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Hydrologic Characteristics of Alder Creek, Iron County, Wisconsin

By

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Alder Creek Hydrology

The purpose of this study was to determine the hydrologic characteristics of Alder Creek, Iron County, Wisconsin, which are needed by water-resource planners to evaluate a reservoir site proposed by the Whitecap Mountain Corporation on Alder Creek. The hydrologic characteristics estimated were the mean flows, low flows, flood peaks, suspended-sediment discharge, and depth to bedrock. Also included is an estimate of the time required to fill the proposed reservoir. The study was done in cooperation with the Wisconsin Department of Natural Resources.

Alder Creek is 13.3 miles (metric conversion, table 8) long and flows in a southwesterly direction from its headwaters near Montreal, Wis., to its confluence with the Potato River (fig. 1). The main channel slope is 11 feet per mile and was determined between points that are 10 and 85 percent of the distance along the channel from the proposed damsite to the basin divide. The elevation ranges from 1,820 feet on the north edge of the basin divide to 1,385 feet at the damsite. The drainage area upstream from the damsite is 21.4 square miles. Approximately 90 percent of the basin is wooded; vegetation on the valley floor consists of marsh grass and alders.

The mean monthly precipitation and mean monthly temper-

ature data recorded at the National Weather Service weather station at Gurney, Wis., are shown in figure 2. The climate is typical of northern Wisconsin, with mild summers and cold winters. The mean daily temperature is 41°F for 1953-72. July has the maximum mean monthly temperature, 67°F, and January has the minimum mean monthly, 12°F. The mean annual precipitation is 35.7 inches; the maximum mean monthly is 4.55 inches (July), and the minimum mean monthly is 1.27 inches (February). The mean annual snowfall for Alder Creek basin is about 100 inches, or approximately 8 inches of water equivalent.

A continuous-record stream-gaging station was installed on Alder Creek near Upson at State Highway 122 (fig. 1) on May 16, 1972, to provide streamflow information for this study. Before the station was installed, daily gage-height readings were taken during April 1 - May 15, 1972. The gaging station is 0.25 mile downstream from the proposed damsite (fig. 1), and the drainage area upstream from the gaging station is 22.3 square miles. Streamflow characteristics at the proposed reservoir site are similar to those determined for the gaging station because the drainage areas are approximately the same.

Geology

Alder Creek occupies an alluvium-filled valley underlain

by southwest-trending Tyler Slate and bounded on the northwest by volcanic rocks and on the southeast by the quartzite and iron formation of the Gogebic Range (Dutton and Bradley, 1970). All the bedrock has low permeability and limits the downward and lateral movement of water. Bedrock on the valley flanks is exposed or covered by thin alluvium.

The ground-water and surface-water divides seem to be similar and the system probably acts as a single basin. Although the proposed reservoir will cause a minor shift in the location of the ground-water divide, it should not significantly affect the quantity of ground water discharging to the stream.

The valley contains about 20 feet of unconsolidated silt, sand, and gravel (table 1). The most permeable sand and gravel beds, 5-10 feet thick, are in the deepest part of the valley and generally underlie the creek. About 10-15 feet of fine silt and sand overlies the sand and gravel. The thinness of the aquifer and the small areal extent, less than half a mile wide and about 10 miles long, indicate that a maximum of 1,000 acre-feet of water could be in storage. The relatively small amount of ground-water storage in the basin also is indicated by the low-flow characteristics of the stream.

The characteristics of the aquifer materials were deter-

mined from test holes drilled at five sites (fig. 3) along or close to the axis of the proposed dam. An additional hole was drilled upstream where County Trunk E crosses Alder Creek. A cross section along the proposed damsite showing lithology in test holes, water table, and bedrock surface is shown in figure 4.

Examination of the proposed dam site indicated no special geologic conditions, other than the permeable sand and gravel underlying the stream channel.

Mean flows

The daily mean and monthly mean discharges at the Alder Creek gaging station during April 1, 1972-March 31, 1973, are shown in table 2. The monthly mean discharges ranged from 156 ft^3/s (cubic feet per second) in April 1972 to 9.2 ft^3/s in September 1972. The maximum instantaneous discharge of 663 ft^3/s and maximum daily mean discharge of 605 ft^3/s occurred August 17, 1972. The minimum instantaneous discharge of 4.0 ft^3/s occurred September 16, 1972. The mean discharge for the period of record was 45 ft^3/s.

The monthly mean discharges from October 1962 to September 1971 (table 3) were estimated from a relationship based on concurrent discharge data for the gaging stations on Alder Creek near Upson and on the Bad River near Odanah (not shown on map). As illustrated in figure 5, the monthly mean dis-

charges for Alder Creek from April 1972 to March 1973 were considerably higher than the mean monthly discharges estimated for 1962-71. These higher discharges were caused by above normal precipitation (fig. 2) from June through August 1972 and November 1972 through March 1973. Above normal temperatures (fig. 2) caused snowmelt and resulted in higher runoff from January through March 1973. The same discharge pattern also is shown on figure 5 for the discharges recorded at the Bad River near Odanah gaging station. The monthly discharges recorded at the Bad River gaging station during 1962-71 are shown in table 4.

Low flow

The low-flow characteristics determined in this study are the annual minimum 7-day mean flow that occurs on the average of once in 2 years ($Q_{7,2}$), and the annual minimum 7-day mean flow that occurs on the average of once in 10 years ($Q_{7,10}$). The values determined for Alder Creek are 0.85 ft^3/s for the $Q_{7,2}$ and 0.35 ft^3/s for the $Q_{7,10}$. These 7-day low-flow discharges are based on a relationship between base-flow discharges recorded at the Alder Creek and Bad River near Odanah gaging stations.

A gain and loss study of Alder Creek October 18, 1972, indicated no appreciable gaining or losing reaches. The measured discharges and water temperatures are shown in table 5; the measuring sites are shown in figure 1. The fairly

uniform gain in base flow and the well logs indicate that the major water-yielding deposits contributing to base flow, mainly the unconsolidated material, are relatively uniform in composition along the length of the stream.

Flood peaks

The 100-year and probable maximum flood (PMF) peaks were determined for Alder Creek to aid water-resource planners in selecting or evaluating the design flood for the proposed dam.

100-year flood.--A 100-year flood peak of 3,000 ft^3/s was estimated for Alder Creek at the damsite. The 100-year flood peak was estimated by a graphical correlation of recorded flood peaks at the Alder Creek and Bad River near Odanah (not shown on map) gaging stations.

The 100-year flood peak for Alder Creek, 3,000 ft^3/s, was plotted along with the 100-year flood peaks for other gaging stations in the Lake Superior basin near the damsite (fig. 6). The 100-year flood peak for Alder Creek is comparable to 100-year flood peaks for most gaging stations in the area, and it plots below an envelope curve.

Probable maximum flood.--The probable maximum flood is defined by Chow (1964, p. 25-26) as the most severe flood considered reasonably possible in a region. It is commonly used as the design flood for a dam, when failure could result in great damage or loss of life. Procedures described by the U.S. Bureau of Reclamation (1960, p. 23) were used to

compute the PMF for Alder Creek at the damsite.

