

Holland system the speed with which the necessary machines, etc. were transported to the site and the rapidity of the job was very gratifying.

Certainly one of the outstanding achievements, from an engineering point of view connected with the erection of emergency pumping equipment in the country, was the way in which plant was assembled and erected for the purpose of evacuating the flood water from Bourne South Fen & Thurlby Fen, enabling a crop to be obtainable this season. In this respect the Ministry of Agriculture & Fisheries, the Mid-Lincs Electric Supply Company and the London Metropolitan Water Board (who supplied the pumps) are to be congratulated on their ready co-operation.

It is interesting to note that, as near as can be computed, an area of about 53,000 acres of land in the Marsh and Fen was at one time or another under varying depths of water and a considerable number of houses were adversely affected.

As is usual in an emergency in the Fens of this type, the majority of the farmers and their employees gave yeomen service in defence of their lands against the floods.

The local N.F.S., the Commandants of the Prisoner of War Camps and the W.V.S. (in serving hot drinks to the workers) - all of them are to be thanked.

The Police carried out all my requests with promptitude and dispatch and are much to be commended for their services.

Transport operators and local tradesmen also played a very important part, co-operating both with this department and their own colleagues during the emergency.

Thanks are also due, in no small measure, to numerous volunteers who undertook, to the best of their ability, any

Engineer's Report

on

1947 FLOOD

within the areas

of

THE RIVER WELLAND CATCHMENT BOARD

and

THE SOUTH HOLLAND LAND DRAINAGE BOARDS

Dated -
May 1947.

Engineer's Office,
Deeping House,
Welland Terrace,
SPALDING, Lincs.

INTRODUCTION

This report is prepared with the view of presenting to various interested people a picture of the operations carried out in this area combating the flood during March and April of 1947, which has affected in various degrees the whole of the country. For your information the Boards coming under the control of the Engineering Administration of Deeping House, to which reference is made in the report, are as follows:-

River Welland Catchment Board.

Deeping Fen, Spalding & Pinchbeck Internal D.B.

South Holland Drainage Board.

South Welland Internal Drainage Board.

South Holland Embankment Drainage Board.

Holland Elloe Internal Drainage Board.

Holland Elloe Court of Sewers.

DESCRIPTION OF AREA

The total area of the Catchment Board is something in the order of 400,000 acres and the remaining Boards in total aggregate something in the order of 150,000 acres of land, partly within the Welland Catchment Board area and partly outside its boundaries. The nature of the land in the Marsh and Fen varies, but in all cases it is low lying and for the main part is composed of silt, and I think that without contradiction it can be said to comprise some of the most valuable agricultural land within the country.

SCOPE OF REPORT

The total length of watercourse under the direct control of the office aggregates something in the order of 1,000 miles and when one considers this fact, together with the considerations of the importance of the area and all its complicated subsidiary drainage works, it will be appreciated that this report, to be reasonably comprehensive, must of necessity include a great variety of information. An effort however has been made to present a general picture of the operations as it affects the whole area rather than making a number of detailed statements running to a great length, and I also feel that it is more satisfactory, and at the same time presents a more comprehensive grasp of the situation, to deal with the matter collectively rather than by a number of separate reports on the activities carried out in each particular Board's area as they were of course completely inter-dependant.

THE EVENTS CULMINATING IN THE FLOOD

The abnormal flood conditions experienced throughout the country as a whole were due to a multitude of causes, the year 1946 was, from a point of view of rainfall, the wettest year since 1927, and during the period from 1868 to 1945 there were only seven years where a greater quantity had been recorded. The average values show over England and Wales during 1946 a rainfall of 6.7 inches above the average in a year. In November it was a particularly wet month and this was followed by unsettled conditions in December, and early in 1947 extremely heavy falls of snow and a heavy frost were followed by a very quick thaw, and

almost at once the country was experiencing perhaps the worst flood conditions within living memory.

The train of events in so far as this area was concerned followed, in general form, that of the remainder of the country. As we all know from bitter experience a considerable amount of snow and freezing conditions were experienced during January, February and the early part of March in 1947, this being preceded during the last five months of 1946 by rainfall totalling in excess of 15 inches and the period was followed by a very rapid thaw, accompanied by very nearly one inch of rain on the 12th and 13th of March.

