TIME-OF-TRAVEL DATA FOR NEBRASKA STREAMS, 1968 to 1977

By Lester R. Petri

U.S. GEOLOGICAL SURVEY

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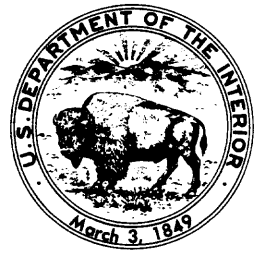

Lincoln, Nebraska

1984

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, Secretary

GEOLOGICAL SURVEY

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CONTENTS

	Page
Abstract	1
Introduction	2
Purpose and scope	2
Cooperation and acknowledgments	4
Methods of data acquisition	5
Selection of injection and sampling sites	5
Injection of dye	6
Collection of samples	6
Measurement of dye in samples	6
Measurements of water discharge	7
Computations of river mileages	7
Explanation of tables and graphs	8
Results of individual studies	12
Big Blue River:	
Study of April 1969	21
Study of August-September 1973	28
Study of May 1974	33
Elkhorn River:	
Study of September 1968	39
Study of September 1972	42
North Loup River, study of September 1972	46
North Platte River, study of October 1972	50
Salt Creek:	
Study of September 6-12, 1972	55
Study of September 25, 1972	58
Study of August 1977	62
References cited	63

ILLUSTRATIONS

		Page
Figure 1.	Map showing locations of stream reaches in Nebraska included in 10 time-of-travel studies, 1968-77	3
2.	Diagrams of dye-concentration curves at downstream sampling sites	9
3.	Map showing locations of injection and(or) sampling sites for three time-of-travel studies on the Big Blue River	13
4.	Graphs showing travel-time/travel-distance curves, Big Blue River, April 1969	21
5.	Graphs showing travel-time/travel-distance curves, Big Blue River, August-September 1973	28
6.	Graphs showing travel-time/travel-distance curves, Big Blue River, May 1974	33
7.	Map showing locations of injection and(or) sampling sites for two time-of-travel studies on the Elkhorn River	34
8.	Graphs showing travel-time/travel-distance curves, Elkhorn River, September 1968	39
9.	Graph showing travel-time/travel-distance curves, Elkhorn River, September 1972	42
10.	Map showing locations of injection and(or) sampling sites for time-of-travel study on the North Loup River	43
11.	Graph showing travel-time/travel-distance curves, North Loup River, September 1972	46
12.	Map showing locations of injection and(or) sampling sites for time-of-travel study on the North Platte River	47
13.	Graph showing travel-time/travel-distance curves, North Platte River, October 1972	50
14.	Map showing locations of injection and(or) sampling sites for three time-of-travel studies on Salt Creek	51
15.	Graphs showing travel-time/travel-distance curves, Salt Creek, September 6-12, 1972	55
16.	Graph showing travel-time/travel-distance curves, Salt Creek, September 25, 1972	58
17.	Graph showing travel-time/travel-distance curves, Salt Creek, August 1977	62

TABLES

		Page
Table 1.	Travel times and travel rates of dye injected into the Big Blue River on April 15, 1969	14
2.	Amount of dye used and concentrations detected in the Big Blue River, April 1969	16
3.	Travel times and travel rates of dye injected into the Big Blue River on August 21, 1973	22
4.	Amount of dye used and concentrations detected in the Big Blue River, August-Spetember 1973	23
5.	Travel times and travel rates of dye injected into the Big Blue River on May 14, 1974	29
6.	Amount of dye used and concentrations detected in the Big Blue River, May 1974	30
7.	Travel times and travel rates of dye injected into the Elkhorn River on September 9, 1968	35
8.	Amount of dye used and concentrations detected in the Elkhorn River, September 1968	36
9.	Travel times and travel rates of dye injected into the Elkhorn River on September 27, 1972	40
10.	Amount of dye used and concentrations detected in the Elkhorn River, September 1972	41
11.	Travel times and travel rates of dye injected into the North Loup River at September 29, 1972	44
12.	Amount of dye used and concentrations detected in the North Loup River, September 1972	45
13.	Travel times and travel rates of dye injected into the North Platte River, October 4, 1972	48
14.	Amount of dye used and concentrations detected in the North Platte River, October 1972	49
15.	Travel times and travel rates of dye injected into Salt Creek on September 6, 1972	52
16.	Amount of dye used and concentrations detected in Salt Creek September 6-12, 1972	53
17.	Travel times and travel rates of dye injected into Salt Creek on September 25, 1972	56
18.	Amount of dye used and concentrations detected in Salt Creek, September 1972	57
19.	Travel times and travel rates of dye injected into Salt Creek on August 16, 1977	59
20.	Amount of dye used and concentrations detected in Salt Creek, August 1977	60

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

Multiply Inch-Pound Units	By	To Obtain SI Units
$feet^3$ per second (ft^3/s)	28.32	$decimeter^3$ per second
mile (mi)	1.609	kilometer
mile per hour (mi/hr)	1.609	kilometer per hour
pound (lb)	.4536	kilogram
degree Fahrenheit (°F)	(°F -32)/1.8	degree Celsius

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ABSTRACT

This report documents the results of 10 time-of-travel studies, using "dye-tracer" methods, conducted on five streams in Nebraska during the period 1968 to 1977. Streams involved in the studies were the North Platte, North Loup, Elkhorn, and Big Blue Rivers and Salt Creek. The Federal Water Quality Act of 1965 (U.S. Congress, Public Law 89-234) requires States to adopt water-quality criteria for interstate waters and to implement plans for their enforcement. Information from these studies has been used by State and Federal agencies in formulating plans for water-quality management and in determining re-aeration coefficients of streams.

Rhodamine WT dye in a 20 percent solution was used as the tracer for all 10 time-of-travel studies. Water samples were collected at several points below each injection site. Concentrations of dye in the samples were measured by determining fluorescence of the sample and comparing that value to fluorescence-concentration curves. Stream discharges were measured before and during each study.

Results of each time-of-travel study are shown on two tables and one graph. The first table shows water discharge at injection and sampling sites, distance between sites, and time and rate of travel of the dye between sites. The second table provides descriptions of study sites, amounts of dye injected in the streams, actual sampling times, and actual concentrations of dye detected. The graphs for each time-of-travel study provide indications of changing travel rates between sampling sites, information on length of dye clouds, and times for dye passage past given points.

INTRODUCTION

Twelve time-of-travel studies were made on six streams in Nebraska from 1966 through 1977. The stimulus for these studies was the passage of the Federal Water Quality Act of 1965 (Public Law 89-234), which required States to adopt water-quality criteria for interstate waters and to implement plans for their enforcement. The studies were made mostly to provide information needed by the State and Federal agencies in formulating required plans for water-quality management. No additional studies have been made from 1977 to the present (1984).

Information from time-of-travel studies is useful for estimating travel time of accidental spills of toxic substances, in routing flood flows, and in many other hydrologic activities. The need for such information was recognized by hydrologists for many years and numerous attempts were made to collect it; however, early methods for obtaining it were not satisfactory. Thomas Buchanan (1964) described a method that was inexpensive, safe, and reliable. His method consisted of injecting a water-soluble, fluorescent dye into a stream and by use of a fluorometer, tracing the dye and computing the rate at which it moved downstream. This "dye tracer" method was refined and improved so that by 1966 it became widely used throughout the U.S. Geological Survey.

The first two time-of-travel studies using the dye-tracer method on Nebraska streams were made on the Missouri River in October and December 1966. Results of these studies were reported in detail by Bowie and Petri (1969) and, therefore, are not included in this report.

From 1968 to 1977, time-of-travel studies were made on major reaches of the Elkhorn and Big Blue Rivers and Salt Creek. The April 1969 study on the Big Blue River included not only most of the reach of the river in Nebraska but also that part of the reach in Kansas between the State line and Tuttle Creek Reservoir. Studies were also made of short reaches of the Elkhorn, North Loup, and North Platte Rivers, and Salt Creek. These studies of short reaches were made in support of a research investigation by the U.S. Environmental Protection Agency into methods for determining re-aeration coefficients of streams. Locations of the longest reach for each of these streams are shown on figure 1.

Purpose and Scope

Most data from time-of-travel studies retain their usefulness indefinitely unless the stream channel to which they apply changes significantly. Consequently, the purpose of this report is to assemble the data from all time-of-travel studies in Nebraska, except for the two on the Missouri River, into a convenient and uniform format for use by future investigators.

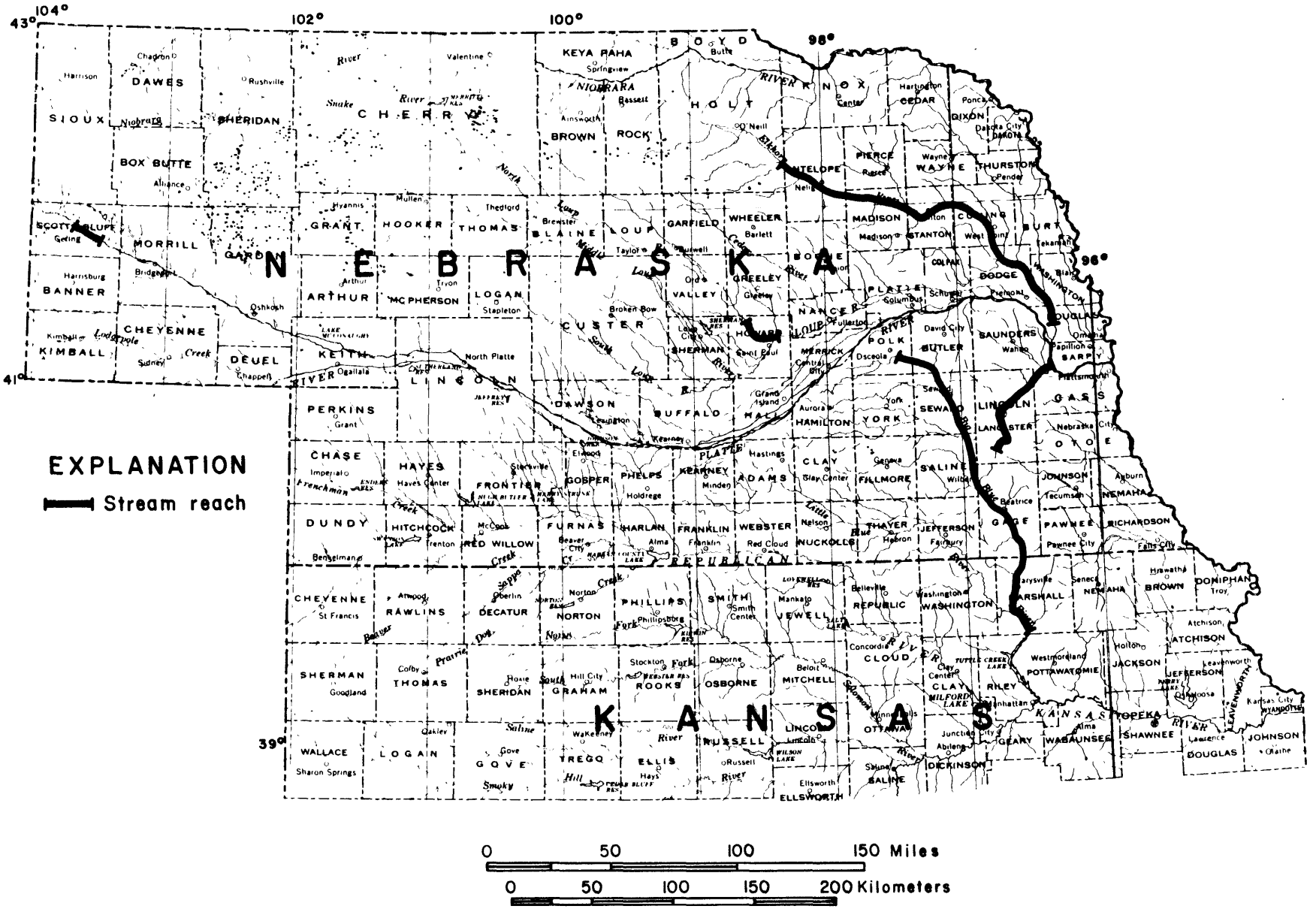


Figure 1.--Locations of stream reaches in Nebraska included in 10 time-of-travel studies, 1968-77.

Preliminary results of the 10 time-of-travel studies included in this report were provided to interested parties in memorandum-type reports at the completion of each of the studies. Because the studies were conducted over a period of 11 years, the data formats for each study were not necessarily the same. Also, new topographic maps have become available in intervening years that provide means for determining more accurate river mileages than previously. Accordingly, for this report all "raw" data have been reexamined, recomputed, and then reorganized into a uniform format.

Studies for which results are included in this report were made during periods of low flow. An exception was the study of the Big Blue River in April 1969, which began during a period of low flow but was interrupted by heavy rains and storm runoff. During periods of low flow, problems involving pollution ordinarily are most acute. At such times the amount of water available for dilution of pollutants is small, turbulence required for mixing the pollutants into the flow is slight, and stream velocities are low, causing pollutants to remain in a stream reach for relatively long periods.

Time-of-travel data obtained for periods of low flow may have little or no application for periods of medium or high flows. If supplemented by data from similar reaches obtained during periods of medium or high flows, interpolative techniques may be used to estimate travel times for any discharge between the low and medium or high flow ranges. Clearly, use of such interpolative techniques would be advantageous in the event of a catastrophic spill of pollutants into a stream.

Cooperation and Acknowledgments

This report was prepared with funds provided equally by the U.S. Geological Survey and the Nebraska Natural Resources Commission. The time-of-travel measurements on which it is based were funded chiefly through cooperative programs of the Geological Survey and the following Nebraska State agencies: Natural Resources Commission; Department of Environmental Control; Department of Health; and Department of Water Resources. Assistance at streamsites during one or more of the time-of-travel studies was provided by the following agencies:

Nebraska Game and Parks Commission
City of Lincoln, Department of Public Utilities
City of Fremont, Utilities Department
Kearney State College
University of Nebraska, Agricultural Extension Service
Upper Elkhorn Natural Resources District
U.S. Army, Corps of Engineers
U.S. Environmental Protection Agency

METHODS OF DATA ACQUISITION

Methods used to obtain time-of-travel data on Nebraska streams, developed from Buchanan's work (1964), are described in detail by Wilson (1968) and by Kilpatrick and others (1970). Whereas these publications were not available when the early studies were made, information on methodology contained in them previously had been made available in training courses, field guides, and special memoranda.

The streams, or parts of streams, under study were divided into reaches ranging in length from less than a mile to more than 50 miles. Predetermined amounts of dye, based on volume of streamflow and length of reach, were poured into the stream at the upper end of each reach. Subsequently, samples of water were collected periodically at several sites downstream in each reach and were analyzed for concentration of dye. Sampling at each of the sites continued until peak concentrations of the dye passed and concentrations decreased nearly to the minimum detection level. Time-of-travel is the amount of time elapsed between pouring the dye into the stream and subsequent detection at a downstream site.

Selection of Injection and Sampling Sites

For several studies that involved only a short reach of stream, dye was injected only at one site. However, for those studies involving major parts of a stream, the stream was divided into several reaches. This was done so that work in the several reaches could be conducted simultaneously, thereby reducing the time required to do the field work and lessening the risk of interference from storm runoff. Also, this was done to reduce the amount of dye needed--considerably less dye is required to attain optimum concentrations for study if the dye is injected at several places along a stream than if it is injected only at the most upstream site.

The first sampling site in each study reach was a relatively short distance from the injection site, but sufficiently downstream to allow for thorough mixing of the dye. Locations of the remaining sites in a given reach were influenced by the availability of bridges or other points of access to the stream, by the locations of major tributaries, dams or other features of hydrologic significance, and by an intent to make the distances between sampling sites roughly comparable.

Injection of Dye

The dye used for the studies was Rhodamine WT in a 20-percent solution. This dye, a close relative to dyes used in food coloring, is highly fluorescent and, therefore, readily detected in very low concentrations. The amount of dye for use at each injection site was estimated from empirical equations and was measured into containers. At the injection site, the dye was poured as rapidly as possible into the stream near midflow. For those studies where streams were divided into several reaches, injection of dye was carried out simutaneously at all injection sites.

Collection of Samples

Water samples were collected in small glass vials numbered individually for identification. For studies through September 1972, samples were collected manually near the midflow of the sampling site using weighted vial holders. In October and November 1972, samples for the four studies of short reaches were collected with special pumping devices anchored in swiftly flowing water near the stream bank. After November 1972, nearly all samples were collected by automatic samplers installed in plastic boats anchored near midstream. The automatic samplers were equipped with spring-activated glass syringes programmed to fill at regular intervals.

Measurement of Dye in Samples

Concentrations of dye in the water samples were determined using Turner Model III[1/] fluorometers. Dial readings on the fluorometers were converted to concentrations by referring to fluorescence-concentration curves prepared in advance. New curves were prepared prior to each study for the specific batch of dye used for that study.

The light sources used in the fluorometers were green T-5 envelope lamps, which provide relatively high intensity excitation light of 546 mu wavelength. Primary filters used were Turner combination filters with peak transmittance at 590 mu. For measuring samples with very high fluorescence a "10-percent neutral density" filter was added to expand the measurement range of the instrument by 10.

The fluorescence of all samples was measured at a common temperature of 80°F (26.6°C). Sample temperatures were adjusted by means of a constant water bath.

1/ For information only; not intended as product endorsement by the U.S. Geological Survey.

Many of the samples collected from the Big Blue River in April 1969 were so turbid that light would not penetrate them and their fluorescence could not be measured directly. These samples were diluted with distilled water until the turbidity was reduced sufficiently to allow some light to pass through. Fluorescence obtained on the diluted samples was multiplied by the appropriate dilution factor and concentrations of dye were then computed. These concentrations checked closely with concentrations determined about a week later after the sediments had settled.

Measurements of Water Discharge

Water discharge was measured for nearly all of the injection and sampling sites. In order to compute the amount of dye to use for each stream reach, it was necessary first to determine the discharge rate near the site farthest downstream in each reach. In the tables, these discharges are given as "near time of injection." Subsequent measurements or estimates are the discharges near the time of first detection of the dye and near the time peak concentrations of dye passed the specific sampling sites.

Discharges "near time of dye passage" were determined in several ways. If the sampling site was also a regular stream-gaging site, discharge was obtained by actual measurement or from water stage using known stage-discharge relationship. If the sampling site was not a regular stream-gaging site, discharge ordinarily was obtained by measurement. In some cases, because of the unpredictability of the time of dye passage, measurements did not coincide with the passage of the dye. In such cases, discharges reported are "best estimates" based on trend of flow in the stream during the study period and related information.

For the studies involving short reaches of several miles, only two discharge measurements were made--one near the time of injection at the upstream site and one near the time of dye passage at the farthest downstream site. Distances between individual sites were so short that, except for Salt Creek, differences in flow probably would have been masked by normal measurement errors. Salt Creek is an exception because outflow from the Lincoln sewage-treatment plant enters the creek between injection and sampling sites.

Computations of River Mileages

River mileages were computed from U.S. Geological Survey 7½-minute quadrangle topographic maps, using methods recommended by the Hydrology Committee of the U.S. Water Resources Council (1968). The one exception

was an 8-mile reach in the headwaters of the Elkhorn River for which such maps were not available. When new or revised maps became available for areas after studies had been completed, river mileages were remeasured and results were recomputed.

River mileages for the Big Blue River used by various agencies are not always consistent. After the filling of Tuttle Creek Reservoir, which began in 1962, a sinuous reach of river became a nonsinuous lake, thereby changing the river-mile locations of all sites upstream. The mileages given in this report were computed using a starting mileage of 101.3 provided by the Corps of Engineers (1969) at the Kansas-Nebraska State line. For time-of-travel studies it is more important that mileages for distances between points of the river are accurate than whether absolute mileage upstream from a starting point is accurate.

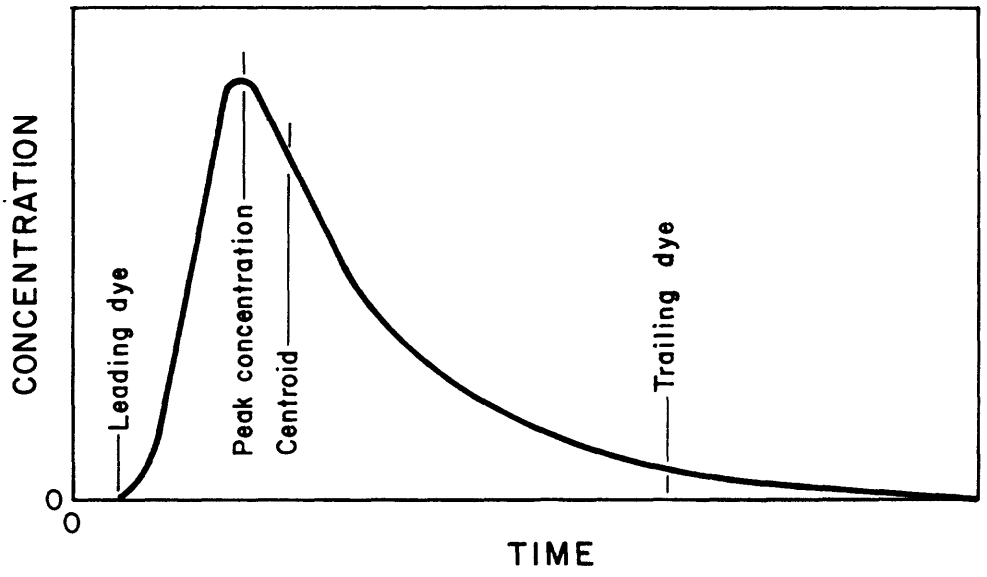
EXPLANATION OF TABLES AND GRAPHS

Data in this report are arranged alphabetically by stream name. If more than one study was made on a given stream, results of the studies are presented in chronological order. Maps preceding the data for each stream indicate the relative locations of all sites used in the studies. Whether a given site was a dye-injection site, a sampling site, or both, is indicated in the data tables that follow the map.

