Little Suncook River
Suncook River Watershed
Merrimack River Basin
Epsom, New Hampshire

Northwood Lake

Dam-Break Flood Analysis

January 1989

US Army Corps of Engineers
New England Division

407-797

Preface

This investigation was performed under the Corps of Engineers' Flood Plain Management Services Authority at the request of the State of New Hampshire. The Flood Plain Management Authority is contained in Section 206 of the Flood Control Act of 1960 which authorizes the U.S. Army Corps of Engineers "...to compile and disseminate information on floods and flood damages...and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard."

The Dam-Break Analysis study presented in this report was prepared under contract by Storch Associates of Boston, Massachusetts and Manchester, New Hampshire. Any questions concerning this report should be addressed to the the Chief of the Hydrology Engineering Section of the Corps of Engineers, New England Division.

NORTHWOOD LAKE DAM

EPSOM, NEW HAMPSHIRE

DAM-BREAK FLOOD ANALYSIS

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NORTHWOOD LAKE DAM

DAM-BREAK FLOOD ANALYSIS

1. INTRODUCTION AND PURPOSE

This report presents the findings of a dam-break flood analysis performed for Northwood Lake Dam. Its purpose is to provide quantitative information for emergency planning use. The dam is owned, operated and maintained by the Water Resources Board of New Hampshire. Included in this report is a description of the pertinent features of the dam, the procedure used for the analysis, the assumed dam-break conditions and the resulting effects on downstream flooded areas. This study was not performed because of any known likelihood of a dam-break at Northwood Lake Dam.

2. DAM DESCRIPTION

Identification No.	NH00285
Name of Dam	Northwood Lake Dam
Town:	Epsom
County and State:	Merrimack County, New Hampshire
Stream:	Little Suncook River
Watershed:	Suncook River
Basin:	Merrimack River

Northwood Lake Dam is a concrete gravity structure approximately 165-foot long and 14-foot high. The spillway is a concrete broad crested overflow weir 110-foot long and 12-foot wide impounding 2,600 ± acre-feet. Total drainage area at the dam is 20.7 square miles. The area downstream of the of the spillway section is partly blocked by tree growth. Large stone blocks have been placed downstream of the spillway in order to dissipate the energy of the overflowing water. The low level outlet is located adjacent to the left side of the spillway section and consists of a passage approximately 2.4-foot wide and approximately 4-foot high, controlled by a sluice gate mounted on the upstream face of the dam. The low level sluice gate hoist is housed in a small building on top of a short non-overflow section adjacent to the spillway. A new 12-foot wide stop plank section located to the left of the low level outlet was added to the dam in 1973. The entire structure has apparently been founded on bedrock.

The downstream channel, Little Suncook River, is well defined with a rocky bottom. The Town of Epsom is the first significant settlement, some 2 miles downstream of the dam.

3. PERTINENT DATA

Data is taken from "Phase I Inspection Report" for Northwood Lake Dam, dated October, 1978.

a. Drainage Area The drainage area consists of 20.7 square miles (13,248 acres) of predominantly agricultural and residential areas.

b. Elevation (ft. above MSL)

(1)	Top of Dam:	519.3 (low point of embankment)
(2)	Recreation pool:	518.16
(3)	Spillway crest:	518.16
(4)	Spillway crest (ungated):	518.16
(5)	Stream bed at centerline of dam (downstream):	505 ± (estimated)
(6)	Stream bed at centerline of dam (upstream):	510 ± (estimated)

c. Spillway

(1)	Type:	Broad crested overflow weir
(2)	Length of weir:	110 ft. (from available records)
(3)	Crest elevation:	518.16 ft.
(4)	Gates:	None
(5)	U/S channel:	Northwood Lake
(6)	D/S Channel:	Discharge flows into a culvert that passes under State Route 107.

d. Reservoir (miles)

(1) Length of maximum pool:	3.4 (estimated)
(2) Length of recreation pool:	3.0 (estimated)

e. Storage (acre-feet)

(1) Recreation pool:	2,400 (elev. 518.16)
(2) Top of dam:	3,000 (elev. 519.3)

f. Reservoir Surface (acres)

(1) Top of dam:	Not known
(2) Recreation pool:	589

g. Discharge at Dam Site

(1) Ungated spillway capacity at top of dam:	350 cfs @ elev. 519.3 MSL

h. Dam

(1) Type:	Concrete gravity with vertical downstream face
(2) Length:	169 ft.
(3) Height:	14 ft. (hydraulic height)
(4) Top width:	12 ft.

i. Diversion and Regulating Tunnel: None

j. Regulating Outlets

(1) Low level outlet:	Listed as 3 ft. x 5 ft., estimated at 28 in. x 48 in. during inspection

(2)	Controls:	Sluice gate at upstream face of dam
(3)	Emergency gates:	None
(4)	Outlet:	Downstream channel of Suncook River

k. Stop Plank Section

(1)	Passages:	3
(2)	Width:	40 in., 38 in., 40 in. net width between retaining beams
(3)	Supports:	8 x 8 steel beams, hinged at bottom
(4)	Stop planks:	Individual, 7 1/2 in. high Invert of passage Elev. 511.4

4. VALLEY DESCRIPTION

Northwood Lake Dam spans the headwaters of the Little Suncook River. It is located about 2 miles upstream from Epsom, 3 miles above the confluence with the Suncook River and approximately 13 miles above the confluence of Suncook River and Merrimack River. The Little Suncook and Suncook River's Valley below the Northwood Lake Dam mostly consists of agricultural and residential areas with some wooded areas along the upper portion of the river channel. The valley a has moderate to moderately flat slope for the entire study reach. Several significant population centers are located in the study reach: Epsom at mile 2.0, Goosville at mile 3.0, Allenstown at mile 10.0 and Suncook at mile 14.2.

5. MODEL DESCRIPTION

The Northwood Lake Dam dam-break analysis was performed using the Microcomputer Version 9-86 of "DAMBRK" the National Weather Service DAM-BREAK Flood Forecasting Model 7-18-84. This microcomputer version is a transference from Dr. D. L. Fread's main frame computer version. The selected option utilized was "Subcritical Dynamic Routing for a single dam and input consisted of:

(a) Storage characteristics of the reservoir

(b) Selected dam breach geometry, and duration

(c) Surveyed geometry and observed characteristics of downstream valley presented in cross-sections and by selected Mannings "n" coefficients along with initial inflows.

(d) Active and inactive flow regions of the study each. Based on the input data, the model computes the dam-break outflow hydrograph and routes it downstream. Dynamic routing of the outflow hydrograph through entire reach of downstream valley is performed by a "honing" interative attenuation process governed by the requirements of both the principles of conservation of mass and momentum. The analysis provides output on the attenuation of the flood hydrograph, resulting flood stages, and timing of the flood wave as it progresses downstream.

6. ASSUMED DAM-BREAK CONDITIONS

The magnitude of a flood resulting from the hypothetical failure of Northwood Lake Dam is a function of many different parameters including size of breach, initial pool level and storage, rate of breach formation, channel and overbank roughness, and antecedent flow conditions. Engineering assumptions of conditions which could be reasonably expected to exist prior to a failure of Northwood Lake Dam, were used in the flood analysis as presented below:

(1) Initial Pool Level 520.5 feet MSL, 1.27 feet above the top of dam during an inflow of 1698 cfs

(2) Breach Invert: 505.0 feet MSL

(3) Breach Base Width 60 feet; vertical side slopes (1.0 vertical: 0.0 horizontal)

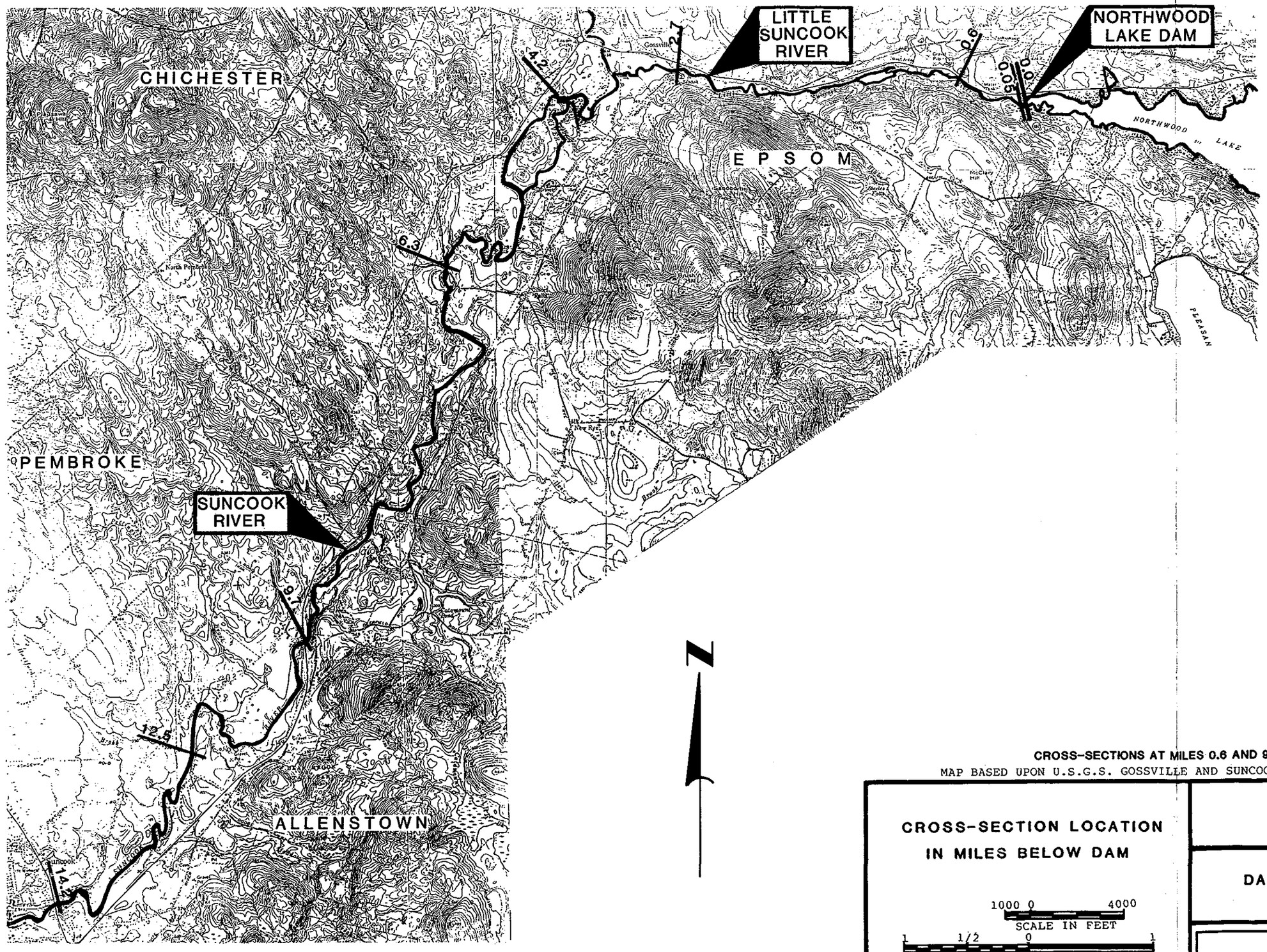
(4) Time to Complete Formation of Breach: 1.0 hour

(5) Downstream Channel Roughness Coefficient: Manning's "n" = 0.035 to 0.06

(6) Pre-Breach Flow: The pre-breach river flow was assumed equal to the March 1936 flood of record. The inflow into Northwood Lake Dam was estimated to be of 1698 cfs (82 csm). During the initial condition the spillway outflow was 1,374 cfs. At the confluence of Little Suncook River and Suncook River an inflow of 12,000 cfs was added.

7. RESULTS

The resulting peak stage flood profiles, timing of the peak stage and leading edge of the flood wave are indicated on the profile and presented in the report. Because of the scarcity of good topographic mapping in the area, profiles are shown in feet above normal summertime (July-August) low water (NLW). Users of the information can establish depth of flooding at particular properties by establishing its relative elevation with respect to the adjacent stream level. Variations in depth above NLW progressing downstream are attributable to changes in natural stream hydraulic capacity as well as changes in peak discharge. The peak dam-break stages, along with the pre-breach stages from Northwood Lake Dam to the downstream limit of the study reach are presented on plate nos. 2A and 2B. The maximum dam-break water surface stages and maximum flows vs. time from start of dam failure are shown on plate nos. 3 and 4 for selected stations of interest. The selected stations are located at mile 0.6, 4.2 and 14.2 miles downstream from the dam. The peak dam-break discharge from Northwood dam was computed to be 10,920 cfs generating a rise of 9.6 feet above the NLW stage and causing a 2.5 +/- foot flood stage at the state highway Route 107 at a point 0.05 mile downstream of the dam. At mile 0.6 below the dam the estimated dam-break discharge is 10,808 cfs producing a rise of 11.25 feet over NLW and causing flooding of state highway Route 9. The initial depth of flooding at Route 9 was estimated to occur at a stage of approximately 7.0 +/- feet. The peak dam break discharge combined with the tributary peak flow of 12,000 cfs of the Suncook River at mile 4.2 below the dam is 20,831 cfs with a rise of of 14.86 feet over NLW stage. At mile 12.5 below the dam, the peak dam-break discharge attenuated to 17,611 cfs generating a rise of 23.76 feet above the NLW stage. Because of the relative long flat study reach and large storage capacity of the Little Suncook River and Suncook River Valley downstream from Northwood Lake Dam, the dam-break peak discharge is attenuated producing a rise in the order of 2-4 feet above pre-breach flow conditions.



