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SURVEY OF BRIDGE SITE
ON SLIDING CLAY FOUNDATION

THESIS FOR THE DEGREE OF C. E.

Louis Frank Levin

1930

THESE

Book, 2

Civil engineering

Bridges

+ roofs

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INTRODUCTION

Lines of communication, whether by water or by land have always been of more than passing interest. Of even more importance and interest is the point at which such lines of communication cross each other. For the most part these junction points of earlier days have become the cities of to-day.

The local history of Chippewa County in Michigan records that in 1621 Etienne Brule journeyed up the waters of the St. Mary's River on a mission of exploration for Champlain. A map prepared by Champlain in 1632 shows some of these settlements and indicates the Munuscong River as a tributary to the St. Mary's River.

The Munuscong River (Munuscong meaning the place of the Duck), which is the source of interest of this Thesis was thus first recorded so far as we know, and was destined to play a part in the development of this country.

Following the establishment of Fur Trading Posts at the Village now known as Sault Ste. Marie, a Mission was established by Father Marquette. In the course of time trails radiated out from the Village and one of these took the course of what is now the Prime Meridian of Michigan, more generally known as U.S.#2. This crossed the Munuscong River one mile South of the Village of Pickford, which is the center of a prosperous farming community.

First settlers to this district came by way of the Munuscong River. In 1881 a boat called the "John Auger" owned and operated by Henry Pickford was placed on a run from Sault Ste. Marie to Sterlingville just to the East of Pickford. This

boat operated until 1890 when it was replaced by the "Northern Bell", operated by William Sterling, and it ran until 1898. The "Northern Bell" drew five feet of water, which is of interest in matters to follow.

The first bridge of any sort to be placed at this point was a temporary wooden structure to enable one Barney Nettleton to cross with a threshing machine. This was in 1881, and was followed in fairly rapid succession by a wooden stringer bridge in 1883, built by a Mr. Waybrant, Approaches were added to this in 1884 by Patrick Taylor, and the whole was replaced by a new wooden structure in 1886. Apparently, this was of short duration as the first pile bridge was erected in 1888 by James Foster, and this remained in place until the first steel bridge was erected in 1905. This was an 80-foot steel Pratt truss bridge sold by the A. Y. Bayne Company, and erected by Leo Welsh, Alva Hilliar and Ford McKee.

HISTORY

This Thesis is primarily concerned with the crossing of the present State Highway U.S.#2 with the Munuscong River at a point one mile South of Pickford. As nearly as can be ascertained the first steel bridge was erected on four steel tubes which were set on piling and filled with concrete. The pile trestle which was in place was cut to allow the insertion of the bridge leaving a portion of the pile trestle at each end. It was planned to make a fill through the trestle to the bridge, but the bridge settled out of position almost at once so that a new steel Pratt truss Bridge of 144-foot span was ordered immediately. The old 80-foot truss was sold to the County and was erected on the same stream just East in the Village of Pickford, and is now in position there.

The second steel truss was erected during the Winter of 1906-07 and was placed on steel tubes as before. The bridge now on the site has evidently been set on three different series of tubes, as it is known that tubes were placed by a Bob McLean, following the original, and later a re-setting was made by a William Freegang. Piles driven as a foundation for these tubes were spliced to a known length of 65 feet at which depth they did not support the weight of the driving hammer. After setting some time, the piles appeared to gain bearing, but when driving was again started they went as easily as before. There is no record of any work being done following this time until 1917. At this time plans were in progress for the improvement of the road itself as Federal Aid Project No. 17. Plans were made in 1918 which called

for placing of new concrete abutments and raising the structure.

Under date of September 13, 1917, a "Situation & Pile Plan" was drawn by the State Highway Department calling for the bridge to be moved 14 feet to the South and the North end to be shifted back to the West 3 feet 6 inches. Under date of September 20, 1917, the Department drew a plan of false work to be used in supporting and moving the bridge, and a contract for the construction of the abutments and moving of the structure was let to Mr. Gus Anderson of Marquette, Michigan. Apparently, before this work was entirely completed, movement of the abutment on the North end began, as the Department prepared a plan of "Abutment and Wind Struts" dated August 12, 1919. The purpose of these struts being to resist the downward movement of this abutment and to maintain the distance between the two abutments. These struts have failed so that they do not perform their function, though the exact time of rupture is not known.

On June 7, 1920 the Department prepared a plan of reference points to abutments. This is the first attempt to determine the direction and magnitude of the movement. A second reference plan was begun on July 18, 1921 based on dividing the adjacent area into 25-foot squares. Only two of these points can be found to-day.

Evidently an effort was made to drain the fill behind the North Abutment as on June 14, 1920 a plan was drawn up showing tile lines and gravel back-fill. All of the foregoing references are interesting in showing what had taken place,

and the efforts that have been made to correct conditions.