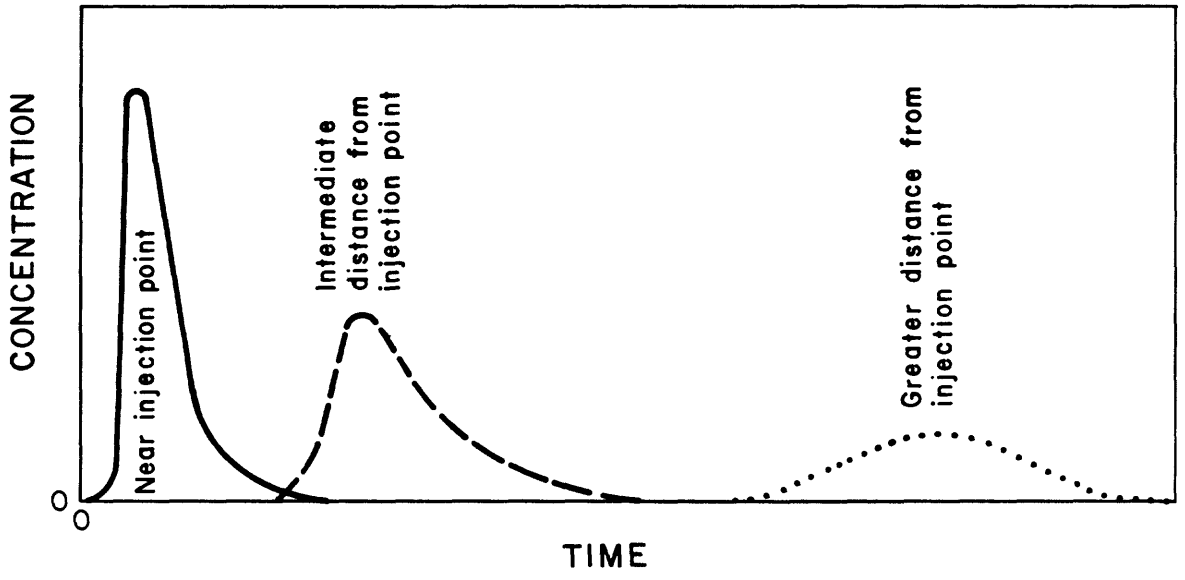
Results of individual studies are given both in tabular and graphic form. To understand the tables and graphs, it is necessary to understand the terms "leading dye," "peak concentration," "centroid," and "trailing dye."

Dye injected into a flowing stream forms a dense cloud in the water that gradually lengthens as it moves downstream. The cloud lengthens because water moves faster in some parts of the stream cross section than in others. If the concentrations of dye in samples taken periodically at sites downstream are plotted against time, the resulting curves are similar to the one shown on figure 2a.

Some of the dye traveling with the fastest moving water arrives at a sampling site ahead of the main body of dye. This will be referred to in the report as the "leading dye." Following arrival of the leading dye, concentrations of the dye increase rapidly to a "peak," normally maintained for a short period of time. Concentrations then diminish, but commonly at a much slower rate than they had increased, thereby causing the curve to be skewed to the right. Because of this, the "centroid" of the dye mass, which represents the time at which half of



A. Major components of the dye cloud.



B. Elongation of the dye cloud as it moves downstream

Figure 2.--Examples of dye concentration curves at downstream sampling sites.

the dye has passed the sampling site, arrives somewhat later than the peak concentration. The centroid is regarded by many investigators as the best indicator of average travel times and rates.

After the peak concentration has been reached at a sampling site, it may take as much as several days for the dye to disappear completely. In this report, "trailing dye" is the dye remaining in water moving past a sampling site after dye concentrations have decreased to 10 percent of the peak concentration. The curves labeled "trailing dye" in the graphs indicate the time or mile-point at which the dye concentration has decreased below 10 percent of the peak at a given site. It does not represent disappearance of the dye, which in most cases did not occur until much later.

When dye concentrations are reduced to very low levels, they often become erratic. To avoid the high cost of sampling for long periods, and to avoid the effects of erratic measurements at very low concentrations, the Geological Survey follows the practice of computing centroids using only data values that exceed 10 percent of the peak concentrations. This was done in computing centroids for this report. However, computation of centroids in time-of-travel studies can be laborious. In most instances, the rate of travel for the peak concentration is not much different than the rate of travel for the centroid and often is used as the principal indicator of travel time if rates for centroids are not computed. All data values, whether used in computing centroids or not, are given in the data tables for the benefit of any who may wish to compute centroids in a different way.

If the same dye is sampled at several downstream sites, the shape of the concentration-time curves will differ in a somewhat predictable way, depending on the distance between sites, turbulence, and other factors. This is illustrated by curves for three sites progressively farther downstream from the injection point (fig. 2b). Curves for sites near the point of injection commonly resemble the curve on figure 2b represented by the solid line. As the distances from injection site to sampling site increase, the peaks diminish and the curves elongate as demonstrated by the curves represented by the dashed and dotted lines.

The results for each of the 10 studies are presented both in tables and graphs. The first table for each study presents water discharge at injection and sampling sites, distance from injection site to sampling site or between sampling sites, and time and rate of travel of the dye between indicated sites. Differences in travel rates between various reaches of stream are readily apparent.

The second table for each study provides descriptions of study sites, amounts of dye injected into the stream, actual sampling times, and actual concentrations of dye detected. Other basic measurements pertaining to water discharge, such as channel dimensions or river mileages, not included in this report, are on file in the District Office, U.S. Geological Survey, 406 Federal Building, 100 Centennial Mall, North, Lincoln, Nebr. 68508.

A set of graphs for each time-of-travel study provides a visual account of the manner in which dye moved in each reach of stream following injection. For example, in the Big Blue River study of May 1974, dye was injected at the upstream end of each of three reaches (see three separate graphs on fig. 6). The travel rates of the leading dye, peak concentration, centroid of dye and trailing dye are indicated by the slope of the curves representing those elements. Because of differences in velocity of water in the stream cross section, the dye cloud, which formed when the dye was poured into the stream, lengthened gradually as it moved downstream. This is shown graphically by the divergence of the curves as mileage increased from zero.

Changes in slope of the curves indicate changes in travel rates from one sampling site to another--steepening of slope represents a slowing of travel rate. In graph "A", the steepening of slope between "Highway 6 at Milford" and "below dam southeast of Milford" illustrates the effect of the dam on slowing the travel rate. Similar effects are shown by other reservoirs in graph "C."

Because the curves are constructed by joining the plots of travel time against travel distance, the length of the dye cloud may be determined at any point along the river by scaling off on the horizontal axis the distance between the curve representing the leading dye and that representing the trailing dye. Likewise, time for the dye to pass any given point may be determined by scaling off on the vertical axis the distance between the same two curves.

RESULTS OF INDIVIDUAL STUDIES

Results of the individual studies for the Big Blue, Elkhorn, North Loup, and North Platte Rivers, and Salt Creek are shown on figures 3-17 and tables 1-20 on the following pages.

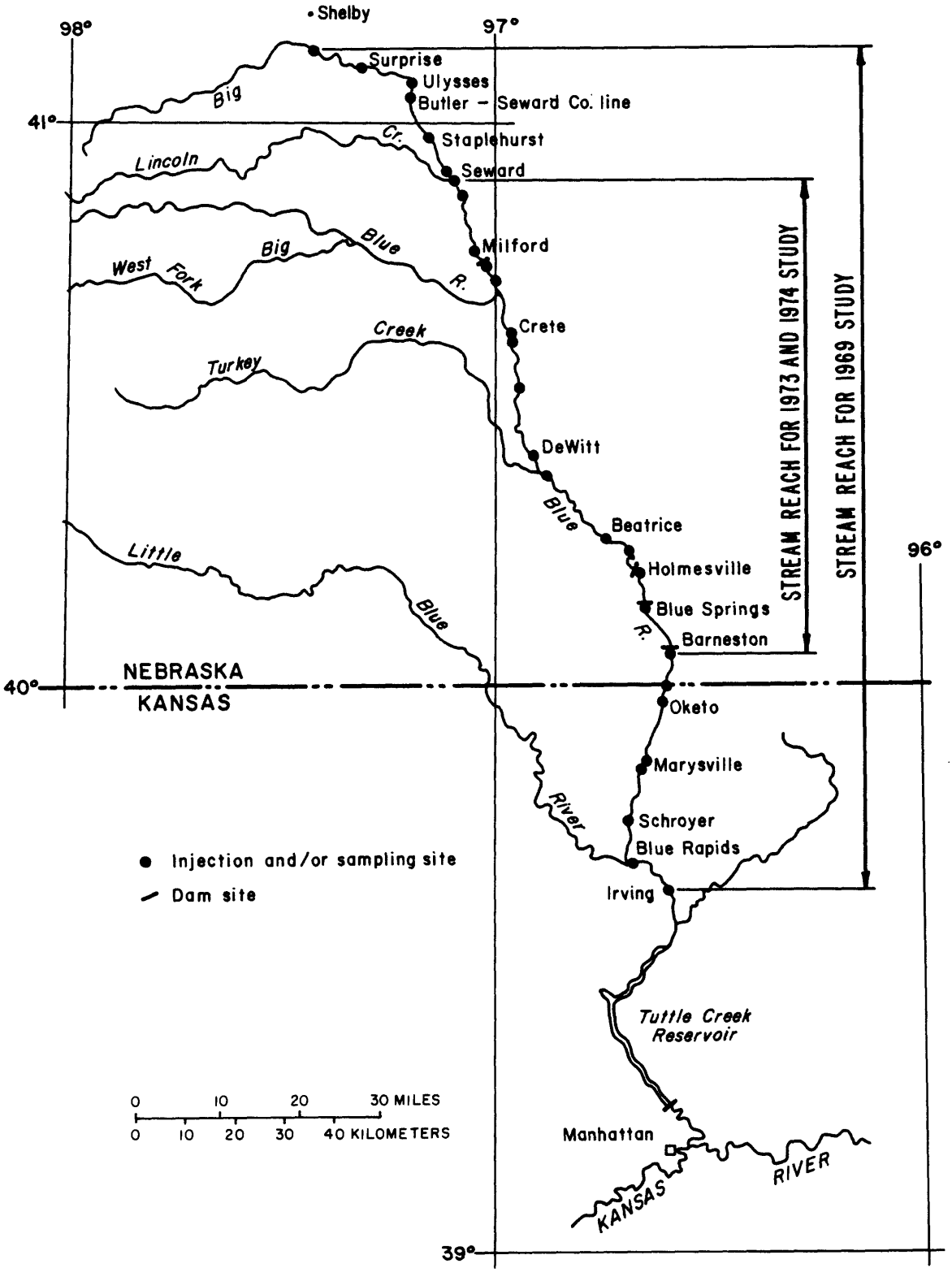


Figure 3.--Locations of injection and (or) sampling sites for three time-of-travel studies on the Big Blue River.

Table 1.--Travel times and travel rates of dye

Dye injection and sampling sites	River mile location	Water discharge (ft^3/s) Near time of injection	Near time of first dye detection	Near time of dye passage	Travel distance (mi) From injection site	From last site upstream
NEBRASKA SITES						
Injection site:						
Hwy. 69 south of Shelby----------	285.1	3.1				
Sampling sites:						
Below dam at Surprise----------	271.2	-------	46	35	13.9	13.9
Spur road 12-C at Ulysses---------	256.3	26	127	101	28.8	14.9
Injection site: Downstream from						
Spur road 12-C at Ulysses---------	256.3					
Sampling sites:						
Butler-Seward County line---------	252.7	27	27	38	3.6	3.6
Spur road 80-C at Staplehurst-----	236.6	-------	88	95	19.7	16.1
County road NW of Seward----------	230.7	-------	97	101	25.6	5.9
Hwy 6 at Milford-----------	208.0	-------	606	(1)	48.3	22.7
Below dam SE of Milford----------	203.4	124	-----	-----	52.9	4.6
Injection site: Downstream from						
dam SE of Milford----------	203.4	124				
Sampling sites:						
County road SE of Milford---------	197.5	127	127	(1)	5.9	5.9
Tuxedo Park bridge at Crete-------	187.0	-------	-----	-----	16.4	10.5
Gaging station at Crete----------	183.4	460	890	920	20.0	3.6
Damsite SE of DeWitt----------	154.2	600		1,130	49.2	29.2
Injection site:						
Downstream from damsite at DeWitt-	154.2	600				
Sampling sites:						
County road SE of DeWitt----------	149.0	606	606	(1)	5.2	5.2
Gaging station at Beatrice--------	131.0	861	861	(1)	23.2	18.0
Below dam at Holmesville----------	121.6	-------	2,600	3,600	32.6	9.4
Below dam at Blue Springs---------	115.7	-------	3,200	4,500	38.5	5.9
Hwy. 8 at Barneston----------	105.5	1,740	4,600	6,820	48.7	10.2
KANSAS SITES						
Injection site: Downstream from						
Hwy. 8 at Barneston, Nebr.--------	105.5	1,740				
Sampling sites:						
Kansas-Nebraska line----------	101.3	-------	690	(1)	4.2	4.2
County road at Oketo----------	96.7	692	690	(1)	8.8	4.6
Railroad bridge at Marysville-----	86.2	-------	-----	-----	19.3	10.5
Hwy. 36 at Marysville----------	84.7	911		977	20.8	1.5
County road at Schroyer----------	76.8	-------	1,120	-----	28.7	7.9
Hwy. 77 at Blue Rapids----------	63.9	-------	-----	3,500	41.6	12.9
Hwy. 113 at Irving----------	58.0	1,660	-----	4,370	47.5	5.9

[1] Little change in discharge during passage of the dye.

injected into the Big Blue River on April 15, 1969

Travel time (hr)						Travel rate (mi/hr)					
From injection site			From last site upstream			From injection site			From last site upstream		
Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid
59.00	61.00	61.75	59.00	61.00	61.75	0.24	0.23	0.23	0.24	0.23	0.23
92.00	96.00	99.28	33.00	35.00	37.53	.31	.30	.29	.45	.43	.40
9.00	10.75	11.42	9.00	10.75	11.42	.40	.33	.32	.40	.33	.32
51.75	54.50	55.01	42.75	43.75	43.59	.38	.36	.36	.38	.37	.37
71.50	75.00	75.31	19.75	20.50	20.30	.36	.34	.34	.30	.29	.29
95.50	100.00	100.45	24.00	25.00	25.14	.51	.48	.48	.95	.91	.90
103.50	106.75	109.49	8.00	6.75	9.04	.51	.50	.48	.58	.68	.51
6.25	7.50	8.22	6.25	7.50	8.22	.94	.79	.72	.94	.78	.72
16.25	20.25	22.73	10.00	12.75	14.51	1.01	.81	.72	1.05	.82	.72
21.00	24.00	25.59	4.75	3.75	2.86	.95	.83	.78	.76	.96	1.26
47.50	49.25	50.90	26.50	25.25	25.31	1.04	1.00	.97	1.10	1.16	1.15
4.75	5.75	6.17	4.75	5.75	6.17	1.09	.90	.84	1.09	.90	.84
23.00	26.00	27.79	18.25	20.25	21.62	1.09	.89	.83	.97	.89	.83
33.50	36.50	37.04	10.50	10.50	9.25	.97	.89	.88	.90	.90	1.01
39.00	41.00	42.18	5.50	4.50	5.14	.99	.94	.91	1.07	1.31	1.15
45.00	47.00	47.77	6.00	6.00	5.59	1.08	1.04	1.02	1.70	1.70	1.82
2.00	2.75	3.07	2.00	2.75	3.07	2.10	1.53	1.37	2.10	1.53	1.37
5.50	6.50	8.05	3.50	3.75	4.98	1.60	1.35	1.09	1.31	1.23	.92
19.00	22.00	23.09	13.50	15.50	15.04	1.02	.88	.84	.78	.68	.70
21.50	24.50	25.93	2.50	2.50	2.84	.97	.85	.80	.60	.60	.60
28.75	31.25	32.11	7.25	6.75	6.18	1.00	.92	.89	1.09	1.17	1.28
36.25	39.50	40.53	7.50	8.25	8.42	1.15	1.05	1.03	1.72	1.56	1.53
40.75	43.00	44.03	4.50	3.50	3.50	1.17	1.10	1.08	1.31	1.69	1.67

Table 2.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, April 1969

Part A.--Reach from Highway 69 south of Shelby to Spur road 12-C at Ulysses

Amount of dye used: 5 pounds
Site of injection: Highway 69 south of Shelby (river mile 285.1)
Time of injection: April 15, 1969 - hour 1530

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at dam at Surprise (river mile 271.2)											
Apr. 18	0200	0.0	Apr. 18	0530	15.8	Apr. 18	0800	2.2	Apr. 18	1030	0.7
	0230	1.5		0600	11.4		0830	1.5		1100	.8
	0300	4.2		0630	7.4		0900	1.2		1130	.8
	0425	19.8		0700	4.4		0930	1.0		1200	.8
	0500	19.4		0730	2.9		1000	.8			
Detected at Spur road 12-C at Ulysses (river mile 256.3)											
Apr. 19	1100	0.0	Apr. 19	1500	3.7	Apr. 19	1700	2.8	Apr. 19	2300	0.2
	1130	.1		1515	3.7		1730	2.2		2400	.2
	1200	.4		1530	4.0		1800	1.8	Apr. 20	0300	.2
	1230	.8		1545	3.7		1830	1.2		0600	.2
	1300	1.4		1600	3.6		1900	1.0		0900	.1
	1330	2.3		1615	3.6		2000	.6		0940	.1
	1400	2.8		1630	3.4		2100	.5		1050	.1
	1430	3.3		1645	3.2		2200	.2	Apr. 21	1025	0.0
	1445	3.7									

Part B.--Reach from Spur road 12-C at Ulysses to dam southeast of Milford

Amount of dye used: 35 pounds
Site of injection: At Highway 315 at Ulysses (river mile 256.3)
Time of injection: April 15, 1969 - hour 1100

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at Butler-Seward County line (river mile 252.7)											
Apr. 15	1930	0.0	Apr. 15	2130	198	Apr. 15	2230	112	Apr. 15	2400	6.4
	2000	0.0		2145	215		2245	72	Apr. 16	0100	1.9
	2030	7.7		2200	192		2300	45		0820	.3
	2100	76		2215	155		2330	16		1100	.2
	2115	132									
Detected at Spur road 80-C at Staplehurst (river mile 236.6)											
Apr. 17	1430	0.0	Apr. 17	1700	26.5	Apr. 17	1845	18.5	Apr. 17	2100	1.7
	1445	0.0		1715	35.0		1900	14.2		2200	.8
	1500	.2		1730	36.5		1915	10.8		2300	.6
	1515	.6		1745	36.4		1930	7.2		2400	.4
	1530	1.3		1800	33.0		1945	5.5	Apr. 18	0100	.3
	1545	3.0		1815	25.2		2000	4.2		0200	.2
	1600	5.8		1830	21.8		2030	2.8		0300	.2
	1630	15.4									

Table 2.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, April 1969--Continued

Part B.--Reach from Spur road 12-C at Ulysses to dam southeast of Milford--Continued

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at county road northwest of Seward (river mile 230.7)											
Apr. 18	1000	0.0	Apr. 18	1300	16.5	Apr. 18	1630	3.4	Apr. 18	2000	0.5
	1030	0.0		1330	23.0		1700	2.1		2030	.5
	1100	.4		1400	23.5		1730	1.6		2100	.4
	1130	1.4		1430	20.0		1800	1.1		2130	.4
	1200	4.7		1500	14.6		1830	.9		2200	.4
	1215	8.0		1530	9.6		1900	.7		2230	.3
	1230	11.5		1600	6.0		1930	.6			
Detected at U.S. Highway 6 at Milford (river mile 208.0)											
Apr. 19	1030	0.0	Apr. 19	1600	3.4	Apr. 19	1830	0.6	Apr. 19	2130	0.4
	1345	2.6		1630	2.6		1900	.6		2200	.4
	1415	3.6		1700	1.9		1930	.8		2230	.4
	1430	4.2		1730	1.4		2000	.4		2300	.5
	1500	4.3		1800	1.1		2100	.6			
	1530	3.9									
Detected at dam southeast of Milford (river mile 203.4)											
Apr. 19	1815	0.0	Apr. 19	1915	0.7	Apr. 19	2145	4.0	Apr. 20	0015	1.6
	1825	.1		1945	1.4		2220	3.9		0050	.8
	1835	.2		2015	2.6		2245	3.3		0115	.6
	1845	.6		2045	3.2		2320	2.9		0215	.4
	1855	.8		2115	3.6		2350	1.8		1200	.8
	1905	.8									

Part C.--Reach from dam southeast of Milford to damsite southeast of DeWitt

Amount of dye used: 35 pounds
Site of injection: At dam southeast of Milford (river mile 203.4)
Time of injection: April 15, 1969 - hour 1115

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at county road southeast of Milford (river mile 197.5)											
Apr. 15	1700	0.0	Apr. 15	1830	135	Apr. 15	2030	21.5	Apr. 15	2230	1.6
	1730	1.3		1900	135		2100	11.5		2300	1.2
	1745	17		1930	97.5		2130	4.3		2330	1.3
	1800	45		2000	45.0		2200	2.4	Apr. 16	1010	.2
Detected at Tuxedo Park bridge at Crete (river mile 187.0)											
Apr. 16	0405	0.0	Apr. 16	0700	8.7	Apr. 16	1000	1.0	Apr. 16	1230	0.5
	0435	.1		0730	10.0		1030	.5		1300	.4
	0525	.9		0800	7.8		1105	.4		1630	.2
	0600	3.1		0830	5.1		1130	.4		1830	.1
	0630	7.0		0935	1.4		1200	.4	Apr. 17	0230	.1

Table 2.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, April 1969--Continued

Part C.--Reach from dam southeast of Milford to damsite southeast of DeWitt--Continued

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at USGS gage south of Crete (river mile 183.4)											
Apr. 16	0715	0.0	Apr. 16	1145	5.9	Apr. 16	1415	0.6	Apr. 16	2250	0.2
	0815	0.0		1215	4.1		1445	.5	Apr. 17	0045	.2
	0920	1.2		1245	2.9		1545	.4		0245	.1
	1015	4.6		1315	1.6		1845	.2		0330	.1
	1115	7.3		1345	1.0		2055	.2		0815	.1
Detected at damsite southeast of DeWitt (river mile 154.2)											
Apr. 17	0940	0.0	Apr. 17	1430	3.4	Apr. 17	1700	1.0	Apr. 17	1930	0.3
	1155	1.9		1500	3.0		1730	.7		2000	.3
	1230	2.6		1530	2.4		1800	.4		2030	.2
	1300	3.5		1600	1.7		1830	.3		2100	.1
	1330	3.9		1630	1.3		1900	.3		2130	.1
	1400	3.6									

Part D.--Reach from damsite southeast of DeWitt to Highway 8 at Barneston

Amount of dye used: 40 pounds
Site of injection: At damsite southeast of DeWitt (river mile 154.2)
Time of injection: April 15, 1969 - hour 1100

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at county road southeast of DeWitt (river mile 149.0)											
Apr. 15	1515	0.0	Apr. 15	1700	31.5	Apr. 15	1830	2.8	Apr. 15	2200	0.1
	1545	.4		1715	27.5		1845	1.9		2300	.1
	1600	5.0		1730	18.5		1900	1.3		2400	.1
	1615	16.0		1745	14.5		1930	.6	Apr. 16	0200	.1
	1630	28.5		1800	8.0		2030	.2		0400	0.0
	1645	36.5		1815	4.3		2100	.1			
Detected at gaging station at U.S. Highway 77 at Beatrice (river mile 131.0)											
Apr. 16	0900	0.0	Apr. 16	1300	7.4	Apr. 16	1600	3.1	Apr. 16	2100	0.6
	1000	.8		1330	6.7		1630	2.6		2200	.4
	1030	2.0		1400	5.7		1700	2.1		2300	.2
	1100	4.6		1430	4.5		1800	1.6	Apr. 17	1900	.6
	1130	4.6		1500	4.0		1900	1.2	Apr. 18	0910	.7
	1200	6.0		1530	3.4		2000	.9			
Detected below dam at Holmesville (river mile 121.6)											
Apr. 16	2000	0.0	Apr. 16	2230	2.1	Apr. 17	0030	2.3	Apr. 17	0300	0.6
	2030	.1		2300	2.7		0100	2.1		0330	.5
	2100	.3		2330	3.4		0130	1.8		0400	.4
	2130	.8		2400	2.8		0200	1.4		1915	1.0
	2200	1.4					0230	.9	Apr. 18	1200	1.2

Table 2.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, April 1969--Continued

Part D.--Reach from dam at DeWitt to Highway 8 at Barneston--Continued

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected below dam at Blue Springs (river mile 115.7)											
Apr. 17	0100	0.0	Apr. 17	0300	1.8	Apr. 17	0500	1.6	Apr. 17	1630	1.0
	0200	.4		0400	2.3		0945	.1	Apr. 18	0955	1.6
	0230	1.0		0430	2.0						
Detected at Highway 8 at Barneston (river mile 105.5)											
Apr. 17	0915	1.0	Apr. 17	1100	1.1	Apr. 17	1300	0.4	Apr. 17	1615	0.2
	0930	1.3		1130	.8		1330	.2		1700	.2
	1000	1.6		1200	.5		1400	.2	Apr. 18	1015	1.1
	1030	1.3		1230	.4		1500	.2			

Part E.--Reach from Highway 8 at Barneston to Highway 113 at Irving, Kans.

