SEDIMENT TRANSPORT AND ACCRETION AND THE HYDROLOGIC ENVIRONMENT OF GROVE CREEK NEAR KENANSVILLE, NORTH CAROLINA

By T.C. Stamey

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ABSTRACT

The Grove Creek basin includes an area of about 42 square miles in Duplin County, southeastern North Carolina. This report evaluates sediment transport and sediment-accretion rates in the lowermost 9-mile reach of Grove Creek by using hydrologic, dendrologic, and radioisotopic data collected at seven sites along the study reach.

Hydrologic data indicate two discharge frequencies. In the swampiest reaches downstream of site 5, inundation occurs 35 percent of the time; above this site, inundation occurs about 15 percent of the time. For the period from October 1982 through September 1987, overbank flows at site 4 occurred 82 times and lasted a total of 632 days with a maximum duration of 3 months.

Distribution of tree species indicates that water-tolerant bald cypress have developed along the lowermost 7 miles of Grove Creek where the flood plain is inundated 35 percent of the time. These swampy conditions have been in existence across limited parts of the flood plain for the last 80 to 150 years. In contrast, the upstream sites have been comparatively dry for the same period.

The sediment that is transported in Grove Creek is predominately silt and clay. Measured suspended-sediment concentrations at discharges less than 100 cubic foot per second are less than 15 milligrams per liter; concentrations at higher discharges did not exceed 67 milligrams per liter. Calculated suspended-sediment loads ranged from 75 to 444 tons per year at the various data-collection sites on Grove Creek.

Sediment-accretion rates estimated from dendrologic data ranged from 0.03 foot per year to 0.06 foot per year. The highest accretion rates occur in the downstream swampy reaches and are due to channel braiding, low channel gradients and flow velocities, and high frequency and duration percentages of overbank flow, which result in the deposition of clay and silt over wide areas of the flood plain.

Sediment-accretion rates along Grove Creek were also estimated by radioisotope methods. Sediment cores from the flood plain showed detectable levels of cesium-137, lead-210, and radium-226. Cesium-137 was not present in the sediment cores below a depth of 10 inches; this indicates a maximum accretion rate of about 0.024 foot per year for the period 1952-87. Lead-210 and radium-226 data from these same sediment cores indicate an average accretion rate of 0.026 foot per year to a depth of about 2 feet. The maximum age of the flood-plain sediment at the 2-foot level is about 80 years. The atmosphere was confirmed as the source of excess lead-210 in flood-plain sediments by nearly matching calculated values of the lead-210 flux at each site with the measured value for atmospheric deposition.

INTRODUCTION

In an effort to control the breeding of mosquitoes by methods other than chemical controls, the North Carolina Department of Human Resources, Vector Control Branch, proposed a channel restoration project for the lowermost reaches of the Grove Creek basin in Duplin County. The restoration project is based on the premise that the present or existing stream channels have aggraded primarily as the result of increased human activities. Sediment-laden runoff from farm fields and roadway construction, along with limbs, logs, and other debris from logging operations, are believed to be primary causes in channel aggradation processes. Presumably, the loss of channel conveyance has resulted in more frequent flooding of the broad, flat flood plains along the stream. Drainage from the inundated flood plains is slow and incomplete, with some areas of standing water remaining for several weeks. These conditions make an ideal breeding environment for mosquitoes.

The restoration technique involves only the removal of deposited sediments, debris, and obstructions along the apparent natural watercourse with no widening or straightening of the existing channel. These modifications are designed to control mosquito populations by improving drainage of the breeding areas. Mosquito populations would be reduced by limiting both the breeding areas and the length of time that standing water is available in the flood plain for hatching mosquito eggs.

The effects of the proposed channel restoration on the environment, particularly mosquito populations, are largely unknown. The degree to which stream-channel characteristics develop as a result of human activities or by natural processes also is uncertain. In 1982, the U.S. Geological Survey (Survey), in cooperation with the North Carolina Department of Human Resources (NCDHR), initiated a program of studies to determine the effects of channel restoration on the hydrology of the Grove Creek basin.

Purpose and Scope

This report describes the results of hydrologic, dendrologic, and radioisotopic analyses in the evaluation of sediment transport and sediment-accretion rates with respect to the hydrologic environment of Grove Creek. The determination of sediment-accretion rates and relative ages of channel and flood-plain sediments help define channel and flood-plain evolution. This knowledge, in turn, can be used to evaluate the effectiveness of channel-restoration techniques with respect to future sediment accumulation, overbank flooding, and mosquito control. The analytical techniques used in this study, which was begun in 1987, included the determination of:

1. Frequency and duration of overbank flooding;
2. Maximum ages, species numbers, and species diversity for trees in the flood plain;
3. Sediment transport loads; and
4. Average sediment-accretion rates as determined from dendrologic and radioisotopic analyses.

Previous Studies

The report, "Frequency and Duration of Flooding of Grove Creek near Kenansville, North Carolina," evaluated frequency and duration of overbank flooding and assessed the effectiveness of proposed stream restoration (Stamey, 1985). The report also provided some data on the age of sediments deposited in the channel of Grove Creek.

Study Basin

Grove Creek, in central Duplin County, is in the southeastern Coastal Plain province of North Carolina. The Grove Creek basin has a drainage area of approximately 42 square miles (mi^2) and is a tributary of the Northeast Cape Fear River (fig. 1). Land-surface elevations in the watershed range from approximately 40 to 95 feet (ft) above sea level.

Most of the basin is sparsely populated except for the town of Kenansville, which had a population of 931 according to the 1980 census (U.S. Bureau of Census, 1982). Major land-use activities in the basin are predominately agricultural and include forests and row crops, with several swine and turkey farms scattered throughout the basin. Average annual rainfall is 52 inches per year (in/yr) (Eder and others, 1983).

Data Collected

Continuous records of stage and discharge are available for site 4 from October 1982 through September 1987; continuous-stage records are available for site 2 from October 1983 through September 1987. Suspended-sediment data have been collected at sites 2, 4, 5, and 7 and are available for the period from October 1983 through September 1987. Geomorphic and dendrologic data were collected in January and September 1987 and in January and February 1988 at all seven of the sites (fig. 1, table 1).

The geomorphic and dendrologic data collected at each site provided information needed in determining sediment deposition in the channel and flood plain. Maximum tree ages, species numbers, and species distribution data were also collected at each site along Grove Creek and used to show the relation between certain dominant species and the frequency and duration of inundation along Grove Creek.

