GINNA STATION

DESIGN BASIS FLOODING STUDY

FOR

ROCHESTER GAS AND ELECTRIC CORPORATION

August 1981

NUS Corporation
4 Research Place
Rockville, Maryland 20850

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY AND RESULTS

The purpose of this study was to determine the flood elevations in Deer Creek near the Ginna Generating Station for storms varying in severity from the 100-year precipitation to the Probable Maximum Precipitation (PMP). The peak discharges were estimated using the rainfall-runoff model developed by the Soil Conservation Service. The calculations were made with the HEC-1 Flood Hydrograph Package computer program. The water surface elevations were estimated with the HEC-2 Water Surface Profiles computer program. Both computer programs were developed by the U.S. Army Corps of Engineers. The results of the calculations are as follows:

Return Period (Years)	Precipitation (Inches)	Flood Discharge (cfs)	Flood Elevation at Culvert Bridge near Ginna Station (ft) - MSL
100	4.8	5,970	264.1
500	5.9	6,974	265.0
1,000	6.3	7,633	265.6
~15,000*	8.0	10,109	267.4
~350,000*	10.0	12,076	268.7
~10^7*	12.0	13,679	269.7
PMF	23.8	32,486	277.1

* Based on straight-line extrapolation on Gumbel probability paper to provide order-of-magnitude approximation.

The conclusions of the study are:

- The 12" storm (about a 10^7-year event) and the 10" storm (about a 350,000-year event) are calculated to produce flood elevations of 269.7 ft and 268.7 ft (msl), respectively, near the Ginna Station. The plant grade elevation is at 270 ft (msl).
- The Deer Creek PMF will flow over the plant yard of the Ginna Station.
- The elimination or improvement of the culvert bridge for minimizing the bridge backwater effect will not solve the Ginna Station flooding resulting from a Deer Creek PMF event.

DEER CREEK WATERSHED

Field reconnaissance of the Deer Creek watershed was conducted on June 3, 1981 to estimate the hydraulic characteristics of the watershed, particularly the channel and overbank areas. The watershed was walked from its mouth in Lake Ontario to the confluence of Deer and Mill Creeks. Location maps showing the Deer Creek watershed in relation to the Ginna Station are presented in Figures 1 and 2.

As determined from the U.S. Geological Survey 7.5 minute quadrangles,[1] the Deer Creek watershed has a drainage area of 13.9 square miles, a channel length of 11.5 miles, and a difference in elevation between its head and mouth of 405 feet.

There are two bridges (Figure 2) over Deer Creek that can influence the backwater elevations near the Ginna Station:

(a) The lower bridge is located about 880 feet upstream of the mouth. It has a trapezoidal bridge opening.

(b) The upper bridge is located about 2300 feet upstream of the mouth and about 320 feet downstream of its confluence with Mill Creek. It is the road to the Station entrance. The bridge opening consists of five circular culverts, each 5 feet in diameter.

The soil mapping units in Deer Creek watershed were determined from the Soil Conservation Service soil survey for Wayne County.[2] The soil mapping units and the corresponding hydrologic soil groups[3] are shown in Table 1. The major portion of the watershed consists of the soil mapping units that correspond to hydrologic soil group "C". This group is defined as:

> Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.[3]

Based on the USGS topographic maps and the field reconnaissance information, the major land use and treatment in the watershed was estimated as row crops in good hydrologic condition.[3]

The channel of Deer Creek is generally well defined with a typical channel width of about 40 feet. However, the hydraulic characteristics of the channel and overbank areas differ significantly from the lower to upper reaches. The Manning's resistance coefficients were estimated using criteria described by Chow.[4] The characteristics of the lower, middle and upper reaches are as follows:

(a) Lower Reach (from mouth to the cross section near the visitor center, about 1820 feet upstream of mouth): The channel is generally clean and winding with some shallow pools, stones and weeds. The overbank areas are generally covered with medium to dense brush and trees. The Manning resistance coefficient for the channel and overbank areas was estimated as 0.045 and 0.05, respectively.

(b) Middle Reach (from cross section near the visitor center to the confluence of Deer and Mill Creeks, about 2620 feet upstream of mouth): The channel is clean and straight. The overbank areas are generally covered with short grass. The Manning resistance coefficient for the channel and overbank areas was estimated as 0.02 and 0.03, respectively.

(c) Upper Reach (upstream of the confluence of Deer and Mill Creeks): The channel is very weedy with heavy stands of underbrush. The overbank areas are generally covered with dense brush and trees. The Manning resistance coefficient for the channel and overbank areas was estimated as 0.10 and 0.06, respectively.

RAINFALL

The rainfall used in this study ranges from the 100-year precipitation to the Probable Maximum Precipitation (PMP).

The 24-hour point precipitations for the Deer Creek watershed for return periods of 1 to 100 years were estimated from generalized charts of the United States.[5] These data, shown in Table 2, were plotted on Gumbel extreme probability graph paper[6] to obtain estimates of the precipitation with return periods of 500 years and greater (Figure 3). The 500- and 1000-year precipitations were estimated as 5.9 and 6.3 inches, respectively. Rainfalls of 8.0, 10, and 12 inches, all with an estimated return period greater than 10,000 years, were also used in this study for comparison purposes.

The Probable Maximum Precipitation (PMP) for the Deer Creek watershed was estimated from a generalized chart of the United States east of the 105th meridian.[3] The 6-hour, 10-square mile PMP is 24.5 inches. The PMPs for 12, 24 and 48 hours, as determined from depth-area-duration curves,[3] are 26.5, 29.4 and 31.4 inches, respectively.

FLOOD DISCHARGE

The peak discharges at the mouth of Deer Creek for the selected precipitations were estimated with the rainfall-runoff model developed by the Soil Conservation Service for small ungaged watersheds.(3) The calculations were made with the HEC-1 Flood Hydrograph Package computer program developed by the U.S. Army Corps of Engineers.(7) . The inputs to HEC-1 are described below.

The time distribution of rainfall developed by the U.S. Corps of Engineers(8) for the Standard Project Flood (SPF) and Probable Maximum Flood (PMF) was used in this study. Since the watershed is only 13.9 square miles in area, the areal reduction factor was not applied to the precipitation other than the PMP. For the latter case, a 24-hour PMP of 23.8 inches was calculated using an areal reduction factor of 0.81 as determined by the HEC-1 PMP option. The time precipitation distributions of the selected precipitations are shown in Table 3.

The watershed time of concentration, T_C, is given by:(3)

$$T_C = \left[\frac{11.9\ L^3}{H}\right]^{0.385}$$

where:

L	=	channel length in miles
H	=	elevation difference in feet.

The time of concentration for the Deer Creek watershed is 4.3 hours. The basin lag is approximately 0.6 T_C, or 2.6 hours.

The amount of rainfall in a period of 5 to 30 days preceding a particular storm is referred to as antecedent rainfall. The resulting condition of the watershed in regard to potential runoff is referred to as an antecedent moisture condition. In general, the heavier the antecedent rainfall, the greater the direct runoff that

occurs from a given storm. The antecedent moisture condition AMC-II, used in this study, is defined as:

> "The average case for annual floods, that is, an average of the conditions which have preceded the occurrence of the maximum annual flood on numerous watersheds."(3)

Precipitation losses were estimated using the direct runoff curve number, CN, which is a function of the hydrologic soil group, the land use and cover, and the antecedent moisture condition. For a hydrologic soil group "C", land use characterized as row crops in good hydrologic condition, and an antecedent moisture condition of AMC-II, the curve number for the Deer Creek watershed was estimated as CN=85.(3)

The calculated unit hydrograph for the Deer Creek watershed is shown in Table 4 and Figure 4. For illustration purposes, the hydrograph for the flood discharge of 12,076 cfs is shown in Figure 5. The estimated peak discharges and precipitation losses for the selected precipitations are as follows:

Estimated Return Period (Years)	Precipitation (Inches)	Precipitation Losses (Inches)	Peak Discharge (cfs)
100	4.8	1.62	5,970
500	5.9	1.69	6,974
1,000	6.3	1.71	7,633
~15,000*	8.0	1.79	10,109
~350,000*	10.0	1.84	12,076
~ 10^7*	12.0	1.89	13,679
PMF	23.8	1.99	32,486

* Based on straight-line extrapolation on Gumbel probability paper to provide order-of-magnitude approximation.

FLOOD ELEVATION

The water surface profiles for the peak flood discharges were calculated using the HEC-2 Water Surface Profiles computer program developed by the U.S. Army Corps of Engineers.[9] The calculational procedure used in HEC-2 is the standard step method for calculating backwater curves. The inputs to HEC-2 are described below.

