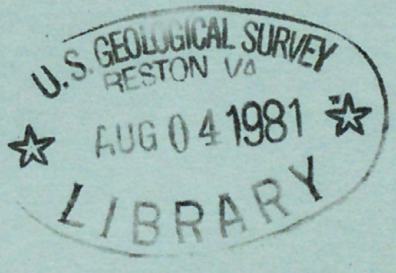
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TIME-OF-TRAVEL STUDY IN THE SEBASTICOOK RIVER BASIN, MAINE

Open-File Report 81-545



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Augusta, Maine

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TABLES

FACTORS FOR CONVERTING INCH-POUND TO INTERNATIONAL SYSTEM UNITS (SI)

To convert from	To	Multiply by
	Length	
Foot (ft)	Meter (m)	0.3048
Mile (mi)	Kilometer (km)	1.609
	Area	
Square mile (mi^2)	Square kilometer (km^2)	2.590
	Flow	
Cubic foot per second (ft^3/s)	Liter per second (L/s)	28.32
Cubic foot per second (ft^3/s)	Cubic meter per second (m^3/s)	0.02832
	Velocity	
Foot per second (ft/s)	Meter per second (m/s)	0.3048

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By Gene W. Parker

ABSTRACT

Time of travel was determined for four reaches of the Sebasticook River, two on the East Branch Sebasticook River, and two on the main stem of the Sebasticook River. Reach A included 7.8 miles of the East Branch Sebasticook River from Dexter to Corinna, Maine. Reach B included 8 miles of the East Branch Sebasticook River from Newport to its mouth, and 1 mile of the Sebasticook River to Peltoma bridge near Pittsfield, Maine. Reach C included 3.5 miles of the Sebasticook River from Hartland to West Palmyra, Maine. Reach D included 31.4 miles of the Sebasticook River from Pittsfield to Winslow, Maine. Using a 20-percent solution of rhodamine WT fluorescent dve, three dye-tracer type time-of-travel study runs were made in each reach. Water samples were collected at 10 sites in the study area. The samples were then analyzed for dye concentrations.

Time-of-travel data for each subreach are depicted in a series of illustrations and summarized in tabular form. Examples are given to illustrate use of the data presented.

INTRODUCTION

The elapsed time necessary for the transport of water or water-borne materials through a lengthwise section (reach) of a river is called either time of travel or traveltime. Time of travel is a function of both stream discharge and channel geometry. One of the most important uses of time-of-travel data is to estimate the time required for a pollutant, spilled into the river at one point, to arrive at a specific site downstream.

In October 1977, the USGS (U.S. Geological Survey) entered into a 3-year joint-funded project with the MDEP (Maine Department of Environmental Protection). The purposes of the project were to evaluate and describe flow characteristics, and define time-of-travel rates of selected streams with known or potential water quality problems. The time-of-travel information is to be used to develop a stream water quality model used by MDEP in discharge licensing and load allocation activities. During the period June through November, 1979, a time-of-travel study was carried out on the Sebasticook and East Branch Sebasticook Rivers. On the East Branch Sebasticook River, two reaches were studied, one between Dexter and Corinna, Maine, and another between Newport and Peltoma bridge near Pittsfield, Maine. Two reaches were also studied on the Sebasticook River, one between Hartland and West Palmyra, Maine, and another between Pittsfield and Winslow, Maine. See fig. 1.

ACKNOWLEDGMENTS

The author would like to acknowledge Gardner Hunt, Fred Greenlaw, and David Dodge from MDEP, who contributed to the study.

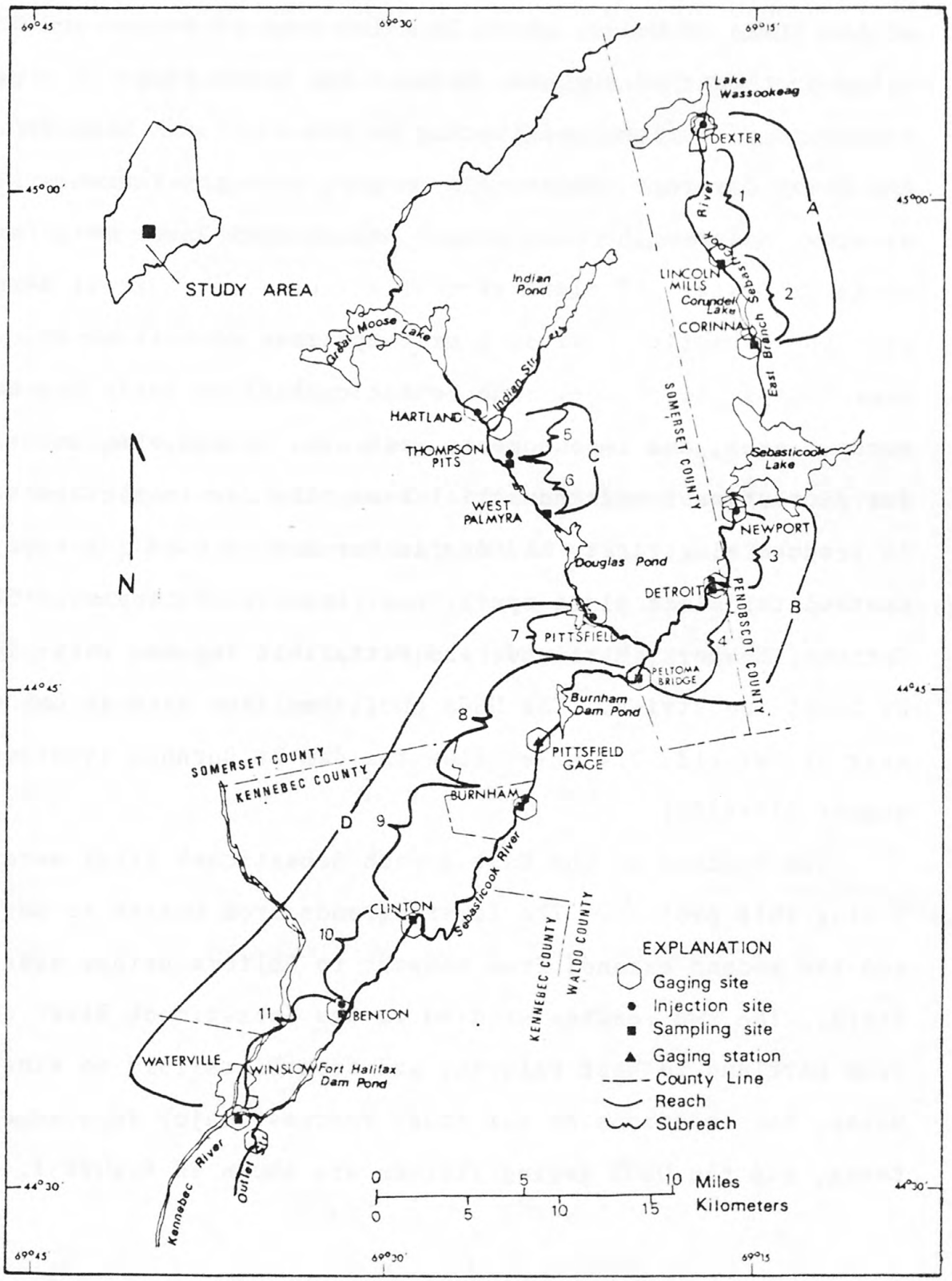

Figure 1.--Map of Sebasticook time-of-travel study area

DESCRIPTION OF STUDY REACHES

The Sebasticook River basin is in the central part of the State of Maine, about 28 miles west of Bangor and 40 miles northeast of Augusta, Maine. The river flows in a generally southward direction, originating in the highlands between Dexter and Dover-Foxcroft, Maine, and merging with the Kennebec River at Winslow, Maine. The East Branch Sebasticook River originates north of Dexter and flows generally southward where it merges with the Sebasticook River 1 mile upstream of Peltoma bridge, near Pittsfield, Maine. The Sebasticook River basin has numerous ponds, lakes, and impoundments with dams maintaining water levels for recreational and industrial uses. The dam in Winslow is used to produce electricity and one in Burnham is used for water level control for float plane operations. Dams in the towns of Dexter, Corinna, Newport, Hartland, and Pittsfield impound water for use by local industries. The USGS publishes flow data at one site near Pittsfield, 0.4 mile below the dam at Burnham (station number 01049000).

Two reaches on the East Branch Sebasticook River were studied during this project. The first extends from Dexter to Corinna, and the second extends from Newport to Peltoma bridge near Pittsfield. The two reaches studied on the Sebasticook River extend from Hartland to West Palmyra, and from Pittsfield to Winslow, Maine. The locations of all study reaches, major impoundments, towns, and the USGS gaging station are shown in figure 1.

METHODS

The procedure used to determine the time of travel involved the use of a 20-percent solution of rhodamine WT fluorescent dye. The dye injection and sampling sites for the study areas were selected from topographic maps. These sites were chosen to separate the four study reaches into the 11 subreaches shown in figure 1.

A field reconnaissance was made to inspect the dye injection and sampling sites, confirm the existance of impoundments, and locate suitable measuring sites.

The desirable discharges for time-of-travel studies agreed upon by the USGS and MDEP were at the 50-, 85-, and 90- (or greater) percent flow durations. These are comparable to discharges of 490, 210, and 130 ft^3/s, respectively as determined for the Pittsfield gaging station.

Data Collection

The Pittsfield gage was used as the principal reference or index gage for the study area but, due to the high number of dams, the following gaging sites were used as index gages as indicated:

	Subreach	Index Gage
Reach A	1	Lincoln Mills
	2	Corinna
Reach B	3 and 4	Detroit
Reach C	5 and 6	Hartland
Reach D	7, 8, 9, 10, and 11	Pittsfield gage

Discharge measurements were made at the following sites:

East Branch Sebasticook River	Sebasticook River
Dexter*	Hartland*
Lincoln Mills*	West Palmyra
Corinna*	Pittsfield*
Newport*	Peltoma bridge*
Detroit*	Pittsfield gage*
	Burnham*
Tributaries	Clinton*
	Benton*
Indian Stream, Hartland	Winslow
Outlet Stream, Winslow*	

At the sites identified by an asterisk, a stage-discharge relation was developed, or an existing relationship confirmed.

Discharge at each of the ungaged sampling sites (see fig.1) was estimated from discharges determined at nearby gaging sites. Adjustments for difference in drainage areas (table 1) were based on runoff per square mile as computed from discharge measurements made at nearby gaging sites.

Discharges at the Pittsfield gage for the three dye runs on reach D were 75, 450, and 3200 ft^3/s. For reach A, the discharges at Lincoln Mills were 15, 20, and 110 ft^3/s. For reach B, the discharges at Detroit were 77, 200, and 1200 ft^3/s. Discharges at Hartland for reach C were 23, 320, 380, and 670 ft^3/s. In general, when a run was made on reach D, runs were made on the other reaches. Exceptions to this were the October runs on reach C and the November run on subreach 11 which were delayed for more favorable flow conditions.

Table 1.--Drainage areas of study sites

Stream	Site	Drainage area, in square miles
East Branch Sebasticook River	Dexter (I)*	12.1
	Lincoln Mills (S)**	28.7
	Corinna (S)	34.5
	Newport (I)	127
	Detroit (S)	208
Sebasticook River	Hartland (I)	230
	Thompson Pit (I,S)	286
	West Palmyra (S)	288
	Pittsfield (I)	313
	Peltoma bridge (S)	545
	Pittsfield gage	572
	Burnham (I,S)	725
	Clinton (S)	827
	Benton (I,S)	862
	Winslow (S)	946

* I = injection site.
** S = sampling site.

A 20-percent solution of rhodamine WT fluorescent dye was used as the tracer. MDEP personnel injected the dye, collected dye-water samples at selected sites, and fluorometrically determined the dye concentrations in the samples. The volume of dye injected for each of the three dye runs was calculated based on discharge determined at index sites, and estimates of mean stream velocity at the time of the dye studies. ("Measurement of time-of-travel and dye dispersion by dye tracing" by F. A. Kilpatrick, L. A. Martens, and J. F. Wilson, Jr., 1970, unpublished data.) During all three dye runs, automatic samplers were used to collect dye-water samples at set time intervals. Samples were later analyzed for dye concentration as outlined by Wilson (1968).

At the Corinna sampling site, only two dye clouds were identified by analysis of dye concentration in water samples. During the September dye run, the flow increased from a discharge of 8 ft^3/s at the time of arrival of the leading edge, to a discharge of 190 ft^3/s at the time of arrival of the peak concentration. This rapid increase in discharge negated the value of travel times developed from the resulting time-concentration curve. For this reason, travel time versus discharge and travel time versus distance curves were not developed to include subreach 2 ending at the Corinna sampling site.

At the Winslow site, four dye clouds were identified during the course of the study. Each dye cloud had been injected at a different location (Benton, Burnham, Pittsfield, and Newport). The Pittsfield and Newport dye runs were not included in the analysis for subreach 1 as they had not been identified at the Benton site.

Data Analysis

Time-Concentration Curves

Measured dye concentrations at each sampling site were plotted against time since injection for each dye study. (See Appendix A, figs. A1-A33.) A smooth curve was drawn through the plotted points, taking into consideration possible background fluorescence and occasionally erroneous analyses of dye concentrations. Background levels were determined from samples collected ahead of the arrival of the dye cloud and were generally less than 0.2 micrograms per liter. One notable exception is A5, which shows varying levels of background fluorescence obtained from waste discharges upstream of the sampling site.

For sample sites where double peaks were observed as illustrated by figs. A10, 16 and 31, two time-concentration curves were developed by the following method.

First, the downward trend of the first curve was extended smoothly to initial background concentration level. Second, the concentration estimated for the first time-concentration curve is subtracted from the observed concentrations. The resulting curves are used to illustrate the passage of the two dye clouds at that site.

From the time-concentration curves, the traveltime of the important features of the dye cloud were determined. The four features considered to be most important (Buchanan, 1964) are:

Leading edge.--The arrival at the sampling site of the first dye particle.

Peak.--The maximum dye concentration.

Centroid.--The center of mass of the dye cloud between the leading and trailing edges.

Trailing edge.--The point at which the dye concentration recedes to 10 percent of the peak concentration.

Leading edge, peak, and trailing edge are determined by inspecting the time-concentration curves. The centroid is computed by the formula:

$$\bar{t} = \frac{\sum_{i=1}^{n} t_i c_i \Delta_i t}{\sum_{i=1}^{n} c_i \Delta_i t}$$

Where:

$\bar{t}$ = the average time for the geometric region under the time-dye concentration curve.

t_i = the elapsed time since the dye injection.

c_i = the dye concentration at time t_i.

$\Delta_i t$ = the interval of time determined by $((t_{i+1} - t_i)/2) + ((t_i - t_{i-1})/2)$.

The area under the curve represents the dye cloud mass. A summary of time-of-travel data for all subreaches is presented in table 2.

Table 2.--Time-of-travel data for all subreaches

Reach	Injection site	Sub-reach No.	Dye run No.	Distance from injection site (m)	Date of injection	Discharge at peak concentration (ft^3/s)	Time of travel leading edge (h)	Time of travel peak (h)	Peak velocity (ft/s)	Time of travel centroid (h)	Centroid velocity (ft/s)	Time of travel trailing edge (h)
A	Dexter	1	1	5.0	06/04/79	110	6.6	7.6	1.0	10	0.7	13
			2		08/03/79	20	12	15	0.5	24	0.3	31
			3		09/25/79	15	15	18	0.4	24	0.3	34
A	Dexter	1,2	1	7.8	06/04/79	95	24	91	0.1	113	0.1	218
			2		09/25/79	22	280	341	0.03	355	0.03	438
B	Newport	3	1	4.0	06/04/79	1200	4.0	7.2	0.8	9.3	0.6	16
			2		07/30/79	77	28	40	0.1	44	0.1	64
			3		09/25/79	220	14	17	0.3	22	0.3	30
B	Newport	3,4	1	9.0	07/30/79	77	80	111	0.1	122	0.1	167
			2		09/25/79	200	38	50	0.3	55	0.2	75
B & D	Newport	3,4,8,9, 10,11	1	36.3	09/25/79	370	213	255	0.2	285	0.2	335
B	Detroit	4	1	5.0	06/06/79	1000	7.2	10	0.7	14	0.5	25
			2		07/30/79	74	42	58	0.1	66	0.1	96
C	Hartland	5	1	2.2	06/07/79	730	3.6	4.5	0.7	5.5	0.6	7.3
			2		06/11/79	370	5.6	8.5	0.4	8.7	0.4	12
			3		07/23/79	23	34	72	0.04	76	0.04	122
			4		10/29/79	280	6.9	8.9	0.4	9.8	0.3	13
C	Hartland	5,6	1	4.5	06/07/79	670	9.5	12	0.6	14	0.5	18
			2		06/11/79	380	17	22	0.3	24	0.3	31
			3		07/23/79	23	123	156	0.04	214	0.03	335
			4		10/29/79	320	17	22	0.3	23	0.3	29
D	Pittsfield	7	1	3.9	06/04/79	3900	1.8	2.7	2.1	3.6	1.6	4.9
			2		07/17/79	115	41	62	0.09	76	0.08	112
			3		09/18/79	460	18	26	0.2	28	0.2	38
D	Pittsfield	7,8	1	11.7	06/04/79	3900	9.4	12	1.4	14	1.2	19
			2		07/17/79	107	130	261	0.07	265	0.06	408
			3		09/18/79	445	73	99	0.2	116	0.1	167
D	Pittsfield	7,8,9, 10,11	1	31.2	09/18/79	470	178	240	0.2	260	0.2	350
D	Burnham	9	1	9.1	07/17/79	115	69	96	0.1	106	0.1	145
			2		09/18/79	460	30	39	0.3	41	0.3	50
D	Burnham	9, 10	1	13.7	06/06/79	3000	9.8	12	1.7	13	1.5	16
			2		07/17/79	115	99	118	0.2	131	0.2	166
			3		09/18/79	460	39	50	0.4	51	0.4	63
D	Burnham	9,10,11	1	19.5	09/18/79	510	78	132	0.2	141	0.2	188
D	Benton	11	1	5.8	11/15/79	2650	16	19	0.4	22	0.4	30

Time-Discharge Curves

The traveltimes to each of the four features of the dye cloud described earlier were plotted against the average discharge of each reach of the Sebasticook River during the respective dye studies. The relations are presented in Appendix B, figures B1-B10. The relation between time of travel and discharge is usually linear on log-log paper. In general, the time-discharge curves in each of figures B1-B10 converge as discharge increases. This convergence indicates that the total passage time of the dye cloud decreases as discharge increases or that generally less longitudinal dispersion occurred at higher flows. Figures B1-B10 can be used to estimate the arrival time of each of the important features of a dye or pollutant cloud for a wide range of flows. Examples of dispersion of a dye cloud as it moves into or through impounded waters are shown in figures B4, B5, B7, and B10. As can be seen from these figures, the effect of impoundments is most noticeable by the convergence of the peak and centroid lines at one of the other ends of the projected discharge range. Examples of dispersion in a reach with major changes in channel characteristics as flow changes are shown in figures B2 and B3. The change of slope that can occur in a dispersion relationship as a river overflows its normal channel boundaries is shown in figures B2 and B3.

In the development of figure B10, only one actual dye run was injected at Benton at 2650 ft^3/s. The second data set for 500 ft^3/s was determined by subtracting arrival times of each feature at Benton from the arrival times at Winslow for a dye cloud that was injected at Burnham.

Time-Distance Relation

A popular way of summarizing time-of-travel data is to plot the traveltime of the centroid of the dye cloud versus the distance between sampling points and the injection site (see Appendix C, figs. C1-C4) at each of the corresponding discharge levels as determined from figures in Appendix B. From these relations, traveltime of the centroid can be estimated to any point in the reach. Also, traveltimes at flows other than those which occurred during the study can be estimated. The discharge values shown in figures C1-C4 are for the designated index gage for that reach. Traveltimes for each site were determined for the index discharge after adjustment for differences in drainage areas.

USE OF TIME-OF-TRAVEL DATA

In addition to model calibration and verification, data can be used as discussed in the two examples that follow. Example A shows how the data presented here can be used to estimate the time necessary for a pollutant instantaneously injected at the upstream end of one of the reaches to arrive at and completely pass one of the sampling sites. Example B provides a guide for estimating the time needed for the centroid, or center of mass, of a pollutant cloud instantaneously injected at the upstream end of one of the reaches, to arrive at a site between sampling locations.

Example A

A pollutant has been spilled into the Sebasticook River at Hartland at 7:45 a.m. The discharge at the index site for this reach of the Sebasticook has been determined to be 50 ft^3/s. At what time would the leading edge of the pollutant arrive at West Palmyra, and how long would it take the pollutant to completely pass that site?

Solution

The figures in Appendix B require that the discharge at the point of interest be estimated. The following procedure provides a means of estimating differences in flow between sites due only to differences in drainage area. From table 1, the drainage areas of the two sites, Hartland and West Palmyra, are 230 mi^2 and 289 mi^2, respectively. Dividing the flow determined at Hartland by its drainage area indicates a runoff of 0.22 $ft^3/s/mi^2$, which when multiplied by the drainage area at West Palmyra provides an estimate of flow of 63 ft^3/s for West Palmyra. From figure B5, the estimated time-of-travel for each feature of the pollutant cloud corresponding to the estimated West Palmyra discharge of 63 ft^3/s is:

Event	Time of occurrence
Spill at Hartland ---------	7:45 a.m., first day
Arrival at West Palmyra of:	
leading edge ---------	2:45 a.m., fourth day
trailing edge --------	6:45 p.m., seventh day
Total passage time --------	88.0 hours

It should be noted that traveltimes for long reaches can be estimated by summing up the traveltimes for individual subreaches obtained in "B" figures, but such additions of subreach traveltimes does not truly reflect the total traveltime you could expect for the entire reach as there was not an overlapping of injection points by dye clouds from upstream subreaches. (Nobuhiro Yotsukura, written communication, 1978.)

Example B

The discharge of the Sebasticook River at the Pittsfield gage is 210 ft^3/s. If a spill occurred at 9:45 a.m. in the town of Pittsfield, when should the centroid, or center of mass of the pollutant cloud, reach a point 1.5 miles downstream of the town of Burnham?

Sclution

Because the discharge of 210 ft^3/s is not shown explicitly on figure C4, it is necessary to interpolate between the two discharges bracketing 210 ft^3/s, namely 200 ft^3/s and 300 ft^3/s. At a distance of 1.5 miles downstream from Burnham, the travel time of the centroid is a composite of the traveltime of the centroid from Pittsfield to Burnham (an interpolated time of 149 hours) and the traveltime from Burnham to the point 1.5 miles downstream (an interpolated time of 10 hours). Thus, the centroid of the pollutant cloud will arrive at the point 1.5 miles downstream of Burnham in about 159 hours, approximately 00:45 a.m. 7 days after the spill occurred.

It should be noted that the procedures discussed in this report are valid only during periods of steady or gradually varying flow conditions.