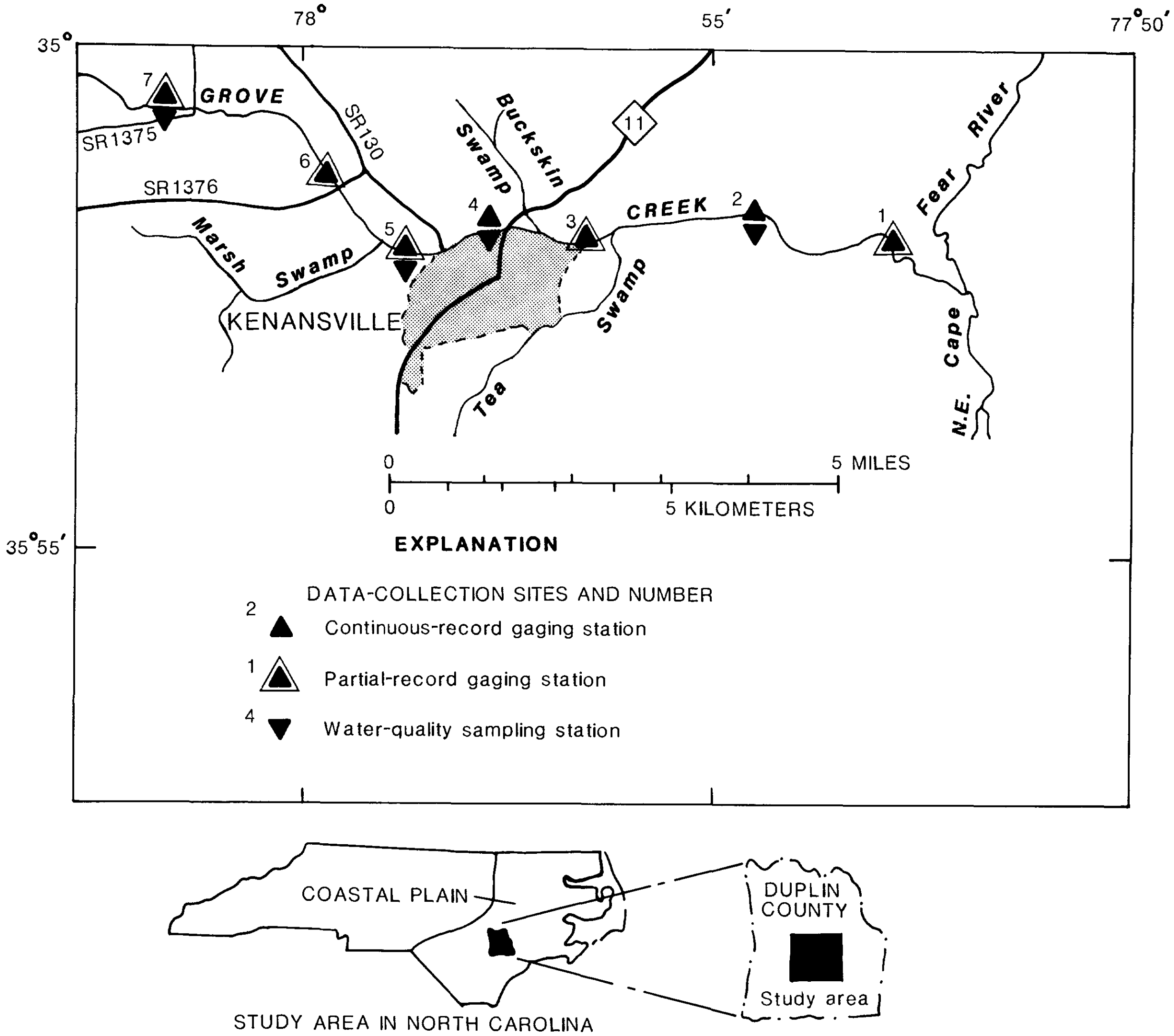


Figure 1.--Location of Grove Creek study reach and data-collection sites.

Channel and flood-plain sediment cores were collected at sites 2 to 5 and analyzed for excess lead-210[1] and cesium-137 radioisotopic activity. Data from the radioisotopic analyses were used to determine mean sediment-accretion rates at each of the sites.

[1]Excess lead-210 activity is that which is supplied through atmospheric deposition and is calculated as total lead-210 activity minus lead-210 activity produced from the decay of radium-226 naturally occurring in the sediment.

Table 1.--*Hydrologic and sediment data collected along Grove Creek*

[USGS number, U.S. Geological Survey downstream order number; a, crest-stage gage, peak stage; b, continuous-record gage height; c, suspended sediment; d, continuous-record streamflow; e, periodic stage and discharge]

Site number (figure 1)	USGS number	Drainage area (square miles)	Types of data collected	Period of record (years)
1	0210789149	38.1	a	3
2	0210789120	35.5	b,c	4
3	0210789110	26	a	3
4	0210789100	22.6	d,c	5
5	0210788875	20.6	a,c	4
6	0210788854	11.2	a	3
7	0210787855	6	e,c	4

Measured land-surface elevations of the stream channel and flood plain (cross sections) at each of the seven data-collection sites (fig. 1) are also available. The measured land-surface elevation data and all gage datums are referenced to sea level. Horizontal distances between sites were scaled from U.S. Department of Agriculture, Soil Conservation Service, aerial photographs. Drainage areas for each site were planimetered on U.S. Geological Survey 7.5-minute quadrangle topographic maps.

Acknowledgments

This report was prepared in cooperation with the North Carolina Department of Human Resources. The author gratefully acknowledges field assistance and advice received from Andrew Simon and Bradley Bryan, of the U.S. Geological Survey's Tennessee District, in obtaining and interpreting initial dendrologic data and Cynthia Rice, of the Survey's Geologic Division, for her advice related to radioisotope dating techniques.

HYDROLOGIC ENVIRONMENT

For the purposes of this report, the hydrologic environment of Grove Creek consists of the stream channel, overflow channels, and the adjacent flood plain. Also included are stream-laid sediments (both channel and flood plain) and several species of trees growing in the flood plain.

Grove Creek is a typical swampy Coastal Plain stream. The study reach extends from the mouth at the Northeast Cape Fear River to site 7 about 6 miles northwest of Kenansville (fig. 1). Within this reach the average stream gradient is 4.5 feet per mile (ft/mi), but in the lower reaches the gradient is as low as 2.9 ft/mi (fig. 2). Streamflow in Grove Creek is confined to a single, defined channel in the upper reach upstream of site 5 and downstream of site 1 near its mouth; elsewhere, the stream course is characterized by braiding and overflow channels.

The flood plain ranges from about 500 to 2,500 ft wide and is typically swampy downstream of site 5. The lower flood plain of Grove Creek is subject to flooding from backwater during floods on the Northeast Cape Fear River.

Flood-plain inundation has been shown to be a dominant factor in controlling plant species distribution by eliminating species that are intolerant to frequent and extended periods of inundation (Leitman and others, 1984). Analyses of hydrologic and dendrologic data were used to show the relations between flood-frequency and duration periods and species distribution in the flood plain of Grove Creek.

Hydrologic Analysis

Hydrologic data collected at the various sites from October 1982 to September 1987 were used to determine the frequency and duration of overbank flows (inundation periods), suspended-sediment discharge, and sediment-transport curves. The sediment-related data are discussed later in this report.

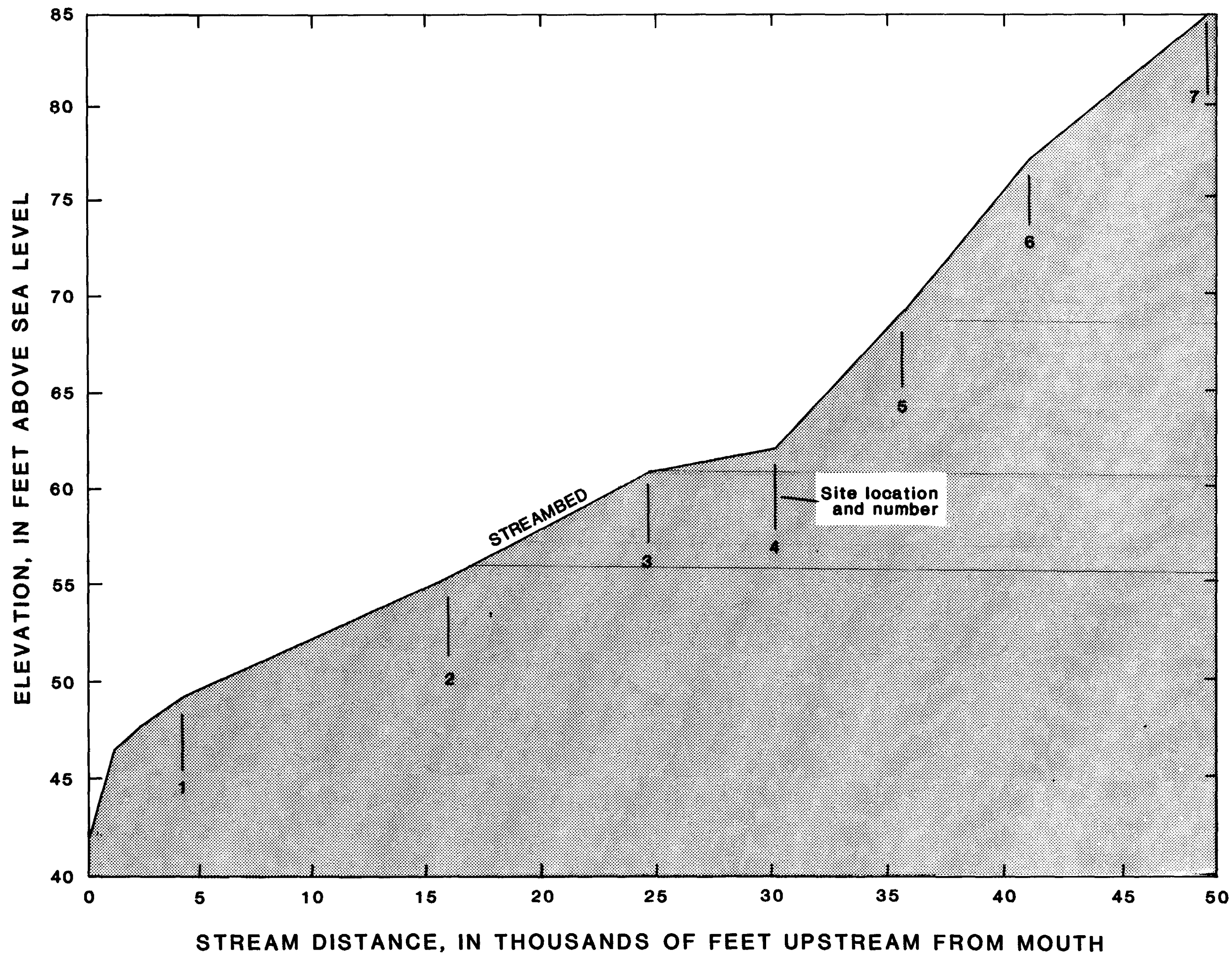


Figure 2.--Streambed profile of study reach in 1984.

