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THE TYPE AND CONDITION OF STREAM IMPROVEMENT WORK DONE IN MICHIGAN BY E.C.W. AND OTHERS

This report deals with observations made on two field trips. On the first trip which extended from December 16 to December 23, representative streams of the Upper Peninsula of Michigan were visited. During the second trip representative work was inspected on certain streams of the northern part of the Lower Peninsula. On this trip we were in the field from January 3 to January 17.

In the Upper Peninsula the first stream to be inspected was the Salmon Trout River. Improvement work had been carried out on this stream in 1932 by the Huron Mountain Club under the writer's direction. The work on this stream differs in part from that on other streams in that about half of it was done on the pond of the dam. Numerous brush shelters were used and the large elms which had been killed by flooding were used to build shelters over deep water in the old stream channel. The remainder of the work was of the usual type and was installed below the dam. Previous to this examination, a recheck had been made in October 1933. On this examination all the structures which were placed in the pond above the dam appeared to be in good condition. The ice made observation rather difficult but as far as one could observe none of the structures had gone out. Below the dam the majority of the structures were in good condition and only three of them had been lost. These were covers which were placed in locations where it was impossible to embed the stakes deeply into the stream bed.

On the way to Watersmeet inquiry was made at the Kenton Ranger Station. The Ranger stated that there had been little or no formal stream improvement done in that region, since the CCC men had confined their efforts to the removal of beaver dams working under the direction of a man furnished by the Bureau of Fisheries.

Near the site of the old Watersmeet Hatchery on the Middle Branch of the Ontonagon, an investigation was made of a portion of the work which had been done in 1934 by the E.C.W. The majority of this work consisted of simple log wing deflectors and bank covers. Some distance below the old hatchery in a shallow and rather rocky section rock, V deflectors had been used. It was difficult to gain an accurate idea of the bank covers and how they had withstood the elements due to the ice and snow. In some instances the cover appeared to have been raised by ice action. These covers were made of logs and brush. The main or holding logs were set into the banks and their outer ends were held by stakes. Brush was then placed over these to form the cover. Since a good thick mat of brush was used, it should last for several years. Due to the ice action on this stream, perhaps submerged covers would have been better. When a bank cover is used it is best to build it below the surface of the water. Other covers of the wing jam type can be built at the surface or a portion of them above the surface. Ice does not seem to damage so severely structures which slant out and down into the stream from the bank. It has little or no action on structures which are submerged below the level at which the surface ice forms.

In most every case the wing deflectors had been raised from a few inches to as much as two feet. In many instances the logs had been lifted with the stakes so they were above the bottom or even partly or entirely above the water. It is quite unusual for wing deflectors to be disturbed by the ice. If they are solidly built and kept low they are generally not disturbed. It is evident that these deflectors were built rather high and were not banked in front with accessory logs. If an apron of hog wire is placed on the upstream side of the deflectors and the seal placed on this hog wire, the deflector is held much more firmly in place. This procedure, in addition to keeping the deflectors low, should insure them against ice action. In sealing the deflectors, it is well to use fairly large rocks at first and them to use finer material to fill around and over these large rocks. Provision should be made to keep the seal from being washed away by placing large boulders at the lower end of the deflectors.

Only a portion of the work on Cook's Run was inspected. While a few log dams had been built, the majority of the work consisted of various types of rock deflectors. These were all in fair condition or had been only slightly flattened.

Pine Creek, which is near Iron Mountain, was the next stream visited. This stream was entirely frozen over and for this reason an adequate idea of the work could not be gained. Since the ice had already raised some of the structures, however, it is believed that many of them will be destroyed this winter. The majority of the work which was done in this stream consisted of wing deflectors, rectangular bank covers, wedge covers, stumps, raft covers, and bank erosion control. It has been found that the old type of rectangular bank cover held in place by stakes is not suitable for streams which have a great deal of ice. Raft covers held in place by wire have also been found to be unsatisfactory. Wedge covers are satisfactory if they are installed in a suitable location; that is, one in which the water is of such a depth that they can be submerged below the level of the ice and yet be far enough above the bottom so they will not fill up underneath with sand and other material. It is rather difficult to hold stumps in streams where the ice becomes quite thick. If the stakes which hold the stump are placed directly in contact with it or are fastened to it rigidly, they will be pulled out in most cases. If stumps are to be placed in such a stream, they should be fastened by means of a 10 or 12 foot cable to a stake deeply embedded in the stream bed and then cut off as near the bottom as possible. This arrangement allows the stump to move up or down without exerting a direct upward pull on the stake. The writer was informed that several stone deflectors were installed. When stones are used for deflectors, it is generally best to confine such structures to gravel bottom streams, as in most instances stone deflectors are not satisfactory in sand bottoms. If bank covers are to be used in such a stream as this, the holding logs should be deeply embedded into the banks and held in place by rocks and gravel. These holding logs should be placed as far into the bank as they project into the stream and they should be some distance below the surface of the water.

