INTERSTATE COMMERCE COMMISSION

REPORT OF THE DIRECTOR OF THE BUREAU OF SAFETY CONCERNING AN ACCIDENT ON THE PENNSYLVANIA RAILROAD NEAR WASHINGTON, D. C., ON AUGUST 24, 1933.

November 8, 1933.

To the Commission:

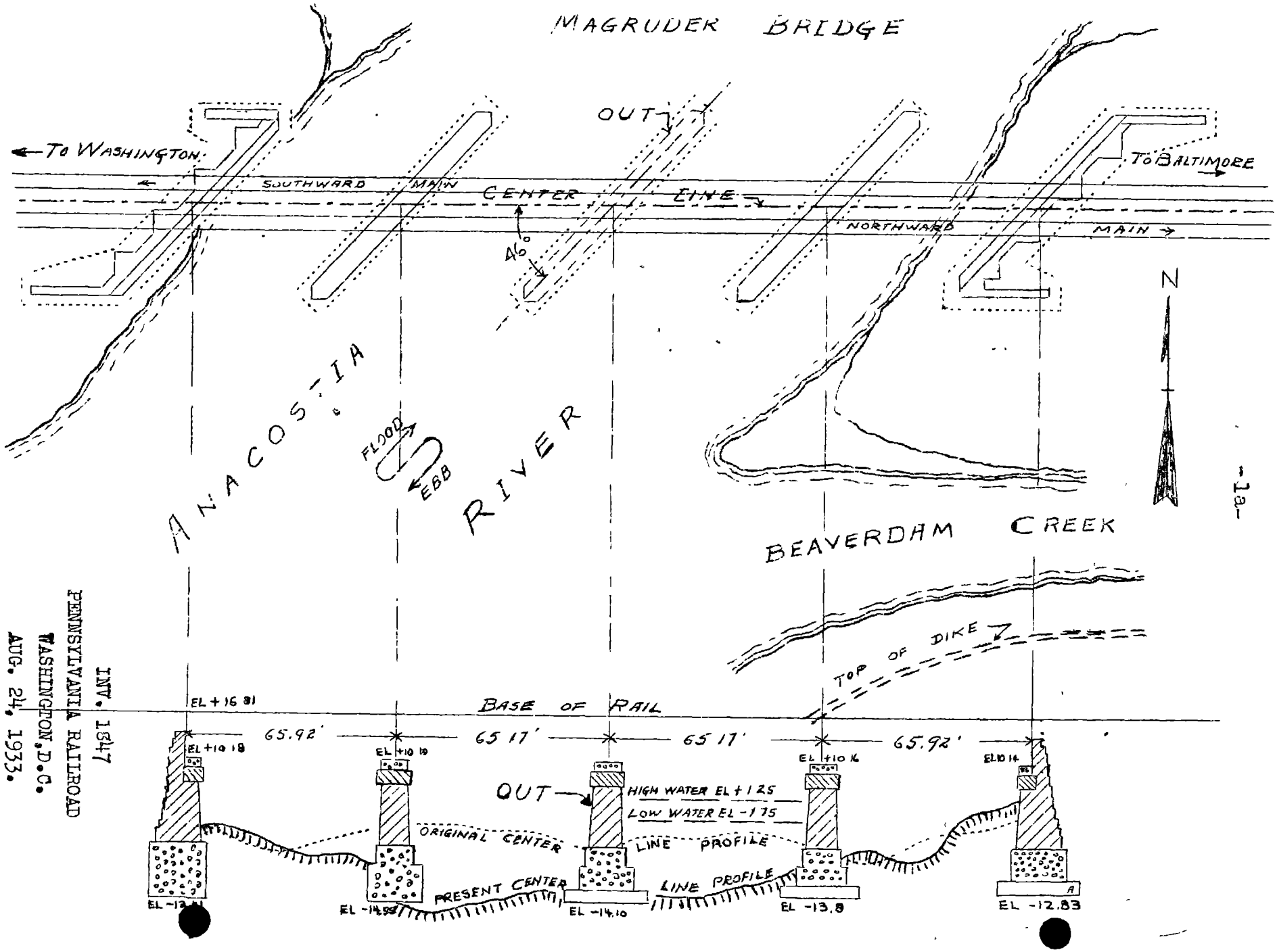
On August 24, 1933, there was a derailment of a passenger train on the Pennsylvania Railroad near Washington, D. C., which resulted in the death of 2 employees, and the injury of 4 passengers, 9 mail clerks, 1 employee on duty, 2 employees off duty, and 4 Pullman employees.