Hydrographs of mean daily discharges at site 4 were used to determine the annual inundation periods from October 1982 to September 1987. The inundation period was determined as the length of time the mean daily discharge exceeded the bankfull discharge for each water year. For the period from October 1982 to September 1987, overbank flows occurred 82 times at site 4 and lasted a total of 632 days with a maximum duration of 3 months. The number of inundaton periods and length of occurrences are summarized in table 2.

Table 2.--*Frequency and duration of overbank flooding at site 4*

[Water year, October 1 to September 30]

Water year	Number of times out of banks	Longest duration (days)	Total time out of banks (days)
1983	15	89.0	199
1984	17	51	175
1985	16	37	48
1986	15	12	48
1987	19	24	162
Total or average	82	42.6	632

Analysis of hydrologic data from site 4, continuous-stage records at site 2, and slope-conveyance flow-modeling (Stamey, 1985) indicate that there are two distinguishable inundation frequencies on Grove Creek. For the typically swampy downstream reaches (sites 1 to 5), inundation occurs 35 percent of the time. In contrast, upstream sites 6 and 7 are inundated only about 15 percent of the time.

Dendrologic Analysis

Increment cores of tree rings have been used for many years by foresters, wood technologists, and dendrochronologists for dating purposes. The same increment-coring techniques were used in the analyses of maximum tree ages at each site on Grove Creek. A total of 170 increment cores were collected and used in determining maximum tree ages. Botanical information on tree species, numbers and diversity, was also collected. Dominant tree species in the flood plain of Grove Creek between sites 1 and 7 include: ash, bald cypress, loblolly pine, red maple, swamp chestnut oak, water oak, and white oak. The locations and maximum ages of dominant tree species are shown in figures 3 to 9. This information indicates the existence of, or relates to the evolution of, swampy conditions along Grove Creek.

Interpretation of the increment cores indicates that the bald cypress are among the oldest trees sampled. The maximum ages of the trees sampled ranged from about 80 to 150 years, and the average age of these trees is around 88 years. However, the oldest tree sampled was a bald cypress from site 5, but due to extremely suppressed growth increments, the maximum age of 208 years is an estimate (Andrew Simon, U.S. Geological Survey, written commun., 1987).

Species-diversity data indicate that there is a distinct pattern in the distribution of species across the flood plain among the sites. Bald cypress, which are indicative of swampy conditions, were common at all sites except at sites 6 and 7. Their location within the flood plain also tended to be restricted to a 400- to 800-foot wide area on either side of the main channel or channels at all sites where the species were noted. Only at sites 1 and 2 were they distributed across about 90 percent of the flood plain, which at those sites is about 2,000 to 2,500 ft wide. Species that are not tolerant of inundation periods lasting more than a few weeks, such as red maple, white oak, and swamp chestnut oak, were occasionally seen along the perimeter of the flood plain between site 1 (fig. 3) and site 5 (fig. 7) but were more common at sites 6 and 7 (figs. 8 and 9), indicating drier conditions at sites 6 and 7.

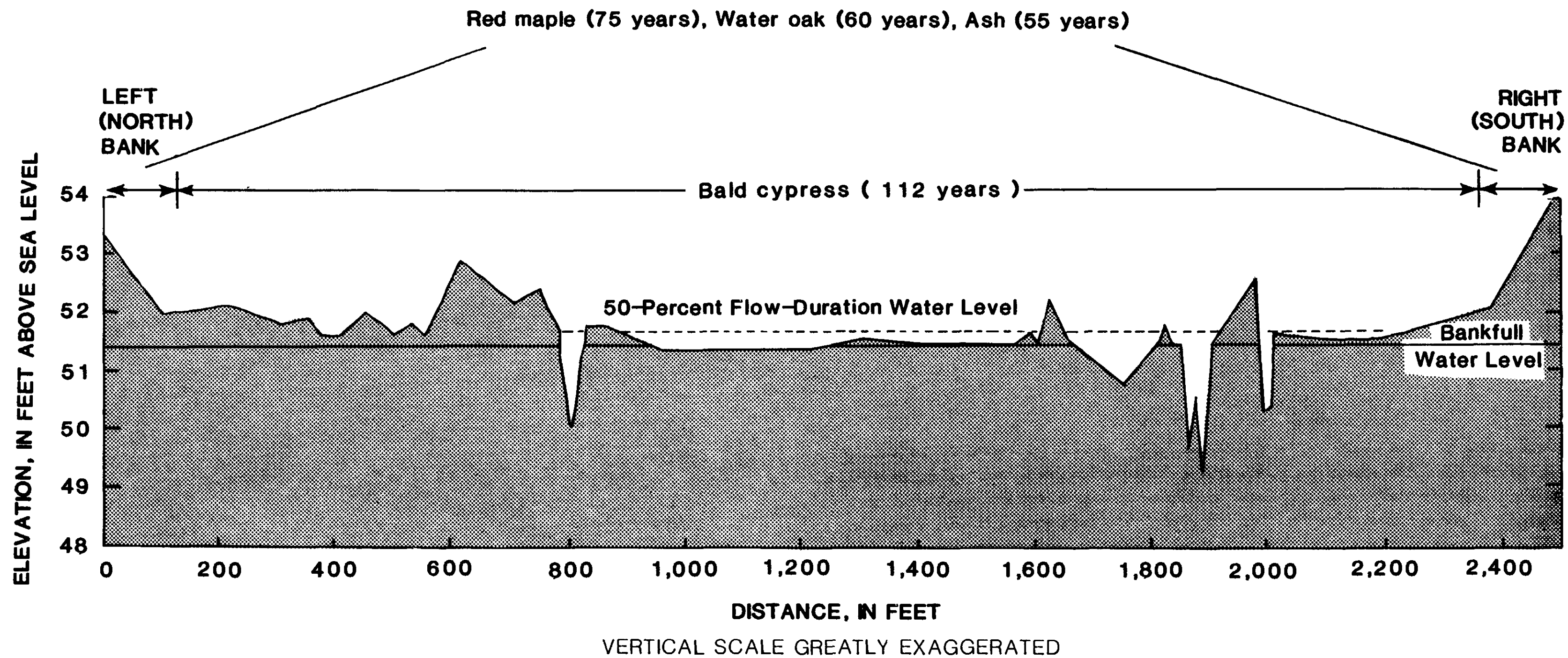


Figure 3.--Locations of dominant tree species, maximum tree age observed for each species, and water level at 50-percent flow duration at Grove Creek, site 1.

