FINAL REPORT ~ FHWA-OK-07-06

CHANNEL-BED DEGRADATION IN MAJOR OKLAHOMA STREAMS VOLUME V OF V: WASHITA RIVER

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VOLUME V of V: WASHITA RIVER

Final Report
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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 about channel degradation in 404-mile reach of Washita River in Oklahoma. In this study, the 409.76 mile river length is divided into two Reaches: Reach 1- river station (RS1) to Foss Dam, and Reach 2- Foss Dam to RS 39. The flowlines of Washita River in Oklahoma were observed for a long period. In Reach 1, RS 3 shows the maximum degradation of 6.08 feet in 74 years. Similarly, RS 31 shows the maximum degradation of 9.61 in feet 34 years. On the other hand, channel aggradation of 22.24 feet is observed at RS 39 in Reach 2.

None of the bridges in Washita River has experienced channel bed degradation above 10 feet. Maximum degradation of 9.61 feet in 34 years in observed in river station 31 (Bridge Key b17956) on S.H. 17A. If this bridge is selected for reconstruction, it is recommended that a detailed hydraulic and geotechnical analysis should be performed.

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

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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

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I. INTRODUCTION

Natural alluvial rivers are seldom in a state of equilibrium. The fluvial process in an alluvial river is a dynamic system, subject to continuous changes such as changes in discharge, flow characteristics, sediment injection by tributaries, varying bed material, and sediment complex composition. Both human activities and natural events can disturb the stability of a river causing readjustment of the energy slope, sediment load, and cross-sectional geometry. If the streambed continues to lower as a result of the aforementioned activities it is called "degradation" and it is "aggradation" if the reverse is true.

A river channel is considered stable if the streambed does not change its average bed elevation over a relatively long river reach and a long period of time. Whether 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 adjust to the quantities of sediment and water transported so that the river bed neither degrades nor aggrades.

Most of the degradation problems in alluvial rivers are not related to natural river changes but are caused by dams or reservoirs which completely intercept the sediment (Tinney, 1962). The post-dam annual suspended-sediment load below 5 miles downstream of Gavin Points dam in Colorado River was observed to be less than 1 percent of the pre-dam load (Williams and

Wolman, 1985). As a result of dam or reservoir construction on a river, the river downstream of a dam or reservoir begins to scour, lowering the channel bed as the sediment-depleted water emerging from the dam attempts to replenish its sediment load. Graf (1999) reports that the impact of dams on river discharge is several times greater than impacts deemed likely as a result of global climate change. Physical changes to stream channels below dams can range from bed degradation and narrowing, to changes in channel-bed texture or armouring, to bed aggradation, bar construction, and channel widening, to no measureable changes whatsoever (Petts, 1979; Wolman, 1984; Chien, 1985; Gilvear and Winterbottom, 1992; Collier et al., 1985; Fassnacth and McClure, 2003).

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

Washita River is a left bank tributary of the Red River which originates in the Texas Panhandle, northwestern Texas, and flows east across the Oklahoma boundary, entering Oklahoma in Roger Mills County, then southeast to south-central Oklahoma, and south into Lake Texoma. With a drainage area of 8,018 square miles (20,767 square km), the river extends over 626 miles.

In Oklahoma, Washita River flows through twelve counties: Rogers Mills, Custer, Washita, Kiowa, Caddo, Grady, Garvin, Murray, Carter, Johnston, Marshall, and Bryan. This study covers the middle 404 miles of the Washita River between State Highway 30, 6 miles downstream of the Oklahoma-Texas, and State Highway 19, just upstream of Lake Texoma (Fig.1). The Washita River in the study reach is characterized by meandering, medium hard shale, fine & coarse sand-mix, and a sandy soil channel. The channel slope averages about 3.3 feet per mile and river-bank height varies from 15 to 60 feet. Throughout the study reach, Washita River has been impounded by Foss reservoir.

According to Oklahoma Water Resources Board (1990), the Foss Lake Dam is on the Washita River at mile 474.4 in Custer County about 6 miles east of Foss, Oklahoma. The Lake has a shore length of about 63 miles, a drainage area of 1,496 square miles and the flood pool capacity of about 436,810 acre-feet. The lake occupies 8,800 acres of area for a conservation pool.

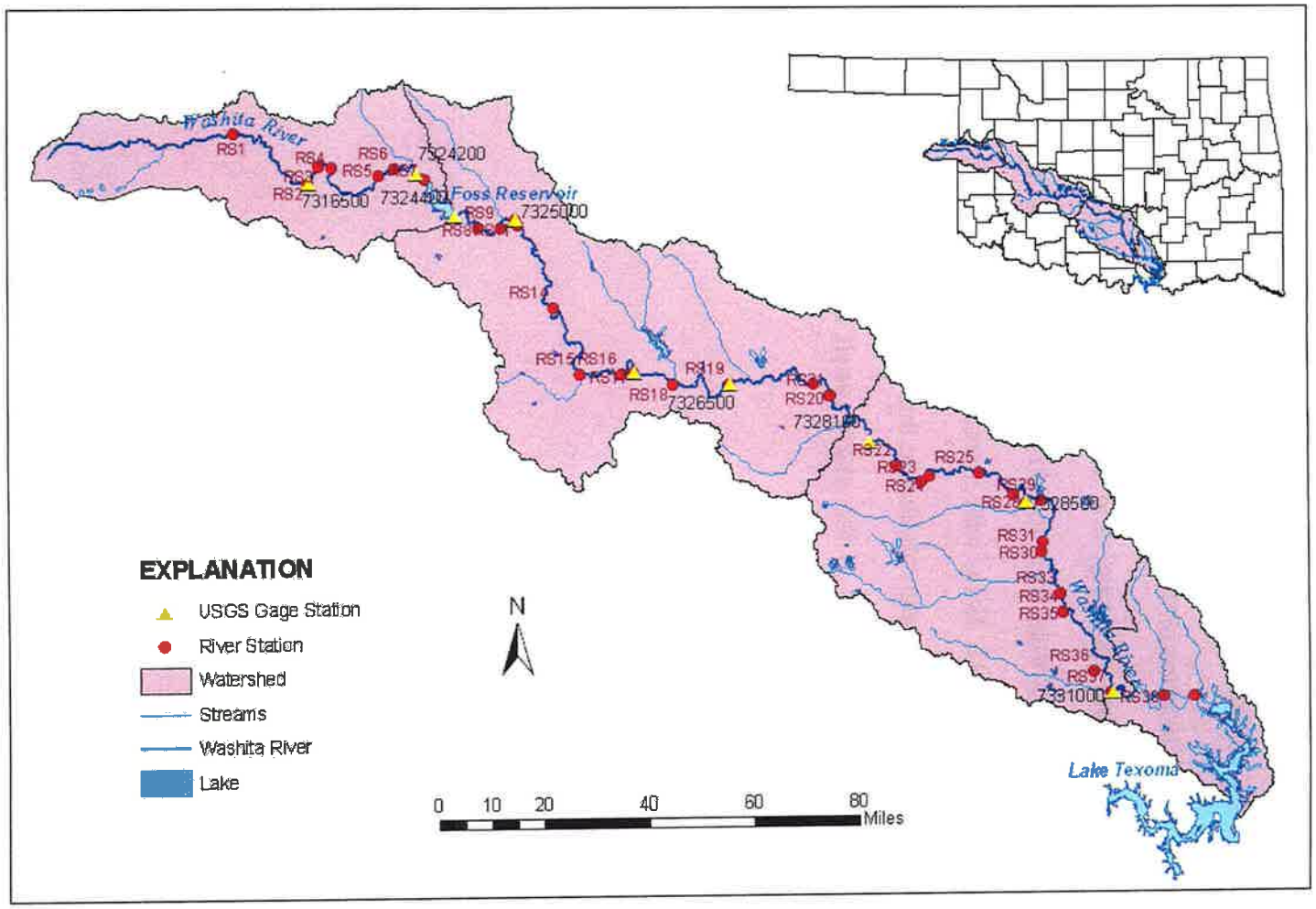


Figure 1. Location of study points and USGS gage stations along the Washita River

III. HYDROLOGY

When the hydrology of the stream changes, it results in changes to the physical characteristics of the stream. Such changes include stream channel-bed degradation, stream widening, and stream bank erosion. As the stream profile degrades and the stream tries to widen to accommodate higher flows, stream bank erosions increase along with increases in sediment loads. USGS stream flow gage stations have been studied in the study reach. Currently there are nine active USGS gage stations in the study reach of Washita River in Oklahoma (Fig.1).

Table 1. Description of USGS gage stations

Data Locations and descriptions	Data Available
USGS 07316500 Washita River near Cheyenne, OK Roger Mills County, Oklahoma Hydrologic Unit Code 11130301 Latitude 35°37'35", Longitude 99°40'05" NAD27 Drainage area 794 square miles Contributing drainage area 794 square miles Gage datum 1,900.98 feet above sea level NGVD29	1934-2007
USGS 07324200 Washita River near Hammon, OK Custer County, Oklahoma Hydrologic Unit Code 11130301 Latitude 35°39'23", Longitude 99°18'21" NAD27 Drainage area 1,387 square miles Contributing drainage area 1,387 square miles Gage datum 1,643.22 feet above sea level NGVD29	1969-2007
USGS 07324400 Washita River near Foss, OK Custer County, Oklahoma Hydrologic Unit Code 11130302 Latitude 35°32'20", Longitude 99°10'10" NAD27 Drainage area 1,551 square miles Contributing drainage area 1,551 square miles Gage datum 1,560 feet above sea level NGVD29	1956-2007
USGS 07325500 Washita River at Carnegie, OK Caddo County, Oklahoma Hydrologic Unit Code 11130302 Latitude 35°07'02", Longitude 98°33'49" NAD27 Drainage area 3,129 square miles Gage datum 1,244.23 feet above sea level NGVD29	1937-2007

Table 1. Continued

Data Locations and descriptions	Data Available
USGS 07325500 Washita River at Carnegie, OK Caddo County, Oklahoma Hydrologic Unit Code 11130302 Latitude 35°07'02", Longitude 98°33'49" NAD27 Drainage area 3,129 square miles Gage datum 1,244.23 feet above sea level NGVD29	1937-2007
USGS 07326500 Washita River at Anadarko, OK Caddo County, Oklahoma Hydrologic Unit Code 11130302 Latitude 35°05'03", Longitude 98°14'35" NAD27 Drainage area 3,656 square miles Contributing drainage area 3,656 square miles Gage datum 1,150.00 feet above sea level NGVD29	1903-2007
USGS 07328100 Washita River at Alex, OK Grady County, Oklahoma Hydrologic Unit Code 11130303 Latitude 34°55'33", Longitude 97°46'25" NAD27 Drainage area 4,787 square miles Contributing drainage area 4,787 square miles Gage datum 990.00 feet above sea level NGVD29	1964-2007
USGS 07328500 Washita River near Pauls Valley, OK Garvin County, Oklahoma Hydrologic Unit Code 11130303 Latitude 34°45'17", Longitude 97°15'04" NAD27 Drainage area 5,330 square miles Contributing drainage area 5,330 square miles Gage datum 854.61 feet above sea level NGVD29	1937-2007

Table 1. Continued

Data Locations and descriptions	Data Available
USGS 07331000 Washita River near Dickson, OK Carter County, Oklahoma Hydrologic Unit Code 11130303 Latitude 34°14'00", Longitude 96°58'32" NAD27 Drainage area 7,202 square miles Contributing drainage area 7,202 square miles Gage datum 650.57 feet above sea level NGVD29	1928-2007

Annual peak discharge is the annual instantaneous maximum discharge. Changes in land use and urbanization can affect flood discharge which affect on the size and stability of channels. Systematic increases or decreases in the magnitude of annual peak discharges along with the slope and width of the stream channel can cause stream beds to either degrade or aggrade. The maximum scour should occur during peak discharge due to the greater stream power on the channel-bed and the shear stress (Capesius and Lehman, 2001). To study the stream-bed scour, annual peak discharges plots were downloaded from USGS gage stations to evaluate past flood occurrences. Large peak stream flows were recorded at different time periods. Table 2 shows the large peak flows at different USGS gage stations.

Table 2. Peak flows recorded at USGS gage stations (USGS)

Locations	Peak flows (cfs)	Year
Cheyenne	69,800	1954
Hammon	167,000	1934
Foss	14,000	1957
Clinton	90,000 66,800	1934 1951
Carnegie	40,600	1954, 1984
Anadarko	52,800	1995
Alex	48,300	1957
Pauls Valley	35,800	1957
Dickson	118,000	1990

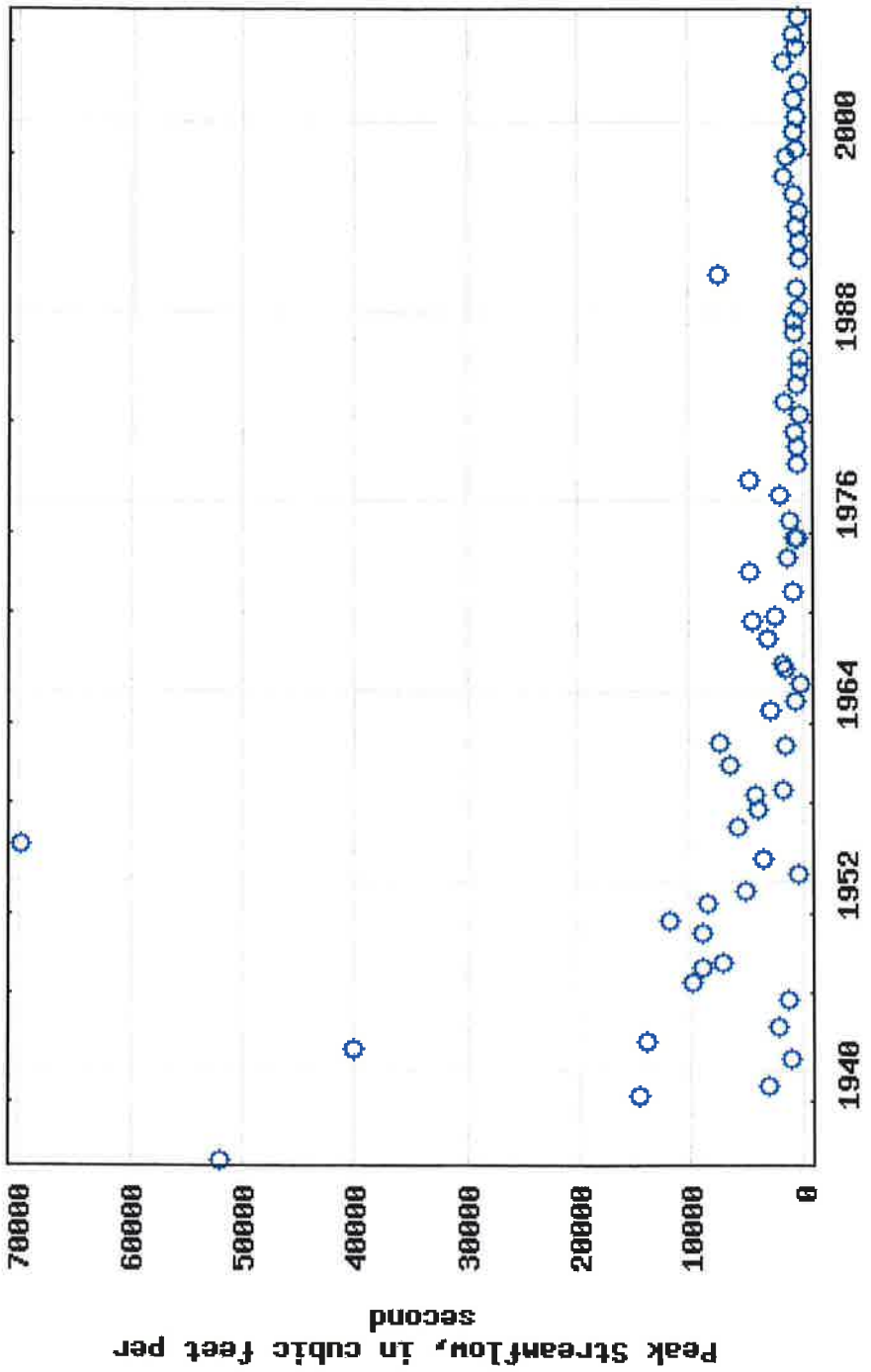


Figure 2. Annual peak streamflow, the Washita River at Cheyenne (USGS 07316500), OK

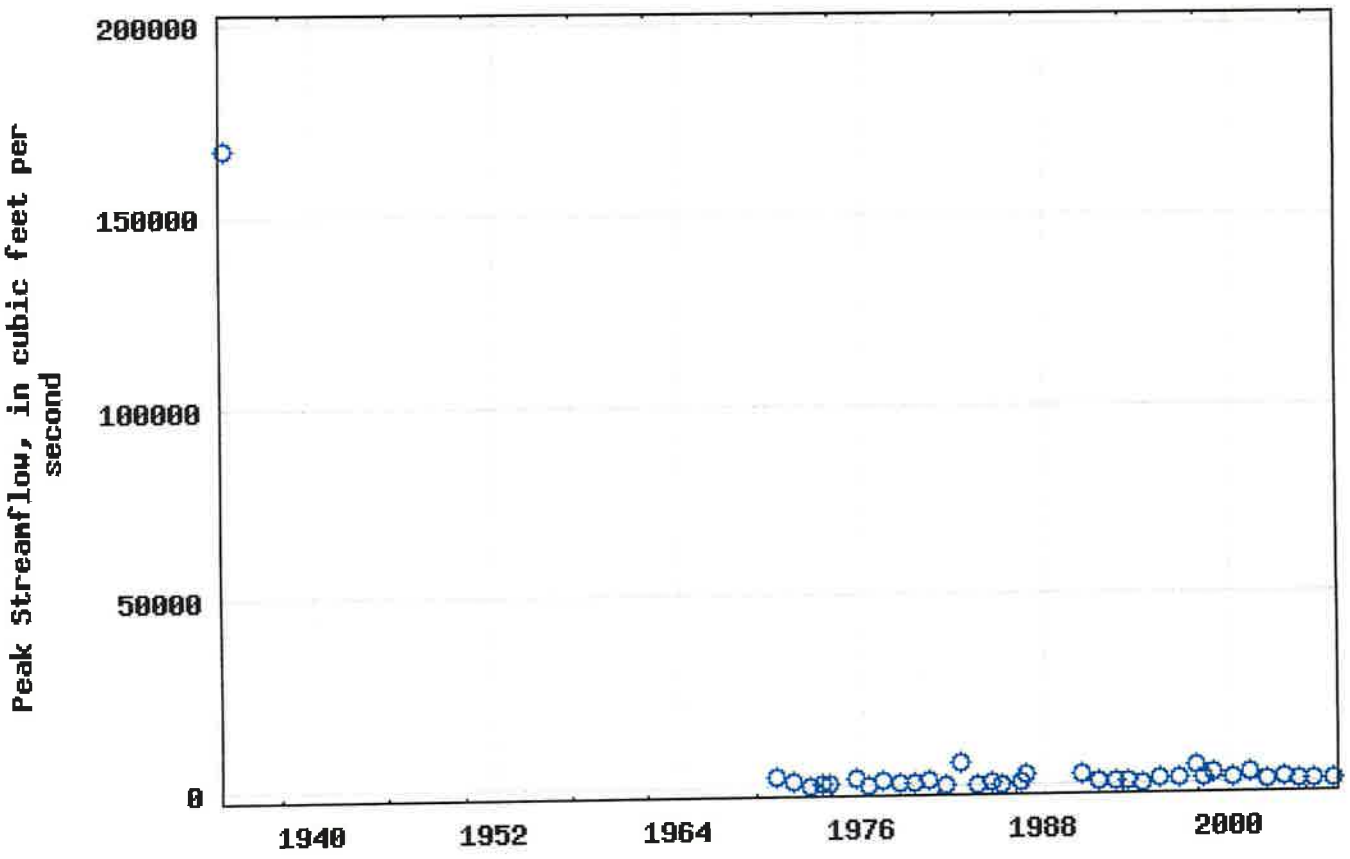


Figure 3. Annual peak streamflow, the Washita River at Hammon (USGS 07324200), OK

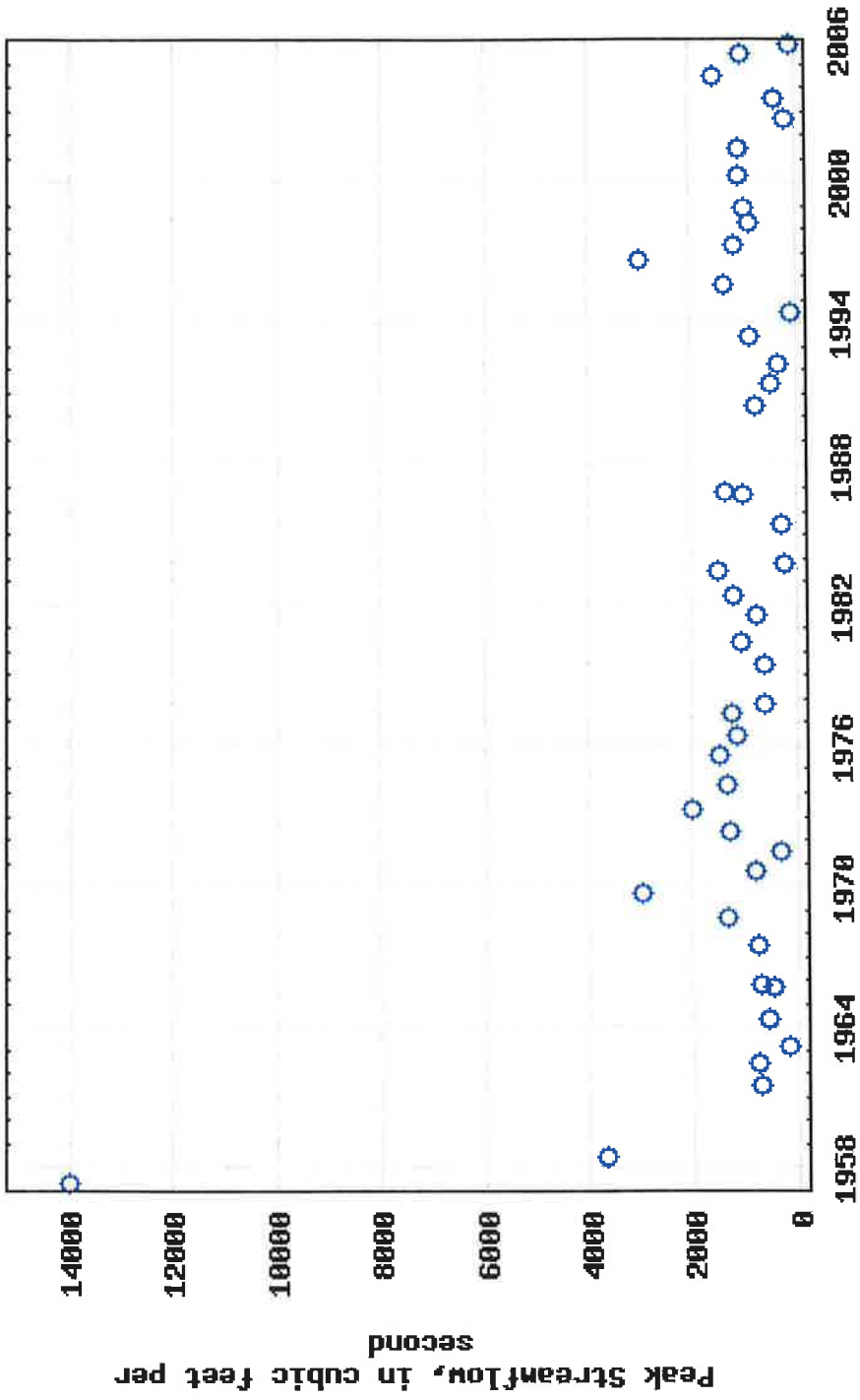


Figure 4. Annual peak streamflow, the Washita River at Foss (USGS 07324400), OK

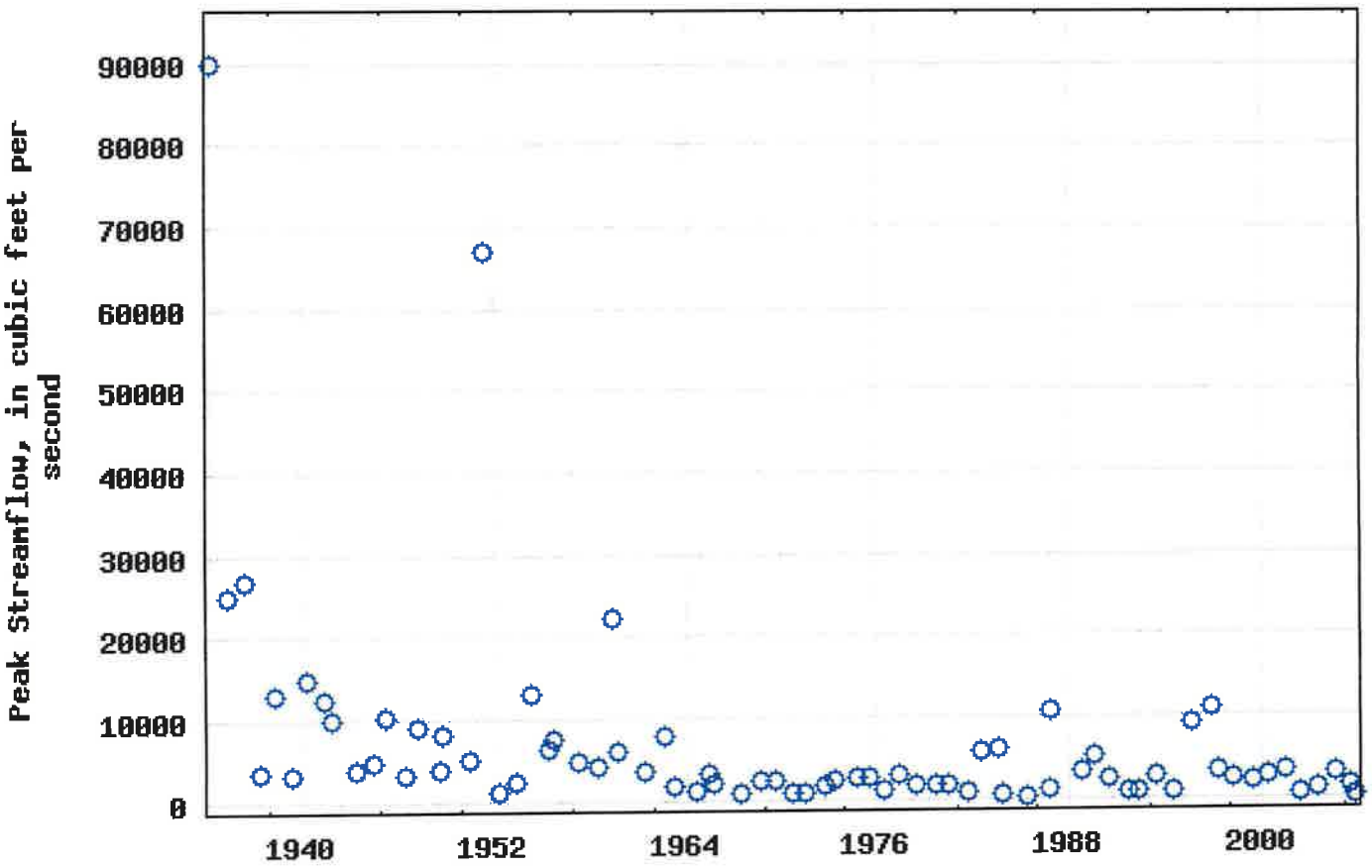


Figure 5. Annual peak streamflow, the Washita River at Clinton (USGS 07325000), OK

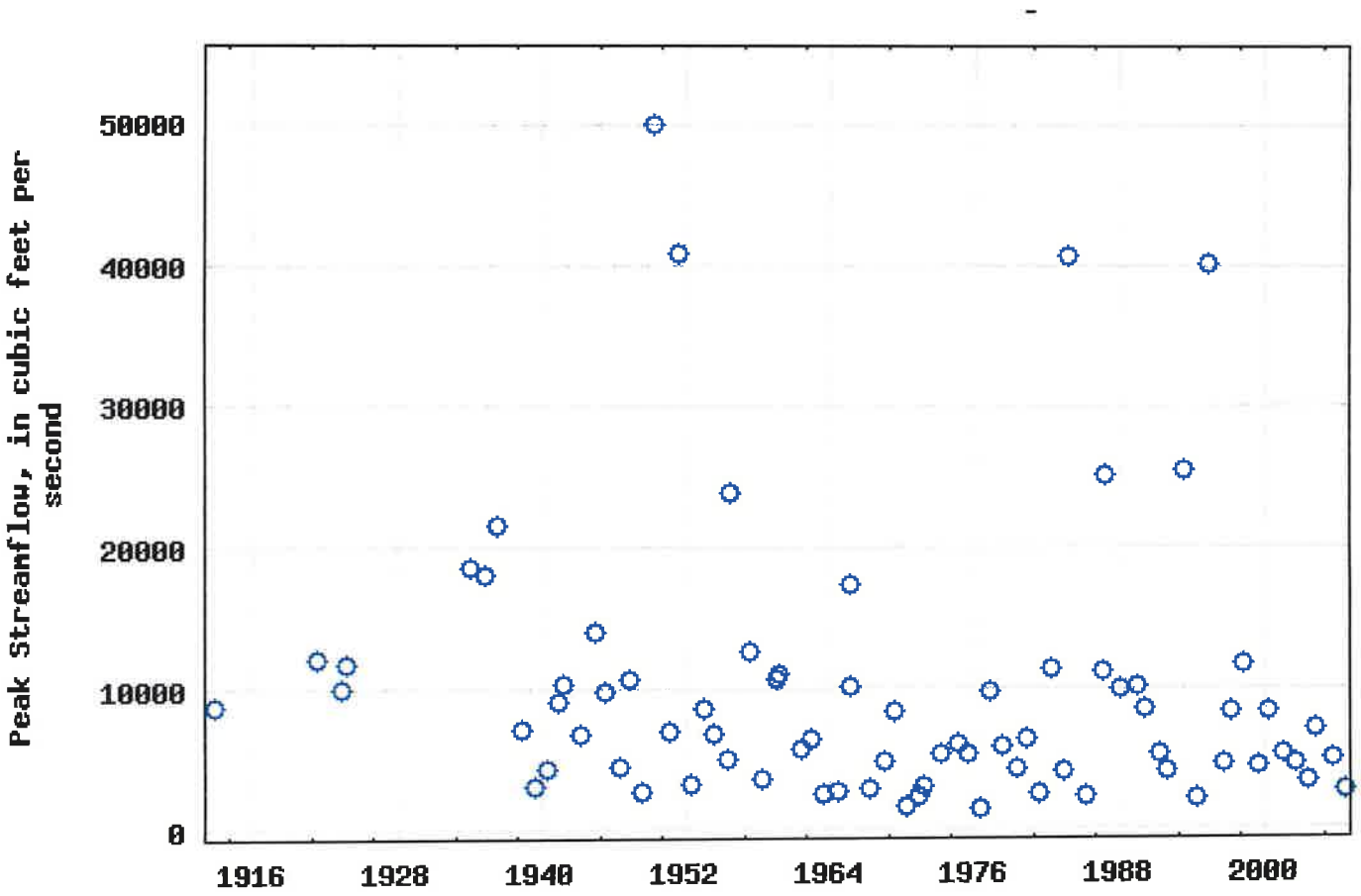


Figure 6. Annual peak streamflow, the Washita River at Carnegie (USGS 07325500), OK

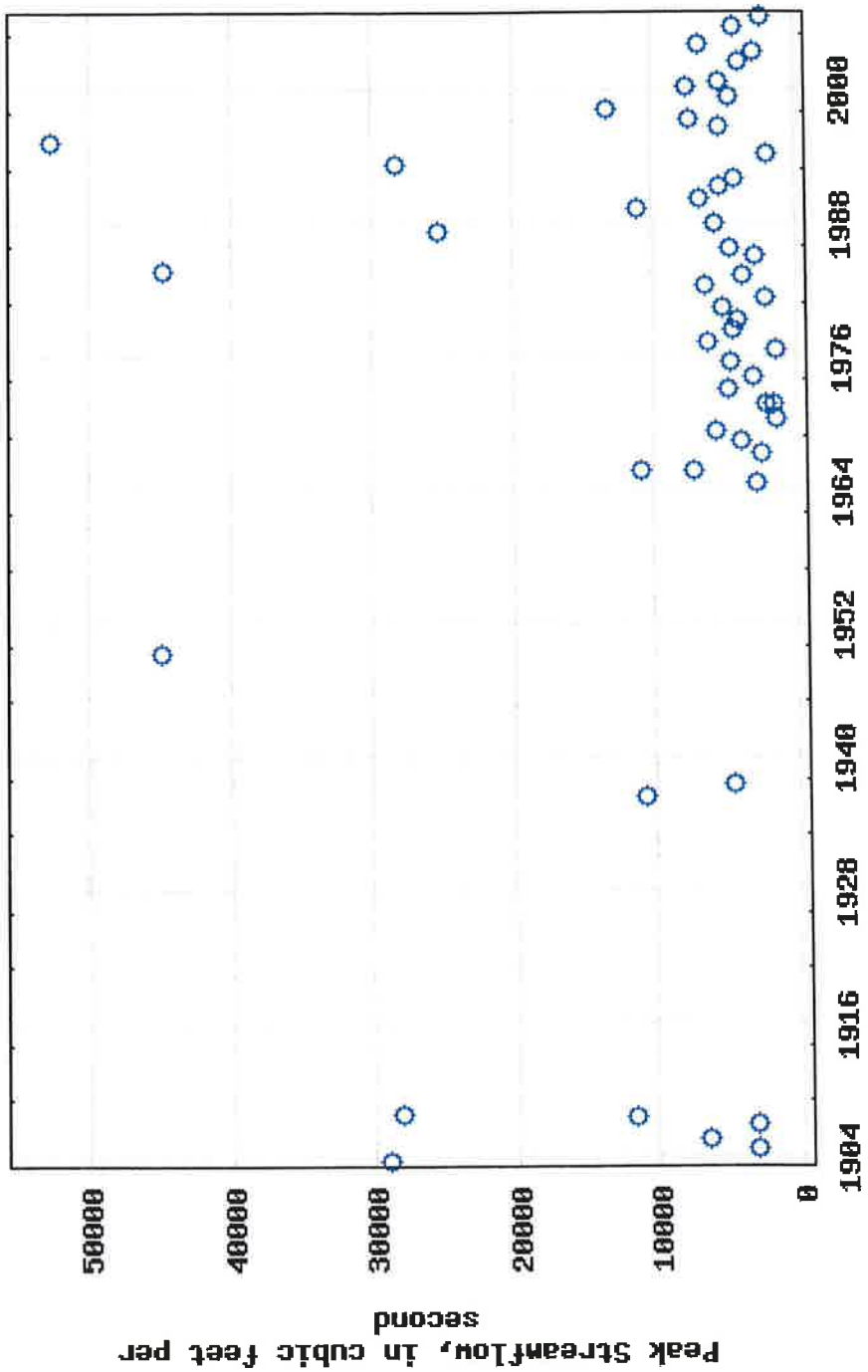


Figure 7. Annual peak streamflow, the Washita River at Anadarko (USGS 07326500), OK

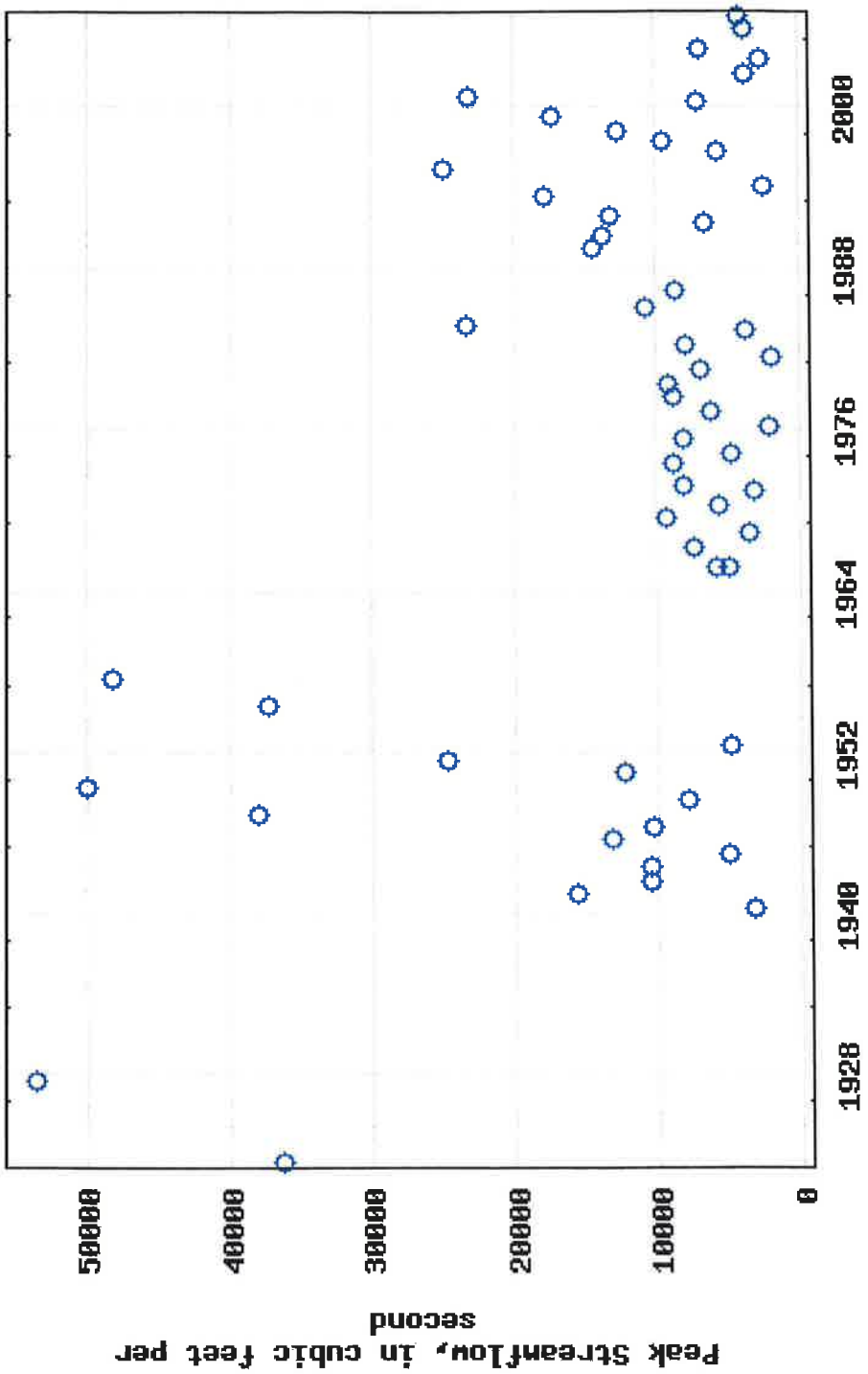


Figure 8. Annual peak streamflow, the Washita River at Alex (USGS 07328100), OK

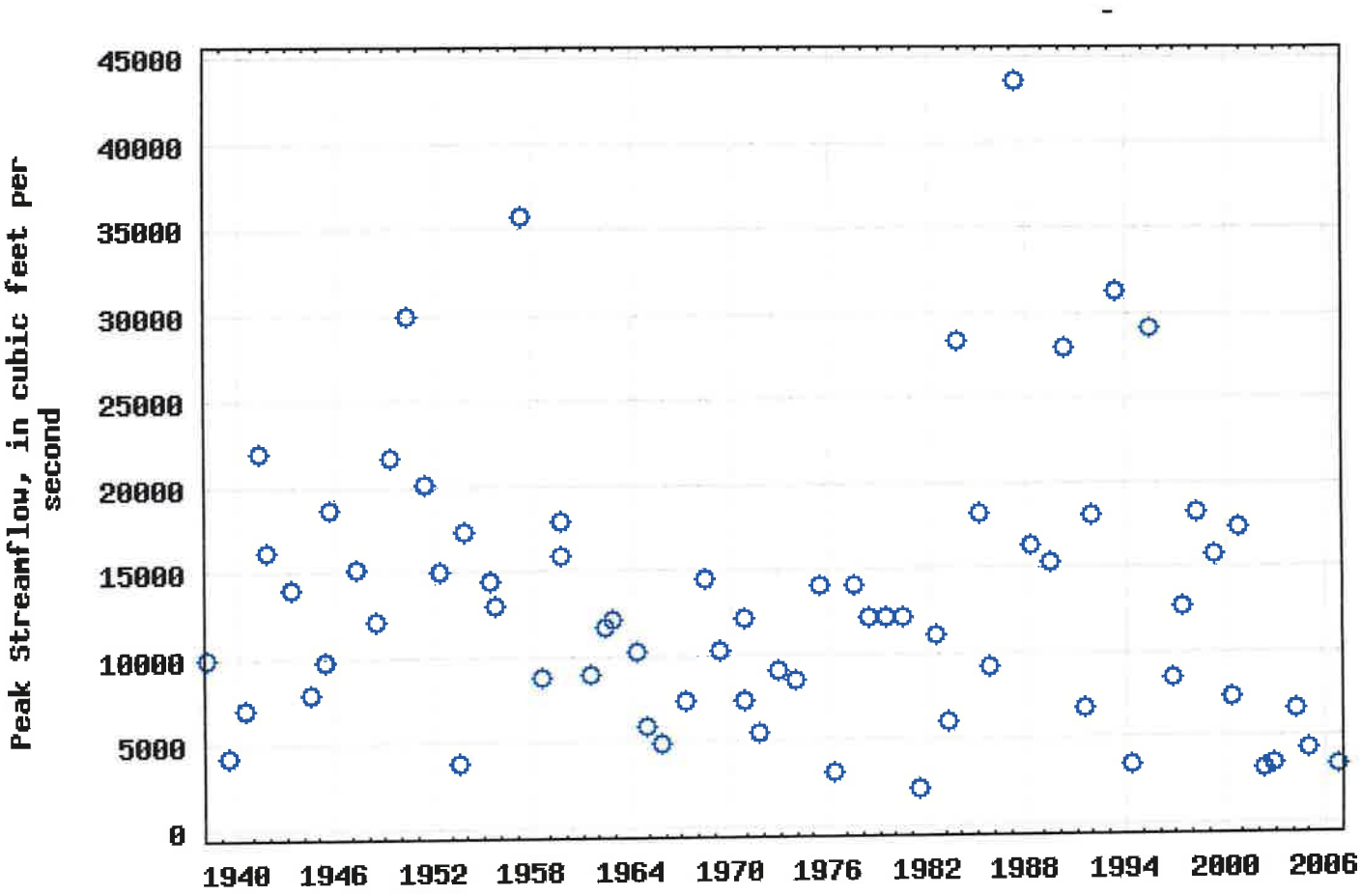


Figure 9. Annual peak streamflow, the Washita River at Pauls Valley (USGS 07328500), OK

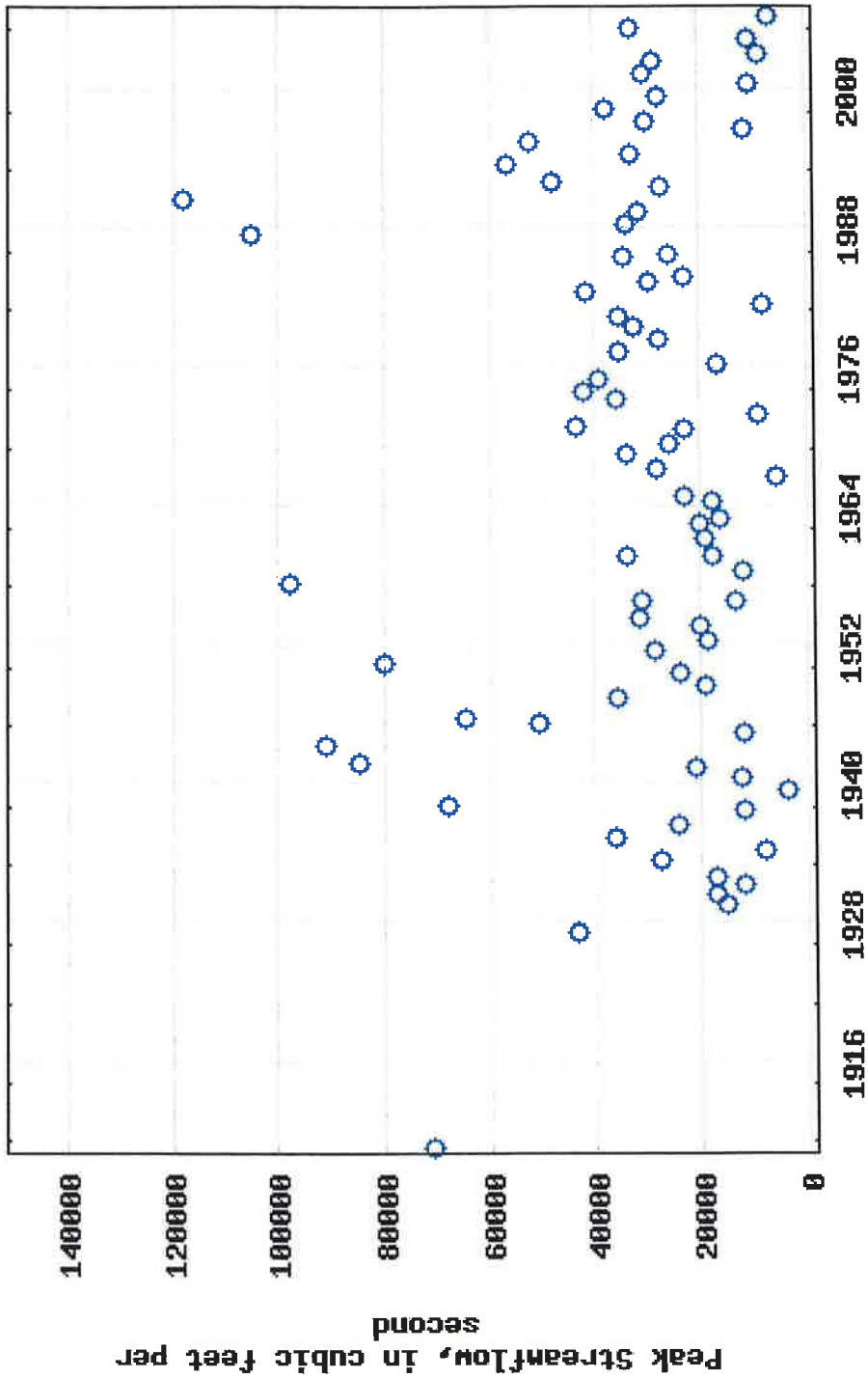


Figure 10. Annual peak streamflow, the Washita River at Dickson (USGS 07331000), OK

Gilvear (1999) uncovered number of areas where fluvial geomorphology is directly relevant and beneficial to river engineering:

1) The river channel as a three dimensional form with longitudinal, transverse, and vertical dimensions (x, y, z-directions) involving changes in morphology and amounts of water and sediment.
2) The fluvial process in response to water and sediment coming from the upstream watersheds.
3) The geomorphic stability of a river system altered by activities such as river training, removing riparian vegetation, land use, and climatic change etc.

