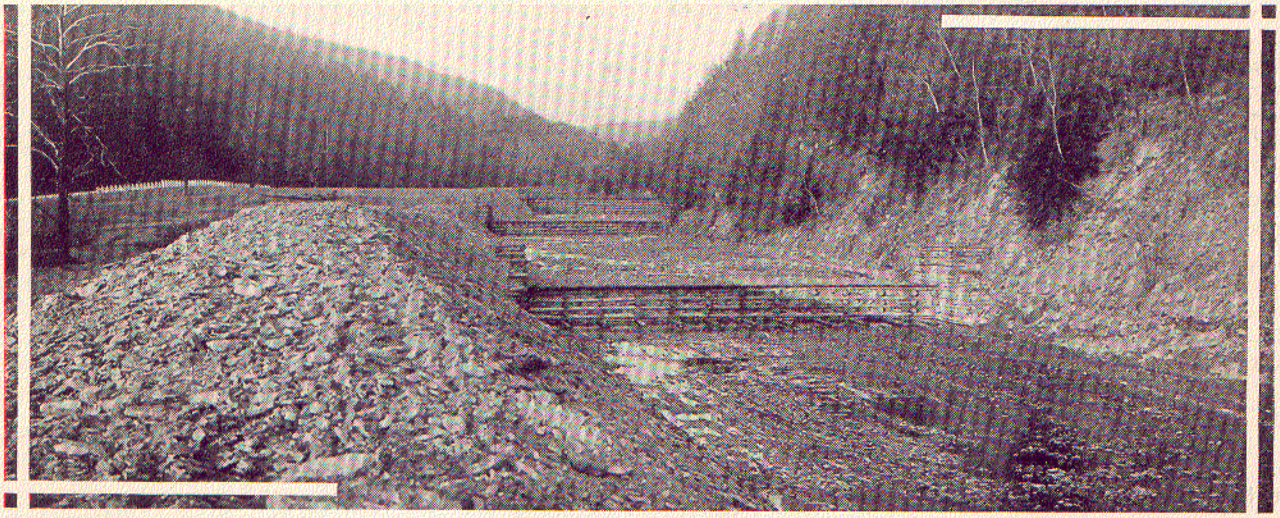


Seven Spillways Were Constructed in Stephens Creek to Produce A Non-Eroding Grade

Erie Solves Severe Erosion Problem in Lateral Streams

Widens creek beds and flattens grades by means of timber spillways to protect roadway from deluge of silt and gravel brought down with storm water

HOW to protect its line against the erosion of lateral streams along the southern tier of counties in New York, especially between Corning and Hornell, a distance of about 40 miles, has been a long-standing problem on the Erie, but one which now seems to have been solved. For more than 30 years the Erie has been forced to give special attention to about 10 streams which cross its right-of-way in this territory, streams which, though tranquil ordinarily and frequently dry during periods in the summer, become raging torrents during spring freshets or after heavy or prolonged storms. Unfortunately, it was not only a matter of taking care of the deluge of water under the tracks when it came, but, of much greater concern, the disposal of tons of gravel, broken rock and debris carried by the water, which not only blocked the streams and bridge underpasses, but which, at times, was carried up over the railroad embankment, completely blocking traffic.