Amount of dye used: 60 pounds
Site of injection: At Highway 8 at Barneston (river mile 105.5)
Time of injection: April 15, 1969 - hour 1100

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at Kansas-Nebraska State line (river mile 101.3)											
Apr. 15	1000	2.2	Apr. 15	1515	16.1	Apr. 15	1615	1.5	Apr. 15	1715	0.3
	1400	4.6		1530	9.0		1630	1.3		1730	.8
	1430	26.6		1545	5.2		1645	.7		1745	0.0
	1500	23.4		1600	3.2		1700	.6			
Detected at Oketo, Kans. (river mile 96.7)											
Apr. 15	1700	0.0	Apr. 15	1830	25.2	Apr. 15	1945	12.2	Apr. 15	2300	0.8
	1730	25.2		1845	25.4		2000	11.9		2400	.2
	1745	17.3		1900	23.2		2030	7.4	Apr. 16	0200	.2
	1800	21.3		1915	18.9		2100	3.7		0530	.1
	1815	22.1		1930	16.9		2130	2.2		0600	.1
Detected at railroad bridge at Marysville, Kans. (river mile 86.2)											
Apr. 16	0630	0.0	Apr. 16	0900	9.0	Apr. 16	1030	11.8	Apr. 16	1300	0.8
	0700	.2		0915	14.6		1045	10.0		1400	.4
	0715	.4		0930	14.8		1100	7.7		1500	.2
	0800	3.6		0945	15.0		1130	4.8		1600	.1
	0815	4.9		1000	14.3		1200	3.5		1700	.1
	0845	7.9		1015	13.1		1230	2.3		1800	0.0
Detected at Highway 36 at Marysville, Kans. (river mile 84.7)											
Apr. 16	0930	0.7	Apr. 16	1130	11.0	Apr. 16	1300	11.7	Apr. 16	1530	1.1
	1000	1.2		1145	12.6		1315	10.5		1600	.9
	1030	3.0		1200	13.7		1330	9.2		1700	.6
	1045	4.8		1215	14.1		1400	5.8		1800	.5
	1100	7.1		1230	13.9		1430	3.4		2000	.4
	1115	9.7		1245	13.0		1500	2.3		2200	.4

Table 2.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, April 1969--Continued

Part E.--Reach from Highway 8 at Barneston to Highway 113 at Irving, Kans.--Continued

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at county road at Schroyer, Kans. (river mile 76.8)											
Apr. 16	1300	0.0	Apr. 16	1800	6.8	Apr. 16	2000	6.6	Apr. 16	2230	0.3
	1600	.2		1830	9.3		2030	4.2		2300	.2
	1630	.2		1900	10.1		2100	2.1		2330	.1
	1700	1.2		1930	8.8		2130	1.0		2400	0.0
	1730	3.2					2200	.6			
Detected at U.S. Highway 77 at Blue Rapids, Kans. (river mile 63.9)											
Apr. 17	0015	0.0	Apr. 17	0245	4.8	Apr. 17	0445	1.9	Apr. 17	0645	0.2
	0115	.3		0315	5.4		0515	1.2		0715	.2
	0145	.9		0345	4.5		0545	.5		0745	.1
	0215	2.5		0415	3.0		0615	.3		0815	0.0
Detected at Highway 113 at Irving, Kans. (river mile 58.0)											
Apr. 17	0430	0.0	Apr. 17	0630	4.5	Apr. 17	0800	2.1	Apr. 17	1000	0.2
	0500	.3		0700	4.4		0830	1.1		1030	.1
	0530	1.3		0730	3.4		0900	.5		1100	0.0
	0600	3.0					0930	.4			

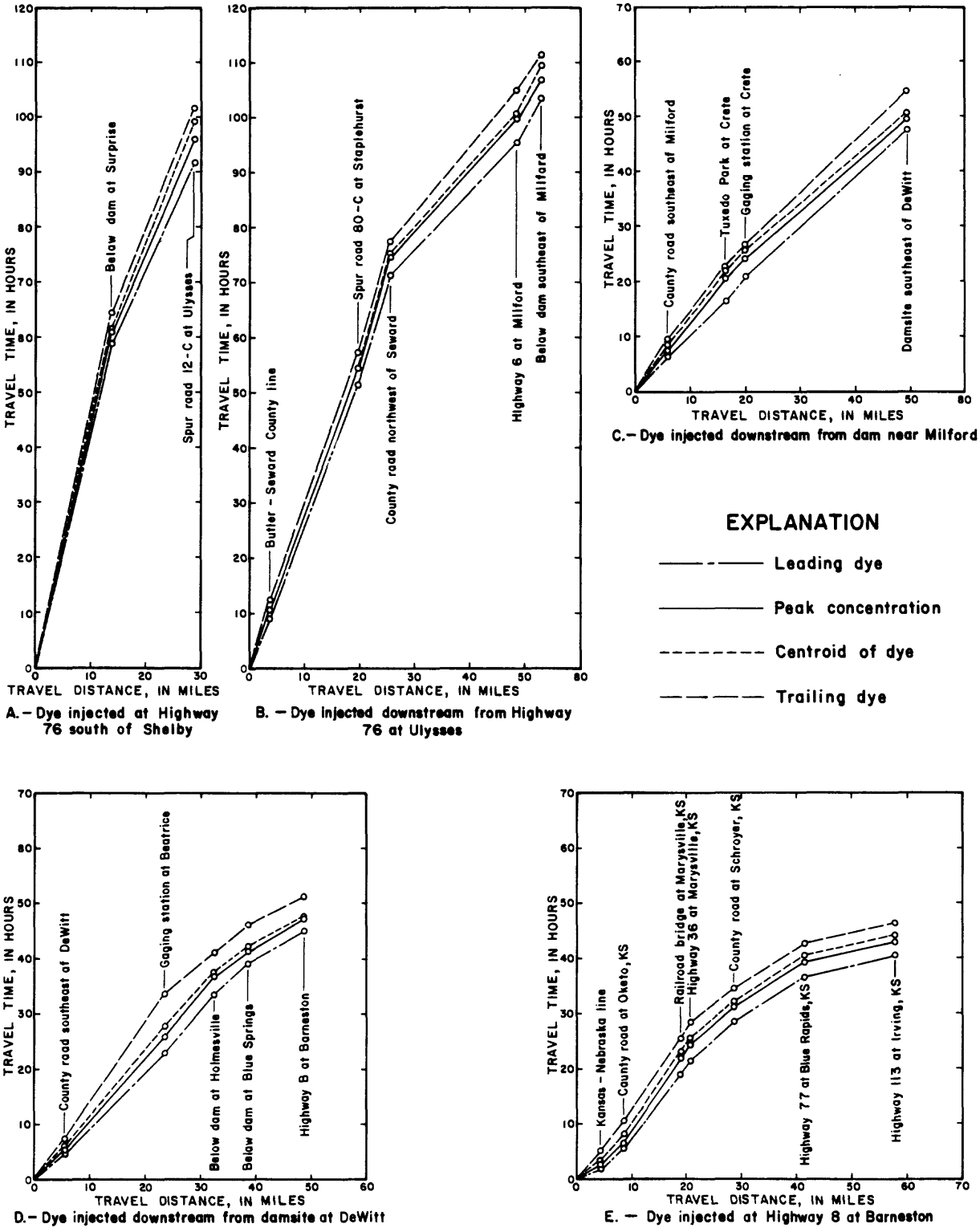


Figure 4.--Travel-time/travel-distance curves, Big Blue River, April 1969.

Table 3.--Travel times and travel rates of dye injected into the Big Blue River on August 21, 1973

Dye injection and sampling sites	River mile location	Water discharge (ft^3/s)		Travel distance (mi)	
		Near time of injection	Near time of dye passage	From injection site	From last site upstream
Injection site: Hwy. 34 at Seward----------	228.5				
Sampling sites:					
1. Gaging station at Seward----------	227.3	----	25.5	1.2	1.2
2. County road SE of Seward----------	223.0	----	25.6	5.5	4.3
3. Hwy. 6 at Milford----------	208.0	----	22.1	20.5	15.0
4. Below dam SE of Milford----------	203.4	----	----	25.1	4.6
5. County road SE of Milford----------	197.5	32.3	20.9	31.0	5.9
Injection site: Below dam SE of Milford-----	203.4				
Sampling sites:					
6. County road SE of Milford----------	197.5	----	32.3	5.9	5.9
7. Gaging station at Crete----------	183.4	----	81.8	20.0	14.1
8. Damsite SE of DeWitt----------	154.2	152	122	49.2	29.2
9. County road SE of DeWitt----------	149.0	----	[1]156	54.4	5.2
Injection site: Damsite at DeWitt----------	154.2				
Sampling sites:					
10. County road SE of DeWitt----------	149.0	----	194	5.2	5.2
11. Gaging station at Beatrice----------	131.0	----	210	23.2	18.0
12. County road NW of Holmesville----------	124.9	----	-----	29.3	6.1
13. Below dam at Holmesville----------	121.6	----	192	32.6	3.3
14. Below dam at Blue Springs----------	115.7	333	295	38.5	5.9
15. Below dam at Barneston----------	106.1	----	[2]122	48.1	9.6

[1] Estimated.
[2] Average daily discharge for August 27 and 28.

Sampling sites	Travel time (hr)						Travel rate (mi/hr)					
	From injection site			From last site upstream			From injection site			From last site upstream		
	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid
1.	2.83	3.75	4.00	2.83	3.75	4.00	0.42	0.32	0.30	0.42	0.32	0.30
2.	24.83	28.58	29.42	22.00	24.83	25.42	.22	.19	.19	.20	.17	.17
3.	84.00	91.00	92.12	59.17	62.42	62.70	.24	.23	.22	.25	.24	.24
4.	154.50	197.22	205.10	70.50	106.22	112.98	.16	.13	.12	.07	.04	.04
5.	179.50	232.85	228.59	25.00	35.63	23.49	.17	.13	.14	.24	.17	.25
6.	13.58	16.68	19.36	13.58	16.68	19.35	.43	.35	.30	.43	.35	.30
7.	32.92	36.95	37.87	19.34	20.27	18.52	.61	.54	.53	.73	.70	.76
8.	78.43	86.07	84.49	45.51	49.12	46.62	.63	.57	.58	.64	.59	.63
9.	87.37	94.12	95.69	8.94	8.05	11.20	.62	.58	.57	.58	.65	.46
10.	5.33	6.33	7.36	5.33	6.33	7.36	.98	.82	.71	.98	.82	.71
11.	28.00	32.33	34.08	22.67	26.00	26.72	.83	.72	.68	.79	.69	.67
12.	38.83	44.38	46.16	10.83	12.05	12.08	.75	.66	.63	.56	.51	.50
13.	57.28	66.83	71.39	18.45	22.45	25.23	.57	.49	.46	.18	.15	.13
14.	76.60	90.50	94.46	19.32	23.67	23.07	.50	.43	.41	.31	.25	.26
15.	133.55	159.36	192.52	56.95	68.86	98.06	.36	.30	.25	.17	.14	.10

Table 4.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, August-September 1973

Part A.--Reach from U.S. Highway 34 at Seward to county road southeast of DeWitt

Amount of dye used: 6 pounds
Site of injection: U.S. Highway 34 at Seward (river mile 228.5)
Time of injection: August 21, 1973 - hour 0800

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at gaging station at Seward (river mile 227.3)											
Aug. 21	1045	0.0	Aug. 21	1135	180.0	Aug. 21	1225	73.0	Aug. 21	1320	15.0
	1050	.5		1145	192.0		1230	68.0		1330	11.0
	1055	4.9		1150	183.0		1235	60.0		1355	5.0
	1100	16.0		1155	153.0		1240	49.0		1415	2.1
	1105	30.0		1200	153.0		1245	40.0		1435	1.9
	1110	55.0		1205	133.0		1250	36.0		1455	1.6
	1115	74.0		1210	102.0		1255	32.0		1515	.6
	1120	97.0		1215	106.0		1300	31.0		1535	.1
	1125	153.0		1220	80.0		1310	19.0		1555	0
	1130	168.0									
Detected at county road southeast of Seward (river mile 223.0)											
Aug. 22	0800	0.0	Aug. 22	1210	43.0	Aug. 22	1612	8.7	Aug. 22	2109	1.1
	0850	.4		1235	45.0		1637	7.5		2239	.6
	0915	.8		1300	43.0		1702	5.2	Aug. 23	0009	.3
	0940	3.7		1325	39.0		1725	5.0		0139	.4
	1005	6.4		1342	37.0		1751	3.3		0309	.4
	1030	11.5		1432	26.0		1809	2.7		0439	.3
	1055	22.0		1457	19.0		1854	2.1		0609	.1
	1120	28.0		1522	16.0		1939	1.8		0824	.1
	1145	39.0		1547	12.0		2024	1.3		0954	0
Detected at U.S. Highway 6 at Milford (river mile 208.0)											
Aug. 24	1900	0.0	Aug. 25	0001	7.6	Aug. 25	0500	9.0	Aug. 25	1030	2.0
	2025	.8		0100	9.7		0600	7.7		1200	1.2
	2105	1.4		0200	10.9		0700	5.8		1330	.9
	2145	2.4		0300	11.4		0800	4.5		1520	.7
	2235	4.2		0400	10.6		0935	2.7		1910	.2
	2322	5.6									
Detected below dam southeast of Milford (river mile 203.4)											
Aug. 27	1812	0.0	Aug. 28	0617	0.8	Aug. 28	1829	1.5	Aug. 29	1637	1.8
	1856	.2		0705	.7		1918	1.5		1815	1.7
	1905	.1		0754	.8		1948	1.6		1953	1.7
	1953	.1		0842	.8		2123	1.5		2131	1.7
	2041	.1		0930	.9		2258	1.7		2309	1.6
	2129	.2		1018	.8	Aug. 29	0033	1.9	Aug. 30	0047	1.4
	2217	.2		1036	.7		0208	2.1		0225	1.3
	2255	.3		1123	.8		0343	2.2		0403	1.2
	2343	.3		1210	1.0		0518	2.2		0541	1.2
Aug. 28	0031	.4		1257	1.2		0653	2.1		0719	1.2
	0119	.5		1344	1.3		0828	2.1		0857	1.2
	0207	.5		1431	1.4		1003	2.1		1035	1.1
	0255	.5		1518	1.3		1138	2.1		1213	1.0
	0343	.5		1605	1.3		1313	2.3		1351	1.0
	0431	.7		1653	1.5		1448	2.1		1530	.9
	0519	.8		1741	1.5		1627	2.1		1645	.9

Table 4.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, August-September--Continued

Part A.--Reach from U.S. Highway 34 at Seward to county road southeast of DeWitt--Continued

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected below dam southeast of Milford (river mile 203.4)--Continued											
Aug. 30	1823	1.0	Aug. 31	0413	1.0	Aug. 31	1417	0.9	Sept. 1	0720	0.3
	2001	1.0		0552	1.3		1430	.4		1040	.4
	2139	1.0		0731	1.1		1752	.4		1240	.3
	2317	.9		0910	1.1		2114	.3		1300	.2
Aug. 31	0056	1.0		1228	1.0	Sept. 1	0036	.3		1619	0
	0234	.9					0358	.3			
Detected at county road southeast of Milford (river mile 197.5)											
Aug. 28	1903	0.0	Aug. 29	1720	1.1	Aug. 30	1645	1.5	Aug. 31	1455	1.0
	1950	.1		1900	1.1		1745	1.6		1820	1.0
	2030	.9		2040	1.5		1927	1.8		2147	.8
	2209	.4		2220	1.2		2109	1.7	Sept. 1	0113	.9
	2348	.7		2400	1.5		2309	1.7		0439	1.0
Aug. 29	0306	.6	Aug. 30	0140	1.3	Aug. 31	0051	1.8		0805	1.0
	0445	.6		0320	1.4		0233	1.7		1131	.7
	0624	.7		0500	1.5		0415	1.7		1400	.6
	0803	.8		0640	1.6		0615	1.6		2120	.2
	0942	.9		0820	1.6		0815	1.6	Sept. 2	0100	.2
	1121	1.0		1020	1.6		0957	1.5		0440	.2
	1300	1.1		1200	1.5		1139	1.5		0820	.1
	1439	1.2		1340	1.5		1321	1.4		1200	.2
	1620	1.3		1520	1.5		1410	1.4		1540	0

Part B.--Reach from dam southeast of Milford to county road southeast of DeWitt

Amount of dye used: 20 pounds
Site of injection: Below dam at Milford (river mile 203.4)
Time of injection: August 21, 1973 - hour 0900

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at county road southeast of Milford (river mile 197.5)											
Aug. 21	2226	0.0	Aug. 22	0200	110.0	Aug. 22	0548	24.0	Aug. 22	1045	4.2
	2245	.5		0220	99.0		0612	19.0		1129	3.7
	2303	2.9		0242	91.0		0636	16.0		1213	3.2
	2324	9.1		0302	82.0		0700	13.0		1257	2.8
	2343	20.0		0325	68.0		0725	10.0		1342	2.5
Aug. 22	0004	39.0		0340	75.0		0750	9.3		1427	2.3
	0023	60.0		0357	68.0		0815	8.0		1512	2.0
	0041	84.0		0417	59.0		0840	7.0		1556	1.9
	0058	102.0		0439	48.0		0905	6.2		2115	1.3
	0120	123.0		0501	38.0		0930	5.0	Aug. 23	1710	.5
	0141	126.0		0524	30.0		0955	5.0			

Table 4.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, August-September 1973--Continued

Part B.--Reach from dam southeast of Milford to county road southeast of DeWitt--Continued

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at gaging station at Crete (river mile 183.4)											
Aug. 22	1733	0.0	Aug. 22	2157	14.0	Aug. 23	0225	3.8	Aug. 23	0610	0.8
	1817	1.6		2241	12.9		0310	2.6		0655	.6
	1901	4.1		2325	11.0		0355	1.9		0740	.5
	1945	9.4	Aug. 23	0010	9.4		0440	1.3		0825	.3
	2029	12.0		0055	7.7		0525	1.0		0910	0
	2113	12.5		0140	5.0						
Detected at damsite at DeWitt (river mile 154.2)											
Aug. 24	1506	0.0	Aug. 24	2158	6.2	Aug. 25	0437	2.7	Aug. 25	1045	0.6
	1551	.1		2242	6.6		0522	2.1		1120	.6
	1636	.2		2326	6.6		0607	1.8		1205	.5
	1721	.6	Aug. 25	0010	6.4		0652	1.5		1250	.5
	1803	1.0		0054	6.2		0737	1.3		1350	.4
	1903	2.5		0138	5.6		0835	.8		1435	.4
	1947	2.9		0223	4.5		0915	.6		1520	.3
	2030	4.1		0308	3.6		1000	.7	Aug. 26	1150	.1
	2114	4.8									
Detected at county road southeast of DeWitt (river mile 149.0)											
Aug. 24	2337	0.0	Aug. 25	0407	3.8	Aug. 25	0925	3.2	Aug. 25	1355	1.1
Aug. 25	0022	.3		0452	4.2		1010	2.8		1515	.9
	0107	1.3		0537	4.4		1055	2.2		1705	.7
	0152	1.2		0622	4.5		1140	2.2		1855	.5
	0237	1.7		0707	4.6		1225	1.8	Aug. 26	0025	.3
	0322	2.4		0800	4.2		1310	1.3		0215	0