On July 19, 1920, when the back-fill on the North end was largely completed, movement had taken place sufficiently to break off entirely the concrete dirt wall at the North end of the truss. Steps were taken immediately to have the back-fill removed, and this work was let to W. J. Clegg of Pickford who used the material to raise the Township road grade immediately to the West. On the 21st. of August, 1920 an Approach Plan was prepared calling for timber construction in place of the back-fill. A photograph taken on September 9, 1920, while preliminary work was under way, shows that the bridge had moved approximately 3 feet 6 inches. Another view shows that on December 2, 1920 the fill had been entirely removed and the approach structure nearly completed.

The writer first came in contact with this bridge matter as a foundation problem in 1921. Due to the repeated movements of this bridge and the buckling it had received, it was in such a weakened condition that on June 10th. the passing of a 10-ton roller caused the failure of a floor-beam hanger. Some of the views accompanying this Thesis will show clearly the buckling which has been taking place in the bridge members. In 1924 the Northeast end post was found cracked badly about midway. Evidently this had existed for some time owing to the appearance of the crack which was rusted and quite open.

A topographical survey made by A. R. Schaefer in January of 1923 cannot be checked up with the stationing of the

road survey, but it does indicate, however, that the North end of the bridge had moved East a considerable distance. At the time of the Spring flood of 1923, the entire bridge was slightly lifted by the floating ice, and the timber approach span was lifted free of the supporting piling. At the request of the State Highway Engineer, a plan was submitted on September 15, 1923 which would take care of the continuous movement of this bridge, and prevent further buckling. Briefly, the plan was to place timber sleepers running lengthwise with the approach to support the bents as they no longer rested on the piling. The pile bents will, at this writing, be found forward of their respective timber bents.

Further, roller nests were ordered and placed under the North end of the bridge. The bridge floor has consisted of one course of 2-inch transverse plank, and a top layer of 2-inch longitudinal plank. Both runs of plank were stopped at the North end of the bridge and provision made for completing the gap in the floor as bridge movement was taken up by the roller nests. For the next two seasons it was necessary to move the entire roller assembly about twice a year, as a movement of approximately 4 inches required the resetting of the entire roller nest. The yearly movement has been decreasing apparently during the last three years. Until May 27, 1927 no effort had been made to correct the downstream movement of the bridge. None of the

road survey stakes could be found, but as nearly as possible, the road centerline was determined and it was found that the North end of the bridge would need to be moved West 29 inches to bring it on centerline, and this was done.

SUBJECT MATTER

It is evident that a new bridge must be built at this site some day, and a complete knowledge, so far as is possible, of what has taken place, and what is likely to take place is essential. There can be no question but that the entire area 500 feet or more in any direction from the bridge is moving to some extent, as this is clearly shown by the farm fences.

The problem of determining this movement was divided into the determination of: Longitudinal Movement

Lateral Movement

Vertical Movement

The problem of the reason for this movement is more abstract, and is not subject to exact determination, but still there is much that can be learned.

A 'Reference' or Base line B0-B7 was first established on the East side of the bridge. Secondary reference lines were then run easterly and westerly through the above mentioned points. Also, two other lines were run parallel with the bridge and at some distance therefrom. The whole formed a four sided polygon with the base line running through the center. The internal angles were carefully recorded, and measurements were carefully taken between intermediate stakes set on each one of the lines above mentioned. Measurements taken in this manner will show whether the area movement is toward the river only, or whether it is combined with a movement downstream as well.

The Approach Plan, which is a part of this Thesis, shows a considerable movement of the bridge with reference to the abutment. There is nothing in this, however, to prove that the North side alone is to blame. In order to determine how far this was true, the road center was chained again carefully from the one-quarter section corner to the North. Chaining in this manner it was found that on February 1, 1930 the stationing of the North pin was 368 plus 94.6. The stationing of the bridge does not appear on the Federal Road plan. A ground plan prepared by D. W. Holland of the State Highway Department gave this stationing as 368-95 in 1920. but only two of his tree references could be found. One was of doubtful value, and the other showed an increased distance of $7 \frac{1}{8}$ inches since 1920. This shows a relative movement of $7 \frac{1}{8}$ inches to North of the South Abutment. This would be increased by any movement of the tree itself to the North. The distance that the North pin is from its normal position over the abutment, less $7 \frac{1}{8}$ inches would be the apparent amount of southward movement of the North Abutment. At the time contract was let for the construction of abutments, the bridge was recorded as being 3.5 feet off center line. This amount, plus the 29 inches it was set over in 1927, plus the amount it was off center line in May, 1930, constitutes the amount which the North end of the bridge has moved Eastward since 1907, or $80 \frac{1}{2}$ inches. Similarly, the movement since 1920 would be $38 \frac{1}{2}$ inches.

