FINAL REPORT ~ FHWA-OK-07-06

CHANNEL-BED DEGRADATION IN MAJOR OKLAHOMA STREAMS VOLUME III OF V NORTH CANADIAN RIVER

A.K. TYAGI, PH.D., P.E., DIRECTOR
PRATIMA POUDYAL, RESEARCH ASSOCIATE

OKLAHOMA INFRASTRUCTURE CONSORTIUM SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING
OKLAHOMA STATE UNIVERSITY

PLANNING & RESEARCH DIVISION
ENGINEERING SERVICES BRANCH
RESEARCH SECTION

spr@odot.org, office: (405)522-3795

ODOT SPR ITEM NUMBER 2191

OKLAHOMA DEPARTMENT OF TRANSPORTATION
200 NE 21ST STREET, OKLAHOMA CITY, OK 73105-3204

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA/07(06), vol. III of V	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Channel-Bed Degradation in Major Oklahoma Streams North Canadian River		5. Report Date December 2007 6. Performing Organization Code
7. Authors Avdhesh K. Tyagi and Pratima Poudyal		8. Performing Organization Report No.
9. Performing Organization Name and Address Avdhesh K. Tyagi School of Civil and Environmental Engineering Oklahoma State University Stillwater, OK 74078		10. Work Unit No. 11. Contract or Grant No. Item 2191
12. Sponsoring Agency Name and Address Oklahoma Department of Transportation Planning & Research Division 200 N.E. 21st Street, Room 3A7 Oklahoma City, OK 73105		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code HTFS-16

Supplementary Notes

15. Abstract

The purpose of this research is to analyze the flowline data and relate it to the degradation of the river bed at bridge locations in the river. This information may then be used to replace or rehabilitate those bridges that experienced severe degradation.

This report evaluates channel degradation in 463.85-mile reach of North Canadian River in Oklahoma. In this study, the 463.85 mile river length is divided into three Reaches: Reach 1- river station (RS) 1 (Bridge Key 16523) to Canton Dam, Reach 2- Canton Dam to Overholser Dam, and Reach 3- Overholser Dam to river station (RS) 40 (Bridge Key b15585). The flowlines of North Canadian River in Oklahoma were observed over a long period. RS 2 in reach 1 shows the maximum degradation of 4.63 feet from 1965 to 2000. In reach 2, RS 9 shows the maximum degradation of 5.83 feet in 58 years. Similarly, in reach 3, RS 33 shows the maximum degradation of 17.67 feet in 38 years. The maximum aggradation of 9.75 in 20 years is observed at RS 21.

The North Canadian River in Oklahoma has experienced degradation over 10 feet at three river stations which have been serving more then 10 years. River station (RS 23) at S.H. 270, RS 33 at I-40, and RS 39 at S.H. 84 have experienced degradation of 15.6 feet in 11 years, 17.67 feet in 38 years, and 15.0 feet in 47 years, respectively. These bridges are defined as critical and recommended for rehabilitation or replacement in the replacement cycle. A detailed hydraulic and geotechnical analysis should be performed before reconstruction.

It is recommended that degradation of tributaries is evaluated to determine the structures where flowline is severely degrading in North Canadian River basin.

17. Key Words Degradation, North Canadian River, Dam, and flowlines	18. Distribution Statement No restriction. This publication is available from the office of Planning & Research Division, Oklahoma DOT.

19. Security Classification. (of this report) Unclassified	20. Security Classification. (of this page) Unclassified	21. No. of Pages 142	22. Price

SI (METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units

Symbol	When you know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	25.40	millimeters	mm
ft	feet	0.3048	meters	m
yd	yards	0.9144	meters	m
mi	miles	1.609	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.0929	square meters	m^2
yd^2	square yards	0.8361	square meters	m^2
ac	acres	0.4047	hectacres	ha
mi^2	square miles	2.590	square kilometers	km^2
	VOLUME			
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallon	3.785	liters	L
ft^3	cubic feet	0.0283	cubic meters	m^3
yd^3	cubic yards	0.7645	cubic meters	m^3
	MASS			
oz	ounces	28.35	grams	g
lb	pounds	0.4536	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
	TEMPERATURE (exact)			
°F	degrees Fahrenheit	(°F-32)/1.8	degrees Celsius	°C
	FORCE and PRESSURE or STRESS			
lbf	poundforce	4.448	Newtons	N
lbf/in^2	poundforce per square inch	6.895	kilopascals	kPa

Approximate Conversions from SI Units

Symbol	When you know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.0394	inches	in
m	meters	3.281	feet	ft
m	meters	1.094	yards	yds
km	kilometers	0.6214	miles	mi
	AREA			
mm^2	square millimeters	0.00155	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.196	square yards	yd^2
ha	hectacres	2.471	acres	ac
km^2	square kilometers	0.3861	square miles	mi^2
	VOLUME			
mL	milliliters	0.0338	fluid ounces	fl oz
L	liters	0.2642	gallon	gal
m^3	cubic meters	35.315	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
	MASS			
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.1023	short tons (2000 lb)	T
	TEMPERATURE (exact)			
°C	degrees Fahrenheit	9/5(°C)+32	degrees Celsius	°F
	FORCE and PRESSURE or STRESS			
N	Newtons	0.2248	poundforce	lbf
kPa	kilopascals	0.1450	poundforce per square inch	lbf/in^2

CONTENTS

FIGURES

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the views of the Oklahoma Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification or regulation. While trade names may be used in this report, it is not intended as an endorsement of any machine, contractor, process or product.

CHANNEL-BED DEGRADATION IN MAJOR OKLAHOMA STREAMS

VOLUME III of V: NORTH CANADIAN RIVER

Final Report
ODOT Item Number 2191

by

A. K. Tyagi, Ph.D., P.E.
Director

and

Pratima Poudyal
Research Associate

Oklahoma Infrastructure Consortium

School of Civil and Environmental Engineering

Oklahoma State University

Stillwater, OK 74078

December 2007

TABLES

Page

I. INTRODUCTION

Natural alluvial rivers generally do not exist in equilibrium. The fluvial process in an alluvial river is a dynamic process, a function of flow and sediment regimes interacting with the physiographic features and vegetative cover of the landscape (Ward and Standford 2006). Streams are not inherently unstable but they are often out of equilibrium due to imposed conditions. Man made activities and natural events are the major factors which disturb the stability of a river, causing high sediment load, high slope, relatively coarse grain size, high lateral mobility rate, and multi-thread, braided stream. If the streambed is eroded, resulting in a low bed elevation it is called "degradation" and if bed elevation is elevated due to an accumulation of sediment it is called "aggradation".

A river channel is considered stable if the streambed does not change its dimension, pattern and profile over a relatively long river reach and long period of time. If the hydraulic, hydrologic, and sedimentological characteristics of the alluvial rivers are altered naturally or by human interference, the river will adjust dynamically and geometrically as the fluvial system seeks to establish a state of equilibrium. The river equilibrium concept was explained by Macklin (1948) as the "graded" river in which channel size, cross-sectional shape, and slope are adjusted to the quantities of sediment and water transported so that the river bed neither degrades nor aggrades.

Human activities such as construction of reservoir are major factors in changing in river equilibrium. When the sediment transport is interrupted by a dam, the flow may become sediment-starved and prone to erode the channel

bed and banks, producing channel incision, and coarsening of bed material (Kondolf 2004).

The purpose of this research is to analyze the flowline data and relate it to the degradation of the river bed at different bridge locations in the river. This information may then be used to replace or rehabilitate those bridges that experienced severe degradation.

II. STUDY AREA

The 800mile long North Canadian River basin is located in the west central portion of Oklahoma, where it is known as Corrumpta Creek. From there it flows eastwardly through the Oklahoma Panhandle, where it is known as the Beaver River. The Coldwater Creek empties into the Beaver River and it flows southwestward into the Texas Panhandle for six miles, turning northeast and back into the Oklahoma Panhandle before continuing on to the east. It enters northwest Oklahoma and turns southeast and takes the name North Canadian River. Just south of the town of Fort Supply, Oklahoma, the river is joined by Wolf Creek. From there, it flows eastward through Oklahoma City and Shawnee on its way to Lake Eufaula in McIntosh County where it joins the waters of the Canadian River (Wikipedia). North Canadian River is a major U.S. waterway. It has total drainage basin of nearly 15,212 sq mi., out of which approximately 61% is in Oklahoma, 33% in Texas, and 6% in New Mexico (Pigg & Coleman 1992).

In Oklahoma North Canadian River flows through thirteen counties: Woodward, Major, Dewey, Blaine, Canadian, Oklahoma, Pottawatomie, Seminole, Okfuskee, Hughes, McIntosh, Pittsburg, and Haskell. The focus of this study area is the middle 463.85 mile reach of the North Canadian River between State Highway 34 crossing in the Woodward County, Oklahoma and US-69 crossing at McIntosh County, Oklahoma (Fig. 1). The North Canadian River starts as a narrow river which gains in size after entering Oklahoma, and becomes a waterway that, in places, is more than a mile wide. Throughout the study reach, North Canadian River has been impounded in two reservoirs:

Canton Lake, Lake Oveholser, and merges into the Canadian River at the Eufaula Lake reservoir.

Canton Lake Dam is on the North Canadian River at mile 394.3, about 2 miles north of the town of Canton and 75 miles northeast of Oklahoma City. The dam was constructed by the corps of engineers and the construction began in 1940 and was completed in 1948. The lake has conservative pool elevation of 1615.0 feet and flood control capacity of 377,100 acre-feet. The shore of the lake is in Blaine County (Kurka 2006).

Lake Overholser in central Oklahoma is located on the east side of Yukon in Canadian county. The lake has a shore length of 7 miles and surface area of 1,500 acres.

Eufaula dam is located on the Canadian river, approximately 12 miles east of Eufaula in McIntosh County, Oklahoma (Austin & Thomas, 2006). At Eufaula Lake North Canadian River merges with the Canadian River. The lake has a drainage area of 47,522 square miles and surface area of 159.375 square miles. The shore length of the lake is over 600 miles. The lake is owned and operated by the U.S. Army Corps of Engineers (Wikipedia).

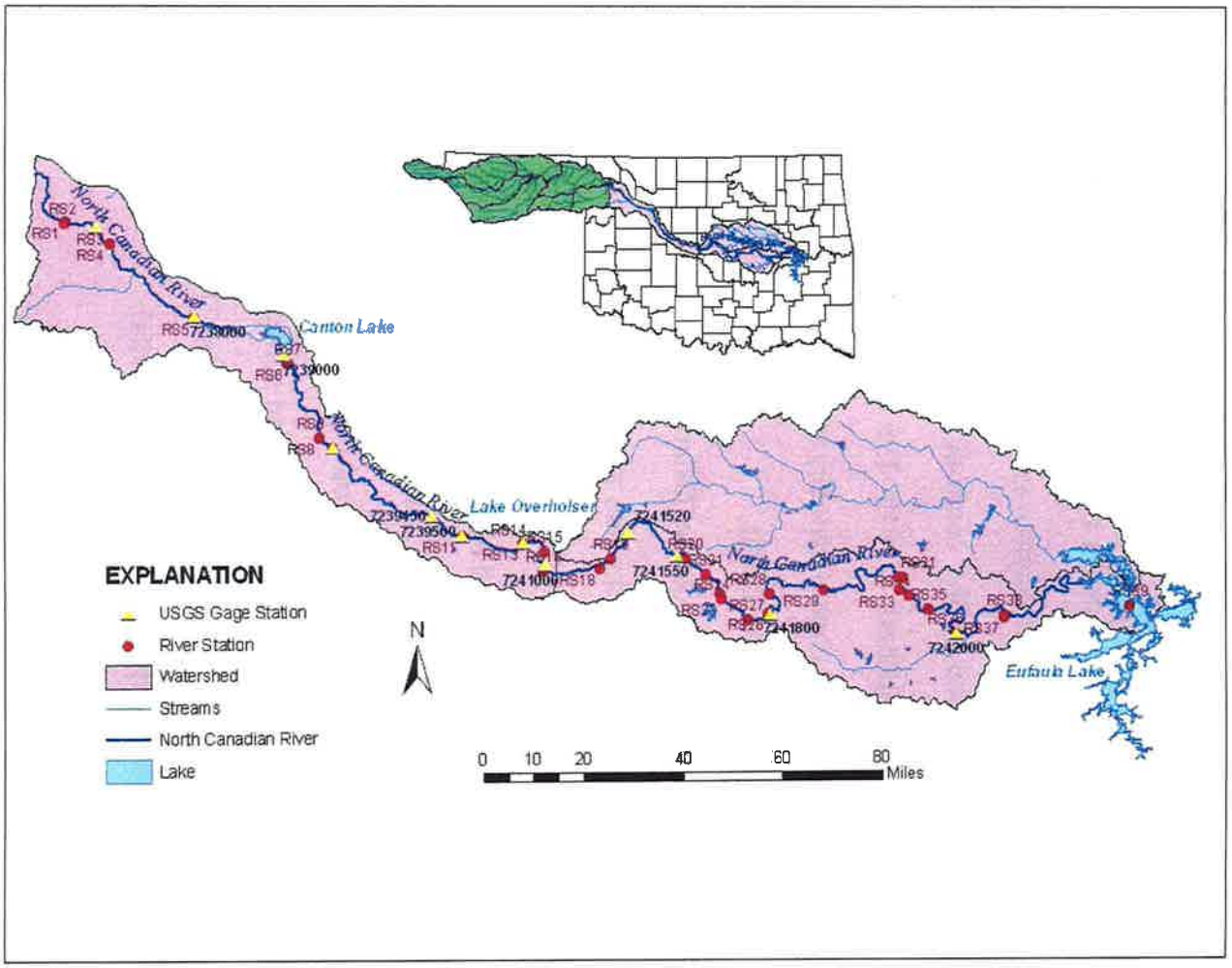


Figure 1. Location of Study points in North Canadian River, and USGS gage stations

III. HYDROLOGY

The physical characteristics of the stream such as channel bed degradation, stream widening, deposition of channel bars, shifting flowline, and stream bank erosion depends on the hydrology of the stream. According to Doyle (2003), "channels formed in fine alluvial material that is easily eroded and transported out of the system with little downstream aggradation will respond to disturbance by lateral adjustments". As the stream profile degrades, the stream tries to widen to accommodate higher flows, and stream bank erosions increase along with increases in sediment loads. Flow measurement of the stream is one of the fundamental tasks in accessing surface hydrology. USGS stream flow gage stations have been studied in the study reach. Currently there are twelve USGS gaging stations in North Canadian River (Fig.1).

Table 1. Description of USGS gage stations

Data Locations and Descriptions	Data Available
USGS 07237500 North Canadian River at Woodward, OK Woodward County, Oklahoma Hydrologic Unit Code 11100301 Latitude 36°26'12", Longitude 99°16'41" NAD27 Drainage area 11,589 square miles Contributing drainage area 6,777 square miles Gage datum 1,829.95 feet above sea level NGVD29	1938-2006
USGS 07238000 North Canadian River near Seiling, OK Major County, Oklahoma Hydrologic Unit Code 11100301 Latitude 36°11'00", Longitude 98°55'15" NAD27 Drainage area 12,261 square miles Contributing drainage area 7,414 square miles Gage datum 1,675.53 feet above sea level NGVD29	1924-2006
USGS 07239000 North Canadian River at Canton, OK Blaine County, Oklahoma Hydrologic Unit Code 11100301 Latitude 36°04'37", Longitude 98°35'47" NAD27 Drainage area 12,484 square miles Contributing drainage area 7,601 square miles Gage datum 1,562.50 feet above sea level NGVD29	1938-2003
USGS 07239300 North Canadian River blw Weavers Ck nr Watonga, OK Blaine County, Oklahoma Hydrologic Unit Code 11100301 Latitude 35°48'43", Longitude 98°25'14" NAD27 Drainage area 12,736 square miles Contributing drainage area 7,837 square miles Gage datum 1,453.60 feet above sea level NGVD29	1984-2006

Table 1. Continued

Data Locations and Descriptions	Data Available
USGS 07239500 North Canadian River near El Reno, OK Canadian County, Oklahoma Hydrologic Unit Code 11100301 Latitude 35°33'47", Longitude 97°57'26" NAD27 Drainage area 13,042 square miles Contributing drainage area 8,143 square miles Gage datum 1,295.00 feet above sea level NGVD29	1903-2006
USGS 07239700 North Canadian River near Yukon, OK Canadian County, Oklahoma Hydrologic Unit Code 11100301 Latitude 35°32'22", Longitude 97°44'32" NAD27 Drainage area 13,183 square miles Gage datum 1,247.66 feet above sea level NGVD29	2000-2006
USGS 07241000 North Canadian River below Lake Overholser near OKC, OK Oklahoma County, Oklahoma Hydrologic Unit Code 11100301 Latitude 35°28'43", Longitude 97°39'47" NAD27 Drainage area 13,222 square miles Contributing drainage area 8,323 square miles Gage datum 1,194.66 feet above sea level NGVD29	1921-2006
SGS 07241520 North Canadian River at Britton Rd at OKC, OK Oklahoma County, Oklahoma Hydrologic Unit Code 11100302 Latitude 35°33'56", Longitude 97°22'01" NAD27 Drainage area 13,413 square miles Contributing drainage area 8,514 square miles Gage datum 1,109.40 feet above sea level NGVD29	1989-2006

Table 1. Continued

Data Locations and Descriptions	Data Available
USGS 07241550 North Canadian River near Harrah, OK Oklahoma County, Oklahoma Hydrologic Unit Code 11100302 Latitude 35°30'01", Longitude 97°11'37" NAD27 Drainage area 13,501 square miles Contributing drainage area 8,602 square milesGage datum 1,055.69 feet above sea level NGVD29	1969-2006
USGS 07241800 North Canadian River at Shawnee, OK Pottawatomie County, Oklahoma Hydrologic Unit Code 11100302 Latitude 35°19'59", Longitude 96°52'09" NAD27 Drainage area 13,730.00 square miles Contributing drainage area 8,831.00 square miles	2001-2006
USGS 07242000 North Canadian River near Wetumka, OK Hughes County, Oklahoma Hydrologic Unit Code 11100302 Latitude 35°15'56", Longitude 96°12'21" NAD27 Drainage area 14,290 square miles Contributing drainage area 9,391 square miles Gage datum 678.28 feet above sea level NGVD29	1924-2006

Annual peak discharge is the annual instantaneous maximum discharge. Human land use practices such as agricultural and forest clearing also impact the fluvial geomorphic systems. In addition to this, channel changes are variable in time, depending somewhat on the timing of floods and droughts. Annual peak discharge plots were downloaded from USGS gaging stations to evaluate the historical flood occurrences. In 1946, record-breaking flood occurred in the streams of the Texas Panhandle and Oklahoma. Precipitation ranged from 1 to more than 8 inches during the period of October 4-10. As a result of which, high water levels were reached in the headwater of the North Canadian River (Jordan 1946). Due to the excessive rainfall in this region, peak streamflow were recorded as 42000cfs at Woodward OK (Fig. 2), 28000 cfs at Seiling OK (Fig. 3), 25000 cfs at Canton OK (Fig. 4), 15000cfs at El Reno OK (Fig. 7), and 15000cfs at Wetunka OK (Fig. 13) in 1946. Peak streamflow records of 14000cfs at El Reno (Fig. 7), 8000cfs at Oklahoma City (Fig. 10), and 25000 at Harrah OK (Fig. 11) mimics the flood of 1997 and peak streamflows of 9000cfs at Oklaoma City OK (Fig. 10), and 17000 cfs at Harrah OK (Fig. 11) were due to the flood in 1995.

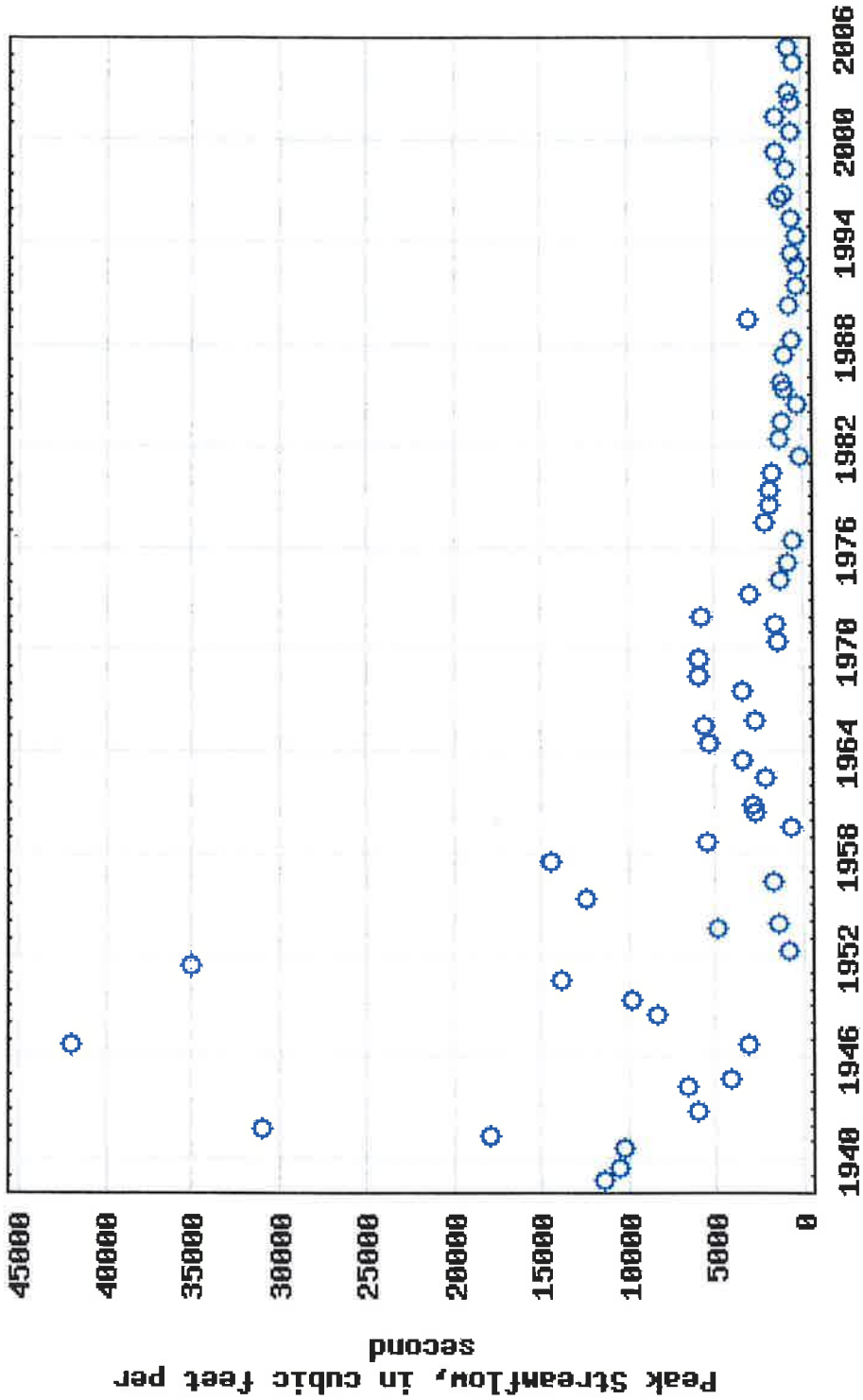


Figure 2 . Annual peak streamflow in North Canadian River at Woodward (USGS 07237500), OK

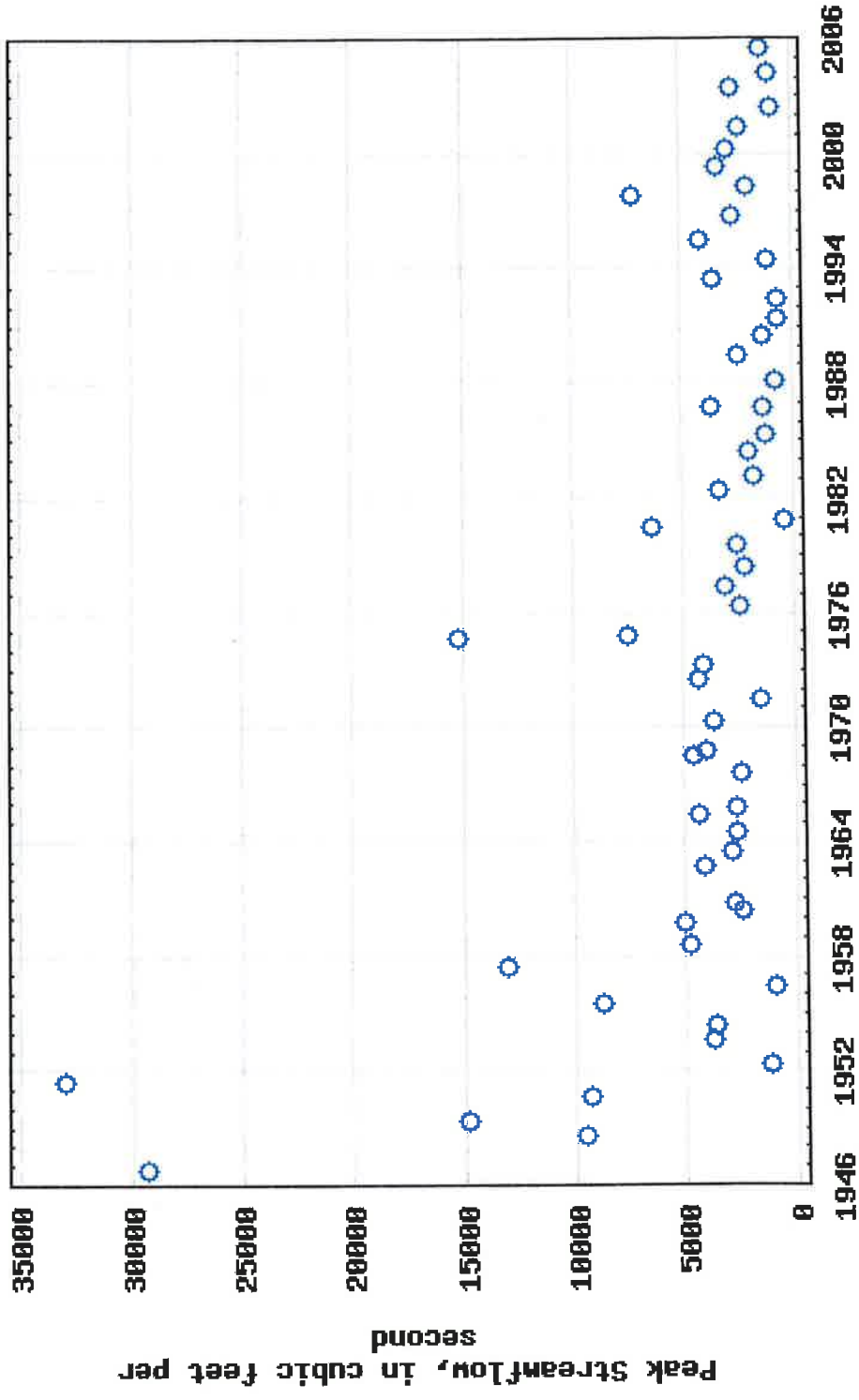


Figure 3. Annual peak streamflow in North Canadian River at Seiling (USGS 07238000), OK

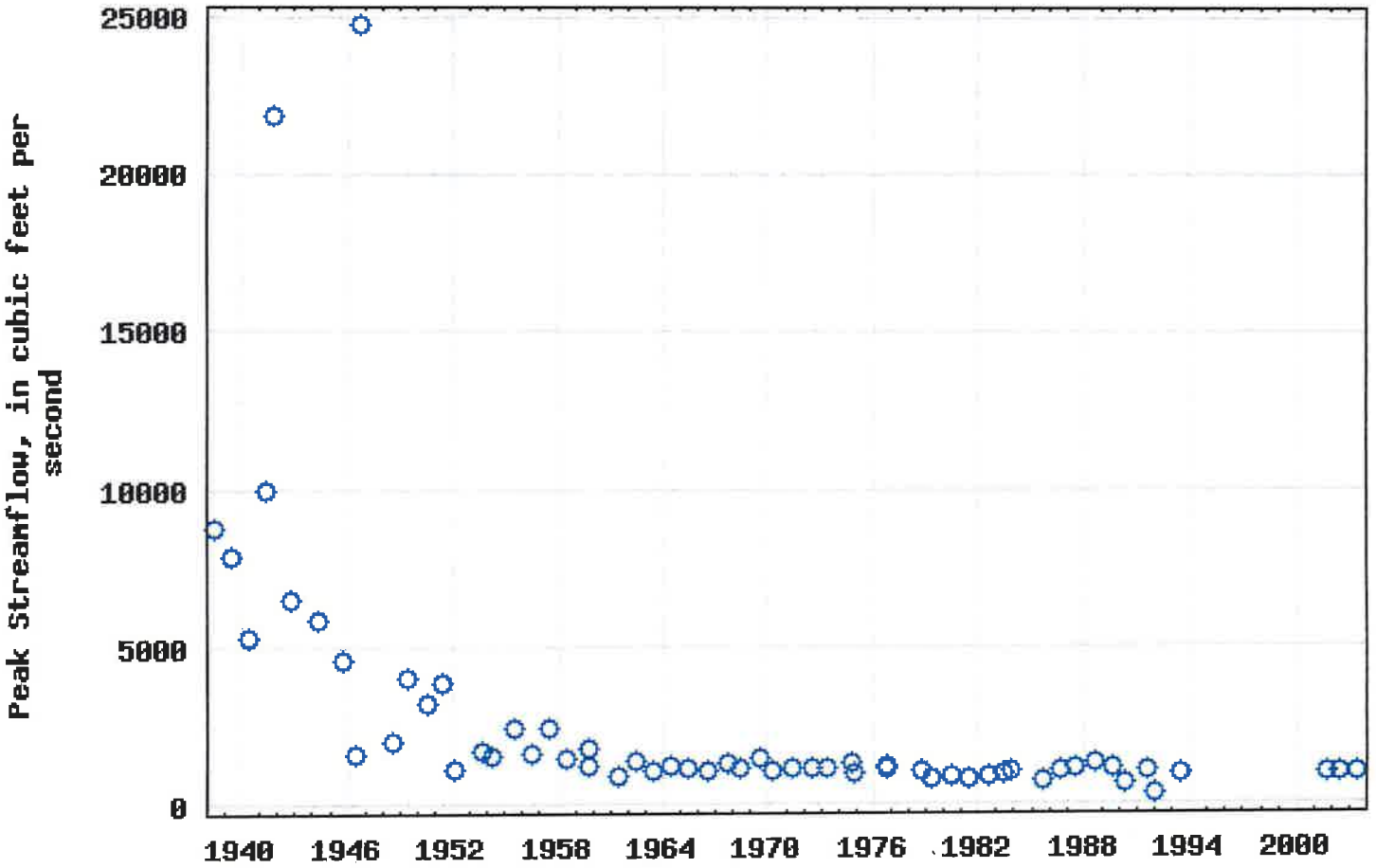


Figure 4. Annual peak streamflow in North Canadian River at Canton (USGS 07239000), OK

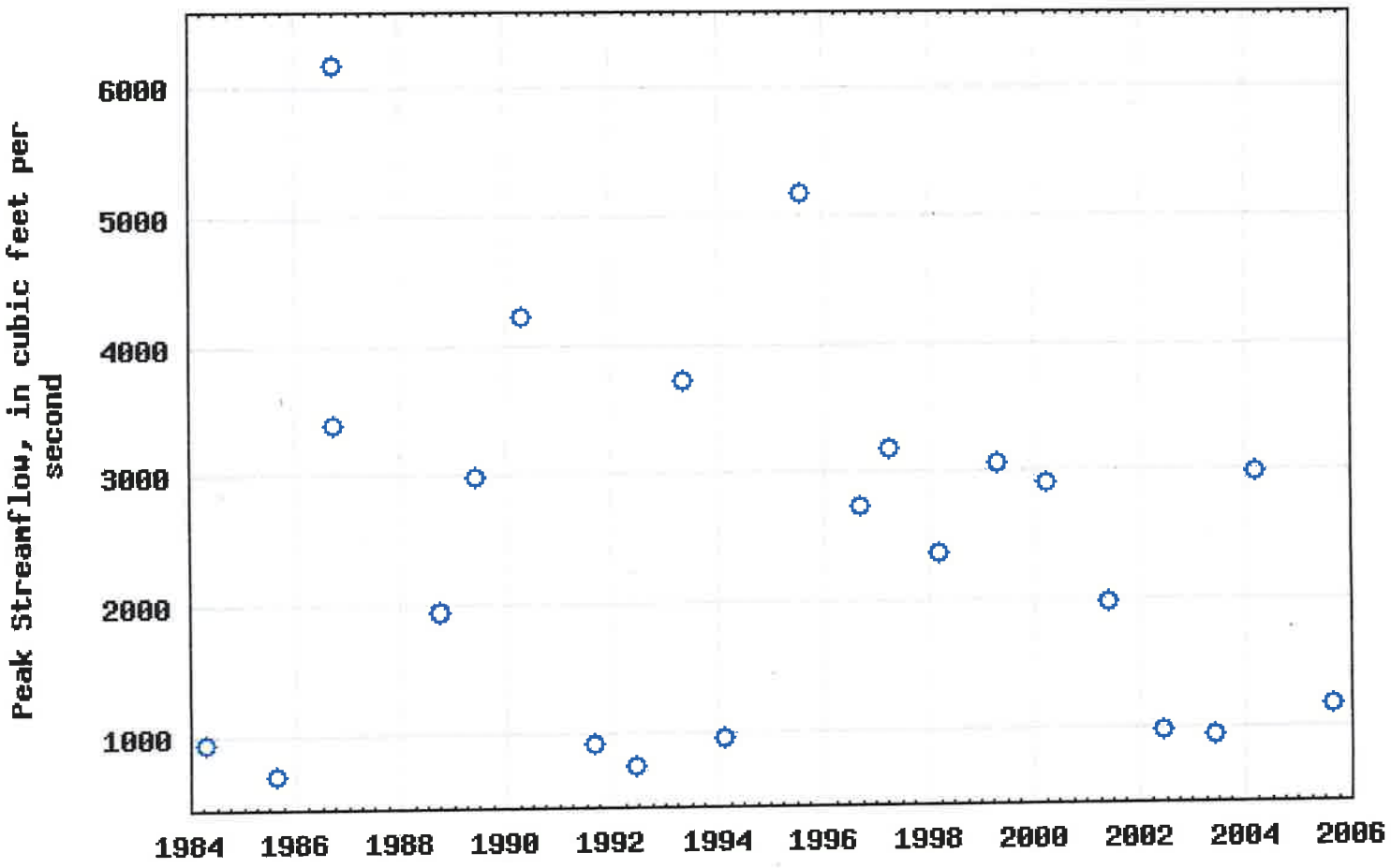


Figure 5. Annual peak streamflow in North Canadian River at Watonga (USGS 07239300), OK

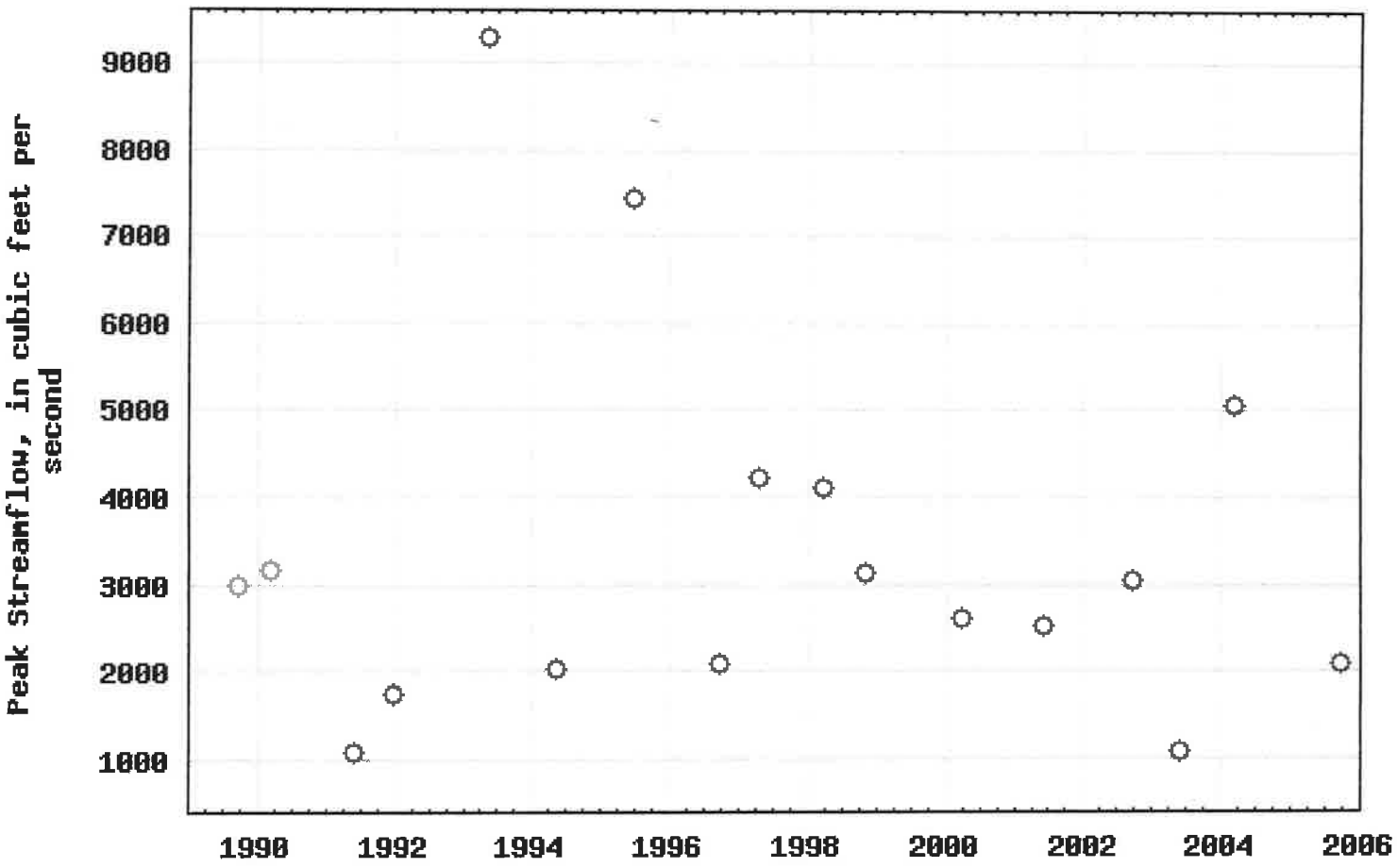


Figure 6. Annual peak streamflow in North Canadian River near Calumet (USGS 07239450),

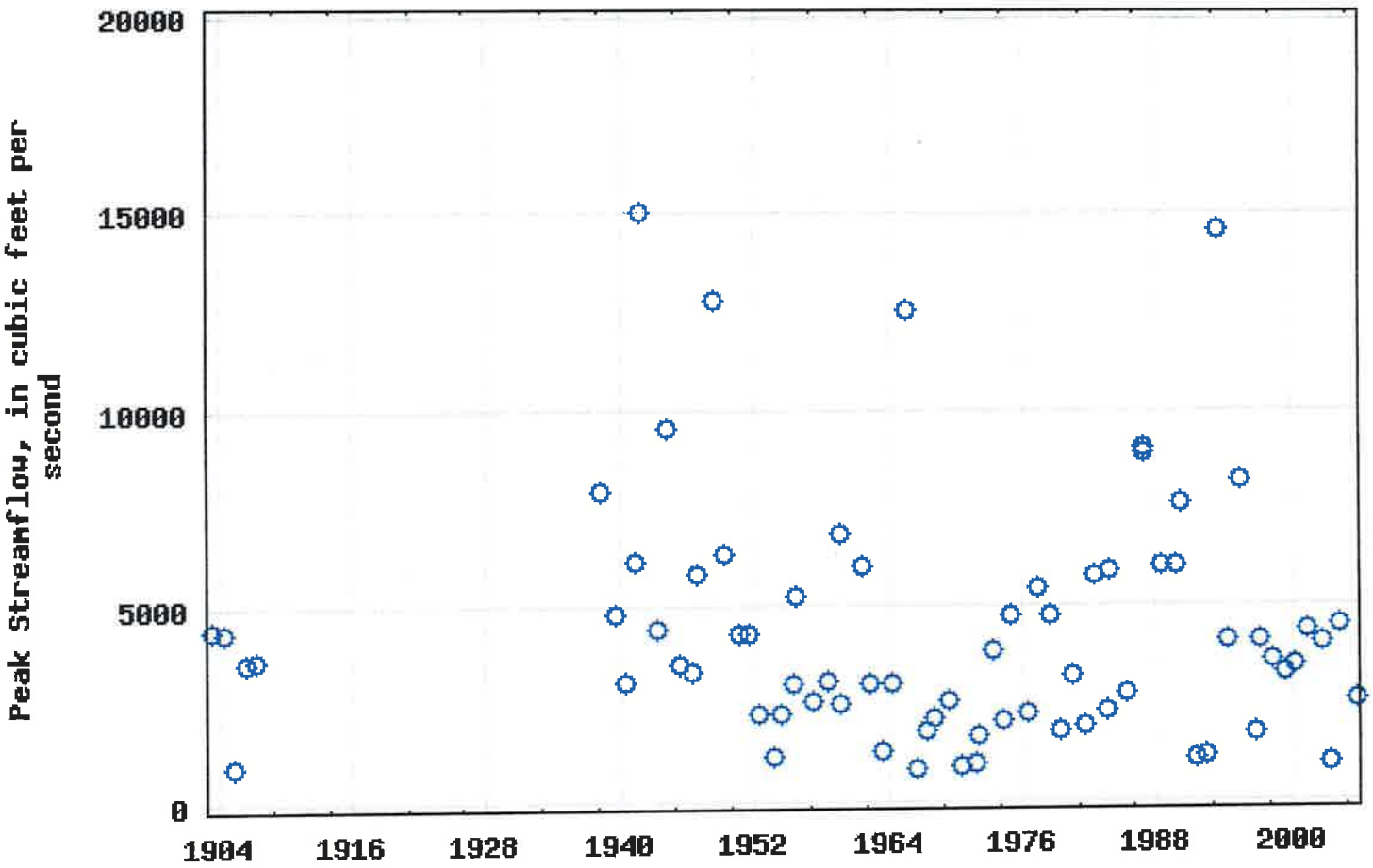


Figure 7. Annual peak streamflow in North Canadian River near El Reno (USGS 07239500), OK

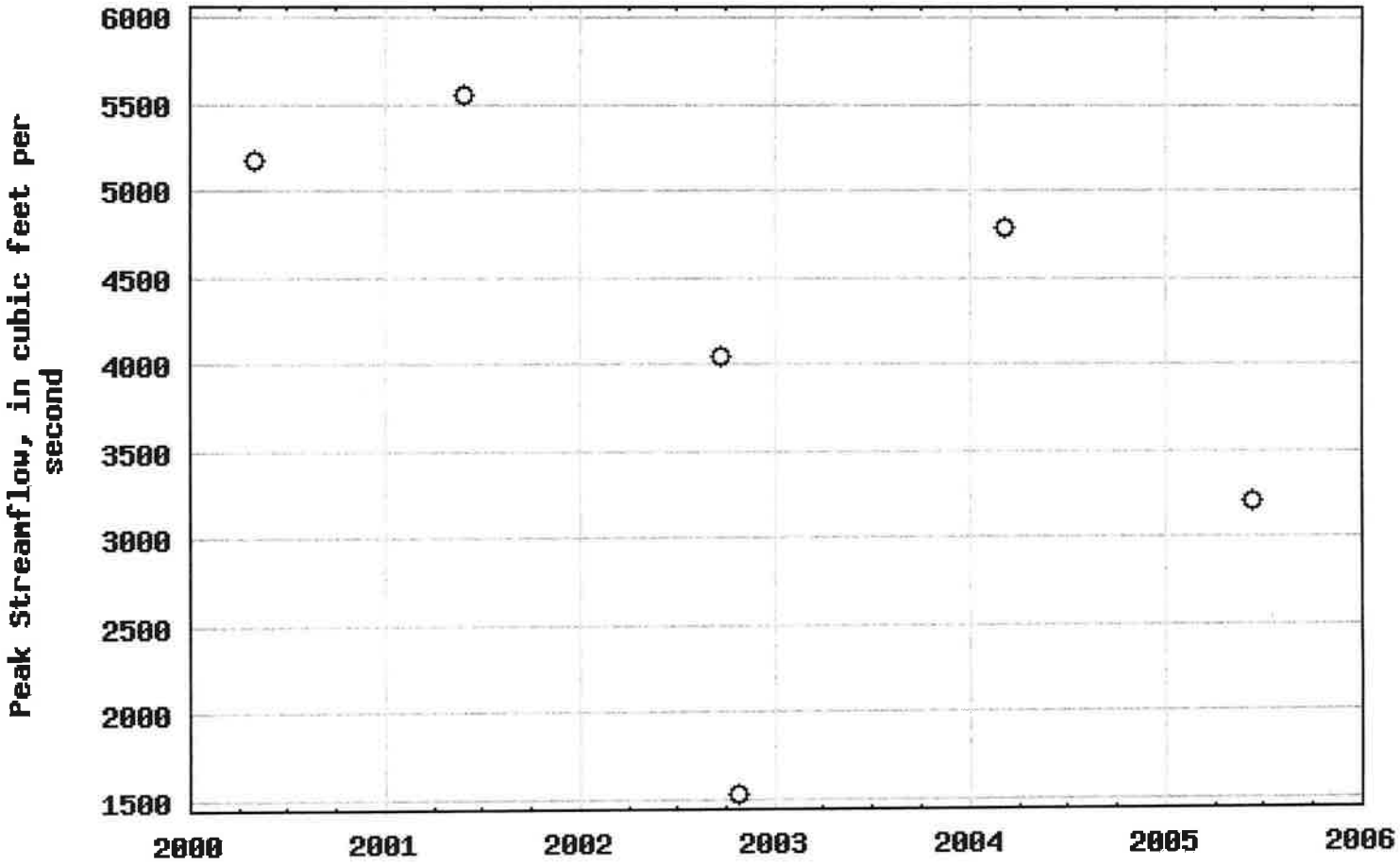


Figure 8. Annual peak streamflow in North Canadian River near Yukon (USGS 07239700), OK

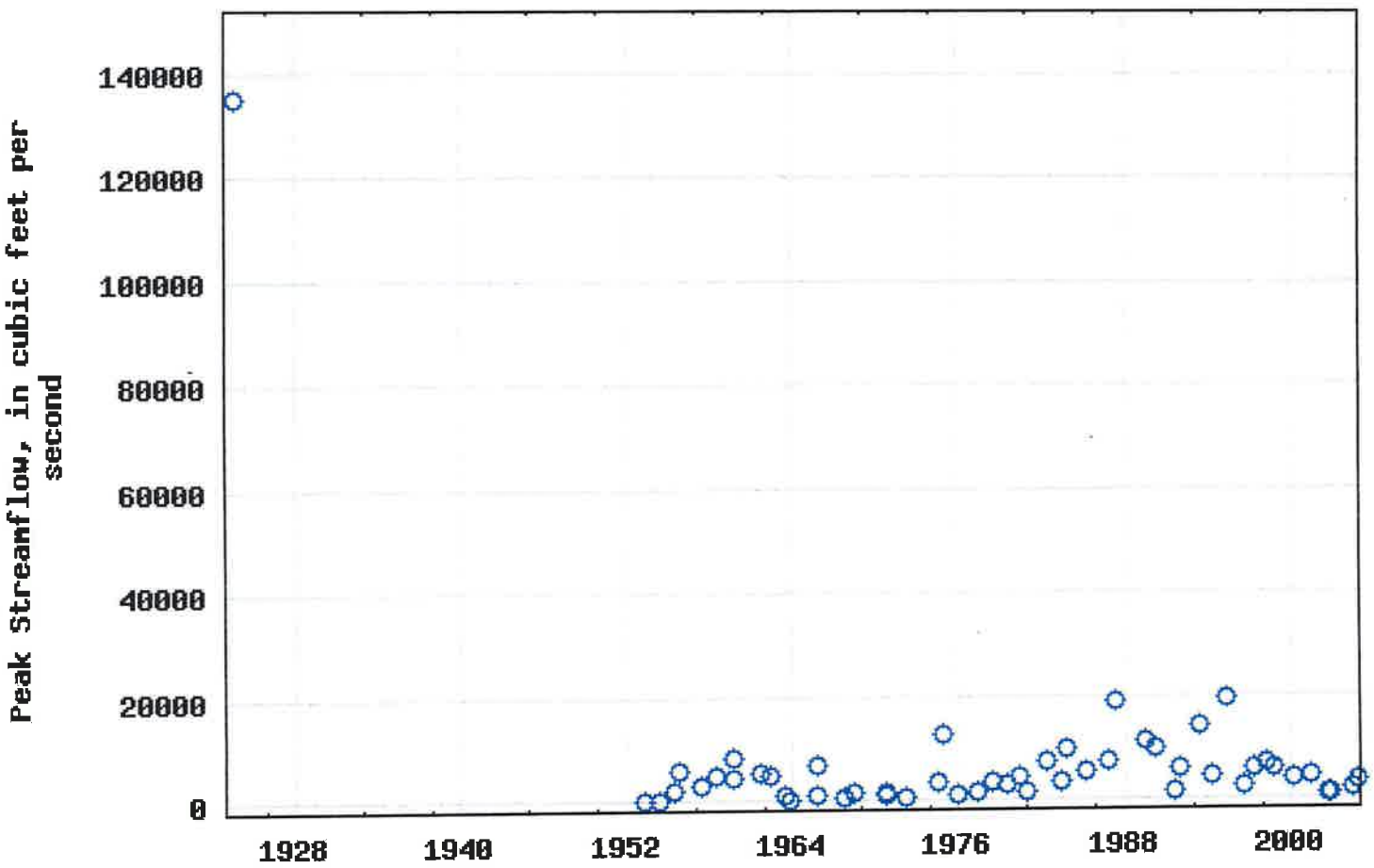


Figure 9. Annual peak streamflow in North Canadian River near OKC (USGS 07241000), OK