The objective of this study is to study the channel-bed elevation changes in Washita River along two reaches; one above Foss dam and another below. Data collection at each site included channel gradients, cross-sectional geometry, and bed material composition. Channel gradient from one river station to another were 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 11 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.

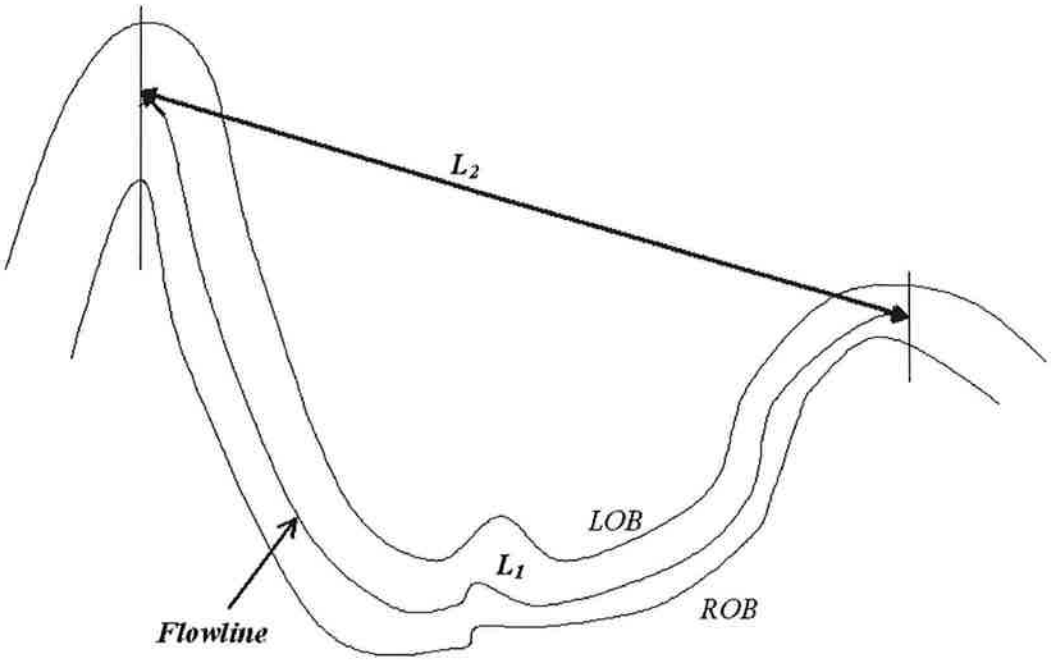
The Washita River in Oklahoma is found to be highly meandering with overall sinuosity of 2.37. The slope of the channel-bed above the Foss reservoir

is about 6.87 ft/mile (Table 3). Longitudinal and vertical changes of the river channel bed were also studied and will be discussed separately in another chapter.

Table 3. Sinuosity and slope study of Washita River

Study of Reach				Study of River Stations		
Reach	**Location**	**Reach Slope (ft/mile)**	**Reach Sinuosity**	**River Stations**	**Slope (ft/mile)**	**Sinuosity**
1	Up stream of Foss Dam	2.02	6.87	RS 1 to RS 2	8.98	1.76
				RS 2 to RS 3	9.19	1.41
				RS 3 to RS 4	7.32	1.48
				RS 4 to RS 5	5.97	2.24
				RS 5 to RS 6	4.47	1.73
				RS 6 to RS 7	3.82	2.08
2	Down stream of Foss Dam	2.45	2.28	RS 7 to RS 8	5.03	1.62
				RS 8 to RS 9	3.34	2.34
				RS 9 to RS 10	0.42	2.08
				RS 10 to RS 11	14.48	1.71
				RS 11 to RS 12	3.47	1.70
				RS 12 to RS 13	104.79 *	0.69
				RS 13 to RS 14	2.64	1.95
				RS 14 to RS 15	2.28	2.24
				RS 15 to RS 16	2.63	2.23
				RS 16 to RS 17	1.73	3.36
				RS 17 to RS 18	2.11	1.62
				RS 18 to RS 19	1.82	3.29
				RS 19 to RS 20	2.13	2.58
				RS 20 to RS 21	282.43*	0.34
				RS 21 to RS 22	0.00	2.21
				RS 22 to RS 23	8.92	1.91
				RS 23 to RS 24	0.22	1.44
				RS 24 to RS 25	2.13	1.96
				RS 25 to RS 26	1.99	1.91
				RS 26 to RS 27	0.00	0.97
				RS 27 to RS 28	3.76	2.83
				RS 28 to RS 29	0.99	1.49
				RS 29 to RS 30	2.91	1.68
				RS 30 to RS 31	1.91	1.54
				RS 31 to RS 32	2.61	1.69
				RS 32 to RS 33	255.23*	1.18
				RS 33 to RS 34	1.77	1.39
				RS 34 to RS 35	54.49	1.06
				RS 35 to RS 36	3.43	1.86
				RS 36 to RS 37	2.98	1.79
				RS 37 to RS 38	1.38	2.15
				RS 38 to RS 39	0.25	1.72

* close bridge points



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

Figure 11. 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 (ODOT) were examined in this study. The River is divided into two reaches by the Foss reservoir. Throughout the study reach, 39 River Stations (RS) were selected: RS 1 to RS 7 in Reach 1, and RS8 to RS 39 in Reach 2. These river stations are located in bridge crossings. Twenty seven out of thirty nine stations have data on cross-section geometry. Cross-sectional geometries of these structures are plotted for different years as data provided by Oklahoma Department of Transportation and these geometries are shown in Figures 12 through 39.

The Washita River at Foss reservoir, about 8 miles upstream of the Foss Dam (Bridge No 13929), has aggraded to 8.59 feet in 45 years. It was expected that the channel-bed should be degraded below Foss Dam but the river station observed at about 10 miles downstream (Bridge No 17344) shows that the stream channel-bed fairly stable. The river stations on highway US 183, approximately about 25 miles downstream of Foss Dam has highly aggraded to 16.8 feet in two years. The sub-surface geology at that point consists of sand. The study reaches of Washita River at 187.25 miles (Bridge No 16625) to 260 miles (Bridge No 14194) have been degraded up to 7 feet. From 310 miles (Bridge No 17047) to 397miles (Bridge No 17598), the river is fairly aggraded in some places and degraded in others. Severe degradation is found below 397 miles (I-35) in the study reach. River bed degradation is evident for about 43 miles below the interstate highway I-35. The Washita River that entered

Oklahoma from the mountain range at an elevation of about 2,200 feet reaches bridge crossing US 77 (Bridge No17959) at the elevation of about 750 feet from sea level and starts to deposit sediments in the river beds. Deposits at bridge number 10076 or SH 19 has accumulated to 22.24 feet in 57 years.

To summarize the study of the abovementioned cross-sectional geometries, the Washita River in Oklahoma is severely aggraded in some areas and degraded in others. Channel widening is not evaluated in this study because river station data are located in bridge crossings. The fluvial dynamics of Washita River vary greatly throughout the study

Williams and Wolman (1984) studied the downstream effects of 21 dams constructed in alluvial rivers in the United States. Generally, the magnitudes of river bed changes were found to be greatest nearest the dam and to diminish with distance downstream. However, the trend line (Fig.40) of bed-elevation changes below Foss Dam does not show this. Bridge crossings such as SH 33 (Bridge No 3782 and13929), US183 (Bridge No 25675), US 77 (Bridge No 17959) and SH 19 (Bridge No 10076) have experienced severe channel-bed aggradation. SH 19 near Texoma reservoir (Fig. 38) has experienced the maximum channel bed deposition of 22.24 feet in 57 years. Bridge crossings such as SH 33 (Bridge No 3792), I-40 (Fig.17), SH 115 (Bridge No 16625), I-35 (Fig. 25), US 77 (Bridge No 16814), SH 19 (Bridge No 7342), and SH 17A (Fig. 31) have experienced the greatest channel-bed degradation of 9.61 feet in 34 years.

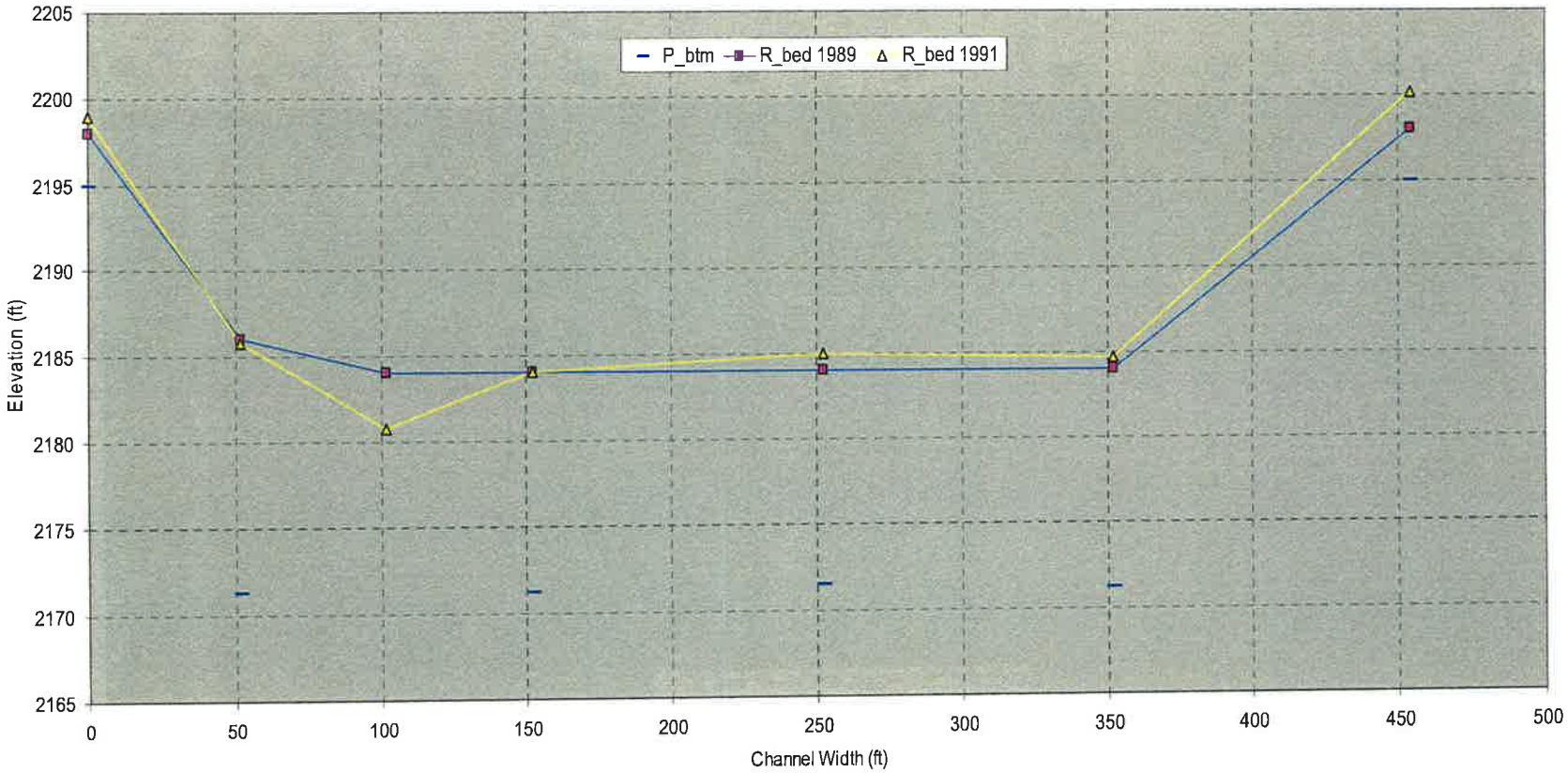


Figure 12. Cross-section at bridge (Bridge No. 14508 and RS 1) on SH 30, Washita River, OK

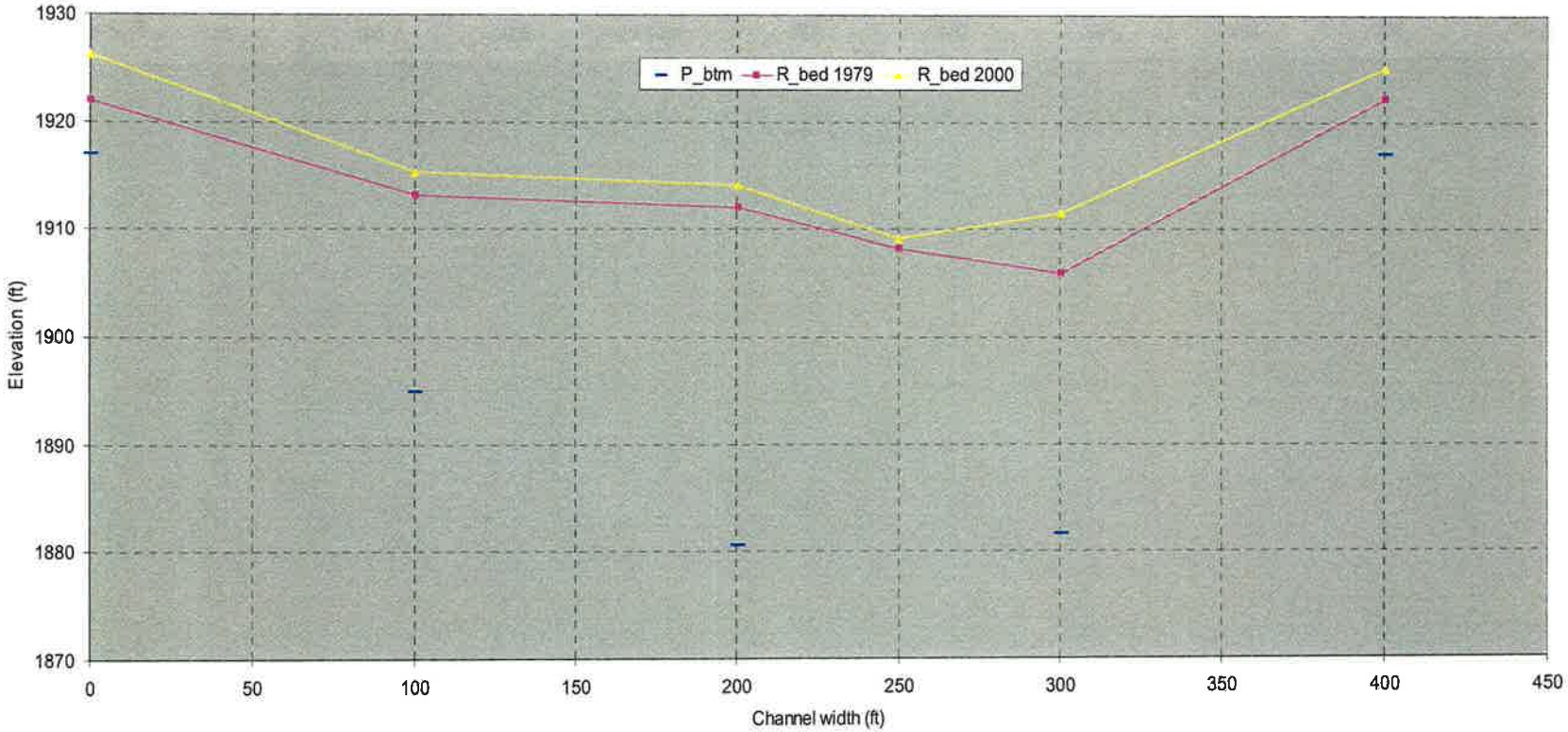


Figure 13. Cross-section at bridge (Bridge No. 19633 and RS 2) on US 283, Washita River, OK

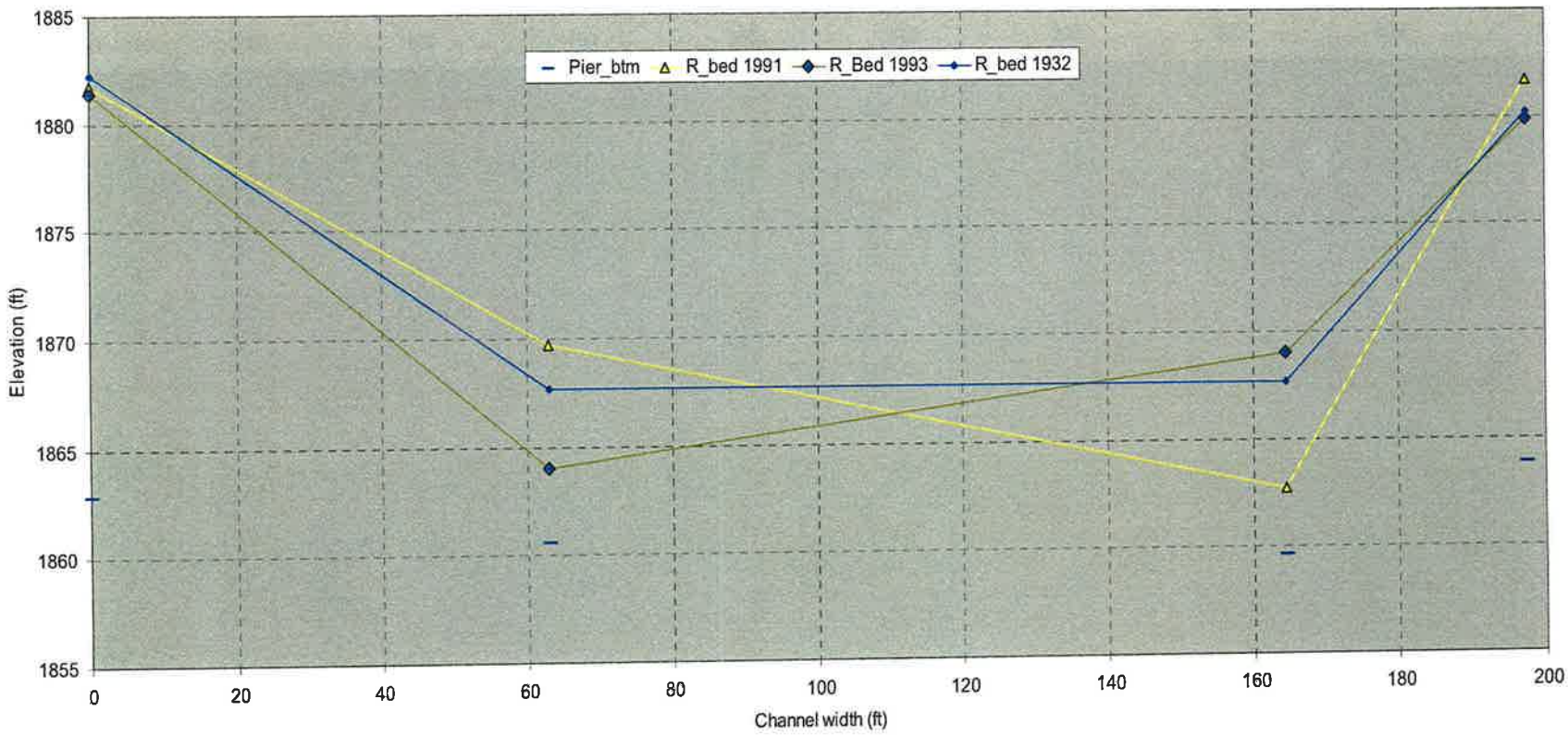


Figure 14. Cross-section at bridge (Bridge No. 03792 and RS 3) on SH 33, Washita River, OK

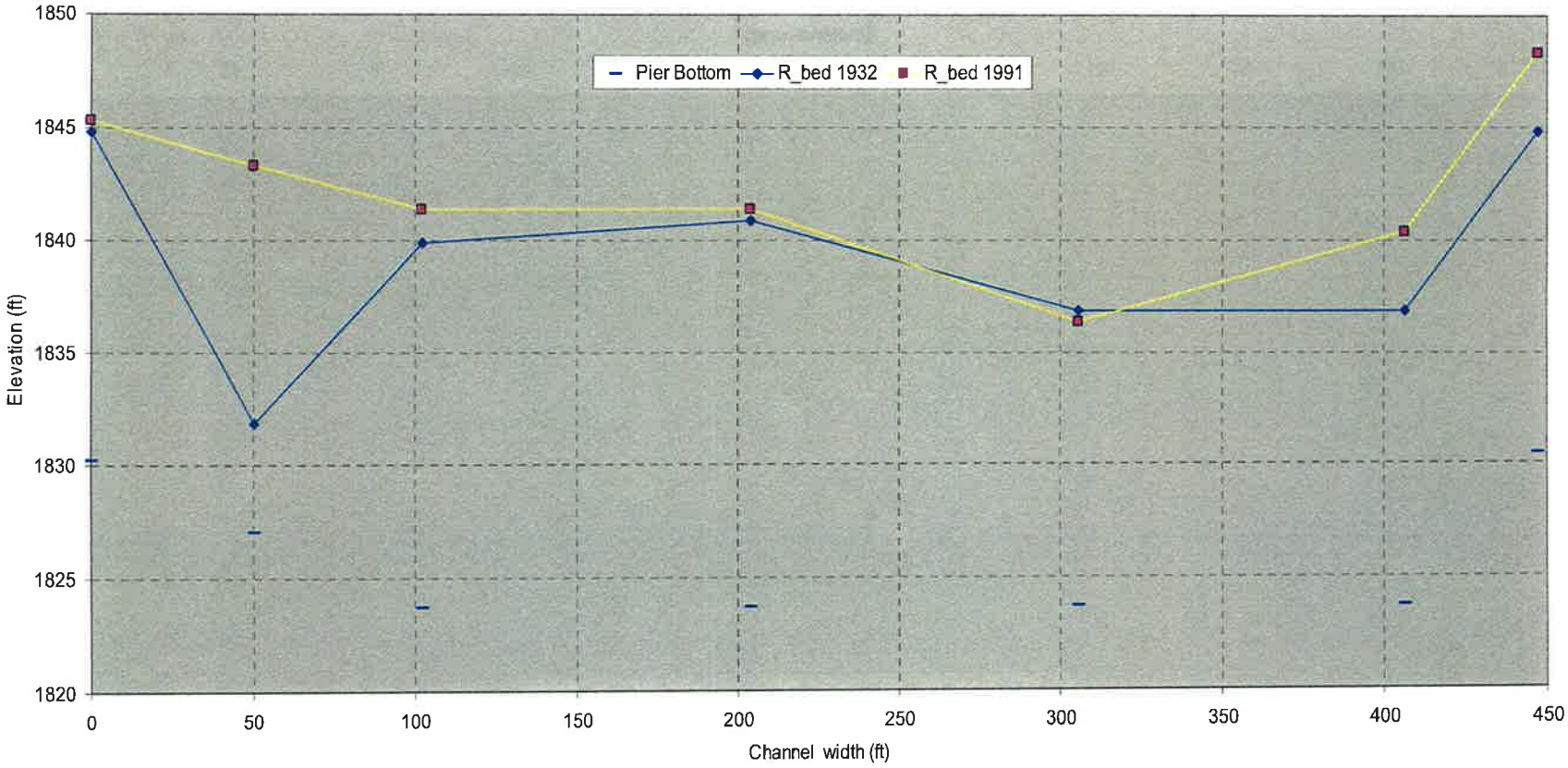


Figure 15. Cross-section at bridge (Bridge No. 03814 and RS 4) on SH 33, Washita River, OK

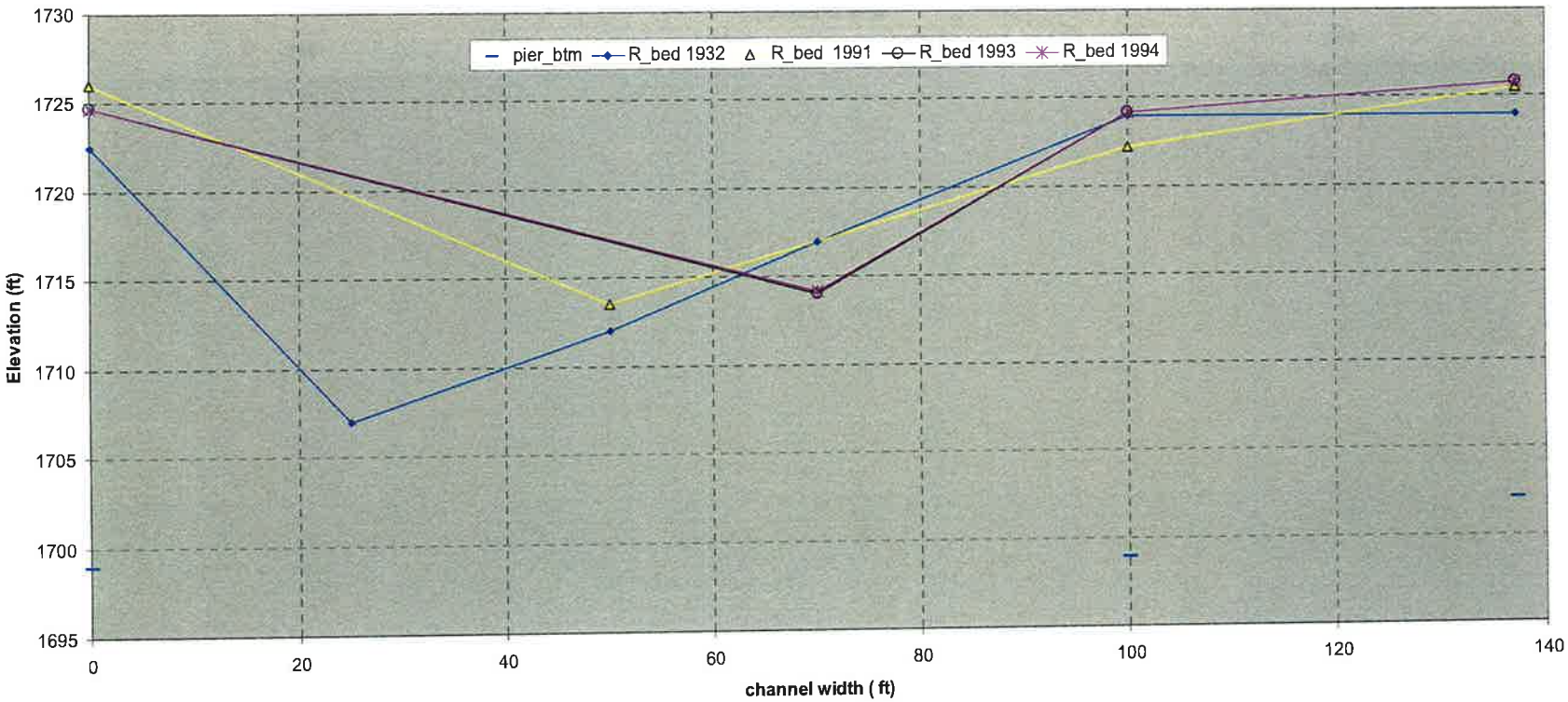


Figure 16. Cross-section at bridge (Bridge No. 03781 and RS 5) on SH 33, Washita River, OK

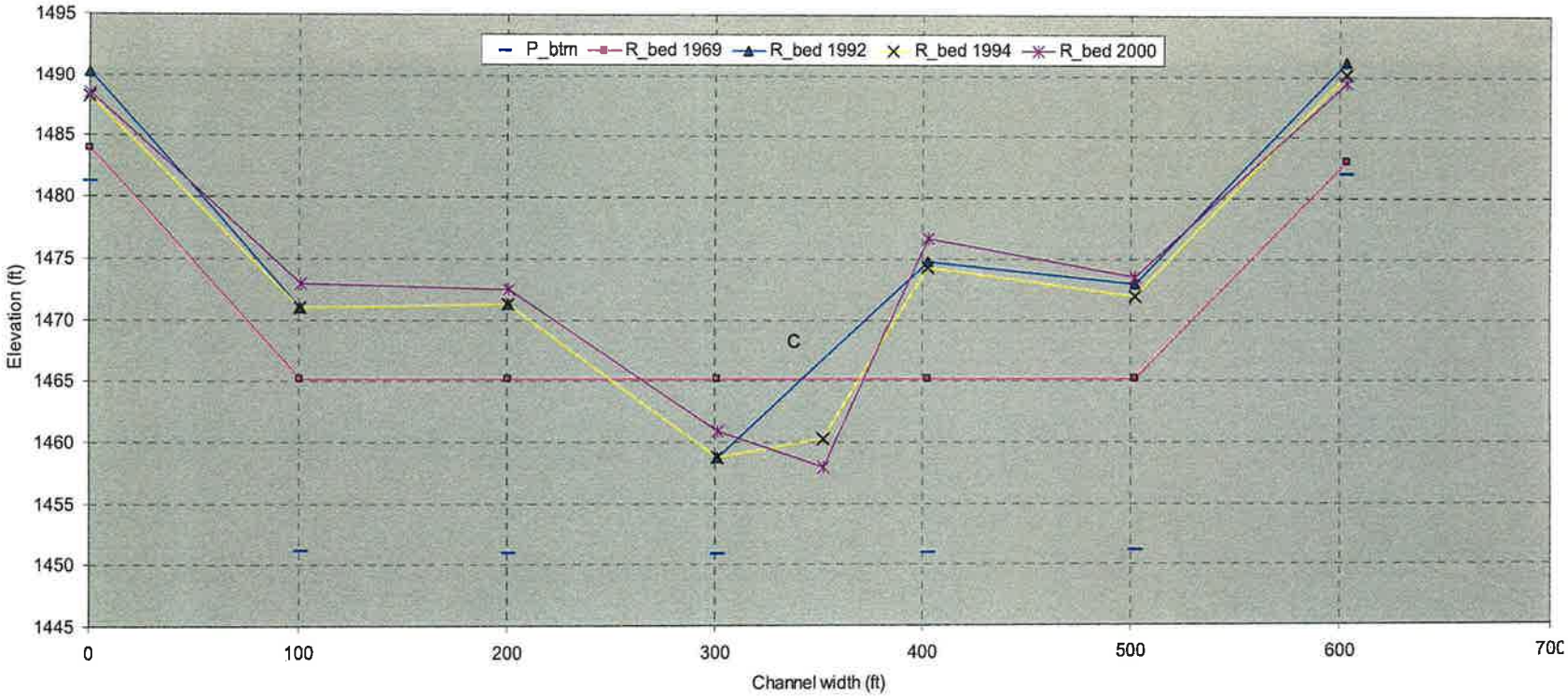


Figure 17. Cross-section at bridge (Bridge No. 17596 and RS 12) on I-40, Washita River, OK

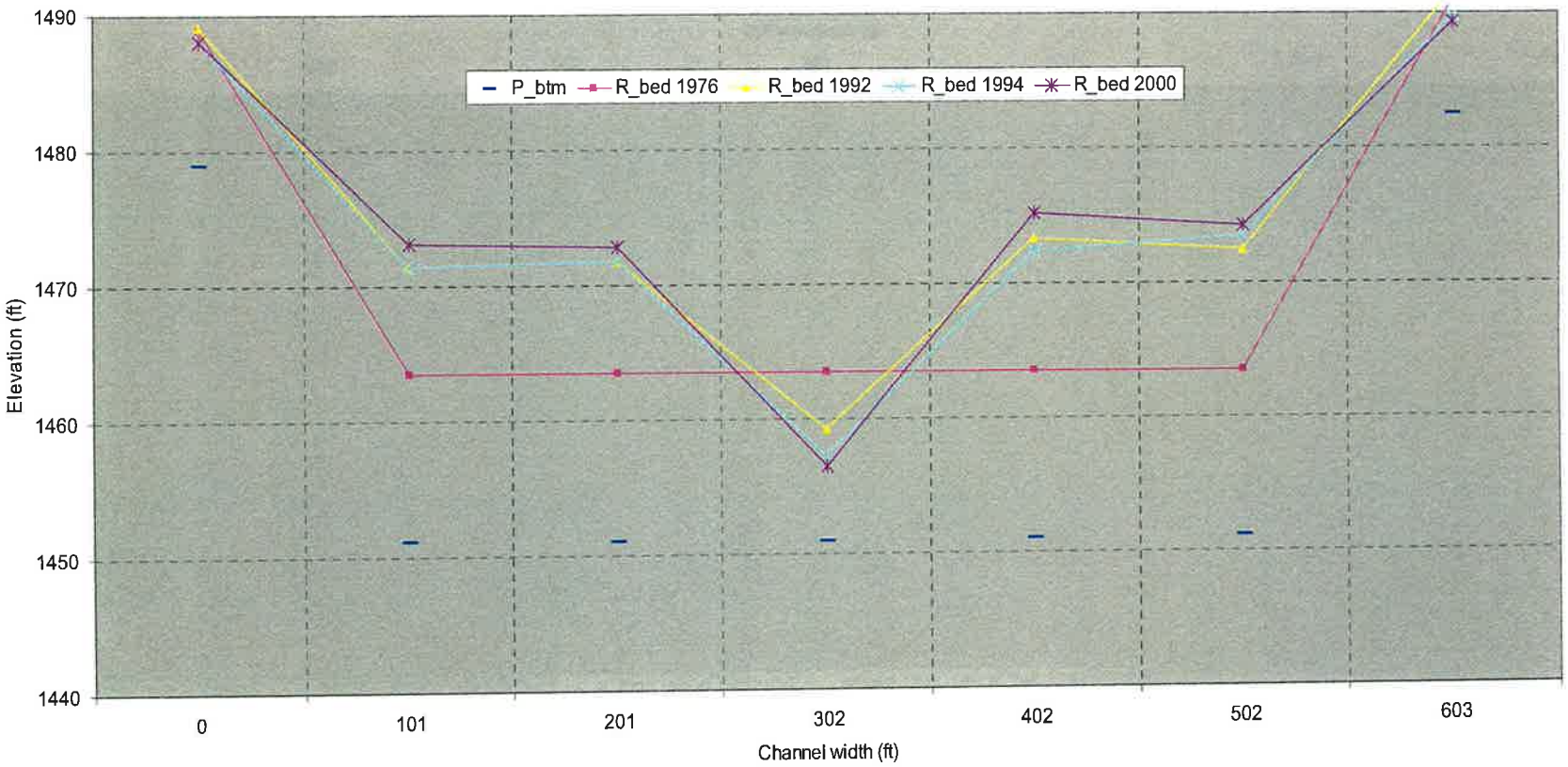


Figure 18. Cross-section at bridge (Bridge No. 17597 and 13) on I-40, Washita River, OK

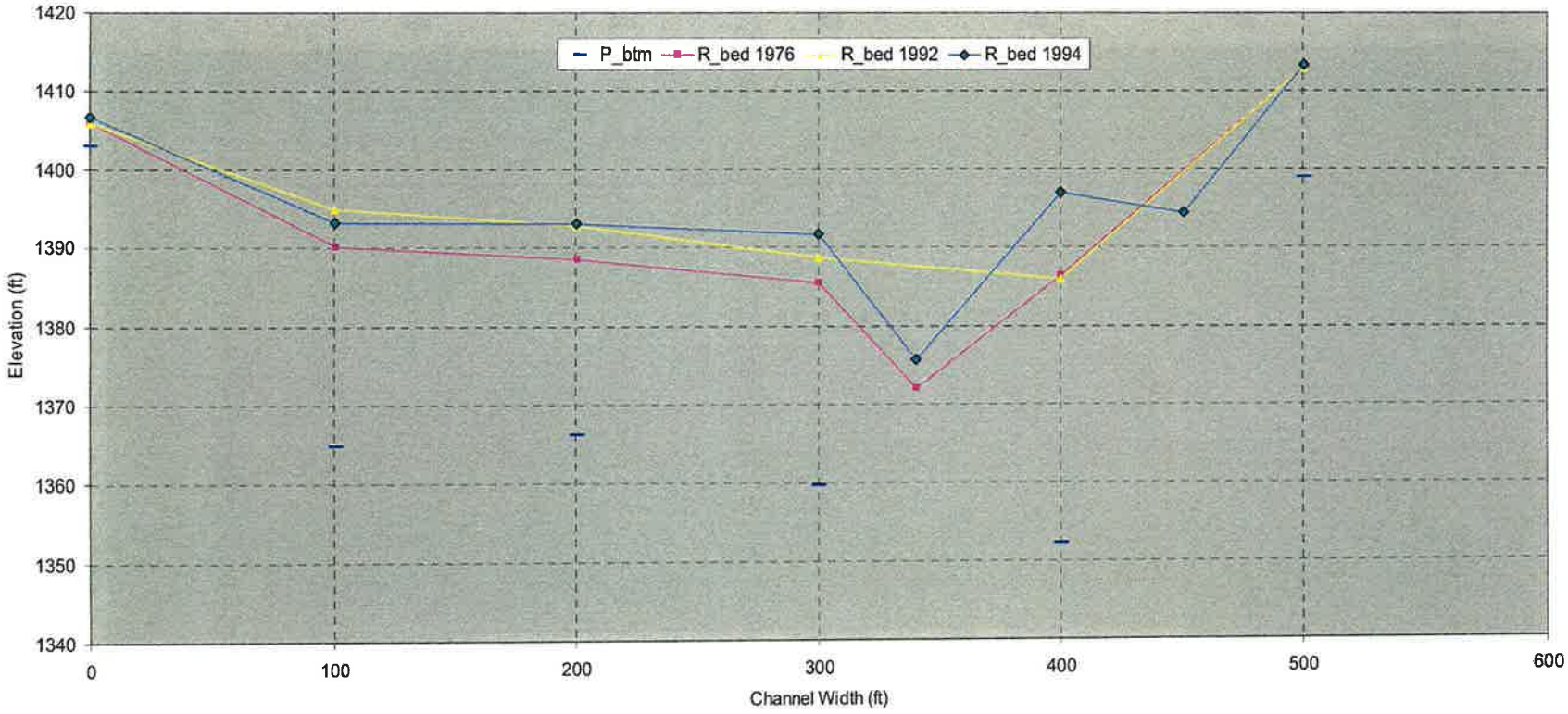


Figure 19. Cross-section at bridge (Bridge No. 19271 and RS 14) on SH 152, Washita River, OK

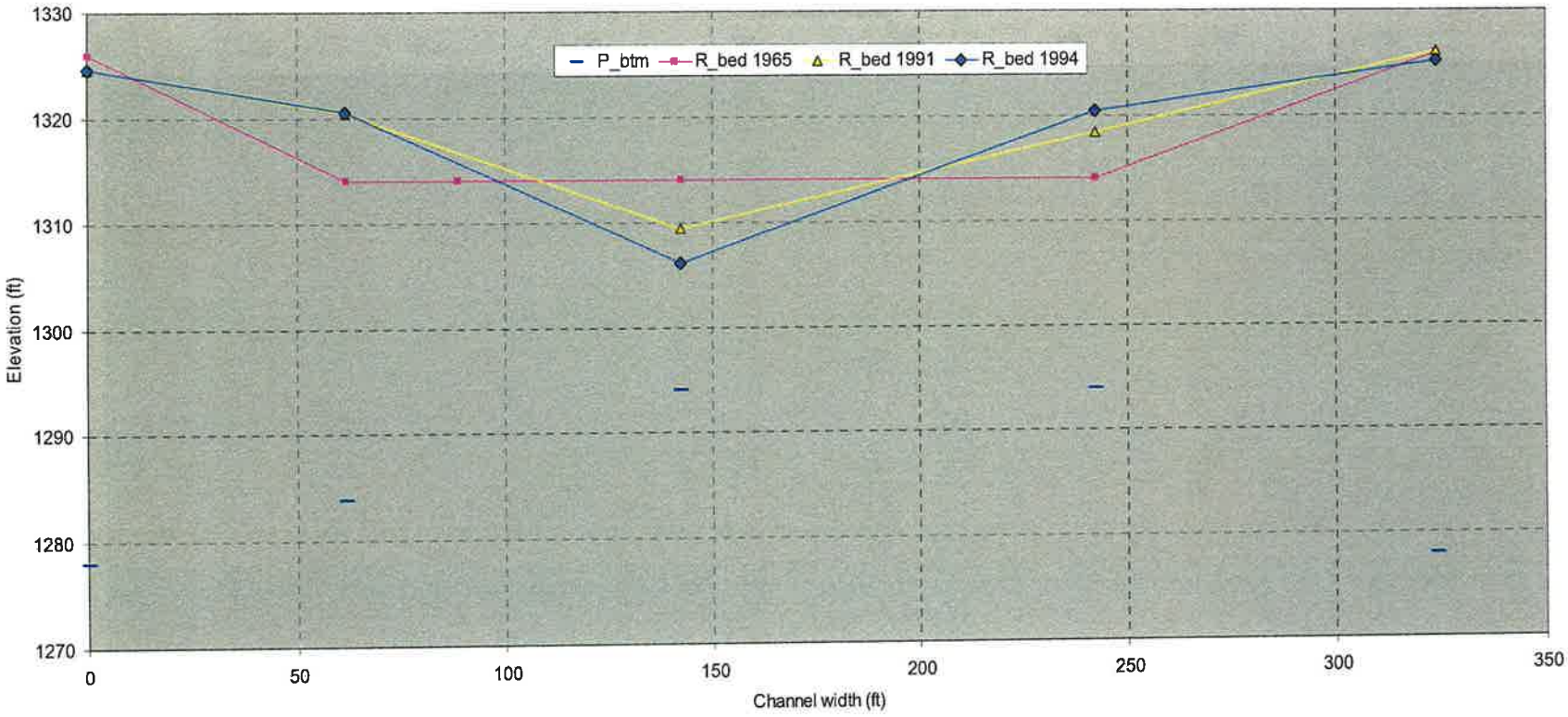


Figure 20. Cross-section at bridge (Bridge No. 16625 and RS 15) on SH 115, Washita River, OK

