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Stream Improvements in Michigan

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Abstract

When wartime curtailments of labor and material forced a retrenchment in Michigan's stream improvement program, greater attention was given to the design and testing of new materials and methods applicable to specific improvement problems. In a uniform-bottomed artificial drain, fishing was improved by installation of 2-foot-square concrete blocks, cast at the site at a cost of $2.50 per block. In 5 years, there has been no maintenance cost. In a sand- and rubble-bottomed stream, deflectors were installed made of Wakefield sheet piling jetted in with a portable pump, and so designed as to escape damage from trash, floating ice or flooding. The original cost was $23.05 per unit, and no maintenance has been required after 1 year of operation. High, eroding sand banks are being protected by planting vegetation and by construction of short wing jetties of Wakefield sheet piling. New fishing areas have been created by restoring flow through old oxbows and bayous by the use of diversion dams, and by creation of small ponds on minor

spring-fed streams. For 200 earth-filled log crib deflectors, original cost was $17.45 per structure and maintenance cost, over a 4-year period was $1.38 per structure per year. Experiments are under way to determine the feasibility of lowering stream temperatures by diverting dam overflows directly into the ground-water table.

In Michigan during the wartime period of curtailments in materials and labor, we expended a considerable portion of our energies on developing stream improvement methods which we believe are new, or at least represent significant modifications of existing methods, and on a closer analysis of the varied problems individual streams present. Far too much stream improvement work has been done with little or no attempt to adapt or develop techniques for specific results. The old "shotgun" method has been and still is used much too often. We grant that for trout stream improvement pools and riffles are generally considered the most needed physical features. However, a heavily sanded stream needs different treatment than a rubble- or rock-bottomed stream. Following is a list of the things most often needed or lacking in trout streams:

1. Pools and riffles
2. Bank erosion control
3. Temperature control
4. Prevention or control of sedimentation
5. Flood control
6. Uniformity of flow
7. Pollution control
8. Food
9. Shade and cover
10. Spawning facilities

Figure 1. Re-usable wooden forms for casting cement blocks.

Figure 2. Arrangement of cement blocks in the stream.

This report will not include the basic surveys but will confine itself to a discussion of techniques developed to meet specific problems.

One problem involved the lack of cover and rest areas for trout on a drainage ditch in the southwestern part of Michigan. This stream had temperatures sufficiently low to support trout but due to conditions inherent in a uniform-bottomed artificial drain contained few pools and little shelter. To provide these features and to meet the difficulty of holding structures in place, 2-foot-square cement blocks weighing approximately 1,150 pounds each were cast on the site, with an iron ring embedded in each block to facilitate handling; the blocks were then placed in staggered rows as indicated in Figure 2. A gin pole with an extended arm was used for placement and proved a simple method. The conventional type of double wing deflector was used. In this particular water a center unit placed midway between the two wings has been most effective due to the increased area of backwater and cover provided. The depth of water, 2 to 4 feet, was such that all but one of the structures required a second layer of blocks superimposed upon the foundation layer. Over the 5-year period there has been a gradual settling, most rapid during the first few days after installation. Now it is our intention to lift the blocks and readjust them at a higher elevation. The placement of these structures in the stream has resulted in concentration of the fishing at the devices and according to the anglers the fishing has been improved by them. The average number of blocks per deflector was 64 and a total of 512 were cast and placed at a cost of $1,312.56. This sum included the necessary form lumber and experimentation to determine a feasible method of handling. The cost per block was $2.50, a figure that can

Figure 3. Earth-filled log-crib wing deflectors in the experimental section of Hunt Creek.

Figure 4. Double wing deflector of matched sheeting in Hunt Creek, showing the transverse submerged "digger-log" below the deflector wings.

Figure 5. Single-wing deflector of triple Wakefield sheeting with submerged log tailing downstream from the end of the wing.

be reduced substantially on subsequent projects. To date there has been no maintenance cost.

