Illinois State Water Survey Division
SURFACE WATER SECTION
AT THE
UNIVERSITY OF ILLINOIS

SWS Contract Report 397

SEDIMENTATION SURVEY OF ASHLEY LAKE, WASHINGTON COUNTY, ILLINOIS

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Prepared for the City of Ashley

Champaign, Illinois
August 1986

Illinois Department of Energy and Natural Resources

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INTRODUCTION

The Illinois State Water Survey, with the cooperation of the City of Ashley, has conducted a sedimentation survey of the Ashley public water supply reservoir. The results of this survey, conducted in July 1985, are summarized in this report. These results include a comparison with the results of a 1954 sedimentation survey which was also conducted by the Water Survey.

Reservoir Location

Ashley Lake is located approximately 1 mile northeast of the city of Ashley in the southwest corner of Section 14, Township 2S., Range 1W. The watershed covers portions of Sections 10, 11, 14, 15, and 22 of the same township in Washington County. Figure 1 shows the location of the city, lake, and watershed.

The reservoir impounds an unnamed tributary to Rayse Creek in the Big Muddy River/Mississippi River drainage unit (Hydrologic Unit 07140106).

Reservoir History

The public water supply system at Ashley was initially installed in 1941. This system, with slight modifications, still served the city in 1985. Prior to 1941, water use in the city was from private well systems and two dug/drilled public wells. The public wells at Geiger Corner and the Glenn Hotel were large-diameter wells dug to 33 feet and drilled another 8 to 12 feet through a sandstone formation. Water from these wells was extremely high in dissolved solids (1800 to 2500 parts per million) and subject to bacterial pollution from several local privies.

Population data for Ashley show that the population was 629 in 1860, increased to 1035 by 1890, and declined to 680 by 1980.

The original water supply system was designed by Bledsoe and McCaslin, Engineers, of Nokomis, Illinois, and included the dam and