CROSS-SECTIONS AT MILES 0.6 AND 9.7 INTERPOLATED

MAP BASED UPON U.S.G.S. GOSSVILLE AND SUNCOOK, N.H. QUADRANGLES, (1967)

CROSS-SECTION LOCATION IN MILES BELOW DAM

1000 0 4000
SCALE IN FEET

1 1/2 0 1
SCALE IN MILES

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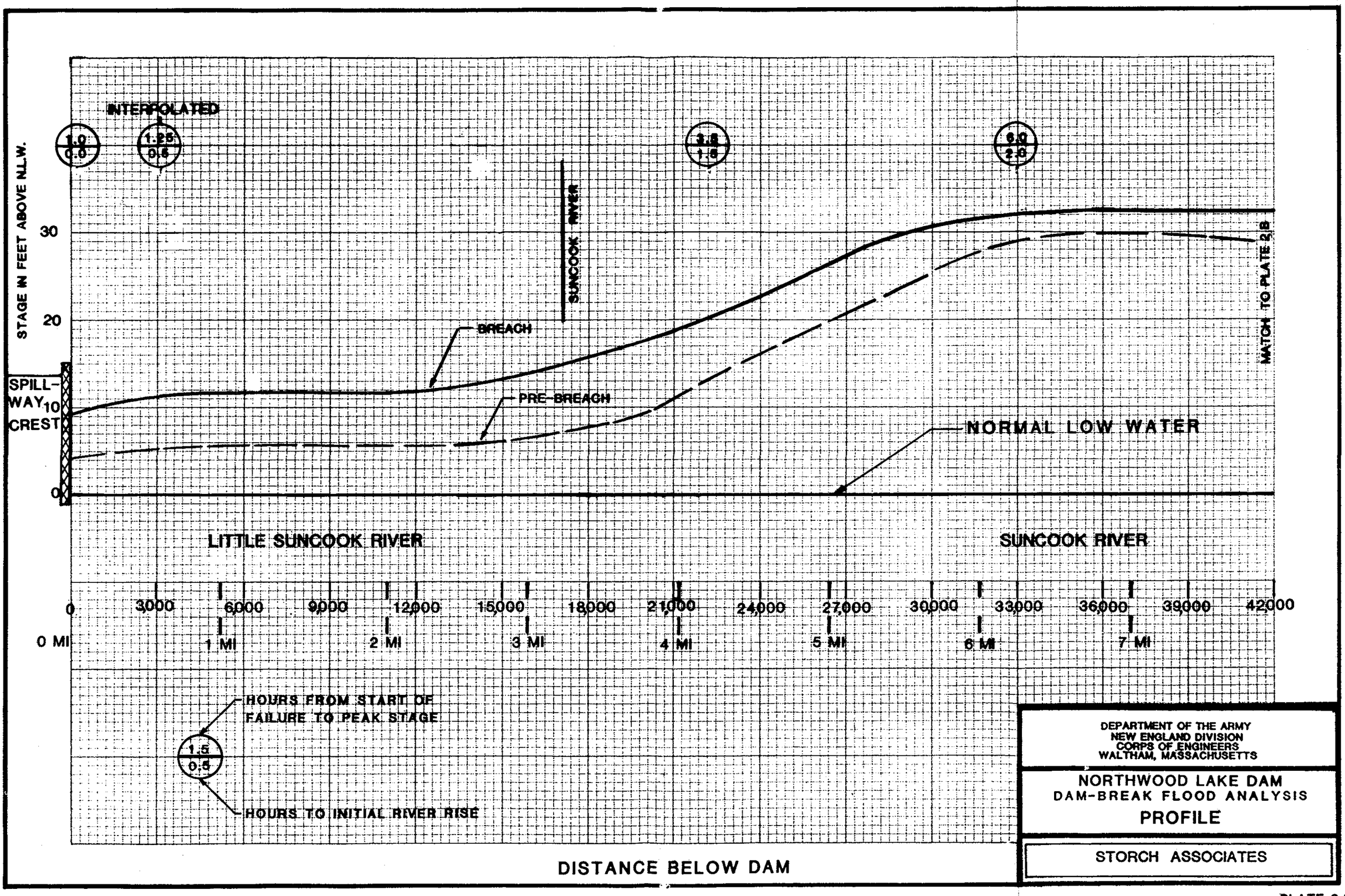
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

NORTHWOOD LAKE DAM
DAM-BREAK FLOOD ANALYSIS
INDEX MAP

STORCH ASSOCIATES



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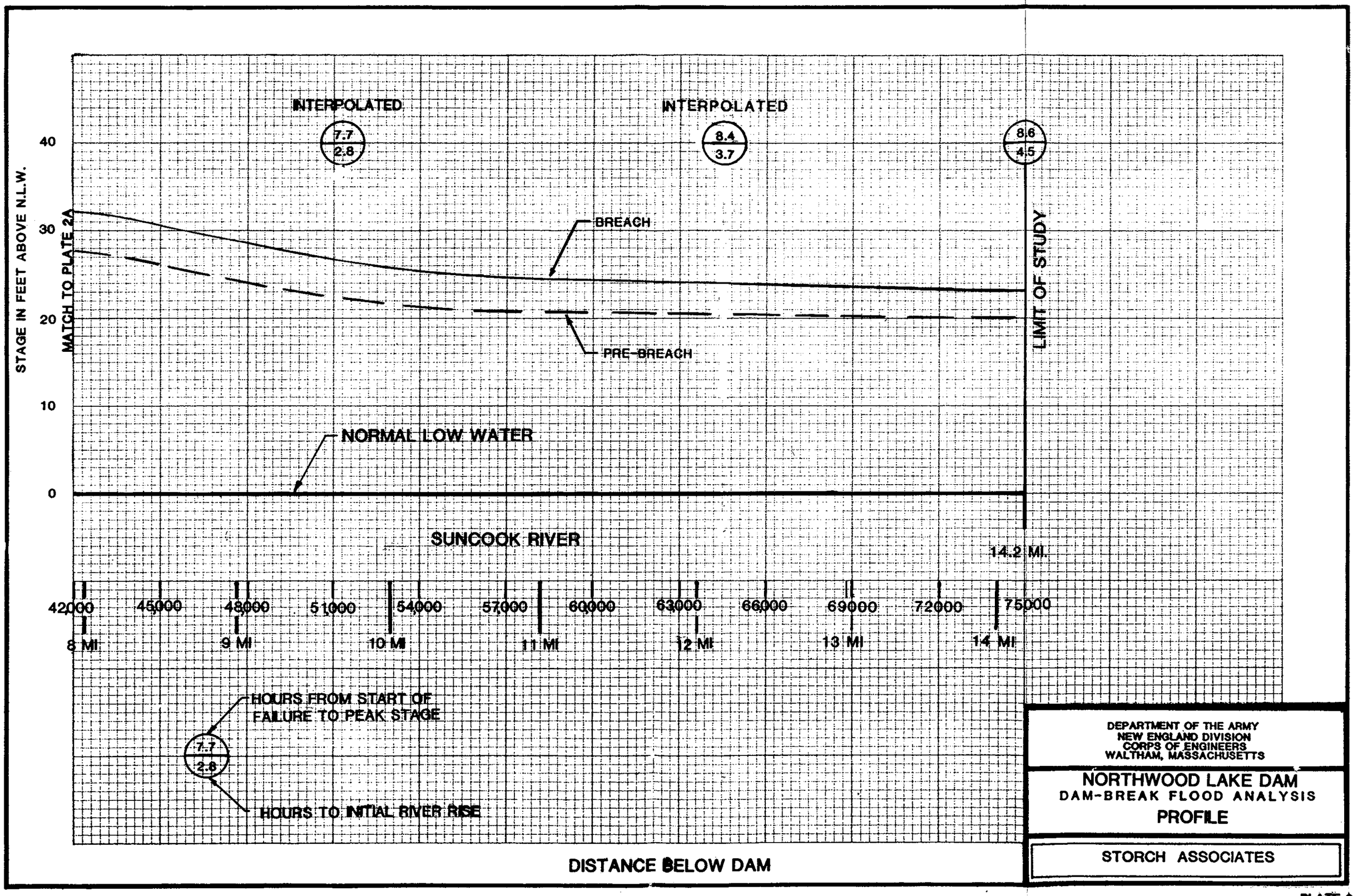
CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

NORTHWOOD LAKE DAM
DAM-BREAK FLOOD ANALYSIS
PROFILE

STORCH ASSOCIATES

PLATE 2A



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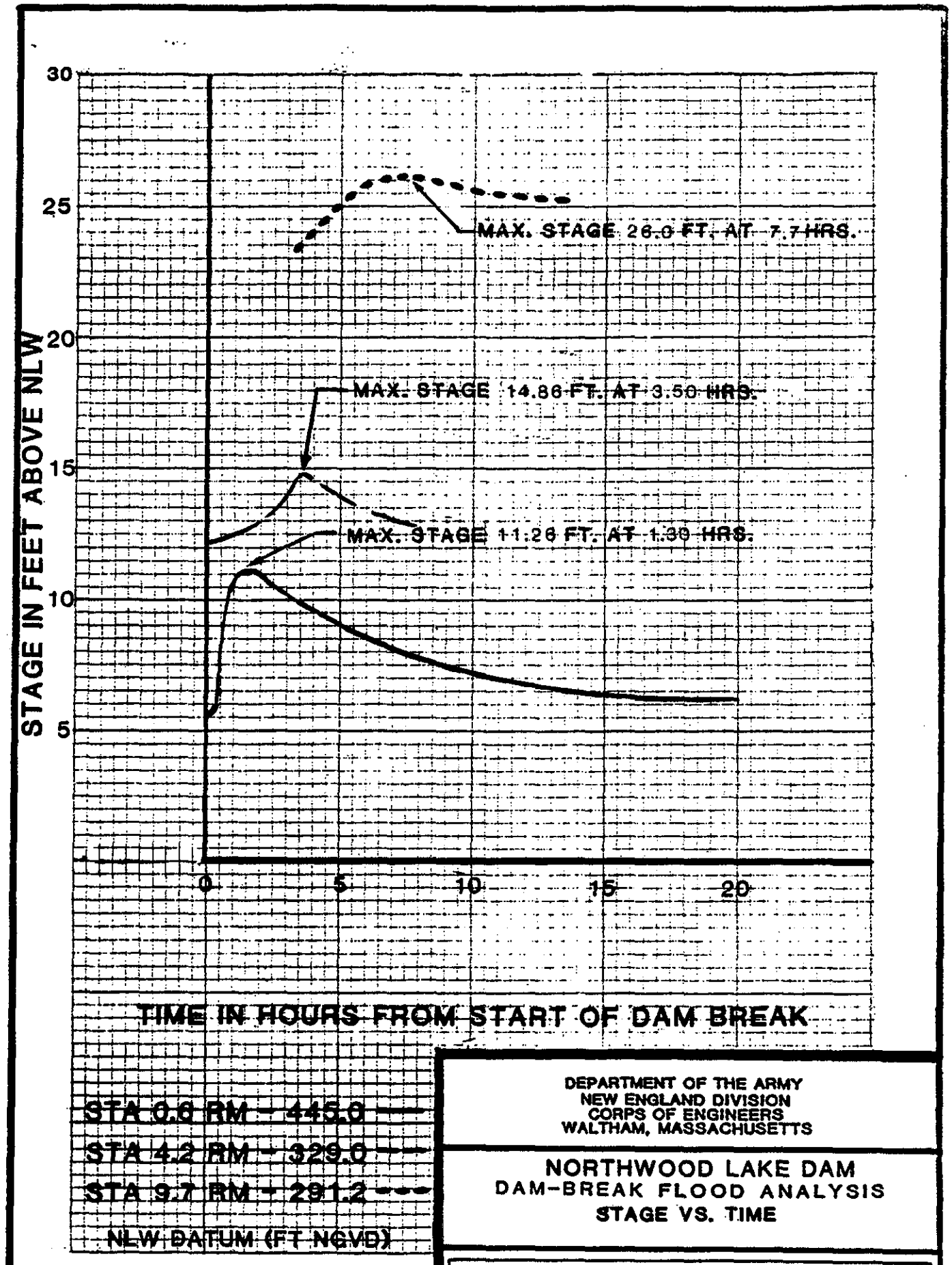
NORTHWOOD LAKE DAM
DAM-BREAK FLOOD ANALYSIS
PROFILE

STORCH ASSOCIATES



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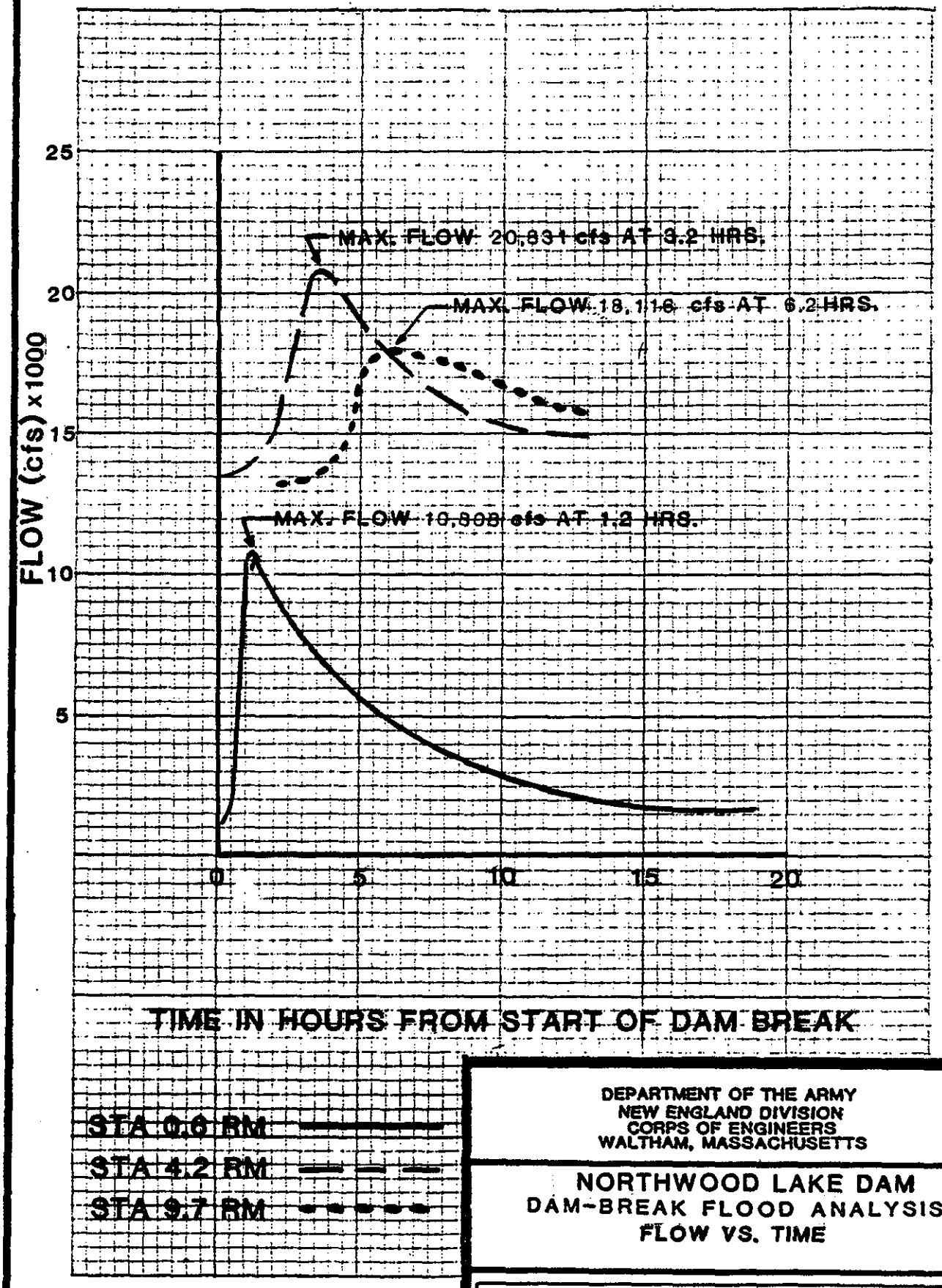
NORTHWOOD LAKE DAM
DAM-BREAK FLOOD ANALYSIS
STAGE VS. TIME