At Hunt Creek, where the Department maintains a research laboratory, two sections of the creek have been improved on an experimental basis. The results in trout production, food, and physical changes are the subject of a separate paper and will not be discussed here. One section was improved in 1943 with the conventional single and double wing deflectors constructed of earth-filled log cribs with sodded tops. These structures have functioned well but have required annual maintenance to keep them at maximum efficiency. Periodically, high water has overridden them causing some washing. The sod and soil thus removed has had to be replaced, but to a lesser extent each year as the vegetation has become more fully rooted. The other section was improved in the fall of 1945 using single and double wing deflectors constructed of sheet piling. Ten of the 13 structures placed were of triple Wakefield sheeting built of salvaged 1 by 10 pine lumber. Three boards are required for each single piling, the center one placed between the two parallel outer planks so that a tongue and groove are formed. This center plank extends laterally 2 inches beyond the outer boards on one side, the opposite side forming a 2-inch groove. The three planks are then nailed together using nails sufficiently long to enable them to be clinched. One end is then cut off at a 45-degree angle with the point always on the tongue side. The individual pilings for this particular section were 5 feet long and were jetted in, using a portable high pressure pump. A guide and support was installed by jetting in 8-foot cedar posts at approximately 5-foot intervals. On the upstream side of the posts, a log stringer was placed, squared on its upstream side, and notched and spiked at its junction with the posts. The posts and stringers were placed below the surface of the stream so that they would be continually submerged. The sheet piling was then started at the outer end, toward the center of the stream, and special care was taken to drive the first one vertically. Cutting a symmetrical point on the first piling facilitated this. It was then spiked to the stringer and provided a guide for subsequent piling. The pointed tongue side fits into the groove and the 45-degree angle cut tends to wedge it tightly against the other piling to form a watertight seal. At the outer end the top of the structure was cut off at the water line and gradually tapered until at the bank line it was 4 inches above the water. The cut was made purposely low to permit flood water to override the device, in order to give pressure relief and clearance for any floating trash that otherwise might collect on the structure. The deflector was built well into the bank to reduce the possibility of cut-around. Additional submerged planks or logs were added as cross current diggers placed slightly downstream from the end of the wing, spiked to posts and jetted in to a depth of 7 feet. Others were placed as a submerged downstream extension to the wing parallel with the current. Between the wings in several of the structures a plank or log was placed below the low-water surface parallel with the current. This particular construction has proved most efficient. After being in place a year no maintenance has been necessary and none is anticipated for some time to come. The other three structures were constructed similarly except that 2 by 6 matched sheeting was substituted for the triple Wakefield sheeting, reducing by two-thirds the amount of lumber necessary per structure, and appear to function equally well. Deep holes have been cut below most of the structures and after one year those with the additional submerged construction at the midstream end of the wings have cut the deeper holes. The 13 structures cost $306.00, or $23.05 per unit. Ten of the structures were of salvage material which has not been evaluated in the above figure. Had new lumber been used throughout the figure would have been doubled approximately figured at the rate of $85.00 per 1,000 board feet. A wing 20 feet long of 5-foot piling (matched sheeting) would take 200 board feet of lumber. The posts and stringers were cut from the adjacent wood lots and represent only labor costs. The particular advantages of this type of construction are: A water-tight seal, long life, the ability under flood conditions to pass floating trash and ice, and the relief of flood pressure by overtopping. Such overtopping would have little or no detrimental effect on the device. This structure has proven very satisfactory when heavily sanded conditions are encountered.

We have a number of streams in Michigan, particularly in the northern zone, that have become badly sanded through the erosion of banks. We are attempting to control this condition on portions of two streams: The Pere Marquette in the Lower Peninsula and the East Branch of the Two Hearted River in the Upper Peninsula. Considerable work was done in the 1930's by the CCC on several of the worst stretches on the Pere Marquette River. This work involved terracing, tree planting, and the protection of the water line by log booms. Some of this work is salvageable, the major failure being at the water line. We believe that by the construction of a series of short wing jetties the current can be deflected from the raw bank. This will give Nature a chance to reestablish a protective cover with some help in the form

Figure 6. A view showing the construction of short wing-jetty of matched sheeting in the Pere Marquette River.

Figure 7. Two wing-jetties in the Pere Marquette River designed to prevent bank erosion. Note the height differential between the stream and bank ends.

grassing or tree and shrub planting. These jetties were constructed like the wing deflectors at Hunt Creek described above, with the exception that the terminal ends extend about a foot above low water line, maintaining this height to within about 6 feet of the bank, and then angle upward until at the bank end they are 3 to 6 feet above the low water line. All of the wood parts extending above the water line were creosoted. The terminal ends were braced to the bank downstream by a submerged log held in place by posts jetted in, was the sheet piling, to a depth of 12 feet. It is necessary to construct one or more of these in series at each of the major bends where erosion is taking place. The angle at which these jetties are placed depends in general on the way the main current strikes the bank, varying between approximately 30 and 45 degrees. Cost figures on this work are not yet available, the work being still in progress. However, it will approximate figures given for Hunt Creek with proportional additional charges for the longer sheet piling and the additional labor in driving it to a greater depth.