On the whole, the Creek did not impress me very favorably as a trout stream. The planting of stream-side shade would be a most worthwhile project on this stream for several reasons: it would aid in cooling the stream; it would help to hold the banks and narrow the stream; and in time, it would aid in the establishment of pools and cover.

A portion of the work done on the East Branch of the Sturgeon River was also examined. In this section the work consisted almost entirely of wing deflectors. These were so scattering that it is felt that their effects on the stream will not be very noticeable. These deflectors were of the usual type.

On a stream such as the East Branch of the Sturgeon, covers formed by felling trees into the stream and fastening them on the bank might be a helpful addition to the work. In soft bottom streams, submerged logs which project out into the stream from the banks, create fine pools and give good cover since they often catch drift. Submerged weirs, submerged deflectors, and over and under logs are rapidly, easily, and cheaply installed, and yet they are very effective without being at all conspicuous. Every effort should be made to keep the structures under water and to model them after naturally occurring structures which have effectively improved pool, food, cover, or spawning conditions.

The West Branch of the Escanaba was rather hurridly examined. Deflectors appeared to be the main structures used in this stream. As far as could be noted, they were functioning well and were quite effective. Some of the deflectors were made of stone but the majority of them were of logs. The log deflectors were sealed on the upstream side with water soaked logs, small pieces of sticks, sand, and gravel. This is considered to be a good practice since they make the deflector more effective in the formation of a pool in the channel around the end. On this stream a further precaution to keep the wing deflectors from undermining was carried out by placing rocks and sticks on the downstream side of the deflector. This type of work is justified since when the wing deflector is kept from undermining a much better bar and mucky area is formed.

In addition to the deflectors, wedge covers, soft covers, bank covers, and digging logs were used. This latter type is what the writer has called an underpass deflector. These structures appeared to be functioning well in so far as they could be observed, as they were covered with ice. While they are holding well at present, it is to be expected

that the ice will destroy some of them.

In addition to installing structures in the river, erosion was controlled on many banks at bends where large amounts of sand were being added to the stream. This work appears to be in fine condition and to date it is effective.

A recheck was made on the work done on the North Branch of the West Branch of the Escanaba in the season of 1933 under the general direction of Mr. Tom McClure. All the brush covers had disappeared; but the deflectors were almost in the same condition as when they were built. This is due to the fact that they are deeply submerged. Most of them are almost a foot below the surface of the water. They are so deep, in fact, that many of them act more as submerged weirs than as deflectors and they have formed a pool below them caused by the water going over the top.

The next stream visited was the Anna River. This another stream improved in 1933 under the general direction of Mr. McClure. It was found that the structures were holding well in this stream. The Anna River floods little if any. It has almost no ice, and on the whole, it is very easy to hold structures in it. This is evidenced by the fact that this is the only stream in which the brush shelters remained in place. They have now waterlogged and sunk to the bottom of the stream, but they are still giving some cover. These brush covers, when they stay in place, make excellent places for certain species of mayflies. Wing deflectors and underpass deflectors were the other structures which were used most in this stream. Since the bottom of this stream is relatively easily eroded, deep holes have been formed. Some of the underpass deflectors have made very fine pools. Most of the structures are submerged. Many of the wings have undercut so they now act as cover over the pools they have formed.

Since this work was done, the various owners have begun to cut the timber in the stream bottom. This is a very unwise practice, as it results in unfavorable changes in the stream. The stream is made much more open and it becomes wider and shallower since the trees and brush are no longer present to hold the banks in place. If the removal of the timber continues, this stream will be greatly changed for the worse, which is very regrettable since the Anna River is one of the best streams in the Upper Peninsula.