STORCH ASSOCIATES



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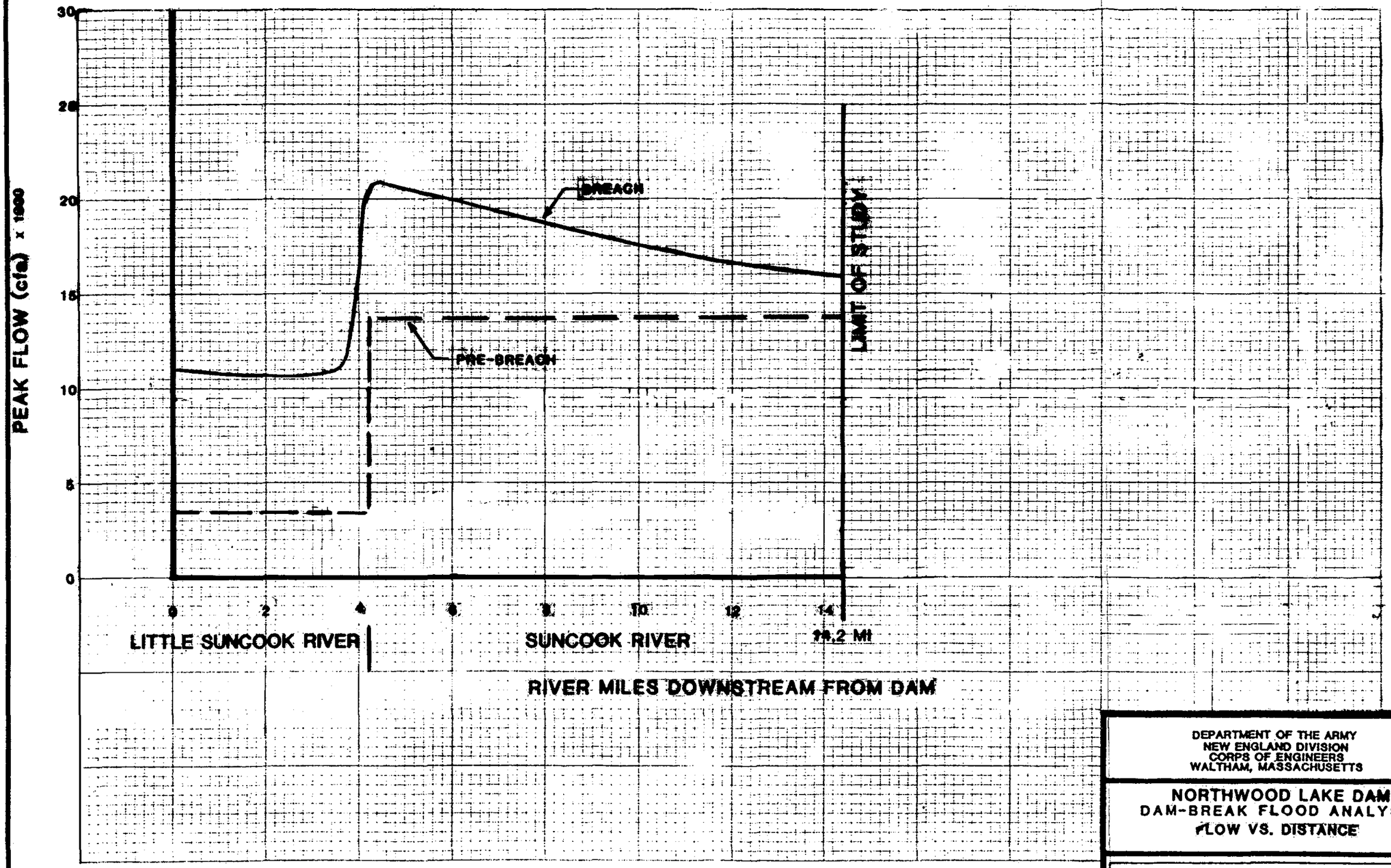
NORTHWOOD LAKE DAM
DAM-BREAK FLOOD ANALYSIS
FLOW VS. TIME

STORCH ASSOCIATES



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NORTHWOOD LAKE DAM
DAM-BREAK FLOOD ANALYSIS
FLOW VS. DISTANCE

STORCH ASSOCIATES

APPENDIX A

INPUT DATA FILE

NORTHWOOD LAKE DAM LITTLE SUNCOOK RIVER STORCH ASSOCIATES
994 CANDIA ROAD, MANCHESTER, N.H. 03103

```
        1       0       0       5       2
        00 0
6500.   5000.   3500.   2400.   0.
525.    522.5   520.    518.2   505.
3.4     520.5   0.      507.    60.     1.      505.    1
520.5   519.3   518.2   0.      0.      0.      44.     0.
40.     350.    2525.   9828.   11832.
.25     1.1     3.8     9.4     10.
0.      24.
1698.   1698.
0.      24.
        8       7       6       0       0       0       1
        1       2       4       5       6       7
0.05
503.    506.    508.    513.    515.    520.    540.
30.     65.     110.    110.    110.    110.    110.
0.      0.      0.      30.     70.     580.    780.
0.6
446.    450.    452.    455.    460.    465.    470.
23.     50.     120.    120.    120.    120.    120.
0.      0.      380.    420.    440.    480.    590.
2.7
343.    352.    354.    360.    365.    370.    380.
45.     70.     160.    160.    160.    160.    160.
0.      0.      260.    350.    420.    580.    650.
4.2
329.    332.    335.    340.    350.    360.    370.
40.     160.    200.    200.    200.    200.    200.
0.      0.      600.    760.    890.    1100.   1360.
6.3
291.    300.    305.    309.    314.    320.    350.
60.     90.     100.    110.    110.    110.    110.
0.      0.      0.      0.      360.    580.    820.
9.7
289.    290.    295.    298.    315.    320.    350.
60.     65.     90.     130.    200.    200.    200.
0.      0.      0.      180.    260.    520.    920.
12.5
286.    295.    300.    310.    320.    330.    350.
80.     100.    130.    220.    220.    220.    220.
0.      0.      180.    460.    750.    820.    940.
14.2
284.    295.    298.    300.    308.    310.    350.
100.    130.    140.    180.    180.    180.    180.
0.      0.      0.      20.     60.     120.    970.
0.06    0.06    0.06    0.06    0.06    0.06    0.06
0.05    0.05    0.05    0.05    0.05    0.05    0.05
0.05    0.05    0.05    0.05    0.05    0.05    0.05
0.055   0.055   0.055   0.055   0.055   0.055   0.055
0.04    0.04    0.04    0.04    0.04    0.04    0.04
0.035   0.035   0.035   0.035   0.035   0.035   0.035
0.04    0.04    0.04    0.04    0.04    0.04    0.04
0.025   0.1     0.03    0.105   0.34    0.56    0.34
.0      .0      .0      .0      .3      .0      .3
.0      .0      .1      .5      60.     .0      .4      1.
        3
12000.  12000.
```

APPENDIX B

OUTPUT DATA FILE

PROGRAM DAMBRK---VERSION-07/18/84
MICROCOMPUTER VERSION - R.G. TRAVER

ANALYSIS OF THE DOWNSTREAM FLOOD HYDROGRAPH

PRODUCED BY THE DAM BREAK OF

NORTHWOOD LAKE DAM

ON

LITTLE SUNCOOK RIVER

ANALYSIS BY

STORCH ASSOCIATES
994 CANDIA ROAD, MANCHESTER, N.H. 03103

BASED ON PROCEDURE DEVELOPED BY

DANNY L. FREAD, PH.D., RESEARCH HYDROLOGIST
HYDROLOGIC RESEARCH LABORATORY
W23, OFFICE OF HYDROLOGY
NOAA, NATIONAL WEATHER SERVICE
SILVER SPRING, MARYLAND 20910

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******************************
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***                        ***
***  SUMMARY OF INPUT DATA ***
***                        ***
******************************
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INPUT CONTROL PARAMETERS FOR NORTHWOOD LAKE DAM

PARAMETER	VARIABLE	VALUE
NUMBER OF DYNAMIC ROUTING REACHES	KKN	1
TYPE OF RESERVOIR ROUTING	KUI	0
MULTIPLE DAM INDICATOR	MULDAM	0
PRINTING INSTRUCTIONS FOR INPUT SUMMARY	KDMP	5
NO. OF RESERVOIR INFLOW HYDROGRAPH POINTS	ITEH	2
INTERVAL OF CROSS-SECTION INFO PRINTED OUT WHEN JNK=9	NPRT	0
FLOOD-PLAIN MODEL PARAMETER	KFLP	0
LANDSLIDE PARAMETER	KSL	0

IOPUT= 0 0 0 0 0 0 0 0 0 0 0 0

NORTHWOOD LAKE DAM RESERVOIR

TABLE OF ELEVATION VS VOLUME

VOLUME (ACRE-FEET) ELEVATION (FT)

SA(K)	HSA(K)
6500.0	525.00
5000.0	522.50
3500.0	520.00
2400.0	518.20
.0	505.00
.0	.00
.0	.00
.0	.00

NORTHWOOD LAKE DAM RESERVOIR

TABLE OF ELEVATION VS SURFACE AREA

SURFACE AREA (ACRES) SA(K)	ELEVATION (FT) HSA(K)
859.6	525.00
340.4	522.50
859.6	520.00
362.6	518.20
1.0	505.00
.0	.00
.0	.00
.0	.00

NORTHWOOD LAKE DAM RESERVOIR AND BREACH PARAMETERS

PARAMETER	UNITS	VARIABLE	VALUE
LENGTH OF RESERVOIR	MI	RLM	3.40
ELEVATION OF WATER SURFACE	FT	YO	520.50
SIDE SLOPE OF BREACH		Z	.00
ELEVATION OF BOTTOM OF BREACH	FT	YBMIN	507.00
WIDTH OF BASE OF BREACH	FT	BB	60.00
TIME TO MAXIMUM BREACH SIZE	HR	TFH	1.00
ELEVATION (MSL) OF BOTTOM OF DAM	FT	DATUM	505.00
VOLUME-SURFACE AREA PARAMETER		VOL	1.00
ELEVATION OF WATER WHEN BREACHED	FT	HF	520.50
ELEVATION OF TOP OF DAM	FT	HD	519.30
ELEVATION OF UNCONTROLLED SPILLWAY CREST	FT	HSP	518.20
ELEVATION OF CENTER OF GATE OPENINGS	FT	HGT	.00
DISCHARGE COEF. FOR UNCONTROLLED SPILLWAY		CS	.00
DISCHARGE COEF. FOR GATE FLOW		CG	.00
DISCHARGE COEF. FOR UNCONTROLLED WEIR FLOW		CDO	44.00
DISCHARGE THRU TURBINES	CFS	QT	.00

QSPILL(K,1)	HEAD(K,1)
40.	.3
350.	1.1
2525.	3.8
9828.	9.4
11832.	10.0
0.	.0
0.	.0
0.	.0

DHF(INTERVAL BETWEEN INPUT HYDROGRAPH ORDINATES) = .00 HRS.

TEH(TIME AT WHICH COMPUTATIONS TERMINATE) = 24.0000 HRS.

INFLOW HYDROGRAPH TO NORTHWOOD LAKE DAM
****

1698.00 1698.00

TIME OF INFLOW HYDROGRAPH ORDINATES

.0000 24.0000

CROSS-SECTIONAL PARAMETERS FOR LITTLE SUNCOOK RIVER
BELOW NORTHWOOD LAKE DAM

PARAMETER	VARIABLE	VALUE
NUMBER OF CROSS-SECTIONS	NS	8
MAXIMUM NUMBER OF TOP WIDTHS	NCS	7
NUMBER OF CROSS-SECTIONAL HYDROGRAPHS TO PLOT	NTT	6
TYPE OF OUTPUT OTHER THAN HYDROGRAPH PLOTS	JNK	0
CROSS-SECTIONAL SMOOTHING PARAMETER	KSA	0
DOWNSTREAM SUPERCRITICAL OR NOT	KSUPC	0
NO. OF LATERAL INFLOW HYDROGRAPHS	LQ	1
NO. OF POINTS IN GATE CONTROL CURVE	KCG	0

NUMBER OF CROSS-SECTION WHERE HYDROGRAPH DESIRED
(MAX NUMBER OF HYDROGRAPHS = 6)

1 2 4 5 6 7

CROSS-SECTIONAL VARIABLES FOR LITTLE SUNCOOK RIVER
BELOW NORTHWOOD LAKE DAM

PARAMETER	UNITS	VARIABLE
LOCATION OF CROSS-SECTION	MI	XS(I)
ELEVATION (MSL) OF FLOODING AT CROSS-SECTION	FT	FSTG(I)
ELEV CORRESPONDING TO EACH TOP WIDTH	FT	HS(K,I)
TOP WIDTH CORRESPONDING TO EACH ELEV (ACTIVE FLOW PORTION)	FT	BS(K,I)
TOP WIDTH CORRESPONDING TO EACH ELEV (OFF-CHANNEL PORTION)	FT	BSS(K,I)
SURFACE AREA CORRESPONDING TO EACH ELEV (ACTIVE FLOW PORTION)	ACRES	DSA(K,I)
SURFACE AREA CORRESPONDING TO EACH ELEV (OFF-CHANNEL PORTION)	ACRES	SSA(K,I)
NUMBER OF CROSS-SECTION		I
NUMBER OF ELEVATION LEVEL		K

CROSS-SECTION NUMBER 1
****

XS(I) = .050 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	503.0	506.0	508.0	513.0	515.0	520.0	540.0
BS ...	30.0	65.0	110.0	110.0	110.0	110.0	110.0
BSS ...	.0	.0	.0	30.0	70.0	580.0	780.0

CROSS-SECTION NUMBER 2
****

XS(I) = .600 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	446.0	450.0	452.0	455.0	460.0	465.0	470.0
BS ...	23.0	50.0	120.0	120.0	120.0	120.0	120.0
BSS ...	.0	.0	380.0	420.0	440.0	480.0	590.0

CROSS-SECTION NUMBER 3
****

XS(I) = 2.700 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	343.0	352.0	354.0	360.0	365.0	370.0	380.0
BS ...	45.0	70.0	160.0	160.0	160.0	160.0	160.0
BSS ...	.0	.0	260.0	350.0	420.0	580.0	650.0

CROSS-SECTION NUMBER 4
****

XS(I) = 4.200 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	329.0	332.0	335.0	340.0	350.0	360.0	370.0
BS ...	40.0	160.0	200.0	200.0	200.0	200.0	200.0
BSS ...	.0	.0	600.0	760.0	890.0	1100.0	1360.0

CROSS-SECTION NUMBER 5
****

XS(I) = 6.300 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	291.0	300.0	305.0	309.0	314.0	320.0	350.0
BS ...	60.0	90.0	100.0	110.0	110.0	110.0	110.0
BSS ...	.0	.0	.0	.0	360.0	580.0	820.0

CROSS-SECTION NUMBER 6
****

XS(I) = 9.700 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	289.0	290.0	295.0	298.0	315.0	320.0	350.0
BS ...	60.0	65.0	90.0	130.0	200.0	200.0	200.0
BSS ...	.0	.0	.0	180.0	260.0	520.0	920.0

CROSS-SECTION NUMBER 7
****

XS(I) = 12.500 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	286.0	295.0	300.0	310.0	320.0	330.0	350.0
BS ...	80.0	100.0	130.0	220.0	220.0	220.0	220.0
BSS ...	.0	.0	180.0	460.0	750.0	820.0	940.0

CROSS-SECTION NUMBER 8
****

XS(I) = 14.200 FSTG(I) = .00 XSL(I) = .0 XSR(I) = .0

HS ...	284.0	295.0	298.0	300.0	308.0	310.0	350.0
BS ...	100.0	130.0	140.0	180.0	180.0	180.0	180.0
BSS ...	.0	.0	.0	20.0	60.0	120.0	970.0

MANNING N ROUGHNESS COEFFICIENTS FOR THE GIVEN REACHES
(CM(K,I),K=1,NCS) WHERE I = REACH NUMBER
****

REACH 1 ...	.060	.060	.060	.060	.060	.060	.060
REACH 2 ...	.050	.050	.050	.050	.050	.050	.050
REACH 3 ...	.050	.050	.050	.050	.050	.050	.050
REACH 4 ...	.055	.055	.055	.055	.055	.055	.055
REACH 5 ...	.040	.040	.040	.040	.040	.040	.040
REACH 6 ...	.035	.035	.035	.035	.035	.035	.035
REACH 7 ...	.040	.040	.040	.040	.040	.040	.040

CROSS-SECTIONAL VARIABLES FOR LITTLE SUNCOOK RIVER
BELOW NORTHWOOD LAKE DAM

PARAMETER	UNITS	VARIABLE
MINIMUM COMPUTATIONAL DISTANCE USED BETWEEN CROSS-SECTIONS	MI	DXM(I)
CONTRACTION - EXPANSION COEFFICIENTS BETWEEN CROSS-SECTIONS		FKC(I)

REACH NUMBER	DXM(I)	FKC(I)
1	.025	.000
2	.100	.000
3	.030	.000
4	.105	.000
5	.340	.300
6	.560	.000
7	.340	.300

DOWNSTREAM FLOW PARAMETERS FOR LITTLE SUNCOOK RIVER
BELOW NORTHWOOD LAKE DAM

PARAMETER	UNITS	VARIABLE	VALUE
MAX DISCHARGE AT DOWNSTREAM EXTREMITY	CFS	QMAXD	.0
MAX LATERAL OUTFLOW PRODUCING LOSSES	CFS/FT	QLL	.000
INITIAL SIZE OF TIME STEP	HR	DTHM	.1000
INITIAL WATER SURFACE ELEVATION DOWNSTREAM	FT	YDN	.50
SLOPE OF CHANNEL DOWNSTREAM OF DAM	FT/MI	SOM	60.00
THETA WEIGHTING FACTOR		THETA	.00
CONVERGENCE CRITERION FOR STAGE	FT	EPSY	.400
TIME AT WHICH DAM STARTS TO FAIL	HR	TFI	.00

LATERAL INFLOW REACH NUMBER

LQX(I)

3

(QL(L, 1),L=1,ITEH)
12000. 12000.

