IRISH-DUTCH PEATLAND STUDY
GEOHYDROLOGY AND ECOLOGY

- O. P. W. Wildlife Service, Dublin
- Geological Survey of Ireland, Dublin
- Department of Nature Conservation, Environmental Protection and Wildlife Management, The Hague
- National Forest Service, Utrecht

HYDROLOGICAL REPORT ON IRISH BOGS

FIELD WORK ON CLARA BOG AND RAHEENMORE BOG

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MARCH 1990

Sketch of Clara Bog by Catherine O' Brien, Clara, County Offaly.

A PRACTICAL PERIOD ON IRISH BOGS.

REPORT OF THE HYDROLOGICAL FIELD WORK ON CLARA BOG AND RAHEENMORE BOG.

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March 1990.

ACKNOWLEDGEMENTS.

To Jos Schouwenaars, thanks to whom I got involved in this project, Roel Dijksma and Marco Glastra for their physical and mental support during the installation of the equipment in the field. To Anton Dommerholt for his assistance during the work in the lab. To Jan Streefkerk for his help to get things started in Clara. To all the technical supervisors in Ireland, John Cross and Jim Ryan of the Research Department of Wildlife Service, Donal Daly and Willy Warren of the Geological Survey and Mathijs Schouten, who were very helpful and were willing to share their knowledge and experience of bogs with me. To the Wildlife officers Pat Warner and John Flynn for their help to make my stay in Clara as comfortable as possible. To Wildlife ranger Jim Moore for his assistance in the field and for his lessons about bogflora and -fauna while doing this work. To Jimmy Rabbitte for all his help to supply us all the things we asked for. To the local pubowners (especially Tommy Dolan) for their hospitality in the evening time. To Nico for letting me use his personal computer. And finally to my fellow students in the house (Annemieke, Frank, Lara, Marco, Marieke, Mary and Richard) for making my stay in Clara as nice as it has been; I wish them all the best and good luck in finishing their research.

CONTENTS.

CHAPTER 1 : INTRODUCTION.

My four months stay in Clara was part of my study Cultuurtechniek at the Agricultural University of Wageningen. This practical period consisted mainly of field work and some data elaboration. The field work was part of a bog research project on two nature reserves, Clara and Raheenmore bog. These are two living raised bogs of international importance. Because in the Netherlands all the raised bogs have been exploited and cultivated (except for some small remnants), the Dutch are very interested in doing research on a still living bog. The goal of this jointly Irish/ Dutch project is to get to know more about living raised bogs and the possibilities of restoration of remnant bogs. On advice of Jos Schouwenaars and Jan Streefkerk, I installed different types of equipment on the bogs. The purpose of this equipment is to be able to deduce a water balance. In order to do this, data have to be collected during the whole period project and have to be analysed.

CHAPTER 2: THE HISTORY OF A RAISED BOG.

The landscape in the Irish Midlands about 9000 years ago was determined by a meandering river which fed into a series of depressions in the underlying limestone. In these depressions the limestone was sealed over with a impervious claylayer and thus forming several small lakes. In the shallow waters of these lakes fed with mineral-rich alkaline water, the conditions became more stagnant once the first plants like pondweeds began to grow. These new conditions provided the first anaerobic spots in which peat formation (partially decayed organic matter of plant origin) could commence. The remains of these plants accumulated on the bottom of the lake until the water was shallow enough to allow the growth of for instance bulrush and common reeds (emergent perrenial plants). Eventually the water became so shallow that other plants like small sedges took over, together with brown mosses. These mosses formed a carpet which could float on the surface at times of high water. This floating mat gradually elevated the surface vegetation above the effects of groundwaterflow and acidic and other products began to accumulate. So the whole chemistry of the system changed, as did the vegetation. Bogbean and later on slender sedge, bog cotton and certain bog mosses started to grow. The surface kept on rising and the final changes began to take place and hummocks of bog mosses started to dominate the vegetation. This vegetation was solely dependent on rainfall. So the whole habitat soured and only the most perfectly adapted plants survived. Then about 4500 years ago the annual rainfall decreased so that the peatsurface dried out. Trees like birch, alder and pine started to grow and a wood or forest peat was formed. This lasted for some 500 years and then the climate became wetter again and the trees disappeared.

Schematically there are four different stages of a raised bog (Bellamy, 1986):

1. lake peats with mineral-rich open water and an aquatic or floating vegetation and later on reed vegetation;

2. fen peats with flowing groundwater and a vegetation characterized by sedges and brown mosses;
3. poor fens, an intermediate between true fens and real bogs with mineral bog mosses;
4. real bog, solely dependent on rainfall and characterized by a poor sour vegetation.

The next figure shows the schematic development of a raised bog:

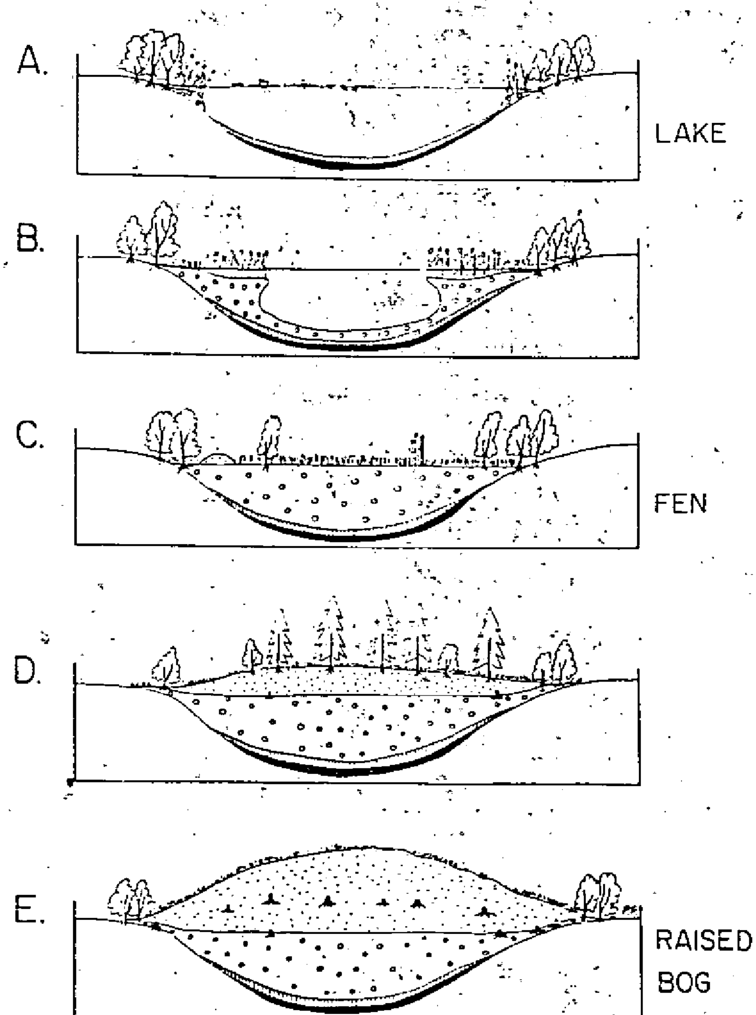


Figure 1: the developmental stages from a lake to a raised bog.