Boundary geometry for the analysis of the flood discharges was specified in terms of ground surface profiles (cross sections) and the distances between them (reach lengths). Cross sections, as shown in Figure 6, were located at intervals along Deer Creek to characterize the flow carrying capability of the channel and overbank areas. Eleven of the cross sections were surveyed for this study. Selected cross sections for Deer Creek are shown in Figure 7 to give indication of channel geometry.

Several types of loss coefficients were selected for use in HEC-2 to evaluate head losses:

(a) Manning resistance coefficient for friction losses

(b) Contraction and expansion coefficients to evaluate transition losses between cross sections

(c) Bridge loss coefficients to evaluate losses related to weir shape, pier configuration, and pressure flow.

The hydraulic characteristics of the channel and overbank areas determine the cross section conveyance. The Manning's coefficients used in this study are as follows:

Reach (feet above mouth)	Manning's Coefficient	
	Channel	Overbank
0-1820	0.045	0.05
1820-2620	0.02	0.03
2620	0.1	0.06

The contraction and expansion coefficients are used to estimate losses associated with changes in the shape of cross sections. Transitions through channel sections in Deer Creek are gradual. Consequently, 0.1 and 0.3 were used for the contraction and expansion coefficients, respectively. The corresponding coefficients for the bridge sections were 0.3 and 0.5.(9)

The HEC-2 special bridge method was used to model the bridges. The culvert bridge was approximated as an equivalent area rectangular bridge opening. The special bridge coefficients used in the calculations are shown in Table 5.(9) In order to examine the backwater effect of the culvert bridge, calculations were also made to determine the water elevations assuming that the culvert bridge is not in existence. The estimated water surface elevations at the culvert bridge location near the Ginna Station are as follows:

Estimated Return Period (Years)	Water Surface Elevations (ft) at the Culvert Bridge Location near Ginna Station	
	With Culvert Bridge	Without Culvert Bridge
100	264.1	263.7
500	265.0	264.6
1,000	265.6	265.2
~15,000*	267.4	267.1
~350,000*	268.7	268.1
~ 10^7*	269.7	269.0
PMF	277.1	276.0

* Based on straight-line extrapolation on Gumbel probability paper to provide order-of-magnitude approximation.

As shown, the backwater effect due to the culvert bridge will raise the PMF elevation to about one foot above the natural flood level condition (i.e., without the bridge). For the other floods considered in this study, the water level raised by the bridge backwater effect is less than one foot.

The lower bridge near the Deer Creek mouth has a relatively large bridge opening and is not considered as a potential location to cause significant backwater effect on the various flood levels.

CONCLUSION

The following conclusions can be drawn from the foregoing study results:

a) The 12" storm event with a return period approximating 10^7 years is calculated to produce a flood peak of 13,679 cfs and a flood elevation of 269.7 ft (msl) at the culvert bridge near the Ginna Station. The plant grade elevation is at 270 ft (msl).

b) The 10" storm event with a return period approximating 350,000 years is calculated to produce a flood peak of 268.7 ft (msl) at the culvert bridge near the Ginna Station.

c) The water level produced by a Probable Maximum Flood of 32,486 cfs on Deer Creek near the station is calculated to be 277.1 ft (msl). Since the plant grade is 270.0 ft (msl), the Deer Creek PMF will flow over the plant yard of the Ginna Station. A similar flood study previously conducted by the U.S. Nuclear Regulatory Commission(10) has calculated a Deer Creek PMF of 37,500 cfs with a flood elevation of about 275 ft (msl). The differences between these two study results are probably caused by the use of differently assumed model input parameters, such as the runoff curve number in HEC-1 and the roughness and transition loss coefficients in HEC-2. It is to be noted that this study has used field surveyed cross sections which provide more reliable channel geometry data.

d) The backwater effect due to the culvert bridge will raise the PMF elevation by about one foot above the natural flood level condition. Since the predicted PMF level is more than one foot higher than the plant grade, the elimination or improvement of the culvert bridge for minimizing the backwater effect will not solve the Ginna Station flooding resulting from a Deer Creek PMF event.

REFERENCES

1. 7½ Minute Quadrangles: Furnaceville, N.Y. (Photorevised 1969); Ninemile Point, N.Y. (1971); Webster, N.Y. (Photorevised 1978); Ontario, N.Y. (Photorevised 1978), U.S. Department of the Interior, Geological Survey.

2. Soil Survey of Wayne County, New York, U.S. Department of Agriculture, Soil Conservation Service (October 1978).

3. Design of Small Dams, U.S. Department of the Interior, Bureau of Reclamation (1977).

4. Ven Te Chow, Open-Channel Hydraulics, McGraw-Hill Book Co., New York (1959).

5. Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years, Technical Paper No. 40, U.S. Department of Commerce, Weather Bureau (May 1961).

6. Probability Tables for the Analysis of Extreme-Value Data, Applied Mathematics Series 22, National Bureau of Standards, U.S. Department of Commerce (July 1953).

7. HEC-1 Flood Hydrograph Package (Feb. 1981 version), User Manual, U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center (July 1981).

8. Standard Project Flood Determinations, EM-1110-2-1411, U.S. Department of the Army, Office of the Chief of Engineers (March 25, 1952).

9. HEC-2 Water Surface Profiles (Apirl 1980 version), User Manual, U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center (January 1981).

10. Evaluation of SEP Topics II-3.A, II-3.B, and II-3.C Hydrology, Flooding and Ultimate Heat Sink - R.E. Ginna Nuclear Plant, U.S. Nuclear Regulatory Commission, Operating Reactors Branch #5, Division of Licensing (December 12, 1980).

TABLE 1

HYDROLOGIC SOIL GROUPS IN DEER CREEK WATERSHED

Soil Mapping Unit	Hydrologic Soil Group
Alluvial Land	-
Alton Gravelly Sandy Loam	B
Canadaigua Silt Loam	C
Cazenovia Gravelly Silt Loam	C
Collamer Silt Loam	B
Elnora Loamy Fine Sand	C
Hilton Gravelly Loam	C
Niagara Silt Loam	-
Ovid Silt Loam	C
Rhinebeck Silty Clay Loam	C
Sodus Gravelly Fine Sandy Loam	C
Williamson Silt Loam	B

TABLE 2

24-HOUR POINT PRECIPITATION

Return Period (Years)	Precipitation (Inches)
1	2.1
2	2.4
5	3.0
10	3.5
25	4.0
50	4.5
100	4.8

TABLE 3

TIME DISTRIBUTION OF 24-HOUR PRECIPITATION

Duration (Hours)	Time Distribution for Indicated 24-Hour Precipitation (Inches)						
	4.8	5.9	6.3	8.0	10.0	12.0	23.81
0-6	0.05	0.06	0.06	0.08	0.32	0.64	0.93
6-12	0.38	0.47	0.50	0.64	1.10	1.66	1.62
12-18	4.18	5.13	5.48	6.96	7.92	8.70	19.86
18-24	0.19	0.24	0.25	0.32	0.66	1.00	1.41

Note: The time distribution of the maximum 6-hour precipitation expressed as a percentage of the maximum 6-hour precipitation is as follows:

Duration (Hours)	Percent of Maximum 6-Hour Precipitation
0-1	10
1-2	12
2-3	15
3-4	38
4-5	14
5-6	11

TABLE 4

DEER CREEK WATERSHED UNIT HYDROGRAPH (24 HR., 1" STORM)

Time (Hours)	Discharge (CFS)	Time (Hours)	Discharge (CFS)
0	0	7.5	241
0.5	195	8.0	180
1.0	591	8.5	134
1.5	1,225	9.0	102
2.0	1,936	9.5	77
2.5	2,299	10.0	58
3.0	2,343	10.5	44
3.5	2,144	11.0	33
4.0	1,829	11.5	25
4.5	1,378	12.0	20
5.0	994	12.5	15
5.5	772	13.0	10
6.0	569	13.5	6
6.5	430	14.0	2
7.0	320	14.5	0

TABLE 5

SPECIAL BRIDGE PARAMETERS

Coefficient	Lower Bridge	Upper Bridge
Pier shape coefficient for use in Yarnell's energy equation	0.9	1.25
Total loss coefficient for use in orifice flow equation	1.6	1.8
Coefficient of discharge for use in weir flow equation	3.0	3.0