TOTAL NUMBER OF CROSS SECTIONS (ORIGINAL+INTERPOLATED) (N) = 134 (MAXIMUM ALLOWABLE = 200

TOTAL VOLUME IN RESERVOIR BEHIND
NORTHWOOD LAKE DAM = 3903.8 ACRE-FEET

DEFINITION OF VARIABLES IN RESERVOIR DEPLETION TABLE

PARAMETER	UNITS	VARIABLE
TIME STEP FROM START OF ANALYSIS		I

ITERATIONS NECESSARY TO SOLVE FLOW EQUATIONS		K
ELAPSED TIME FROM START OF ANALYSIS	HRS	TTP(I)
TOTAL OUTFLOW FROM DAM	CFS	Q(I)
ELEVATION OF WATER SURFACE AT DAM	FT	H2
ELEVATION OF BOTTOM OF BREACH	FT	YB
EST DEPTH OF FLOW IMMEDIATELY DOWNSTREAM	FT	D
SUBMERGENCE COEFFICIENT		SUB
VELOCITY CORRECTION		VCOR
TOTAL VOLUME DISCHARGED FROM TIME OF BREACH	AC-FT	OUTVOL
BREACH WIDTH FT BB		
RECTANGULAR BREACH DISCHARGE COEFFICIENT		COFR
INFLOW TO RESERVOIR	CFS	QI(I)
BREACH OUTFLOW	CFS	QBRECH
SPILLWAY OUTFLOW	CFS	QSPIL

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	******	********	*******	*******	*******	****	****	*********	****	****	*****	******	*****
1	0	.000	1374	520.50	519.30	507.53	1.00	1.00	.0	.0	3.10	1698.	0.	1374.
2	1	.020	1376	520.50	519.05	507.53	1.00	1.01	2.3	1.2	3.10	1698.	6.	1370.
3	1	.040	1382	520.50	518.81	507.54	1.00	1.01	4.6	2.4	3.10	1698.	17.	1366.
4	1	.060	1392	520.50	518.56	507.55	1.00	1.01	6.8	3.6	3.10	1698.	31.	1362.
5	1	.080	1406	520.50	518.32	507.58	1.00	1.01	9.2	4.8	3.10	1698.	49.	1358.
6	1	.100	1424	520.50	518.07	507.60	1.00	1.01	11.5	6.0	3.10	1698.	71.	1354.
7	1	.120	1448	520.50	517.82	507.64	1.00	1.01	13.9	7.2	3.10	1698.	99.	1349.
8	1	.140	1476	520.50	517.58	507.68	1.00	1.01	16.3	8.4	3.10	1698.	131.	1345.
9	1	.160	1510	520.50	517.33	507.73	1.00	1.01	18.8	9.6	3.10	1698.	170.	1341.
10	1	.180	1549	520.51	517.09	507.79	1.00	1.01	21.3	10.8	3.10	1698.	213.	1336.
11	1	.200	1594	520.51	516.84	507.85	1.00	1.01	23.9	12.0	3.10	1698.	263.	1332.
12	1	.220	1645	520.51	516.59	507.92	1.00	1.01	26.6	13.2	3.10	1698.	319.	1327.
13	1	.240	1703	520.51	516.35	508.00	1.00	1.01	29.3	14.4	3.10	1698.	381.	1322.
14	1	.260	1771	520.51	516.10	508.07	1.00	1.01	32.2	15.6	3.10	1698.	450.	1321.
15	1	.280	1847	520.51	515.86	508.14	1.00	1.01	35.2	16.8	3.10	1698.	526.	1321.
16	1	.300	1929	520.51	515.61	508.22	1.00	1.01	38.3	18.0	3.10	1698.	609.	1321.
17	1	.320	2019	520.50	515.36	508.31	1.00	1.01	41.6	19.2	3.10	1698.	699.	1320.
18	1	.340	2116	520.50	515.12	508.40	1.00	1.01	45.0	20.4	3.10	1698.	797.	1320.
19	1	.360	2221	520.50	514.87	508.50	1.00	1.01	48.6	21.6	3.10	1698.	903.	1319.
20	1	.380	2333	520.50	514.63	508.60	1.00	1.01	52.4	22.8	3.10	1698.	1016.	1318.
21	1	.400	2453	520.50	514.38	508.71	1.00	1.01	56.3	24.0	3.10	1698.	1137.	1316.
22	1	.420	2582	520.50	514.13	508.82	1.00	1.01	60.5	25.2	3.10	1698.	1267.	1315.
23	1	.440	2718	520.50	513.89	508.93	1.00	1.01	64.9	26.4	3.10	1698.	1406.	1313.
24	1	.460	2864	520.49	513.64	509.05	1.00	1.01	69.5	27.6	3.10	1698.	1553.	1311.
25	1	.480	3017	520.49	513.40	509.18	1.00	1.01	74.3	28.8	3.10	1698.	1709.	1309.
26	1	.500	3180	520.49	513.15	509.31	1.00	1.01	79.4	30.0	3.10	1698.	1874.	1307.
27	1	.520	3352	520.48	512.90	509.44	1.00	1.02	84.8	31.2	3.10	1698.	2048.	1304.
28	1	.540	3533	520.48	512.66	509.58	1.00	1.02	90.5	32.4	3.10	1698.	2232.	1301.
29	1	.560	3723	520.48	512.41	509.73	1.00	1.02	96.5	33.6	3.10	1698.	2426.	1298.
30	1	.580	3923	520.47	512.17	509.87	1.00	1.02	102.9	34.8	3.10	1698.	2630.	1294.
31	1	.600	4133	520.47	511.92	510.02	1.00	1.02	109.5	36.0	3.10	1698.	2843.	1290.
32	1	.620	4353	520.46	511.67	510.18	1.00	1.02	116.5	37.2	3.10	1698.	3068.	1285.
33	1	.640	4583	520.46	511.43	510.34	1.00	1.02	123.9	38.4	3.10	1698.	3303.	1281.
34	1	.660	4824	520.45	511.18	510.50	1.00	1.03	131.7	39.6	3.10	1698.	3549.	1275.
35	1	.680	5075	520.44	510.94	510.67	1.00	1.03	139.9	40.8	3.10	1698.	3806.	1270.
36	1	.700	5338	520.43	510.69	510.84	1.00	1.03	148.5	42.0	3.10	1698.	4075.	1264.
37	1	.720	5612	520.43	510.44	511.01	1.00	1.03	157.5	43.2	3.10	1698.	4356.	1257.
38	1	.740	5898	520.42	510.20	511.19	1.00	1.04	167.0	44.4	3.10	1698.	4649.	1250.
39	1	.760	6196	520.41	509.95	511.37	1.00	1.04	177.0	45.6	3.10	1698.	4954.	1243.
40	1	.780	6507	520.40	509.71	511.56	1.00	1.04	187.5	46.8	3.10	1698.	5273.	1235.
41	1	.800	6830	520.39	509.46	511.75	1.00	1.05	198.6	48.0	3.10	1698.	5604.	1226.
42	1	.820	7166	520.38	509.21	511.95	1.00	1.05	210.1	49.2	3.10	1698.	5950.	1217.
43	1	.840	7517	520.36	508.97	512.14	1.00	1.05	222.3	50.4	3.10	1698.	6310.	1207.
44	1	.860	7881	520.35	508.72	512.35	1.00	1.06	235.0	51.6	3.10	1698.	6685.	1197.
45	1	.880	8261	520.34	508.48	512.55	1.00	1.06	248.3	52.8	3.10	1698.	7075.	1186.
46	1	.900	8656	520.32	508.23	512.77	1.00	1.07	262.3	54.0	3.10	1698.	7481.	1175.
47	1	.920	9067	520.31	507.98	512.98	1.00	1.07	277.0	55.2	3.10	1698.	7904.	1163.
48	1	.940	9495	520.29	507.74	513.20	1.00	1.08	292.3	56.4	3.10	1698.	8345.	1150.
49	1	.960	9941	520.28	507.49	513.43	1.00	1.08	308.4	57.6	3.10	1698.	8804.	1137.
50	1	.980	10405	520.26	507.25	513.66	1.00	1.09	325.2	58.8	3.10	1698.	9283.	1123.

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	******	********	*******	*******	*******	****	****	*********	****	****	*****	******	*****
51	1	1.000	10890	520.24	507.00	513.90	1.00	1.10	342.8	60.0	3.10	1698.	9782.	1108.
52	1	1.020	10919	520.22	507.00	513.91	1.00	1.10	360.8	60.0	3.10	1698.	9827.	1093.
53	1	1.040	10892	520.20	507.00	513.90	1.00	1.10	378.8	60.0	3.10	1698.	9814.	1078.
54	1	1.060	10856	520.19	507.00	513.88	1.00	1.10	396.8	60.0	3.10	1698.	9793.	1063.
55	1	1.080	10818	520.17	507.00	513.86	1.00	1.10	414.7	60.0	3.10	1698.	9770.	1048.
56	1	1.100	10781	520.15	507.00	513.84	1.00	1.10	432.6	60.0	3.10	1698.	9748.	1034.
57	1	1.120	10744	520.13	507.00	513.82	1.00	1.10	450.4	60.0	3.10	1698.	9725.	1019.
58	1	1.140	10707	520.11	507.00	513.81	1.00	1.10	468.1	60.0	3.10	1698.	9703.	1005.
59	1	1.160	10671	520.10	507.00	513.79	1.00	1.10	485.8	60.0	3.10	1698.	9681.	991.
60	1	1.180	10635	520.08	507.00	513.77	1.00	1.10	503.4	60.0	3.10	1698.	9659.	976.
61	1	1.200	10599	520.06	507.00	513.75	1.00	1.10	520.9	60.0	3.10	1698.	9638.	962.
62	1	1.220	10564	520.04	507.00	513.74	1.00	1.10	538.4	60.0	3.10	1698.	9616.	948.
63	1	1.240	10529	520.03	507.00	513.72	1.00	1.10	555.8	60.0	3.10	1698.	9595.	935.
64	1	1.260	10494	520.01	507.00	513.70	1.00	1.10	573.2	60.0	3.10	1698.	9574.	921.
65	1	1.280	10460	519.99	507.00	513.68	1.00	1.10	590.5	60.0	3.10	1698.	9553.	907.
66	1	1.300	10425	519.97	507.00	513.67	1.00	1.10	607.8	60.0	3.10	1698.	9532.	894.
67	1	1.320	10391	519.96	507.00	513.65	1.00	1.10	625.0	60.0	3.10	1698.	9511.	880.
68	1	1.340	10356	519.94	507.00	513.63	1.00	1.10	642.1	60.0	3.10	1698.	9490.	866.
69	1	1.360	10321	519.92	507.00	513.62	1.00	1.10	659.2	60.0	3.10	1698.	9469.	853.
70	1	1.380	10287	519.91	507.00	513.60	1.00	1.10	676.3	60.0	3.10	1698.	9448.	839.
71	1	1.400	10252	519.89	507.00	513.58	1.00	1.09	693.2	60.0	3.10	1698.	9427.	825.
72	1	1.420	10217	519.87	507.00	513.56	1.00	1.09	710.2	60.0	3.10	1698.	9406.	811.
73	1	1.440	10183	519.86	507.00	513.55	1.00	1.09	727.0	60.0	3.10	1698.	9385.	798.
74	1	1.460	10148	519.84	507.00	513.53	1.00	1.09	743.8	60.0	3.10	1698.	9364.	784.
75	1	1.480	10113	519.82	507.00	513.51	1.00	1.09	760.6	60.0	3.10	1698.	9343.	770.
76	1	1.500	10078	519.80	507.00	513.50	1.00	1.09	777.3	60.0	3.10	1698.	9322.	756.
77	1	1.520	10043	519.79	507.00	513.48	1.00	1.09	793.9	60.0	3.10	1698.	9301.	742.
78	1	1.540	10008	519.77	507.00	513.46	1.00	1.09	810.5	60.0	3.10	1698.	9280.	728.
79	1	1.560	9973	519.75	507.00	513.44	1.00	1.09	827.0	60.0	3.10	1698.	9259.	715.
80	1	1.580	9938	519.74	507.00	513.43	1.00	1.09	843.4	60.0	3.10	1698.	9238.	701.
81	1	1.600	9903	519.72	507.00	513.41	1.00	1.09	859.8	60.0	3.10	1698.	9217.	687.
82	1	1.620	9868	519.70	507.00	513.39	1.00	1.09	876.2	60.0	3.10	1698.	9196.	673.
83	1	1.640	9832	519.68	507.00	513.37	1.00	1.09	892.5	60.0	3.10	1698.	9174.	659.
84	1	1.660	9797	519.67	507.00	513.35	1.00	1.09	908.7	60.0	3.10	1698.	9153.	645.
85	1	1.680	9762	519.65	507.00	513.34	1.00	1.09	924.8	60.0	3.10	1698.	9132.	631.
86	1	1.700	9727	519.63	507.00	513.32	1.00	1.09	940.9	60.0	3.10	1698.	9111.	616.
87	1	1.720	9691	519.61	507.00	513.30	1.00	1.09	957.0	60.0	3.10	1698.	9089.	602.
88	1	1.740	9656	519.60	507.00	513.28	1.00	1.09	973.0	60.0	3.10	1698.	9068.	588.
89	1	1.760	9620	519.58	507.00	513.26	1.00	1.09	988.9	60.0	3.10	1698.	9047.	574.
90	1	1.780	9584	519.56	507.00	513.25	1.00	1.09	1004.8	60.0	3.10	1698.	9025.	560.
91	1	1.800	9549	519.54	507.00	513.23	1.00	1.09	1020.6	60.0	3.10	1698.	9004.	546.
92	1	1.820	9513	519.53	507.00	513.21	1.00	1.09	1036.4	60.0	3.10	1698.	8982.	531.
93	1	1.840	9477	519.51	507.00	513.19	1.00	1.09	1052.1	60.0	3.10	1698.	8961.	517.
94	1	1.860	9442	519.49	507.00	513.17	1.00	1.09	1067.7	60.0	3.10	1698.	8939.	503.
95	1	1.880	9406	519.47	507.00	513.16	1.00	1.09	1083.3	60.0	3.10	1698.	8918.	488.
96	1	1.900	9370	519.45	507.00	513.14	1.00	1.09	1098.8	60.0	3.10	1698.	8896.	474.
97	1	1.920	9334	519.44	507.00	513.12	1.00	1.09	1114.2	60.0	3.10	1698.	8875.	459.
98	1	1.940	9298	519.42	507.00	513.10	1.00	1.09	1129.6	60.0	3.10	1698.	8853.	445.
99	1	1.960	9262	519.40	507.00	513.08	1.00	1.09	1145.0	60.0	3.10	1698.	8832.	430.
100	1	1.980	9225	519.38	507.00	513.06	1.00	1.09	1160.3	60.0	3.10	1698.	8810.	416.