Part C.--Reach from damsite at DeWitt to below the dam at Barneston

Amount of dye used: 35 pounds
Site of injection: Damsite at DeWitt (river mile 154.2)
Time of injection: August 21, 1973 - hour 0910

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at county road southeast of DeWitt (river mile 149.0)											
Aug. 21	1420	0.0	Aug. 21	1540	114.0	Aug. 21	1700	9.4	Aug. 21	1840	0.9
	1430	.9		1550	84.0		1710	6.9		1900	.7
	1440	8.0		1600	68.0		1720	4.5		1920	.6
	1450	29.0		1610	53.0		1730	3.6		1940	.5
	1500	59.0		1620	30.0		1740	2.8		2000	.7
	1510	118.0		1630	25.0		1750	2.1	Aug. 22	0840	.2
	1520	121.0		1640	19.0		1800	1.7	Aug. 23	1200	0
	1530	135.0		1650	13.0		1820	1.2			

Table 4.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, August-September 1973--Continued

Part C.--Reach from damsite at DeWitt to below the dam at Barneston--Continued

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at gaging station at U.S. Highway 77 at Beatrice (river mile 131.0)											
Aug. 22	1300	0.0	Aug. 22	1510	9.0	Aug. 22	1720	21.0	Aug. 22	2100	6.1
	1310	.1		1520	10.5		1730	22.0		2120	5.2
	1320	.2		1530	11.0		1740	20.0		2140	4.4
	1330	.4		1540	13.0		1750	19.0		2200	4.3
	1340	.7		1550	17.0		1800	19.0		2220	3.6
	1350	1.1		1600	17.0		1810	18.0		2240	3.4
	1400	1.6		1610	17.0		1820	17.0		2300	3.0
	1410	2.4		1620	18.0		1840	16.0		2320	2.8
	1420	3.0		1630	20.0		1900	15.0		2340	2.2
	1430	3.9		1640	19.0		1940	11.0	Aug. 23	0730	.6
	1440	4.8		1650	20.0		2000	9.0		1120	.2
	1450	6.0		1700	20.0		2020	9.2		1630	0
	1500	7.4		1710	20.0		2040	8.7			
Detected at county road northwest of Holmesville (river mile 124.9)											
Aug. 22	2340	0.0	Aug. 23	0340	10.2	Aug. 23	0750	11.0	Aug. 23	1115	3.0
	2400	.1		0410	13.4		0815	10.0		1140	2.7
Aug. 23	0040	.2		0447	14.0		0840	9.0		1205	2.5
	0107	.6		0517	15.0		0905	7.0		1230	2.4
	0140	1.4		0550	15.0		0930	5.5		1255	2.4
	0210	3.0		0622	14.6		0955	5.2		1320	2.2
	0243	5.7		0652	13.0		1020	4.2		1345	2.0
	0311	7.2		0725	12.0		1050	3.8		1620	1.1
										2010	.8
Detected below dam at Holmesville (river mile 121.6)											
Aug. 23	1814	0.0	Aug. 23	2259	4.4	Aug. 24	0307	9.0	Aug. 24	0755	5.6
	1840	.1		2323	5.2		0333	9.0		0820	5.1
	1906	.3		2349	5.0		0400	9.0		1220	1.2
	1931	.5	Aug. 24	0005	5.8		0426	9.0		1420	1.1
	1957	.9		0030	6.4		0452	9.0		1620	.7
	2023	1.0		0056	6.7		0518	8.8		1920	.5
	2049	1.4		0122	7.2		0544	8.0		2200	.4
	2115	1.7		0148	7.5		0610	7.6	Aug. 25	0800	.3
	2141	2.1		0215	8.0		0637	7.0		1400	.2
	2207	2.4		0241	8.4		0703	6.5	Aug. 26	1110	.2
	2233	3.0					0729	6.4		1830	.1

Table 4.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, August-September 1973--Continued
Part C.--Reach from damsite at DeWitt to below the dam at Barneston--Continued

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected below dam at Blue Springs (river mile 115.7)											
Aug. 24	1333	0.0	Aug. 24	2028	3.8	Aug. 25	0315	7.1	Aug. 25	1025	2.2
	1359	.1		2054	4.0		0340	7.6		1050	2.0
	1425	.2		2120	4.1		0405	7.0		1115	1.8
	1451	.3		2146	4.4		0430	7.2		1140	1.6
	1517	.5		2211	4.5		0455	7.1		1205	1.5
	1543	.6		2237	4.9		0520	7.2		1231	1.5
	1609	.8		2305	4.9		0545	7.1		1257	1.2
	1635	1.0		2330	5.6		0610	6.3		1323	1.0
	1700	1.3		2355	5.4		0635	6.3		1349	1.0
	1726	1.7	Aug. 25	0020	5.6		0700	5.8		1415	1.0
	1752	2.2		0045	6.0		0726	5.4		1800	.9
	1818	2.6		0110	6.3		0752	4.7		2100	.7
	1844	3.2		0135	6.8		0817	4.2	Aug. 26	0700	.3
	1910	3.5		0200	6.9		0845	3.6		1100	.5
	1936	3.5		0225	6.9		0910	3.5		1820	.3
	2002	3.7		0250	7.0		0935	2.8	Aug. 27	2000	0
							1000	2.3			
Detected below dam at Barneston (river mile 106.1)											
Aug. 26	2100	0.0	Aug. 27	2248	3.4	Aug. 29	0045	1.6	Aug. 30	0430	0.5
	2243	.1	Aug. 28	0032	3.4		0230	1.5		0614	.5
Aug. 27	0026	.1		0217	3.4		0415	1.4		0758	.4
	0209	.2		0401	3.1		0600	1.4		0942	.4
	0352	.3		0546	3.2		0745	1.3		1126	.3
	0535	.4		0730	3.4		0930	1.3		1310	.4
	0718	.6		0915	3.2		1115	1.3		1454	.4
	0901	.6		1059	3.2		1259	1.1		1638	.3
	1044	.9		1244	3.0		1443	1.0		1822	.2
	1227	1.1		1429	2.9		1628	.9	Aug. 31	0700	.4
	1410	1.4		1613	2.9		1810	.8		1800	1.0
	1553	2.0		1758	2.7		1950	.6	Sept. 1	0700	.9
	1736	2.4		1930	2.0		2134	.7		1800	.8
	1919	3.1		2115	2.0		2318	.6	Sept. 2	0700	.3
	2103	3.2		2300	1.8	Aug. 30	0102	.6		1800	.1
							0246	.5			

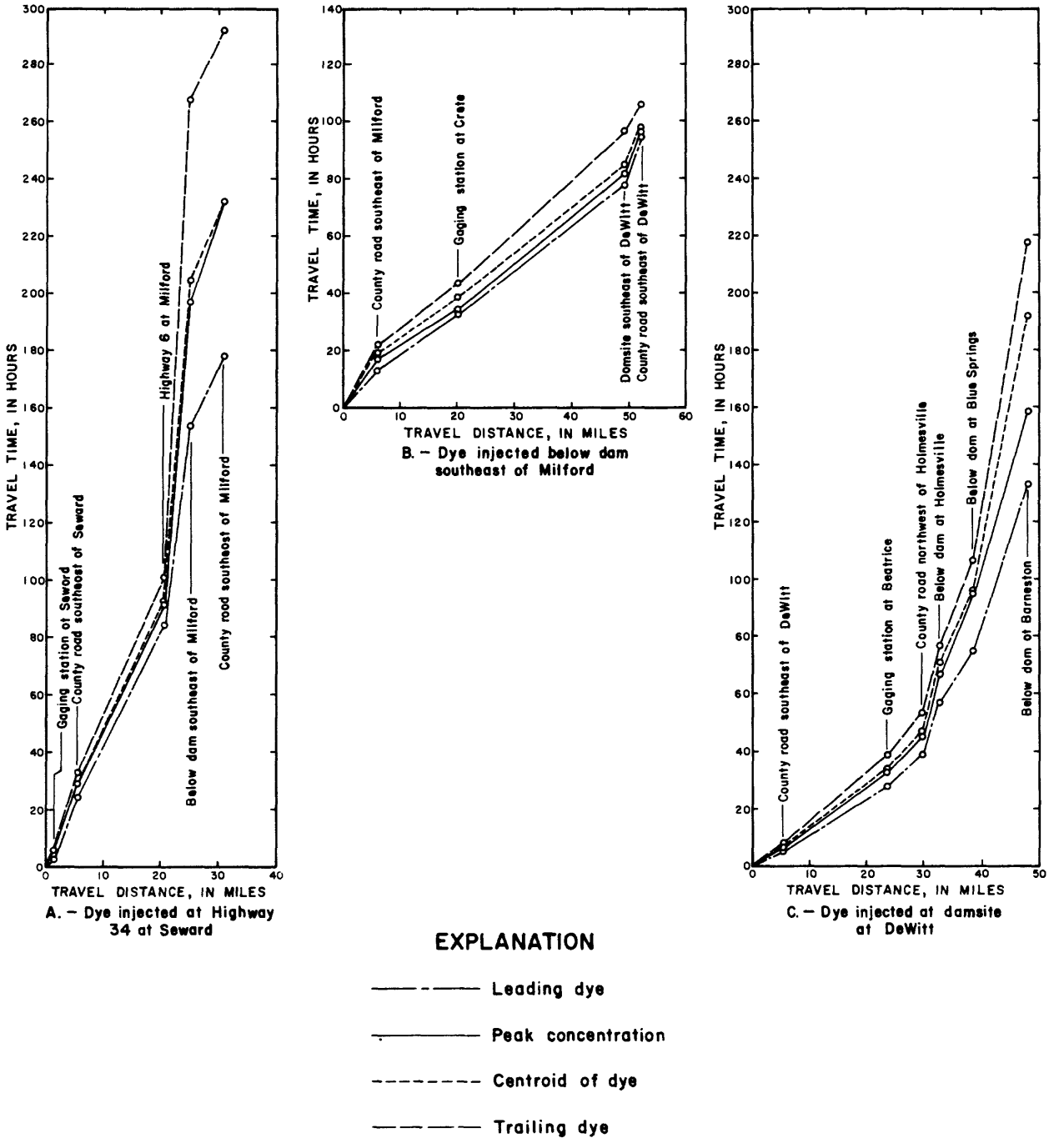


Figure 5.--Travel-time/travel-distance curves, Big Blue River, August to September 1973.

Table 5.--Travel times and travel rates of dye injected into the Big Blue River on May 14, 1974

Dye injection and sampling sites	River mile location	Water discharge (ft^3/s)		Travel distance (mi)	
		Near time of injection	Near time of dye passage	From injection site	From last site upstream
Injection site: Hwy. 34 at Seward----------	228.5				
Sampling site:					
1. Gaging station at Seward----------	227.3	200	200	1.2	1.2
2. County road SE of Seward----------	223.0	---	220	5.5	4.3
3. Hwy. 6 at Milford----------	208.0	---	230	20.5	15.0
4. Below dam SE of Milford----------	203.4	---	230	25.1	4.6
5. Gaging station at Crete----------	183.4	---	380	45.1	20.0
6. Damsite SE of DeWitt----------	154.2	---	430	74.3	29.2
7. County road SE of DeWitt----------	149.0	---	430	79.5	5.2
Injection site: Below dam SE of Milford-----	203.4				
Sampling site:					
8. County road SE of Milford----------	197.5	230	230	5.9	5.9
9. Gaging station at Crete----------	183.4	---	380	20.0	14.1
10. Hwy. 41 at Wilber----------	168.4	---	390	35.0	15.0
11. Damsite SE of DeWitt----------	154.2	---	430	49.2	14.2
12. County road SE of DeWitt----------	149.0	---	430	54.4	5.2
Injection site: Damsite SE of DeWitt--------	154.2				
Sampling site:					
13. County road SE of DeWitt----------	149.0	440	440	5.2	5.2
14. Gaging station at Beatrice----------	131.0	---	470	23.2	18.0
15. County road NW of Holmesville----------	124.9	---	480	29.3	6.1
16. Below dam at Holmesville----------	121.6	---	490	32.6	3.3
17. Below dam at Blue Springs----------	115.7	---	490	38.5	5.9
18. Hwy. 8 at Barneston----------	105.5	---	[1]630	48.7	10.2

[1]Mean daily discharge.

Sampling sites	Travel time (hr)						Travel rate (mi/hr)					
	From injection site			From last site upstream			From injection site			From last site upstream		
	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid
1.	1.02	1.25	1.30	1.02	1.25	1.30	1.18	0.96	0.92	1.18	0.96	0.92
2.	6.33	7.03	7.02	5.31	5.78	5.72	.87	.78	.78	.81	.74	.75
3.	24.60	25.75	26.18	18.27	18.72	19.16	.82	.80	.78	.82	.80	.78
4.	36.48	38.88	39.42	11.88	13.13	13.24	.69	.65	.64	.39	.35	.35
5.	53.28	57.98	58.36	16.80	19.10	18.94	.85	.78	.77	1.19	1.05	1.06
6.	89.50	93.77	93.83	36.22	35.79	35.47	.83	.79	.79	.81	.82	.82
7.	94.75	97.53	98.52	5.25	3.76	4.69	.84	.82	.81	.99	1.38	1.12
8.	4.25	5.58	5.69	4.25	5.58	5.69	1.39	1.06	1.04	1.39	1.06	1.04
9.	17.00	18.58	18.71	12.75	12.90	13.02	1.18	1.08	1.07	1.11	1.09	1.08
10.	35.25	37.08	37.99	18.25	18.60	19.28	.99	.94	.92	.82	.81	.78
11.	48.50	51.40	52.12	13.25	14.32	14.13	1.01	.96	.94	1.07	.99	1.00
12.	53.67	57.28	57.36	5.17	5.88	5.24	1.01	.95	.95	1.01	.88	.99
13.	3.92	4.72	4.87	3.92	4.72	4.87	1.33	1.10	1.07	1.33	1.10	1.07
14.	19.75	22.58	23.64	15.83	17.86	18.77	1.17	1.03	.98	1.14	1.01	.96
15.	27.33	30.17	30.91	7.58	7.59	7.27	1.07	.97	.95	.80	.80	.84
16.	36.50	40.33	42.20	9.17	10.16	11.29	.89	.81	.77	.36	.32	.29
17.	47.45	52.00	55.06	10.95	11.67	12.86	.81	.74	.70	.54	.51	.46
18.	75.22	87.00	88.00	27.77	35.00	32.94	.65	.56	.55	.37	.29	.31

Table 6.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, May 1974

Part A.--Reach from Seward to DeWitt

Amount of dye used: 10 pounds
Site of injection: State Highway 34 at Seward (river mile 228.5)
Time of injection: May 14, 1974 - hour 0800

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at gaging station at Seward and at Highway 15 (river mile 227.3)											
May 14	0900	0.0	May 14	0915	76.0	May 14	0930	16.0	May 14	0945	1.1
	0905	9.6		0920	48.0		0935	6.8		0950	0
	0910	53.0		0925	30.0		0940	3.0			
Detected at county road southeast of Seward (river mile 223.0)											
May 14	1409	0.0	May 14	1451	23.0	May 14	1523	9.3	May 14	1554	0.6
	1420	.1		1502	24.0		1533	4.6		1605	.1
	1430	4.9		1512	17.0		1544	1.9		1615	0
	1441	13.0									
Detected at Highway 6 at Milford (river mile 208.0)											
May 15	0813	0.0	May 15	0922	4.4	May 15	1031	5.3	May 15	1150	0.8
	0836	.1		0945	6.4		1054	3.5		1213	.1
	0859	2.4		1008	6.1		1127	2.0		1236	0
Detected below dam southeast of Milford (river mile 203.4)											
May 15	2005	0.0	May 15	2205	3.5	May 15	2350	4.0	May 16	0207	0.8
	2029	.1		2229	4.0	May 16	0015	3.5		0233	.2
	2053	.8		2253	4.3		0041	2.8		0258	.1
	2117	1.5		2317	4.2		0116	2.1		0324	0
	2141	2.6		2342	4.0		0141	1.5			
Detected at gaging station at Crete (river mile 183.4)											
May 16	1200	0.0	May 16	1540	0.7	May 16	1759	2.3	May 16	2145	0.6
	1317	.1		1607	.9		1943	1.6		2210	.4
	1330	.2		1615	1.0		2009	1.4		2235	.2
	1356	.2		1641	1.6		2035	1.2		2300	.1
	1422	.4		1707	1.7		2100	1.2		2325	0
	1448	.4		1733	2.0		2120	.6			
Detected at damsite southeast of DeWitt (river mile 154.2)											
May 18	0110	0.0	May 18	0414	1.1	May 18	0632	1.2	May 18	0935	0.4
	0156	.2		0500	1.3		0718	1.0		0953	.1
	0242	.4		0546	1.4		0814	.7		1039	0
	0328	.9					0900	.6			
Detected at county road southeast of DeWitt (river mile 149.0)											
May 18	0630	0.0	May 18	0847	0.7	May 18	1115	0.6	May 18	1332	0.4
	0715	.3		0932	.9		1201	.5		1417	.3
	0801	.5		1030	.6		1246	.4		1503	0

Table 6.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, May 1974--Continued

Part B.--Reach from dam southeast of Milford to county road southeast of DeWitt

Amount of dye used: 16.5 pounds
Site of injection: Below dam southeast of Milford (river mile 203.4)
Time of injection: May 15, 1974 - hour 1030

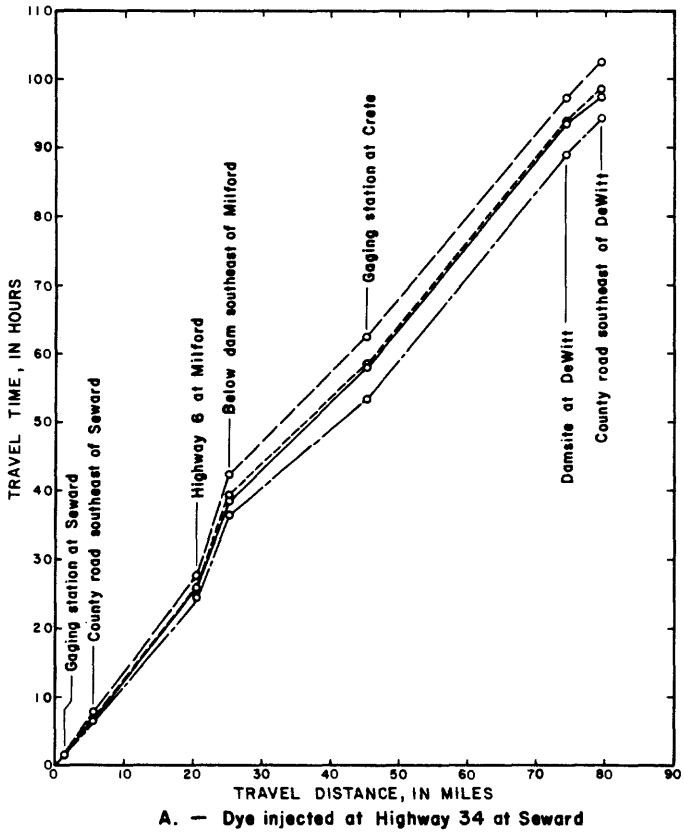
Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at county road southeast of Milford (river mile 197.5)											
May 15	1438	0.0	May 15	1544	24.0	May 15	1650	12.0	May 15	1756	0.9
	1450	2.3		1555	26.0		1701	6.6		1803	.6
	1500	2.6		1617	27.0		1712	5.4		1814	.3
	1511	3.1		1628	23.0		1724	3.8		1825	.2
	1522	8.0		1639	17.0		1735	2.4		1836	0
	1533	19.0					1746	1.6			
Detected at gaging station at Crete (river mile 183.4)											
May 16	0300	0.0	May 16	0434	8.5	May 16	0549	5.6	May 16	0704	0.9
	0330	1.3		0459	9.2		0614	3.3		0729	.8
	0400	4.5		0524	7.9		0639	1.4		0930	0
	0415	6.5									
Detected at Highway 41 at Wilber (river mile 168.4)											
May 16	2135	0.0	May 16	2335	8.8	May 17	0120	3.2	May 17	0516	0.3
	2155	1.2		2355	6.9		0140	2.5		0600	.6
	2215	2.5	May 17	0015	6.5		0304	1.4		0644	.3
	2235	4.2		0035	5.7		0348	.5		0720	.1
	2255	5.5		0055	4.6		0432	.3		0750	0
	2315	7.8									
Detected at damsite southeast of DeWitt (river mile 154.2)											
May 17	1058	0.0	May 17	1354	4.6	May 17	1650	1.1	May 17	1946	0.5
	1142	1.2		1438	3.8		1734	.9		2120	.1
	1226	2.6		1522	2.6		1818	.5		2206	0
	1310	4.3		1606	1.8		1902	.4			
Detected at county road southeast of DeWitt (river mile 149.0)											
May 17	1600	0.0	May 17	1902	3.3	May 17	2118	2.3	May 17	2341	0.3
	1645	.4		1947	3.5		2210	1.4	May 18	0026	.1
	1731	1.4		2033	2.8		2255	.6		0112	0
	1816	3.0									

Table 6.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Big Blue River, May 1974--Continued