Location and method of operation

This accident occurred on that part of the Baltimore Division which extends between North Point (Baltimore,) Md., and New York Avenue, (Washington) D. C., a distance of 44.3 miles. In the vicinity of the point of accident this is a double-track line over which trains are operated by time table, train orders, and an automatic block and cab-signal system. The accident occurred at bridge 2.95, which is located 4.2 miles north of Washington; approaching this point from the north, the track is tangent and the grade practically level for nearly 1 mile. The track is laid with 130-pound rails, 39 feet in length, with 22 ties to the rail length, fully tieplated, and ballasted with rock to a depth of 12 or more inches.

In the immediate vicinity of the point of accident the tracks extend across marsh land through which flows the Anacostia River. Bridge 2.95 carries the tracks over the river and on each side of the bridge the tracks are laid on a 10 to 12-foot embankment which extends about 2,500 feet north of the bridge and about 1,400 feet south of that point. The bridge itself was a 4-span, deck plate-girder structure, on a 46° skew, built in 1904; the distances between piers, as well as between piers and abutments, were between 65 and 66 feet, measuring from the center lines, the openings under the bridge varying in width from 41 to 45 feet. The total length of the bridge was about 262 feet.

The construction of the piers provided for the laying of four tracks but only two were built, these being the two nearest the center line of the bridge. The abutments and piers were constructed of 24-inch sandstone ashlar masonry backed with rubble and provided with an 18-inch granite



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coping. These piers and abutments were superimposed on a concrete sub-foundation which in turn rested in a gravel stratum; preliminary investigation had indicated that this gravel stratum had a minimum depth of 7 feet at mid-stream and this was penetrated by the sub-foundations to a depth of about 2 feet.

The center pier of the bridge, which is the one primarily involved in this accident, consisted of a layer of concrete 95 feet long, 14.5 feet wide, and 1 foot in thickness; the next step was 91 feet long, 9 feet wide, and 4.37 feet in thickness, and the final step of the sub-foundation was 88 feet long, 7 feet wide, and 4 feet in thickness, giving a total thickness of concrete sub-foundation of 9.37 feet. The ashlar masonry on top of the concrete was 87 feet long, 6 feet wide, and 13 feet 9¾ inches in height, and on top of the masonry were the plate girders and the track structure. The other piers and also the abutments were somewhat similar to the center pier in their construction with the exception that the abutments were provided with back and wing walls of stone masonry. In 1928 a reinforced concrete seat 16 inches in height was added in order to raise the track in conformity with changes in grade on either side of the bridge; this addition extended only under the two tracks and constituted the only structural change made in the bridge subsequent to its erection in 1904. The following measurements are below the base of the rail:

North abutment footing	29.63 feet
North pier footing	30.60 feet
Center pier footing	30.90 feet
South pier footing	31.35 feet
South abutment footing	29.21 feet
Mean low water	18.77 feet
Top of bridge seat	6.64 feet
Top of gravel strata on which center pier rested	28.80 feet

The Anacostia River is formed by the junction of two branches at a point 2.65 miles upstream from the bridge and it empties into the Potomac River 6.16 miles below the bridge. The territory drained by the stream above the bridge embraces about 133 square miles. It is estimated that under normal conditions the stream had a depth at the bridge of 3 or 4 feet at mean low water, while the tide at this point measures about 3 feet.

A tropical storm had prevailed during August 23, accompanied by unusually heavy rainfall, and it was still raining slightly at the time of the accident, which occurred about 3:26 a.m., August 24.

Description

South-bound passenger train no. 147, known as the Crescent Limited, consisted of 2 mail cars, 1 combination car, 2 sleeping cars, 1 club car , 3 sleeping cars and an observation car, all of steel construction and in the order named, hauled by engine 3855, and was in charge of Conductor Wilson and Engineman Bryde. After leaving Baltimore this train lost time on account of the prevailing weather conditions and also while running between Winans and Severn, 32.3 and 25.8 miles from Washington, respectively, in accordance with train order no. 364, which required the crew to look out for poles which might blow across the tracks; the train passed Landover, Md. 7.1 miles from Washington, at 3:23 a.m., according to the train sheet, 45 minutes late, and was derailed at bridge 2.95 while traveling at a speed variously estimated at from 30 to 50 miles per hour.