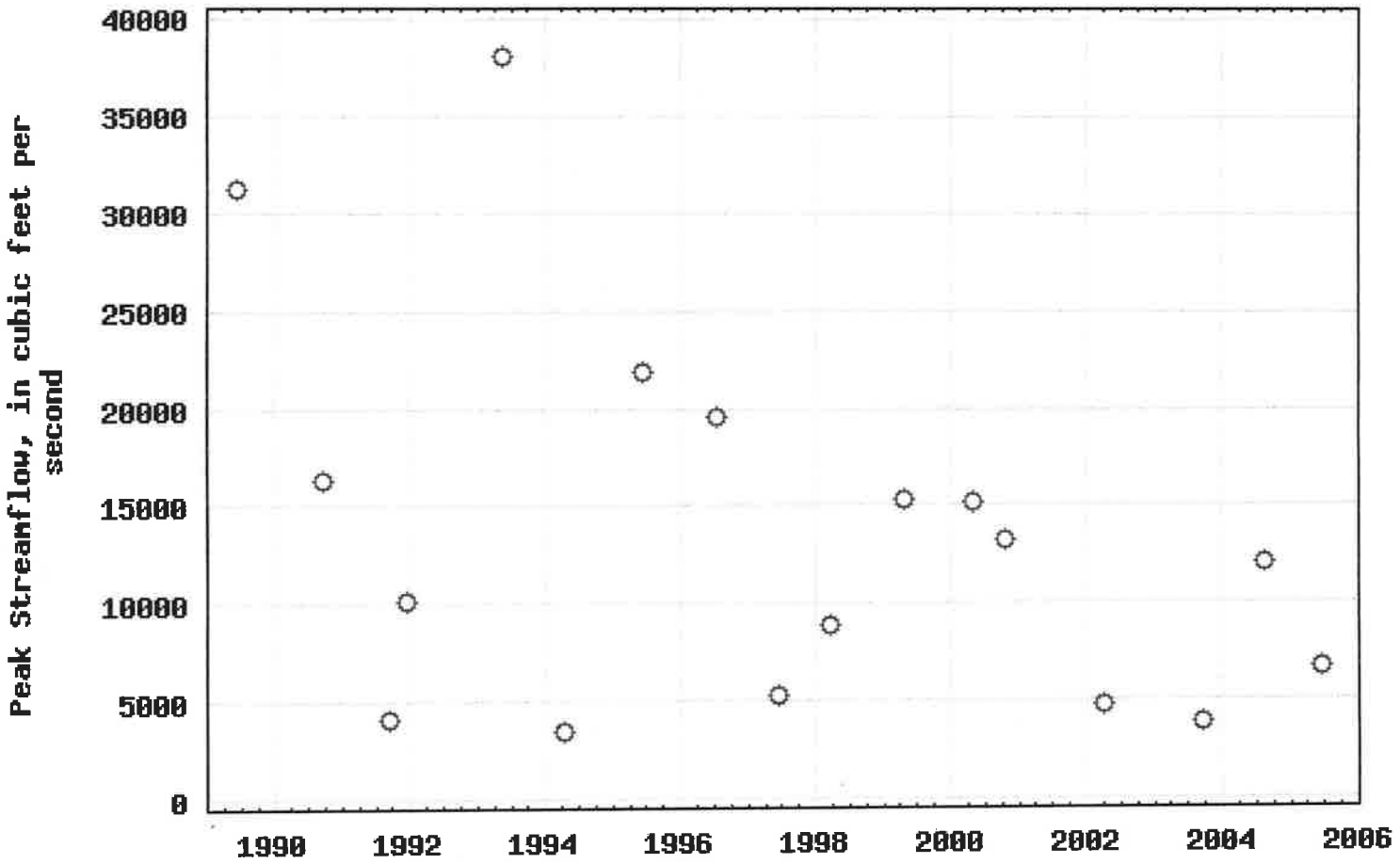


Figure 10. Annual peak streamflow in North Canadian River at OKC (USGS 07241520), OK

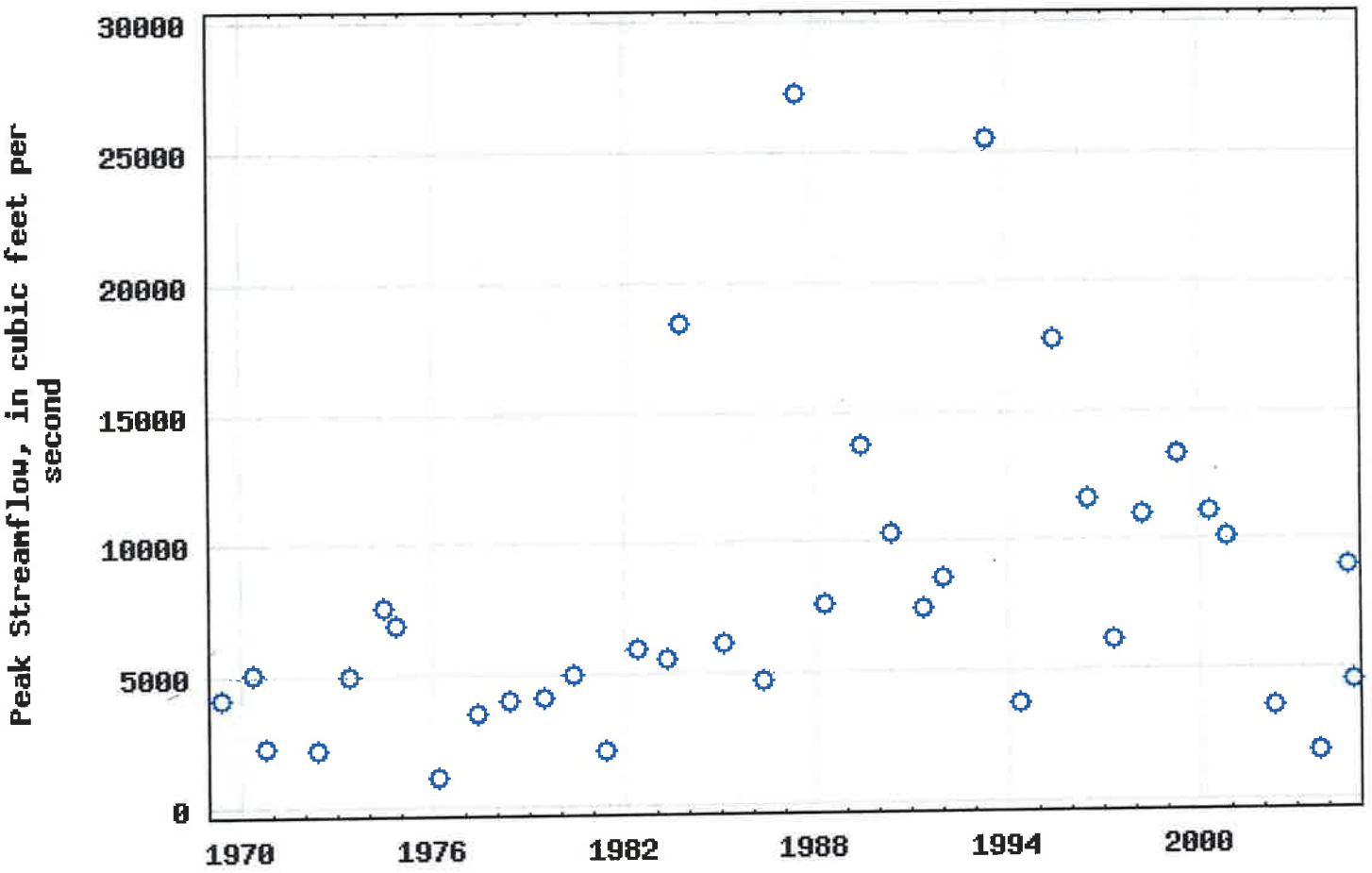


Figure 11. Annual peak streamflow in North Canadian River near Harrah (USGS 07241550),

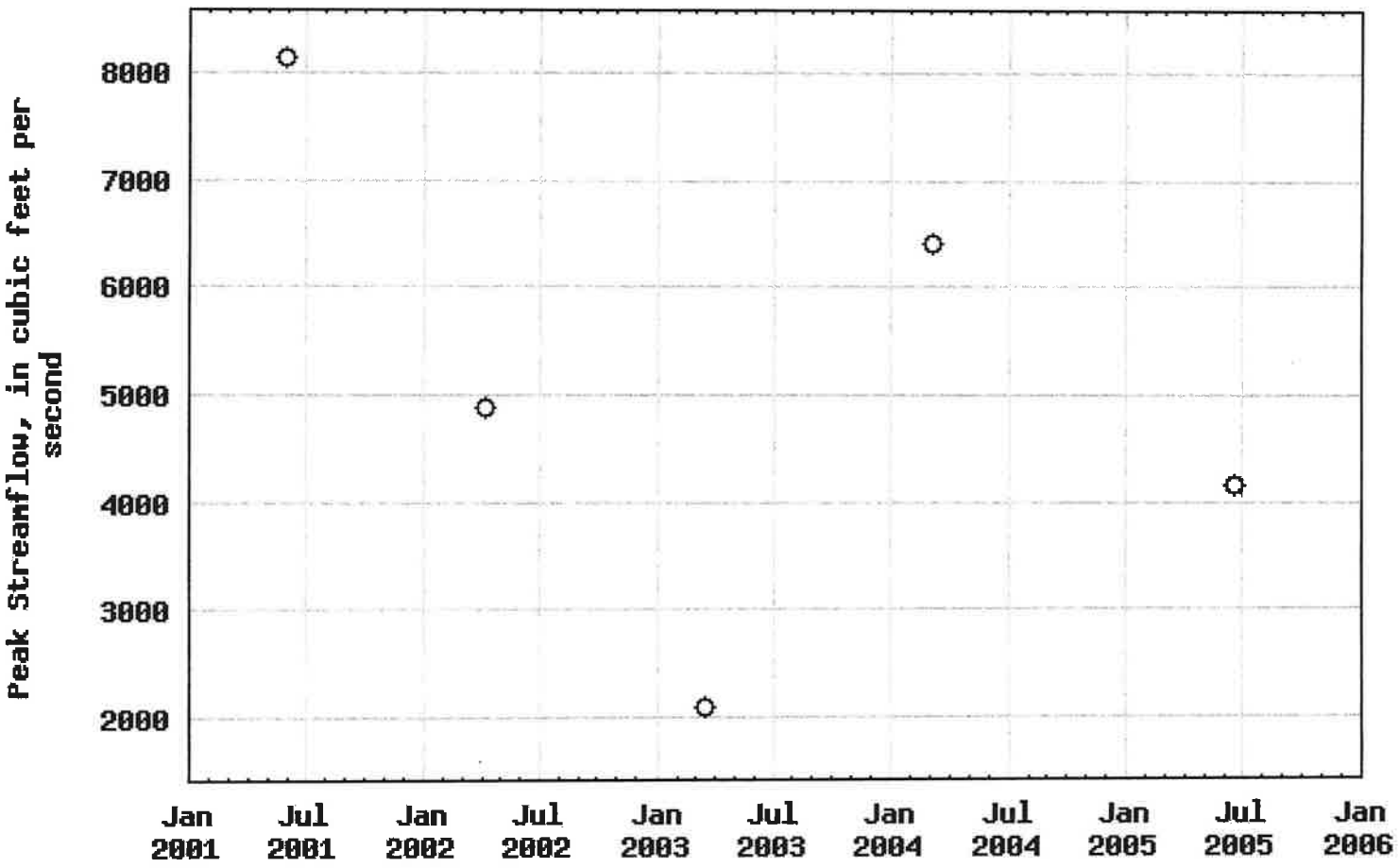


Figure 12. Annual peak streamflow in North Canadian River at Shawnee (USGS 07241800), OK

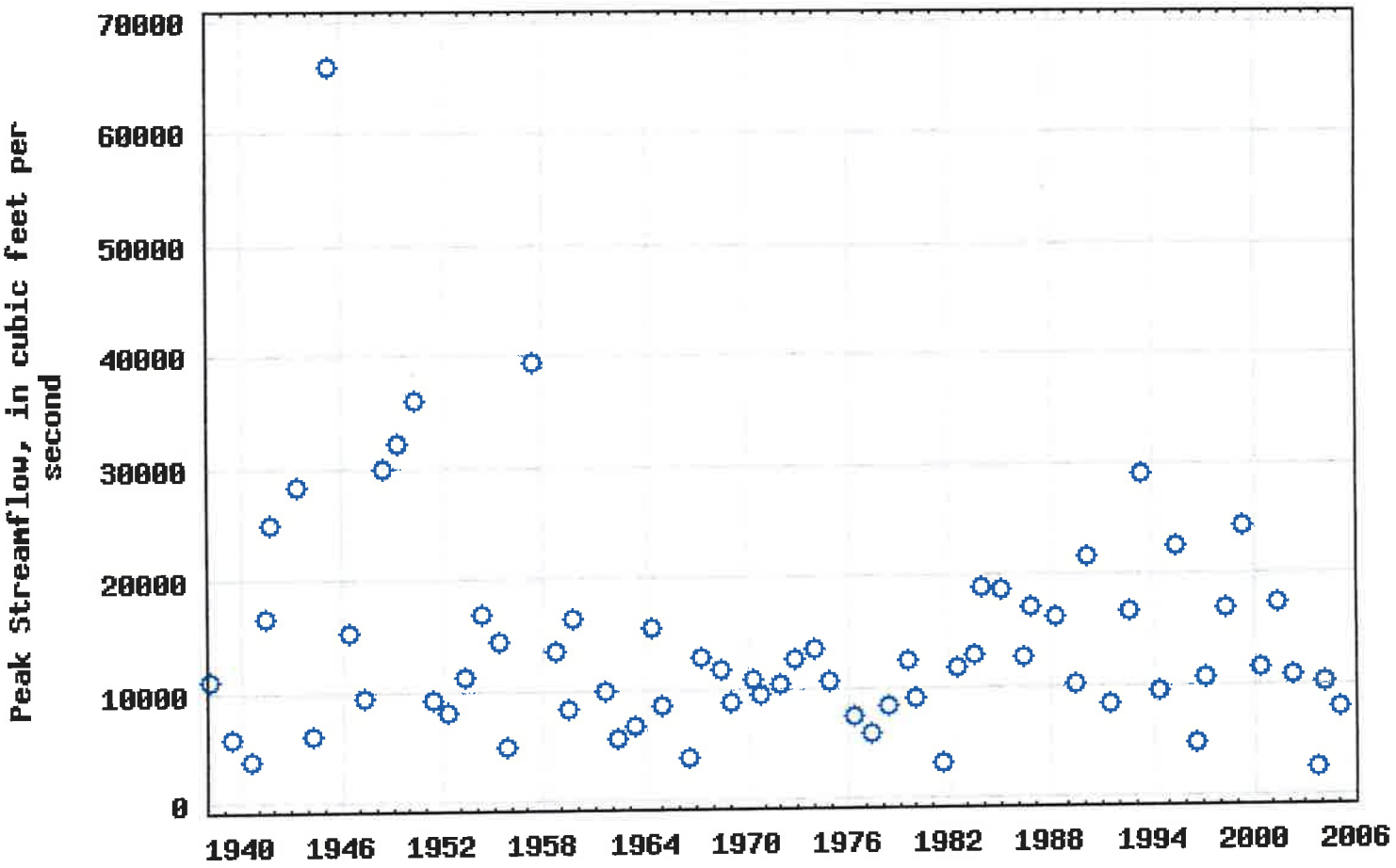


Figure 13. Annual peak streamflow in North Canadian River at Wetunka (USGS 07242000), OK

Gilvier (1999) studied a number of areas in which fluvial geomorphology is directly relevant and beneficial to river engineering. These are when:

1) River channel functions as a three dimensional form with longitudinal, transverse, and vertical dimensions (x,y,z-directions) involving changes in morphology and amount of water and sediment.
2) The river system functions in response to water and sediment coming from the upstream watersheds.
3) The planform of a river normally varies through time, but the dynamics of natural channel adjustment varies between and along rivers.
4) The geomorphic stability of a river system is disturbed by activities such as river training, removing riparian vegetation, land use, and climatic change etc.

In this study, the 463.85 mile river is divided into 3 Reaches: Reach 1- RS1 to Canton Lake Dam, Reach 2- Canton Lake Dam to Lake Overholser dam, and Lake Overholser dam to RS 40 (Bridge No. 15585). The objective of this study was to evaluate the downstream effects of each dam in river degradation. Data collection at each site included channel gradient, cross-sectional geometry, and bed material composition. Channel gradient from one river station to another was calculated arithmetically and taken mean for each study Reach. River meandering between two successive river stations was determined by calculating sinuosity as shown in Figure 14 using Geographic Information System (GIS), to examine the downstream effects of dams in meandering channels. Sinuosity is

defined as a ratio of total length between two river stations along the flowline to shortest length of the channel.

The meandering tendency of the North Canadian River in Oklahoma increases as its flows. As the sinuosity is increasing along the length, the slope of the river is simultaneously decreasing. Reach-1 is less meandered where the slope is high. Reach-3 is highly meandered where the slope is less (Table 2).

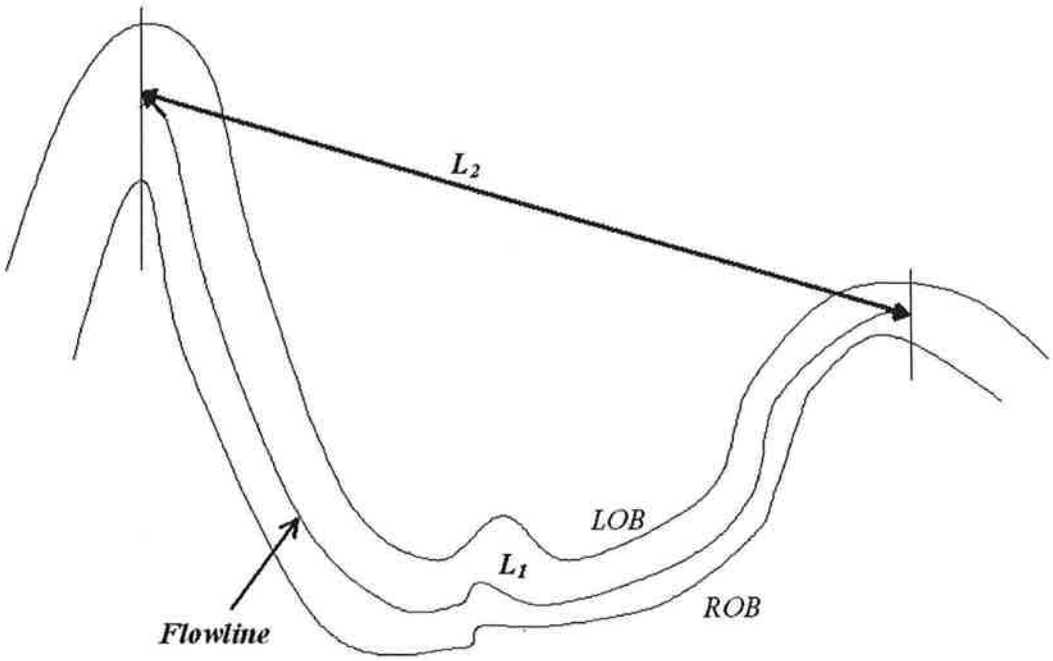
Longitudinal and vertical changes of the river channel bed are also studied and will be discussed separately in another chapter.

Table 2. Sinuosity and slope study of North Canadian River

Study of reach				Study of River Stations		
Reach	**Location**	**Reach slope**	**Reach Sinuosity**	**River Stations**	**Slope**	**Sinuosity**
1	RS 1 (b16523) to Canton Lake Dam	3.83	1.53	RS 1 to RS 2	0.00	0.00
				RS 2 to RS 3	3.94	1.35
				RS 3 to RS 4	0.00	1.12
				RS 4 to RS 5	4.13	1.51
2	Canton Lake Dam to Lake Overholser Dam	3.08	1.80	RS 5 to RS 6	3.42	1.64
				RS 6 to RS 7	0.00	0.00
				RS 7 to RS 8	3.13	1.77
				RS 8 to RS 9	0.00	1.33
				RS 9 to RS 10	3.60	1.14
				RS 10 to RS 11	2.87	1.00
				RS 11 to RS 12	-35.17	1.80
				RS 12 to RS 13	2.66	1.37
				RS 13 to RS 14	0.00	0.00
				RS 14 to RS 15	0.00	0.00
3	Lake Overholser Dam to RS 40 (b15585)	2.53	2.24	RS 15 to RS 16	2.06	1.65
				RS 16 to RS 17	6.85	1.64
				RS 17 to RS 18	0.00	1.00
				RS 18 to RS 19	3.19	1.21
				RS 19 to RS 20	1.90	1.04
				RS 20 to RS 21	2.31	2.58

Table 2. Continued

Study of reach				Study of River Stations		
Reach	Location	Reach slope	Reach Sinuosity	River Stations	Slope	Sinuosity
3	Lake Overholser Dam to RS 40 (b15585)	2.53	2.4	RS 20 to RS 21	2.31	2.58
				RS 21 to RS 22	1.67	1.39
				RS 22 to RS23	3.03	2.41
				RS 23 to RS 24	-2.97	2.22
				RS 24 to RS 25	0.00	0.79
				RS 25 to RS 26	4.27	1.39
				RS 26 to RS 27	2.73	1.69
				RS 27 to RS 28	0.87	2.90
				RS 28 to RS 29	4.30	10.82
				RS 29 to RS 30	3.22	2.15
				RS 30 to RS 31	2.41	2.29
				RS 31 to RS 32	0.00	0.00
				RS 32 to RS 33	11.87	1.57
				RS 33 to RS 34	0.00	0.00
				RS 34 to RS 35	12.11	1.35
				RS 35 to RS 36	-0.77	1.87
				RS 36 to RS 37	2.98	3.16
				RS 37 to RS 38	4.81	1.71
				RS 38 to RS 39	0.00	0.00
				RS 39 to RS 40	2.33	1.78



$$Sinuosity = \frac{Flowline \quad Length(L_1)}{Shortest \quad Length(L_2)}$$

Figure 14. Schematic diagram of sinuosity of natural channels

IV. ANALYSIS OF CROSS-SECTIONAL GEOMETRY

Field data measured for a long period of time by Oklahoma Department of Transportation were examined in this study. Throughout the study reach, 40 River Stations (RS) were selected: RS 1 to Canton Lake Dam in Reach 1, Canton Lake Dam to Lake Overholser dam in Reach 2, Lake Overholser dam to RS 40 in Reach 3. Twenty-four out of forty River Stations have data on cross-section geometry. These river stations are measured in bridge crossings.

Among the 5 river stations in Reach 1, aggradations are observed in RS 1 and RS 3. RS 1 has the aggradation of 1.1 feet from year 1965 to 1991 whereas RS 3 is the most stable river station in Reach 1 having only the slight aggradation of 0.31 feet from years 1969 to 1991. Bed materials at RS 1 and RS 3 (Fig. 16) are characterized as Sand to Red Bed. RS 2 (Fig. 15) at the crossing of SH 34 shows the maximum degradation of 4.63 feet from year 1965 to 2000. The degradation is primarily on the left side of the river section. RS 4 at the crossing of SH 50 and RS 5 (Fig. 17) at the crossing of US 60 shows the degradation of 2.78 feet and 3.40 feet in 22 and 34 years respectively.

Reach-2 has eleven river stations from RS 6 to RS 15. Among these river stations, five are observed with aggradations. Downstream of Canton Lake Dam, two conjugative river stations, RS 6 (Fig. 18), and RS 7, shows the aggradation of 0.68 feet, and 0.50 feet in 48, 46 years respectively. The aggradations at these river stations shows notable results since both of the river stations are only 3.69 miles downstream of the Canton Lake Dam. Similarly, RS 12 (Fig. 22) at the crossing of US-81, RS 13 (Fig. 23) at the crossing of SH-4, and RS 16 (Fig. 26) at the crossing of US-66 show the

aggradation of 1.75 feet, 0.5 feet, and 8.4 feet in 32, 53, and 47 years respectively. RS 9 (Fig. 20) at the crossing of US-270 shows the maximum degradation of 5.83 feet in Reach-2. The degradation is occurred in the 58 year time period from 1937 to 1995. Similarly, RS 11 at the crossing of US-81 shows the maximum degradation rate of 1.01 feet/year.

Reach-3 has twenty-four river stations from RS 17 to RS 40. Degradation is observed in RS 17 (Fig. 27) and RS 18 (Fig. 28) at the crossing of I-40. These two conjugative river stations are at the downstream of the Lake Overholser dam at the distance of 2.40 miles. From 1964 to 2005, RS 17 is subjected to a degradation of 5 feet and RS 18 for 3.33 feet respectively. Bed materials for both of the river stations are characterized as Sand to Red Bed. Beyond RS 18, four conjugative river stations are subjected to the aggradations. Among them, RS 21 (Fig. 30) at the crossing of US-62, has the maximum aggradation of 9.75 feet in 20 years from 1985. RS 20 (Fig. 29) at the crossing of US-62 shows the aggradation of 4.75 feet in 19 years and the flowline at this river station has shifted from right to the middle. Bed materials for these four river stations are characterized as Sand and Sand Stone. RS 23 at the crossing of SH-270 is observed with maximum degradation rate in whole study reach. This river station has experienced 15.6 feet degradation in 11 years from 1983 to 1994. Bed material at this river stations is characterized as Sand and Soft Sandy Clay. Similarly, RS 24 to RS 27, RS 29, RS 31, and RS 32 are subjected to the constant degradation which ranges from 0.09 feet to 4.43 feet. RS 33 (Fig. 32) at the crossing of I-40 has experienced maximum degradation of 17.67 feet throughout the study reach from 1962 to 2000. Bed material at this river station is Sand to Medium Hard Shale. At this river station degradation occurs

primarily on the right side and Pier Nos. 15 and 16 are in danger. In contrast to this, calculated value at RS 34 (Fig. 33) at the same distance of RS 33 has experienced the aggradation of 0.42 feet in 40 years. Similarly, RS 36 (Fig. 35) at the crossing of SH-27 has the aggradation of 4.08 feet in 55 years. Other river stations RS 35 (Fig. 34), and RS 37 (Fig. 36) to RS 40 (Fig. 38) are facing degradation of the bed. Among them, RS 39 (Fig. 36) at the crossing of SH-84 has experienced maximum degradation of 15 feet from year 1958 to 2005 and degradation is primarily on the left side which has created potential threat to Pier Nos. 1 and 2. At RS 35, the flowline has shifted from right to the middle. RS 40 (Fig. 38) is within the Eufaula Lake dam which has experienced a degradation of 3.50 feet from 1958 to 2003. Bed material at this river station is Rock.

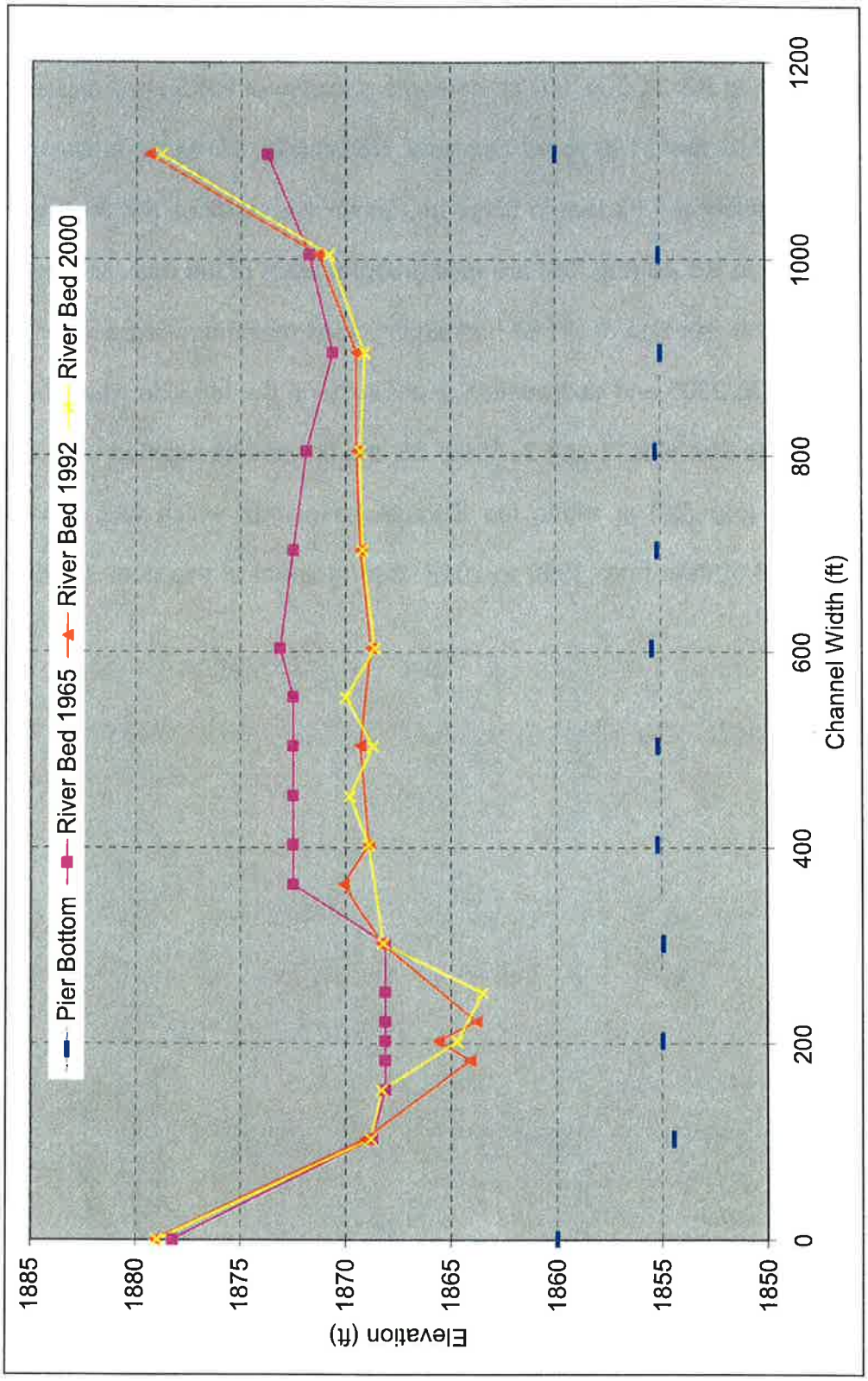


Figure 15. Cross-section at bridge (Key No. 16642 and RS 2) on SH 34, North Canadian River, OK

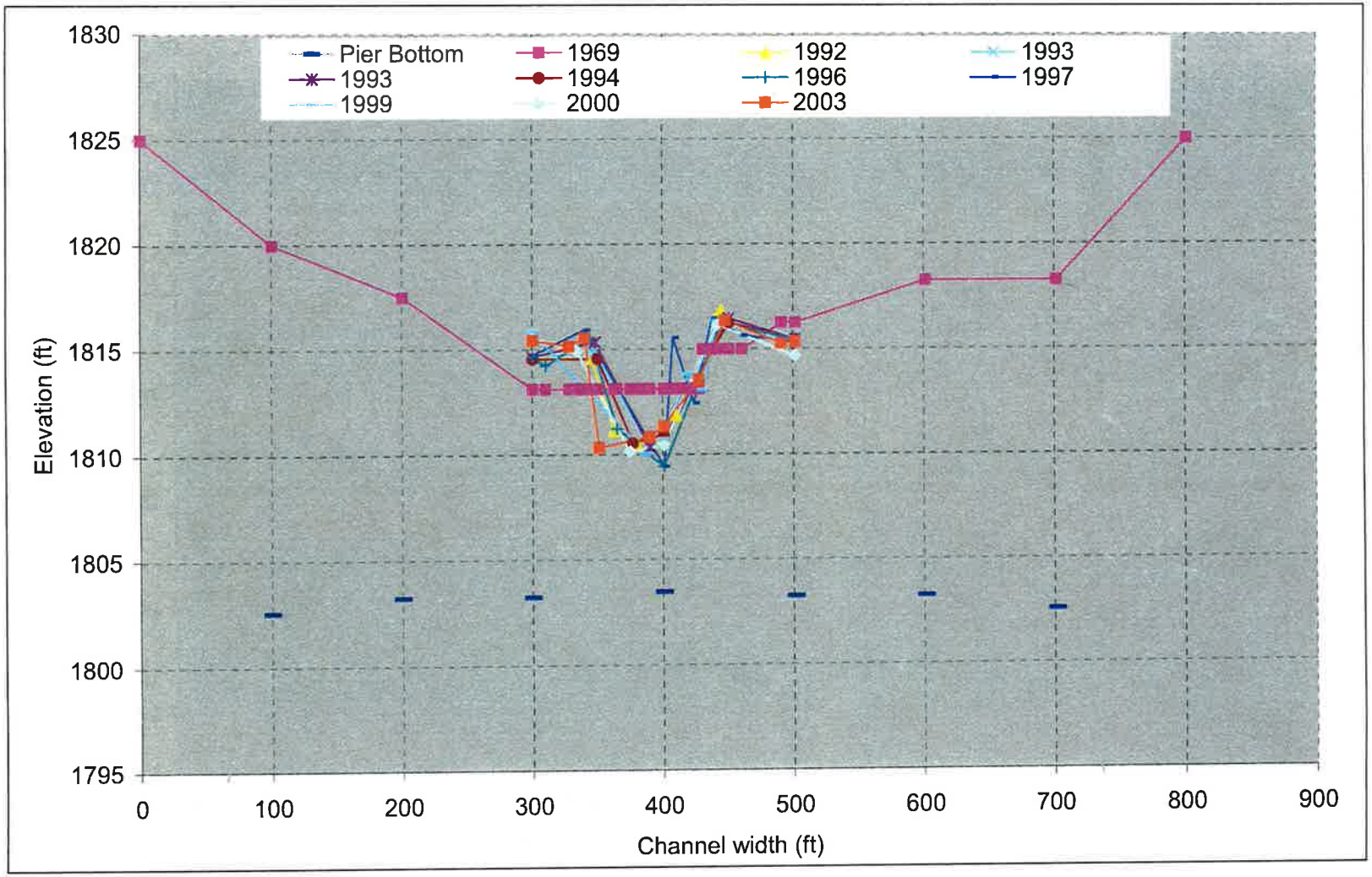


Figure 16. Cross-section at bridge (Key No. 17602 and RS 4) on SH 50, North Canadian River, OK

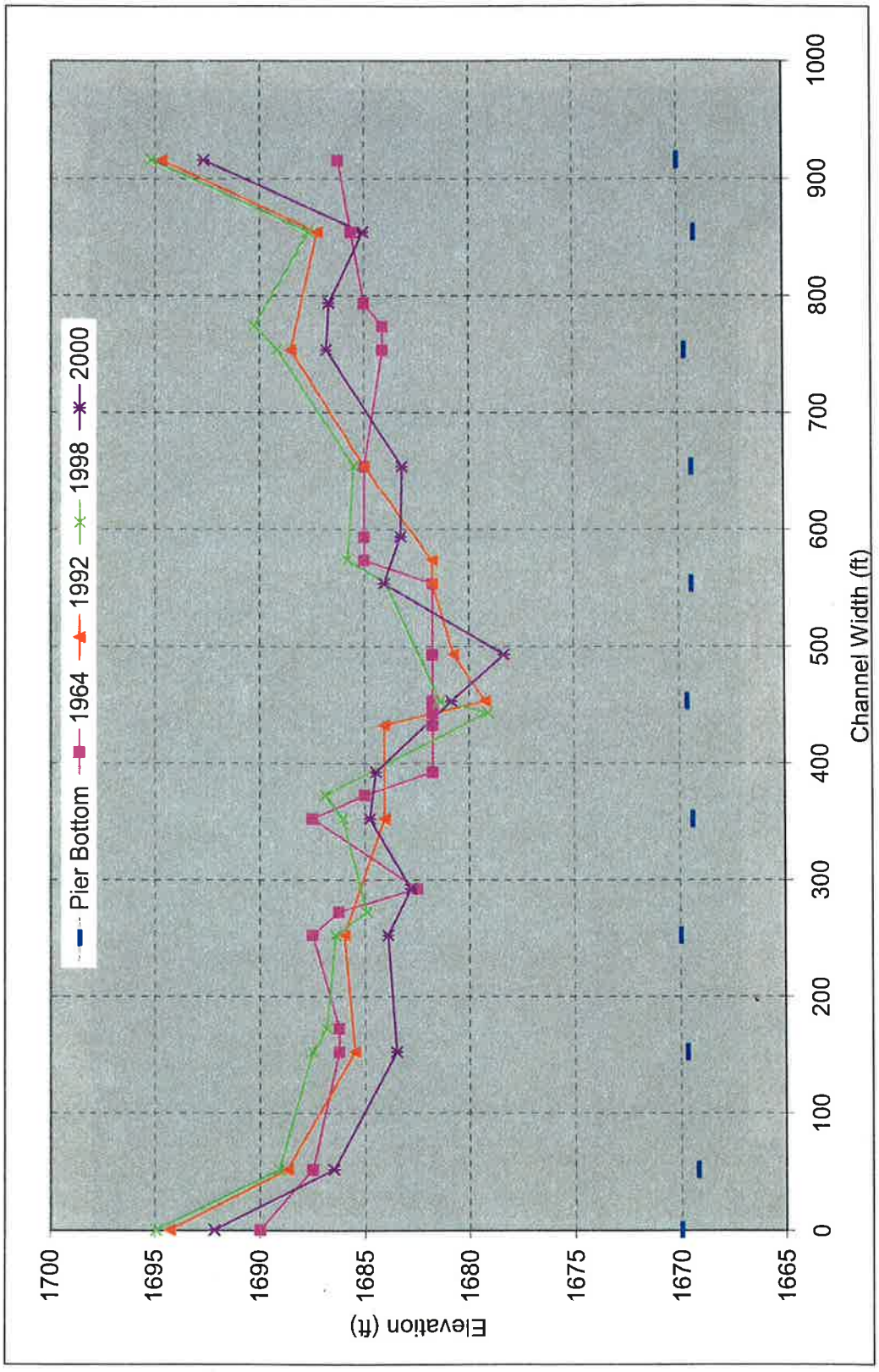


Figure 17. Cross-section at bridge (Key No. 16193 and RS 5) on US 60, North Canadian River, OK

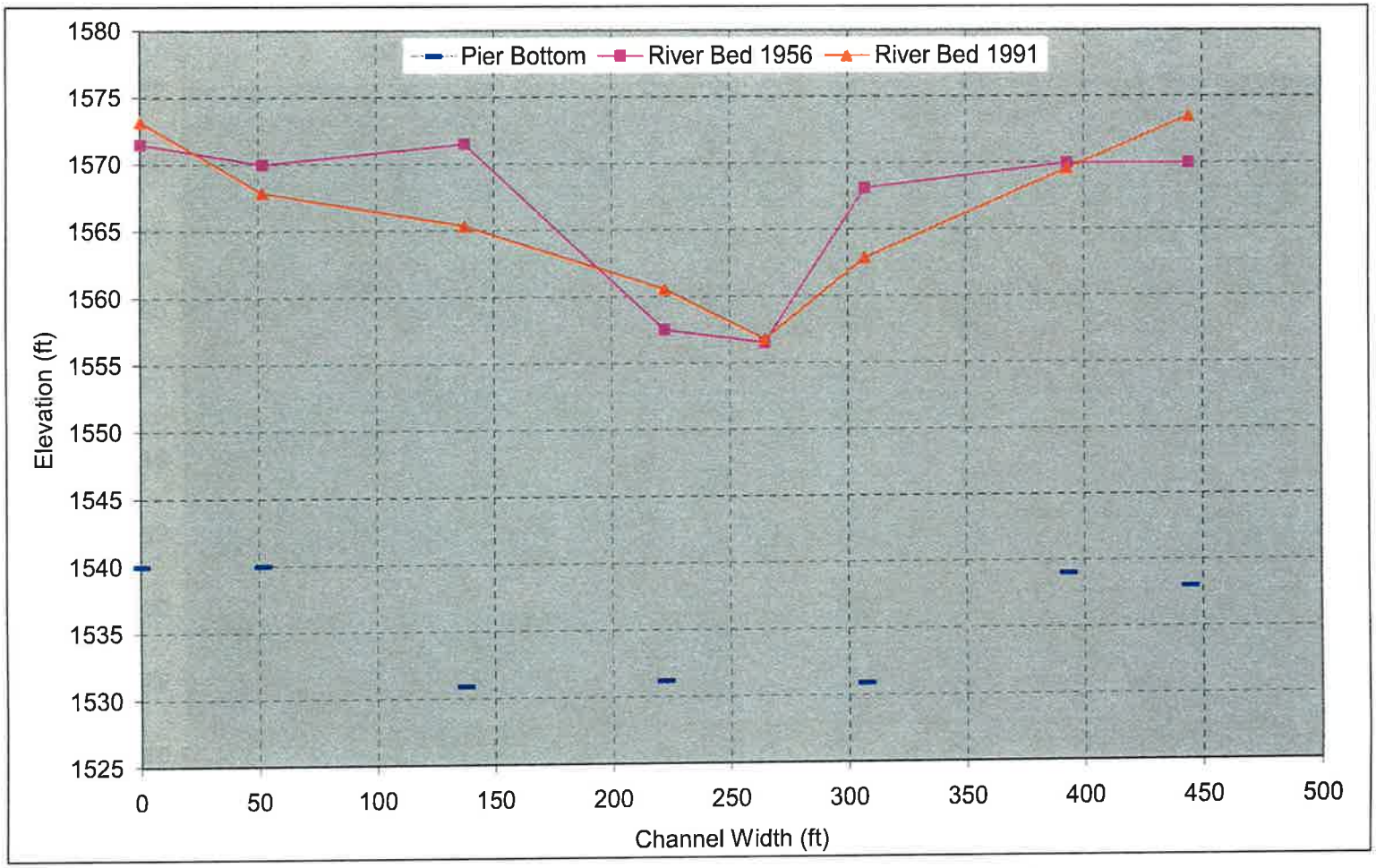


Figure 18. Cross-section at bridge (Key No. 13679 and RS 6) on SH 51, North Canadian River, OK

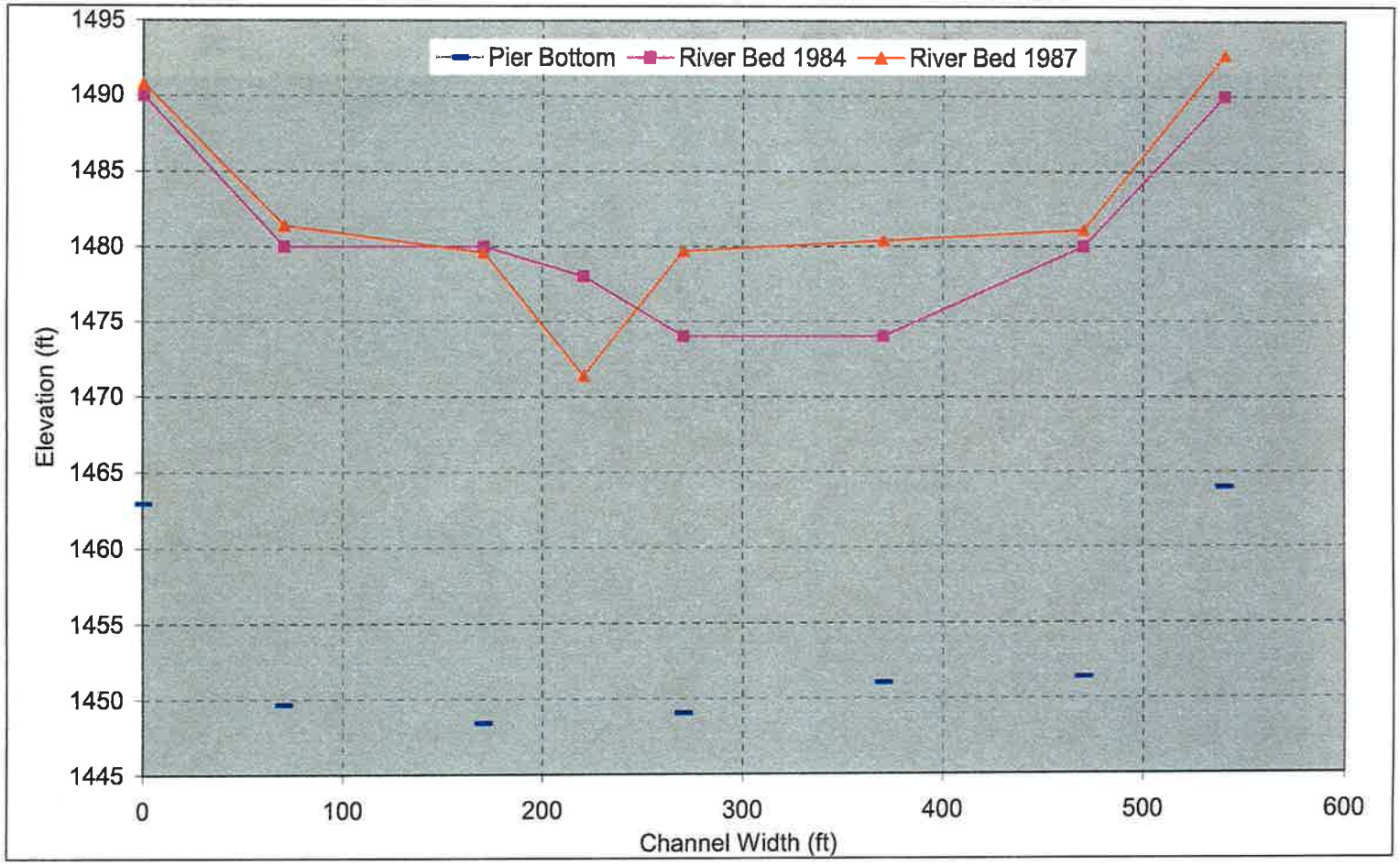


Figure 19. Cross-section at bridge (Key No. 20864 and RS 8) on US 270, North Canadian River, OK

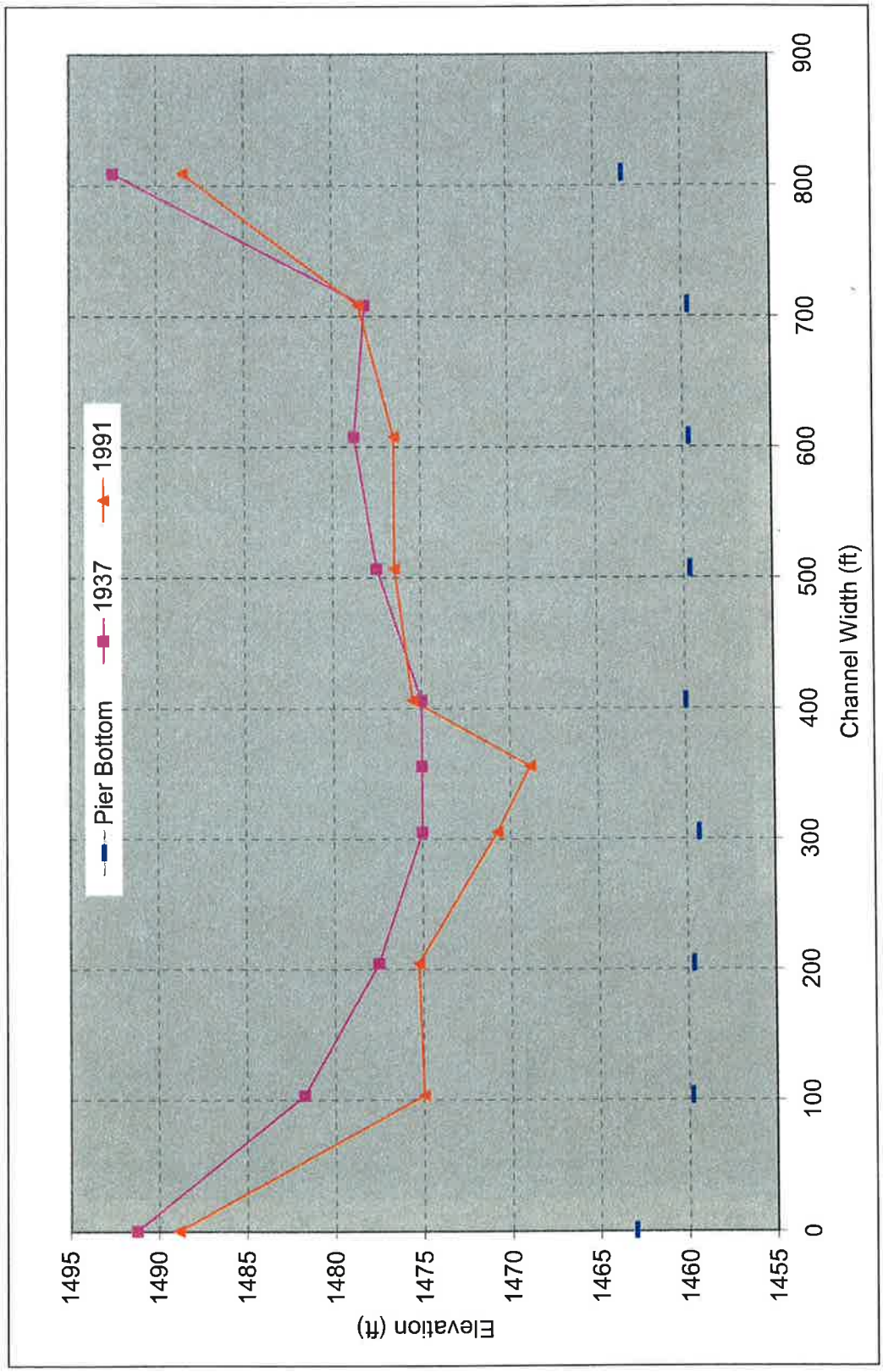


Figure 20. Cross-section at bridge (Key No. 05523 and RS 9) on US 270, North Canadian River, OK