In the Fen and Marsh areas the icing conditions have been so severe that many of the main and subsidiary watercourses were virtually solid with frozen snow and ice and it was impossible for any water, resulting from the first stages of the thaw or the heavy rainfall previously mentioned, to gravitate to its normal outfall. The fact that the thaw was accompanied by this rain also meant that a very high peak run-off was experienced as the resultant water was flowing over frozen ground without any infiltration whatsoever, and as soon as the thaw became fully established the thawing of the water content of the ground was another thing contributing partly towards the problems of the flood, in so far that it helped to create another flood peak in the watercourses dealing with highland water.

The foregoing will, I think, give some idea of the circumstances which led to the flood of unprecedented proportions which began to make itself felt to a serious degree in this area by the 12th March 1947.

THE FIRST STAGES OF THE FLOOD.

On Wednesday the 12th March water was beginning to collect in the flat areas of the district owing to the fact that the thaw could only affect the surface of the snow and in many cases miles of drain were literally frozen solid to land level, with the inevitable result that the water had no path of escape from the land on which it was lying.

By Thursday the 13th March the situation in the Marsh and Fen district was becoming really serious as the thaw conditions were very greatly aggravated by the rainfall of the previous day, which amounted to something in the order of $\frac{3}{4}$ of an inch. At this time however the highland rivers in their upper reaches were behaving in a manner rather similar to a normal flood and this phenomena can be accounted for, to some degree, by the fact that practically the whole of the flood water being dealt with was resultant upon the previous days rainfall and the fact that the water was moving, whereas in the relatively flat areas it was, of necessity, impounded.

At this time considerable concern was being experienced as to the stability of many structures, banks, etc. owing to the "explosive action" of their water content becoming frozen during the long frost, and the thaw now having the effect of removing the cohesion owing to ice. The first structure to fail was the Bell End Bridge over the Little Holland Drain and immediate steps were put in hand for the erection of a temporary structure to open the normal traffic communications.

During the course of the first days of the flood period as has been previously mentioned, one of the greatest difficulties was the fact that drains were frozen

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to land level and various devices were put to operation for dealing with this ice and frozen snow, including hand labour methods with a variety of tools, tractors and/or horses towing balks of timber and trees, dragline work etc, and in particular I would like to mention the following experiments which showed some very good results as far as they went. In one case two track laying tractors were used in parallel with a cable suspended between the two of them and from this cable a variety of objects were suspended so that with one tractor moving on either side of the drain a path was broken along the line of the watercourse, this method had the advantage over single tractor operations as the position of the tow-weight could be determined with some degree of accuracy and its depth of cut could also be determined by having the tractors relatively close together for a reasonably deep cut and wide apart for a relatively shallow cut. I might add that this method was only practicable in areas relatively free from obstruction and it was subject to certain delays where side drains joined the watercourses which had been dealt with. With regard to draglines, the ordinary operation of the dragline was successful but slow and in some cases a dragline was loco'd with the head of the jib over the line of drain with the object of clearing frozen snow, but this method for a variety of reasons was not used very extensively. There was one thing however with which a dragline could deal in a more satisfactory manner than any other tool that was tried and that was anchor ice which in some districts assumed quite serious proportions. One further improvisation is I think worthy of mention, namely the outrigging of a device similar to a mole plough from an angledozer blade which in effect drew a mole drain along the line of a

frozen watercourse. One of the difficulties of this particular tool was to get a satisfactory "rig" and the other was that if a sudden obstruction was met by the mole plough device the fact that it was so far offset from the tractor created very great difficulties from a point of control and on a number of occasions tractors with this type of device on them, not necessarily exactly as described, got into very serious difficulties through being thrown off their normal path.

I think it would be opportune to here mention a fact that is not generally appreciated. One of the greatest difficulties when thaw conditions are starting is that if the drains are opened up in an indiscriminate manner ice will be carried by the flow of water, and the chances are that if there are local obstructions "mushing" will occur with the result that a permanent closure of the drain is made at that particular point. In particular, every effort must be made to prevent ice flowing in drains which are evacuated by means of pumps, as it is virtually impossible to keep the normal trash rack clear of ice unless it is in some way restricted and it is obvious of course, that if the trash racks are completely iced up no water can be pumped.

During the early part of Thursday most of the flooding trouble was being experienced in the Marsh and the Fen area and to mention only a few cases where difficulty was experienced would be somewhat invidious but in all probability the worst affected were the following:-

The Hurdletree Bank area where potato graves were at the mercy of water owing to the long feeder drains being

iced up, houses in the Weston and Moulton district, the Pennygate and Hereward Estate district of Spalding.