The stationing of the North Pins on Truss as found by chaining one-half mile from a known point is 368-95.05 and the stationing of the same point, as shown by the Holland Plan of 1920, is 368-95. The Reference Polygon plan will show an Ash tree used

as a distance tie to a nail in a plug in the S.W. Bridge wing. This distance of 95'-9-5/8" in June of 1920 had increased to 96'-4³/₄", or an increase of 7-1/8 inches. In view of this, it is evident that the chained measurement is not exact, as it must necessarily be less than it originally was in 1920. This does show, however, that there could be little if any movement of the reference tree, and therefore the South abutment has had a total movement to the North of about 7 inches.

Now consider the fact that originally the Truss pin was 3 feet back from the face of the abutment, and see by the "Approach Plan" how this distance has increased until on February 7, 1930 a total movement of 6.8 feet was shown. From this should be deducted the movement of the bridge itself to the North, which would make a net movement of slightly over 6 feet. It is significant also that in 1920 the distance from the center of the first pile bent to face of abutment, as nearly as can be scaled from the photograph, was about 17.5 feet, whereas now it is 18.8 feet, which shows that the movement of the abutment has been faster than that of the trestle. However, the fact that the distance from the South pile bent to the Truss Pin has been decreased more than the bridge has moved to the North, shows that the entire approach must have moved also. This is also borne out by inspection of the several rows of pile which originally supported the timber approach, but do so no longer because each row has moved toward the river. Those nearer the river moving a greater amount than those shoreward.

The vertical movement of these abutments is also interesting as shown by the tabulation of elevations taken on the bridge seats. The earlier records were secured from the Files of the State Highway Department. Disregarding the earlier variations in the recorded levels, it is found that the 10-year period shows a settlement of 1.13 feet in the North abutment, and an amount of 0.3 feet in the South abutment.

In conclusion, the opinion of the writer is that the South abutment is moving toward the river in a northerly and westerly direction, though the accuracy of the movement to the West is dependent upon the accuracy with which the road centerline was re-established. Measurements as taken showed the center line of the South end about a foot to the West. The North abutment has moved easterly about 38 inches in the same period of time which it moved 6 feet to the South. This movement, it will be noted, is also directly toward the river. Changes, as recorded by reading taken last Fall, and this Spring, will be found on the "Reference Polygon Plan". These will be small as it is known through ten years of association with this bridge that the movement takes place sometime between May and July after which there is little, if any, movement until the next year. The greater part of the proof for this lies in the fact that at that time the adjustment of the roller nests needs careful watching.

In regard to the nature of the material upon which the bridge is placed, it can be stated that it is a heavy reddish blue clay. Efforts were made to sound the material with a

common auger, using a four foot handle. Additional lengths of four feet each had been prepared, and arrangements were made overhead to assist in withdrawing the auger when full. The attempt was considered a failure, in so far as boring was concerned, as in a few minutes a 16-foot length could be pushed down all of the way, and when withdrawn, the hole closed immediately. This was tried under the bridge, and also about midway of the approach to the North.

A sample of this clay was sent to the Soils Testing Laboratory of the Bureau of Public Roads, and the results are published herewith. The writer's opinion of the reason for the unusual action of this bridge area is the fact that this clay is easily washed, and this, combined with the strong flow of the river in the Spring, scours out the river bed allowing the sides to slide in. There is evidence of this sliding in the clay island pushed upon the middle of the stream as shown in the photographs, which are a part of this Thesis.

As noted by the introduction, this river was once considered navigable, but it is far from being that now.

Grateful acknowledgment for suggestions and help is made to Professor C. A. Allen of the Michigan State College, Professor L. J. Rothgery, Field Engineer of the Engineering Experiment Station, and Mr. C. A. Melick, Bridge Engineer of the Michigan State Highway Department.

Below will be found the report of the Subgrade soil tests as given by the U. S. Bureau of Public Roads under date of March 19, 1930.

Physical characteristics of material passing the 0.5 sieve.

Sample No.	: Lower:	Plas-:	:Moisture equivalent:		:
B.P.R.:	State:	liquid:	ticity:	Shrinkage	:Centri- : Field :
:	:	limit:	index:	Limit:	Ratio: fuge : :Group:
5210	:	67	39	21	1.7 : 90* : 44 : A-7 :

Remarks:- * Sample waterlogged.

Mechanical Analysis*

Sample No.	:Percent of particles having diameters smaller than :
B.P.R.:	State:2 mm.:0.5 mm.:0.25 mm.:0.05 mm.:0.005 mm.:0.001 mm. :
5210	: 99 : 96 : 93 : 80 : 38 : 15 :

* Particles above 0.10 mm. in diameter by sieve method; particles below 0.10 mm. in diameter by hydrometer method.