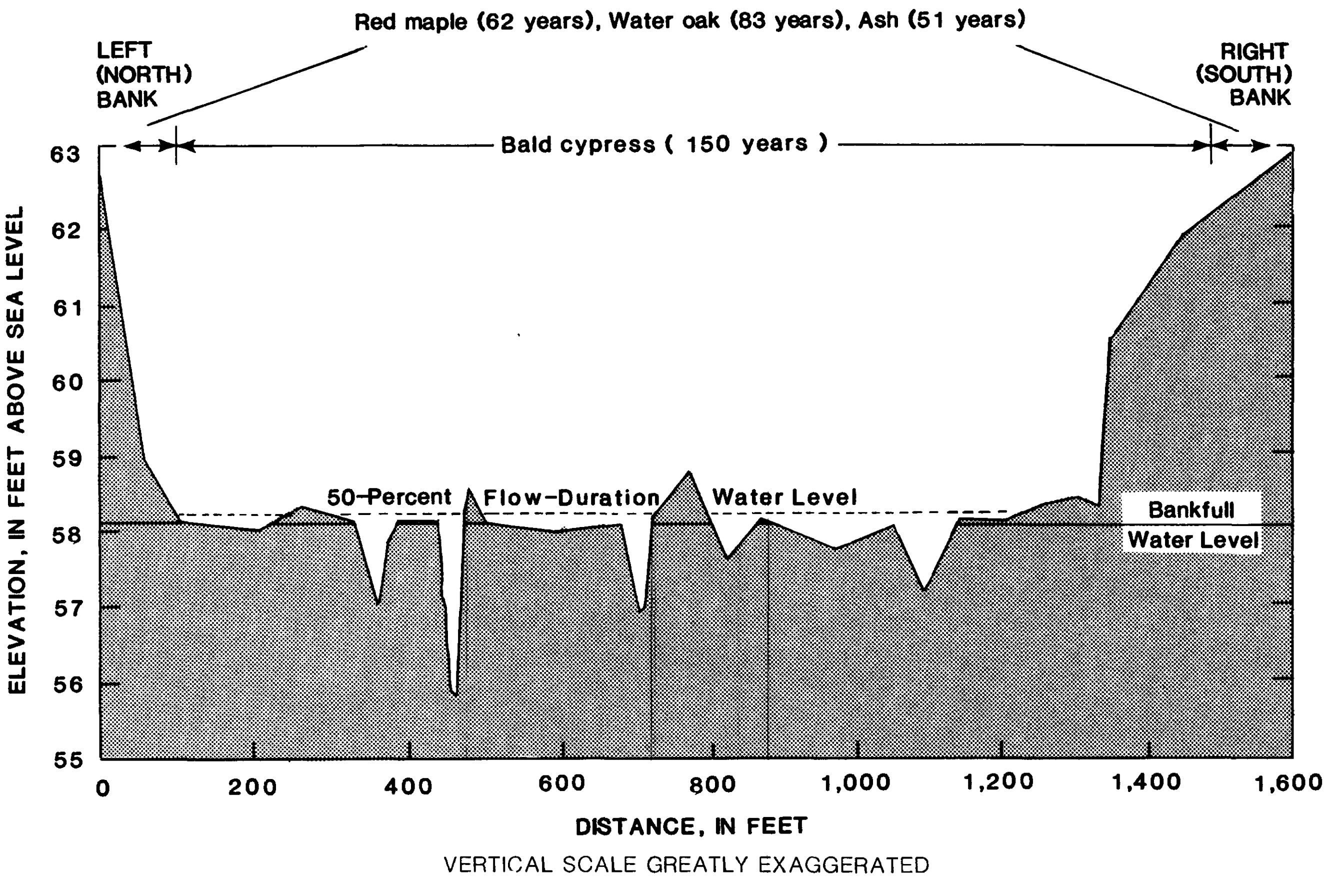


Figure 4.--Locations of dominant tree species, maximum tree age observed for each species, and water level at 50-percent flow duration at Grove Creek, site 2.

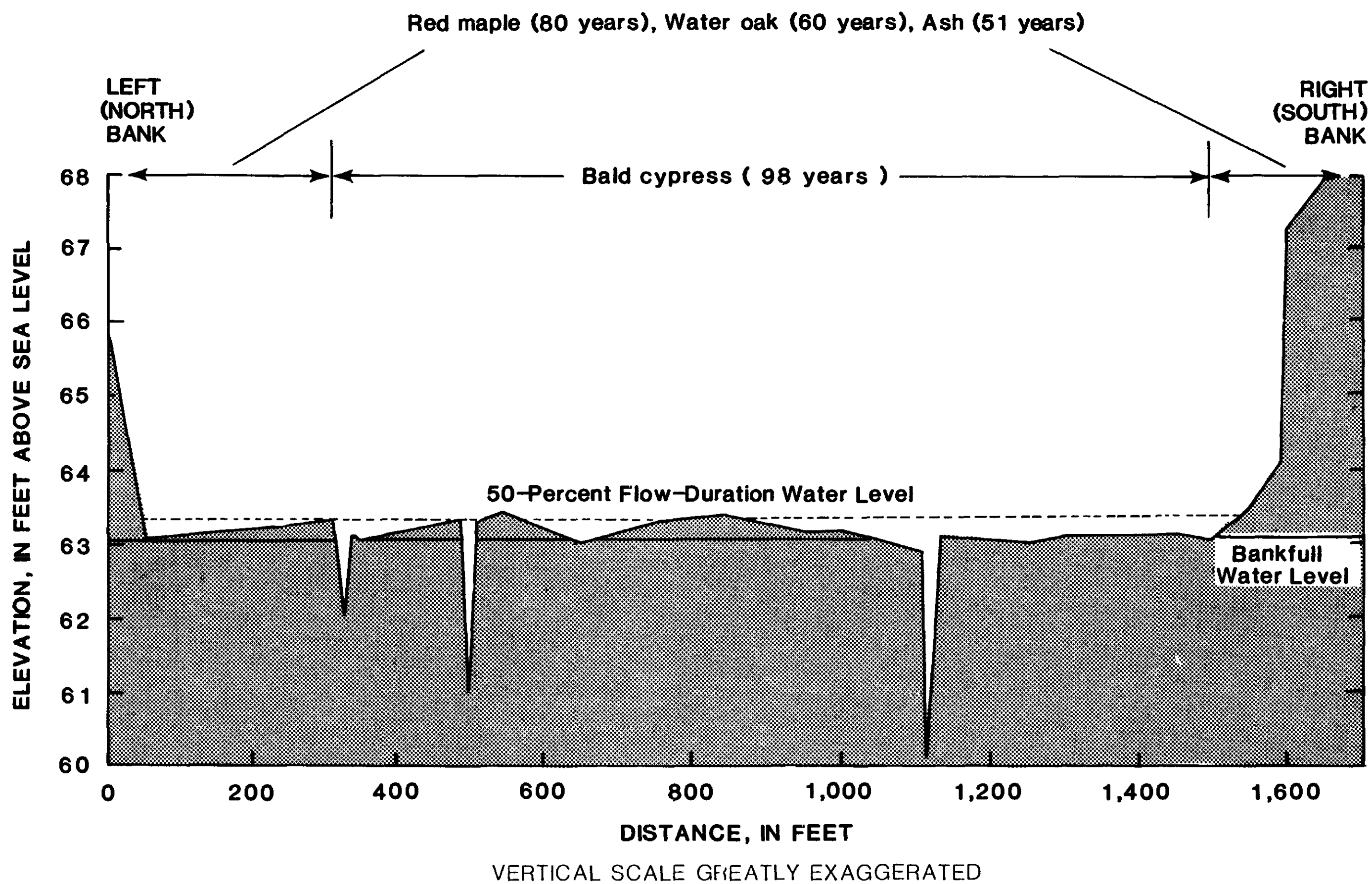


Figure 5.--Locations of dominant tree species, maximum tree age observed for each species, and water level at 50-percent flow duration at Grove Creek, site 3.

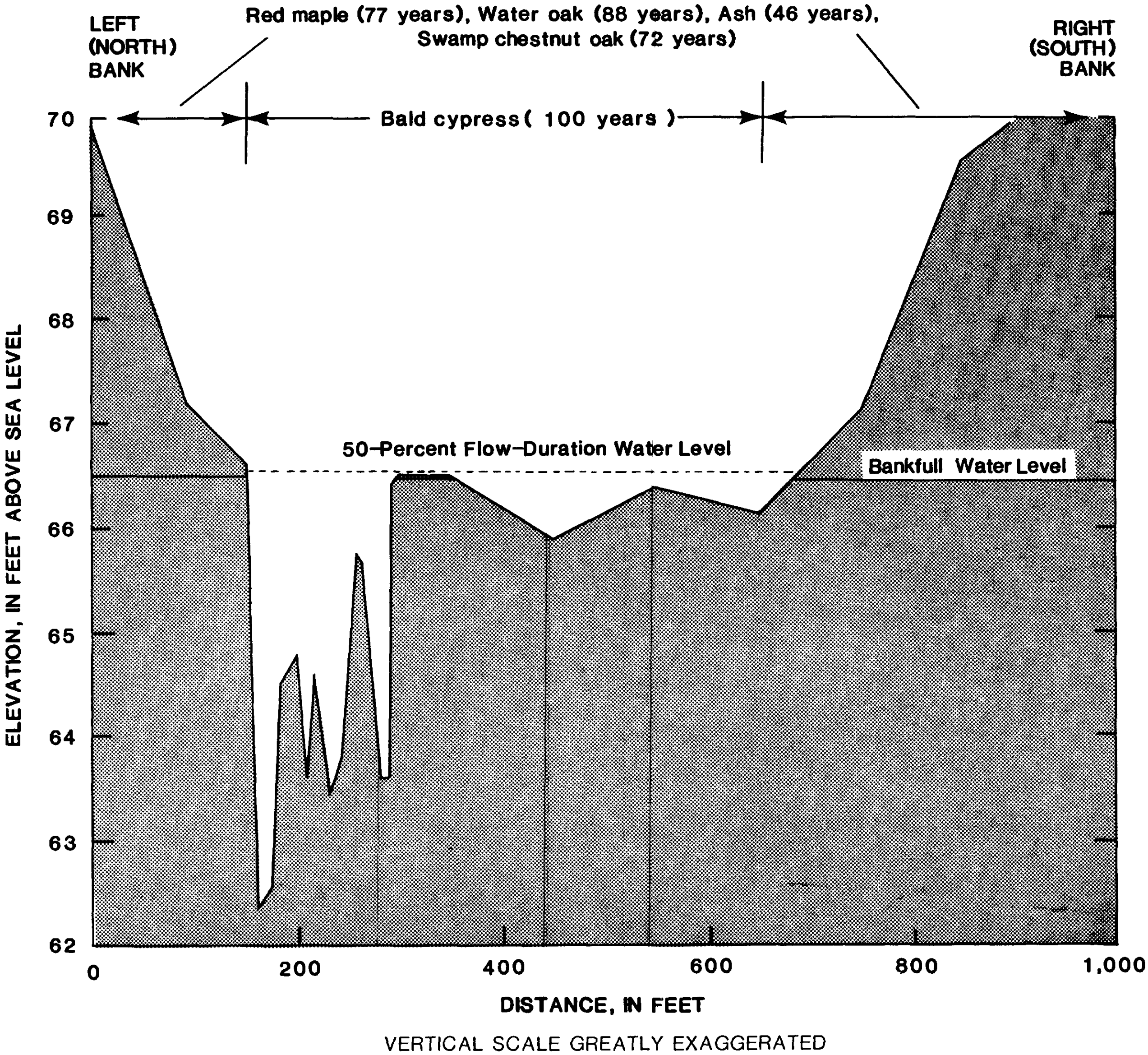


Figure 6.--Locations of dominant tree species, maximum tree age observed for each species, and water level at 50-percent flow duration at Grove Creek, site 4.