SUMMARY

For the time-of-travel studies conducted during June through November 1979, a 20-percent solution of rhodamine WT, a fluorescent dye, was injected into the Sebasticook River and East Branch Sebasticook River at the sites indicated on figure 1. Water samples were collected at regular time intervals at sites indicated in figure 1 and dye concentrations were determined. The discharges at the USGS gaging station near Pittsfield were 75, 450, and 3,200 ft^3/s, for the three time-of-travel runs on the Lower Sebasticook River reach D. Time-of-travel runs were made on the other three study reaches A, B, and C in the same period of time or were delayed for more favorable discharge conditions.

The dye concentrations at each sampling site were plotted against time since injection. For each dye run, the arrival times of the leading edge, peak, centroid, and trailing edge were determined from the time-concentration curve. At each sampling site, the arrival times of these four features were plotted against the corresponding discharge. The arrival time of the centroid for each sampling site was plotted against distance upstream from the mouth of the Sebasticook River or East Branch Sebasticook River, respectively.

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Fontaine, R. A., 1980, Drainage areas of surface water bodies of the Kennebec River basin in central Maine: U.S. Geological Survey (unpublished data).

Wilson, J. F., Jr., 1968, Fluorometric procedures for dye tracing: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A12, 31 p.

APPENDIX A

TIME VERSUS CONCENTRATION CURVES

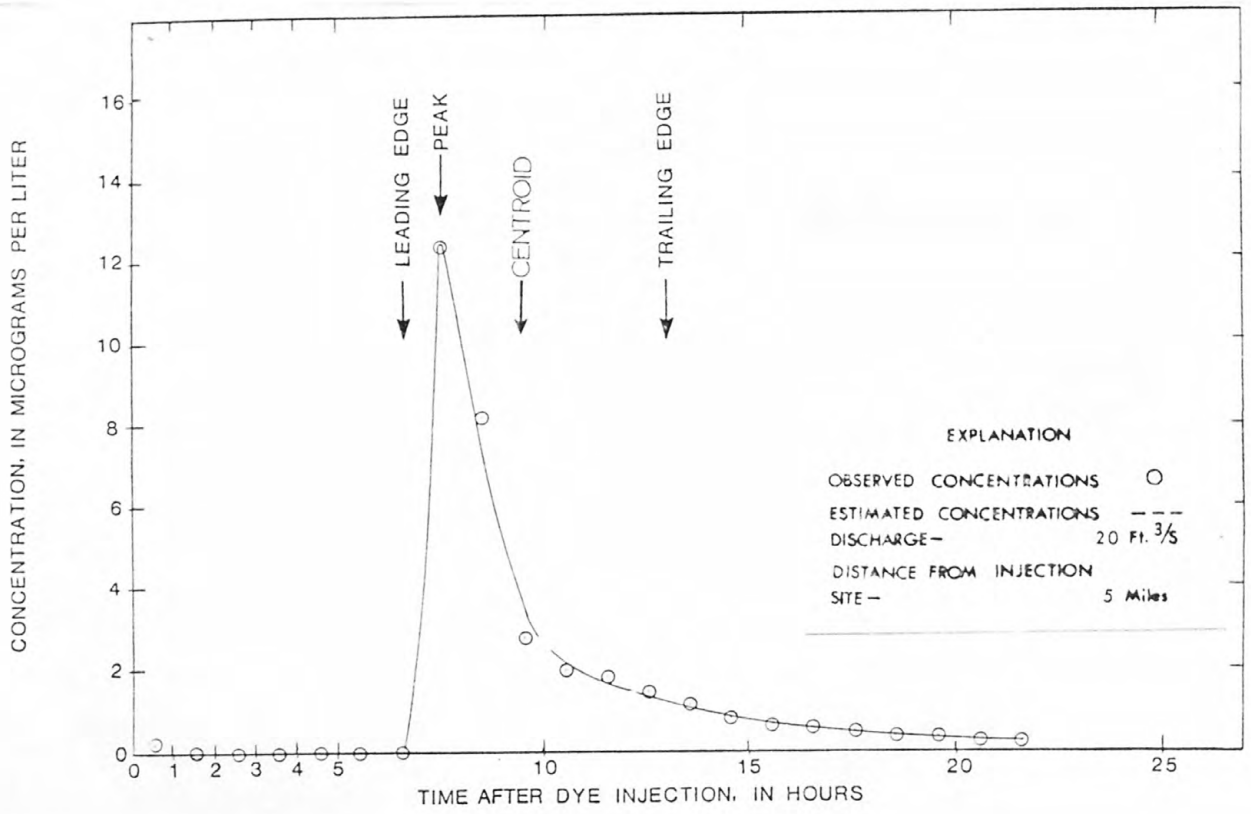

Figure A1.--Traveltime from Dexter versus concentration at Lincoln Mills, Maine, June 4-5, 1979.

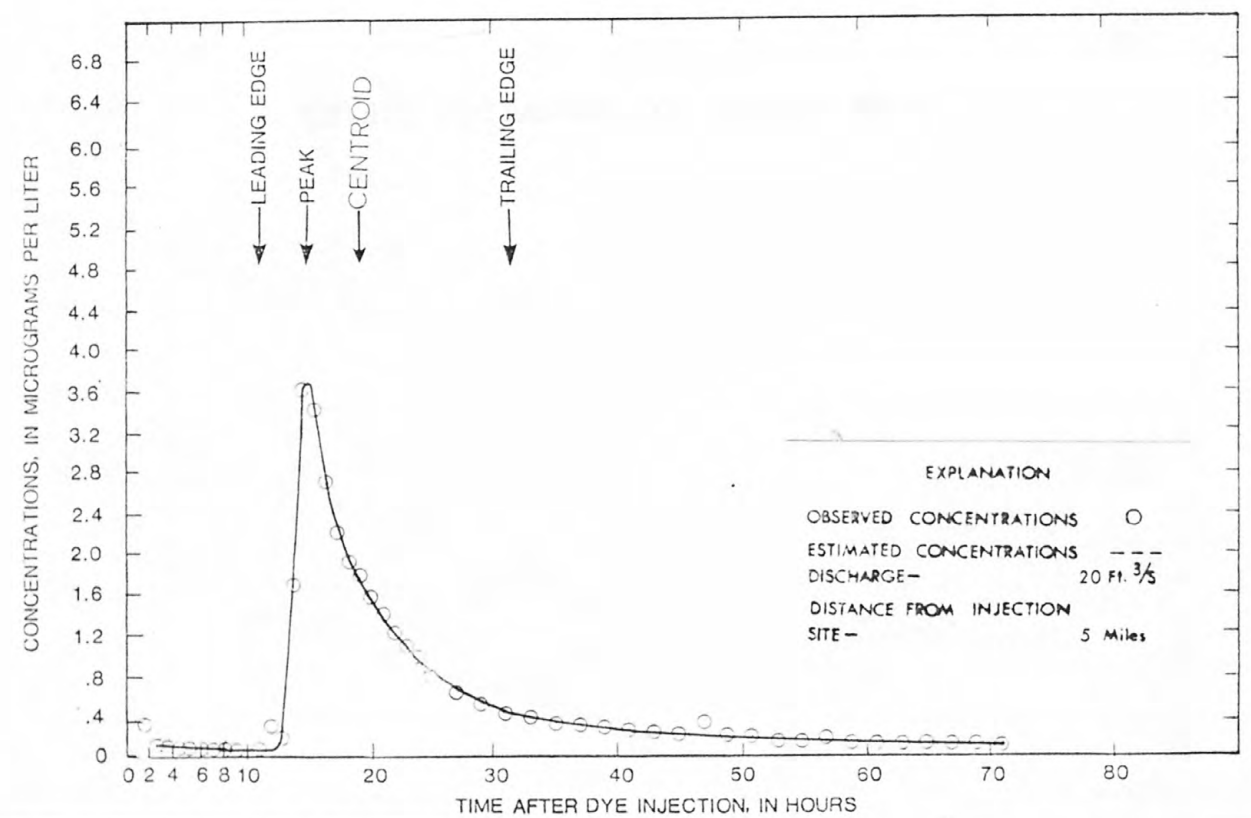

Figure A2.--Traveltime from Dexter versus concentration at Lincoln Mills, Maine, August 3-6, 1979.

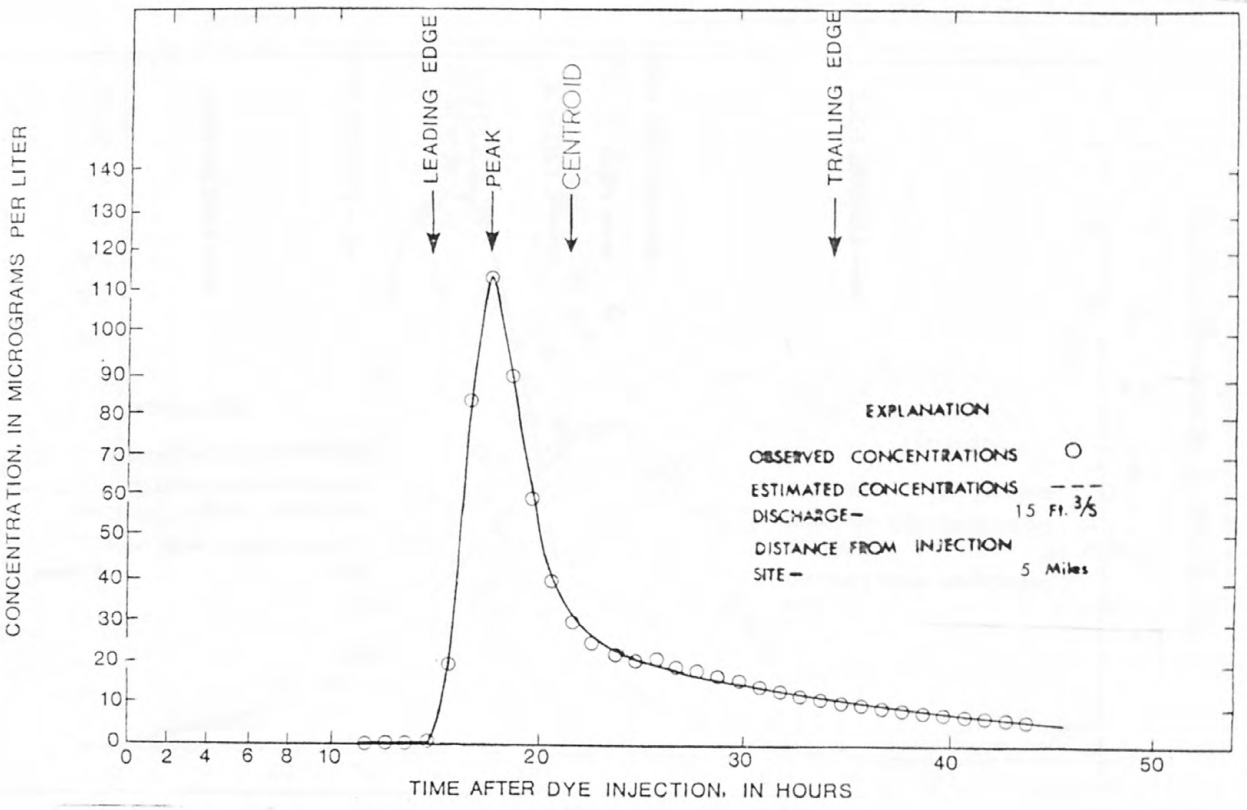

Figure A3.--Traveltime from Dexter versus concentration at Lincoln Mills, Maine, September 25-27, 1979.

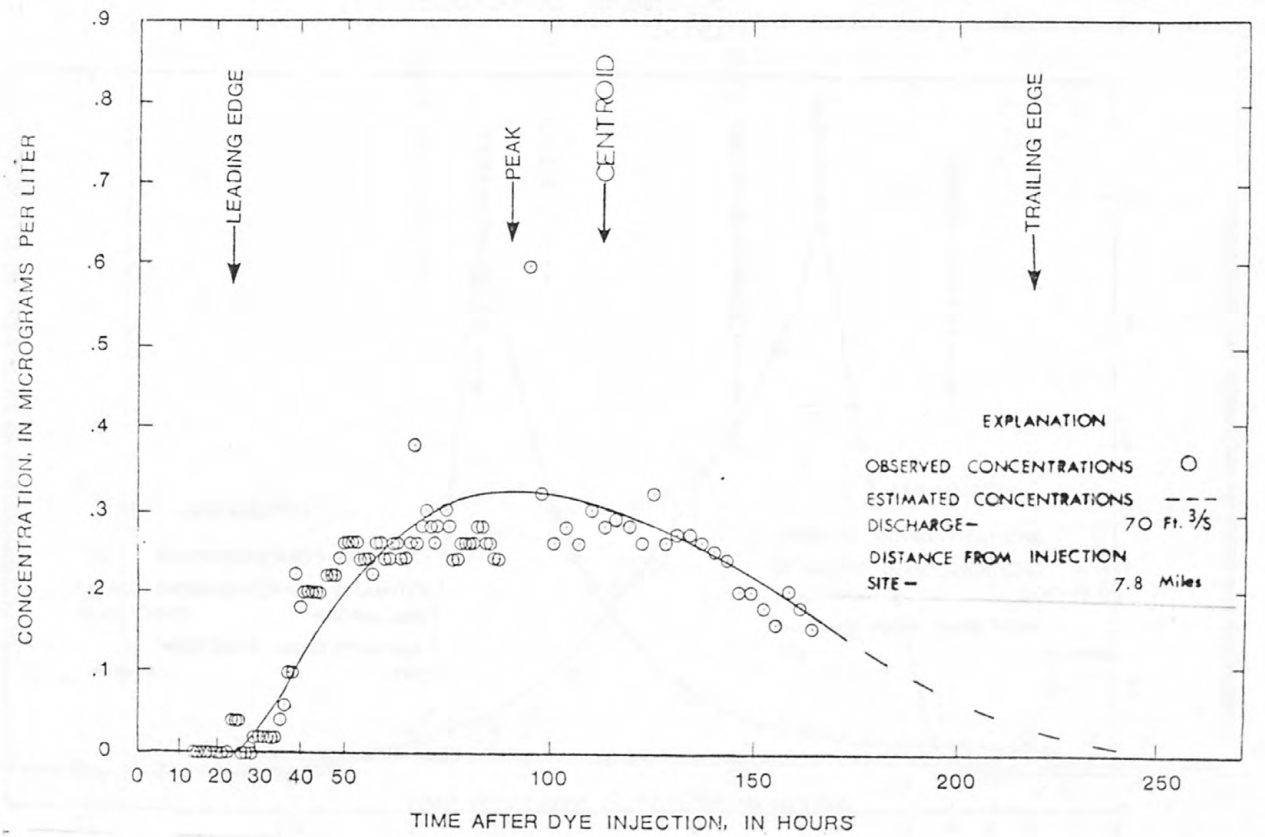

Figure A4.--Traveltime from Dexter versus concentration at Corinna, Maine, June 4-11, 1979.

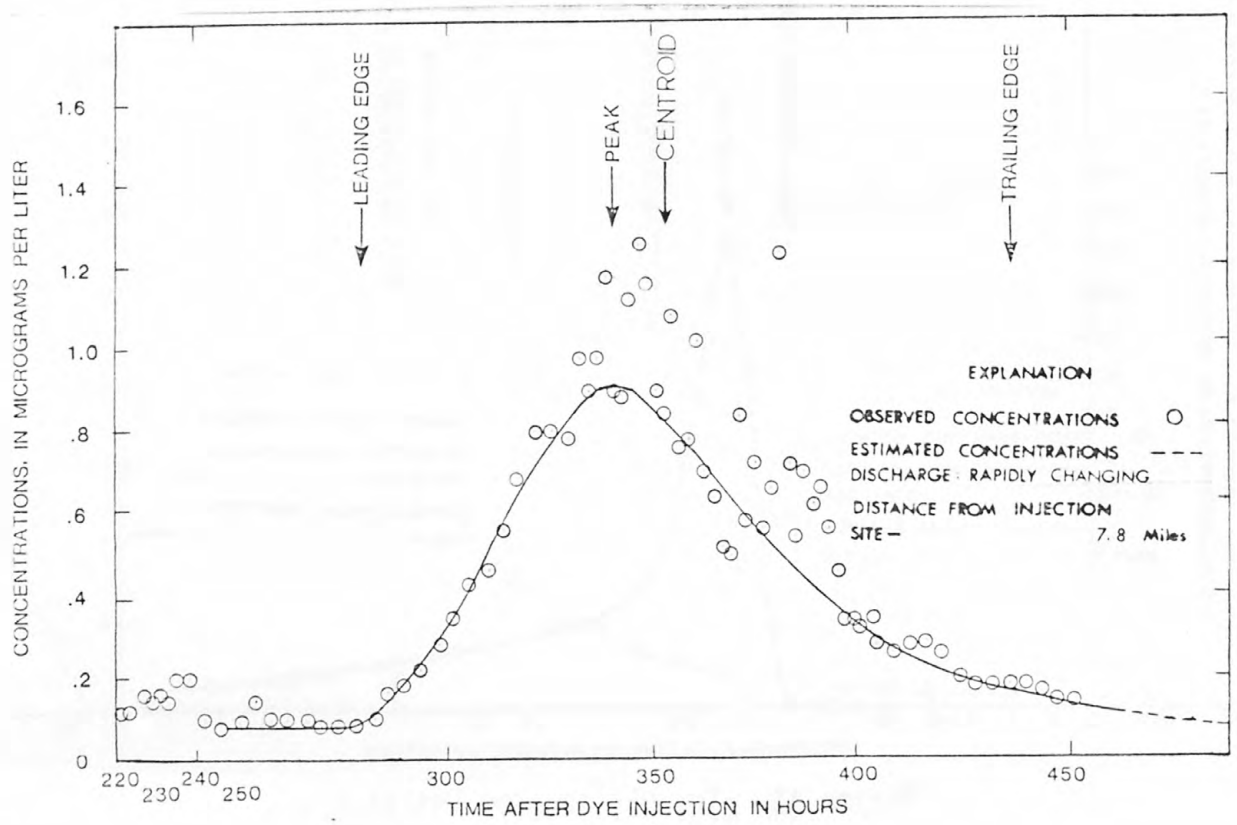

Figure A5.--Traveltime from Dexter versus concentration at Corinna, Maine, September 26-October 13, 1979.

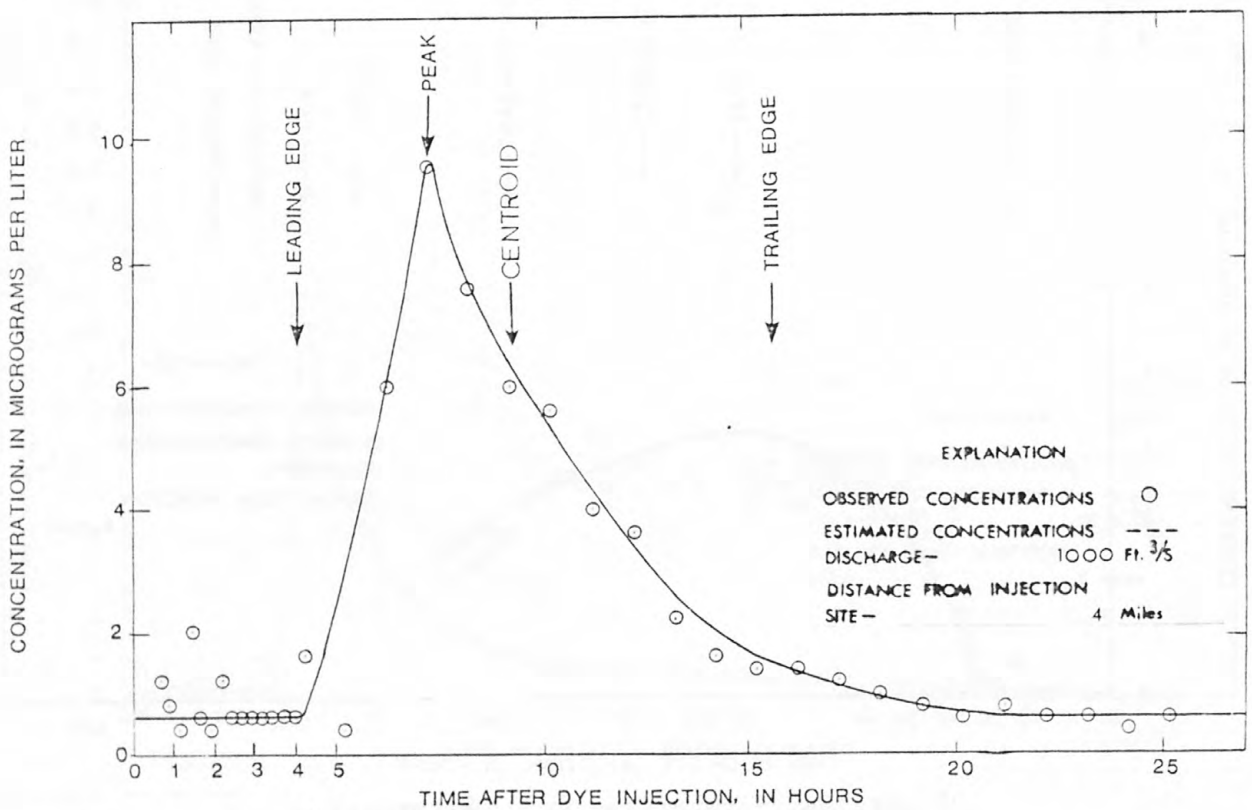

Figure A6.--Traveltime from Newport versus concentration at Detroit, Maine, June 4-5, 1979.

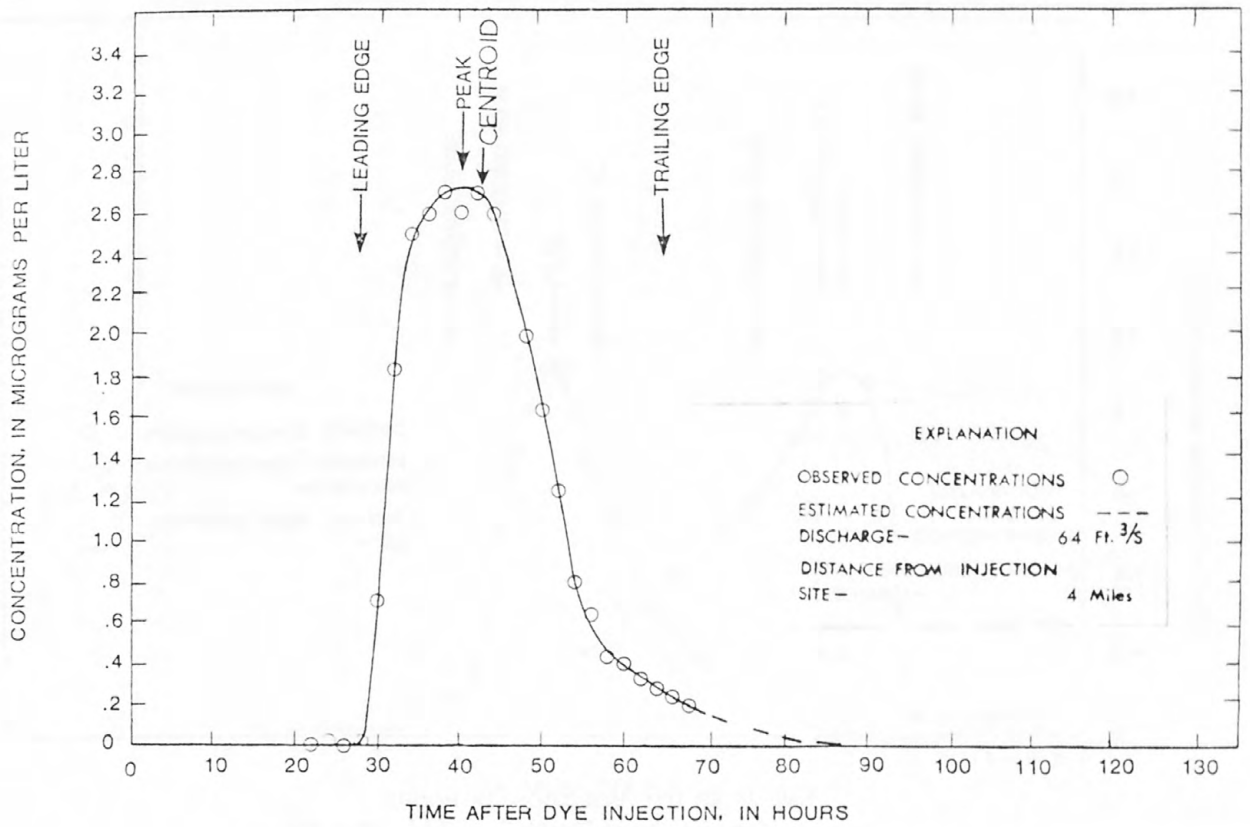

Figure A7.--Traveltime from Newport versus concentration at Detroit, Maine, July 30-August 2, 1979.