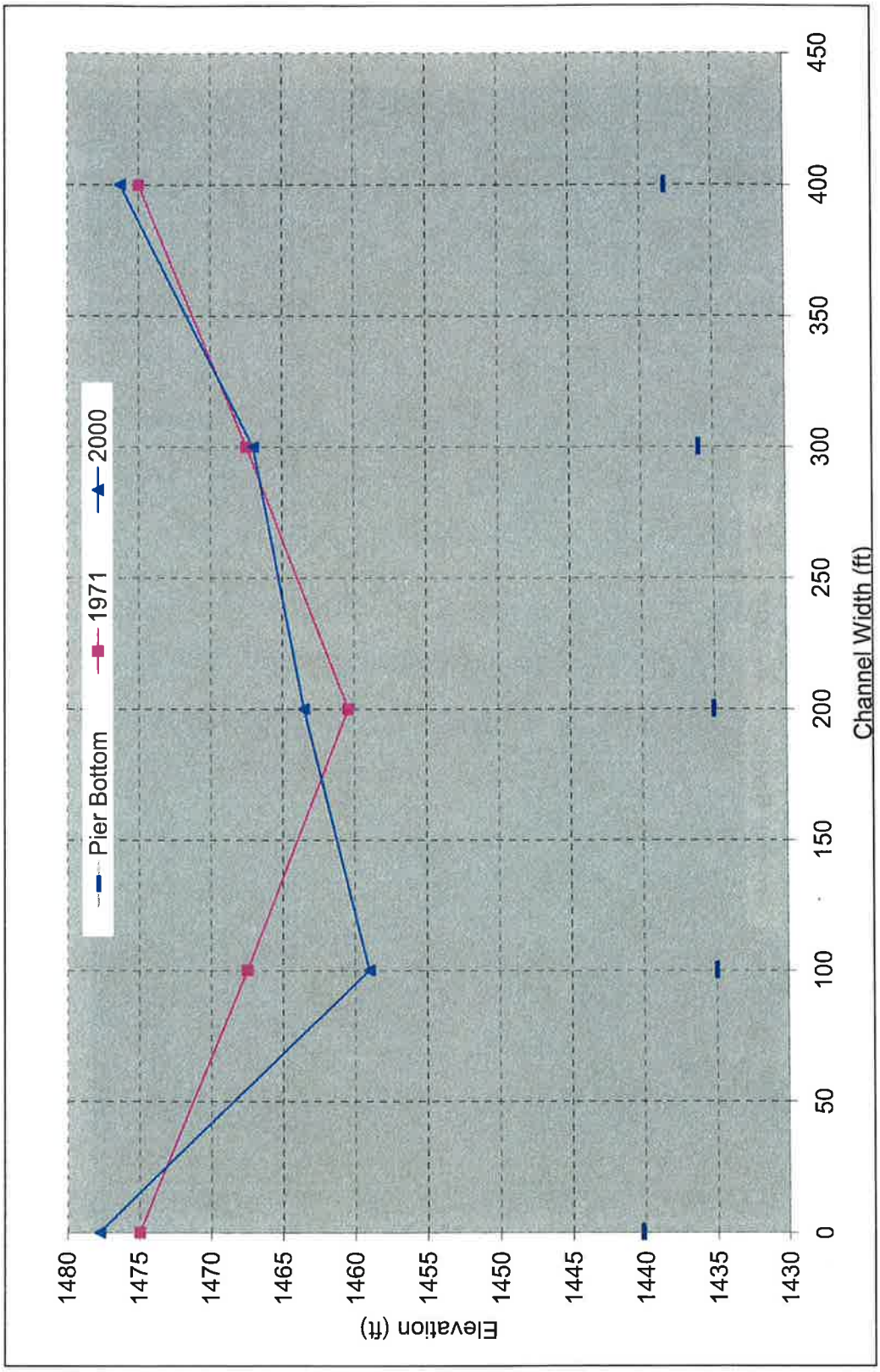


Figure 21. Cross-section at bridge (Key No. 18134 and RS 10) on US 270, North Canadian River, OK

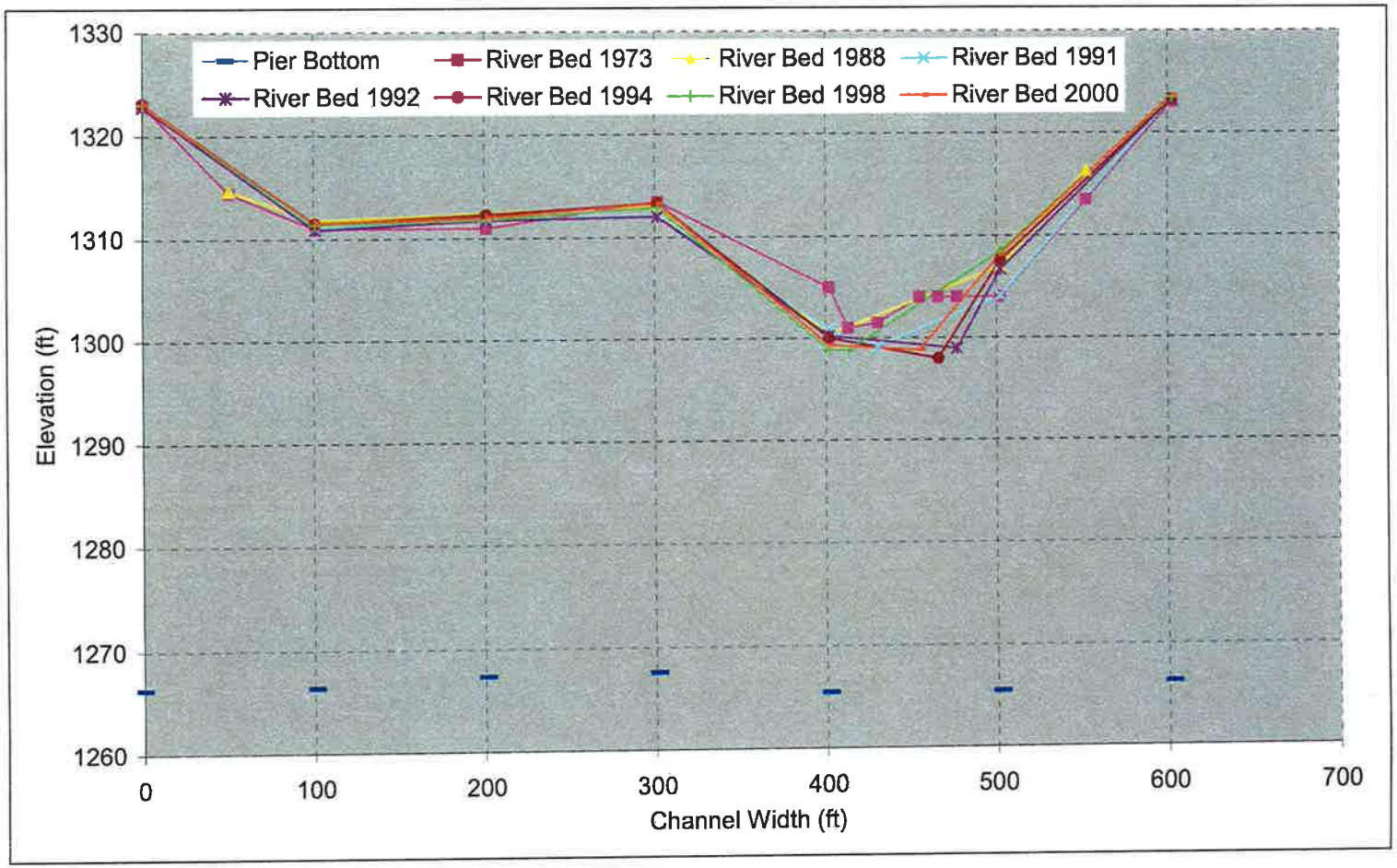


Figure 22. Cross-section at bridge (Key No. 18608 and RS 12) on US 81, North Canadian River, OK

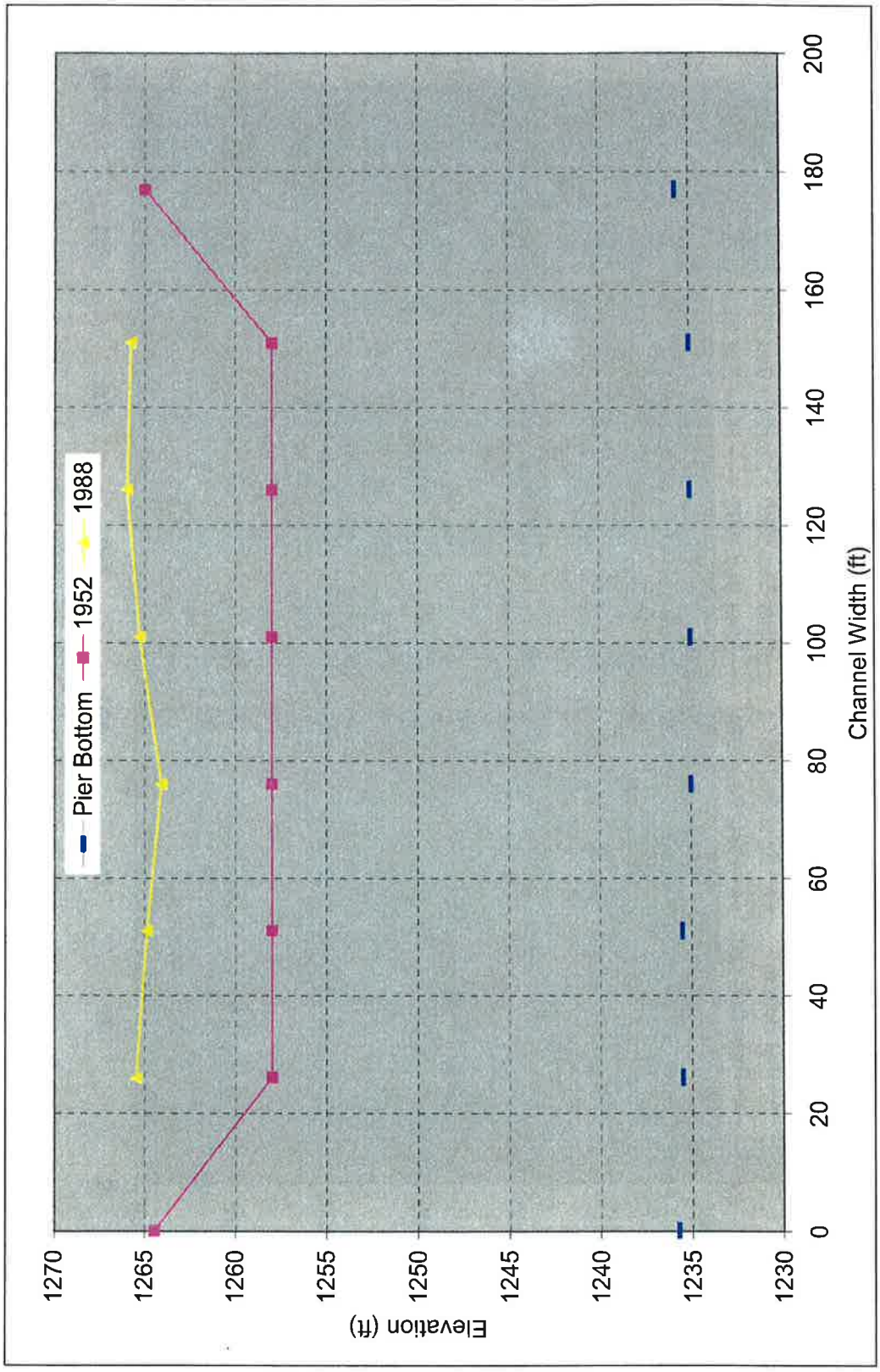


Figure 23. Cross-section at bridge (Key No. 12832 and RS 13) on SH 4, North Canadian River, OK

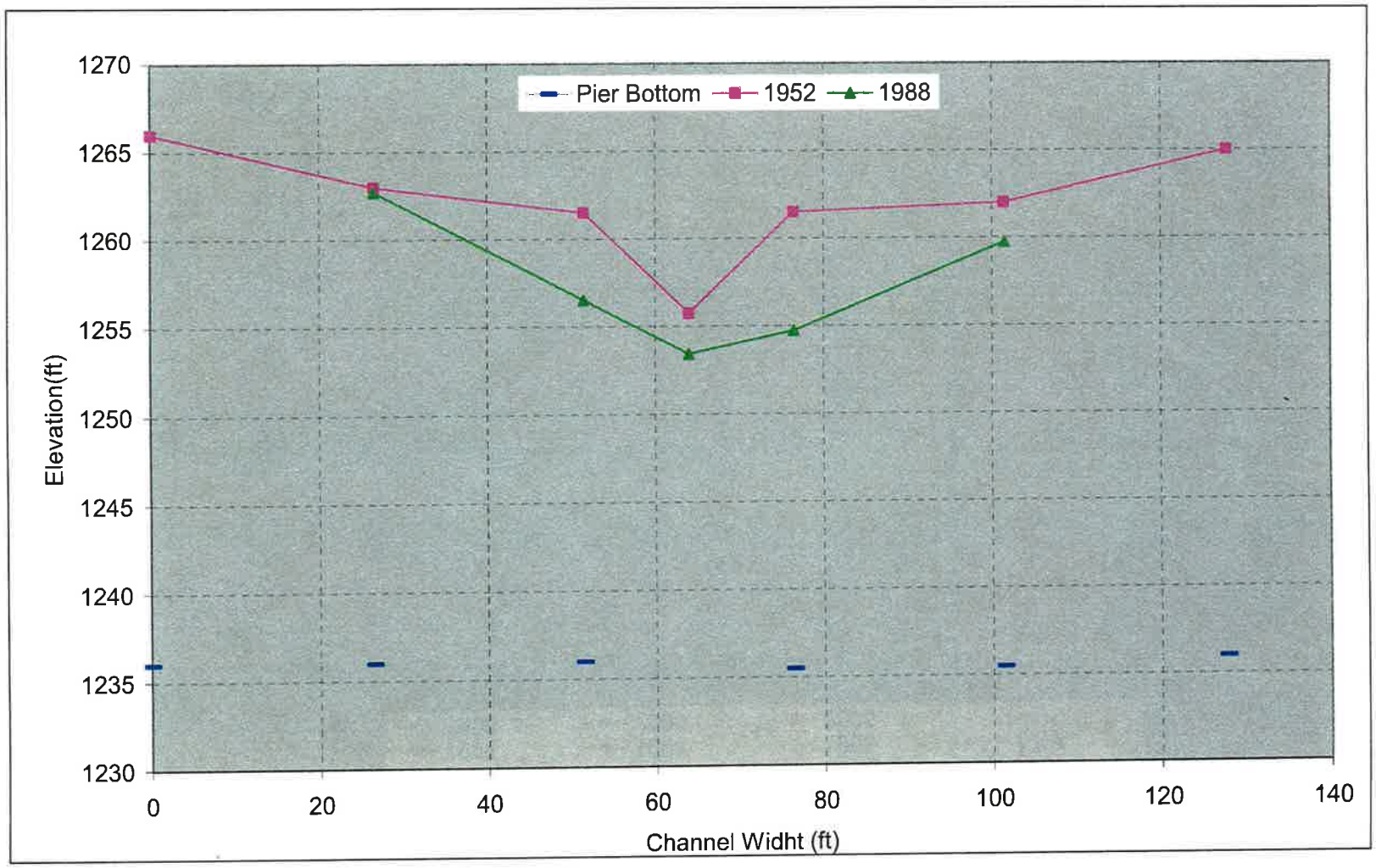


Figure 24. Cross-section at bridge (Key No. 12820 and RS 14) on SH 4, North Canadian River, OK

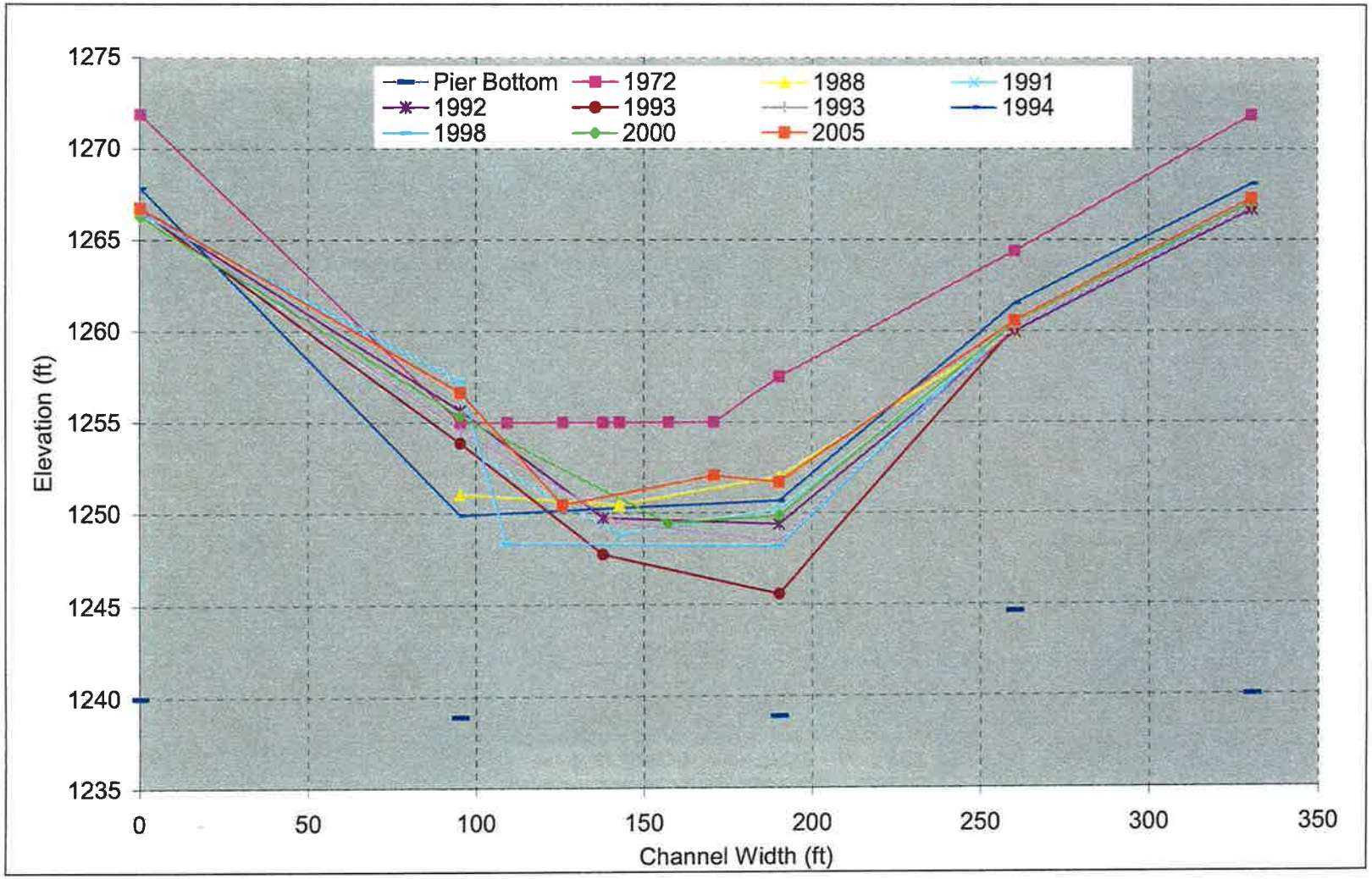


Figure 25. Cross-section at bridge (Key No. 18352 and RS 15) on SH 4, North Canadian River, OK

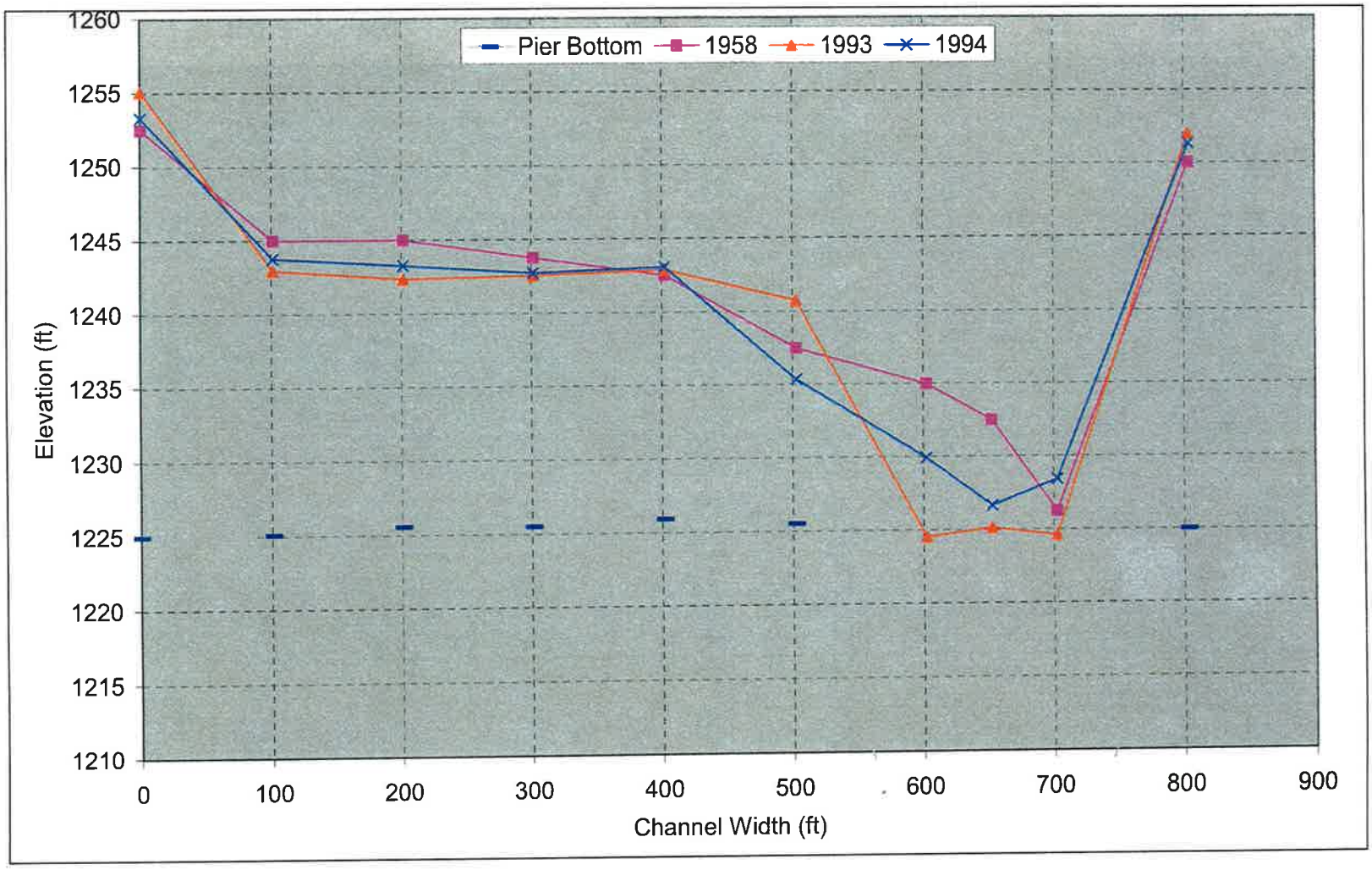


Figure 26. Cross-section at bridge (Key No. 14208 and RS 16) on US 66, North Canadian River, OK

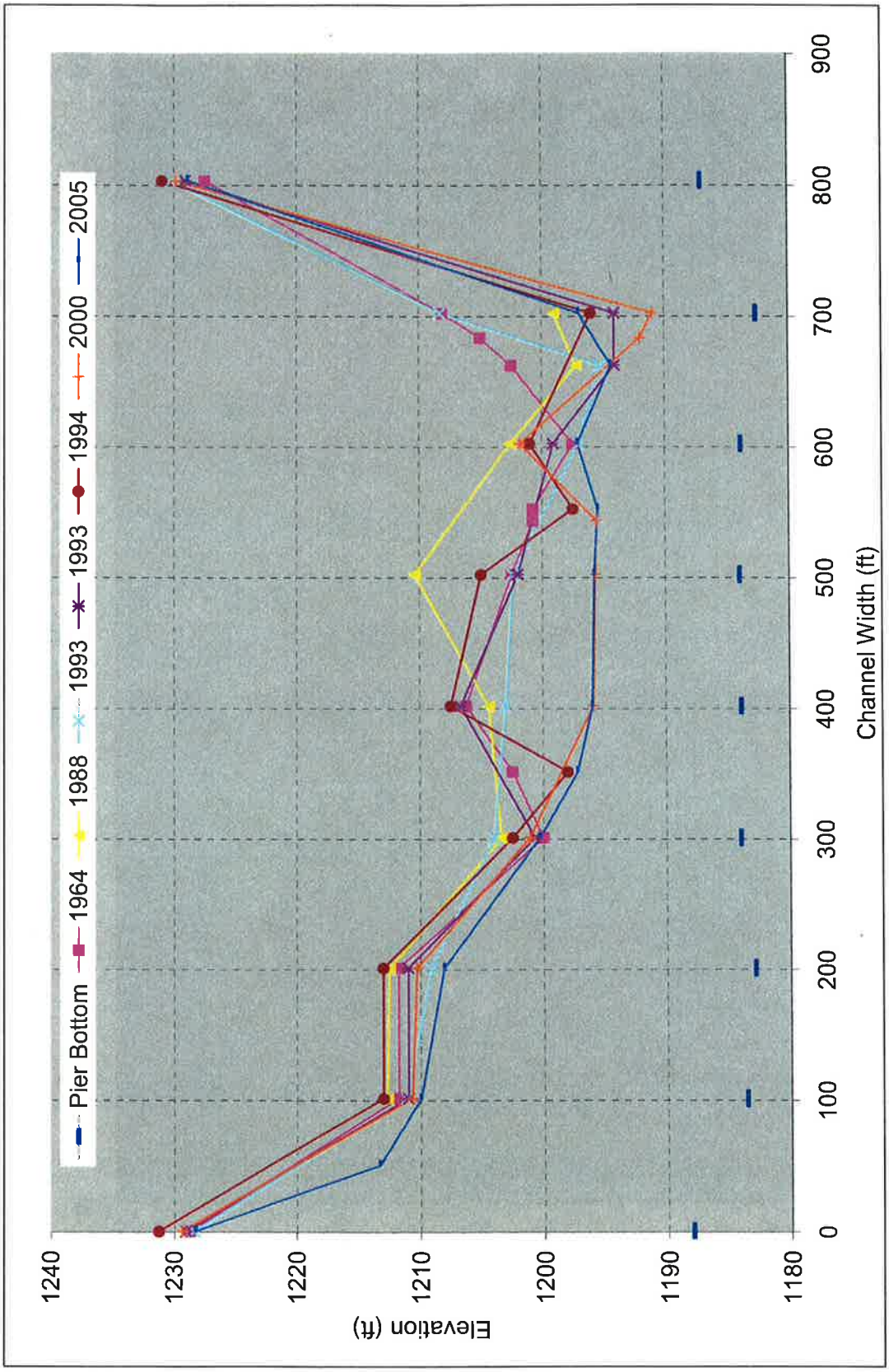


Figure 27. Cross-section at bridge (Key No. 16189 and RS 17) on I-40, North Canadian River, OK

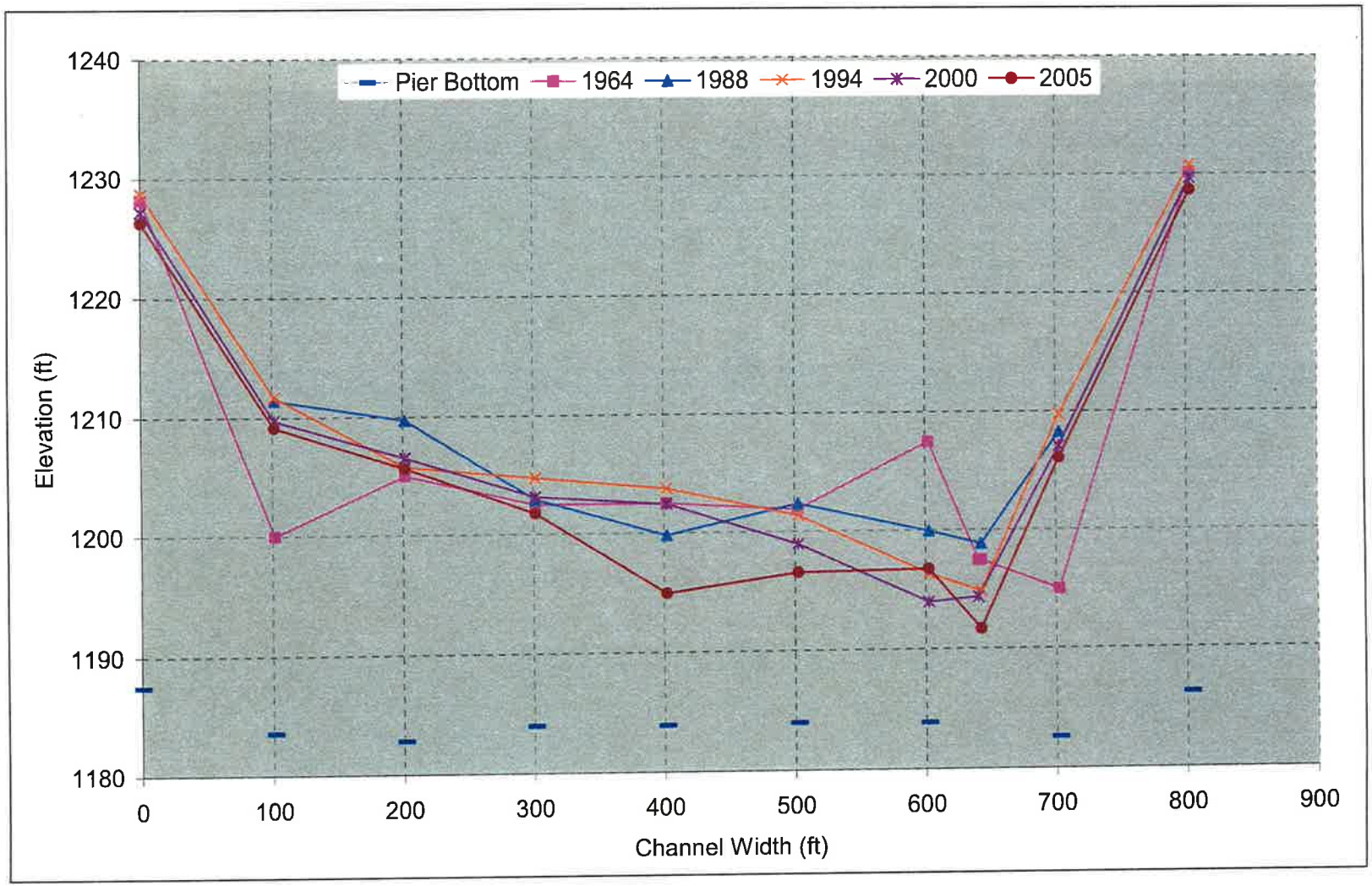


Figure 28. Cross-section at bridge (Key No. 16190 and RS 18) on I-40, North Canadian River, OK

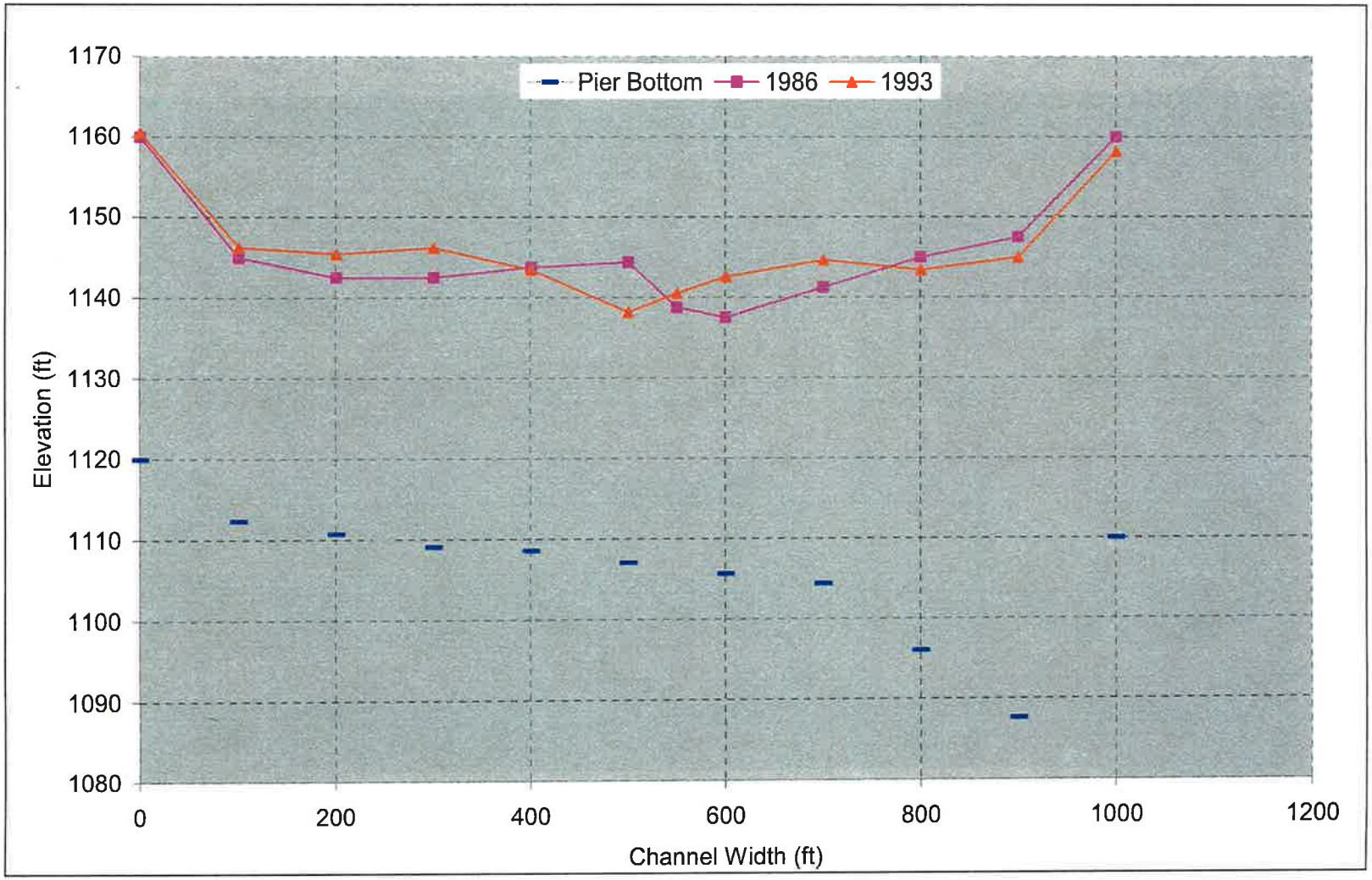


Figure 29. Cross-section at bridge (Key No. 21357 and RS 20) on US 69, North Canadian River, OK

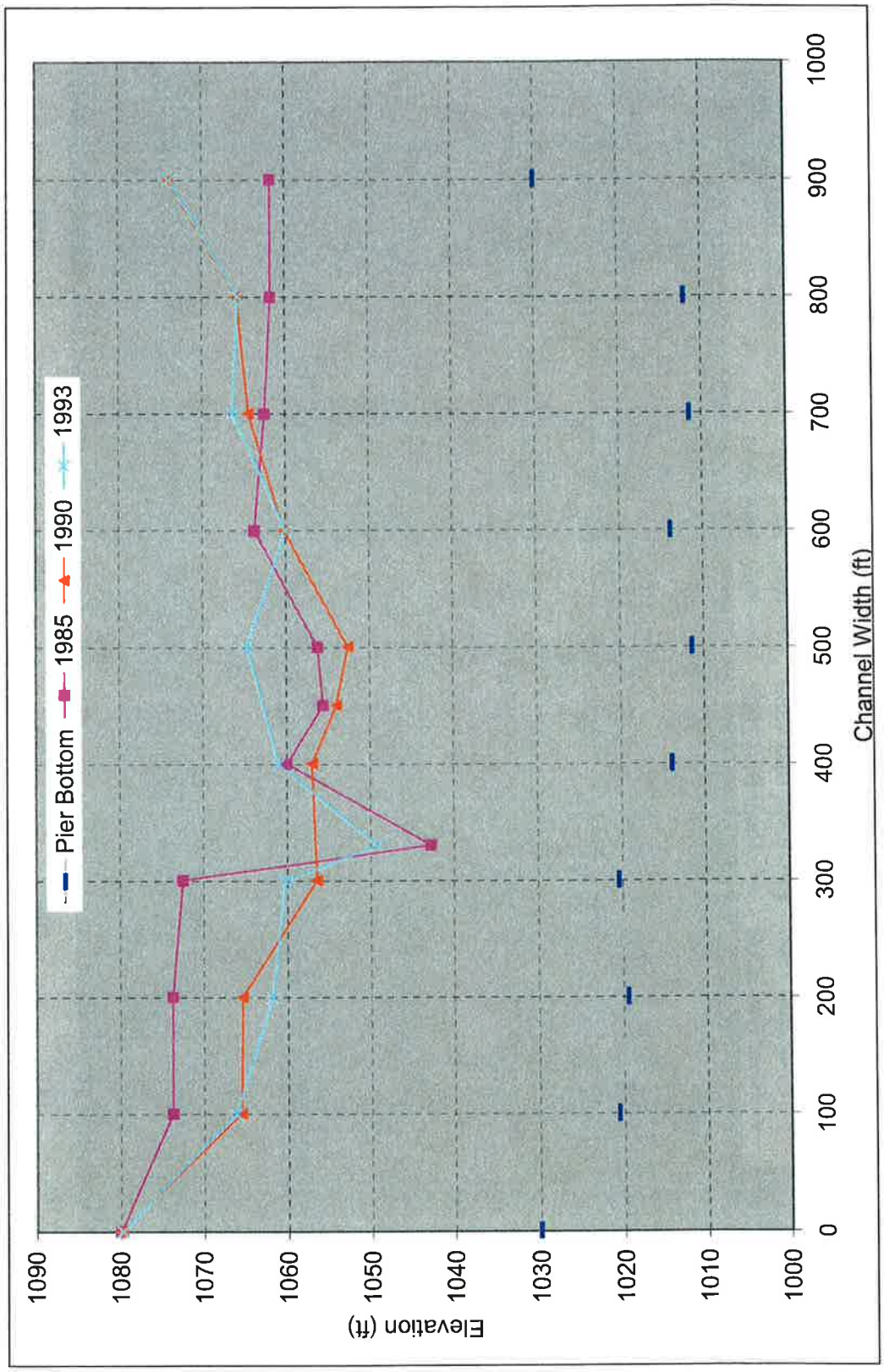


Figure 30. Cross-section at bridge (Key No. 21129 and RS 21) on US 62, North Canadian River, OK

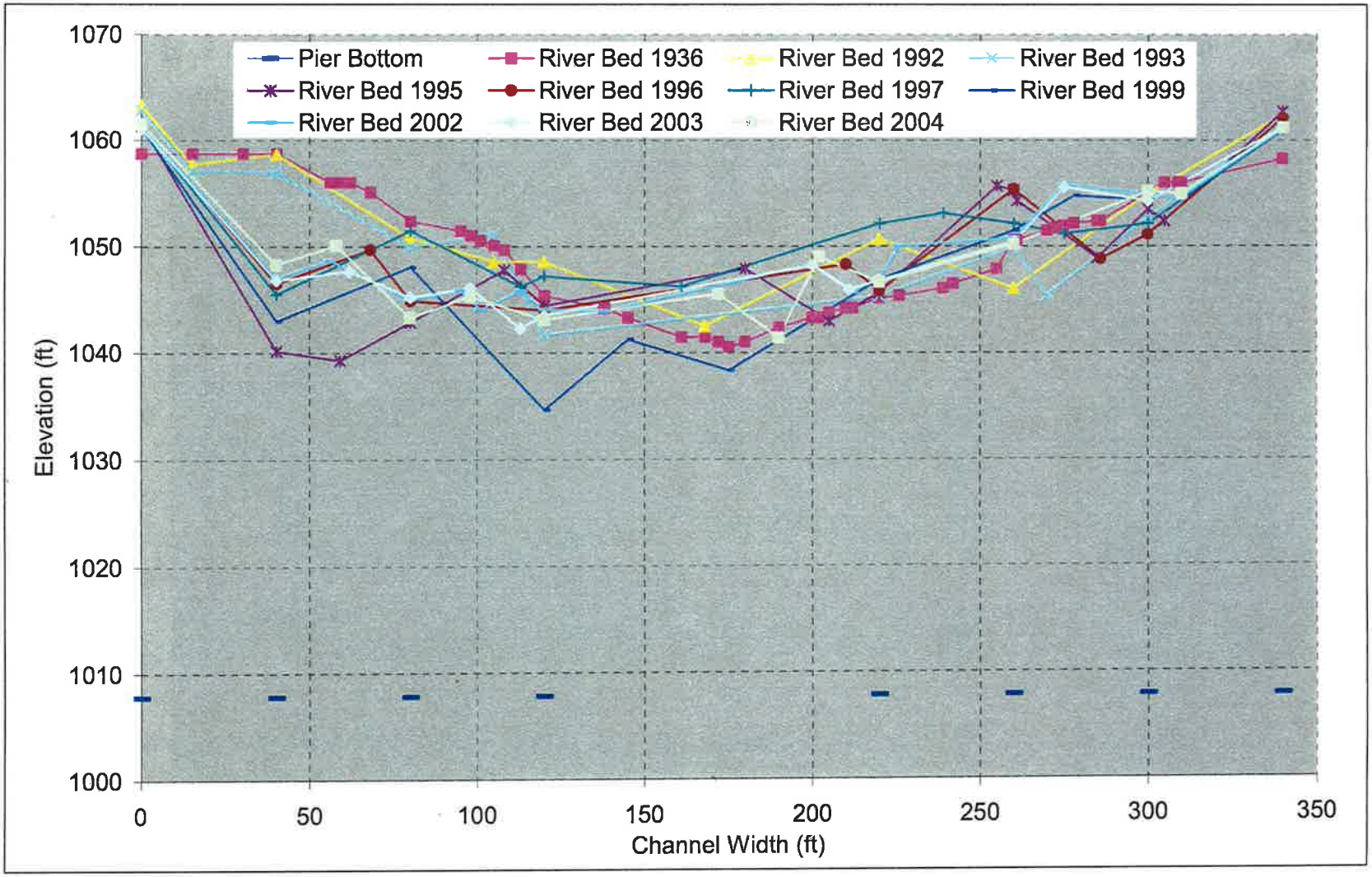


Figure 31. Cross-section at bridge (Key No. 05040 and RS 22) on SH 102, North Canadian River, OK

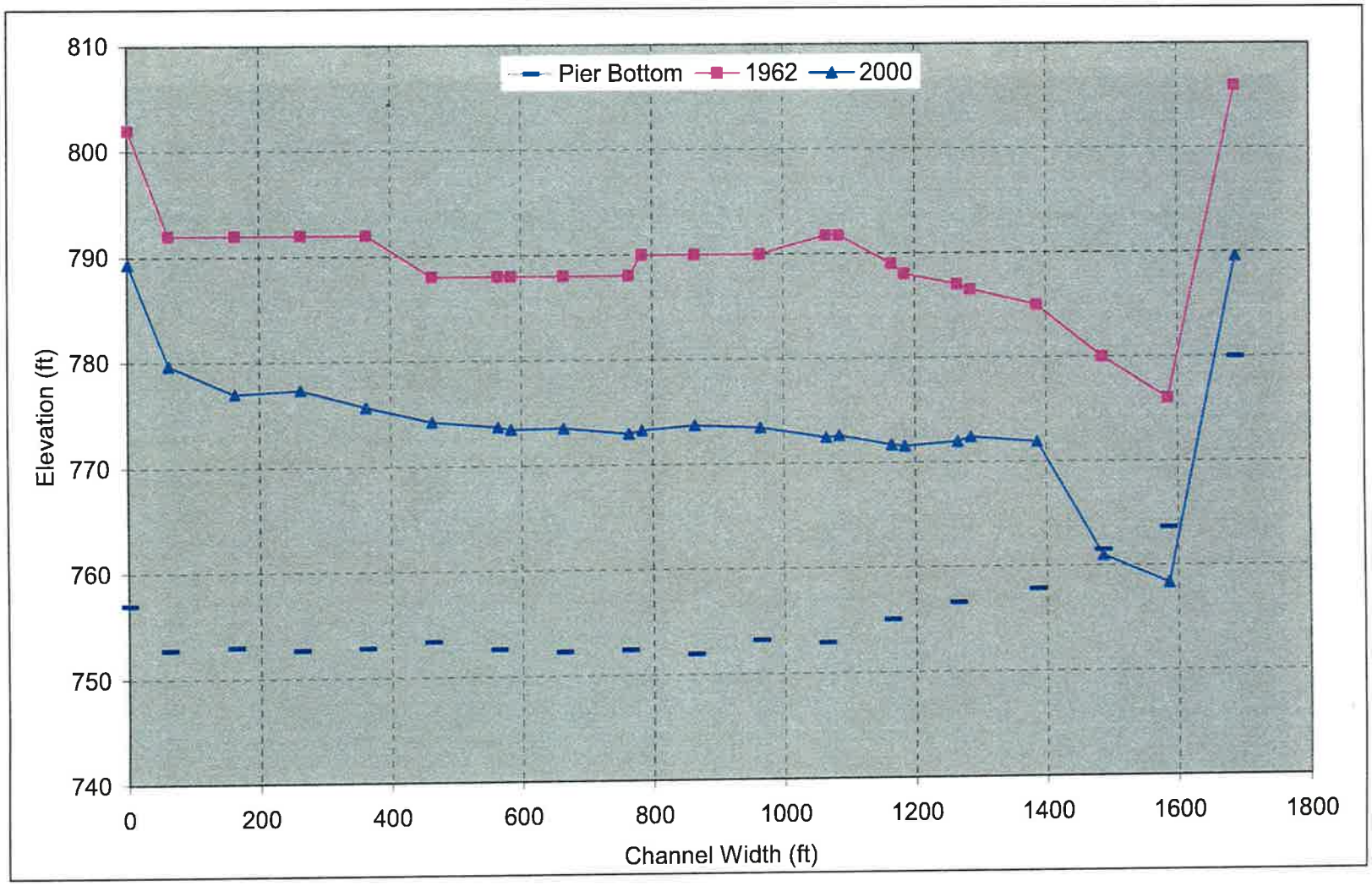


Figure 32. Cross-section at bridge (Key No. 15870 and RS 33) on I-20, North Canadian River, OK

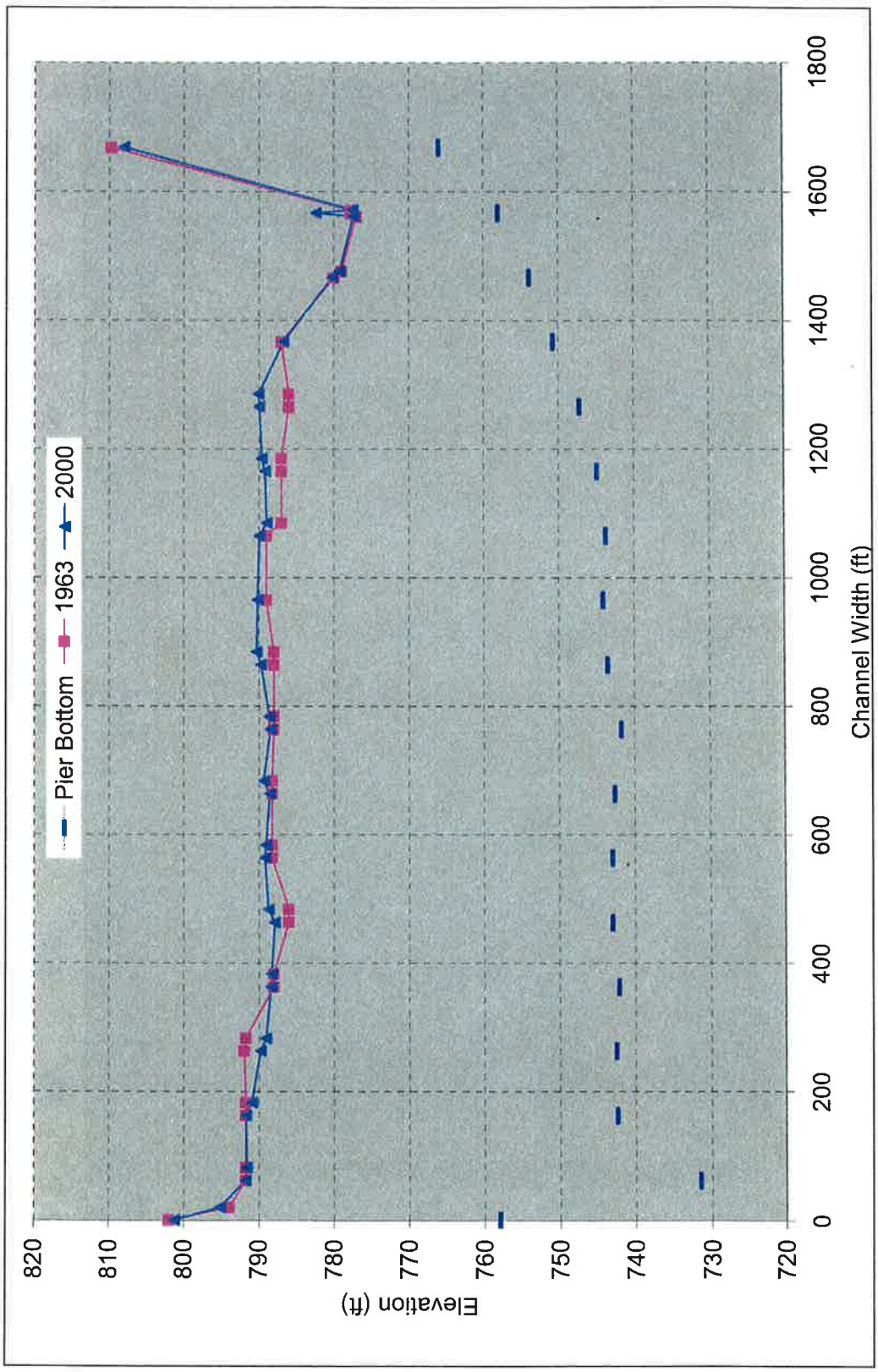


Figure 33. Cross-section at bridge (Key No. 15871 and RS 34) on I-40, North Canadian River, OK