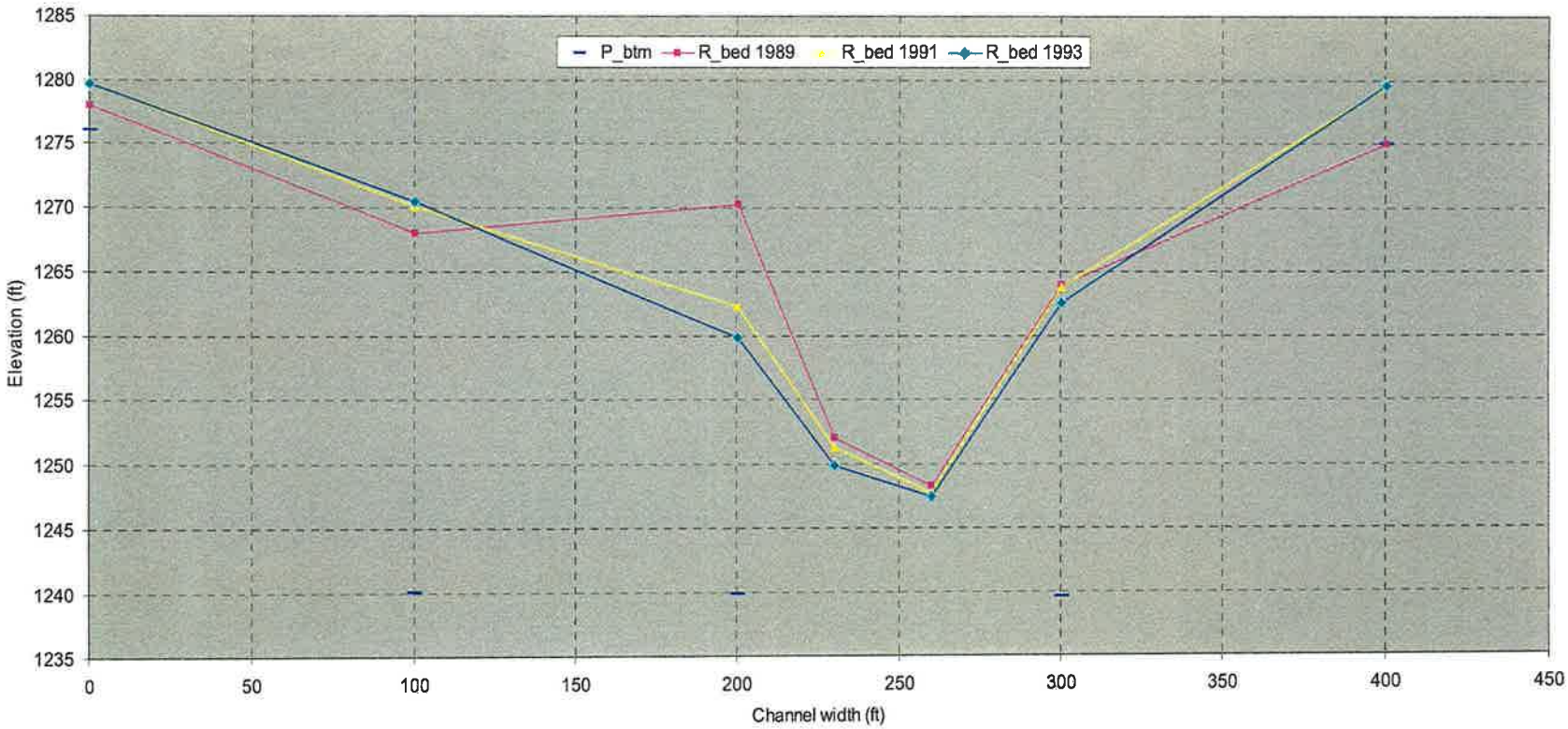


Figure 21. Cross-section at bridge (Bridge No. 21351 and RS 17) on SH 9, Washita River, OK

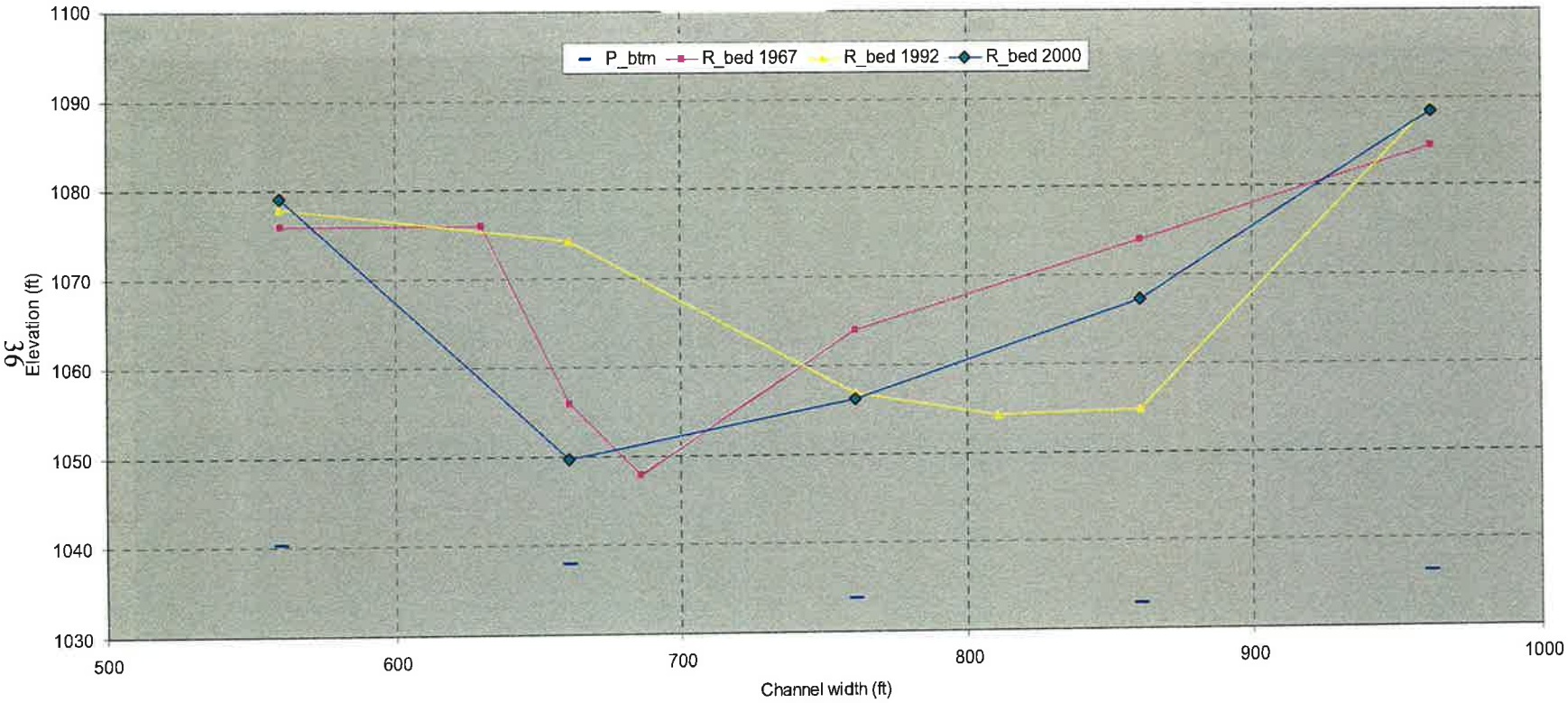


Figure 22. Cross-section at bridge (Bridge No. 17047 and RS 20) on US 62, Washita River, OK

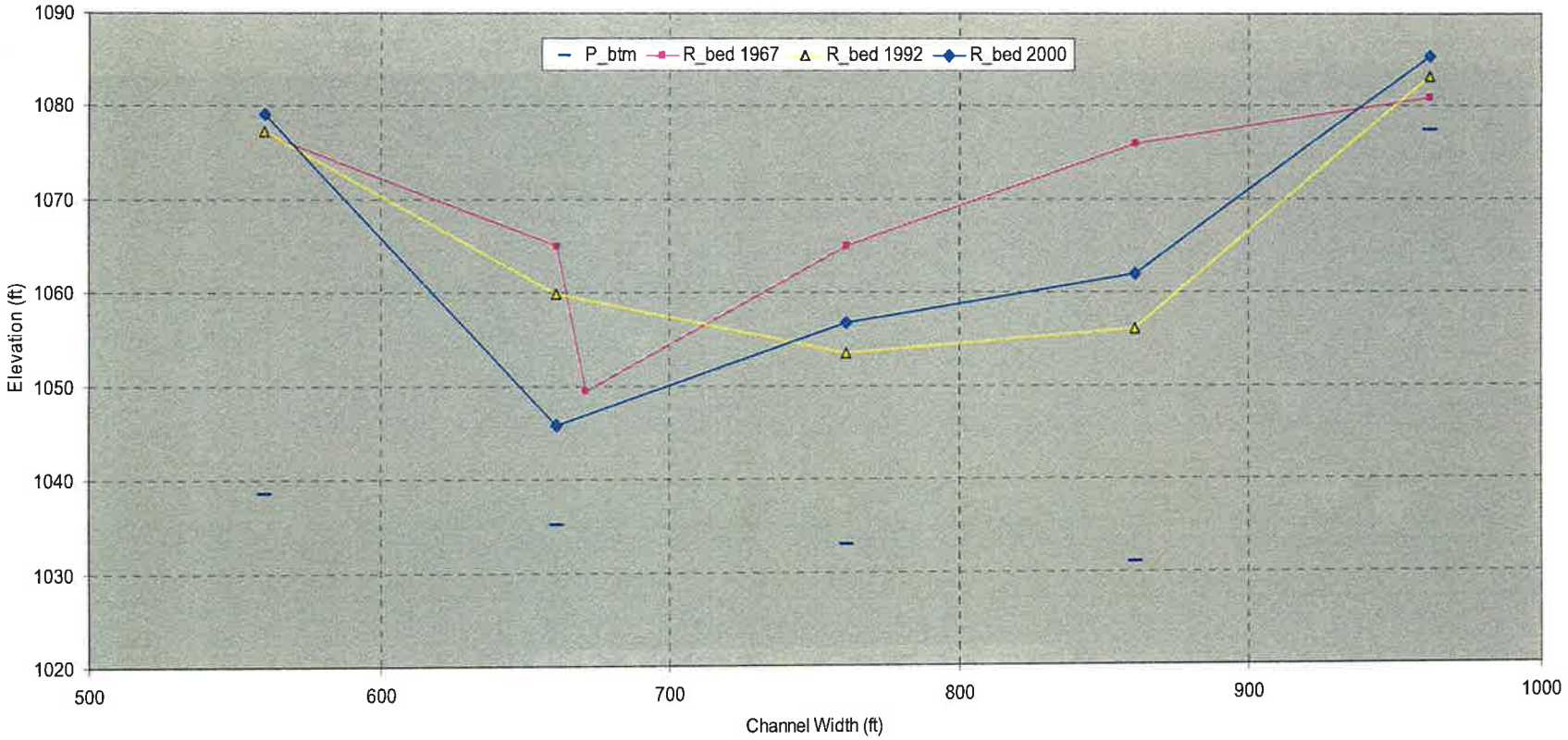


Figure 23. Cross-section at bridge (Bridge No. 17049 and RS 21) on US 62, Washita River, OK

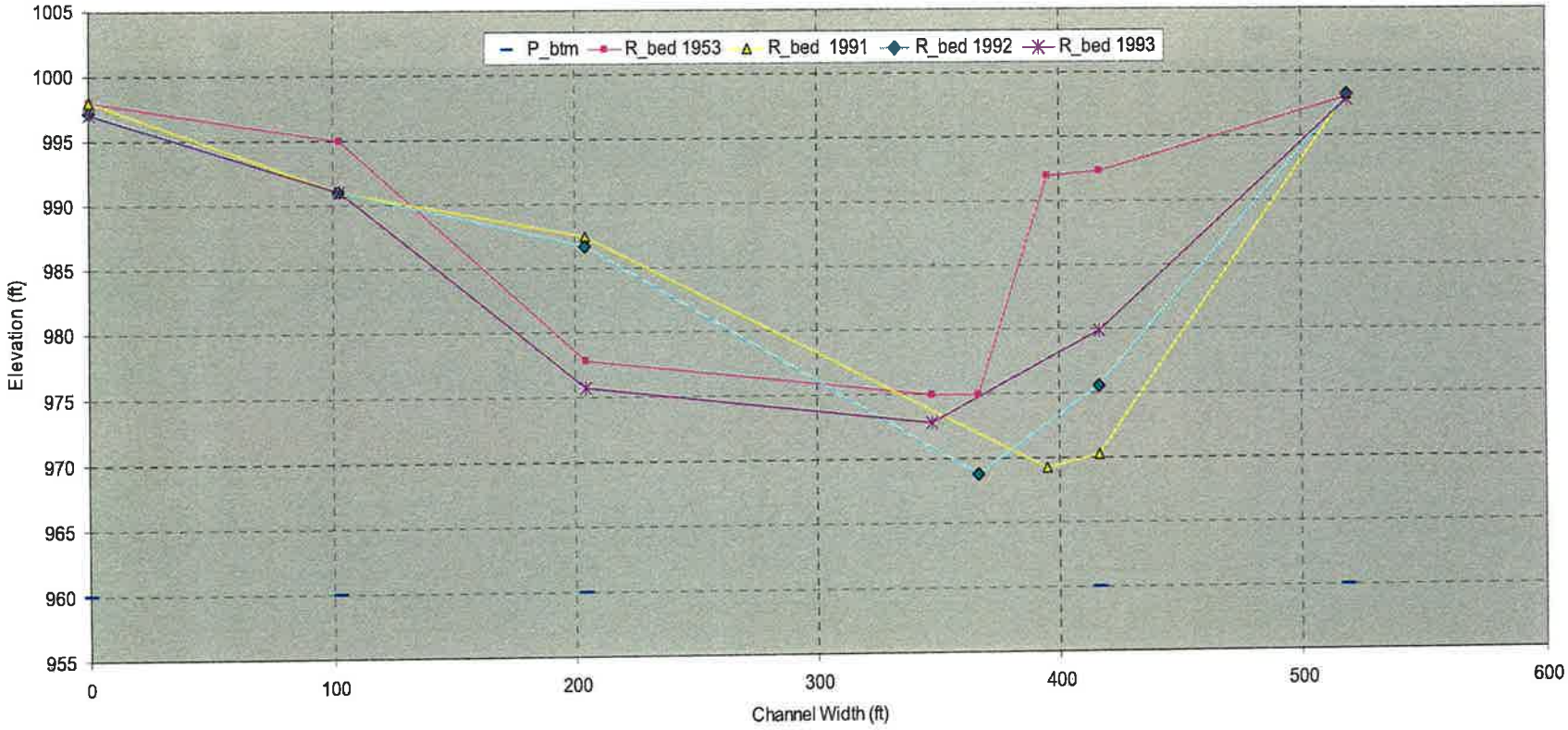


Figure 24. Cross-section at bridge (Bridge No. 13119 and RS 22) on SH 19, Washita River, OK

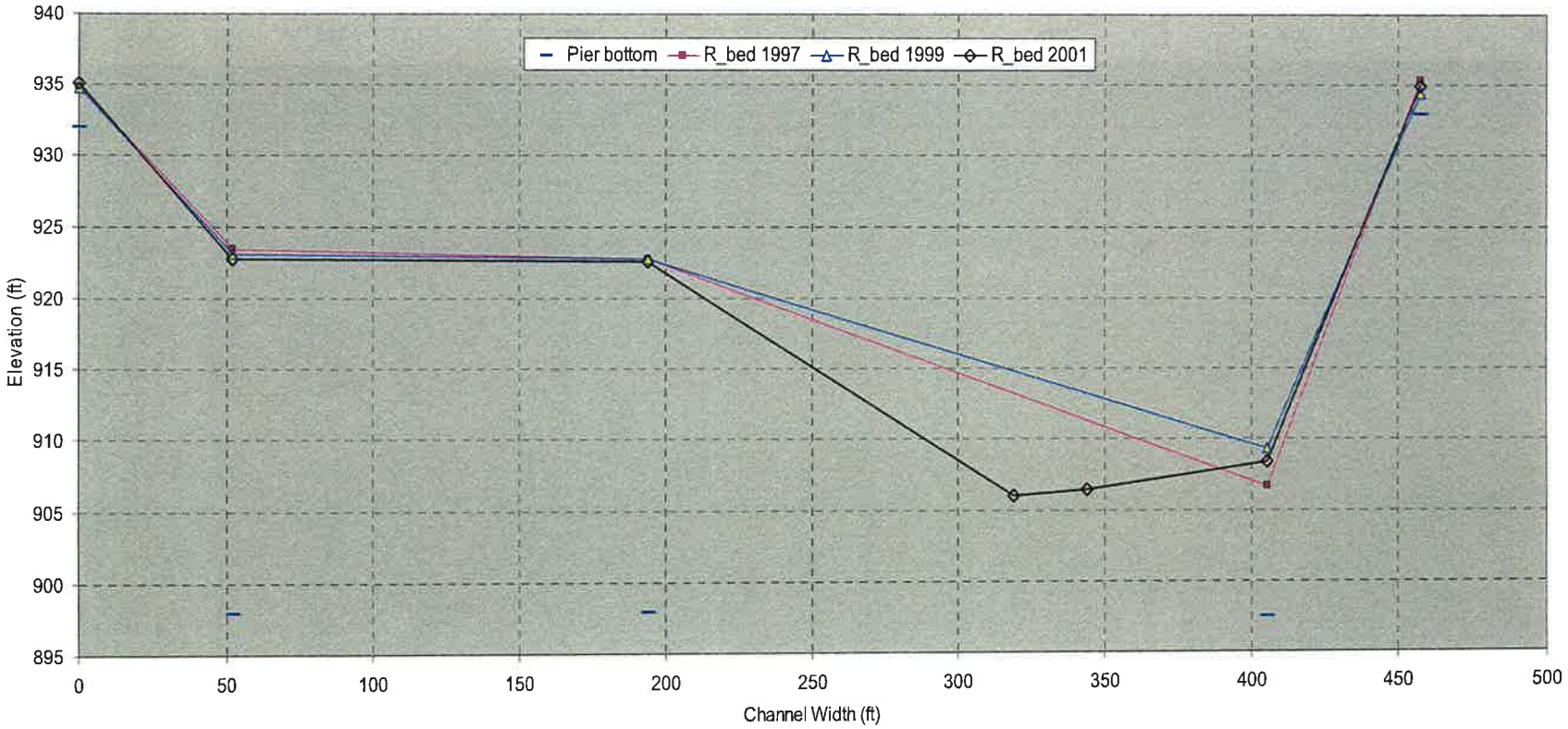


Figure 25. Cross-section at bridge (Bridge No. 12484 and RS 25) on SH 74, Washita River, OK

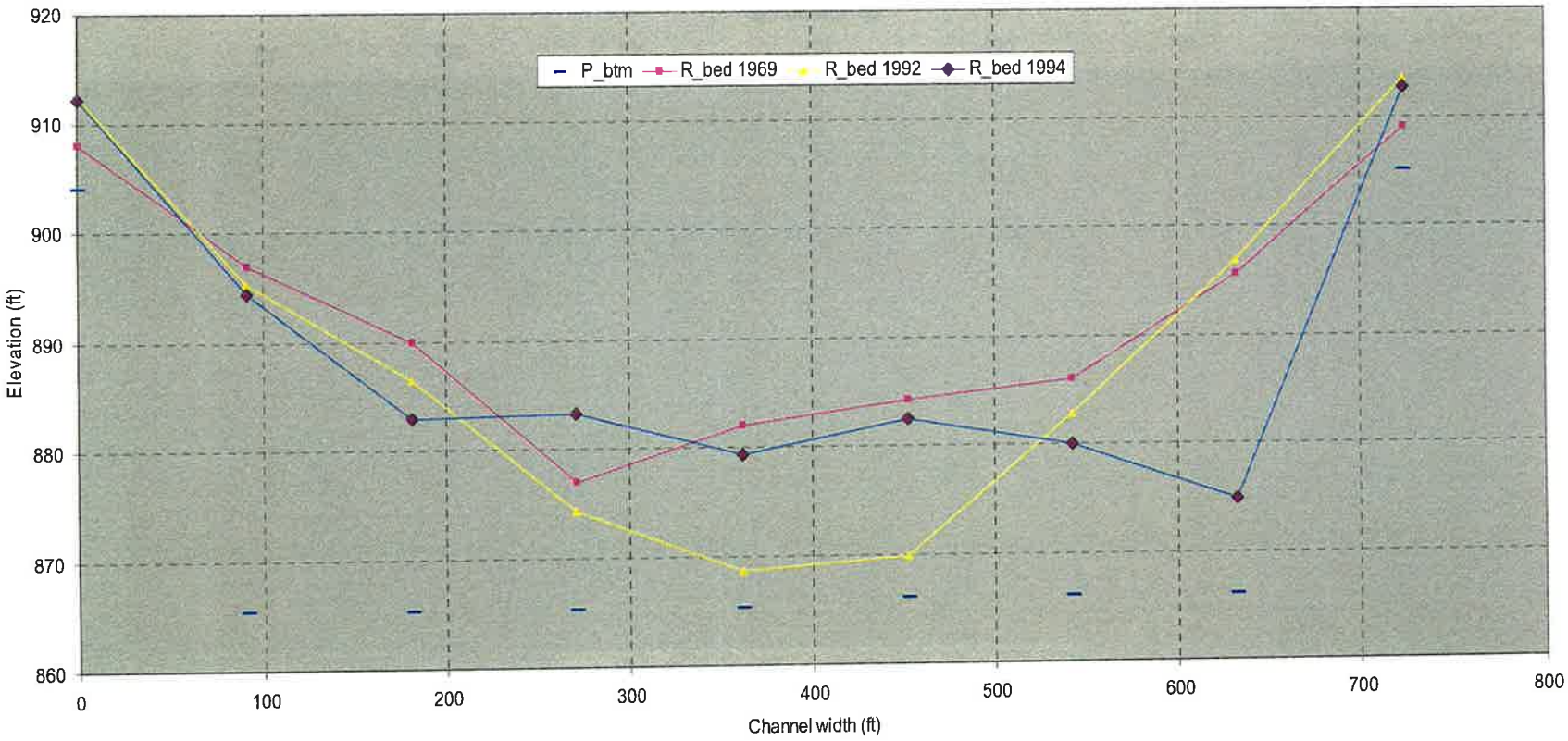


Figure 26. Cross-section at bridge (Bridge No. 17598 and RS 26) on I-35, Washita River, OK

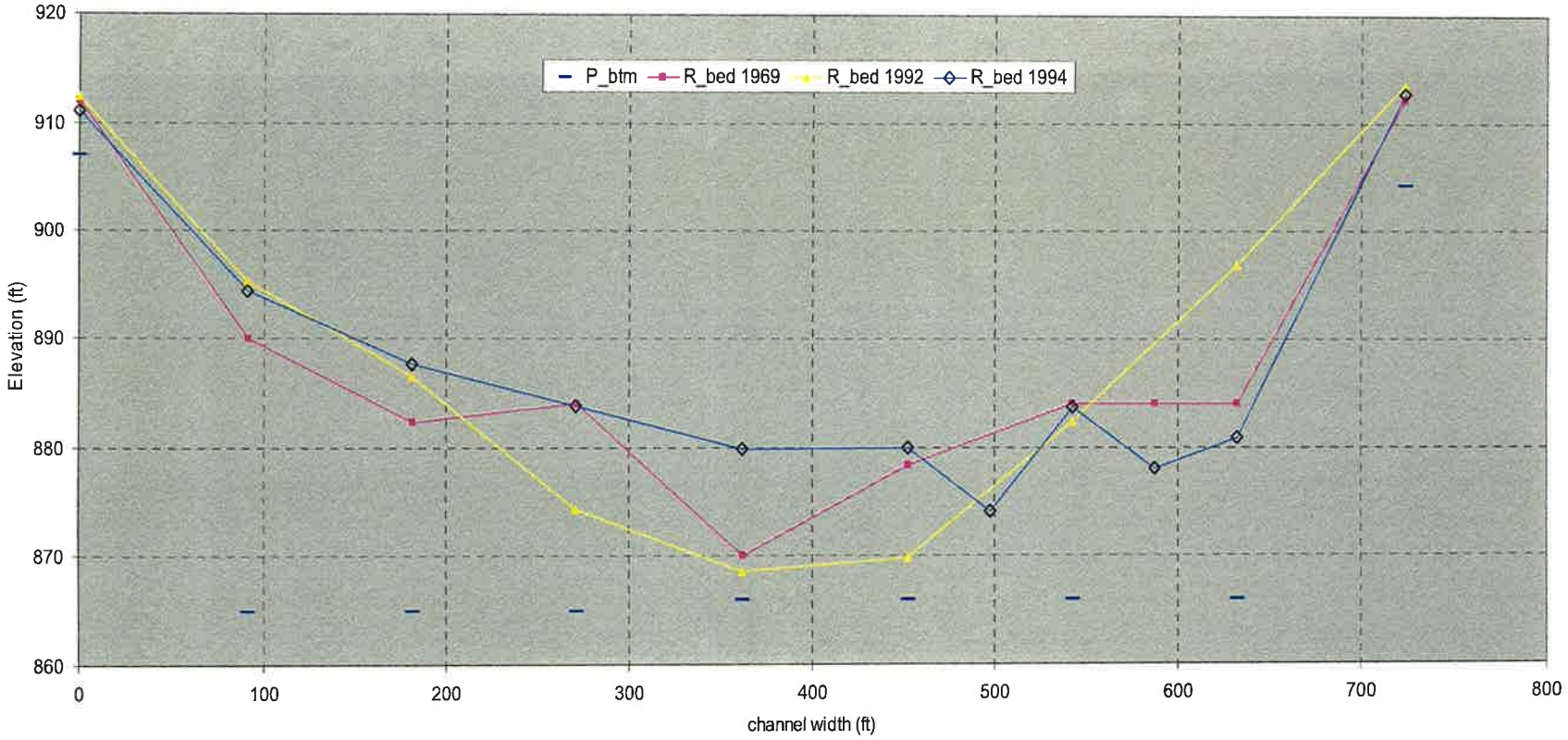


Figure 27. Cross-section at bridge (Bridge No. 17599 and RS 27) on I-35, Washita River, OK

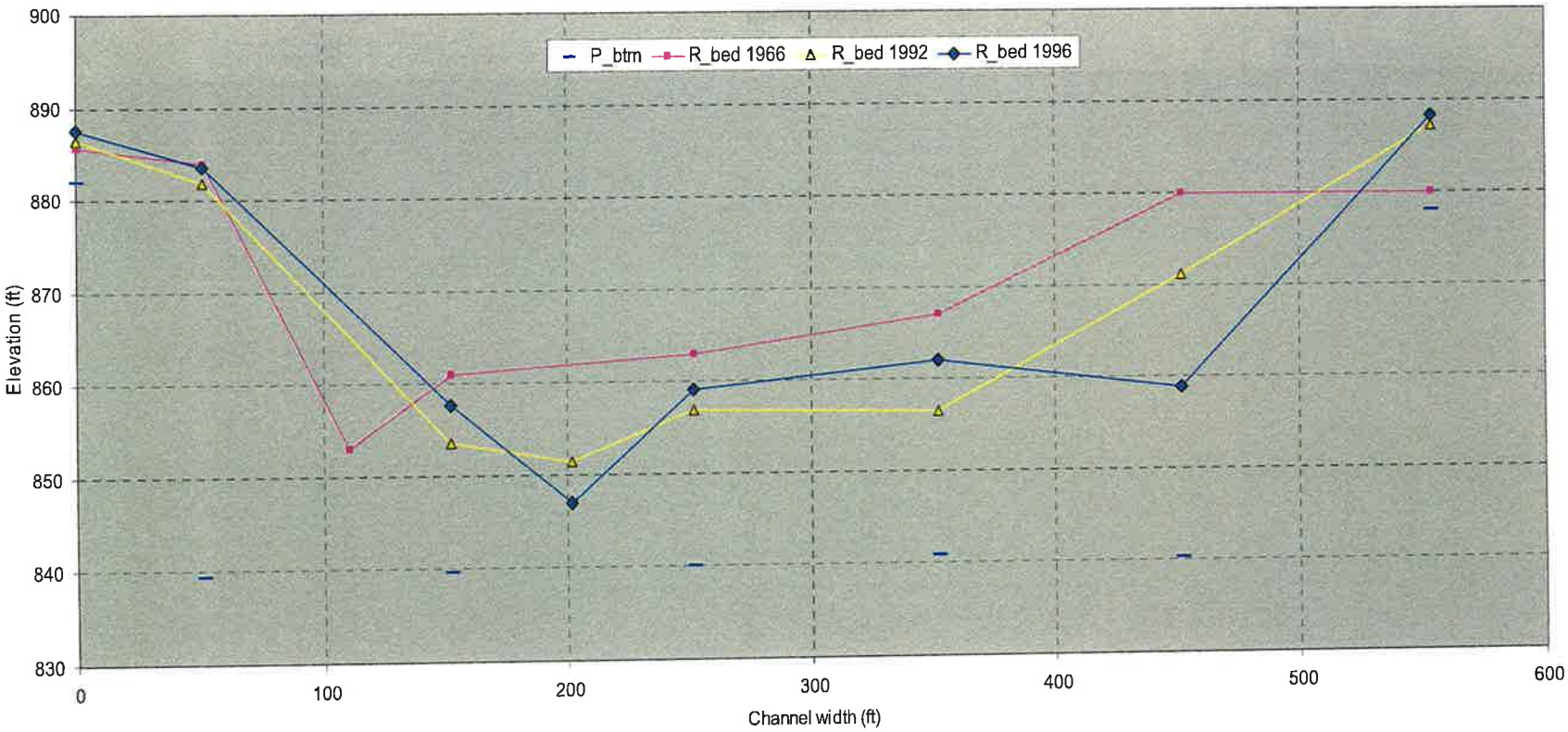


Figure 28. Cross-section at bridge (Bridge No. 16814 and RS 28) on US 77, Washita River, OK

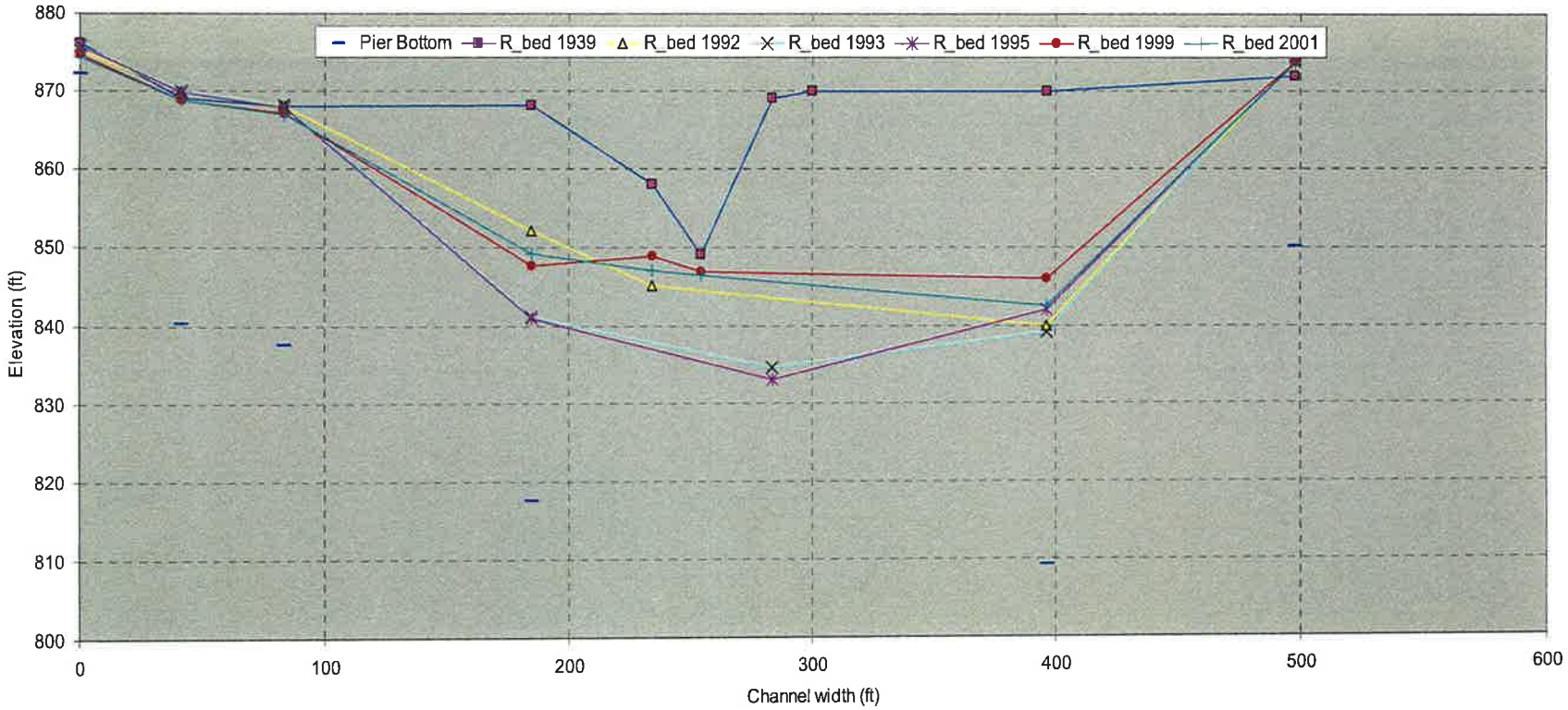


Figure 29. Cross-section at bridge (Bridge No. 07342 and RS 29) on SH 19, Washita River, OK

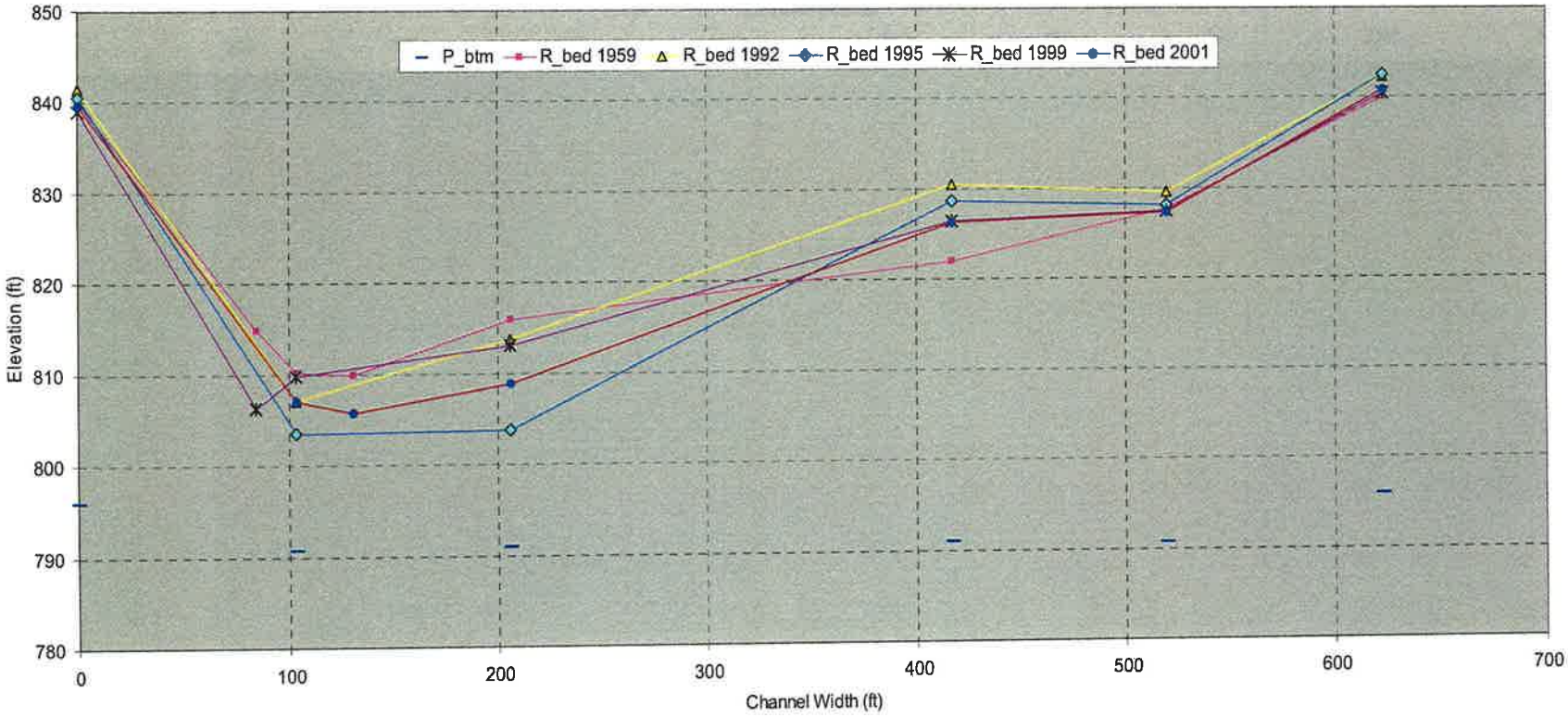


Figure 30. Cross-section at bridge (Bridge No. 14516 and RS 30) on US 77, Washita River, OK

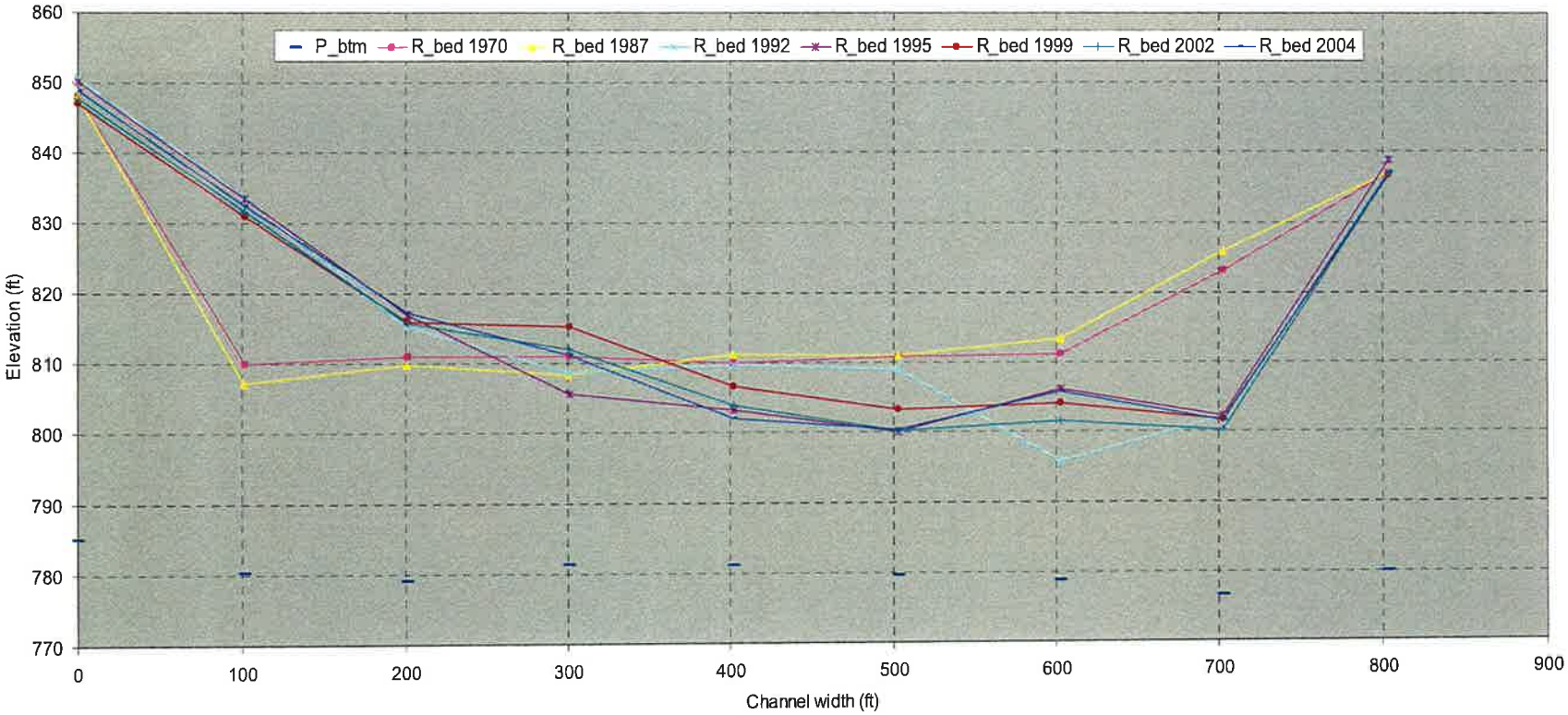


Figure 31. Cross-section at bridge (Bridge No. 17956 and RS 31) on SH 17A, Washita River, OK

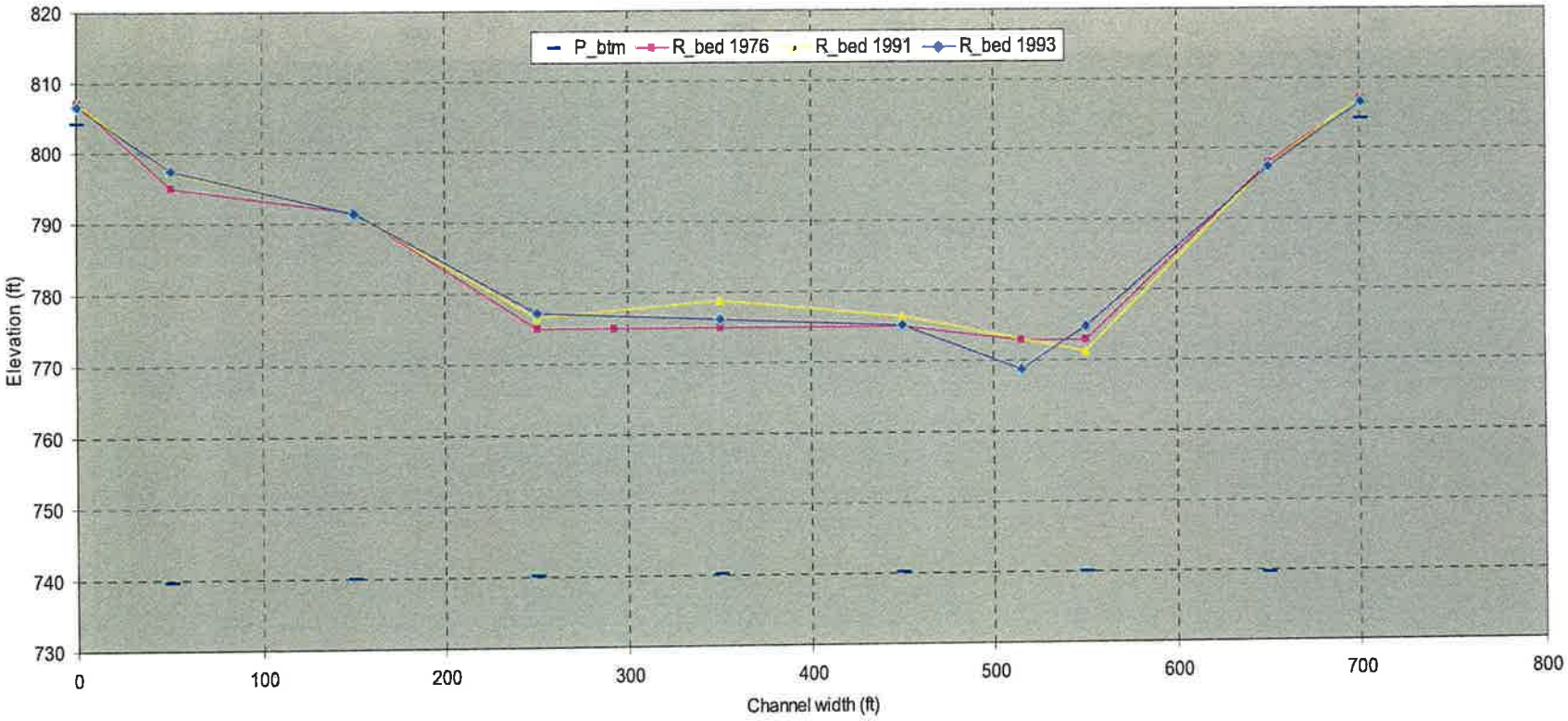


Figure 32. Cross-section at bridge (Bridge No. 19273 and RS 33) on SH 7, Washita River, OK