A probable maximum precipitation of 21 inches in 6 hours (U.S. Bureau of Reclamation, 1960, pp. 29 and 30) would cause the PMF in the Alder Creek basin. Rainfall data were arranged in critical increments to produce the largest peak and were distributed into hourly values not exceeding those indicated by the regional depth-duration curves (U.S. Bureau of Reclamation, 1960, p. 32). An infiltration rate of 0.63 inch per hour, obtained from soil properties listed by the U.S. Soil Conservation Service (1969), was subtracted from the hourly increments.

The PMF at the damsite of the proposed reservoir had a peak of 41,000 ft^3/s and a 24-hour volume of 19,700 acre-feet (fig. 7). This flood is an inflow flood to the reservoir and includes the effect of the reservoir. A full reservoir reduces the time of concentration of storm runoff, which results in a higher peak discharge than under pre-impoundment conditions.

The PMF values were computed by the unit-hydrograph method. The unit hydrograph (fig. 8) was computed from recorded flood data at the gaging station on Alder Creek near Upson.

The probable maximum flood for Alder Creek at the damsite is shown on figure 9.

Filling of reservoir

Four potential pool elevations were used to calculate the time needed to fill the reservoir. The planned elevation of the proposed reservoir was not known, therefore, potential elevations were selected to bracket possible pool elevations. The estimated filling times ranged from 18 months for an elevation of 1,410 feet to 76 months for an elevation of 1,430 feet. The estimated filling times and the corresponding reservoir elevations and capacities are listed in table 6. These filling times do not include seepage losses under the dam or through abutments. Seepage losses from the reservoir will occur under the dam in the permeable sand and gravel deposits unless preventive measures are taken.

The filling times were estimated using the mean monthly discharge of the stream for 1962-71; it was assumed that the reservoir would be empty at the beginning of October. A required minimum release from the reservoir of 25 percent of the natural low flow ($Q_{7,2}$), 0.21 ft^3/s, was used in the computation, with an annual evaporation loss of 25 inches (U.S. Weather Bureau, 1959).

Suspended-sediment discharge

Instantaneous suspended-sediment discharges were measured at the Alder Creek gaging station during the investigation.

These measurements and corresponding water discharges are listed in table 7. Using these data and a duration curve of water discharge for Alder Creek (Johnson, 1971, p. 4-8), 230 tons per year of suspended sediment were estimated as inflow to the reservoir with a pool elevation of 1,422 feet. A trap efficiency of 98 percent was determined (Chow, 1964, p. 21-22). At this efficiency, sediment deposition was estimated to be 220 tons per year (0.13 acre-foot per year).

References

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U.S. Bureau of Reclamation, 1960, Design of small dams, Chapter II: Washington, U.S. Govt. Printing Office, p.21-57.

U.S. Soil Conservation Service, 1969, Wisconsin soils, their properties and uses: U.S. Dept. Agr. interim rept., 216 p.

U.S. Weather Bureau, 1959, Evaporation maps for the United States: U.S. Weather Bur. Tech. Paper 37, 13 p.

Table 1.--Test hole data

Well Number	Elevation of top of casing, in feet above mean sea level	Land surface elevation, in feet above mean sea level	Water level elevation, May 23, 1973, in feet above mean sea level	Test hole log
Ir-105	1390.54	1387	1383.98	0-5 ft - medium-fine red sand, some organics 5-10 ft - clean, red, medium-fine sand 10-15 ft - clean, red medium sand, some fine gravel at 15 ft no penetration, probable bedrock
Ir-106	1386.84	1386	1385.94	0-10 ft - fine and very fine red sand, much silt 10-15 ft - medium-fine clean sand 15-18 ft - medium clean red sand and fine-medium gravel at 18 ft no penetration, probable bedrock
Ir-107	1436.15	1436	1435.63	0-5 ft - very fine red sand and silt, much fine-medium gravel 5-10 ft - fine red sand, silt and fine gravel at 10 ft no penetration, probable bedrock
Ir-108	--	--	--	0-4 ft - fill dirt 4-6 ft - blue-green clay 6-10 ft - fine-medium red sand 10-15 ft - medium-coarse red sand, some fine gravel 15-22 ft - coarse red sand, some medium sand, and fine gravel at 22 ft no penetration, probable bedrock

Table 1.--Test hole data (cont.)

Well Number	Elevation of top of casing, in feet above mean sea level	Land surface elevation, in feet above mean sea level	Water level elevation, May 23, 1973, in feet above mean sea level	Test hole log
Ir-109	1423.95	1423	1416.15	0-5 ft - very fine red sand and silt 5-8 ft - fine-very fine red sand, at 8 ft no penetration, probable bedrock
Ir-110	1406.18	1406	1397.83	0-5 ft - very fine red sand and silt, much fine-medium gravel 5-8 ft - fine-medium red sand and much coarse gravel at 8 ft no penetration, probable bedrock

Form 9-239B
(Mar. 1970)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Station Number .....

DAILY COMPUTATION FORM

Table 2.--Daily mean and monthly mean discharges at Alder Creek gaging station.

DAY	April 1972	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 1973	Feb.	Mar.
1	25	222	26	39	13	7.2	15	8.9	12	14	14	10
2	25	205	15	20	10	6.2	13	38	12	14	13	11
3	25	148	11	13	9.3	5.3	19	137	11	15	13	11
4	25	98	8.4	12	8.2	4.6	33	124	10	15	13	12
5	25	69	7.8	9.8	6.9	4.4	39	76	10	16	13	14
6	25	70	7.8	6.7	6.7	5.1	35	58	10	16	12	19
7	26	74	7.1	7.8	6.3	6.7	29	71	10	16	12	26
8	27	86	6.3	6.7	8.4	6.7	23	125	9.9	16	12	35
9	31	44	5.5	6.5	9.8	6.2	18	119	9.8	15	12	50
10	35	30	5.1	6.3	9.3	5.3	14	84	9.7	14	12	71
11	40	24	4.8	5.7	12	4.8	13	64	9.4	14	11	93
12	50	16	4.8	5.5	13	4.4	14	59	9.1	14	11	111
13	67	17	5.3	5.1	11	4.8	13	46	9.0	13	11	148
14	75	18	19	5.1	9.1	4.8	11	37	9.1	13	11	207
15	88	18	22	4.9	8.4	4.4	9.7	31	8.9	13	11	260
16	117	16	16	4.5	155	5.3	9.1	32	8.7	12	11	288
17	102	15	11	4.8	605	6.2	8.6	28	8.6	13	10	238
18	276	14	8.6	7.8	324	5.8	8.0	22	8.4	14	10	170
19	420	12	14	8.2	137	6.0	7.5	23	8.4	17	10	115
20	458	11	174	14	64	12	7.5	21	8.2	19	10	74
21	430	11	245	33	44	14	11	18	8.2	19	10	61
22	237	12	136	136	42	10	16	17	8.5	19	9.9	50
23	237	10	58	268	41	8.6	16	16	8.8	18	9.8	48
24	158	9.1	24	202	38	9.1	14	15	8.8	18	9.8	57
25	124	8.0	15	98	33	17	13	15	8.8	17	9.8	83
26	154	7.1	11	44	26	21	12	15	8.8	16	9.8	141
27	243	6.5	12	24	21	21	12	16	8.7	16	9.8	189
28	377	7.5	28	19	15	20	11	15	9.5	15	10	221
29	422	9.6	53	21	12	24	10	14	9.8	15		254
30	340	34	63	21	9.4	16	9.7	12	11	14		207
31		41		17	7.7		9.1		13	14		156
Total	4684	1363	1024	1076	1716	277	473	1357	296	474	311	3428
Mean	156	44.0	34.1	34.7	55.4	9.2	15.3	45.2	9.6	15.3	11.1	111

Maximum instantaneous discharge, 663 ft^3/s on Aug. 17, 1972; minimum instantaneous discharge, 4.0 ft^3/s on Sept. 16, 1972.