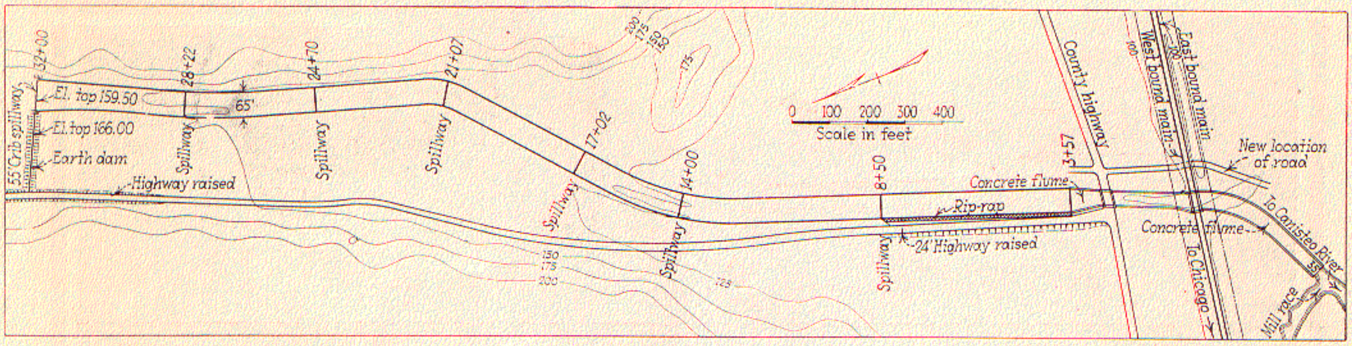
Permanent Relief Provided

For many years the difficulties encountered were fought with steam shovels or draglines in an effort to restore the stream beds after a heavy storm or series of storms, and it was not until three or four years ago that work was started on a large and comprehensive scale to afford permanent relief from the trouble experienced. In this work the principal aim has been to produce non-eroding flow in the streams, even at its highest stages. This has been done by the clearing and widening of the channels and by the construction of dams and spillways across the streams to cut down their steep natural slopes. Eight streams have been treated in this manner, as many as 19 dams having been constructed in a single stream in order to produce a non-eroding slope.

In the early work of this nature, the smaller streams were given first consideration, the work being done largely by the maintenance of way forces. Some of these smaller streams necessitated more dams than certain of the larger streams, but in most cases the dams were relatively low and short, and of relatively light timber construction. Work on two of the largest and most unruly streams, Stephens and Cunningham creeks, was done under the direction of the engineering department, and is more representative of what is now considered on the road as the best practice in meeting the difficult conditions presented. Therefore, while all of the work is of interest, even on some of the smallest streams, this article will be confined largely to a description of the measures adopted in connection with the two largest streams.

Conditions at Larger Streams

Stephens creek is located about a mile east of Canisteo, N. Y., while Cunningham creek is located about a mile west of the town, both streams flowing down the steep slopes of a valley, at right angles to the railroad, and emptying into the Canisteo river, which closely parallels the tracks on the south side. Both creeks presented the same problem. While ordinarily peaceful streams with little water, they became eroding torrents with heavy rainfalls, carry-



General Plan of Improvements Made in Stephens Creek

ing hundreds of yards of sand and gravel and, at times, loose rock as large as eight inches in diameter, from the steep upper reaches, to be deposited on the flatter slopes across and on both sides of the right-of-way. To keep the channels open, steam shovels and draglines were put to work one or more times a year, dredging out the debris. This material was thrown up to form high dykes along both sides of the waterways, dykes which helped to confine the water, but which sluffed off severely with every freshet, again filling the channel and choking the waterways beneath the railroad. Unfortunately, the bridge openings at Stephens and Cunningham creeks were both inadequate to meet flood conditions, particularly in height, which could not be remedied readily by either raising the tracks or lowering the beds of the streams. During heavy storms these openings became blocked frequently, in spite of the efforts of the section forces to keep them open, and the water, still carrying tons of sand and stone, would flood adjacent property and, not infrequently, surge over and down the tracks. This situation not only required vigilance on the part of the road during storms, but caused delay to trains, damage to the roadbed, and expense in removing the rock from the tracks, which has been known to pile up as high as two or three feet over the rails.

