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SILTING OF THE LAKE AT AUSTIN, TEXAS

By

T. U. TAYLOR

Professor of Civil Engineering

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . : It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

SILTING OF THE LAKE AT AUSTIN, TEXAS

By T. U. Taylor

In the former calculations included in reports in regard to the silting of the lake at Austin, the distances from station to station were scaled from the best maps in existence. On account of the fact that some of the later maps did not agree with the land office maps, the writer had these distances measured by steel tape in August, 1924, from Santa Monica to the dam. The former distance by map was scaled at 13.7 miles; but by steel tape measurement this was found to be 12.525 miles. The present lake (1924) terminates this side of Santa Monica Springs, and the distances were not chained above this point. From Santa Monica Springs up, the distances are scaled from the best maps; but these distances do not affect the present lake. All of the calculations of areas and quantities in this bulletin are based on steel tape measurements.

In 1890, cross-sections of the lake formed by the Austin Dam were taken at different points, as shown in the following tabular statement, and in Figure 1. The crest of the old Austin Dam was an elevation of 60 feet above the toe or apron of the downstream face, while the overflow crest of the new dam is 9 feet lower, or at an elevation of 51 feet above the toe.

The water first flowed over the crest of the old dam in May, 1893, and there were at this time 79,537,303 cubic yards, or 49,300 acre-feet of water in the lake up to the level of the crest of the dam, and in January, 1900, there were 41,528,810 cubic yards, or 25,741 acre-feet. If these volumes are estimated in depths on a square mile base, we have in 1893 in the lake a volume of water equal to a depth of 77.03 feet, and in 1900 a depth of 40.22 feet of water and 37.01 feet of silt. This was the result from May, 1893, to January, 1900, a period of 6.75 years, on a square mile base.

The accompanying table shows the maximum and mean depths of water for 1893 and 1900, the maximum and mean