Miner's River, similar to Anna River, was improved in 1933 under the general direction of Mr. McClure. The improvements in this stream consisted for the greater part of stone deflectors and low stone dams. Rather small stones were used for these structures; in fact, they were not large enough to withstand normal flood conditions and many of the structures have been flattened to such an extent that their effectiveness has been greatly reduced or the structure has been totally destroyed. Miner's River differs from the Anna in that it does have some high water and this is the reason why these structures, while they would perhaps have been strong enough for the Anna, did not remain in Miner's River. It is thought that stone structures can be made to stay in Miner's River if large rocks are used and they are correctly placed. The structures which were built above the M-94 bridge were made of larger stone and they have withstood the elements much better than those installed below the bridge.

The East Branch of the Fox River was improved during the season of 1935. The lower portion of the work differs from that installed farther upstream. The structures in the lower portion of the improved area near and just above the state road are of the usual type. They consist of bank covers held with stakes, raft covers, large bend rafts to stop erosion on sand banks at bends, and log deflectors. Some of these deflectors were built high with the idea of deflecting the current away from eroding sand banks, thus reducing the addition of sand to the stream. Good material was rather scarce along this stream so the structures had to be built with whatever material could be secured. The result is that many of the structures are rather unsightly. It would have been well to have built some of these structures lower. In this stream, due to its relatively soft bottom, submerged structures such as the submerged weir, submerged digging logs, submerged logs projecting from the banks and wing jam covers would have been quite efficient in forming pools and cover. Underpass deflectors would also have been a valuable addition to the work.

In the upper portion of the improved section, brush deflectors were installed. These were built by driving two rows of stakes out into the stream in the position desired for the deflectors. These rows of stakes were about three feet apart and the

space between them was filled with alder brush. This brush was weighted down with logs and the whole mass held in place by stretching wires over it and fastening them to the stakes. As this portion of the river is relatively free from ice and severe floods, these brush deflectors have a good chance of staying in place. On the whole, they have been quite effective. Good pools have been formed where the current flows along their upstream side and the brush has spread out enough so it gives excellent cover over these pools. Large mucky flats are being created in the quiet water below these deflectors and plants are becoming established on many of them. These mucky areas and plant beds should bring about a decided increase in the food supply. On the whole, it appears that, to date, the brush deflectors have functioned more effectively than the log deflectors.

The Mackinac camp did a good deal of stream improvement in the Black River. In the section examined most of the improvements consisted of stone deflectors. These were built rather close together and almost all of them had fairly long directors. Since large rocks were used for the construction of these devices, they should be relatively permanent. These devices have effectively narrowed the stream by confining it into one channel and the water in this channel has been considerably deepened. While these structures did not impress one as being unpleasing when covered with snow and ice, they are built rather high and they are apt to appear rather unnatural during the summer period. Above this section where rocks were used, logs had been used, and rafts, bank covers, and deflectors used. Only a few of these structures were noted.

The stone deflectors were built very high and many are higher than the bank at their junction. Structures built in this manner deflect the current against the bank, causing it to erode. For this reason it is a good practice always to keep the outer ends of the deflectors lower than the inner ends and always to keep all parts of the deflector lower than the banks which they join. It is also best to keep the deflectors as low as possible and not pile the stones up one on top of another.

Only a small portion of the work in Davenport Creek was examined. It is felt that the type of structures which were installed were not needed in this stream.

Lower Peninsula Streams

The Little Manistee River was the first stream visited on the second trip. Besides checking the work done in 1930, the work done by M.E.C.W., private individuals, and the U. S. Forest Service was also noted and examined.

The improvement work on the Little Manistee River was the first real improvement project undertaken by the Department of Conservation. Since it is also to the writer's knowledge the first project of its kind in the country, it was of necessity largely experimental. For this reason many devices were installed which have since been abandoned. In addition to this many of the structures which have since proven to be beneficial were not built strong enough to withstand the elements. For these reasons many of them have been destroyed. Those which remain were checked, however, and their action observed. A good deal of valuable information has been obtained from the work done on this stream.