Tabulation of Check Levels on Abutments.

Date	Elevation of Bridge Seats			
	NE	NW	SE	SW
8-13-20	493.47	493.46	494.01	493.99
8-30-20	493.42	493.42	494.02	494.02
9-9-20	493.42	493.42	492.02	494.02
9-16-20	493.40	493.40	493.99	493.99
9-24-20	493.37	493.37	494.01	493.99
9-30-20	493.39	493.40	494.02	494.02
10-4-20	493.43	493.45	494.06	494.06
10-13-20	493.46	493.48	494.13	494.13
10-20-20	493.45	493.47	494.15	494.14
10-28-20	493.46	493.46	494.15	494.14
11-3-20	493.42	493.42	494.06	494.06
11-9-20	493.42	493.42	494.07	494.07
11-17-20	493.41	493.42	494.06	494.05
11-22-20	493.39	493.41	494.11	494.10
11-30-20	493.40	493.41	494.08	494.08
4-21-21	493.23	493.23	493.98	493.96
7-18-21	493.29	493.33	494.05	494.02
8-6-21	493.29	493.33	494.05	494.02
11-15-21	493.33	493.38	494.08	494.05
10-6-21	493.33	493.38	494.08	494.05
11-8-29	492.42		493.74	
5-5-30	492.34	492.31	493.71	493.65

Levels from Reference or Base Line Plan

Station	Fall of 1929		Spring of 1930	
	Stake	Ground	Stake	Ground
A-0	500.835	499.98	500.954	500.07
A-1	490.096	488.75	490.234	488.90
A-2	488.707	487.94	488.730	487.99
A-3	488.567	487.23	488.609	487.21
A-4	494.338	493.033	494.328	492.95
A-5	497.827	496.633	497.801	496.41
B-0	505.489	503.34	505.350	503.40
B-1	487.628	487.12	487.650	487.06
B-2	485.957	485.39	485.963	485.24
B-3	484.687	484.28	484.768	484.29
B-4	485.590	484.64	485.533	484.57
B-5	485.347	484.14	485.295	484.10
B-6	487.354	485.71	487.307	485.61
B-7	501.380		501.380	
C-0	507.954	507.26	508.034	507.28
C-1	490.10	489.13	489.922	489.08
C-2	485.995	485.13	485.949	484.99
C-3	484.452	483.40	484.190	483.46
C-4	491.403	489.34	491.424	489.38
C-5	494.830	493.55	495.010	493.60
NE. Abut.	492.418		492.344	
NW. Abut.	492.45		492.313	
N. Floor	497.193		497.157	
SE. Abut.	493.743		493.708	
SW. Abut.	493.67		493.654	
S. Floor	497.893		497.839	
NE Tube	489.363		489.322	



This view shows the fill practically completed, and movement has already begun. Note that back-wall is already broken.



This view shows cribbing in place for new support to bridge contemplating removal of fill, and building of timber approach. 6'-5" face of abutment to pin. About 3'-6" net movement.



This view shows fill removed and approach partly completed.



This view shows buckled lower chord, and has been repeated many times.