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	******	********	*******	*******	*******	****	****	*********	****	****	*****	******	*****
101	1	2.000	9189	519.36	507.00	513.04	1.00	1.09	1175.5	60.0	3.10	1698.	8788.	401.
102	1	2.020	9153	519.35	507.00	513.03	1.00	1.09	1190.6	60.0	3.10	1698.	8766.	387.
103	1	2.042	9113	519.33	507.00	513.01	1.00	1.09	1207.2	60.0	3.10	1698.	8743.	371.
104	1	2.066	9069	519.30	507.00	512.98	1.00	1.09	1225.4	60.0	3.10	1698.	8717.	353.
105	1	2.093	9030	519.28	507.00	512.96	1.00	1.09	1245.3	60.0	3.10	1698.	8688.	342.
106	1	2.122	8989	519.25	507.00	512.94	1.00	1.09	1267.1	60.0	3.10	1698.	8657.	333.
107	1	2.154	8945	519.22	507.00	512.92	1.00	1.08	1291.0	60.0	3.10	1698.	8624.	322.
108	1	2.190	8897	519.19	507.00	512.89	1.00	1.08	1317.1	60.0	3.10	1698.	8588.	310.
109	1	2.229	8843	519.15	507.00	512.87	1.00	1.08	1345.7	60.0	3.10	1698.	8547.	296.
110	1	2.272	8783	519.11	507.00	512.83	1.00	1.08	1376.9	60.0	3.10	1698.	8502.	282.
111	1	2.319	8717	519.07	507.00	512.80	1.00	1.08	1411.0	60.0	3.10	1698.	8452.	265.
112	1	2.371	8643	519.02	507.00	512.76	1.00	1.08	1448.3	60.0	3.10	1698.	8397.	247.
113	1	2.428	8561	518.96	507.00	512.72	1.00	1.08	1488.8	60.0	3.10	1698.	8336.	226.
114	1	2.490	8470	518.90	507.00	512.67	1.00	1.08	1533.0	60.0	3.10	1698.	8267.	203.
115	1	2.559	8368	518.83	507.00	512.62	1.00	1.08	1581.0	60.0	3.10	1698.	8190.	178.
116	1	2.635	8253	518.75	507.00	512.56	1.00	1.08	1633.2	60.0	3.10	1698.	8104.	149.
117	2	2.719	8124	518.66	507.00	512.48	1.00	1.08	1689.8	60.0	3.10	1698.	8008.	116.
118	2	2.811	7977	518.56	507.00	512.40	1.00	1.08	1750.9	60.0	3.10	1698.	7898.	79.
119	2	2.912	7810	518.44	507.00	512.31	1.00	1.08	1816.9	60.0	3.10	1698.	7774.	37.
120	2	3.023	7618	518.31	507.00	512.20	1.00	1.08	1887.7	60.0	3.10	1698.	7630.	-12.
121	2	3.145	7464	518.15	507.00	512.11	1.00	1.08	1964.0	60.0	3.10	1698.	7465.	0.
122	2	3.280	7289	517.97	507.00	512.01	1.00	1.08	2046.0	60.0	3.10	1698.	7289.	0.
123	2	3.428	7101	517.78	507.00	511.91	1.00	1.08	2134.0	60.0	3.10	1698.	7101.	0.
124	2	3.591	6899	517.58	507.00	511.79	1.00	1.08	2228.2	60.0	3.10	1698.	6900.	0.
125	2	3.770	6686	517.36	507.00	511.67	1.00	1.08	2328.8	60.0	3.10	1698.	6686.	0.
126	2	3.967	6459	517.12	507.00	511.53	1.00	1.08	2435.8	60.0	3.10	1698.	6459.	0.
127	2	4.184	6219	516.87	507.00	511.39	1.00	1.08	2549.3	60.0	3.10	1698.	6220.	0.
128	2	4.422	5967	516.60	507.00	511.23	1.00	1.08	2669.3	60.0	3.10	1698.	5968.	0.
129	2	4.684	5704	516.32	507.00	511.07	1.00	1.08	2795.8	60.0	3.10	1698.	5705.	0.
130	2	4.973	5431	516.02	507.00	510.90	1.00	1.08	2928.5	60.0	3.10	1698.	5431.	0.
131	2	5.290	5149	515.70	507.00	510.72	1.00	1.08	3067.2	60.0	3.10	1698.	5149.	0.
132	2	5.639	4860	515.37	507.00	510.53	1.00	1.08	3211.6	60.0	3.10	1698.	4860.	0.
133	2	6.023	4566	515.03	507.00	510.33	1.00	1.08	3361.1	60.0	3.10	1698.	4567.	0.
134	1	6.445	4271	514.68	507.00	510.13	1.00	1.08	3515.3	60.0	3.10	1698.	4272.	0.
135	1	6.910	3978	514.32	507.00	509.92	1.00	1.08	3673.7	60.0	3.10	1698.	3978.	0.
136	1	7.420	3690	513.97	507.00	509.70	1.00	1.08	3835.6	60.0	3.10	1698.	3690.	0.
137	1	7.983	3411	513.61	507.00	509.49	1.00	1.08	4000.5	60.0	3.10	1698.	3411.	0.
138	1	8.601	3146	513.26	507.00	509.28	1.00	1.08	4168.0	60.0	3.10	1698.	3146.	0.
139	2	9.281	2898	512.93	507.00	509.08	1.00	1.08	4337.9	60.0	3.10	1698.	2898.	0.
140	2	10.029	2671	512.61	507.00	508.89	1.00	1.08	4510.1	60.0	3.10	1698.	2671.	0.
141	2	10.852	2468	512.33	507.00	508.72	1.00	1.08	4684.9	60.0	3.10	1698.	2469.	0.
142	2	11.757	2292	512.07	507.00	508.56	1.00	1.08	4862.9	60.0	3.10	1698.	2292.	0.
143	2	12.753	2142	511.85	507.00	508.42	1.00	1.08	5045.4	60.0	3.10	1698.	2143.	0.
144	2	13.848	2020	511.66	507.00	508.31	1.00	1.08	5233.9	60.0	3.10	1698.	2021.	0.
145	2	15.053	1923	511.51	507.00	508.22	1.00	1.08	5430.2	60.0	3.10	1698.	1924.	0.
146	2	16.378	1850	511.39	507.00	508.15	1.00	1.08	5636.9	60.0	3.10	1698.	1850.	0.
147	2	17.836	1796	511.31	507.00	508.09	1.00	1.08	5856.5	60.0	3.10	1698.	1796.	0.
148	2	19.440	1758	511.24	507.00	508.05	1.00	1.08	6092.1	60.0	3.10	1698.	1758.	0.
149	2	21.203	1733	511.20	507.00	508.03	1.00	1.08	6346.6	60.0	3.10	1698.	1733.	0.
150	2	23.144	1717	511.18	507.00	508.01	1.00	1.08	6623.3	60.0	3.10	1698.	1717.	0.

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	******	********	*******	*******	*******	****	****	*********	****	****	*****	******	*****
151	2	25.278	1708	511.16	507.00	508.00	1.00	1.08	6925.4	60.0	3.10	1698.	1708.	0.

PARAMETER	UNITS	VARIABLE	VALUE
INITIAL FLOW	CFS	Q(1)	1374.
MAX FLOW	CFS	QM	10920.
FINAL FLOW	CFS	Q(NU)	1708.
TIME TO MAX FLOW	HRS	TP	1.02
NUMBER OF TIME STEPS		NNU	151
TOTAL VOLUME DISCHARGED FROM RESERVOIR	AC-FT	DISVOL	6925.

TIME PARAMETERS OF OUTFLOW HYDROGRAPH IMMEDIATELY DOWNSTREAM OF DAM

PARAMETER	UNITS	VARIABLE	VALUE
TIME TO FAILURE	HR	TFH	1.000
TIME TO START OF RISING LIMB OF HYDROGRAPH	HR	TFO	.020
TIME TO PEAK	HR	TP	1.020
TIME STEP SIZE	HR	DTHI	.100

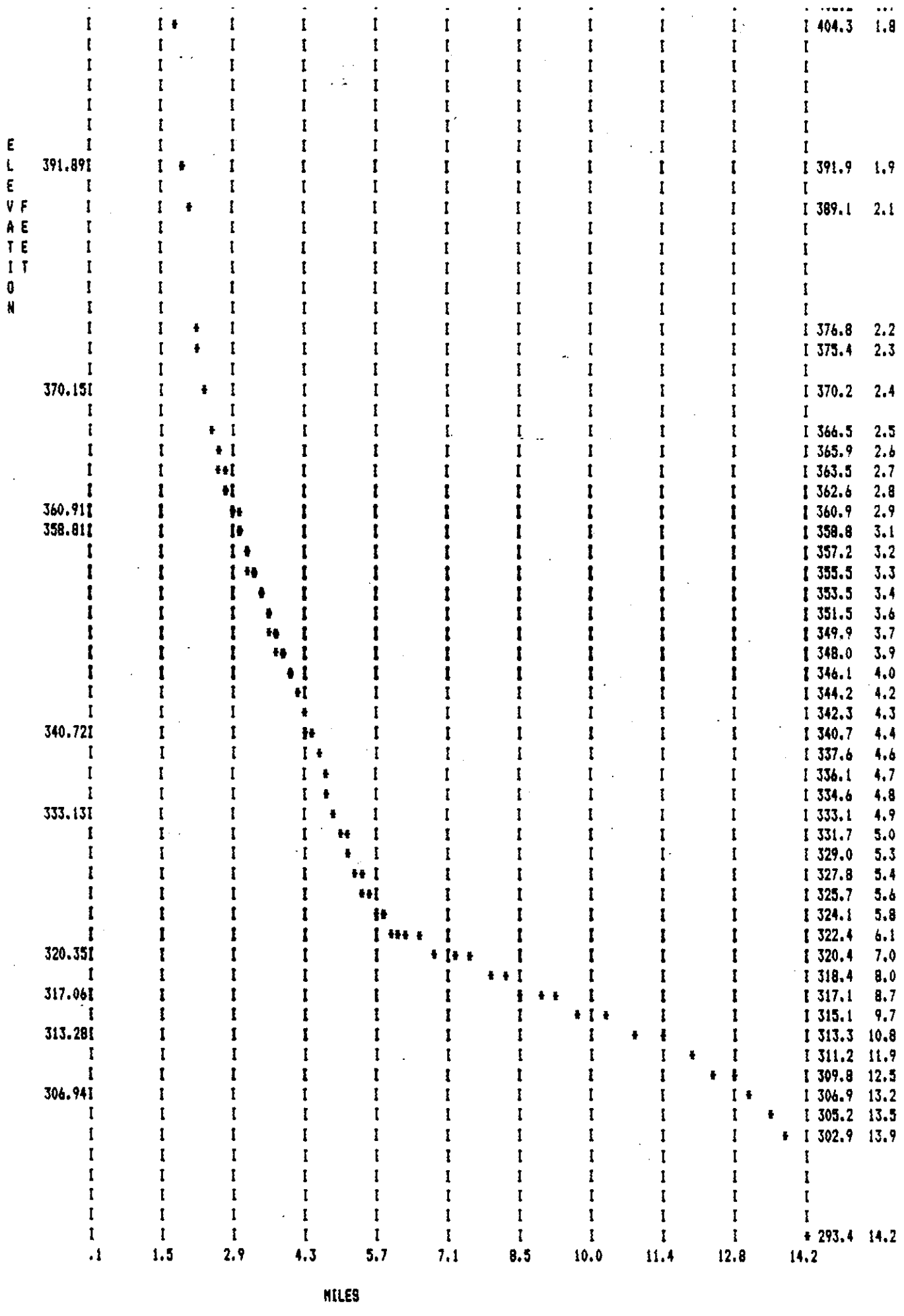
ROUTING COMPLETED.