U.S. GOVERNMENT PRINTING OFFICE 16—72702-4

9-220c
(Oct. 1951)

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Sheet _____ _____ Sheets

Table 3.--Estimated mean

Monthly and annual discharge, in cubic feet per second, of Alder Creek ~~River~~ near Upson, Wis.
[Drainage area, 22.3 square miles]

16—26489-6 U.S. GOVERNMENT PRINTING OFFICE

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual	
1962	11	16	7.0	4.7	4.3	7.5	56	69	18	5.8	4.8	24	19	
1963	13	16	10	3.8	3.8	22	59	39	12	3.8	3.9	3.8	16	
1964	4.0	9.6	6.1	3.8	2.5	7.3	112	91	8.7	2.8	3.6	12	22	
1965	11	13	7.5	5.9	4.5	6.8	126	76	15	7.7	8.0	17	25	
1966	22	12	24	14	14	74	87	28	15	6.6	21	7.0	27	
1967	26	18	9.3	8.2	7.4	11	122	27	64	14	10	5.3	27	
1968	13	18	6.6	3.6	4.2	32	69	72	42	20	7.3	14	25	
1969	32	23	23	15	13	14	142	25	14	12	5.4	6.6	27	
1970	22	20	8.5	6.9	5.8	11	60	52	15	4.1	2.6	4.6	18	
1971	15	31	18	8.4	9.0	27	170	38	11	9.0	6.1	6.7	29	
Total	169	176.6	120	74.3	68.5	212.6	1003	517	214.7	85.8	72.7	101	235	
Avg.	17	18	12	7.4	6.8	21	100	52	21	8.6	7.3	10	23	
1972							156	44	34	35	55	9.2		
1973	15	45	9.6	15	11	111							45 (Apr. 1972 - Mar. 1973)	

9-220c
(Oct. 1951)

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Table 4.--Mean

Monthly and annual discharge, in cubic feet per second, of Bad River near Odanah, Wis.
[Drainage area, 611 square miles]

16—26489-6 U.S. GOVERNMENT PRINTING OFFICE

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1962	298	411	186	128	116	199	1350	1661	448	152	129	595	473
1963	346	399	260	105	103	545	1413	950	304	101	107	103	395
1964	109	253	163	103	69.3	192	2616	2171	230	77.9	100	315	532
1965	285	361	199	158	122	180	2958	1805	381	204	209	442	608
1966	549	322	594	370	365	1761	2063	692	398	175	539	187	670
1967	651	447	243	217	197	289	2846	668	1549	350	262	143	653
1968	337	466	177	99.9	114	794	1663	1720	1023	497	193	361	620
1969	793	569	578	381	334	357	3332	630	367	307	147	178	662
1970	556	511	222	181	157	288	1438	1274	389	111	72.2	126	444
1971	384	762	471	220	239	689	3947	939	276	235	162	179	706
51													
Total	4308	4501	3093	1962.9	1816.3	5294	23626	12510	5365	2209.9	1920.2	2629	5763
Avg.	431	450	309	196	182	529	2363	1251	536	221	192	263	576
1972							2395	1096	606	1258	1546	403	
1973	552	918	240	294	284	2550							1010 (Apr. 1972-Mar. 1973)

Table 5.--Discharge and water temperature of Alder Creek during gain and loss study of October 18, 1972

Measuring site	Location	Discharge (ft^3/s)	Water temperature (°F)	Water temperature (°C)	River mile, measured upstream from mouth
1	Upstream from proposed reservoir at railroad bridge near Pence	0.16	33	1	11.9
2	At county road	1.46	33	1	9.5
3	Tributary at mouth near Iron Belt	.79	34	1	-
4	Downstream from Alder Creek tributary	4.62	36	2	5.8
5	At County Trunk Highway E	5.91	37	3	2.7
6	Tributary downstream from damsite at trail crossing	.37	35	2	-
7	At gaging station near Upson at State Highway 122	7.48	36	2	0.4

Table 6.--Reservoir capacity and filling time for several pool elevations

Reservoir elevation	Capacity (acre-feet)	Filling time (months)
1,410	19,400	18
1,415	26,200	25
1,422	38,400	42
1,430	66,400	76

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Table 7.--Suspended-sediment discharge at Alder Creek gaging station

Date	Instantaneous water discharge (ft^3/s)	Instantaneous suspended-sediment discharge (tons per day)
May 15, 1972	22	0.12
July 7, 1972	7.5	.08
Aug. 16, 1972	270	8.75
Aug. 16, 1972	322	13.0
Aug. 17, 1972	659	24.9
Aug. 17, 1972	650	10.9
Sept. 19, 1972	5.3	.01
Nov. 1, 1972	8.9	.05
Nov. 8, 1972	140	1.13
Jan. 11, 1973	14	.15
Jan. 30, 1973	14	.02

6/18/73

Table 8.--Factors for converting English units to International System (SI) units

Multiply English units	By	To obtain SI units
	Length	
inches (in)	.0254	meters (m)
feet (ft)	.3048	meters (m)
miles (mi)	1.609	kilometers (km)
	Area	
square miles (mi^2)	2.590	square kilometers (km^2)
	Volume	
acre-feet (acre-ft)	1233	cubic meters (m^3)
	Flow	
cubic feet per second (ft^3/s)	28.32	liters per second (l/s)
	.02832	cubic meters per second (m^3/s)
	Mass	
ton (short)	.9072	tonne (t)