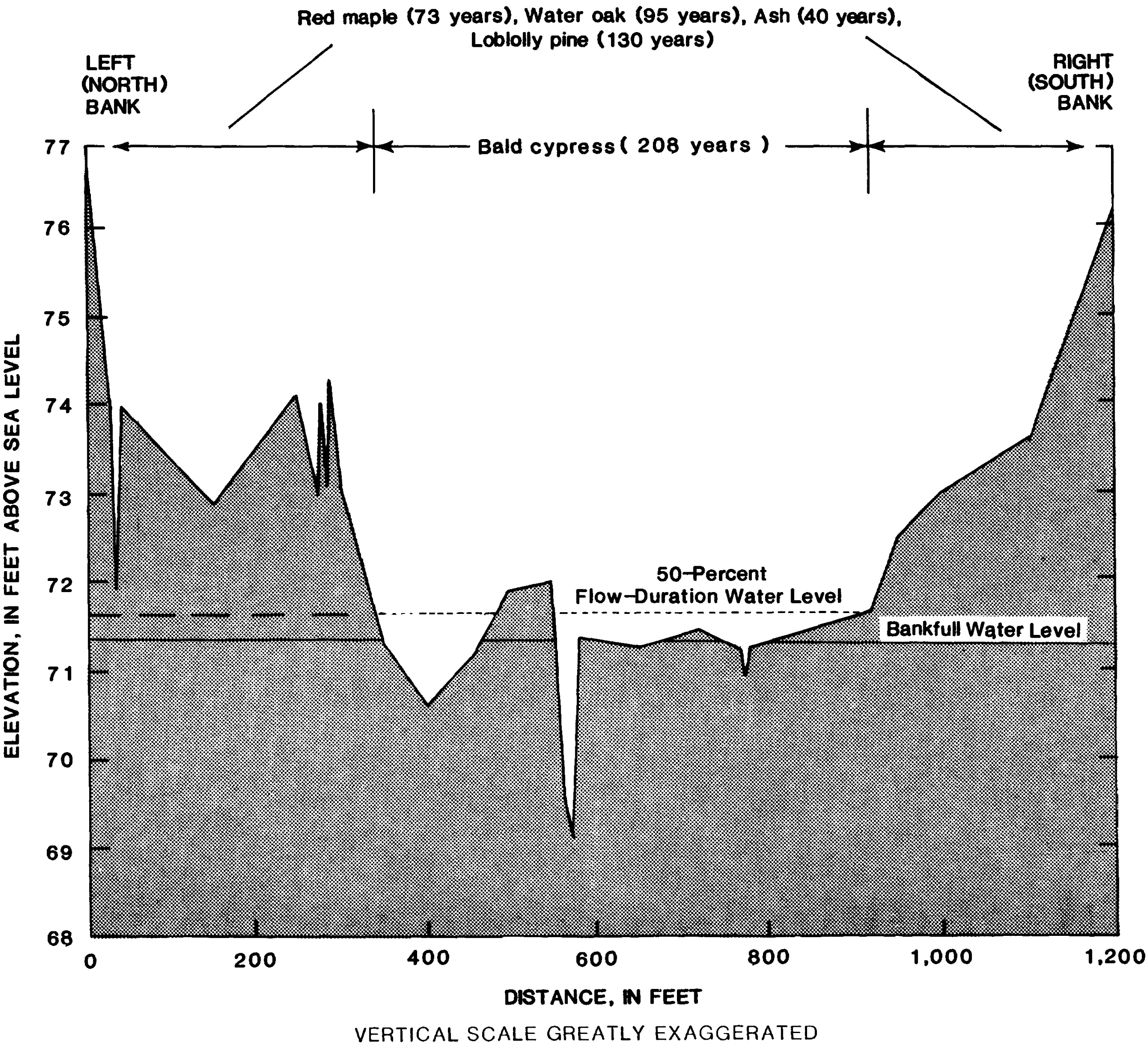


Figure 7.--Locations of dominant tree species, maximum tree age observed for each species, and water level at 50-percent flow duration at Grove Creek, site 5.

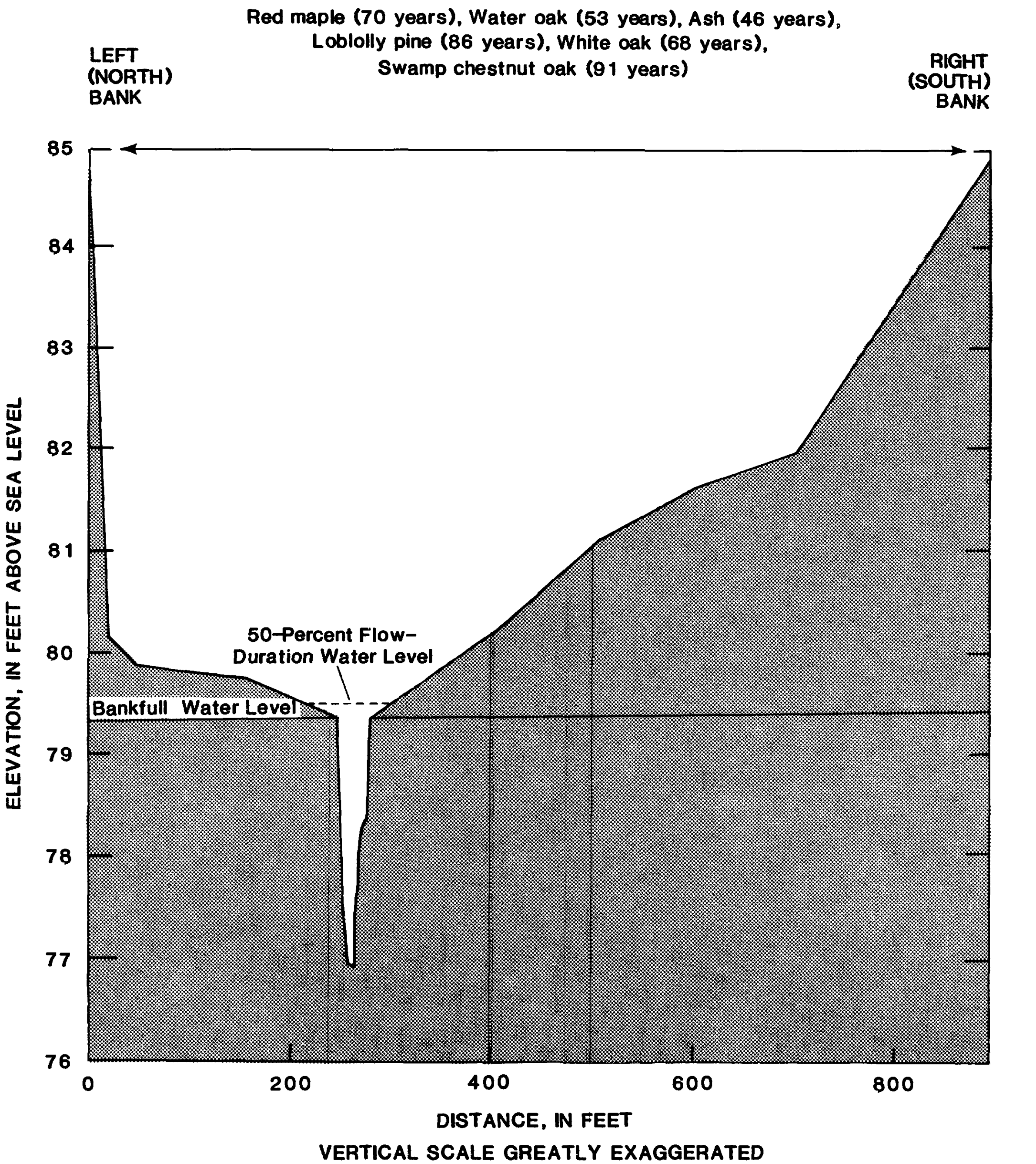


Figure 8.--Locations of dominant tree species, maximum tree age observed for each species, and water level at 50-percent flow duration at Grove Creek, site 6.