The engine apparently became derailed about the middle of the bridge and then continued across it before turning over on its right side and going down the embankment to the right about 300 feet south of the south abutment and 40 feet from the track; the tender remained coupled to the engine and stopped on its right side immediately behind the engine. The first seven cars crossed the bridge and were derailed in various positions to the right of the track; the eighth car turned over on its right side and fell into the river with its head end resting on the bank near the south abutment; the ninth car was suspended over the river with its head end resting on the rear of the eighth car and its rear end on the bridge, held by its coupling to the tenth car which remained upright on the rails. Subsequently the ninth car fell into the river and in doing so it turned the tenth car over on its side. The employees killed were the engineman and fireman, and the employee on duty who was injured was an assistant road foreman of engines.

Summary of evidence

Assistant Road Foreman of Engines Johnson, who was riding on the engine, said the train ran slowly in the territory covered by train order no. 364 and then continued at reduced speed as far as Odenton, 3.5 miles south of Severn. He had received information at Baltimore that there was no water in the track pans at Stony Run, which is in the territory between Winans and Severn, and when approaching Bowie, 11.1 miles north of bridge 2.95, he measured the depth of water in the tank and consulted with

the engineman, the result being that they decided they had enough water to enable them to reach Washington; after passing Odenton the speed was increased, being about 70 miles per hour at Lanham, 5.6 miles from bridge 3.95, but in the meantime the left injector had started to gurgle slightly and he had told Engineman Bryde to use a drifting throttle after passing Landover, 2.9 miles from the bridge, and allow the train to drift into Washington. Mr. Johnson was riding on the fireman's side of the engine and on approaching the bridge he leaned out of the cab window to look at the water in the river and thought the engine was about half way across the bridge when the accident occurred, at which time the speed was between 40 and 50 miles per hour. There had been no crash, no breaking of iron, or anything to indicate what was occurring. Mr. Johnson also added that the engine was in perfect condition and that the cab signals had been displaying clear indications.

Conductor Wilson, who was riding in the fifth car in the train, said he felt the car quiver, following which it became derailed; prior to this time there had been no application of the brakes and he estimated the speed to have been about 30 or 35 miles per hour. After the accident Conductor Wilson crossed the bridge several times on the north-bound track in order to use a telephone located on the north side of the bridge, and during these trips he observed the center pier in position under that track, but about an hour after the accident this portion of the pier suddenly collapsed, taking with it girders supporting the north-bound track and leaving that track suspended between the north and south piers. Conductor Wilson said the water in the stream had been close to the bottom of the girders and that the current was very strong.

Rear Brakem[illegible]. Douglass, riding in the rear car, felt a slight bumping followed by a sudden stop; he estimated the speed to have been 35 or 40 miles per hour and said there was no indication of anything having been derailed north of the bridge. Baggagemaster Selfridge estimated the speed to have been about 35 miles per hour.

Engineman Hare, who piloted Baltimore & Ohio passenger train no. 9 over the bridge south-bound about 1 hour and 30 mintes prior to the accident, said he passed over it at a speed of 50 or 55 miles per hour and noticed nothing unusual about its condition, although he did note that the water was very high.

Engineman Urban and Fireman Huckins, of north-bound passenger train no. 400, which passed over the bridge about 35 minutes prior to the accident, said the bridge seemed to be in normal condition although the water was very high; their speed at that point was slow because of an order requiring them not to exceed 5 miles per hour between the bridge and Tuxedo.

Track Foreman Bushey, whose territory included bridge 2.95 and also extended northward to Tuxedo, said he went off duty at 3:30 p.m. August 23; he had asked the track walker, however, about conditions when the latter returned from his trip and was told that everything seemed to be all right, and the storm did not cause him to have any fears for the safety of the bridge. In talking with the supervisor's office, however, before going off duty, he was told to hold himself in readiness, which he did, and when he finally was called to duty it was about 4:30 a.m., instructions being given to him to proceed to the scene of the accident. Track Foreman Bushey further stated that about a year previously he had noticed dredging being done in the river east of the bridge but he had not noticed any of this work nearer to the bridge than about 200 yards.

Track Foreman Reigle, in charge of the section to the north of that on which the accident occurred, said he was called out by the assistant track supervisor because of high water in the vicinity of Tuxedo, near the southern end of his section, and afterwards he continued southward as far as bridge 2.95, reaching there between 10 and 11 p.m. At that time the water was 3 or 4 feet below the tops of the piers, flowing freely, and he did not see anything to indicate an unsafe condition.