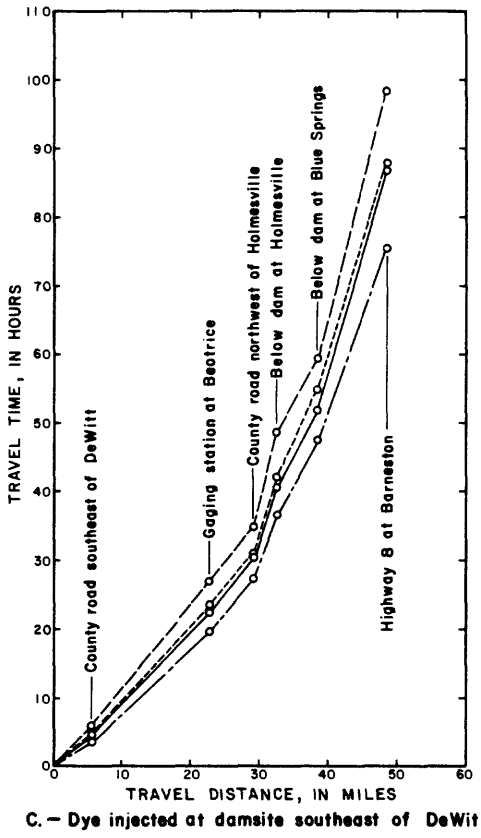
Part C.--Reach from damsite southeast of DeWitt to Highway 8 near Barneston

Amount of dye used: 40 pounds
Site of injection: Damsite southeast of DeWitt (river mile 154.2)
Time of injection: May 15, 1974 - hour 0800

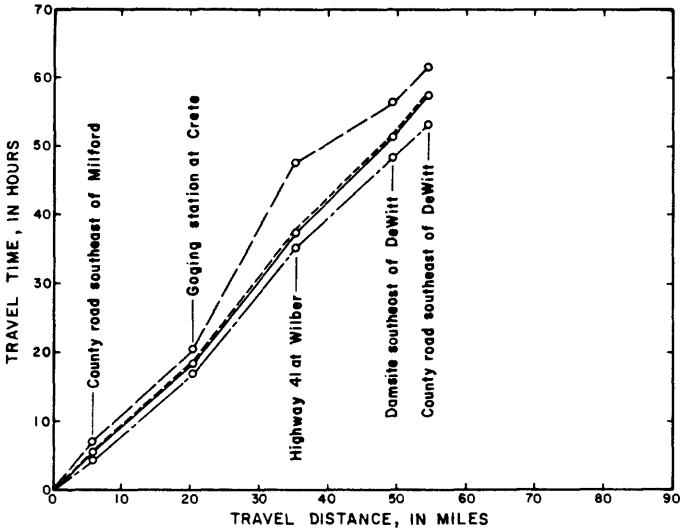
Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at county road southeast of DeWitt (river mile 149.0)											
May 15	1149	0.0	May 15	1243	44.0	May 15	1340	6.6	May 15	1456	0.2
	1155	.8		1253	35.0		1351	3.5		1506	.2
	1200	1.4		1304	25.0		1402	2.1		1517	.2
	1210	12.0		1315	22.0		1413	1.4		1528	.1
	1215	15.0		1324	18.0		1424	.9		1539	.1
	1221	31.0		1334	12.0		1434	.8		1550	0
	1232	39.0					1445	.4			
Detected at gaging station at Beatrice (river mile 131.0)											
May 16	0320	0.0	May 16	0635	10.0	May 16	0841	4.0	May 16	1130	0.9
	0345	.1		0700	9.6		0905	2.8		1200	.8
	0435	.6		0727	9.6		0925	2.0		1230	.7
	0455	2.2		0744	8.9		1018	1.8		1300	.7
	0520	3.2		0753	7.1		1024	1.7		1400	.7
	0545	7.8		0817	5.6		1100	1.0		1500	0
	0610	8.4									
Detected at county road northwest of Holmesville (river mile 124.9)											
May 16	1057	0.0	May 16	1433	8.0	May 16	1726	1.4	May 16	2010	0.3
	1141	.4		1516	6.6		1810	1.2		2112	.1
	1224	2.6		1600	4.2		1823	1.1		2250	.1
	1307	5.2		1643	2.4		1903	.7	May 17	0010	0
	1350	8.0					1946	.4			
Detected below dam at Holmesville (river mile 121.6)											
May 16	2000	0.0	May 17	0020	6.4	May 17	0438	1.9	May 17	0904	0.6
	2030	.1		0103	5.4		0521	1.4		0947	.4
	2050	.4		0146	5.3		0604	1.2		1031	.4
	2128	1.4		0229	4.0		0647	1.0		1115	.4
	2211	2.4		0312	3.2		0730	.8		1126	.4
	2254	4.1		0355	2.2		0900	.6		1600	0
	2337	4.4									
Detected below dam at Blue Springs (river mile 115.7)											
May 17	0700	0.0	May 17	1030	5.1	May 17	1332	5.4	May 17	1759	1.1
	0727	.2		1100	5.6		1417	4.4		1844	1.0
	0800	.6		1130	6.0		1501	3.8		1927	.7
	0830	1.0		1200	6.2		1546	3.0		2100	.5
	0900	1.9		1207	5.8		1630	2.1	May 18	1120	.2
	0930	2.6		1247	5.7		1714	1.2		1600	0
	1000	3.8									
Detected at Highway 8 near Barneston (river mile 105.5)											
May 18	1027	0.0	May 18	1549	0.7	May 18	2130	3.0	May 19	0633	1.5
	1113	.1		1721	1.6	May 19	0030	3.1		0719	1.3
	1159	.1		1805	2.0		0201	2.9		0805	1.2
	1245	.2		1850	2.4		0332	2.4		0851	.8
	1331	.2		1910	2.6		0417	2.1		0937	.7
	1417	.3		1940	2.8		0502	1.8		1015	.4
	1503	.5		2045	3.0		0547	1.7		1300	0



A. — Dye injected at Highway 34 at Seward



C. — Dye injected at damsite southeast of DeWitt



B. — Dye injected below dam southeast of Milford

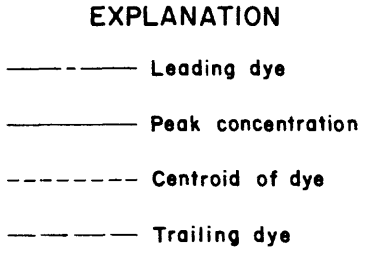


Figure 6.--Travel-time/travel-distance curves, Big Blue River, May 1974.

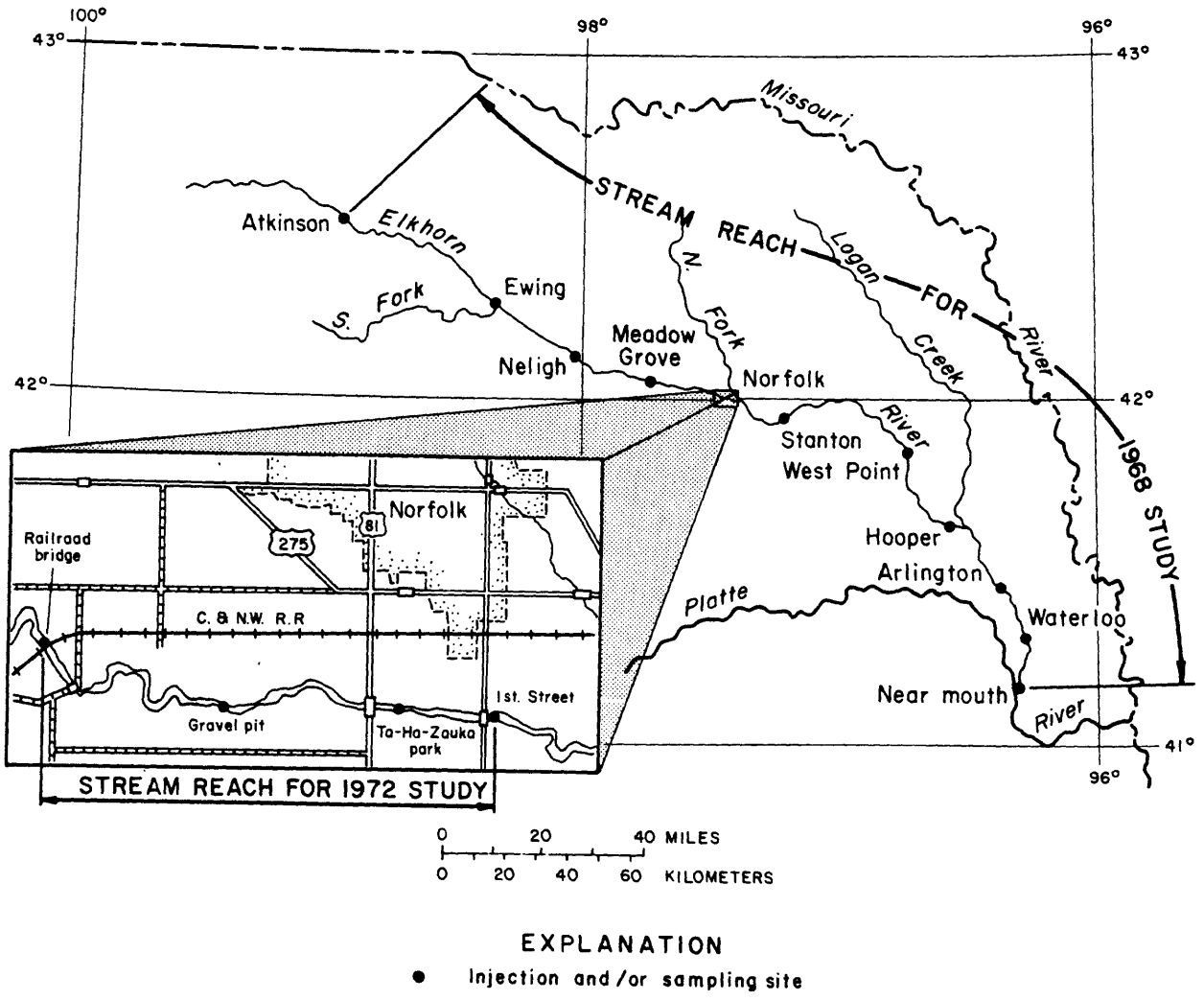


Figure 7.--Locations of injection and (or) sampling sites for two time-of-travel studies on the Elkhorn River.

Table 7.--Travel times and travel rates of dye injected into the Elkhorn River on September 9, 1968

Dye injection and sampling sites	River mile location	Water discharge (ft^3/s) Near time of injection	Water discharge (ft^3/s) Near time of dye passage	Travel distance (mi) From injection site	Travel distance (mi) From last site upstream
Injection site: Hwy. 11 at Atkinson---------	265.8	8.5			
Sampling site:					
1. Gaging station at Ewing----------	199.3		20.0	66.5	66.5
Injection site: Link road 45-B at Ewing-----	199.3	20			
Sampling site:					
2. Gaging station at Neligh----------	173.2	-----	70.7	26.1	26.1
3. County road north of Meadow Grove------	150.4	-----	103	48.9	22.8
4. Ta-Ha-Zouka Park at Norfolk----------	127.9	-----	122	71.4	22.5
Injection site: Ta-Ha-Zouka Park at Norfolk-	127.8	122			
Sampling site:					
5. Hwy. 57 at Stanton----------	111.6	-----	174	16.2	16.2
6. Hwy. 32 at West Point----------	79.3	-----	188	48.5	32.3
7. County road north of Hooper----------	54.4	-----	190	73.4	24.9
Injection site: County road north of Hooper-	54.4	190			
Sampling site:					
8. Hwy. 30 at Arlington----------	30.7	-----	266	23.7	23.7
9. Gaging station at Waterloo----------	13.5	-----	358	40.9	17.2
10. Near mouth----------	.7	-----	374	53.7	12.8

Sampling sites	Travel time (hr) From injection site Leading dye	Peak concentration	Centroid	From last site upstream Leading dye	Peak concentration	Centroid	Travel rate (mi/hr) From injection site Leading dye	Peak concentration	Centroid	From last site upstream Leading dye	Peak concentration	Centroid
1.	114.50	123.00	-----	114.50	123.00	-----	0.58	0.54	-----	0.58	0.54	-----
2.	34.50	38.00	44.34	34.50	38.00	44.34	.76	.69	0.59	.76	.69	0.59
3.	66.00	71.00	81.10	31.50	33.00	36.76	.74	.69	.60	.72	.69	.62
4.	94.00	101.00	111.90	28.00	30.00	30.80	.76	.71	.64	.80	.75	.73
5.	17.25	19.75	22.34	17.25	19.75	22.34	.94	.82	.73	.94	.82	.73
6.	55.00	60.75	67.57	37.75	41.00	45.23	.88	.80	.72	.86	.79	.71
7.	81.00	88.75	97.80	26.00	28.00	30.23	.91	.83	.75	.96	.89	.82
8.	22.78	25.50	27.58	22.78	25.50	27.58	1.04	.93	.86	1.04	.93	.86
9.	39.50	44.00	48.85	16.72	18.50	21.27	1.04	.93	.84	1.03	.93	.81
10.	53.50	58.00	60.15	14.00	14.00	11.30	1.00	.93	.89	.91	.91	1.13

Table 8.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Elkhorn River - September 1968

Part A.--Reach from Atkinson to Ewing

Amount of dye used: 10 pounds
Site of injection: State Highway 11 at Atkinson (river mile 265.8)
Time of injection: September 9, 1968 - hour 2000

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at Ewing at Link road 45-B and USGS gage 06797500 (river mile 199.3)											
Sept. 14	1400	0.0	Sept. 14	1700	0.6	Sept. 14	2200	1.9	Sept. 15	0530	1.7
	1430	.1		1730	.8		2300	2.1		0700	1.5
	1500	.1		1810	1.0		2400	2.0		0900	1.4
	1530	.2		1900	1.3	Sept. 15	0100	2.0		1100	1.3
	1600	.3		2000	1.6		0200	2.0		1245	1.3
	1630	.4		2100	1.8		0330	1.9			

Part B.--Reach from Ewing to Norfolk

Amount of dye used: 25 pounds
Site of injection: Link road 45-B at Ewing (river mile 199.3)
Time of injection: September 9, 1968 - hour 1800

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at Neligh at old State Highway 14 and USGS gage 06798500 (river mile 173.2)											
Sept. 11	0400	0.0	Sept. 11	0715	23.0	Sept. 11	0945	22.0	Sept. 11	1700	4.2
	0430	.2		0730	25.0		1000	21.0		1800	3.7
	0500	1.1		0745	27.0		1015	19.0		2000	2.7
	0530	3.3		0800	27.5		1030	18.0		2200	2.5
	0545	5.4		0815	27.5		1100	16.5		2400	1.9
	0600	7.9		0830	27.5		1200	13.0	Sept. 12	0400	1.4
	0615	10.7		0845	27.5		1300	9.3		0800	1.1
	0630	13.4		0900	26.0		1400	7.4		1200	.8
	0645	16.9		0915	25.0		1500	6.0		1645	.6
	0700	19.5		0930	24.0		1600	5.1	Sept. 13	1005	.2
Detected at Meadow Grove at county road 1 mi north of town (river mile 150.4)											
Sept. 12	1130	0.0	Sept. 12	1600	5.8	Sept. 12	2000	5.8	Sept. 13	0200	2.6
	1200	.2		1630	6.2		2030	5.4		0400	2.3
	1230	.4		1700	7.2		2100	5.2		0600	1.9
	1300	.7		1730	7.0		2130	4.9		0800	1.7
	1330	1.2		1800	6.8		2200	4.4		1200	1.4
	1400	2.7		1830	6.5		2230	4.2		1350	1.4
	1430	3.4		1900	6.3		2300	3.9		1845	.9
	1500	4.4		1930	6.0		2330	3.5	Sept. 14	1120	.3
	1530	5.4					2400	3.4			
Detected at Norfolk at Ta-Ha-Zouka Park (river mile 127.8)											
Sept. 13	1530	0.0	Sept. 13	1900	1.6	Sept. 13	2230	3.4	Sept. 14	0730	1.6
	1600	.1		1930	2.0		2300	3.5		1000	1.3
	1630	.4		2000	2.3		2350	3.3		1210	1.2
	1700	.4		2030	2.5		2400	3.3		1950	.8
	1730	.7		2100	3.0	Sept. 14	0100	3.1	Sept. 15	0950	.4
	1800	1.1		2130	3.2		0200	2.7		1030	.4
	1830	1.4		2200	3.3		0630	1.7			

Table 8.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Elkhorn River - September 1968--Continued

Part C.--Reach from Norfolk to Hooper

Amount of dye used: 40 pounds
Site of injection: At Norfolk at Ta-Ha-Zouka Park (river mile 127.8)
Time of injection: September 9, 1968 - hour 1800

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at Stanton at State Highway 57 (river mile 111.6)											
Sept. 10	1100	0.0	Sept. 10	1315	28.0	Sept. 10	1600	14.6	Sept. 10	2200	1.9
	1115	.2		1330	29.8		1630	11.3		2300	1.6
	1130	.8		1345	31.8		1700	9.3	Sept. 11	0100	1.3
	1145	2.2		1400	30.7		1730	6.3		0300	.8
	1200	4.0		1415	30.3		1800	5.5		0600	.6
	1215	8.6		1430	28.3		1830	4.5		0900	.4
	1230	11.6		1445	24.5		1900	3.9		1200	.2
	1245	16.3		1500	23.8		2000	2.9		1500	0.0
	1300	24.5		1530	18.0		2100	2.4	Sept. 12	1100	0.0
Detected at West Point at State Highway 32 (river mile 79.3)											
Sept. 12	0030	0.0	Sept. 12	0430	5.1	Sept. 12	0830	6.2	Sept. 12	1800	2.2
	0100	.1		0500	6.0		0900	5.8		1900	1.9
	0130	.3		0530	6.5		1000	5.3		2000	1.7
	0145	.4		0600	6.9		1100	4.7		2100	1.5
	0200	.6		0630	7.0		1200	4.0		2400	1.1
	0215	.9		0645	7.2		1300	3.3	Sept. 13	0300	.8
	0230	1.2		0700	7.1		1400	3.1		0600	.7
	0300	2.1		0730	6.7		1500	2.7		1200	.4
	0330	2.9		0800	6.4		1600	2.7		1930	.2
	0400	4.0					1700	2.4			
Detected at Hooper at county road 1 mi north of town (river mile 54.4)											
Sept. 13	0200	0.0	Sept. 13	0915	3.7	Sept. 13	1300	3.5	Sept. 13	2000	1.7
	0300	.1		0930	3.8		1330	3.3		2100	1.6
	0400	.2		0945	3.9		1400	3.2		2200	1.5
	0500	.4		1000	4.0		1430	3.0		2300	1.4
	0530	.5		1015	4.0		1500	2.8		2400	1.3
	0600	.9		1030	4.1		1530	2.6	Sept. 14	0300	1.1
	0630	1.2		1045	4.2		1600	2.4		0600	.8
	0700	1.7		1100	4.1		1630	2.3		0900	.7
	0730	2.2		1115	4.1		1700	2.2		1200	.5
	0800	2.8		1130	4.1		1730	2.1		1500	.4
	0830	3.0		1200	3.9		1800	2.0		1800	.4
	0900	3.5		1230	3.7		1900	1.8		2100	.3

Table 8.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Elkhorn River - September 1968--Continued

Part D.--Reach from Hooper to mouth

Amount of dye used: 60 pounds
Site of injection: At Hooper at county road north of town (river mile 54.4)
Time of injection: September 9, 1968 - hour 1800

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at Arlington at U.S. Highway 30 (river mile 30.7)											
Sept. 10	1630	0.0	Sept. 10	1815	19.9	Sept. 10	2000	38.9	Sept. 10	2200	13.7
	1645	.2		1830	26.6		2015	34.7		2230	10.7
	1700	1.8		1845	31.2		2030	32.6		2300	8.0
	1715	2.0		1900	35.6		2045	27.1		2330	6.6
	1730	4.1		1915	41.1		2100	24.7		2400	5.0
	1745	8.2		1930	42.2		2115	20.4	Sept. 11	0100	3.5
	1800	13.7		1945	41.6		2130	18.6		0245	1.8
Detected at Waterloo at State Highway 64 and USGS gage 06800500 (river mile 13.5)											
Sept. 11	0900	0.0	Sept. 11	1145	6.7	Sept. 11	1330	19.5	Sept. 11	1530	15.1
	0930	.1		1200	8.7		1345	19.6		1600	13.4
	1000	.2		1215	11.1		1400	19.9		1630	11.2
	1015	.5		1230	12.7		1415	19.6		1700	9.5
	1040	1.0		1245	15.3		1430	19.2		1730	8.0
	1055	1.7		1300	16.6		1445	18.7		1800	6.3
	1115	3.4		1315	18.3		1500	17.4	Sept. 12	0800	.6
	1130	4.5					1515	16.2			
Detected near mouth (river mile 0.7)											
Sept. 11	2300	0.0	Sept. 12	0130	6.3	Sept. 12	0345	15.1	Sept. 12	0730	7.5
	2330	.4		0145	7.8		0400	15.2		0800	6.7
	2345	.8		0200	9.2		0415	14.8		0830	5.9
	2400	1.0		0215	9.9		0430	14.5		0900	5.3
Sept. 12	0015	1.2		0230	11.3		0445	14.0		0930	4.6
	0030	1.8		0245	12.7		0500	13.6		1000	3.6
	0045	2.7		0300	13.8		0530	12.7		1130	2.9
	0100	3.4		0315	15.0		0600	10.9		1310	1.0
	0115	5.0		0330	15.0					1500	.3

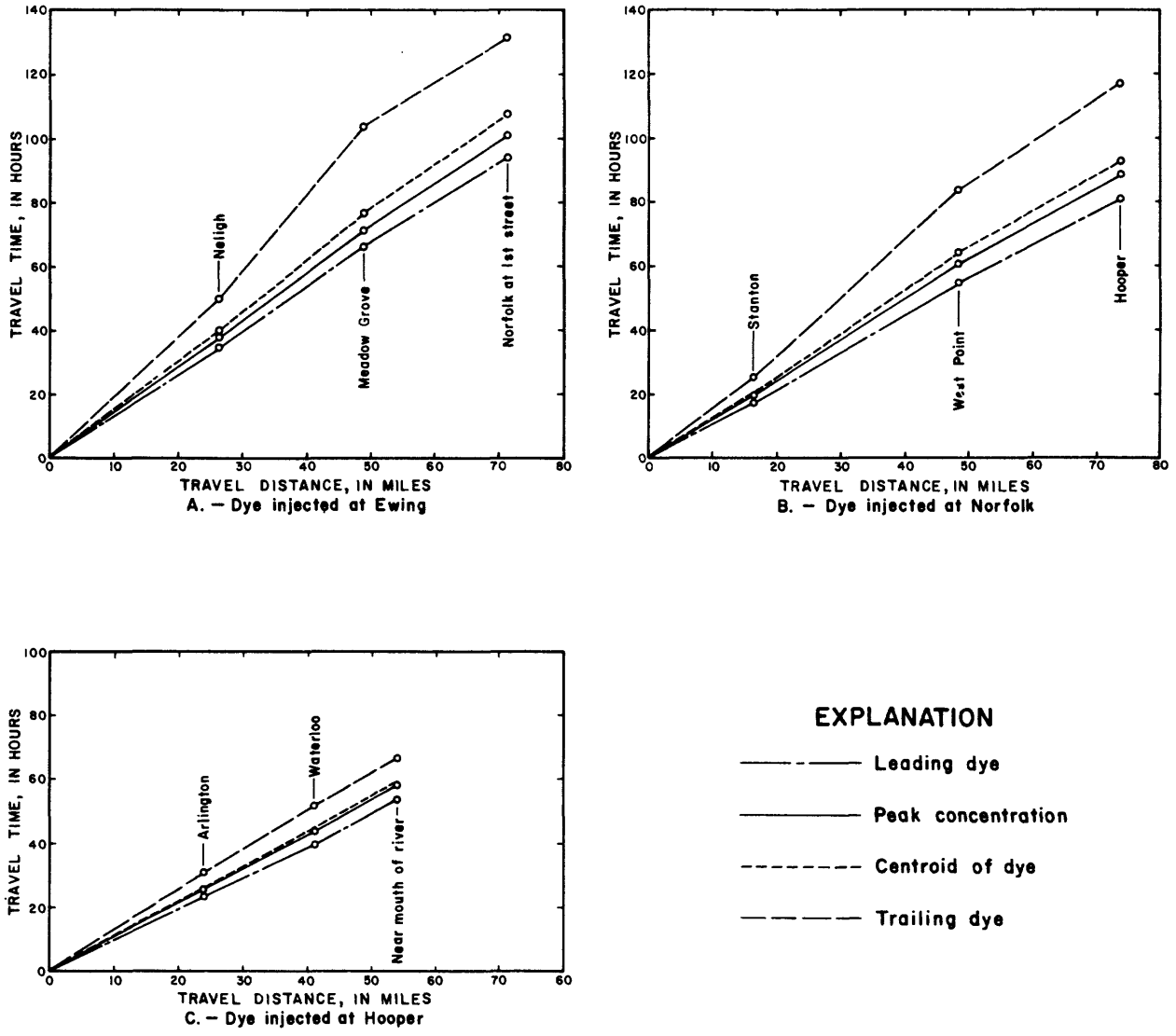


Figure 8.--Travel-time/travel-distance curves, Elkhorn River, September 1968.