A simple method of providing more fishing, creation of new water, has been followed on the Little Manistee River in Michigan by the construction of a diversion dam which directs the water through an old oxbow and provides 1,700 feet of new trout water. To divert the water it was necessary to build a dam that would provide a head of not less than 2 feet. The dam was constructed of double rows of triple Wakefield sheeting 6 feet apart, braced by 4 by 6 oak walers and tied together by 3/4-inch steel rods. The space between the sheet piling was filled with earth and the top seeded to grass and rye. Additional dirt was placed on the downstream side for added strength, completely covering the sheet piling and providing 2 feet additional freeboard.

Figure 8. Earth-filled sheet piling dam on a tributary of the Fox River. A series of these dams have been placed on this stream to form trout ponds.

Figure 9. Single wing deflector with the terminal end protected by sheet piling. Note the formation of bar behind the wing.

The slope was sodded to the water line and the approaches grassed and planted to jack pine. The considerable amounts of silt and muck accumulated during the many years since the oxbow had been cut off from the main stream, were largely flushed out in the first 2 days of operation. In the construction of the dam a box-type spillway was used to permit the driving of the sheet piling with but slight increase in head. Since then the spillway has been filled with earth to give the structure additional strength. The dam is 110 feet overall, and extends well into the banks at each end. The total cost was $1,538.07.

We have in Michigan a large number of small, spring-fed tributary streams, many of which are in the southern part of the state where trout fishing facilities are most meagre. The majority of these are so small that little or nothing has been done in the way of development or stocking. At present we are embarked on a program to develop them where the physical and biological conditions justify. During the depression period a rearing pond for warm water fishes was developed in one of the southern counties by the U. S. National Parks Service. This pond functioned as originally designed for a short period and then was abandoned as a rearing pond. Investigations by the Michigan Institute for Fisheries Research revealed that the pond had possibilities for trout. In 1943 it was stocked with legal trout and opened to the public for fishing during the regular trout season. Special regulations were invoked limiting the catch to two legal fish, permitting only artificial flies to be used, and allowing no boats and no night fishing. This pond proved extremely popular and as a result several additional rearing ponds have been made available for public fishing. Their success stimulated interest in developing similar ponds on waters formerly considered too small to warrant much attention. In the fall of 1945 a dam was constructed in the Waterloo State Park Area on a stream whose flow was approximately 120 gallons per minute. This dam forms a pond of about 2 acres which was stocked with legal trout in the winter of 1945-46 and enjoyed considerable public use during the summer of 1946. Two additional ponds will be constructed during the fall of 1946, one of 6-1/2 acres, the other of 5 acres. All will be subject to the same regulations as outlined above. The possibilities of expanding this program are great and will provide trout fishing in a section of the state most deficient in this type of sport.

In the north central part of the lower peninsula we have the Clam River whose source is Lakes Mitchell and Cadillac near the city of Cadillac. The stream flows southeastward into the Muskegon River. It is considered marginal for trout because of the relatively high temperatures that may occur during warm periods. There are at least two causes for this, one the warm water from the source lakes, the other the widening and the shoaling of a considerable portion of the stream. Seepage runs conducted with the cooperation of the U. S. Geological Survey in the summer of 1946, a period when no water was spilling over the dam from Lake Mitchell into the river, indicated a pick-up of 22 second-feet of water between the source and a point approximately 20 miles downstream by river. This rather large volume of spring and seepage water has maintained a temperature sufficiently low most of the time to support trout. Because of the marginal condition of the stream it was considered a worth-while project to attempt temperature reduction by narrowing the stream channel and planting the stream banks. With the cooperation of the Cadillac Rod and Gun Club, easements were obtained along the greater portion of the 20-mile stretch permitting public access and the right to construct and maintain improvements. To date 200 devices, mostly single wing deflectors, have been installed. The narrowing of the channel has been accomplished by so placing the structures that bars could form behind them. In the 5-year period since the first structures were installed, portions of the stream have been narrowed by two-thirds of their former width. By carefully checking and maintaining the structures each year, with the addition of auxiliary structures where needed, it has been possible in some instances to extend the bar formation from one structure to the next. All but 12 of the structures were made of materials garnered from the adjacent stream bank and consist of earth-filled log cribs with sodded tops. The terminal ends of 20 of them have been protected against cutting by 6 to 8 feet of sheet piling and in many cases the banks opposite the single wing deflectors have been protected either by boom logs or sheet piling. The treeless portions of the banks have been planted to white cedar, spruce, pine, and mixed hardwoods. The total cost to date of these 200 structures has been $3,490.00 or $17.45 per structure. Their maintenance for the 4-year period cost $1,092.00 or $5.46 per structure, or $1.38 per structure per year.