Assistant Track Supervisor Smucker said reports had been received that at a point south of Tuxedo both tracks were under water. After examining the track with Track Foreman Reigle, he went to the telephone at River Road overhead bridge, located about 3,300 feet north of bridge 2.95, and arranged for necessary assistance. While at this point he looked southward and he said that by the light of the automatic signal just north of bridge 2.95, he could see that the tracks were not submerged and after leaving the telephone he returned northward, about 9:30 p.m., giving further instructions to Track Foreman Reigle and then proceeding to Landover preparatory to accompanying a

work train to a washout on the Camp Meade branch. No reports of difficulty farther south on the main line had been received by Mr. Smucker and he said he did not feel any apprehension concerning the safety of bridge 2.95, neither had he ever known of any condition requiring slow orders over the bridge.

Track Supervisor Pevler had started from Washington by automobile about 5:15 p.m., en route to several points which had been reported to be under water, but found the highways impassable and finally returned and rode the engine of north-bound train no. 158, passing over the bridge about 7:15 p.m.; at that time the water was 4 or 4½ feet below the tops of the piers and he saw nothing to cause any apprehension as to the safety of the bridge.

Train Dispatcher Eicker said a 5-mile an hour slow order had been issued at 7:38 p.m. covering the territory between Tuxedo and bridge 2.95, but that this order was annulled at 11:11 p.m. and that subsequent to that time there had not been any slow order in effect on the south-bound track between Severn and Washington.

Bridge Inspector Erdman said he made monthly inspections of all bridges on the Baltimore division between Baltimore and Washington and that he last inspected bridge 2.95 on August 1, 1933. This inspection, however, was confined to such parts of the bridge as were above the water line, no under-water inspection being made, and he said that if he observed no cracks in the masonry or the joints he assumed that the foundation below the water line must be all right. On the occasion of the inspection of August 1, he found no apparent defect in any portion of the masonry. Bridge Inspector Erdman also said that he would consider it his duty after a flood to make an underwater inspection of every large bridge, but no such inspection of bridge 2.95 had been made by him since his assignment to this territory as bridge inspector on December 1. Prior to this assignment he had worked out of the office of the bridge engineer at Philadelphia, making semi-annual inspections in company with the various division inspectors, and for 10 or 12 years he had been making such inspections in the territory in which bridge 2.95 is located; all of these inspections, however, had been confined to those parts which were above water.

Master Carpenter Benton said he had inspected the masonry and steel work of bridge 2.95 in June or July of this year and had found it to be in good condition; there were some cracks in the lower flange angles of the girders and the bridge was badly in need of paint, but neither of

these conditions affected its safety. In 1928, the track across the bridge was raised about 16 inches, at which time the water around the south pier was 5 or 6 feet in depth; the masonry of all piers was good at that time, showing no cracks or any indications of settlement. No inspection of the foundation below the water line had been made and it was not the practice to make such inspections; both the semi-annual and annual inspections are above-water inspections. It was customary, however, after a storm to send bridge inspectors to bridges where there had been any indication of washouts, previous experience determining which bridges should receive such an inspection, and such occasions were the only times when soundings would be made; there had been no occasion for making such an examination of bridge 2.95. There are no periodical soundings made for the purpose of ascertaining whether a stream is scouring or changing its bed from year to year. It further appeared from the statements of Master Carpenter Benton that dredging east of the bridge had been going on at intervals since 1928, and some since about May of the present year, and he thought this work extended to within about 100 feet from the bridge. Prior to the accident he thought this dredging would not endanger the piers of the railroad bridge, but since then he had formed the opinion that the dredging might have been the cause of undermining the piers which led to this accident because the current would tend to wash out the gravel under the bridge on account of the change in elevation of the stream bed where it had been dredged out below the bridge.

Division Engineer Fox, who had been acting in this capacity on the Baltimore Division only since July 1 of this year, said that soundings made 5 days after the accident alohg the center line of the bridge indicated that there had been excessive scouring at the center pier location, this scouring extending to a maximum depth of 12 feet below the original bed of the river. Mr. Fox also stated that the periodical bridge inspections consist of an inspection of steel work and such portions of the piers and abutments as are above water and that

if there are no indications of irpairment it is taken for granted that the foundation under water is undisturbed. Mr. Fox said he found no marks of derailment north of the bridge, and it was his opinion the accident was due to the collapse of the center pier under the engine as a result of its having been undermined by this particular flood.