Table 9.--Travel times and travel rates of dye injected into the Elkhorn River on September 27, 1972

Dye injection and sampling sites	River mile location	Water discharge (ft^3/s)		Travel distance (mi)	
		Near time of injection	Near time of dye passage	From injection site	From last site upstream
Injection site:					
R.R. bridge SW of Norfolk----------	131.81	219			
Sampling site:					
1. Gravel pit----------	129.65	---	---	2.16	2.16
2. Ta-Ha-Zouka Park----------	127.86	---	---	3.95	1.79
3. Bridge on 1st Street----------	127.06	---	225	4.75	.80

Sampling sites	Travel time (hr)						Travel rate (mi/hr)					
	From injection site			From last site upstream			From injection site			From last site upstream		
	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid
1.	2.00	2.40	2.59	2.00	2.40	2.59	1.08	0.90	0.83	1.08	0.90	0.83
2.	3.58	4.18	4.57	1.58	1.78	1.98	1.10	.94	.86	1.13	1.01	.90
3.	4.33	4.93	5.34	.75	.75	.77	1.10	.96	.89	1.07	1.07	1.04

Table 10.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the Elkhorn River, September 1972

Amount of dye used: 2.6 pounds
Site of injection: At Chicago & Northwestern Railway bridge southwest of Norfolk (river mile 131.81)
Time of injection: September 27, 1972 - hour 0725

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at gravel pit, EPA site 2 (river mile 129.65)											
Sept. 27	0920	0.0	Sept. 27	0946	17.5	Sept. 27	1010	6.2	Sept. 27	1038	1.1
	0925	.5		0949	18.2		1013	5.0		1043	1.0
	0928	1.7		0952	17.5		1016	4.1		1048	.8
	0931	3.0		0955	16.0		1019	3.9		1053	.7
	0934	5.2		0958	14.8		1022	3.0		1058	.7
	0937	9.8		1001	11.5		1025	2.3		1108	.5
	0940	11.6		1004	9.3		1028	1.9		1128	.3
	0943	16.5		1008	7.2		1033	1.6		1230	.1
Detected at Ta-Ha-Zouka Park, EPA site 3 (river mile 127.86)											
Sept. 27	1050	0.0	Sept. 27	1128	10.2	Sept. 27	1200	5.0	Sept. 27	1250	0.9
	1100	.1		1132	11.1		1204	4.2		1300	.7
	1104	.5		1136	11.4		1208	3.5		1330	.4
	1108	1.3		1140	10.9		1212	2.8		1400	.3
	1112	2.4		1144	9.9		1216	2.4		1500	.3
	1116	3.8		1148	8.9		1220	2.0		1524	.1
	1120	5.8		1152	7.5		1230	1.5		1600	.1
	1124	8.2		1156	6.6		1240	1.1			
Detected at bridge at 1st Street, EPZ site 4 (river mile 127.06)											
Sept. 27	1140	0.0	Sept. 27	1209	7.2	Sept. 27	1233	8.1	Sept. 27	1311	2.1
	1145	.2		1213	8.2		1237	7.3		1321	1.4
	1149	.7		1217	9.2		1241	6.6		1336	1.0
	1153	1.4		1221	9.5		1246	5.4		1406	.6
	1157	2.4		1225	9.3		1251	3.9		1530	.2
	1201	3.8		1229	8.6		1256	3.7		1600	.1
	1205	5.3					1301	2.9			

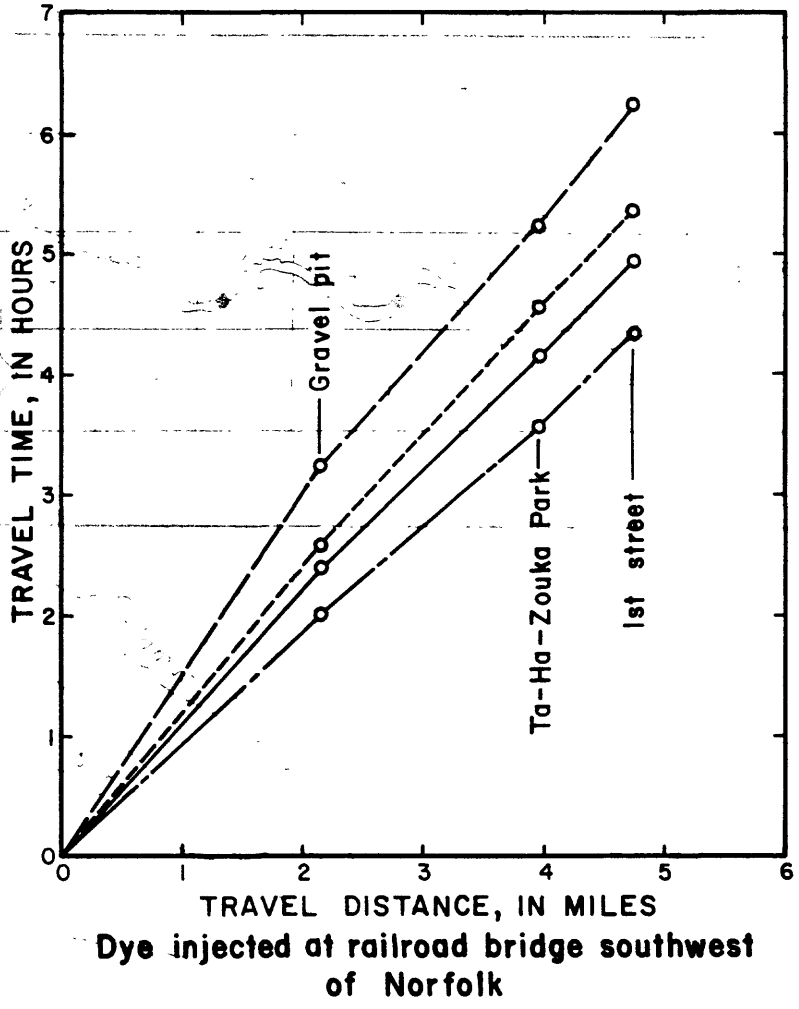


Figure 9.--Travel-time/travel-distance curves, Elkhorn River, September 1972.

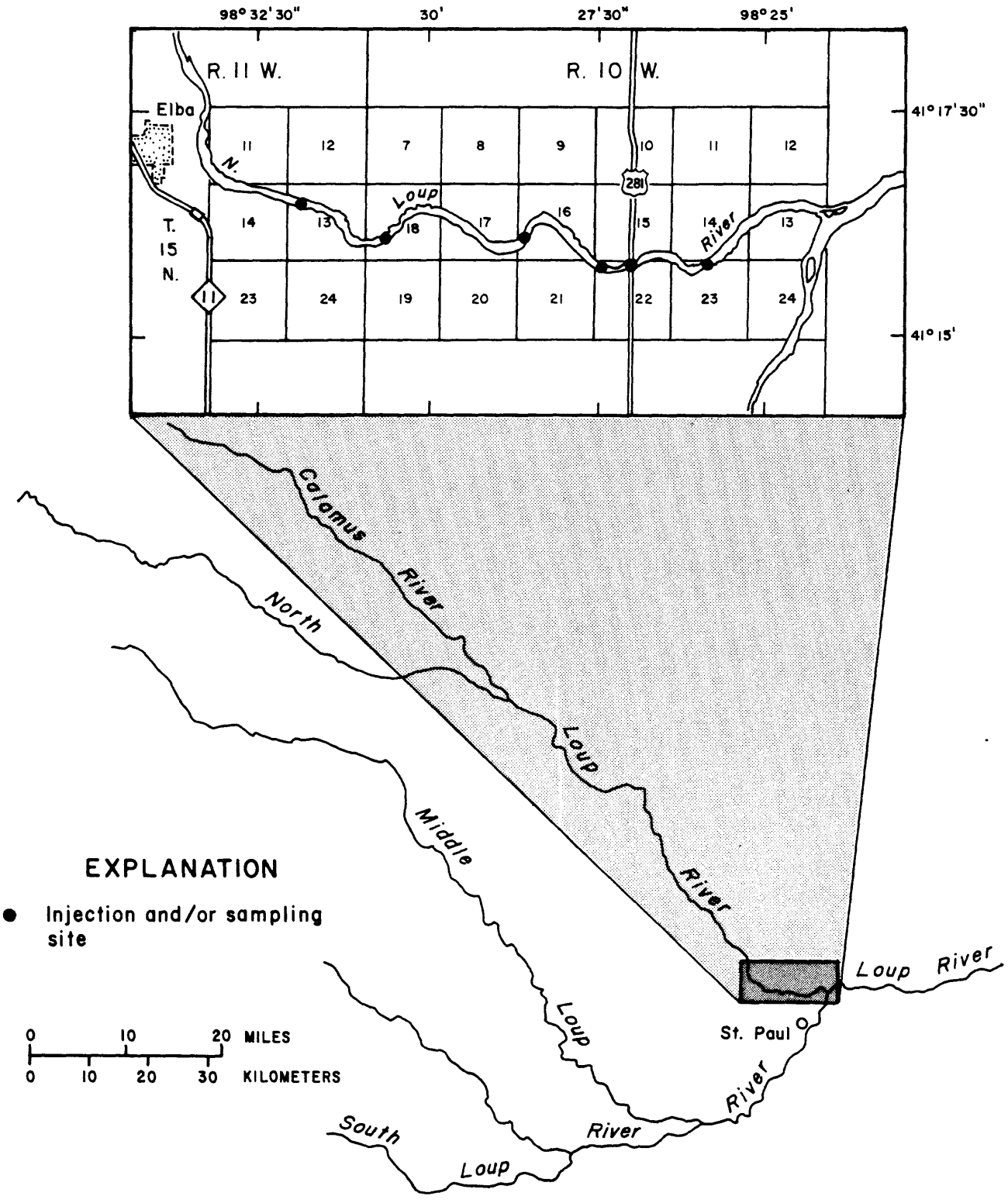


Figure 10.--Locations of injection and (or) sampling sites for time-of-travel study on the North Loup River.

Table 11.--Travel times and travel rates of dye injected into the North Loup River on September 29, 1972

Dye injection and sampling sites	River mile location	Water discharge (ft^3/s)		Travel distance (mi)	
		Near time of injection	Near time of dye passage	From injection site	From last site upstream
Injection site:					
1.5 mi SE of Elba----------	8.38	842			
Sampling site:					
1. SW¼ sec. 18, T.15 N., R.11 W.----------	6.88	-----	-----	1.50	1.50
2. SW¼ sec. 16, T.15 N., R.10 W.----------	4.88	-----	-----	3.50	2.00
3. NW¼ sec. 22, T.15 N., R.10 W.----------	3.40	-----	-----	4.98	1.48
4. Bridge on Hwy. 281----------	2.90	-----	-----	5.48	.50
5. SE¼ sec. 23, T.15 N., R.10 W.----------	1.77	-----	887	6.61	1.13

Sampling sites	Travel time (hr)						Travel rate (mi/hr)					
	From injection site			From last site upstream			From injection site			From last site upstream		
	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid
1.	1.12	1.28	1.38	1.12	1.28	1.38	1.34	1.17	1.09	1.34	1.17	1.09
2.	2.72	3.13	3.34	1.60	1.85	1.96	1.29	1.12	1.05	1.25	1.08	1.02
3.	3.72	4.13	4.50	1.00	1.00	1.16	1.34	1.21	1.11	1.48	1.48	1.28
4.	3.95	4.33	4.76	.23	.20	.26	1.39	1.27	1.15	2.17	2.50	1.92
5.	4.92	5.37	5.79	.97	1.04	1.03	1.34	1.23	1.14	1.16	1.09	1.10

Table 12.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the North Loup River, September 1972

Amount of dye used: 7.86 pounds
Site of injection: NW¼ sec. 13, T.15 N., R.11 W., about 1.5 mi southeast of Elba (river mile 8.38)
Time of injection: September 29, 1972 - hour 0803

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at SW¼ sec. 18, T.15 N., R.11 W., EPA site 1 (river mile 6.88)											
Sept. 29	0905	0.0	Sept. 29	0926	34.8	Sept. 29	0945	2.1	Sept. 29	1030	0.4
	0910	.1		0929	21.2		0950	1.6		1045	.3
	0914	21.2		0932	13.6		0956	1.1		1100	.2
	0917	49.5		0935	7.1		1000	.9		1115	.1
	0920	58.0		0940	3.5		1010	1.1		1130	0
	0923	53.2					1020	.6			
Detected at SW¼ sec. 16, T.15 N., R.10 W., EPA site 2 (river mile 4.88)											
Sept. 29	0916	0.0	Sept. 29	1116	20.0	Sept. 29	1146	3.1	Sept. 29	1230	0.7
	1046	.1		1121	16.5		1151	2.4		1246	.5
	1051	.1		1126	12.5		1156	2.0		1256	.6
	1056	6.6		1131	8.8		1206	1.5		1306	.6
	1101	15.0		1136	6.2		1216	1.1		1316	.4
	1106	23.0		1141	3.8		1226	.8		1341	.3
	1111	23.5									
Detected at NW¼ sec. 22, T.15 N., R.10 W., EPA site 3 (river mile 3.40)											
Sept. 29	1125	0.0	Sept. 29	1211	17.0	Sept. 29	1237	7.3	Sept. 29	1330	1.0
	1146	.1		1214	16.5		1241	5.6		1352	.7
	1151	1.2		1217	15.5		1245	3.9		1410	.6
	1154	3.0		1220	14.0		1250	3.1		1430	.4
	1157	6.7		1223	12.5		1255	2.4		1450	.3
	1200	10.8		1226	12.3		1300	2.1		1510	.3
	1203	13.5		1229	10.2		1310	1.6		1530	.2
	1206	15.5		1233	8.5		1323	1.2		1550	.2
Detected at bridge on U.S. Highway 281, EPA site 4 (river mile 2.90)											
Sept. 29	1155	0.0	Sept. 29	1229	14.5	Sept. 29	1253	5.7	Sept. 29	1409	0.7
	1200	1.0		1232	13.5		1256	4.8		1419	.6
	1205	4.5		1235	11.9		1259	4.2		1429	.5
	1210	10.0		1238	10.8		1309	2.5		1439	.5
	1214	11.0		1241	9.8		1319	1.9		1449	.4
	1217	14.0		1244	8.6		1329	1.4		1519	.3
	1220	15.0		1247	7.4		1339	1.2		1549	.2
	1223	16.0		1250	6.2		1349	1.0		1715	.1
	1226	15.5					1359	.8			
Detected at SE¼ sec. 23, T.15 N., R.10 W. (river mile 1.77)											
Sept. 29	1252	0.0	Sept. 29	1320	10.8	Sept. 29	1345	6.9	Sept. 29	1420	1.9
	1258	.9		1325	11.4		1350	5.5		1430	1.5
	1301	2.4		1330	10.6		1355	4.4		1510	.7
	1305	3.9		1335	9.3		1400	3.5		1540	.4
	1310	7.0		1340	7.7		1405	2.9		1725	.1
	1315	9.8					1410	2.4			

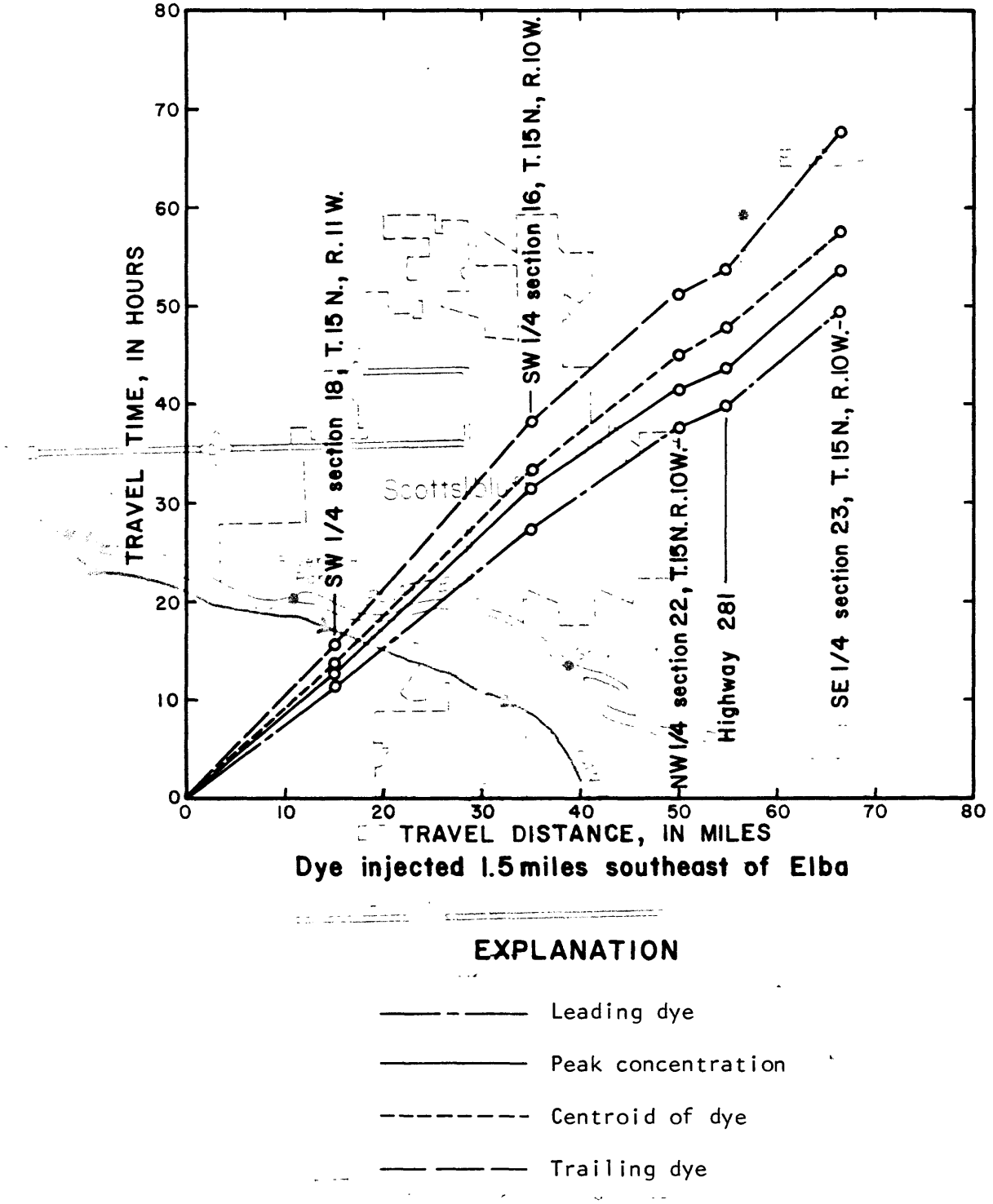


Figure 11.--Travel-time/travel-distance curves, North Loup River, September 1972.