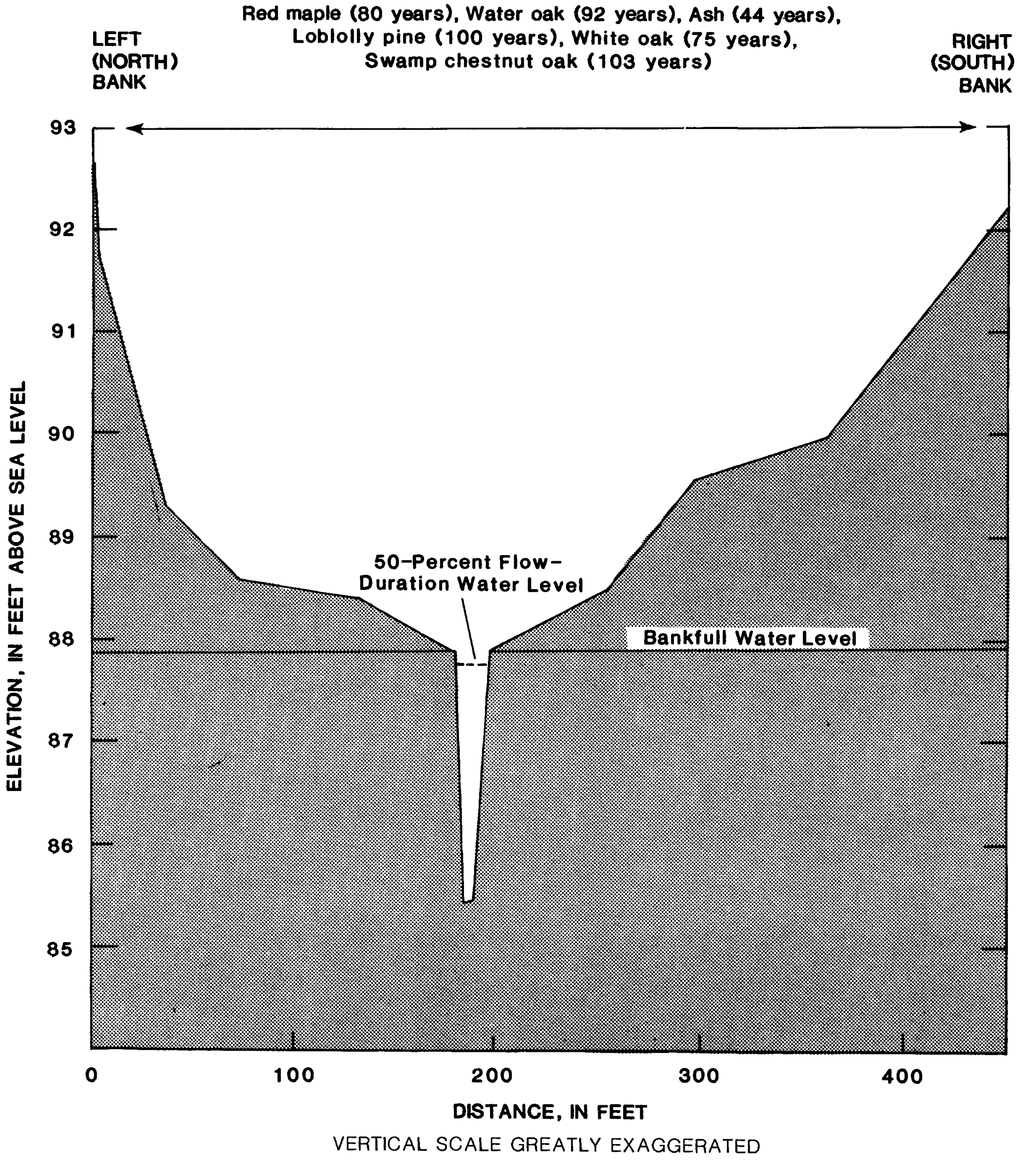


Figure 9.--Locations of dominant tree species, maximum tree age observed for each species, and water level at 50-percent flow duration at Grove Creek, site 7.

The species-distribution data indicate that stands of the water-tolerant bald cypress are more widely developed between sites 1 and 5, where annual inundation periods of approximately 4.2 months (35 percent duration) have occurred. This indicates that swampy conditions have been existent in this flood plain reach for at least the last 80 to 150 years. In contrast, the conditions at sites 6 and 7 seem to have been comparatively drier for the last 50 to 100 years.

SEDIMENT TRANSPORT

Sediment-transport characteristics of streams are affected by land use, soil properties, type and degree of vegetation cover, flow velocities, channel and flood-plain characteristics, along with various other factors. As in most North Carolina streams, suspended-sediment concentrations in Grove Creek vary with streamflow and reach maximum levels during floods. Suspended-sediment concentrations at low and medium discharges (less than 100 cubic feet per second (ft^3/s)) are generally less than 15 milligrams per liter (mg/L) at all sampling sites but range from 0 to 20 mg/L. Concentrations during floods reached an observed maximum of 67 mg/L.

Suspended sediment in Grove Creek is comprised predominately of silt and clay-size particles; flow velocities are usually too low to scour and transport coarser bottom materials. Flow data from site 4 suggest that at discharges greater than 104 ft^3/s velocities are above 1 foot per second (ft/s), and at that point the stream can transport sandy bed material along the main channel as suspended load (Colby, 1964). However, flow-duration data indicate that flows greater than 104 ft^3/s occur only 8 percent of the time. During flood events, suspended materials in overbank flow settle out of the slower moving waters that inundate the swampy flood plain.

Suspended-sediment relations and loads were calculated for sites 2, 4, 5, and 7 using the flow-duration method described by Simmons (1988). Loads ranged from 79 tons per year (tons/yr) at site 7, to 440 tons/yr at site 2 (table 3). However, sediment yields at the two sites were nearly the same at 13.2 tons per year per square mile ($tons/yr/mi^2$) and 12.4 $tons/yr/mi^2$, respectively.

Table 3.--*Suspended-sediment yields for selected sites on Grove Creek from October 1982 to September 1987*

Site number (figure 1)	Number of samples	Drainage area (square miles)	Sediment load (tons per year)	Sediment yield (tons per year per square mile)	Coefficient of determination (r^2) for log-log transport relations
2	71	35.5	440	12.4	0.86
4	79	22.6	298	13.2	.87
5	77	20.6	225	10.9	.84
7	76	6	79	13.2	.86

SEDIMENT ACCRETION

Transported sediments are deposited as flow velocities decrease due to increased conveyance in overbank flow, flatter slopes, or receding flood flows. Deposits of fine sand, silt, and clay occur on the flood-plain surface along Grove Creek. Results of sieve analyses indicate that particle sizes of the deposited sediments are fairly uniform with depth, except at sites 6 and 7 where they are more variable with depth and there are more sand-size materials. In this reach, the stream gradient is nearly 5 ft/mi (fig. 2) so that greater stream velocity during floods accounts for the variability in sediment particles deposited in the flood plain. Lower gradients and velocities along downstream reaches result in more uniform deposition of silt and clay particles and are areas of the highest accretion rates. Accretion rates are variable in some reaches due to debris that blocks the stream channels, thereby redistributing the flow. The blockages also shift with different storm events and alter accretion patterns and rates.

Sediment-accretion rates were estimated by two independent dating methods based on (1) dendrologic data and (2) radioisotopic analyses of sediment cores. Collection of the dendrologic data involved exhuming several small trees and measuring the depth of deposited sediment above the different root collars, along with determining the age of the plant between the root collars. Analyses of these pieces of information allowed sediment-accretion rates to be calculated. Several small trees were examined at each site across the flood plain to determine average accretion rates.

Analyses of sediment cores using radioisotopes enabled the dating of sediment deposition to greater depths than was possible from the dendrologic data. The radioisotopes used were lead-210, radium-226, and cesium-137. The maximum dating range using lead-210 and radium-226 is about 100 to 150 years before the sample was collected and is controlled by the amount of "excess" lead-210 present over the background lead-210 concentration that results from decay of radium-226 in the sediment column. Cesium-137 is a by-product of above-ground testing of the atomic bomb, which began in 1952. It should not be detectable in pre-1952 sediments. The methods of analyses used are described in detail by Robbins and Edgington (1975) and Yang and Ambats (1981).

Dendrologic Analysis

Average sediment-accretion rates in the Grove Creek flood plain, based on dendrologic analysis, ranged from 0.03 foot per year (ft/yr) at site 7 to 0.06 ft/yr at sites 1 and 2 (table 4). The highest rates of accretion are at the downstream swampy sites where lower gradients, lower velocities, and longer periods of overbank flow than at upstream sites facilitate the accumulation of clay and silt on the flood plain.