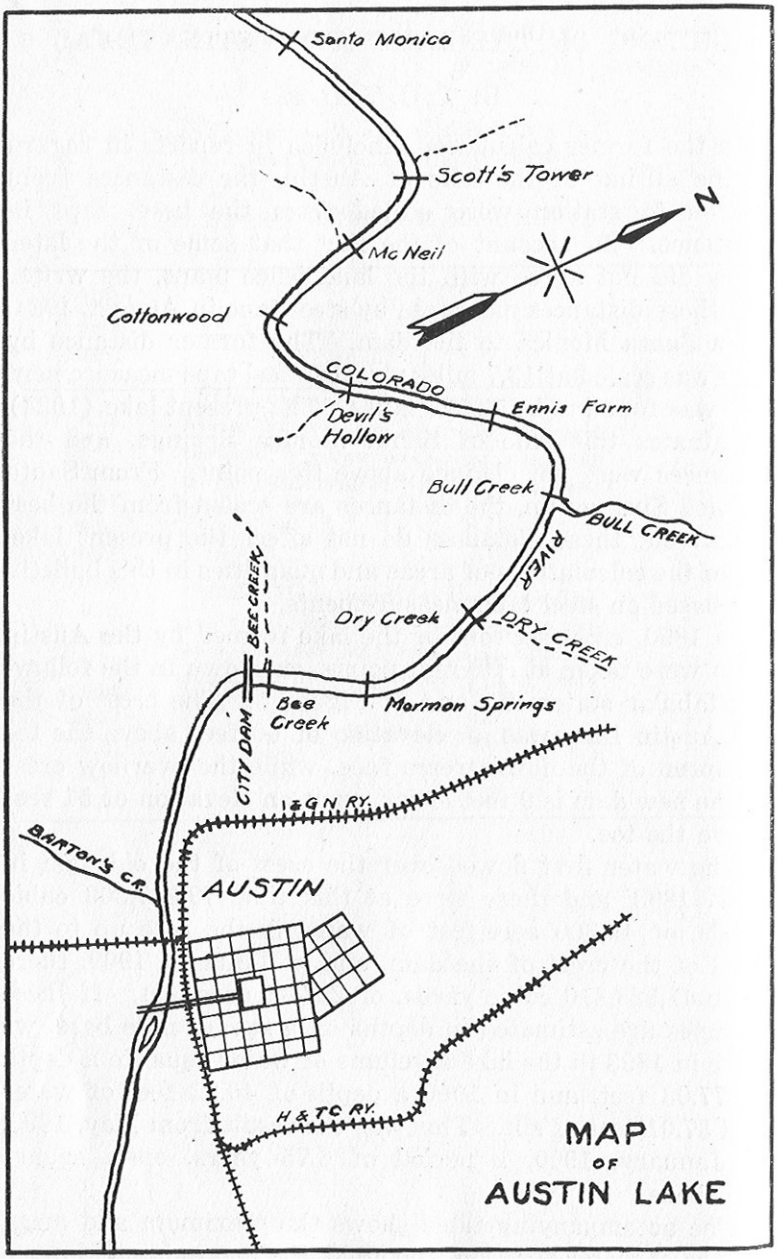

Santa Monica
Scott's Tower
N
Mc Neil
Cottonwood
COLORADO
Devil's Hollow
Ennis Farm
Bull Creek
BULL CREEK
RIVER
BEE CREEK
Dry Creek
DRY CREEK
Bee Creek
Mormon Springs
CITY DAM
I & G N RY.
BARTON'S CR.
AUSTIN
H & TC RY.
MAP
OF
AUSTIN LAKE

FIGURE 1

depths of silt for 1900, and the percentage of silting up at the respective stations:

Depths of Water and Silt in the Reservoir Formed by the Great Dam at Austin, Texas.

TABLE FOR MAXIMUM DEPTH

Station Miles from Dam	Depth of Water in feet		Silt Feet 1900
	1893	1900	
0.0	66.0	39.0	27.0
0.221	65.7	38.0	27.7
1.173	63.8	35.5	28.3
2.698	56.0	31.5	24.5
4.012	47.8	31.5	19.0
5.337	47.5	27.5	23.0
6.799	47.0	22.0	26.0
7.810	44.8	20.5	25.0
9.189	40.4	13.4	29.0
10.221	40.9	13.5	27.4
12.525	29.4	9.8	26.0
13.425	24.0	12.5	16.0
14.725	16.6	12.0	15.0
16.225	13.2	9.5	7.0
17.725	3.7	2.2	1.5

TABLE FOR MEAN DEPTH

Station Miles from Dam	Mean Depth of Water in feet		Mean Depth of Silt in feet	Amount of Filling Up
	1893	1900	1900	Pct. of Total
0.0	40.1	27.5	12.6	31.2
0.221	37.6	26.5	11.1	32.2
1.173	30.6	21.7	8.9	30.2
2.698	33.4	21.5	11.9	38.8
4.012	38.0	23.5	14.5	37.9
5.337	36.7	23.0	13.7	42.0
6.799	36.3	17.4	18.9	56.3
7.810	30.7	15.4	15.3	56.3
9.189	30.8	10.2	20.6	66.9
10.221	27.2	7.9	19.3	71.8
12.525	20.3	5.5	14.8	78.9
13.425	17.2	9.0	8.2	50.4
14.725	13.2	10.0	3.2	60.0
16.225	11.2	8.8	2.4	30.0
17.725	5.6	3.9	1.7	33.0

The maximum depth of silt is not always equal to the differences of the maximum depths of water for 1893 and 1900, as the silt has shifted at several points. This was very noticeable at Station 12.525, known as Santa Monica, or Sulphur Springs. The column of percents is the ratio that the cross-section of 1900 of silt bore to the original cross-section of water. Thus, at Santa Monica Springs (12.525), 78.9 per cent of the original cross-section had filled up in 6.75 years.

In February, 1900, there were beneath the level of the top of the old dam, 41,528,810 cubic yards (25,741 acre-feet) of water in the main channel of the lake, or 40.22 feet on a square-mile base, and 37.01 feet of silt. The 48 per cent of the original storage capacity of the lake had filled with silt in 6.75 years.