Ever since Dr. Jan Metzelaar worked on the Little Manistee, property owners along the river have shown interest in the work and have installed various improvements. This activity has been more pronounced during the past two years. The property owners have banded together in a sort of association, getting together in the fall and improving certain sections of the river. They have used wing, V and I deflectors, wing jams, raft and tree covers. Some of these structures are doing excellent work and it is felt that they have materially improved the stream. The first year the structures were not built strong enough, but the owners have profited by experience and they are now making their structures better and stronger. It is felt that such projects as this should be encouraged.

M.E.C.W. attempted to begin the improvements of the Little Manistee a short distance below Luther but they had to abandon the project due to the nightly floods caused by the power dam at Luther. It would appear that these floods have increased in intensity during the last two years. This is probably due to an increased demand for electricity at Luther. The water is used and released at night. A daily fluctuation in level of 14 to 18 inches is produced. During the summer the stream goes almost dry during the day time and fish have been caught in pockets produced by the receding waters.

Such conditions are detrimental to the stream.

During the past six years the writer has had occasion to make frequent observations of the Little Manistee River. Notes have been taken and rather careful observations of conditions have been recorded. During this period great changes have taken place in the stream. At the time of the last visit the stream had changed so greatly that it would hardly have been recognized by the writer if he had been placed there without his knowledge. What was before a rather narrow, well shaded stream now resembles a drainage ditch in certain sections. The constant flooding and the removal of trees and brush from the stream bottom by cutting are considered as the causes. It is estimated that the section of stream below Luther has been widened about four feet. More exact measurements could be made if it were considered desirable.

The effects of the flooding are much more pronounced in the upper portions than ~~it is~~ they are farther down stream where the flood flow is not so large in relation to the normal flow. For this reason most of the damage has been done in the upper portion just below Luther. Here, in addition to the erosion of the banks and the widening of the stream, cover has been removed and a flat shifting sand bottom has been produced.

A good deal of cutting has been carried on along this section of the stream. It is felt that the removal of trees from this and other of our stream bottoms is one of the worst things we can do. It makes the stream much more open, it removes the source of additional cover, it allows the banks to erode and the stream to widen, it removes the roots which cause fine pools along the edges of the stream, and, finally, it causes the banks to dry out, and a good share of the humus to be removed. All these changes are brought about by the activities of man; our rather puny efforts to improve a stream by placing structures in it can never bring fishing back to its original state.

As was stated before, M.E.C.W. operations in the upper portion of the stream were abandoned and transferred to Twin Creek. About a mile of Twin Creek was worked and then the work was continued down the main river. The improvements from the "Box Car" down to the 63 Bridge were examined by walking the stream. Erosion control had been carried out on four sand banks in this portion of the stream. The type of work differed from that done on the Pere Marquette as brush was used on these banks.

The banks were covered with large alders laid so their butt ends were along the base of the bank. They were held in place by placing a pole across them near their butt ends and then holding this pole firmly in place by staking it down. The purpose of this brush is to break the force of rain, to hold the sand from sliding down, to prevent wind action, thus giving vegetation an opportunity to become established. While this method of control has not yet been throughly tested it was used with good results on the banks along the Pigeon in 1933 and it is felt that it will be beneficial.

The base of the banks, the point at which erosion actively takes place was protected with a wall of logs held in place by stakes. Short deflectors were built out from this wall at frequent intervals. The purpose of these is to direct the current away from the bank. Certain improvements could be made in these deflectors. It would have been better to have slanted them so they would be a good deal higher at the inner end than the outer end. In some cases they were left with an opening around their inner ends. High water will find its way through these openings and erode the bank. In all cases it is best to set the upper log back into the bank and to fit the lower logs as tightly as possible.

The structures placted directly in the river consisted almost entirely of submerged bank covers. These were well placed and very well built and should give good shelter for many years to come.

Beaver have been quite active in this section of the stream. They were first noted in the summer of 1933. Since that time they have cut a great many aspens and migrated down stream for several miles. Beaver cut many more trees than they ever utilize. Only a small proportion of the cut is utilized and for this reason it does not take them long to cut the aspens in the stream bottom. Since cutting done by beaver has much the same effects as cutting by man, it is apparent that they will bring about much the same harmful results that have been enumerated heretofore.

In the short time of one year these beaver cut an entire grove of aspen. They have now moved further down stream and are continuing their cutting. They have two dams at present. One of these dams has continually washed around one end and at the time of examination had widened the stream about 70 feet. There is every indication that

this process will continue. This and other physical changes brought about by the beaver are considered as distinctly harmful. Large amounts of sand are being added to the stream and large bottom areas are being worked over.