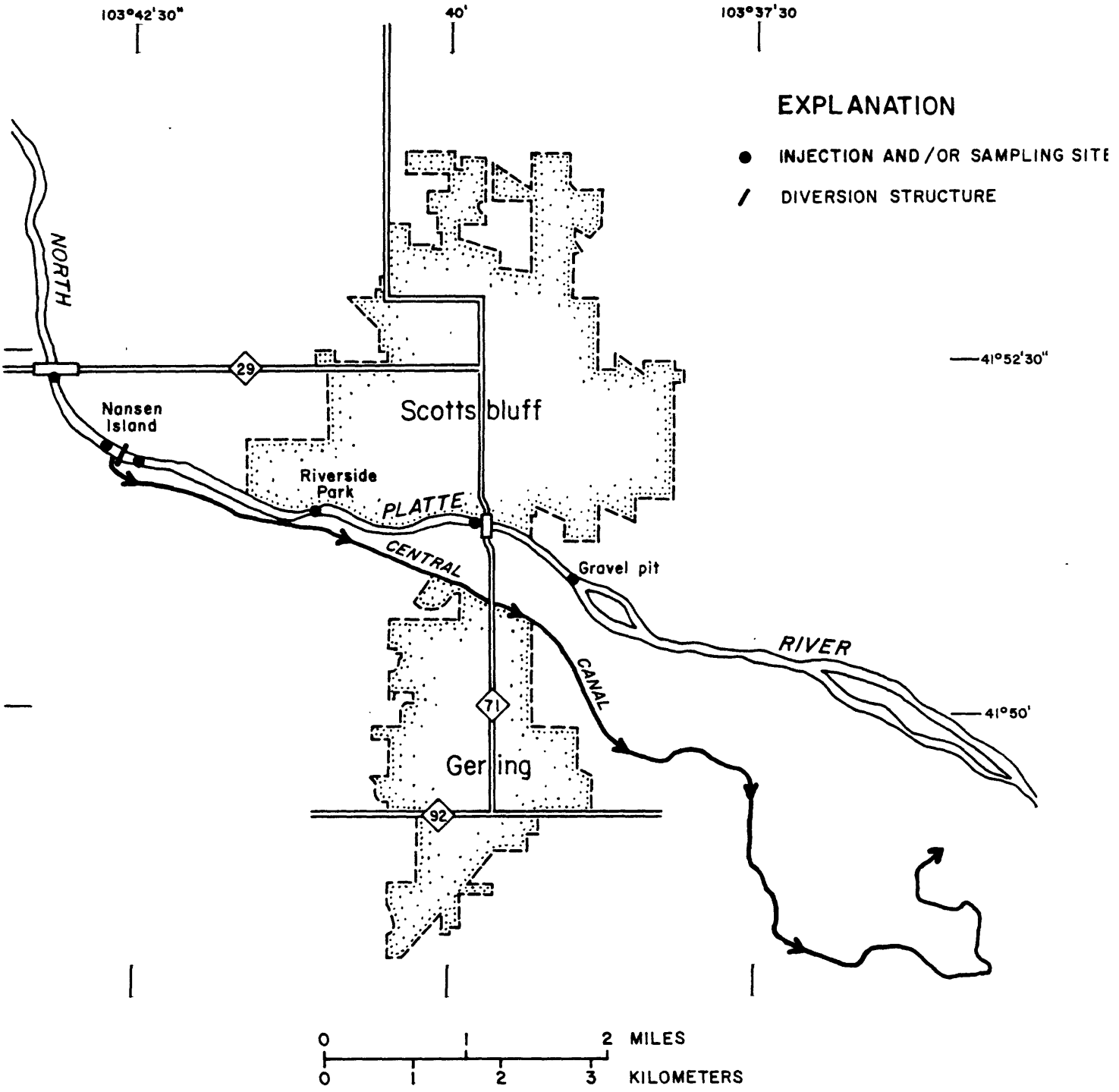


Figure 12.--Locations of injection and (or) sampling sites for time-of-travel study on the North Platte River.

Table 13.--Travel times and travel rates of dye injected into the North Platte River on October 4, 1972

Dye injection and sampling sites	River mile location	Water discharge (ft^3/s)		Travel distance (mi)	
		Near time of injection	Near time of dye passage	From injection site	From last site upstream
Injection site:					
Hwy. 29 west of Scottsbluff----------	178.80	1,170			
Sampling sites:					
1. Upstream from diversion dam at Nansen Island----------	177.62	-----	-----	1.18	1.18
2. Downstream from diversion dam at Nansen Island----------	177.53	-----	-----	1.27	.09
3. Riverside Park----------	176.40	-----	-----	2.40	1.13
4. Bridge on Hwy. 71----------	175.19	-----	-----	3.61	1.21
5. Gravel pit----------	174.28	-----	1,250	4.52	.91

Sampling sites	Travel time (hr)						Travel rate (mi/hr)					
	From injection site			From last site upstream			From injection site			From last site upstream		
	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid
1.	0.64	0.65	0.67	0.64	0.65	0.67	1.84	1.82	1.76	1.84	1.82	1.76
2.	.67	.72	.73	.03	.07	.06	1.90	1.76	1.74	3.00	1.29	1.50
3.	1.27	1.34	1.52	.60	.62	.79	1.89	1.79	1.58	1.89	1.82	1.43
4.	1.67	2.00	2.08	.40	.66	.56	2.16	1.80	1.74	3.02	1.83	2.16
5.	2.00	2.42	2.64	.33	.42	.57	2.26	1.87	1.71	2.76	2.17	1.58

Table 14.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in the North Platte River, October 1972

Amount of dye used: 5.24 pounds
Site of injection: At bridge at State Highway 29 near Scottsbluff (river mile 178.8)
Time of injection: October 4, 1972 - hour 0935

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected just upstream from diversion dam at Nansen Island, EPA site 1 (river mile 177.62)											
Oct. 4	1009	0.0	Oct. 4	1018	10.8	Oct. 4	1025	0.6	Oct. 4	1040	0.1
	1013	29.4		1019	4.4		1027	.6		1045	.2
	1014	58.2		1022	1.7		1030	.4		1050	.1
	1015	44.6		1023	.9		1033	.3		1055	0
	1016	27.2					1036	.2			
Detected just downstream from diversion dam at Nansen Island, EPA site 2 (river mile 177.53)											
Oct. 4	1012	0.0	Oct. 4	1021	6.2	Oct. 4	1027	0.5	Oct. 4	1034	0.1
	1015	2.2		1022	3.6		1028	.4		1036	.1
	1016	8.5		1023	2.1		1029	.4		1038	.3
	1017	17.6		1024	1.4		1030	.2		1040	.1
	1018	22.8		1025	1.1		1031	.2		1042	.1
	1019	14.5		1026	.7		1032	.1		1044	0
	1020	9.5									
Detected at Riverside Park, EPA site 3 (river mile 176.40)											
Oct. 4	1045	0.0	Oct. 4	1102	15.2	Oct. 4	1121	3.7	Oct. 4	1146	0.4
	1051	2.3		1105	12.0		1126	1.9		1151	.3
	1053	8.3		1108	10.0		1131	1.1		1201	.2
	1055	20.5		1111	8.7		1136	.6		1211	.1
	1057	18.0		1116	6.5		1141	.5		1241	0
	1059	17.5									
Detected at bridge at State Highway 71, EPA site 4 (river mile 175.19)											
Oct. 4	1110	0.0	Oct. 4	1130	8.8	Oct. 4	1143	7.8	Oct. 4	1210	0.3
	1115	.1		1131	11.4		1147	7.8		1220	.5
	1120	1.2		1133	11.8		1151	4.9		1230	.2
	1125	4.0		1135	12.4		1155	3.5		1240	.1
	1128	7.2		1136	12.2		1200	3.4		1300	.1
	1129	9.1		1139	11.4		1205	.7		1330	0
Detected at gravel pit, EPA site 5 (river mile 174.28)											
Oct. 4	1130	0.0	Oct. 4	1205	8.1	Oct. 4	1240	1.0	Oct. 4	1315	0.1
	1135	.2		1210	7.8		1245	.8		1320	.2
	1140	.1		1215	7.0		1250	.7		1325	.1
	1145	.1		1220	4.9		1255	.5		1330	.1
	1150	.9		1225	3.3		1300	.4		1335	.1
	1155	4.5		1230	2.0		1305	.3		1340	.2
	1200	8.3		1235	1.4		1310	.3			

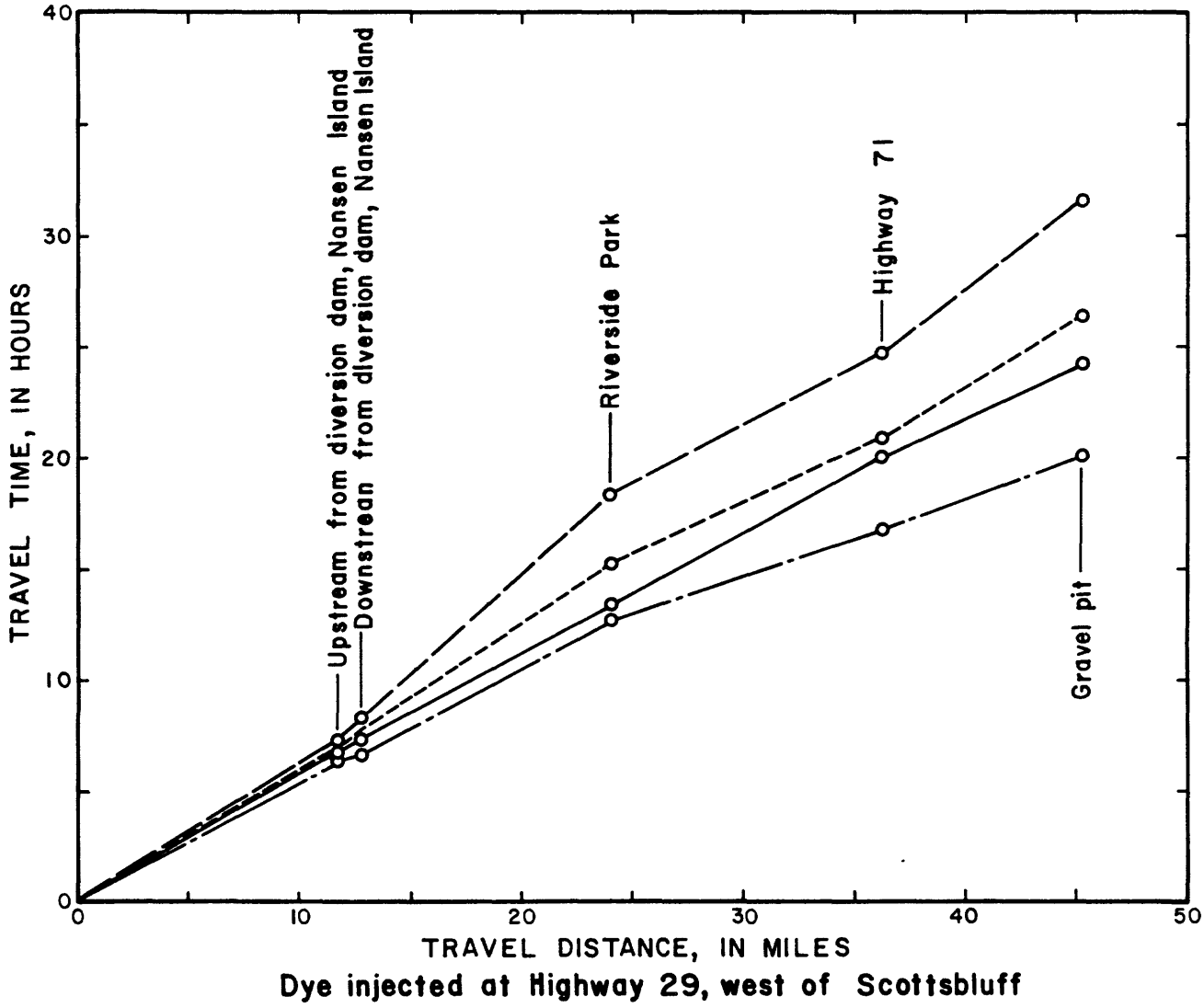


Figure 13.--Travel-time/travel-distance curves, North Platte River, October 1972.

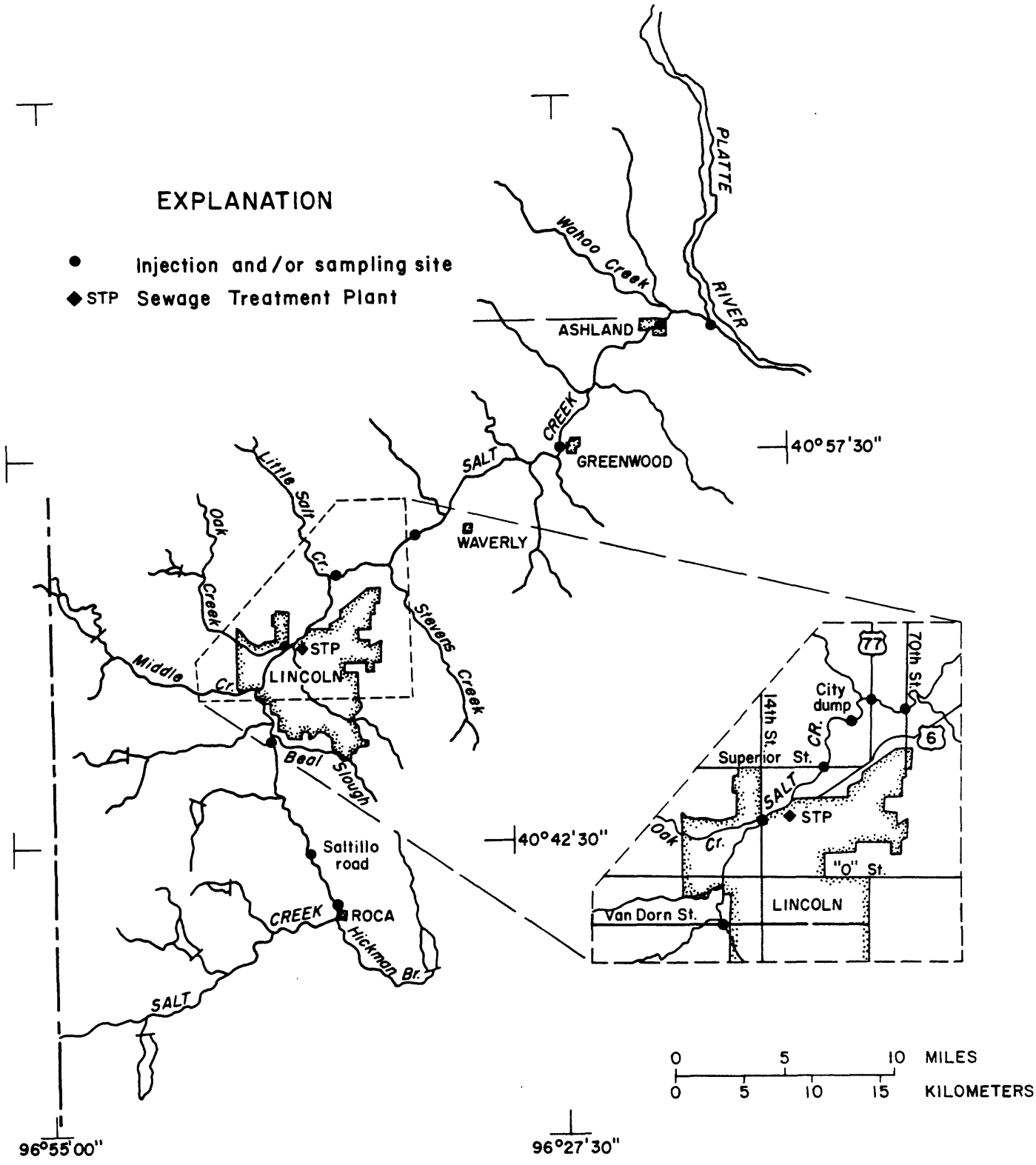


Figure 14.--Locations of injection and (or) sampling sites for three time-of-travel studies on Salt Creek.

Table 15.--Travel times and travel rates of dye injected into Salt Creek on September 6, 1972

Dye injection and sampling sites	River mile location	Water discharge (ft^3/s)		Travel distance (mi)	
		Near time of injection	Near time of dye passage	From injection site	From last site upstream
Injection site: Gaging station at Roca------	56.90	5.14			
Sampling site:					
1. Bridge on Saltillo Road----------	50.46	----	5.23	6.44	6.44
2. Bridge above Beal Slough----------	38.09	----	6.66	18.81	12.37
3. Bridge at 14th Street----------	32.30	----	28.7	24.60	5.79
4. Bridge on Hwy. 77----------	26.55	----	110	30.35	5.75
Injection site: Bridge at 14th Street-------	32.30	----			
Sampling site:					
5. Bridge on Hwy. 77----------	26.55	----	87.0	5.75	5.75
6. Below Stevens Creek near Waverly-------	22.79	----	93.3	9.51	3.76
7. Gaging station at Greenwood----------	12.84	----	106	19.46	9.95
8. Hwy 63 bridge at Ashland----------	4.61	----	107	27.69	8.23
9. At mouth of Salt Creek----------	.10	----	144	32.20	4.51

Sampling sites	Travel time (hr)						Travel rate (mi/hr)					
	From injection site			From last site upstream			From injection site			From last site upstream		
	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid
1.	36.75	44.25	52.57	36.75	44.25	52.57	0.18	0.15	0.12	0.18	0.15	0.12
2.	108.50	121.00	124.95	71.75	76.75	72.38	.17	.16	.15	.17	.16	.17
3.	130.50	141.00	143.97	22.00	20.00	19.02	.19	.17	.17	.26	.29	.30
4.	138.00	150.50	150.20	7.50	9.50	6.23	.22	.20	.20	.77	.60	.92
5.	6.75	7.75	8.25	6.75	7.75	8.25	.85	.74	.70	.85	.74	.70
6.	11.00	12.58	13.56	4.25	4.83	5.31	.86	.76	.70	.88	.78	.71
7.	23.00	25.45	27.07	12.00	12.87	13.51	.85	.76	.72	.83	.77	.74
8.	34.50	37.75	40.06	11.50	12.30	12.99	.80	.73	.69	.72	.67	.63
9.	43.50	48.00	53.99	9.00	10.25	13.93	.74	.67	.60	.50	.44	.32

Table 16.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in Salt Creek, September 6-12, 1972

Part A.--Reach from Roca to U.S. Highway 77

Amount of dye used: 10 pounds
Site of injection: At USGS gage 06803000 at Roca (river mile 56.90)
Time of injection: September 6, 1972 - hour 0800

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at bridge on county road at Saltillo siding (river mile 50.46)											
Sept. 7	2030	0.0	Sept. 8	0130	67.0	Sept. 8	0630	130	Sept. 8	1430	11.5
	2045	.2		0145	78.0		0645	119		1500	11.0
	2100	.2		0200	84.0		0700	114		1530	9.7
	2115	.6		0215	96.0		0715	109		1600	9.2
	2130	1.0		0230	114		0729	103		1630	7.7
	2145	1.4		0245	128		0745	98.0		1700	6.7
	2200	2.0		0300	136		0800	95.0		1730	6.7
	2217	3.4		0315	142		0815	90.0		1800	6.2
	2230	5.4		0331	142		0831	74.0		1830	5.5
	2245	6.5		0345	153		0900	60.0		1900	5.4
	2300	8.7		0400	162		0930	50.0		1930	5.2
	2317	14.0		0415	162		1000	40.0		2000	5.0
	2330	17.5		0430	159		1030	37.0		2100	4.5
	2345	21.0		0445	159		1100	28.0		2200	4.1
	2400	25.0		0500	159		1130	25.0		2300	3.8
Sept. 8	0025	31.0		0515	153		1200	21.0		2400	3.6
	0035	41.0		0530	151		1230	18.0	Sept. 9	0900	2.0
	0045	41.0		0545	140		1300	15.0		1205	1.8
	0100	47.0		0600	137		1330	14.5		1845	1.6
	0115	58.0		0615	132		1400	13.0	Sept. 10	1115	.9
Detected at county road bridge above Beal Slough (river mile 38.09)											
Sept. 10	2005	0.0	Sept. 11	0400	18.0	Sept. 11	1010	34.5	Sept. 11	2030	7.5
	2102	.2		0500	23.0		1107	33.0		2130	7.3
	2200	.8		0600	28.0		1200	28.0	Sept. 12	0230	3.9
	2300	1.2		0700	33.0		1255	26.5		0530	3.2
	2400	2.3		0800	36.0		1357	22.0		0830	1.8
Sept. 11	0100	4.3		0810	37.5		1520	18.0		1150	1.8
	0120	5.4		0900	38.0		1625	15.0		1625	1.8
	0200	7.7		1005	35.0		1850	8.8		2000	1.3
	0300	11.5					1945	8.7			
Detected at bridge at 14th Street (river mile 32.30)											
Sept. 11	1815	0.1	Sept. 12	0100	5.3	Sept. 12	0755	6.2	Sept. 12	1700	1.4
	1830	.4		0200	6.8		0850	5.6		1800	1.1
	2000	.9		0300	6.6		0958	4.9		2000	.9
	2045	1.7		0400	7.0		1100	3.7		2235	1.4
	2100	1.7		0500	7.9		1200	2.7	Sept. 13	0010	.9
	2200	2.6		0605	7.2		1300	1.9		0215	.8
	2300	3.5		0705	6.4		1500	1.7		0500	.8
	2400	4.1								0820	.6
Detected at bridge on U.S. Highway 77 (river mile 26.55)											
Sept. 11	2400	0.0	Sept. 12	0805	1.2	Sept. 12	1515	2.0	Sept. 12	2210	0.5
Sept. 12	0200	.1		1035	1.7		1645	1.8	Sept. 13	0030	.3
	0320	.2		1135	1.6		1730	1.4		0200	.2
	0420	.3		1245	1.9		1830	1.3		0445	.2
	0515	.5		1400	2.0		1940	.6		0800	.2
	0624	.7									

Table 16--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in Salt Creek, September 6-12, 1972--Continued

Part B.--Reach from 14th Street bridge to mouth

Amount of dye used: 10 pounds
Site of injection: At bridge at 14th Street (river mile 32.30)
Time of injection: September 6, 1972 - hour 0800