CHAPTER 3: RESEARCH PROJECT ON CLARA BOG AND RAHEENMORE BOG.

The Wildlife Service of the Office of Public Works, which owns Clara and Raheenmore bog since 1986, and its Dutch counterpart Staatsbosbeheer and Natuur-Milieu-Faunabeheer (N.M.F.) are undertaking a research project on these two nature reserves. The work, which started in October 1989, will take three years and is jointly funded by the Irish and Dutch governments.
Clara bog is an unique type of raised bog with its soaksystem (an open water on the bog) and well developed hummock and hollow systems. The total area of this bog is about 670 ha of which 460 ha is protected by the Wildlife Service. Raheenmore bog is a good example of a raised bog in a deep basin (the thickness of the peatlayer is estimated more than 15 metres in some parts).
The Irish goal of this project is to acquire various bogs with a sound hydrological management as nature reserves. The general idea is to make a hydrological advice for the purpose of reservation and management of raised bogs. This will de done by combining the Irish knowledge and experience in intact raised bogs combined with the Dutch knowledge about restoration and hydrological management of remnant bogs. The Dutch participators are particularly interested in the hydrology of intact raised bogs for the restoration of the remnants bogs in the Netherlands, which are also raised bogs.
The hydrological problems are of two kinds: the management and the conservation of the bogs. To be able to achieve a sound hydrological management, it is important to know the effects and damage done by ditches on the bog, deep ditches on edges of the bog and by the cutaway-areas. The three most important conservation problems are the lack of specific hydrological knowledge regarding bogsystems in general, the effects of hydrological interventions and the possibilities of restoration of that bogsystem in particular. Therefore the idea is to examine about the general bog hydrology, the soaksystem, the functions and restoration of

laggzones and the minimum size of bog remnants. For the Dutch restoration projects matters like the conditions on Sphagnum growth, the hydrological balance on living bogsystems and the hydro-chemical characteristics of living bogs are very important. Once a good impression of the hydrological conditions and the chances of survival of raised bogs have been acquired, this knowledge can be translated to the Dutch situation.

CHAPTER 4: THE WATER BALANCE.

4.1: In general.

To be able to deduce the water balance, the incoming water and the water that flows out of the bog have to be measured. Such a water balance will be made for two catchment-areas, whose boundaries will be determined by the leveling of the surveyors. The incoming water is solely the rainfall. The amount of water that flows out of the bog superficially is measured with two weirs (V-notches). To determine the evaporation, data from the meteorological station in Birr are used. The different terms of a water balance are:

$$P - E_a + S_u - S_d - R_o = S_t$$

P = precipitation; E_a = evaporation; S_u = upward seepage; S_d = downward seepage; R_o = run-off; S_t = storage.

4.2: The rainfall.

The average annual rainfall is about 850 mm in the Midlands (according to the meteorological station in Birr). To get a more detailed impression of the rainfall during the year, four rain-gauges have been installed. Near the two V-notches automatic recorders have been installed and near each of the two surface water recorders a manual raingauge has been installed. The automatic recorders both have a circulation time of 8 days and therefore the charts have to be changed every week. The one in Clara bog is a Tipping Bucket recording totals of 0.2 mm. This Tipping Bucket, which has a diameter of 8 inches, is connected to an Event Recorder. The automatic raingauge in Raheenmore, which also has a diameter of 8 inches, registers and collects the rainfall. After 10 mm of rain, the recorder empties itself by a syphon and the water flows into a bottle underneath the recorder. At the end of the week the content of the bottle is measured as a check on the accuracy of the registration. The two manual raingauges have a 5 inch diameter and they are measured every week. The height of each recorder is about 40 cm above the peat-surface (standard height).

4.3: The weirs.

The amount of water coming out of the catchment-areas is measured by means of a weir. Because of its shape, this weir is also called a V-notch. A foundation has been made because this V-notch has to be balanced. This foundation exists of two rainpipes filled with concrete, which are standing on the mineral soil underneath the peat. To prevent any form of leakage, the V-notch has been connected to a piece of plywood (3*2 m) and this plywood is standing in a drain (see figure 2). The discharge of this drain is (or should be) the only water coming out of the catchment-area of the bog.
The discharge is measured by means of a stilling well. This stilling well is a SEBA waterlevel recorder standing on a foundation (see figure 3). The idea is that this recorder measures the waterlevel in a perforated tube (diameter 4 inch) standing in the drain. Because the waterlevel at the V-notch is the same as the waterlevel at the recorder, the waterheight (H) above the V-notch is actually known.
The relation between the waterheight and the discharge is known because the weirs have been tested in the lab. This relation is called the QH-equation. Because the two weirs have a slightly different shape, the equation is somewhat different for each weir.
The equation of the weir in Clara is:

$$\text{Log } Q = 0.3333 + 2.7522 \text{ Log } H + 0.1331 (\text{Log } H)^2$$

(H in m, Q in m^3/sec).

The equation of the one Raheenmore bog is:

$$\text{Log } Q = 0.2466 + 2.5081 \text{ Log } H - 0.0398 (\text{Log } H)^2$$

(H in m, Q in m^3/sec).

For the total results of the tests, see appendix IV.
The automatic waterlevel recorder has a circulation-time of 16

days. The time mechanism is an electrical clockwork, which is battery-powered in Clara and has to be wound in Raheenmore. The scale of the charts was at first 1:5 (1 cm waterrise on the chart is 5 cm waterrise in the drain). Recently the gears have been changed and the scale is now 1:1. This is more accurate but it can only register 25 cm water rise or fall. So when the waterlevel starts to rise quickly after some heavy rainfall, the chart has to be checked regularly.

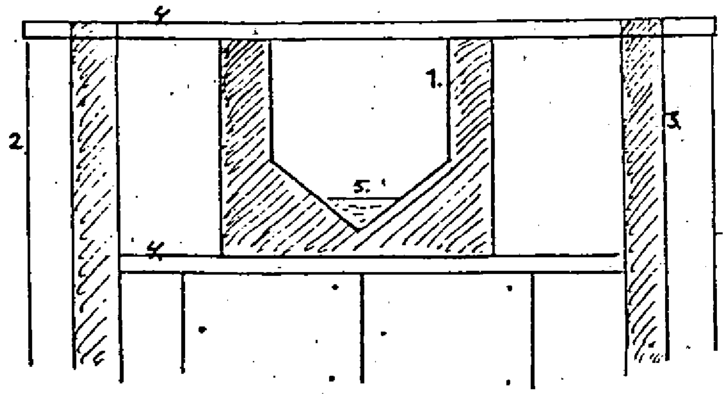


Figure 2: the V-notch.
1: the weir; 2: the plywood; 3: the foundation pipe; 4: the iron bars for support; 5: the overflow.