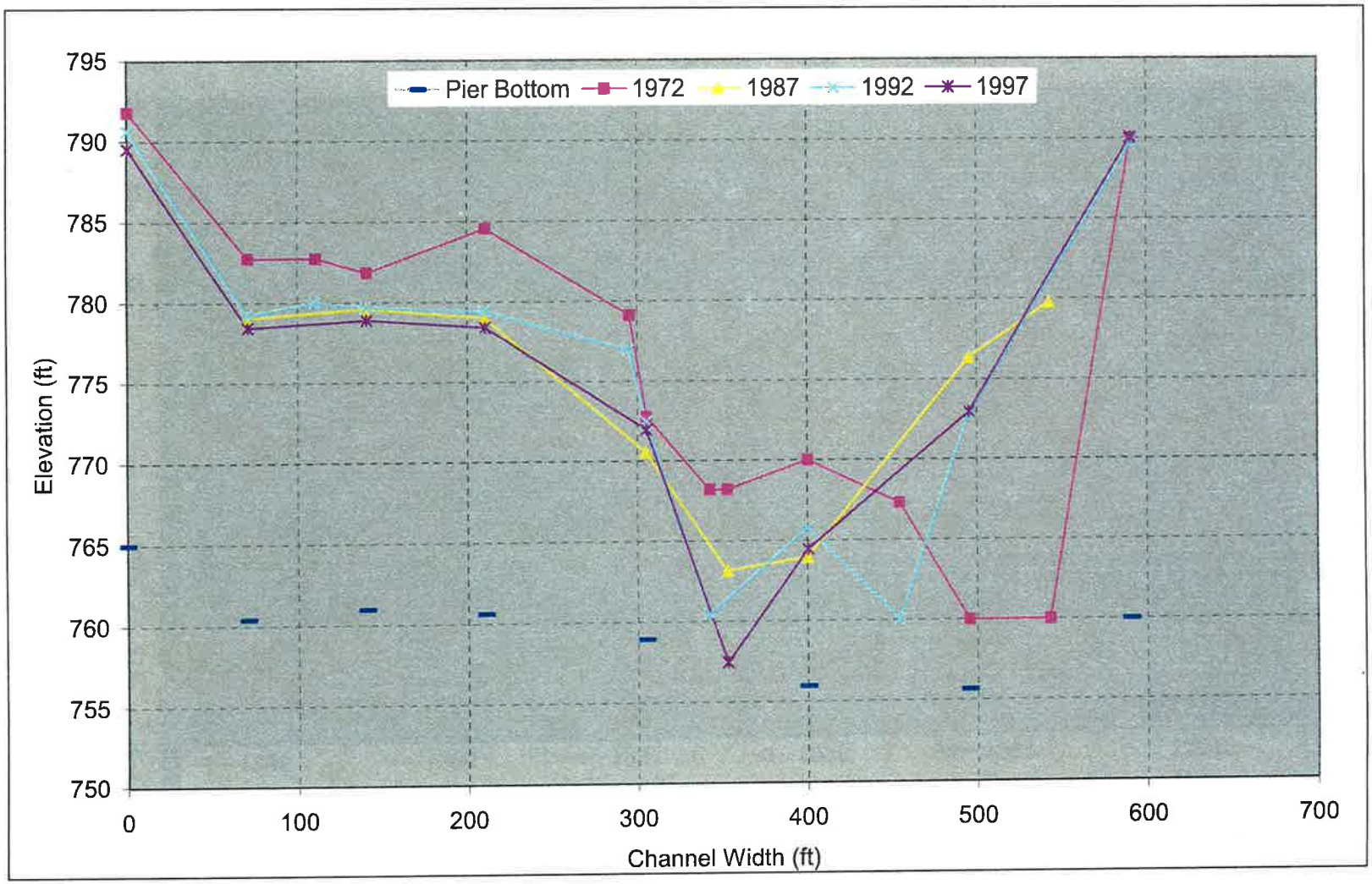


Figure 34. Cross-section at bridge (Key No. 18361 and RS 35) on S.H.48, North Canadian River, OK

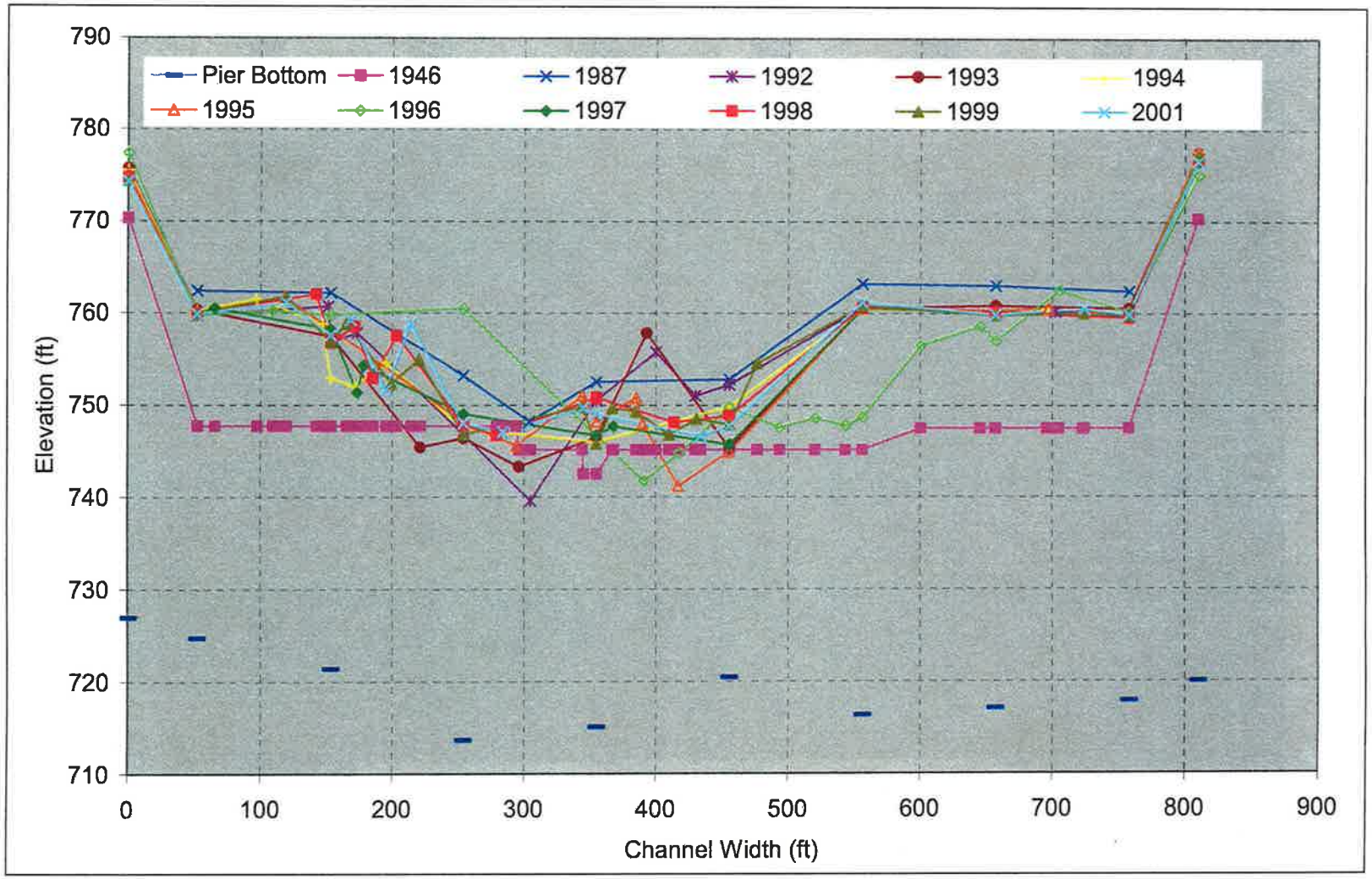


Figure 35. Cross-section at bridge (Key No. 10570 and RS 36) on S.H.27, North Canadian River, OK

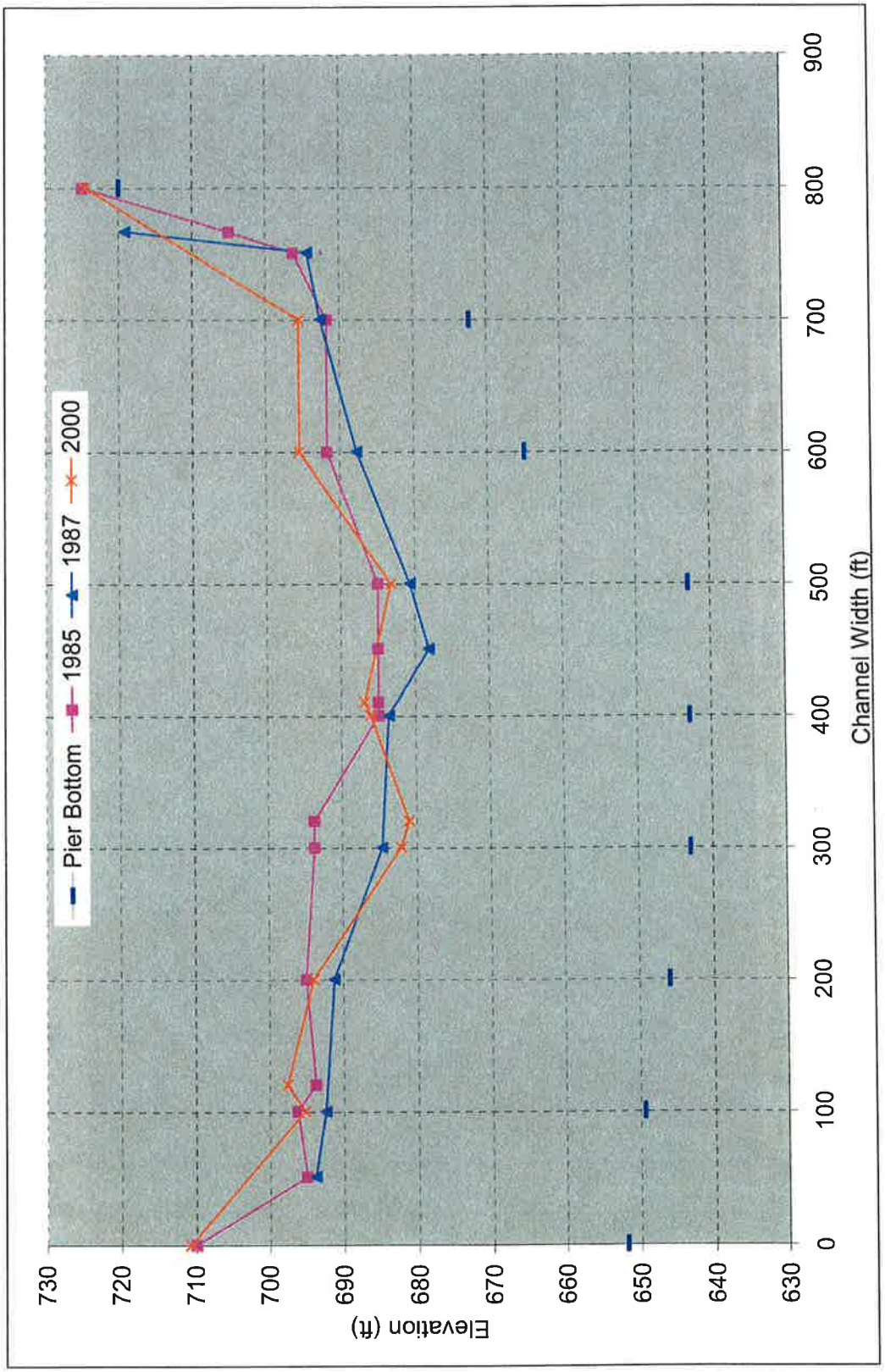


Figure 36. Cross-section at bridge (Key No. 21128 and RS 37) on U.S.75, North Canadian River, OK

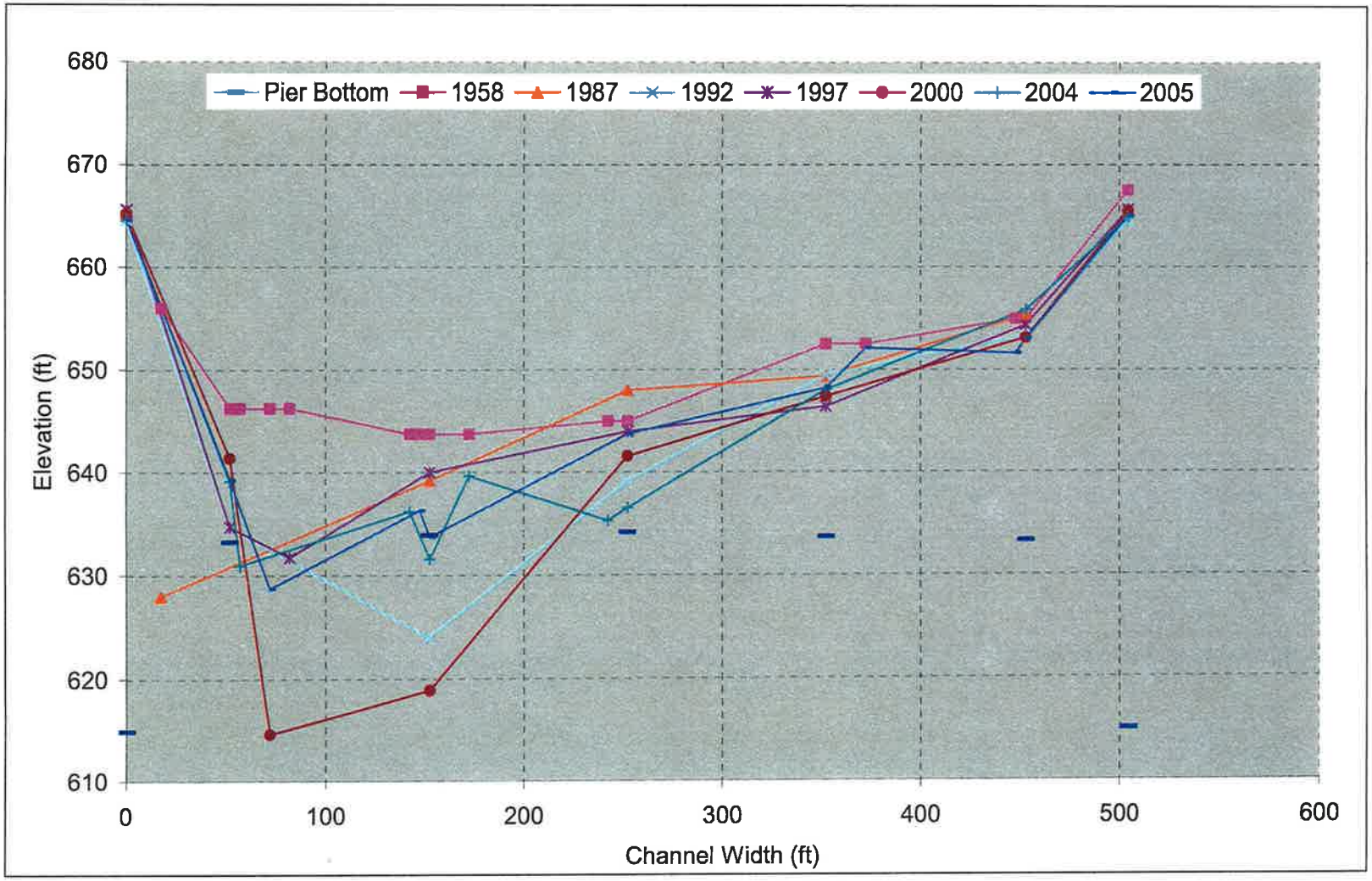


Figure 37. Cross-section at bridge (Key No. 14200 and RS 39) on S.H. 84, North Canadian River, OK

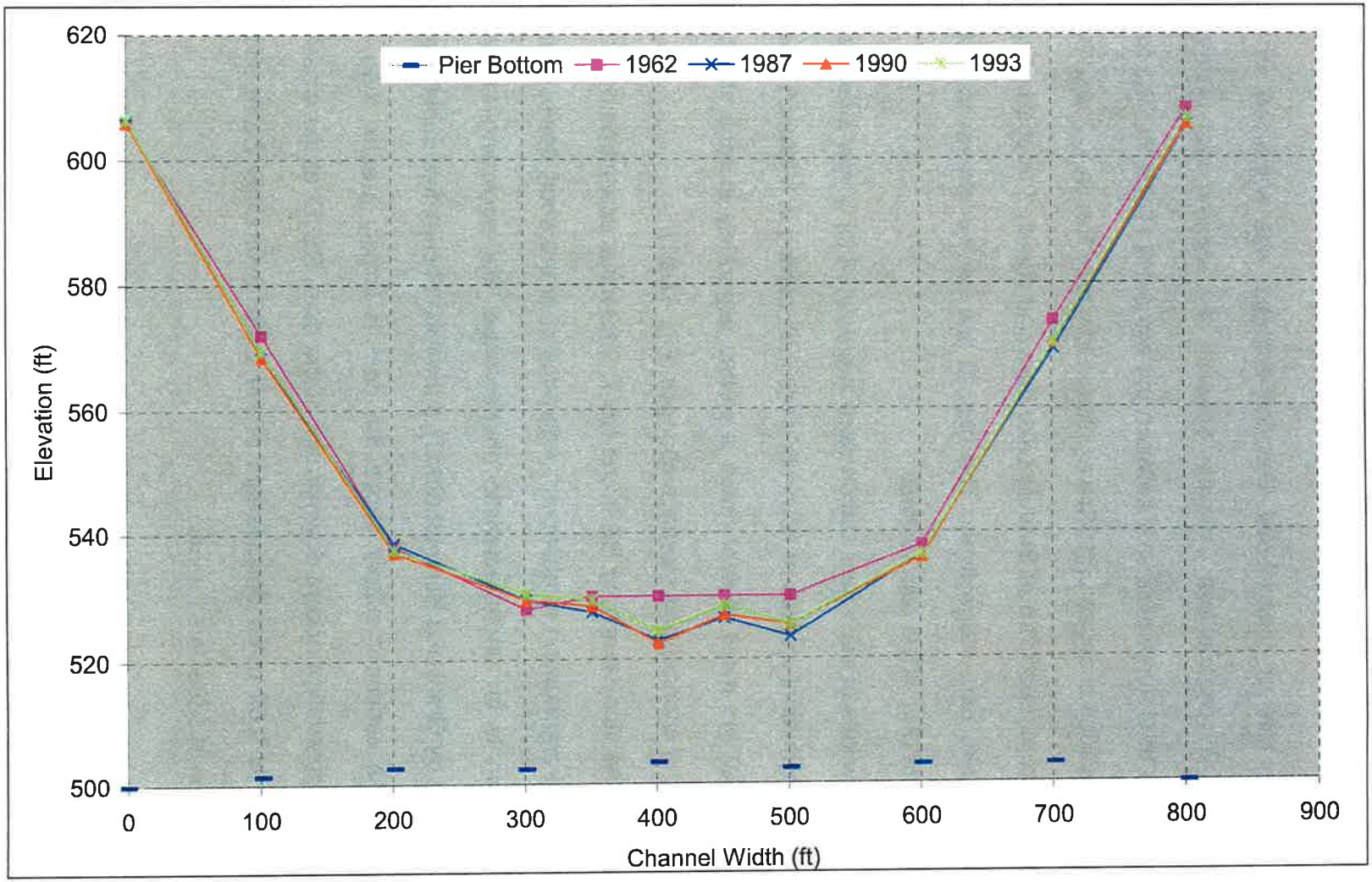


Figure 38. Cross-section at bridge (Key No. 15585 and RS 40) on U.S. 69, North Canadian River, OK

V. ANALYSIS OF FLOWLINE PROFILE

The rate of channel-bed elevation changes was estimated as the net difference in channel-bed elevation between the starting and ending dates divided by total duration of time between the two dates (Table 3). The trend line of bed-elevation changes (Fig.39) was plotted for study Reach 1, 2, and 3. Reach 1 and 2 are at upstream of Eufaula Lake dam and Reach 3 is at downstream of Eufaula Lake dam respectively. The best fit line for the stream bed elevation change rate (Fig. 40) is also plotted.

Flowlines at each river station were interpolated for 5 year intervals (Table 4) and longitudinal profiles of flowlines were then plotted in Microsoft Excel (Fig. 41). Twenty five miles of river reach is plotted separately in each sheet for the evaluation of channel-bed elevation changes (Fig. 42-61).

In the study reach, at RS 6 and RS 7, 3.69 miles downstream the Canton Lake Dam aggradation is observed. Aggradation at the short downstream point of the dam is an uncharacteristic phenomenon. But according to the study conducted by Grant and Schmidt (2003), if the ratio of sediment supply below the dam to the sediment supply above the dam is largely greater than 1, then channel aggradation occurs downstream of the dam. RS 17 at the crossing of I-40, which is 1.69 miles downstream of the Lake Overholser Dam, shows the degradation of 5 feet in 41 years.

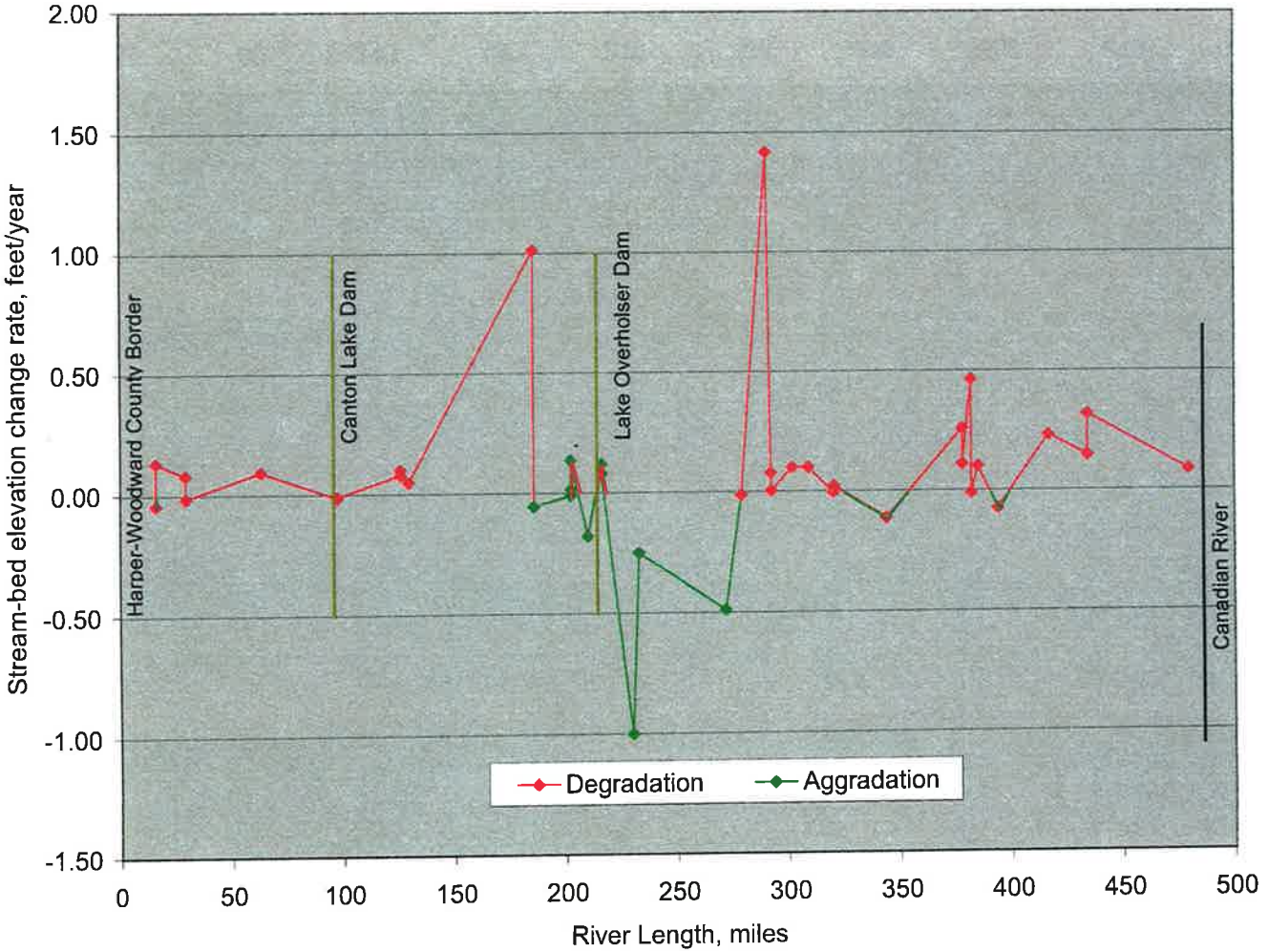


Figure 39. Trend line of stream-bed elevation changes

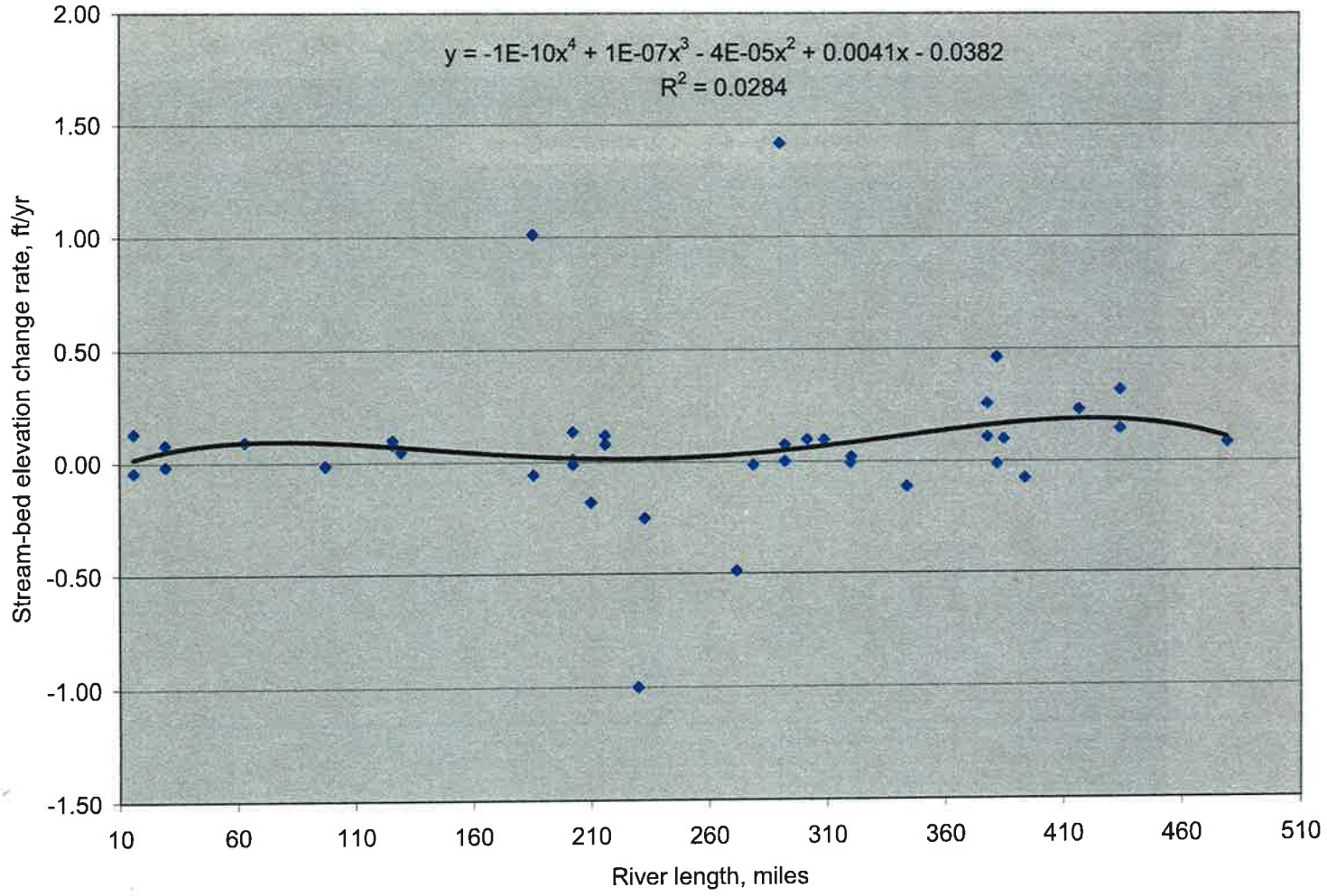


Figure. 40. The best fit line of stream-bed elevation change rate (ft/yr) versus river length in miles

Table 3. Summary- channel –bed elevation change, North Canadian River

BRI_key	River Station	Miles	Highway	Bridge Installed	Stratum	Max. Scour** (ft)	Duration (yr)	Scour Rate** (ft/yr)
*b16523	RS1	15.72	S.H.34	1965	Sand to Medium Hard Red Bed	-1.10	26	-0.042
b16642	RS2	15.72	S.H.34	1965	Sand to Medium Hard Red Bed	4.63	35	0.1321
*b17509	RS3	29.05	S.H. 50	1969	Sand to Soft Red Bed	-0.31	22	-0.0142
b17602	RS4	29.15	S.H. 50	1969	Sand to Soft Red Bed	2.78	34	0.0816
b16193	RS5	62.82	U.S. 60	1964	Sand to Medium Hard Shale	3.40	36	0.0944
b13679	RS6	97.12	S.H. 51	1956	Sand to Red Bed	-0.68	48	-0.0142
*b13655	RS7	97.12	S.H. 51	1956	Sand to Red Bed	-0.50	46	-0.0109
b20864	RS8	125.64	U.S. 270	1984	Sand to Red Bed	1.60	20	0.0800
b05523	RS9	125.67	U.S. 270	1937	Sand to Red Bed	5.83	58	0.1005
b18134	RS10	129.29	U.S. 270	1971	Sand to Medium Hard Sale	1.40	29	0.0483
*b26237	RS11	185.37	U.S. 81	2000	Sand to Medium Hard Red Bed	5.06	5	1.0125
b18608	RS12	185.57	U.S. 81	1973	Sand to Medium Hard Red Bed	-1.75	32	-0.0547
b12832	RS13	202.22	S.H. 4	1952	Medium Packed Sand to Shale	-0.50	53	-0.0094
b12820	RS14	202.22	S.H. 4	1952	Sand to Rock Sand	0.80	53	0.0151
b18352	RS15	202.22	S.H.4	1972	Sand to Red Bed	4.55	33	0.1379

Table 3. (Continued)

BRI_key	River Station	Miles	Highway	Bridge Installed	Stratum	Max. Scour** (ft)	Duration (yr)	Scour Rate** (ft/yr)
b14208	RS16	209.88	U.S. 66	1958	Sand to Red Bed	-8.40	47	-0.1787
b16189	RS17	216.03	I-40	1964	Sand to Red Bed	5.00	41	0.1220
b16190	RS18	216.04	I-40	1964	Sand to Red Bed	3.33	41	0.0812
*b27867	RS19	229.72	I-40 WB TO I-35 NB	2003	Sand to Sand Stone	-2.00	2	-1.0000
b21357	RS20	232.75	U.S. 62	1986	Sand to Sand Stone	-4.75	19	-0.2500
b21129	RS21	271.65	U.S. 62	1985	Sand to Sand Stone	-9.75	20	-0.4875
b05040	RS22	278.83	S.H. 102	1936	Sand	-0.83	68	-0.0122
*b20576	RS23	290.19	S.H. 270	1983	Sand to Soft Sandy Clay	15.60	11	1.4182
*b15380	RS24	292.30	I-40	1961	Sand to Red Bed	2.03	26	0.0781
*b15381	RS25	292.31	I-40	1961	Sand to Hard Sand Stone	0.09	26	0.0035
*b15388	RS26	301.79	U.S. 270	1961	Sand to Red Bed	4.43	44	0.1007
*b19276	RS27	308.91	S.H.-3E	1976	Fine Sand to Hard Shale	2.70	27	0.1000
*b15865	RS28	320.10	N/A	1962	Clay to Shale	-0.17	33	-0.0052
*b15864	RS29	320.42	N/A	1962	Sand to Hard Red Bed	0.73	33	0.0221
*b22683	RS30	343.98	S.H. 99	1990	Silty Sand to Shaley Clay	-1.45	13	-0.1115
*b22686	RS31	378.25	S.H. 56	1990	Weathered Sandstone to Rock	3.90	15	0.2600
*b22666	RS32	378.25	S.H. 57	1990	Weathered Shale to Rock	1.66	15	0.1107
b15870	RS33	382.16	I-40	1962	Sand to Medium Hard Shale	17.67	38	0.4650

Table 3. (Continued)

BRI_key	River Station	Miles	Highway	Bridge Installed	Stratum	Max. Scour** (ft)	Duration (yr)	Scour Rate** (ft/yr)
b15871	RS34	382.16	I-40	1963	Sand to Gray Shale	-0.42	40	-0.0105
b18361	RS35	385.13	S.H.48	1972	Sand to Hard Sand Stone	2.54	25	0.1018
b10570	RS36	394.03	S.H. 27	1946	Sand to Shale to Rock	-4.08	55	-0.0742
b21128	RS37	417.02	U.S. 75	1985	Sand to Coarse Sandy Clay to Gray Shale	3.95	17	0.2324
*b14189	RS38	434.44	S.H. 84	1958	Sand to Shale	5.00	34	0.1471
b14200	RS39	434.44	S.H. 84	1958	Sand to Sand Stone	15.00	47	0.3191
b15585	RS40	479.66	U.S. 69	1962	Rock	3.50	41	0.0854

* Bridges without cross section data

**Note: (-) Aggradation
: (+) Degradation

Table 4. Flowline interpolated data for 5 years interval, North Canadian River

Location			Years								
BRI_KEY	River Station	Miles	1965	1970	1975	1980	1985	1990	1995	2000	2005
16523	RS1	15.72	1869.33	1869.63	1869.48	1869.43	1869.85	1870.43	1870.43	1870.43	1870.43
16642	RS2	15.72	1868.13	1865.40	1865.00	1864.40	1864.70	1864.10	1863.87	1863.50	1862.52
17509	RS3	29.05		1814.61	1813.33	1813.29	1815.26	1815.31	1815.31	1815.31	1815.31
17602	RS4	29.15		1810.85	1811.25	1810.38	1811.25	1809.90	1810.00	1810.15	1810.48
16193	RS5	62.82	1680.06	1678.76	1679.26	1678.16	1677.31	1676.56	1677.30	1678.35	1676.36
13679	RS6	97.12	1557.18	1556.18	1554.68	1555.51	1555.48	1556.23	1557.88	1555.46	1559.02
13655	RS7	97.12	1561.40	1561.51	1561.56	1561.61	1561.79	1561.71	1562.00	1561.59	1561.19
20864	RS8	125.64	1476.40	1476.30	1475.50	1475.37	1473.13	1471.90	1477.40	1474.62	1471.84
5523	RS9	125.67	1468.50	1468.40	1467.60	1467.47	1465.93	1468.19	1469.17	1469.54	1469.91
18134	RS10	129.29			1460.45	1461.53	1460.25	1460.05	1461.25	1459.05	1456.85
26237	RS11	185.37								1300.83	1295.77
18608	RS12	185.57			1302.55	1301.97	1300.75	1300.05	1298.23	1298.85	1302.75
12832	RS13	202.22	1263.00	1258.50	1260.16	1261.82	1258.00	1257.80	1258.05	1258.27	1258.50
12820	RS14	202.22	1258.15	1259.15	1255.15	1256.82	1255.25	1254.05	1254.75	1255.01	1254.95
18352	RS15	202.22			1253.88	1251.88	1250.38	1249.38	1249.49	1249.45	1250.45
14208	RS16	209.88	1237.75	1232.95	1232.91	1232.87	1240.75	1230.79	1227.3955	1231.02	1234.65

Table 4. (Continued)											
Location			Years								
BRI_KEY	River Station	Miles	1965	1970	1975	1980	1985	1990	1995	2000	2005
16189	RS17	206.03	1199.22	1207.80	1200.50	1200.58	1198.70	1196.70	1195.17	1191.00	1192.50
16190	RS18	216.04	1197.10	1207.58	1199.68	1199.51	1198.33	1196.08	1194.73	1193.98	1191.68
27867	RS 19	229.72									1148.00
21357	RS20	23275						1140.45	1143.26	1142.75	1142.25
21129	RS21	271.65					1042.75	1052.60	1050.06	1051.28	1052.50
05040	RS22	278.83	1050.93	1052.71	1048.64	1046.81	1045.75	1043.44	1042.91	1037.78	1040.51
20576	RS 23	290.19					1001.25	992.68	991.35	999.05	1006.05
15380	RS 24	292.30	1015.59	1015.15	1015.07	1014.61	1014.15	1013.70	1013.24	1012.78	1012.32
15381	RS 25	292.31	1014.31	1014.59	1014.51	1014.26	1014.01	1013.76	1013.51	1013.26	1013.01
15388	RS 26	301.79	974.47	974.47	973.97	972.97	975.67	973.53	972.97	972.97	972.57
19276	RS 27	308.91				955.60	955.00	954.29	953.83	953.50	953.17
15865	RS 28	320.10	929.62	928.62	928.07	929.27	927.27	925.97	931.17	937.30	943.42
15864	RS 29	320.42	929.77	928.47	929.27	929.47	926.57	926.07	930.77	936.40	942.02
22683	RS 30	343.98						865.00	867.25	866.75	866.25
22686	RS 31	378.25						787.50	786.00	784.50	783.60
22666	RS 32	378.25						802.50	801.28	801.00	800.84

Table 4. (Continued)

Location			Years								
BRI_KEY	River Station	Miles	1965	1970	1975	1980	1985	1990	1995	2000	2005
15871	RS 34	382.16	777.30	777.67	776.50	777.50	777.50	775.30			
18361	RS 35	385.13			764.27	762.34	762.31	762.66	777.50	777.45	777.40
10570	RS 36	394.03	748.74	746.38	743.74	745.99	747.54	746.84	761.46	751.46	741.46
21128	RS 37	417.02					685.00	680.00	741.24	746.25	748.30
14189	RS 38	434.44	656.40	656.52	656.60	656.55	656.50	659.00	684.17	681.94	679.70
14200	RS 39	434.44	638.85	624.75	630.75	633.25	620.25	619.55	641.00	618.50	596.00
15585	RS 40	479.66	527.93	527.83	527.72	527.61	527.50	522.50	620.75	614.67	628.75