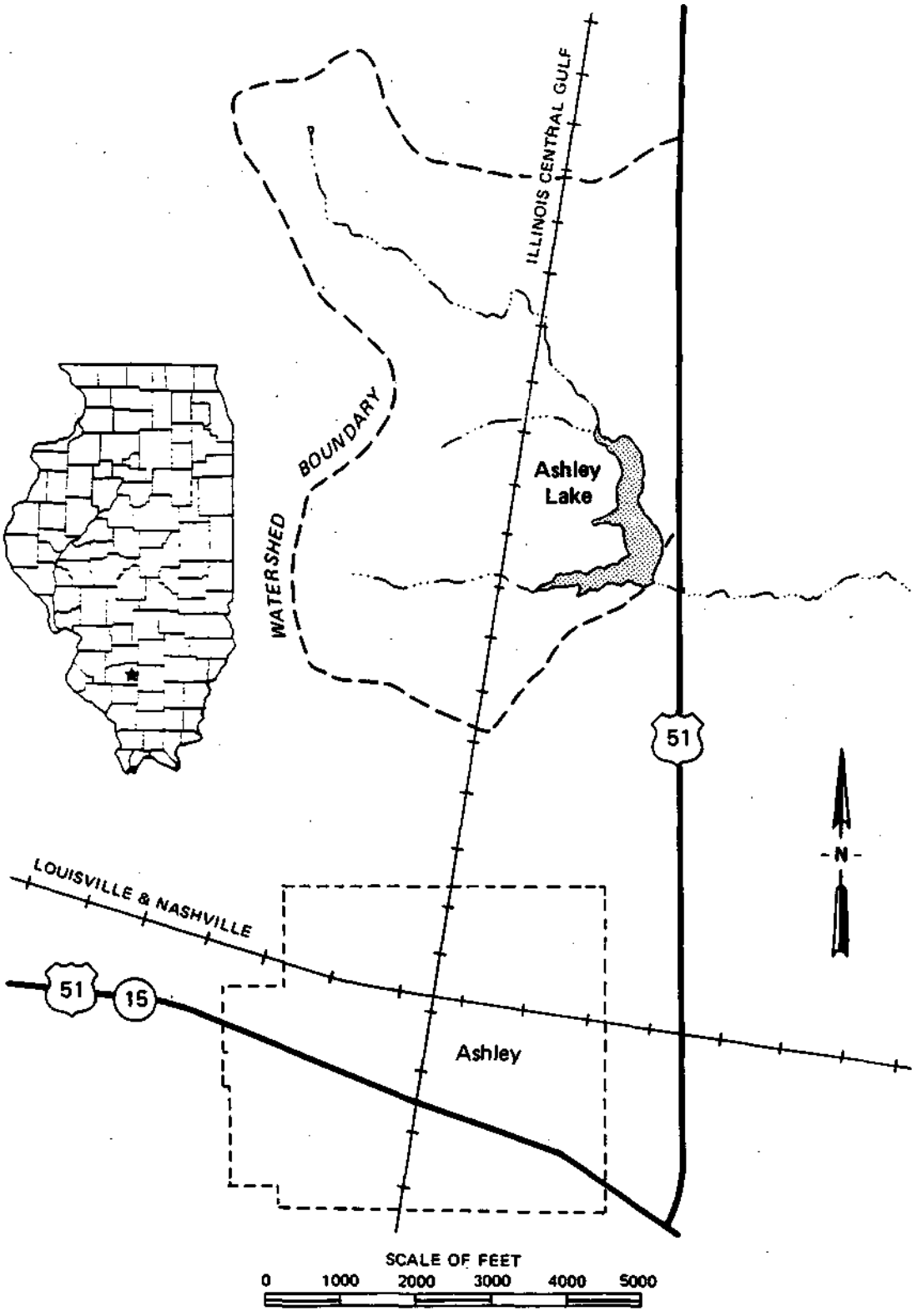

Figure 1. Ashley Lake location

reservoir, water treatment plant, and distribution system. The spillway of the dam/reservoir system was raised 1.5 feet in 1954 by the addition of a wall at the spillway crest.

A dam safety report prepared in 1980 by Mead and Hunt, Inc., consulting engineers, indicated that although the concrete spillway structure was in good condition there were indications of underseepage below the spillway. There were also indications of seepage through the dam at an area 50 feet north of the spillway. The dam safety report indicates a spillway elevation of 530 feet msl at the top of the concrete wall added in 1954.

Climate

The following climatologic summary is based on the data from the DuQuoin National Weather Service station approximately 15 miles south of Ashley.

Normal monthly temperatures range from 31.0 degrees in January to 78.2 degrees in July. Normal annual temperature is 56.1 degrees. Extremes in monthly and annual temperatures range from 9 to 16 degrees above and below the normals. Normal annual precipitation is 39.6 inches and has varied from 26.3 inches in 1953 to over 50 inches in several years. Normal snowfall is about 12 inches with annual accumulations ranging from less than 6 inches to over 25 inches. The normal number of heating degree days is 4598, while the normal number of cooling degree days is 1391 (National Oceanic and Atmospheric Administration, 1975 and 1982).

Watershed

The watershed of Ashley Lake is located in the Mt. Vernon Hill Country, Till Plains Section of the Central Lowland Physiographic Province. Land surface elevations range from 600 feet msl in the northwest corner of the watershed to 534 feet msl at the spillway. The major surficial deposits consist of 4 feet of loess. The soils in the watershed are classified as Cisne silt loam and Hoyleton silt loam and are typically poorly drained with frequent slick spots or scalds (Smith and Smith, 1937).

Land use data for this watershed are not available. However, the land use data for Washington County are probably representative of the Ashley watershed. For Washington County, acreage in field crops increased

from 171,600 acres in 1945 to 271,100 acres in 1982. In 1945, 21% of this cropland was in corn and soybeans, 63% in wheat and oats, and 16% in barley, rye, and hay. In 1982, 77% of all cropland was in corn and soybeans, 17% in wheat and oats, and 7% in hay (Illinois Cooperative Crop Reporting Service, var.). Aerial photographs taken by the Agricultural Stabilization and Conservation Service indicate that large areas of the Ashley watershed were in orchards in the late 1930s.

SEDIMENTATION SURVEYS

The 1954 sedimentation survey was conducted during an extreme drought. Water level at the time of the survey was 6.7 feet below the original spillway crest and 8.2 feet below the present (1985) spillway crest. The spillway level had been increased at the time of the 1954 survey; however, water levels had never recovered sufficiently to refill the reservoir. Horizontal control consisted of temporary range lines (figure 2) on which measurements were taped from the bank to the water's edge and open water depth readings were evenly spaced by eye. Water depth and sediment thickness were measured in open water areas only.

Two samples of the accumulated sediment were collected in 1954 and analyzed for unit weight. No samples were collected or analyzed for particle size distribution.