KTIME=240 ALLOWABLE KTIME= 698 TT= 24.0

PEAK ELEVATION PROFILE

MILES

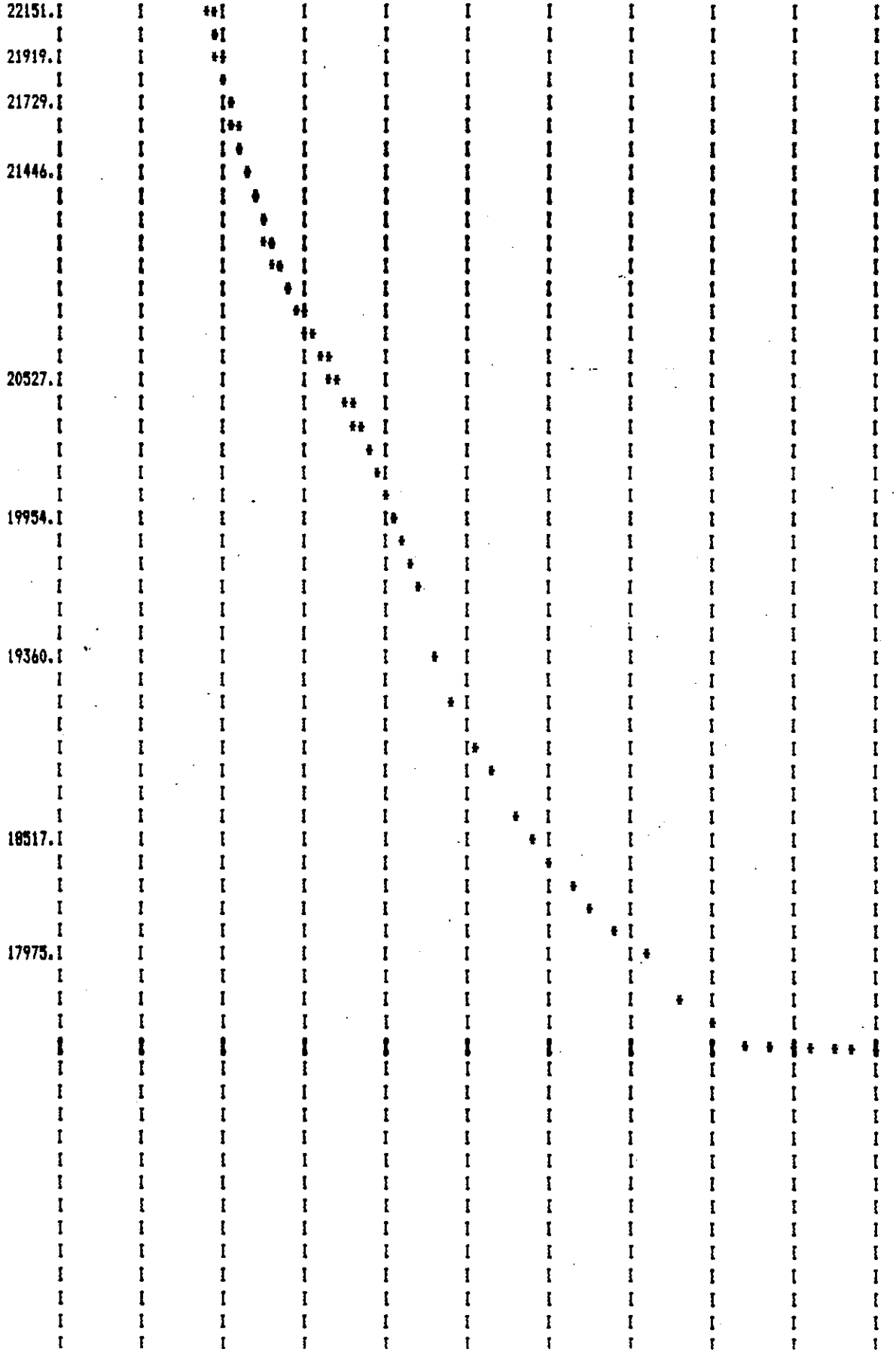
```
                                                                                                                ELEV
                                                                                                                FEET  MILE
     .1        1.5       2.9       4.3       5.7       7.1       8.5      10.0      11.4      12.8      14.2

512.58*        I         I         I         I         I         I         I         I         I         I 512.6   .1
     *         I         I         I         I         I         I         I         I         I         I 510.0   .1
     *         I         I         I         I         I         I         I         I         I         I 507.5   .1
     I         I         I         I         I         I         I         I         I         I         I
     *         I         I         I         I         I         I         I         I         I         I 505.0   .1
     *         I         I         I         I         I         I         I         I         I         I 502.4   .2
499.86*        I         I         I         I         I         I         I         I         I         I 499.9   .2
     I         I         I         I         I         I         I         I         I         I         I
     I*        I         I         I         I         I         I         I         I         I         I 497.3   .2
     I*        I         I         I         I         I         I         I         I         I         I 494.8   .2
     I         I         I         I         I         I         I         I         I         I         I
     I*        I         I         I         I         I         I         I         I         I         I 492.2   .3
     I*        I         I         I         I         I         I         I         I         I         I 489.7   .3
487.10I*       I         I         I         I         I         I         I         I         I         I 487.1   .3
     I         I         I         I         I         I         I         I         I         I         I
     I*        I         I         I         I         I         I         I         I         I         I 484.5   .3
     I *       I         I         I         I         I         I         I         I         I         I 482.0   .4
     I         I         I         I         I         I         I         I         I         I         I
     I *       I         I         I         I         I         I         I         I         I         I 479.4   .4
     I *       I         I         I         I         I         I         I         I         I         I 476.8   .4
474.30I *      I         I         I         I         I         I         I         I         I         I 474.3   .4
     I         I         I         I         I         I         I         I         I         I         I
     I *       I         I         I         I         I         I         I         I         I         I 471.8   .5
     I  *      I         I         I         I         I         I         I         I         I         I 469.2   .5
     I         I         I         I         I         I         I         I         I         I         I
     I  *      I         I         I         I         I         I         I         I         I         I 466.7   .5
     I  *      I         I         I         I         I         I         I         I         I         I 464.1   .5
461.62I  *     I         I         I         I         I         I         I         I         I         I 461.6   .6
     I         I         I         I         I         I         I         I         I         I         I
     I  *      I         I         I         I         I         I         I         I         I         I 458.8   .6
     I  *      I         I         I         I         I         I         I         I         I         I 457.3   .6
     I         I         I         I         I         I         I         I         I         I         I
     I   *     I         I         I         I         I         I         I         I         I         I 452.4   .7
     I         I         I         I         I         I         I         I         I         I         I
     I         I         I         I         I         I         I         I         I         I         I
     I    *    I         I         I         I         I         I         I         I         I         I 447.5   .8
     I         I         I         I         I         I         I         I         I         I         I
     I         I         I         I         I         I         I         I         I         I         I
442.70I     *  I         I         I         I         I         I         I         I         I         I 442.7   .9
     I         I         I         I         I         I         I         I         I         I         I
     I     *   I         I         I         I         I         I         I         I         I         I 437.9  1.0
     I         I         I         I         I         I         I         I         I         I         I
     I         I         I         I         I         I         I         I         I         I         I
     I      *  I         I         I         I         I         I         I         I         I         I 433.1  1.1
     I         I         I         I         I         I         I         I         I         I         I
     I         I         I         I         I         I         I         I         I         I         I
     I       * I         I         I         I         I         I         I         I         I         I 428.2  1.2
     I         I         I         I         I         I         I         I         I         I         I
     I       * I         I         I         I         I         I         I         I         I         I 423.5  1.3
     I         I         I         I         I         I         I         I         I         I         I
     I         I         I         I         I         I         I         I         I         I         I
418.59I        *I        I         I         I         I         I         I         I         I         I 418.6  1.4
     I         I         I         I         I         I         I         I         I         I         I
     I         *         I         I         I         I         I         I         I         I         I 414.0  1.5
     I         I         I         I         I         I         I         I         I         I         I
     I         I         I         I         I         I         I         I         I         I         I
     I         *         I         I         I         I         I         I         I         I         I 409.2  1.6
     I         I         I         I         I         I         I         I         I         I         I
     I         I*        I         I         I         I         I         I         I         I         I 405.2  1.7
```


ELEVATION
391.89
370.15
360.91
358.81
340.72
333.13
320.35
317.06
313.28
306.94
404.3 1.8
391.9 1.9
389.1 2.1
376.8 2.2
375.4 2.3
370.2 2.4
366.5 2.5
365.9 2.6
363.5 2.7
362.6 2.8
360.9 2.9
358.8 3.1
357.2 3.2
355.5 3.3
353.5 3.4
351.5 3.6
349.9 3.7
348.0 3.9
346.1 4.0
344.2 4.2
342.3 4.3
340.7 4.4
337.6 4.6
336.1 4.7
334.6 4.8
333.1 4.9
331.7 5.0
329.0 5.3
327.8 5.4
325.7 5.6
324.1 5.8
322.4 6.1
320.4 7.0
318.4 8.0
317.1 8.7
315.1 9.7
313.3 10.8
311.2 11.9
309.8 12.5
306.9 13.2
305.2 13.5
302.9 13.9
293.4 14.2
.1 1.5 2.9 4.3 5.7 7.1 8.5 10.0 11.4 12.8 14.2
MILES

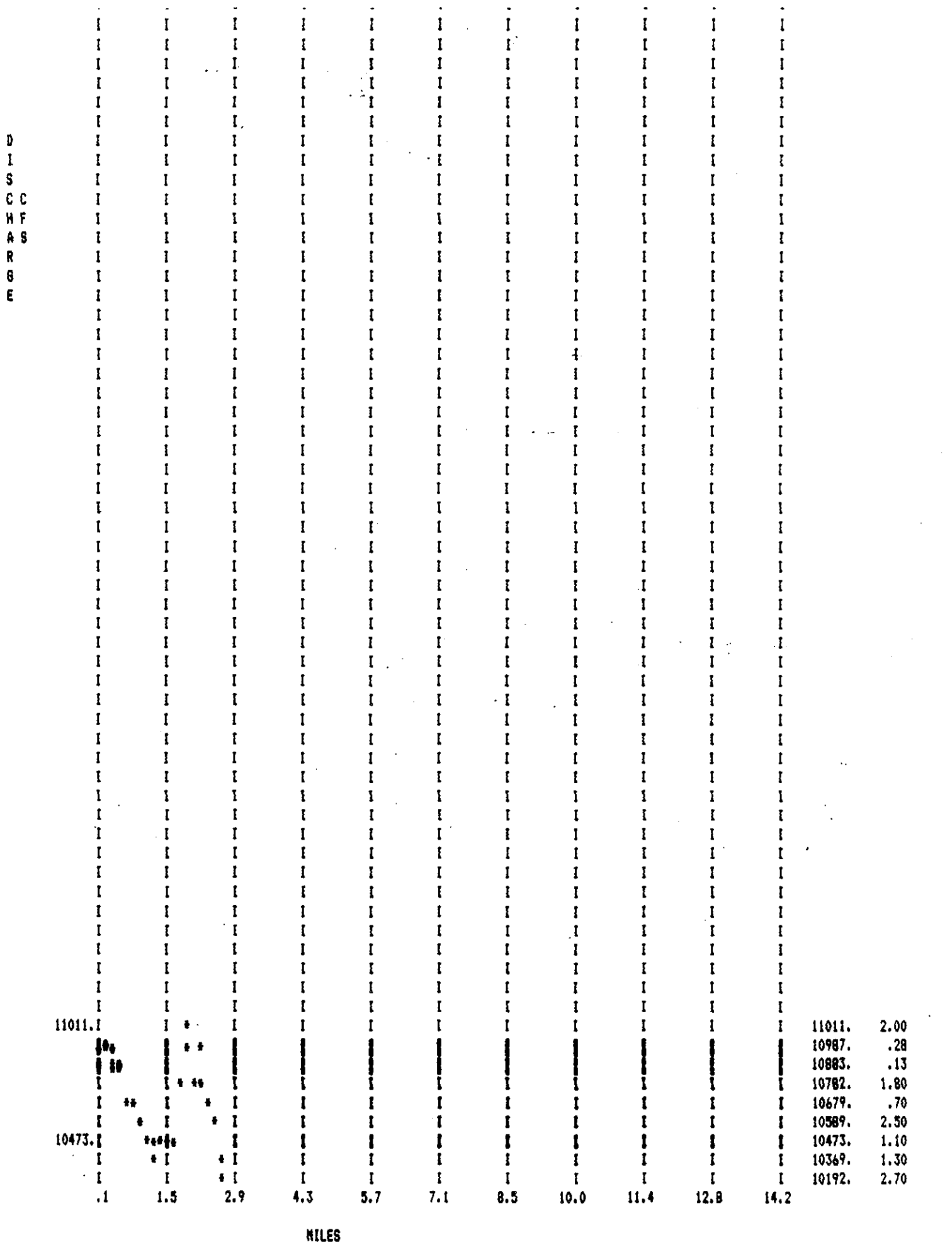
PEAK DISCHARGE PROFILE

MILES

.1 1.5 2.9 4.3 5.7 7.1 8.5 10.0 11.4 12.8 14.2

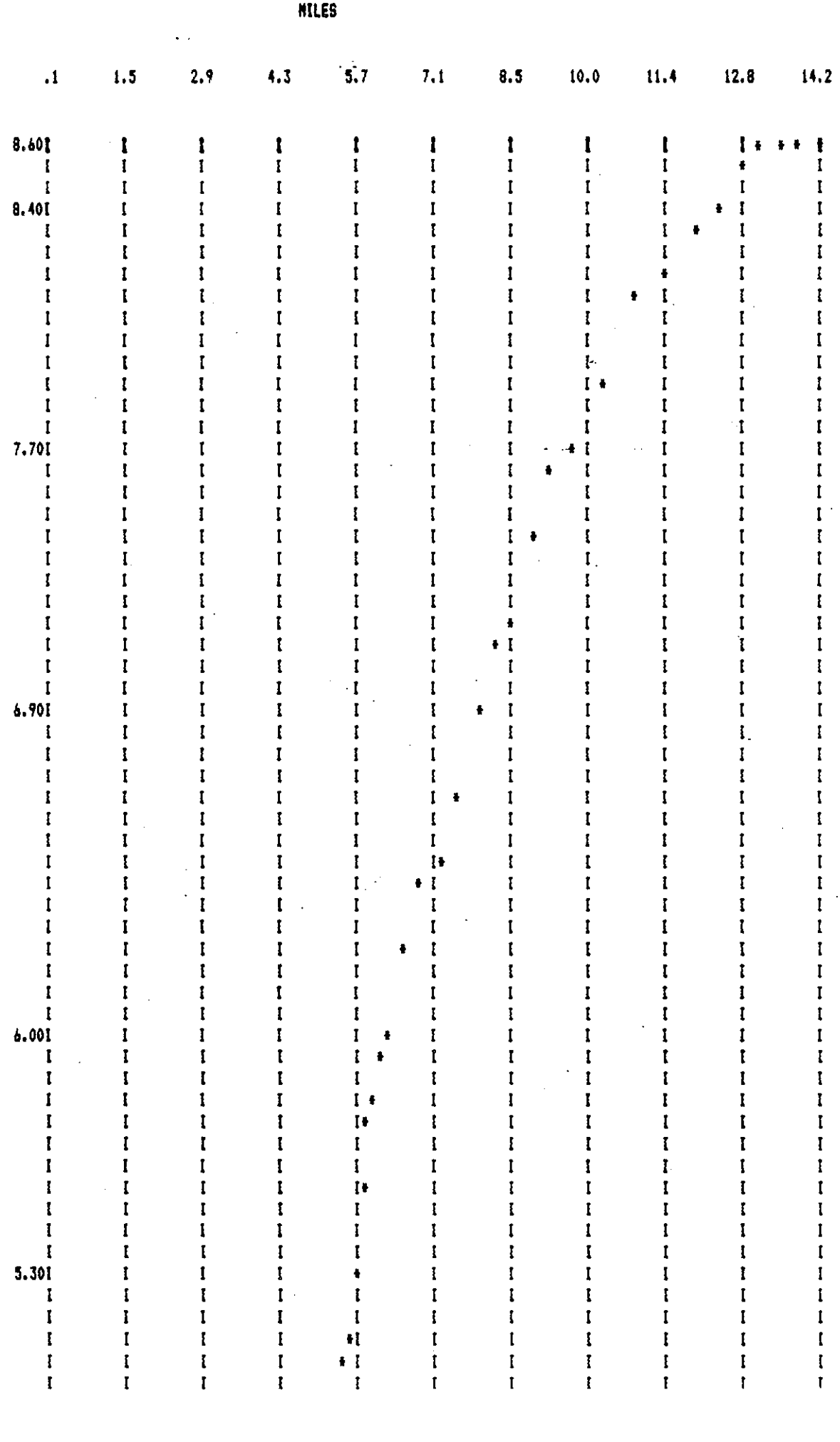


DISCHARGE CFS	MILE
22151.	2.73
22046.	2.79
21919.	2.88
21841.	2.94
21729.	3.03
21626.	3.12
21548.	3.21
21446.	3.33
21352.	3.45
21240.	3.60
21153.	3.72
21047.	3.87
20942.	4.02
20847.	4.17
20716.	4.41
20620.	4.62
20527.	4.83
20441.	5.04
20345.	5.25
20235.	5.46
20104.	5.67
20032.	5.78
19954.	5.88
19789.	6.09
19705.	6.20
19617.	6.30
19360.	6.64
19139.	6.98
18948.	7.32
18784.	7.66
18642.	8.00
18517.	8.34
18403.	8.68
18300.	9.02
18204.	9.36
18116.	9.70
17975.	10.26
17842.	10.82
17735.	11.38
17657.	11.94