Accretion rates also showed some variability across the flood plain at each site. Higher accretion rates occurred closer to the stream channel than at the edges of the flood plain at sites 6 and 7. This is probably due to greater differences between the channel and overbank velocities, which cause higher deposition rates at the interface of channel and flood-plain flow. At the other sites, the accretion rates seem to be about the same across the flood plain, except at sites 2 and 3 where deposition is greater in the middle part of the flood plain. This is a result of channel braiding, which decreases flow velocity and increases deposition rates during flooding of the flood plain.

Table 4.--*Sediment-accretion rates for the Grove Creek flood plain based on dendrologic data*

Site number (figure 1)	Tree age (years)	Depth of sediment accretion (feet)	Sediment-accretion rate (feet per year)	Remarks
1	8	0.62	0.08	near channel
	5	.25	.05	near channel
	5	.32	.06	near middle of flood plain
	7	.34	.05	near edge of flood plain
				average rate = 0.06 foot per year
2	7	.55	.08	near channel
	4	.50	.12	near middle of flood plain
	5	.25	.05	near middle of flood plain
	10	.30	.03	near edge of flood plain
	10	.45	.04	near edge of flood plain
	5	.22	.04	near edge of flood plain
				average rate = 0.06 foot per year
3	9	.52	.06	near channel
	13	.54	.04	near channel
	10	.45	.05	near middle of flood plain
	7	.30	.04	near edge of flood plain
				average rate = 0.05 foot per year
4	7	.32	.05	near channel
	5	.25	.05	near channel
	8	.51	.06	near channel
	5	.25	.05	near middle of flood plain
	5	.33	.07	near middle of flood plain
	16	.66	.04	near edge of flood plain
				average rate = 0.05 foot per year
5	8	.31	.04	near channel
	11	.30	.03	near channel
	9	.40	.04	near middle of flood plain
	11	.46	.04	near middle of flood plain
	13	.35	.03	near edge of flood plain
				average rate = 0.04 foot per year
6	7	.40	.06	near channel
	10	.80	.08	near channel
	9	.18	.02	near middle of flood plain
	7	.25	.04	near middle of flood plain
	9	.30	.03	near edge of flood plain
	11	.44	.04	near edge of flood plain
				average rate = 0.04 foot per year
7	12	.50	.04	near channel
	5	.25	.05	near channel
	12	.30	.02	near middle of flood plain
	10	.22	.02	near middle of flood plain
				average rate = 0.03 foot per year

During flooding of Grove Creek, the finer sediments are winnowed out by the higher velocities at the upstream sites leaving the coarser sediment behind. Because the coarser sediments require higher velocities for suspension, they are deposited close to the main channel when lower velocity, overbank flows occur. At the downstream sites, only the finer sediments remain in suspension, even at low velocities, and are spread more or less uniformly over the flood plain.

The accretion rates estimated from the dendrologic data are probably higher than the actual rate of accumulation. This is due to the fact that the first roots encountered were generally under the first leaf layer, and when flooded, the organic materials expand or are buoyed. Therefore, the accretion rates should be considered a maximum estimate (Andrew Simon, U.S. Geological Survey, written commun., 1987).

Radioisotopic Analysis

Several radioisotopic methods have been used successfully to date sediment and determine rates of deposition under almost undisturbed conditions, such as in lakes and reservoirs (Martin and Rice, 1981). Both vertical distribution profiles and the initial appearance of certain radioisotopes at different depths can be used as a means of establishing sediment chronology. The relative age of deposited sediments at depths and locations across the flood plain may show a correlation with the development of human activities and the possible expansion of swampy conditions due to sediment accretion.

Sediments deposited in the stream channel are subject to scour, redeposition, and possible intermixing of recent and older sediments and thus may not be readily dated. As reported by Stamey (1985), channel sediment radioisotopic analyses for Grove Creek show that only the top 6 to 8 inches of these sediments may be reliably dated with respect to post-1952 atomic test radioisotopes. In contrast, sediment deposits on the flood plain are less likely to be intermixed and might, therefore, yield more reliable accumulation rates.

A total of 10 flood-plain sediment cores were collected and analyzed for lead-210, radium-226, and cesium-137. Sediment cores were collected across the flood plain at sites 2 through 5 to sample lateral accretion variability. Cores were collected near the channel and approximately midway between the channel and the edge of the flood plain; at two sites, cores were taken also near the edge of the flood plain. The sediment core lengths ranged from 1.8 to 3.6 ft.

The flood-plain sediment cores contained cesium-137, lead-210, and radium-226. The cesium-137 data indicate that, for all sites sampled, there were no detectable levels of the radioisotope below a depth of 10 inches. This indicates that the sediments down to that depth were deposited after 1952 and corresponds to a sedimentation rate of about 0.024 ft/yr for the period 1952-87. This is considered a maximum accretion rate because it is the maximum depth at which cesium-137 is present. Data from the lead-210 and radium-226 analyses were used to determine average sediment-accretion rates at the various sites, as described earlier. This method of analysis is considered reliable in dating sediments up to around 100 to 150 years old (Yang and Ambats, 1981).

Results of the excess lead-210 computations at sites 2, 3, 4, and 5 show the same accretion patterns across the flood plain as did the dendrologic data, although calculated rates of accretion were less. Average accretion rates were within a small range from 0.025 ft/yr at sites 3 and 5 to 0.03 ft/yr at site 2. The minimum and maximum rates of 0.02 and 0.04 ft/yr, respectively, also occurred at these same sites (table 5). Results also indicate an average rate of accretion at all sites of about 0.026 ft/yr.

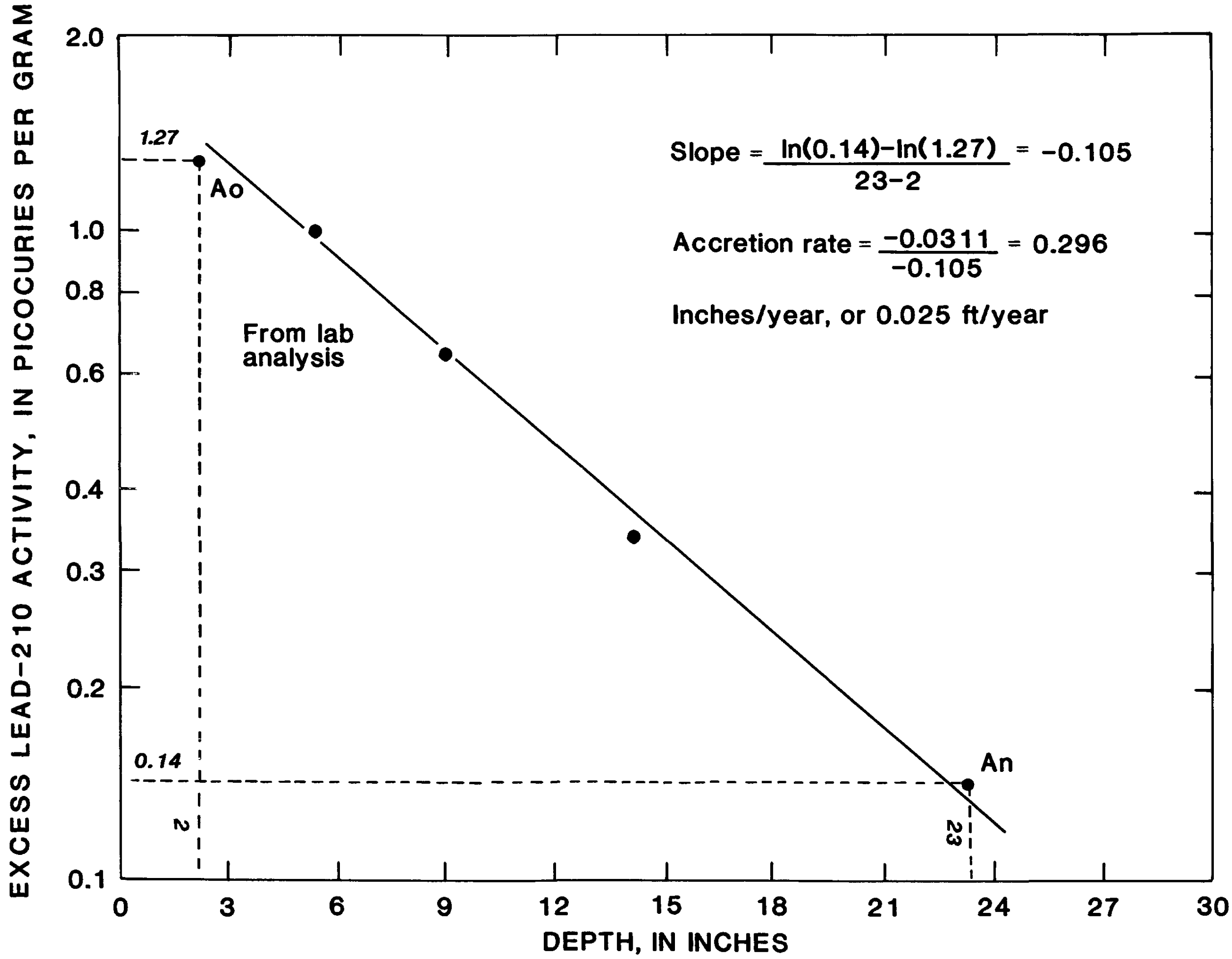
Average sediment-accretion rates were computed and are independent of any compaction effects and are the most useful in evaluating the type of environment at Grove Creek (Robbins and Edgington, 1975). Average sediment-accretion rates are determined by plotting the normal log of excess lead-210 activities in cored samples against the sample depth. Where a linear relation was exhibited, a least-squares linear regression line was calculated for the normal log of excess lead-210 versus depth, and the slope of the line was determined. Using the slope of the line with the radioactive decay equation as described by Robbins and Edgington (1975), an average accretion rate was determined for each flood-plain sediment core collected. An example of one determination at site 2 is shown in figure 10.