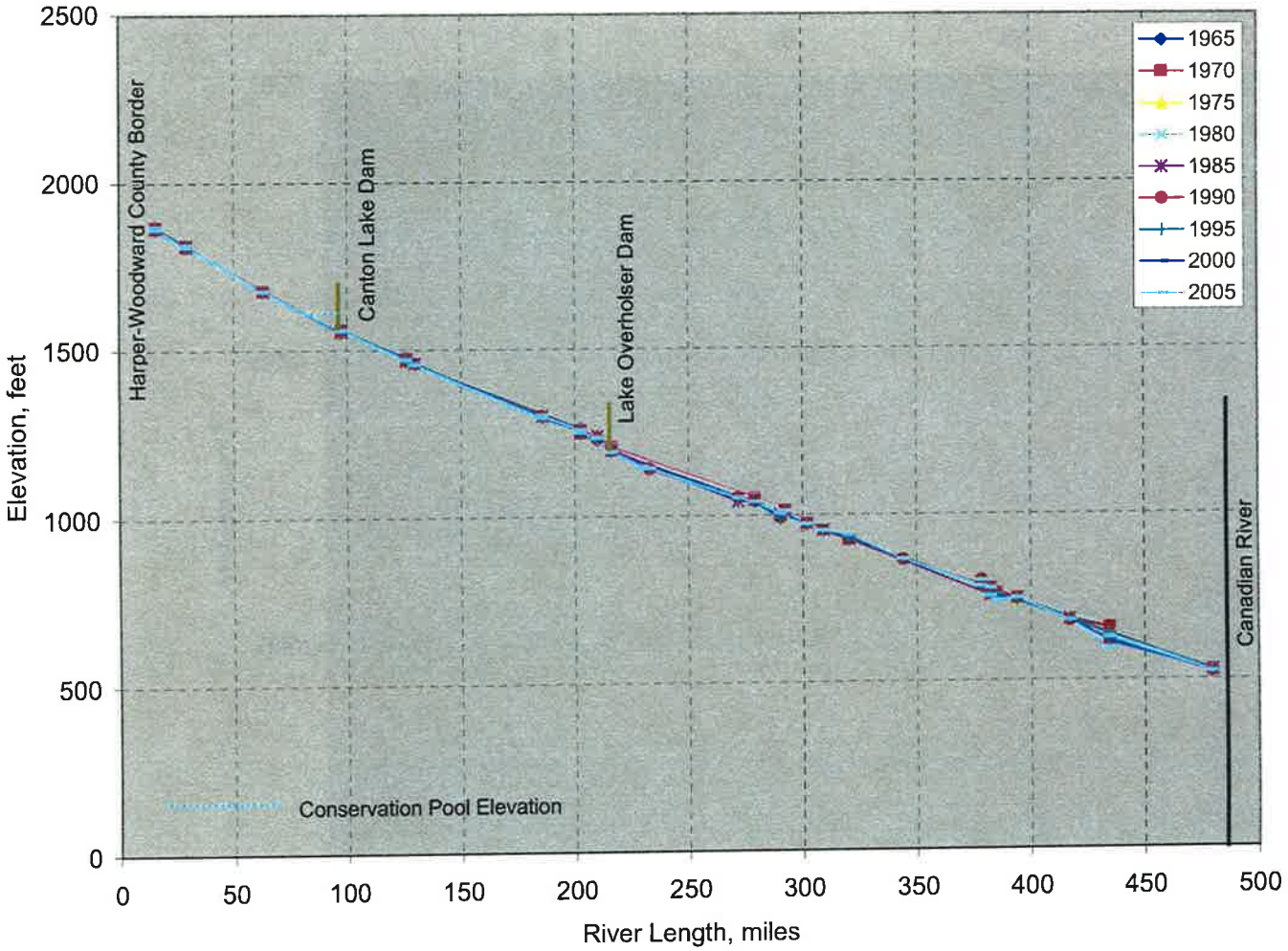


Figure 41. Longitudinal Profile of North Canadian River Bed, Oklahoma

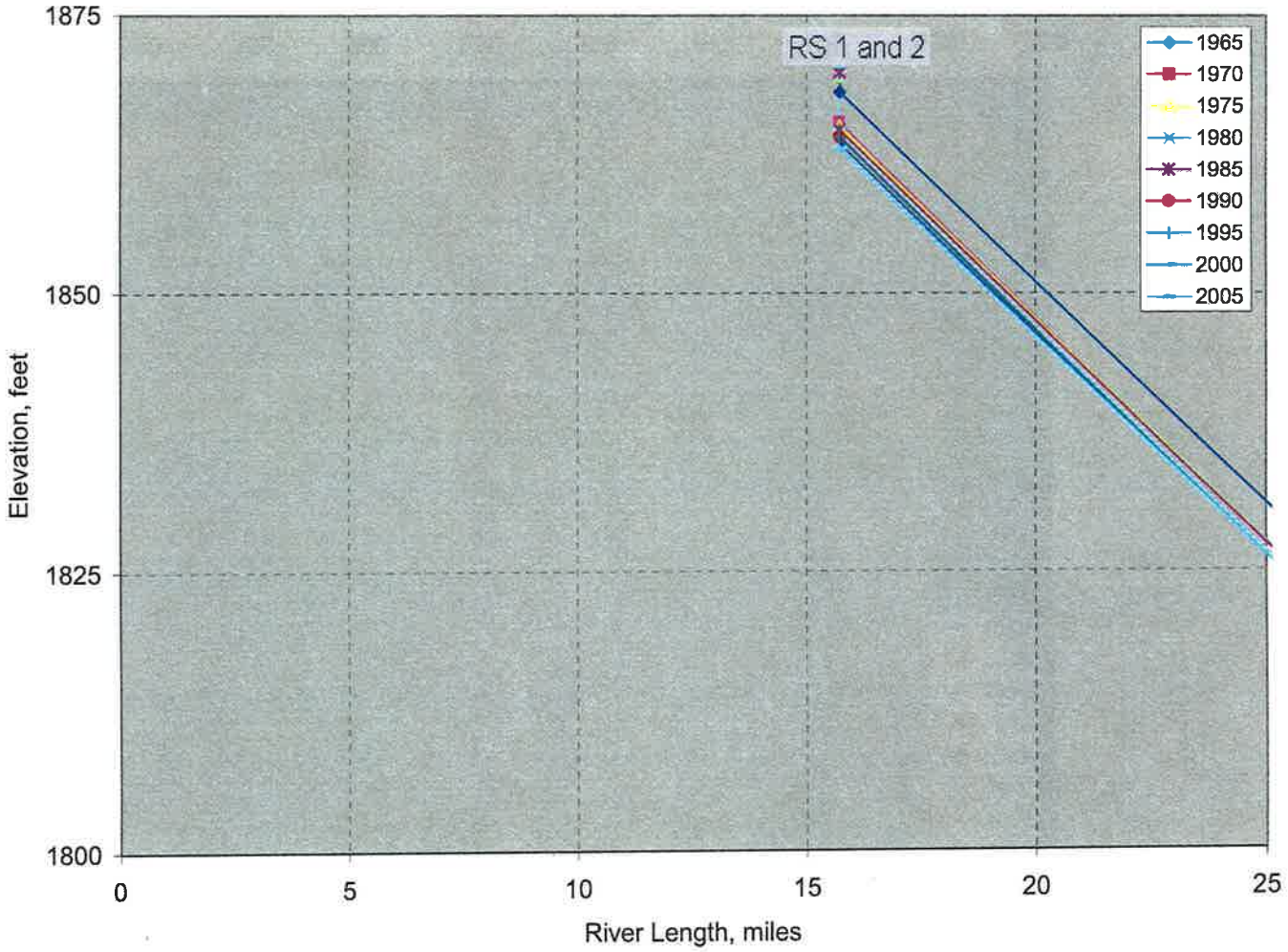


Figure 42. Longitudinal Profile of North Canadian River Bed, Oklahoma

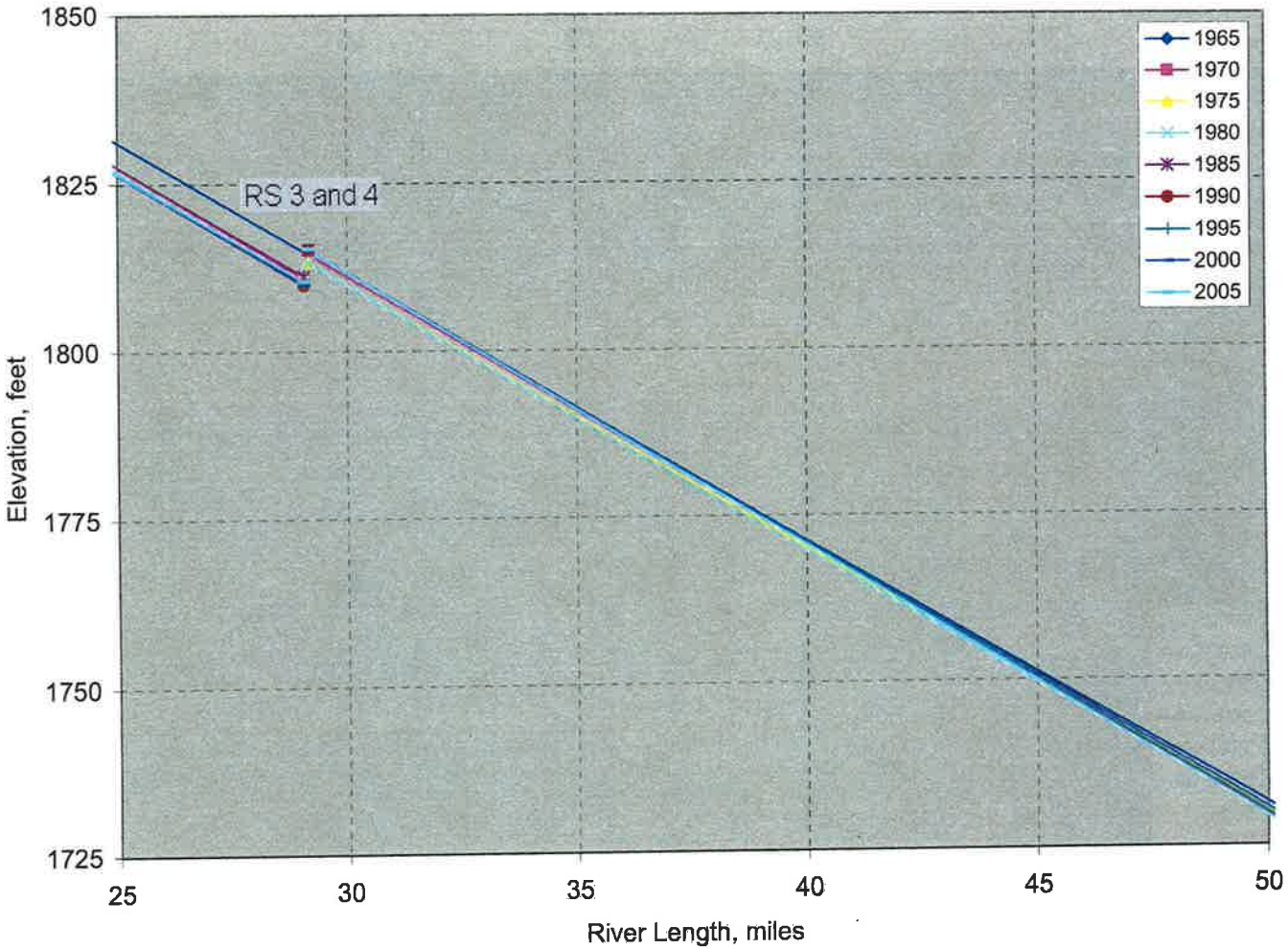


Figure 43. Longitudinal Profile of North Canadian River Bed, Oklahoma

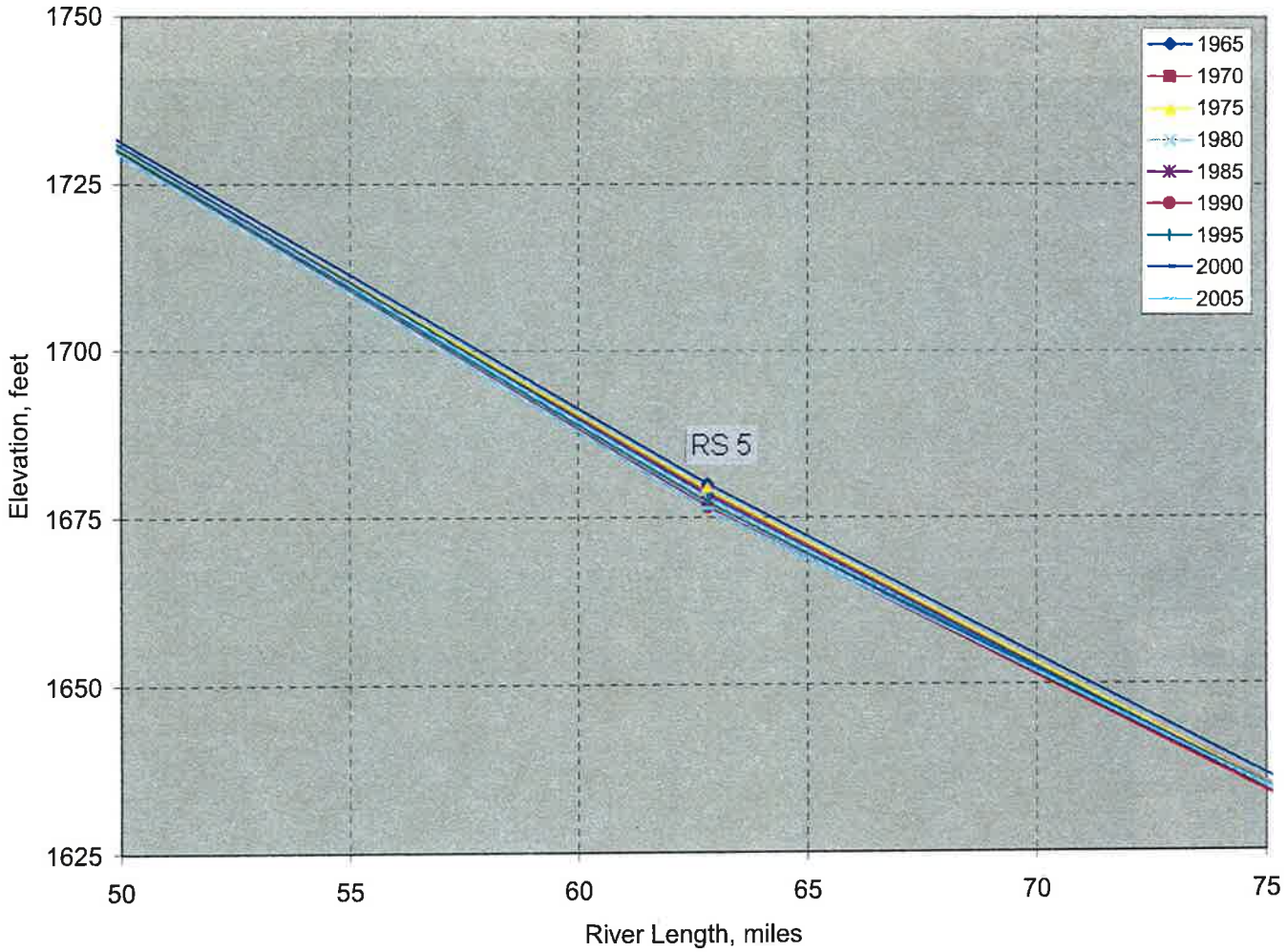


Figure 44. Longitudinal Profile of North Canadian River Bed, Oklahoma

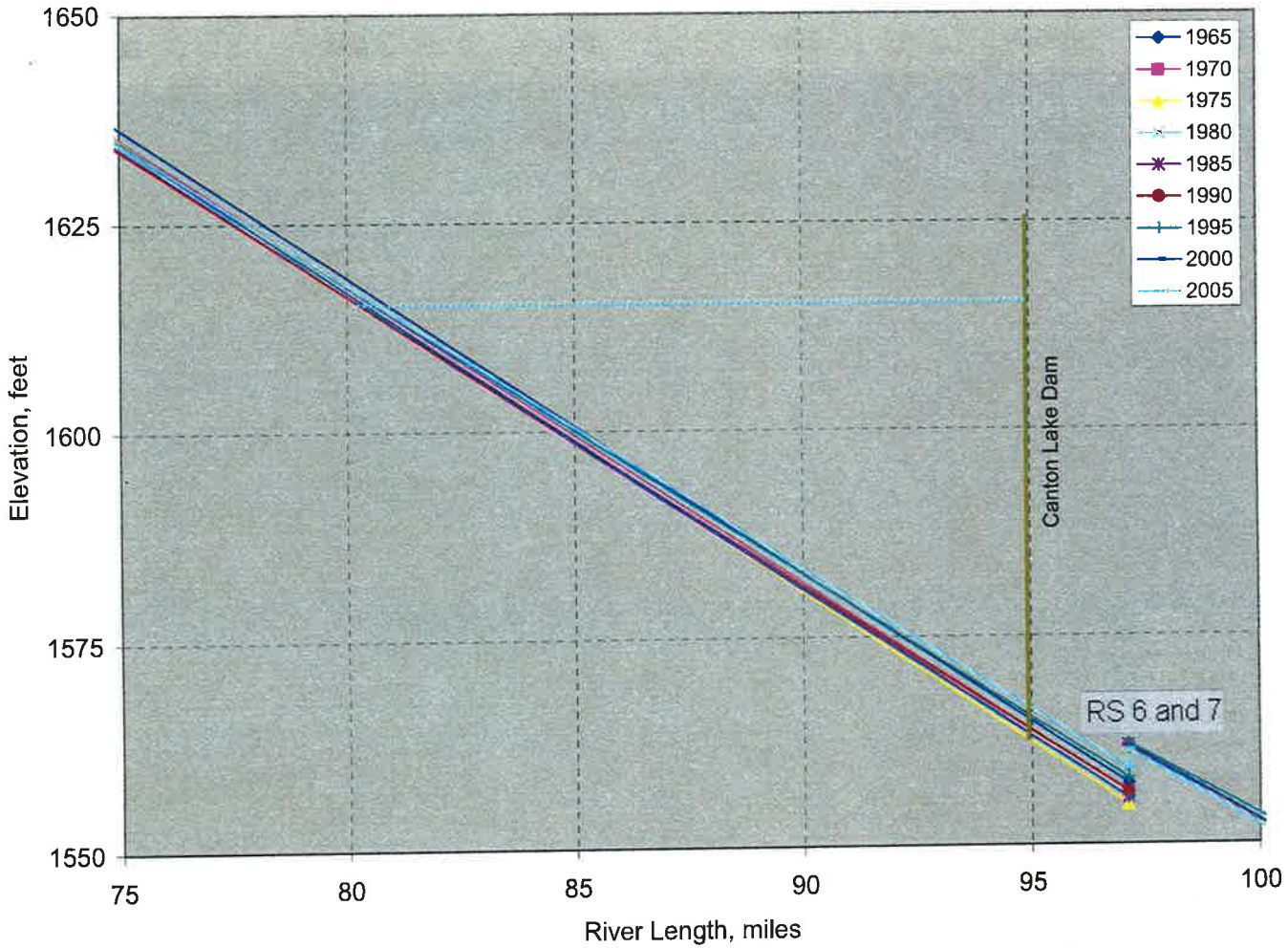


Figure 45. Longitudinal Profile of North Canadian River Bed, Oklahoma

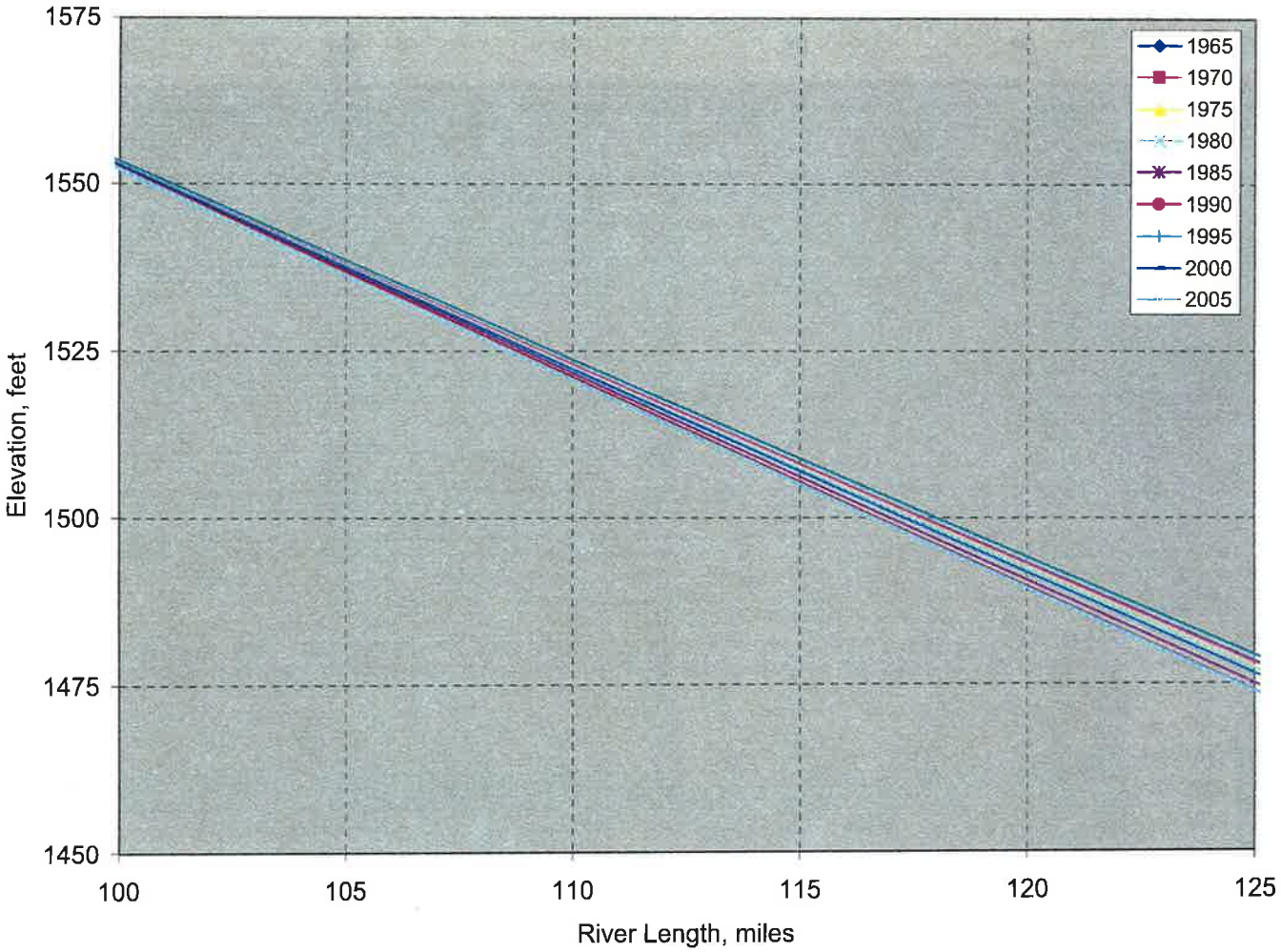


Figure 46. Longitudinal Profile of North Canadian River Bed, Oklahoma

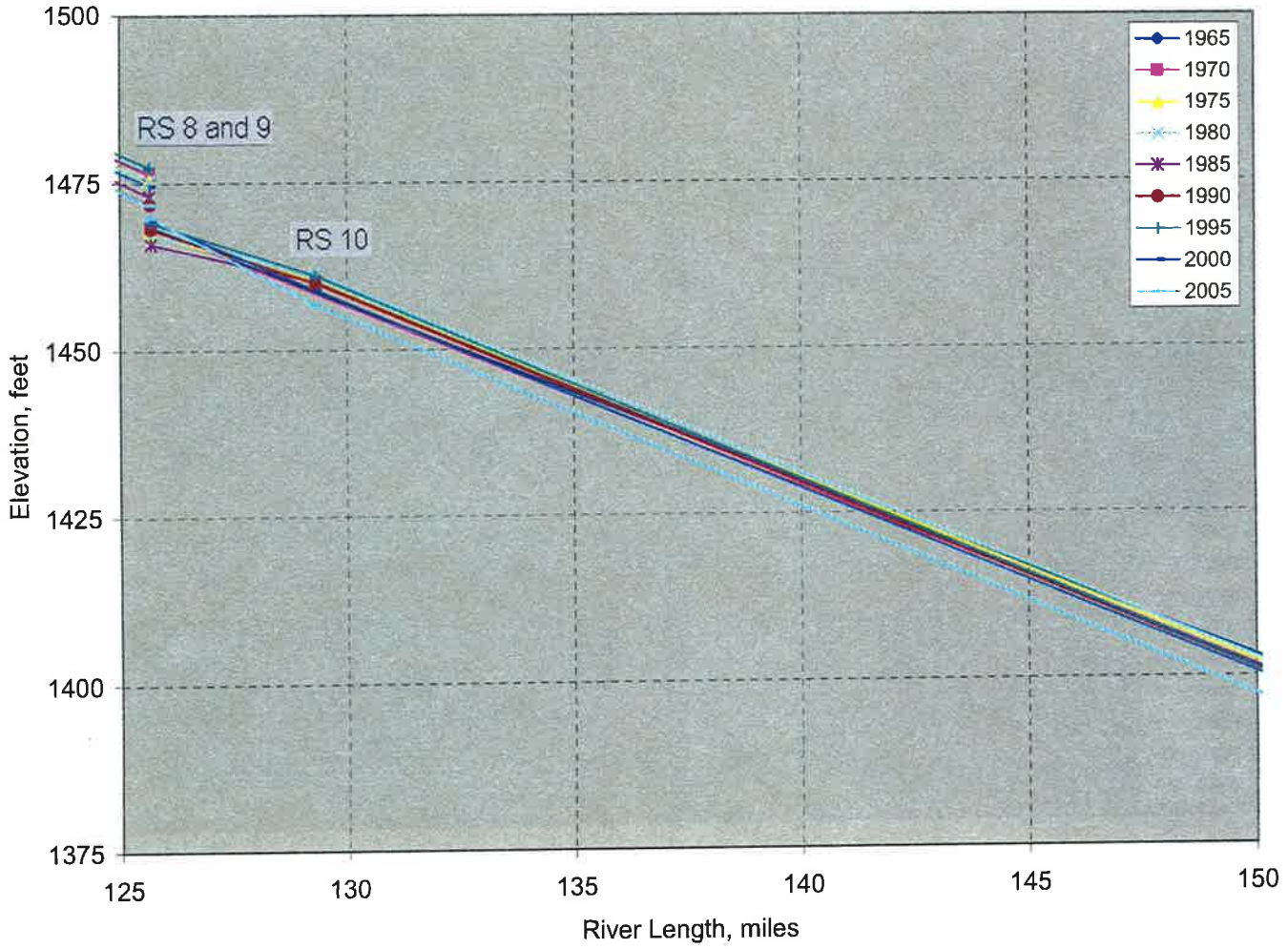


Figure 47. Longitudinal Profile of North Canadian River Bed, Oklahoma

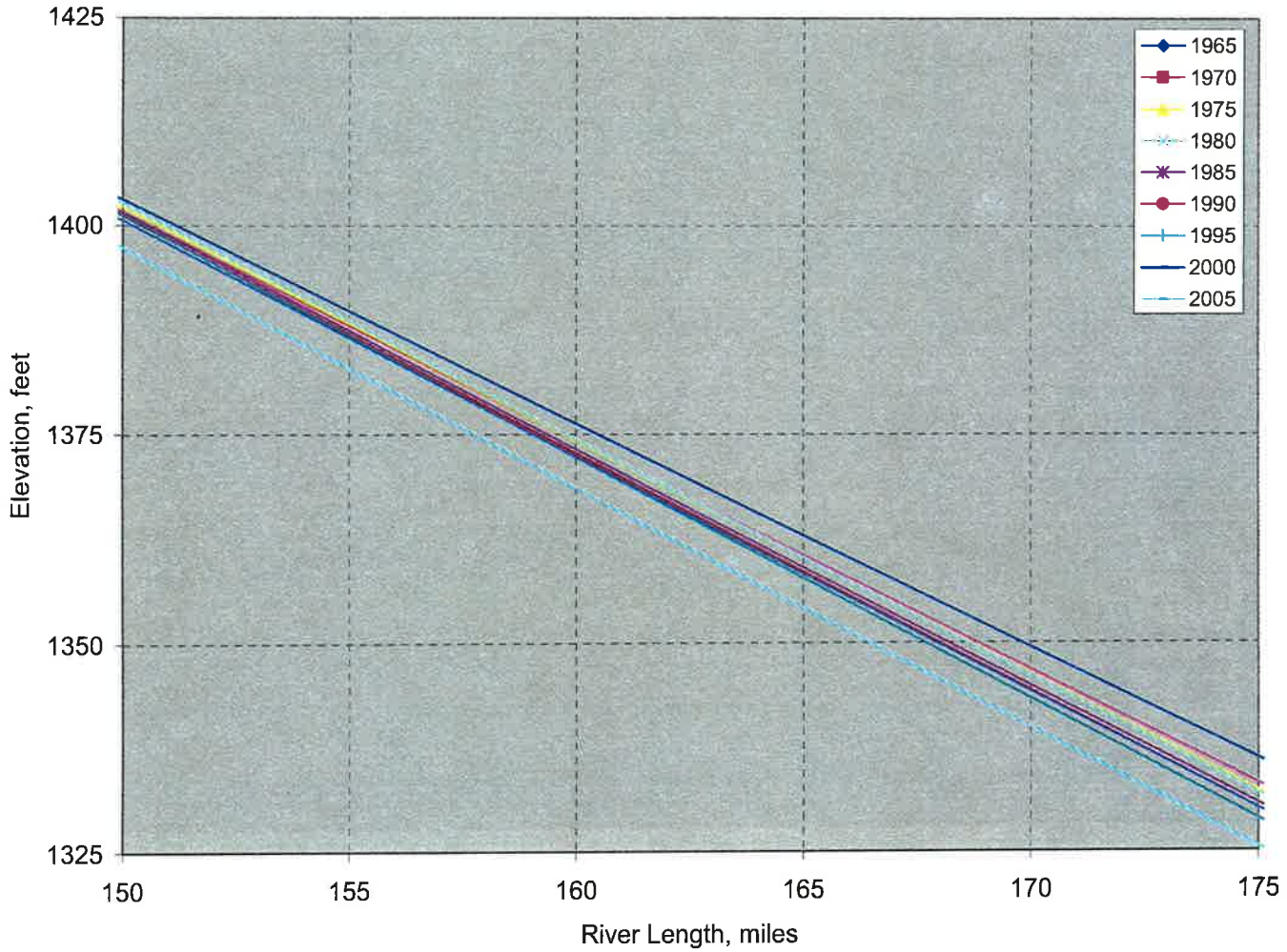


Figure 48. Longitudinal Profile of North Canadian River Bed, Oklahoma

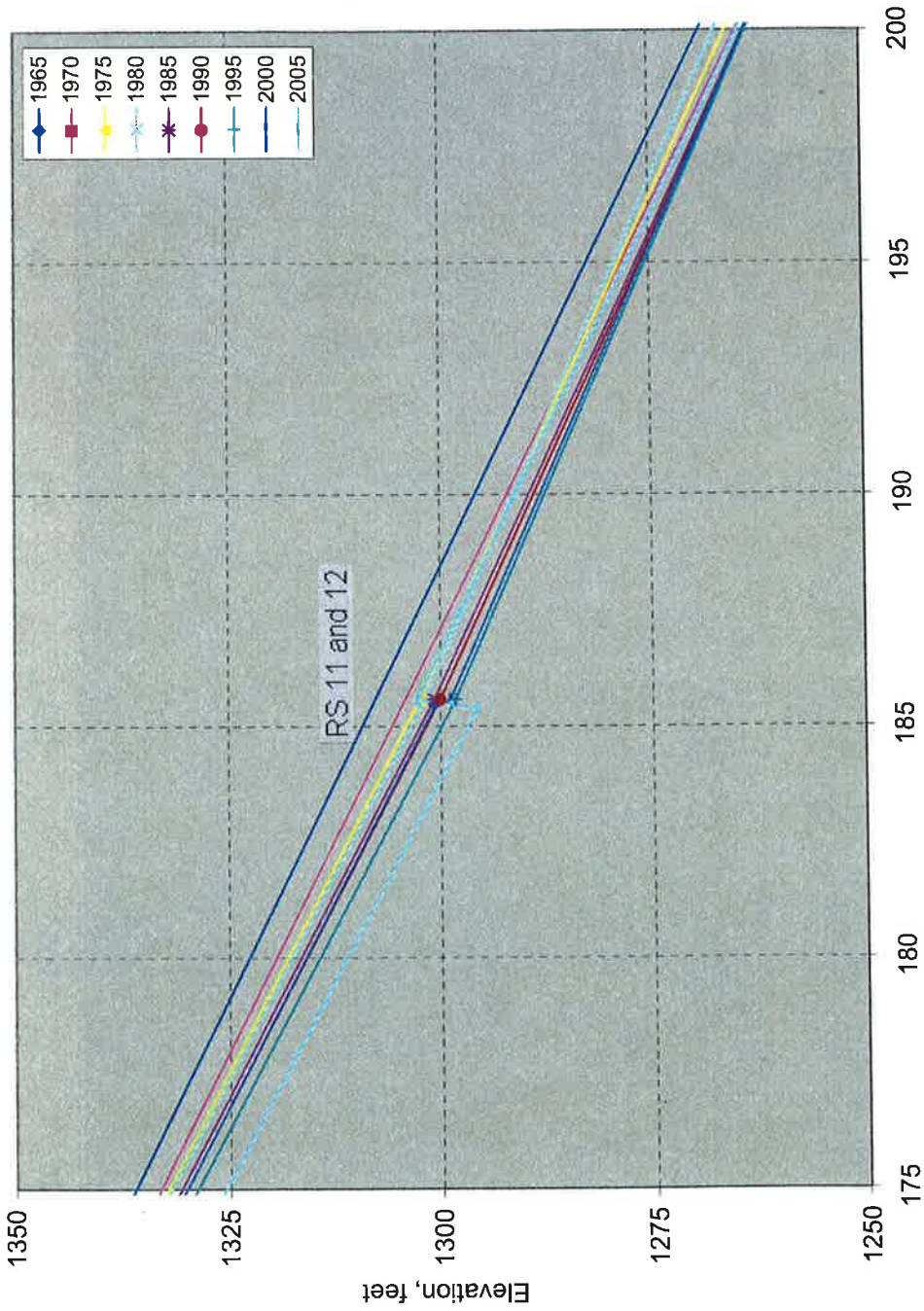


Figure 49. Longitudinal Profile of North Canadian River Bed, Oklahoma

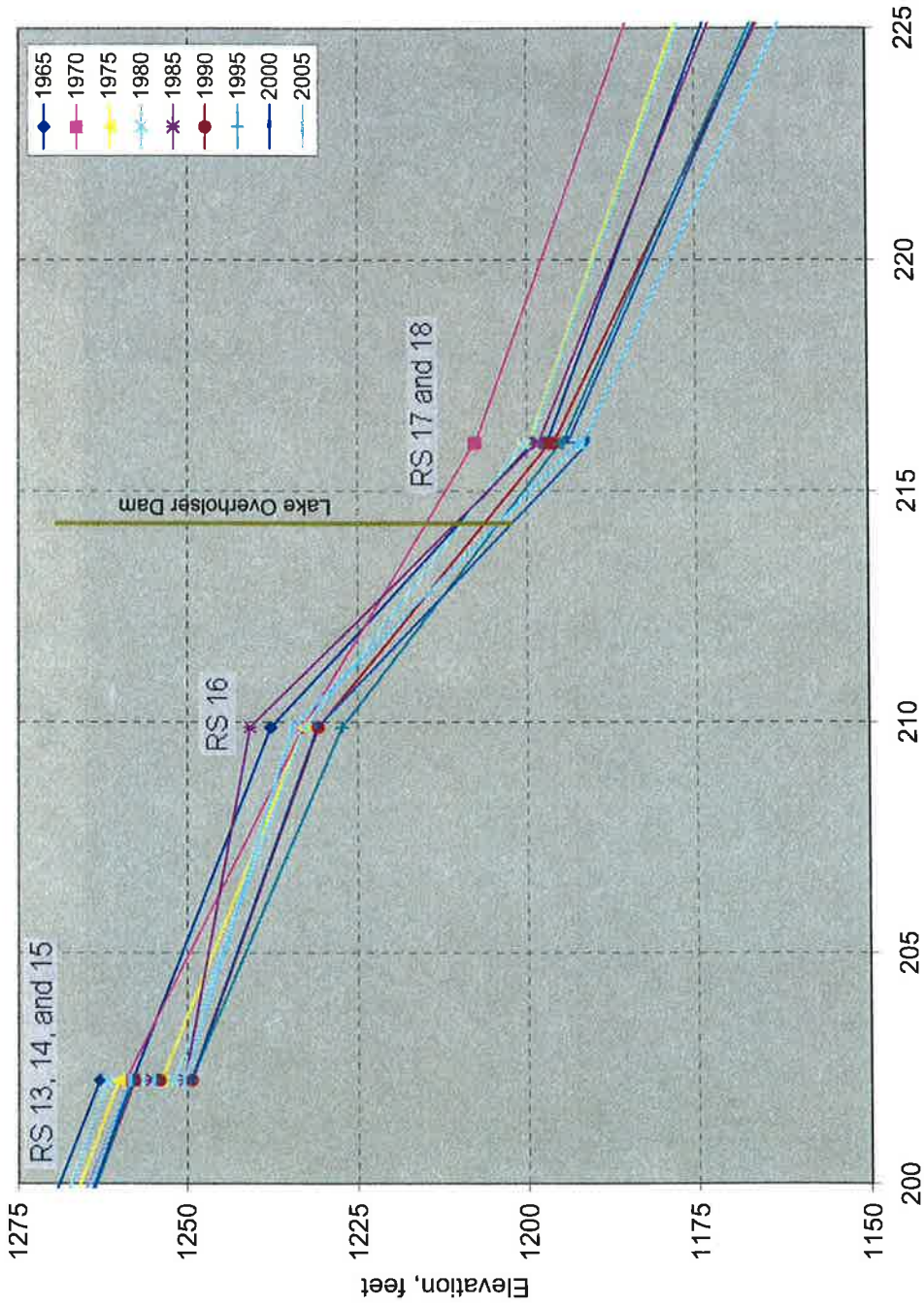


Figure 50. Longitudinal Profile of North Canadian River Bed, Oklahoma

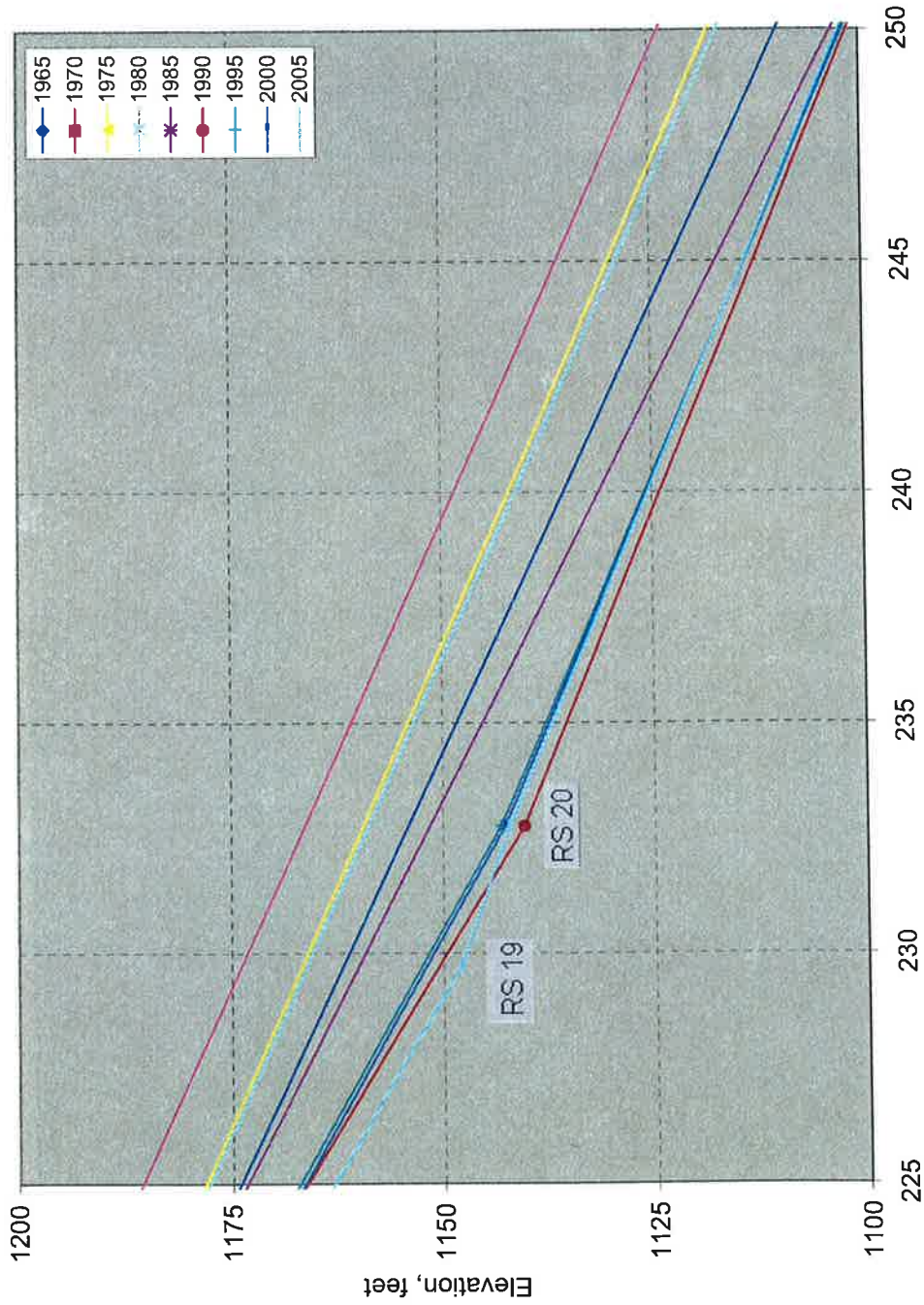


Figure 51. Longitudinal Profile of North Canadian River Bed, Oklahoma

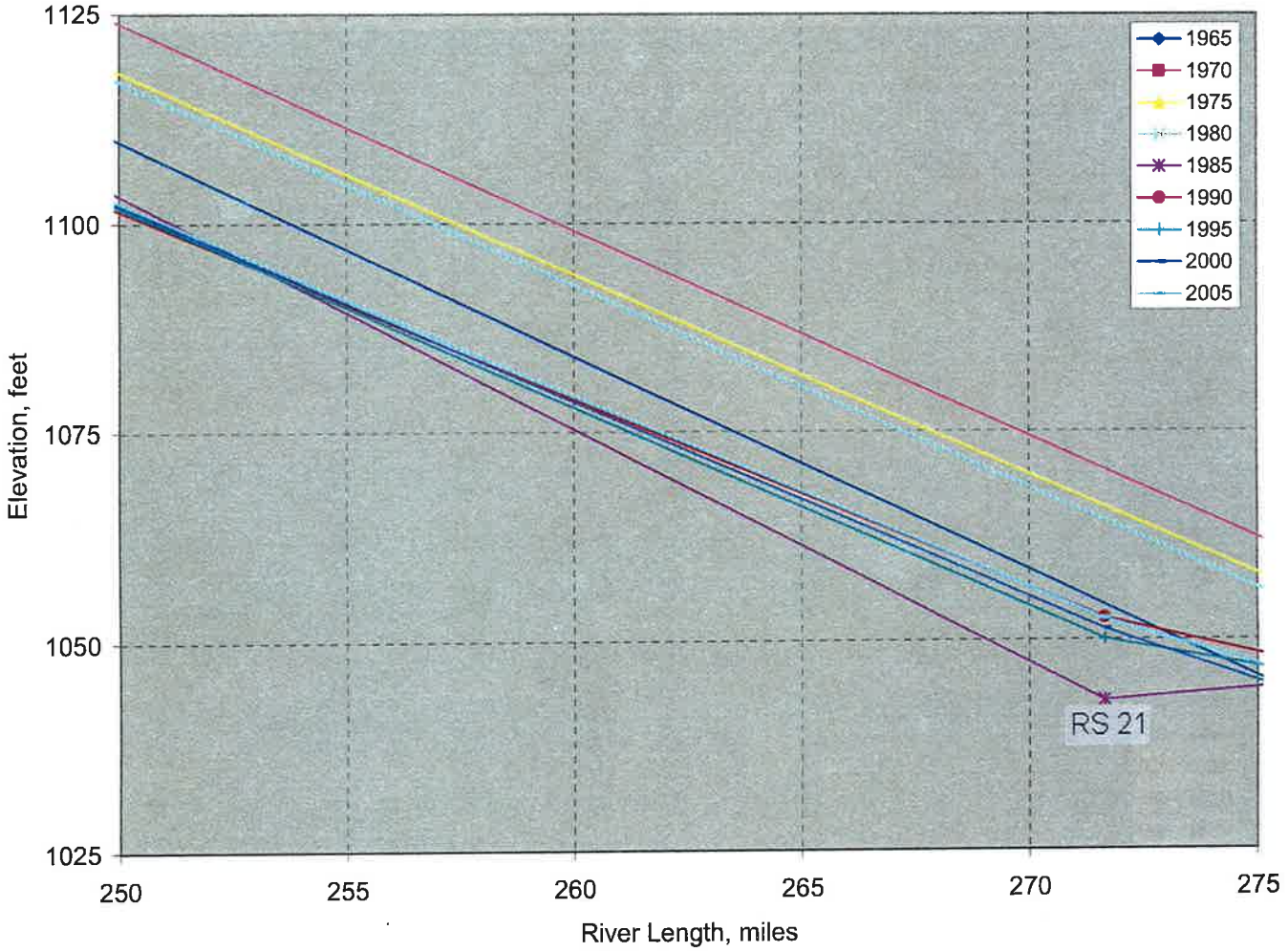


Figure 52. Longitudinal Profile of North Canadian River Bed, Oklahoma

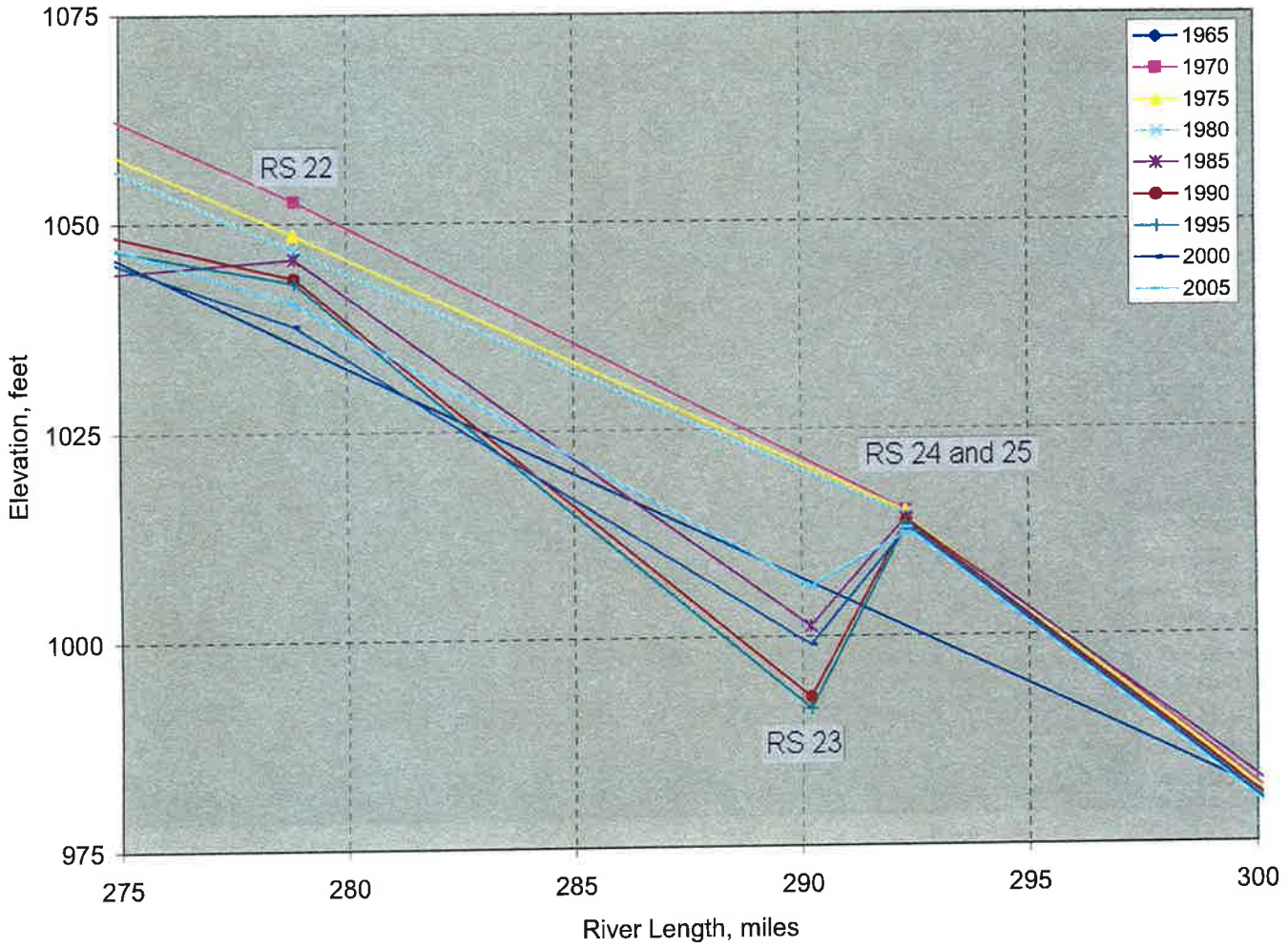


Figure 53. Longitudinal Profile of North Canadian River Bed, Oklahoma

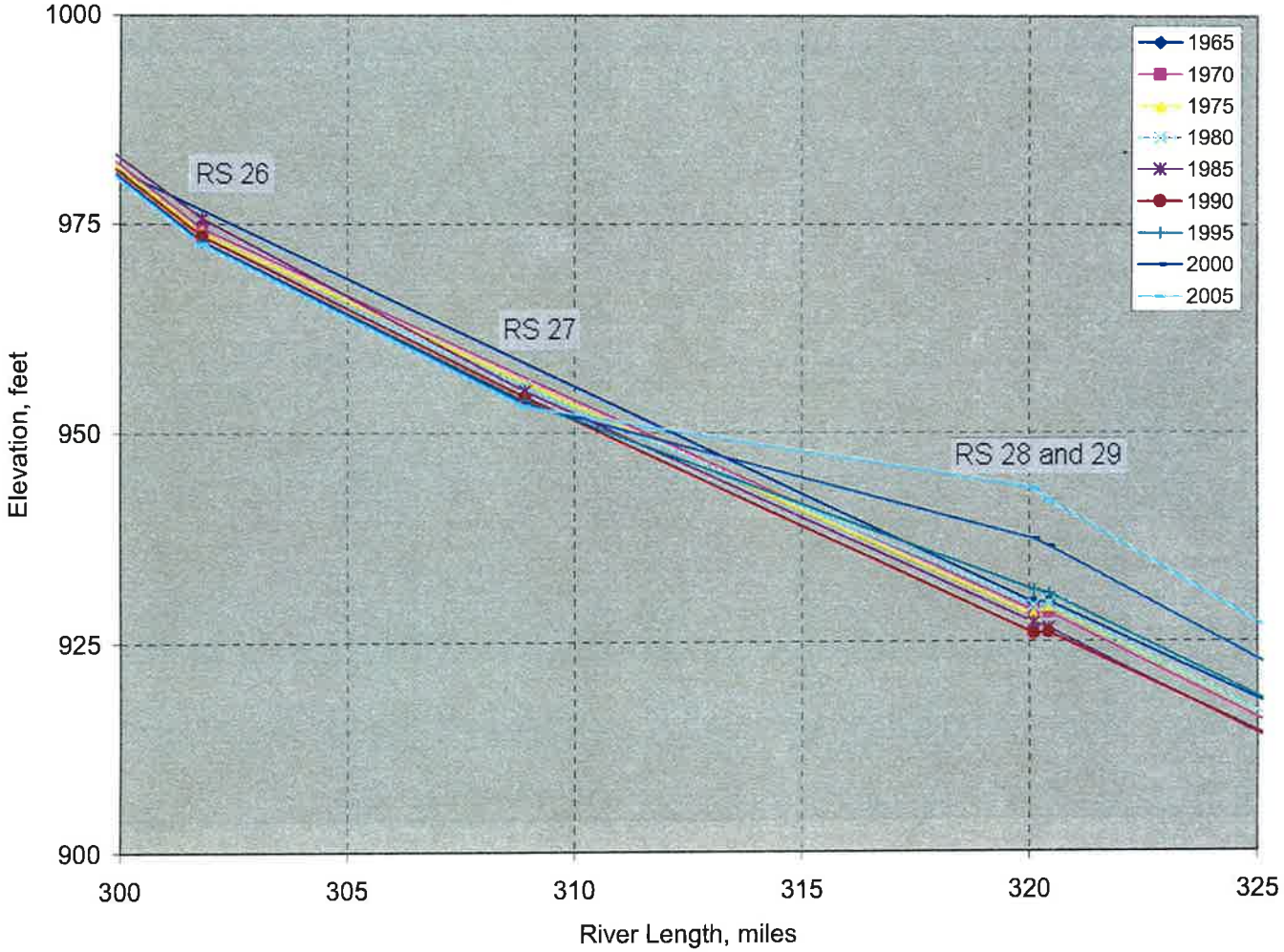


Figure 54. Longitudinal Profile of North Canadian River Bed, Oklahoma

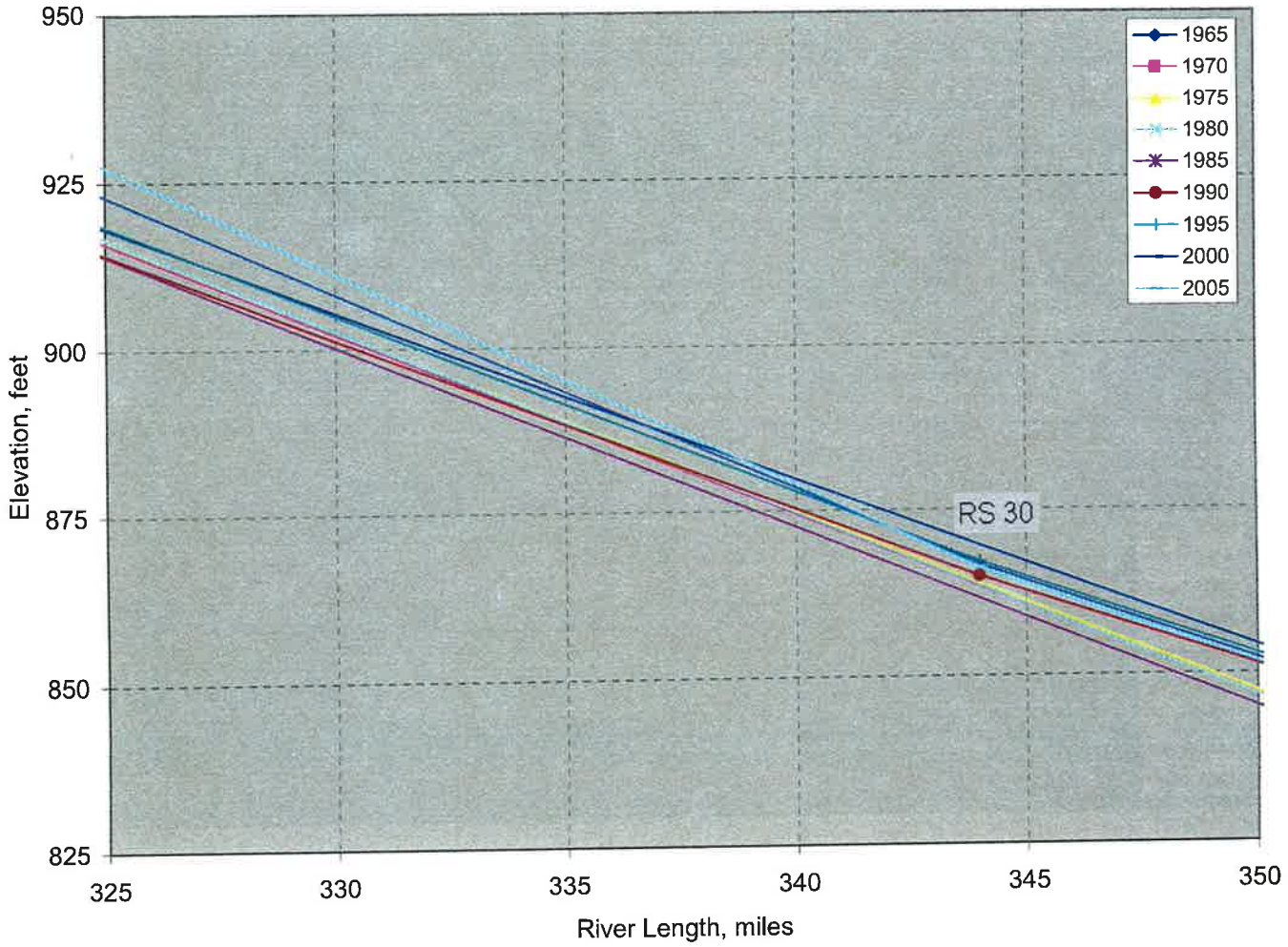


Figure 55. Longitudinal Profile of North Canadian River Bed, Oklahoma

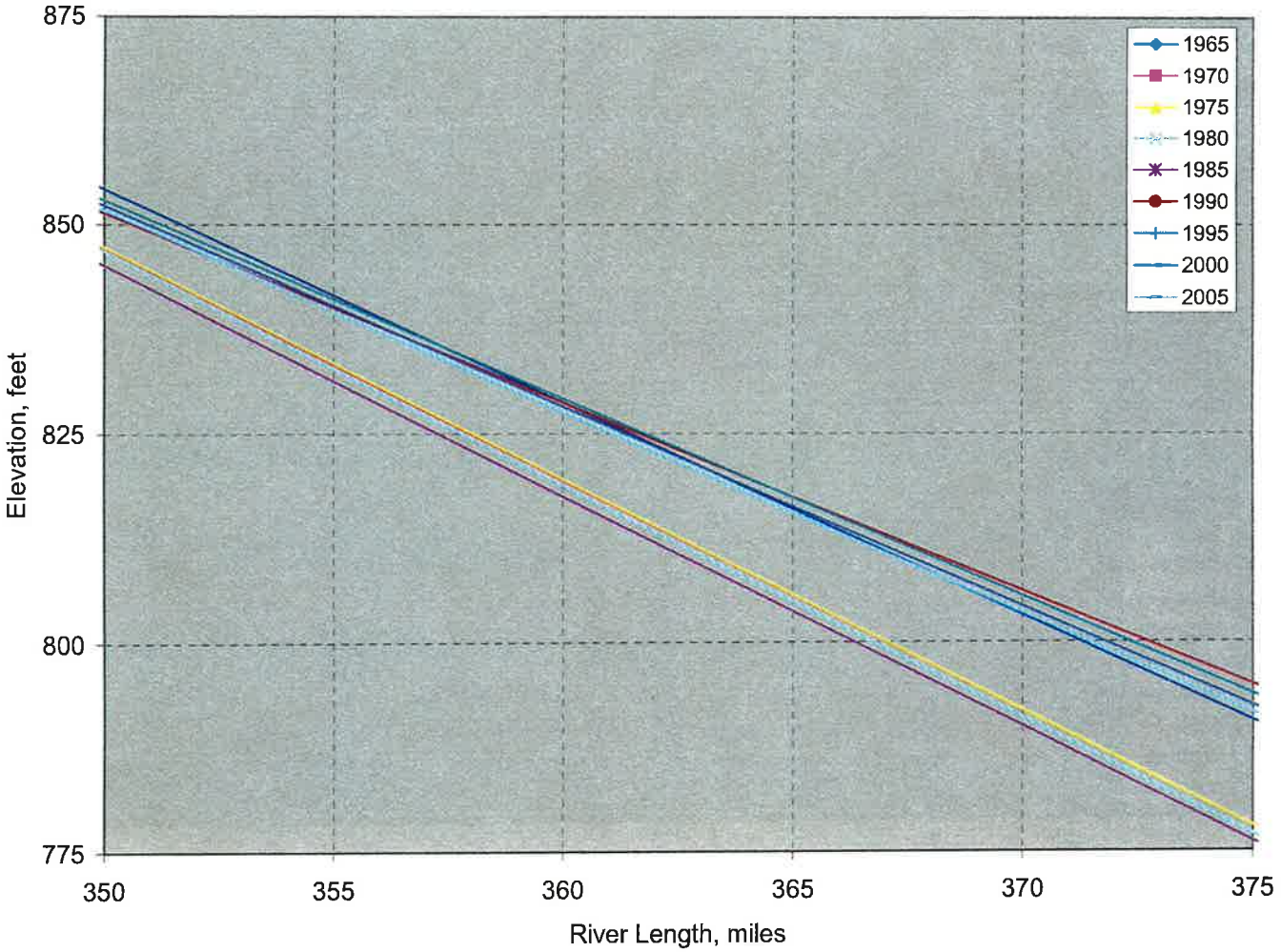


Figure 56. Longitudinal Profile of North Canadian River Bed, Oklahoma

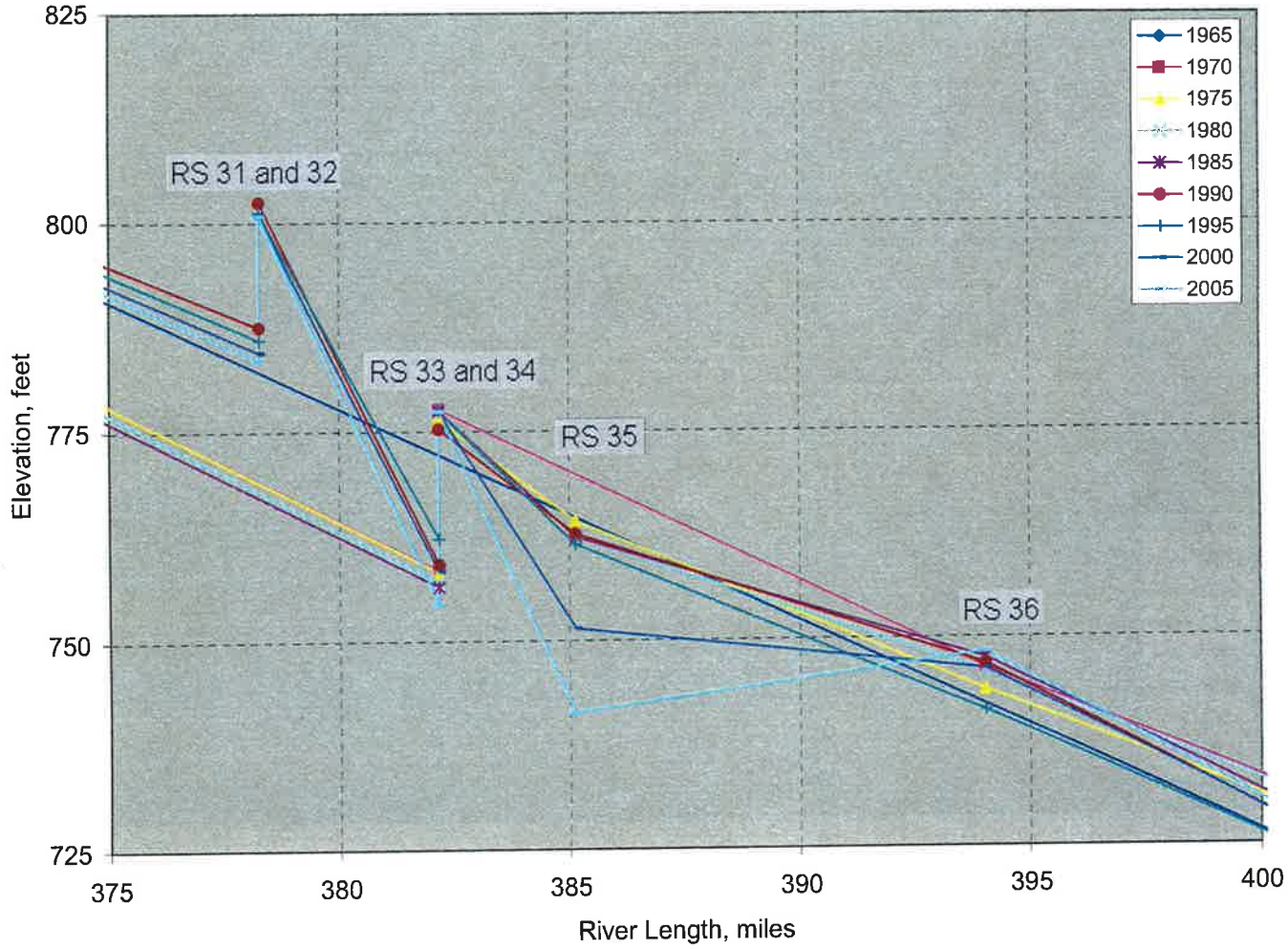


Figure 57. Longitudinal Profile of North Canadian River Bed, Oklahoma

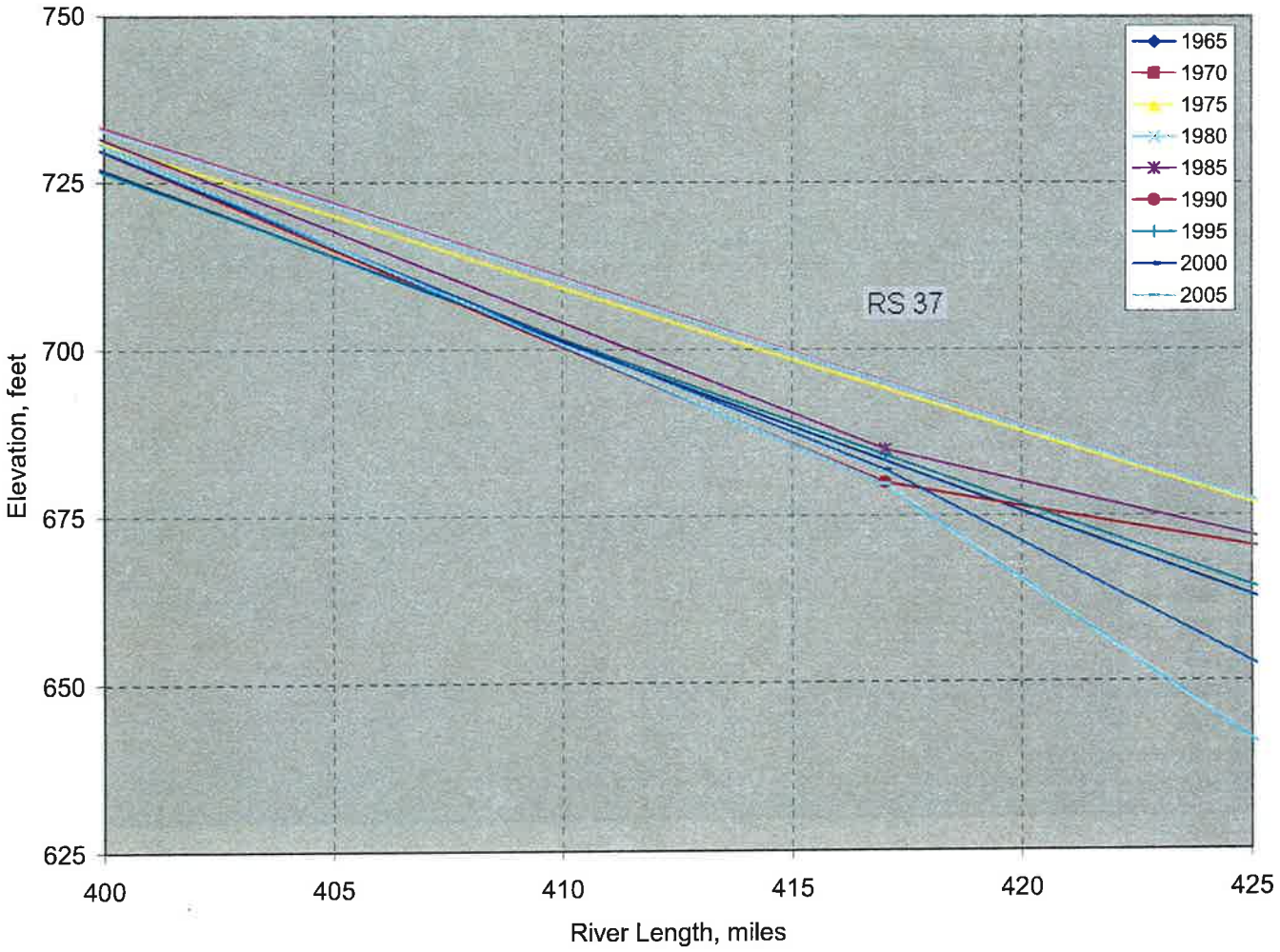


Figure 58. Longitudinal Profile of North Canadian River Bed, Oklahoma

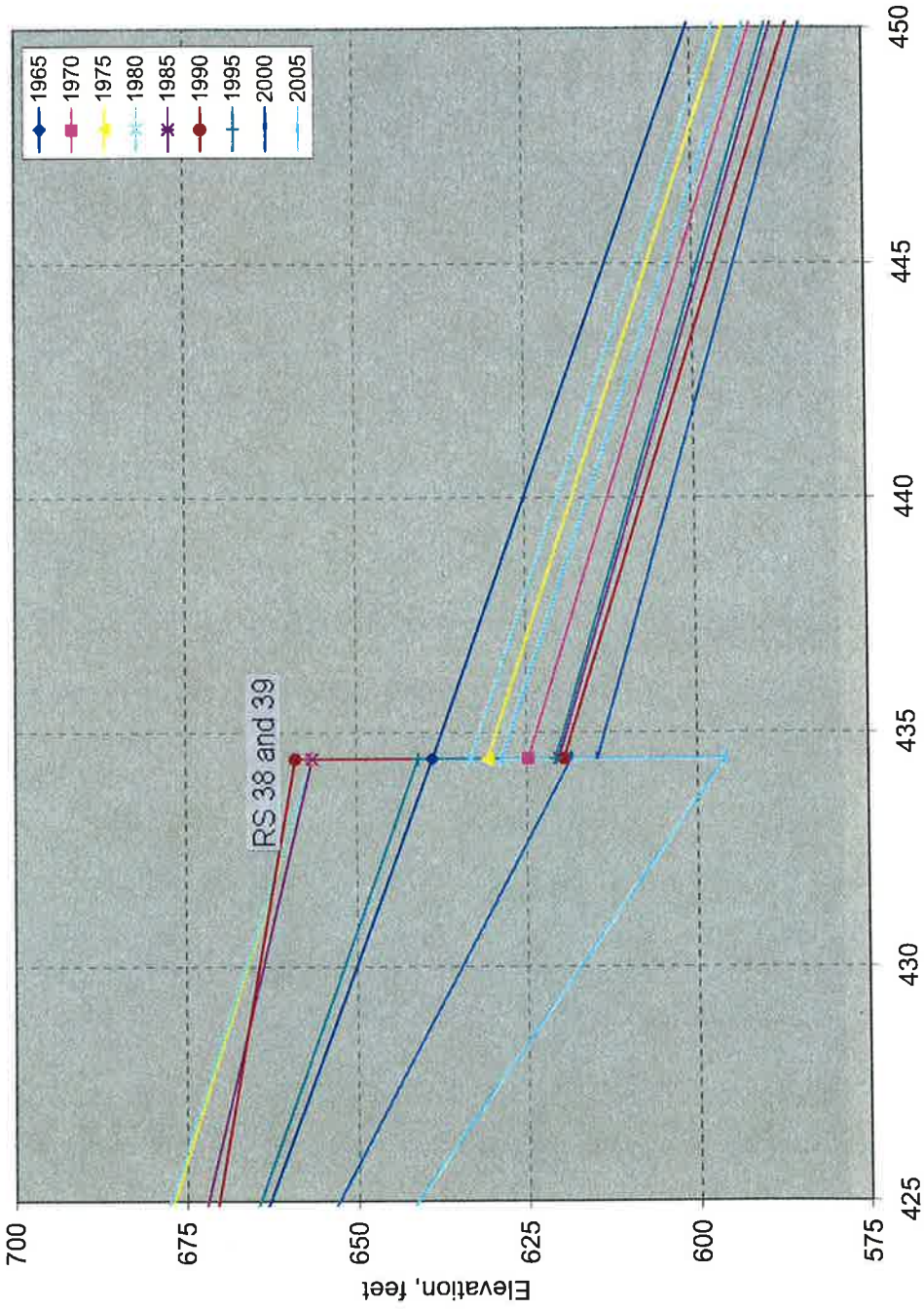


Figure 59. Longitudinal Profile of North Canadian River Bed, Oklahoma

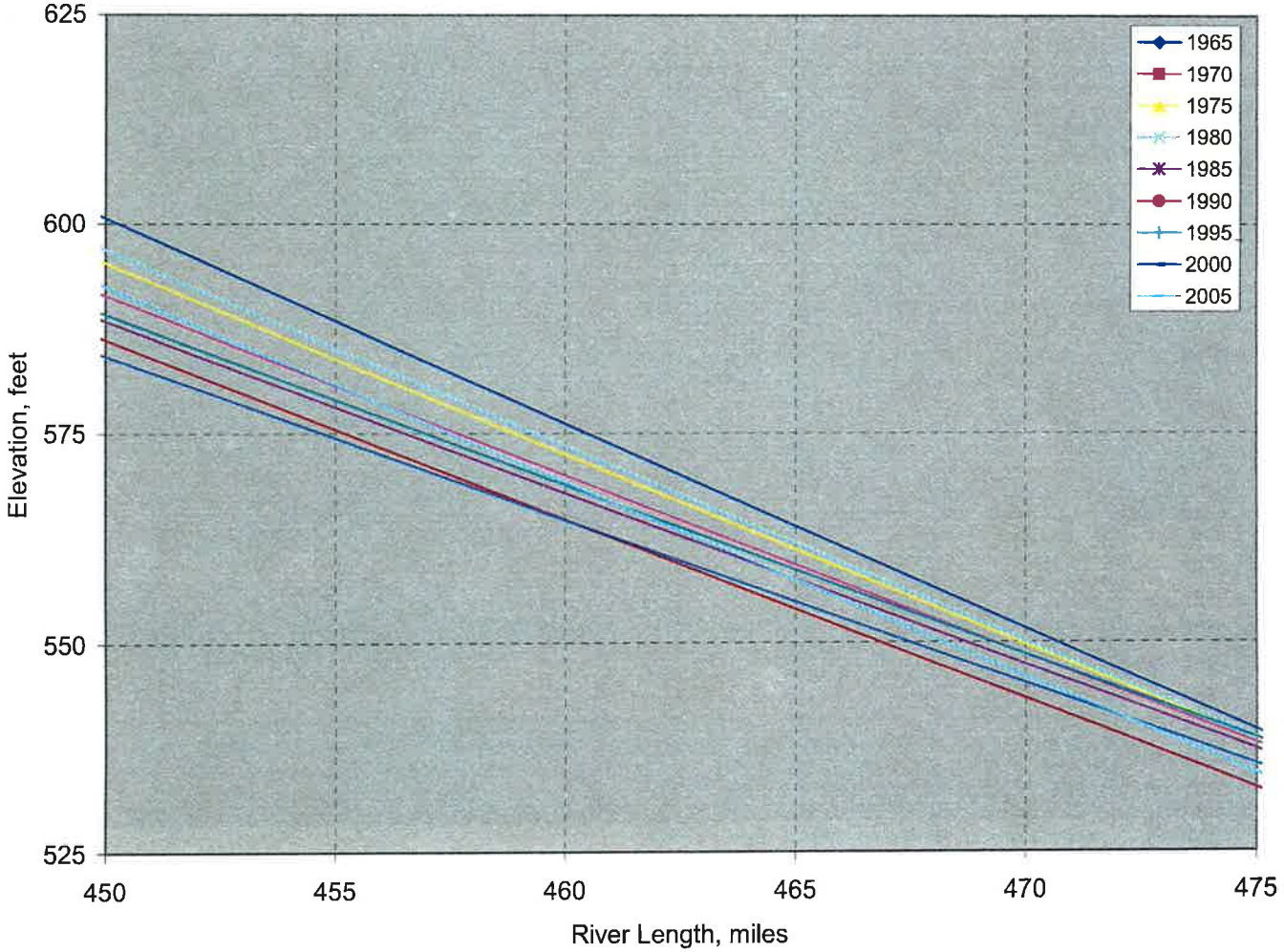


Figure 60. Longitudinal Profile of North Canadian River Bed, Oklahoma

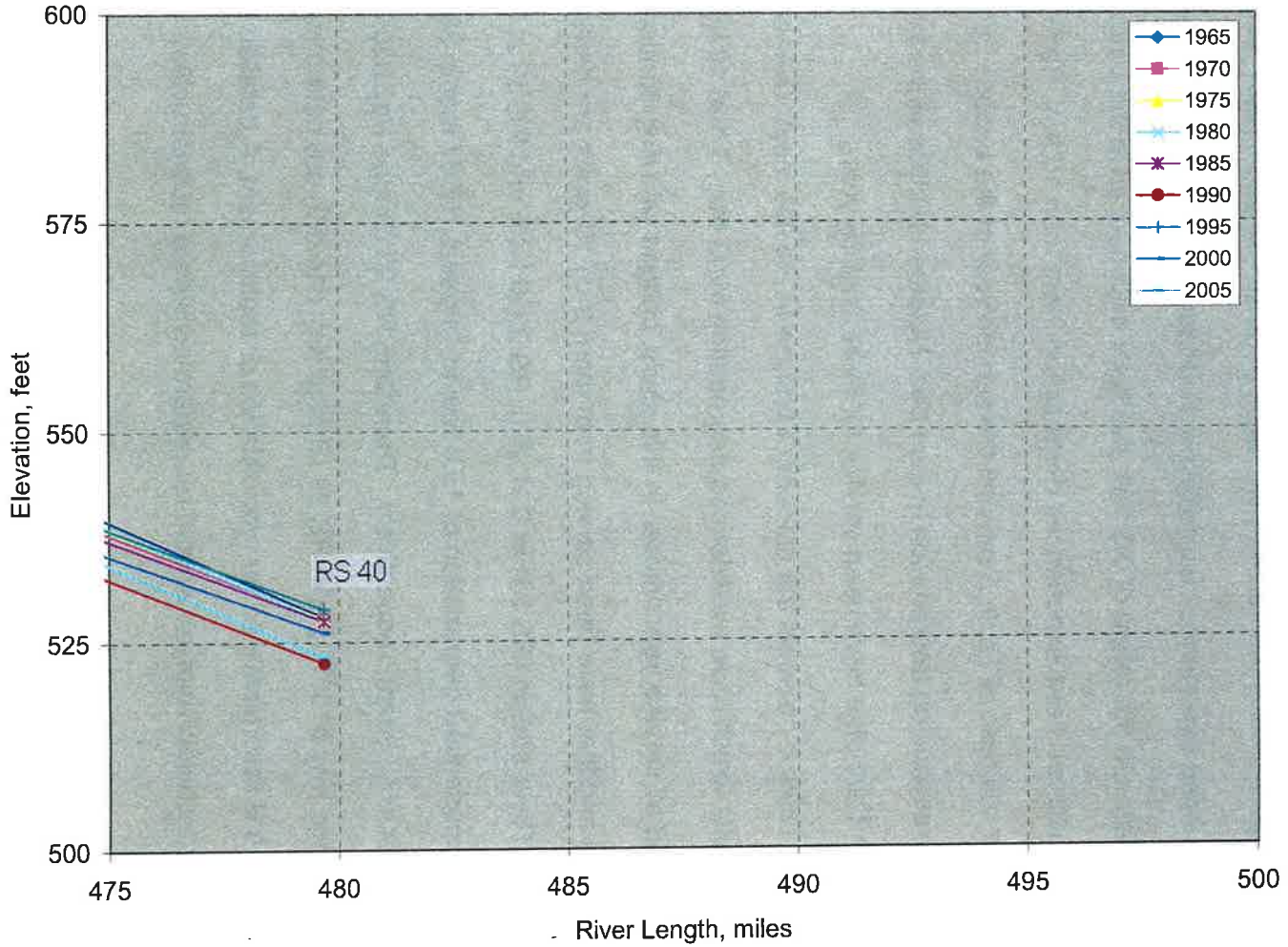


Figure 61. Longitudinal Profile of North Canadian River Bed, Oklahoma

VI. DISCUSSION OF RESULTS

Table 5 presents the summary of bridges which has experienced degradation. Along the 463.85-mile reach of North Canadian River, twenty-five bridges have experienced degradation. Fourteen bridges have experienced degradation in the range of 0-5 feet, two have experienced in the range of 5-10 feet, and three have experienced degradation more then 10 feet. Sixth and seventh columns of Table 5 present the service year of the bridges through 2007 and corresponding degradation in river bed. Nineteen bridges in the study reach of North Canadian have been serving for more than 30 years.

Table 6 presents the number of bridges in the five major river basins of Oklahoma which have experienced degradation more than 5 and 10 feet with 10 year and all service year criteria. In this study, bridges with degradation of 10 feet or more and that have been serving from more then 10 years are determined as critical. River station (RS 23) at S.H. 270, RS 33 at I-40, and RS 39 at S.H. 84 have experienced degradation of 15.6 feet in 11 years, 17.67 feet in 38 yeas, and 15.0 feet in 47 years, respectively. Therefore, RS 23 (Bridge Key b20576), RS 33 (Bridge Key b15870), and RS 39 (Bridge Key b14200) are determined as critical. It is recommended for rehabilitation or replacement. A detailed hydraulic and geotechnical analysis should be performed before reconstruction.

Table 5. Summary of river bed degradation, North Canadian River

Bri_key	River Station	Highway	Miles	Brigde Installed	Years of Construction through 2007	Max. Scour (ft)	Duration (yr)	Scour Rate (ft/yr)
b16642	RS2	S.H.34	15.72	1965	42	4.63	35	0.1321
b17602	RS3	S.H. 50	29.05	1969	38	2.78	34	0.0816
b16193	RS5	U.S. 60	62.82	1964	43	3.40	36	0.0944
b20864	RS8	U.S. 270	125.64	1984	23	1.60	20	0.0800
b05523	RS9	U.S. 270	125.67	1937	70	5.83	58	0.1005
b18134	RS10	U.S. 270	129.29	1971	36	1.40	29	0.0483
b26237	RS11	U.S. 81	185.37	2000	7	5.06	5	1.0125
b12820	RS14	S.H. 4	202.22	1952	55	0.80	53	0.0151
b18352	RS15	S.H.4	202.22	1972	35	4.55	33	0.1379
b16189	RS17	I-40	216.03	1964	43	5.00	41	0.1220
b16190	RS18	I-40	216.04	1964	43	3.33	41	0.0812
b20576	RS23	S.H. 270	290.19	1983	24	15.60	11	1.4182
b15380	RS24	I-40	292.30	1961	46	2.03	26	0.0781
b15381	RS25	I-40	292.31	1961	46	0.09	26	0.0035
b15388	RS26	U.S. 270	301.79	1961	46	4.43	44	0.1007
b19276	RS27	S.H.-3E	308.91	1976	31	2.70	27	0.1000
b15864	RS29	N/A	320.42	1962	45	0.73	33	0.0221
b22686	RS31	S.H. 56	378.25	1990	17	3.90	15	0.2600
b22666	RS32	S.H. 57	378.25	1990	17	1.66	15	0.1107
b15870	RS33	I-40	382.16	1962	45	17.67	38	0.4650
b18361	RS35	S.H.48	385.13	1972	35	2.54	25	0.1018
b21128	RS37	U.S. 75	417.02	1985	22	3.95	17	0.2324
b14189	RS38	S.H. 84	434.44	1958	49	5.00	34	0.1471
b14200	RS39	S.H. 84	434.44	1958	49	15.00	47	0.3191
b15585	RS40	U.S. 69	479.66	1962	45	3.50	41	0.0854

Table 6. Summary of bridges with degradation in five river basins

River Basin	Degradation in ≥10 years		Degradation with all service year criteria	
	≥ 5.0 feet	≥ 10.0 feet	≥ 5.0 feet	≥ 10.0 feet
Arkansas	5	1	5	1
Cimarron	6	2	6	2
North Canadian*	8	3	9	3
Canadian	7	3	9	5
Washita	12	1	12	1
Total	38	10	41	12

* This report includes the river basin as indicated. Refer to other volumes **I** through **V** for different river basins.

VII. CONCLUSIONS AND RECOMMENDATION

Following conclusions can be drawn based on this research:

1) Degradation predominates in Reach 1 from river station (RS)1 to Canton Lake Dam, except some river stations have slight aggradation. Maximum degradation at river station 2 and aggradation at river station 1 both on S.H. 34 in Reach 1 are 4.63 and 1.1 feet, respectively.
2) In Reach 2 from Canton Lake Dam to Lake Overholser Dam, degradation is predominant. Maximum degradation of 5.83 feet is observed in river station 9 on U.S. 270.
3) Bed profile data in Reach 3 from Lake Overholser Dam to river station (RS) 40, shows both aggradation and degradation. The river station 17 downstream of Lake Overholser dam shows the degradation of 5.0 feet in 41 years. In this reach maximum aggradation of 9.75 feet is observed at river station 21 at U.S. 62 and maximum degradation of 17.67 feet is observed at river station 33 at I-40.
4) The North Canadian River in Oklahoma has experienced degradation over 10 feet at three river stations which have been serving more then 10 years. River station (RS 23) at S.H. 270, RS 33 at I-40, and RS 39 at S.H. 84 have experienced degradation of 15.6 feet in 11 years, 17.67 feet in 38 years, and 15.0 feet in 47 years, respectively. These bridges are defined as critical and recommended for rehabilitation or replacement in the replacement cycle. A detailed hydraulic and geotechnical analysis should be performed before reconstruction.

It is recommended that degradation of tributaries is evaluated to determine the structures where flowline is severely degrading in North Canadian River basin.

VIII. REFERENCES

Austin, B. and Thomas D. (2006). "Volumetric survey report of Eufaula lake dam June 2004 survey." Texas Water Development Board.

Doyel, W. M. and Harbor, M. J. (2003). "Modeling the effects of form and profile adjustments on the channel equilibrium timescales." *Earth Surface Processes and Landforms,* 1271-1287.

Gilvear, D. J. (1999). "Fluvial geomorphology and river engineering: future roles utilizing a fluvial hydrosystems framework." *Geomorphology 31*: 229–245.

Grant, G. E., Schmidt C. J., and Lewis, L. S., (2003). "A Geological Framework for Interpreting Downstream Effects of Dams on Rivers." American Geophysical Union.

Jorden, C. R., (1946). "River stages and flood for October 1946." <http://docs.lib.noaa.gov/rescue/mwr/074/mwr-074-10-0176.pdf>, retrieved on August 9, 2007.

Kondolf, M. G. (2004) "Hungry Water: Effects of Dams and Gravel Mining on River Channels". *Environmental Management,* 533-551.

Kurka, M. P., (2006). "Canton lake dam safety assurance evaluations supplement Canton." U.S. army corps of engineers.

Pigg, J., Coleman, S. M., and Duncan, J. (1992). "An Ecological Investigation of the Ichthyofauna of the North Canadian River in Oklahoma: 1976-1989." State Oklahoma.

Macklin, J. H. (1948). "Concept of the graded river." *Geological Society of America Bulletin 59*, 463-512.

McCord, W. M, (2005), "Canadian river." <http://southwestpaddler.com/docs/canadianok2.html>, retrieved on August 9, 2007.

Ward, J. V. and Standford J. A. (2006). "Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation." *Regulated Rivers: Research and Management,* 11 (1), 105-119.

APPENDIX A

TABLES OF CROSS-SECTIONAL GEOMETRIES,

NORTH CANADIAN RIVER, OK

Table 7. Structure, and Flowline Details
Bridge No 16523 (RS 1) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b16523	1.1 MI N JCT SH 15	36-27-06	99-23-18	S.H. 34	1965	105.90

Year	1965	1969	1970	1977	1982	1989	1991
Flowline	1869.33	1869.43	1869.63	1869.43	1869.43	1870.43	1870.43

Table 8. Structure, Cross-section, and Flowline Details
Bridge No 16642 (RS 2) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b16642	8 MI N JCT SH 15	36-26-48	99-23-18	S.H.34	1965	1,105.00

Pier_No	Distance	Pier_BTM	Pier_Top	R-bed 65	S-Rding92	R-bed92	S-Rding00	R-bed00
S-A	0.00	1860.00	1882.00	1878.25	10.00	1879.10	10.10	1879.00
1	102.00	1854.47	1882.47	1868.75	20.00	1869.10	20.30	1868.80
	152.00			1868.13			20.80	1868.30
	182.00			1868.13	25.00	1864.10		
2	202.00	1854.98	1882.98	1868.13	23.50	1865.60	24.40	1864.70
	222.00			1868.13	25.30	1863.80		
	252.00			1868.13			25.60	1863.50
3	302.00	1854.93	1882.93	1868.13	20.80	1868.30	20.90	1868.20
	362.00			1872.50	19.00	1870.10		
4	402.75	1855.21	1883.21	1872.50	20.20	1868.90	20.20	1868.90
	452.75			1872.50			19.30	1869.80
5	503.50	1855.17	1883.17	1872.50	19.80	1869.30	20.40	1868.70
	553.50			1872.50			19.10	1870.00
6	603.50	1855.45	1883.46	1873.13	20.30	1868.80	20.50	1868.60
7	703.50	1855.19	1883.19	1872.50	19.80	1869.30	19.90	1869.20
8	804.25	1855.26	1883.26	1871.88	19.60	1869.50	19.80	1869.30
9	905.00	1855.00	1883.00	1870.63	19.60	1869.50	20.00	1869.10
10	1005.00	1855.07	1883.07	1871.75	17.80	1871.30	18.30	1870.80
N-A	1107.00	1860.00	1882.00	1873.75	9.70	1879.40	10.30	1878.80

Year	1965	1967	1969	1970	1971	1973	1974	1979
Flowline	1866.1	1866.1	1866.1	1865.4	1865.1	1865.2	1865.10	1864.60

Year	1982	1985	1987	1989	1990	1992
Flowline	1864	1864.70	1864.1	1864.1	1864.1	1864.1

Table 9. Structure, and Flowline Details
Bridge No 17509 (RS 3) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b17509	5.3 MI N JCT US 183	36-23-18	99-13-42	S.H. 50	1969	160.10

Year	1970	1977	1982	1989	1991
Flowline	1814.61	1812.81	1815.21	1815.31	1815.31

Table 10. Structure, Cross-section, and Flowline Details
Bridge No 17602 (RS 4)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b17602	5.4 MI N JCT US 183	36-23-18	99-13-42	S.H. 50	1969	801.50

PIER_NO	DISTANCE	PIER_BTM	PIER_TOP	R_BED 69	S_RDING 92	R_BED 92	S_RDING 93	R_BED 93
S-A	0.00	1780.00	1827.09	1825.00				
1	100.00	1802.56	1827.56	1820.00				
2	200.00	1803.24	1828.84	1817.50				
3	300.00	1803.25	1828.25	1813.13	21.60	1814.65	21.60	1814.65
	310.00			1813.13				
	328.00			1813.13				
	334.00			1813.13				
	340.00			1813.13				
	344.00			1813.13				
	346.00			1813.13	21.70	1814.55		
	348.00			1813.13			21.30	1814.95
	350.00			1813.13				
	351.00			1813.13				
	363.00			1813.13	25.10	1811.15		
	365.00			1813.13				
	375.00			1813.13				
	377.00			1813.13				
	380.00			1813.13	25.70	1810.55		
	387.00			1813.13				
	390.00			1813.13			26.00	1810.25
4	400.75	1803.48	1828.42	1813.13	25.50	1810.75	25.70	1810.55

Table 10. (Continued)

PIER_NO	DISTANCE	PIER_BTM	PIER_TOP	R_BED 69	S_RDING 92	R_BED 92	S_RDING 93	R_BED 93
	407.75			1813.13				
	410.75			1813.13	24.40	1811.85		
	419.75			1813.13				
	423.75			1813.13				
	427.75			1813.13				
	430.75			1815.00				
	437.75			1815.00				
	441.75			1815.00			19.90	1816.35
	444.75			1815.00	19.40	1816.85		
	447.75			1815.00				
	450.75			1815.00				
	460.75			1815.00				