During the afternoon the Carr Dyke was overflowing and discharging quite a considerable quantity of water into Bourne South Fen, and this might with some truth be said to be the real beginning of the extensive flooding which was experienced in that particular Fen. Another district in which trouble was experienced during the day was at Towngate near Market Deeping where a considerable quantity of water was coming down from the rather higher land and through Towngate into the Fen, making the whole of that district, and Towngate in particular, difficult from a point of view of transport and impossible from a point of view of agriculture.

During the afternoon and evening the upland rivers were beginning to show signs that the recent weather conditions were definitely going to produce something fairly extensive in the way of a flood. The Glen and Gwash were beginning to put water in fairly large quantities into the embanked part of the rivers and a very heavy discharge on the main River Welland was being experienced in the Rockingham district during the afternoon, and as the night progressed critical water levels in many places were reached, the "upland" valleys becoming extensively flooded.

The first extensive cradging to be done was on the Carr Dyke but in spite of every effort to raise the level of the bank protecting Bourne South Fen and Thurlby Fen a considerable quantity of water was not contained, it was fortunate however that the sub-catchment of this particular portion of main river was relatively steep and of a local nature, as a result by mid-day of Friday the water level in

the water-course in question had dropped by about 3ft. and cradging was no longer necessary.

THE HEIGHT OF THE FLOOD.

On Friday the 14th at 9 o'clock in the morning the River Welland had risen to a gauge reading of 23ft. 9ins. at Market Deeping Bridge and the River Glen had risen to a gauge reading of 22ft. 9ins. at Kates Bridge whilst at Stamford Bridge the River Welland level was 72ft. 2ins. By noon the peak flow in the Welland had passed Rockingham Bridge and a 3 inch fall had taken place and by 7.30 at night the peak level of 73ft. 6ins. was reached at Stamford Bridge with an estimated discharge slightly in excess of 4,000 cu.secs. from an area of about 135,000 acres, which represents a run-off of approximately 30 cu.secs. per thousand. By Friday evening the Glen had passed its first peak of 23ft. 7ins. at Kates Bridge and it was hoped that once the water level in this particular system had started to fall serious troubles within the Glen would not be again evident, but, as this report goes on to show, this hope unfortunately was not fulfilled.

Probably the worst trouble during this particular day, and the possibility of a major flood developing being also associated with this particular area, was throughout the length of Deeping villages where water was flowing in considerable quantities into Deeping Fen and the Maxey area from the main river. Practically all the roads in Market Deeping and Deeping St. James were flooded in many cases being virtually impassable, and from early morning efforts were being made to cradge against the rising water level but

although this work did much to restrict the quantity of water flowing into the Deeping Fen system it was impossible to keep pace with the rising river level. One of the difficulties of the particular operation was the fact that all the land within the immediate district of the bank was flooded so that "borrowed spoil" was practically unobtainable locally, and the fact that the roads were flooded made transport of filled bags to the site a virtual impossibility. The most satisfactory way of dealing with the particular problem was to bring in loads of material which were dumped in heaps at strategic points to serve as bases to fill bags for cradging, and a number of such points were established. In the lowland areas, water was beginning to move during Friday and as an example of this a reasonably steady water level could be obtained with two pumps running more or less continuously at Pote Hole, a state of affairs which had not, until this time, existed with the result that very little pumping had been done. The Fourth District Pumping Station was now running to full capacity and the water level in the main drain was steadily rising in spite of 100% running at the pumping station. In the Marsh areas frantic work was still proceeding in an effort to clear some of the main drains and the effect of this work was beginning to make itself felt to a small degree in one or two areas, but there were still large districts where water levels were uncomfortably high and in many places appreciably above ground level.

The South Holland system by this time was also beginning to receive considerable quantities of water in the Main Drain where once water had found its way into the Main Channel no appreciable trouble was being experienced, and it is fortunate that the Improvement Scheme, which has been in hand for some while on this particular area, had

progressed to such an advanced stage that it was capable of affording some very considerable benefit to the district as a whole.

By 10 a.m. on Saturday the 15th March the River Welland level at Market Deeping Bridge reached a peak of 24ft. 4½ins. but by 6.30 at night this level had dropped to 23ft. 11ins. and during the whole of the day men were still engaged on cradging work throughout the Deeping district. This steady fall in water level was maintained through the Saturday night and early Sunday morning and it was hoped that this river had now passed its worst but again, as in the case of the Glen, the hopes of a complete respite from the flood were ill-founded, a second peak being experienced at a later date.

During the day the water level at Kates Bridge dropped by a few inches and at 6.30 at night was down to 22ft. 11in. With this water level some trouble was still being experienced in the embanked section of the Glen and in a number of cases water was coming through the bank, in the majority of cases however the quantity was not particularly high and it did not appear that the bank was eroding seriously and in no case during this first peak did the water overtop the bank level.