Table 5.--*Sediment-accretion rates for the Grove Creek flood plain based on lead-210 and radium-226 data*

Site number (figure 1)	Depth sampled (inches)	Sediment-accretion rate (feet per year)	Remarks
2	22	0.025	near channel
	36	.040	near middle of flood plain
	24	.025	near edge of flood plain
			average rate = 0.030 foot per year
3	26	.030	near channel
	18	.020	near middle of flood plain
			average rate = 0.025 foot per year
4	24	.030	near channel
	24	.024	near middle of flood plain
	24	.025	near edge of flood plain
			average rate = 0.026 foot per year
5	22	.030	near channel
	20	.020	near middle of flood plain
			average rate = 0.025 foot per year

These accretion rates are considered accurate only to depths of about 2 ft, below which lead-210 reaches background levels. Using the average rate of accretion for all sites, the maximum age of the sediment would be about 80 years at a depth of 2 ft, having been deposited around 1910. Note that the depth of 2 ft is the limit of the lead-210 methodology and does not imply this is the oldest or maximum thickness of sediment on the flood plain.

The average sedimentation rates derived from the lead-210 and cesium-137 analyses agree quite well at all sites. Accretion rates obtained from the lead-210 analyses are compared to those from the cesium-137 analyses in table 6 and show a high degree of correlation.



EXPLANATION

$$\text{Slope} = \frac{\ln(An) - \ln(Ao)}{h}, \text{ where :}$$

ln = standard notation for base e logs;

An = excess lead-210 activity at average depth of lowermost core sample, in picocuries per gram;

Ao = excess lead-210 activity at average depth of uppermost core sample, in picocuries per gram; and

h = difference in average sample depths, in inches.

$$\text{Accretion rate} = \frac{C}{\text{slope}}, \text{ where :}$$

C = decay constant for lead-210 = -0.0311 years

Figure 10.--Example of radioisotope method used to determine sediment-accretion rates.

Table 6.--*Average sediment-accretion rates for the Grove Creek flood plain based on lead-210 and cesium-137 data*

[(dpm/cm^2)/yr, disintegrations per minute per square centimeter per year]

Site number (figure 1)	Average sediment-accretion rate from lead-210 data (feet per year)	Average sediment-accretion rate from cesium-137 data (feet per year)	Correlation coefficient for lead-210 sediment-accretion rate regression	Correlation coefficient for cesium-137 sediment-accretion rate regression	Average annual excess lead-210 flux [(dpm/cm^2)/yr][1/]
2	0.030	0.027	0.98	0.99	2.4
3	.025	.024	.97	.99	2.1
4	.026	.023	.98	.99	2
5	.025	.022	.96	.98	2

[1/] Lead-210 flux, in disintegrations per minute per square centimeter per year, is calculated from extrapolation of the regression line to the sediment surface for each core.

To determine and verify if the lead-210 sediments that are carried in the stream are the primary source of deposition on the flood plain, the average annual lead-210 flux was computed as follows. The average annual atmospheric flux of lead-210 was obtained by multiplying the sedimentation rate and activity of lead-210 at the sediment core surface. The surface activity level was determined from the regression line for each core. Results indicate that the flux of lead-210 at each site is nearly equal, but does vary slightly, with the measured atmospheric deposition rate of approximately 2.22 disintegrations per minute per square centimeter per year [(dpm/cm^2)/yr] (Martin and Rice, 1981) (table 6). Therefore, it is assumed that the atmospheric fallout of lead-210 is physically incorporated with the stream-carried sediments containing negligible lead-210 and that these stream-carried sediments are deposited on the flood plain during inundation events (Schroeder, 1985).

SUMMARY AND CONCLUSIONS

This report describes the results of the hydrologic, dendrologic, and radioisotopic analyses used in the evaluation of sediment transport and sediment-accretion rates along Grove Creek. The overall results of these analyses indicate that the determined accretion rates probably have been constant since the turn of the century, at least, when a lot of land clearing for roads and farms was being done. However, no precise dating of sediment layers could be done on the cores collected to indicate a direct correlation with human activities or natural events with the methodology used in the study. The average sediment-accretion rates should remain about the same as long as other interrelated conditions, such as the stream channel(s), farming practices, weather patterns, etc., remain the same.

The hydrologic data indicated two inundation frequencies within the Grove Creek flood plain. For the typical swampy reaches below site 5, inundation occurs 35 percent of the time, whereas upstream reaches are inundated only about 15 percent of the time. For the period from October 1982 through September 1987, overbank flows occurred 82 times at site 4 and lasted a total of 632 days with a maximum duration of 3 months.

Species-diversity data for trees in the study reach indicate a distinct pattern in distribution of tree species among collection sites that can be related to the two inundation frequencies. Bald cypress, which are water tolerant and indicative of swampy conditions, were commonly seen at sites 1 to 5, where inundation occurs 35 percent of the time. Bald cypress were not observed at sites 6 and 7. Most of the bald cypress at sites 3, 4, and 5 were within a 400- to 800-ft wide area on either side of the channel. Only at sites 1 and 2 were the bald cypress distributed across at least 90 percent of the flood plain, which ranges from about 2,000 to 2,500 ft wide. Indications are that swampy conditions have been existent at sites 1 through 5 across limited parts of the flood plain for at least the last 80 to 150 years. Conditions along Grove Creek at sites 6 and 7 seem to have been comparatively drier than the other sites for the last 50 to 100 years and not conducive to the growth of bald cypress.

The sediment that is transported in Grove Creek is predominately silt and clay. Suspended-sediment concentrations in Grove Creek vary with streamflow and reach maximum levels during floods. At low and medium discharges (less than 100 ft^3/s), suspended-sediment concentrations are generally less than 15 mg/L, whereas concentrations at higher discharges were observed to reach 67 mg/L. Calculated suspended-sediment loads ranged from 79 tons/yr at site 7 to 440 tons/yr at site 2.

Flow velocities are usually too low to scour and transport channel-bottom sand. The mean velocity required to transport sand is about 1 ft/s, which corresponds to a discharge of at least 104 ft^3/s. Flow-duration data at site 4 indicate that flows greater than 104 ft^3/s occur only 8 percent of the time.

The accreted sediments on the flood plains of Grove Creek are composed of silt, clay, and organic material. Sediment-accretion rates were determined from dendrologic and sediment-core data. Average accretion rates, as determined from the dendrologic data, ranged from 0.03 ft/yr at site 7 to 0.06 ft/yr at sites 1 and 2. Accretion rates were highest near the stream channel than at the edges of the flood plain at sites 6 and 7, whereas sediment-accretion rates were more uniform across the flood plain along the swampiest reaches downstream. These uniform rates of deposition of silt and clay are due to channel braiding, lower gradients and flow velocities, and the greater frequency and duration of overbank flow.

Several radioisotopic methods have been used to date sediment and determine rates of deposition under almost undisturbed conditions that may exist in the flood plain. The vertical distribution and initial appearance of detectable amounts of the different isotopes at different depths were used as a means of determining sediment-accretion rates.

Radioisotopic analyses of the flood-plain sediment cores indicated detectable amounts of cesium-137, lead-210, and radium-226. Analyses of the cesium-137 data indicate that for all sites sampled, there were no detectable amounts of post-1952 cesium-137 below a depth of 10 inches. Therefore, the maximum sediment-accretion rate associated with this depth would be about 0.024 ft/yr for the period 1952-87.

Analyses of the lead-210 and radium-226 data indicate an average accretion rate of about 0.026 ft/yr down to depths of about 2 ft. By using the average rate of deposition for all sites, the maximum age of the accreted sediment at a depth of 2 ft would be about 80 years.

To confirm that atmospheric deposition of lead-210 is incorporated in the sediment deposited in the flood plain, the average annual atmospheric flux of lead-210 was calculated. This flux at each site was nearly equal to the measured atmospheric deposition rate of 2.22 disintegrations per minute per square centimeter per year.

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