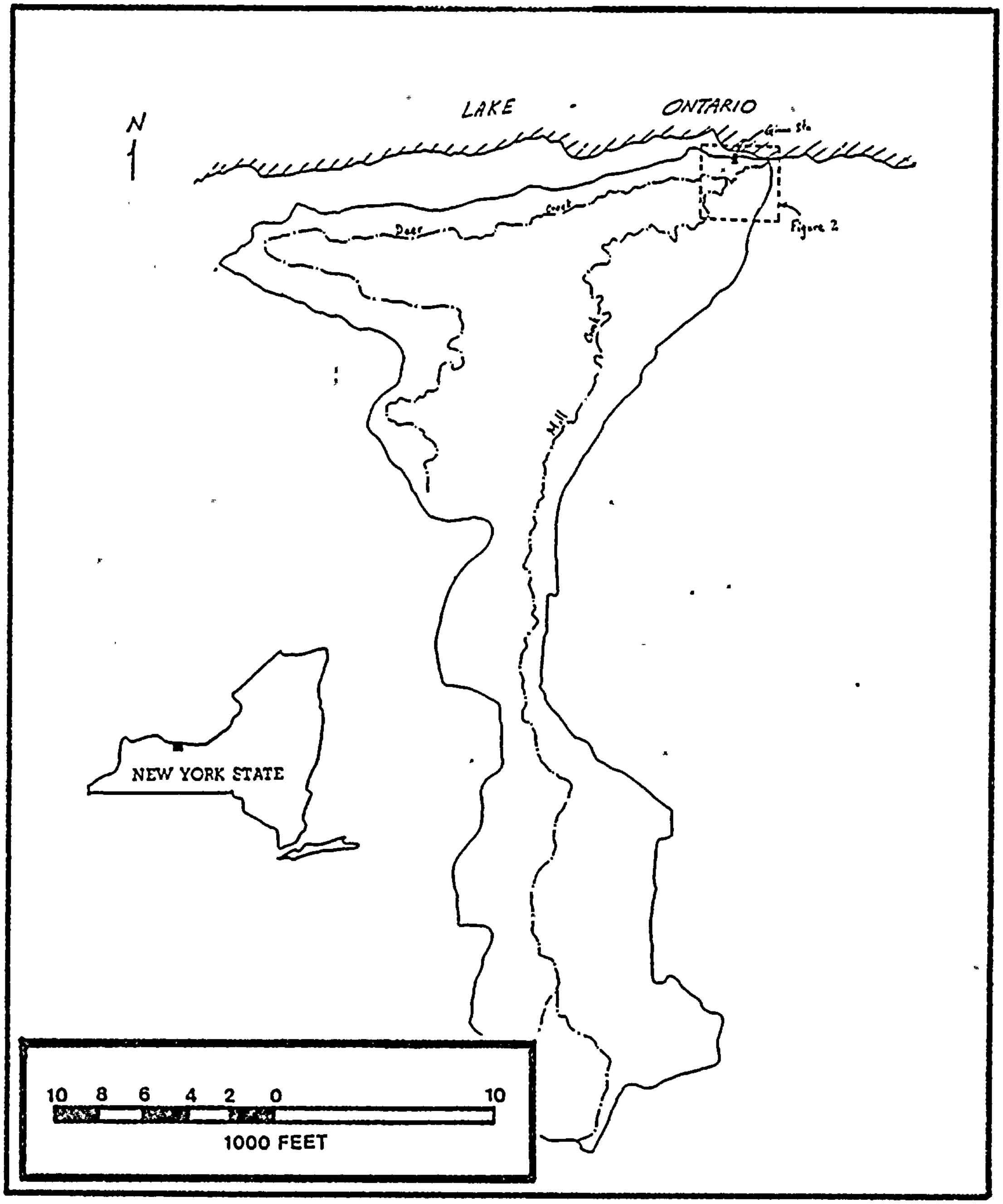


Figure 1 - Deer Creek Watershed Location Map
(Source: USGS Maps[1])

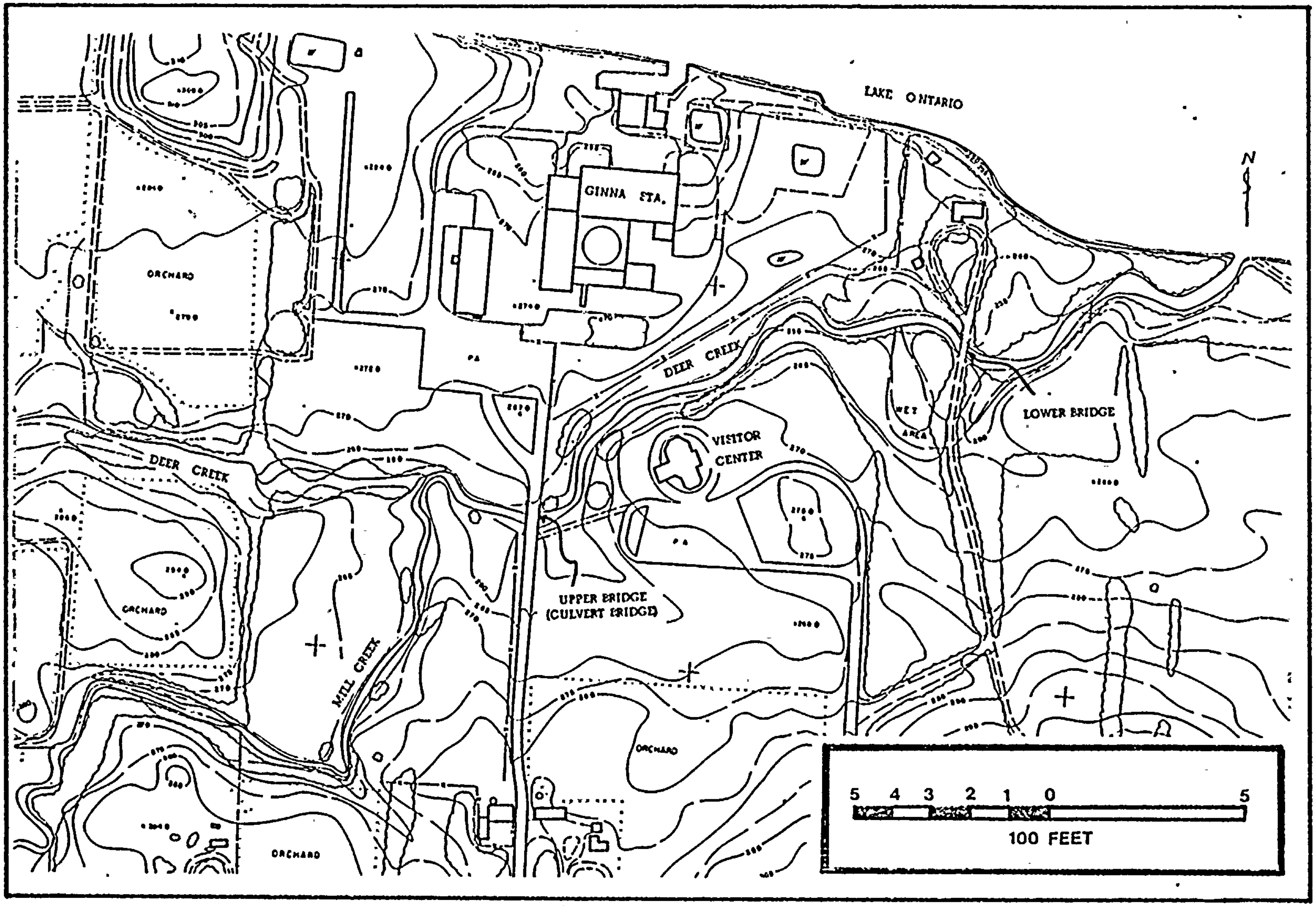


Figure 2 - Deer Creek Watershed near Ginna Station (Source: RG&E Drawing No. SK447-93)