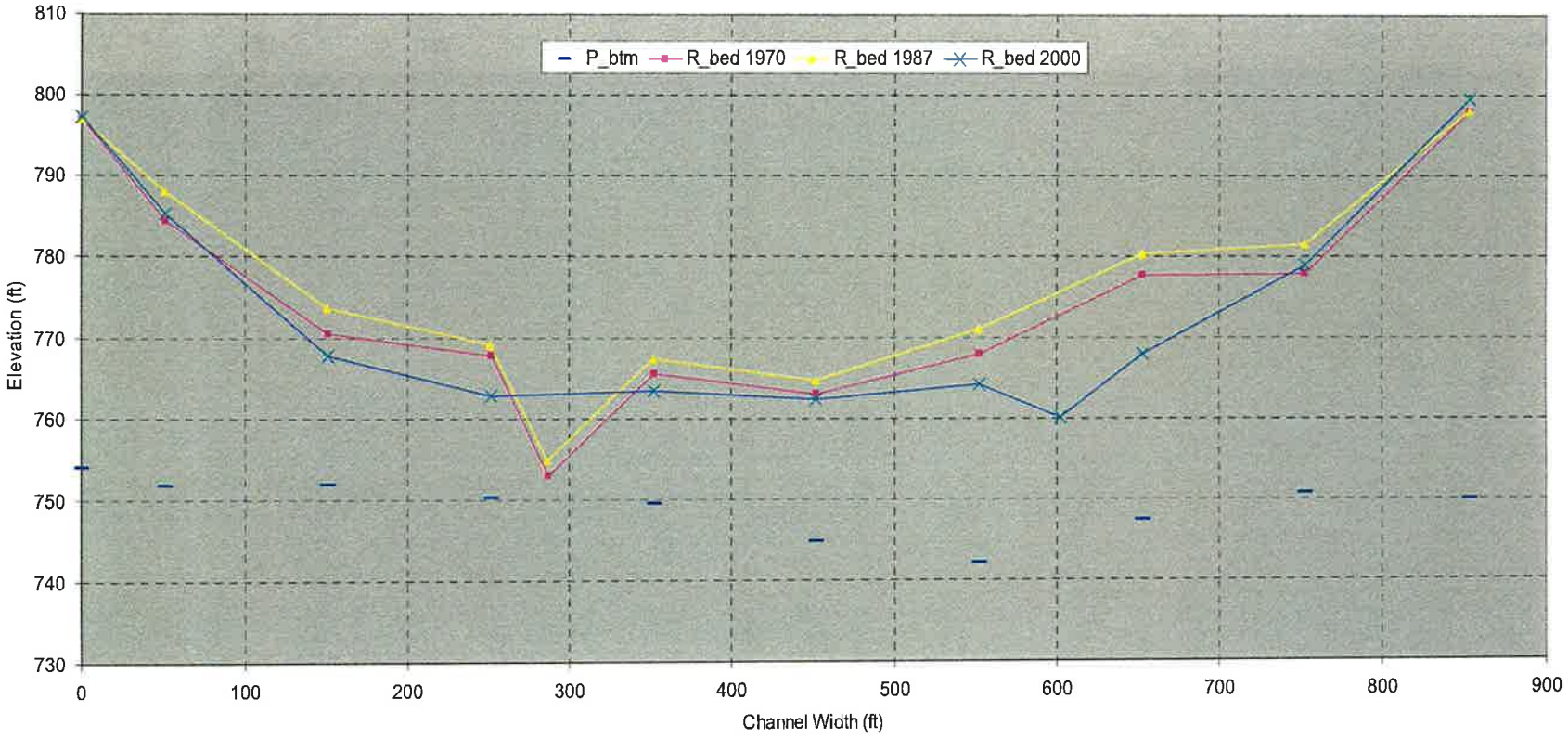


Figure 33. Cross-section at bridge (Bridge No. 17959 and RS 34) on US 77, Washita River, OK

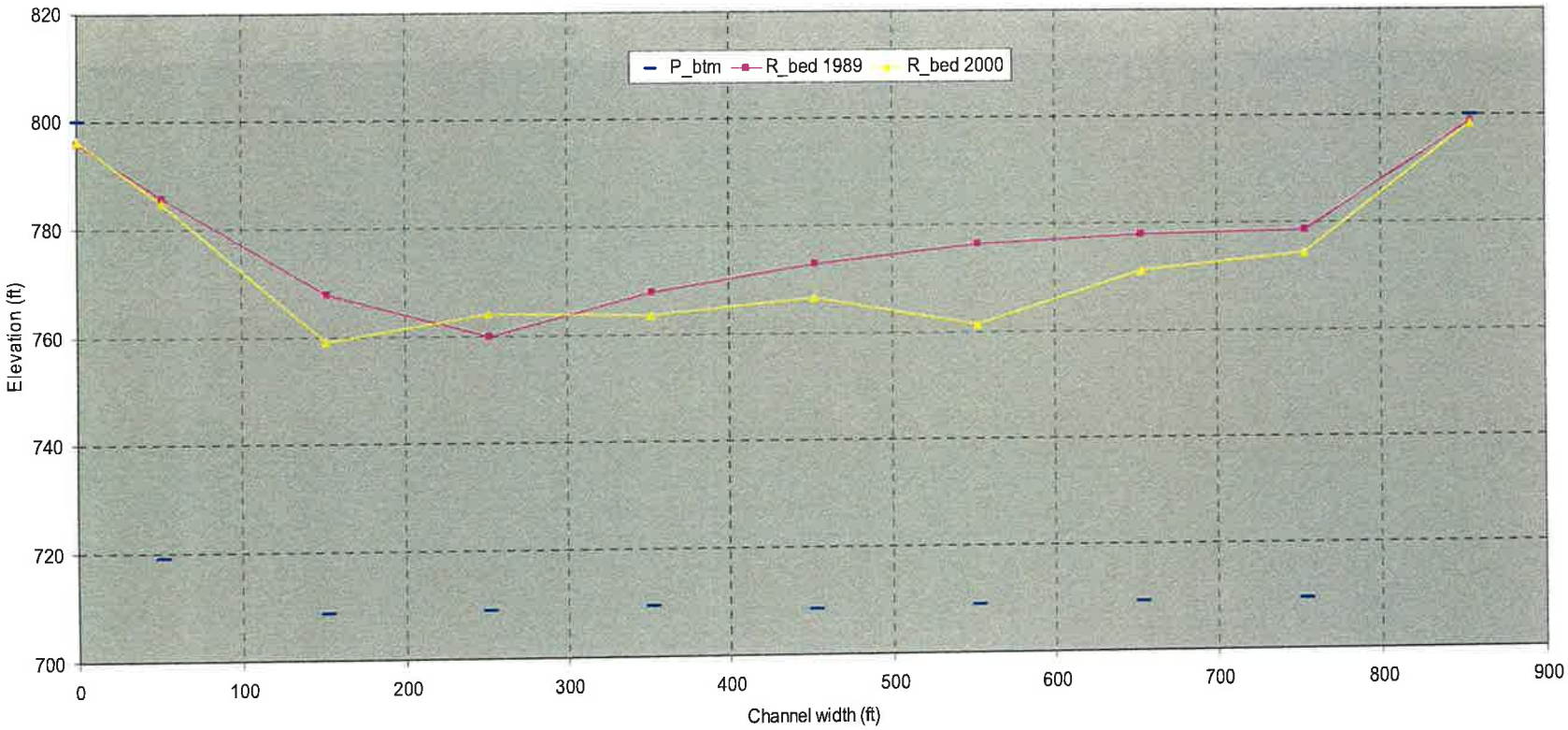


Figure 34. Cross-section at bridge (Bridge No. 22416 and RS 35) on US 77, Washita River, OK

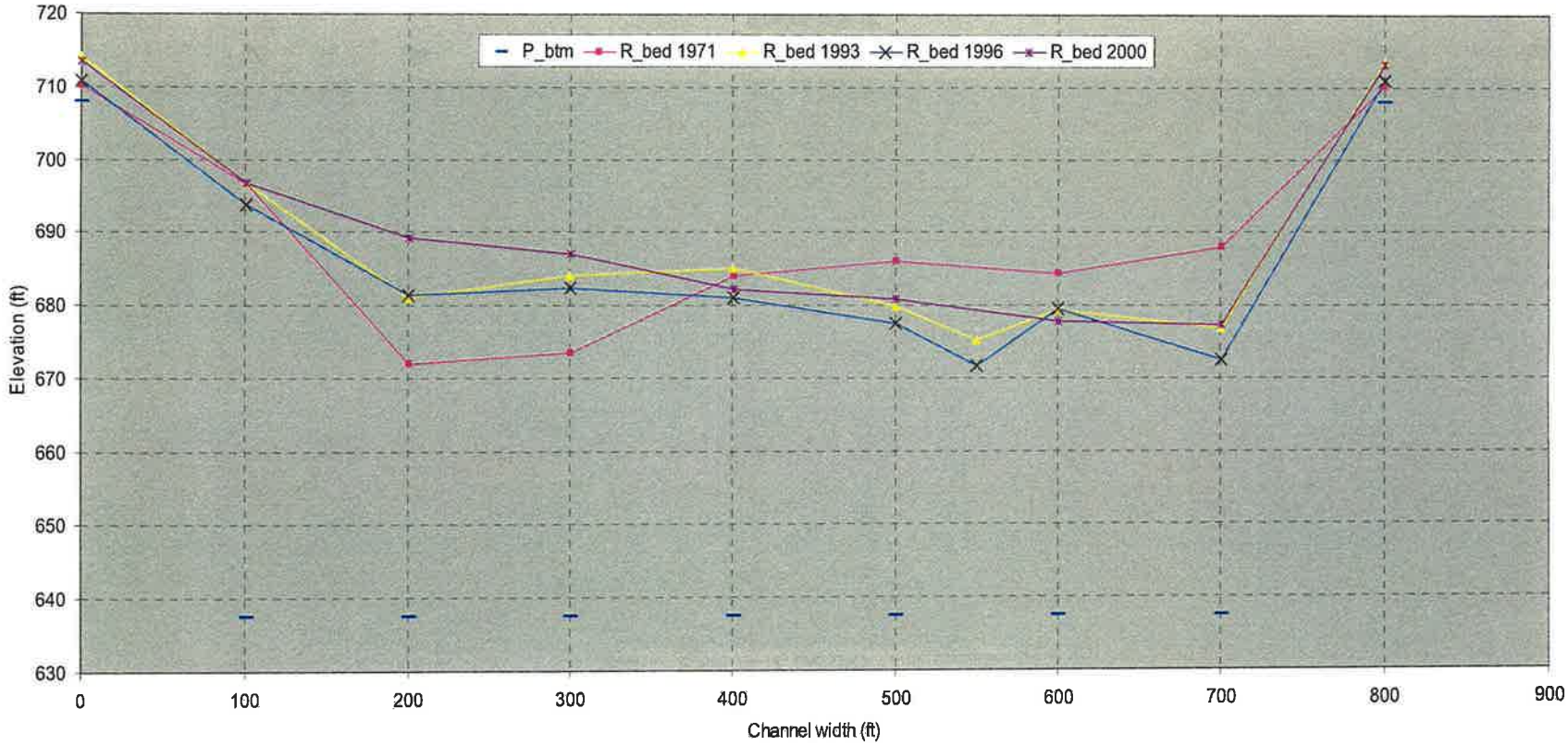


Figure 35. Cross-section at bridge (Bridge No. 18144 and RS 36) on SH 54, Washita River, OK

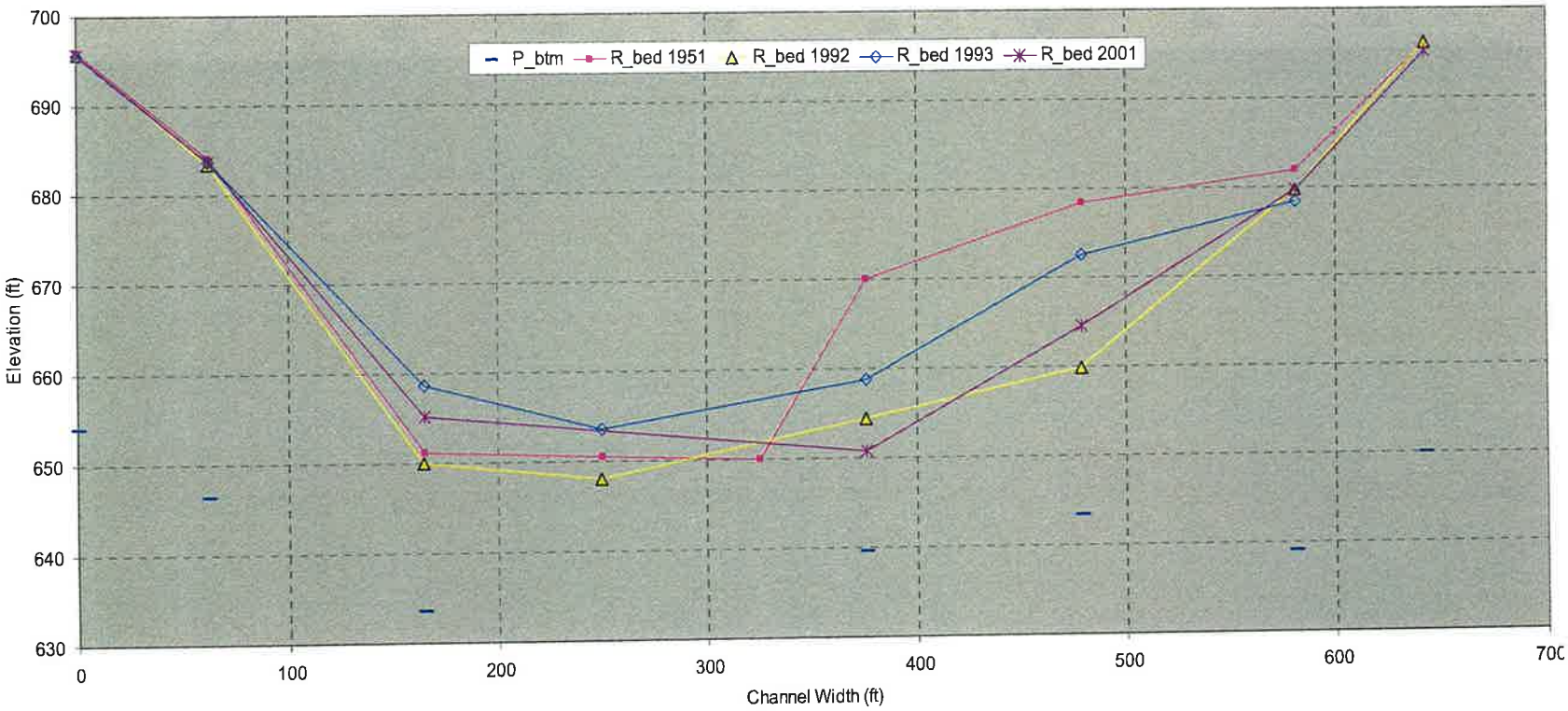


Figure 36. Cross-section at bridge (Bridge No. 12645 and RS 37) on US 177, Washita River, OK

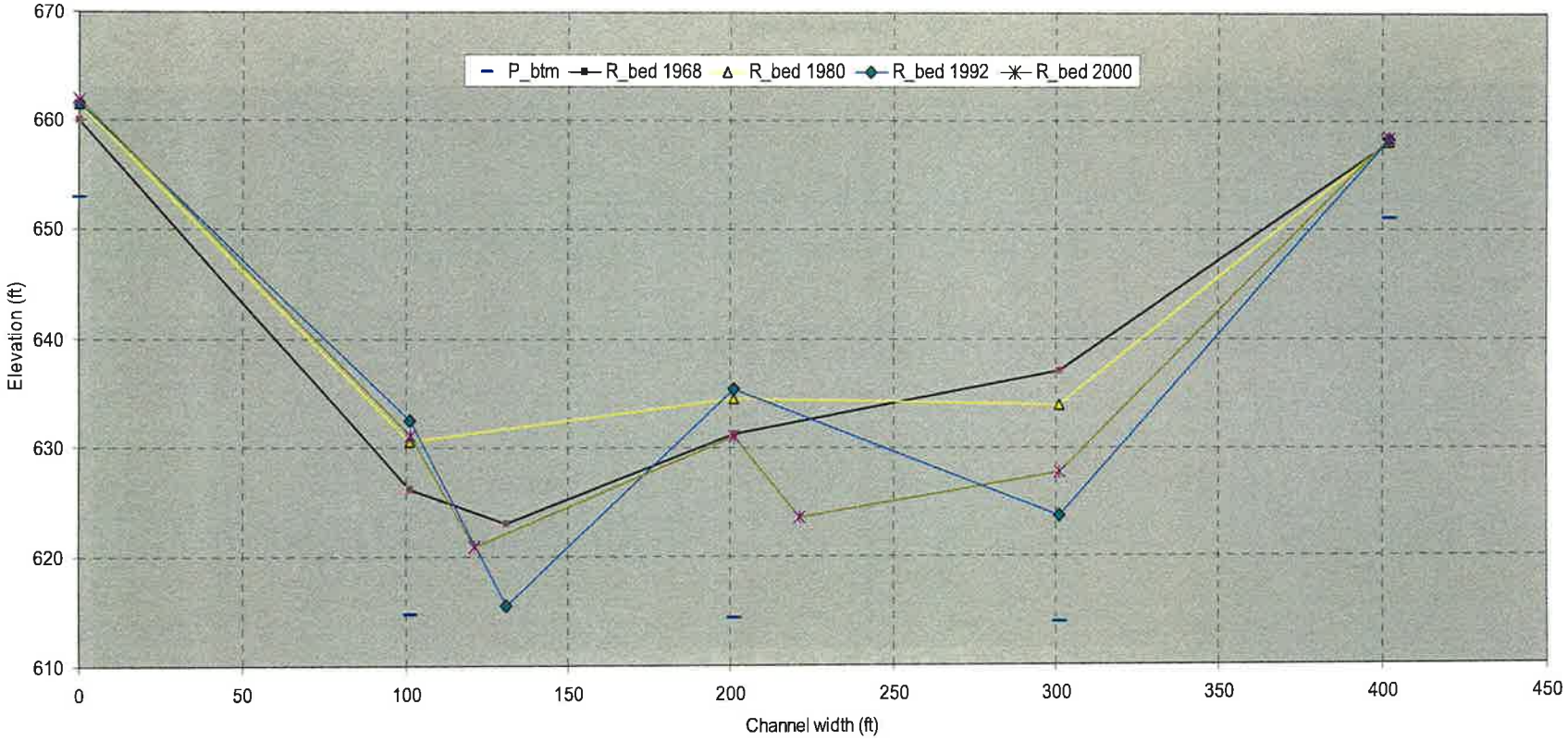


Figure 37. Cross-section at bridge (Bridge No. 17351 and RS 38) on SH 1, Washita River, OK

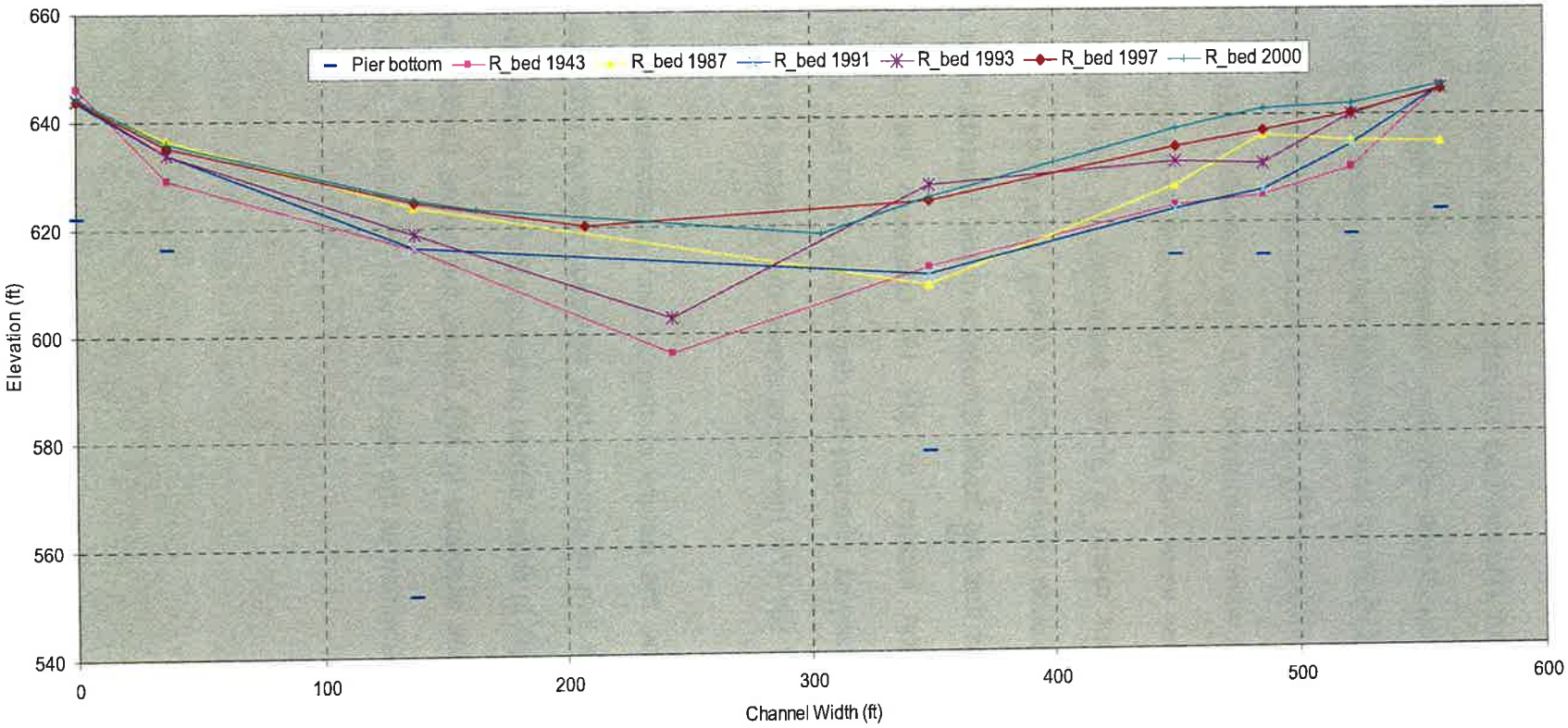


Figure 38. Cross-section at bridge (Bridge No. 10076 and RS 39) on SH 19, Washita River, OK

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 4). The trend line of bed-elevation changes (Fig. 39) was plotted for Study Reaches. Flowlines at each river station were interpolated at 5-year intervals (Table 5) and longitudinal profiles of flowlines were then plotted in Microsoft Excel (Fig. 41). Each twenty-five miles of river reach is plotted separately in each sheet for evaluating channel-bed elevation changes (Figs. 40-61). The study of river-bed elevation change elucidates that the fluvial dynamics of the Washita River are not stable. The River Station located at SH 19, upstream the Lake Texoma, has experienced the largest channel-bed deposition, 22.24 feet, in the Washita River in Oklahoma and SH 17A has experienced the greatest channel bed erosion of 9.61 feet.

To describe the nature of degradation phenomena along the Washita River, the best fit line of channel-bed elevation change rate was plotted along with the river length in miles. Based on the coefficient of correlation, the R^2 value, and the trend lines available in MS Excel, the spline function with sixth order equation was determined as the best fit line with R^2 value of 0.11 (Fig. 40).

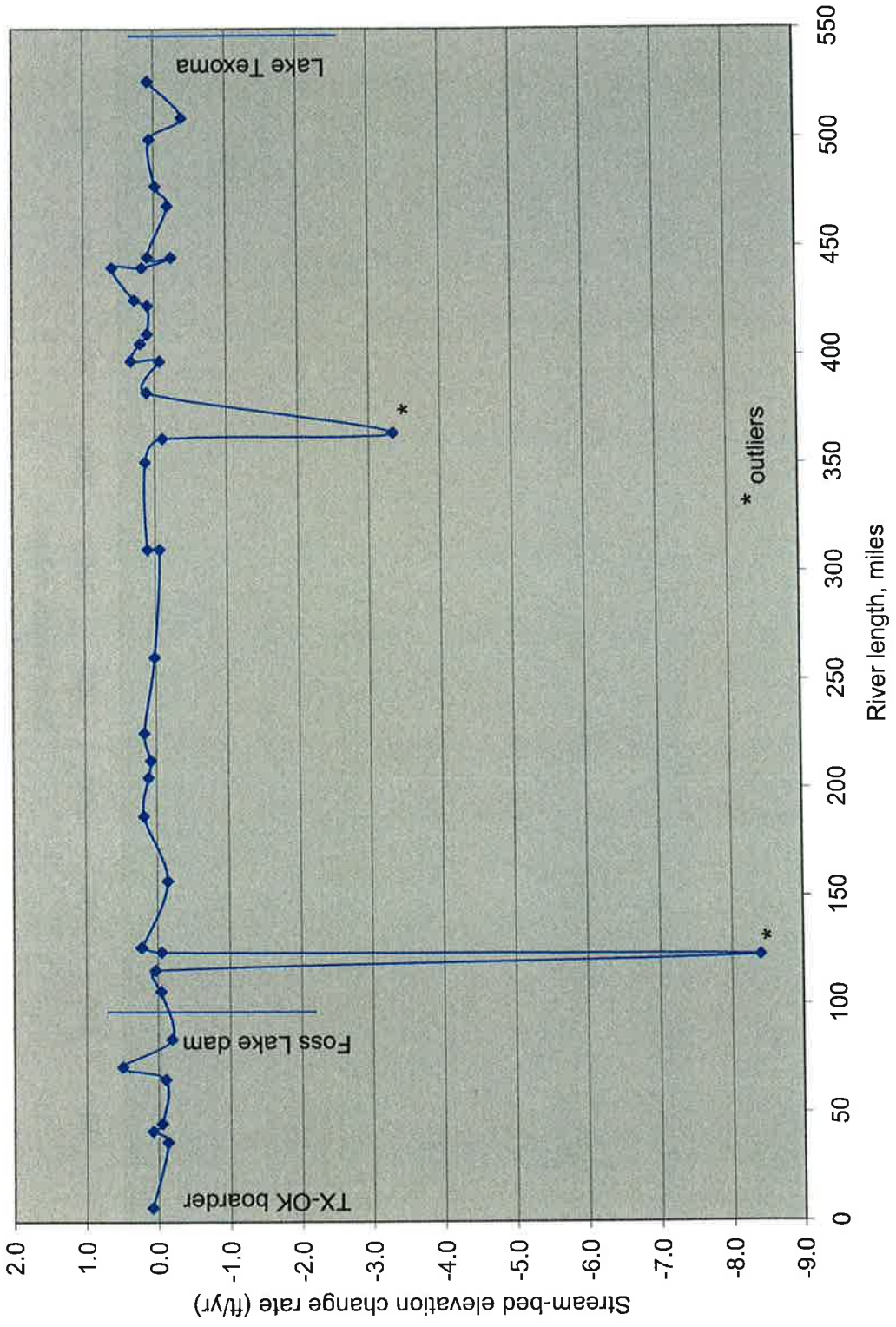


Figure 39. Trend line of stream-bed elevation changes

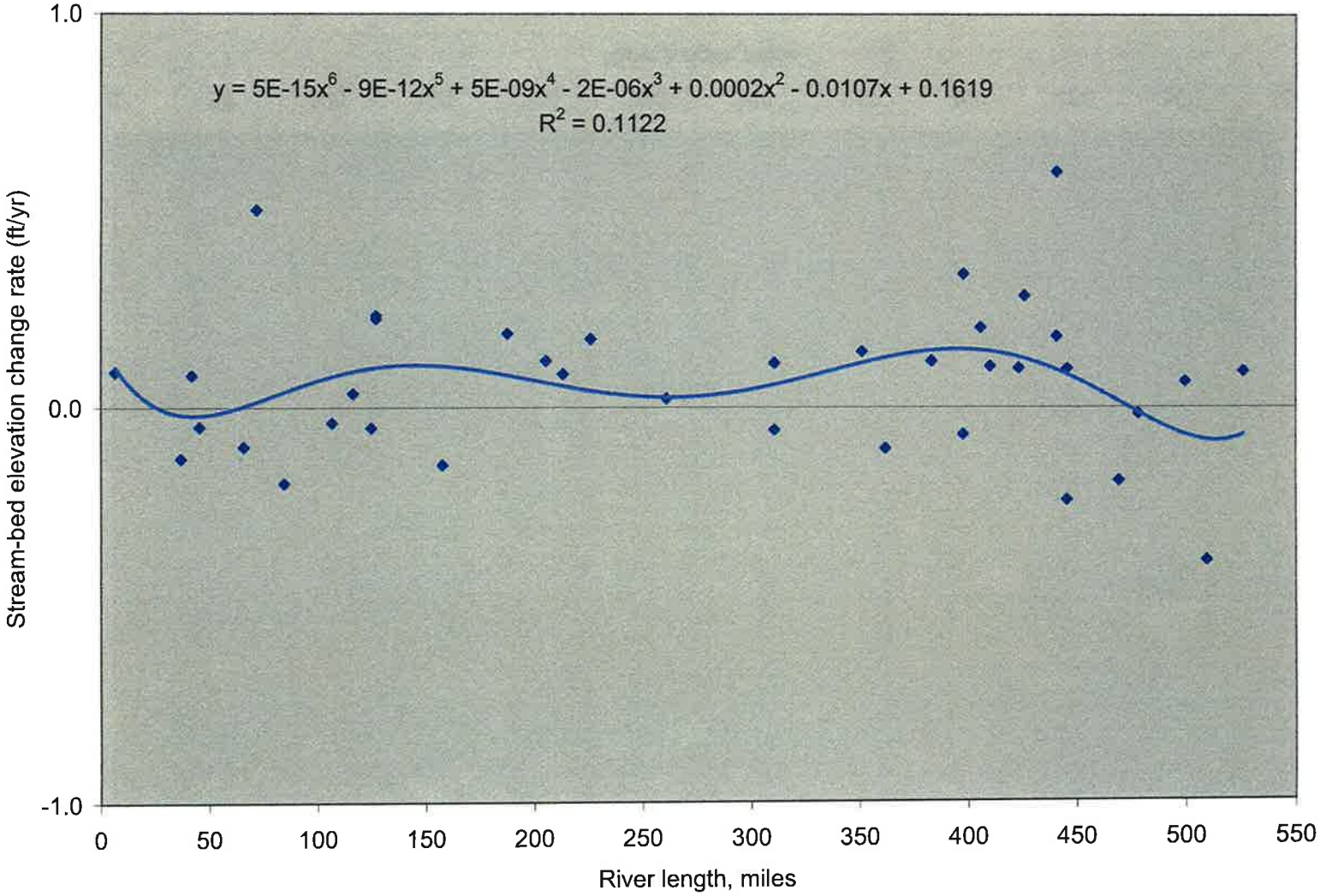


Figure 40. The best fit line of stream-bed elevation change rate (ft/yr) versus river length in miles

Table 4. Summary- River bed elevation change rate - Washita River

Bridge No.	River station	Miles	Highway	Bridge Installed	Stratum	Max. Sour** (ft)	Duration (yr)	Scour Rate** (ft/yr)
14508	RS1	6.2	SH 30	1959	Sand to sholey clay	3.76	42	0.090
19633	RS2	36.41	US 283	1979	Medium hard shale	-4.11	32	-0.128
3792	RS3	41.56	SH 33	1932	Loose sand	6.08	74	0.082
3814	RS4	45.10	SH 33	1932	Loose sand	*3.58	74	-0.045
3781	RS5	65.46	SH 33	1932	Sandy clay	-7.17	73	-0.098
*25277	RS6	71.23	SH 34	1997	Rock	2.5	5	0.500
*13929	RS7	84.06	SH 33	1957	Sand and clay	-8.59	45	-1.191
*17344	RS8	106.18	SH 73	1968	Sand to med. Hard shale	-1.3	34	-0.038
*17580	RS9	115.94	SH 33	1969	Fine sand to sand	1.2	33	0.036
25675	RS10	122.53	US 183	2002	Sandstone	-16.8	2	-8.400
13123	RS11	124.41	I-40 BUS	1953	Sandy soil	-2.1	41	-0.051
17596	RS12	126.61	I-40	1969	Sandy soil	7.22	31	0.233
17597	RS13	126.62	I-40	1969	Sandy soil	6.97	31	0.225
19271	RS14	157.29	SH 152	1976	Fine sand to shale	-3.46	24	-0.144
16625	RS15	187.25	SH 115	1965	Fine sand with clay	6.75	36	0.188
*5045	RS16	205.14	US 77	1936	Sand to rock	4.87	41	0.119
21351	RS17	212.97	SH 9	1986	Silty sand to red bed	1.53	18	0.085
*21116	RS18	225.69	SH 9	1985	Silty sand to red bed	3.3	19	0.174

Table 4. (Continued)

Bridge No.	River station	Miles	Highway	Bridge Installed	Stratum	Max. Sour** (ft)	Duration (yr)	Scour Rate** (ft/yr)
*14194	RS19	260.72	US 281	1958	Sandy soil to rock	1.05	46	0.023
17047	RS20	310.45	US 62	1967	Silty sand	-1.87	33	-0.057
17049	RS21	310.47	US 62	1967	Silty sand	3.71	33	0.112
13119	RS22	350.71	SH 19	1953	Sandy soil	5.96	42	0.142
*13121	RS23	361.63	SH 76	1953	Sandy soil toi red bed	-4.25	41	-0.104
*25272	RS24	364.06	SH 19	1999	Sandy soil to rock	-3.34	1	-3.340
12484	RS25	382.92	SH 74	1950	Sandy clay to sandstone	6.04	51	0.118
17598	RS26	397.42	I-35	1969	Fine sand to hard shale	-1.78	26	-0.068
17599	RS27	397.45	I-35	1969	Fin sand to hard shale	8.78	26	0.338
16814	RS28	405.45	US 77	1966	Sand and brown shale	6.06	30	0.202
7342	RS29	409.94	SH 19	1939	Sandy soil to sandstone	6.48	62	0.105
14516	RS30	423.08	US 77	1959	Sandy soil to soft shale	4.18	42	0.100
17956	RS31	425.69	SH 17A	1970	Sand to soft red bed	9.61	34	0.283
*27398	RS32	440.49	SH 7	2004	Rock	0.6	1	0.600
19273	RS33	440.51	SH 7	1976	Fine sand to hard clay	5.39	30	0.180
17959	RS34	445.27	US 77	1970	Fine sand to med hard shale	-7.07	30	-0.236
22416	RS35	445.29	US 77	1989	Sandy clay to shale	1.08	11	0.098

Table 4. (Continued)

Bridge No.	River station	Miles	Highway	Bridge Installed	Stratum	Max. Sour** (ft)	Duration (yr)	Scour Rate** (ft/yr)
18144	RS36	469.02	SH 53	1971	Sand with mixed gravel	-5.42	29	-0187
12645	RS37	479.00	US 177	1951	Sandy Clay to Shale	-0.84	52	-0.016
17351	RS38	499.50	SH 1	1968	Fine sand to soft shale	2.09	32	0.065
10076	RS39	509.40	SH 19	1943	Unknown	-22.24	57	-0.390

* Bridge without cross section data

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

Table 5. Interpolated flowline data for 5 year interval – Washita River

Location			Years								
Bridge No.	River station	Miles	1965	1970	1975	1980	1985	1990	1995	2000	2005
14508	RS1	6.2	2181.91	2180.17	2182.82	2181.42	2180.41	2180.92	2181.47	2180.12	
19633	RS2	36.41				1906.70	1907.44	1906.11	1906.91	1909.00	
3792	RS3	41.56	1867.71	1865.71	1866.81	1867.55	1866.12	1864.49	1862.73	1861.60	1861.63
3814	RS4	45.10	1831.93	1834.85	1835.95	1837.55	1836.68	1836.25	1836.21	1835.71	1835.45
3781	RS5	65.46	1713.50	1713.3	1713.67	1713.66	1713.10	1713.30	1714.20	1714.19	1714.17
25277	RS6	71.23								1688.40	1688.65
13929	RS7	84.06	16928.40	1629.49	1630.57	1632.54	1632.54	1635.10	1641.50	1639.42	
17344	RS8	106.18		1526.77	1527.46	1527.25	1527.25	1527.00	1527.67	1528.20	
17580	RS9	115.94		1495.90	1492.90	1491.90	1491.90	1491.90	1494.37	1495.55	
25675	RS10	122.53									1492.80
13123	RS11	124.41	1462.45	1464.00	1464.91	1468.20	1468.20	1468.00	1465.60		
17596	RS12	126.61		1461.47	1454.73	1456.03	1456.03	1459.13	1458.61	1457.98	
17597	RS13	126.62		1460.86	1456.83	1457.33	1457.33	1459.13	1457.11	1456.53	
19271	RS14	157.29			1372.00	1373.64	1373.64	1374.76	1373.14	1375.46	
16625	RS15	187.25	1314.00	1302.63	1301.75	1304.45	1304.45	1304.43	1306.28	1307.09	
5045	RS16	205.14	1265.20	1266.00	1264.50	1263.50	1263.50	1263.40	1262.12	1260.00	1261.30
21351	RS17	212.97						1248.69	1250.28	1246.45	1246.98
21116	RS18	225.69						1222.70	1221.75	1219.54	1220.99
14194	RS19	260.72	1154.95	1153.80	1154.00	1156.91	1156.91	1158.70	1156.13	1155.70	1155.38
17047	RS20	310.45	1047.00	1050.55	1055.12	1055.95	1055.95	1052.40	1047.62	1049.67	
17049	RS21	310.47	1049.50	1050.63	1050.63	1050.13	1050.13	1050.43	1045.23	1045.79	
13119	RS22	350.71	973.30	973.14	973.14	973.47	973.47	970.46	969.05		

Table 5. (Continued)

Location			Years								
Bridge No.	River station	Miles	1965	1970	1975	1980	1985	1990	1995	2000	2005
13121	RS23	361.63	953.75	952.65	954.90	952.59	951.45	949.02	948.35		
25272	RS24	364.06								947.82	
12484	RS25	382.92	910.36	909.76	906.36	910.26	904.36	909.06	905.26	907.66	
17598	RS26	397.42		876.38	873.28	877.23	872.08	872.39	878.78		
17599	RS27	397.45		871.00	875.99	876.78	874.78	873.08	878.78		
16814	RS28	405.45	861.00	546.91	855.91	859.14	856.01	852.55	848.71		
7342	RS29	409.94	846.22	845.52	843.82	843.15	846.12	842.32	833.12	844.27	
14516	RS30	423.08	816.06	813.43	810.33	811.16	805.03	807.39	803.53	806.06	
17956	RS31	425.69		810.00	806.02	802.05	805.40	8/04.66	800.03	801.09	799.39
27398	RS32	440.49									762.50
19273	RS33	440.51			773.00	771.88	771.11	769.56	770.61	768.51	767.61
17959	RS34	445.27		753.00	762.77	759.44	763.82	757.90	754.77	760.07	
22416	RS35	445.29						758.69	759.73	758.92	
18144	RS36	469.02		672.00	669.75	667.50	667.50	665.50	673.50	677.42	
12645	RS37	479.00	653.34	649.64	646.89	652.54	649.60	651.04	655.54	650.54	
17351	RS38	499.50		623.00	623.00	630.55	620.49	621.49	624.49	620.91	
10076	RS39	509.40	617.72	616.27	611.92	606.21	607.34	610.04	616.77	618.44	614.94