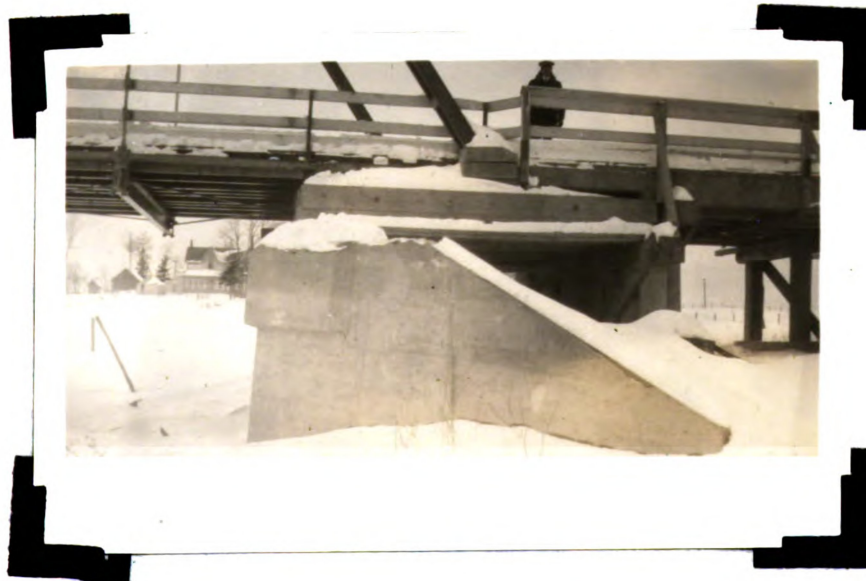
General view of Bridge and Approach



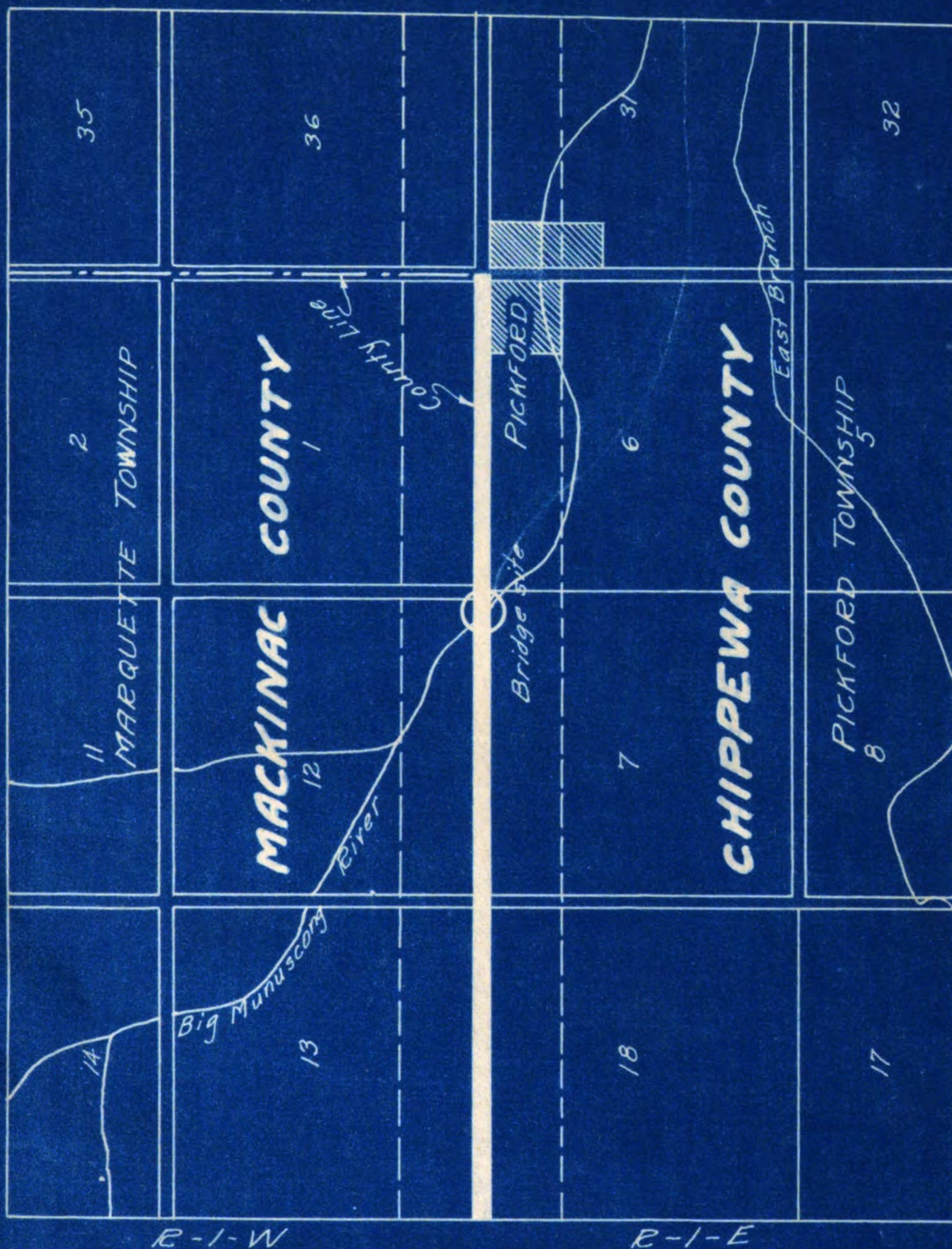
This view shows river bottom raised apparently by side hill pressure.



This view shows lateral movement which has taken place in North Abutment.

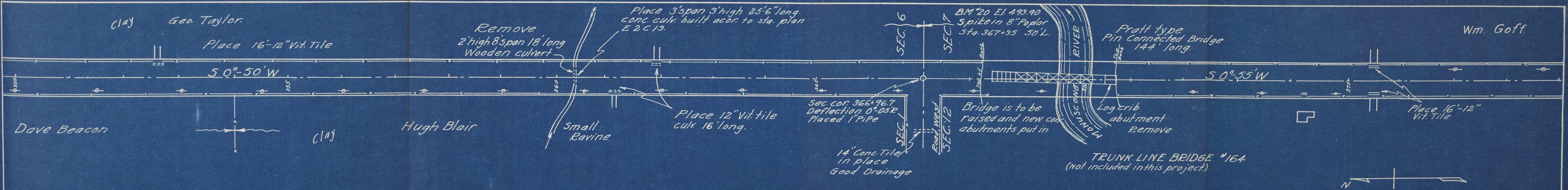


This view shows longitudinal movement in North Abutment.