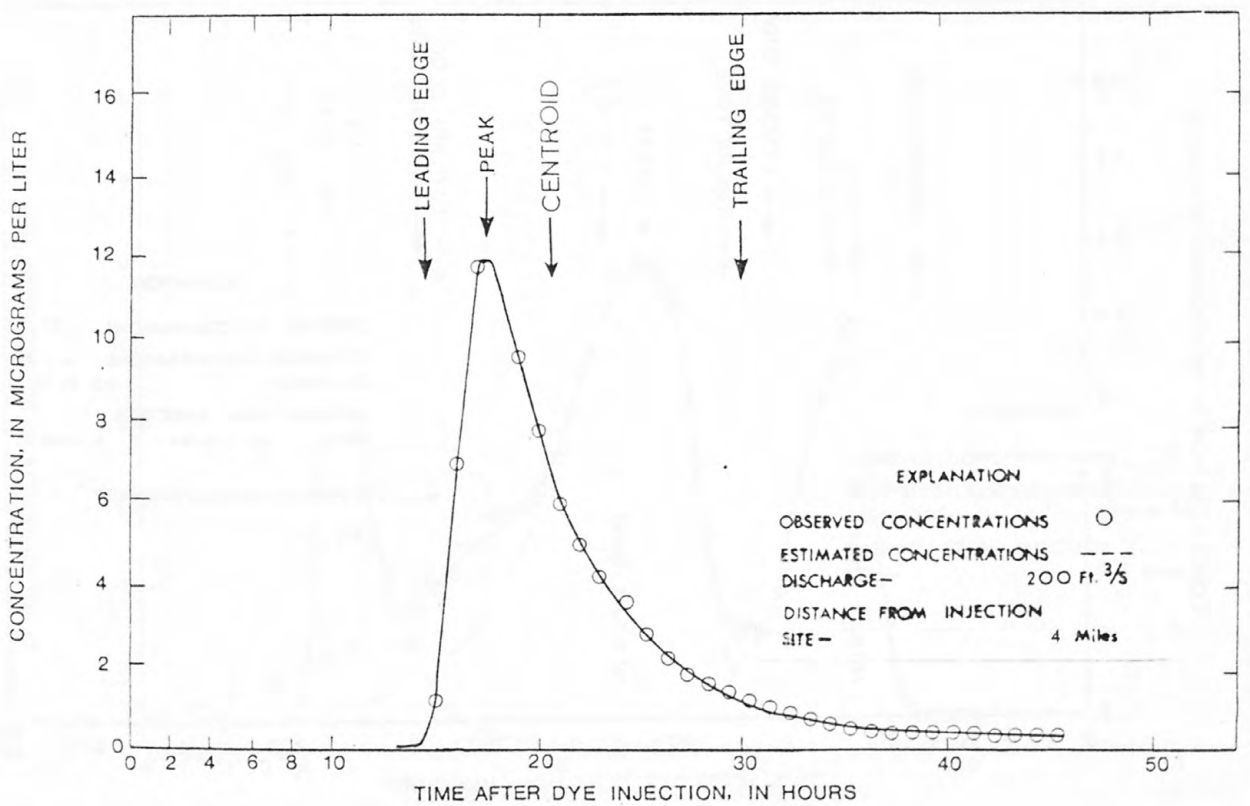

Figure A8.--Traveltime from Newport versus concentration at Detroit, Maine, September 25-27, 1979.

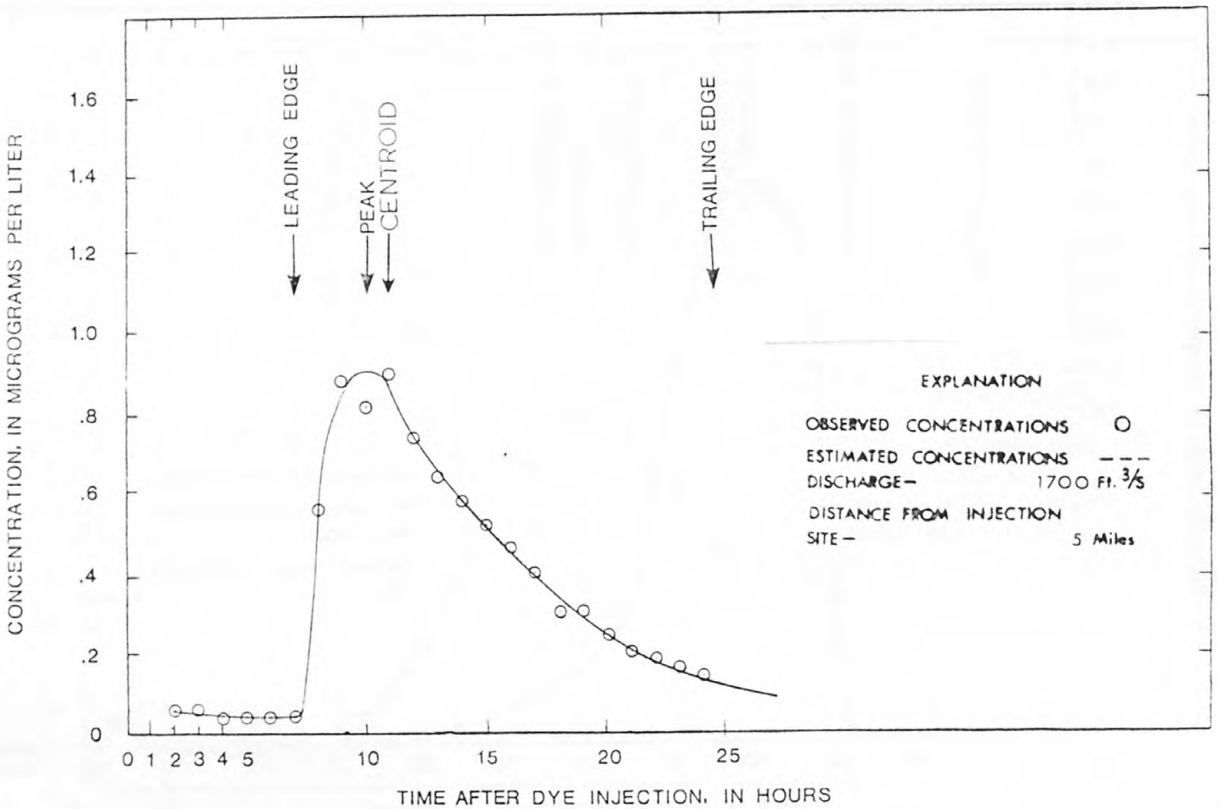

Figure A9.--Traveltime from Detroit versus concentration at Peltoma bridge near Pittsfield, Maine, June 6-7, 1979.

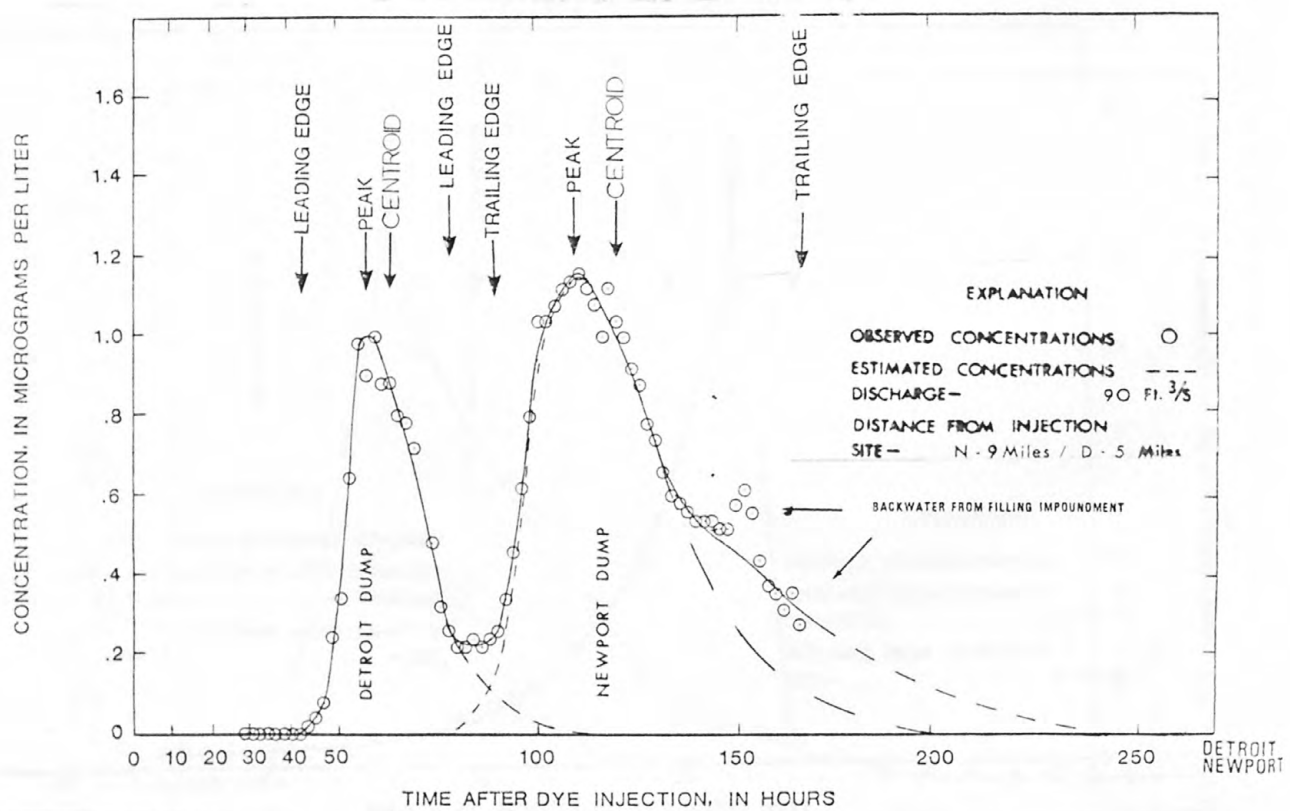

Figure A10.--Traveltime from Detroit and Newport versus concentration at Peltoma bridge near Pittsfield, Maine, July 30-August 6, 1979.

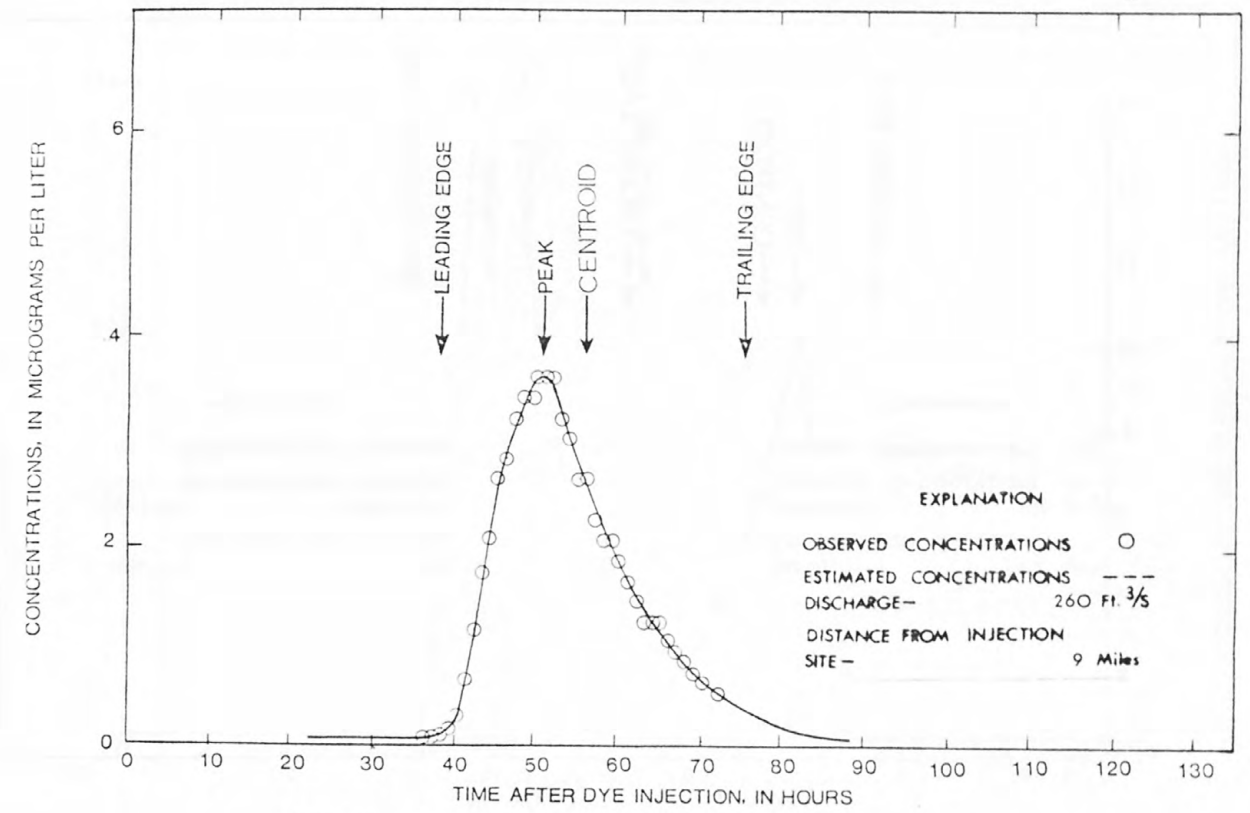

Figure A11.--Traveltime from Newport versus concentration at Peltoma bridge near Pittsfield, Maine, September 25-28, 1979.

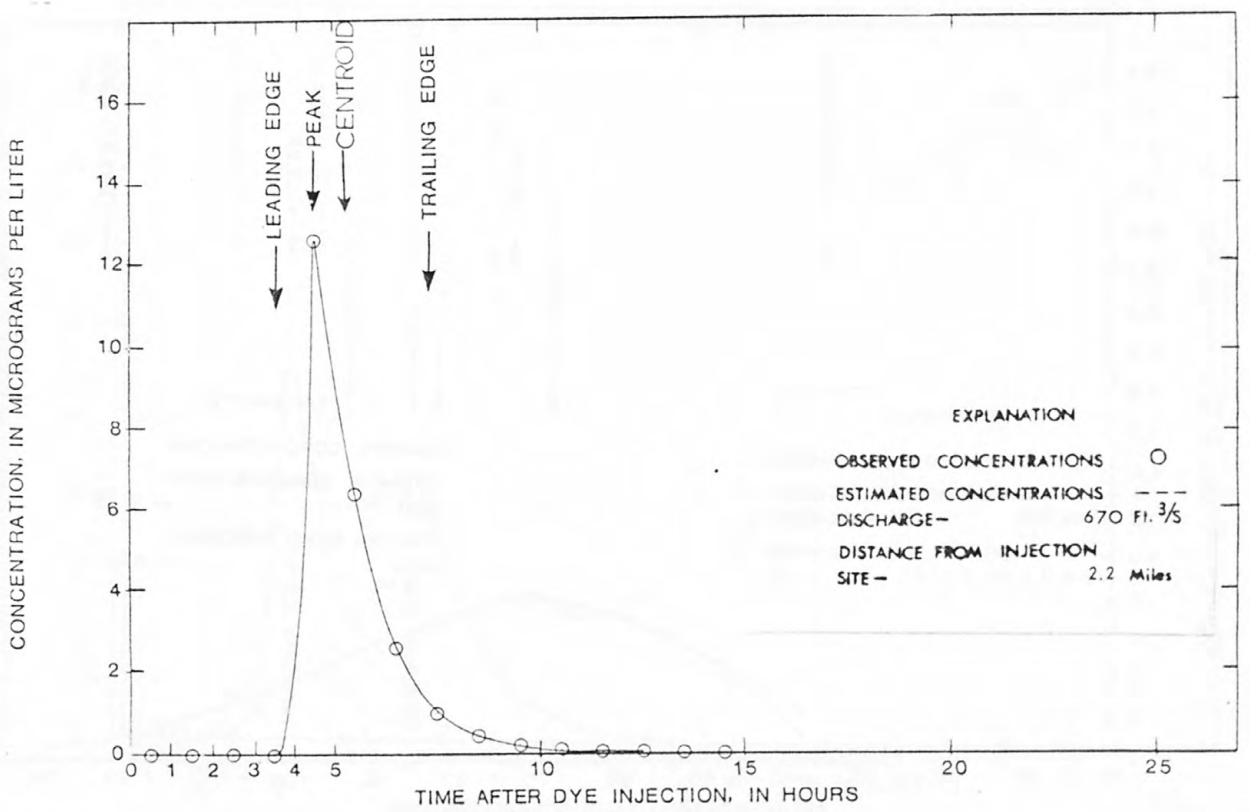

Figure A12.--Traveltime from Hartland versus concentration at Thompson Pits, Maine, June 7-8, 1979.

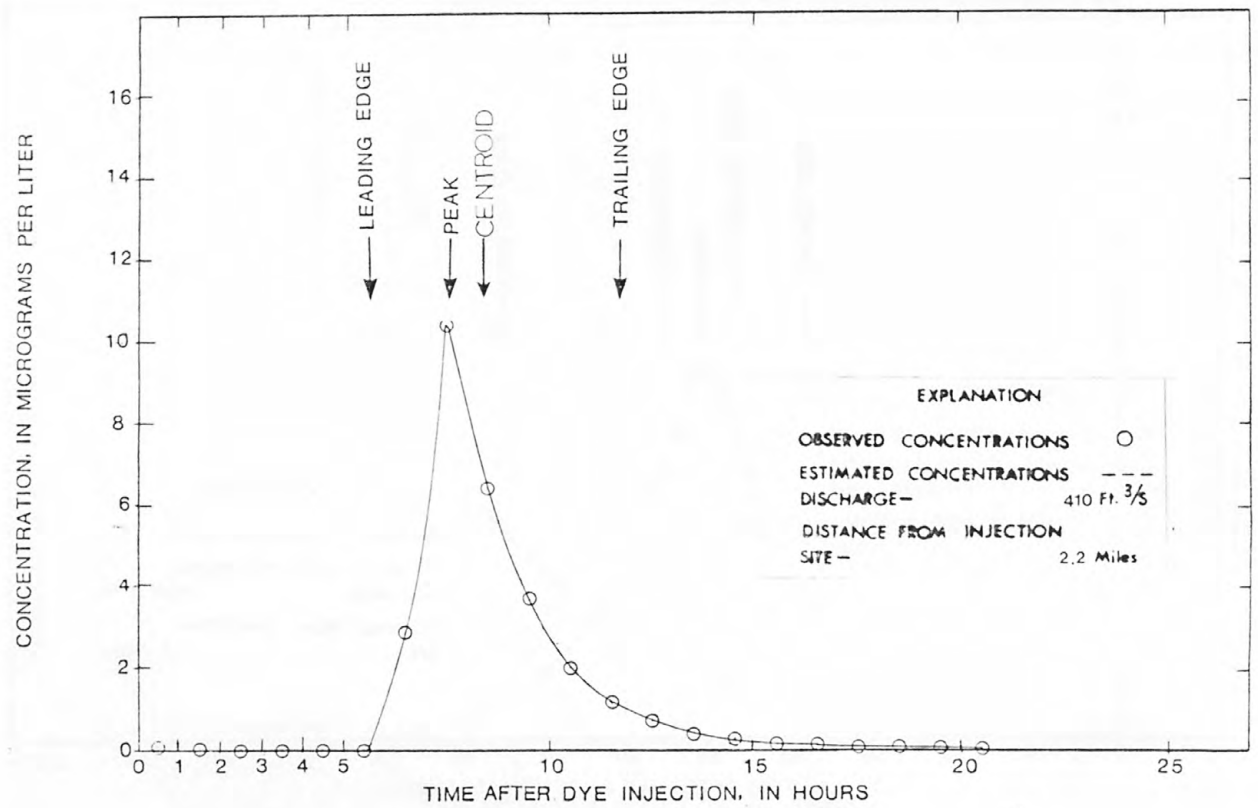

Figure A13.--Traveltime from Hartland versus concentration at Thompson Pits, Maine, June 11-12, 1979.