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at bridge on U.S. Highway 77 (river mile 26.55)											
Sept. 6	1430	0.0	Sept. 6	1600	45.0	Sept. 6	1715	6.4	Sept. 6	1845	2.1
	1445	.4		1615	26.0		1730	4.8		1900	1.7
	1500	9.1		1630	19.0		1745	4.3		2014	1.0
	1515	38.0		1645	14.0		1800	3.3		2109	.8
	1530	50.0		1700	8.9		1815	2.6		2207	.6
	1545	53.0					1830	2.2			
Detected below Stevens Creek near Waverly (river mile 22.79)											
Sept. 6	1845	0.0	Sept. 6	2035	34.0	Sept. 6	2220	8.3	Sept. 6	2400	2.5
	1900	.2		2045	33.0		2230	6.6	Sept. 7	0030	2.1
	1921	1.7		2056	30.0		2245	5.0		0100	1.8
	1930	4.2		2121	21.0		2300	4.3		0130	1.5
	1945	11.0		2130	18.0		2315	3.8		0325	.9
	2000	21.0		2145	15.0		2330	3.1		0515	.7
	2025	31.0		2155	13.0		2345	2.8			
Detected at USGS gage 06803555 at Greenwood (river mile 12.84)											
Sept. 7	0630	0.0	Sept. 7	0945	12.0	Sept. 7	1116	7.1	Sept. 7	1430	1.8
	0700	.5		1000	11.0		1130	6.3		1513	1.5
	0730	1.9		1016	10.0		1200	4.7		1613	1.2
	0755	4.2		1031	10.0		1230	3.6		1713	.9
	0845	13.0		1047	8.9		1300	3.0		1922	.7
	0915	14.0		1103	7.8		1330	2.5		2117	.5
	0930	14.0					1400	2.3			
Detected at bridge on State Highway 63 at Ashland (river mile 4.61)											
Sept. 7	1800	0.0	Sept. 7	2155	7.9	Sept. 8	0130	2.4	Sept. 8	0500	1.1
	1906	2.2		2245	6.8		0200	2.0		0600	1.0
	1940	3.9		2302	5.5		0230	1.8		0700	.7
	2000	5.2		2330	4.8		0300	1.7		0800	.7
	2030	7.5		2400	4.0		0330	1.5		0920	.6
	2100	8.1	Sept. 8	0030	3.5		0400	1.3		1435	.3
	2138	8.2		0055	3.1						
Detected at mouth of Salt Creek (river mile 0.1)											
Sept. 8	0305	0.0	Sept. 8	0735	3.8	Sept. 8	1420	1.4	Sept. 9	0032	0.4
	0350	.4		0820	3.8		1602	.8		0214	.4
	0435	.5		0905	3.6		1744	.7		0356	.4
	0520	1.1		0950	3.3		1926	.7		0538	.4
	0605	2.0		1035	2.6		2108	.8		0720	.4
	0650	3.0		1120	2.2		2250	.5		0920	.7

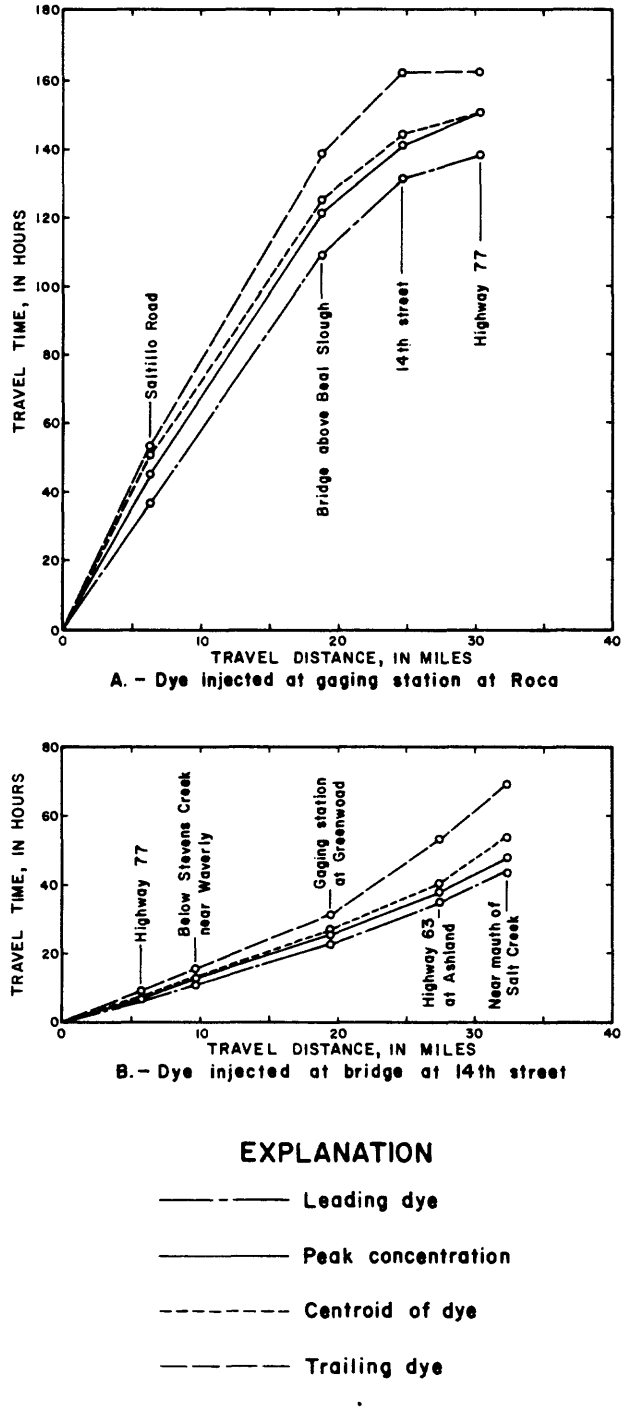


Figure 15.--Travel-time/travel-distance curves, Salt Creek, September 6-12, 1972.

Table 17.--Travel times and travel rates of dye injected into Salt Creek on September 25, 1972

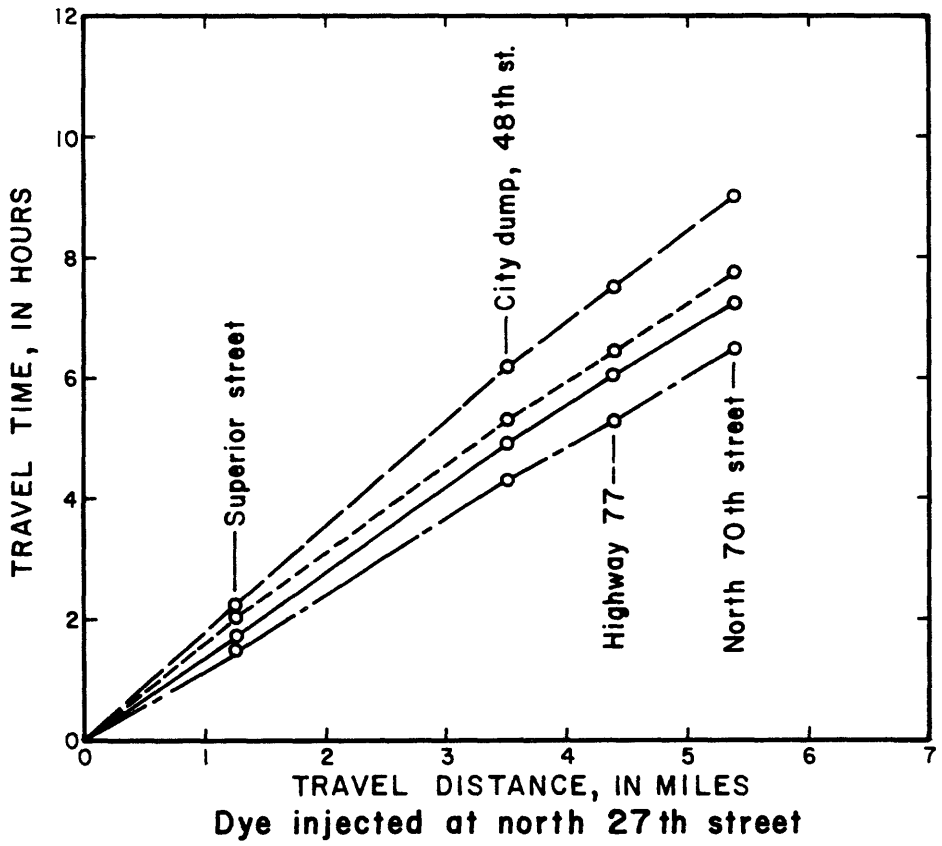
Dye injection and sampling sites	River mile location	Water discharge (ft^3/s)		Travel distance (mi)	
		Near time of injection	Near time of dye passage	From injection site	From last site upstream
Injection site:					
Near bridge on 27th Street at Lincoln------	30.90	52.4			
Sampling site:					
1. Bridge on Superior Street----------	29.68	----	----	1.22	1.22
2. City dump on North 48th Street---------	27.44	----	----	3.46	2.24
3. Bridge on Hwy. 77----------	26.55	----	----	4.35	.89
4. Bridge on North 70th Street----------	25.57	----	84.7	5.33	.98

Sampling sites	Travel time (hr)						Travel rate (mi/hr)					
	From injection site			From last site upstream			From injection site			From last site upstream		
	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid
1.	1.51	1.75	2.07	1.51	1.75	2.07	0.81	0.70	0.59	0.81	0.70	0.59
2.	4.28	4.87	5.29	2.77	3.12	3.22	.81	.71	.65	.81	.72	.70
3.	5.31	6.02	6.44	1.03	1.15	1.15	.82	.72	.68	.86	.77	.77
4.	6.46	7.22	7.74	1.15	1.20	1.30	.83	.74	.69	.85	.82	.75

Table 18.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in Salt Creek, September 1972

Amount of dye used: 2.6 pounds
Site of injection: Near bridge on No. 27th Street at Lincoln (river mile 30.90)
Time of injection: September 25, 1972 - hour 0752

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at bridge on Superior Street (river mile 29.68)											
Sept. 25	0920	0.0	Sept. 25	0943	58.0	Sept. 25	1020	6.4	Sept. 25	1120	1.4
	0923	1.5		0945	55.0		1025	4.9		1130	1.0
	0925	6.5		0947	47.0		1030	3.9		1140	.7
	0927	15.5		0950	37.0		1035	3.2		1150	.6
	0929	33.0		0953	31.0		1040	2.5		1200	.6
	0931	54.0		0957	23.5		1045	2.0		1215	.4
	0933	69.0		1000	19.5		1050	1.7		1230	.4
	0935	90.0		1005	14.5		1055	2.9		1300	.3
	0937	96.0		1010	10.5		1100	2.4		1330	.2
	0939	86.0		1015	7.9		1110	1.8		1545	.2
	0941	77.0									
Detected at city dump, extension of No. 48th Street (river mile 27.44)											
Sept. 25	1207	0.0	Sept. 25	1239	25.0	Sept. 25	1312	14.0	Sept. 25	1415	2.1
	1209	.5		1242	26.0		1315	13.5		1425	1.8
	1212	.8		1245	26.0		1320	11.0		1435	1.4
	1215	2.4		1248	24.5		1325	9.5		1445	1.2
	1218	5.4		1251	24.0		1330	8.6		1455	.9
	1221	8.5		1254	23.0		1335	7.2		1505	.8
	1224	12.2		1257	24.0		1340	6.3		1515	.7
	1227	14.0		1300	21.0		1345	5.1		1525	.7
	1230	17.0		1303	19.0		1350	4.3		1600	.6
	1233	21.0		1306	18.0		1355	3.7		1645	.3
	1236	24.0		1309	16.0		1405	2.8			
Detected at bridge on U.S. Highway 77 (river mile 26.55)											
Sept. 25	1308	0.0	Sept. 25	1350	21.0	Sept. 25	1429	10.6	Sept. 25	1510	3.0
	1311	.3		1353	22.0		1432	9.8		1515	2.6
	1314	.8		1356	21.0		1435	8.8		1520	2.2
	1317	1.5		1359	21.0		1438	8.5		1525	2.0
	1320	2.3		1402	19.5		1441	7.7		1530	1.8
	1323	4.5		1405	18.0		1444	6.9		1540	1.6
	1326	6.7		1408	17.5		1447	6.4		1550	1.3
	1329	10.4		1411	16.5		1450	6.0		1600	1.1
	1332	12.2		1414	14.5		1453	4.7		1610	.9
	1335	16.0		1417	14.0		1456	4.4		1630	.7
	1338	17.0		1420	13.0		1459	4.0		1705	.6
	1341	19.0		1423	11.0		1502	3.6		1728	.4
	1344	20.0		1426	11.0		1505	3.4		1802	.3
	1347	20.0									
Detected at bridge at No. 70th Street (river mile 25.57)											
Sept. 25	1416	0.0	Sept. 25	1450	10.4	Sept. 25	1530	13.5	Sept. 25	1635	2.6
	1420	.2		1455	13.5		1535	12.0		1645	2.3
	1423	.5		1500	17.0		1540	10.8		1700	1.4
	1425	.7		1505	18.5		1545	9.9		1735	.9
	1430	2.0		1510	18.0		1555	8.1		1800	.8
	1435	3.7		1515	18.0		1605	6.0		1830	.5
	1440	6.2		1520	16.5		1615	4.2		1900	.5
	1445	8.5		1525	16.0		1625	3.3			



EXPLANATION

- Leading dye
- Peak concentration
- Centroid of dye
- Trailing dye

Figure 16.--Travel-time/travel-distance curves, Salt Creek, September 25, 1972.

Table 19.--Travel times and travel rates of dye injected into Salt Creek on August 16, 1977

Dye injection and sampling sites	River mile location	Water discharge (ft^3/s)		Travel distance (mi)	
		Near time of injection	Near time of dye passage	From injection site	From last site upstream
Injection site:					
Bridge above Beal Slough----------	38.09	28.4			
Sampling site:					
1. Bridge on Van Dorn Street----------	36.29	----	32.2	1.80	1.80
2. Bridge on 14th Street----------	32.30	----	87.5	5.79	3.99
3. Bridge on Hwy. 77----------	26.55	----	660	11.54	5.75
4. Gaging station at Greenwood----------	12.84	----	444	25.25	13.71
5. Bridge on Hwy. 63 at Ashland----------	4.61	----	418	33.48	8.23
6. At mouth of Salt Creek----------	.10	----	470	37.99	4.51

Sampling sites	Travel time (hr)						Travel rate (mi/hr)					
	From injection site			From last site upstream			From injection site			From last site upstream		
	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid	Leading dye	Peak concentration	Centroid
1.	2.42	3.08	4.06	2.42	3.08	4.06	0.74	0.58	0.44	0.74	0.58	0.44
2.	7.08	8.50	9.46	4.66	5.42	5.40	.82	.68	.61	.86	.74	.74
3.	11.62	13.55	14.72	4.54	5.05	5.26	.99	.85	.78	1.27	1.14	1.09
4.	21.42	24.93	25.91	9.80	11.38	11.19	1.18	1.01	.97	1.40	1.20	1.23
5.	27.33	33.10	33.45	5.91	8.17	7.54	1.23	1.01	1.00	1.39	1.01	1.09
6.	34.60	38.20	39.57	7.27	5.10	6.12	1.10	1.00	.96	.62	.88	.74

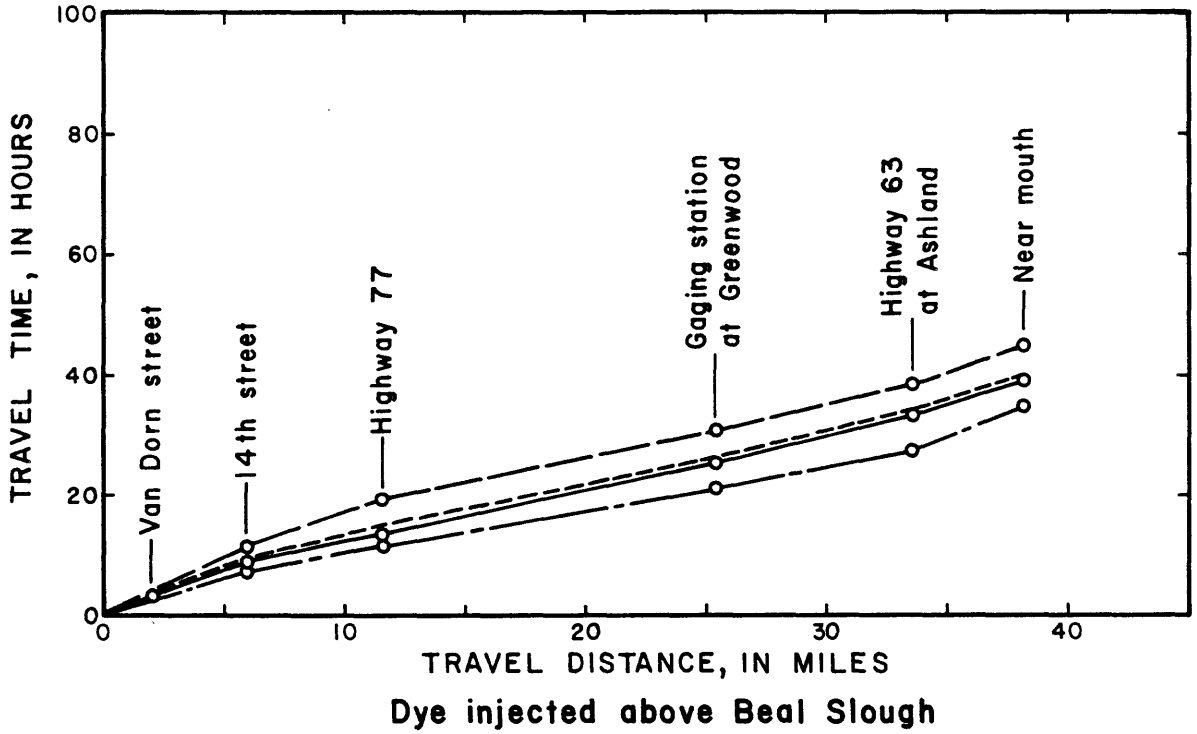
Table 20.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in Salt Creek, August 1977

Amount of dye used: 30 pounds
Site of injection: Bridge above Beal Slough at Lincoln (river mile 38.09)
Time of injection: August 16, 1977 - hour 1140

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at Van Dorn Street bridge (river mile 36.29)											
Aug. 16	1405	0.0	Aug. 16	1510	476	Aug. 16	1615	92.0	Aug. 16	1810	7.8
	1410	1.3		1515	390		1620	86.0		1835	4.9
	1415	28		1520	390		1625	76.0		1900	5.4
	1420	75		1525	380		1630	64.0		1925	4.6
	1425	194		1530	356		1635	54.0		1950	3.8
	1430	330		1535	276		1640	52.5		2015	3.6
	1435	459		1540	232		1645	46.0		2040	3.5
	1440	603		1545	225		1650	40.0		2105	3.5
	1445	652		1550	200		1655	35.0		2130	3.8
	1450	596		1555	178		1700	30.5		2155	4.3
	1455	572		1600	155		1710	26.0		2220	4.1
	1500	564		1605	121		1720	17.4		2245	4.4
	1505	552		1610	108		1745	12.4	Aug. 17	0840	0
Detected at 14th Street bridge (river mile 32.30)											
Aug. 16	1845	0.0	Aug. 16	2045	88	Aug. 16	2245	19	Aug. 17	0045	3.6
	1855	2.8		2055	88		2255	14		0141	3.3
	1905	9.0		2105	82		2305	13		0207	2.9
	1915	19.4		2115	73		2315	12		0233	2.6
	1925	36		2125	56		2325	9.6		0300	2.2
	1935	72		2135	47		2335	9.3		0326	2.0
	1945	79		2145	41		2345	8.6		0352	1.8
	1955	100		2155	37		2355	7.0		0418	1.2
	2005	108		2205	28	Aug. 17	0005	6.0		0511	1.0
	2015	108		2215	23		0015	5.0		0603	.6
	2025	103		2225	21		0025	4.7		0656	.1
	2035	93		2235	20		0035	4.2		0748	0
Detected at U.S. Highway 77 bridge (river mile 26.55)											
Aug. 16	2317	0.0	Aug. 17	0039	8.2	Aug. 17	0147	9.2	Aug. 17	0306	4.3
	2329	.3		0050	9.6		0158	8.7		0317	3.8
	2340	.8		0101	10.0		0209	8.2		0329	3.2
	2351	1.6		0113	10.3		0221	7.4		0430	2.9
Aug. 17	0005	3.6		0124	10.0		0232	6.4		0530	2.7
	0016	5.1		0135	9.5		0243	5.8		0700	.2
	0027	7.2					0255	5.2		0727	0
Detected at USGS gage 06803555 at Greenwood (river mile 12.84)											
Aug. 17	0905	0.0	Aug. 17	1236	7.1	Aug. 17	1600	2.2	Aug. 17	1920	0.5
	0928	0.0		1300	6.9		1623	1.8		1943	.3
	0952	.4		1323	6.4		1646	1.4		2006	.2
	1015	1.0		1340	5.8		1709	1.3		2029	.2
	1039	2.4		1403	5.2		1732	.9		2052	.2
	1102	3.6		1426	4.1		1756	.8		2116	.3
	1126	5.1		1449	3.7		1819	.4		2139	.1
	1149	6.4		1512	3.0		1842	.4		2202	.1
	1213	6.9		1536	2.4		1905	.4		2225	0

Table 20.--Amount of dye (Rhodamine WT, 20 percent solution) used and concentrations detected in Salt Creek, August 1977--Continued

Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)	Date	Time (hr)	Concentration (ug/L)
Detected at State Highway 63 bridge at Ashland (river mile 4.61)											
Aug. 17	1500	0.0	Aug. 17	1859	3.6	Aug. 17	2232	3.4	Aug. 18	0205	0.5
	1620	.1		1952	4.1		2325	2.4		0258	.3
	1713	1.1		2046	4.6	Aug. 18	0020	1.2		0351	.1
	1806	2.0		2139	4.4		0102	1.0		0445	0
Detected at mouth of Salt Creek (river mile 0.10)											
Aug. 17	2216	0.0	Aug. 18	0058	1.8	Aug. 18	0340	2.2	Aug. 18	0632	0.8
	2310	.5		0152	2.4		0434	1.9		0736	.6
Aug. 18	0004	1.2		0246	2.3		0538	1.4		0830	.2
										0924	0



EXPLANATION

——— - ——— Leading dye

——————— Peak concentration

——— — ——— Centroid of dye

——— ——— Trailing dye

Figure 17.--Travel-time/travel-distance curves, Salt Creek, August 1977.

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