S. H. Brackin, at present the engineer in charge of the Philadelphia Improvement, said he was in charge of the construction of bridge B.95 in the year 1904. Borings had previously been made, although not under his personal supervision, and according to the blueprint record of these borings one of them was made on each bank of the stream and one near its center, the latter boring indicating that at that time in mid-stream there were 8 feet of mud and sand on top of a layer of sand and gravel which had a minimum depth of 5 feet; in addition, they went down with the test rod 5 or 6 feet below what they thought was a good bottom. Mr. Brackin said the question of the proper depth of sub-foundation was left to his judgment and that in this instance it was approved by Mr. Farnham, who at that time was the assistant engineer of construction in charge of the work being done in and around Washington. According to Mr. Brackin, the open coffer dam method was followed in the construction of the center pier; 3-inch wooden sheet piling was driven and this piling was left in place after the construction work had been finished, being cut off about at the low water mark. The sub-foundation was built of concrete, not reinforced, and the only change which Mr. Brackin said he would recommend today from the methods used at that time would be the use of interlocked steel sheet piling to form a casing around the foundation, driving it 2 or 3 feet below the foundation if possible. He did not think the use of piling under the foundation, as a means of supporting it, would be practicable because of the short penetration obtainable in the gravel stratum which exists at this point. It was Mr. Brackin's judgment that periodical under-water inspections were not necessary.

Robert Farnham, at present chief engineer in charge of the Philadelphia Improvement, said he was assistant engineer of construction in the territory in and around Washington at the time bridge 8.95 was built. The usual location surveys were made, data obtained as to high water, drainage area, etc. after which the bridge was designed in the office of the chief engineer with the exception that the depth of the foundation was left indefinite so that the engineer directly in charge in the field could determine the depth according to what in his judgment was necessary. Mr. Farnham referred to conferences held at the time with United States Army engineers and said he received information that there frequently would be high water, usually the result of ice jams backing up the water from the Potomac River. At the time bridge 8.95 was built he considered that the gravel stratum constituted a sufficient foundation for the piers, because this gravel was very compact and cemented, capable of withstanding a load of double the load of 3 or 3½ tons per square foot which the bridge would place upon it. Mr. Farnham further stated that all streams are more or less susceptible to changes in the stream bed and it was his opinion that soundings should be made after a period of high water in order to determine what changes, if any, have been made, and he thought that such soundings must have been made at bridge 8.95 from time to time although he said he had no actual knowledge as to that fact. Mr. Farnham also stated that dredging operations carried on below the bridge would aid in lowering the bottom of the river above the dredged area.

A. R. Wilson, engineer bridges and buildings, said bridge 8.95 as built conformed to the standard in effect on the Pennsylvania Railroad at that time and he did not think there was any necessity for the use of a pile foundation under the piers; the borings had indicated at least 5 feet of gravel at the approximate center pier location and a bridge engineer is much pleased when he finds a reasonable depth of good gravel upon which to place bridge foundations, piling being used as a means of support only when the engineers are satisfied that the soil will not sustain the load. Subsequent to the accident, Mr. Wilson checked some soundings which indicated that there had been 8½ feet of scour on the south side of the center pier and 10 feet on the north side, and from his inspection of the whole situation he said he was satisfied that the accident was due to the collapse of the center pier as a result of its having been undermined incident to the extremely high water which had prevailed. Questioned as to whether he thought some of the scour might have occurred previously, Mr. Wilson said the top layer of silt might have moved, and possibly some of the sand, but that it would take a much higher velocity of flow to scour the gravel than is normal for this river, and this would

apply regardless of dredging done either above or below the bridge. Small scours, however, might have developed as a result of the dredging, and then have been accentuated by the flood conditions preceding the accident. Mr. Wilson further stated that there was no requirement governing the inspection of foundations below the water line unless there was some indication above the water line to justify such action, the absence of defects above the water warranting the assumption that the foundation below was in good condition, particularly in the case of a stream such as the one here involved. At the same time, however, Mr. Wilson said that as a result of the knowledge he had acquired as a consequence of this accident, he believed periodical inspection for scouring should be made, as well as closer studies of drainage areas, and that foundations should be placed at a greater depth and protected with steel sheet piling.