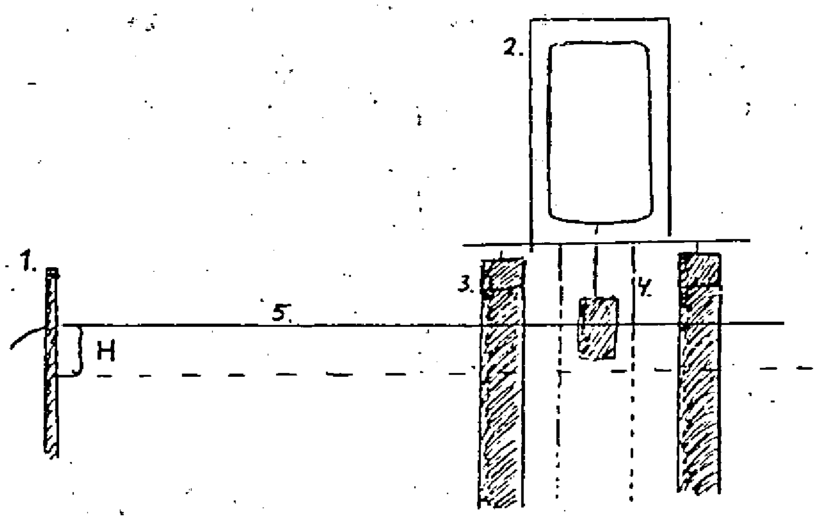


Figure 3: the stilling well.
1: the weir; 2: the recorder; 3: the foundation; 4: the float; 5: the waterlevel in the drain.

4.4: The flow meter.

To measure the discharge of the second drain on Clara bog, a flowmeter has been installed. This is a device through which the water flows. This water passes a propeller and by the rotation of this propeller a counter registers the discharge. The relation between the measured and the real discharge has been tested in the lab. For the results, see appendix IV. To prevent dirt from coming into the propeller, a filter has been installed in front of the flowmeter. The situation is shown in figure 4.

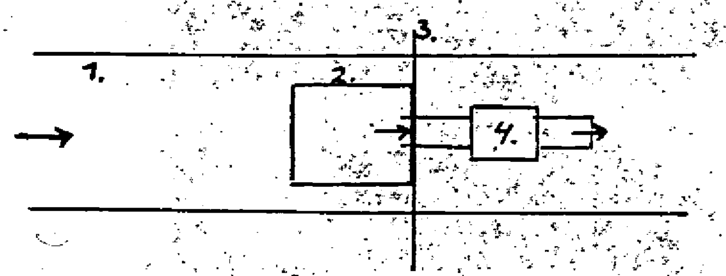


Figure 4: the flowmeter.
1: the drain; 2: the filter; 3: the timber; 4: the flowmeter.

In wet conditions far too much leakage occurs beside this flowmeter, this is why a new dam has to be digged. To find the exact location of this dam, the area on the east side of the flowmeter has to be leveled as soon as possible.

4.5 The surface water recorder.

On Clara bog as well as on Raheenmore bog another automatic recorder has been installed: an OTT waterlevel recorder. The purpose of these recorders is to get a continuous registration of the surface water level on those spots. In Clara the recorder is situated near the soak (together with a raingauge) and in Raheenmore the recorder is located in transect C-C' near piezometer 206 (again together with a raingauge). Due to the fact that a clockwork with a circulation time of 16 days was not available, the circulation time of the one on Clara bog is 32 days and the one on Raheenmore bog is 8 days. The scale of registration is in both cases 1:2 (1 cm on the chart is 2 cm waterrise in the tube).

CHAPTER 5 : THE PIEZOMETERS AND PHREATIC TUBES.

5.1 What they are made of.

All the tubes that have been installed on the bogs are hand-made. They are made out of plastic tubes with a diameter of 1 inch (about 2.5 cm). In these tubes holes of a diameter of 5 mm have been drilled with an electric hammer-drill. Each tube rises about 25 cm above the peat surface.

The piezometers are perforated with about 50 holes for 15 cm, beginning 3 cm from the bottom of the tube. The depths of the piezometers are 1.5 m, 3.0 m and 4.5 m. In some cases the piezometer is standing on the mineral soil underneath the peat. In that case the depth of the piezometer is the same as the thickness of the peatlayer. In the transects on the bogs, piezometersets have been installed. Each set contains a phreatic tube and three or four piezometers. For instance piezometerset 206 at Raheenmore contains:

206A: phreatic tube;
206B: piezometer 1.5 m below the peatsurface;
206C: piezometer 3.0 m below the peatsurface;
206D: piezometer 4.5 m below the peatsurface;
206S: piezometer standing on the mineral soil,
in this case 6.6 m below the peat surface.

The bottom of the tube is protected against dirt by a cap. The perforated part of the tube is protected by a nylon stocking (see figure 5).

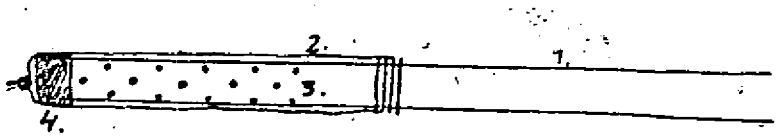


Figure 5: the piezometers.
1: the tube; 2: the stocking; 3: the perforated holes; 4: the cap.

The phreatic tubes are made in the same way as the piezometers except for the fact that they are perforated for the whole length of the tube. About 150 holes have been drilled in these tubes.

5.2 The phreatic tubes in Clara-west.

The phreatic tubes in this part of Clara bog are situated around the soak. The purpose of these tubes is to find out whether or not there is a relation between the different types of vegetation and the surface waterlevel during the year. Therefore Mathijs Schouten (Dutch ecologist) indicated 11 spots each with a different type of vegetation. On these spots phreatic tubes have been installed, which are being measured every two weeks.

5.3 The phreatic tubes in Clara-east.

Just before the Wildlife Service was able to buy Clara bog (1986), Bord na Mona drained the whole eastern part of Clara bog. The distance between these drains is about 15 metres. In 1989 most of these drains were blocked with peat from the toplayer. The first impression of this work is satisfactory; there is a clear difference in waterheight on both sides of the dams.
To get an impression of the surface waterlevel during the year and the shrinkage of the peat between these drains, 45 phreatic tubes have been installed. These tubes are situated in three different plots (wet, medium and dry) to see if the consequenses of the drainage are the same in those three area's. Because of the movement of the tubes with the rising/shrinking of the peatsurface, the tubes have to be leveled regularly. Therefore three reference points have been made (each standing on the mineral soil) from which the tubes can be leveled every month. The waterlevel in the tubes are measured every two weeks. The position of the tubes between the drains is shown in figure 6. The location of the three plots is situated on the map (Appendix I). Plot A is the wettest, plot B the medium and

plot C is the dryest.