While observations were being made on stream improvements, the results of beaver activities and of beaver dam removal were also observed. To the writer the great weakness of the beaver control program is the fact that beaver quickly rebuild their dams. While a great number of dams have been removed, it is not logical to believe that the program can continue indefinitely or that funds will be available to so continue it. It is apparent that during the past fall many of the active dams have been replaced. If food is still abundant, the beaver usually rebuild at or near the site of the original dam, or, if they have thinned out the food, they usually build down stream. In addition the practice of removing dams is somewhat like locking the stable after the horse is stolen. If the dams are installed and allowed to remain for some time the unfavorable physical conditions are brought about before control is undertaken. It would seem that the best method of control is to remove the beaver from certain streams where their works are judged to be harmful.

Below the M-37 bridge the U. S. Forest Service has installed some improvement devices. These consist for the most part of wing and I deflectors, raft covers, submerged bank covers, rectangular center covers, riffle logs, and underpass deflectors. These structures are working well at present and they should hold fairly well. It would have been better if larger stakes had been used and the structures had been built somewhat stronger. The wing deflectors should have been embedded in the banks at their inner ends. As they were built only up to the bank, the water is going around their inner ends and eroding the banks.

Pere Marquette River

A portion of this stream was improved under the direction of Mr. Clarence Johnson in 1933. While the majority of the time was spent in controlling bank erosion, about 100 improvement devices were placed in the stream. These consisted of wing deflectors, bank covers, and raft covers. The upper portion of the work down to McDugalls, was

examined by floating down stream in a boat, while that below was examined by walking down stream. Below McDugalls all the structures were in place, but several in the upper section had been injured. Many of the deflectors had been raised by the ice and some had been destroyed. The stakes were pulled to such an extent, in many instances, that the logs were entirely above the surface of the water. The reason for this is due at least in part to the fact the deflectors were built high and were not banked on the upstream side. It may also be due in part to the fact the stakes were jetted into the stream bottom, as some believe that jetted stakes do not hold as well as those which are driven. Many of the bank covers were raised by the stakes being lifted but the covers fastened to trees or other structures on or along the banks have withstood the ice in good shape.

Due to the covering of snow the results of the bank erosion control could not be checked as closely as was desired, but it was possible to observe the gross results of the work. It is quite apparent that this work has already held back large quantities of sand which would otherwise have gone into the stream. On the whole, up to the present time, the work on the banks has been very successful. While all types of work with the exception of the chicken wire are holding well, it is judged that the use of the large pine logs as uprights on the face of the bank and the fastening of poles to them to form small terraces is the best method. At least this method was the only one used for Irwin's bank and this latter one appears to be inbetter condition than the others.

When the large bank near Kenney Creek was to be controlled, Mr. Johnson tried several suggested methods. Among these was the use of chicken wire on frames. This method has thoroughly demonstrated itself to be ineffective and unsatisfactory as it has not checked the erosion. However, it does give a measure of the effectiveness of the other methods and the amount of erosion they have prevented. The portion of the bank under the chicken wire has slipped off in large masses and the bank has eroded back about three feet. This erosion coupled with the action of a spring at the base of the bank has acted at least in part to bring about the destruction of the section next to it. This section was covered by mats made of poplar poles, suspended

on the bank. Many of these have broken loose and have lodged at the base of the bank. The other sections of the bank are in good shape. On the first bank to be controlled, step terraces were used. These are still all in good shape and holding well. The banks just below this on which brush was used are also holding well.

In addition to the demonstration of the value of the work through the failure of the chicken wire section, its value has been shown in another way. The bank just above the Kenny Creek bank was eroding in two places while the central portion of the bank was covered with vegetation and was judged to be in good condition. For this reason it was not disturbed, and the work was confined to the eroding sections on each side of it. Now the two portions of the bank which were protected are in good shape, while the portion which was judged to be in good condition has broken away and is sliding into the river.