This silt, from the dam to a point within three miles of the head of the lake, was, in 1900, a fine impalpable absolutely gritless deposit. At the head of the lake, and for about three miles down the lake, the silt consisted of sand, which readily deposited when the velocity of the stream was checked by the relatively still waters of the lake. At

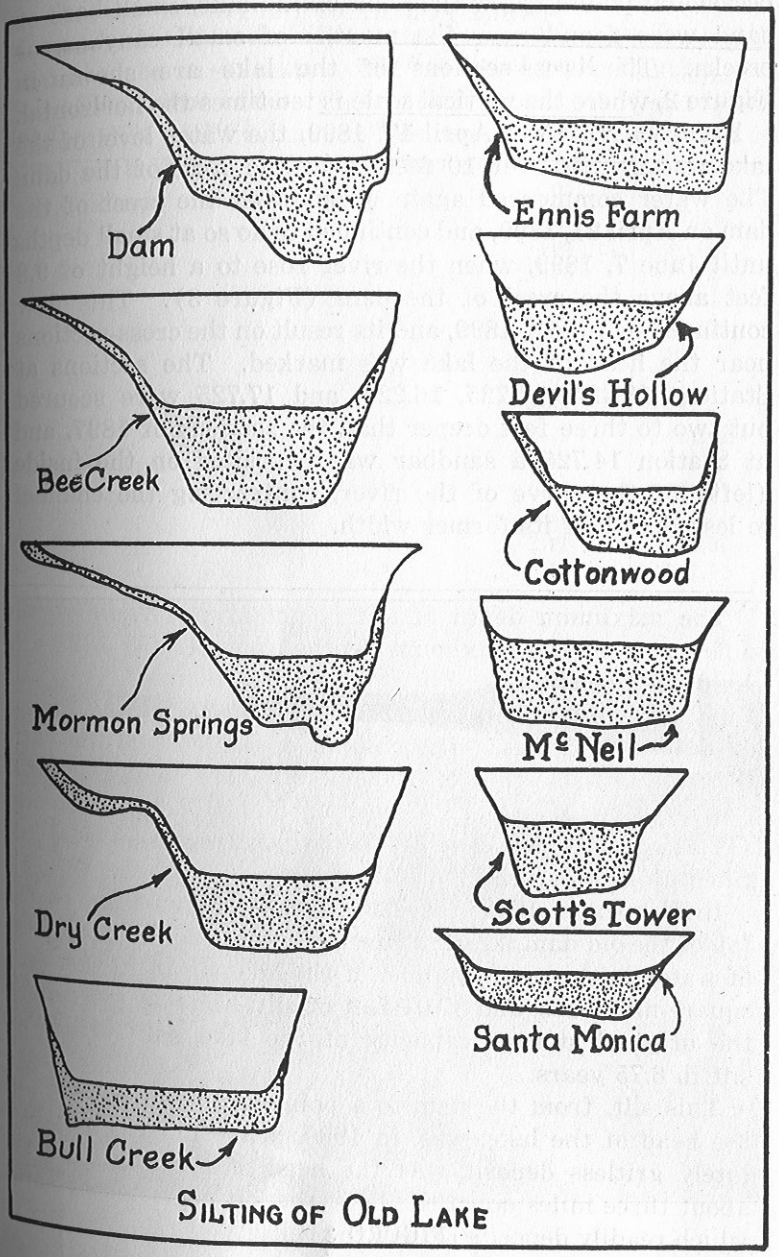

Dam
Ennis Farm
Devil's Hollow
BeeCreek
Cottonwood
Mormon Springs
McNeil
Dry Creek
Scott's Tower
Santa Monica
Bull Creek
SILTING OF OLD LAKE

FIGURE 2

occasional points below the head of the lake, small bars of sand were found near the mouths of small canyons, or creeks. The cross-sections of the lake are shown in Figure 2, where the vertical scale is ten times the horizontal.

From March 15 to April 17, 1899, the water level of the lake was a little over 10 feet below the crest of the dam. The water commenced again overflowing the crest of the dam on April 21, 1899, and continued to do so at small depths until June 7, 1899, when the river rose to a height of 9.8 feet above the crest of the dam (Figure 3). This flow continued to June 2, 1899, and its result on the cross-sections near the head of the lake was marked. The sections at Stations 13.425, 14.725, 16.225, and 17.725 were scoured out two to three feet deeper than the sections of 1897, and at Station 14.725 a sandbar was deposited on the inside (left) of the curve of the river, contracting the channel to less than half its former width.