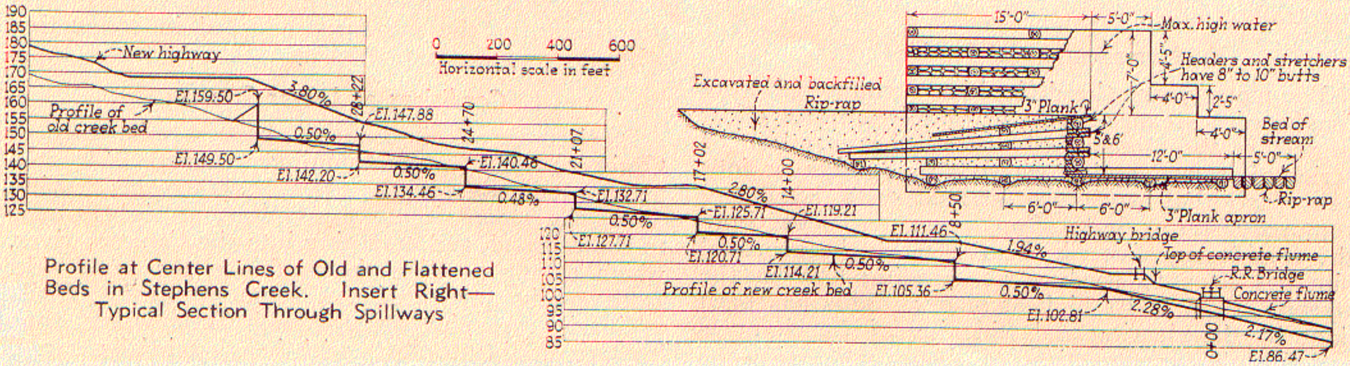
Flow Reduced to Eight Feet Per Second

Recognizing that the solution of the problem in these two creeks lay in widening the channels and in producing non-eroding slopes, a most exhaustive study was made of each stream and of corrective measures. This was necessary primarily because of the lack of accurate flow data on the streams and the lack of precedent in solving the problems presented. Stephens creek, although only about 5 miles long, had a drainage area of approximately 7¼ sq. mi. High water marks were not available because of the broken meandering course of the stream at its lower end during high water, and, it was necessary, therefore, to determine the runoff from rainfall and drainage area data. With the average annual rainfall in this vicinity known to be approximately 33.5 in. and the maximum hourly fall about 2½ in., the flow of the creek was computed to be between 2,500 and 2,800 cu. ft. per sec. Study of the creek bottom and the material which had been moved by storms led to the conclusion that a maximum mean velocity of 8 ft. per sec., which would produce a side and bottom velocity of only about 6 ft. per sec., would be non-eroding. Using this figure with the largest calculated volume of flow, 2,800 cu. ft. per sec., it was determined that the creek slope, which varied from about 1 to 5 per cent, would have to be flattened to 0.5 per cent, and the channel widened to 65 ft. throughout a distance of about 3,200 ft. up stream from the railroad, within which territory the greatest movement of material occurred.

Seven Spillways Put in Creek

In effecting this, an earth dam and a timber spillway were constructed at Sta. 32+00, and six other spillways were provided at points further downstream. At Sta. 32+00, the dam and spillway lie practically in a straight line, the dam being 220 ft. long and from 5 ft. to 10 ft. high, and the spillway 85 ft. long and approximately 10 ft. high. These structures not only direct the water to the proper channel during flood stage and prevent the flooding of a large section of the valley west of the channel, but also produce a large area of backwater behind them which, it is felt, will check any eroded material which may be brought down from above. In connection with the construction of the dam, it was necessary to raise an oil-bound macadam highway a maximum of about five feet throughout a distance of 750 ft. This was done with material excavated from the stream bed.

From the foot of the first spillway, downstream to



Profile at Center Lines of Old and Flattened Beds in Stephens Creek. Insert Right—Typical Section Through Spillways

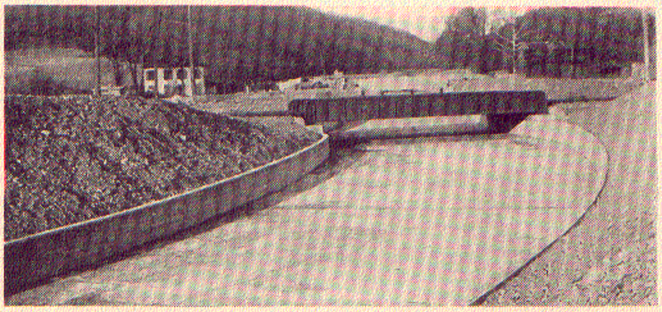
Sta. 3+57, the old channel was widened to 65 ft., the excavated material being thrown up on each side to form banks, and six other timber spillways were constructed, from five to six feet high and spaced from 300 ft. to 550 ft. apart, depending upon the natural fall in the stream. These spillways did not increase the height of the water in the stream appreciably at any point, as they were set down in the bed of the stream and the new slope of 0.5 per cent was formed by excavating the old channel in front of them. Thus the new channel from Sta. 3+57 to Sta. 32+00 is a series of seven steps, with a relatively flat slope between the spillways. The flood crest over the spillways is estimated at about 4½ ft., but in each case this is well below the top of the new high and wide embankment on each side of the stream. With the velocity of the water down to 8 ft. per sec., even at flood stage, it is not expected that the banks will wash or otherwise be disturbed, but, as an added precaution, anchor cribs, with a rock and timber face, were provided at the ends of the spillways and were keyed firmly into the embankments.

Throughout this section of the stream, it was necessary to relocate and raise about 850 ft. of the highway paralleling it on the west side. The new roadway runs directly along on top of the embankment forming the west bank, at an elevation well above any anticipated high water. As a special precaution throughout this section, the toe of the embankment, to a height of six feet, was paved with rip-rap.