The purpose of the various types of terraces and mats placed on these eroding banks was to hold the soil until plants could become established on them. It is felt that when plants become established and capture the banks, they will hold them in position. Thus in order to speed up the process, in addition to the mats, various grasses were sown and several kinds of shrubs and trees were planted. Of these the black locust appears to be growing best. On Irwin's bank and portions of the other banks they are abundant and will in themselves greatly aid in preventing erosion. Sweet clover appears to be the next most successful plant. It has grown well and should spread further over the banks. Many willows have grown on the lower parts of the banks but they have not done nearly so well as either the sweet clover or the locusts.

While the various methods used have been quite successful in holding the banks, the walls built along the bases of these banks to prevent erosion at the water line have not been so successful. The sand bags used behind the log walls quickly decayed and in most every case the water has almost completely removed the fill from behind these walls. In some instances the walls themselves have been destroyed. It is suggested that strong triangular crib deflectors, wing jams or slanting trees be used

as devices to keep the current away from the base of these banks. It has also been found that shingling the banks with stone from below water level to above the high water level is a very effective means of preventing erosion.

The West Branch of Big Creek was the next stream on which improvements were examined. The improvements in this stream consist of wing, V, and underpass deflectors, stumps, and bank covers. These structures have been sodded, but in many cases the sod has been partially removed. As a whole, the work has brought about a good deal of improvement in the stream. Springs have been cleaned out, beaver dams removed, and unfavorable chemical conditions eliminated; cover has been installed, and many fine pools have been formed. There are, however, a few improvements which might be made on the work. It is felt that the sod will not remain on the deflectors. Sodding the deflectors gives them a massive and solid appearance which in reality they do not have. This may be the reason the deflectors in this stream are rather light and loosely put together. They should have been built of larger material and should have been stronger. It would have been well also to bank them with logs, sticks, stones, and gravel on their upstream side to prevent undermining. The wing deflectors should have been embedded into the bank at their inner ends and kept lower at the outer end, so the water could not go around the inner end and erode the bank. Also deflectors should not be built higher than the banks. When sod was placed on the deflectors in this stream, it made many of them higher than the bank and forced the water around the inner ends, since they were not set into the bank.

The stumps which were installed in this stream have a natural appearance and they are doing good work. They were quite cleverly installed and since it appears that ice is not much of a factor in this stream, they should remain in place. The bank covers which are set solidly into the bank and covered with sod are very natural in appearance and look good. While they appear to be a little narrow, no judgment can be passed on them as yet.

In the lower section of the improved area the work consisted largely of the rearrangement of natural materials and the confining and clearing of the stream. A great many underpass logs were used. Since the stakes which hold these wer hidden by the use of three logs, they have quite a natural appearance. The digging logs which extend out from the bank are also doing good work and blend well with the surroundings.

The improvements placed in Hunt Creek resemble those in the West Branch of Big Creek to a certain degree, and about the same suggestions for their improvement apply. Perhaps the most important comment is that it would have been well to build them stronger. In the case of wooden structures, the logs could have been larger and the stakes larger and more numerous. The stone devices should have been made of larger rocks and they should have been carefully toed in place rather than piled. While the structures which were installed below the deflectors make fine riffles and form a pool, their value for cover is somewhat questioned. Formerly Hunt Creek was a swift, shallow stream with a uniform and level gravel bottom. For this reason the pools which have been produced should encourage larger fish to remain in the stream and thus bring about an improvement in the fishing. The stone V deflectors have produced deep holes as have also many of the other deflectors.

Ice action in this stream has damaged a very few of the structures, but it does not seem that the ice will be much of a problem in this stream.

The structures in Gilchrist Creek have been built much larger and stronger. Since, in places, the bottom of this stream is fairly easily eroded, many of the deflectors have produced deep pools. Stones have been used in the construction of many of the deflectors for the purpose of sealing them or building directors. When stones were not used, logs were often used for a seal. Where a seal was used, undermining has not been so pronounced and a better mucky area has been established. In every case where a V deflector was used in this stream, a deep hole has been formed.