The 1985 survey was designed to coincide as nearly as possible with the 1954 survey. The 1954 range lines were located visually and rerun. A minor alteration in the location of R1-R2 (figure 2) resulted in an overrun of line R3-R4. Therefore R3-R4 was not resurveyed.

Horizontal control was maintained for the 1985 survey by use of a marked polyethylene cable. Range ends for the 1985 survey were marked with wooden stakes, which were later replaced by concrete markers.

The reservoir water surface was again used for vertical control, with water depth and sediment thickness measured only in the open water areas. At the time of the survey the water level was down 2.8 feet from the top of the spillway wall.

, Water depth and sediment thickness were measured by using a 2-inch-diameter aluminum sounding pole. At each vertical, a water depth measurement was made by using an 8-inch sounding shoe on the end of the pole. Sediment thickness was then measured by manually driving the pole

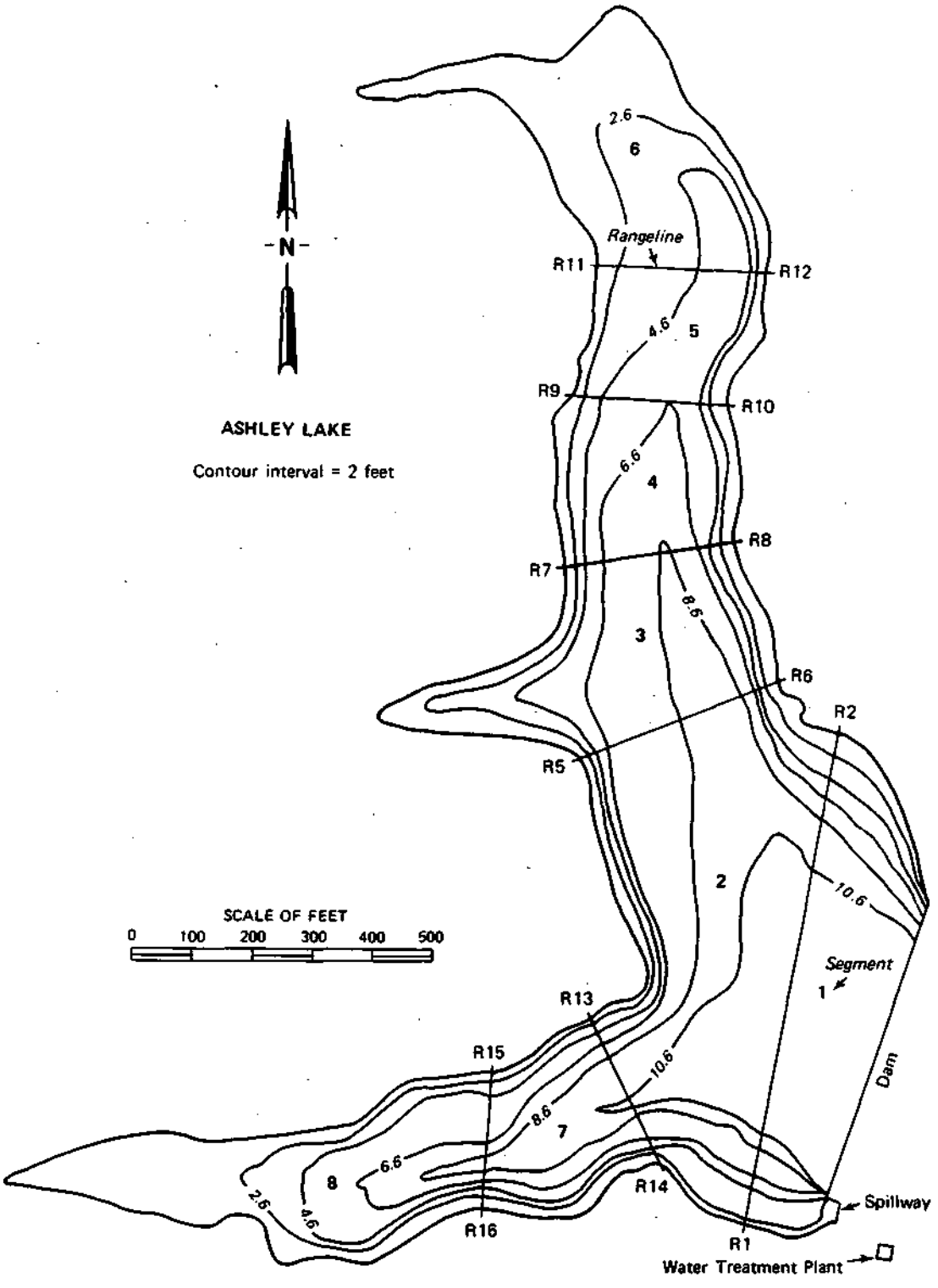

Figure 2. Ashley Lake survey plan with 1985 bathymetry

through the accumulated sediment to a point of refusal. This was presumed to be the interface between the accumulated sediments and the original or virgin soil.