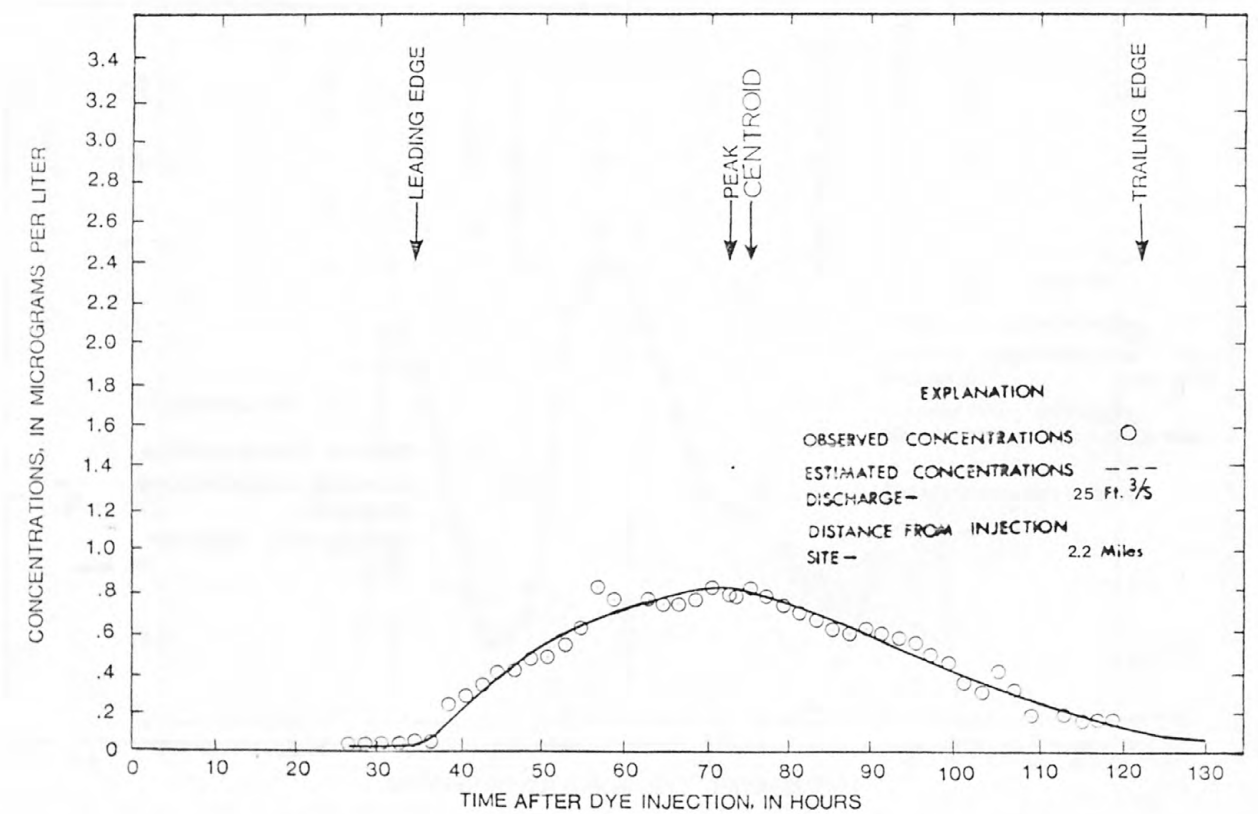

Figure A14.--Traveltime from Hartland versus concentration at Thompson Pits, Maine, July 23-29, 1979.

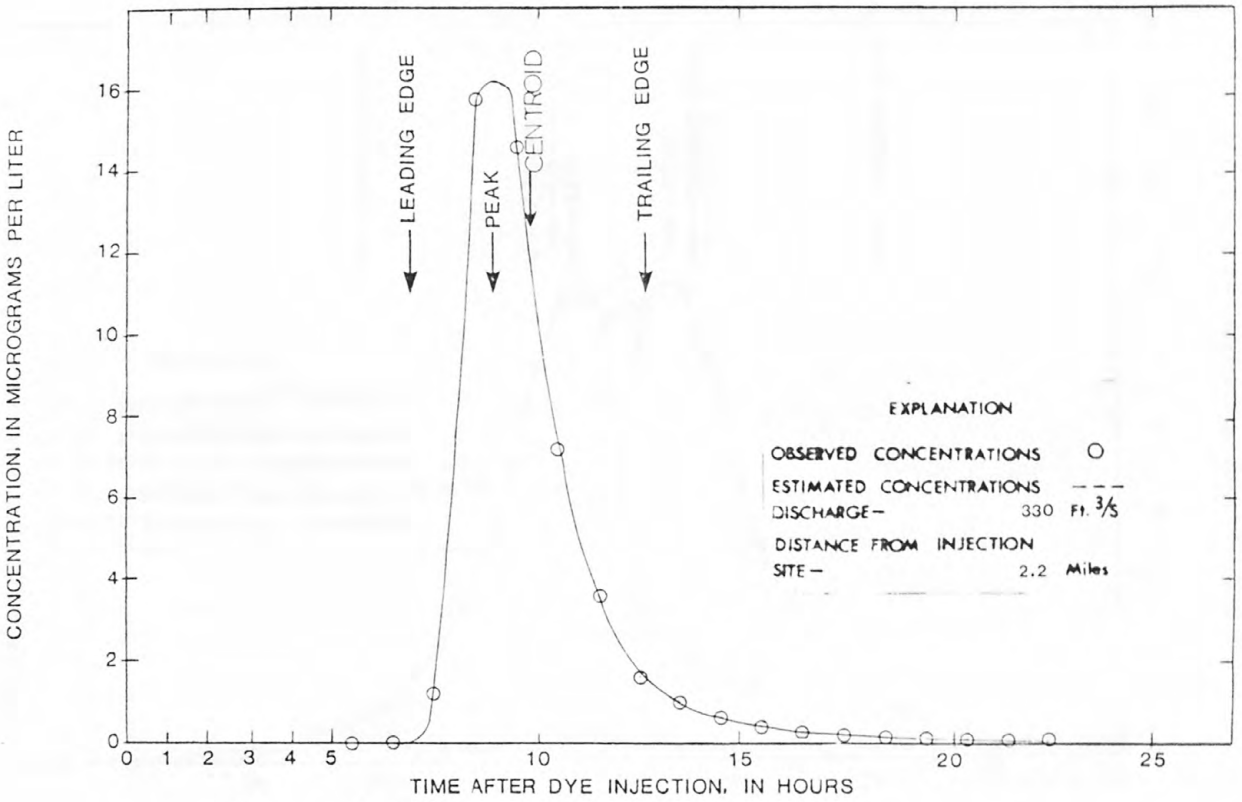

Figure A15.--Traveltime from Hartland versus concentration at Thompson Pits, Maine, October 29-30, 1979.

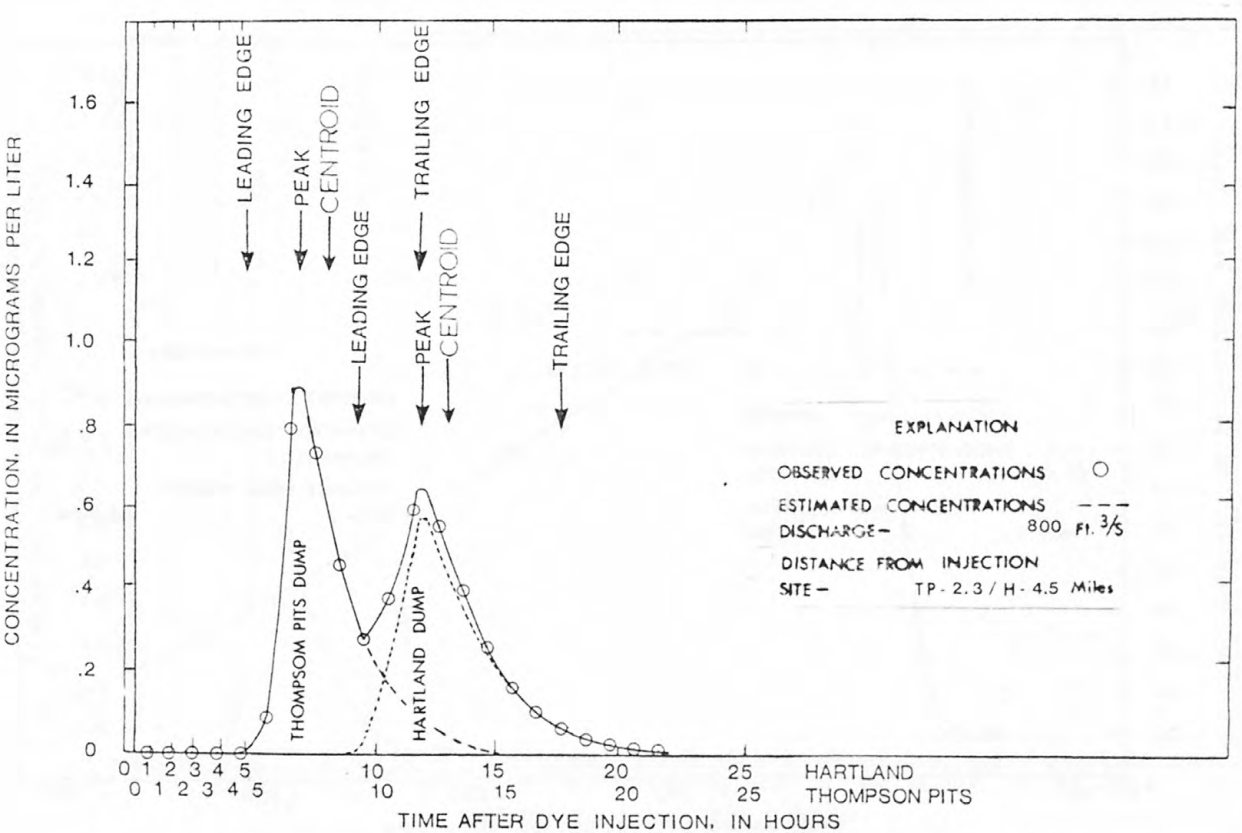

Figure A16.--Traveltime from Hartland and Thompson pits versus concentration at West Palmyra, Maine, June 7-8, 1979.

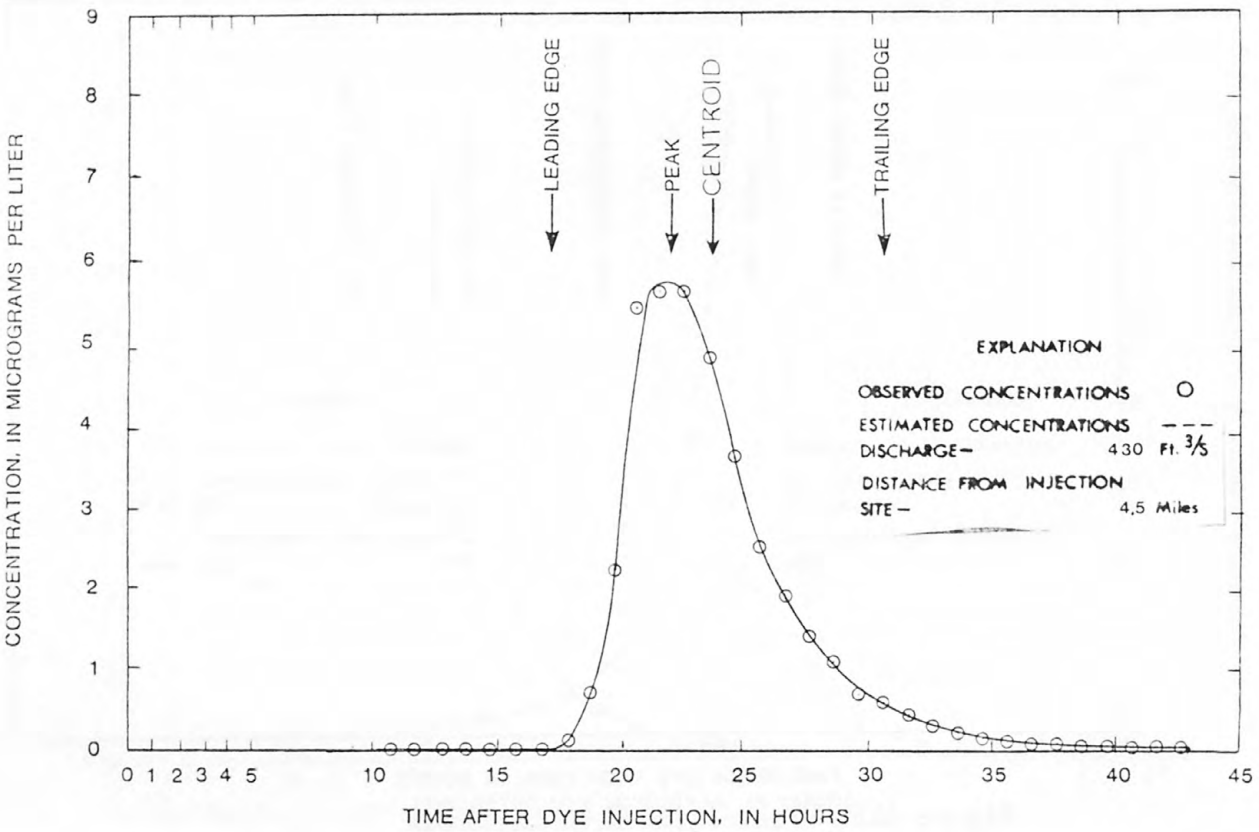

Figure A17.--Traveltime from Hartland versus concentration at West Palmyra, Maine, June 11-12, 1979.

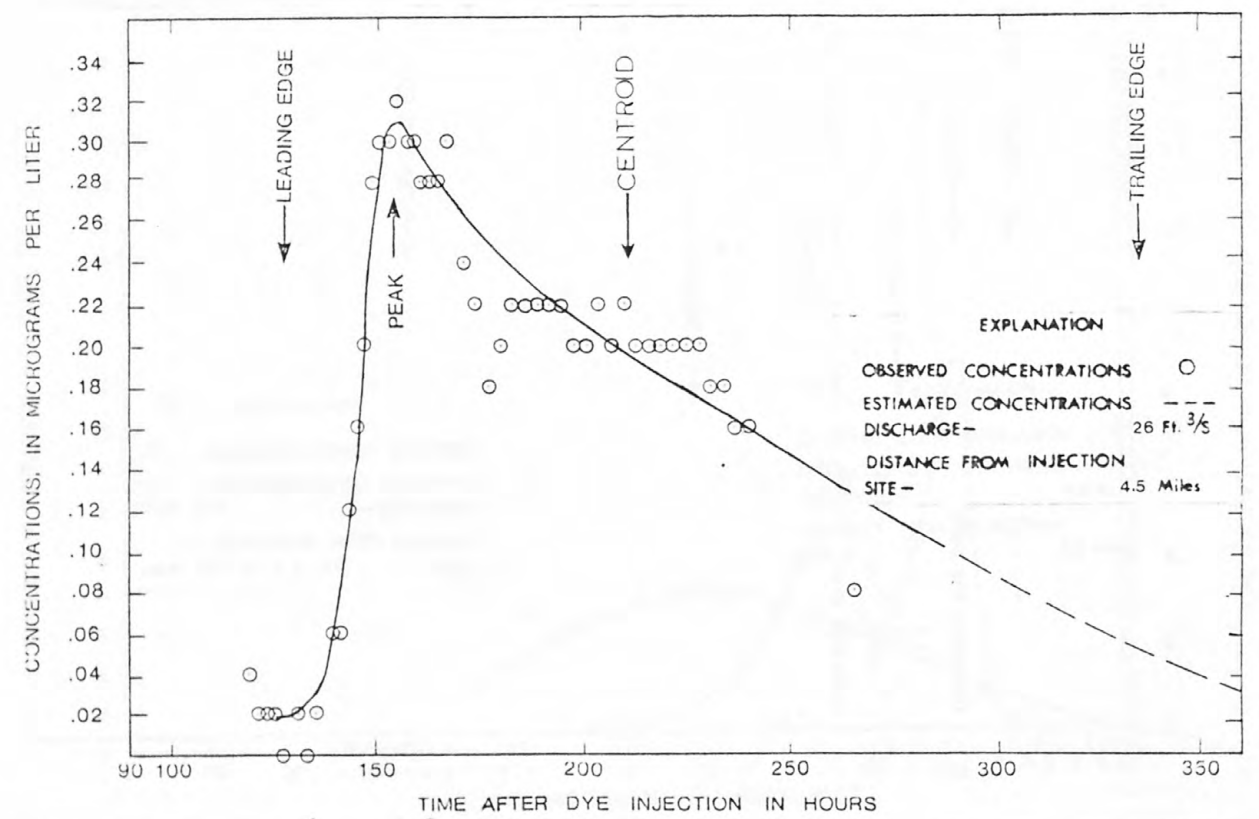

Figure A18.--Traveltime from Hartland versus concentration at West Palmyra, Maine, July 23-August 3, 1979.

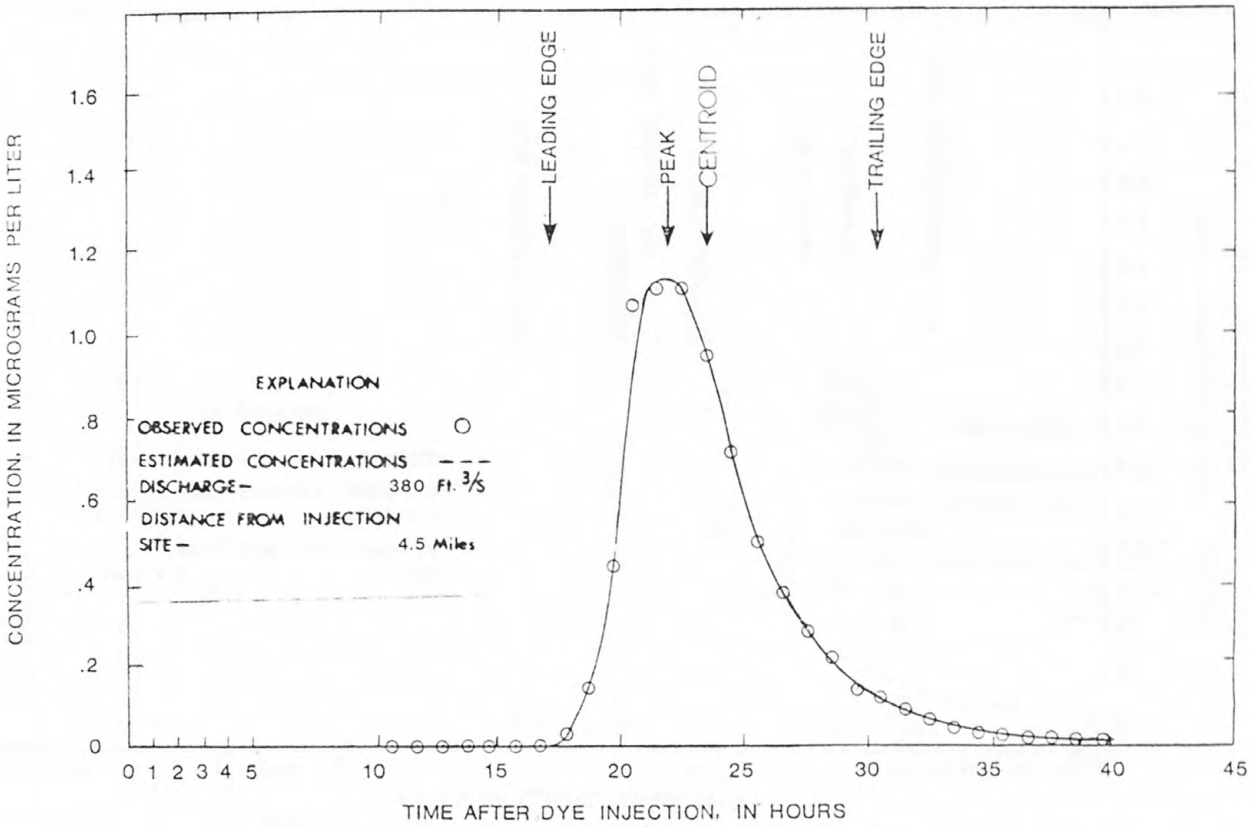

Figure A19.--Traveltime from Hartland versus concentration at West Palmyra, Maine, October 29-31, 1979.

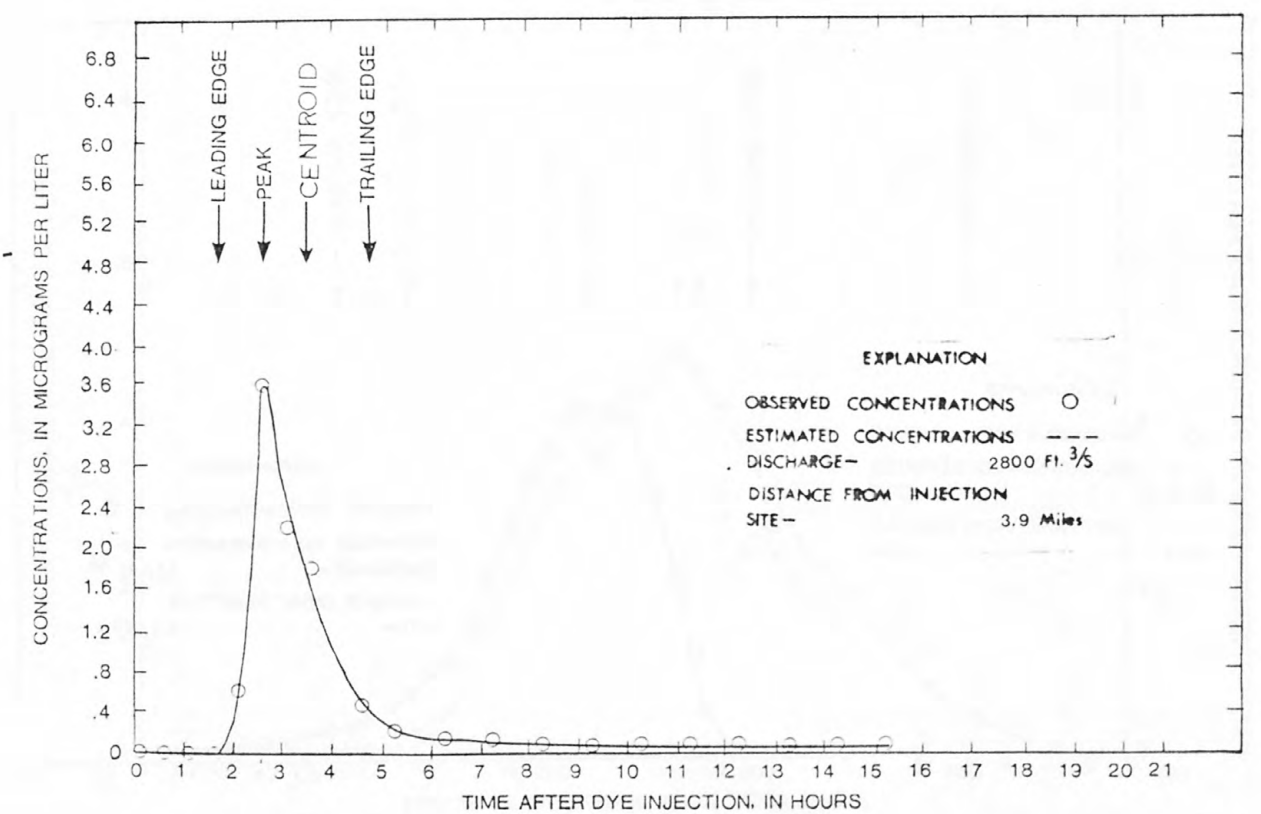

Figure A20.--Traveltime from Pittsfield versus concentration at Peltoma bridge near Pittsfield, Maine, June 4-5, 1979.