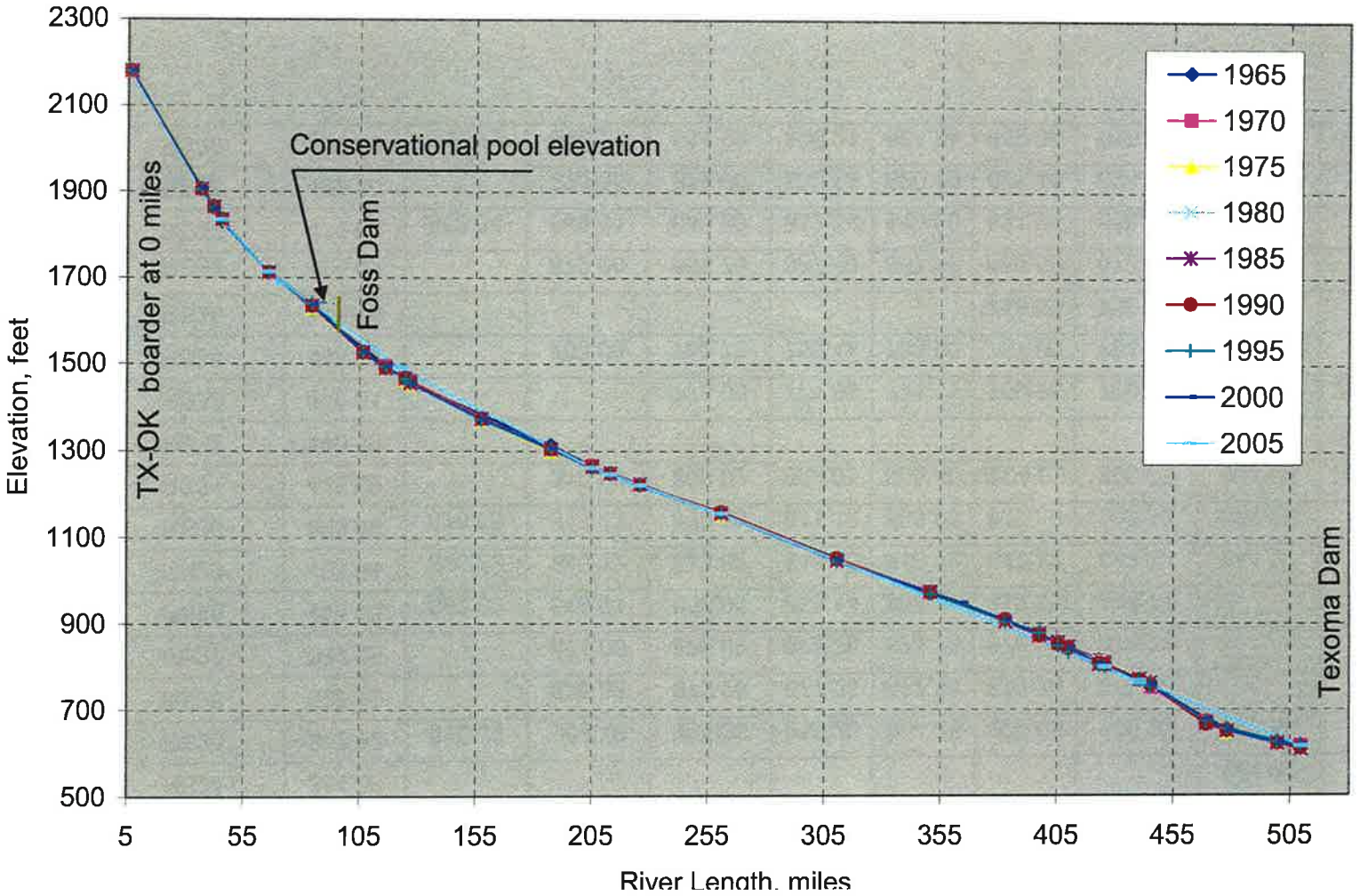


Figure 41. Longitudinal Profile of Washita River Bed, Oklahoma

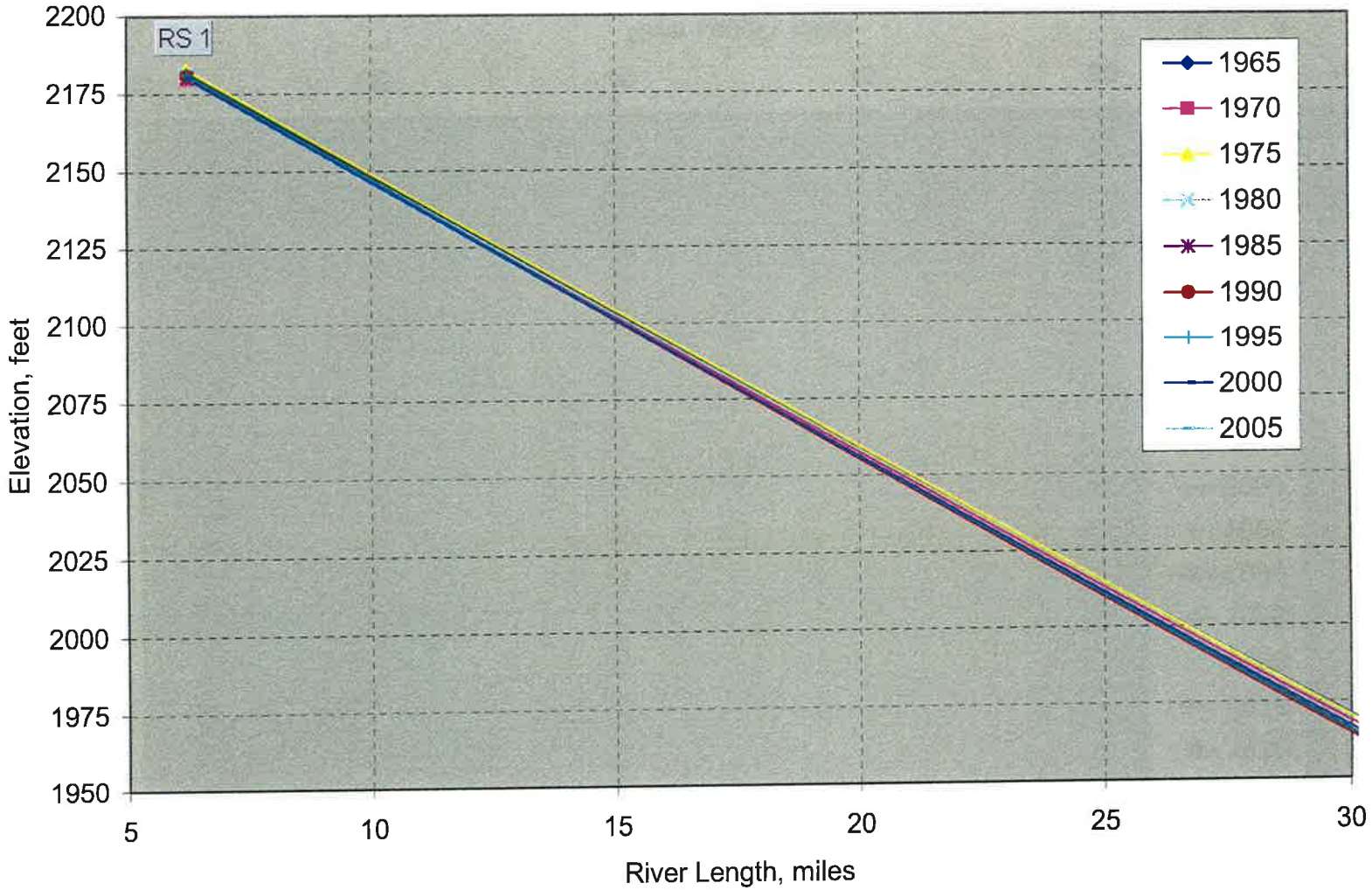


Figure 42. Longitudinal Profile of Washita River Bed, Oklahoma

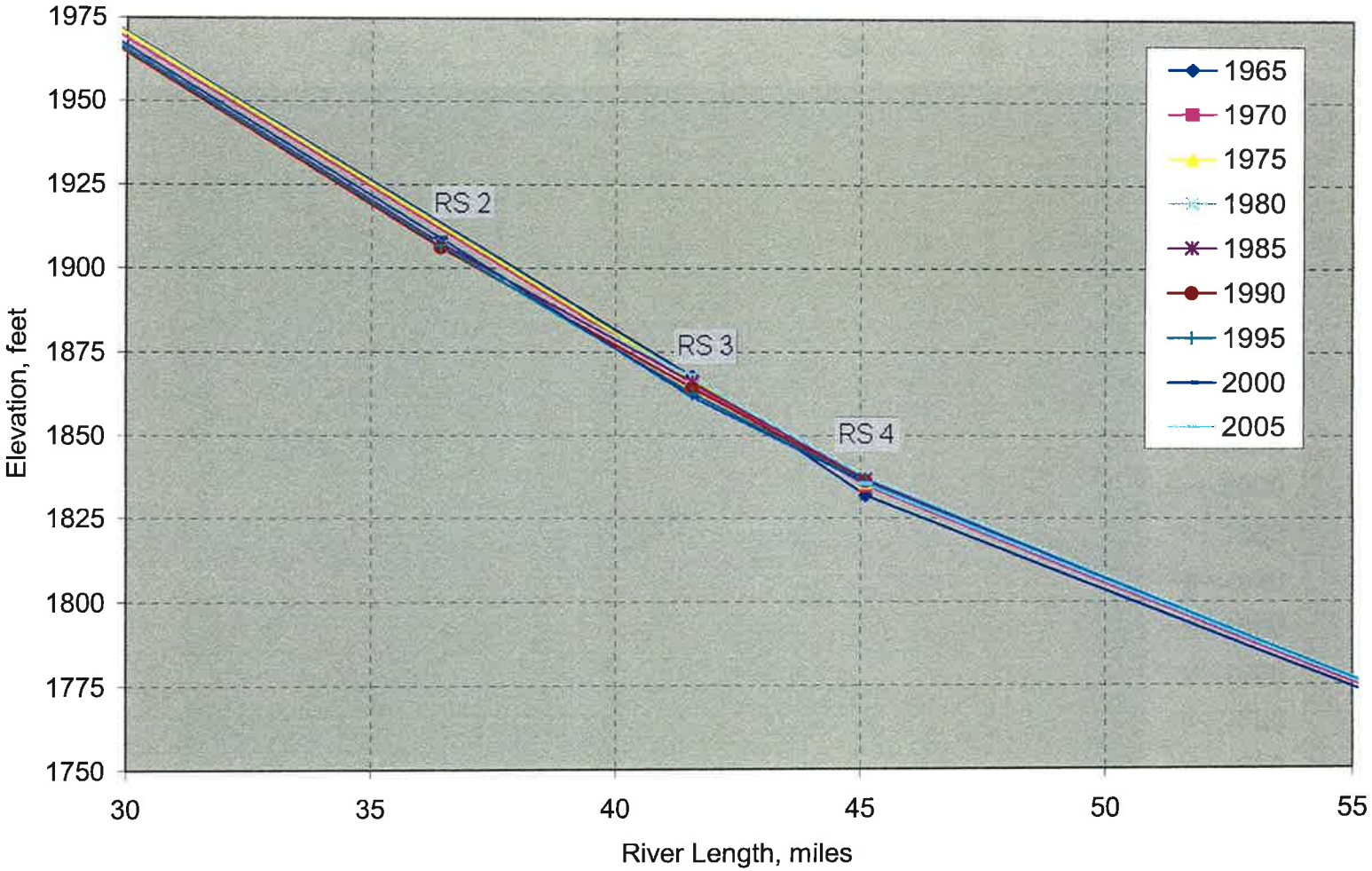


Figure 43. Longitudinal Profile of Washita River Bed, Oklahoma

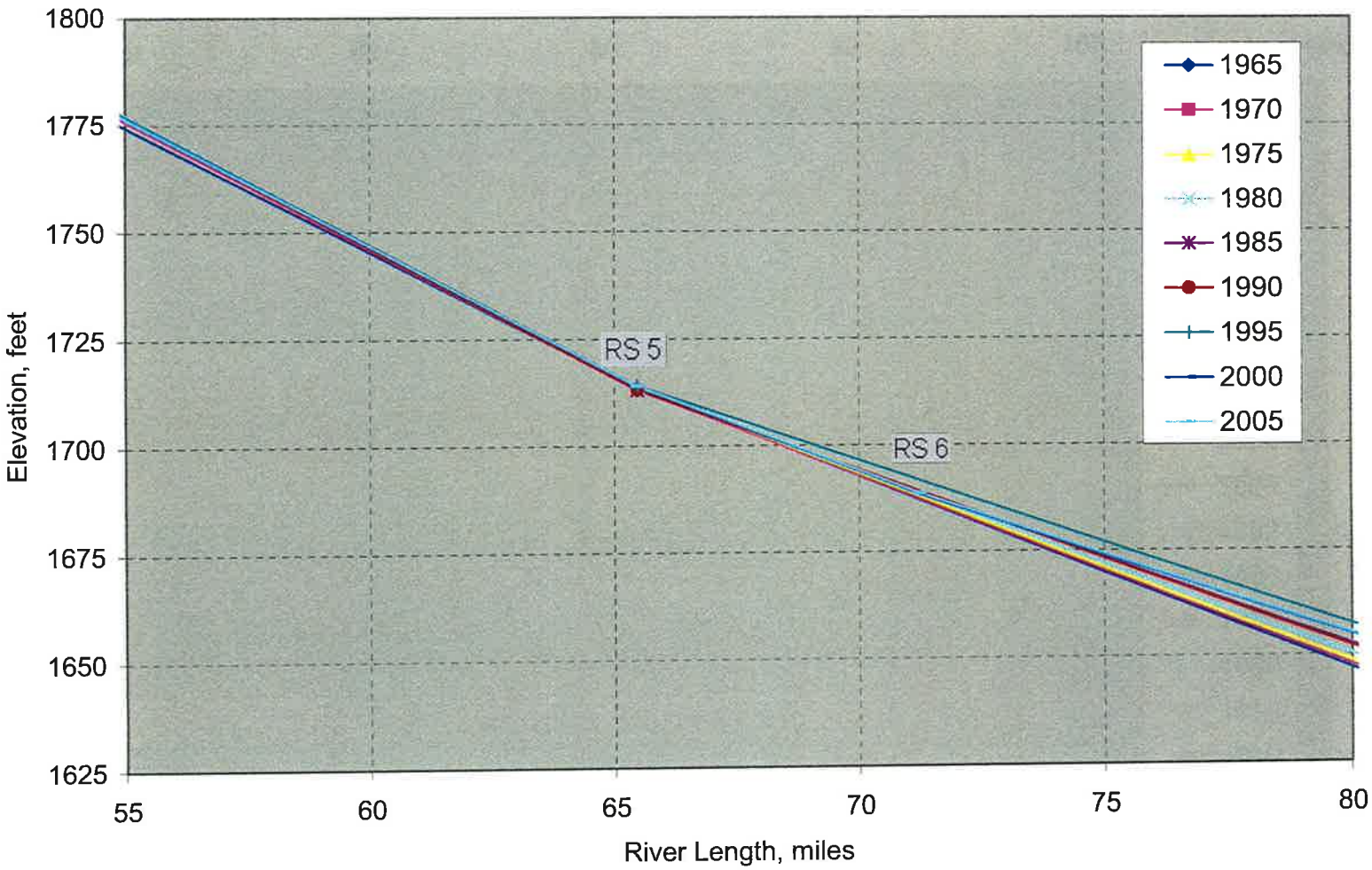


Figure 44. Longitudinal Profile of Washita River Bed, Oklahoma

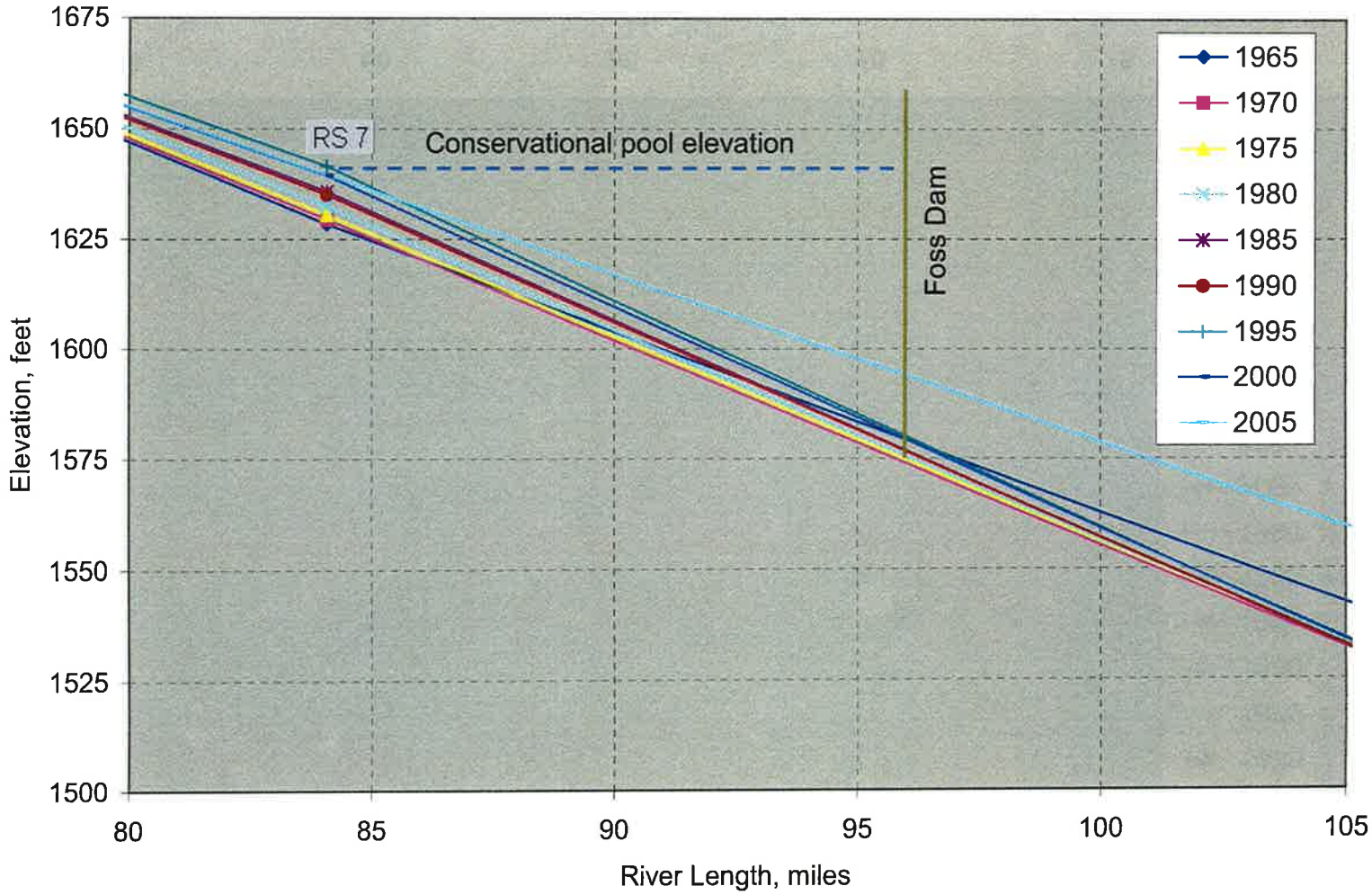


Figure 45. Longitudinal Profile of Washita River Bed, Oklahoma

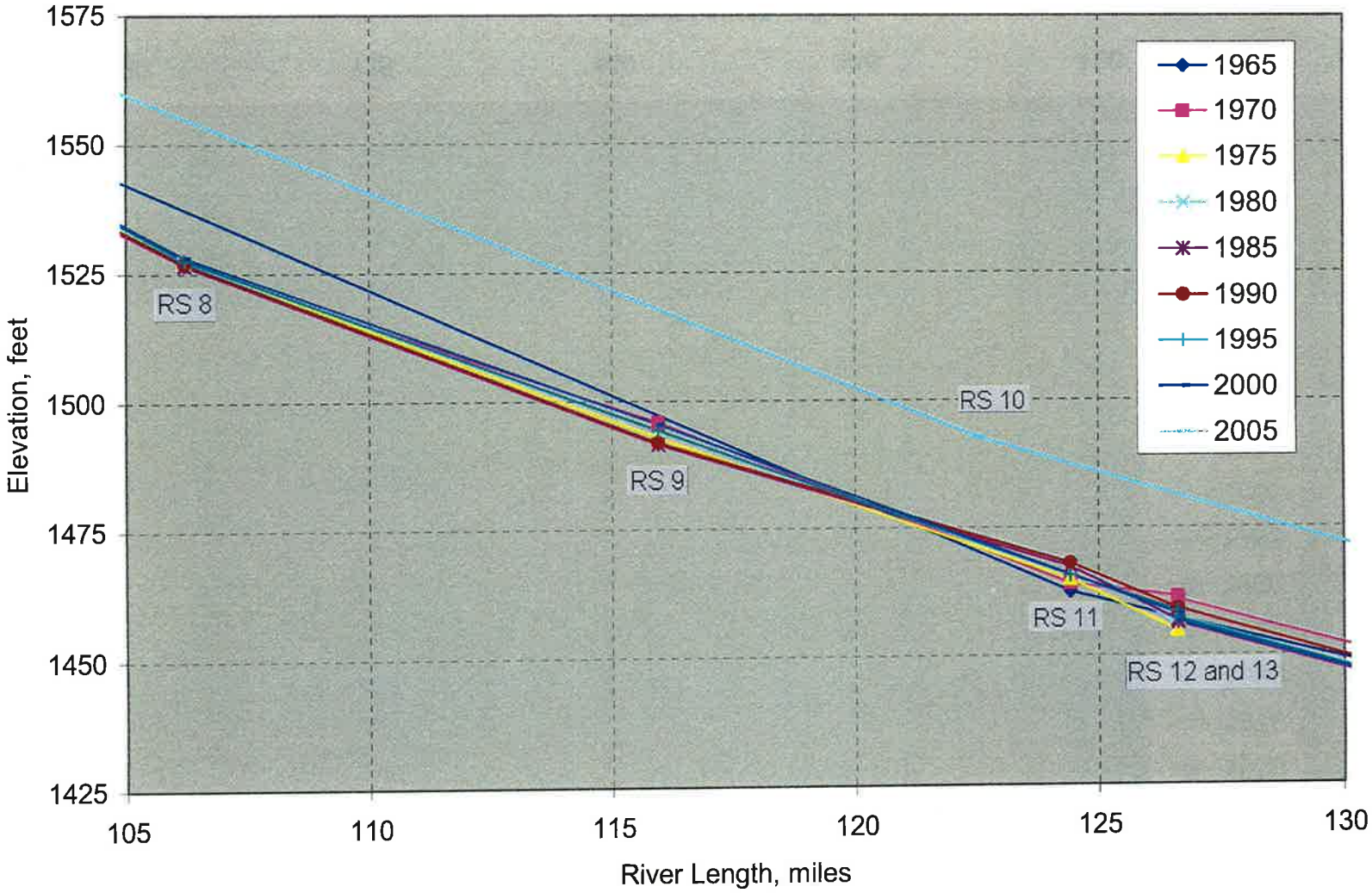


Figure 46. Longitudinal Profile of Washita River Bed, Oklahoma

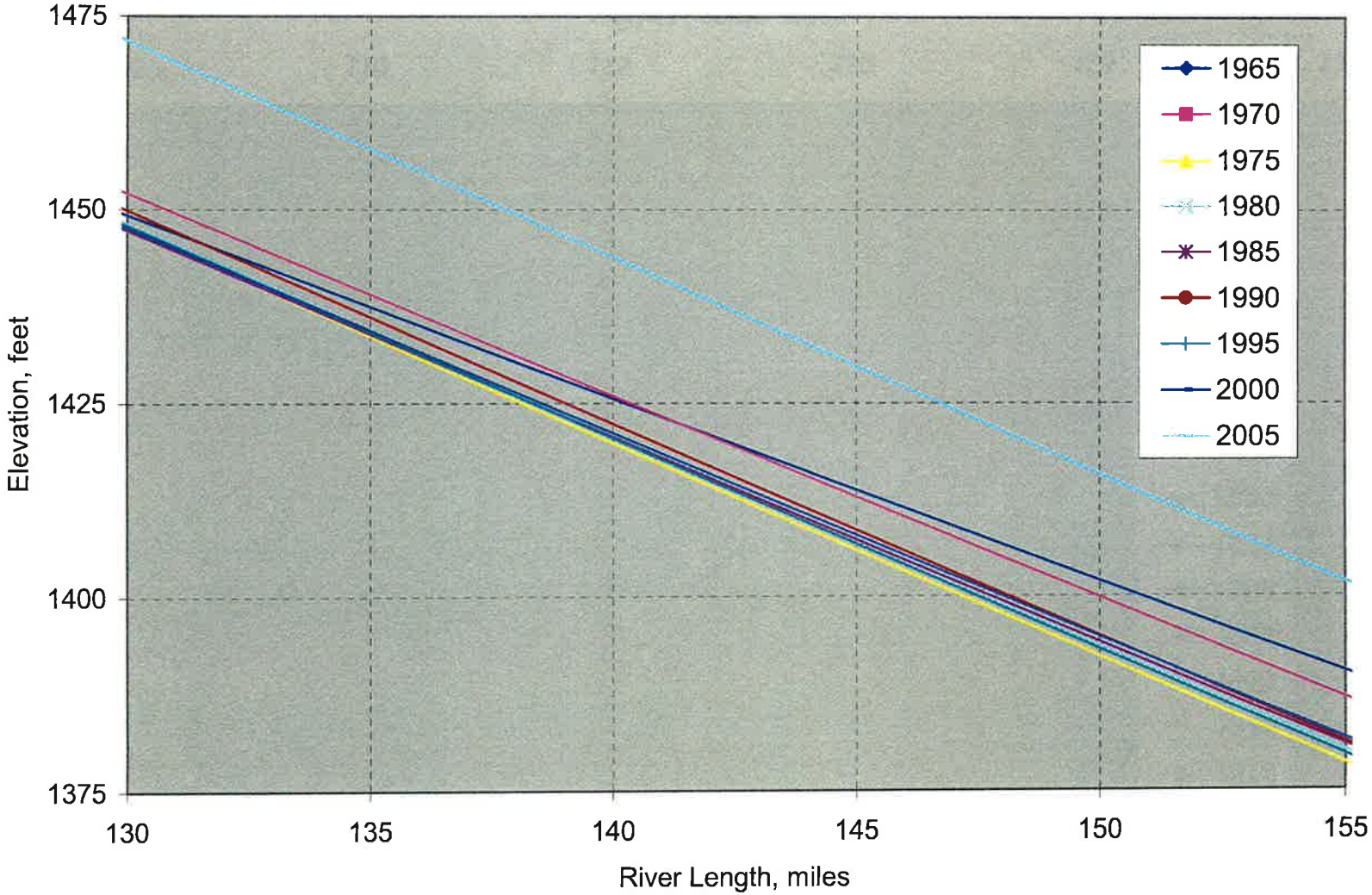


Figure 47. Longitudinal Profile of Washita River Bed, Oklahoma

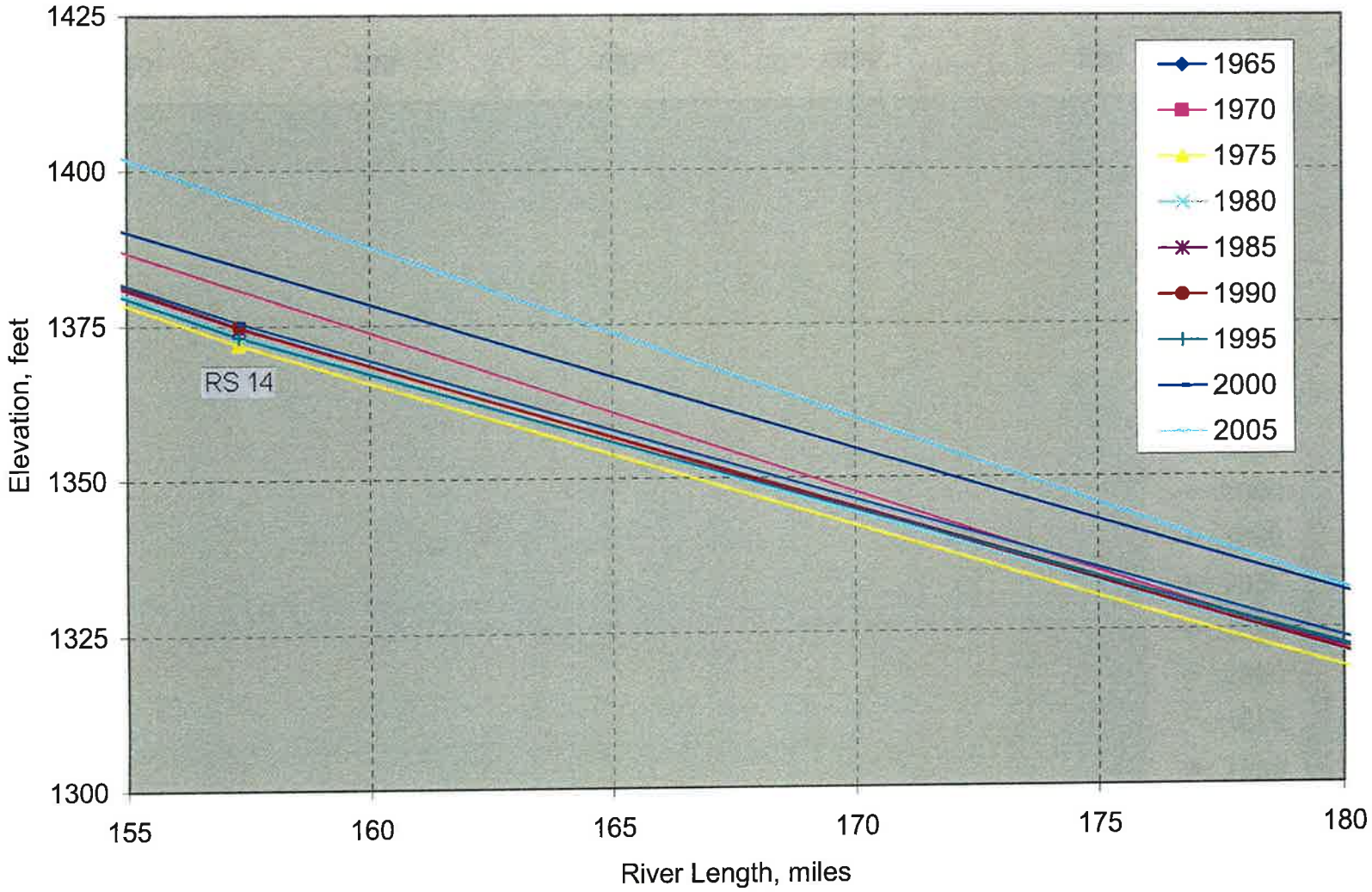


Figure 48. Longitudinal Profile of Washita River Bed, Oklahoma

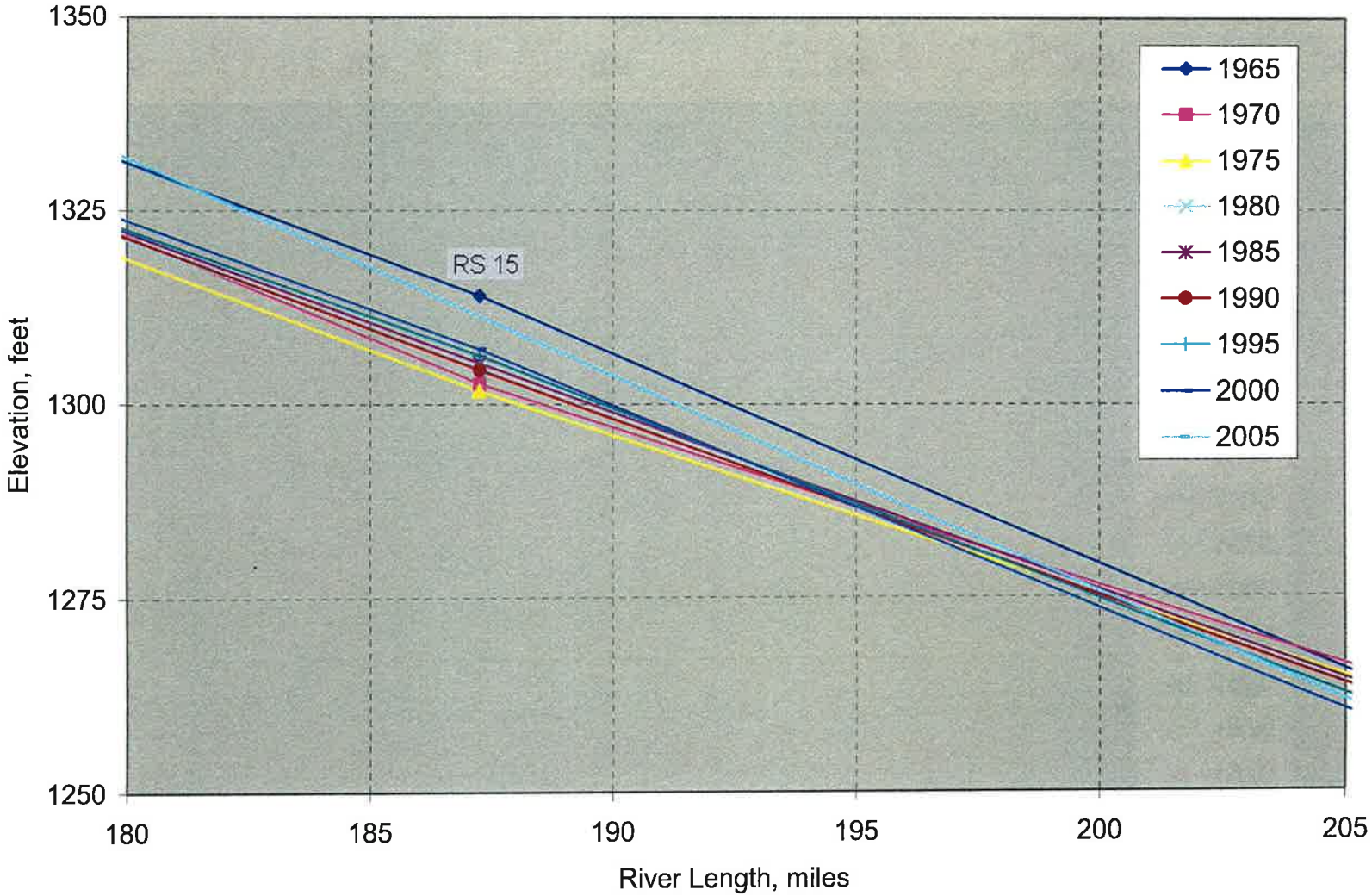


Figure 49. Longitudinal Profile of Washita River Bed, Oklahoma

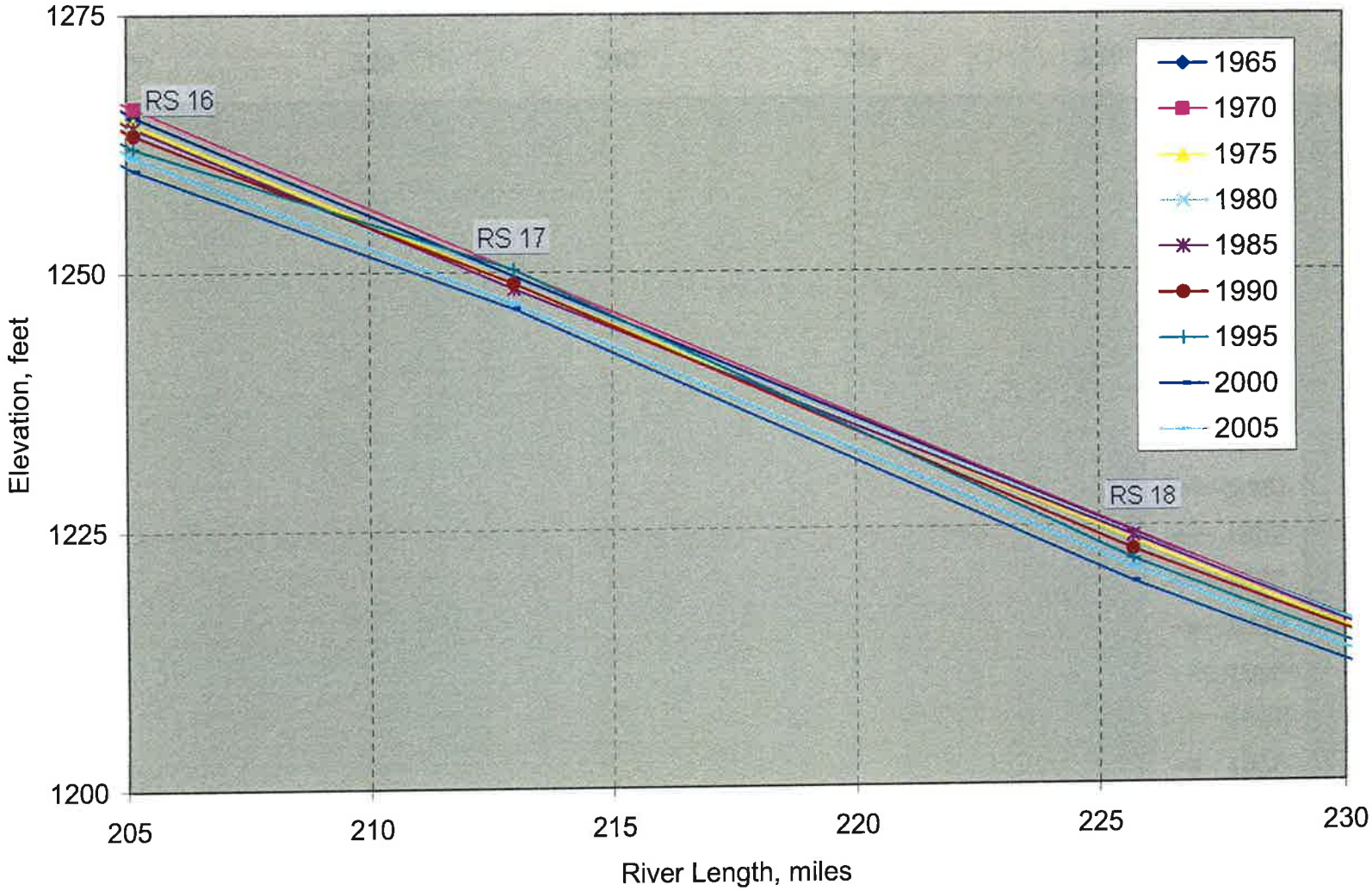


Figure 50. Longitudinal Profile of Washita River Bed, Oklahoma

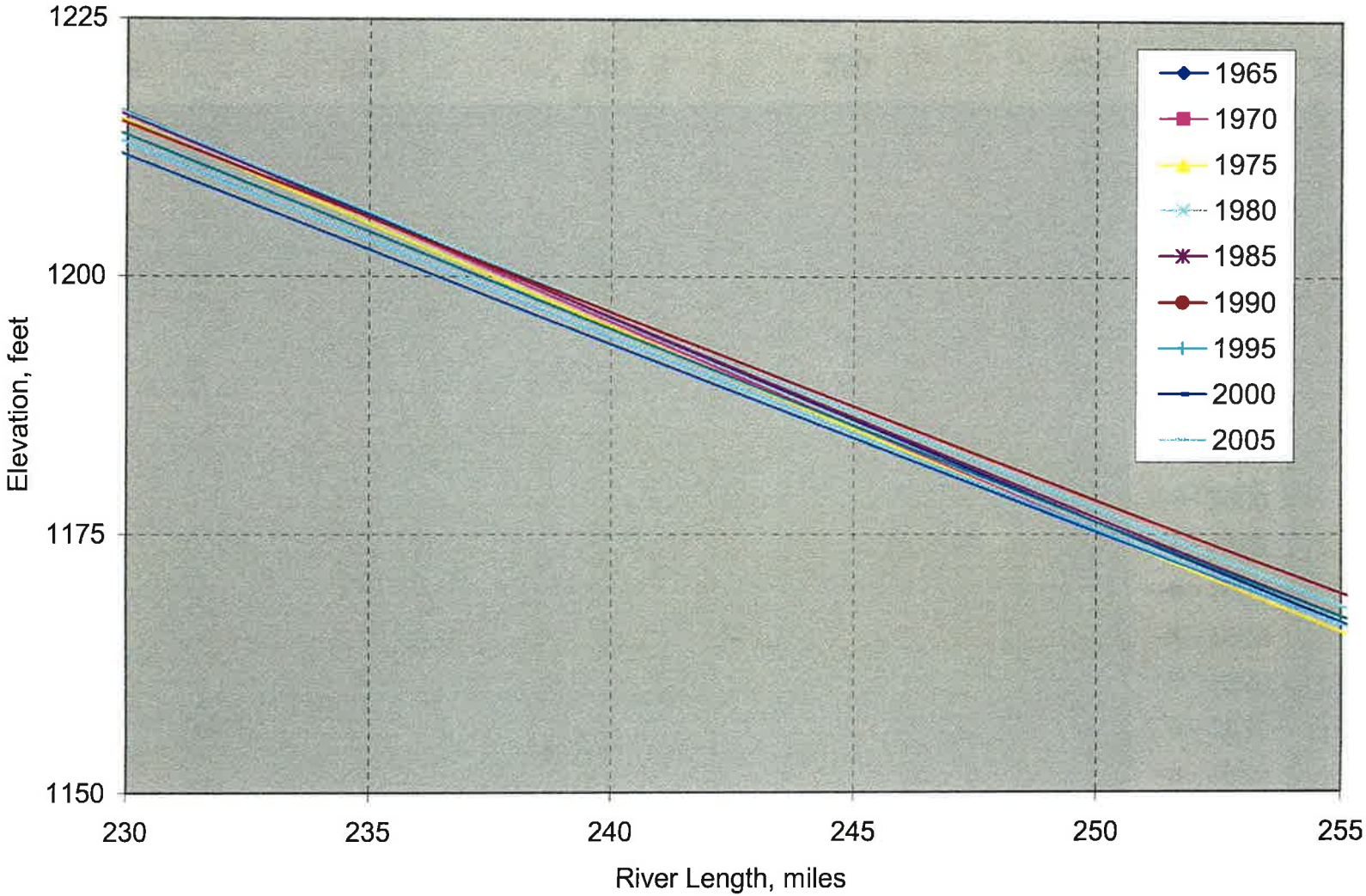


Figure 51. Longitudinal Profile of Washita River Bed, Oklahoma

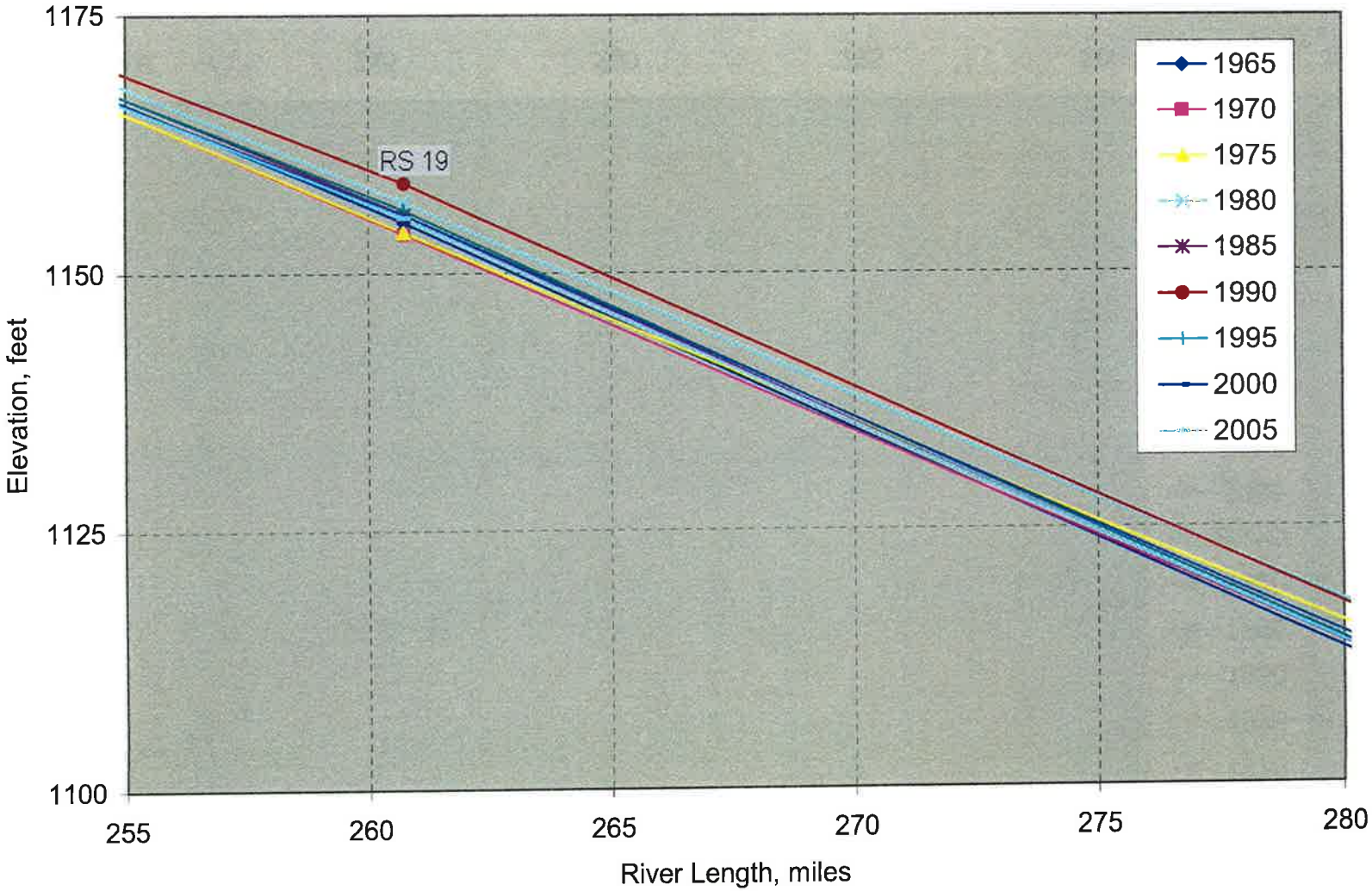


Figure 52. Longitudinal Profile of Washita River Bed, Oklahoma

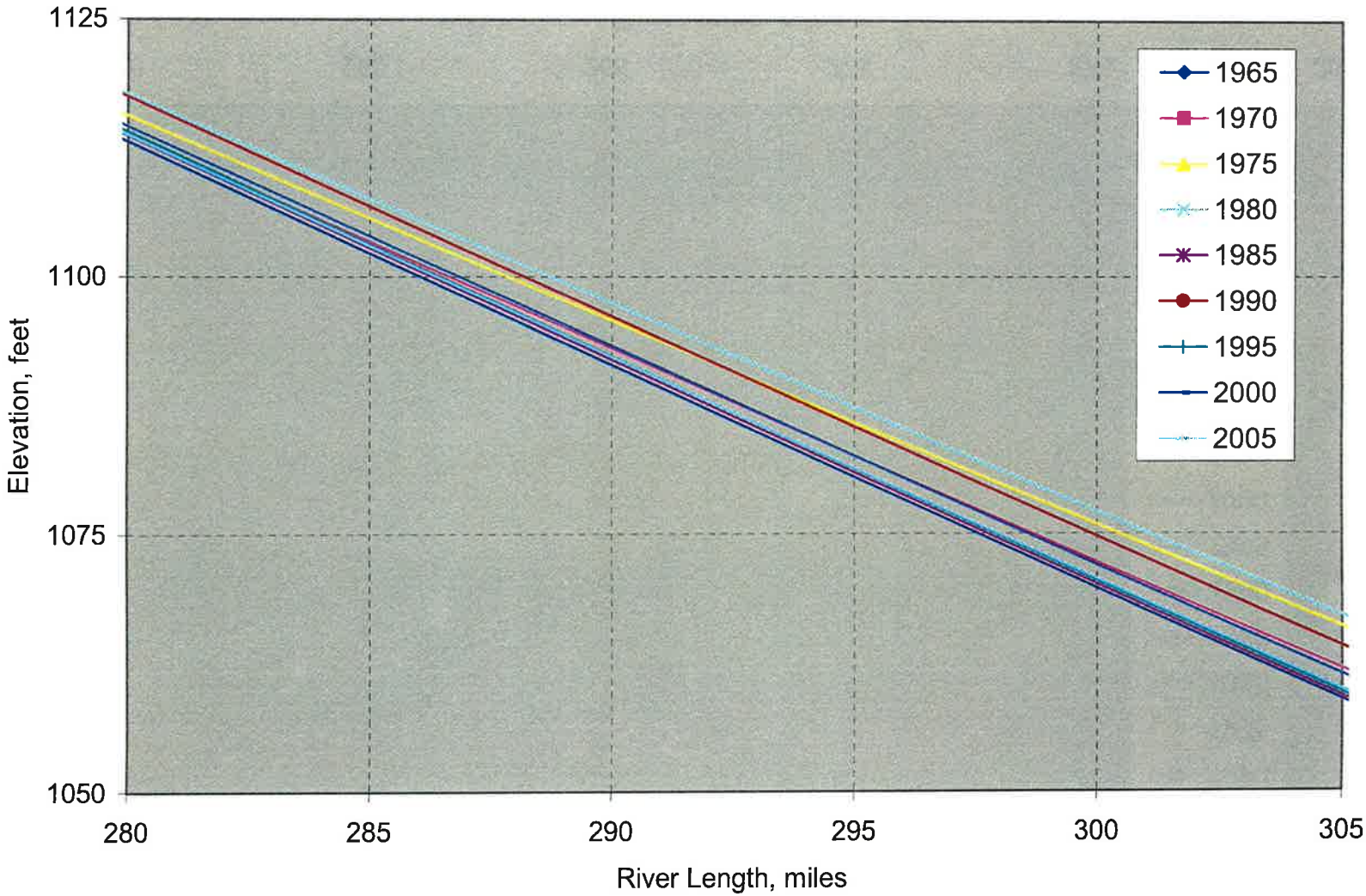


Figure 53. Longitudinal Profile of Washita River Bed, Oklahoma

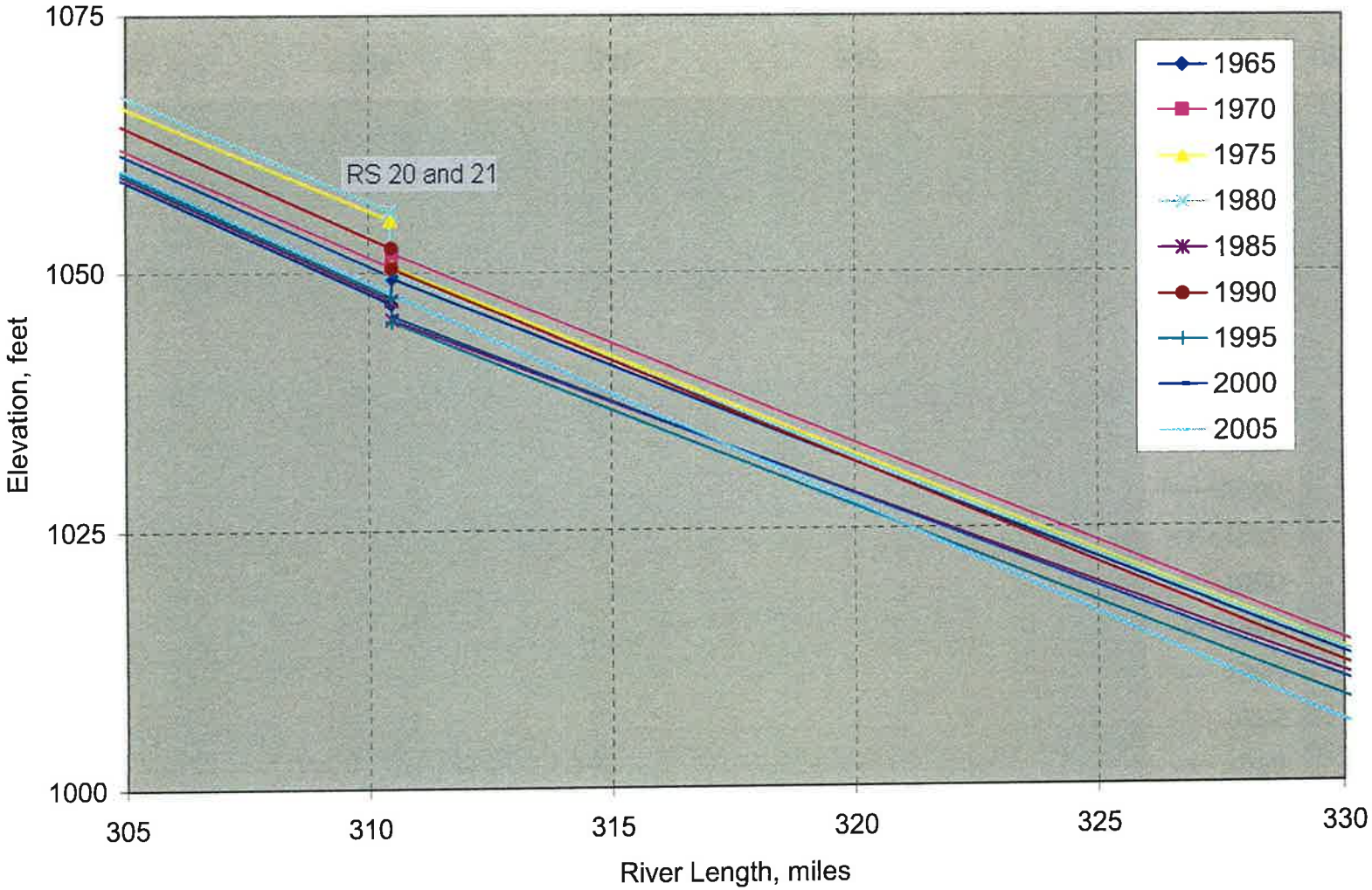


Figure 54. Longitudinal Profile of Washita River Bed, Oklahoma

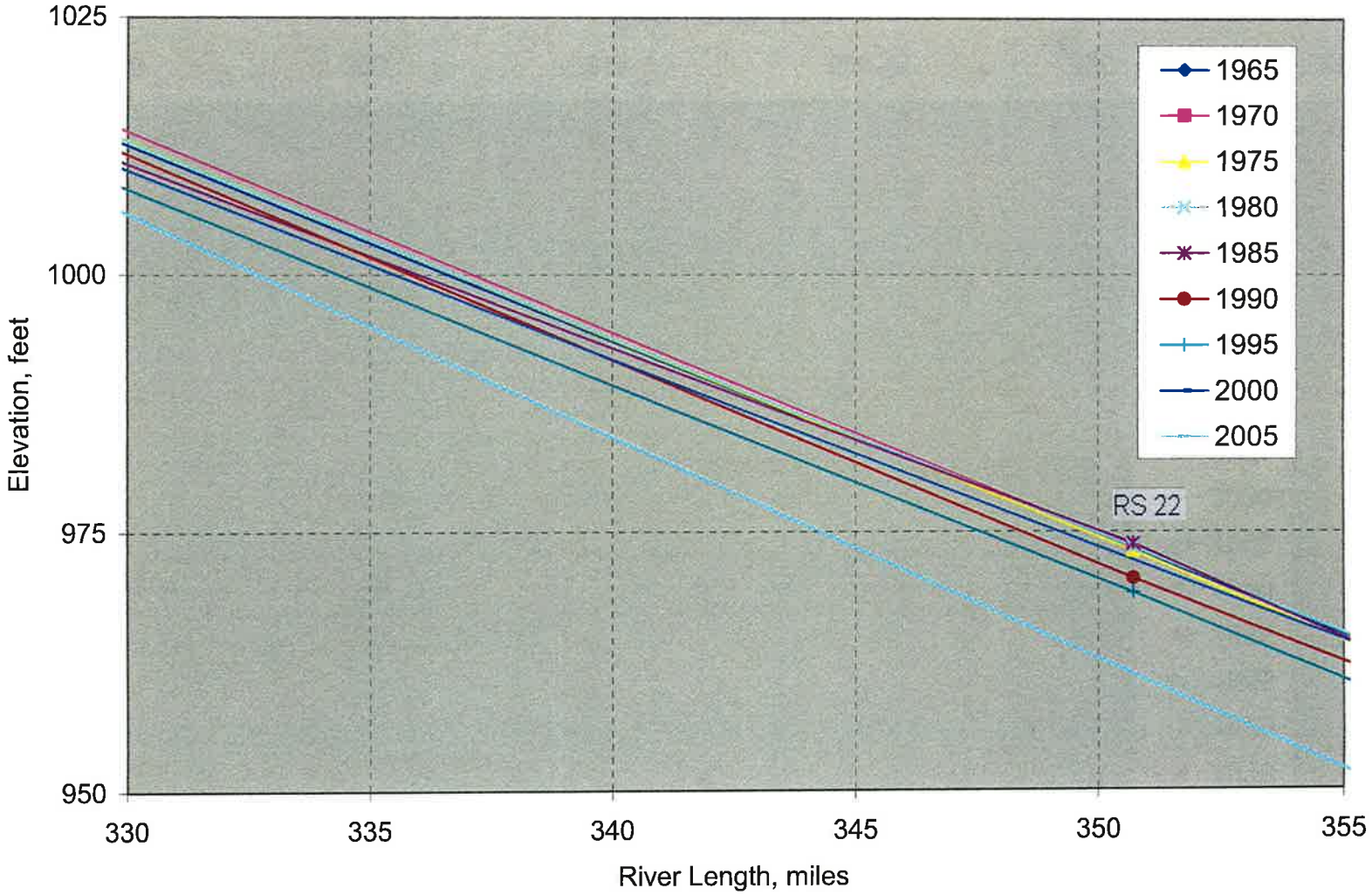


Figure 55. Longitudinal Profile of Washita River Bed, Oklahoma

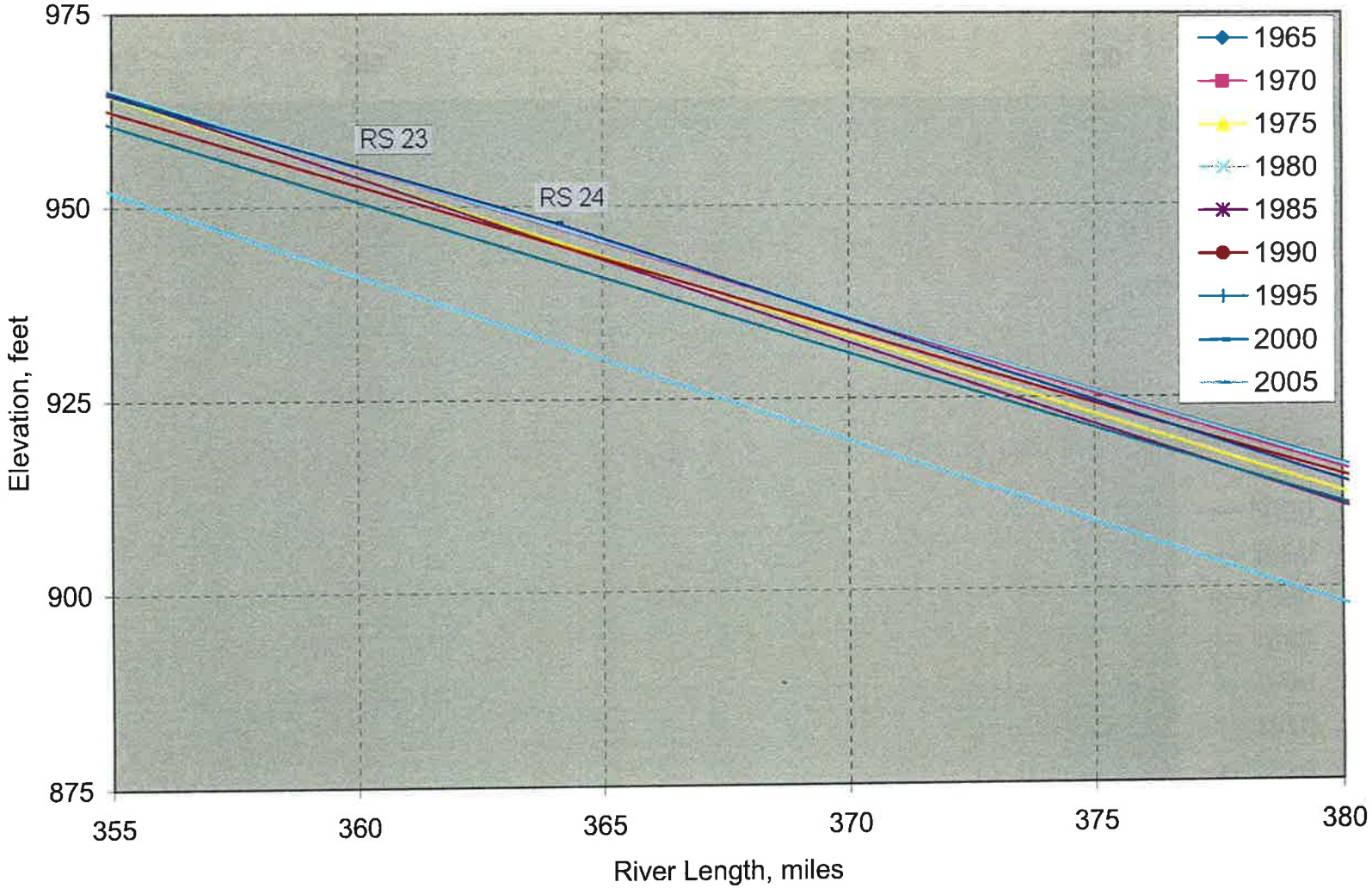


Figure 56. Longitudinal Profile of Washita River Bed, Oklahoma

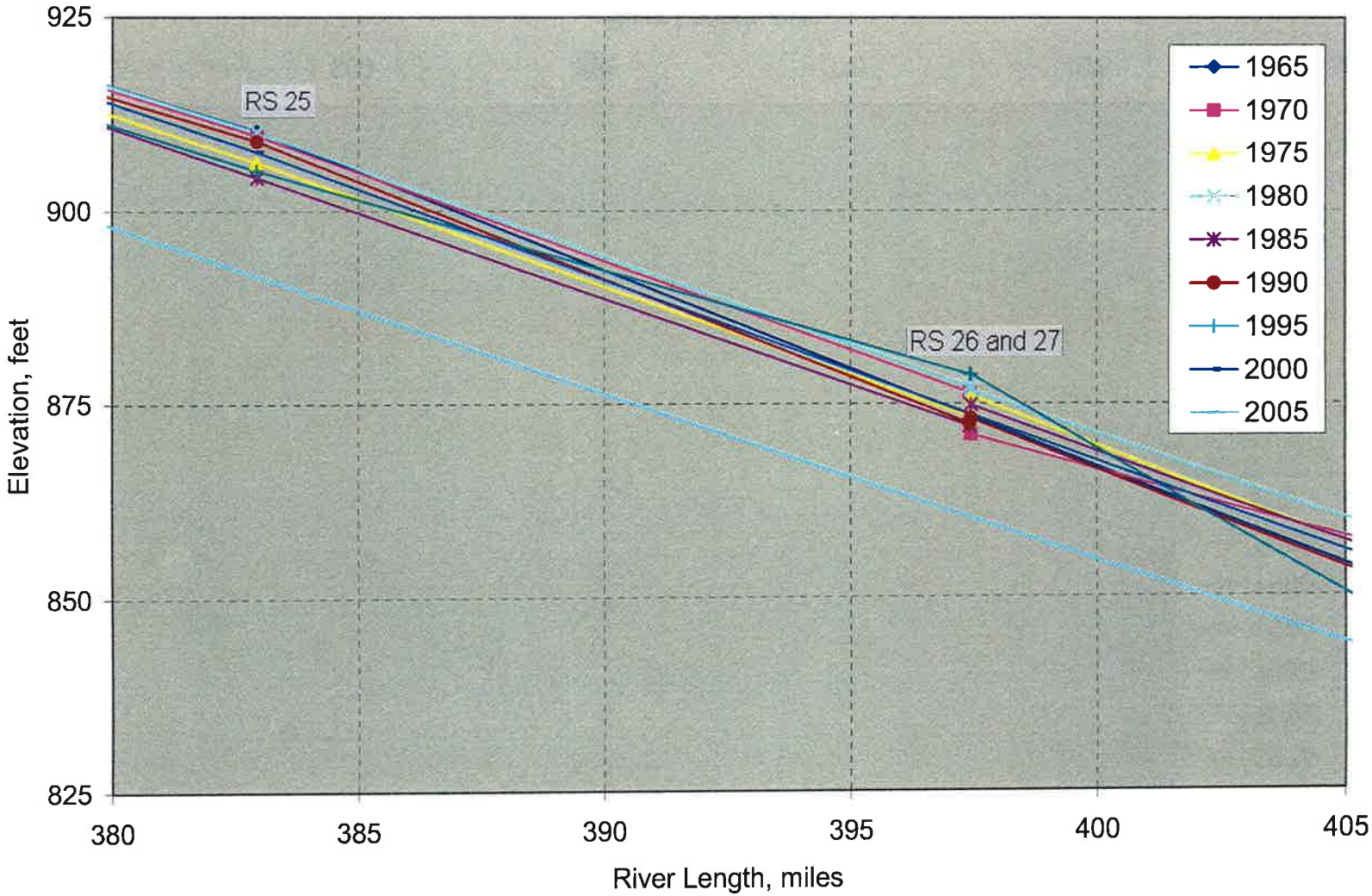


Figure 57. Longitudinal Profile of Washita River Bed, Oklahoma

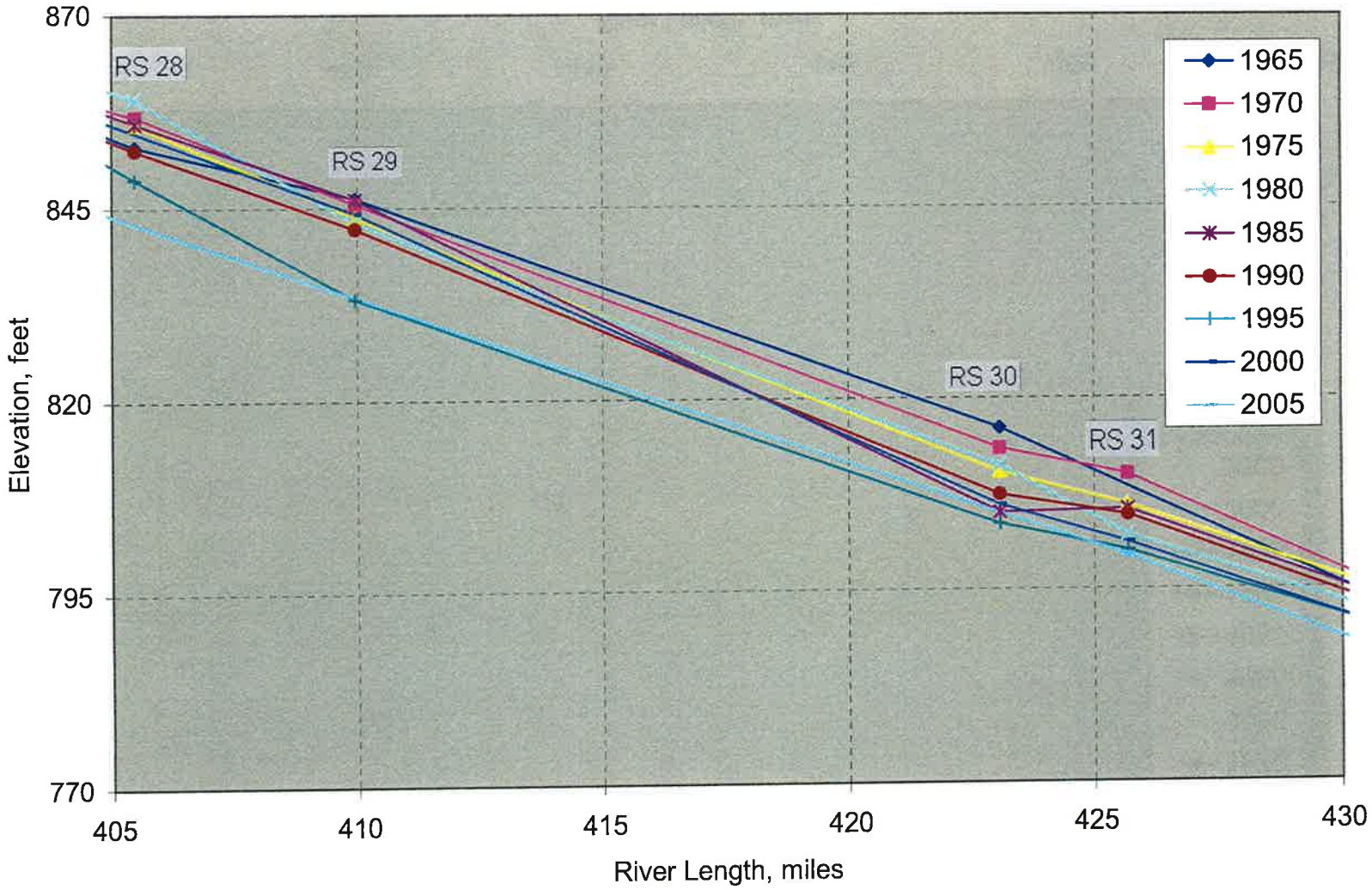


Figure 58. Longitudinal Profile of Washita River Bed, Oklahoma

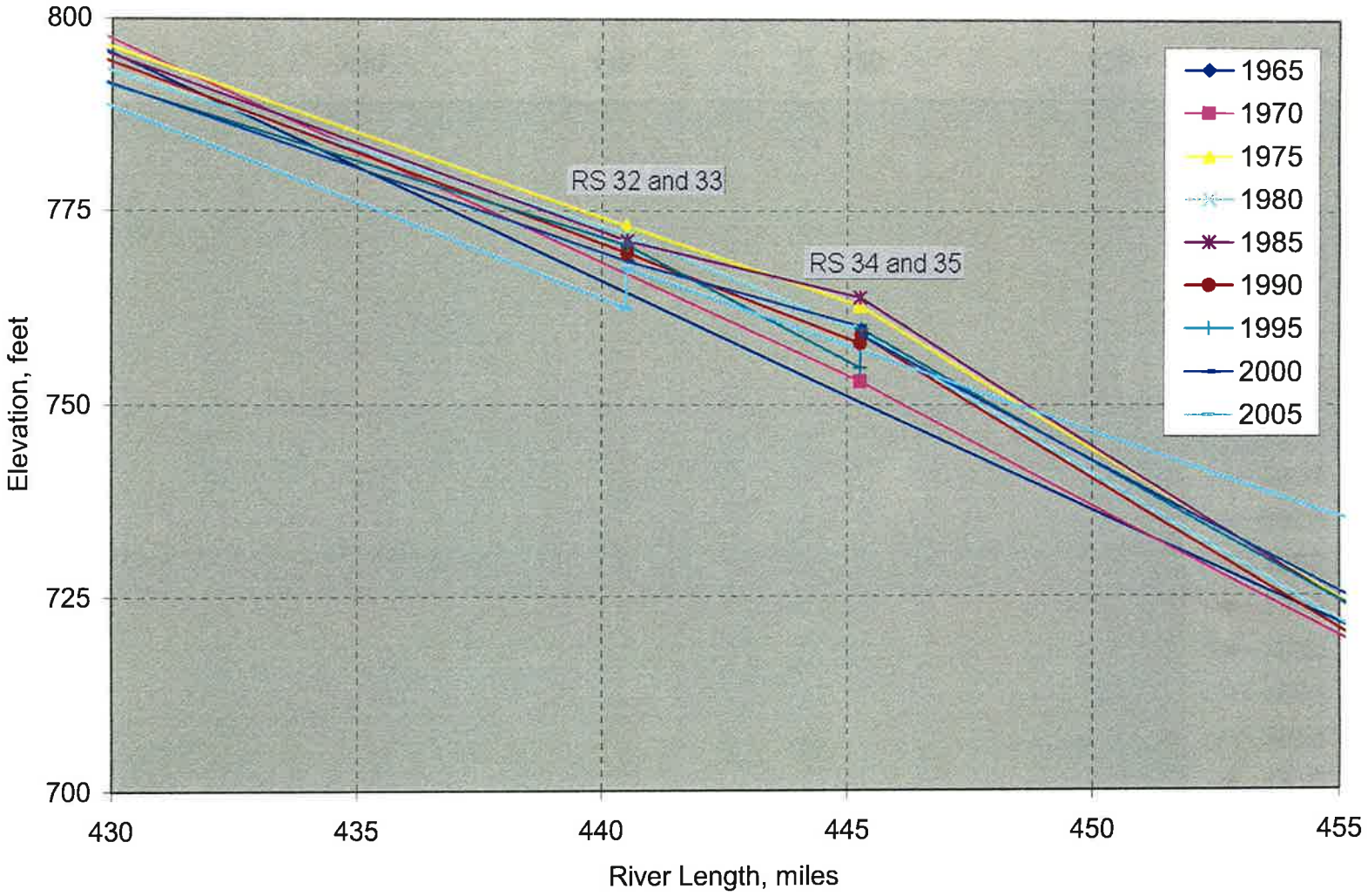


Figure 59. Longitudinal Profile of Washita River Bed, Oklahoma

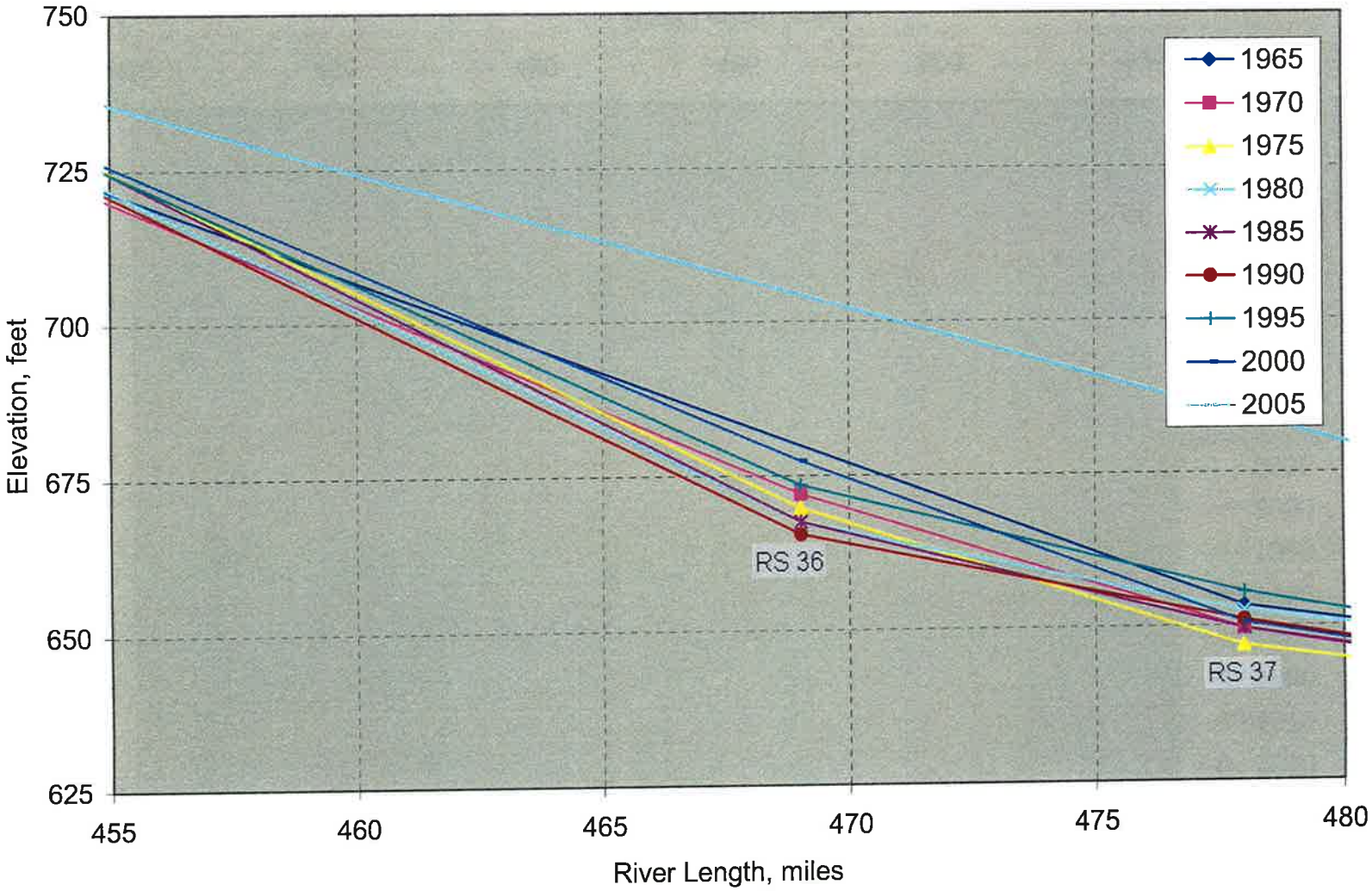


Figure 60. Longitudinal Profile of Washita River Bed, Oklahoma

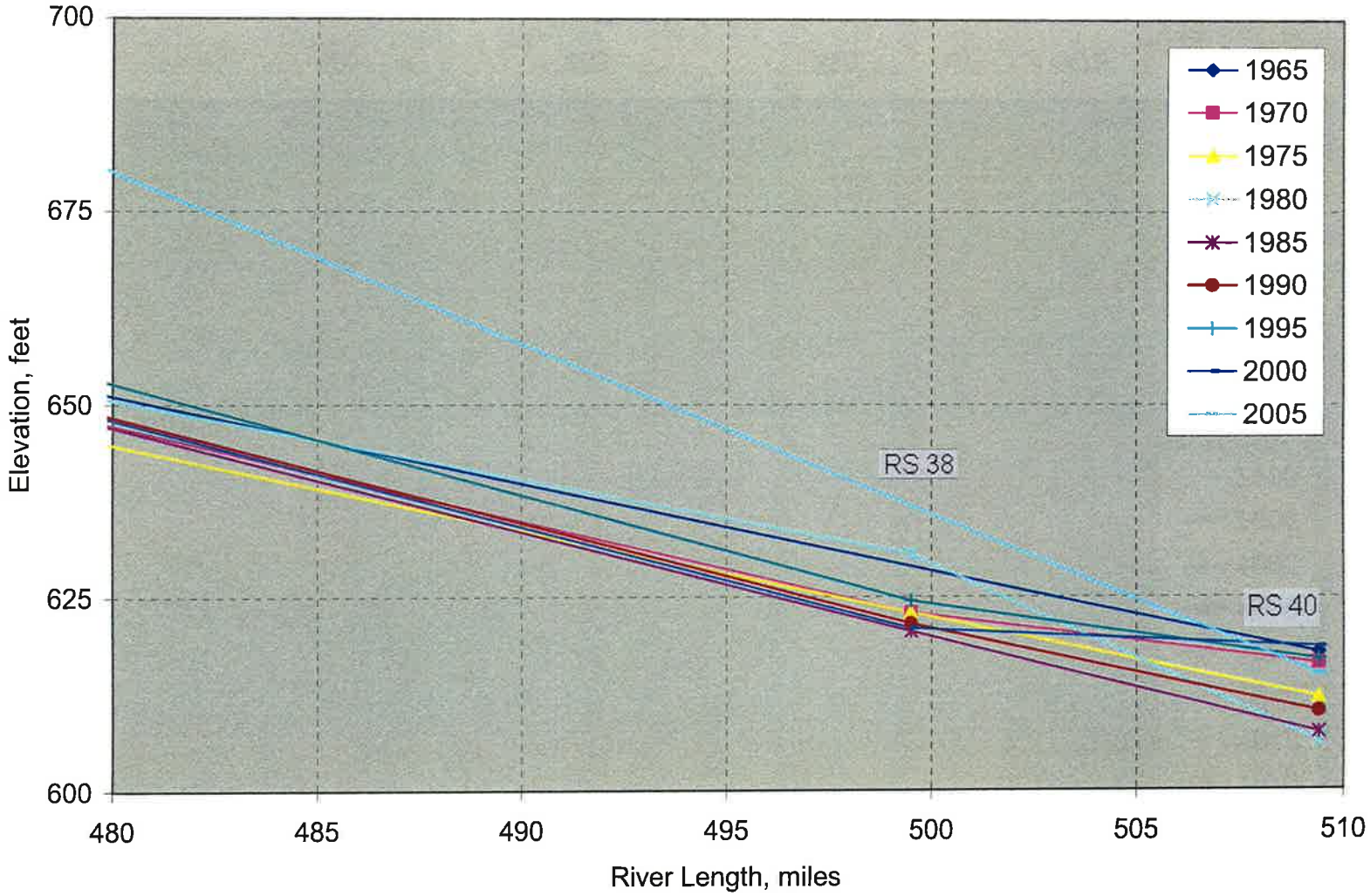


Figure 61. Longitudinal Profile of Washita River Bed, Oklahoma

VI. DISCUSSION OF RESULTS

Table 6 presents the summary of bridges which has experienced degradation. Along the 404-mile reach of Washita River, twenty-three bridges have experienced degradation. Among these twenty-three bridges, twelve bridges have experienced degradation in the range of 0-5 feet, and eleven have experienced in the range of 5-10 feet. Sixth and seventh columns of Table 5 present the service year of the bridges through 2007 and corresponding degradation in river bed. Eighteen bridges in the study reach of Washita River have been serving from more then 30 years.

Table 7 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. Bridges with degradation of 10 feet or more and that have been serving from more then 10 years are determined as critical. In the study reach of Washita River none of the river stations have experienced degradation above 10 feet. However, S.H. 17A bridge located at river station 31 (Bridge Key b17956) has experienced 9.61 feet in 34 years. A detailed hydraulic and geotechnical analysis may be performed when it is reconstructed in the replacement cycle.

Table 6. Summary of flowline degradation, Washita River

Bri_Key	River Stations	Miles	Highway	Bridge Installed	Years of Construction through 2007	Max. Scour (ft)	Duration (yr)	Scour Rate (ft/yr)
b14508	RS1	S.H. 30	6.22	1959	48	3.76	42	0.090
b3792	RS3	S.H. 33	41.56	1932	75	6.08	74	0.082
b25277	RS6	S.H. 34	71.23	1997	10	2.5	5	0.500
b17596	RS12	I. 40	126.61	1969	38	7.22	31	0.233
b17597	RS13	I. 40	126.62	1969	38	6.97	31	0.225
b16625	RS15	S.H. 115	187.25	1965	42	6.75	36	0.188
b5045	RS16	U.S. 77	205.14	1936	71	4.87	41	0.119
b21351	RS17	S.H.9	212.97	1986	21	1.53	18	0.085
b21116	RS18	S.H.9	225.69	1985	22	3.3	19	0.174
b14194	RS19	U.S. 281	260.72	1958	49	1.05	46	0.023
b17049	RS21	U.S. 62	310.47	1967	40	3.71	33	0.112
b13119	RS22	S.H. 19	350.71	1953	54	5.96	42	0.142
b12484	RS25	S.H. 74	382.92	1950	57	6.04	51	0.118
b17599	RS27	I. 35	397.45	1969	38	8.78	26	0.338
b16814	RS28	U.S. 77	405.45	1966	41	6.06	30	0.202
b7342	RS29	S.H 19	409.94	1939	68	6.48	62	0.105
b14516	RS30	U.S 77	423.08	1959	48	4.18	42	0.100
b17956	RS31	S.H. 17A	425.68	1970	37	9.61	34	0.283
b27398	RS32	S.H. 7	440.49	2004	3	0.6	1	0.600
b19273	RS33	S.H. 7	440.51	1976	31	5.39	30	0.180
b22416	RS35	U.S. 77	445.29	1989	18	1.08	11	0.098
b17351	RS38	S.H. 1	499.50	1968	39	2.09	32	0.065
b12485	RS40	S.H. 199	526.05	1953	54	3.74	41	0.091

Table 7. 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 are drawn based on this research:

1) Bridge crossings such as SH 33 (Bridge Key b3792 and b13929) at river stations 3 and 7, US183 (Bridge Key b25675) at river station 10, US 77 (Bridge Key b17959) at river station 34, and SH 19 (Bridge Key b10076) at river station 39 have experienced severe channel-bed aggradation. SH 19 near Texoma reservoir at river station 39 has experienced the maximum channel bed deposition of 22.24 feet in 57 years.
2) None of the bridges in Washita River has experienced channel bed degradation above 10 feet. However, a maximum degradation of 9.61 feet in 34 years in observed in river station 31 (Bridge Key b17956) on S.H. 17A.
3) If the S.H. 17A bridge is selected for reconstruction, a detailed hydraulic and geotechnical analysis should be performed before rehabilitation or replacement.

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

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APPENDIX A

TABLES OF CROSS-SECTIONAL GEOMETRIES, WASHITA RIVER, OK

Table 8. Structure, cross-section, and flowline details
Bridge No. 14508 (RS 1) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b14508	7.5 mi N JCT SH 47	35-45-36	99-55-30	SH 30	1959	452.1

Pier-No	Distance	Pier-btm	Top-crb	R-bed59	Data91	R-bed91	wse91
S-A	0.00	2195.00	2205.99	2198.00	7.00	2198.99	2181.72
1	51.58	2171.32	2205.78	2186.00	20.00	2185.78	2181.72
	101.86		2205.72	2184.00	25.00	2180.72	2181.72
2	152.16	2171.21	2205.67	2184.00	21.70	2183.97	2181.72
3	252.16	2171.51	2205.97	2184.00	21.00	2184.97	2181.72