Observations of conditions at the bridge a few hours after the occurrence of the accident showed that the center pier had been broken in two about midway its length and that the downstream half, which the conductor said was in place for about an hour after the accident, had entirely disappeared while the upstream half was tipped downward at its upstream end with the result that that end had disappeared from view while the opposite end was still visible, although settled considerably, and it was still supporting the girders under the south-bound track; these girders were sagging where they rested on this settled section of the pier and also had moved sidewise toward the upstream side of the bridge. The two girder spans which had been under the north-bound track on either side of the center pier were in the water, the most northerly of these two spans having entirely disappeared from view while the other was supported at its southern end by the south pier, with the north end in the water, downstream from the bridge location at an angle of about 45°. The south pier had broken off on the upstream end just outside of the bridge seat, the broken-off portion tipping toward the upstream side and also northward toward the middle of the stream. The north pier was in place as well as both abutments and the end spans, although considerable damage had been done to the south abutment by derailed equipment. C. E. Heineman, a diver, made an examination of that portion of the south pier which remained in place and it was found that the bottom of this pier, which was 9 feet in width, was undermined on its north side to within 20 feet of its downstream end. This undermining became progressively deeper toward the upstream end, reaching a maximum of 3 feet 6 inches at the point where the pier had fractured and extending in under the pier for a distance of 6 feet at the fractured end.

The railroad company had no record of soundings

made between the time the bridge was built and the time of the accident which could be used in determining what effect the flood waters had had on the stream bed or whether any dangerous conditions had begun to develop prior to the occurrence of the storm. There was a depth of water of about 3 feet at mean low water at the time the bridge was built, this depth of water being principally between the center pier and the north pier, with a depth of about 5 feet at one point close to the south abutment. The record of soundings made by United States engineers in September, 1928, a few weeks after a storm of unusual severity, showed that substantial filling in had taken place between the north abutment and the north pier and also between the north and center piers, but between the center and south piers, where formerly there had been very little water, there was a scour having a maximum depth at mean low water of 5.4 feet. Soundings made by the United States engineers 6 days after the occurrence of the accident showed that the stream bed had been scoured out very badly since the 1928 soundings were taken; the maximum variation was at the north side of the center pier, where in 1928 the stream bed was about 1½ feet above mean low water whereas 6 days after the accident it was 13 feet below mean low water, or much more than sufficient to undermine the center pier. It was also found that the scour noted in 1928 between the center pier and the south pier had been extended until it reached a point more than 12 feet under mean low water; there also had been considerable scour, although less pronounced, between the south pier and the south abutment. These figures practically corroborated the soundings made by representatives of the railroad company on the previous day as to the greatly increased depth of water on either side of the center pier location, as well as the lesser increases between the south pier and the south abutment. One very noticeable feature of these soundings as made by the railroad company was the fact that 500 feet above the bridge the maximum depth of the stream at mean low water was 4 feet, this depth increasing gradually to a maximum of 16 feet at the upstream side of the bridge, following which it decreased gradually until it was only from 4 to 6 feet in depth at a point 500 feet below the bridge.

Blueprints furnished by the United States engineer's office indicated that formerly the Anacostia River at low water had an average maximum width of about 100 feet and a depth of 3 feet and that on each bank it was bordered by flats and marshes which at some points reached a width of 4,000 feet. Subsequently improvements were undertaken on the downstream side of the bridge, consisting of widening the channel to 300 feet with a maximum depth of 6 feet, these improvements also calling for the erection of dikes along

the banks and the filling in of the flats and marshes behind the dikes. According to representatives of the United States engineers' office, this work in the channel was carried out and the channel dredged to within 50 feet of the downstream ends of the piers.

Preceding the accident there had been a storm of unusual intensity, the records of the Weather Bureau at Washington showing a rainfall of 6.39 inches during the 24-hour period of August 23, of which 5.11 inches fell between 10 a.m. and 8 p.m. An automatic tide gauge maintained by the Coast and Geodetic Survey at a point about 1.6 miles above the bridge showed that beginning at 6 a.m. the depth of water began to increase, the amount of the increase being 10 feet by 10 p.m. and remaining at or above that height until 7 o'clock the following morning, with a maximum amount of rise of 11.9 feet at 1 a.m. and again at 2 a.m. The only other gauge operating continuously was located at Bellevue on the Potomac River about 8 miles below bridge 2.95, and at that point the maximum height of the water was at high tide, about 9 p.m., this having been the highest tide recorded since 1891. By 2 a.m., August 24, when the water at the gauge above bridge 2.95 still was at its maximum height, the tide had been going down for several hours and the water at Bellevue had dropped 4.1 feet; further evidence indicative of the fact that water was being impounded above the bridge is found in measurements made at the power house of the Potomac Electric Power Company, 1.86 miles down stream from bridge 2.95, which showed that at various times between 3 p.m., August 23, and 8 a.m., August 24, the water at that point was from 2.4 to 4.3 feet lower than the water above the bridge, although before the storm started the difference in the level of the water at these two points was only a few inches. Data furnished by the United States engineers' office indicated that at a point just below the bridge the flood waters reached a maximum of 12 feet above mean low water.