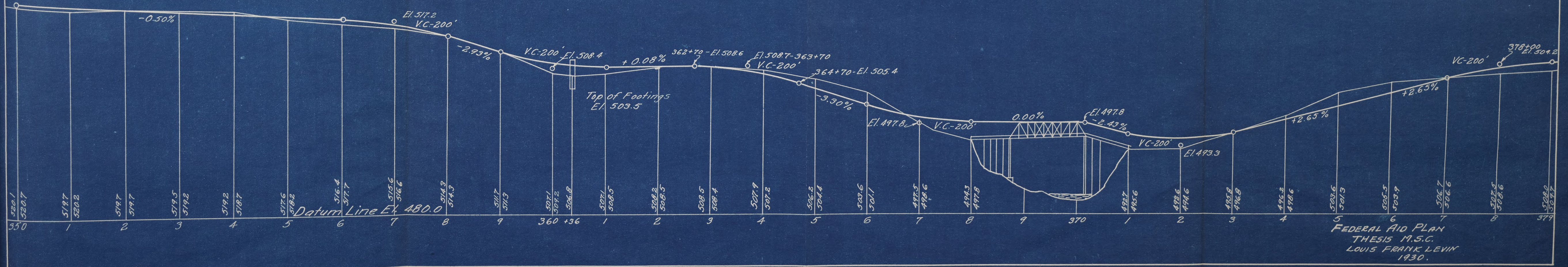


FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
7	MICH	17	1918	1	24

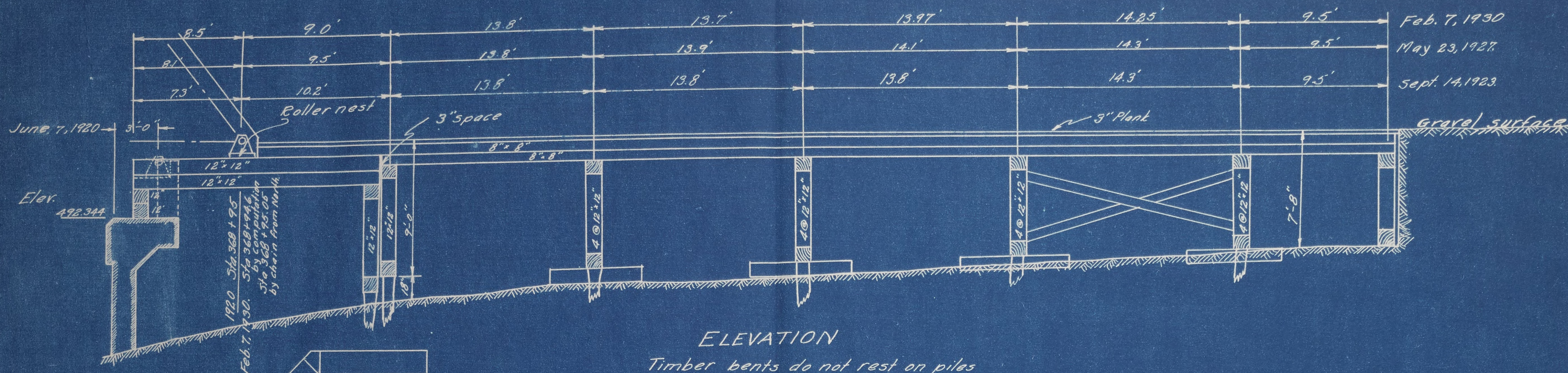
Location Map
 THESIS M.S.C.
 Survey of Bridge Site
 On Sliding Clay Foundation
 LOUIS FRANK LEVIN
 1930



FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
7	MICH	17	1918 1919	58.6	24