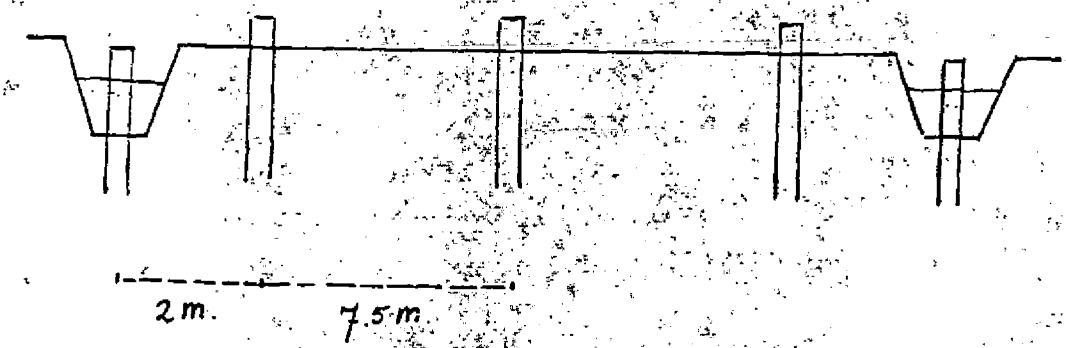


Figure 6: the five phreatic tubes between two drains in Clara east.

The first impression is that the differences between plot A and B are not that big. The thickness of the peatlayer in these plots varies from 10.30 and 10.20 metres in plot A and B to 6.60 metre in plot C. These thicknesses have been measured at the reference points (AR, BR and CR) in the centre of the plots.

5.4 The transects.

On both the bogs transects have been made. These transects contain several piezometersets and phreatic tubes situated from the edge of the bog to the centre of the bog. At the edge the distance between the piezometers is smaller because the variation in the waterhead of the different peatlayers is bigger. At about 40 m from the edge, the influence of the cut-away area or the ditch probably is far less. The purpose of these transects is to analyse the watermovement in the different peatlayers.
The first two transects are situated in the catchment-area of the weir in Clara-west. The form of the transects is crossshaped to get a better impression of the effects of the cut-away areas on the pressure head. In the transects the piezometersets are alternated

with phreatic tubes. The numbers of the tubes and the distance between them are shown in figure 7. Appendix II will give a more detailed picture of all the piezometers in the transects.

The third transect, which is situated on Raheenmore bog, is much larger, but the distance between the tubes is also much larger because the horizontal gradient of the pressure head is expected to be smaller. This transect is linked up with an old transect (1987) of the Wildlife Service. This latter transect has a total length of 1000m all across the bog and contains 46 piezometersets.

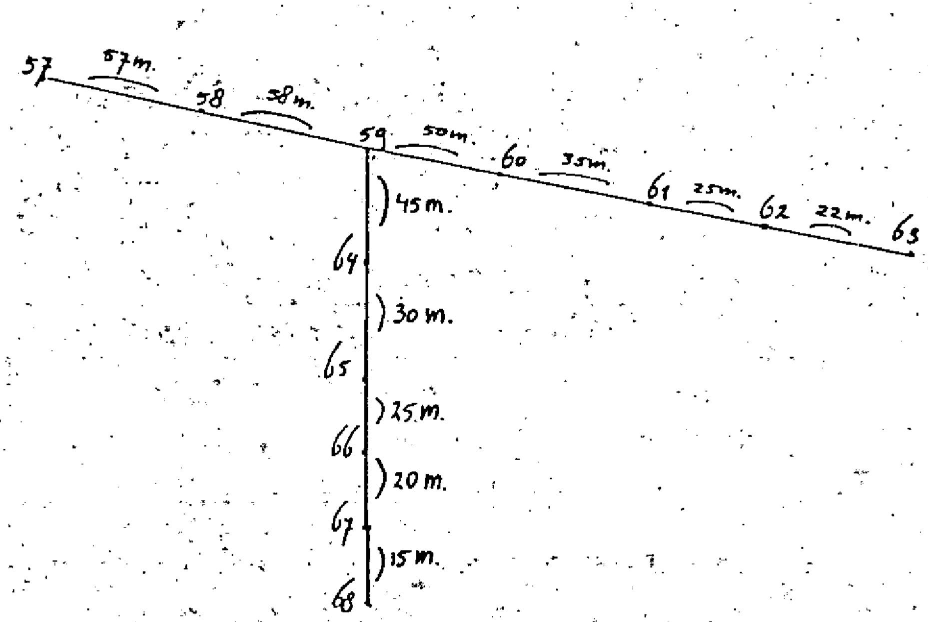


Figure 7: the transects on Clara bog, numbers and distances

The distance between these sets at the edge of the bog is only a few metres, this to get a better impression of the influence of the ditch on the pressure head of the peatlayers of the bog. Figure 8 shows the new transect. Again appendix II will give a more detailed picture.

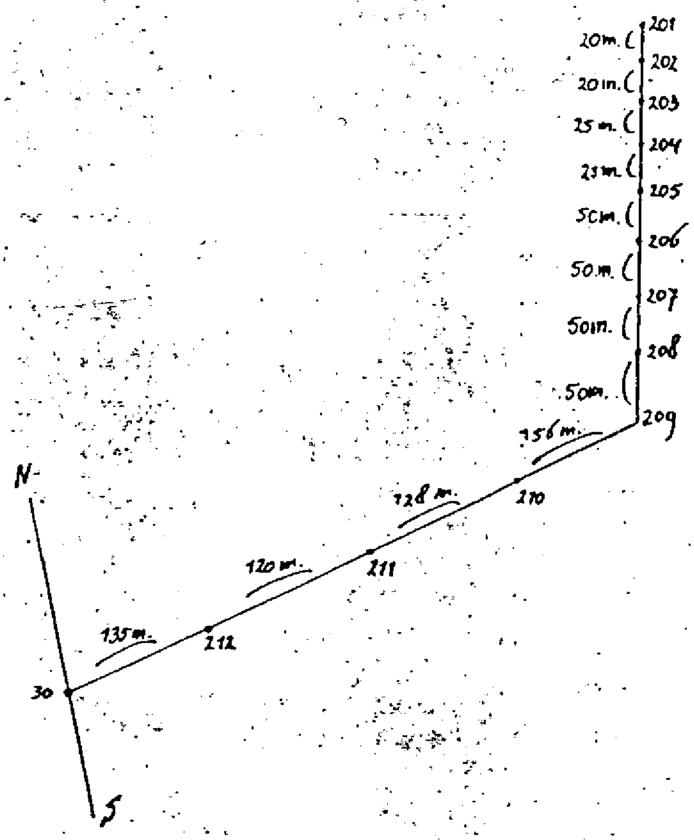


Figure 8: the transect on Raheenmore bog, numbers and distances.

CHAPTER 6: THE WORKPLAN.

First the things that should be done regularly:

- the readings of the raingauges (both automatic and manual) should be done every week;
- the changing of the charts of the surface water recorder at the transect C-C' in Raheenmore has to be done every week (this will be every two weeks when a proper clockwork will be available);
- the readings of the other three recorders (at the two weirs and the surface water recorder) have to be done every two weeks;
- the measuring of all the tubes (freatic tubes and piezometers) should be done every two weeks;
- the levelling of all the equipment has to be done every now and then (about every two or three months) because of the possible changes in the peatsurface; this is especially important in the three plots on the east side of Clara bog.