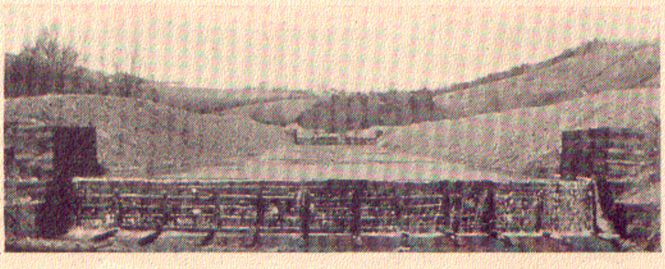
Bridge Openings Too Small

Below Sta. 3+57 the stream passed under an old through truss highway bridge at about Sta. 2+55, and then under the two-track through plate girder bridge of the railroad at Sta. 0+00. Below this point the old channel swung abruptly to the east over low lying land and continued for about 2,700 ft. to a junction with the Canisteo river.

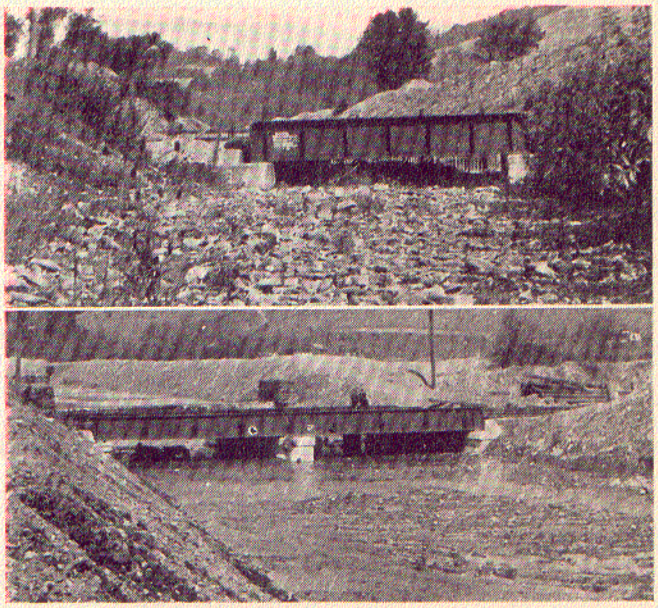
From Sta. 3+57 down, the old creek bed was on a slope of only about 0.7 per cent, a slope which retarded greatly the rapid flow of water from above and provided a natural settling basin for the silt and stone that was brought down during high water. Hundreds of tons of this material were deposited on the right-of-way each year and had to be cleared away. The extent of the work caused is seen in the fact that it had cost approximately $6,000 a year to cope with the situation at this point, and promised to cost in excess of this amount in later years when an increased accumulation of debris would make it necessary to haul some of it away.



Looking Upstream in Stephens Creek Over the Flume Which Accelerates the Flow Across the Right-of-Way



One of the Three Spillways in Cunningham Creek



Cunningham Creek in the Vicinity of the Right-of-Way, Before and After Improvements

Another primary source of trouble in handling the water in the immediate vicinity of the right-of-way, was the fact that the openings under both the highway and railroad bridges were too narrow and shallow, the highway bridge providing a clear opening only 39 ft. wide and the railroad bridge an opening of only 48 ft. An attempt was made to maintain the height of openings at four feet, but this was practically impossible without constant work and, therefore, the openings were seldom more than two feet high.

Concrete Flume Provided at Lower End

In making improvements in this vicinity, it was recognized that it was necessary either to increase the size of the openings under the bridges by providing new structures of greater span, or to accelerate the flow of water across this territory by means of a concrete flume. Study of the relative advantages and costs of the two solutions led to the adoption of the flume.

The flume, which has a paved bottom, is of concrete construction. From an inside width of 65 ft. at Sta. 3+57, the normal width of the new channel above, the flume narrows down to a width of about 38 ft. where it passes under the highway bridge, and then continues at this width to within about 100 ft. of the railroad bridge, where it is flared out to the maximum width possible under that structure. The slope provided in the bottom of the flume down to the lower side of the railroad bridge is uniformly 2.28 per cent, sufficient, it was calculated, to produce a mean velocity of flow of over 20 ft. per sec., more than enough to carry any suspended matter brought down with the water.

Below the railroad bridge, it was either a matter of allowing the old long channel across the flats to the river to remain or to provide a new short-cut channel to a connection with an old mill race which emptied directly into the river. The latter plan was decided upon for two reasons: First, it was known that water would be discharged from the end of the new flume at the railroad bridge at a speed somewhere near 20 ft. per sec., which would cause serious erosion in the natural stream bed immediately below, and particularly on the south side of the channel where it curved abruptly to the east; and second, that any suspended material carried by the water would then be deposited below where the velocity fell sufficiently, with the certain result that it would cause trouble later.

In the plan adopted, the concrete flume provided down to and under the railway bridge was extended a distance of approximately 170 ft. on an easy curve to a connection with the mill race. This section of the flume was provided with a concrete floor on a slope of 2.17 per cent, and was tapered down in width from 48 ft. at the bridge to 35 ft. at its lower end.