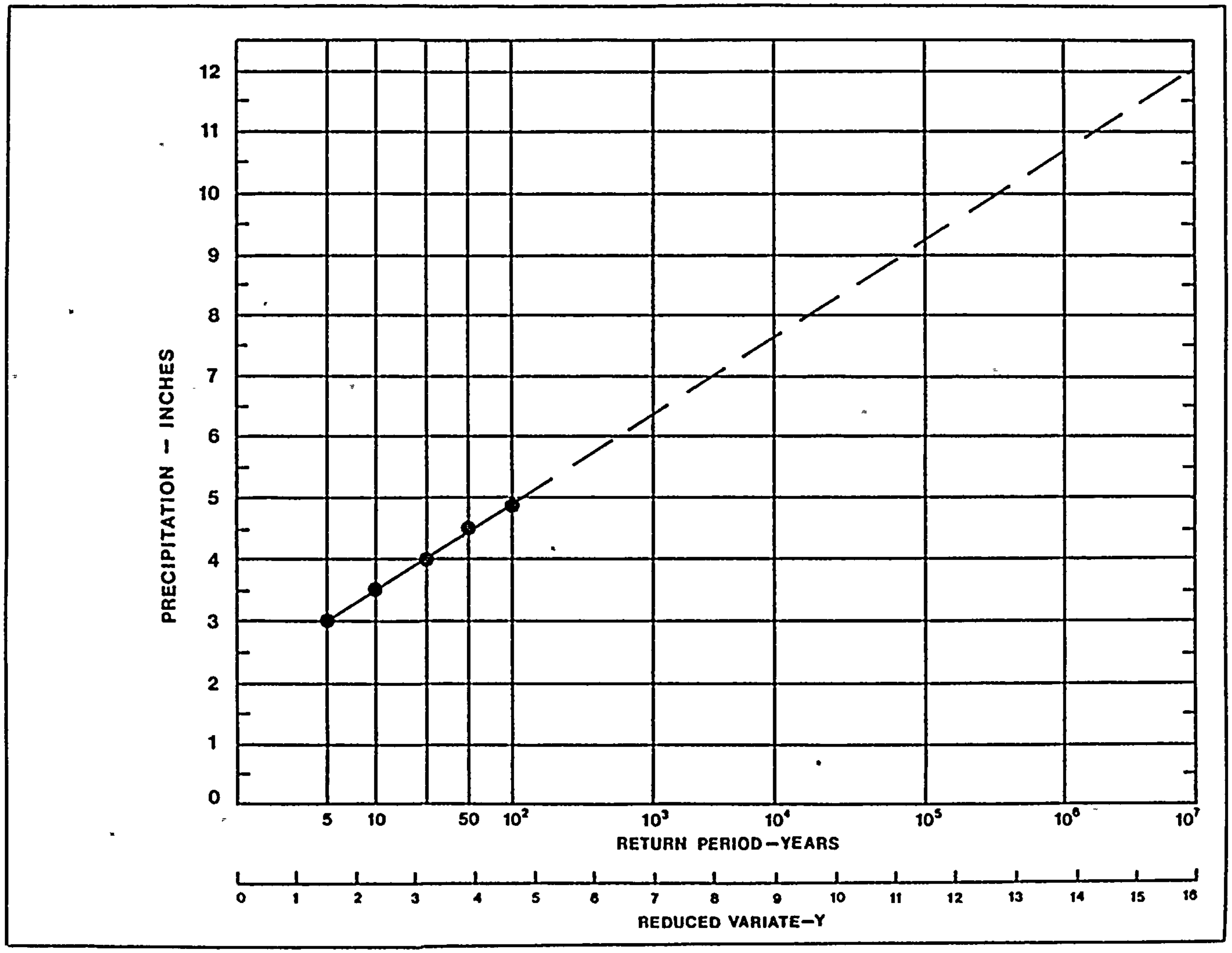


Figure 3 - Return Periods for 24-Hour Precipitations

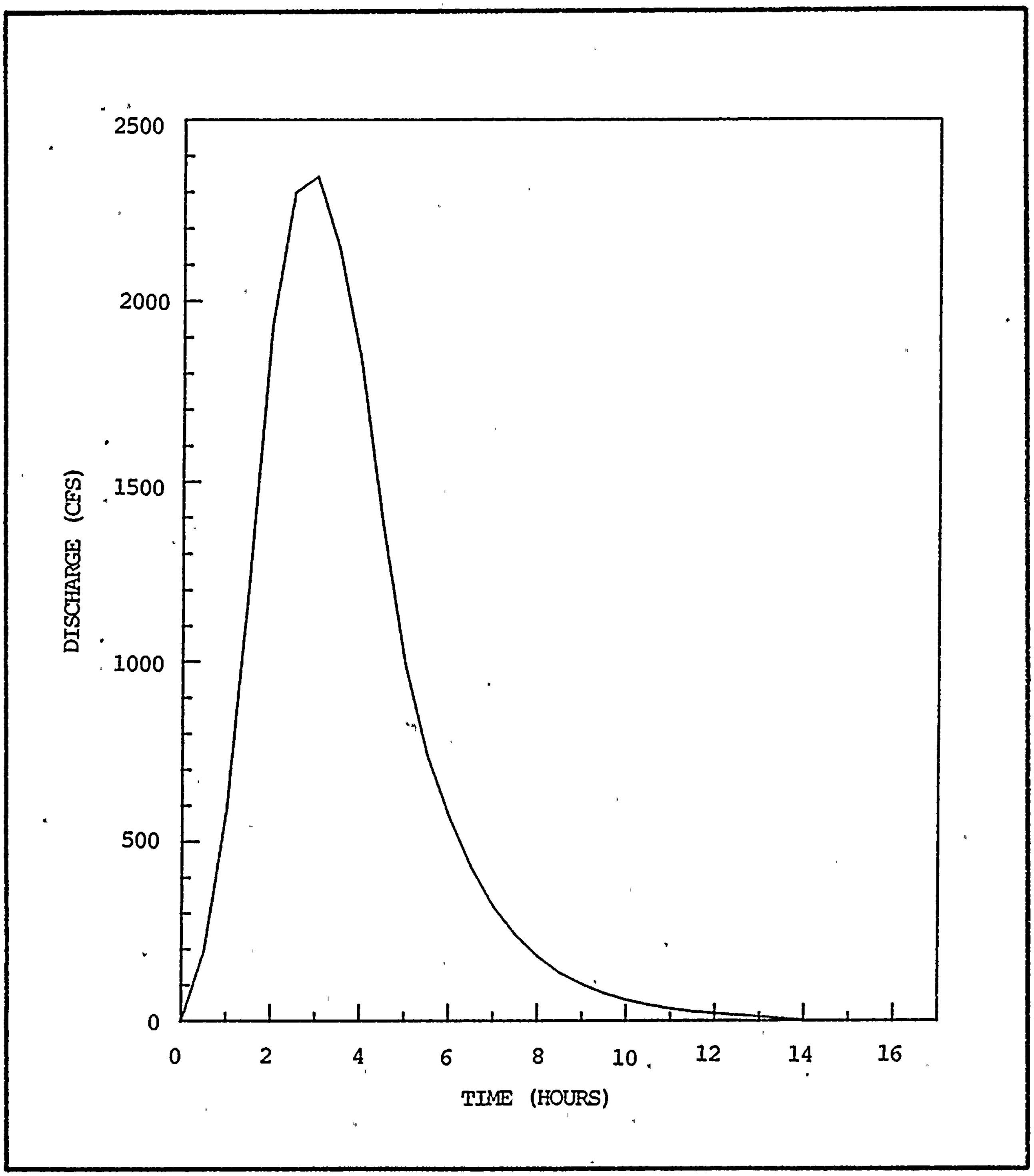


Figure 4 - Unit Hydrograph for Deer Creek (24 Hr., 1" Storm)