Secondly some major works should be done as soon as possible:

- the levelling of the catchment-area of the V-notch in Clara has to be done by the surveyors;
- the digging of a new dam in Clara has to be done to prevent leakage beside the flowmeter; futhermore some repair works have to be done to improve the operation of the flowmeter.
- the blocking of some old drains on Raheenmore bog to prevent leakage from this drains out of the catchment-area;
- the installation of a few phreatic tubes near the boundary of the catchment-area to see if the topografic boundary is the same as the real boundary of the catchment-area.

Finally the charts of the automatic recorders have to be digitalized to know the discharge of the catchment-area for some specific periods and at every moment.

Because of the fact nobody exactly knew how the situation would be like during the wet winter period, the winter 89/90 was a kind of testing period for the equipment. It appeared that there were some severe leakages near the flowmeter in Clara and in some old drains in Raheenmore. Repair works have to de carried out in order to prevent these leakages the next two winters.

CHAPTER 7: EVALUATION.

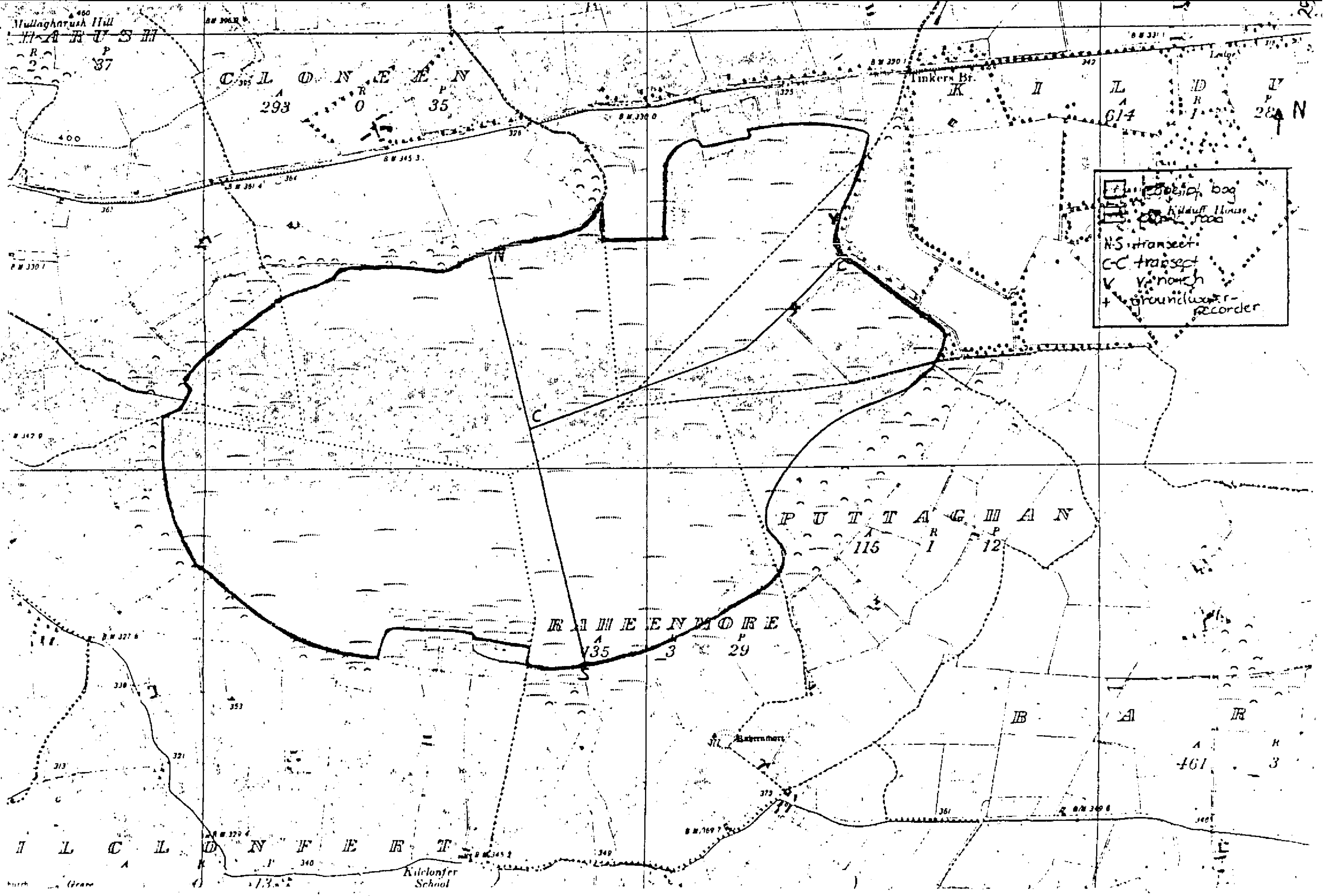
First of all I have experienced my stay in Clara as being very useful. The work itself was pleasant and useful. It was nice to be out on the bog all day, enjoying the beautiful Irish landscape and the peacefulness of the bog. It was quite different than being in class all day. The field work was also very interesting because now I have an idea what kind of problems can occur during the work. I also have a better idea how long things take to be done and how to solve different kind of problems or even how to improvise in the field when things are not at hand. It was also very useful to learn how to handle the equipment and in what kind of situation it's being used.

Secondly the setting up of a project like this, and the problems that can occur with it, has been very useful to me. Working with so many supervisers turned out to be quite difficult, especially when the division of tasks is not very clear. On the one hand I had the disadvantage of being one of the first students in Clara, which implied we had to wait for things like the computer and our allowances. On the other hand I had the privilege to see this project get started, meet all the supervisers and discuss what had to be done out in the field. I am very interested in the further developments and results of this project. I also hope to go back and see what has become of the bog and the planned information centre near Clara bog.

Another advantage of this project for me was meeting different people of different fields of study. It was very interesting to see what their plans and expectations were. This was very useful because you can't study the hydrology without regarding the geology, geomorphology, geo-hydrology and ecology. Also my assistance in the geo-physical work of the University of Amsterdam was very interesting and totaly different of my own work. I had used their equipment once before, but I had never analysed all the conductivity measurements, nor ever tried to work out a schematic picture of different layers underneath the peat. Unfortunately I haven't been able to

take a closer look at the bog vegetation. All in all I think I have a good impression now what a raised bog looks like.
Finally I liked the experience of being in a foreign country for a few months. Especially in an English-speaking country with different customs and another standard of living. Sometimes I did miss the life in the Netherlands, but most of the times I really enjoyed the quiet little town of Clara and the easy way of living over there.

APPENDIX I.