Twelve samples of the accumulated sediment were collected for use in determining unit weights. An additional eight samples were collected for particle size analysis.

Volumes

Calculations of the volumes of Ashley Lake were made by using the Fortran program PRIMOID on the University of Illinois CYBER computer. All surface areas were digitized off a tracing of an aerial photograph. Cross-sectional end areas were calculated using the trapezoidal method for the 1985 survey data. The 1954 cross-sectional end areas were calculated by using the 1954 average water depth and adjusting for an 8.2-foot increase in the water surface elevation. After a preliminary analysis, an unexplained discrepancy existed between the 1954 and 1985 volumes. The volumes calculated with data from the 1954 survey resulted in significantly smaller values than would be expected. In order to account for this discrepancy, it was presumed that some error existed in the 1954 analysis due to adjustments for the spillway increase. However, these adjustments could not be substantiated by information available in 1985.

The results of both the 1954 and 1985 surveys are presented in table 1. This table shows the total volume of the reservoir at the 1985 spillway elevation. All volumes are given for a water level at the top of the spillway wall. The volume of the reservoir at this level was 174 acre-feet (56.7 million gallons) in 1940, 162 acre-feet (52.8 million gallons) in 1954, and 123 acre-feet (40.1 million gallons) in 1985.

The 1985 water depths were used to generate the bathymetric map in figure 2 and the stage versus volume curve in figure 3. The stage versus volume curve can be used to determine the volume of the reservoir for a given water stage below the spillway crest. For the example shown by a dashed line in figure 3, a water level 2 feet below spillway level indicates a reservoir volume of 88 acre-feet or 28.7 million gallons. Continued sedimentation will change the volume versus stage relationship from that in figure 3.

Table 1. Ashley Lake Volumetric Summary

Total Watershed Area 1.21 sq mi (774 acres)

Net Sediment Contributing Area (excludes reservoir area) 1.18 sq mi

	Age (years)	Lake area (acres)	Basin volume at 1985 spillway elevation (acre-feet)	(mil. gal)	Capacity to watershed ratio (ac-ft/ sq mi)	Percent of original capacity
Constructed 1940		21.6	174	56.7	147	100
Surveyed 1954	14	21.6	162	52.8	137	93
Surveyed 1985	45	21.6	123	40.1	104	71