The high water level experienced at Market Deeping on the Welland however was creating, and continued to do so for several days, a very serious situation in the Deeping villages and the upper end of Deeping Fen. The water from the Welland was continually feeding the area in the Cross Drain district of Deeping Fen and cradging was put in hand along certain sections of the Cross Drain in an effort to prevent the flood water from inundating the centre of the Deeping Fen Area.

During Sunday the 16th. water levels in both the River Welland and the Glen at their points of entry into the Fen, namely Market Deeping and Kates Bridge, remained more or less stationary and in fact if anything the tendency was for them to fall by an inch or so during the course of the day. The Marsh area was beginning to free itself to some degree of ice, and the drains were beginning to flow although no actual relief from flooding was experienced owing to the fact that the thaw coupled with rainfall was still providing more water than the quantity with which the drains could cope satisfactorily. Some of the plant engaged on snow and ice clearing had been working through the nights with the assistance of flares and lamps where it was possible to provide them, and by Sunday some of the machines were equipped with emergency lighting sets to enable continuous work to proceed more satisfactorily in an effort to further speed the snow and ice clearing. The Deeping Fen area was also beginning to thaw out and the Pote Hole Pumping Station had a full load at a reasonable water level for the two largest pumps by about mid-day and this was the prelude to the longest run ever recorded at that particular station. The 4th District was by this time beginning to get additional water into the area by seepage through the River Glen bank, and although the quantity getting into the Fen by this means was at this time not serious by way and comparison with later standards, it had given some indication of what might be expected during the course of the next few days. It should be remembered that as has been mentioned on a number of previous occasions, the Glen usually peaks rapidly and then falls off equally rapidly from a point of discharge, but the Glen banks were by this time beginning to show some signs that they were

weakening as a flood of fairly high proportion had been imposing a load on them for the last five days, and it was anticipated that as time passed the resultant infiltration through the banks would in all probability worsen, with the consequent detrimental effect on the flood position on the whole of the Fens under their command. Throughout the day on Sunday, water levels in the whole of the Fen and Marsh area were rising steadily thus covering further areas of land which had previously been relatively dry, and the water level in the Crowland and Cowbit Wash was also rising slowly reaching 16ft. 5ins. O.D. Liverpool by mid-day and this level had risen by a further inch at 5 o'clock in the afternoon. The ice formation on the Washes which had not yet broken up as a result of the thaw was beginning to create a serious problem with the water level at this height, in many cases some fretting of a moderately serious nature was experienced and this situation became very much worsened as the result of the unprecedented gale which was experienced during the Sunday night.

The gale had a very far reaching effect on the flood situation which might not at first be fully realised, besides creating the usual difficulties such as blowing trees out of banks, ice being wind whipped to cut batters etc., practically every telephone line in the district was affected, this fact alone making the normal methods of communication for the next few days an absolute impossibility except in a few odd cases. The telephone system was upset to an appreciable extent for several days further, with the inevitable result that many messages had to be delivered by "runner" and in a good many cases messages failed to get through for some appreciable time with consequent waste of time and effort.

During the Sunday it was quite obvious that water levels in the Crowland and Cowbit Wash would reach such a height that they would create some difficulty in so far as the stability of the high level banks was concerned, and it was also anticipated that the town of Spalding would be subject to the possibilities of extensive flooding as the result of water first of all backing up in the surface water system of the town, and secondly, over-topping the banks in some places.

By Monday the 17th in the early morning the situation so far as flood water at the upstream end of the gravitational systems in the Marsh area was concerned was to some very small degree improving because by this time the thaw had been in progress for a sufficient period to allow some relief to be obtained from the blocking of drains with ice and snow. A typical example of this was that on Tuesday and Wednesday the 11th and 12th the water level at the upstream end of the South Holland Drain (Wheatmere Sluice) was in the order of 5 O.D.N. and this very slowly fell until by Monday March 17th at mid-day it was something in the order of 4.25. This illustration shows that where a gravity system was employed, as distinct from a pumped area, once the drains began to move some benefit was immediately forthcoming, but perhaps the illustration might be misleading if it is not borne in mind that the South Holland Drain, although its upstream end is not yet completed from a point of view of improvement, is one of the largest in the lowland system controlled from the office and it was, of course, some time later than the above dates when the long feeder drains with smaller cross sectional areas began to feel any appreciable benefit from a point of view of water levels giving an adequate freeboard. It might be well to add that the