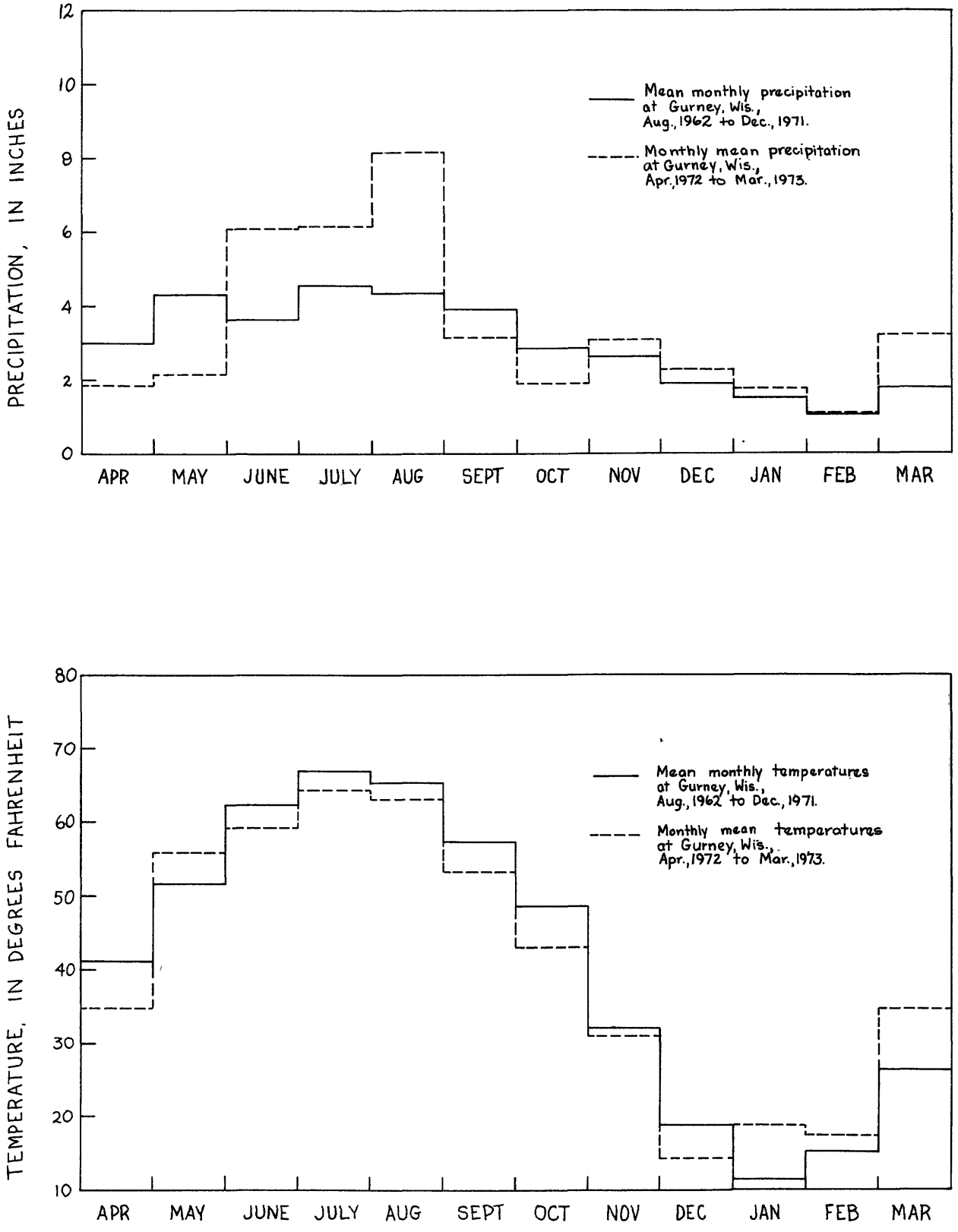
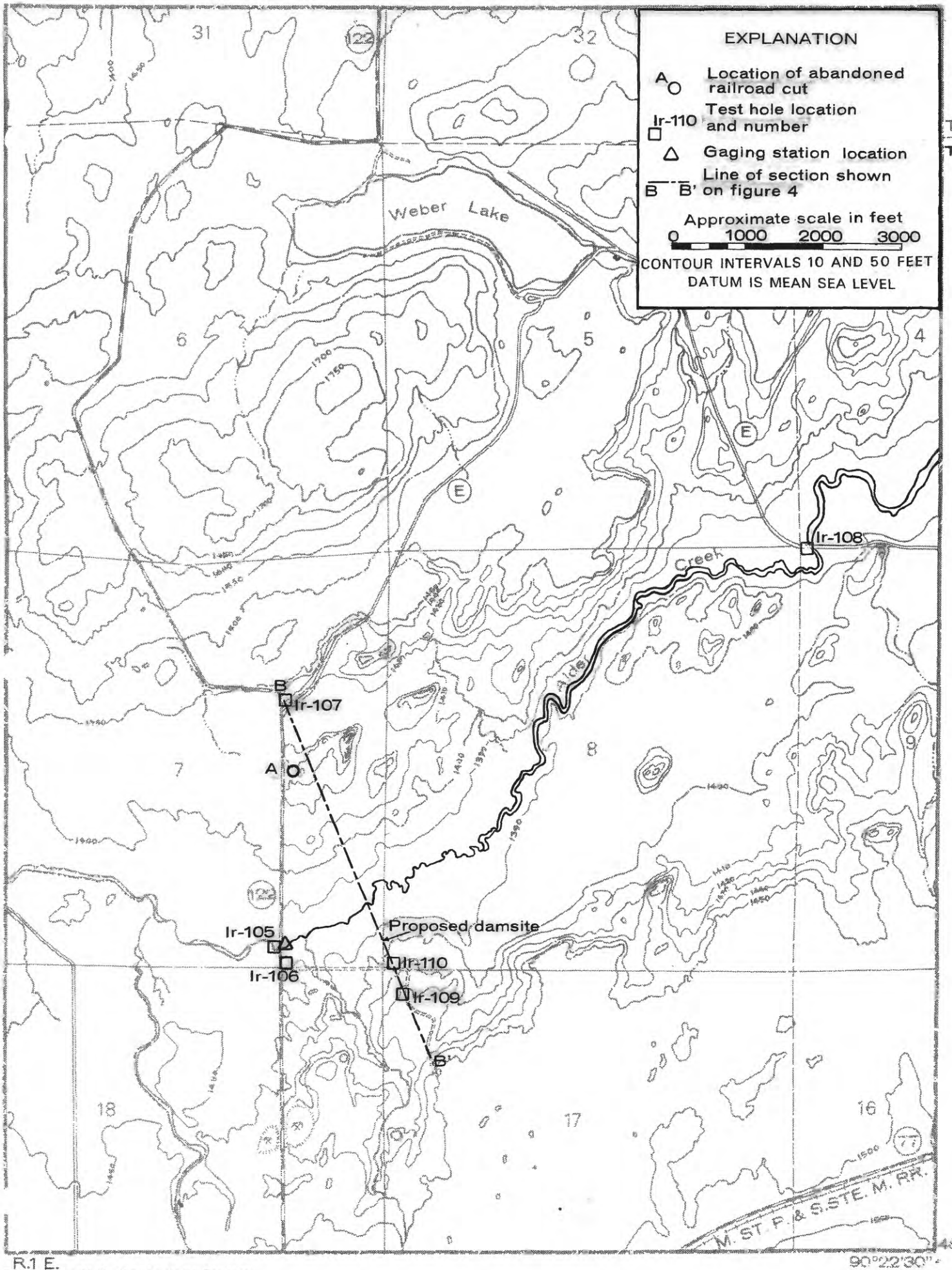


FIGURE 2 .-- Monthly precipitation and temperature data at Gurney, Wis. for the periods from August, 1962 to December, 1971 and April, 1972 to March, 1973.



