1989 F=BASE
RV     SD      1989         1      1989                  3       200
EP      1
SF               2     192.7     197.1     199.8     201.8     204.4     208.2     211.9     215.1
SF 220.7
RV     SD      1989         2      1989                  3       200
EP      2
SF               3     192.7     197.1     199.8     201.8     204.4     208.2     211.9     215.1
SF 220.7
RV     SD      1989         3      1989                  3     211.9
ER      3
```

EAD INPUT FILE

ATTACHMENT 7

ATTACHMENT 8

** EXPECTED ANNUAL DAMAGE SUMMARY BY REACH **

** INPUT DATA YEARS = 1989

** DAMAGE BASE = OCT 1989 DOLLARS

** FLOOD PLAIN MANAGEMENT PLANS
1 - WITHOUT PROJECT - NATURAL CONDITIONS
2 - WITHOUT PROJECT - EXISTING CONDITIONS WITH BLUE MARSH OPERATING
3 - WITH PROJECT - FLOODWALL w/100 PROTECTION IN REACHES 010109-010113

GRAND SUMMARY - ALL DAMAGE CATEGORIES
FOR INPUT DATA YEAR 1989

REACH NO	REACH ID	BASE CONDITION (PLAN 1)	PLAN 2 DAMAGE W/PLAN	PLAN 2 DAMAGE REDUCED	PLAN 3 DAMAGE W/PLAN	PLAN 3 DAMAGE REDUCED
1	010101	7.99	5.39	2.61	5.39	2.61
2	010102	2.74	1.80	.94	1.80	.94
3	010103	118.09	72.82	45.27	72.82	45.27
4	010104	131.11	78.16	52.95	78.16	52.95
5	010105	91.18	53.09	38.10	53.09	38.10
6	010106	.96	.47	.49	.47	.49
7	010107	35.55	21.66	13.89	21.66	13.89
8	010108	.00	.00	.00	.00	.00
9	010109	.00	.00	.00	.00	.00
10	010110	32.08	18.25	13.83	11.41	20.67
11	010111	1313.52	800.52	513.00	330.46	983.06
12	010112	611.48	362.32	249.17	222.99	388.50
13	010113	163.47	91.84	71.63	76.65	86.82
TOTAL		2508.18	1506.31	1001.87	874.89	1633.29

GRAND SUMMARY - ALL DAMAGE CATEGORIES
FOR INPUT DATA YEAR 1989

DAMAGE CATEGORY	BASE CONDITION (PLAN 1)	PLAN 2 DAMAGE W/PLAN	PLAN 2 DAMAGE REDUCED	PLAN 3 DAMAGE W/PLAN	PLAN 3 DAMAGE REDUCED
RES	106.96	54.78	52.18	52.23	54.73
RESCON	70.85	36.25	34.60	34.28	36.57
COM	280.99	167.12	113.87	135.70	145.29
PUB	88.41	52.41	35.99	47.01	41.39
IND	1472.44	888.47	583.97	410.60	1061.84
RDS	242.84	151.41	91.43	135.15	107.70
RLS	19.86	13.34	6.52	1.32	18.55
UTL	154.66	96.62	58.04	47.49	107.17
EMR	71.18	45.91	25.27	11.11	60.08
TOTAL	2508.18	1506.31	1001.87	874.89	1633.29

EAD OUTPUT FILE

DIFFERENT STUDY

FREQUENCY SENSITIVITY ANALYSIS

FREQ.	Plan 1 [1]	Plan 2	Plan 3	Plan 4
	stages			
2 yr.	9.9	9.9	9.9	9.9
1 yr.	—	9.0	9.0	9.6
0.5 yr.	—		8.0	9.3
0.25 yr	—	—	7.0	9.0
AAD	$91,500	$203,300	$326,300	$565,300

1) Plan 1 was initial attempt to measure AAD

2) Plan 2 was final selected plan for RECON. However, there is a zero damage elevation of 5.0 (out of bank) with a recent history of multiple flooding within 1 year which causes damages below 9.9 feet.

3) Plan 3 reduces stages by about 1 foot

4) Plan 4 takes the stage difference between the 5 yr. event and 2 yr event (0.3) and extrapolates.

ATTACHMENT 9