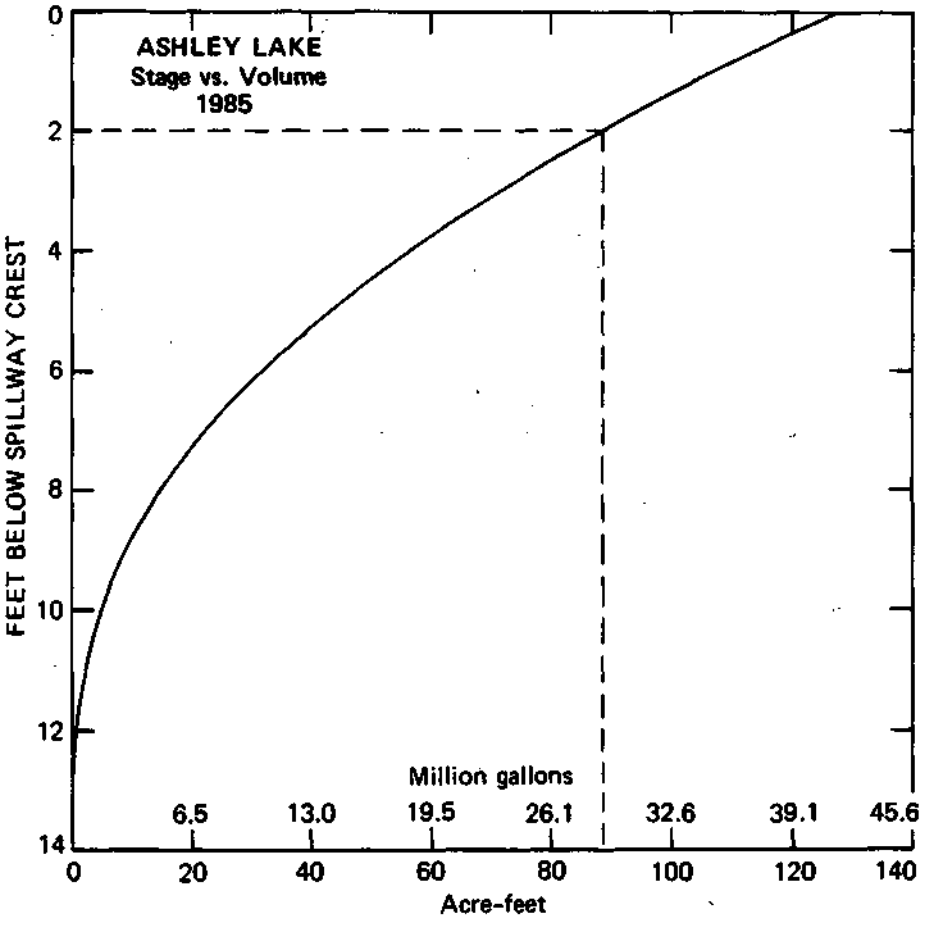

Figure 3. Stage versus volume relationship for Ashley Lake

Sedimentation Patterns

Sediment distribution patterns in a lake are mainly dependent on four factors: 1) sediment types, 2) water inflow rates to the reservoir, 3) reservoir stage, and 4) previous sedimentation patterns.

Water moving in a stream carries with it materials which have been eroded in the watershed through sheet, rill, gully, streambank, and streambed erosion. The materials carried will vary from one storm to another depending on storm intensity and field conditions such as cropping, land treatment, soil moisture, soil temperature, and soil cover.

As the stream carries the water into the relatively still waters of a reservoir, the moving water loses momentum and its sediment load is deposited. The first materials to drop from suspension are the coarse fractions (sands and gravels). These materials will drop out very quickly following entry into the reservoir. As the water moves slowly through the reservoir the smaller-size sediment fractions are released until at the dam (or outflow structure) only very fine silts and clays remain in suspension.

If the lake level is low or if previous sedimentation has reduced the flow area in the upper end of the reservoir, coarser sediments will be carried further into the lake. This will result in coarser sediment layers overlying fine sediments.

The results of the sediment particle size analysis for Ashley Lake are typical of those for lake sediments in longitudinal profile. Figure 4 shows a plot of particle size distributions of surficial sediments from the reservoir. Each sample is identified by the code for the range line on which it is located (figure 2). In figure 4, the median particle diameter at R11-R12, the inflow point on the north branch of the lake, is 0.01 mm. At R7-R8 the median diameter is 0.005 mm, and at R1-R2 the median diameter is less than 0.002 mm.

Particle size analyses from the west branch of the lake seem to indicate finer sediments from this portion of the watershed. However, these differences may reflect differences in the locations of the cross sections or some hydraulic variable.

Two sets of samples were taken to determine vertical variability in the sediments. These sample analyses are shown in figure 5 and indicate that finer sediments have been accumulating in the reservoir in recent years. These finer particle size distributions may be either short- or