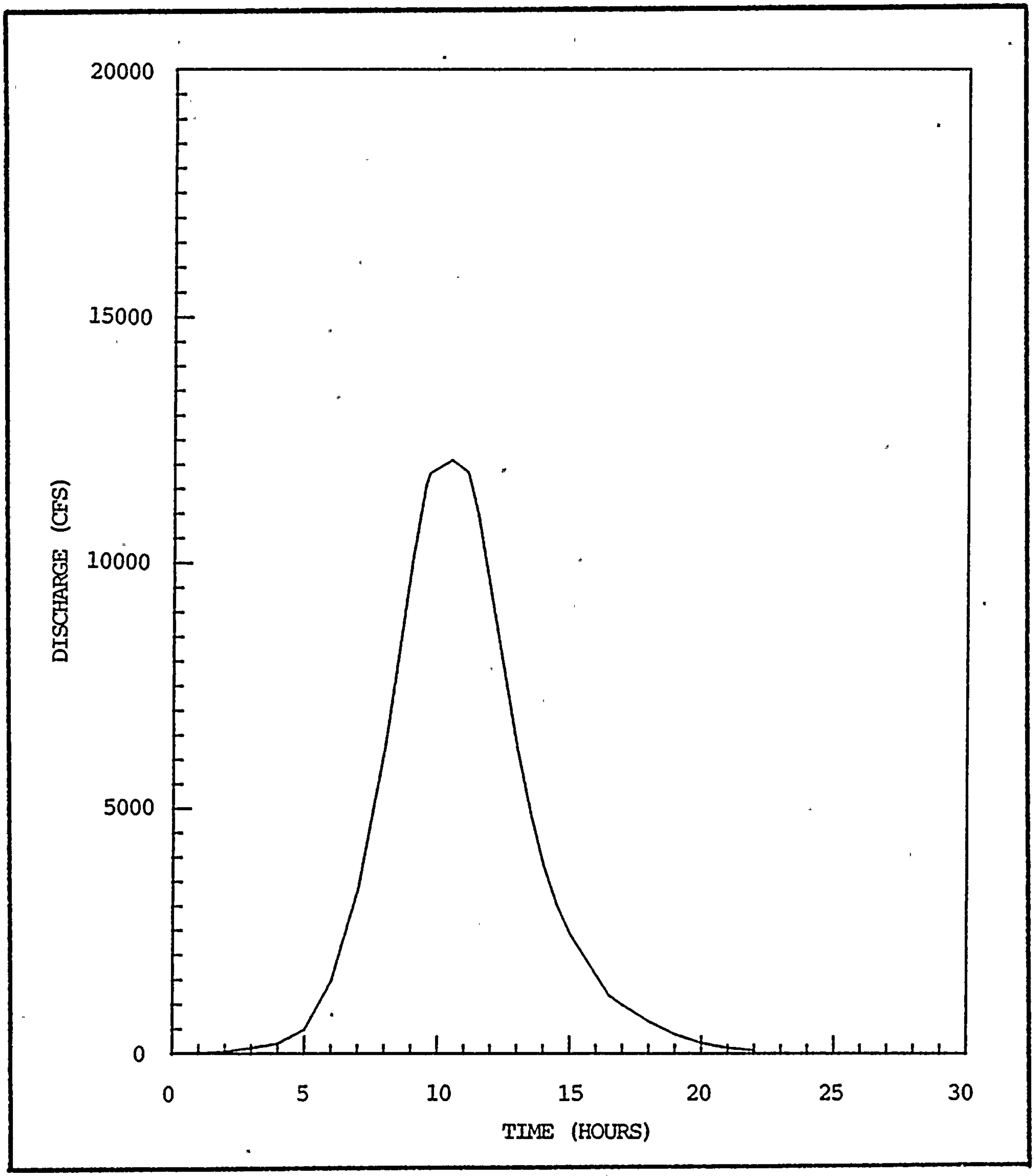


Figure 5 - Deer Creek Flood Hydrograph (24 Hr., 10" Storm)

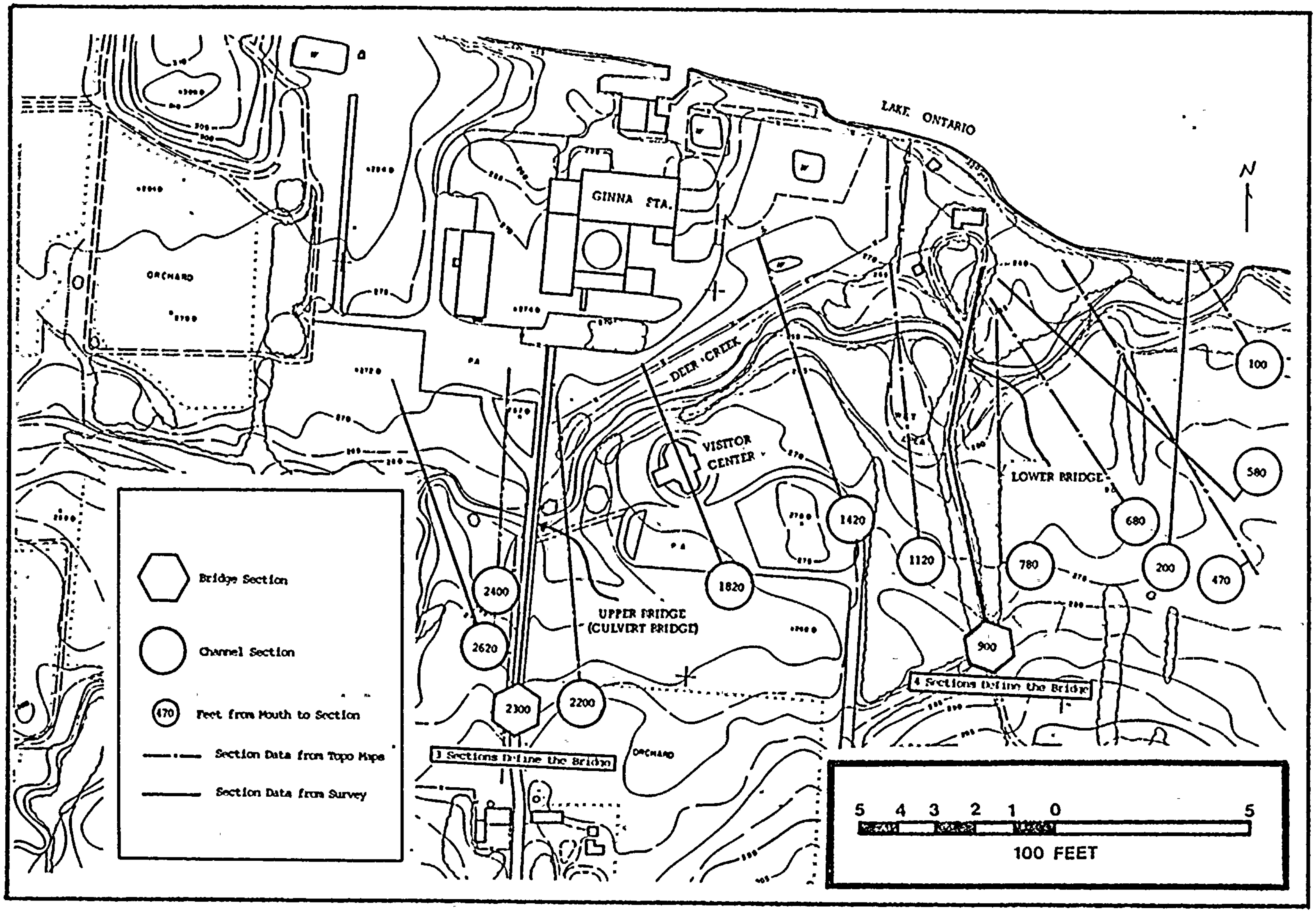


Figure 6 - Stream Cross Sections Location Map (Source: RG&E Drawing No. SK447-93)