4	352.16	2171.21	2205.67	2184.00	21.00	2184.67	2181.72
N-A	454.16	2195.00	2206.17	2198.00	6.00	2200.17	2181.72

Year	2001	1999	1995	1989	1987	1984	1981
Flowline	2180.24	2180.00	2181.47	2180.81	2180.64	2180.37	2180.17

Year	1979	1976	1974	1973	1970	1991	1959
Flowline	2182.67	2182.67	2182.97	2182.97	2180.17	2180.72	2184.00

Table 9. Structure, cross-section, and flowline details
Bridge No. 19633 (RS 2) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b19633	0.8 mi N JCT SH 47	35-37-30	99-40-06	US 283	1979	401.9

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed79	Data00	R-bed00	wse00
S-A	0.00	1917.00	1934.74	1922.00	8.50	1926.24	1910.11
1	100.25	1894.98	1934.98	1913.20	19.60	1915.38	1910.11
2	200.25	1880.61	1935.11	1912.10	21.00	1914.11	1910.11
	250.25		1935.11	1908.20	26.00	1909.11	1910.11
3	300.25	1881.62	1935.12	1906.00	23.60	1911.52	1910.11
N-A	400.50	1917.00	1935.01	1922.20	10.00	1925.01	1910.11

Year	2001	2000	1999	1995	1992	1991
Flowline	1910.11	1909.11	1910.19	1906.91	1906.51	1906.11

Year	1989	1987	1984	1982	1979
Flowline	1906.11	1905.51	1908.41	1908.11	1906.00

Table 10. Structure, cross-section, and flowline details
Bridge No. 03792 (RS 3) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b03792	3 mi E JCT US 283	35-40-18	99-38-00	SH 33	1932	192.9

Pier-No	Distance	Pier-btm	Top-crb	R-bed32	Data91	R-bed91	wse91	Data93
W-A	0	1862.83	1886.71	1882.21	5.00	1881.71	1864.71	5.30
1	62.87	1860.61	1886.71	1867.71	17.00	1869.71	1864.71	22.67
2	164.49	1859.61	1886.71	1867.71	24.00	1862.71	1864.71	17.67
E-A	197.36	1863.83	1886.71	1880.21	5.00	1881.71	1864.71	6.83

R-bed93	Wse93
1881.41	1864.87
1864.04	1864.87
1869.04	1864.87
1879.88	1867.87

Year	1932	1970	1973	1974	1976	1979	1984	1987
Flowline	1867.71	1865.71	1864.11	1866.21	1867.41	1867.91	1866.11	1866.13

Year	1989	1991	1992	1993	1994	1998	2001	2006
Flowline	1866.28	1862.71	1864.38	1864.04	1863.13	1861.55	1861.63	1861.63

Table 11. Structure, cross-section, and flowline details
Bridge No. 03814 (RS 4)on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b03814	5.4 mi E JCT US 283	35-40-18	99-35-30	SH 33	1932	448.2

Pier-No	Distance	Pier-btm	Top-crb	R-bed32	Data91	R-bed91	wse91
W-A	0	1830.22	1854.35	1844.85	9.00	1845.35	1837.35
	50	1827.05	1854.35	1831.85		1843.30	1837.35
1	102	1823.75	1854.35	1839.85	13.00	1841.35	1837.35
2	203.83	1823.75	1854.35	1840.85	13.00	1841.35	1837.35
3	305.66	1823.75	1854.35	1836.85	18.00	1836.35	1837.35
4	406.58	1823.75	1854.35	1836.85	14.00	1840.35	1837.35
E-A	447.28	1830.47	1854.35	1844.85	6.00	1848.35	1837.35

Year	1932.00	1970	1973	1976	1979	1982	1984
Flowline	1831.85	1834.85	1835.15	1836.35	1837.35	1837.95	1836.65

Year	1987	1989	1991	1994	1998	2001	2006
Flowline	1836.75	1836.15	1836.35	1836.25	1836.10	1835.52	1835.43

Table 12. Structure, cross-section, and flowline details
Bridge No. 03781 (RS 5) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b03781	3.1 mi WJCT SH 34	35-39-06	99-25-48	SH 33	1932	175.9

Pier-No	Distance	Pier-btm	Top-crb	R-bed32	Data91	R-bed91	Data93	R-bed93	Data94	R-bed94
W-A	0	1698.90	1731.50	1722.50	5.50	1726.00	6.83	1724.67	6.83	1724.67
	25.00		1731.50	1707.00						
	50.00		1731.50	1712.00	18.00	1713.50				
	70.00		1731.50	1717.00			17.43	1714.07	17.33	1714.17
1	100	1698.90	1731.50	1724	9.30	1722.20	7.33	1724.17	7.33	1724.17
E-A	137.25	1702.12	1731.50	1724	6.00	1725.50	5.67	1725.83	5.67	1725.83

Year	1932	1960	1965	1970	1973	1974	1976	1979	1982	1984
Flowline	1707.00	1713.7	1713.5	1713.3	1711	1714.1	1713.25	1713.3	1714.4	1713.1

Year	1987	1989	1991	1992	1993	1994	1998	2001	2005
Flowline	1713.1	1713.1	1713.5	1714.1	1714.1	1714.17	1714.25	1714.17	1714.17

Table 13. Structure, cross-section, and flowline details
Bridge No. 25277 (RS 6) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b25277	1.9 mi N JCT SH 33	35-40-06	99-22-36	SH 34	1997	182.1

Year	1997	2000	2002
Flowline	1691	1688.4	1688.5

Table 14. Structure, cross-section, and flowline details
Bridge No. 13929 (RS 7) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b13929	5.8 mi E JCT SH 33	35-38-18	99-16-24	SH 33	1957	453.1

Year	1957	1964	1976	1984	1989	1990	1991	1992	2002
Flowline	1630	1628.19	1630.79	1634.29	1635.8	1635	1637.1	1642.8	1638.6

Table 15. Structure, cross-section, and flowline details
Bridge No. 17344 (RS 8) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17344	4.8 mi E JCT SH 44	35-30-30	99-05-24	SH 73	1968	262.1

Year	2002	2000	1998	1996	1991	1989	1987	1984
Flowline	1527.8	1528.2	1530.8	1527.64	1527.8	1526	1526.2	1526.9

Year	1976	1968
Flowline	1527.6	1526.5

Table 16. Structure, cross-section, and flowline details Bridge No. 17580 (RS 9) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17580	9 mi N E JCT SH 44	35-30-30	99-01-00	SH 33	1969	327.1

Year	2002	2000	1998	1996	1991	1987	1984	1982
Flowline	1495.3	1495.55	1496.05	1494.89	1492.3	1492	1491.6	1490.8

Year	1980	1976	1969
Data	34.4	34	
Flowline	1491.9	1492.3	1496.5

Table 17. Structure, cross-section, and flowline details Bridge No. 25675 (RS 10) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b25675	1 mi N JCT I-40 BUS	35-31-51	98-58-00	US 183	2002	836.9

Year	2002	2004
Flowline	1476	1492.8

Table 18. Structure, cross-section, and flowline details Bridge No. 13123 (RS 11) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b13123	0.5 mi E JCT US 183	35-30-54	98-57-18	I-40 BUS	1953	801.8

Year	1953	1959	1962	1964	1970	1973	1980	1982	1985
Flowline	1463	1464.1	1462.6	1462.1	1464	1463.6	1468.2	1467.7	1467.3

Year	1990	1992	1994
Flowline	1468	1464.1	1465.1

Table 19. Structure, cross-section, and flowline details
Bridge No. 17596 (RS 12) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17596	1.3 mi E JCT US 183	35-30-06	98-56-42	I-40	1969	603

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed69	Data92	R-bed92	Data94	R-bed94
W-A	0.00	1481.20	1499.25	1484.00	9.00	1490.25	11.00	1488.25
1	100.75	1451.14	1498.96	1465.20	28.00	1470.96	28.00	1470.96
2	200.75	1451.00	1499.32	1465.20	28.00	1471.32	28.00	1471.32
3	301.50	1450.91	1499.73	1465.20	41.00	1458.73	41.00	1458.73
	351.88		1499.78				39.50	1460.28
4	402.25	1451.01	1499.83	1465.20	25.00	1474.83	25.50	1474.33
5	502.25	1451.15	1499.97	1465.20	27.00	1472.97	28.00	1471.97
E-A	603.00	1482.00	1500.17	1483.00	9.00	1491.17	10.00	1490.17