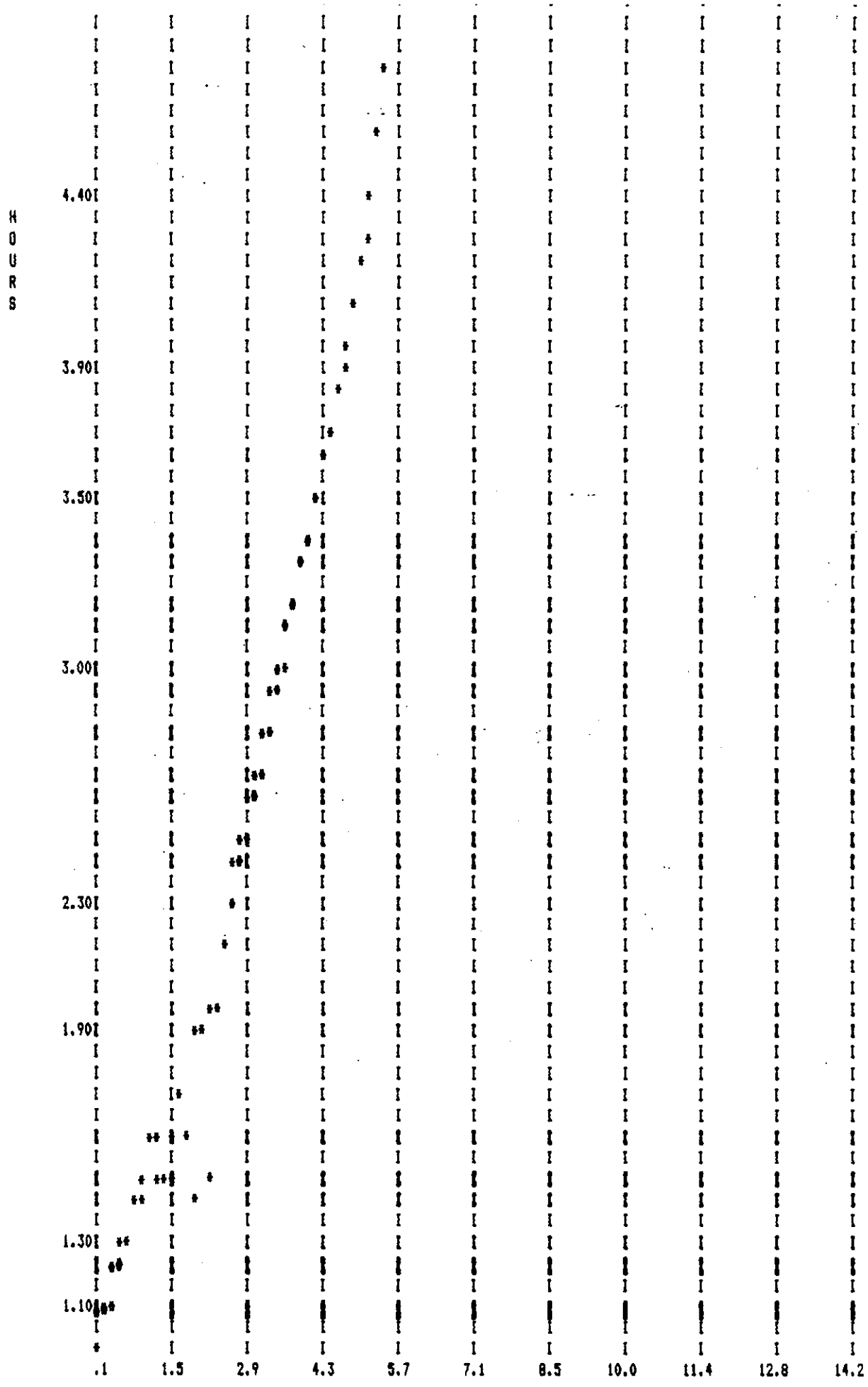

DISCHARGE
CFS
11011.
10473.
.1
1.5
2.9
4.3
5.7
7.1
8.5
10.0
11.4
12.8
14.2
MILES
11011. 2.00
10987. .28
10883. .13
10782. 1.80
10679. .70
10589. 2.50
10473. 1.10
10369. 1.30
10192. 2.70

TIME TO PEAK ELEVATION PROFILE

MILES



HOUR	MILE	ELEV
8.6	14.2	293.4
8.5	12.8	308.4
8.4	12.5	309.8
8.3	11.9	311.2
8.2	11.4	312.3
8.1	10.8	313.3
7.9	10.3	314.2
7.7	9.7	315.1
7.6	9.4	315.7
7.4	9.0	316.4
7.2	8.7	317.1
7.1	8.3	317.7
6.9	8.0	318.4
6.7	7.7	319.1
6.5	7.3	319.7
6.4	7.0	320.4
6.2	6.6	321.0
6.0	6.3	321.6
5.9	6.2	322.0
5.8	6.1	322.4
5.7	6.0	322.9
5.5	5.9	323.5
5.3	5.8	324.1
5.1	5.7	324.9
5.0	5.6	325.7



4.8	5.5	326.7
4.6	5.4	327.8
4.4	5.3	329.0
4.3	5.1	330.3
4.2	5.0	331.7
4.1	4.9	333.1
4.0	4.8	334.6
3.9	4.7	336.1
3.8	4.6	337.6
3.7	4.5	339.2
3.6	4.4	340.7
3.5	4.2	343.9
3.4	4.1	344.6
3.3	4.0	346.4
3.2	3.9	348.0
3.1	3.7	349.9
3.0	3.6	351.5
2.9	3.5	353.1
2.8	3.4	354.7
2.7	3.2	356.7
2.6	3.1	358.4
2.5	2.9	360.5
2.4	2.8	362.2
2.3	2.7	365.8
2.2	2.5	366.5
2.0	2.4	370.2
1.9	2.1	389.1
1.7	1.7	405.2
1.6	1.8	404.3
1.5	2.2	376.8
1.4	1.9	391.9
1.3	.7	452.4
1.2	.6	458.8
1.1	.4	479.4
1.0	.1	512.6

DISCHARGE HYDROGRAPH FOR LITTLE SUNCOOK RIVER ... STATION NUMBER 1
BELOW NORTHWOOD LAKE DAM AT MILE .05

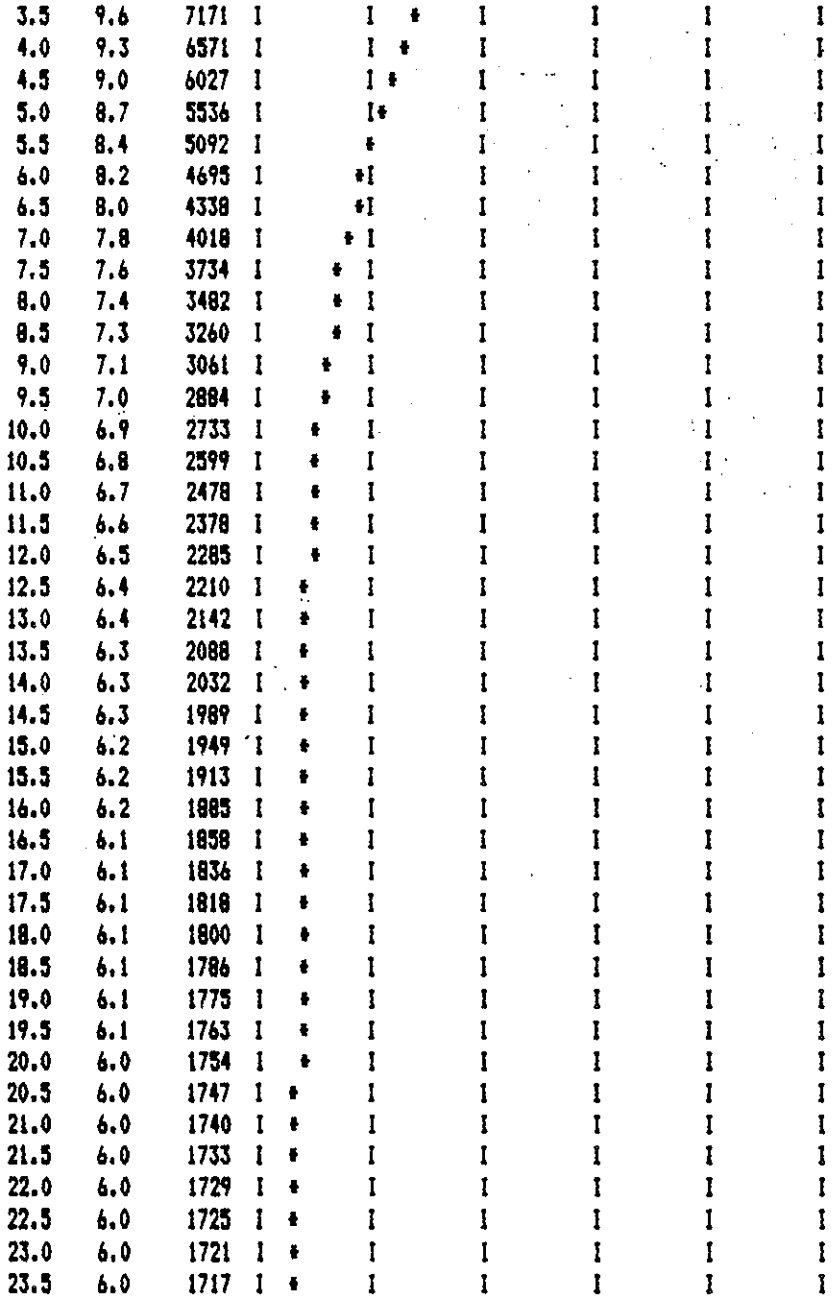
GAGE ZERO = 503.00 MAX ELEVATION REACHED BY FLOOD WAVE = 512.58
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 9.58 AT TIME = 1.000 HOURS
MAX FLOW = 10891 AT TIME = 1.000 HOURS

HR	STAGE	FLOW	0	5000	10000	15000	20000	25000
.0	4.0	1374	*					
.5	5.7	3181		*				
1.0	9.6	10891			*			
1.5	9.3	10079			*			
2.0	8.9	9190			*			
2.5	8.6	8456			*			
3.0	8.2	7658		*				
3.5	7.9	7012		*				
4.0	7.6	6423		*				
4.5	7.3	5890		*				
5.0	7.0	5407		*				
5.5	6.8	4975		*				
6.0	6.6	4584		*				
6.5	6.4	4237		*				
7.0	6.2	3927		*				
7.5	6.0	3651		*				
8.0	5.8	3404		*				
8.5	5.7	3189		*				
9.0	5.6	3001		*				
9.5	5.5	2832		*				
10.0	5.4	2680		*				
10.5	5.3	2555		*				
11.0	5.2	2440		*				
11.5	5.1	2342		*				
12.0	5.0	2256		*				
12.5	5.0	2181		*				
13.0	4.9	2115		*				
13.5	4.8	2059		*				
14.0	4.8	2008		*				
14.5	4.7	1968		*				
15.0	4.7	1928		*				
15.5	4.7	1899		*				
16.0	4.6	1871		*				
16.5	4.6	1845		*				
17.0	4.6	1827		*				
17.5	4.6	1809		*				
18.0	4.5	1792		*				
18.5	4.5	1780		*				
19.0	4.5	1769		*				
19.5	4.5	1758		*				
20.0	4.5	1750		*				
20.5	4.5	1743		*				
21.0	4.5	1736		*				
21.5	4.5	1731		*				
22.0	4.5	1727		*				
22.5	4.4	1723		*				
23.0	4.4	1719		*				
23.5	4.4	1716		*				

DISCHARGE HYDROGRAPH FOR LITTLE SUNCOOK RIVER ... STATION NUMBER 23
BELOW NORTHWOOD LAKE DAM AT MILE .60

GAGE ZERO = 446.00 MAX ELEVATION REACHED BY FLOOD WAVE = 457.26
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 11.26 AT TIME = 1.300 HOURS
MAX FLOW = 10808 AT TIME = 1.200 HOURS

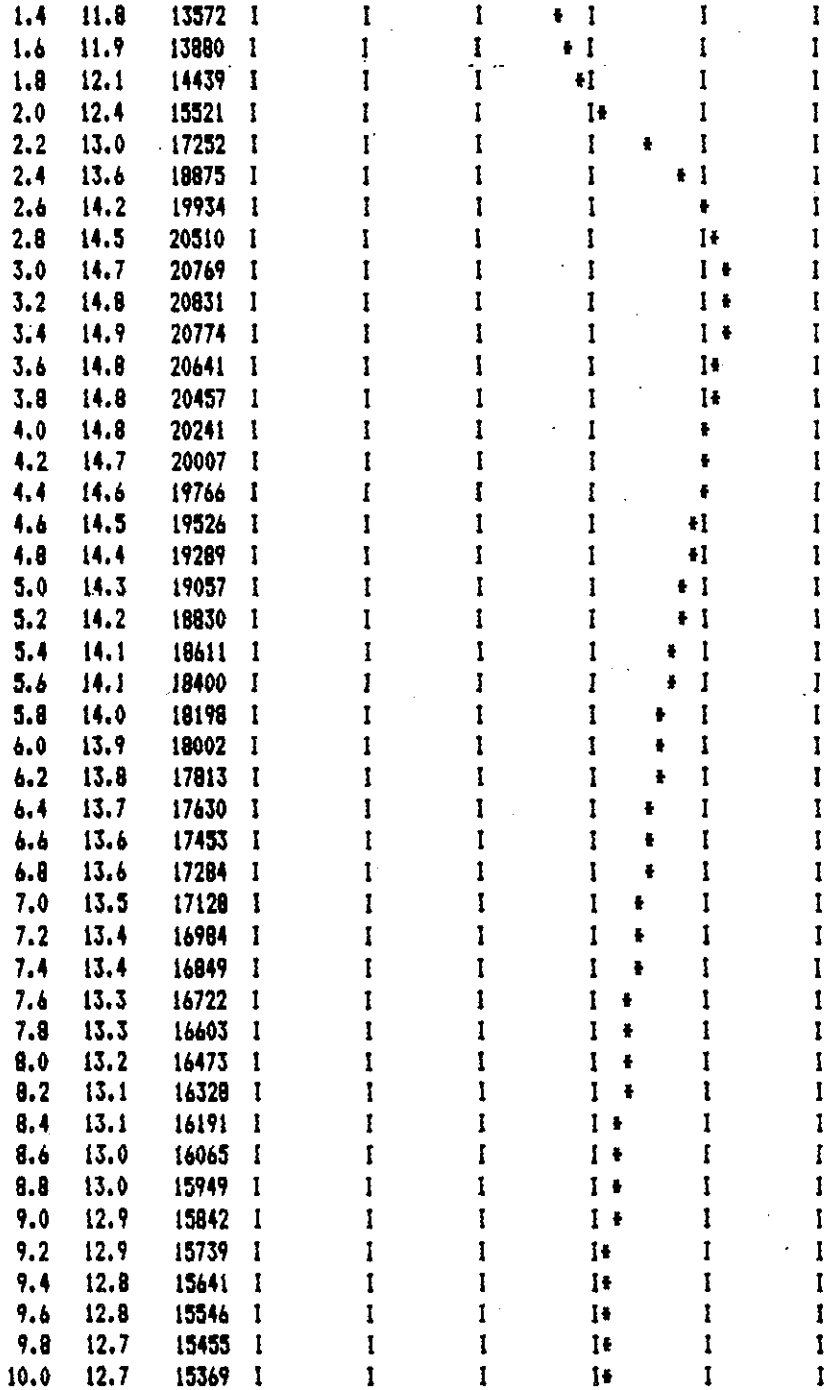
HR	STAGE	FLOW
.0	5.5	1374
.5	6.0	1829
1.0	9.9	8325
1.5	11.1	10276
2.0	10.7	9404
2.5	10.3	8629
3.0	10.0	7867
3.5	9.6	7171
4.0	9.3	6571
4.5	9.0	6027
5.0	8.7	5536
5.5	8.4	5092
6.0	8.2	4695
6.5	8.0	4338
7.0	7.8	4018
7.5	7.6	3734
8.0	7.4	3482
8.5	7.3	3260
9.0	7.1	3061
9.5	7.0	2884
10.0	6.9	2733
10.5	6.8	2599
11.0	6.7	2478
11.5	6.6	2378
12.0	6.5	2285
12.5	6.4	2210
13.0	6.4	2142
13.5	6.3	2088
14.0	6.3	2032
14.5	6.3	1989
15.0	6.2	1949
15.5	6.2	1913
16.0	6.2	1885
16.5	6.1	1858
17.0	6.1	1836
17.5	6.1	1818
18.0	6.1	1800
18.5	6.1	1786
19.0	6.1	1775
19.5	6.1	1763
20.0	6.0	1754
20.5	6.0	1747
21.0	6.0	1740
21.5	6.0	1733
22.0	6.0	1729
22.5	6.0	1725
23.0	6.0	1721
23.5	6.0	1717



DISCHARGE HYDROGRAPH FOR LITTLE SUNCOOK RIVER ... STATION NUMBER 94
BELOW NORTHWOOD LAKE DAM AT MILE 4.20

BASE ZERO = 329.00 MAX ELEVATION REACHED BY FLOOD WAVE = 343.86
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 14.86 AT TIME = 3.500 HOURS
MAX FLOW = 20831 AT TIME = 3.200 HOURS