Mullaghorush Hill
CLONEEN
293
35
Tinkers Br.
KILDUFF
614
28
N
bog
Kilduff House
road
N-S transect
C-C' transect
V V-notch
+ groundwater-recorder
N
C
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PUTTAGHAN
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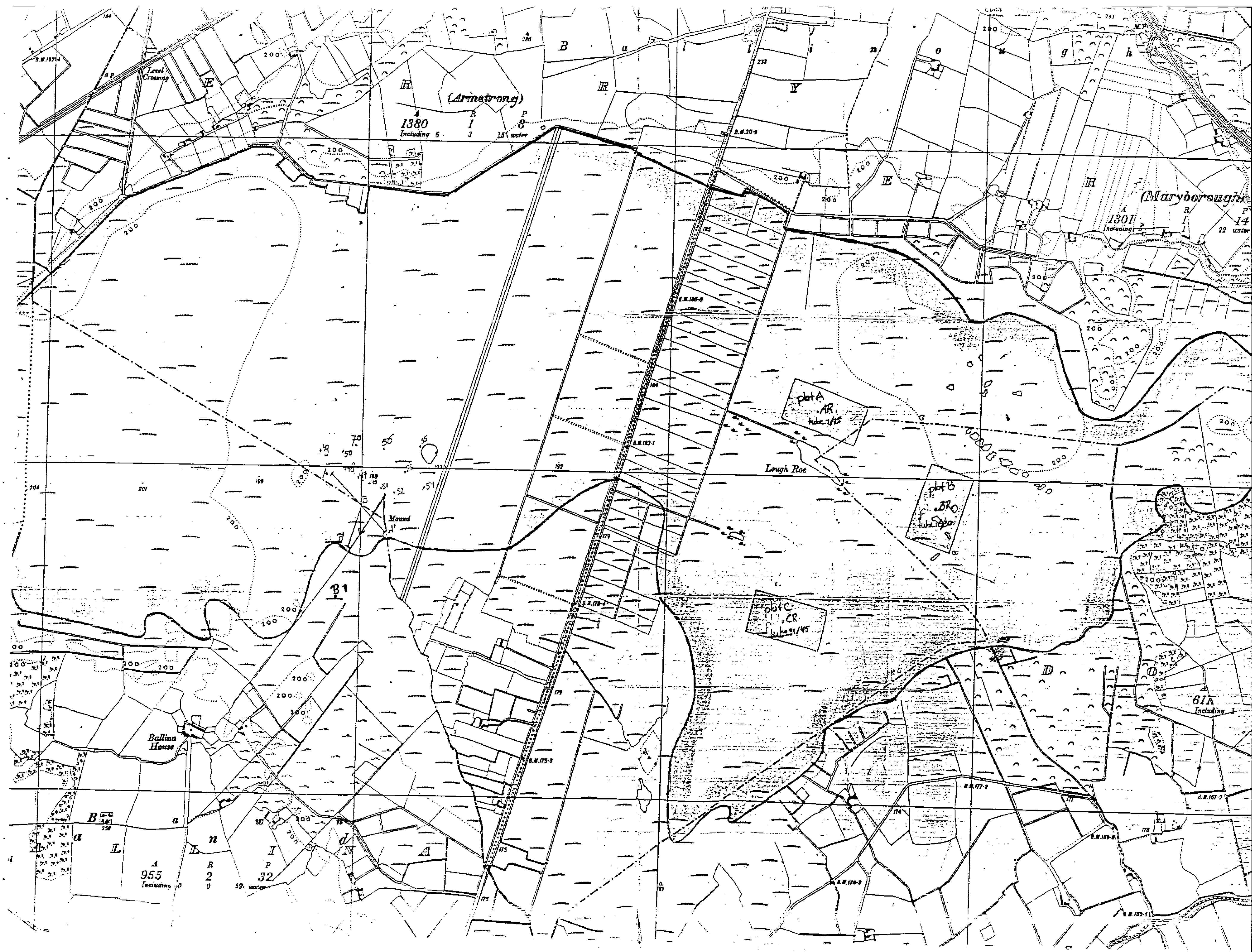
3
29
BAR
461
3
Kilclonfer School


Level Crossing
(Armstrong)
1380
Including
(Maryborough)
1301
Lough Roe
Mound
Ballina House
plot A
AR
plot B
BR
plot C
CR
B1
955

APPENDIX II.

TRANSECT A-A' IN CLARA BOG WEST.

Piezometerset 57 containing
57A: phreatic tube (1.00 m below surface);
57B: piezometer (1.50 m below surface);
57C: piezometer (3.00 m below surface);
57D: piezometer (4.50 m below surface).
Phreatic tube 58A (1.00 m below surface).
Piezometerset 59 containing
59A: phreatic tube (1.00 m below surface);
59B: piezometer (1.50 m below surface);
59C: piezometer (3.00 m below surface);
59D: piezometer (4.50 m below surface).
Phreatic tube 60A (1.00 m below surface).
Piezometerset 61 containing
61A: phreatic tube (1.00 m below surface);
61B: piezometer (1.50 m below surface);
61C: piezometer (3.00 m below surface);
61D: piezometer (4.50 m below surface).
Phreatic tube 62A (1.00 m below surface).
Piezometerset 63 containing
63A: phreatic tube (1.00 m below surface);
63B: piezometer (1.50 m below surface);
63C: piezometer (3.00 m below surface).

TRANSECT B-B' IN CLARA BOG WEST.

Piezometerset 59 containing
59A: phreatic tube (1.00 m below surface);
59B: piezometer (1.50 m below surface);
59C: piezometer (3.00 m below surface);
59D: piezometer (4.50 m below surface).

Phreatic tube 64A (1.00 m below surface).

Piezometerset 65 containing

65A: phreatic tube (1.00 m below surface);
65B: piezometer (1.50 m below surface);
65C: piezometer (3.00 m below surface);
65D: piezometer (4.50 m below surface).

Phreatic tube 66A (1.00 m below surface).

Piezometerset 67 containing

67A: phreatic tube (1.00 m below surface);
67B: piezometer (1.50 m below surface);
67C: piezometer (3.00 m below surface);
67D: piezometer (4.50 m below surface).

Piezometerset 68 containing

68A: phreatic tube (1.00 m below surface);
68B: piezometer (1.50 m below surface);
68C: piezometer (3.00 m below surface).

At the second surface waterrecorder near the soak another piezometerset is installed: piezometerset 70 containing

70A: phreatic tube (1.00 m below surface);
70B: piezometer (1.50 m below surface);
70C: piezometer (3.00 m below surface);
70D: piezometer (4.50 m below surface);
70S: piezometer (8.40 m below surface).

TRANSECT C-C'IN RAHEENMORE BOG.

Piezometerset 201 containing

201A: phreatic tube (1.00 m below surface);
201B: piezometer (1.50 m below surface);
201C: piezometer (3.00 m below surface);
201D: piezometer (3.60 m below surface).

Piezometerset 202 containing

202A: phreatic tube (1.00 m below surface);
202B: piezometer (1.50 m below surface);
202C: piezometer (3.00 m below surface);
202D: piezometer (4.50 m below surface).

Phreatic tube 203A (1.00 m below surface).

Piezometerset 204 containing

204A: phreatic tube (1.00 m below surface);
204B: piezometer (1.50 m below surface);
204C: piezometer (3.00 m below surface);
204D: piezometer (4.50 m below surface).

Phreatic tube 205A (1.00 m below surface).

Piezometerset 206 containing

206A: phreatic tube (1.00 m below surface);
206B: piezometer (1.50 m below surface);
206C: piezometer (3.00 m below surface);
206D: piezometer (4.50 m below surface);
206S: piezometer (6.60 m below surface).

Phreatic tube 207A (1.00 m below surface).

Phreatic tube 208A (1.00 m below surface).