Data00	R-bed00
10.70	1488.55
26.00	1472.96
26.80	1472.52
38.80	1460.93
41.80	1457.98
23.10	1476.73
26.40	1473.57
10.70	1489.47

Year	2000	1994	1992	1990	1989	1987	1985	1982
Flowline	1457.98	1458.73	1458.73	1459.13	1459.23	1459.33	1456.73	1457.03

Year	1976	1974	1971	1969
Flowline	1457.03	1455.43	1457.73	1465.20

Table 20. Structure, cross-section, and flowline details
Bridge No. 17597 (RS 13) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17597	1.3 mi E JCT US 183	35-30-06	98-56-42	I-40	1969	603

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed69	Data92	R-bed92	Data94	R-bed94	Data00	R-bed00
W-A	0.00	1479.00	1498.16	1489	9.00	1489.16	10.00	1488.16	10.00	1488.16
1	100.75	1451.14	1498.46	1463.5	27.00	1471.46	27.00	1471.46	25.30	1473.16
2	200.75	1451.00	1498.82	1463.5	27.00	1471.82	27.00	1471.82	26.00	1472.82
3	301.50	1450.91	1499.23	1463.5	40.00	1459.23	42.00	1457.23	42.70	1456.53
4	402.25	1451.01	1499.33	1463.5	26.00	1473.33	27.00	1472.33	24.10	1475.23
5	502.25	1451.15	1499.47	1463.5	27.00	1472.47	26.00	1473.47	25.20	1474.27
S-A	603.00	1482.50	1499.67	1491	8.00	1491.67	10.00	1489.67	10.30	1489.37

Year	2000	1994	1992	1990	1989	1987	1985	1976
Flowline	1456.53	1457.23	1459.23	1459.13	1459.23	1458.83	1456.23	1454.43

Year	1982	1974	1971	1969
Flowline	1457.53	1456.73	1458.23	1463.50

Table 21. Structure, cross-section, and flowline details
Bridge No. 19271 (RS 14) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b19271	0.8 mi E JCT SH 54	35-17-30	98-50-12	SH 152	1976	502

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed76	Data92	R-bed92	Data93	R-bed93	Data94	R-bed94
W-A	0.00	1403.00	1416.75	1406.00		1406.00	10.41	1406.34	10.00	1406.75
1	100.25	1364.79	1417.93	1390.20	23.00	1394.93	24.83	1393.10	24.67	1393.26
2	200.25	1366.15	1419.29	1388.60	26.50	1392.79	25.00	1394.29	26.16	1393.13
3	300.25	1359.68	1420.82	1385.50	32.16	1388.66	29.16	1391.66	29.08	1391.74
	340.25		1421.46	1372.00	43.83		45.75	1375.71	45.75	1375.71
4	400.25	1352.26	1422.40	1386.40	36.50	1385.90	23.25	1399.15	25.41	1396.99
	451.25		1423.20				29.00	1394.20	28.75	1394.45
S-A	500.50	1399.00	1424.00	1413.00		1413.00	10.83	1413.17	10.67	1413.33

Year	2002	2000	1998	1994	1993	1992.00	1991
Flowline	1375.46	1376.46	1376.56	1372.00	1375.71	1385.90	1375.06

Year	1989	1984	1982	1976
Flowline	1374.46	1374.66	1374.46	1372.00

Table 22. Structure, cross-section, and flowline details
Bridge No. 16625 (RS 15) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b16625	1.1 mi N SH 9	35-06-36	98-44-42	SH 115	1965	321.9

Pier-No	Distance	P_Btm	Top-crb	Top-Ppw	R-bed65	Data91	R-bed91
S-A	0.00	1278.00	1335.30	1338.30	1326.00	10.70	1324.60
1	61.50	1283.90	1335.29	1338.29	1314.00	14.90	1320.39
	88.50		1335.34		1314.00		
2	142.25	1294.06	1335.45	1338.45	1314.00	26.10	1309.35
3	242.25	1293.99	1335.38	1338.38	1314.00	17.00	1318.38
N-A	324.00	1278.00	1335.12	1338.12	1326.00	9.10	1326.02

Data92	R-bed92	Data94	R-bed94
11.08	1324.22	10.75	1324.55
14.91	1320.38	14.75	1320.54
29.33	1306.01		
22.93	1312.62	29.33	1306.12
15.16	1320.22	14.92	1320.46
9.83	1325.29	10.00	1325.12

Year	2001	1994	1993	1992	1991	1991	1982
Flowline	1307.25	1306.12	1313.35	1306.01	1317.35	1307.45	1305.85

Year	1976	1970	1969	1966	1965
Flowline	1301.65	1302.25	1300.95	1299.95	1314.00

Table 23. Structure and flowline details
Bridge No. 05045 (RS 16) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b5045	0.7 mi N JCT SH 9	35-06-42	98-36-12	US 77	1936	747

Year	1955	1960	1965	1967	1970	1975	1980	1984	1985
Flowline	1266.2	1266.3	1265.2	1266.5	1266	1264.5	1263.9	1264.2	1264.1

Year	1986	1988	1990	1992	1994	1998	2000	2000	2006
Flowline	1264.5	1263.5	1263.4	1262.2	1262.5	1261	1260	1261.3	1261.3

Table 24. Structure, cross-section, and flowline details
Bridge No. 21351 (RS 17) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b21351	4 mi E Kiowa c/l	35-07-06	98-33-42	SH 9	1986	401.9

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed89	Data91	R-bed91	Data92	R-bed92
W-A	0.00	1276.00	1289.40	1278.00	9.70	1279.70	9.70	1279.70
1	100.25	1240.08	1289.38	1268.00	19.30	1270.08	19.30	1270.08
2	200.25	1239.90	1289.20	1270.20	26.90	1262.30	26.90	1262.30
	230.25		1289.09	1252.00	37.80	1251.29	37.00	1252.09
	260.25		1289.00	1248.30	41.30	1247.70	41.90	1247.10
3	300.25	1239.58	1288.88	1264.00	25.10	1263.78	24.50	1264.38
E -A	400.50	1275.00	1288.40	1276.00	8.90	1279.50	8.30	1280.10

Data93	R-bed-93
9.70	1279.70
19.00	1270.38
29.30	1259.90
39.20	1249.859
41.60	1247.40
26.30	1262.58
8.80	1279.60

Year	2004	2000	1998	1994	1993	1992	1991
Flowline	1246.87	1246.45	1247.53	1251.20	1247.60	1247.30	1247.90

Year	1990	1988	1986
Flowline	1248.90	1249.70	1248.40

Table 25. Structure, and flowline details
Bridge No. 21116 (RS 18) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b21116	6.3 MI N W JCT US 62	35-05-06	98-26-06	SH 9	1985	702

Year	2004	2000	1998	1994	1992	1990	1988	1986	1985
Flowline	1220.7	1219.54	1221.87	1221.7	1223.2	1223	1222.8	1224.3	1224

Table 26. Structure, and flowline details
Bridge No. 14194 (RS 19) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b14194	0.8 N US 62 Anadarko	35-05-00	98-14-36	US 281	1958	382.9

Year	1958	1960	1965	1967	1970	1975	1981	1984
Flowline	1956.5	1154.95	1154.95	1154.55	1153.8	1154	1157.6	1155.2

Year	1985	1986	1990	1992	1994	1998	2000	2004
Flowline	1155.7	1156.5	1158.7	1155.9	1156.3	1155.8	1155.7	1155.45

Table 27. Structure, cross-section, and flowline details
Bridge No. 17047 (RS 20) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17047	1.9 mi N US 81	35-03-06	97-54-24	US 62	1967	961.9

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed67	Data92	R-bed92	Data00	R-bed00
W-A	0.00	1044.20	1097.00	1086.50				
1	40.00	1044.20	1097.41	1071.00				
Over flow								
12	480.00	1044.20	1099.83	1074.50			24.08	1075.75
13	520.00	1044.20	1099.85	1076.00			24.16	1075.69
14	560.00	1040.31	1100.42	1076.00	22.50	1077.92	21.33	1079.09
	630.00		1100.30	1076.00				
15	660.75	1037.97	1100.08	1056.00	25.70	1074.38	50.41	1049.67
	685.75		1100.03	1047.80				
16	760.75	1033.81	1099.92	1064.00	43.10	1056.82	43.67	1056.25
	810.75		1099.45		45.20	1054.25		
17	860.75	1032.92	1099.01	1074.00	44.30	1054.71	31.75	1067.26
E-A	962.05	1036.26	1098.90	1084.50	10.00	1088.90	10.50	1088.40

Year	2000	1995	1992	1991	1990	1988	1987
Flowline	1049.67	1047.62	1054.25	1052.42	1052.4	1052.4	1047.32

Year	1985	1984	1981	1975	1967
Flowline	1047.42	1047.52	1054.12	1055.12	1047.8

Table 28. Structure, cross-section, and flowline details
Bridge No. 17049 (RS 21) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17049	1.9 mi E US 81	35-03-06	97-54-24	US 62	1967	994.1

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed67	Data92	R-bed92	Data00	R-bed00
14	560.00	1038.60	1098.87	1077.00	21.60	1077.27	19.75	1079.12
15	660.75	1035.19	1098.46	1065.00	38.50	1059.96	52.67	1045.79
	670.75		1098.43	1049.50				
16	760.75	1032.98	1098.25	1065.00	44.80	1053.45	41.42	1056.83
17	860.75	1031.01	1097.28	1076.00	41.20	1056.08	35.33	1061.95
E-A	962.05	1077.50	1096.70	1081.00	13.50	1083.20	11.25	1085.45

Year	2000	1995	1992	1991	1990	1988	1987
Flowline	1045.79	1045.23	1053.45	1054.43	1050.43	1050.53	1048.43

Year	1985	1984	1981	1975	1970	1967
Flowline	1045.93	1050.83	1050.03	1050.63	1051.93	1049.50

Table 29. Structure, cross-section, and flowline details
Bridge No. 13119 (RS 22) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b13119	1.5 mi NW Garvin Co.	34-51-36	97-41-00	SH 19	1953	520

Pier-No	Distance	Pier-btm	Top_rail	R-bed53	Data91	R-bed91	Data92	R-bed92	Data93	R-bed93
W-A	0.00	960.00	1009.60	998.00	11.60	998.00	12.40	997.20	12.50	997.10
1	102.14	960.00	1010.00	995.00	19.00	991.00	19.00	991.00	19.00	991.00
2	204.31	960.00	1010.24	977.80	22.80	987.44	23.50	986.74	34.50	975.74
	347.31		1010.24	975.00					37.40	972.84
	366.31		1010.24	975.00			41.50	968.74		
	395.00		1010.24	992.00	41.00	969.24				
3	416.56	960.00	1010.24	992.40	40.00	970.24	34.70	975.54	30.30	979.94
E-A	518.78	960.00	1009.60	998.00	11.40	998.20	11.40	998.20	11.80	997.80

Year	1953	1955	1960	1964	1970	1975	1981
Flowline	975.00	971.94	974.04	973.24	973.54	973.14	973.54

Year	1985	1987	1991	1992	1993	1995
Flowline	973.84	974.14	969.24	968.74	972.84	969.04

Table 30. Structure, and flowline details
Bridge No. 13121 (RS 23) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b13121	9.4 mi N Stephens Co	34-49-00	97-35-54	SH 76	1953	622

Year	1953	1960	1965	1970	1975	1978	1983	1985	1992	1994
Flowline	944	953.45	953.75	952.65	954.9	952.75	952.35	951.45	948.05	948.25

Table 31. Structure, and flowline details
Bridge No. 25272 (RS 24) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b25272	5.6 mi E Grady c/l	34-49-54	97-34-30	SH 19	1999	495.1

Year	1999	2000
Flowline	944.476	947.82

Table 32. Structure, cross-section, and flowline details
Bridge No. 12484 (RS 25) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b12484	1.4 mi N JCT SH 19	34-50-12	97-24-18	SH 74	1950	457

Pier-No	Distance	Pier-btm	Top-crb	Top_rail	R-bed50	Data92	R-bed92	Data93	R-bed93	Data94
N-A	0.00	932.00	943.37	945.37	936.00	7.90	935.47	10.30	933.07	8.30
1	52.16	897.88	944.05	946.05	930.80	20.00	924.05	20.40	923.65	20.40
2	194.10	897.88	944.36	946.36	922.30	20.50	923.86	20.00	924.36	20.20
	319.00		944.46	946.46	914.00			39.30	905.16	
	344.00		944.66	946.66	912.00	35.30	909.36			
3	405.46	897.52	944.36	946.36	916.00	33.40	910.96	33.70	910.66	37.50
S-A	457.62	933.00	943.85	945.85	937.00	7.80	936.05	8.10	935.75	8.00

R0bed94	Data95	R-bed95	Data96	R-bed96	Data97	R-bed97	Data99	R-bed99	Data01	R-bed01
935.07	8.40	934.97	9.00	934.37	10.50	934.87	10.60	934.77	10.30	935.07
923.65	20.60	923.45	21.10	922.95	22.63	923.42	23.00	923.05	23.30	922.75
924.16	20.70	923.66	20.20	924.16	23.62	922.74	23.60	922.76	23.80	922.56
	39.20	905.26	35.00	909.46					40.50	905.96
									40.20	906.46
906.86	32.10	912.26	34.10	910.26	39.69	906.67	37.00	909.36	38.00	908.36
935.85	8.40	935.45	8.30	935.55	10.50	935.35	11.40	934.45	10.90	934.95

Year	1985	1990	1992	1993	1994	1995	1996	1997
Flowline	904.36	909.06	905.06	905.16	906.86	905.26	909.46	906.67

Year	1999	2001
Flowline	909.36	905.96

Table 33. Structure, cross-section, and flowline details
Bridge No. 17598 (RS 26) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17598	3.3 mi N JCT SH 19	34-46-08	97-17-07	I-35	1969	724

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed69	Data92	R-bed92	Data93	R-bed93	Data94	R-bed94
S-A	0.00	904.00	921.13	908.00	8.70	912.43	9.00	912.13	9.00	912.13
1	91.00	865.40	921.43	897.00	26.10	895.33	27.00	894.43	27.00	894.43
2	181.00	865.30	921.68	890.00	35.20	886.48	39.00	882.68	38.80	882.88
3	271.00	865.30	921.78	877.00	47.50	874.28	39.00	882.78	38.50	883.28
4	361.75	865.30	921.81	882.00	53.20	868.61	45.00	876.81	42.50	879.31
5	452.50	866.00	921.93	884.20	52.10	869.83	43.00	878.93	39.50	882.43
6	542.50	866.00	921.99	886.00	39.20	882.79	41.00	880.99	42.00	879.99
7	632.50	866.00	921.90	895.60	25.00	896.90	48.00	873.90	47.00	874.90
N-A	723.50	905.00	921.75	909.00	8.20	913.55	9.50	912.25	9.00	912.75

Year	1995	1994	1993	1992	1989	1985	1983	1977
Flowline	878.78	874.90	873.90	868.61	874.28	872.08	876.78	877.68

Year	1975	1969
Flowline	873.28	877.00

Table 34. Structure, cross-section, and flowline details
Bridge No. 17599 (RS 27) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17599	1.5 mi N JCT SH 19	34-46-08	97-17-07	I-35	1969	724

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed69	Data92	R-bed92	Data93	R-bed93	Data94	R-bed94
S-A	0.00	907.00	921.13	912.00	8.70	912.43	10.00	911.13	10.00	911.13
1	91.00	865.00	921.43	890.00	26.10	895.33	28.00	893.43	27.00	894.43
2	181.00	865.00	921.68	882.30	35.20	886.48	33.00	888.68	34.00	887.68
3	271.00	865.00	921.78	884.00	47.50	874.28	34.00	887.78	38.00	883.78
4	361.75	866.00	921.81	870.00	58.00	863.81	40.00	881.81	42.00	879.81
5	452.50	866.00	921.93	878.40	52.10	869.83	45.00	876.93	42.00	879.93
	497.50		922.06						48.00	874.06
6	542.50	866.00	922.19	884.00	39.90	882.29	39.00	883.19	38.50	883.69
	587.50		922.03	884.00					44.00	878.03
7	632.50	866.00	921.90	884.00	25.00	896.90	40.00	881.90	41.00	880.90
N-A	723.5	904.20	921.76	912.20	8.20	913.56	8.50	913.26	9.00	912.76

Year	1995	1994	1993	1992	1990	1989	1985	1977	1969
Flowline	878.78	874.06	876.93	863.81	873.08	874.78	874.78	877.98	870.00

Table 35. Structure, cross-section, and flowline details
Bridge No. 16814 (RS 28) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b16814	5.3 mi S JCT Paoli	34-44-42	97-14-06	US 77	1966	551.8

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed66	Data92	R-bed92	Data96	R-bed96
S-A	0.00	882.00	898.54	885.70	12.00	886.54	11.00	887.54
1	51.25	839.46	898.55	884.00	16.70	881.85	15.00	883.55
	110.25		898.65	853.00				
2	152.00	839.62	898.71	861.00	45.20	853.51	41.00	857.71
	202.00		898.94		47.50	851.44	52.00	846.94
3	252.00	840.00	899.15	863.00	42.30	856.85	40.00	859.15
4	352.00	840.90	898.99	867.00	42.50	856.49	37.00	861.99
5	452.00	840.32	898.41	880.00	27.30	871.11	39.50	858.91
N-A	554	878.00	898.17	880.00	11.00	887.17	10.00	888.17

Year	1996	1995	1994	1992	1991	1990	1987	1983
Flowline	846.94	848.71	846.71	851.44	851.21	852.55	854.71	857.31

Year	1981	1978	1975	1970	1967	1966
Flowline	859.01	859.21	855.91	856.71	859.71	853.00

Table 36. Structure, cross-section, and flowline details
Bridge No. 07342 (RS 29) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b07342	2.2 mi E JCT US 77	34-45-36	97-11-54	SH 19	1939	498

Pier-No	Distance	Pier-btm	Top-crb	Top_rail	R-bed39	Data92	R-bed92	Data93	R-bed93
E-A	0.00	872.20	884.12	886.12	876.20	8.80	875.32	8.20	875.92
1	41.25	840.36	884.12	886.12	869.00	14.10	870.02	14.20	869.92
2	82.87	837.68	884.12	886.12	868.00	16.10	868.02	16.00	868.12
3	184.47	817.55	884.12	886.12	868.15	32.00	852.12	43.00	841.12
	234.47		884.12	886.12	858.00	39.00	845.12		
	254.47		884.12	886.12	849.00				
	283.47		884.12	886.12	869.00			49.50	834.62
	300		884.12	886.12	870.00				
4	396.28	809.20	884.12	886.12	870.00	44.20	839.92	45.00	839.12
W-A	498.09	850.12	884.12	886.12	872.00	10.00	874.12	9.50	874.62

Data95	R-bed95	Data96	R-bed96	Data99	R-bed99	Data01	R-bed01
8.30	875.82	8.30	875.82	11.50	874.62	11.70	874.42
14.30	869.82	14.70	869.42	17.30	868.82	17.30	868.82
16.20	867.92	16.30	867.82	19.00	867.12	19.20	866.92
43.20	840.92	41.00	843.12	38.50	847.62	36.90	849.22
				37.30	848.82	39.00	847.12
		37.40	846.72	39.20	846.92	39.60	846.52
51.00	833.12						
42.00	842.12	35.90	848.22	40.10	846.02	43.60	842.52
10.40	873.72	9.50	874.62	12.360	873.82	12.50	873.62

Year	1939	1950	1954	1956	1965	1970	1975	1978	1981
Flowline	849.00	846.62	848.62	847.62	846.22	845.52	843.82	843.62	842.92

Year	1983	1985	1987	1992	1993	1995	1996	1999	2001
Flowline	848.92	846.12	845.925	839.92	834.62	833.12	843.12	846.02	842.52

Table 37. Structure, cross-section, and flowline details
Bridge No. 14516 (RS 30) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b14516	2.7 mi N Murray c/l	34-38-42	97-11-24	US 77	1959	622

Pier-No	Distance	Pier-btm	Top-crb	Top-Ppw	R-bed59	Data92	R-bed92	Data93	R-bed93
E-A	0.00	796.00	849.34	851.50	840.00	7.80	841.54	7.80	841.54
	84.00			851.70	815.00				
1	103.25	790.76	849.63	851.79	810.25	42.60	807.03	47.30	802.33
	130.25			851.82	810.00				
2	205.95	790.94	849.81	851.97	816.00	36.10	813.71	40.00	809.81
3	417.15	790.94	849.81	851.97	822.00	19.30	830.51	20.00	829.81
4	519.85	790.76	849.63	851.79	827.70	20.10	829.53	20.50	829.13
W-A	623.10	796.00	849.34	851.50	840.00	7.00	842.34	7.50	841.84

Data95	R-bed95	Data97	R-bed97	Data99	R-bed99	Data01	R-bed01
8.70	840.64	11.48	840.02	12.50	839.00	11.80	839.70
				45.40	806.30		
46.10	803.53	46.90	804.89	42.00	809.79	44.70	807.09
						46.00	805.82
46.00	803.81	39.03	812.94	38.90	813.07	43.10	808.87
21.10	828.71	25.58	826.39	25.50	826.47	25.60	826.37
21.50	828.13	24.60	827.19	24.30	827.49	24.40	827.39
6.80	842.54	9.51	841.99	11.00	840.50	10.60	840.90

Year	2001	1999	1997	1995	1993	1992	1987	1985
Flowline	805.82	806.30	804.89	803.53	802.33	807.03	807.63	805.03

Year	1983	1981	1978	1975	1970	1965	1956	1959
Flowline	808.83	810.63	812.23	810.33	813.43	816.03	812.13	810.00

Table 38. Structure, cross-section, and flowline details
Bridge No. 17956 (RS 31) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17956	0.8 mi E I-35	34-37-24	97-12-06	SH 17A	1970	803.1

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed70	Data87	R-bed87	Data92	R-bed92	Data93	R-bed93
E-A	0.00	785.00	860.90	848.20		848.20	10.20	850.70	10.70	850.20
1	101.00	780.36	859.45	810.00	52.30	807.15	25.60	833.85	26.00	833.45
2	201.00	779.08	858.17	811.00	48.40	809.77	42.90	815.27	41.80	816.37
3	301.00	781.26	856.85	811.00	48.50	808.35	48.20	808.65	42.90	813.95
4	401.75	781.07	855.66	810.00	44.40	811.26	45.90	809.76	46.20	809.46
5	502.65	779.64	854.23	810.80	43.20	811.03	45.30	808.93	58.90	795.33
6	602.65	778.86	852.95	811.20	39.50	813.45	57.20	795.75	45.60	807.35
7	702.65	776.54	851.63	823.20	25.70	825.93	49.60	802.03	48.80	802.83
W-A	803.65	780.00	850.46	837.00		837.00	11.40	839.06	11.00	839.46

Data94	R-bed94	Data95	R-bed95	Data96	R-bed96	Data99	R-bed99	Data01	R-bed01
10.50	850.40	10.70	850.20	11.10	849.80	12.90	847.16	12.50	847.56
26.00	833.45	25.90	833.55	26.00	833.45	27.70	830.91	27.00	831.61
41.30	816.87	41.20	816.97	45.10	813.07	41.40	815.93	41.00	816.33
40.30	816.55	51.20	805.65	46.40	810.45	40.80	815.21	47.40	808.61
46.40	809.26	52.40	803.26	49.40	806.26	48.10	806.72	53.90	800.92
47.20	807.03	54.20	800.03	49.30	804.93	50.10	803.29	50.00	803.39
49.50	803.45	46.80	806.15	46.00	806.95	48.00	804.11	49.20	802.91
47.60	804.03	49.70	802.23	46.90	804.73	49.10	801.69	50.30	800.49
11.40	839.06	11.50	838.96	11.70	838.76	12.90	836.72	12.80	836.82

Table 38. (Continued)

Data02	R-bed02	Data03	R-bed03	Data04	R-bed04
12.20	847.86	11.10	848.96	11.10	848.96
26.90	831.71	26.00	83.2.61	26.20	832.41
41.50	815.83	39.90	817.43	40.00	817.33
44.00	812.01	42.70	813.31	44.80	811.21
50.80	804.02	53.10	801.72	52.70	802.12
53.20	800.19	52.00	801.39	53.00	800.39
50.60	801.51	50.00	802.11	46.30	805.81
50.60	800.19	49.10	801.68	49.20	801.59
12.70	836.92	12.50	837.12	12.50	837.12

Year	2004	2003	2002	2001	1999	1996	1995	1994
Flowline	800.39	801.39	800.19	800.49	801.69	804.73	800.03	803.45

Year	1993	1992	1991	1989	1987	1983	1981	1970
Flowline	795.33	795.75	804.636	804.66	807.15	803.66	801.26	810.00

Table 39. Structure, and flowline details
Bridge No. 27398 (RS 32) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b27398	.8 W JCT US 77	34-30-18	97-08-30	SH 7	2004	702

Year	2004	2005
Flowline	763.1	762.5

Table 40. Structure, cross-section, and flowline details
Bridge No. 19273 (RS 33) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b19273	0.8 mi W JCT US 77	34-30-18	97-08-30	SH 7	1976	702.1

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed76	Data91	R-bed91	Data92	R-bed92	Data93	R-bed93
S-A	0.00	804.20	816.73	807.00		807.00	10.10	806.63	10.10	806.63
1	50.58	739.70	816.20	795.00	18.90	797.30	18.00	798.20	18.80	797.40
2	150.25	739.96	816.46	791.50	25.10	791.36	25.40	791.06	25.10	791.36
3	250.25	740.11	816.61	775.00	40.10	776.51	42.70	773.91	39.30	777.31
4	350.25	740.17	816.67	775.00	37.80	778.87	39.70	776.97	40.40	776.27
	292.25		816.65	775.00			48.90	767.75		
5	450.25	740.11	816.61	775.00	40.20	776.41	42.40	774.21	41.50	775.11
	515.25		816.51	773.00					47.70	768.81
6	550.25	739.96	816.46	773.00	45.30	771.16	45.90	770.56	41.70	774.76
7	649.92	739.70	816.20	798.00	18.60	797.60	18.90	797.30	18.80	797.40
N-A	700.50	804.20	816.73	807.00		807.00	10.10	806.63	10.10	806.63

Year	2006	2000	1998	1995	1993	1992	1991	1989
Flowline	767.61	768.51	764.01	770.61	768.81	767.75	768.51	770.61

Year	1981	1976
Flowline	771.61	773.00

Table 41. Structure, cross-section, and flowline details
Bridge No. 17959 (RS 34) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17959	6.5 mi N carter c/l	34-25-06	97-08-30	US 77	1970	854

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed70	Data87	R-bed87	Data00	R-bed00
S-A	0.00	754.00	809.49	797.00		797.00	12.16	797.33
1	50.75	751.72	809.65	784.50	21.60	788.05	24.33	785.32
2	150.87	752.00	809.93	770.60	36.20	773.73	42.16	767.77
3	251.24	750.28	810.21	767.80	41.00	769.21	47.33	762.88
	286.24		810.32	753.00	55.50	754.82		
4	351.61	749.56	810.49	765.50	43.10	767.39	47.00	763.49
5	451.98	744.86	810.77	763.00	46.10	764.67	48.43	762.34
6	552.35	742.12	811.05	768.00	40.10	770.95	46.83	764.22
	602.54		811.15				51.08	760.07
7	652.72	747.40	811.33	777.80	31.00	780.33	43.42	767.91
8	753.08	750.68	811.61	778.00	30.10	781.51	32.67	778.94
N-A	853.70	750.00	811.88	798.00		798.00	12.25	799.63

Year	2000	1997	1995	1993	1991	1987	1985	1981
Flowline	760.07	766.77	754.77	753.47	758.93	754.82	763.97	758.77

Year	1975	1971	1970
Flowline	762.77	766.77	753.00

Table 42. Structure, cross-section, and flowline details
Bridge No. 22416 (RS 35) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b22416	6.3 mi N Carter c/l	34-25-06	97-08-30	US 77	1989	854

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed89	Data00	R-bed00
S-A	0.00	800.00	808.65	796.00	12.33	796.32
1	51.00	718.96	808.96	785.90	24.16	784.80
2	151.37	708.75	809.25	768.00	50.33	758.92
3	251.74	709.03	809.53	760.00	45.50	764.03
4	352.11	709.31	809.81	768.00	46.33	763.48
5	452.48	708.59	810.09	773.00	43.50	766.59
6	552.85	708.87	810.37	776.40	49.16	761.21
7	653.22	709.15	810.65	778.00	39.58	771.07
8	753.59	709.43	810.93	778.60	36.50	774.43
N-A	854.71	800.00	811.21	799.00	12.67	798.54

Year	2000	1997	1995	1993	1991	1989
Flowline	758.92	764.13	759.73	759.53	757.96	760.00

Table 43. Structure, cross-section, and flowline details
Bridge No. 18144 (RS 36) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b18144	7.79 mi E JCT US 77	34-17-18	97-00-54	SH 53	1971	801.8

Pier-No	Distance	Pier-btm	Top-crb	Top-Ppw	R-bed71	Data93	R-bed93	Data96	R-bed96
W-A	0.00	708.00	720.50	723.50	710.11	9.40	714.10	9.70	710.80
1	100.25	637.61	720.50	723.50	696.50	26.70	696.80	26.70	693.80
2	200.25	637.61	720.50	723.50	672.00	42.50	681.00	39.10	681.40
3	300.25	637.61	720.50	723.50	673.50	39.50	684.00	38.20	682.30
4	400.25	637.61	720.50	723.50	684.00	38.50	685.00	39.50	681.00
5	500.25	637.61	720.50	723.50	686.00	43.60	679.90	43.00	677.50
	550.25		720.50	723.50		48.30	675.20	48.80	671.70
6	600.25	637.61	720.50	723.50	684.30	44.20	679.30	41.00	679.50
7	700.25	637.61	720.50	723.50	688.00	46.70	676.80	48.00	672.50
S-A	800.50	708.00	720.50	723.50	710.11	10.00	713.50	9.50	711.00

Data00	R-bed00
10.00	713.50
26.67	696.83
34.33	689.17
36.50	687.00
41.25	682.25
42.67	680.83
45.60	677.90
46.08	677.42
10.43	713.07

Year	2000	1996	1995	1993	1992	1990	1988	1980	1971
Flowline	677.42	671.70	673.50	673.60	673.00	665.50	667.50	667.50	672.00

Table 44. Structure, cross-section, and flowline details
Bridge No. 12645 (RS 37) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b12645	3.3 mi N JCT SH 199	34-14-00	96-58-36	US177	1951	641.1

Pier-No	Distance	Pier-btm	Top-rail	R-bed51	Data92	R-bed92	Data93	R-bed93	Data01	R-bed01
S-A	0.00	654.00	704.60	696.00	8.90	695.70	9.00	695.60	8.90	695.70
1	61.67	646.39	703.67	684.10	20.20	683.47	20.00	683.67	20.00	683.67
2	164.17	633.56	703.84	651.15	53.90	649.94	45.12	658.72	48.70	655.14
	249.17		703.84	650.50	55.90	647.94	50.20	653.64		
	324.77		703.84	650.00						
3	376.00	699.56	703.84	670.00	49.50	654.34	45.10	658.74	53.00	650.84
4	478.70	643.39	703.67	678.40	43.80	659.87	31.20	672.47	39.20	664.47
5	580.90	639.10	703.38	682.00	23.60	679.78	25.00	678.38	23.60	679.78
N-A	642.57	650.00	704.60	696.00	8.50	696.10	9.40	695.20	9.40	695.20

Year	1951	1960	1965	1970	1976	1980	1988	1990
Flowline	650.0	648.44	653.3	649.64	646.34	652.54	647.84	651.04

Year	1990	1992	1993	1995	1997	1998	2001
Flowline	651.04	647.94	653.64	655.54	654.94	650.24	650.84

Table 45. Structure, cross-section, and flowline details
Bridge No. 17351 (RS 38) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b17351	3.9 mi N Marshal co	34-13-18	96-48-06	SH 1	1968	401.9

Pier-No	Distance	Pier-btm	Top-Ppw	R-bed68	Data80	R-bed80	Data92	R-bed92	Data93	R-bed93
S-A	0.00	653.00	671.14	660.00	9.70	661.44	9.50	661.64	10.10	661.04
1	101.00	614.69	670.85	626.20	40.30	630.55	38.40	632.45	40.50	630.35
	121.00		670.81							
	131.00		670.73	623.00			55.20	615.53		
2	201.00	614.33	670.49	631.20	36.00	634.49	35.10	635.39	53.20	617.29
	221.00		670.41							
	251.00		670.22		49.00				52.30	617.92
3	301.00	613.89	670.05	637.00	36.20	633.85	46.40	623.65	62.00	608.05
N-A	402.00	651.00	669.53	658.00	11.40	658.13	11.20	658.33	10.20	659.33

Data00	R-bed00
9.20	661.94
39.80	631.05
49.90	620.91
39.50	630.99
46.80	623.61
42.30	627.75
11.10	658.43

Year	2000	1995	1994	1993	1992	1991	1990	1989	1987
Flowline	620.91	624.49	617.99	608.05	615.53	615.29	621.49	626.69	621.49

Year	1985	1980	1975	1968
Flowline	620.49	630.55	622.99	623.00

Table 46. Structure, cross-section, and flowline details
Bridge No. 10076 (RS 39) on Washita River

Bridge No.	Location	Latitude	Longitude	Highway	Year Built	Length
b10076	1.2 mi N JCT SH 22	34-13-12	96-42-06	SH 19	1943	559.1

Pier-No	Distance	Pier-btm	Top-crb	Top_rail	R-bed43	Data87	R-bed87	Data91	R-bed91
N-A	0.00	622.00	647.20	649.37	646.00	3.50	643.70	3.60	643.60
1	36.25	616.27	647.20	649.37	629.00	10.70	636.50	13.30	633.90
2	137.75	551.20	647.07	649.24	616.00	23.30	623.77	30.90	616.17
	163.00			649.24					
	207.75		647.07	649.24					
	243.25		647.07	649.24	596.20				
	305.00			649.24					
3	348.75	577.23	647.07	649.24	612.00	38.60	608.47	36.50	610.57
4	450.25	613.67	647.20	649.37	623.10	20.50	626.70	24.70	622.50
5	486.25	613.49	648.83	651.00	625.00	12.80	636.03	23.00	625.83
6	522.25	617.49	648.83	651.00	630.00	13.90	634.93	14.50	634.33
S-A	558.50	622.00	648.83	651.00	645.50	14.00	634.83	3.60	645.23

Data92	R-bed92	Data93	R-bed93	Data94	R-bed94	Data96	R-bed96	Data97	R-bed97
4.00	643.20	3.10	644.10	4.40	642.80	5.00	642.20	5.58	643.79
12.00	635.20	13.30	633.90	12.90	634.30	12.20	635.00	14.10	635.27
25.00	622.07	28.30	618.77	15.40	631.67	22.10	624.97	24.60	624.64
30.00	617.07							29.19	620.05
		44.20	602.87			27.60	619.47		
19.00	628.07	19.90	627.17	33.00	614.07	22.70	624.37	24.93	624.31
23.00	624.20	15.90	631.30	12.50	634.70	11.80	635.40	15.42	633.95
16.00	632.83	18.00	630.83	12.30	636.53	10.90	637.93	14.10	636.90
12.00	636.83	8.80	640.03	11.00	637.83	9.20	639.63	10.82	640.18
5.00	643.83	3.80	645.03	4.00	644.83	4.20	644.63	6.23	644.77

Table 46. (Continued)

Data98	R-bed98	Data99	R-bed99	Data00	R-bed00
5.25	644.12	6.10	643.27	5.00	644.37
12.46	6936.91	13.00	636.37	13.40	635.97
23.94	625.30	21.50	627.74	24.00	625.24
32.20	617.4	30.10	619.14		
				30.80	618.44
25.26	623.968	24.30	624.94	24.40	624.84
11.81	637.26	11.40	637.97	11.50	637.57
9.84	641.16	9.90	641.10	9.80	641.20
9.18	641.825	10.00	641.00	9.10	641.90
5.58	645.42	6.00	645.00	5.40	645.60

Year	1943	1950	1970	1974	1981	1987	1991	1992
Flowline	596.20	622.07	616.27	613.07	605.07	608.47	610.57	617.07

Year	1993	1994	1996	1997	1998	1999	2000
Flowline	602.87	614.07	619.47	620.05	617.04	619.14	618.44

APPENDIX A

FLOW PATH OF WASHITA RIVER IN OKLAHOMA

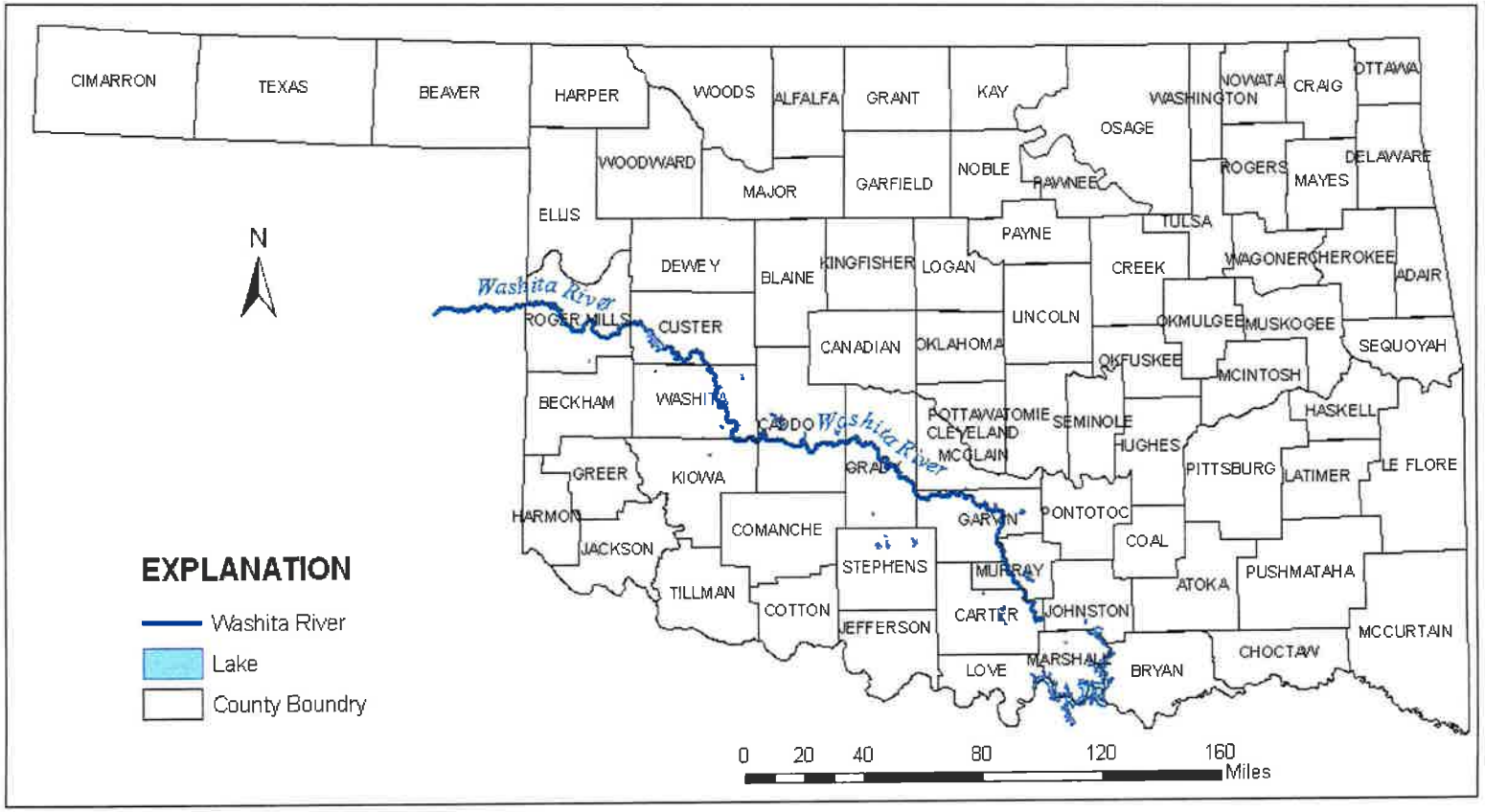
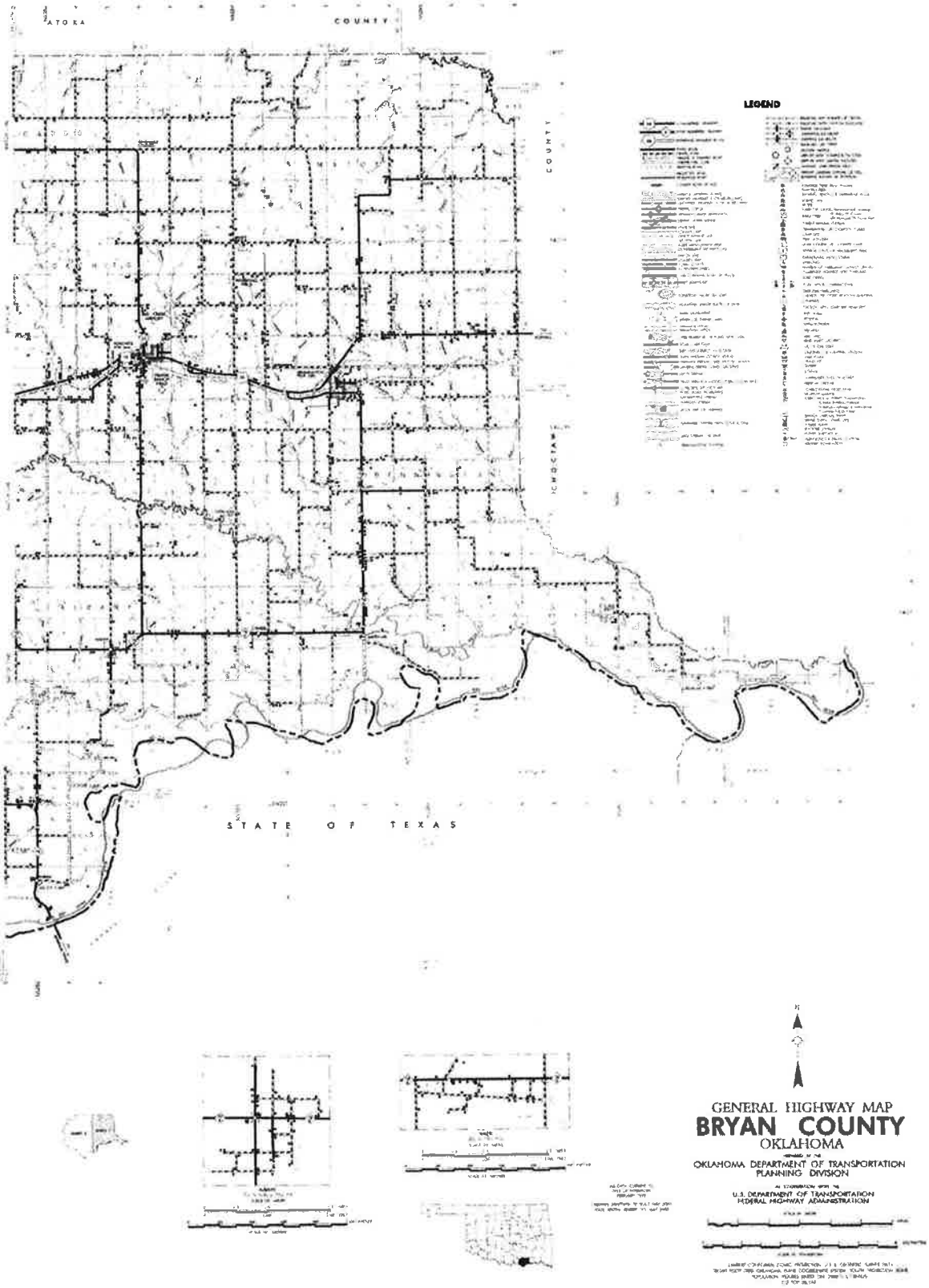


Figure B-1. Flowpath of Washita River in Oklahoma

QUAD MAP LEGEND
WASHITA RIVER, OKLAHOMA

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

County Name
Roger Mills
Custer
Washita
Kiowa
Caddo
Grady
Garvin
Murray
Carter
Johnston
Marshall
Bryan