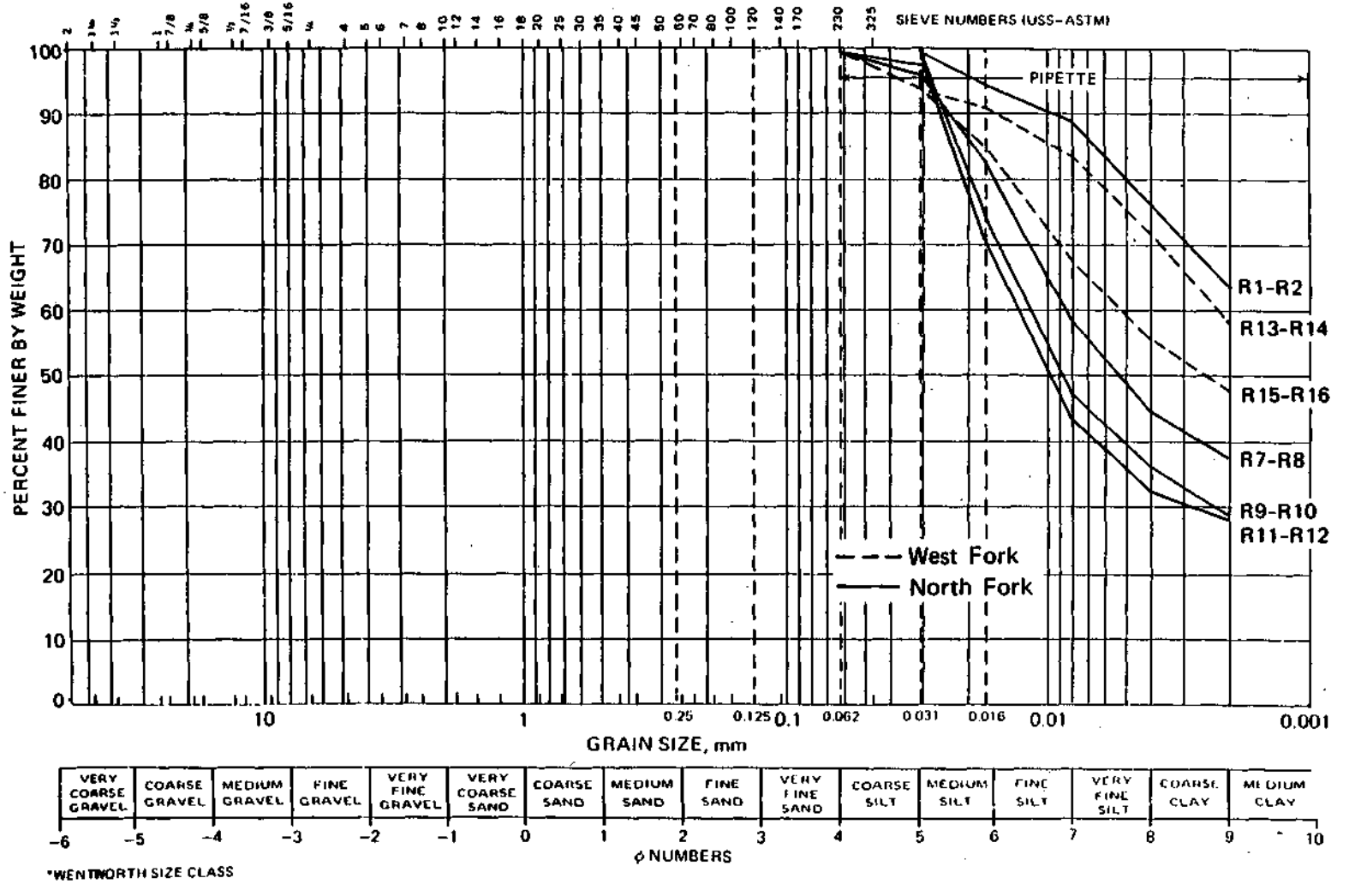

Figure 4. Particle size distribution for surficial sediments deposited in Ashley Lake