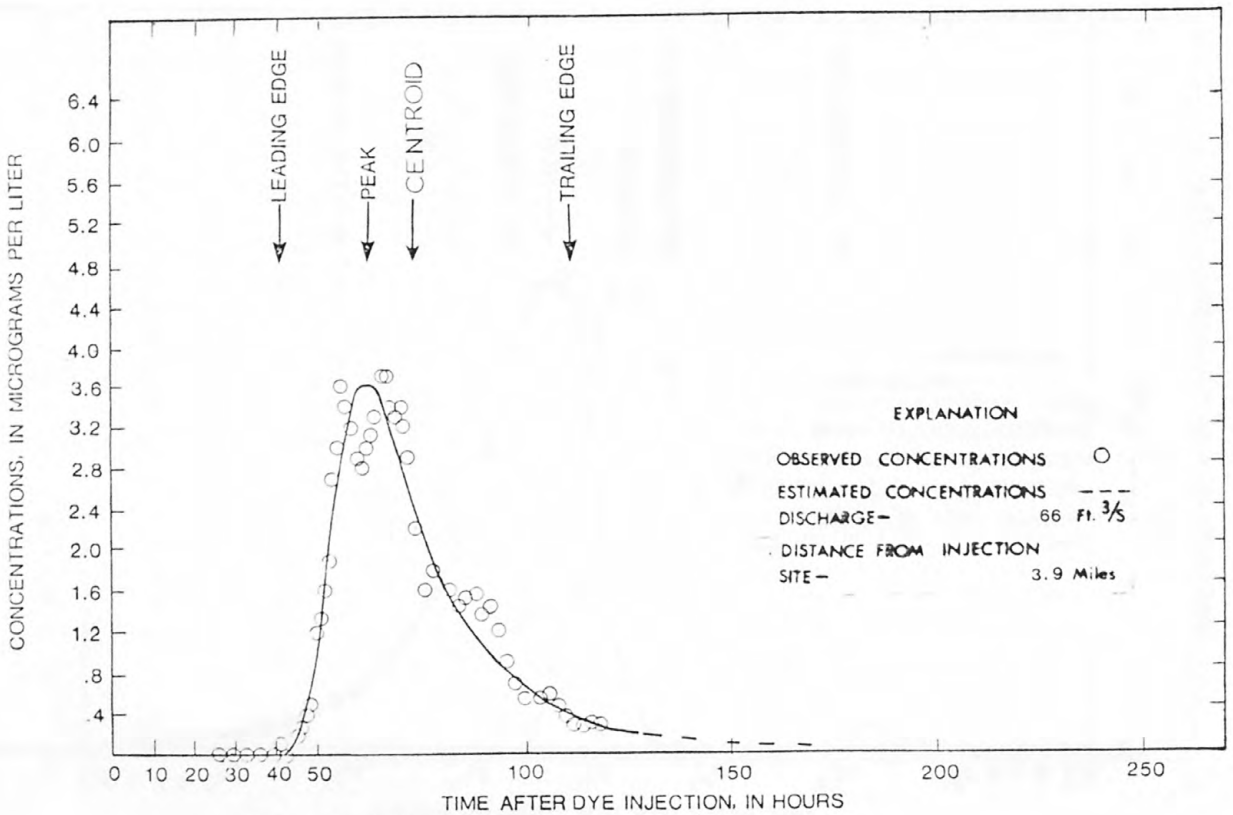

Figure A21.--Traveltime from Pittsfield versus concentration at Peltoma bridge near Pittsfield, Maine, July 17-22, 1979.

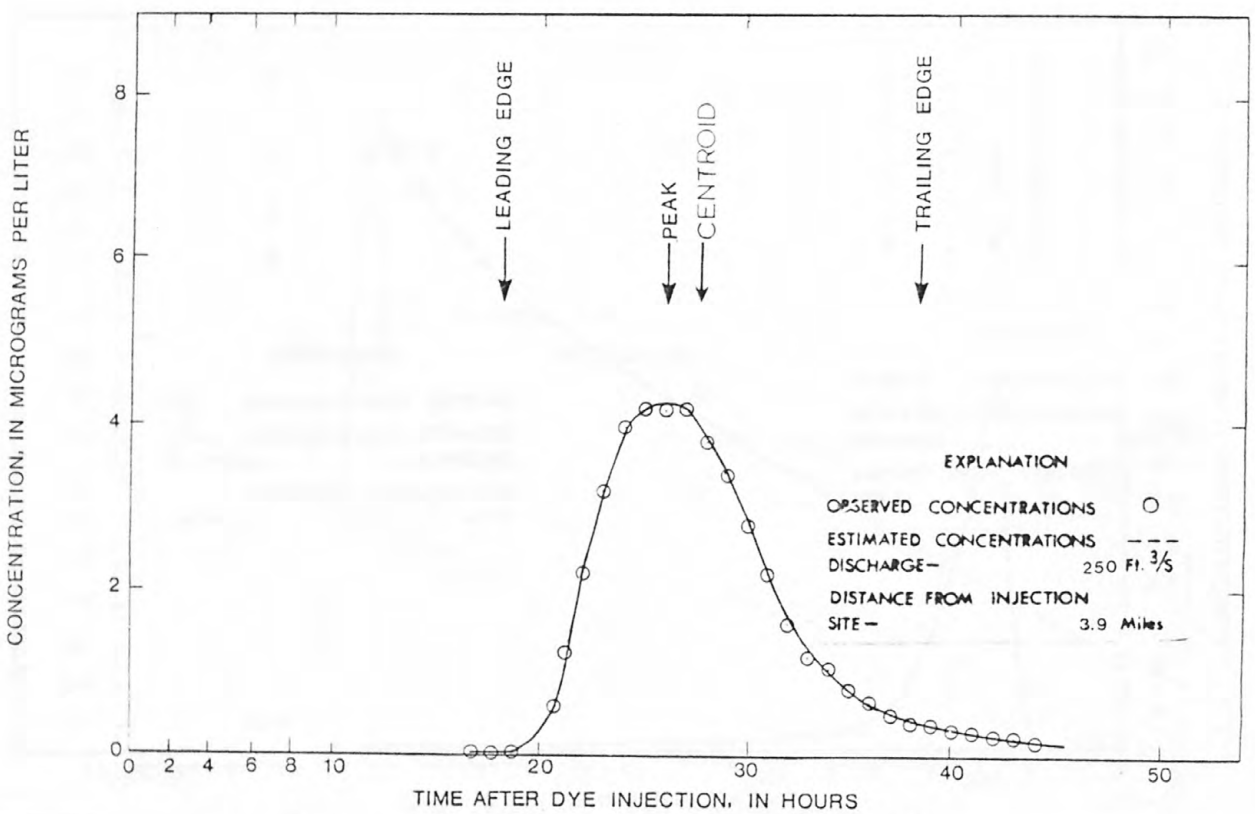

Figure A22.--Travel time from Pittsfield versus concentration at Peltoma bridge near Pittsfield, Maine, September 18-21, 1979.

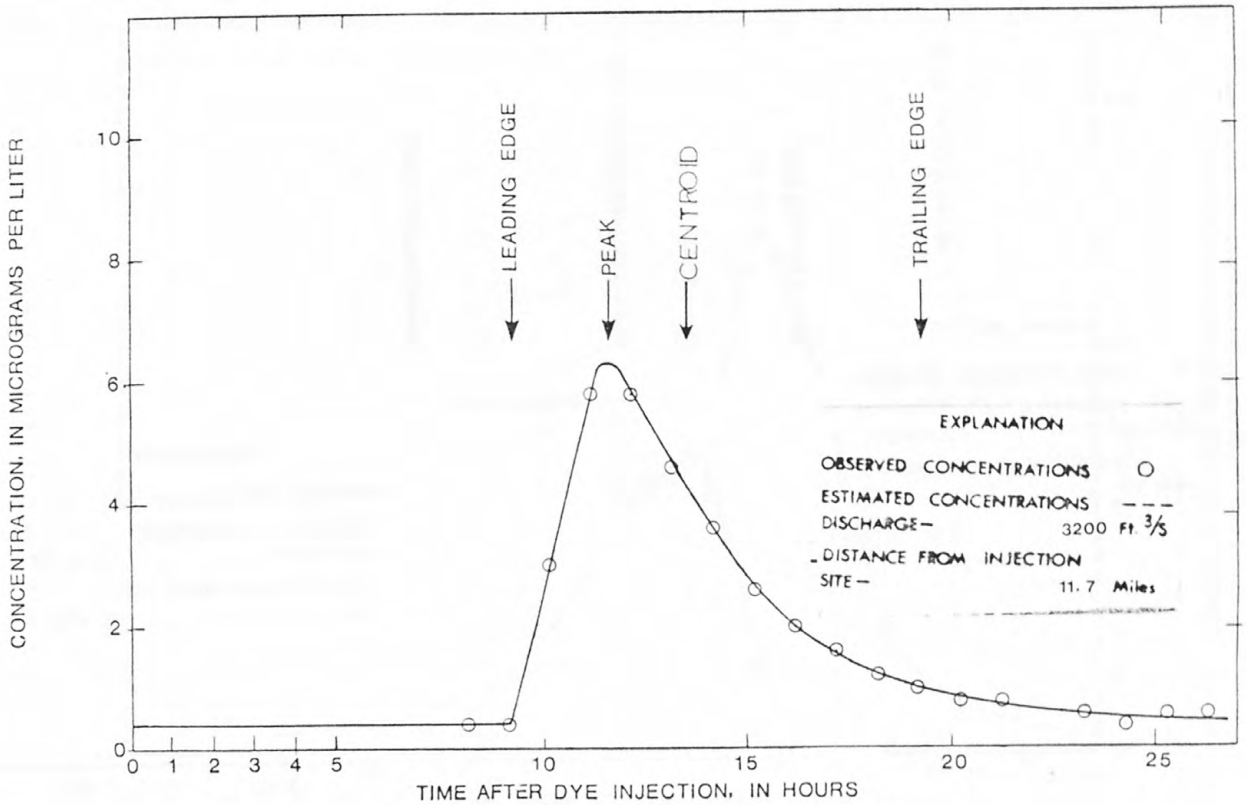

Figure A23.--Traveltime from Pittsfield versus concentration at Burnham, Maine, June 4-5, 1979.

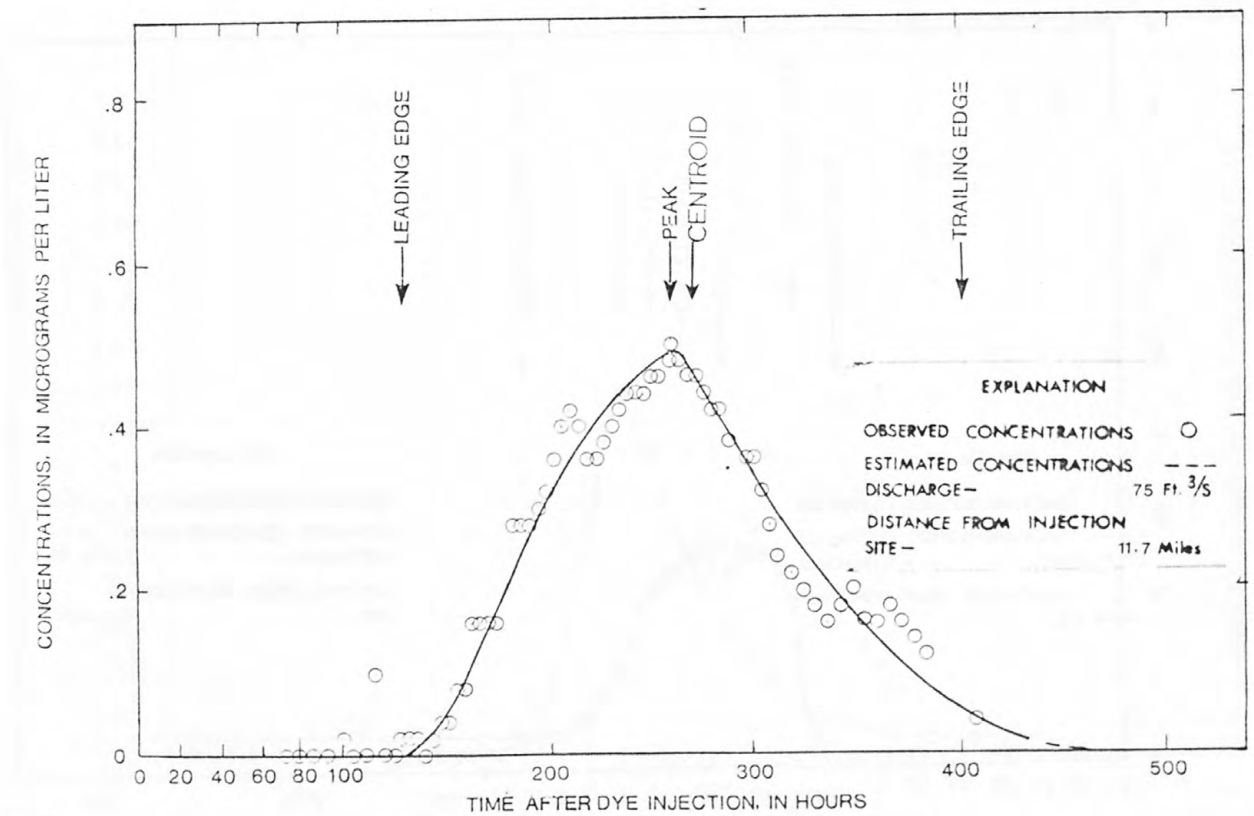

Figure A24.--Traveltime from Pittsfield versus concentration at Burnham, Maine, July 17-August 3, 1979.

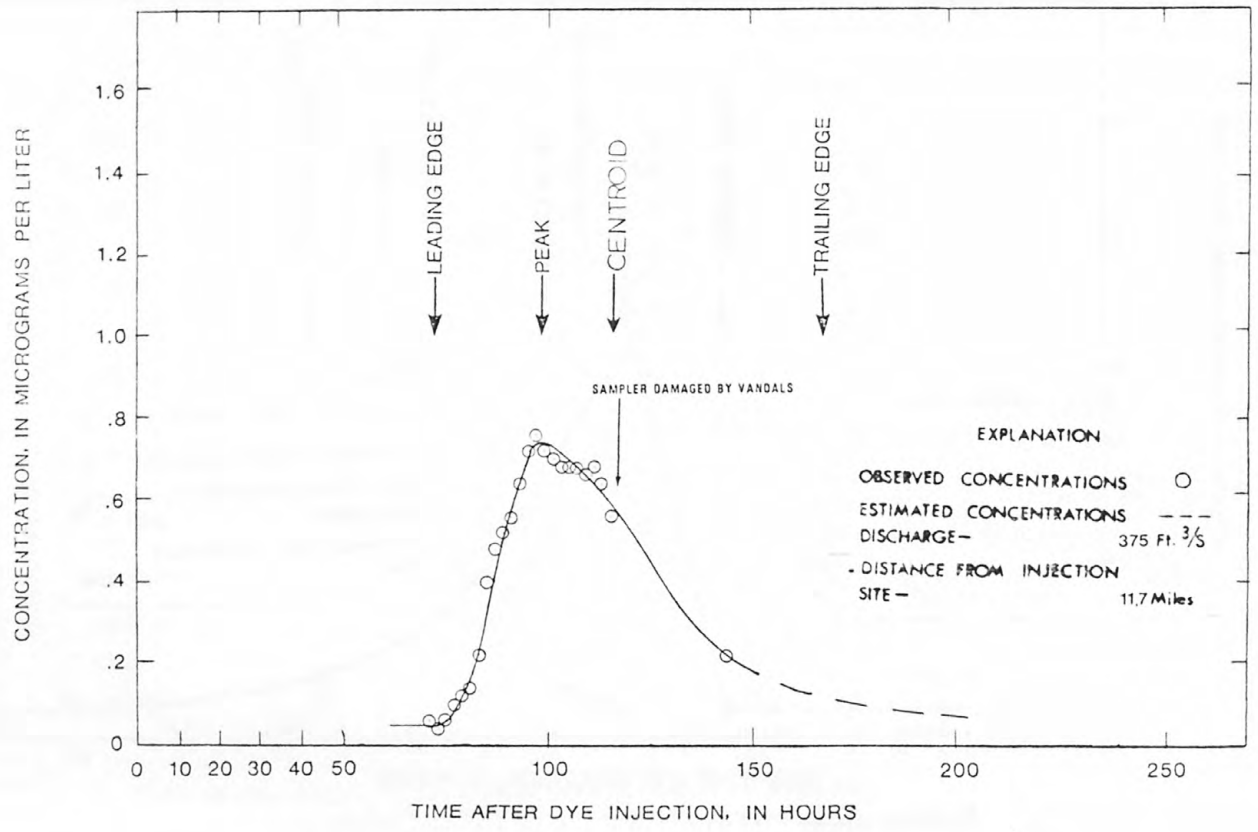

Figure A25.--Traveltime from Pittsfield versus concentration at Burnham, Maine, September 18-24, 1979.

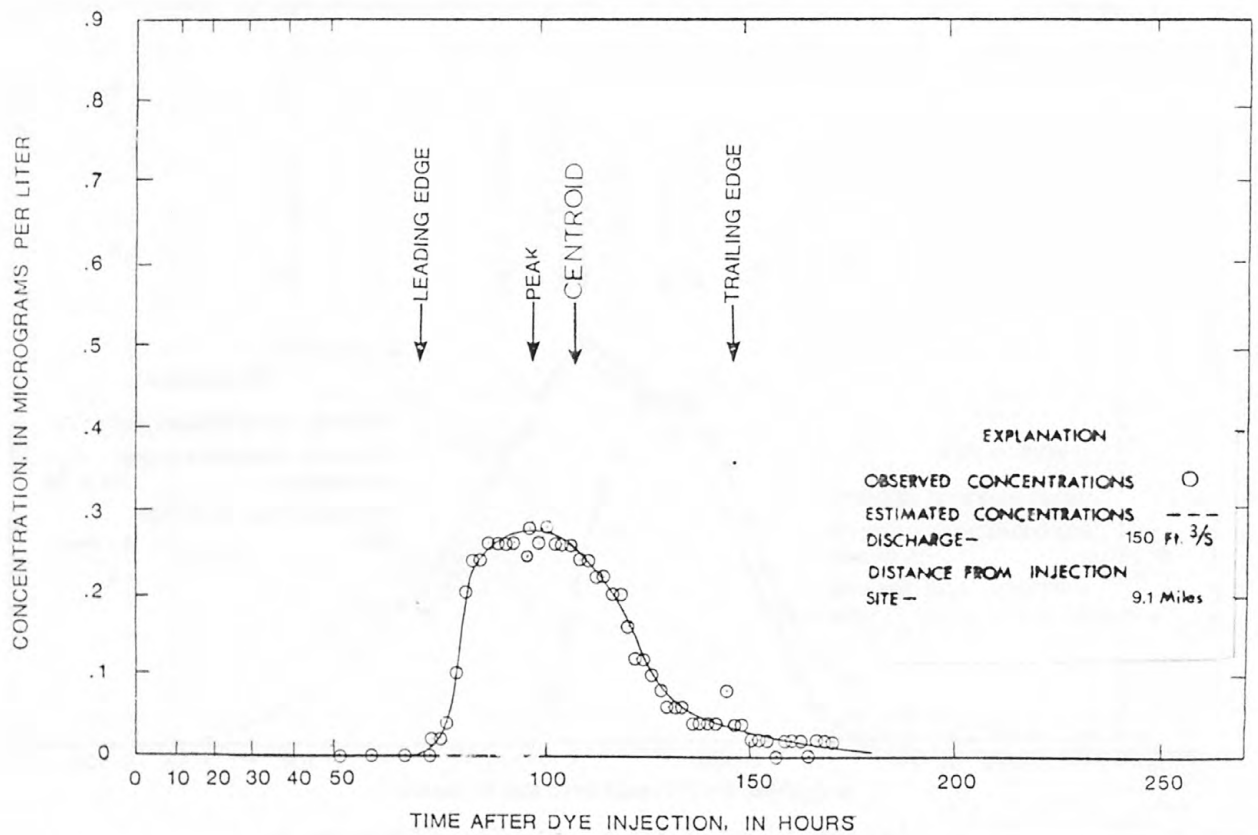

Figure A26.--Traveltime from Burnham versus concentration at Clinton, Maine, July 17-24, 1979.

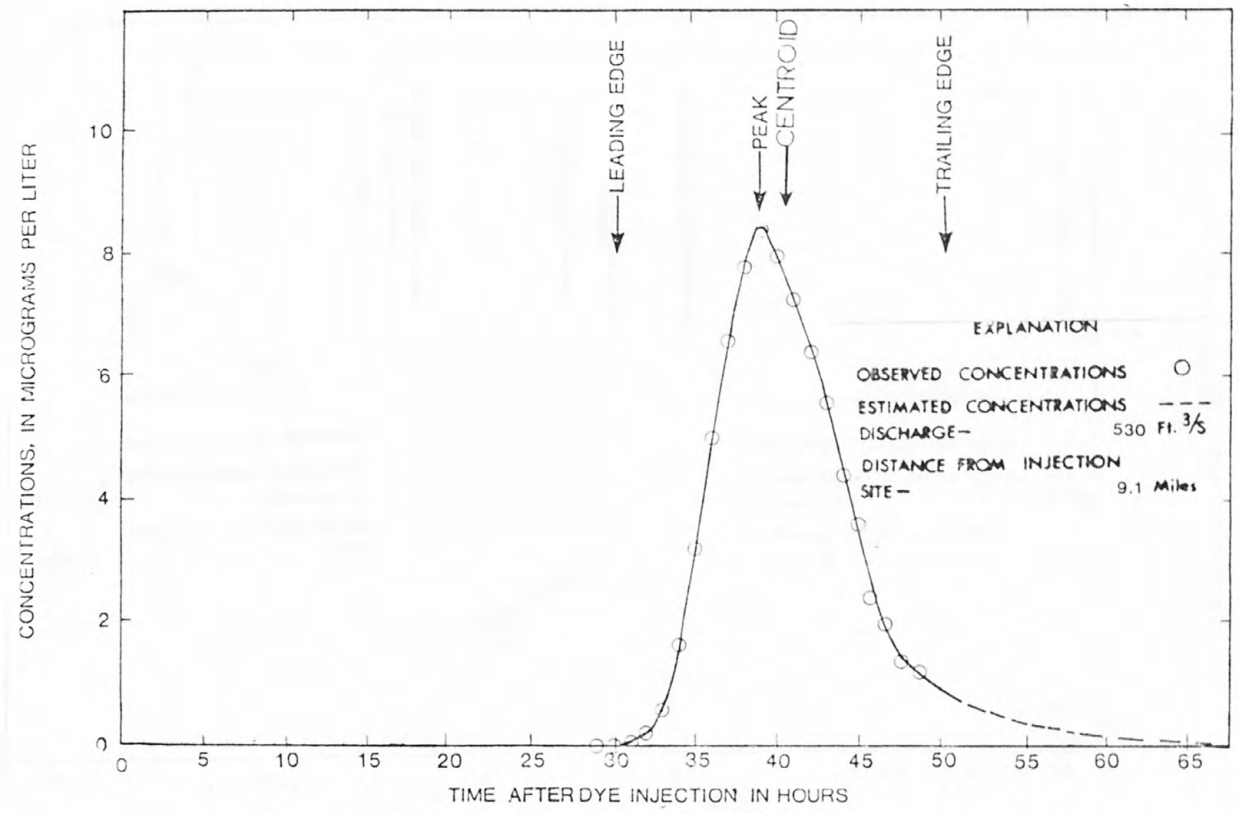

Figure A27.--Traveltime from Burnham versus concentration at Clinton, Maine, September 18-20, 1979.