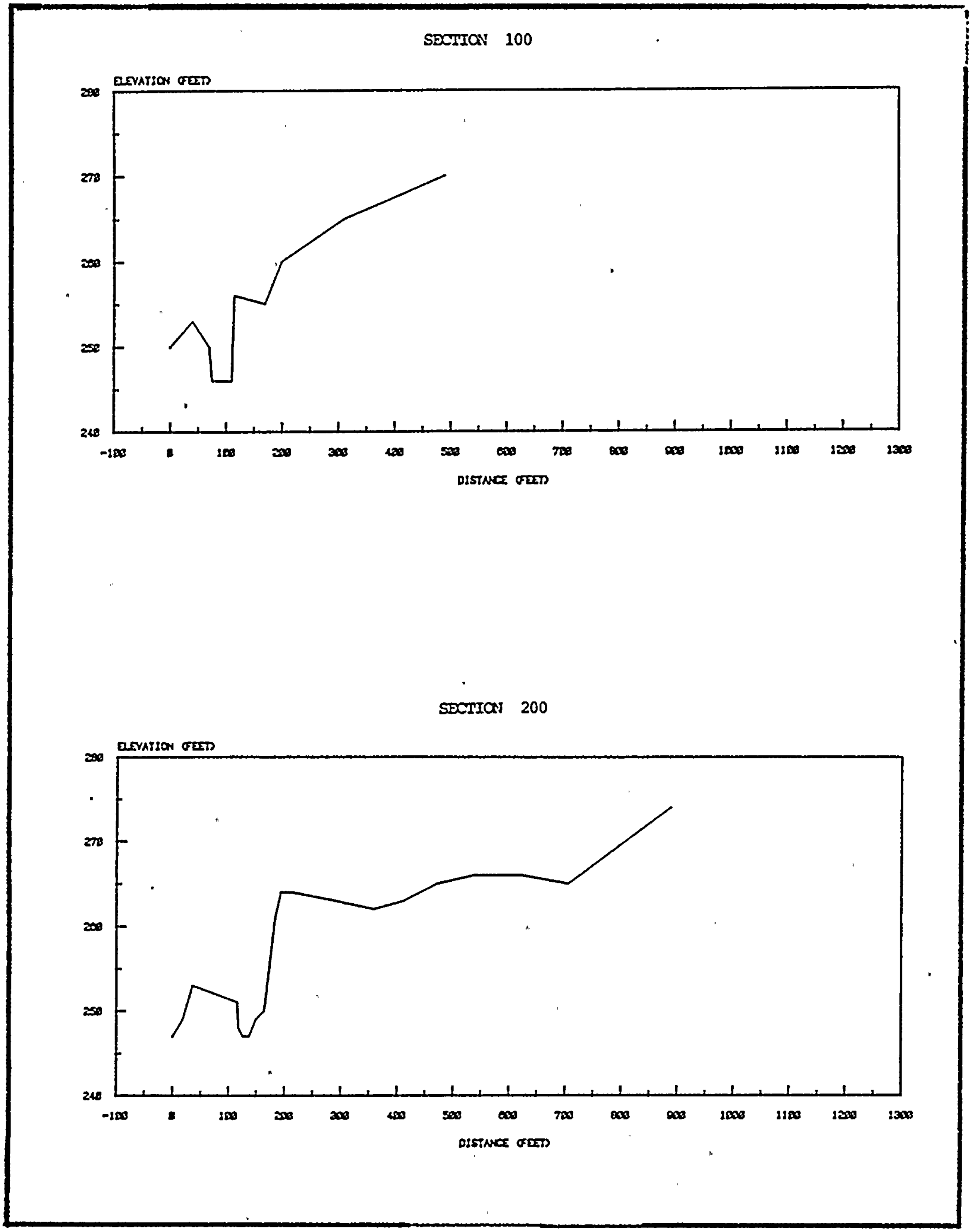
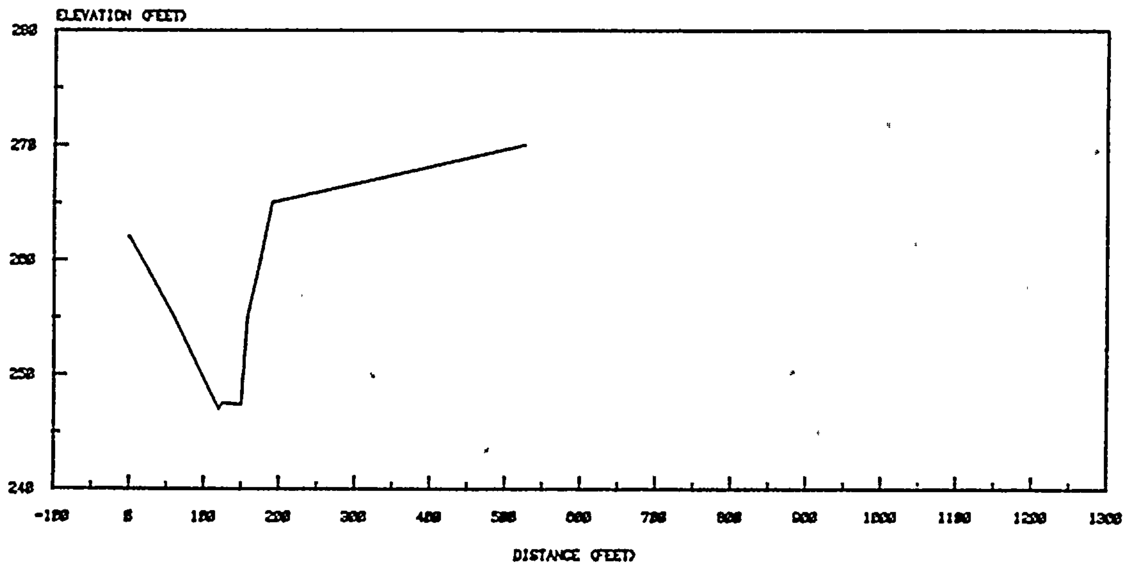


Figure 7 - Deer Creek Cross Section Data (Looking Downstream)

SECTION 470



SECTION 580

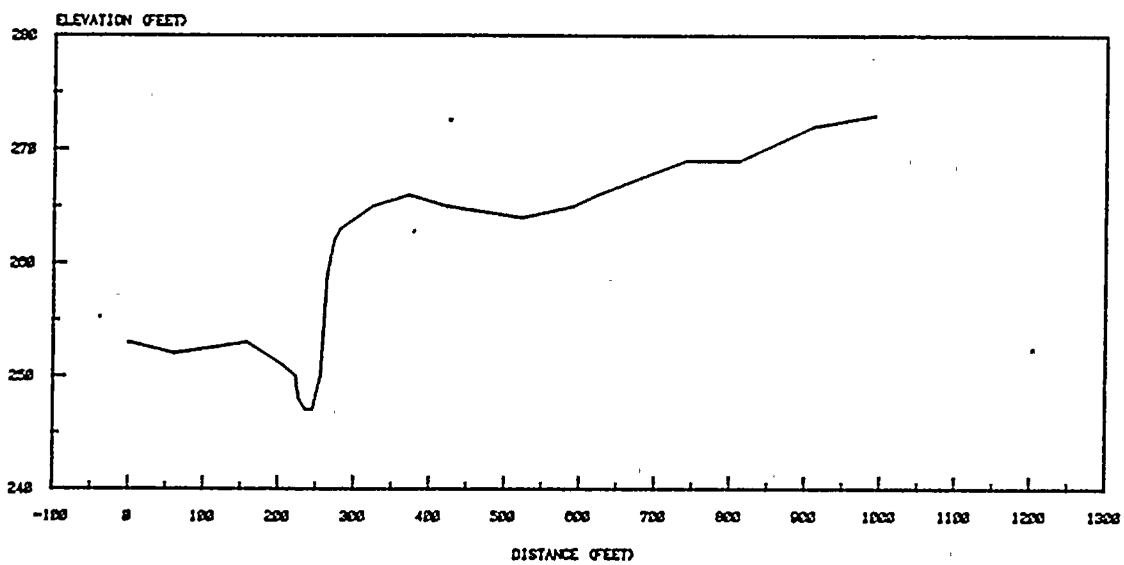


FIGURE 7 - Continued

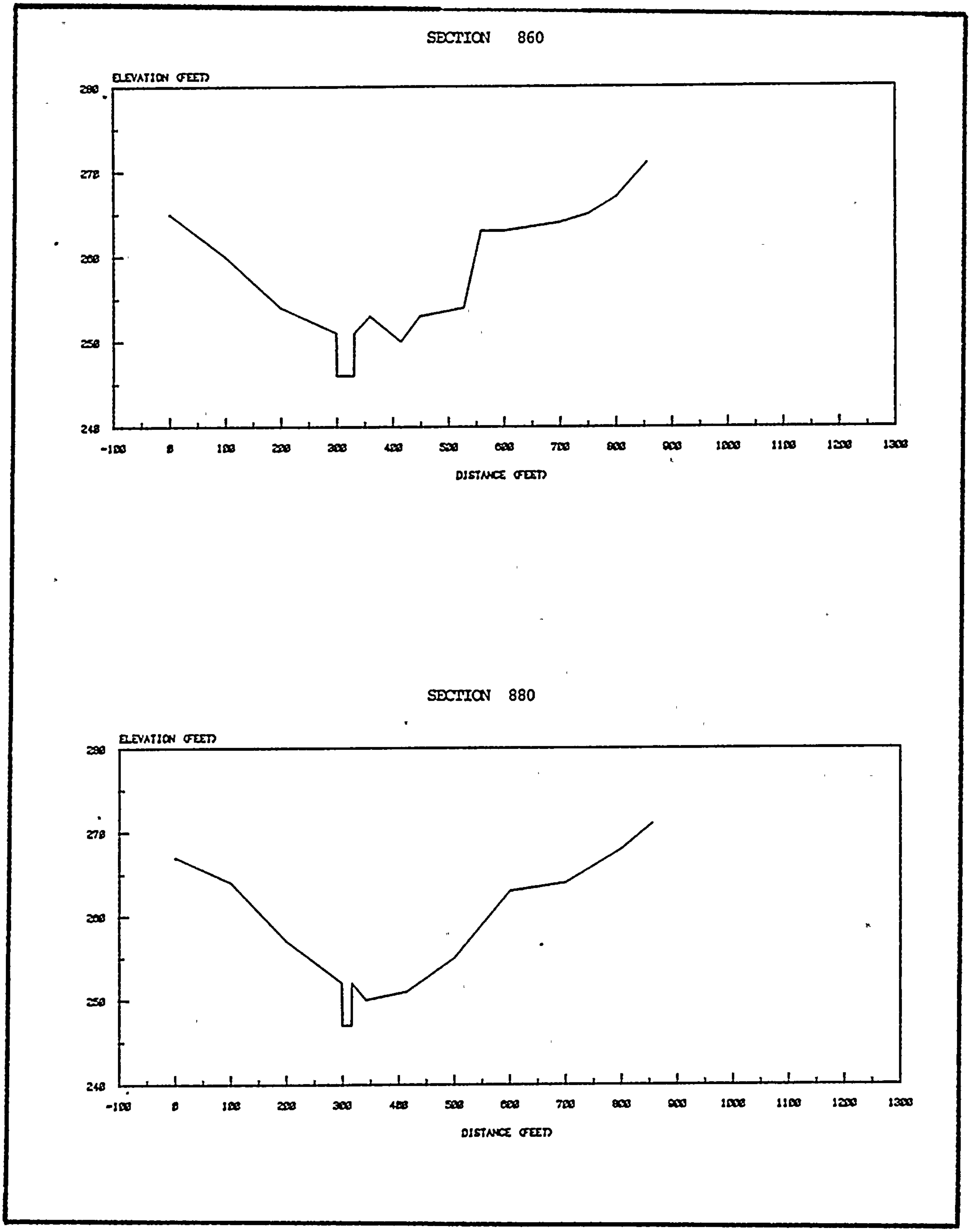
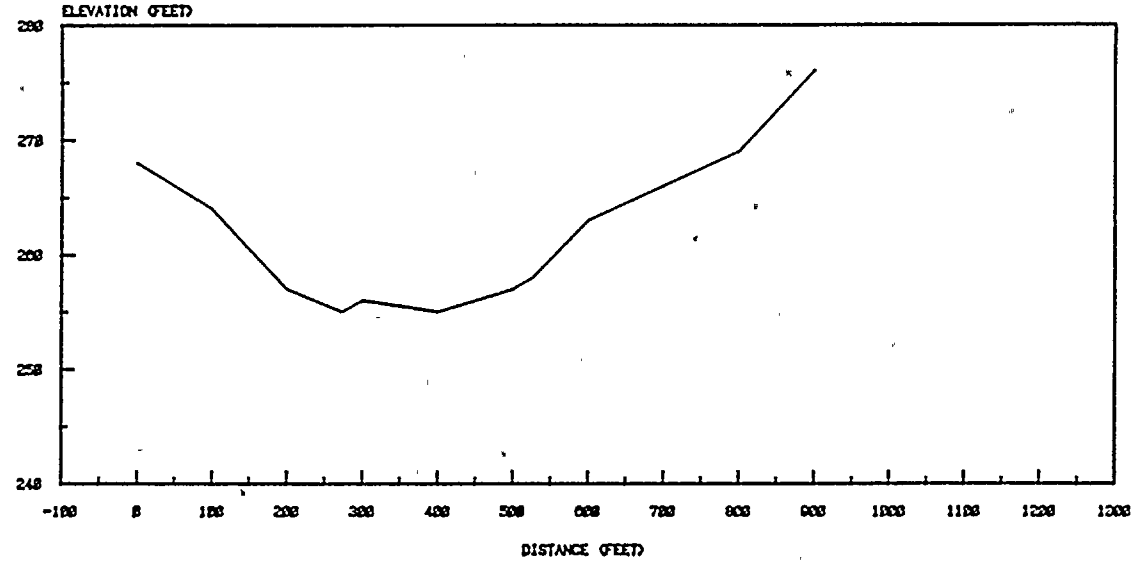