Base from U.S. Geological Survey
Saxon, 1956

Figure 3.--Proposed damsite and test hole locations.

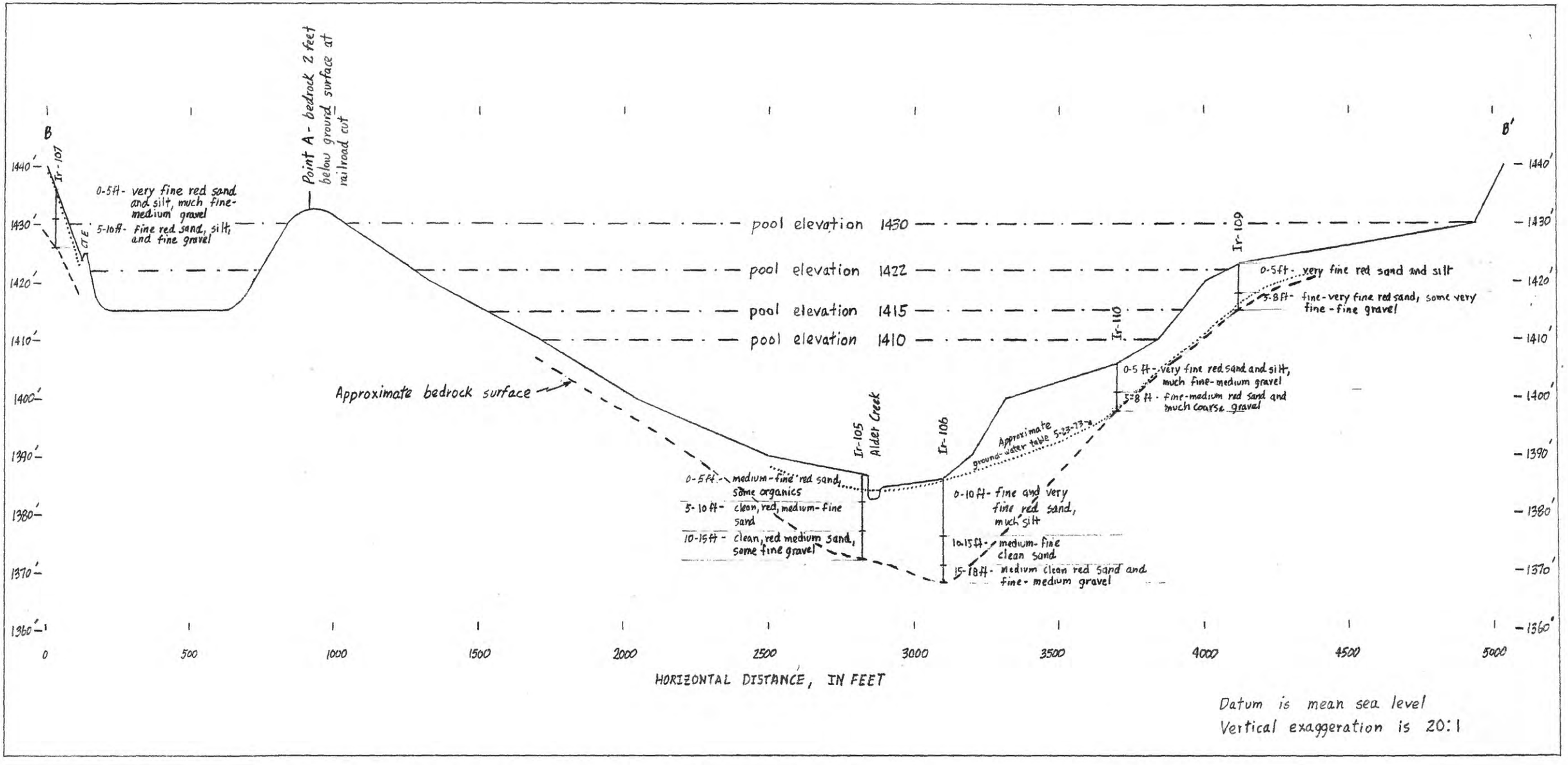


Figure 4. -- Cross section along axis of proposed damsite showing lithology in test holes, approximate ground-water table, and approximate position of bedrock surface.