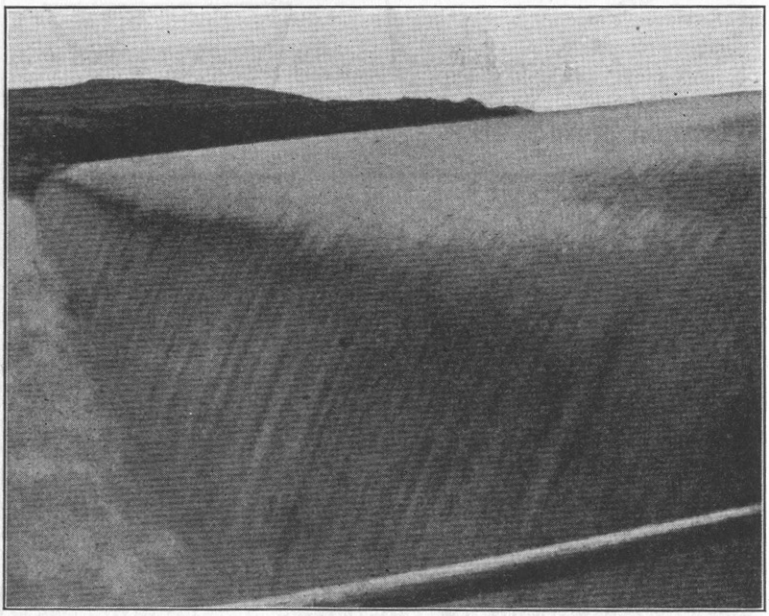


FIGURE 3

The river for 300 miles flows through a hilly country from above Colorado City on the Texas & Pacific Railroad, and absorbs in its course the waters of the Concho, the San Saba, the Llano, Pecan Bayou, and those of the Pedernales. All the country drained by these tributaries is hilly, with the exception of a few miles along the head of the Colorado and the Conchos.

THEORY OF SILTING-UP OF LAKE AUSTIN

The silting-up of reservoirs, for purposes of comparison, is best reduced to heights or depths on a square-mile base. To derive an expression for the amount of silt deposited in a given time, let x=depth (in feet) of silt deposited by each foot in height per year; h=original depth of water in reservoir. The depths of silt at end of 1, 2, 3, n years are:

1 year, silt=hx.
2 years, silt=$hx+x(h-hx)=2hx-hx^2=h(1-(1-x)^2)$
3 years, silt=$(2hx-hx^2)\ (1-x)=3hx-3hx^2+hx^3=h(1-(1-x)^3)$

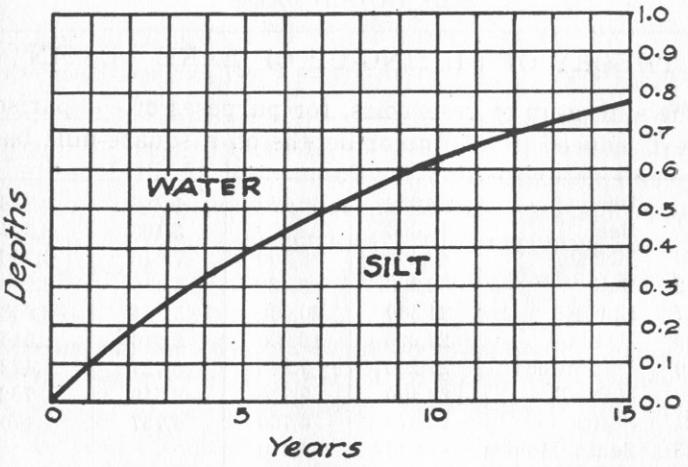
That is:
At the end of 1 year, depth of water=$h(1-x)$
At the end of 2 years, depth of water=$h(1-x)^2$
At the end of 3 years, depth of water=$h(1-x)^3$
At the end of n years, depth of water=$h(1-x)^n$

Hence if we let d=depth of water at end of n years, we have, $d=h(1-x)^n$

The following table will give the results for each year.