FIGURE 7 - Continued

SECTION 900



SECTION 920

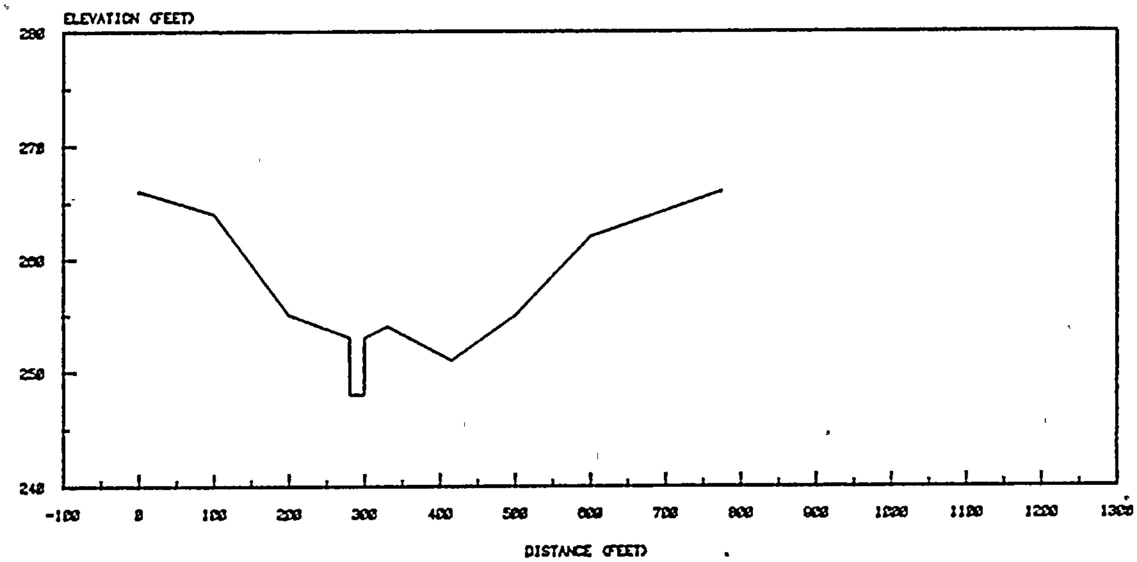
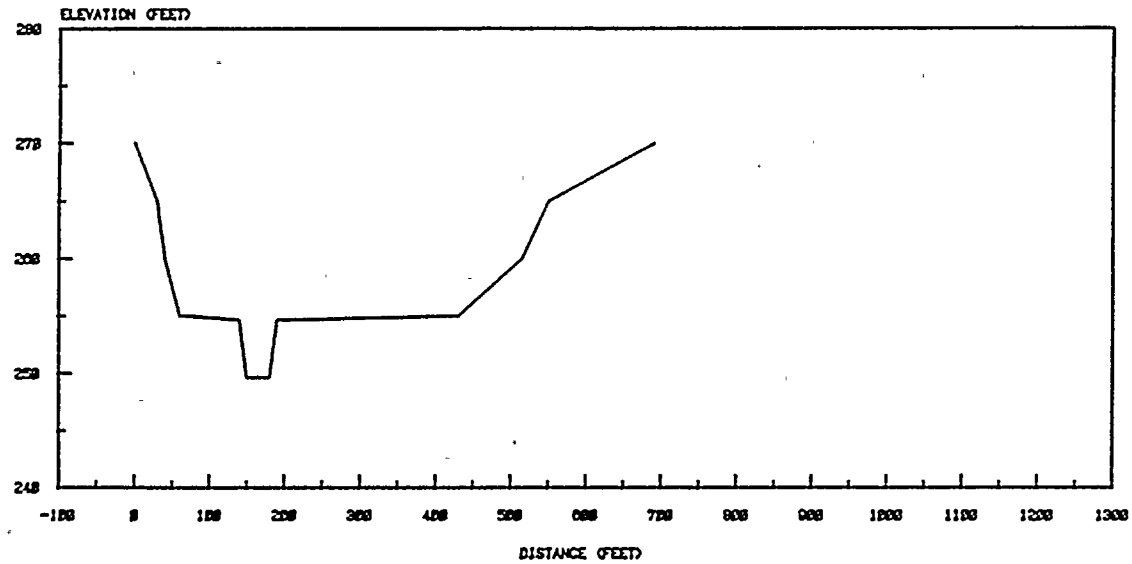