The North Branch of the Au Sable presents a difficult problem for one who would improve it by the installation of various structures. It is excessively wide, uniform, and shallow. The structures which have been installed in the stream to date are of

two main types, namely, wing deflectors, and blunt A or wedge deflectors. These have as their purpose the narrowing of the stream or the dividing of the stream into two narrow channels. It is hoped by those in charge that the A deflectors will cause islands to form and thus produce two narrow and deep channels. While these A deflectors may build up islands in time, it is rather doubtful unless something more is done. The process of island formation can be greatly accelerated by placing a thick mat of brush over the bottom where it is desired to form the island. This brush should be securely fastened to the stream bed. The brush is for the purpose of catching and holding the more durable materials which the stream carries during flood time. While a thick dark deposit has formed behind these structures without the aid of brush, it is of such a loose, flocculent nature that it would be removed by a flood which would go over the top of the barrier. The crib covers which have been placed on each side of the stream just below the lower ends of the A deflectors have in some instances formed good pools, while in other instances they have filled up. In shallow water covers of this type generally become filled underneath. It is estimated that over half of these covers in the North Branch have partially filled.

The action of the wing deflectors differs from that of the A deflectors. The bars built up by a wing are usually of heavier, more solid materials, but as in the case of the A deflectors, if the channel is to be effectively narrowed by causing the stream to fill in behind the wing, it is necessary to cover the area where filling is desired with a thick mat of brush. Where this has been done in streams which carry sand, extensive bars 12 to 18 inches higher than normal flow have been built up in less than two years. Sedges and grass soon grow on these bars and thus aid in establishing them and making them permanent.

If bars are to be formed behind wing deflectors, it is desirable to form them as soon as possible, since in some streams such as the North Branch certain winter conditions are not favorable to fish life. Since the water is quiet behind the wings and there is a tremendous production of food in the mucky areas, there is quite a concentration of fish behind the deflectors. During periods of rather extreme cold,

ice forms behind these deflectors. While it becomes quite thick, it has not been known to freeze all the way to the bottom except in the North Branch. This may be due to the fact that the deflectors in the North Branch are extremely long and the water is very shallow. This winter after the temperature had dropped to 22° below zero, the water behind these deflectors in the North Branch froze solid and at least in some cases fish were trapped and smothered there. When warmer weather came, the writer found many dead fish behind the deflectors. These included trout, suckers, sticklebacks, minnows, darters, and lampreys. Organic material has collected behind the wings to such an extent that it amounts almost to natural pollution. The stream bottom in these sections is colored red, because it is literally a mass of red chironomid larvae. These would naturally attract the fish to these places where under conditions of extreme temperature many of them would be killed. Due to the fact that by far the great majority of the fish which were killed were non-game species and only a few trout were trapped, it cannot be said whether the results of these wings are harmful or beneficial. The great increase in food production might more than compensate for the few trout which are killed. At least further study and investigation is needed before any conclusions can be reached.

West Branch of Sturgeon River

The section of the West Branch of the Strugeon which was improved was formerly a very uniform, gravel bottomed stream. The stream was almost of uniform depth, having very few pools. There were no plant beds and practically no mucky area. The bottom was of a uniform grade of fine to medium gravel. Thus all the food which was produced in the stream was almost of the same type and there were very few suitable places for minnows and large trout. The improvements which were installed in 1933 were designed especially to produce plant beds and mucky areas, so that a diversity of foods could be produced, especially those suitable for young fish. These areas were also desired in order to make the stream more favorable for minnows. In addition to these quiet areas, fast riffle areas were made to produce rubble bottom areas for food production. Bank covers were placed where there were already pools and where pools were to be formed.

Since notes were taken on the conditions of the stream before improvement, rather detailed notes were taken at each recheck. A complete report on these rechecks will be given at a later date. At present it can only be said that this work has been more successful than any other in the production of mucky areas and plant beds.

The improvement of this stream was continued in 1934. During this season the greater part of the work consisted of stone deflectors. Very long directors were used to hold the flow in a narrow channel. Two dams were installed and numerous stumps were fastened in for cover.

While the two dams have made fine pools below them, sand is collecting in the quiet water above, reducing the productivity of large areas of the bottom. It is doubtful if these two good pools will compensate for the reduction of the food supply brought about by the collection of the sand. Since the bottom of this stream can be deeply eroded by an underpass deflector, it is questionable if the greater cost of the dams is justified.