	490.75			1816.25				
5	501.50	1803.25	1828.25	1816.25			20.70	1815.55
6	601.50	1803.24	1828.24	1818.25				
7	701.50	1802.56	1827.55	1818.25				
N-A	801.50	1780.00	1827.09	1825.00				

Table 10. (Continued)

S_RDING 93	R_BED 93	S_RDING 94	R_BED 94	S_RDING 96	R_BED 96	S_RDING 97	R_BED 97
21.60	1814.65	21.70	1814.55	21.60	1814.65	21.50	1814.75
				22.00	1814.25		
						20.30	1815.95
				20.70	1815.55		
20.90	1815.35						
		21.70	1814.55				
				25.00	1811.25		
		25.70	1810.55				
25.90	1810.35						
25.60	1810.65	25.30	1810.95	26.80	1809.45	26.80	1809.45

Table 10. (Continued)

S_RDING 93	R_BED 93	S_RDING 94	R_BED 94	S_RDING 96	R_BED 96	S_RDING 97	R_BED 97
						20.70	1815.55
						23.80	1812.45
						19.80	1816.45
				20.00	1816.25		
19.80	1816.45	20.00	1816.25				
						20.60	1815.65
20.80	1815.45	20.80	1815.45	20.80	1815.45	20.90	1815.35

Table 10. (Continued)

S_RDING 99	R_BED 99	S_RDING 00	R_BED 00	S_RDING 03	R_BED 03
20.40	1815.85	20.70	1815.55	20.80	1815.45
				21.10	1815.15
		21.3	1814.95		
				20.70	1815.55
				25.90	1810.35
		26.1	1810.15		
26.20	1810.05				
				25.40	1810.85
25.50	1810.75	25.80	1810.45	24.90	1811.35

Table 10. (Continued)

S_RDING 99	R_BED 99	S_RDING 00	R_BED 00	S_RDING 03	R_BED 03
22.40	1813.85				
				22.70	1813.55
23.20	1813.05				
19.90	1816.35	20.10	1816.15		
				19.90	1816.35
				21.00	1815.25
21.10	1815.15	21.60	1814.65	20.90	1815.35

Table 10. (Continued)

Year	1970	1971	1973	1974	1977	1979	1982
Flowline	1810.85	1811.25	1811.25	1811.25	1811.25	1810.35	1810.45

Year	1985	1987	1989	1991	1992	1993
Flowline	1811.25	1811.25	1810.25	1809.55	1810.55	1809.35

Table 11. Structure, Cross-section, and Flowline Details
Bridge No 16193 (RS 5) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b16193	1.5 MI. N. Dewey C/L	36-11-00	98-55-12	U.S. 60	1964	924.00

Pier-No	Distance	Pier-BTM	Pier-Top	R-bed64	S-Rding92	R-bed92	S-Rding98	R-bed98	S-Rding00	R-bed00
S-A	0.00	1670.00	1696.91	1690.00	9.50	1694.29	8.83	1694.96	11.60	1692.19
1	51.25	1669.20	1697.20	1687.50	16.80	1688.70	16.42	1689.08	19.00	1686.50
2	152.00	1669.69	1697.69	1686.25	20.00	1685.50	18.00	1687.50	22.00	1683.50
	172.00			1686.25			18.67	1686.83		
3	252.00	1669.98	1698.38	1687.50	19.50	1686.00	19.08	1686.42	21.60	1683.90
	272.00			1686.25			20.58	1684.92		
	292.00			1682.50					22.70	1682.80
4	352.00	1669.40	1698.40	1687.50	21.50	1684.06	19.50	1686.06	20.80	1684.76
	372.00			1685.00			18.67	1686.89		
	392.00			1681.75					21.10	1684.46
	432.00			1681.75	21.50	1684.06				
	442.75			1681.75			26.42	1679.15		
5	452.75	1669.63	1698.63	1681.75	27.50	1679.25	25.33	1681.42	25.90	1680.85
	492.75			1681.75	26.00	1680.75			28.40	1678.35
6	553.50	1669.40	1698.40	1681.75	23.80	1681.76	21.58	1683.98	21.50	1684.06
	573.50			1685.00	23.80	1681.76	19.75	1685.81		
	593.50			1685.00					22.30	1683.26
7	653.50	1669.38	1698.38	1685.00	20.50	1685.00	20.00	1685.50	22.30	1683.20
8	753.50	1669.69	1697.69	1684.13	17.00	1688.50	16.33	1689.17	18.70	1686.80
	773.50			1684.13			15.25	1690.25		
	793.50			1685.00					18.20	1686.68
9	854.25	1669.20	1697.20	1685.63	17.00	1687.25	16.58	1687.67	19.20	1685.05
N-A	915.50	1670.00	1696.27	1686.25	9.70	1694.69	9.17	1695.22	11.70	1692.69

Year	1965	1967	1969	1970	1971	1973	1975	1979
Flowline	1680.06	1679.56	1680.76	1678.76	1678.56	1678.46	1679.26	1677.96

Year	1982	1984	1986	1989	1990	1991	1993	1994
Flowline	1678.56	1678.06	1676.56	1676.56	1676.56	1678.66	1676.56	1676.06

Table 12. Structure, Cross-section, and Flowline Details
Bridge No 13679 (RS 6) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b13679	3.1 MI E Dewey C/L	36-03-18	98-34-54	S.H. 51	1956	444.50

Pier-No	Distance	Pier-BTM	Pier-Top	R-bed56	S-Rding91	R-bed91
W-A	0.00	1540.00	1575.00	1571.5	7.00	1573.18
1	51.50	1540.00	1575.76	1570.00	12.30	1567.88
2	137.25	1530.89	1575.89	1571.50	14.80	1565.38
3	222.25	1531.19	1576.13	1557.50	19.60	1560.58
	264.75			1556.50	23.40	1556.78
4	307.25	1530.89	1575.89	1568.13	17.30	1562.88
5	393.00	1539.00	1575.76	1570.00	10.60	1569.58
E-A	444.50	1538.00	1576.25	1570.00	7.00	1573.50

Year	1959	1965	1969	1970	1971	1973	1974	1976
Flowline	1557.18	1557.18	1557.08	1556.18	1555.78	1554.88	1554.78	1554.58

Year	1979	1982	1984	1987	1989	1991	1991	1995
Flowline	1555.58	1555.38	1555.58	1555.28	1555.68	1557.58	1553.58	1557.88

Year	1999	2002	2004
Flowline	1556.43	1553.51	1557.18

Table 13. Structure, and Flowline Details
Bridge No 13655 (RS 7) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b13655	3.5 MI. E Dewey C/L	36-03-18	98-34-36	S.H. 51	1956	150.90

Year	1965	1976	1984	1991	1995	1999	2002
Flowline	1561.40	1561.00	1561.80	1561.70	1562.00	1561.67	1561.59

Table 14. Structure, Cross-section, and Flowline Details
Bridge No 20864 (RS 8)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b20864	10.2 MI E Dewey C/L	35-50-30	98-27-54	U.S. 270	1984	540.58

Pier-No	Distance	Pier-BTM	Pier-Top	R-bed84	S-Rding87	R-bed87
E-A	0.00	1463.00	1492.00	1490.00	10.60	1490.80
1	70.29	1449.67	1493.17	1480.00	20.00	1481.40
2	170.29	1448.44	1493.44	1480.00	21.80	1479.60
	220.29			1478.00	30.00	1471.40
3	270.29	1449.06	1493.55	1474.00	21.70	1479.70
4	370.29	1451.07	1493.57	1474.00	21.00	1480.40
5	470.29	1451.42	1493.42	1480.00	20.30	1481.10
W-A	540.58	1464.00	1492.00	1490.00	9.00	1492.74

Year	1984	1987	1989	1991	1995	2004
Flowline	1474.30	1472.90	1472.40	1471.40	1477.40	1472.40

Table 15. Structure, Cross-section, and Flowline Details
Bridge No 05523 (RS 9) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b05523	10.5 MI E Dewey C/L	35-50-30	98-27-54	U.S. 270	1937	809.50

Pier-No	Distance	Pier-BTM	Pier-Top	R-bed37	S-Rding91	R-bed91
E-A	0.00	1463.03	1494.18	1491.25	6.00	1488.88
1	103.08	1459.81	1494.18	1481.75	18.00	1475.00
2	204.00	1459.68	1494.18	1477.50	19.00	1475.25
3	304.92	1459.31	1494.18	1475.00	23.50	1470.75
	355.38			1475.00	26.00	1468.88
4	405.83	1459.99	1494.18	1475.00	20.00	1475.50
5	506.75	1459.68	1494.18	1477.50	19.00	1476.50
6	607.67	1459.68	1494.18	1478.75	19.00	1476.50
7	708.58	1459.68	1494.18	1478.13	17.00	1478.50
W-A	809.50	1463.37	1494.18	1492.50	7.00	1488.50

Year	1954	1959	1965	1970	1971	1973	1974	1976
Flowline	1468.20	1468.50	1468.50	1468.40	1468.40	1467.90	1467.70	1467.50

Year	1979	1982	1984	1987	1989	1991	1995
Flowline	1467.60	1467.20	1466.40	1465.00	1467.50	1467.50	1469.17

Table 16. Structure, Cross-section, and Flowline Details Bridge No 26237 (RS 10)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
B18134	2.2 MI S. SH. 33	35-48-48	98-25-12	U.S. 270	1971	400.00

PIER_NO	DISTANCE	PIER_BTM	PIER_TOP	R_BED 71	S_RDING 00	R_BED 00	WSE 00
S-A	0.00	1440.19	1477.48	1475.00	9.70	1477.80	1479.50
1	100.00	1435.00	1477.50	1467.50	27.20	1459.05	1460.75
2	200.00	1435.08	1477.58	1460.45	22.70	1463.55	1465.25
3	300.00	1436.00	1477.50	1467.50	19.20	1467.05	1468.75
N-A	400.00	1438.29	1477.48	1475.00	11.20	1476.30	1478.00

Year	1971	1973	1974	1976	1979	1984
Flowline	1460.45	1460.45	1460.45	1460.25	1461.95	1459.85

Year	1987	1989	1990	1992	1995
Flowline	1461.05	1460.25	1460.05	1460.25	1461.25

Table 17. Structure, and Flowline Details Bridge No 26237 (RS 11)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b26237	2.2 N. JCT. S.H. 66	Missing	Missing	U.S. 81	2000	602.50

Year	2005
Flowline	1295.77

Table 18. Structure, Cross-section, and Flowline Details
Bridge No 18608 (RS 12) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b18608	2.2 MI. N. JCT. SH 66	35-33-30	97-57-30	U.S. 81	1973	602.77

Pier-No	Distance	Pier-BTM	Pier-Top	R-bed73	S-Rding88	R-bed88	S-Rding91	R-bed91
S-A	0.00	1266.30	1325.42	1323.00			10.90	1322.85
	50.32			1314.50	19.50	1314.75		
1	100.63	1266.40	1325.93	1311.00	22.70	1311.80	23.40	1311.10
2	201.01	1267.40	1326.23	1311.00	22.30	1312.45	22.90	1311.85
3	301.39	1267.60	1326.33	1313.50	21.60	1313.15	22.60	1312.15
4	401.76	1265.48	1326.23	1305.00	34.40	1300.35	33.90	1300.85
	413.00			1301.00				
	430.26			1301.50			35.60	1299.15
	454.76			1304.00				
	465.76			1304.00				
	476.76			1304.00				
5	502.14	1265.48	1325.03	1304.00	27.50	1307.00	30.40	1304.10
	552.46			1313.50	17.90	1316.35		
N-A	602.77	1266.30	1325.42	1323.00			10.40	1323.35

S-Rding92	R-bed92	S-Rding94	R-bed94	S-Rding98	R-bed98	S-Rding00	R-bed00
10.90	1322.85	10.62	1323.13	10.69	1323.06	10.60	1323.15
23.60	1310.90	22.99	1311.51	23.09	1311.41	22.90	1311.60
23.00	1311.75	22.44	1312.31	22.90	1311.85	22.70	1312.05
22.70	1312.05	21.39	1313.36	21.81	1312.94	21.40	1313.35
34.50	1300.25	34.71	1300.04	35.82	1298.93	35.40	1299.35
				35.89	1298.86		
						35.90	1298.85
		36.48	1298.02				
35.50	1299.00						
27.80	1306.70	26.90	1307.60	25.98	1308.52	26.30	1308.20
10.50	1323.25	10.49	1323.26	10.30	1323.45	10.10	1323.65

Table 18. (Continued)

Year	1973	1975	1981	1984	1985	1990	1991	1992
Flowline	1302.25	1302.55	1301.85	1301.15	1300.75	1299.95	1300.05	1301.25

Year	1993	2005
Flowline	1298.85	1302.75

Table 19. Structure, Cross-section, and Flowline Details
Bridge No 12832 (RS 13) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b12832	2.0 MI. N. JCT. SH 66	35-32-12	97-44-30	S.H. 4	1952	177.00

Pier-No	Distance	Pier-BTM	Pier-Top	R-bed52	S-Rding88	R-bed88
S-A	0.00	1235.75	1267.33	1264.5		
1	26.00	1235.50	1267.33	1258.00	4.50	1265.50
2	51.00	1235.50	1267.33	1258.00	5.10	1264.90
3	76.00	1235.00	1267.33	1258.00	5.90	1264.10
4	101.00	1235.00	1267.33	1258.00	5.70	1265.30
5	126.00	1235.00	1267.33	1258.00	5.00	1266.00
6	151.00	1235.00	1267.33	1258.00	5.20	1265.80
N-A	177.00	1235.75	1267.33	1265.00		

Year	1955	1960	1965	1966	1967	1969	1970
Flowline	1261.50	1263.00	1263.00	1263.00	1259.50	1257.60	1258.50

Year	1981	1985	1988	1990	1991	1994	2005
Flowline	1265.80	1258.00	1260.20	1257.80	1256.40	1258.00	1258.50

Table 20. Structure, Cross-section, and Flowline Details
Bridge No 12820 (RS 14)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b12820	2.3MI. N. JCT. SH66	35-32-30	97-44-30	S.H. 4	1952	127.84

Pier-No	Distance	Pier-BTM	Pier-Top	R-bed52	S-Rding 88	R-bed 88
S-A	0.00	1236.00	1267.97	1266.00		
1	26.42	1236.00	1267.72	1263.00	8.00	1262.75
2	51.42	1236.00	1267.47	1261.50	14.20	1256.55
	63.92			1255.75	17.30	1253.45
3	76.42	1235.50	1267.22	1261.50	16.00	1254.75
4	101.42	1235.50	1266.97	1262.00	11.00	1259.75
N-A	127.84	1236.00	1266.75	1265.00		

Year	1955	1958	1960	1965	1967	1969	1970	1972	1975
Flowline	1261.05	1261.65	1258.25	1258.15	1258.35	1258.95	1259.15	1257.25	1255.15

Year	1981	1984	1985	1988	1990	1991	1995	2005
Flowline	1257.15	1255.75	1255.25	1253.45	1254.05	1254.25	1254.75	1254.95

Table 21. Structure, Cross-section, and Flowline Details
Bridge No 18352 (RS 15)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b18352	22 MI. N. JCT. SH 66	35-32-18	97-44-30	S.H.4	1972	330.50

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed72	S-Rding88	R-bed88	S-Rding91	R-bed91
S-A	0.00	1240.00	1268.78	1271.88			10.70	1266.68
1	95.25	1238.92	1268.92	1255.00	25.70	1251.05	23.00	1253.75
	109.25			1255.00				
	125.75			1255.00				
	137.75			1255.00				
	142.75			1255.00	26.30	1250.45	27.90	1248.85
	157.25			1255.00				
	170.75			1255.00				
2	190.25	1238.92	1268.92	1257.50	25.40	1251.98	27.20	1250.18
3	260.25	1244.63	1269.63	1264.38	18.00	1260.00	18.00	1260.00
N-A	330.50	1240.00	1268.55	1271.88			10.80	1267.20

S-Rding92	R-bed92	S-Rding93	R-bed93	S-Rding93	R-bed93	S-Rding94	R-bed94
10.60	1266.78	10.70	1266.68	10.60	1266.78	9.51	1267.86
21.10	1255.65	22.90	1253.85	22.20	1254.55	26.84	1249.91
27.00	1249.75	29.00	1247.75				
				27.30	1249.45		
28.00	1249.38	31.80	1245.58	28.90	1248.48	26.71	1250.67
18.00	1260.00	17.80	1260.20	17.80	1260.20	16.47	1261.53
11.30	1266.70	11.10	1266.90	11.10	1266.90	9.88	1268.12

Table 21. (Continued)

S-Rding98	R-bed98	S-Rding00	R-bed00	S-Rding05	R-bed05
10.86	1266.52	11.10	1266.28	10.60	1266.78
19.46	1257.29	21.40	1255.35	20.10	1256.65
28.38	1248.37				
				26.30	1250.45
		27.30	1249.45		
				24.70	1252.05
29.17	1248.21	27.50	1249.88	25.70	1251.68
17.42	1260.58	17.50	1260.50	17.40	1260.60
10.89	1267.11	10.90	1267.10	10.70	1267.30

Year	1972	1973	1975	1981	1984	1985	1988	1991
Flowline	1251.88	1252.58	1253.88	1251.48	1250.88	1250.38	1248.58	1249.98

Year	1993	1994	2005
Flowline	1245.58	1249.88	1251.68

Table 22. Structure, Cross-section, and Flowline Details
Bridge No 14208 (RS 16) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b14208	0.3 MI E Canadian C/L	35-30-54	97-40-00	U.S. 66	1958	803.50