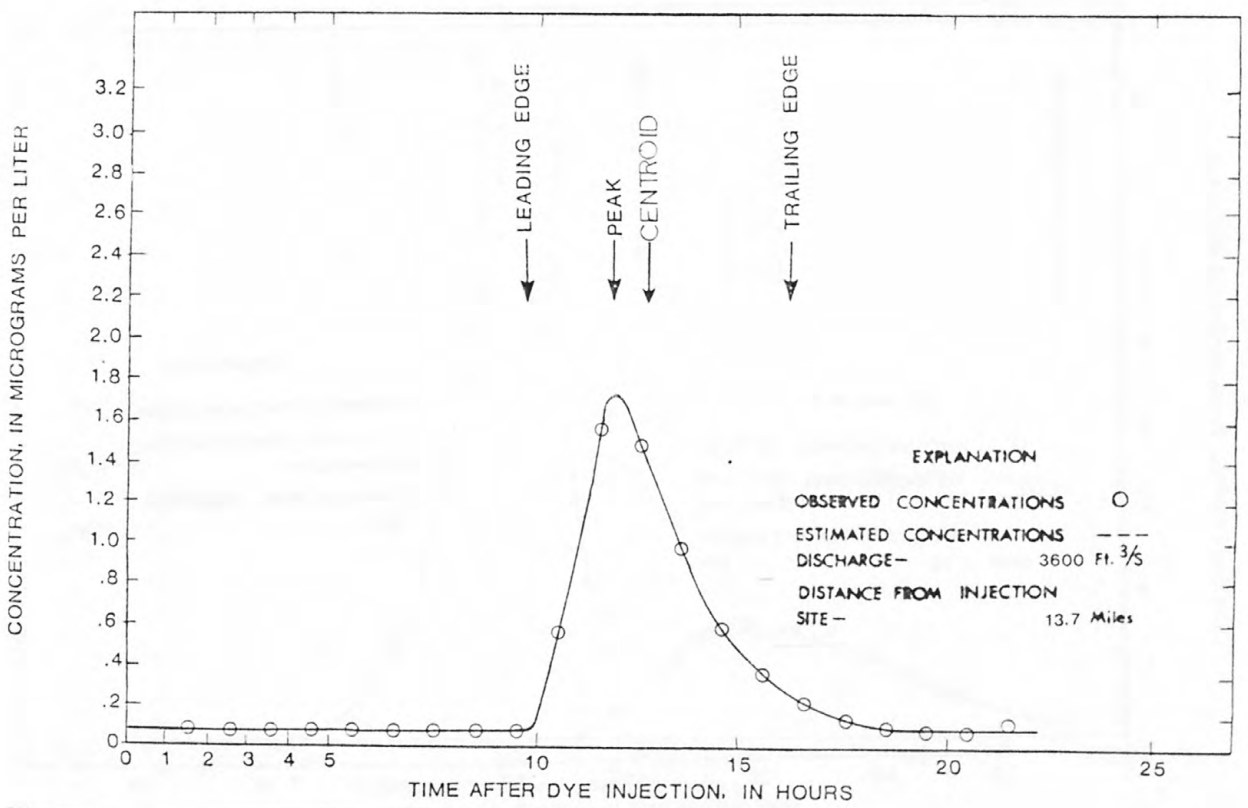

Figure A28.--Traveltime from Burnham versus concentration at Benton, Maine, June 6-7, 1979.

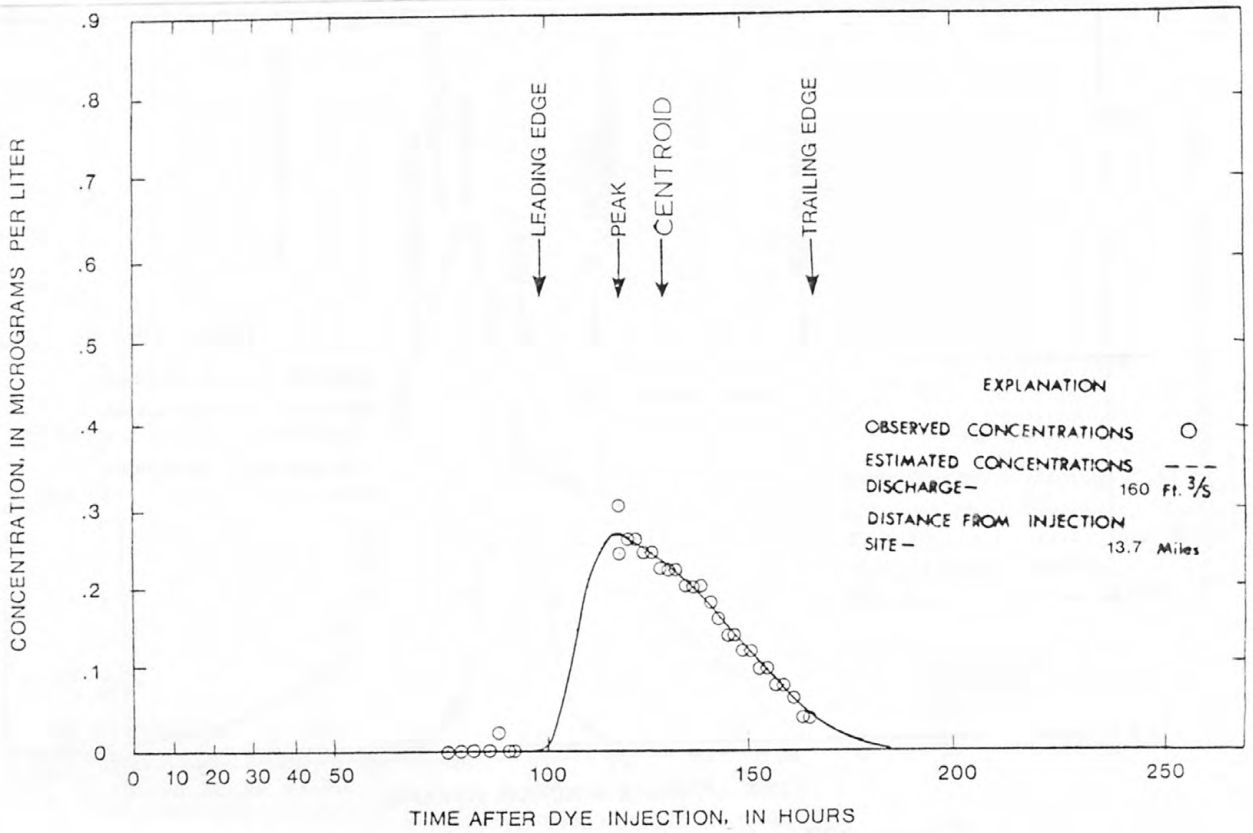

Figure A29.--Traveltime from Burnham versus concentration at Benton, Maine, July 17-24, 1979.

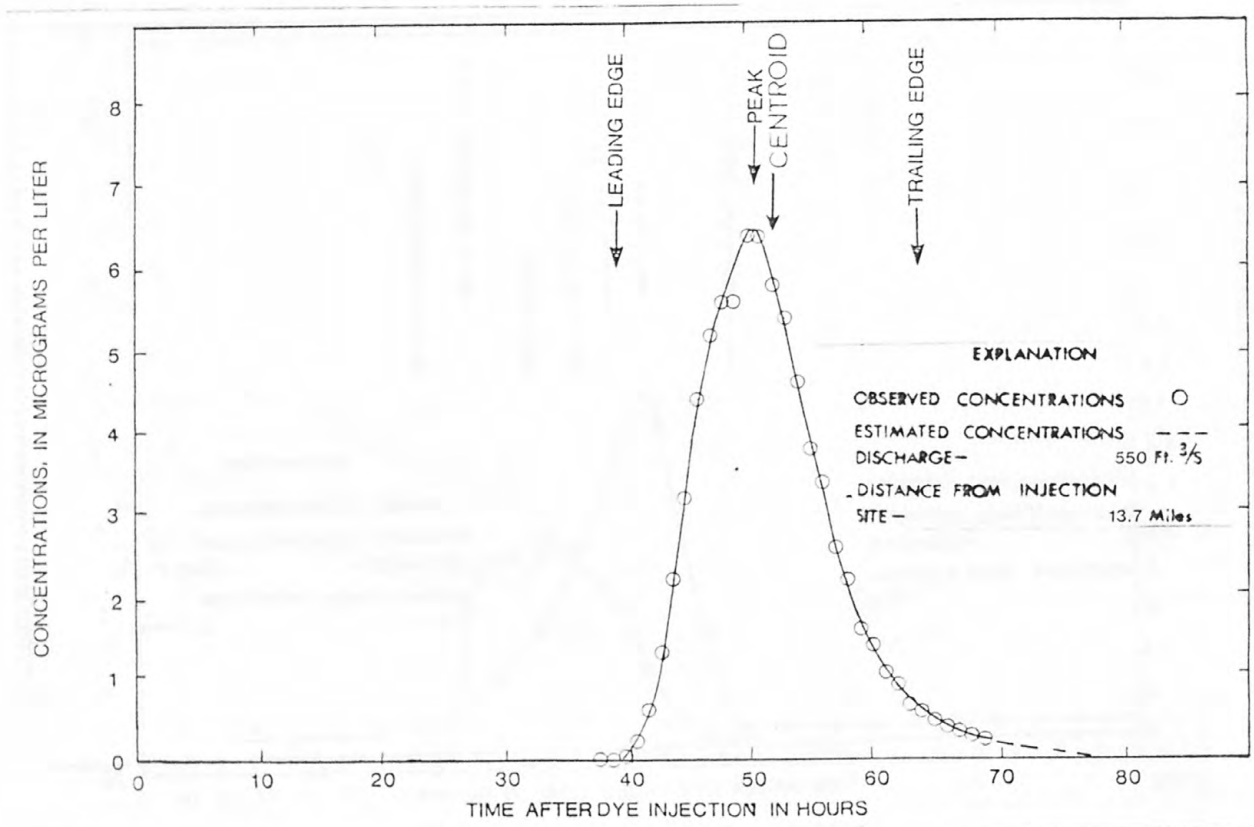

Figure A30.--Traveltime from Burnham versus concentration at Benton, Maine, September 18-21, 1979.

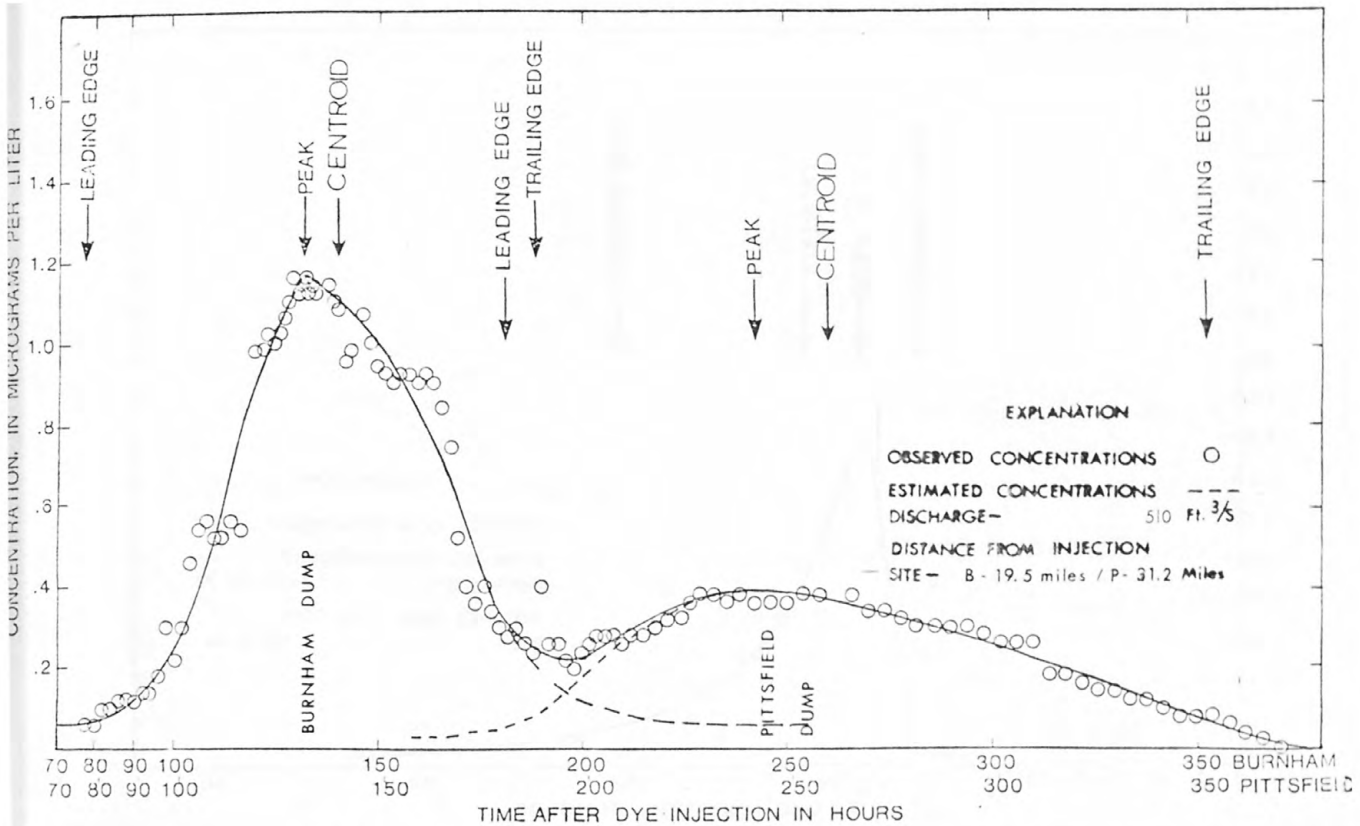

Figure A31.--Traveltime from Burnham and Pittsfield versus concentration at Winslow, Maine, September 18-October 2, 1979.

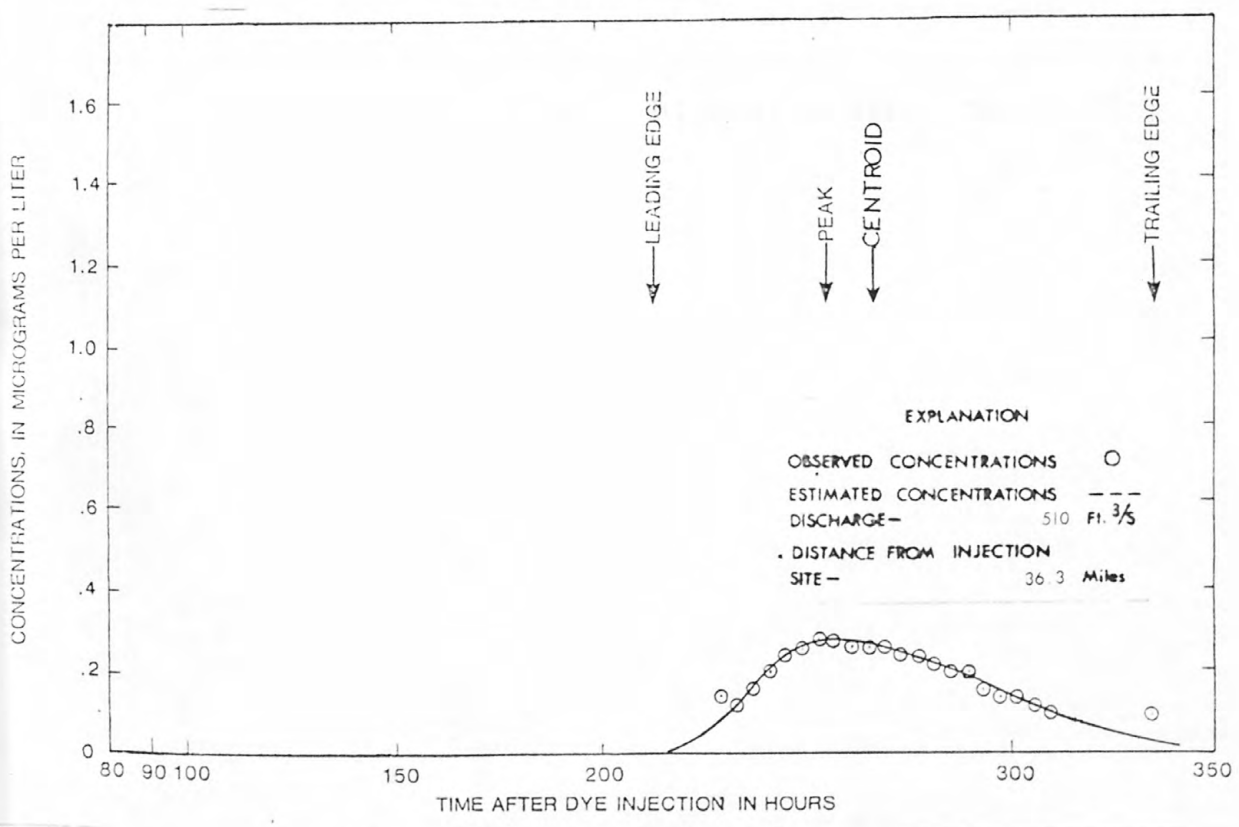

Figure A32.--Traveltime from Newport versus concentration at Winslow, Maine, September 25-October 10, 1979.

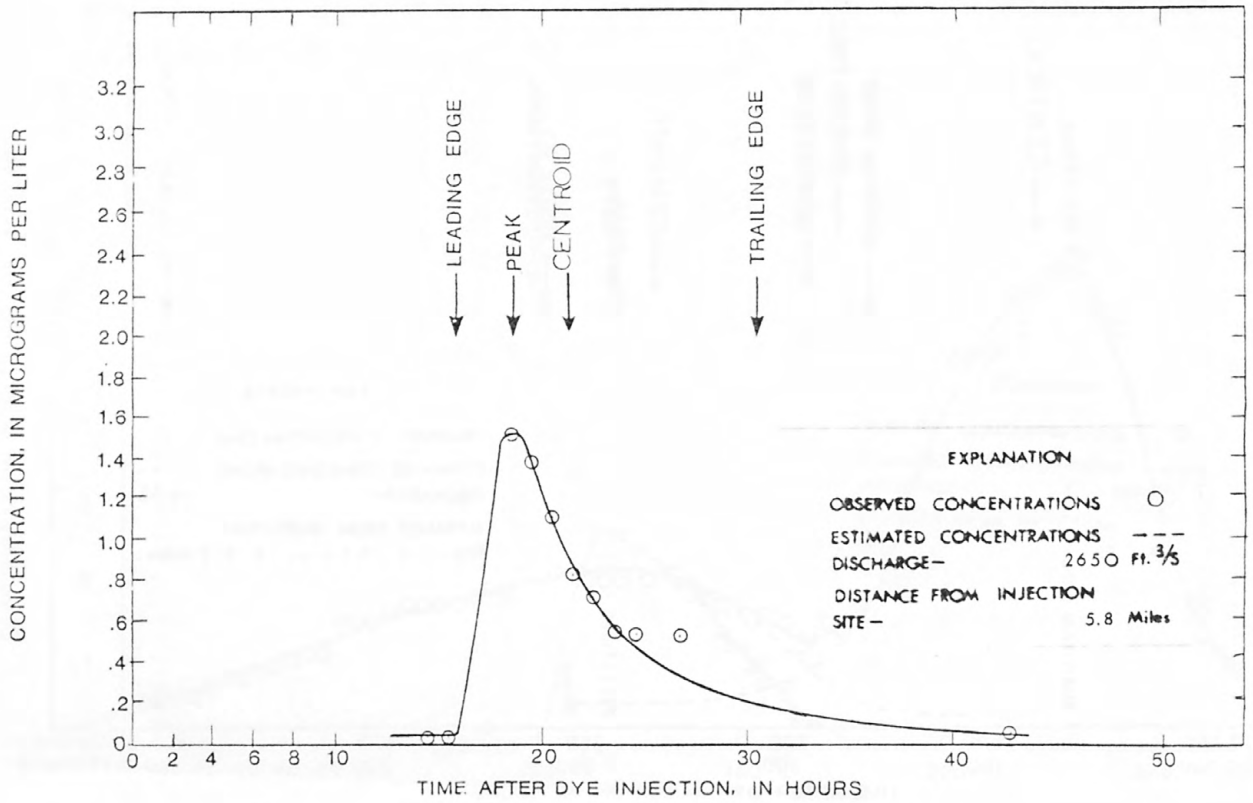

Figure A33.--Traveltime from Benton versus concentration at Winslow, Maine, November 15-17, 1979.

APPENDIX B

TIME VERSUS DISCHARGE RELATIONS

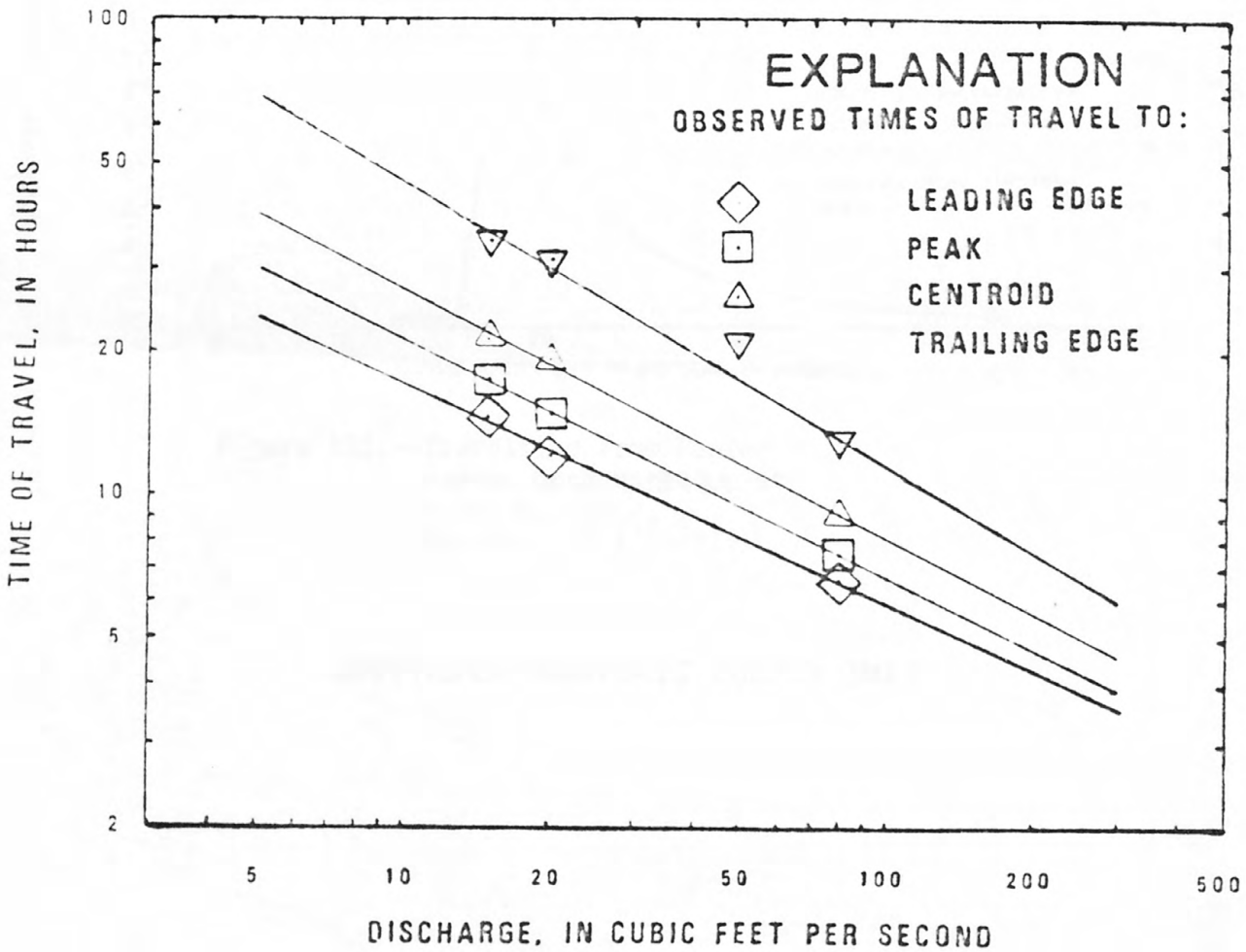

Figure B1.--Time-of-travel versus discharge, Dexter to Lincoln Mills, Maine.