Conclusions

This accident was caused by the undermining of the center pier of bridge 2.95.

In this vicinity there had been a general storm of unusual proportions and intensity immediately prior to the occurrence of the accident, 6.39 inches of rainfall having been recorded at Washington on August 23, with the result that flood conditions prevailed throughout the territory in question. The last available record, made by United States engineers in 1938, indicated that at that time the channel of the river had been partly filled in between the center pier and the north pier, but according to the measurements made by these engineers 6 days after the accident the bed of the stream had been scoured to a depth of 15 feet below

mean low water or sufficiently to undermine the center pier to a depth of at least 3 feet. Investigation by a diver developed the fact that the south pier also had been partly undermined. It was apparent that the settlement of the center pier under the train precipitated the derailment.

The center pier, as well as the other piers and also the abutments, had been built on gravel, no piling being driven as a means of support under the piers in the event of scouring because it was stated that the gravel was too compact to permit the driving of piles; no other form of protection against scour was provided. It also appeared that the railroad company had made no underwater inspection or taken any soundings for the purpose of detecting possible scour at any time subsequent to the building of the bridge in 1904, although soundings made by United States engineers in 1928 indicated that there had been some scouring or at least a considerable lowering of the bed of the stream between the center and the south piers. There is no doubt that the existing flood conditions completed the undermining of the center pier sufficiently to cause its collapse under train no. 147, but because of the lack of prior underwater examination it is impossible to say whether all of the undermining was done by this particular storm or whether the center pier and also the south pier, had been partly undermined at some previous time.

Inspections and soundings to discover evidence of undermining should be made immediately after the occurrence of flood conditions, before the waters have had a chance to fill in the scouring which may have been created; there had been previous heavy rains in the territory drained by this river which might well have resulted in scourings, and careful inspection and the taking of soundings immediately following such flood conditions might have developed a necessity for action which would have prevented the occurrence of this accident and it is recommended that such inspections and soundings be made in the future, for without them it will be difficult if not impossible to detect the existence of scour or the tendency of a stream to shift its channel and create conditions which may lead to a dangerous situation. The American Railway Engineering Association rules for the inspection of bridges, trestles and culverts provide in part as follows:

MASONRY AND COMPOSITE STRUCTURES

(A) Points to be Examined:

(f) A careful inspection shall be made at the water or ground line for disintegration due to the action of water or ice.

(g) The inspection of foundations shall include an examination for indications of scouring or undermining and when necessary, soundings shall be taken for this purpose.

(j) Soundings shall be taken to determine the relative elevation of the bed of stream and the bottom of the masonry.

From the data available it appeared that the water at flood attained a height 11 or 12 feet above mean low water. In view of the fact that 6 days after the accident the bed of the stream at the bridge was scoured to a maximum depth of 15 feet below mean low water, this indicates that at the time of the accident the depth of water passing under the bridge may have been as much as 26 or 27 feet. The evidence indicated that the water had been impounded above the bridge until it was considerably higher than the water below the bridge, and the head of water thus produced undoubtedly accounted for much of the scour which took place. That there was a rush of the water through the comparatively narrow bridge opening is further indicated by the fact that 5 days after the accident the water both 500 feet above the bridge and 500 feet below had a depth at mean low water of only 4 feet and then increased gradually toward the bridge opening until it was 16 feet deep at that point.

Some question was raised at the investigation as to whether dredging operations carried on below the bridge, together with the confining of the stream to a maximum width of 300 feet instead of allowing it to spread out over the adjoining marsh land, might have had some bearing on what occurred. There is no positive evidence on this point, and even so, it was the duty of the railroad company to keep informed concerning changes which might have any effect on the safety of its bridge, and to take such precautions as were necessary under the circumstances.

Respectfully submitted,

W. P. BORLAND

Director.