Year	Silt Amount	Year	Amount Silt	Year	Amount Silt	Year	Amount Silt
1	0.094	6.75	0.480	12	0.692	18	0.829
2	0.178	7	0.497	13	0.721	19	0.845
3	0.225	8	0.568	14	0.747	20	0.860
4	0.325	9	0.586	15	0.770	25	0.914
5	0.388	10	0.625	16	0.792	30	0.947
6	0.445	11	0.660	17	0.811	20	0.980

These results will not be true for any reservior in which there is an appreciable current acting on the bottom of basin; i.e., on the upper surface of the silt. In the old lake at Austin the lake level could sink to ten feet below the crest of the dam, and still have a fair current in the penstocks, as the bottom of the forebay was twelve feet below the crest of the dam. When this condition obtained, as it did during the months of March, April, and October, 1899, there was



Curve Illustrating Silting Up in Lake Austin

FIGURE 4

a current on the upper part of the lake Unless the lake was drained by the three-foot pipes at the west end of the dam, it was not possible for the current under ordinary conditions to affect the silt in the lower two-thirds of the lake. The results of the table are represented graphically in Figure 4, the "Silt Curve."

SILT IN OLD LAKE

Station	Name	Area in Square Feet		Volume of Water in Acreage Below Crest of Dam	
		1893	1900	1893	1900
0.0	Dam	48,000	33,000	1,286	878
0.221	Bee	48,000	32,500	5,100	3,504
1.173	Mormon	40,400	28,200	7,316	4,796
4.012	Bull	32,980	20,480	5,419	3,250
5.337	Ennis	34,500	20,000	5,531	2,853
6.799	Devils	27,925	12,200	3,010	1,315
7.810	Cottonwood	21,200	9,265	3,727	1,422
9.189	McNeill	23,400	7,750	2,519	782
10.221	Scotts	16,870	4,750	4,757	1,170
12.525	Santa Monica	17,200	3,630		
TOTAL				44,377	23,488
13.425		11.180	5,500	1,548	498
14.725		7,700	3,300	1,487	670
16.225		5,100	3,500	1,163	591
17.725		2,880	1,940	725	494
GRAND TOTAL				49,300	25,741

SILTING OF NEW LAKE AUSTIN

The contract for the present Austin dam was let in 1911, and the dam was partially completed by the summer of 1913. In September, 1913, the lake was filled with water up to the present spillway, which is fifty-one feet above the toe of the old dam, which was the datum usually adopted. The dam has not yet been accepted by the City of Austin, and it has been in the hands of a receiver, Guy A. Collett, since 1916. In 1918, Mr. Collett, with the consent of the Federal authorities, sold the water in the lake to the rice growers in the lower counties, for the purpose of irrigating the thousands of acres of rice on both sides of the Colorado River, and this drained the lake.

During the latter part of the summers of 1922 and 1924, the writer made measurements of the cross-section of the present lake at the old stations, and found the results as given in the table below:

CHECKED SURVEY OF LAKE AT AUSTIN, AUGUST, 1924

Station Distance From Dam in Miles	Water Areas in Square Feet Below Crest of Dam			Water Volume in Acre-Feet Below Crest of Dam		
	1913	1922	1924	1913	1922	1924
0.0	36,000	13,000	11,600	981	322	249
0.221	37,300	11,100	6,980	3,790	982	520
1.173	28,400	5,930	2,040	5,037	920	316
2.698	26,100	3,030	1,380	4,000	470	224
4.012	24,130	2,870	1,430	4,009	469	227
5.337	25,800	2,970	1,390	4,075	582	292
6.799	20,200	3,600	1,900	2,450	357	250
7.810	19,800	2,230	2,186	3,000	382	308
9.189	16,100	2,350	1,460	1,695	310	187
10.231	11,000	2,610	1,530	2,988	568	328
12.525	10,400	1,460	820			
Total volume in acre-feet				32,025	5,362	2,901

The measurements were carried no farther up the lake, for the reason that the next station above Santa Monica

was filled entirely with sand. In fact, sand was encountered about one-half mile above Santa Monica, or at thirteen miles from the dam. The table includes only the fine gritless mud.

Volume of water in 1913=32,025 acre-feet.
Volume of water in 1922= 5,362 acre-feet.
Volume of water in 1924= 2,901 acre feet.

If these volumes be reduced to the depths in feet, on a square-mile basis, we get:

Volume of water in 1913=50.05 feet on square-mile base.
Volume of water in 1922= 8.38 feet on square-mile base.
Volume of water in 1924= 4.53 feet on square-mile base.
Ratio of water volumes=$\frac{\text{Volume of 1924}}{\text{Volume of 1913}}$=.0906=9.06%

Thus in the eleven years the Austin Lake has filled 90.94 per cent of its volume in 1913. The volume of water now (1924) is less than one-tenth of the volume in 1913.