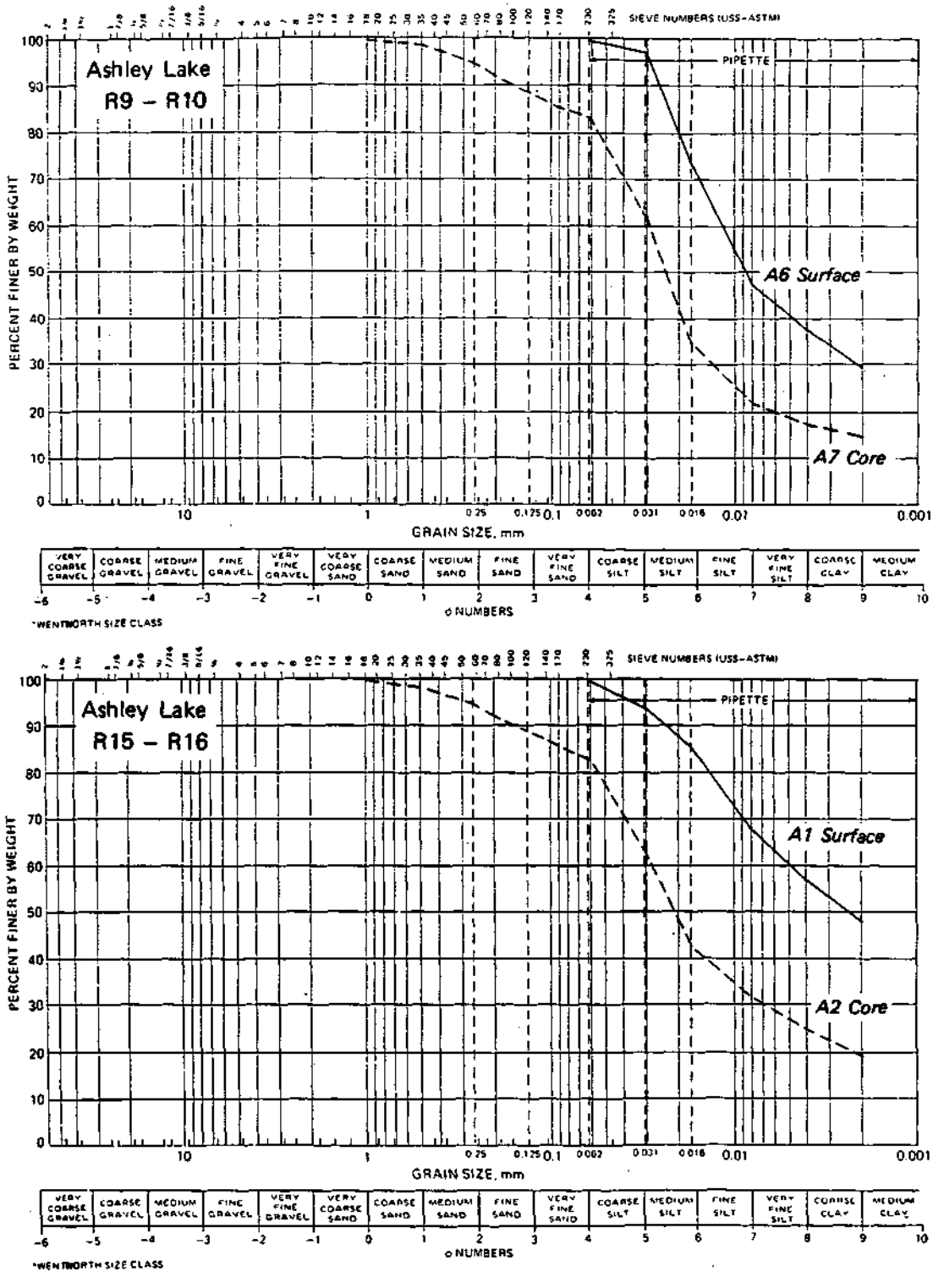

Figure 5. Vertical variability of sediment particle size in Ashley Lake

long-term phenomena. If the change in distribution is a short-term phenomenon, they would result from annual variability of stream runoff. If the phenomenon is long-term, it may represent a change in sediment inflow patterns from the watershed.

The distribution of sediment in Ashley Lake is shown in table 2. This table indicates the volume and weight of sediment which had accumulated in each of the lake segments shown in figure 2 at the time of both the 1954 and 1985 surveys. Also shown in table 2 are the average depth and weight of accumulated sediments at the time of the 1985 survey. With the exception of the shallower upstream segments, these values indicate a very even distribution of sediments throughout the reservoir due to the fine nature of the inflowing sediments.

Sedimentation Rates

This analysis of sedimentation rates at Ashley Lake will be made in terms of delivery rates from the watershed as well as accumulation rates in the reservoir. The in-lake accumulation rates provide the means of extrapolating from past and present conditions to future lake conditions for evaluating water supply integrity. The watershed delivery rates are the link between soil erosion processes in the watershed and water supply quantity and quality impacts in the reservoir. These delivery rates support continuing efforts to control soil erosion as the principal tool in preventing reservoir sedimentation.

The sedimentation rates are given for three time intervals: 1940 to 1954, 1954 to 1985, and 1940 to 1985. It should be noted that the sedimentation survey of 1954 was conducted as a reduced precision reconnaissance survey. Horizontal location was determined by eye rather than direct measurements, and the lake was not monumented for future surveys. This reduced precision may be a factor in the variability of sedimentation rates presented in this report. Therefore, the sub-period sedimentation rate should be used for comparison only. The 1940-1985 sedimentation rate should be used to extrapolate future lake conditions.