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed58	S-Rding93	R-bed93	S-Rding94	R-bed94
W-A	0.00	1225.00	1254.04	1252.50	5.90	1255.07	7.67	1253.30
1	101.00	1225.09	1254.09	1245.00	18.30	1242.95	17.48	1243.77
2	201.00	1225.59	1254.59	1245.00	18.90	1242.35	17.97	1243.28
3	301.00	1225.54	1250.54	1243.75	18.70	1242.55	18.53	1242.72
4	401.75	1225.94	1254.94	1242.50	19.00	1242.88	18.79	1243.09
5	502.50	1225.54	1254.54	1237.50	20.50	1240.75	25.88	1235.37
6	602.50	1198.59	1254.59	1235.00	36.70	1224.55	31.29	1229.96
	652.50			1232.50	36.10	1225.15	34.58	1226.67
7	702.50	1198.09	1254.09	1226.25	36.00	1224.63	32.18	1228.45
E-A	803.50	1225.00	1254.04	1250.00	9.00	1251.99	9.67	1251.32

Year	1965	1970	1982	1984	1986	1988	1994	2005
Flowline	1237.75	1232.95	1232.85	1248.25	1233.25	1234.95	1228.77	1234.65

Table 23. Structure, Cross-section, and Flowline Details
Bridge No 16189 (RS 17) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b16189	1MI E Canadian Co	35-27-36	97-40-12	I-40	1964	804.00

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed64	S-Rding88	R-bed88	S-Rding93	R-bed93
W-A	0.00	1188.00	1230.12	1228.75			11.60	1228.40
	50.00							
1	101.00	1183.58	1230.58	1211.75	27.30	1212.70	28.90	1211.10
2	201.00	1182.86	1230.86	1211.75	27.50	1212.50	30.90	1209.10
3	301.00	1183.98	1230.98	1200.00	36.60	1203.40	36.00	1204.00
	351.38			1202.50				
4	401.75	1183.92	1230.92	1206.25	35.60	1204.40	37.00	1203.00
5	502.50	1183.98	1230.98	1202.50	29.60	1210.40	37.60	1202.40
	543.50			1200.75				
	552.50			1200.75				
6	602.50	1183.86	1230.86	1197.50	37.40	1202.60	43.00	1197.00
	662.50			1202.50	42.80	1197.20	44.70	1195.30
	683.50			1205.00				
7	702.50	1182.58	1230.58	1208.13	41.00	1199.00	31.70	1208.30
E-A	803.50	1187.00	1230.12	1227.50			9.70	1230.30

Table 23. (Continued)

S-Rding93	R-bed93	S-Rding94	R-bed94	S-Rding00	R-bed00	S-Rding05	R-bed05
10.90	1229.10	8.70	1231.30	10.60	1229.40	11.70	1228.30
						26.70	1213.30
29.00	1211.00	27.00	1213.00	29.30	1210.70	30.00	1210.00
29.00	1211.00	27.00	1213.00	29.70	1210.30	31.90	1208.10
39.30	1200.70	37.50	1202.50	38.90	1201.10	39.70	1200.30
		42.00	1198.00			42.80	1197.20
33.30	1206.70	32.50	1207.50	44.10	1195.90	44.00	1196.00
38.00	1202.00	35.00	1205.00	44.30	1195.70	44.20	1195.80
				44.40	1195.60		
		42.50	1197.50			44.50	1195.50
40.90	1199.10	39.00	1201.00	38.20	1201.80	42.90	1197.10
45.90	1194.10					45.60	1194.40
				48.00	1192.00		
45.90	1194.10	44.00	1196.00	49.00	1191.00	43.00	1197.00
10.90	1229.10	9.00	1231.00	10.10	1229.90	11.10	1228.90

Year	1970	1975	1981	1984	1986	1988	1990
Flowline	1207.80	1200.50	1200.60	1200.00	1197.40	1197.20	1196.70

Year	1994	2005
Flowline	1196.00	1192.50

Table 24. Structure, Cross-section, and Flowline Details
Bridge No 16190 (RS 18)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b16190	0.1 MI E Canadian Co.	35-27-36	97-40-12	I-40	1964	803.50

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed64	S-Rding88	R-bed88	S-Rding94	R-bed94
W-A	0.00	1187.50	1230.12	1228.25			10.00	1228.75
1	101.00	1183.58	1230.58	1200.00	27.30	1211.45	27.00	1211.75
2	201.00	1182.86	1230.86	1205.00	29.00	1209.75	33.00	1205.75
3	301.00	1183.98	1230.98	1202.50	35.80	1202.95	34.00	1204.75
4	401.75	1183.92	1230.92	1202.50	38.90	1199.85	35.00	1203.75
5	502.50	1183.98	1230.98	1201.88	37.00	1202.38	38.00	1201.38
6	602.50	1183.86	1230.86	1207.50	39.40	1199.98	43.00	1196.38
	640.50			1197.50				
	642.50			1197.50	40.50	1198.88	44.50	1194.88
	650.50							
7	702.50	1182.58	1230.58	1195.00	30.50	1208.25	29.00	1209.75
E-A	803.50	1186.25	1230.12	1230.12			8.00	1230.75

S-Rding00	R-bed00	S-Rding05	R-bed05
11.50	1227.25	12.40	1226.35
29.00	1209.75	29.60	1209.15
32.20	1206.55	33.10	1205.65
35.60	1203.15	37.00	1201.75
36.30	1202.45	43.80	1194.95
40.40	1198.98	42.80	1196.58
45.40	1193.98	42.60	1196.78
45.00	1194.38		
		47.70	1191.68
31.70	1207.05	32.70	1206.05
9.10	1229.65	10.10	1228.65

Year	1970	1975	1981	1984	1986	1988	1990	1994	2005
Flowline	1207.58	1199.68	1199.48	1199.88	1196.78	1198.88	1196.08	1194.88	1191.68

Table 25. Structure, and Flowline Details
Bridge No 27867 (RS 19) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b27867	0.25 E I-35/I-40 Ft. Smith	35-28-06	97-28-00	I-40 WB TO I-35 NB	2003	660.60

Year	2005
Flowline	1148.00

Table 26. Structure, Cross-section, and Flowline Details
Bridge No 21357 (RS 20) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b21357	2MI E JCT I-35	35-29-36	97-25-42	U.S. 62	1986	1,000.50

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed86	S-Rding93	R-bed93
W-A	0.00	1120.000	1166.47	1160.00	9.50	1160.50
1	100.25	1112.390	1161.89	1145.00	25.00	1146.25
2	200.25	1110.770	1162.76	1142.50	25.80	1145.45
3	300.25	1109.105	1163.60	1142.50	26.30	1146.20
4	400.25	1108.590	1164.36	1143.75	30.30	1143.45
5	500.25	1107.055	1164.55	1144.38	36.80	1138.20
	550.25			1138.75	34.50	1140.50
6	600.25	1105.640	1164.13	1137.50	32.40	1142.60
7	700.25	1104.375	1163.37	1141.25	29.10	1144.65
8	800.25	1096.040	1162.54	1145.00	27.20	1143.43
9	900.25	1087.655	1161.66	1147.50	25.00	1145.00
E-A	1000.5	1110.000	1166.19	1160.00	11.20	1158.18

Year	1988	1990	1994	2005
Flowline	1140.25	1140.45	1143.36	1142.25

Table 27. Structure, Cross-section, and Flowline Details
Bridge No 21129 (RS 21) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b21129	17.5 MI E OF JCT I-35	35-29-36	97-09-42	U.S. 62	1985	900.34

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed85	S-Rding90	R-bed90	S-Rding93	R-bed93
S-A	0.00	1030.00	1080.00	1080.00	12.60	1079.90	12.70	1079.80
1	100.17	1020.62	1082.62	1073.75	24.40	1065.60	23.80	1066.20
2	200.17	1019.45	1081.45	1073.75	24.60	1065.40	28.20	1061.80
3	300.17	1020.46	1080.46	1072.50	33.50	1056.50	29.80	1060.20
	330.17			1042.75			40.80	1049.20
4	400.17	1013.92	1079.92	1060.00	33.00	1057.00	29.00	1061.00
	450.17			1055.63	34.10	1054.03		
5	500.17	1011.44	1079.44	1056.25	34.90	1052.60	22.80	1064.70
6	600.17	1013.87	1078.87	1063.75	27.30	1060.20	27.50	1060.00
7	700.17	1011.48	1078.48	1062.50	23.10	1064.40	21.20	1066.30
8	800.17	1012.00	1078.00	1061.75	21.70	1065.80	21.80	1065.70
N-A	900.34	1030.00	1077.44	1061.75	12.20	1074.05	12.30	1073.95

Year	1986	1988	1990	1994	2005
Flowline	1055.30	1053.20	1053.40	1049.81	1052.50

Table 28. Structure, Cross-section, and Flowline Details
Bridge No 05040 (RS 22)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b05040	0.7 MI N OF SH 270	35-26-48	97-05-24	S.H. 102	1936	340.00

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed36	S-Rding92	R-bed92	S-Rding93	R-bed93
N-A	0.00	1007.85	1060.47	1058.76	8.80	1063.32	9.20	1062.92
	15.00			1058.76	14.40	1057.72	15.00	1057.12
	30.00			1058.76				
1	40.00	1007.85	1060.47	1058.76	13.40	1058.72	15.10	1057.02
	56.00			1056.03				
	58.00			1056.03				
	59.00			1056.03				
	62.00			1056.03				
	68.00			1055.12				
2	80.00	1007.85	1060.47	1052.40	20.40	1050.81	21.20	1050.01
	95.00			1051.49				
	98.00			1051.03				
	101.00			1050.58				
	105.00			1050.12	22.60	1048.61	20.00	1051.21
	108.00			1049.67				
	113.00			1047.85				
3	120.00	1007.85	1060.47	1045.35	22.60	1048.61	29.50	1041.71
	138.00			1044.21				
	145.00			1043.30				
	161.00			1041.49				
	168.00			1041.49	28.70	1042.51		
	172.00			1041.03				
	175.00			1040.58				
	180.00			1041.03				
	190.00			1042.40				
	200.00			1043.30				
	202.00			1043.30				
	205.00			1043.76				
	210.00			1044.21				
	211.00			1044.21				
	212.00			1044.21				
4	220.00	1007.85	1060.47	1045.12	21.40	1050.72	26.80	1045.32
	226.00			1045.35				

Table 28. (Continued)

	239.00			1046.03				
	242.00			1046.49				
	255.00			1047.85				
5	260.00	1007.85	1060.47	1050.58	25.20	1046.01	21.30	1049.91
	261.00			1050.58				
	270.00			1051.49			25.80	1045.41
	272.00			1051.71				
	275.00			1051.94				
	278.00			1052.17				
	285.00			1052.40				
	286.00			1052.40				
6	300.00	1007.85	1060.47	1055.12	16.20	1055.01	18.50	1052.71
	305.00			1056.03				
	309.00			1056.03				
	310.00			1056.03				
S-A	340.00	1007.85	1060.47	1058.30	8.80	1062.41	9.50	1061.71

S-Rding95	R-bed95	S-Rding96	R-bed96	S-Rding97	R-bed97	S-Rding99	R-bed99
10.70	1061.42	10.80	1061.32	10.82	1061.30	11.00	1061.12
31.90	1040.22	25.60	1046.52	26.57	1045.55	29.10	1043.02
32.80	1039.32						
		22.40	1049.72				
28.30	1042.91	26.30	1044.91	19.68	1051.53	23.10	1048.11
23.40	1047.81						
				24.93	1046.28		
26.80	1044.41	27.20	1044.01	23.95	1047.26	36.50	1034.71
						29.90	1041.31
				24.93	1046.28		
						32.80	1038.41
23.30	1047.91						

Table 28. (Continued)

28.20	1043.01						
		22.90	1048.31				
25.60	1045.61	25.40	1045.81	19.02	1052.19	24.30	1046.91
				18.04	1053.17		
15.50	1055.71						
15.90	1055.31	15.80	1055.41	19.02	1052.19	19.70	1051.51
16.90	1054.31						
				20.01	1051.20		
						16.40	1054.81
22.30	1048.91						
		22.40	1048.81				
17.70	1053.51	20.10	1051.11	19.02	1052.19	16.80	1054.41
18.80	1052.41						
8.50	1062.71	9.10	1062.11	10.17	1061.04	10.10	1061.11

S-Rding02	R-bed02	S-Rding03	R-bed03	S-Rding04	R-bed04
10.80	1061.32	11.00	1061.12	10.60	1061.52
25.10	1047.02	25.30	1046.82	23.80	1048.32
23.40	1048.72				
				22.00	1050.12
		24.40	1047.72		
26.20	1045.01	26.00	1045.21	27.90	1043.31
25.30	1045.91				
		25.10	1046.11	25.90	1045.31
27.10	1044.11				

Table 28. (Continued)

25.40	1045.81	28.90	1042.31		
27.10	1044.11	27.70	1043.51	28.10	1043.11
27.30	1043.91				
				25.70	1045.51
				29.80	1041.41
22.90	1048.31	23.00	1048.21		
				22.20	1049.01
		25.30	1045.91		
25.50	1045.71				
24.20	1047.01	24.40	1046.81	24.60	1046.61
21.20	1050.01				
20.40	1050.81	20.80	1050.41	21.00	1050.21
15.40	1055.81	15.60	1055.61		
16.20	1055.01	16.90	1054.31	16.00	1055.21
16.70	1054.51				
				16.20	1055.01
10.10	1061.11	10.00	1061.21	10.00	1061.21

Year	1970	1977	1980	1983	1985	1992	2003	2004
Flowline	1052.71	1047.01	1046.81	1046.61	1046.21	1042.51	1042.31	1043.11

Table 29. Structure, and Flowline Details
Bridge No 20576 (RS 23) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b20576	0.4 MI E Dale	35-23-30	97-02-24	S.H. 270	1983	801.80

Year	1985	1992	1994
Flowline	1001.25	989.25	990.65

Table 30. Structure, and Flowline Details
Bridge No 15380 (RS 24)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b15380	6.1 MI E OK C/L	35-22-36	97-02-18	I-40	1961	400.90

Year	1969	1975	1987
Flowline	1015.17	1015.07	1013.97

Table 31. Structure, and Flowline Details
Bridge No 15381 (RS 25) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b15381	6.1 MI E OK C/L	35-22-36	97-02-18	I-40	1961	400.90

Year	1969	1975	1987
Flowline	1014.61	1014.51	1013.91

Table 32. Structure, and Flowline Details
Bridge No 15388 (RS 26)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b15388	3.9 MI S JCT SH 3	35-18-54	96-56-36	U.S. 270	1961	803.10

Year	1963	1965	1967	1969	1970	1971	1973	1975	1977
Flowline	976.77	974.47	974.47	974.67	974.47	974.27	974.47	973.97	974.47

Year	1980	1983	1985	1987	1992	1994	2003	2005
Flowline	972.97	971.97	975.67	974.37	972.97	972.97	972.97	972.57

Table 33. Structure, and Flowline Details
Bridge No 19276 (RS 27) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b19276	2.2 MI E JCT SH 18	35-20-00	96-52-18	S.H. 3E	1976	852.00

Year	1977	1980	1983	1985	1992	1994	2003
Flowline	958.00	955.60	956.00	955.00	954.00	953.90	953.30

Table 34. Structure, and Flowline Details
Bridge No 15865 (RS 28)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b15865	N/S	N/A	N/A	N/A	1962	N/A

Year	1969	1971	1973	1975	1980	1985	1987	1989	1990
Flowline	927.77	929.47	929.27	928.07	929.27	927.27	927.07	926.27	925.97

Year	1991	1995
Flowline	926.27	931.17

Table 35. Structure, and Flowline Details
Bridge No 15864 (RS 29)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b15864	N/A	N/A	N/A	N/A	1962	N/A

Year	1969	1971	1973	1975	1980	1985	1987	1989
Flowline	927.47	929.47	929.27	929.27	929.47	926.57	928.27	926.27

Year	1990	1991	1995
Flowline	926.07	926.27	930.77

Table 36. Structure, and Flowline Details
Bridge No 22683 (RS 30)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b22683	Pott-Seminole C/L	35-23-54	96-40-12	S.H. 99	1990	812.00

Year	1992	2003
Flowline	867.55	866.45

Table 37. Structure, and Flowline Details
Bridge No 22686 (RS 31)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b22686	2.5 MI E Seminole Co.	35-25-48	96-24-30	S.H. 56	1990	1,501.00

Year	2003	2005
Flowline	783.60	783.60

Table 38. Structure, and Flowline Details
Bridge No 22666 (RS 32) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b22666	3.4 MI E Seminole Co.	35-25-42	96-23-24	S.H. 56	1990	211.00

Year	1992	2003	2005
Flowline	801.44	800.84	800.84

Table 39. Structure, Cross-section, and Flowline Details
Bridge No 15870 (RS 33)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b15870	2.5 MI E Seminole Co	35-23-36	096-24-06	I-40	1962	1,687.75

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed62	S-Rding00	R-bed00
W-A	0.00	757.00	802.00	802.00	9.67	789.33
1	61.25	752.77	802.77	792.00	19.33	779.67
2	162.00	753.03	803.03	792.00	22.00	777.00
3	262.00	752.70	803.70	792.00	21.67	777.33
4	362.00	752.83	803.83	792.00	23.33	775.67
5	462.75	753.38	804.34	788.00	24.75	774.25
6	563.50	752.64	804.64	788.00	25.25	773.75
	583.50			788.00	25.50	773.50
7	663.50	752.31	805.31	788.00	25.41	773.59
8	763.50	752.44	805.44	788.00	26.00	773.00
	783.50			790.00	25.67	773.33
9	864.25	751.99	805.99	790.00	25.25	773.75
10	964.25	753.24	806.24	790.00	25.50	773.50
11	1064.25	752.91	806.91	791.75	26.50	772.50
	1084.25			791.75	26.33	772.67
12	1164.25	755.04	807.04	789.00	27.25	771.75
	1184.25			788.00	27.41	771.59
13	1265.00	756.59	807.59	787.00	27.00	772.00
	1285.00			786.50	26.58	772.42
14	1385.75	757.85	807.85	785.00	27.08	771.92
16	1585.75	763.65	808.65	776.00	40.67	758.33
E-A	1687.75	780.00	808.00	806.00	9.41	789.59

Year	1969	1975	1980	1989	1990	1992	1995
Flowline	758.40	758.20	757.00	756.00	759.10	758.70	762.20

Table 40. Structure, Cross-section, and Flowline Details
Bridge No 15871 (RS 34) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b15871	2.5 MI. E. Seminole Co	35-23-36	96-24-06	I-40	1963	1,668.50

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed63	S-Rding00	R-bed00
W-A	0.00	758.00	802.58	802.00	10.17	801.33
	20.00			794.00	16.25	795.25
1	61.25	731.52	803.58	791.75	20.17	791.83
	81.25			791.75	20.58	791.67
2	162.00	742.41	802.91	791.75	20.75	791.75
	182.00			791.75	21.50	791.00
3	262.00	742.56	803.58	792.00	22.67	789.83
	282.00			791.75	23.42	789.08
4	362.00	742.21	803.71	788.00	24.33	788.42
	382.00			788.00	24.67	788.33
5	462.75	742.99	804.99	786.00	25.33	787.92
	482.75			786.00	24.75	788.75
6	563.50	743.02	804.52	788.25	25.25	789.25
	583.50			788.25	25.67	789.08
7	663.50	742.69	805.19	788.25	26.17	788.58
	683.50			788.25	25.33	789.42
8	763.50	741.82	805.32	788.00	26.25	788.50
	783.50			788.00	26.08	788.67
9	864.25	743.60	806.60	788.00	25.75	789.75
	884.25			788.00	25.17	790.33
10	965.00	744.12	806.12	789.00	25.75	790.25
11	1065.00	743.79	806.79	789.00	26.25	790.00
	1085.00			787.00	27.25	789.00
12	1165.00	744.92	806.92	787.00	27.25	789.25
	1185.00			787.00	27.08	789.67
13	1265.75	747.20	808.20	786.00	26.75	790.00
	1285.75			786.00	26.67	790.08
14	1366.50	750.73	807.73	787.00	30.75	786.75
15	1466.50	753.90	808.40	780.00	37.75	780.25
	1476.50			779.00	39.00	779.25
	1561.50			777.00	41.08	777.42
16	1566.50	758.03	808.53	777.75	36.08	782.42
	1571.50			777.75	41.00	777.50
E-A	1668.50	766.00	809.20	809.75	10.42	808.08

Year	1969	1975	1980	1989	1990	1992	1995
Flowline	777.90	776.50	777.50	777.50	775.30	776.20	777.50

Table 41. Structure, Cross-section, and Flowline Details
Bridge No 18361 (RS 35) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b18361	1.8 MI S JCT 140	35-22-30	96-22-12	S.H.48	1972	590.50

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed72	S-Rding87	R-bed87	S-Rding92	R-bed92	S-Rding97	R-bed97
S-A	0.00	765.00	793.92	791.81			8.90	790.65	10.00	789.55
1	70.25	760.40	793.40	782.76	21.40	779.06	21.20	779.26	22.00	778.46
	110.25			782.76			20.90	780.01		
2	140.25	760.98	795.98	781.86	21.30	779.61	21.20	779.71	22.00	778.91
3	210.25	760.62	795.62	784.57	21.90	779.01	21.50	779.41	22.50	778.41
	295.25			779.10			23.50	776.96		
4	305.25	758.93	795.93	772.76	29.90	770.56	28.00	772.46	28.50	771.96
	342.25			768.19			40.00	760.46		
	352.75			768.19	37.30	763.16			43.00	757.46
5	400.25	755.95	795.98	770.00	36.50	763.96	34.70	765.76	36.00	764.46
	454.25			767.29			40.40	760.06		
6	495.25	755.66	795.66	760.00	24.10	776.36	27.60	772.86	27.50	772.96
	542.88			760.00	20.70	779.76				
N-A	590.50	760.00	795.08	790.00			9.90	789.65	9.50	790.05

Year	1973	1975	1981	1983	1987	1989	1990	1992	1994
Flowline	764.06	764.66	761.96	761.46	763.16	762.46	762.66	760.06	763.46

Table 42. Structure, Cross-section, and Flowline Details
Bridge No 10570 (RS 36)on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b10570	4.2 MI NW Hughes Co	35-20-00	96-18-00	S.H. 27	1946	810.00

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed46	S-Rding01	R-bed01	S-Rding99	R-bed99
S-A	0.00	727.00	770.34	770.34	8.53	774.31	8.40	774.44
1	52.08	724.75	770.34	747.75	22.96	759.88	22.90	759.94
	65.08			747.75				
	97.08			747.75				
	109.08			747.75				
	118.08			747.75				
	119.08			747.75	21.65	761.19	21.00	761.84
	142.08			747.75				
	147.08			747.75				
	151.08			747.75				
2	152.92	721.42	772.93	747.75	25.26	757.58	26.00	756.84
	164.92			747.75			24.00	758.84
	167.92			747.75	23.62	759.22		
	170.92			747.75				
	172.92			747.75				
	177.92			747.75				
	184.92			747.75				
	194.92			747.75	31.16	751.68		
	198.92			747.75			30.50	752.34
	202.92			747.75				
	213.92			747.75	23.95	758.89		
	219.92			747.75			27.90	754.94
	220.92			747.75				
3	253.75	713.73	772.93	747.75	34.77	748.07	36.00	746.84
	278.75			747.75				
	283.75			747.75	35.76	747.08		
	293.75			747.75				
	295.75			745.17				
	303.79			745.17				
	304.75			745.17				
	343.75			745.17			33.00	749.84
	344.75			742.58	33.13	749.71		
4	354.59	715.12	772.93	742.58	33.79	749.05	37.00	745.84
	366.59			745.17			33.10	749.74

	367.59			745.17				
	384.59			745.17			33.50	749.34
	389.59			745.17				
	390.59			745.17				
	392.59			745.17				
	399.59			745.17				
	409.59			745.17			36.00	746.84
	413.59			745.17				
	416.59			745.17				
	417.59			745.17				
	429.59			745.17				
	430.59			745.17			34.30	748.54
	433.59			745.17	36.18	746.66		
5	455.42	720.49	772.93	745.17	35.10	747.74	34.90	747.94
	476.42			745.17			28.30	754.54
	493.42			745.17				
	520.42			745.17				
	520.42			745.17				
	543.42			745.17				
6	556.25	716.35	772.93	745.17	21.65	761.19	22.00	760.84
	600.25			747.55				
	645.25			747.55				
7	657.09	717.07	772.93	747.55	22.96	759.88	23.00	759.84
	696.09			747.55				
	697.09			747.55				
	702.09			747.55				
6	556.25	716.35	772.93	745.17	21.65	761.19	22.00	760.84
	705.09			747.55				
	723.09			747.55			22.80	760.04
	724.09			747.55	22.30	760.54		
8	757.92	717.83	770.34	747.55	22.96	759.88	23.00	759.84
N-A	810.00	720.00	770.34	770.34	6.23	776.61	5.50	777.34

Table 42. (Continued)

S-Rding98	R-bed98	S-Rding97	R-bed97	S-Rding96	R-bed96	S-Rding95	R-bed 95
8.10	774.74	8.20	774.64	5.40	777.44	7.70	775.14
22.90	759.94	22.96	759.88	23.10	759.74	22.80	760.04
		22.30	760.54				
				22.60	760.24		
						21.10	761.74
20.80	762.04						
26.10	756.74	24.60	758.24	23.00	759.84	24.60	758.24
24.30	758.54						
		31.49	751.35				
		28.54	754.30				
29.90	752.94						
25.30	757.54						
35.00	747.84	33.79	749.05	22.30	760.54	34.70	748.14
36.10	746.74						
						37.20	745.64
						31.80	751.04
32.00	750.84	36.08	746.76	36.10	746.74	34.60	748.24
		35.10	747.74				
						32.00	750.84
						34.80	748.04
				41.00	741.84		

34.70	748.14						
						41.60	741.24
				38.00	744.84		
34.00	748.84	37.07	745.77	33.00	749.84	37.90	744.94
				35.20	747.64		
				34.20	748.64		
				35.00	747.84		
22.20	760.64	22.30	760.54	34.10	748.74	22.30	760.54
				26.30	756.54		
				24.20	758.64		
22.70	760.14	22.63	760.21	25.80	757.04	22.50	760.34
						22.30	760.54
				20.30	762.54		
23.30	759.54	22.96	759.88	22.70	760.14	22.90	759.94
6.00	776.84	6.23	776.61	7.70	775.14	5.10	777.74

Table 42. (Continued)

S-Rding94	R-bed94	S-Rding93	R-bed93	S-Rding92	R-bed92	S-Rding87	R-bed87
7.30	775.54	7.10	775.74	7.50	775.34		
22.60	760.24	22.50	760.34	23.10	759.74	20.40	762.44
21.30	761.54						
24.00	758.84						
				22.10	760.74		
29.90	752.94	25.40	757.44	26.00	756.84	20.60	762.24
30.80	752.04						
				25.00	757.84		
28.20	754.64						
		37.40	745.44				
35.30	747.54	36.40	746.44	36.00	746.84	29.60	753.24
		39.50	743.34				
						34.60	748.24
				43.20	739.64		
36.80	746.04	36.30	746.54	32.30	750.54	30.30	752.54
		25.00	757.84				
				27.10	755.74		

				31.80	751.04		
33.00	749.84	37.50	745.34	30.60	752.24	30.00	752.84
22.40	760.44	22.30	760.54	22.20	760.64	19.60	763.24
22.50	760.34	22.00	760.84	22.80	760.04	19.80	763.04
22.30	760.54						
				22.60	760.24		
22.80	760.04	22.30	760.54	23.10	759.74	20.40	762.44
5.10	777.74	5.30	777.54	5.60	777.24		

Year	1954	1960	1961	1962	1964	1965	1966	1971
Flowline	750.84	747.84	748.84	748.84	748.04	748.74	748.54	745.84

Year	1973	1981	1983	1987	1989	1991	1992	1994
Flowline	742.84	746.44	746.84	748.24	746.84	746.84	743.34	745.94

Table 43. Structure, Cross-section, and Flowline Details
Bridge No 21128 (RS 37) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b21128	2.9 S Okfuskee C/L	35-15-48	96-12-24	U.S. 75	1985	800.34

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed85	S-Rding87	R-bed87	S-Rding00	R-bed00
S-A	0.00	651.88	710.00	710.00			8.00	710.75
	50.85			695.00	25.50	693.88		
1	100.17	649.45	714.95	696.25	27.50	692.50	24.75	695.25
	120.17			693.75			23.00	697.63
2	200.17	646.02	916.52	695.00	30.60	691.28	27.90	693.98
3	300.17	643.01	718.01	693.75	38.40	684.73	41.00	682.13
	320.17			693.75			42.70	681.05
4	400.17	642.92	719.42	685.00	41.30	683.70	38.90	686.10
	410.17			685.00			38.10	686.90
	450.85			685.00	46.80	678.20		
5	500.17	642.99	720.99	685.00	45.50	680.75	43.00	683.25
6	600.17	664.98	722.48	691.75	39.70	687.80	32.00	695.50
7	700.17	672.39	723.89	691.75	36.70	692.68	33.80	695.58
	750.85			696.25	35.60	694.40		
	766.95			705.00	10.80	719.20		
N-A	800.34	720.00	725.46	725.00			6.67	724.58

Year	1985	1987	1989	1991	1995
Flowline	678.70	680.70	680.00	680.00	684.17

Table 44. Structure, Cross-section, and Flowline Details
Bridge No 14189 (RS 38) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b14189	1.4 MI N Hughes Co	35-18-36	96-02-06	S.H. 84	1958	322.50

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed58	S-Rding87	R-bed87
S-A	0.00	629.38	667.67	670.00		
1	41.25	629.38	667.94	656.25	15.40	659.60
2	81.25	628.13	668.14	656.25	15.40	659.60
3	121.25	628.13	668.26	656.25	15.40	659.60
4	161.25	628.13	668.30	656.25	15.50	659.50
5	201.25	628.13	668.26	656.25	15.50	659.50
6	241.25	628.13	668.14	658.75	15.50	659.50
7	281.25	626.25	667.94	658.75	14.20	660.80
N-A	322.50	626.25	667.67	665.00		

Year	1965	1970	1975	1985	1987	1989	1991	1992
Flowline	656.40	656.50	656.60	656.50	659.50	659.00	659.00	654.50

Table 45. Structure, Cross-section, and Flowline Details
Bridge No 14200 (RS 39) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b14200	1.7 MI N Hughes Co	35-18-48	96-02-06	S.H. 84	1958	504.50

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed58	S-Rding87	R-bed87	S-Rding92	R-bed92	S-Rding97	R-bed97	S-Rding00	R-bed00
S-A	0.00	615.00	668.10	665.00			10.00	664.62	9.00	665.62	7.42	665.20
	17.21			656.00	46.60	628.02						
1	51.63	633.30	668.35	646.25			39.00	634.75	39.00	634.75	30.33	641.42
	56.63			646.25								
	71.63			646.25							57.08	614.67
	81.63			646.25					42.00	631.75		
	142.25			643.75								
	147.25			643.75								
2	152.25	633.94	668.74	643.75	35.80	639.20	51.00	624.00	35.00	640.00	54.08	618.92
	172.25			643.75								
	242.25			645.00								
3	252.25	634.21	669.21	645.00	27.00	648.00	35.90	639.10	31.00	644.00	31.42	641.58
4	352.25	633.74	668.74	652.50	25.00	649.38	24.90	649.48	28.00	646.38	25.00	647.38
	372.25			652.50								
	447.88			655.00								
5	452.88	633.35	668.35	655.00	19.00	655.38	21.00	653.38	20.00	654.38	19.25	653.13
N-A	504.50	615.00	668.10	667.50			10.00	664.62	9.00	665.62	7.17	665.45

Table 45. (Continued)

S-Rding04	R-bed04	S-Rding05	R-bed05
8.00	664.62	8.00	664.62
32.58	639.17	32.42	639.33
40.75	631.00		
		43.00	628.75
36.75	636.25		
		36.67	636.33
41.42	631.58	39.25	633.75
33.33	639.67		
37.67	635.33		
36.42	636.58	29.25	643.75
24.33	648.04	24.17	648.21
		20.25	652.13
		20.75	651.63
16.50	655.88	19.33	653.04
7.75	664.87	7.58	665.04

Year	1960	1961	1962	1965	1966	1969	1970	1971	1973
Flowline	640.15	639.75	641.05	638.85	637.75	624.25	624.75	636.75	629.75

Year	1981	1983	1985	1987	1989	1990	1994	1995	2005
Flowline	633.75	635.25	620.25	625.15	619.75	619.55	620.75	620.75	628.75

Table 46. Structure, Cross-section, and Flowline Details
Bridge No 15585 (RS 40) on North Canadian River

Bridge No	Location	Latitude	Longitude	Highway	Design Year	Length
b15585	8.6 MI N Pittsburg Co	35-13-18	95-35-48	U.S. 69	1962	801.80

Pier-No	Distance	Pier-Btm	Pier-Top	R-bed62	S-Rding87	R-bed 87	S-Rding D/S90	R-bed D/S90	S-Rding U/S90	R-bed U/S90
S-A	0.00	500.00	607.14	606.00	8.50	606.00	8.50	606.00	10.00	604.50
1	101.25	501.50	607.31	572.00	46.00	568.50	46.00	568.50	47.00	567.50
2	201.25	502.70	607.72	538.00	76.00	538.50	77.50	537.00	77.00	537.50
3	301.25	502.50	607.81	528.00	85.00	529.50	85.00	529.50	85.50	529.00
	351.25			530.00	87.00	527.50	86.00	528.50	86.50	528.00
4	401.25	503.50	608.14	530.00	91.50	523.00	92.00	522.50	90.00	524.50
	451.25			530.00	88.00	526.50	87.50	527.00	86.00	528.50
5	501.25	502.50	607.81	530.00	91.00	523.50	89.00	525.50	86.00	528.50
6	601.25	503.00	607.72	538.00	78.00	536.50	78.50	536.00	76.00	538.50
7	701.25	503.00	609.31	574.00	45.00	569.50	44.00	570.50	44.50	570.00
N-A	802.50	500.00	607.14	608.00	9.20	605.30	9.00	605.50	9.90	604.60

S-Rding93	R-bed93
8.00	606.50
45.00	569.50
77.00	537.50
84.00	530.50
85.00	529.50
90.00	524.50
86.00	528.50
89.00	525.50
78.00	536.50
44.00	570.50
8.00	606.50

Year	1985	1987	1989	1990.00	1992	1994
Flowline	527.50	523.50	523.00	524.50	526.50	529.50

APPENDIX B

FLOW PATH OF NORTH CANADIAN RIVER IN OKLAHOMA

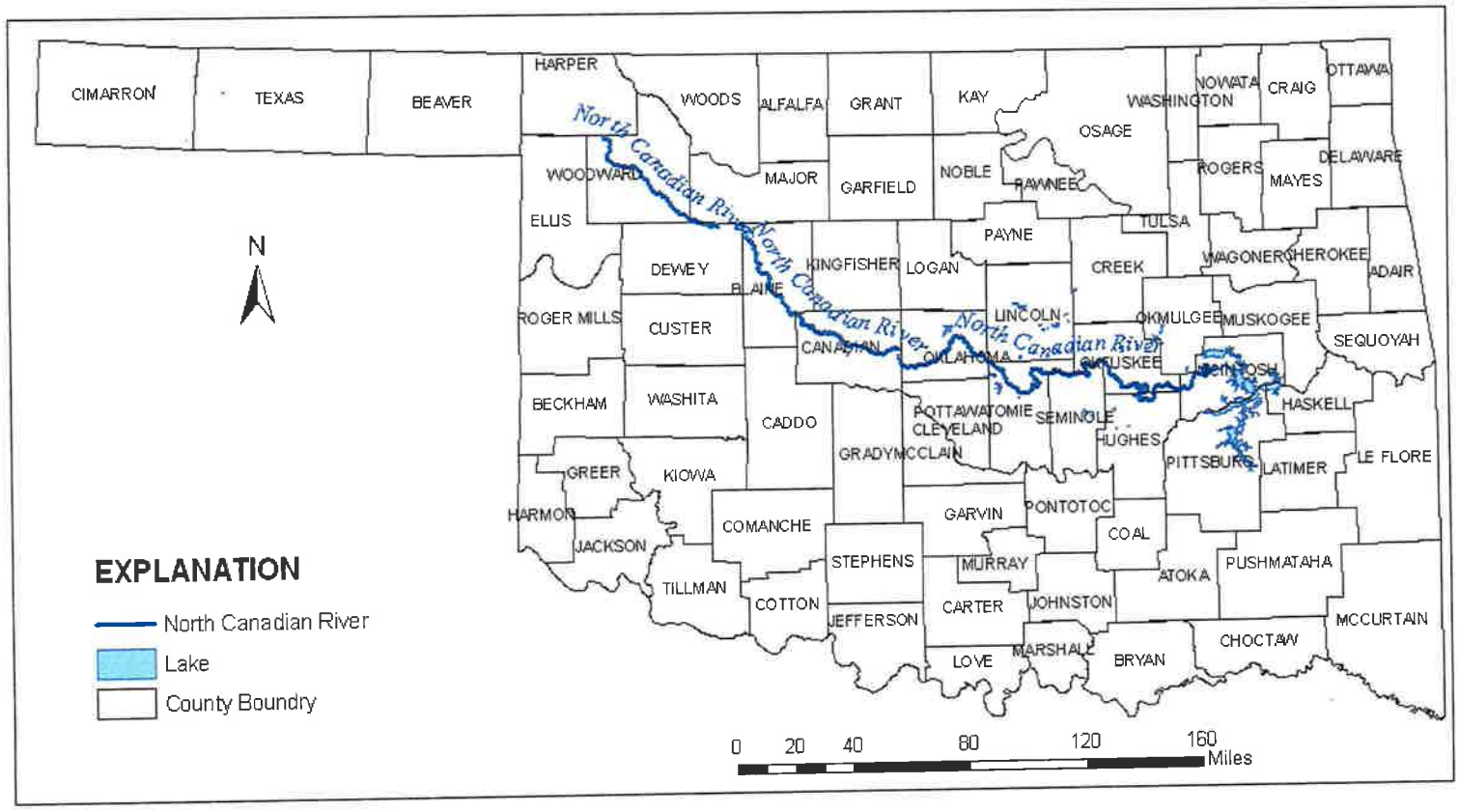
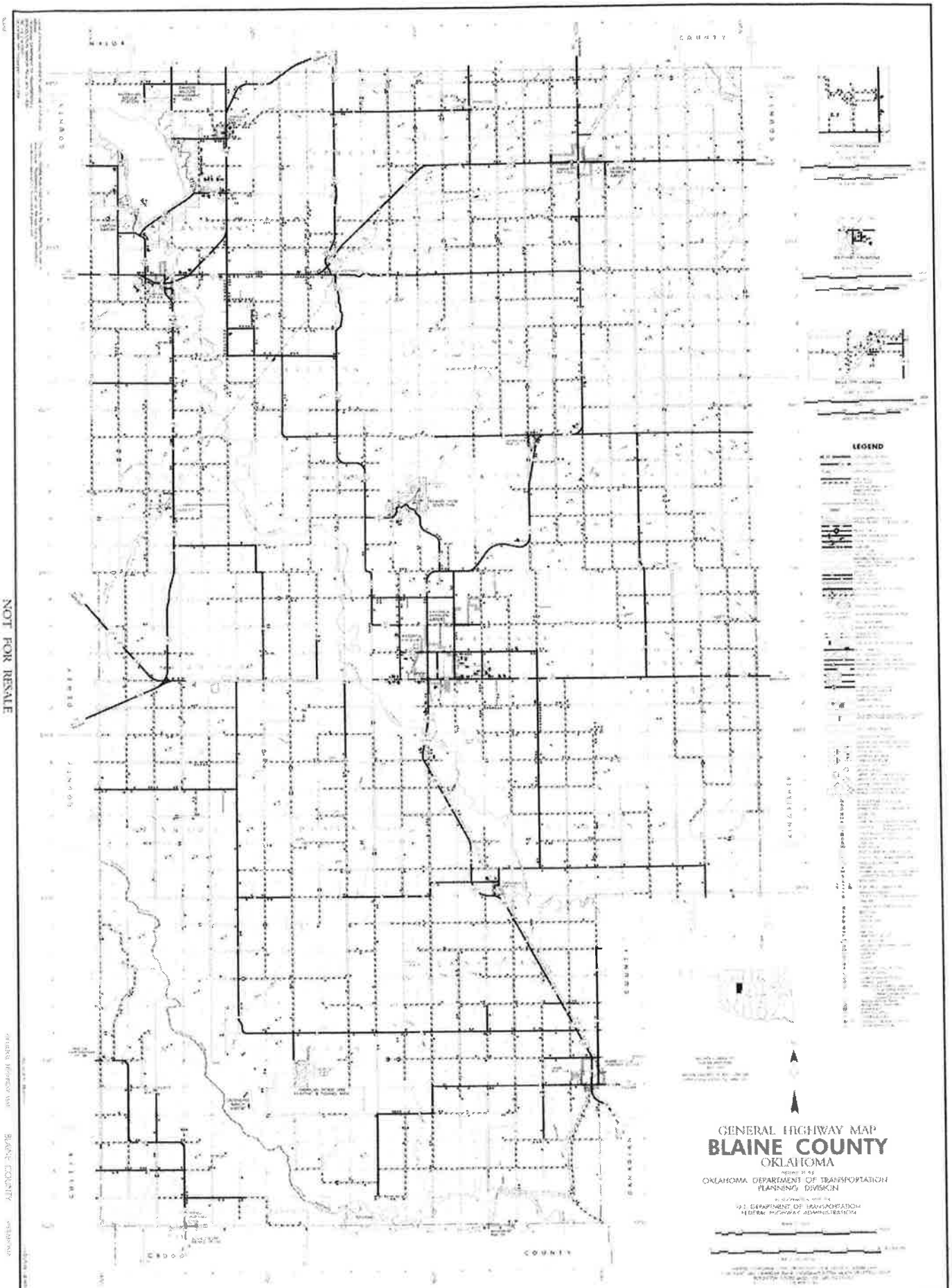


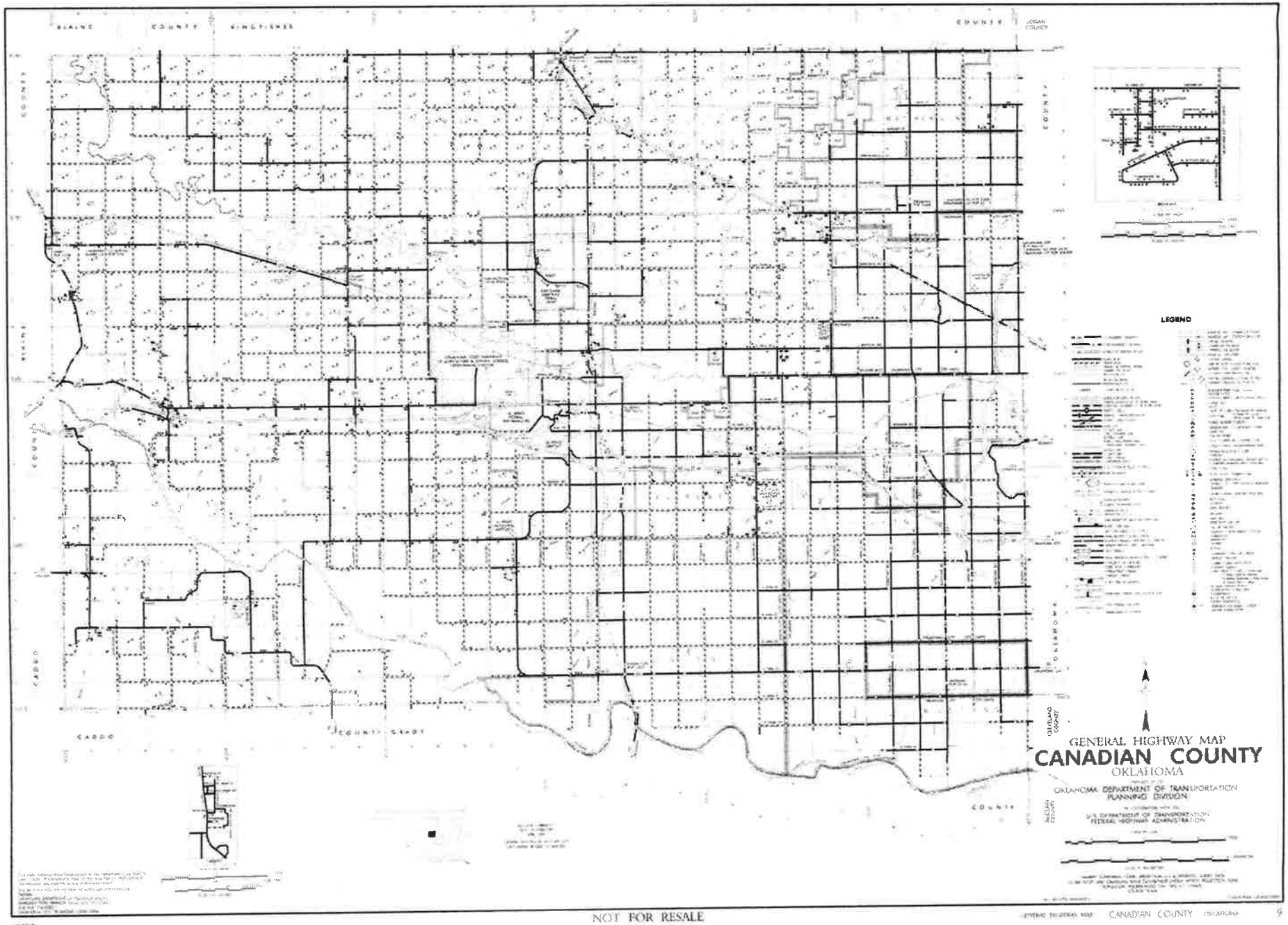
Figure B-1. Flowpath of North Canadian River in Oklahoma

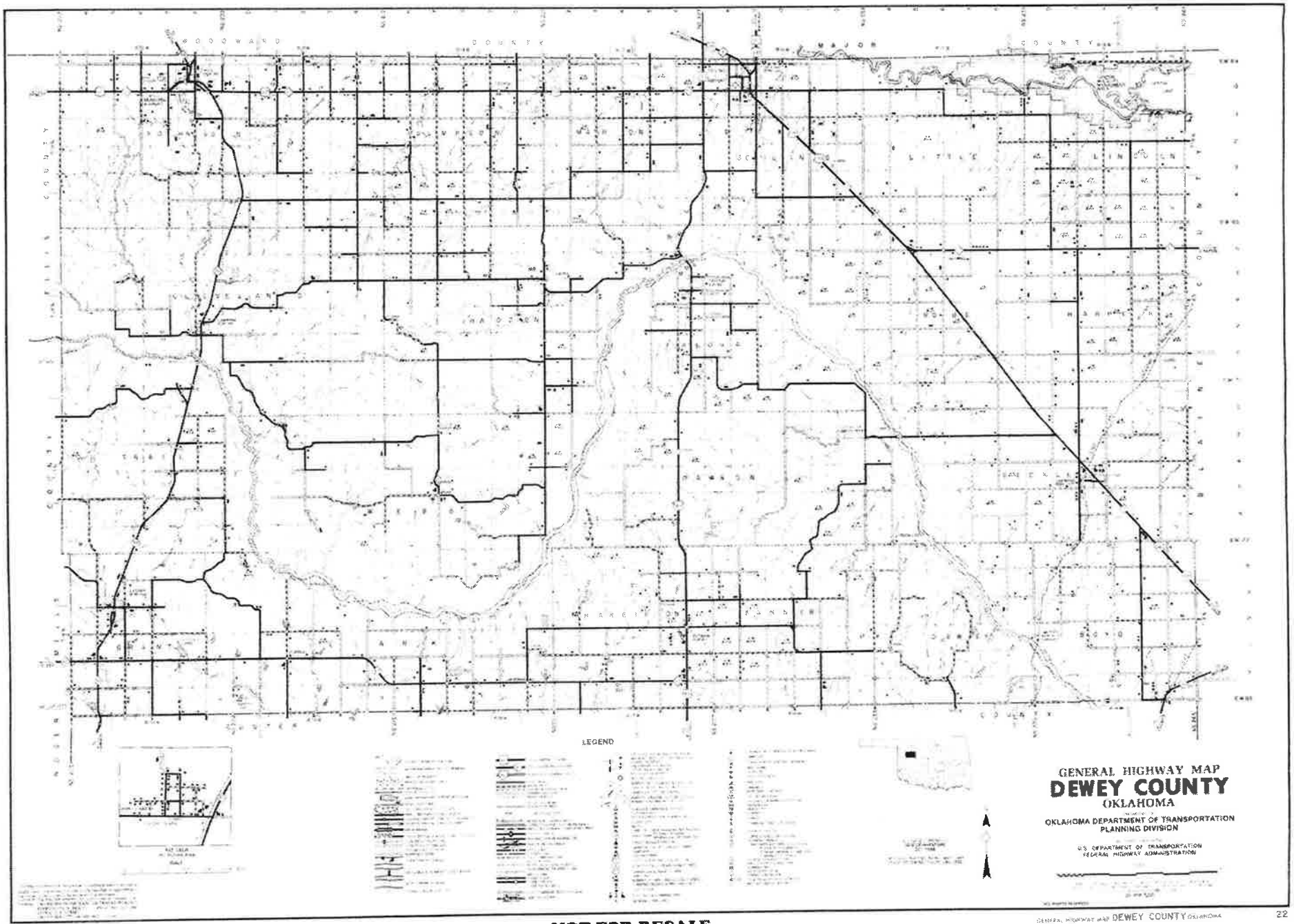
QUAD MAP LEGEND
NORTH CANADIAN RIVER, OKLAHOMA