Details of Spillway and Flume Design

The seven spillways provided across the creek were all constructed from timber cut in the vicinity and are of the same general design. Essentially they consist of a series of pole stretchers across the face, separated by pole headers of from 20 ft. to 25 ft. in length, which extend upstream and are buried in the creek bed. Details of their construction are shown in one of the accompanying illustrations. Specifications for the spillways called for the use of white or rock oak poles with 9-in. to 10-in. butts for all headers and face stretchers, and for the use of 3-in. by 6-in. or 8-in. white oak plank for the spillway deck and apron.

To give the spillways stability, all pole intersections were drifted together with ⅞-in. wrought iron drift pins, and the cribwork formed by the headers and auxiliary stretchers back of the face was backfilled with rock as built up. Furthermore, the stretchers in the bottom course were embedded firmly in the channel bed and all of the stretcher members were spiked to and made to extend at least 18 in. into the side anchor cribs.

The anchor cribs were more or less similar in construction to the spillways themselves, consisting of timber headers and stretchers, the headers extending well back into the side embankments. These structures were made to extend from the newly excavated floor of the channel at the base of the spillway, to well above maximum high water over the spillway, and of such length as to afford full protection to the section of embankment immediately each side of the spillway crest. In backfilling the anchor cribs, which was done as they were built up, large stones were placed in the face to prevent the possible washing out of the back-fill material.

The flume provided below Sta. 3+57 consists essentially of mass concrete side walls, varying in height from about 5 ft. to 6 ft. above a 6-in. floor, reinforced with welded fabric. To take care of expansion and contraction in the concrete, the flume was constructed in sections approximately 40 ft. in length, with expansion joints at each end in the side walls and also in the floor. Furthermore, expansion joints were provided between the floor and the side walls, the two parts of the structure being entirely independent. Under the center line of the new highway bridge constructed, with its span of 39½ ft., a vertical clearance of 5 ft. 6 in. was provided, and under the existing railroad bridge, with its span of 48 ft., the maximum height of the opening is approximately 4 ft. 5 in.

Similar Work at Cunningham Creek

At Cunningham creek, where the problem encountered was practically identical to that at Stephens creek, the same corrective measures were applied, but in this case three spillways were sufficient to flatten out the creek profile, and, the enlarging of the opening under the tracks by the erection of a new bridge precluded the necessity for the construction of a flume.

A study of the situation in this creek, which had a drainage area of about 5.2 sq. mi., showed that by far the greatest trouble with erosion occurred within a distance of 1,600 ft. upstream from the railroad. Within this territory the accumulation of rock and debris brought down from above had been thrown up into high banks along each side of the channel, which became undermined and sloughed off with every heavy flow, blocking the channel and the inadequate opening under the tracks.

Since it was expected that little more coarse material would be brought downstream from above Sta. 16 + 00, or 1,600 ft. above the railroad bridge, owing to the fact that the stream bed had eroded to bed rock at many places and to the further fact that extensive sections of bank revetments had been provided where wash had been the most severe, the work of the railroad extended only up to this point. Using a maximum discharge figure of 2,250 cu. ft. per sec., determined from actual measurements and checked by state discharge charts, and, for the same reasons as at Stephens creek, holding to a maximum mean velocity of 8 ft. per sec., calculations dictated that the new channel should be flattened to a 0.6 per cent slope and widened to 66 ft.

To secure the new slope necessitated the construction of three spillways, having a total height of 23 ft. These spillways, two of which are 8 ft. high, and one 7 ft. high, are of the same general type of construction as those in Stephens creek, modified only as was necessary because of their slightly greater height. As in Stephens creek also, the spillways were set down in the stream bed so as not to raise the height of the water, and the excavation necessary in lowering the gradient between spillways, and in widening the channel, was done by a dragline. The anchor cribs provided for the spillways in Cunningham creek were constructed of old bridge timbers and were provided with a tight face to prevent possible wash of the backfill.

The old single-span three-track through girder bridge carrying the railroad over the creek provided an opening only about 20 ft. in width and 20 in. in height. This unfavorable situation was remedied by erecting a new two-span girder bridge, with two clear openings of 35 ft. by 4 ft. 6 in., sufficient to take care of maximum possible flow.

Below the lowest dam, beneath the bridge and for some distance beyond, the natural bottom gradient of 1 per cent was lowered to 0.75 per cent and for the last 300 ft. of the stream, before its junction with Canisteo creek, the gradient was made 1.67 per cent.