In the formula for rate of silting,

$h(1-x)^n$=depth of water after n years, we have h=50.05, and depth of water=4.53.

Hence, $52.87\ (1-x)^{11}=4.53$
Or, $(1-x)^{11}=0.0906$; Hence x=.1969.

That is, on an equal base, 19.69 per cent of silt was deposited each year on an average. Figure 5 illustrates the relative amount of silt and water in September, 1924.

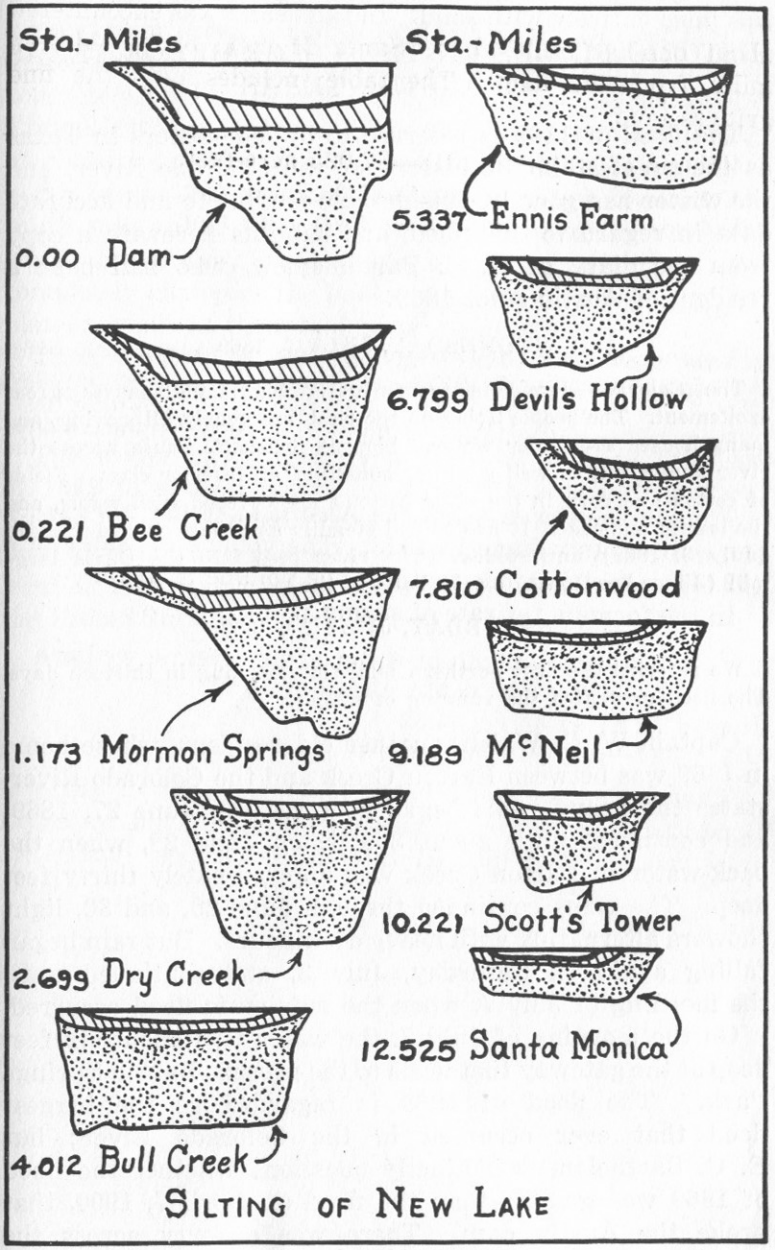

Sta.- Miles
Sta.- Miles
0.00 Dam
5.337 Ennis Farm
6.799 Devil's Hollow
0.221 Bee Creek
7.810 Cottonwood
1.173 Mormon Springs
9.189 Mc Neil
10.221 Scott's Tower
2.699 Dry Creek
12.525 Santa Monica
4.012 Bull Creek
SILTING OF NEW LAKE

FIGURE 5

HISTORIC FLOODS ON THE COLORADO OF TEXAS AT AUSTIN, TEXAS

The flood of 1869 is referred to by old settlers in Texas as the greatest in the history of the Colorado River, and the writer has gone to considerable trouble to find accurate data in regard to this flood, and submits herewith a copy from the diary of E. C. Bartholomew, who had been a resident of Austin since 1869.