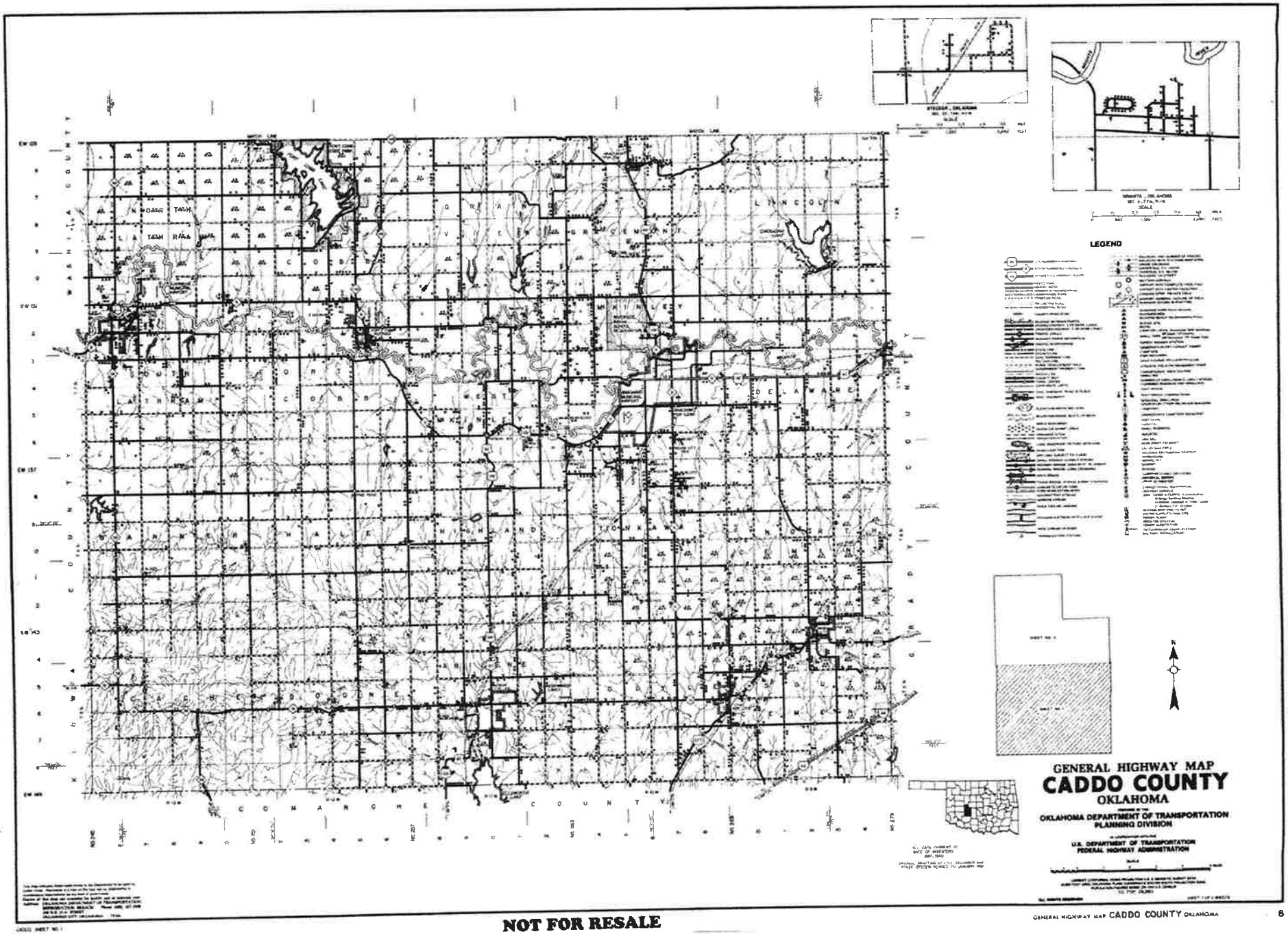
GENERAL HIGHWAY MAP

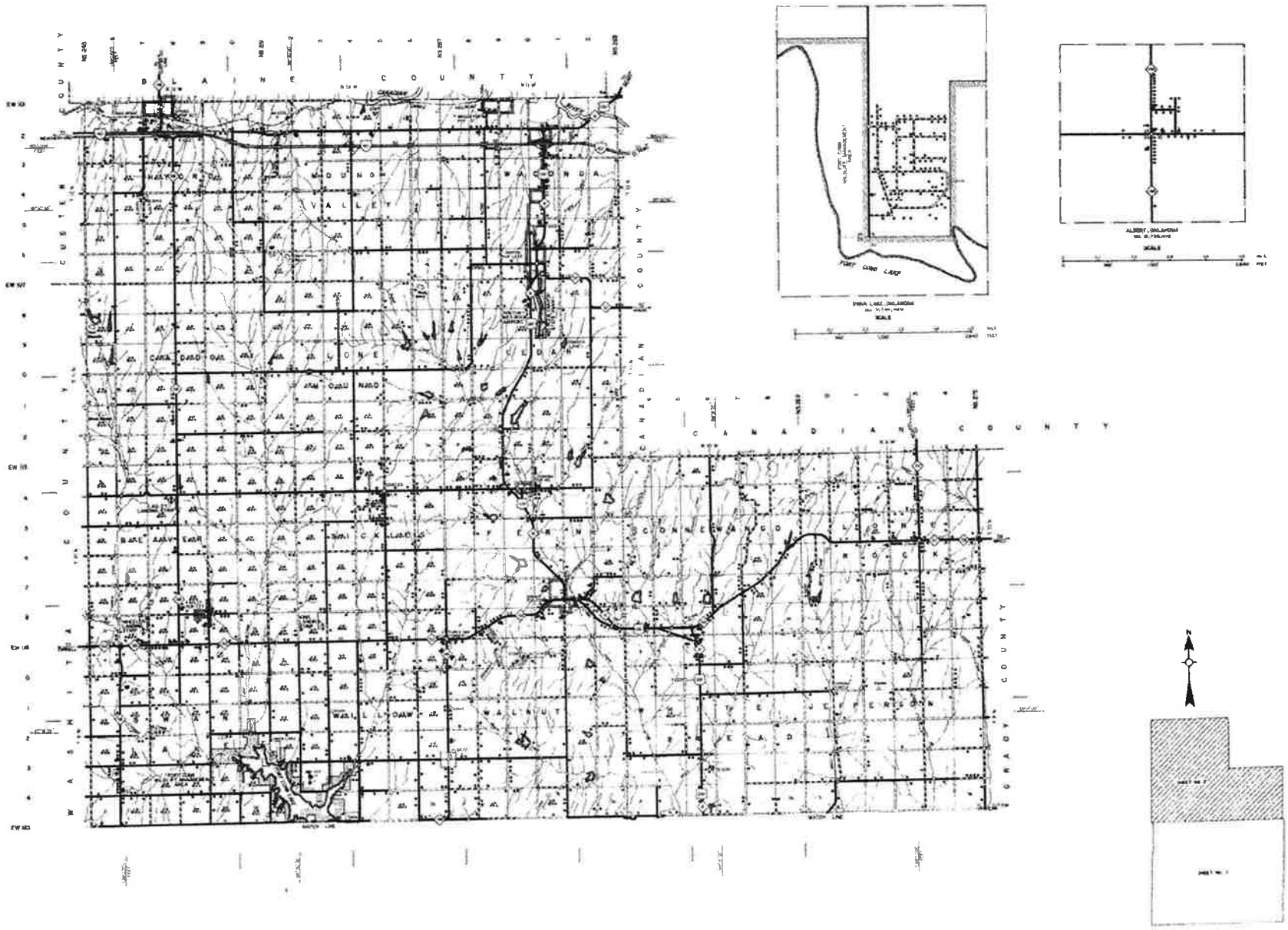
BRYAN COUNTY

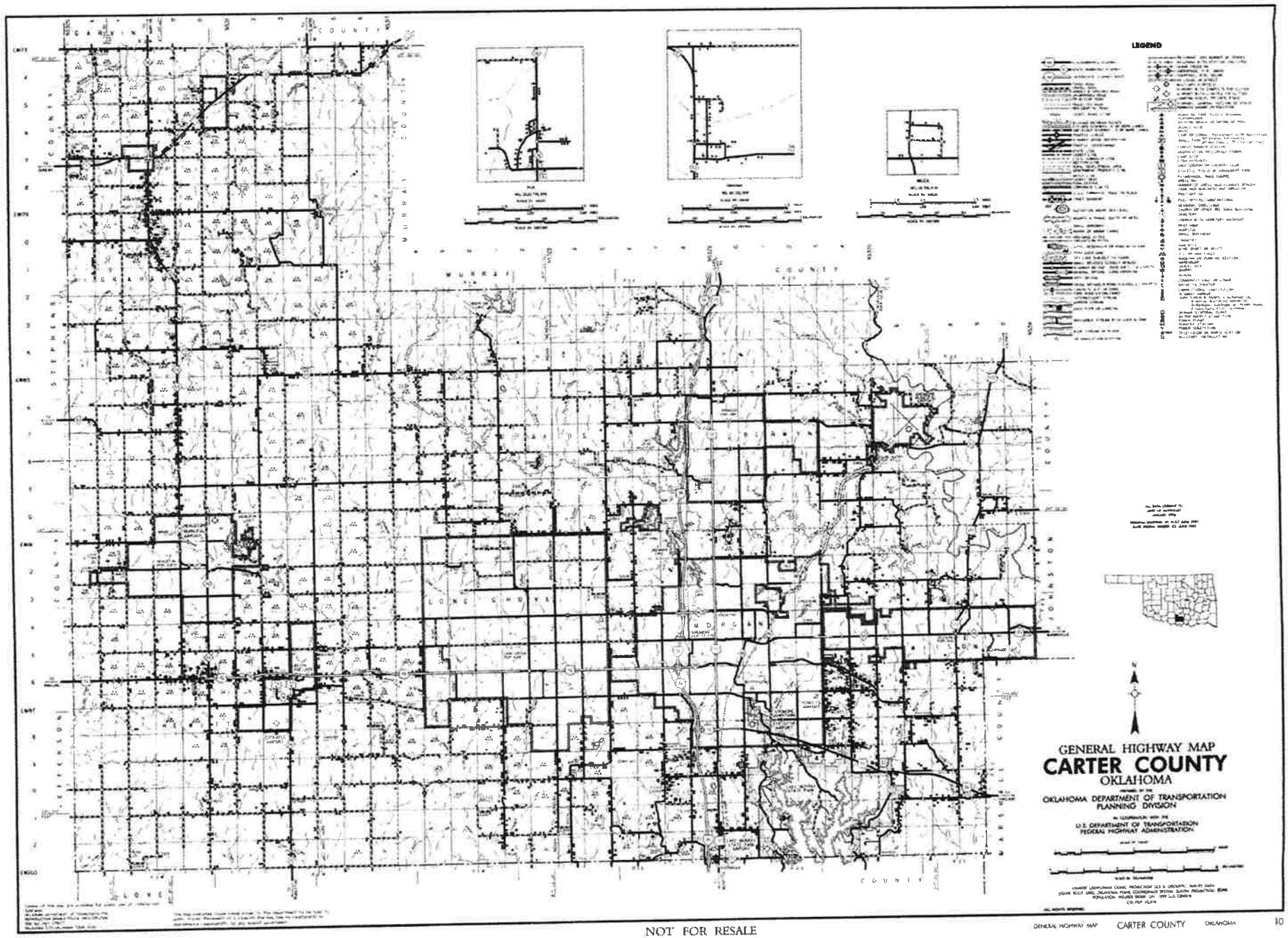
OKLAHOMA

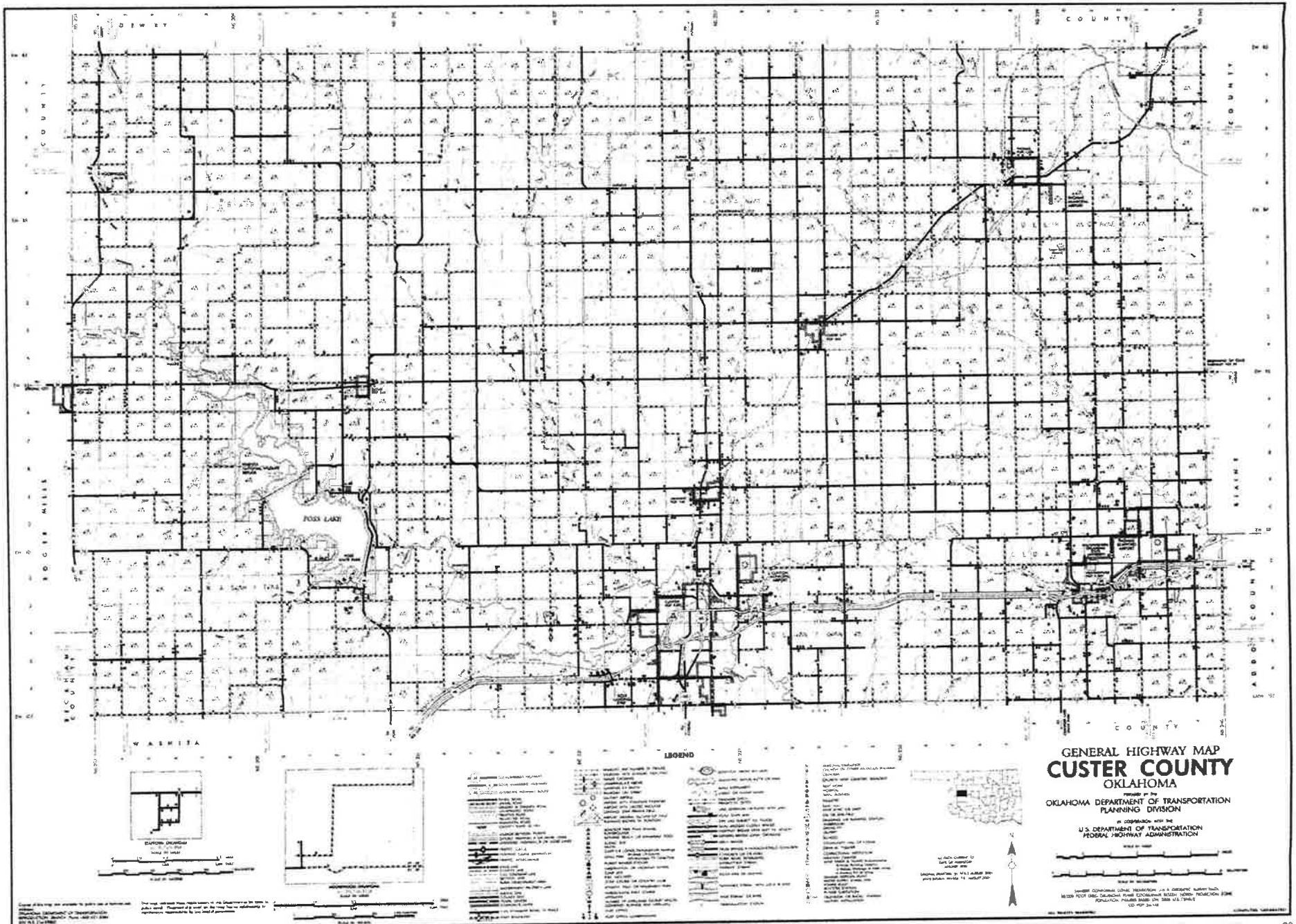
OKLAHOMA DEPARTMENT OF TRANSPORTATION
PLANNING DIVISION

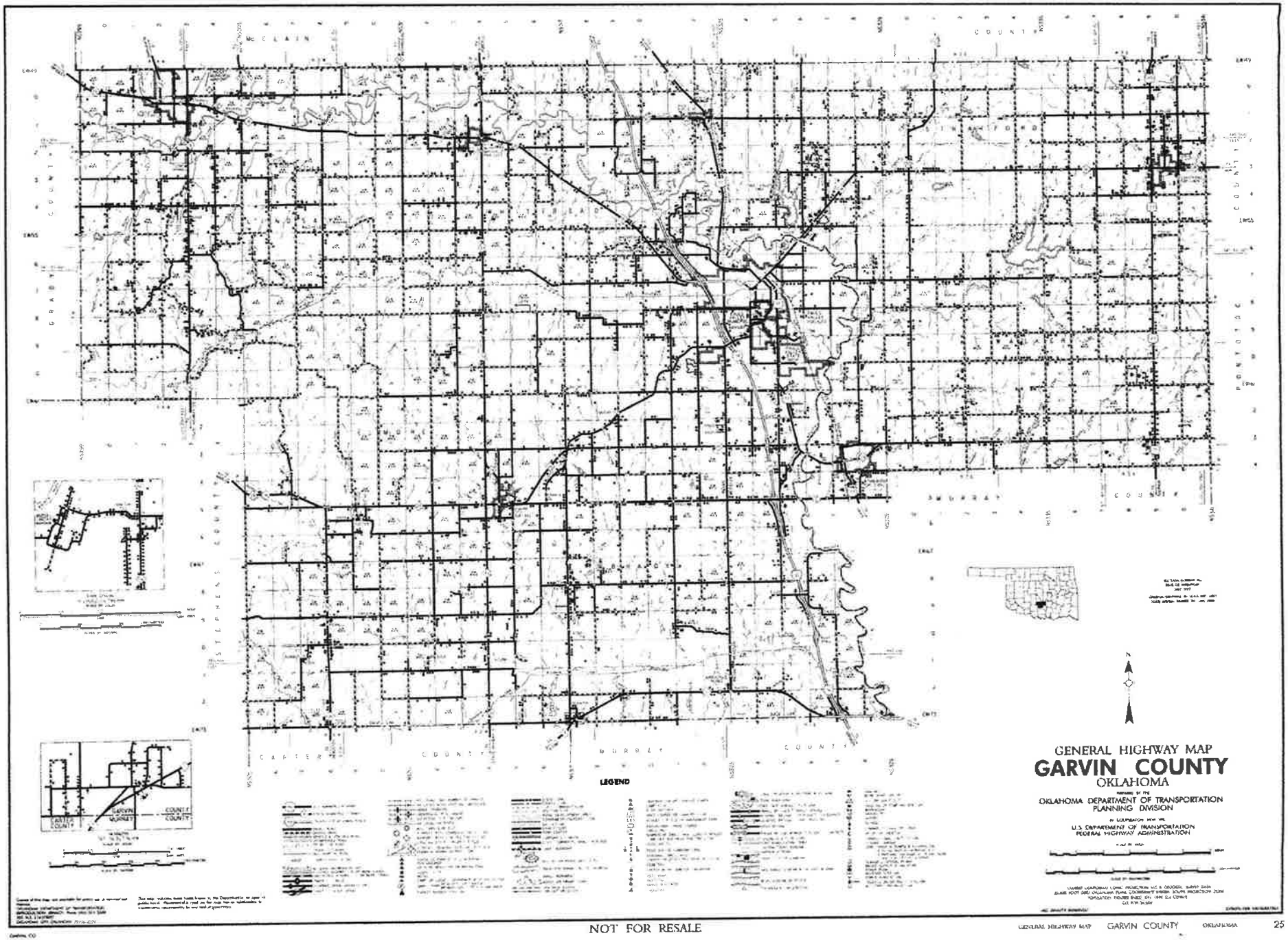
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

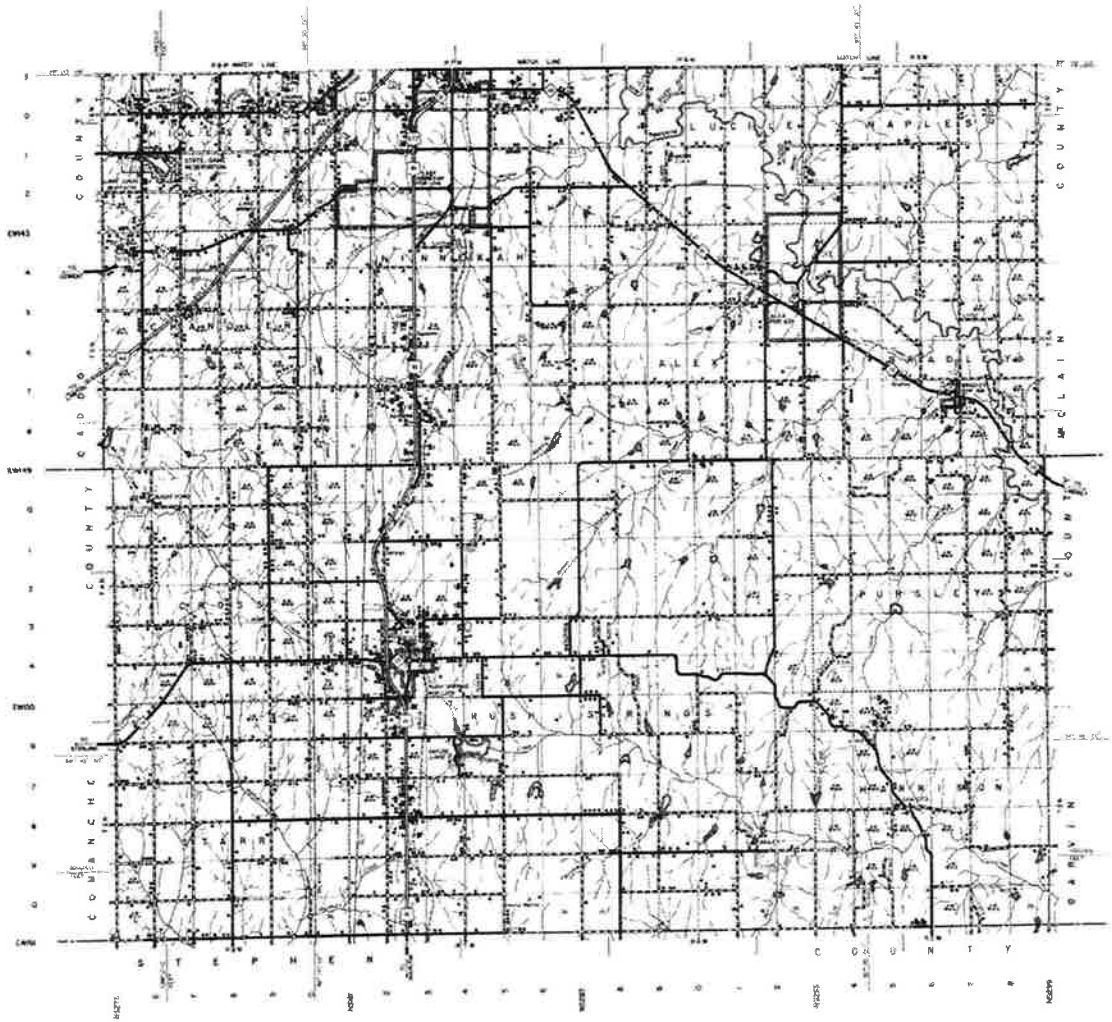












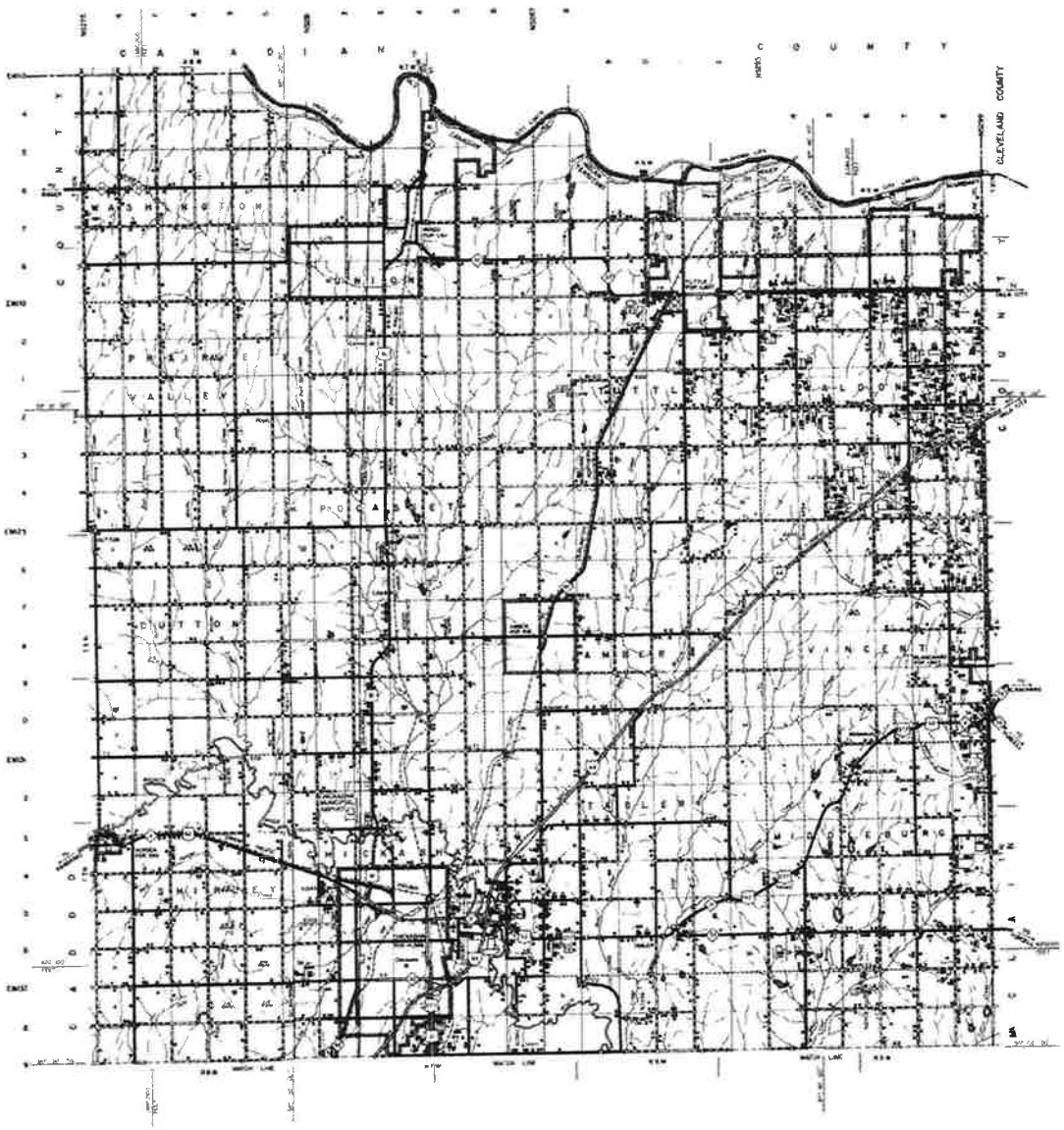
GENERAL HIGHWAY MAP

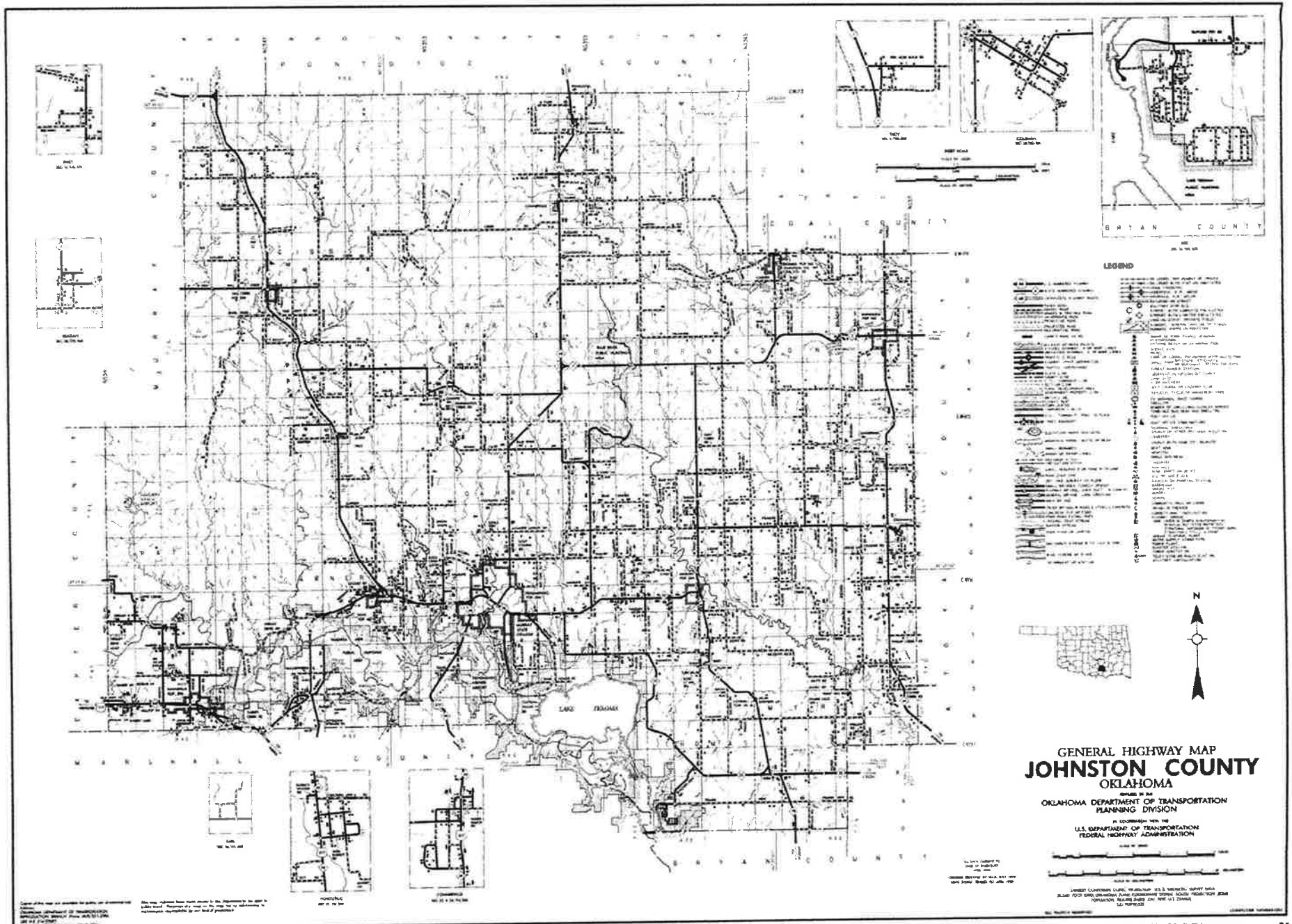
GRADY COUNTY

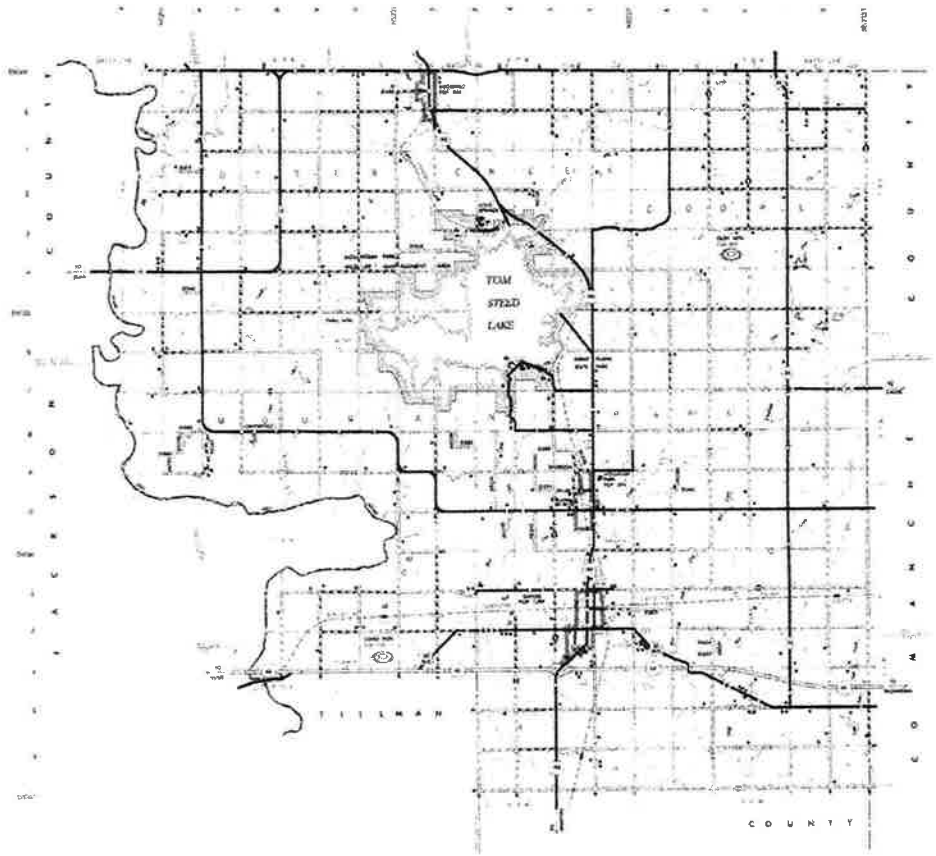
OKLAHOMA

OKLAHOMA DEPARTMENT OF TRANSPORTATION
PLANNING DIVISION

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION







LEGEND

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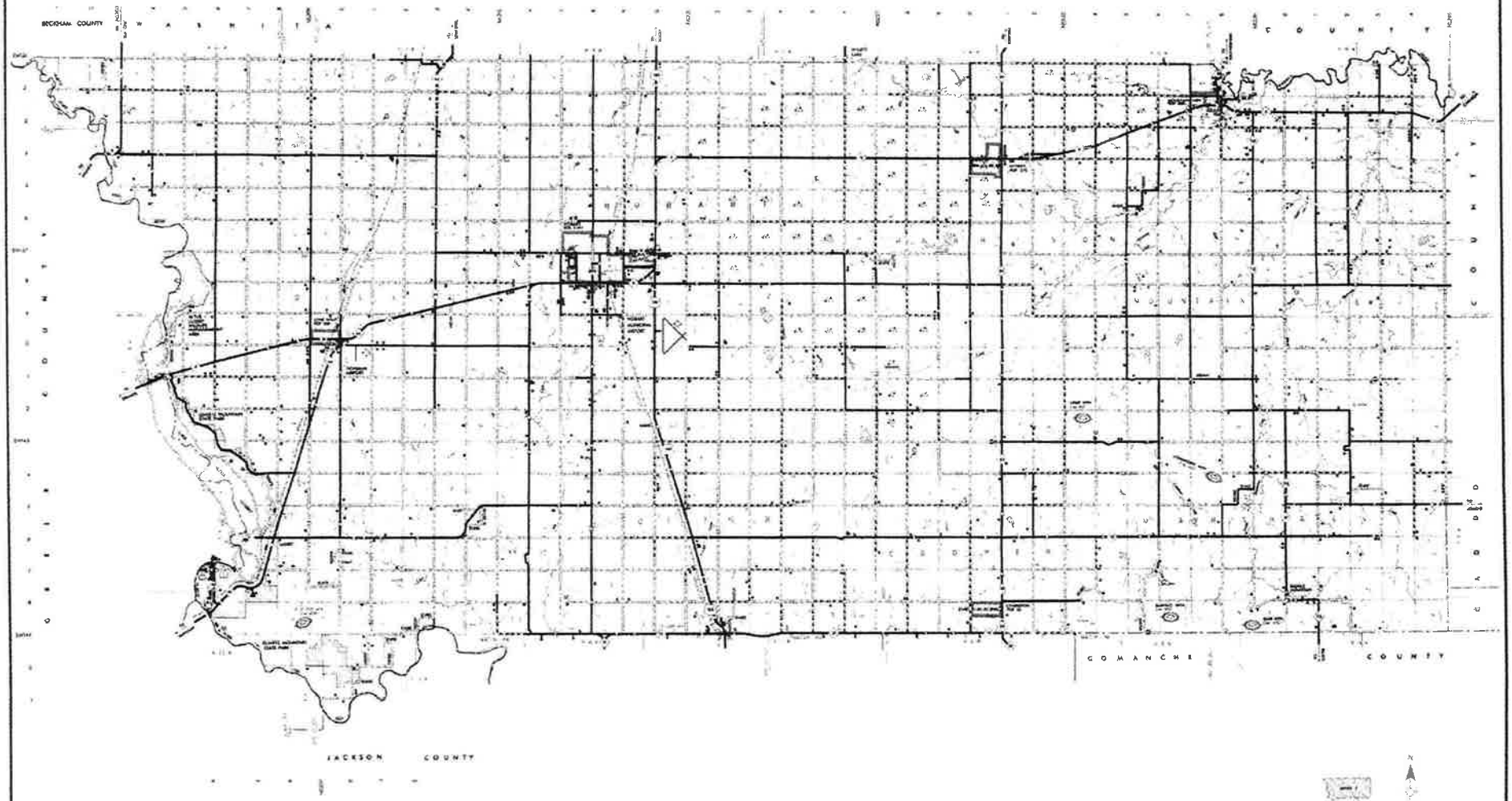
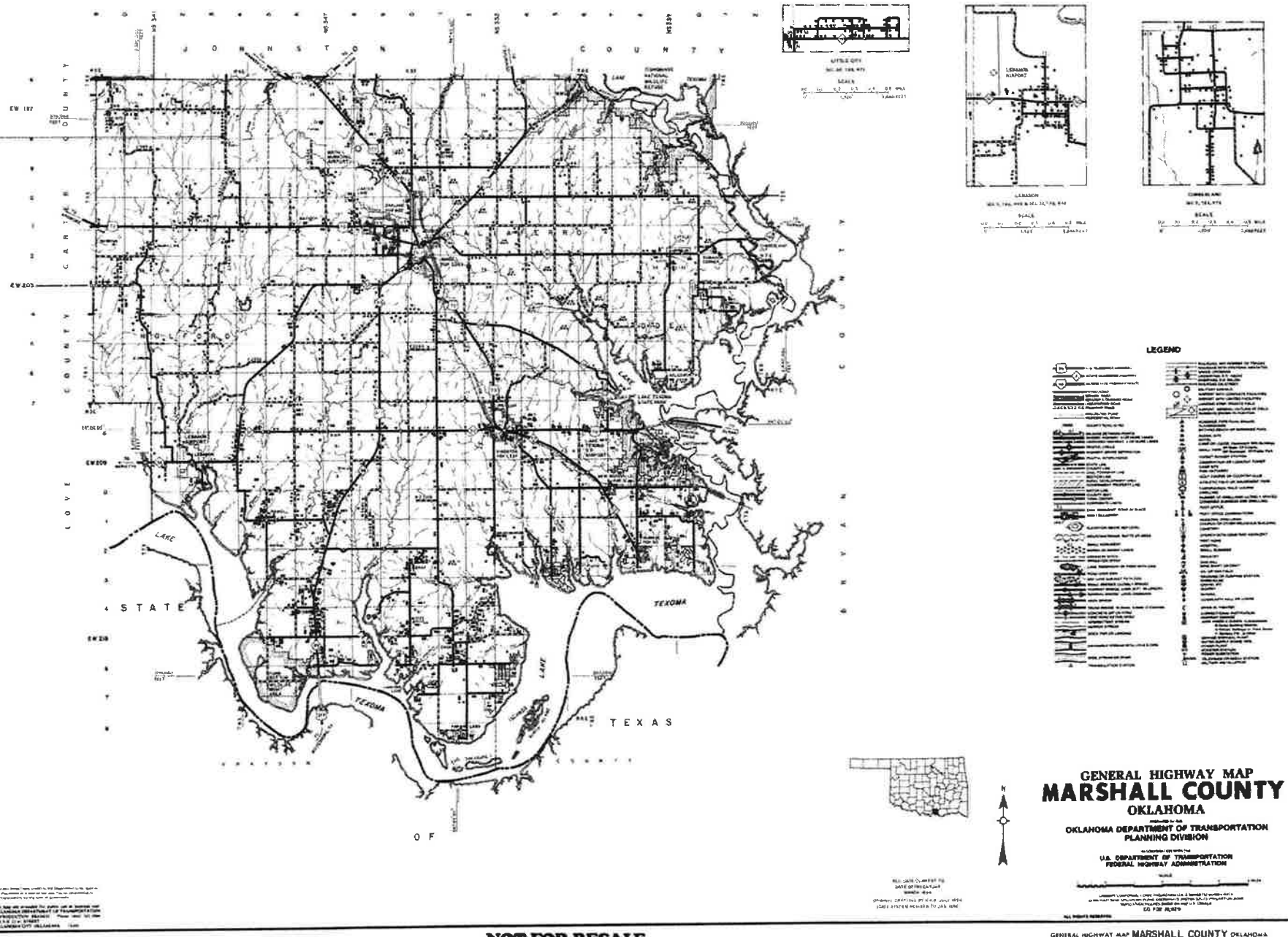
GENERAL HIGHWAY MAP
KIOWA COUNTY
OKLAHOMA

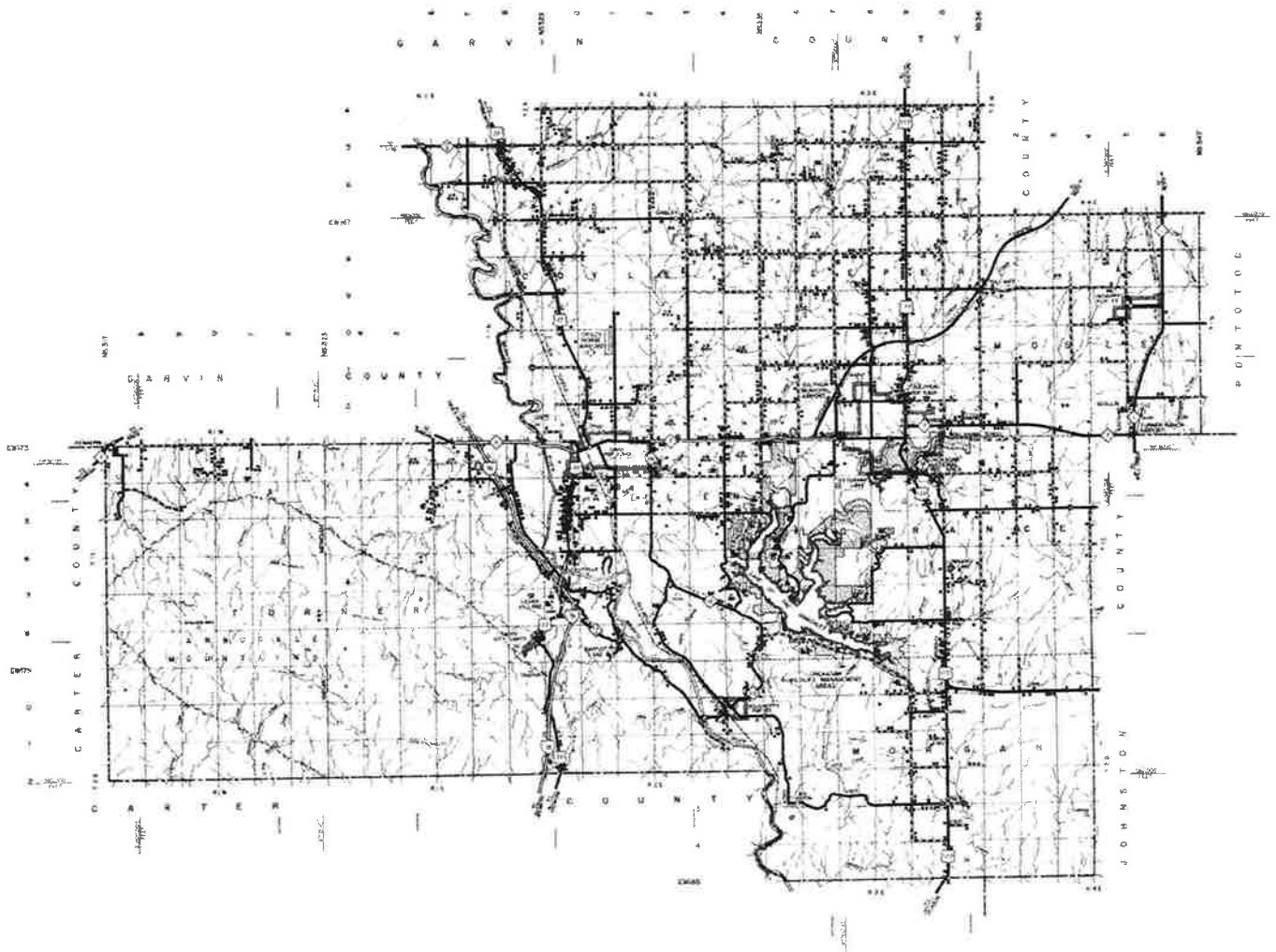
PREPARED BY THE
OKLAHOMA DEPARTMENT OF TRANSPORTATION
PLANNING DIVISION

IN COOPERATION WITH THE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

NOT FOR RESALE







GENERAL HIGHWAY MAP
MURRAY COUNTY
OKLAHOMA

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U.S. DEPARTMENT OF TRANSPORTATION
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