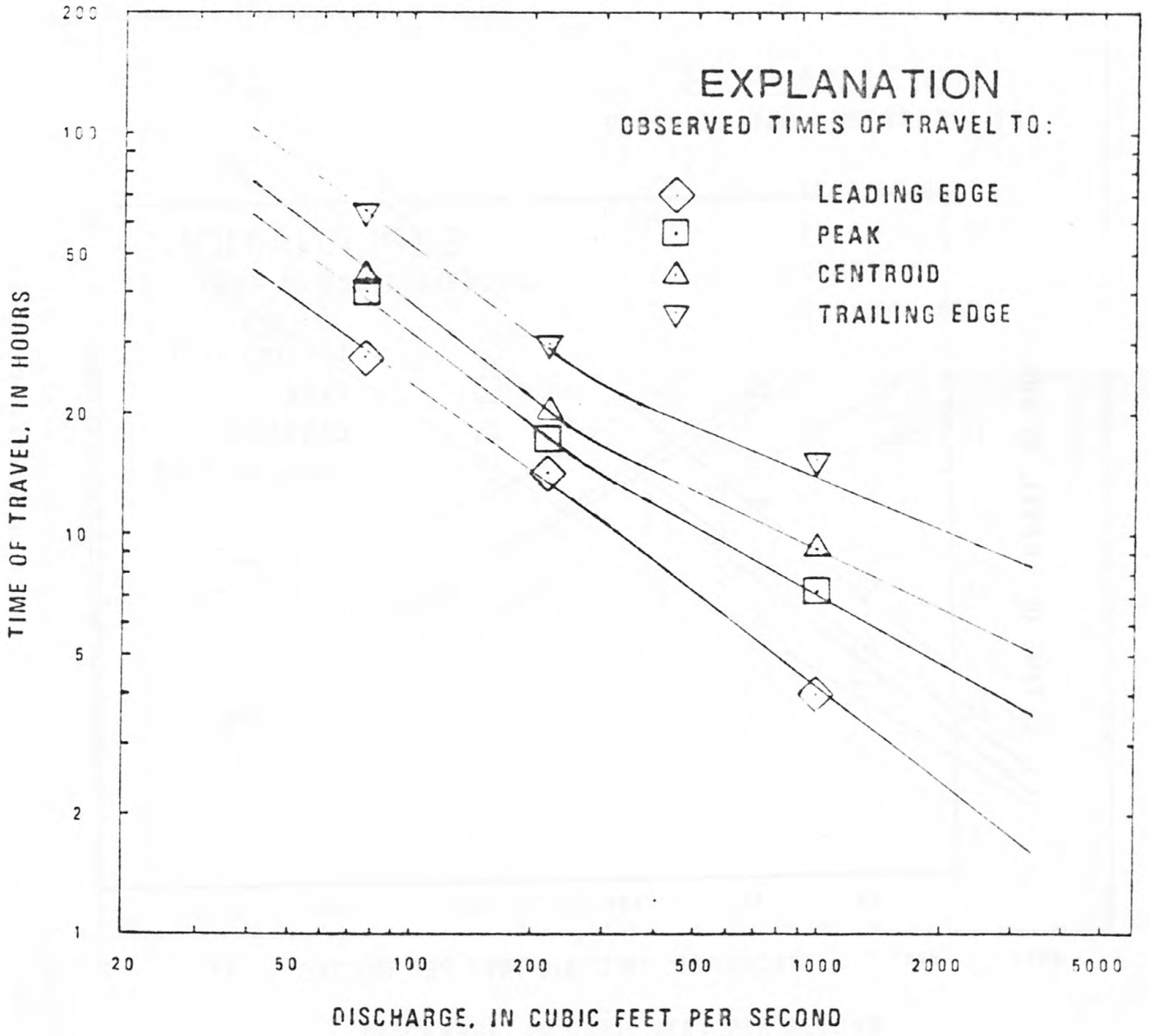

Figure B2.--Time-of-travel versus discharge Newport to Detroit, Maine.

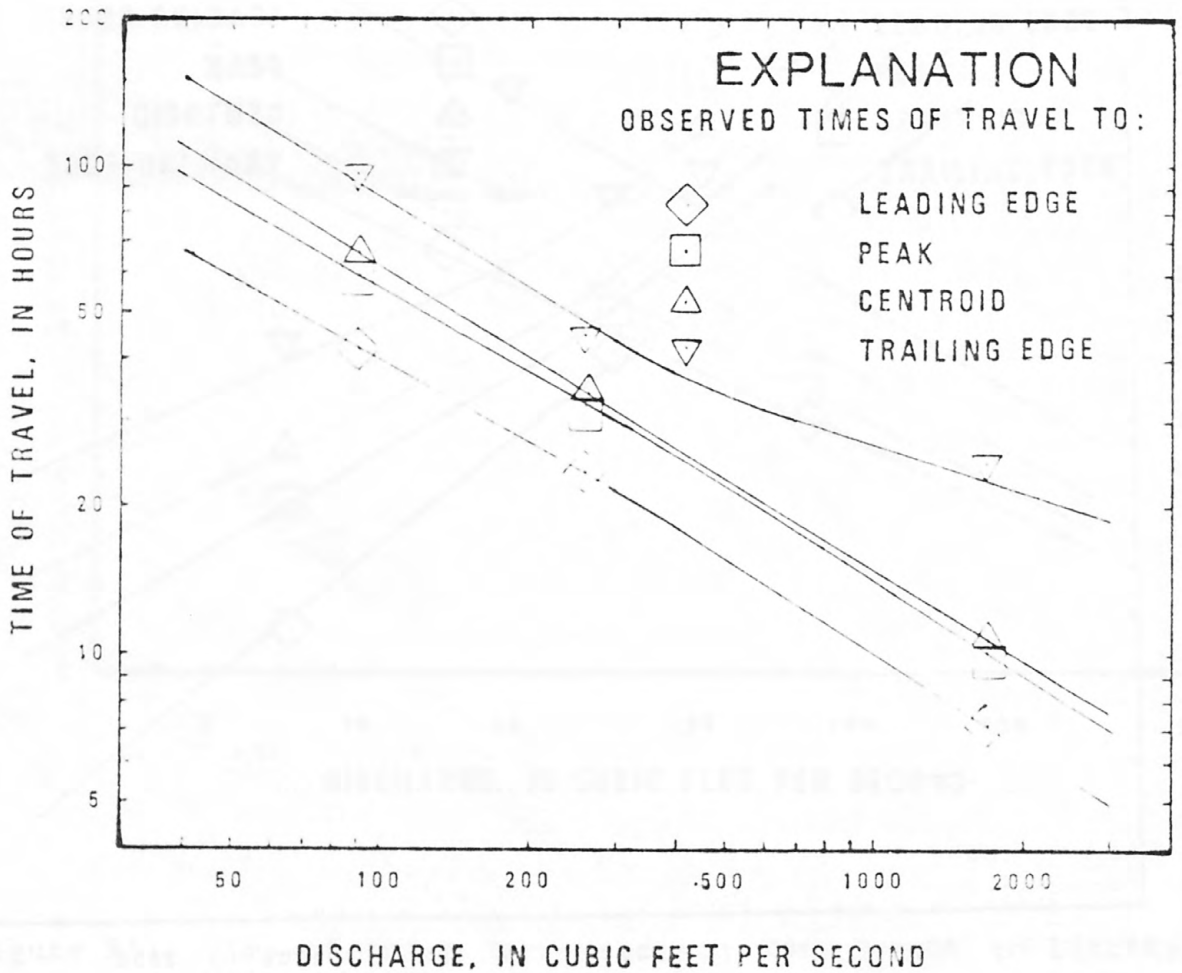

Figure B3.--Time-of-travel versus discharge Detroit to Peltoma bridge, near Pittsfield, Maine.

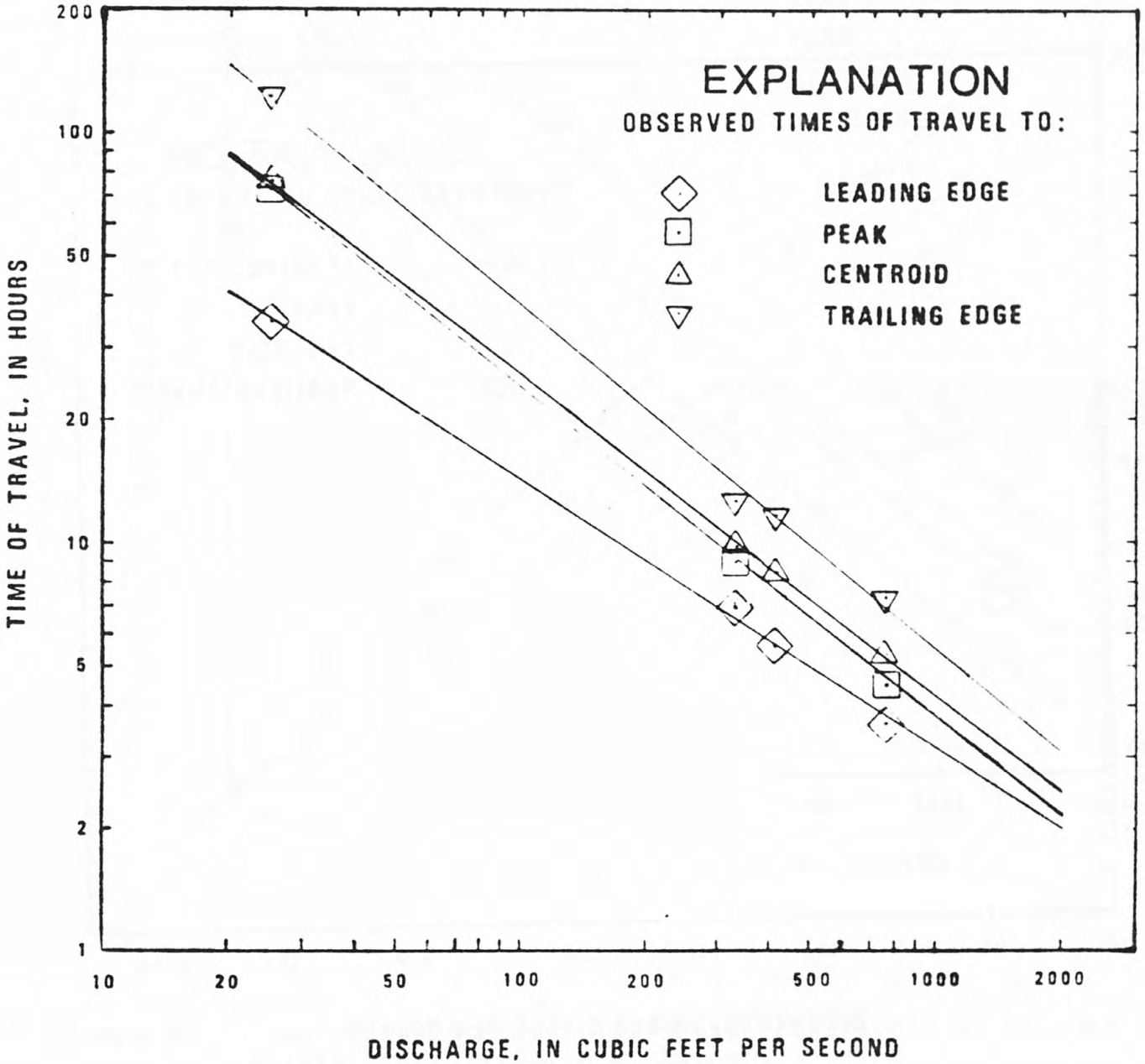

Figure B4.--Time-of-travel versus discharge Hartland to Thompson pits, Maine.

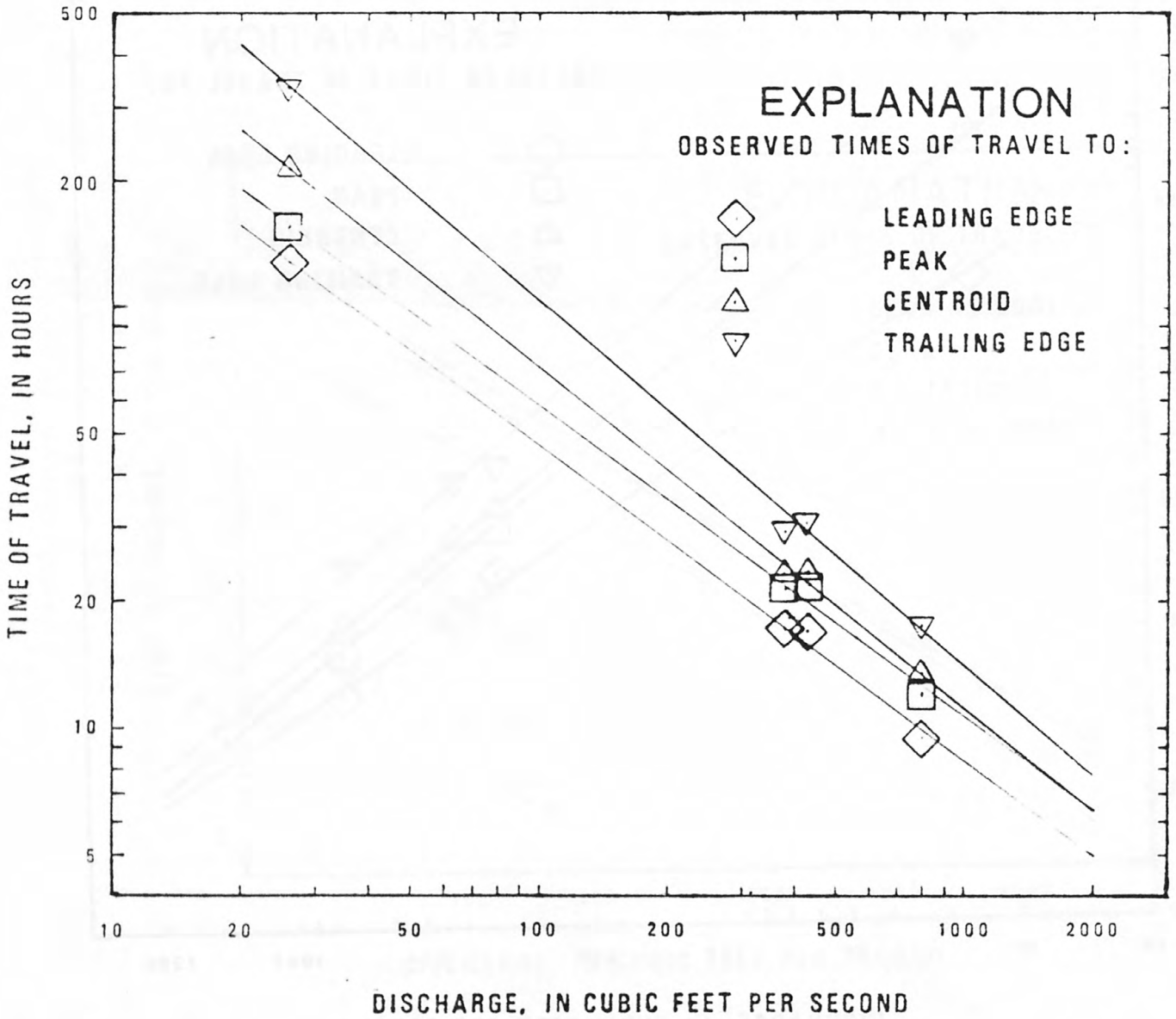

Figure B5.--Time-of-travel versus discharge Hartland to West Palmyra, Maine.

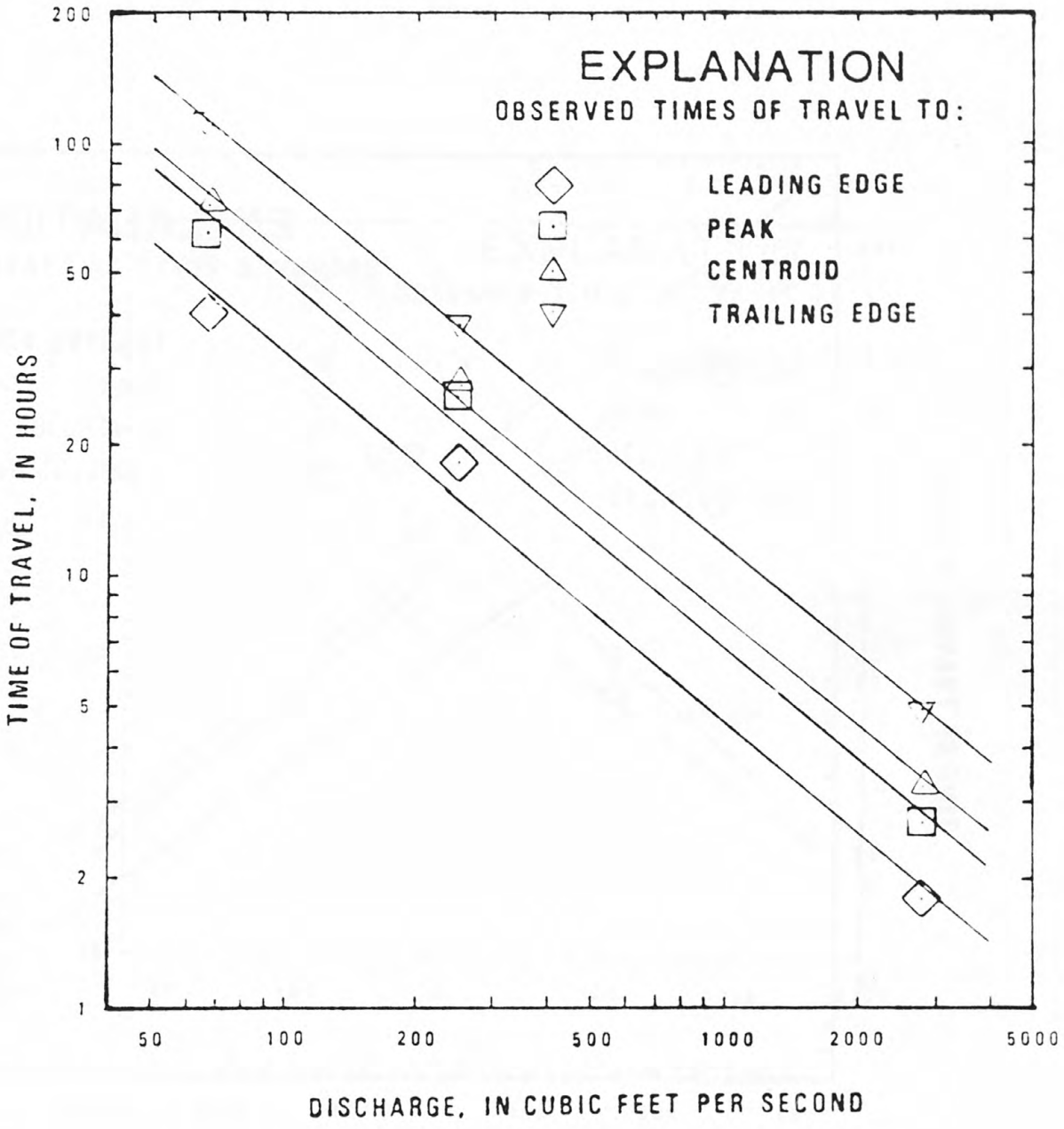

Figure B6.--Time-of-travel versus discharge Pittsfield to Peltoma bridge, near Pittsfield, Maine.

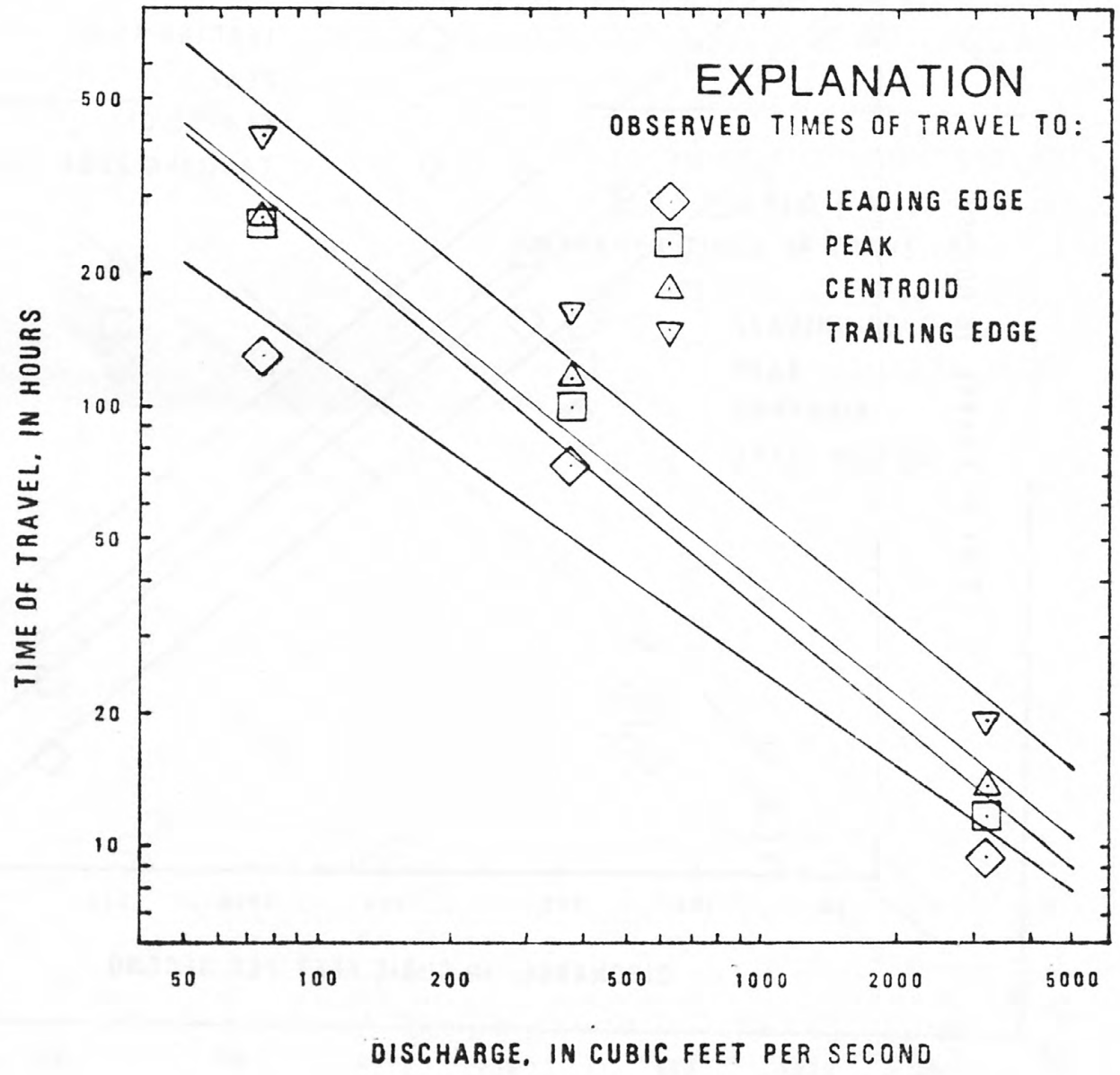

Figure B7.--Time-of-travel versus discharge Pittsfield to Burnham, Maine.