Piezometerset 209 containing

209A: phreatic tube (1.00 m below surface);
209B: piezometer (1.50 m below surface);
209C: piezometer (3.00 m below surface);
209D: piezometer (4.50 m below surface).

Piezometerset 210 containing

210A: phreatic tube (1.00 m below surface);
210B: piezometer (1.50 m below surface);
210C: piezometer (3.00 m below surface);
210D: piezometer (4.50 m below surface).

Piezometerset 211 containing

211A: phreatic tube (1.00 m below surface);
211B: piezometer (1.50 m below surface);
211C: piezometer (3.00 m below surface);
211D: piezometer (4.50 m below surface).

Piezometerset 212 containing

212A: phreatic tube (1.00 m below surface);
212B: piezometer (1.50 m below surface);
212C: piezometer (3.00 m below surface);
212D: piezometer (4.50 m below surface).

Near the V-notch another piezometer has been installed:

213S (5.60 m below surface).

The actual depth of the perforated holes in the all these tubes is about 18 cm above the bottom of the tube (see page 11).

APPENDIX III.

LEVELLING IN CLARA BOG WEST.

This levelling was done on December the 12th with bench mark 1 as reference point. The height of this known point is 58.58 m above sealevel.

The heights (in m above sealevel) of the phreatic tubes around the soak are:

46: 57.94 m
47: 57.85 m
48: 58.02 m
49: 60.56 m
50: 58.32 m
51: 57.94 m
52: 57.74 m
53: 57.07 m
54: 57.94 m
55: 57.95 m

Phreatic tube 56 was not yet installed on this date, so the height of this tube was not levelled in.

The heights of the tubes in the transects (again in m above sealevel) are:

Transect A-A':
57A: 58.40 m; 57B: 58.41 m; 57C: 58.44 m; 57D: 58.44 m.
58A: 58.21 m.
59A: 57.70 m; 59B: 57.70 m; 59C: 57.69 m; 59D: 57.70 m.
60A: 57.48 m.
61A: 57.47 m; 61B: 57.47 m; 61C: 57.47 m; 61D: 57.46 m.
62A: 57.30 m.
63A: 57.28 m; 63B: 57.29 m; 63C: 57.29 m.

Transect B-B':
59A: 57.70 m; 59B: 57.70 m; 59C: 57.69 m; 59D: 57.70 m.
64A: 57.64 m.
65A: 57.76 m; 65B: 57.77 m; 65C: 57.78 m; 65D: 57.76 m.

66A: 57.68 m.
67A: 57.48 m; 67B: 57.48 m; 67C: 57.48 m; 67D: 57.49 m.
68A: 57.38 m; 68B: 57.40 m; 68C: 57.40 m.
The height of piezometerset 70 is:
70A: 58.11 m; 70B: 58.10 m; 70C: 58.09 m; 70D: 58.10 m;
70S: 58.58 m.
The height of the gauge in the soak (P103) is 58.21 m above sealevel.

LEVELLING PHREATIC TUBES IN CLARA BOG EAST.

This levelling was done on December the 12th 1989. All the heights are in metres above sealevel.

Plot A: AR: 58.68 m

1: 58.80 m	6: 58.75 m	11: 58.41 m
2: 58.86 m	7: 58.73 m	12: 58.46 m
3: 58.84 m	8: 58.72 m	13: 58.42 m
4: 58.82 m	9: 58.73 m	14: 58.39 m
5: 58.76 m	10: 58.71 m	15: 58.36 m

Plot B: BR: 59.03 m

16: 58.51 m	21: 58.76 m	26: 58.92 m
17: 58.52 m	22: 58.90 m	27: 59.02 m
18: 58.63 m	23: 58.91 m	28: 59.08 m
19: 58.63 m	24: 58.87 m	29: 58.99 m
20: 58.66 m	25: 58.87 m	30: 58.98 m

Plot C: CR: 59.76 m

31: 58.92 m	36: 59.69 m	41: 59.35 m
32: 58.99 m	37: 59.71 m	42: 59.45 m
33: 59.05 m	38: 59.72 m	43: 59.38 m
34: 59.08 m	39: 59.75 m	44: 59.32 m
35: 59.10 m	40: 59.63 m	45: 59.18 m

LEVELLING OF TRANSECT C-C' IN RAHEENMORE BOG.

This levelling was done on December the 5[th] 1989. As reference for this leveling benchmark 3 (which is situated on the surveying map) was used. The height of benchmark 3 is 100.94 m above sealevel (ASL).

The heights (in metres above sealevel) of the tubes are:

201A: 100.61m; 201B: 100.57m; 201C: 100.57m; 201D: 100.58m
202A: 101.30m; 202B: 101.30m; 202C: 101.31m; 202D: 101.28m
203A: 101.96m
204A: 102.42m; 204B: 102.43m; 204C: 102.45m; 204D: 102.43m
205A: 103.30m
206A: 104.03m; 206B: 104.04m; 206C: 104.05m; 206D: 104.06m
206S: 104.06m
207A: 104.11m
208A: 104.26m
209A: 104.53m; 209B: 104.54m; 209C: 104.54m; 209D: 104.53m
210A: 105.30m; 210B: 105.30m; 210C: 105.33m; 210D: 105.30m
211A: 105.80m; 211B: 105.85m; 211C: 105.89m; 211D: 105.87m
212A: 106.17m; 212B: 106.18m; 212C: 106.20m; 212D: 106.18m

APPENDIX IV

THE TESTS OF THE EQUIPMENT.

The weir in Clara.

	F	Q (l/s)	Reading (m)		Reference (m)		H (m)
1.	3.30-3.51	3.352	0.2478	-	0.1643	=	0.0835
2.	6.25-6.43	6.293	0.2733		0.1643		0.1090
3.	9.81-10.01	9.870	0.2939		0.1643		0.1296
4.	14.56-14.78	14.62	0.3153		0.1643		0.1510
5.	19.7-19.9	19.80	0.3343		0.1643		0.1700
6.	24.8-25.0	24.96	0.3504		0.1643		0.1861
7.	29.8-30.1	30.07	0.3646		0.1643		0.2003
8.	34.7-34.9	34.98	0.3768		0.1643		0.2125
9.	39.6-39.9	39.99	0.3881		0.1643		0.2238
10.	44.3-44.8	44.84	0.3988		0.1643		0.2345
11.	49.6-49.8	50.06	0.4099		0.1643		0.2456
12.	54.7-54.9	55.22	0.4207		0.1643		0.2564
13.	59.8-59.9	60.33	0.4309		0.1643		0.2666
14.	64.7-65.0	65.39	0.4406		0.1643		0.2763
15.	69.4-69.6	70.09	0.4496		0.1643		0.2853
16.	74.8-75.1	75.61	0.4597		0.1643		0.2954
17.	79.6-80.0	80.52	0.4685		0.1643		0.3042
18.	84.6-85.0	85.58	0.4775		0.1643		0.3132
19.	89.7-90.1	90.69	0.4861		0.1643		0.3218
20.	99.4-99.7	100.5	0.5027		0.1643		0.3384
21.	109.5-109.9	110.8	0.5211		0.1643		0.3568
22.	119.5-119.9	120.9	0.5374		0.1643		0.3731
23.	129.1-129.9	130.8	0.5541		0.1643		0.3898
24.	139.1-140.0	141.0	0.5696		0.1643		0.4053
25.	148.9-150.4	151.2	0.5844		0.1643		0.4201

F is the meter reading and Q is the corrected discharge (mean).