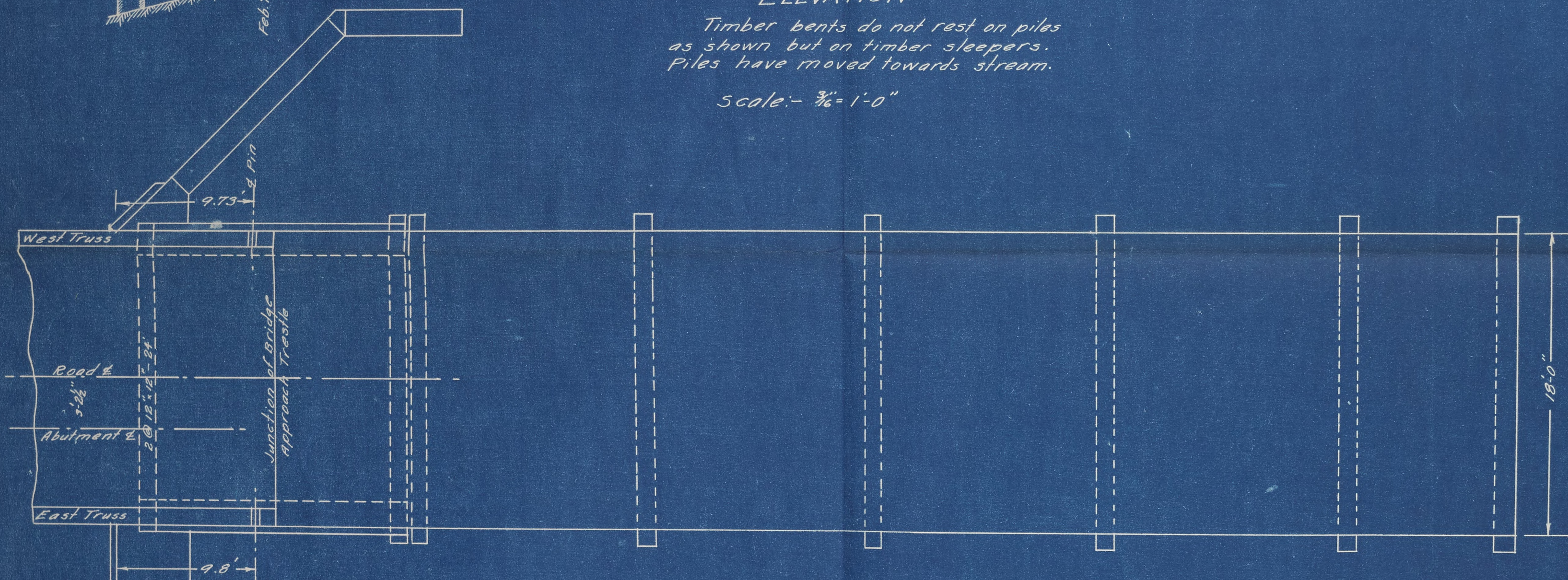
FEDERAL AID PLAN
 THESIS M.S.C.
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ELEVATION

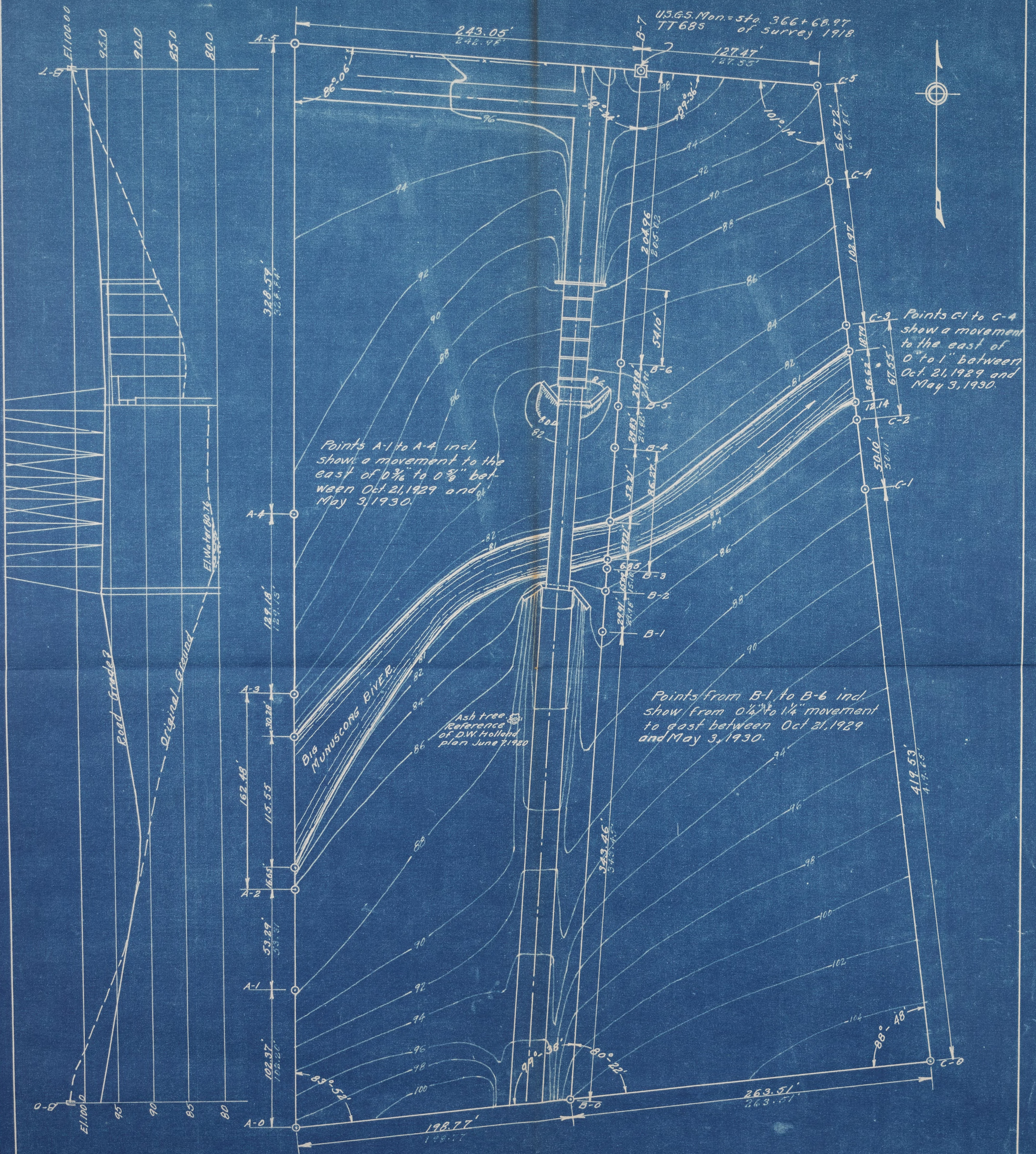
Timber bents do not rest on piles
 as shown but on timber sleepers.
 Piles have moved towards stream.