FIGURE 7 - Continued

SECTION 1120



SECTION 1420

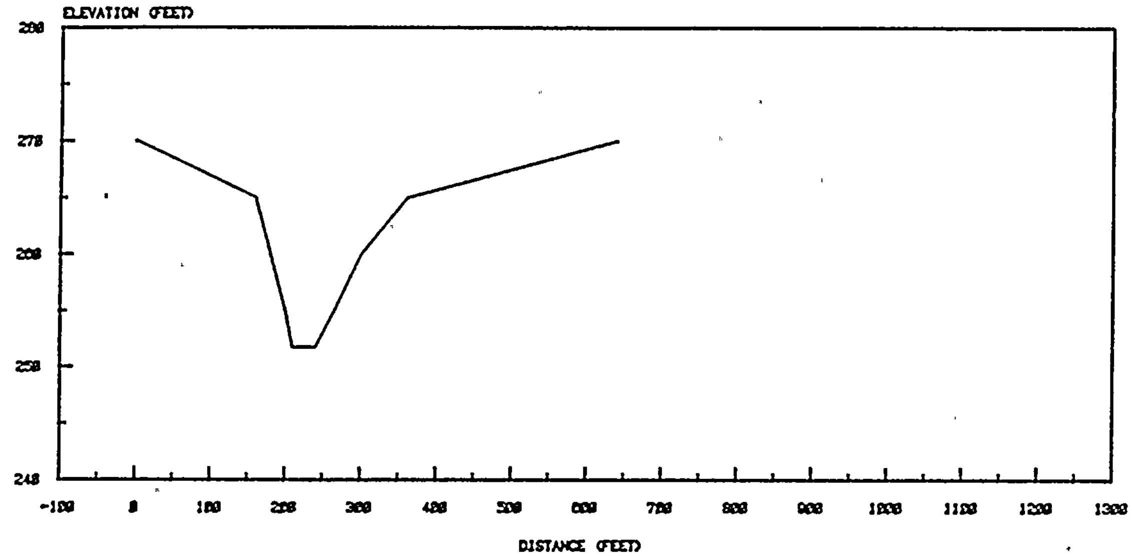
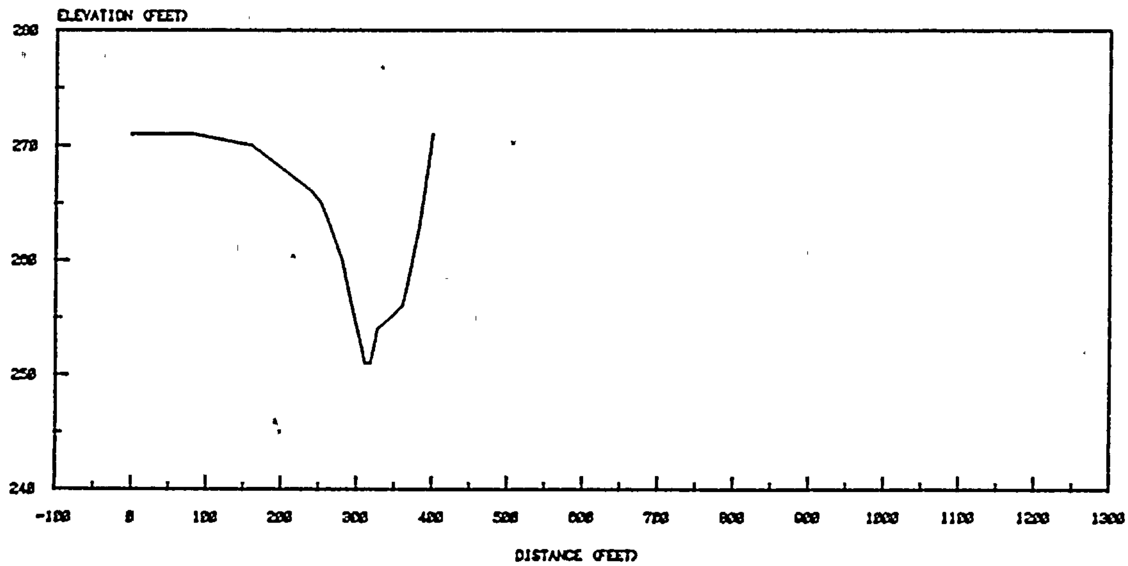


FIGURE 7 - Continued

SECTION 1820



SECTION 2280

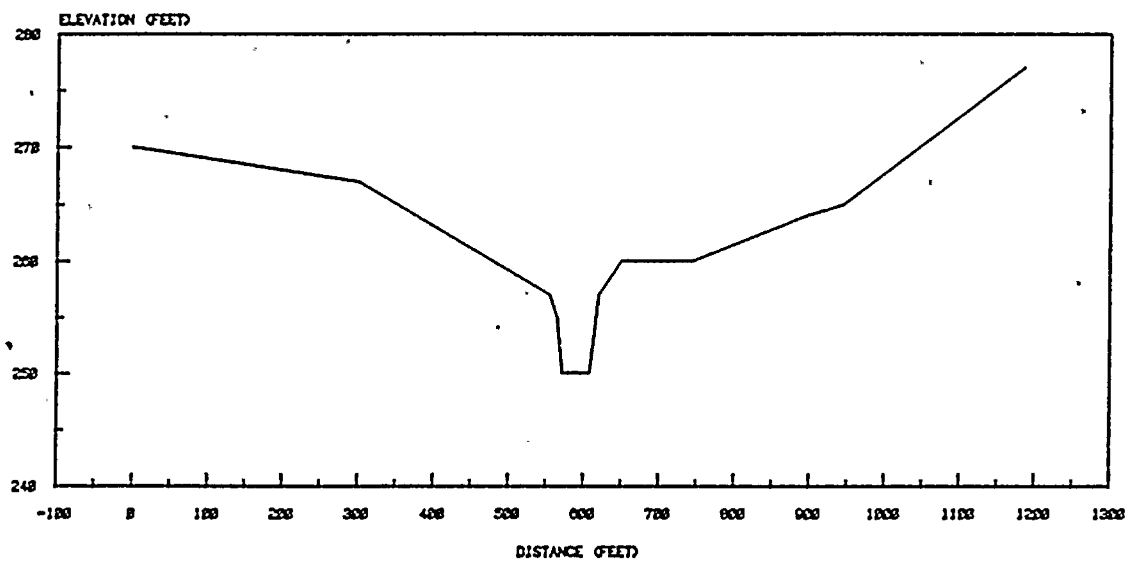


FIGURE 7 - Continued

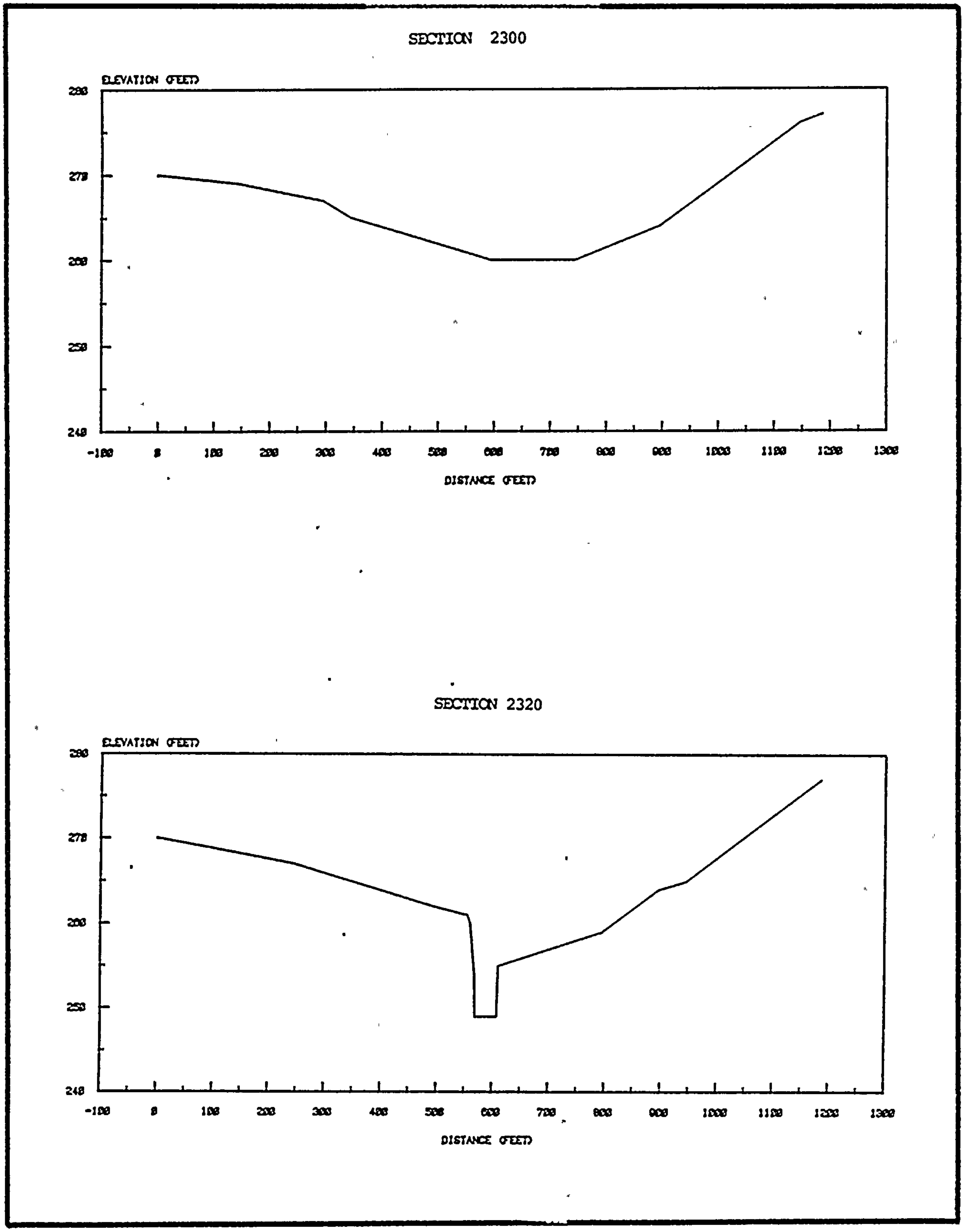


FIGURE 7 - Continued