WEDNESDAY, JULY 7, 1869

The Colorado River is tremendously high, and causes great excitement. The people living on the bank are nearly all moving, and many houses are under water. Monroe Swisher's house across the river floated off, as well as other houses of an inferior class. Fields of cotton and corn in the river bottoms are covered with water, and the loss is immense. It has rained steadily since last Saturday night (July 3, 1869) until today. The river rose into the Davis large mill (Zilker Ice House) on the bank of the river.

SATURDAY, JULY 17, 1869

We received the first northern mail this morning in thirteen days. The flood prevented the running of stages.

Captain W. C. Walsh, another old resident, whose home in 1869 was between Barton Creek and the Colorado River, states the heavy rains began at 4 P.M. on June 27, 1869, and continued until about 3 A.M. on June 28, when the back-water in Barton Creek was approximately thirty feet deep. The rains continued through June 29, and 30, light showers alternating with heavy downpours. But rain began falling again on Saturday, July 3, and continued until the morning of July 7, when the maximum flood occurred.

On the morning of July 7, the water was about six feet deep at the gateway that leads to the present Barton Springs Park. The flood of 1869 is regarded as the biggest flood that ever occurred in the Colorado River; but E. C. Bartholomew distinctly questions whether the flood of 1869 was greater than the flood of April 7, 1900, that broke the Austin dam. There was a ferry across the Colorado River at the foot of Congress Avenue, where the

present reinforced concrete bridge exists. Old settlers all unite in stating that there was a high bluff from the present concrete bridge to the railroad bridge of the International & Great Northern Railway. This bluff was composed largely of alluvial deposits, and was nearly as high as the present north bank. The flood of 1869 cut this high bank on the south side, cut it down, and on the morning of July 7, the whole topography on the south side of the river was completely changed; the banks had been cut down, and the plateau south of them had been eroded many feet.

Thus, the flood of 1869 and the flood of 1900 were passing through channels whose cross-sections were entirely different, and there is no basis of comparison.

The writer has traced the high-water level of the flood of 1869 to several points on the north side of the river. By the present United States Geological Survey gauge, the flood of 1869 was a gauge height of 43 feet. The high-water level of 1869 was 5.9 feet below the cement walk, opposite the United State Geological Survey gauge.

TERRIBLE FLOOD IN THE COLORADO AND BRAZOS RIVERS

(From Dallas *Herald*, July 24, 1869.)

Our exchange from the South brings us accounts of an unprecedented and most destructive flood in the Colorado and Brazos rivers, on the 8th, 9th and 10th inst. We clip the following telegrams:

LAGRANGE, July 9.—6 P.M.—There is a tremendous rise in the Colorado River, higher than the great rise in 1852. The first street toward the river is ten feet under water. The water has just reached the courthouse square. Merchants are moving their goods to the second stories. Families are moving to the farther side of the town. All the farms in the valley are submerged. The old settlers estimate the damage at $1,500,000. In the valley, several houses were seen floating down. One negro is reported drowned. The river continues rising, by actual measurement, at the rate of two feet an hour.

The line to Austin is down.

LATER.—7 P.M.—The water is now knee deep in the courthouse square.

The river is rising at the rate of one-fourth inch in two minutes.

Everybody is moving to the hill.

Captain J. W. Russell of LaGrange telegraphs his son in this city, as follows:

"LAGRANGE, July 10.—Ten feet of water on the public square. I have lost everything but life."

The alarm, Mr. Russell says, was sent about 1 P.M., and the river was then rising The public square of LaGrange is higher than mose of the river plantations on the west bank.

COLUMBUS, July 12.—The place is entirely surrounded by water. Have just heard from LaGrange by telegraph. Water ten feet on public square. T. D. C.

COLUMBUS, July 12.—The Colorado River is higher than ever before known; the water rose forty-seven feet eight inches. Colorado valley is entirely covered with water.

The damage to this county will probably reach $1,000,000. The railroad is damaged to the amount of $150,000.