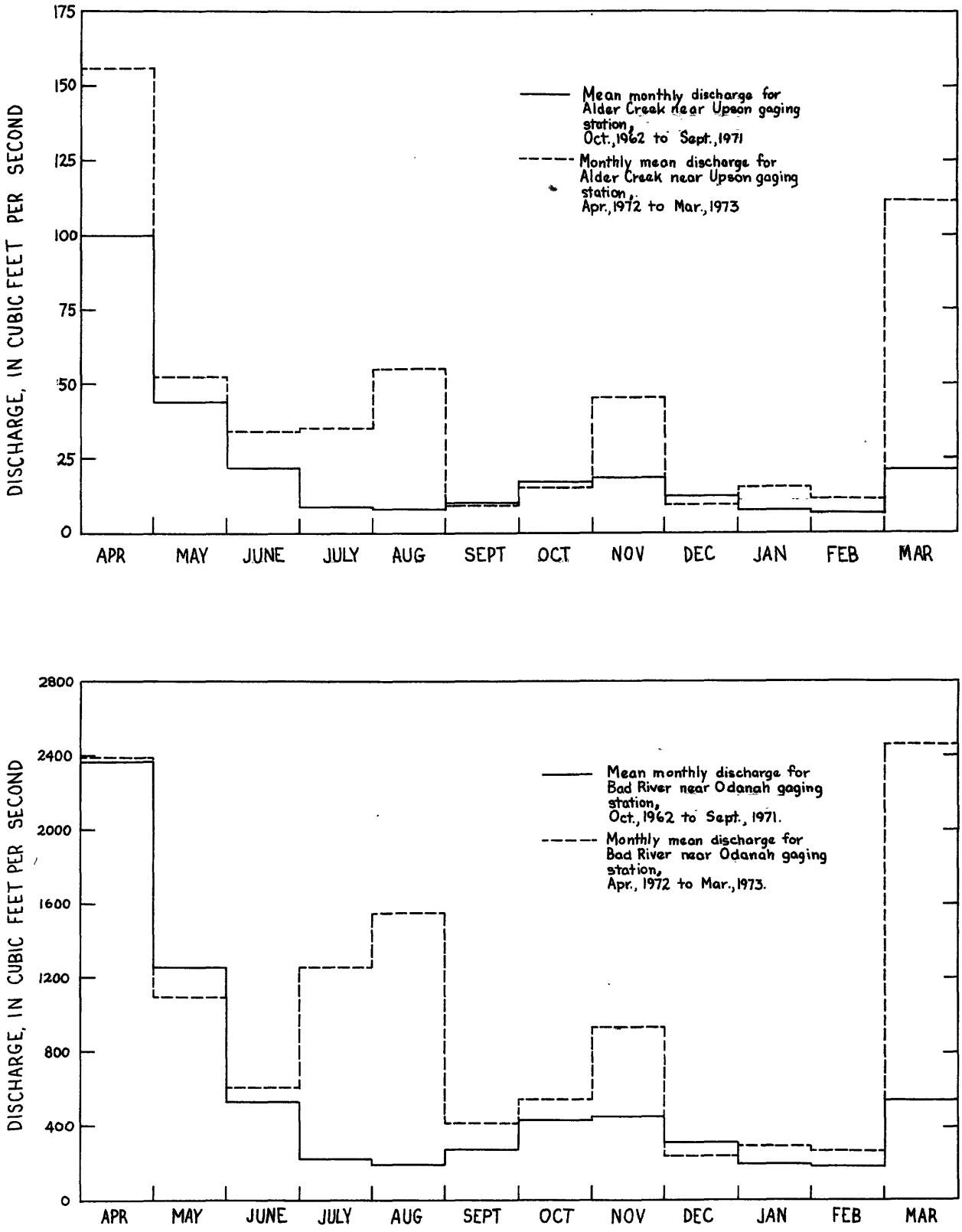


FIGURE 5 .-- Comparison of discharges of Alder Creek near Upson and Bad River near Odanah gaging stations.

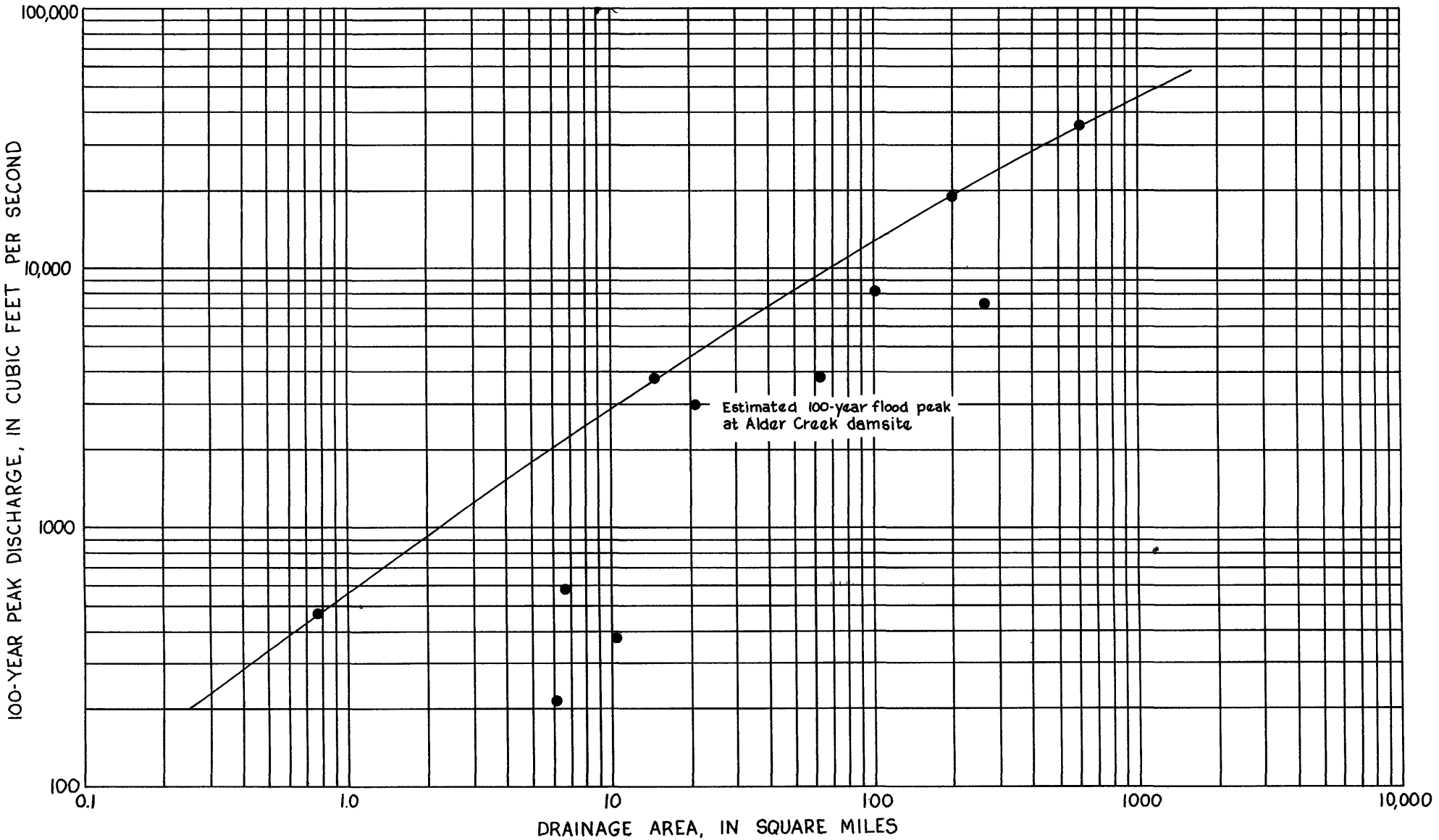


Figure 6.-- Envelope curve of 100-year flood peaks for gaging stations in the Lake Superior Basin near Iron County.