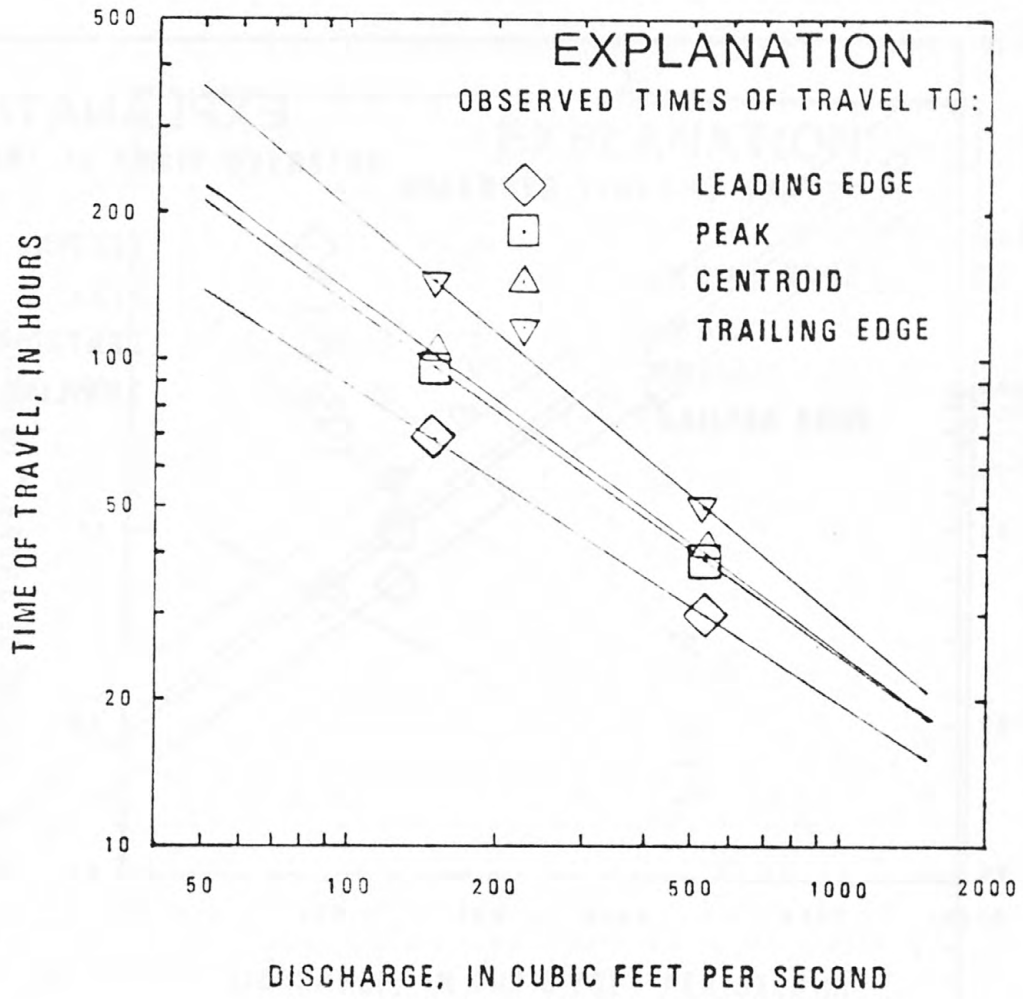

Figure B8.--Time-of-travel versus discharge Burnham to Clinton, Maine.

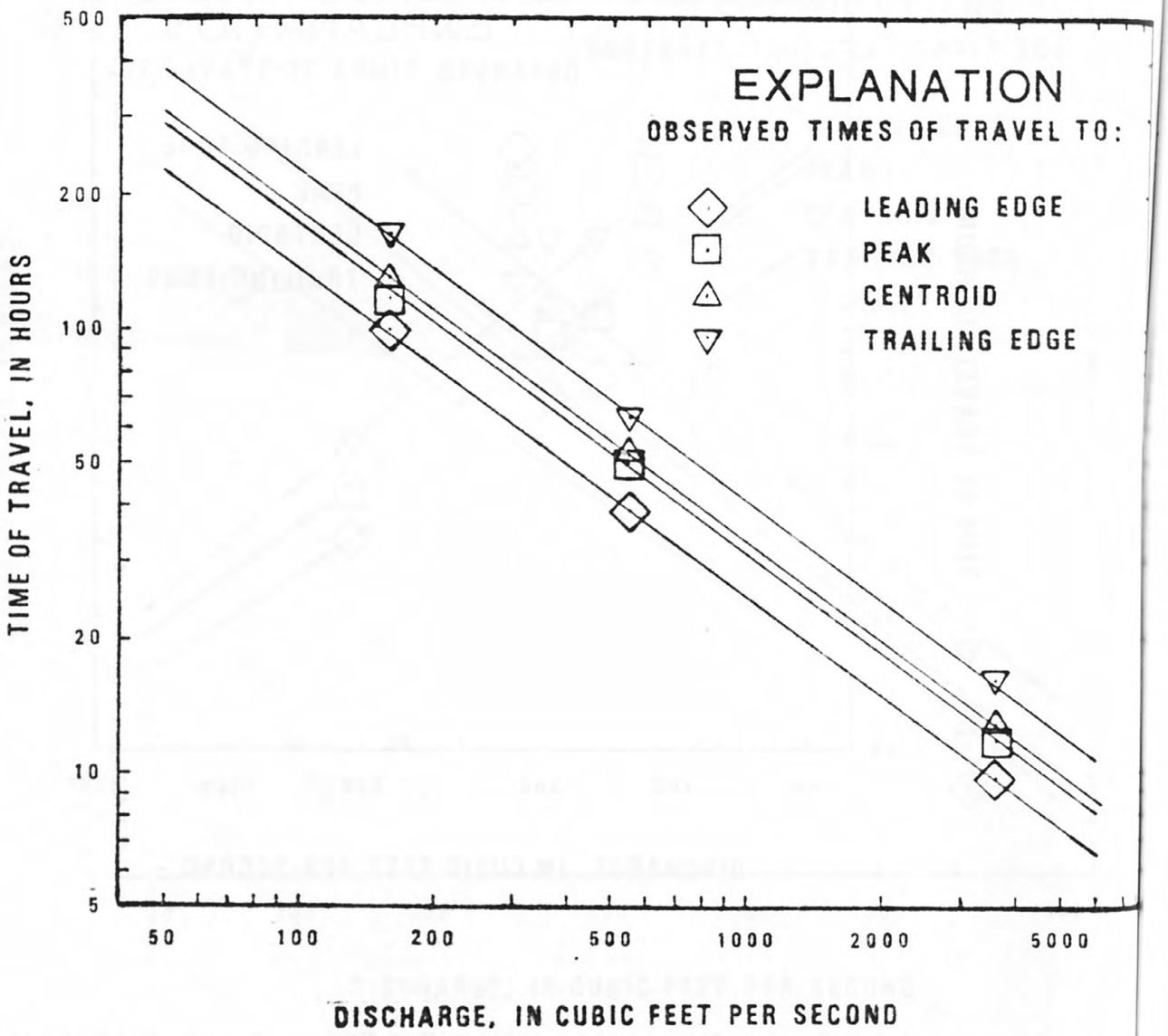

Figure B9.--Time-of-travel versus discharge Burnham to Benton, Maine.

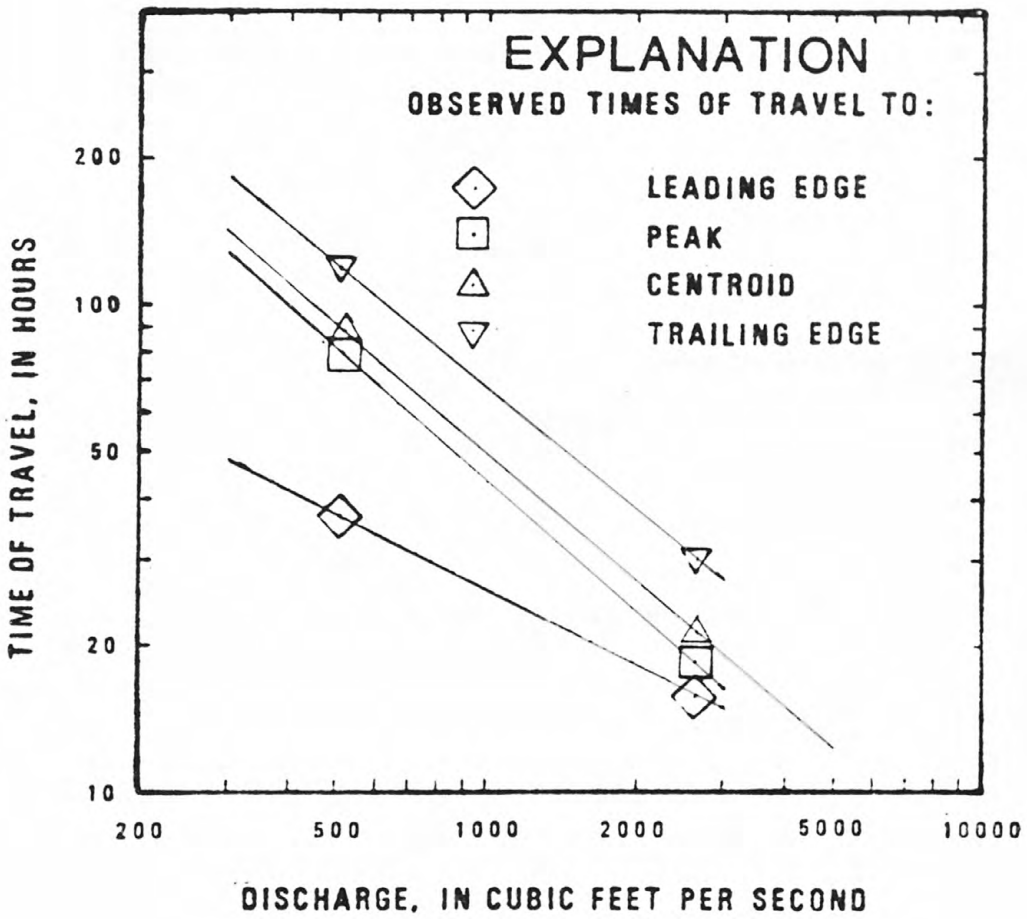

Figure B10.--Time-of-travel versus discharge Benton to Winslow, Maine.

APPENDIX C

TIME VERSUS DISTANCE RELATIONS

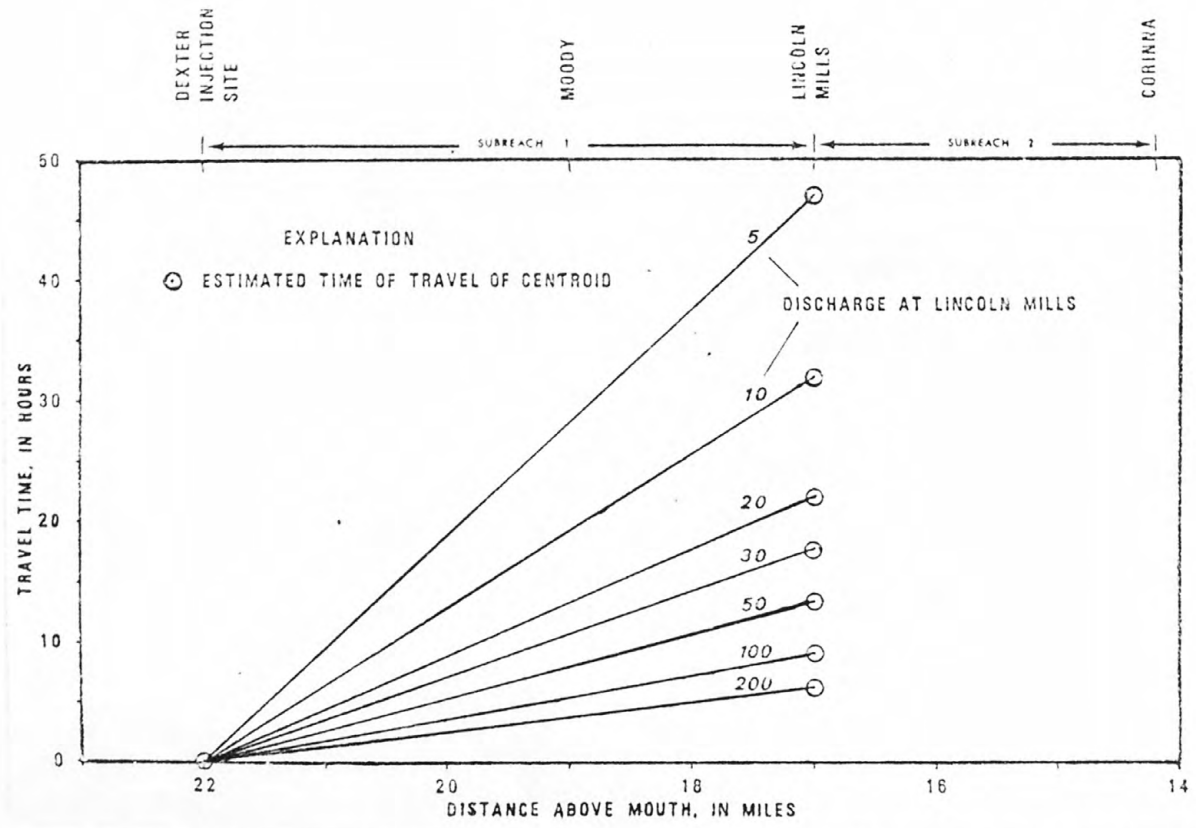

Figure C1.-- Centroid traveltime versus distance above mouth of East Branch Sebasticook River, Reach A.

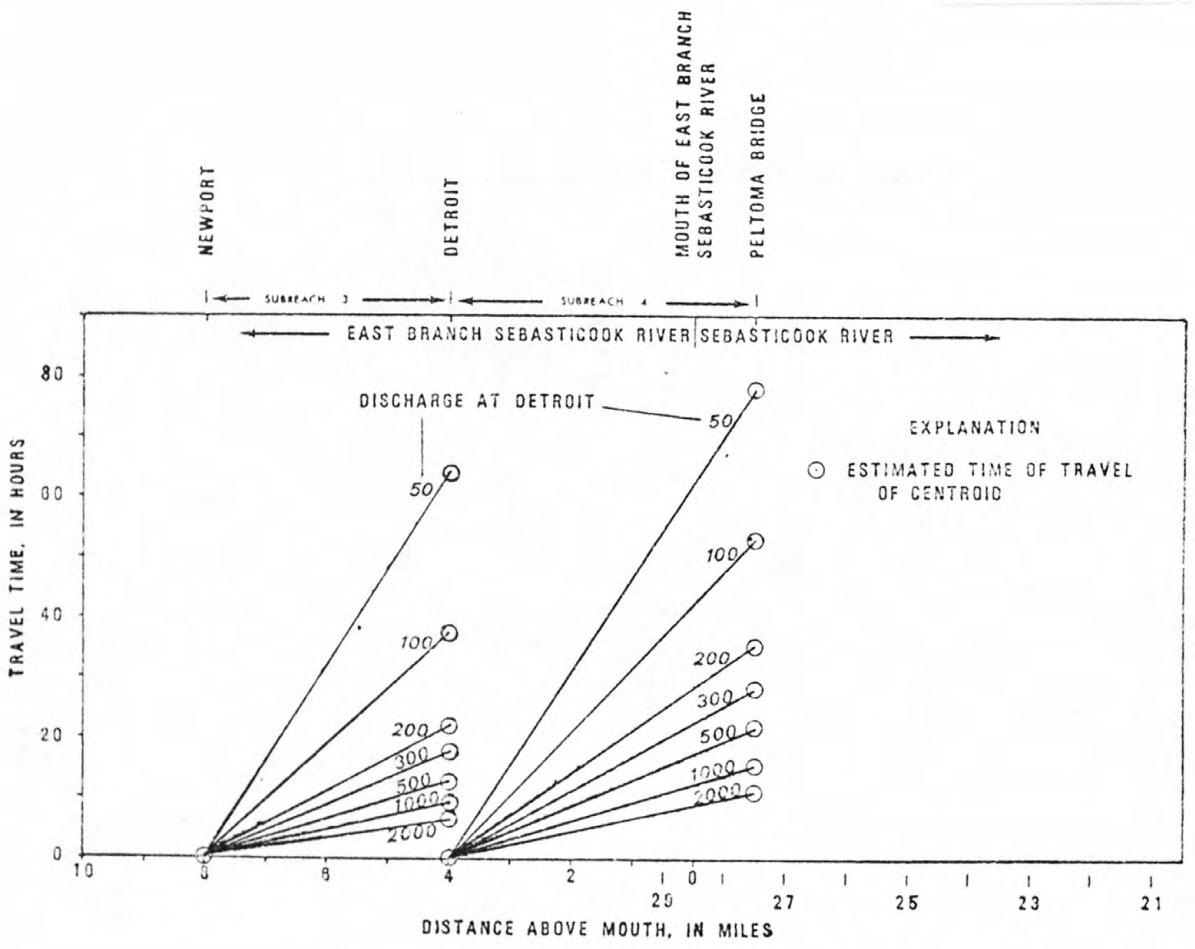

Figure C2.-- Centroid traveltime versus distance above mouth of East Branch Sebasticook River and Sebasticook River, Reach B.

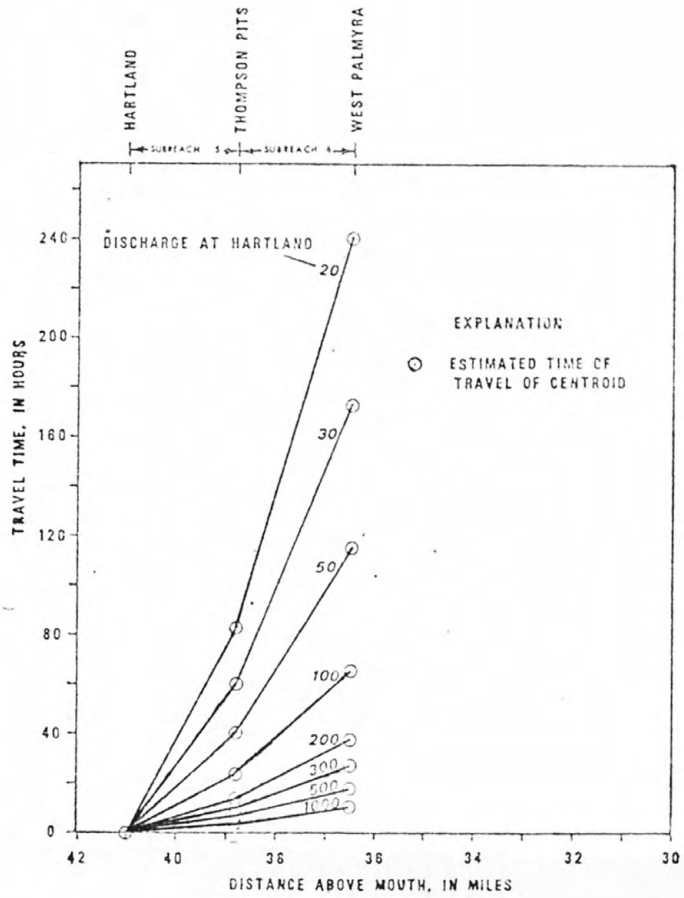

Figure C3.-- Centroid traveltime versus distance above mouth of Sebasticook River, Reach C.

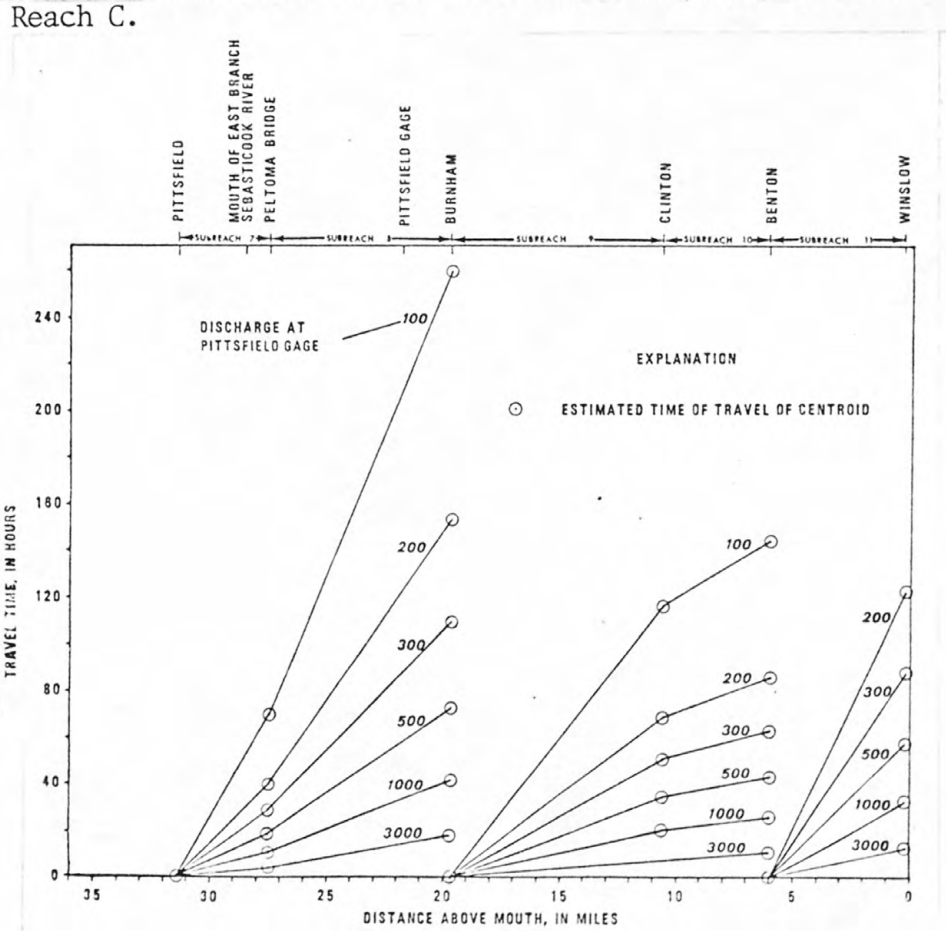

Figure C4.-- Centroid traveltime versus distance above mouth of Sebasticook River, Reach D.