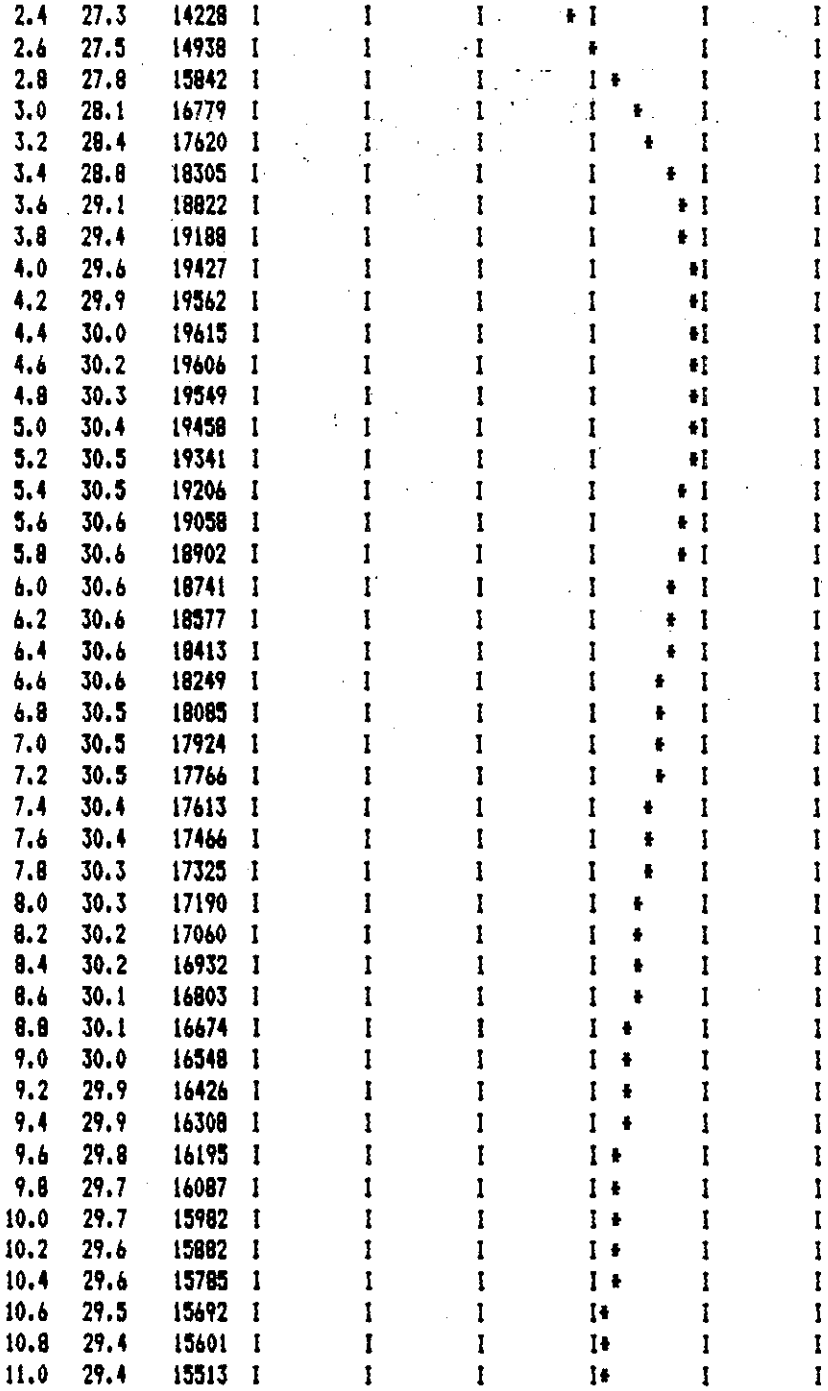
HR	STAGE	FLOW
.0	11.8	13374
.2	11.8	13374
.4	11.8	13374
.6	11.8	13374
.8	11.8	13374
1.0	11.8	13385
1.2	11.8	13432
1.4	11.8	13572
1.6	11.9	13880
1.8	12.1	14439
2.0	12.4	15521
2.2	13.0	17252
2.4	13.6	18875
2.6	14.2	19934
2.8	14.5	20510
3.0	14.7	20769
3.2	14.8	20831
3.4	14.9	20774
3.6	14.8	20641
3.8	14.8	20457
4.0	14.8	20241
4.2	14.7	20007
4.4	14.6	19766
4.6	14.5	19526
4.8	14.4	19289
5.0	14.3	19057
5.2	14.2	18830
5.4	14.1	18611
5.6	14.1	18400
5.8	14.0	18198
6.0	13.9	18002
6.2	13.8	17813
6.4	13.7	17630
6.6	13.6	17453
6.8	13.6	17284
7.0	13.5	17128
7.2	13.4	16984
7.4	13.4	16849
7.6	13.3	16722
7.8	13.3	16603
8.0	13.2	16473
8.2	13.1	16328
8.4	13.1	16191
8.6	13.0	16065
8.8	13.0	15949
9.0	12.9	15842
9.2	12.9	15739
9.4	12.8	15641
9.6	12.8	15546
9.8	12.7	15455
10.0	12.7	15369



DISCHARGE HYDROGRAPH FOR LITTLE SUNCOOK RIVER ... STATION NUMBER 114
BELOW NORTHWOOD LAKE DAM AT MILE 6.30

GAGE ZERO = 291.00 MAX ELEVATION REACHED BY FLOOD WAVE = 321.60
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 30.60 AT TIME = 6.000 HOURS
MAX FLOW = 19617 AT TIME = 4.500 HOURS

HR	STAGE	FLOW
1.0	27.2	13375
1.2	27.2	13375
1.4	27.2	13377
1.6	27.2	13395
1.8	27.2	13443
2.0	27.2	13556
2.2	27.2	13787
2.4	27.3	14228
2.6	27.5	14938
2.8	27.8	15842
3.0	28.1	16779
3.2	28.4	17620
3.4	28.8	18305
3.6	29.1	18822
3.8	29.4	19188
4.0	29.6	19427
4.2	29.9	19562
4.4	30.0	19615
4.6	30.2	19606
4.8	30.3	19549
5.0	30.4	19458
5.2	30.5	19341
5.4	30.5	19206
5.6	30.6	19058
5.8	30.6	18902
6.0	30.6	18741
6.2	30.6	18577
6.4	30.6	18413
6.6	30.6	18249
6.8	30.5	18085
7.0	30.5	17924
7.2	30.5	17766
7.4	30.4	17613
7.6	30.4	17466
7.8	30.3	17325
8.0	30.3	17190
8.2	30.2	17060
8.4	30.2	16932
8.6	30.1	16803
8.8	30.1	16674
9.0	30.0	16548
9.2	29.9	16426
9.4	29.9	16308
9.6	29.8	16195
9.8	29.7	16087
10.0	29.7	15982
10.2	29.6	15882
10.4	29.6	15785
10.6	29.5	15692
10.8	29.4	15601
11.0	29.4	15513



DISCHARGE HYDROGRAPH FOR LITTLE SUNCOOK RIVER ... STATION NUMBER 124
BELOW NORTHWOOD LAKE DAM AT MILE 9.70

GAGE ZERO = 289.00 MAX ELEVATION REACHED BY FLOOD WAVE = 315.08
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 26.08 AT TIME = 7.700 HOURS
MAX FLOW = 18116 AT TIME = 6.200 HOURS

HR	STAGE	FLOW	0	5000	10000	15000	20000	25000
2.0	23.2	13375	I	I	I	* I	I	I
2.2	23.2	13391	I	I	I	* I	I	I
2.4	23.2	13435	I	I	I	* I	I	I
2.6	23.3	13529	I	I	I	* I	I	I
2.8	23.3	13704	I	I	I	* I	I	I
3.0	23.4	13979	I	I	I	* I	I	I
3.2	23.5	14345	I	I	I	*I	I	I
3.4	23.6	14774	I	I	I	*	I	I
3.6	23.8	15235	I	I	I	*	I	I
3.8	24.0	15692	I	I	I	I*	I	I
4.0	24.2	16124	I	I	I	I *	I	I
4.2	24.4	16521	I	I	I	I *	I	I
4.4	24.6	16873	I	I	I	I *	I	I
4.6	24.8	17175	I	I	I	I *	I	I
4.8	25.0	17427	I	I	I	I *	I	I
5.0	25.1	17632	I	I	I	I *	I	I
5.2	25.3	17797	I	I	I	I *	I	I
5.4	25.4	17922	I	I	I	I *	I	I
5.6	25.5	18012	I	I	I	I *	I	I
5.8	25.7	18071	I	I	I	I *	I	I
6.0	25.7	18104	I	I	I	I *	I	I
6.2	25.8	18116	I	I	I	I *	I	I
6.4	25.9	18110	I	I	I	I *	I	I
6.6	26.0	18088	I	I	I	I *	I	I
6.8	26.0	18054	I	I	I	I *	I	I
7.0	26.0	18010	I	I	I	I *	I	I
7.2	26.1	17957	I	I	I	I *	I	I
7.4	26.1	17895	I	I	I	I *	I	I
7.6	26.1	17827	I	I	I	I *	I	I
7.8	26.1	17753	I	I	I	I *	I	I
8.0	26.1	17675	I	I	I	I *	I	I
8.2	26.1	17595	I	I	I	I *	I	I
8.4	26.0	17512	I	I	I	I *	I	I
8.6	26.0	17427	I	I	I	I *	I	I
8.8	26.0	17340	I	I	I	I *	I	I
9.0	26.0	17252	I	I	I	I *	I	I
9.2	25.9	17161	I	I	I	I *	I	I
9.4	25.9	17068	I	I	I	I *	I	I
9.6	25.9	16975	I	I	I	I *	I	I
9.8	25.8	16881	I	I	I	I *	I	I
10.0	25.8	16787	I	I	I	I *	I	I
10.2	25.7	16694	I	I	I	I *	I	I
10.4	25.7	16601	I	I	I	I *	I	I
10.6	25.6	16509	I	I	I	I *	I	I
10.8	25.6	16418	I	I	I	I *	I	I
11.0	25.6	16328	I	I	I	I *	I	I
11.2	25.5	16239	I	I	I	I *	I	I
11.4	25.5	16151	I	I	I	I *	I	I
11.6	25.4	16064	I	I	I	I *	I	I
11.8	25.4	15979	I	I	I	I *	I	I
12.0	25.3	15895	I	I	I	I *	I	I

DISCHARGE HYDROGRAPH FOR LITTLE SUNCOOK RIVER ... STATION NUMBER 129
BELOW NORTHWOOD LAKE DAM AT MILE 12.50

GAGE ZERO = 286.00 MAX ELEVATION REACHED BY FLOOD WAVE = 309.76
FLOOD STAGE NOT AVAILABLE
MAX STAGE = 23.76 AT TIME = 8.400 HOURS
MAX FLOW = 17611 AT TIME = 8.100 HOURS

HR	STAGE	FLOW	0	5000	10000	15000	20000	25000
2.00	21.1	13374	I	I	I	* I	I	I
2.25	21.1	13374	I	I	I	* I	I	I
2.50	21.2	13374	I	I	I	* I	I	I
2.75	21.2	13374	I	I	I	* I	I	I
3.00	21.2	13395	I	I	I	* I	I	I
3.25	21.2	13512	I	I	I	* I	I	I
3.50	21.3	13691	I	I	I	* I	I	I
3.75	21.4	13938	I	I	I	* I	I	I
4.00	21.6	14235	I	I	I	* I	I	I
4.25	21.7	14569	I	I	I	*I	I	I
4.50	21.9	14919	I	I	I	*	I	I
4.75	22.2	15271	I	I	I	I*	I	I
5.00	22.4	15612	I	I	I	I*	I	I
5.25	22.6	15931	I	I	I	I *	I	I
5.50	22.8	16229	I	I	I	I *	I	I
5.75	23.0	16502	I	I	I	I *	I	I
6.00	23.1	16750	I	I	I	I *	I	I
6.25	23.3	16963	I	I	I	I *	I	I
6.50	23.4	17145	I	I	I	I *	I	I
6.75	23.5	17296	I	I	I	I *	I	I
7.00	23.6	17413	I	I	I	I *	I	I
7.25	23.6	17500	I	I	I	I *	I	I
7.50	23.7	17560	I	I	I	I *	I	I
7.75	23.7	17595	I	I	I	I *	I	I
8.00	23.7	17610	I	I	I	I *	I	I
8.25	23.8	17606	I	I	I	I *	I	I
8.50	23.8	17586	I	I	I	I *	I	I
8.75	23.8	17552	I	I	I	I *	I	I
9.00	23.7	17506	I	I	I	I *	I	I
9.25	23.7	17450	I	I	I	I *	I	I
9.50	23.7	17384	I	I	I	I *	I	I
9.75	23.7	17310	I	I	I	I *	I	I
10.00	23.6	17229	I	I	I	I *	I	I
10.25	23.6	17143	I	I	I	I *	I	I
10.50	23.6	17052	I	I	I	I *	I	I
10.75	23.5	16958	I	I	I	I *	I	I
11.00	23.5	16860	I	I	I	I *	I	I
11.25	23.4	16761	I	I	I	I *	I	I
11.50	23.4	16660	I	I	I	I *	I	I
11.75	23.3	16559	I	I	I	I *	I	I
12.00	23.3	16458	I	I	I	I *	I	I
12.25	23.2	16360	I	I	I	I *	I	I
12.50	23.2	16261	I	I	I	I *	I	I
12.75	23.1	16163	I	I	I	I *	I	I
13.00	23.1	16066	I	I	I	I *	I	I
13.25	23.0	15970	I	I	I	I *	I	I
13.50	23.0	15877	I	I	I	I *	I	I
13.75	22.9	15785	I	I	I	I *	I	I
14.00	22.9	15695	I	I	I	I*	I	I
14.25	22.8	15608	I	I	I	I*	I	I

APPENDIX C

BREACH FORMATION AND SIZING CALCULATION

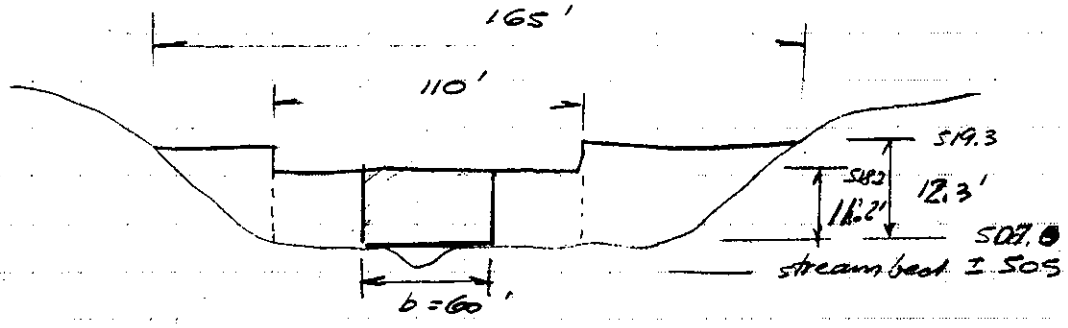
STORCH ASSOCIATES
Engineers - Surveyors - Planners
Landscape Architects
Environmental Scientists

JOB 6384 - NH Dams - Northwood
SHEET NO. ____ OF ____
CALCULATED BY JH DATE 11-21-87
CHECKED BY ____ DATE ____
SCALE ____ - Breach Sizing

Breach formation and sizing:

Northwood Lake Dam is a concrete gravity structure
overall length 165 LF
L_d = 55 LF (top of dam) Elev. 519.3
streambed invert 505.0
L_s = 110 LF (spillway crest) EL. 518.16 use 518.2

h_d = 19.3 Ft z = 0 - rectangular shape



average formed breach in concrete
$h_d < b < 3h_d$ => b_d = 19.3' to 57.9 or 60.4 = 66'
use 60 LF
assuming partial monolitic failure
bottom of breach 507.0

Reservoir length 3.4 mi
W.S. during PMF El. 527.6
PMF inflow 12,826 cfs
outflow 10,870 cfs

PRODUCT 204-1 NEBS Inc., Groton, Mass. 01471.