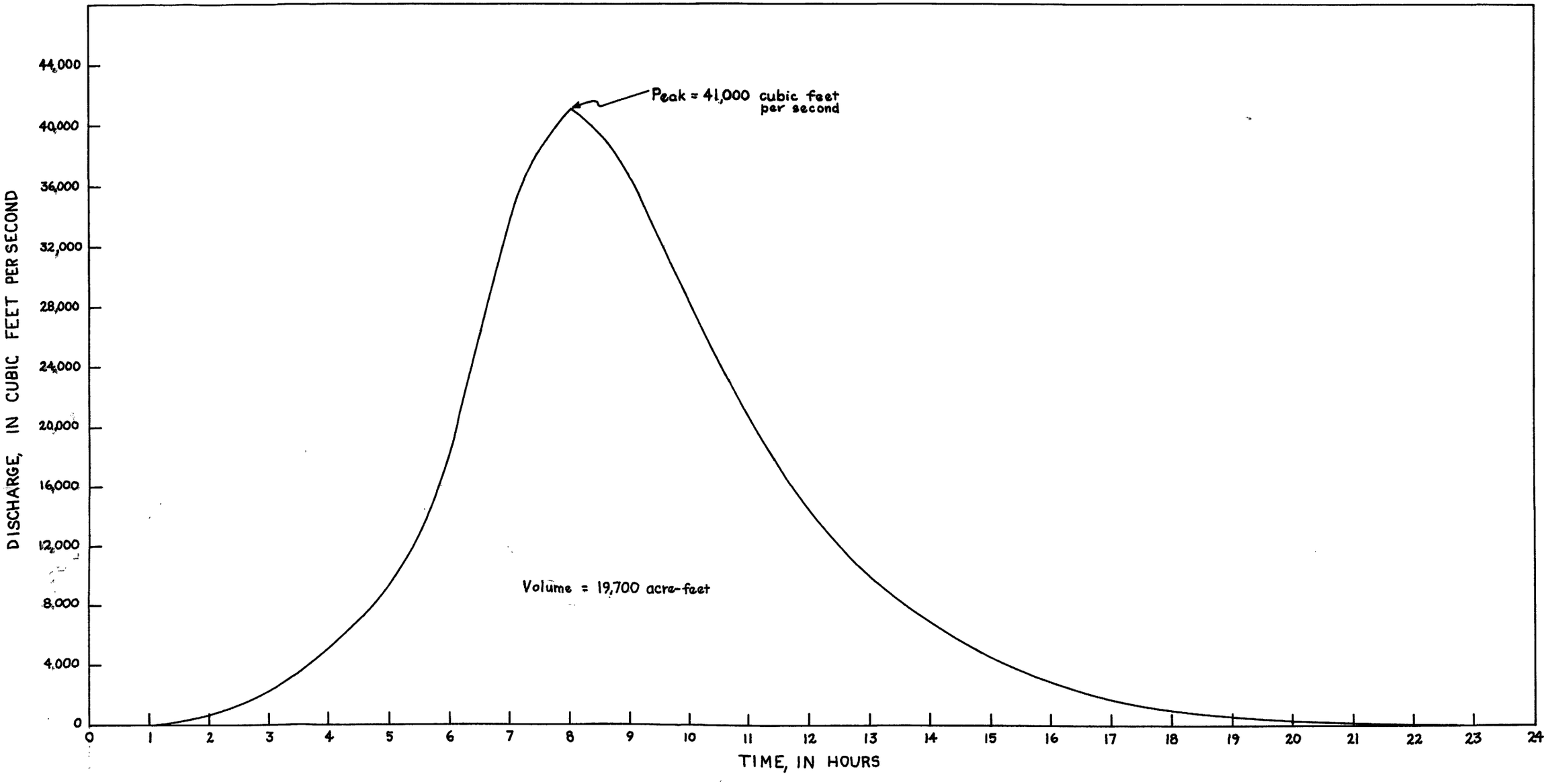


FIGURE 7.-- Probable maximum flood for Alder Creek at damsite.

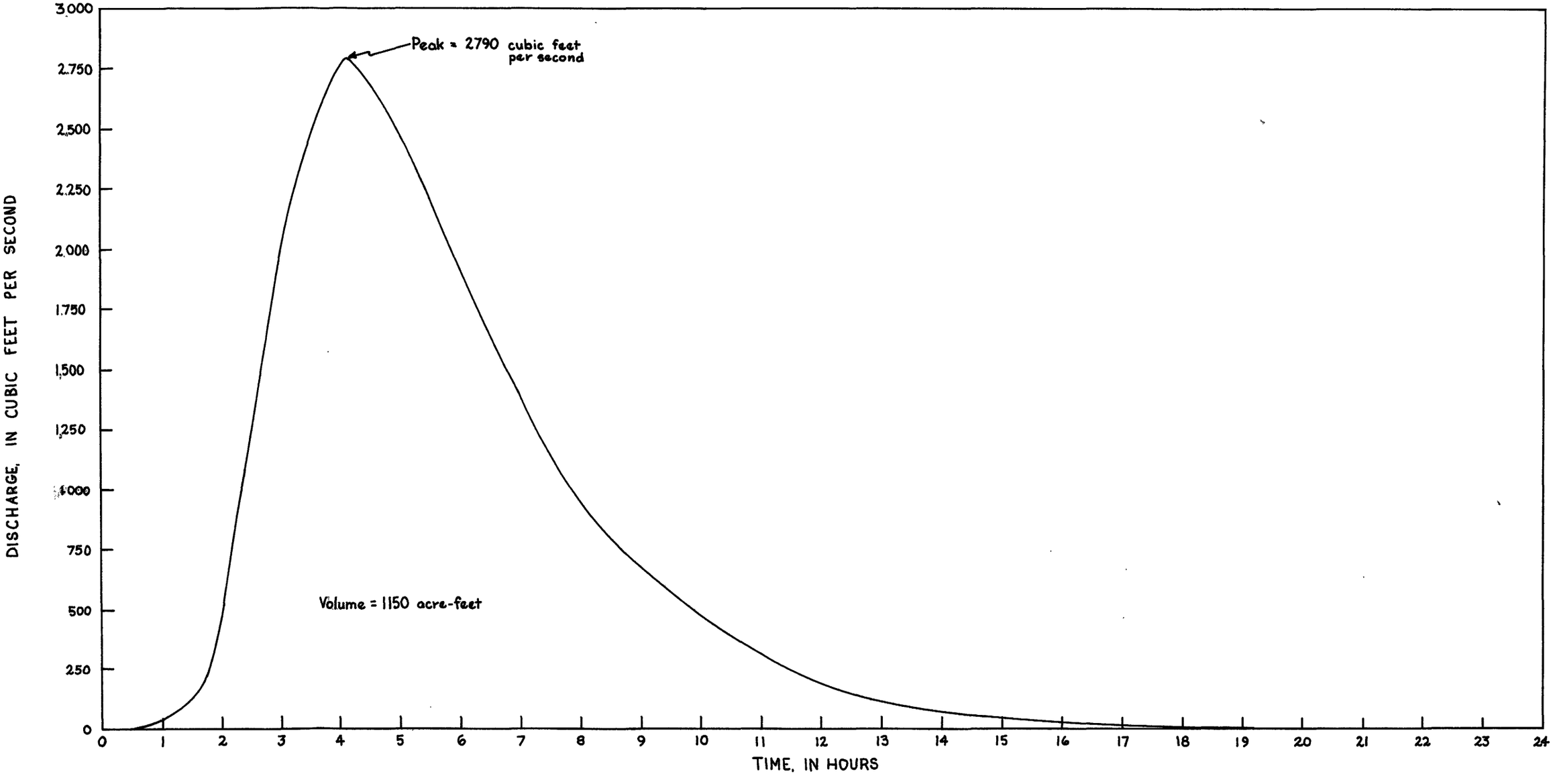


FIGURE 8.-- Unit hydrograph for Alder Creek at damsite.