(There is a mark on the Von Rosenberg store in LaGrange that shows the maximum height of the 1869 flood. This mark is 4.50 feet above the level of the sidewalk in front of the store.)

THE FLOOD OF 1870

Colorado River Flood of 1870. From the Diary of the Late E. C. Bartholomew:

MONDAY, OCTOBER 17, 1870

It rained hard all night, and when I arose this morning, the river was up nearly as high as it was one year ago last July. The water carried off the pontoon bridge, and has caused great destruction on plantations below.

The biggest floods of which we have record are those of 1869, 1870, 1899, 1900, and 1913. The discharge of these floods has been estimated, but no reliable measurements were made of any of them, except that of 1900. The flood of June, 1899, is shown in Figure 3. The old Austin dam had a rounded crest of 1,091 feet long, and we could apply the Francis Weir formula to the calculation of the discharge. The coefficient in the Francis Weir formula is 3.33, but it is a well known fact that this increases as the depth increases, and the writer is of the opinion that in the case of the Austin Dam this coefficient was nearer 4.00 than 3.33. A coefficient of 4.00 in the Francis Weir formula will give a discharge of 160,000 cubic feet per second for the flood of April 7, 1900. It is to be recalled that this flood was produced almost entirely by the rains that fell in the canyon section, between Marble Falls and Austin. The heavy rains began at 6 P.M. on April 6, 1900, and continued for about twelve hours steadily, and at 11:20 A.M. on April 7, 1900, the old Austin Dam cracked.

In 1910 and 1918, the Colorado River reached its very lowest flow of recorded history In 1910, the writer measured the flow from August 15 to September 28 at the dam, and obtained a flow of only twenty-one second-feet. In 1918, after the water had been drawn from the lake, the whole current of the river plowed a narrow furrow through the silt above the dam, and the channel was so narrow that it was easy to hop across it at one jump. At this time, the whole discharge of the Colorado River was only nine second-feet immediately above the dam. Figure 6

illustrates the width of the stream where the man in the bathing suit is astride the whole channel of the river, as it flowed along the narrow furrow that it had cut in the silt. The stream at this point was about four feet wide.

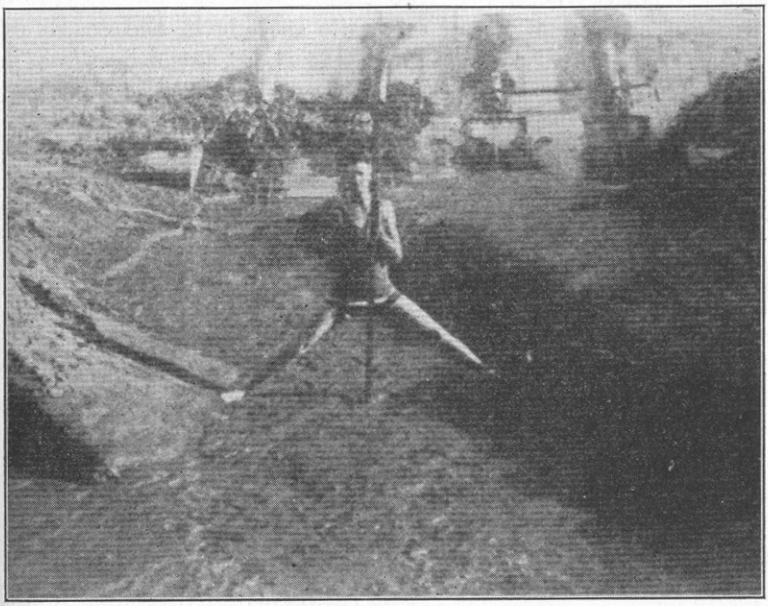


FIGURE 6

PROFILE OF LAKE BED

From Dry Creek to the dam, there is a gradual, though not regular, downward inclination of the silt surface along the max-depth axis. There are no sharp bends in the river between these two points.

At the blazed cottonwood (Station 7.810), there is a sharp bend in the river. The result is that the centrifugal force scours at this point and the depth of water is nine feet; but as the centrifugal force loses its effect opposite Devil's Hollow, or the summer home of Professor J. E. Pearce, the silt is deposited and the depth of water at this point is only five feet.