In addition to the control of temperatures by narrowing the stream channel and planting the banks, data are being obtained on the feasibility of introducing all or a portion of the stream flow near the source of the Clam River directly into the ground-water reservoir which we believe feeds the springs that are now contributing most of the cold water to the stream. It is presumed that the greater volume of spring flow will reduce the water temperature materially in the warm summer months. Introduction of surface flow into the ground-water reservoir would be accomplished by a diversion dam of low head designed to divert any desired portion of the flow through distributing ditches, or by direct flooding of an area sufficient to absorb the diverted water. The stream flows through a rather large glacial outwash plain of highly pervious sand and gravel of considerable depth. In March 1945, fourteen test wells were jetted in 2 to 5 feet below the level of the ground-water table in the area that may be flooded. These wells have been checked at bi-monthly intervals up to June 1946. From June 1 to date weekly checks have been made and will continue to be made each week for an indefinite future period. The data thus obtained indicate the fluctuation in the level of the ground-water table, and to a degree the speed of percolation through the aquafer, by reflecting changes following precipitation. The lateral variations in the table depth between wells indicates the ground-water gradient, which in turn is an indicator of the direction of flow of the subsurface waters. The level of the ground-water table in the test area has remained consistently below the level of the stream, the degree of difference increasing in proportion to the distance from the stream at which the well is located. These data indicate a flow from the stream to the underground waters and also the ability of the ground-water reservoir to absorb additional waters. An effluent flow is indicated further by the above-mentioned seepage runs wherein the section under discussion lost one second-foot of water between two stations, a distance of a mile and a half. Three miles below the site of the proposed spreading operation is the first tributary. We believe that this spring-fed tributary marks the first outcropping, other than the Clam River itself, of the water table that we propose to augment by the spreading operation. If this be true we may have arrived at a rather simple method of temperature reduction of many streams of similar character.

So far as the author can determine, the proposed plan will be the first application of the artificial recharging of the ground-water table for the improvement of trout streams by temperature reduction. The principle involved is not new. It has been used for many years in California and other western states for irrigation purposes, conserving water in one of the cheapest and most efficient types of reservoirs, the ground-water table. Many places in the eastern states of Ohio, New Jersey, New York, West Virginia and others are using this method of returning water to the underground reservoirs for varying purposes, such as the cooling of water for air conditioning, and the recharging of reservoirs in industrial areas where heavy pumping has depleted the ground water supply. Meinzer (1946) states that "The plan involves recharging the water from the public supply in winter when the surface water is cold, thus increasing the supply of cool ground water in summer when the surface water is too warm to be satisfactory for cooling purposes." The successful use of the principle of artificial recharge has been demonstrated many times both in Europe and the United States and its application to the improvement of trout streams through temperature reduction is merely a new use for a proven method.

The high internal friction of even the most permeable of aquafers assures a considerable time lag between the recharging operation and the discharge through seepage and spring flow into the stream. This time lag is determined by the distance through which the ground water percolates, porosity and permeability of the aquafer, and the ground-water gradient. This lag is of great value from a stream improvement standpoint for generally the period of greatest recharge would be at the time of the spring break-up. The water thus stored would be released gradually at low temperature during the critical period in July and August.

A recording thermograph was placed 4 miles downstream from the site of the prospective spreading operation and has been running continuously since June 3, 1946. The maximum temperature recorded for the water in the summer of 1946 was 81° F. on July 19 and remained at that figure for a 3-hour period. The maximum air temperature on that day was 91° F. and remained above 88° F. for 5 hours. Comparisons will be made between the average air and water temperatures for a considerable period both before and after the spreading operation. In cooperation with the U. S. Geological Survey a stream gage was installed near the site of the thermograph and 5-day-a-week recordings indicating the volume of flow have been made since June 3, 1946.

The various data collected since 1945 will be analyzed and the resulting conclusions will determine the nature of the spreading operation and the time of the initiation of the project.

Summary

During this war period of material and labor curtailment Michigan's Stream Improvement Program has confined itself largely to the following developments:

1. Cement block installation for cover and rest areas.

2. Single and double wing deflectors of earth-filled log cribs and sheet piling.

3. Bank control by jetties and vegetation cover.

4. Creation of new water by a diversion dam.

5. Construction of ponds to provide trout fishing in the southern part of the state.

6. Reduction of water temperatures by means of channel narrowing and bank planting.

7. Collection of data basic to the proposed augmentation of the water table by means of a spreading operation with its attendant temperature reduction.

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