When stumps are placed on a gravel bottom stream they usually cause a sand bar to form below them. It is doubtful if the pool formed under the stump will always more than compensate for the gravel area covered with sand. During the summer months the long directors on the stone deflectors cause large dark bottom areas to be formed. Since mucky areas are rich in food, a superficial examination would lead one to believe that the food had been greatly increased. Examination at other seasons, however, discloses that high water periodically removes about 75% of these mucky deposits. Thus in such a constantly changing habitat neither a mucky bottom fauna nor a gravel bottom fauna can be established. This results in a reduction in food production rather than an increase. If a mucky area is to be a benefit to food production in a stream, it must have a certain degree of permanence. For this reason it is best to use a director only 10 to 12 feet long and let the mucky areas be built up in high water as a result of the swirl produced around the end and behind the deflector.

While small stones were used for the structures and they were piled rather than fitted in place, they are nevertheless holding well since they were built wide at the base. Most of the structures are in good condition, and they should hold for many

years. It might be well to shorten some of the directors.

It had been reported that much of the early work in the Pigeon River had been removed by the Parks Camp and other structures installed. An examination shows that the Parks Camp did very little work and removed only five of the former improvements and used two others to hold their log jams. About all that was worked was the stretch of river which could be seen from the road. Since the trees which were placed in the stream were not solidly fastened, their stability is questioned.

With the exception of the first seven structures below the bridge on the Vanderbilt road, none of the structures have been modified in any way. The improvements installed in 1931 and 1932 are almost exactly as they were when checked in 1933 and 1934. Several of the improvements installed in 1933 went out due to the exceptional hard winter of that year, but since that they have not changed. Deflectors, stumps, bank covers, and wedge covers were not damaged during the winter of 1934-35.

The work installed by M.E.C.W. during the season of 1934 was examined that fall and again on this last inspection trip. The deflectors are in good condition--in fact, almost all the structures are in good shape. Since the winters have been mild following the installation of this work, it is not known how they will stand up under a severe winter.

The dam put in some distance above the ford has undercut and gone out. When dams are placed in Michigan streams, great care must be used to prevent undercutting. The submerged rectangular and wedge covers were placed in rather shallow water and thus it was necessary to place them very near the bottom of the stream. This has caused them to be almost totally ineffective as most of them have partially or completely filled up so it would be difficult for fish to get under them. The bank covers are still holding up well and giving fine cover. It is expected that they will become water soaked in a couple of years and then a few of them may become ineffective.

Beaver are still quite active on the Pigeon. In the last year and a half they have almost completely removed a large grove of aspen. They have almost totally removed the shade from the stream for 300 yards in one place, and they have also cut all the

trees some distance back from the stream. It is felt that they have distinctly harmed the stream in this section.

The improvements which were installed in Gamble Creek in 1931 were also examined on this last trip. Only 3 have been lost and the stream has been decidedly improved.

General Summary of Suggestions

In building log deflectors there are certain general rules which it is best to follow. These can be listed as follows:

1. Always build the deflectors lower than the banks of the stream and slope them so they are lower at the outer end.
2. Embed the deflectors well into the bank.
3. Protect the bank in the vicinity of the deflector by shingling with stone at least to the height of flood water.
4. If it is desired to create mucky areas and plant beds, carefully seal the structure with logs, poles, sticks, and gravel.
5. Place a large rock at the lower end to prevent the sealfrom being removed.
6. In streams where there is a decided tendency to undermine, use a hog wire apron to hold the seal.
7. Directors increase the efficiency of deflectors.

Many of the above suggestions also apply to the construction of rock deflectors. Others are as follows:

1. Keep the inner end higher and build it up gradually so it merges smoothly with the slope of the bank and extends to the height of high water.
2. Use the largest boulders available and arrange them in a line which defines the deflector. Then build up from these rocks as a base, carefully placing the rocks and toeing them in so they cannot be moved. Never pile the rocks.
3. Round the outer end of the deflector to prevent undercutting.
4. Seal with gravel and place a large boulder near the outer end of the wing to keep the seal from being washed away.

In regard to cover, it is well to use submerged structures whenever possible. The cross or holding logs of all bank covers should be embedded into the stream bank as far as they project into the stream. Seal these logs into the bank with gravel and tramp it well in place. Replace all sod.

On sandy bottoms use submerged structures for digging pools.

Use stumps when possible; but be certain provision is made to hold them where ice action is pronounced. Use judgment when placing stumps over a gravel bottom.

Do not build stone deflectors in sections having a deep sand bottom.

Use trees and slanting logs when possible to create pools and to give cover.

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