The sedimentation rates for the Ashley reservoir and watershed are presented in table 3. From 1940 to 1985 the reservoir lost an annual volume of 0.37 million gallons of capacity (1.14 acre-feet) to sediment

Table 2. Sediment Accumulation in Ashley Lake

Segment number	1954 Sediment volume (ac-ft)	1954 Sediment weight (1000 tons)	1985 Sediment volume (ac-ft)	1985 Sediment weight (1000 tons)	1985 Sediment thickness (feet)	1985 Average sediment weight (tons/ac)
1	1.54	1.40	8.30	7.54	2.86	2,600
2	2.53	2.41	15.54	14.83	2.88	2,750
3	0.64	0.72	7.55	8.47	2.60	2,920
4	0.99	1.20	4.11	4.98	2.42	2,930
5	1.99	2.58	.3.93	5.11	2.81	3,650
6	2.44	3.18	4.62	6.02	1.65	2,150
7	0.69	0.91	3.36	4.42	2.24	2,950
8	1.14	1.87	3.75	6.12	1.25	2.040
Total	11.96	14.27	51.16	57.48	2.4	2,700

Table 3. Ashley Lake Annualized Sedimentation Rates

Time period	Volume	Weight (tons)	Percent of 1940 volume
Entire Watershed			
1940-1954	0.86 ac-ft (0.28 MG)	1020	0.49
1954-1985	1.26 ac-ft (0.41 MG)	1390	0.73
1940-1985	1.14 ac-ft (0.37 MG)	1280	0.65
Per Square Mile			
1940-1954	0.73 ac-ft	864	
1954-1985	1.07 ac-ft	1180	
1940-1985	0.97 ac-ft	1080	
Per Acre			
1940-1954	50 cu-ft	1.35	
1954-1985	73 cu-ft	1.84	
1940-1985	66 cu-ft	1.69	

accumulation. This volume of sediment would correspond to 1280 tons per year. In terms of volume, this amounts to filling a 50- x 100-foot residential lot to a depth of 10 feet every year. Over 45 years, this would amount to 450 feet of fill, the height of a 30-story building.

At a rate of 0.37 million gallons per year, the capacity of the reservoir is reduced by 1.1 million gallons every 3 years. This is the equivalent of 14 days' water supply for the city.

The sedimentation rate over the period 1954 to 1985 shows an apparent 50% increase over the 1940 to 1954 rate. This increase may reflect a number of factors, including increased trap efficiency due to the spillway level increase in 1954, an increase in soil erosion rates due to changing cropping patterns and land use, or the lower precision of the 1954 survey measurements.

Reservoir Yield Analysis

A water supply yield analysis of the reservoir was prepared on the basis of the 1985 reservoir condition as well as the 2010 condition, with the reservoir sedimentation projection based on the 1940-1985 sedimentation rate. Water use was presumed to be 80,000 gallons per day for both the present condition and the 2010 condition. Yield analysis was calculated on the basis of information given by Terstriep et al. (1982).

The results of this analysis (table 4) indicate that the reservoir is capable of sustaining a 50-year recurrence interval drought presuming maximum storage (top of spillway wall) and negligible seepage. Net yield in 2010 under the same conditions would also meet current consumption demands but would be borderline.

However, there are strong indications that the present condition of the dam and reservoir is *not* one of negligible seepage. The reservoir generally does not hold water within its upper 2 feet. The yield analysis in table 4 accounts for this loss. With seepage the reservoir yield is insufficient to sustain the city's current needs through a 50-year recurrence interval drought without use restrictions. Under 2010 conditions with seepage, the reservoir will most likely fail to sustain water needs even with restrictions.

This analysis provides a strong argument for making the necessary repairs to the dam and spillway to reduce seepage.

Table 4. Ashley Lake Yield for a 50-year Recurrence Interval Drought

Year	Yield without seepage (gallons per day)	Yield with seepage (gallons per day)
1985	100,000	72,000
2010	84,000	44,000

SUMMARY

Water supply for the city of Ashley in Washington County, Illinois, is taken from a 21.6-acre reservoir 1 mile northeast of the city. The dam and reservoir were constructed in 1941 and modified in 1954 to raise the spillway 1.5 feet. This report presents the results of two sedimentation surveys (1954 and 1985) conducted by the Illinois State Water Survey.

At the 1985 spillway level of 530 feet msl, the 1940 reservoir volume of 56.7 million gallons was reduced to 52.8 million gallons by 1954 and 40.1 million gallons by 1985. The overall rate of sediment accumulation (1940-1985) has been 1,280 tons per year and has resulted in a volume loss of 0.65% per year.

Sedimentation in the reservoir is fairly well distributed throughout the lake due to the fine particle sizes of the incoming sediments.

A yield analysis for both 1985 and 2010 reservoir conditions indicates that the reservoir will meet current water supply demands provided seepage rates through the dam are reduced significantly.

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