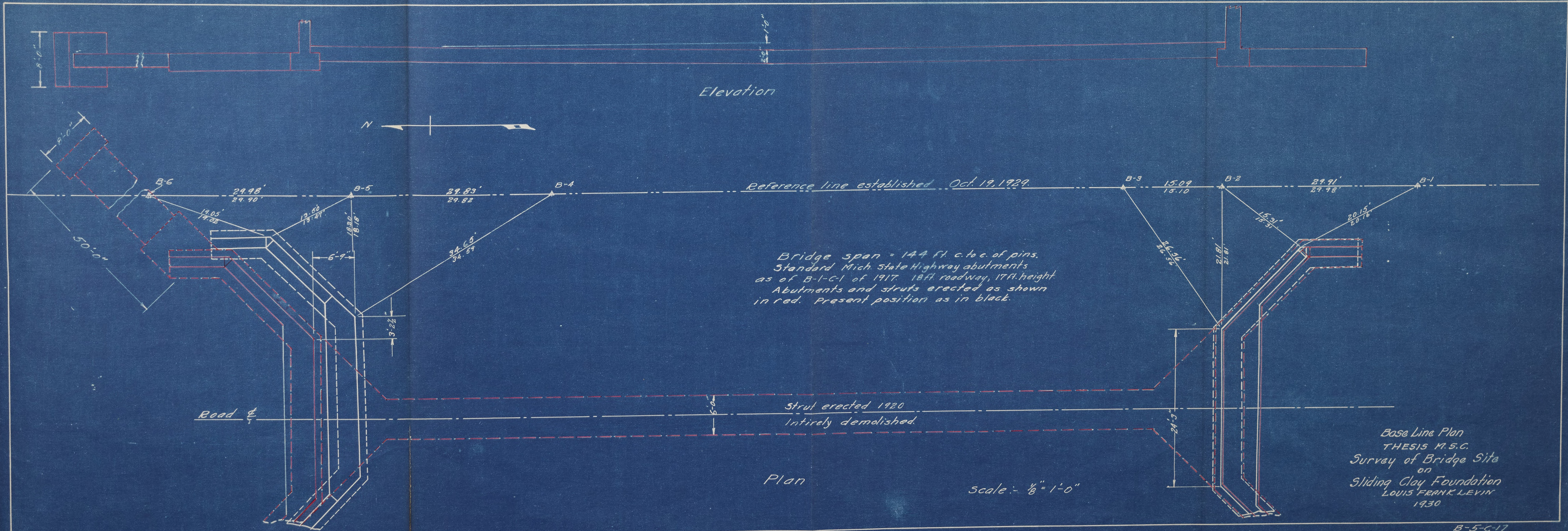
Scale: $\frac{3}{16}$ " = 1'-0"



PLAN

Approach Plan
 THESIS M.S.C.
 Survey of Bridge Site
 on
 Sliding Clay Foundation
 LOUIS FRANK LEVIN
 1930





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