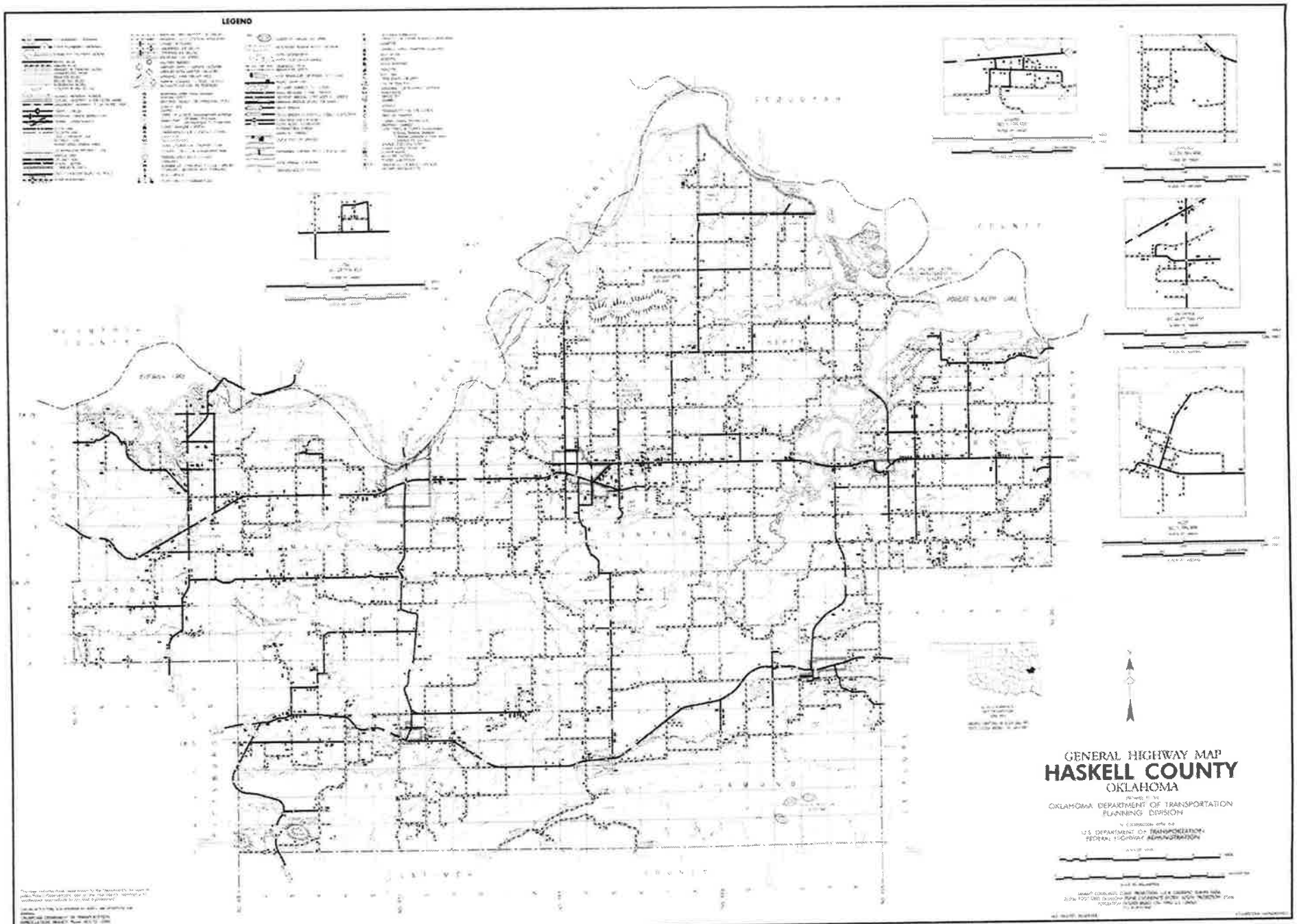
Source: http://www.okladot.state.ok.us/hqdiv/p-r-div/maps/2003county/index.htm

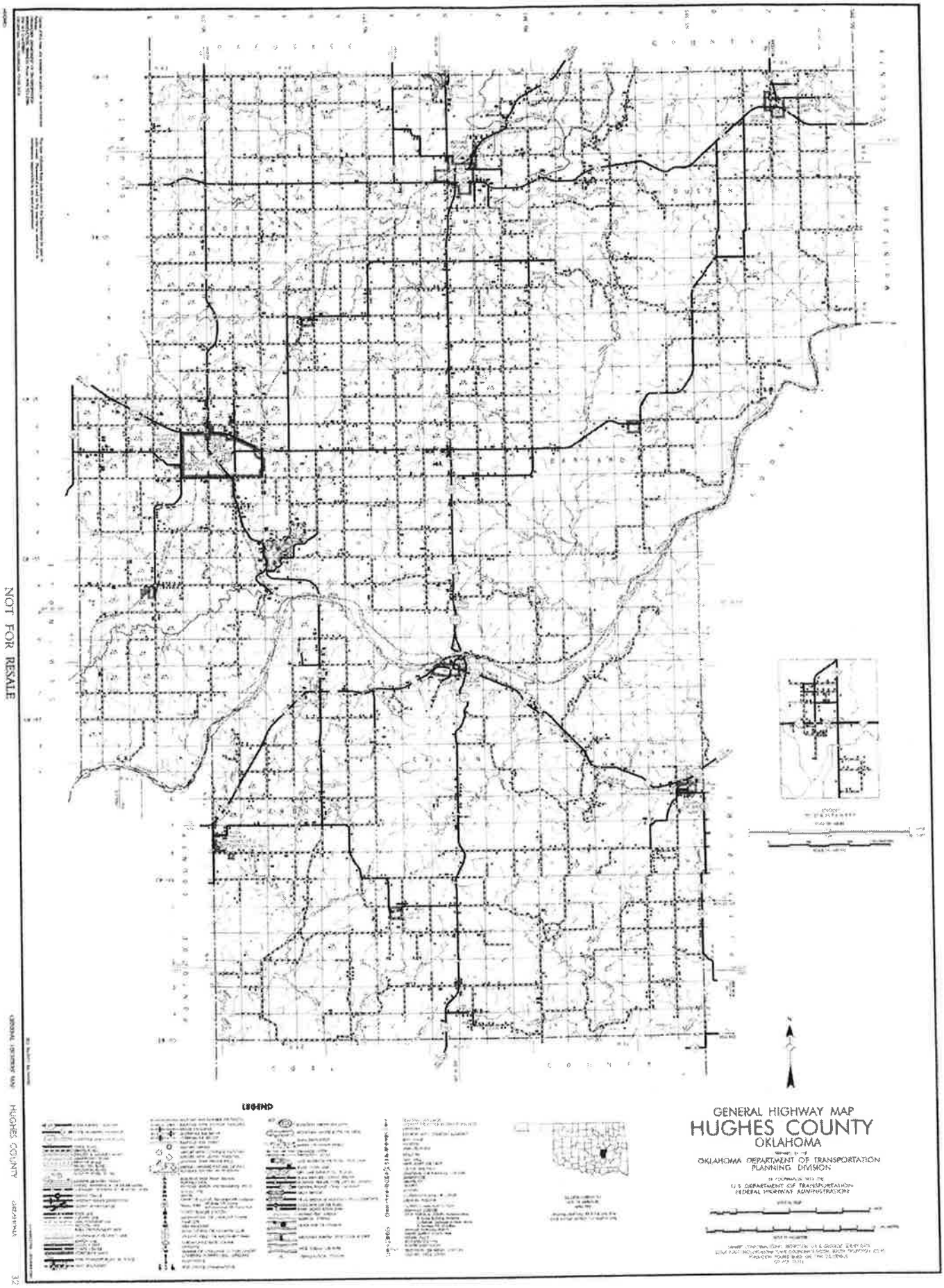
County Name
Woodward
Major
Dewey
Blaine
Canadian
Oklahoma
Pottawatomie
Seminole
Okfuskee
Hughes
McIntosh
Pittsburg
Haskell

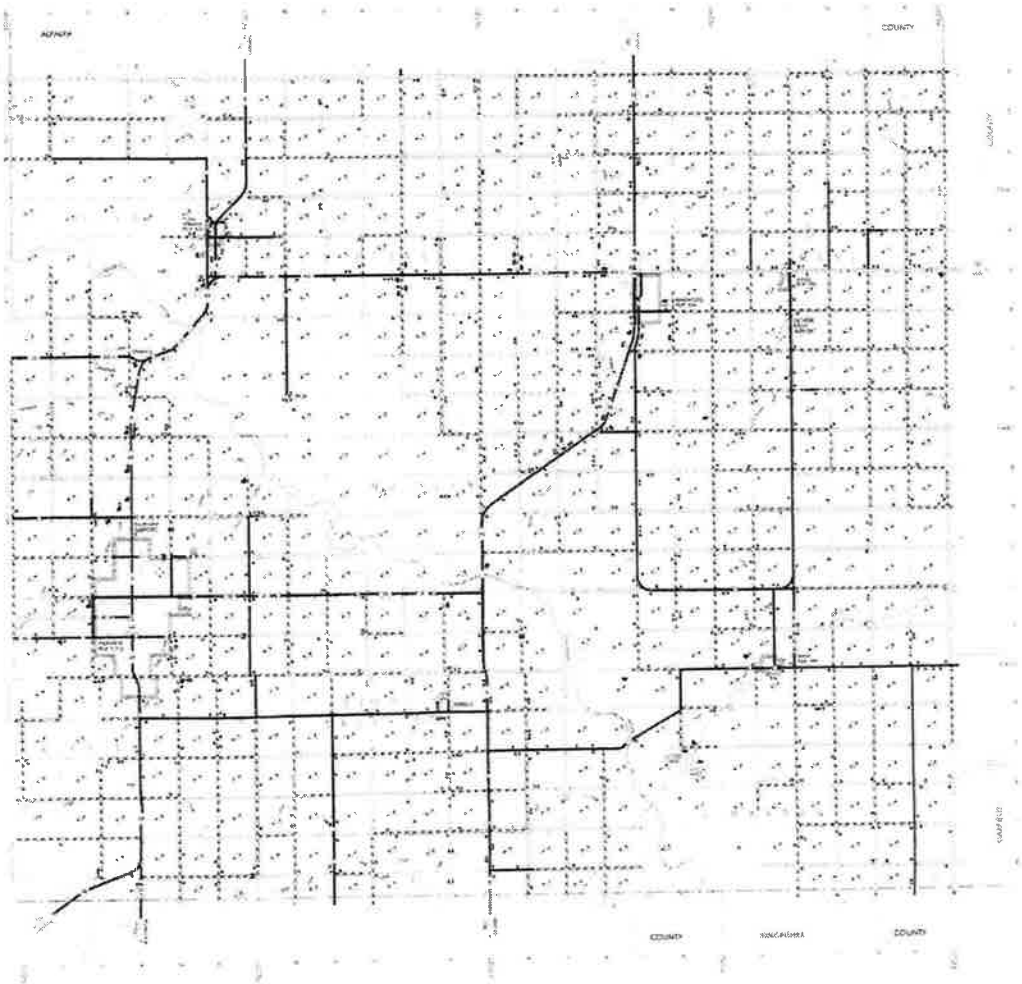


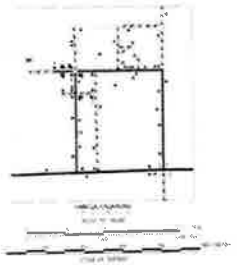












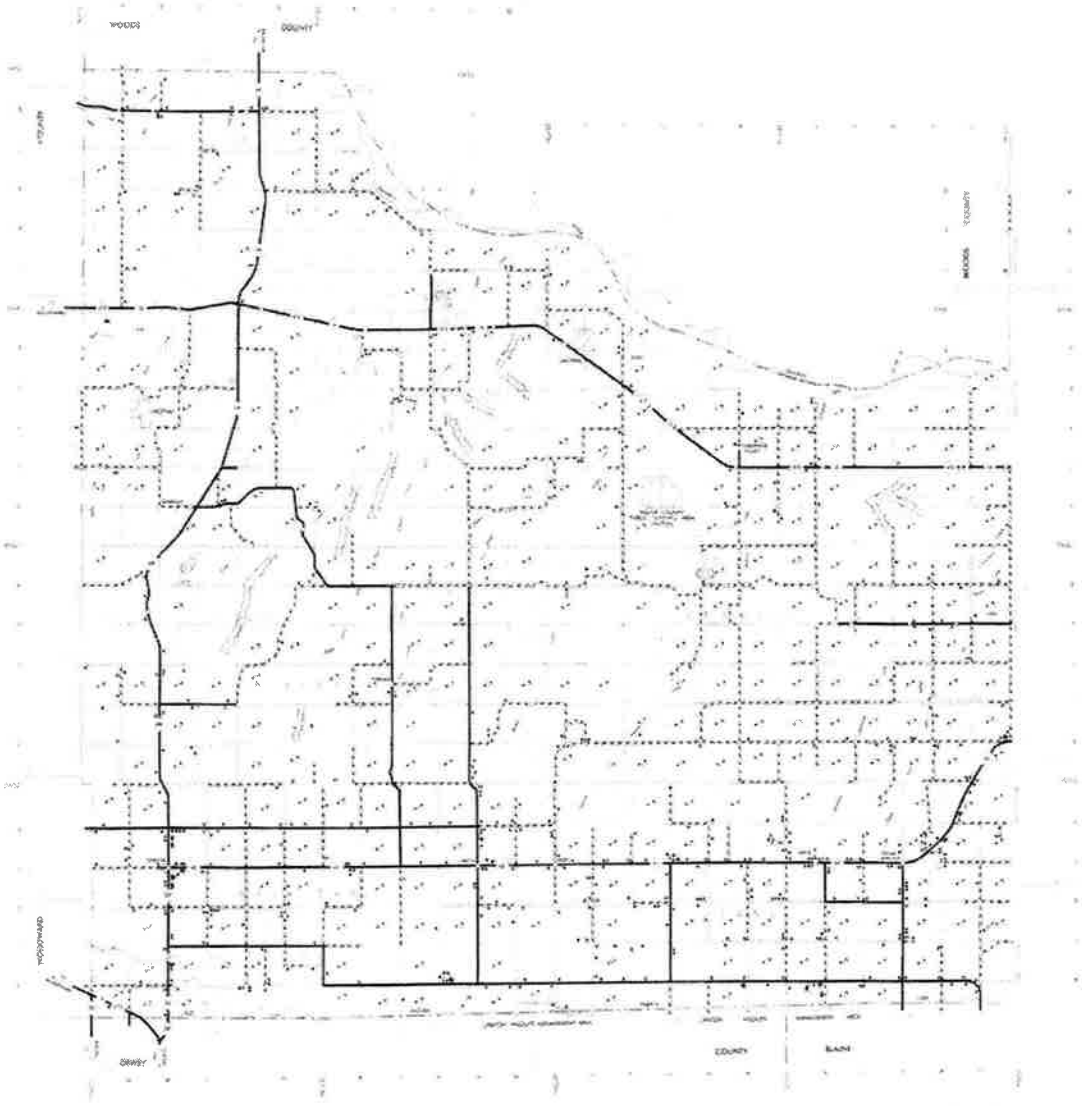
GENERAL HIGHWAY MAP

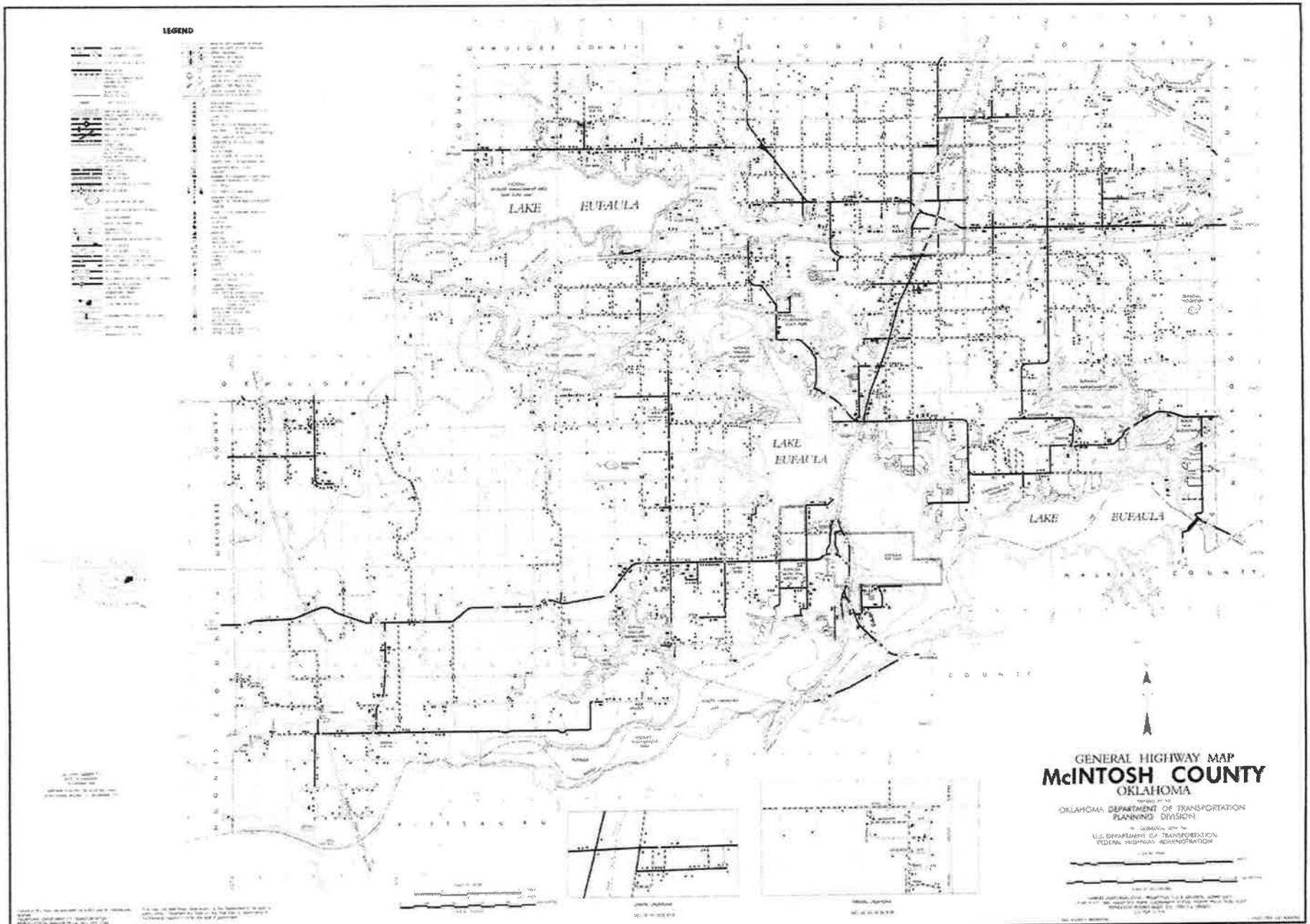
MAJOR COUNTY

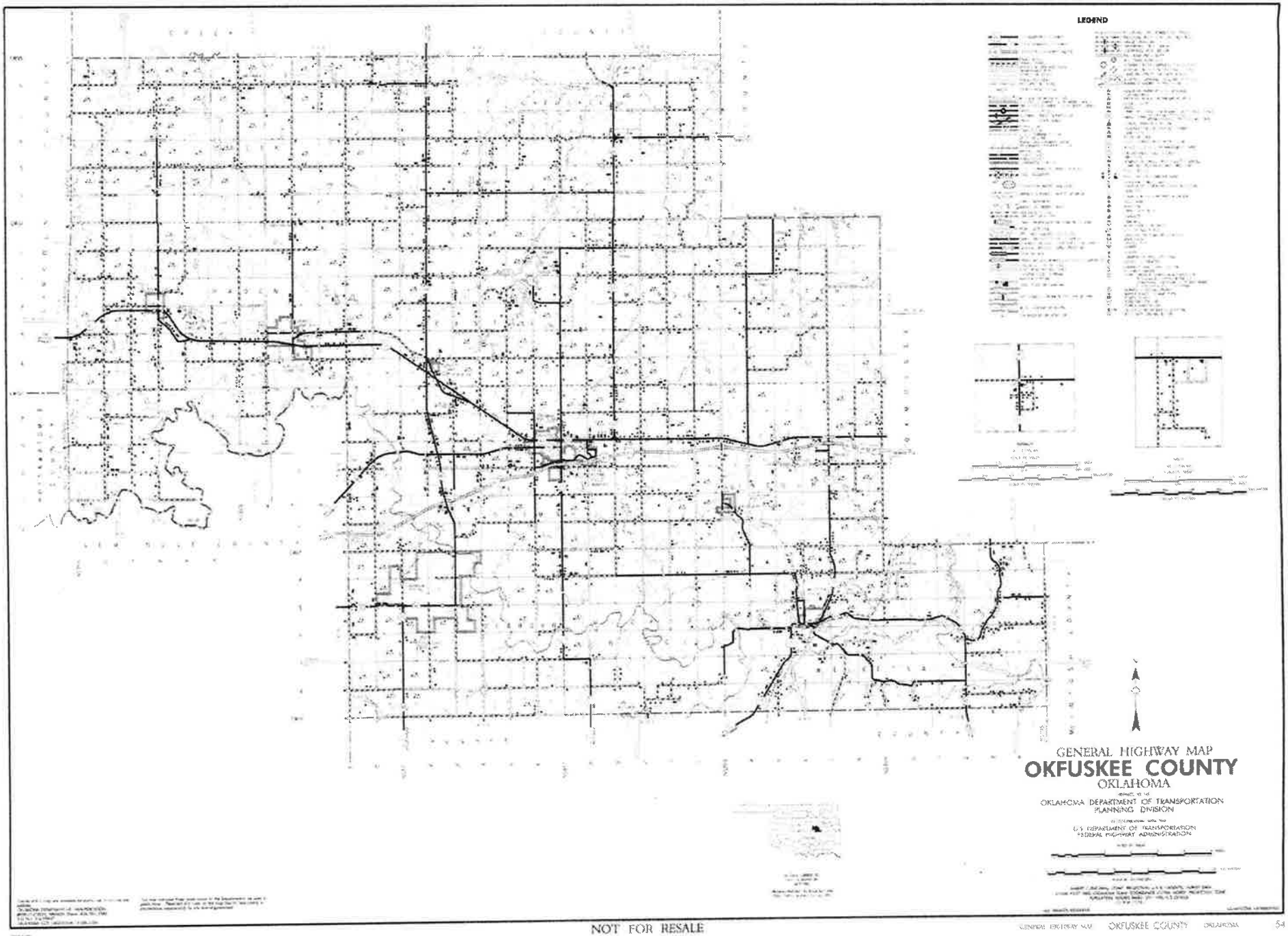
OKLAHOMA

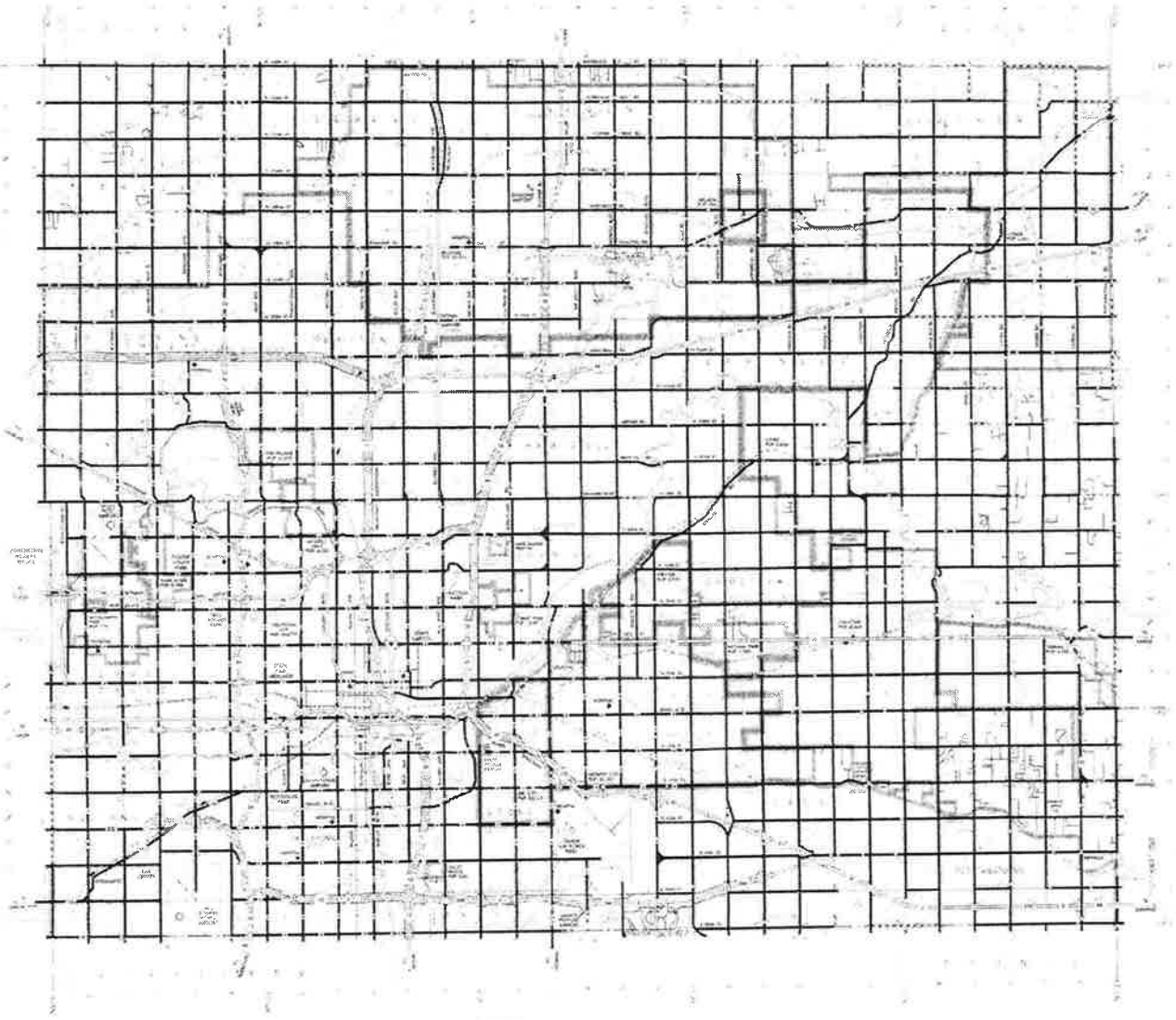
OKLAHOMA DEPARTMENT OF TRANSPORTATION
PLANNING DIVISION

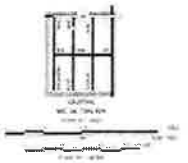
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION











LEGEND

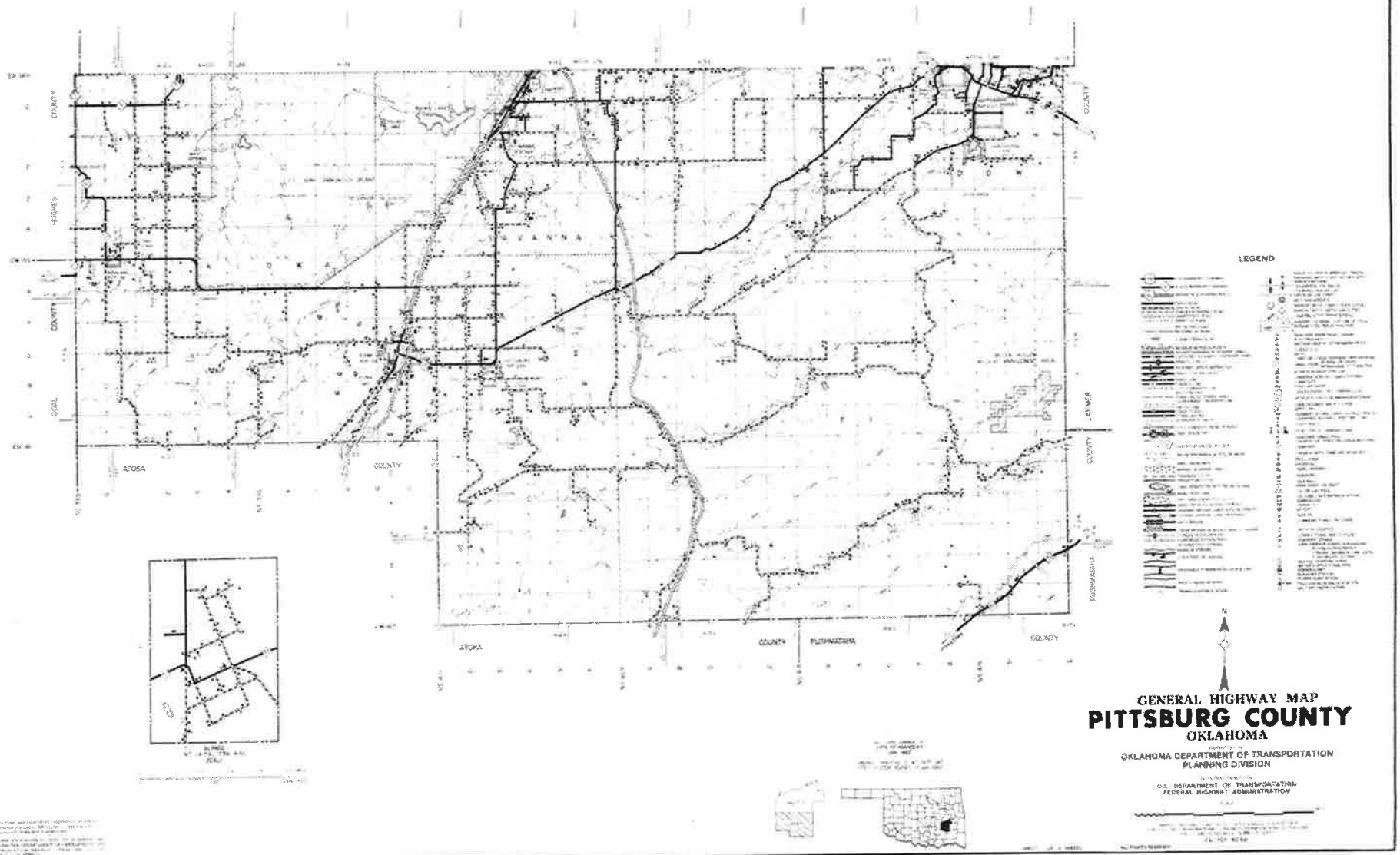
GENERAL HIGHWAY MAP

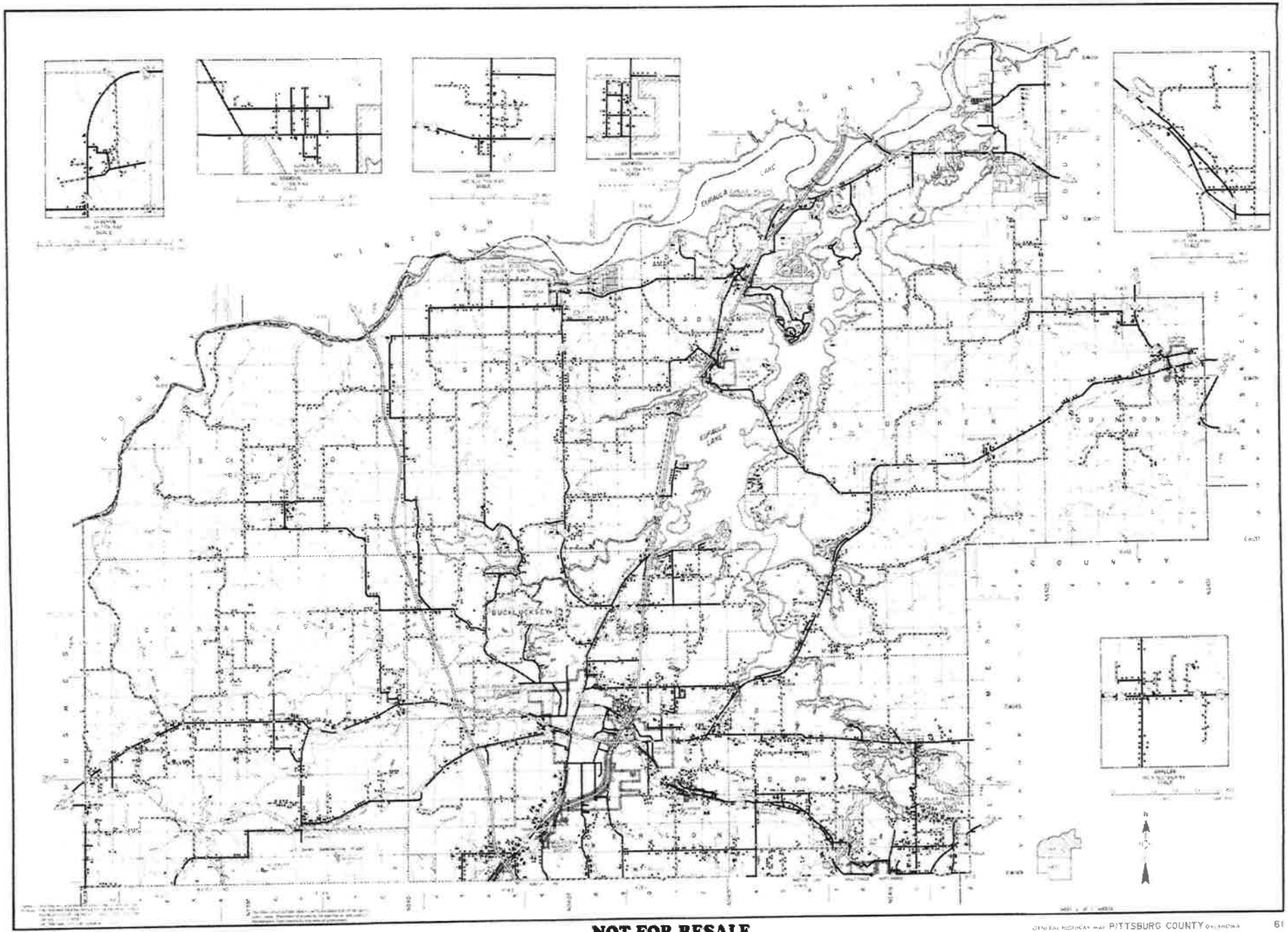
OKLAHOMA COUNTY

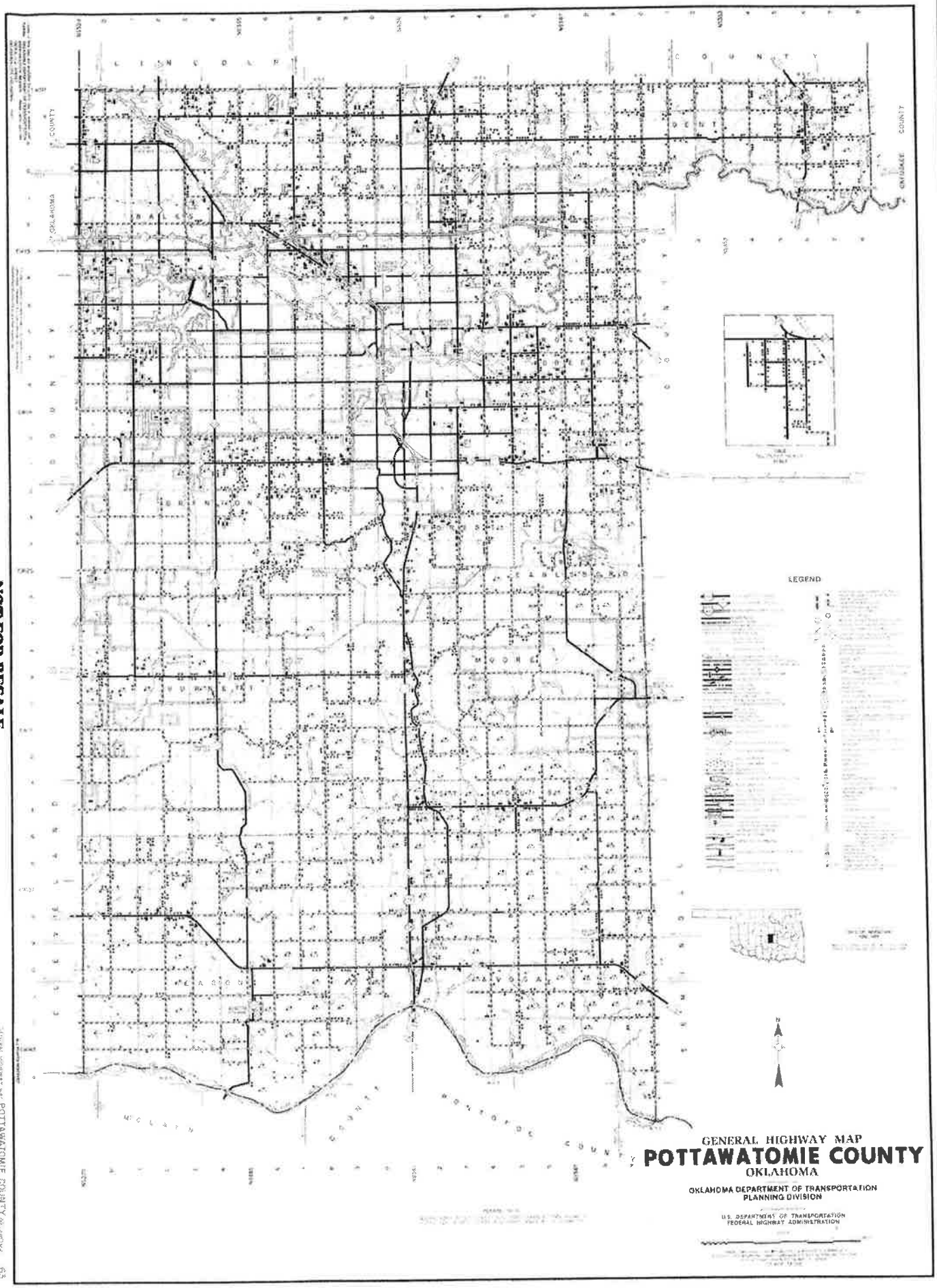
OKLAHOMA

OKLAHOMA DEPARTMENT OF TRANSPORTATION
PLANNING DIVISION

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION







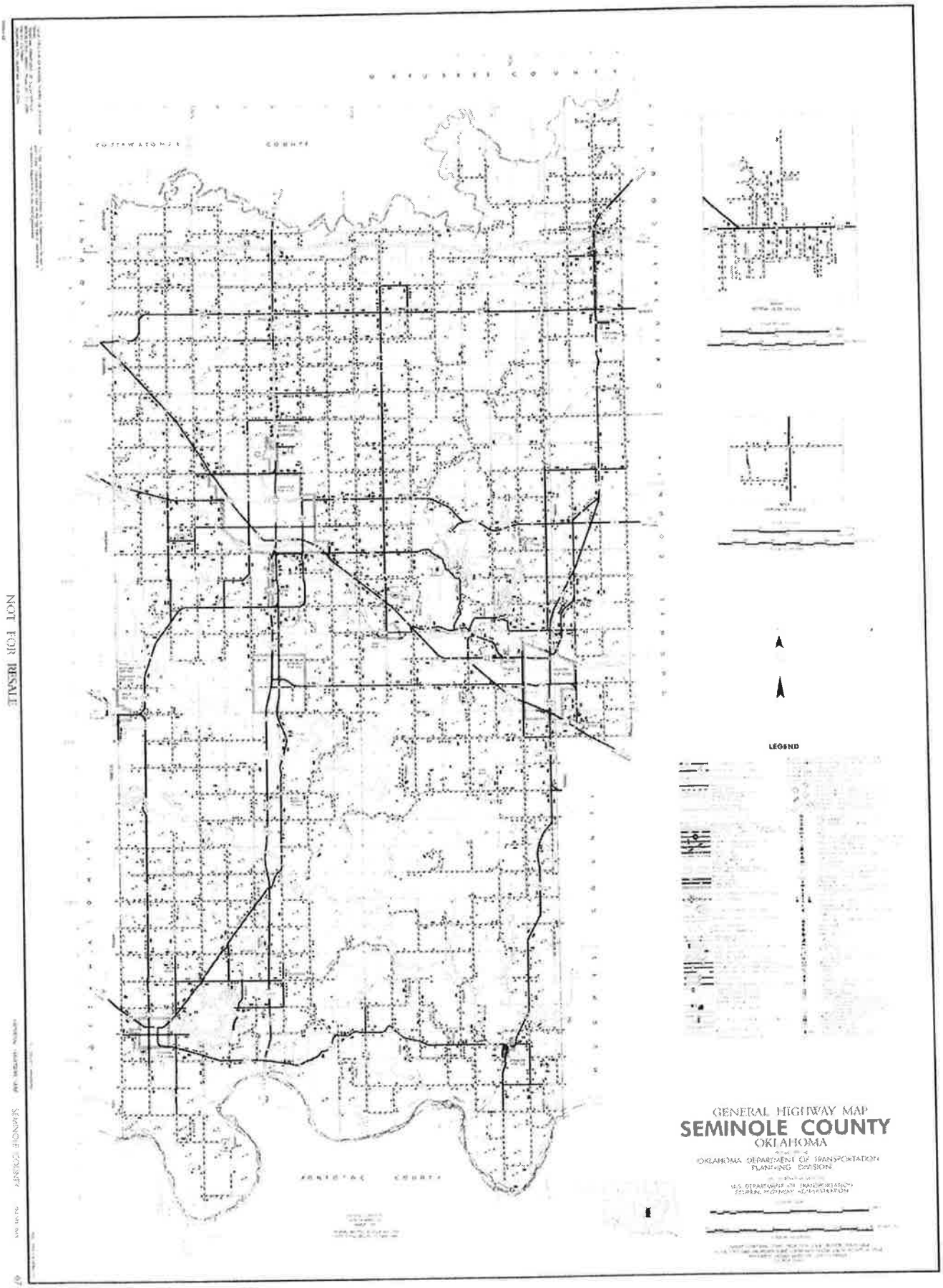
GENERAL HIGHWAY MAP

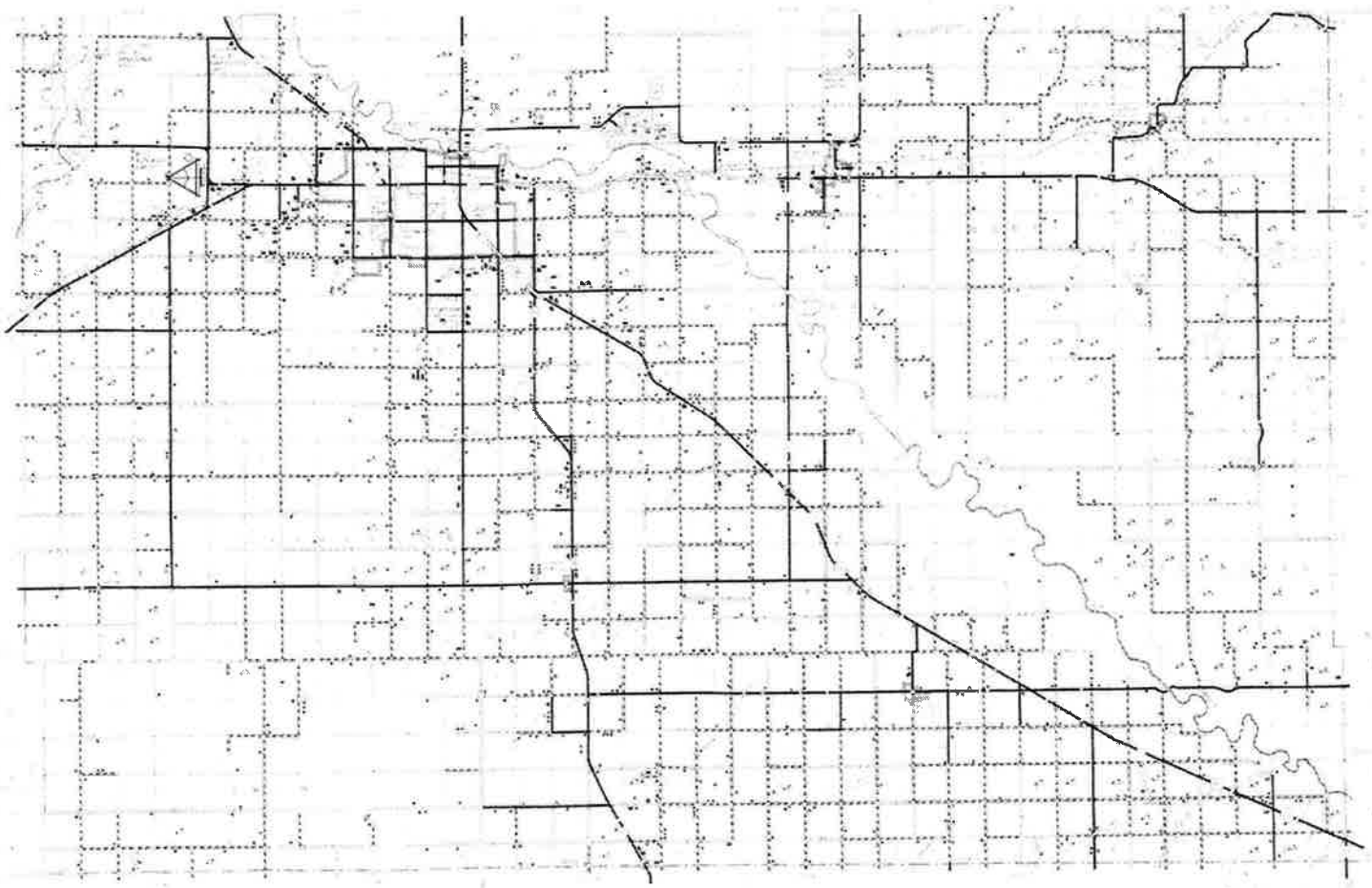
POTTAWATOMIE COUNTY

OKLAHOMA

OKLAHOMA DEPARTMENT OF TRANSPORTATION
PLANNING DIVISION

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION


LEGEND
GENERAL HIGHWAY MAP
SEMINOLE COUNTY
OKLAHOMA
OKLAHOMA DEPARTMENT OF TRANSPORTATION
PLANNING DIVISION
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION



LEGEND

GENERAL HIGHWAY MAP

WOODWARD COUNTY

OKLAHOMA

PREPARED BY THE

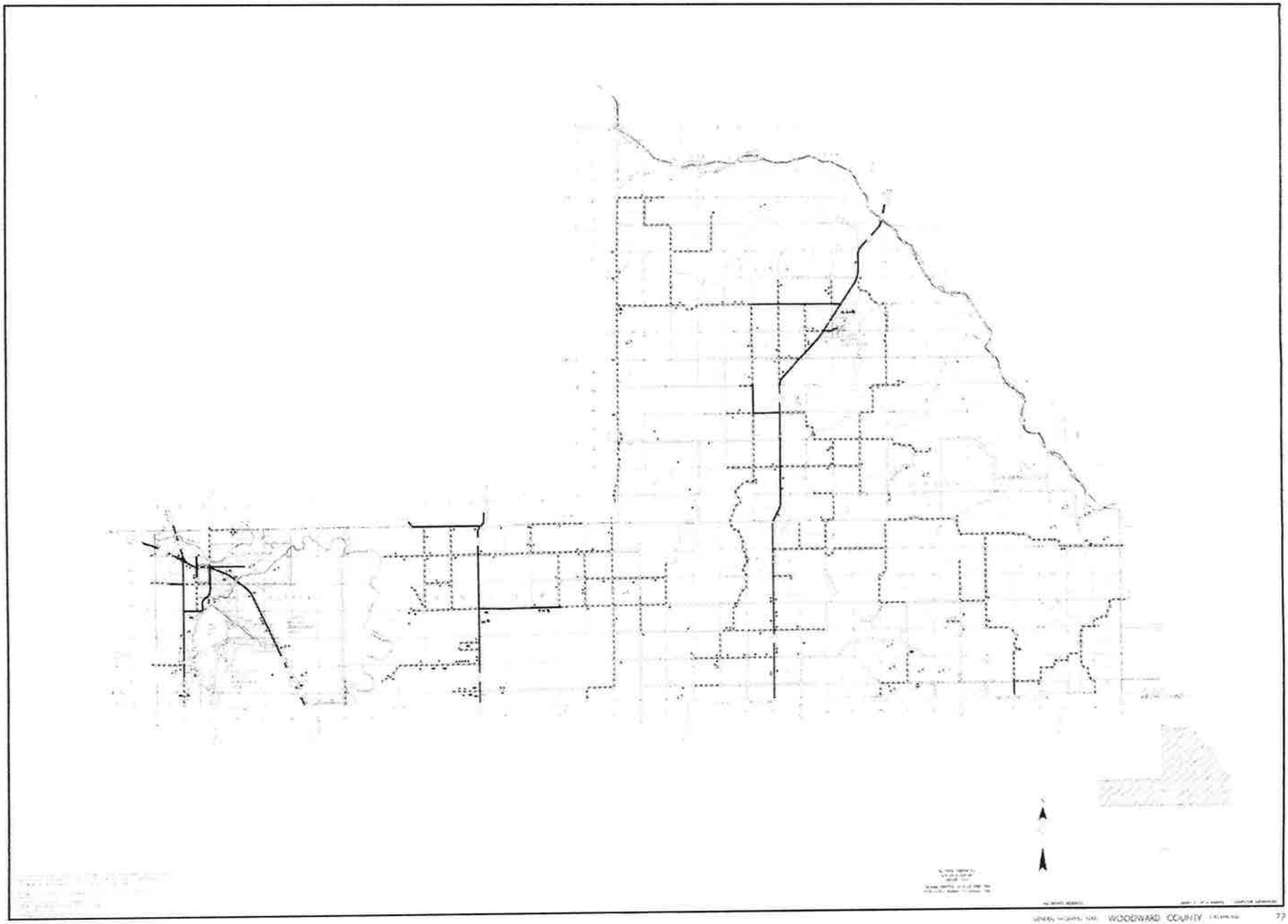
OKLAHOMA DEPARTMENT OF TRANSPORTATION

PLANNING DIVISION

IN COOPERATION WITH THE

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION



WOODWARD COUNTY

77