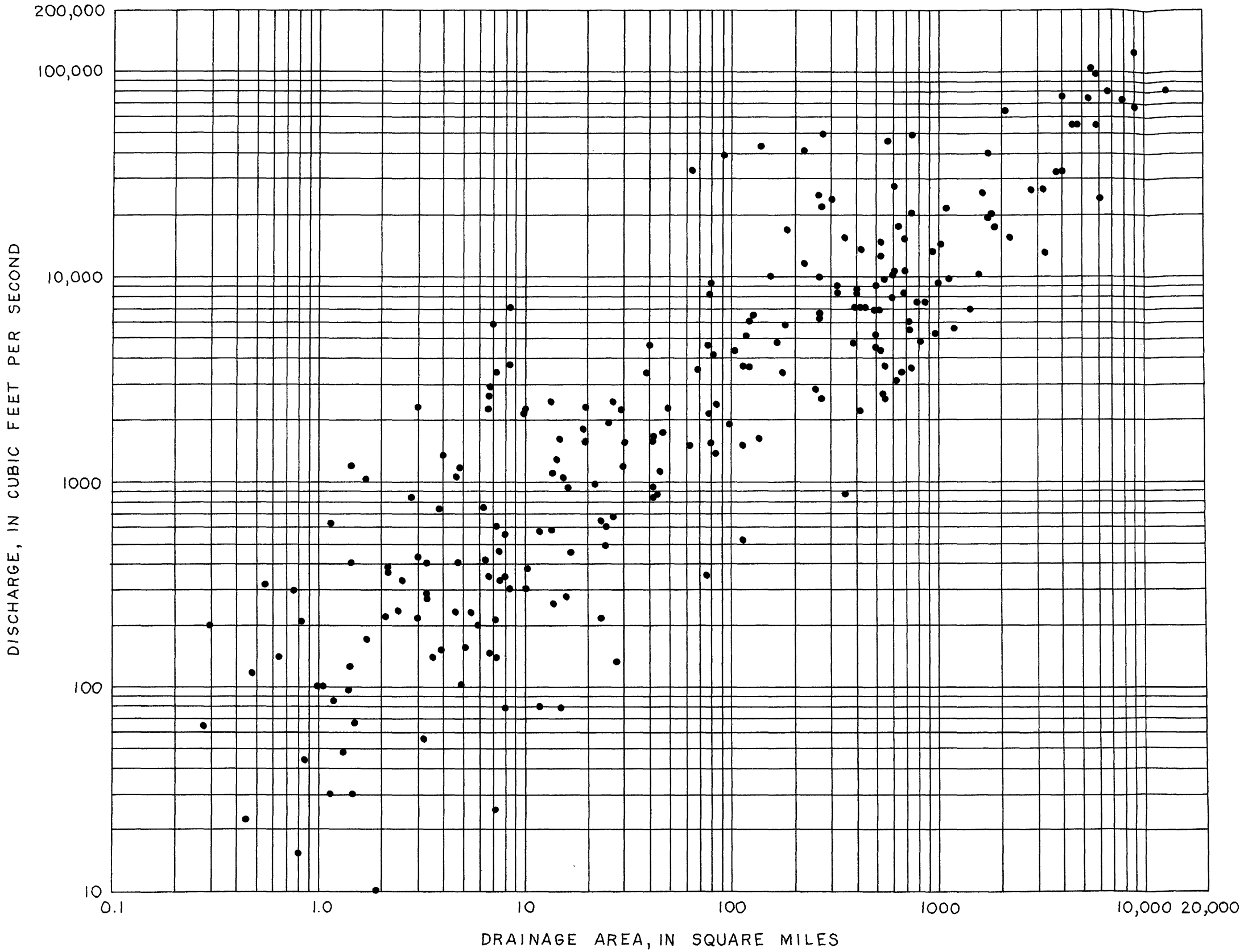
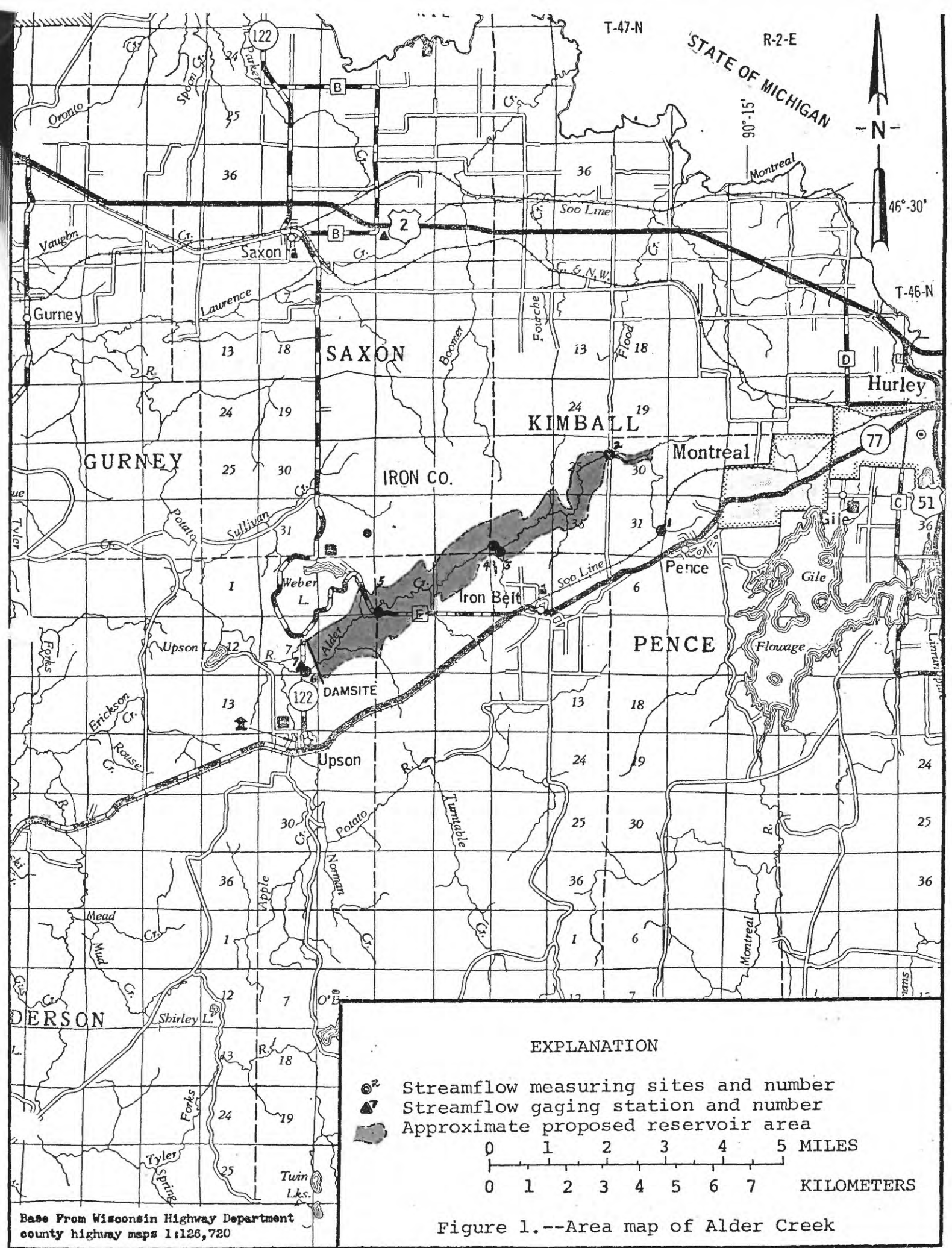


Figure 9.--Relation of maximum recorded discharge to drainage area for streams with gaging stations in Wisconsin.



Base From Wisconsin Highway Department county highway maps 1:126,720

Figure 1.--Area map of Alder Creek