The weir in Raheenmore.

	F	Q (l/s)	Reading (m)		Reference (m)		H (m)
1.	3.15-3.32	3.187	0.2491	-	0.1649	=	0.0842
2.	6.24-6.36	6.25	0.2737		0.1649		0.1088
3.	10.66-10.84	10.71	0.2991		0.1649		0.1342
4.	14.93-15.13	15.00	0.3181		0.1649		0.1532
5.	19.6-19.8	19.70	0.3353		0.1649		0.1704
6.	24.5-24.7	24.66	0.3511		0.1649		0.1862
7.	29.7	29.82	0.3651		0.1649		0.2002
8.	34.7-34.8	34.93	0.3775		0.1649		0.2126
9.	39.8-40.1	40.19	0.3895		0.1649		0.2246
10.	44.5-44.9	45.00	0.3996		0.1649		0.2347
11.	49.0-49.7	49.96	0.4098		0.1649		0.2449
12.	54.5-54.8	55.07	0.4200		0.1649		0.2551
13.	59.0-59.2	59.57	0.4287		0.1649		0.2638
14.	64.3-64.7	65.03	0.4389		0.1649		0.2740
15.	69.1-69.4	69.83	0.4476		0.1649		0.2827
16.	74.2-74.6	74.85	0.4564		0.1649		0.2915
17.	79.1-79.2	79.86	0.4647		0.1649		0.2998
18.	84.1-84.4	85.02	0.4731		0.1649		0.3082
19.	89.4-89.7	90.38	0.4815		0.1649		0.3166
20.	94.2-94.6	95.29	0.4894		0.1649		0.3245
21.	99.1-99.5	100.3	0.4973		0.1649		0.3324
22.	109.2-109.7	110.5	0.5135		0.1649		0.3486
23.	119.2	120.4	0.5278		0.1649		0.3629
24.	129.2	130.5	0.5421		0.1649		0.3772
25.	139.8	141.2	0.5582		0.1649		0.3933
26.	149.0	150.5	0.5709		0.1649		0.4060

F is the meter reading and Q is the corrected discharge (mean).

The flow meter.

Measurement I:

	Q (l/s)	Time (s)	cal.discharge		mes.discharge
			(m^3)	(m^3)	(l/s)
1.	2.510	542	1.36	1.00	1.85
2.	4.364	635	2.77	2.70	4.25
3.	7.605	488	3.71	4.00	8.20
4.	10.02	488	4.89	5.00	10.25
5.	12.27	399	4.90	5.00	12.53
6.	15.12	400	6.05	6.20	15.50
7.	17.90	266	4.78	5.00	18.80

Measurement II:

	Q (l/s)	Time (s)	cal.discharge		mes.discharge
			(m^3)	(m^3)	(l/s)
1.	2.22	633	1.41	1.00	1.58
2.	4.60	435	2.00	2.00	4.60
3.	6.55	403	2.64	2.80	6.95
4.	9.03	396	3.58	3.70	9.34
5.	11.80	394	4.65	4.70	11.87
6.	14.39	390	5.61	5.70	14.62
7.	16.83	318	5.35	5.50	17.30
8.	18.70	242	4.54	4.70	19.42

D = 59 m

AFVOER IN M^3/SEC.

BEREKEND UIT DE FORMULE: $LOG\ Q = 0.3333 + 2.7522\ LOG\ H + 0.1331\ (LOG\ H)^2$ (H IN M, Q IN M^3/SEC)

H(M)	0	1	2	3	4	5	6	7	8	9
0.08	0.00298	0.00307	0.00317	0.00327	0.00336	0.00346	0.00356	0.00367	0.00377	0.00388
0.09	0.00399	0.00410	0.00421	0.00432	0.00444	0.00456	0.00468	0.00480	0.00492	0.00505
0.10	0.00518	0.00531	0.00544	0.00557	0.00571	0.00585	0.00599	0.00613	0.00627	0.00642
0.11	0.00657	0.00672	0.00687	0.00702	0.00718	0.00734	0.00750	0.00766	0.00783	0.00799
0.12	0.00816	0.00834	0.00851	0.00869	0.00886	0.00904	0.00923	0.00941	0.00960	0.00979
0.13	0.00998	0.01018	0.01037	0.01057	0.01077	0.01098	0.01118	0.01139	0.01160	0.01182
0.14	0.01203	0.01225	0.01247	0.01269	0.01292	0.01315	0.01338	0.01361	0.01385	0.01408
0.15	0.01432	0.01457	0.01481	0.01506	0.01531	0.01557	0.01582	0.01608	0.01634	0.01661
0.16	0.01687	0.01714	0.01741	0.01769	0.01797	0.01825	0.01853	0.01881	0.01910	0.01939
0.17	0.01969	0.01998	0.02028	0.02058	0.02089	0.02120	0.02151	0.02182	0.02214	0.02245
0.18	0.02278	0.02310	0.02343	0.02376	0.02409	0.02443	0.02477	0.02511	0.02545	0.02580
0.19	0.02615	0.02651	0.02686	0.02722	0.02759	0.02795	0.02832	0.02869	0.02907	0.02945
0.20	0.02983	0.03021	0.03060	0.03099	0.03138	0.03178	0.03218	0.03258	0.03299	0.03340
0.21	0.03381	0.03423	0.03465	0.03507	0.03549	0.03592	0.03635	0.03679	0.03723	0.03767
0.22	0.03811	0.03856	0.03901	0.03947	0.03992	0.04039	0.04085	0.04132	0.04179	0.04227
0.23	0.04274	0.04323	0.04371	0.04420	0.04469	0.04519	0.04568	0.04619	0.04669	0.04720
0.24	0.04771	0.04823	0.04875	0.04927	0.04980	0.05033	0.05086	0.05140	0.05194	0.05249

AFVOER IN M^3/SEC.

BEREKEND UIT DE FORMULE: $LOG\ Q = -0.3289 + 0.8532\ LOG\ H + -1.2151\ (LOG\ H)^2$ (H IN M, Q IN M^3/SEC)

H(M)	0	1	2	3	4	5	6	7	8	9
0.25	0.05213	0.05261	0.05310	0.05359	0.05407	0.05456	0.05506	0.05555	0.05604	0.05654
0.26	0.05704	0.05754	0.05804	0.05854	0.05905	0.05955	0.06006	0.06057	0.06108	0.06159
0.27	0.06211	0.06262	0.06314	0.06366	0.06418	0.06470	0.06522	0.06574	0.06627	0.06679
0.28	0.06732	0.06785	0.06838	0.06891	0.06944	0.06998	0.07051	0.07105	0.07159	0.07213
0.29	0.07267	0.07321	0.07375	0.07430	0.07484	0.07539	0.07594	0.07648	0.07704	0.07759
0.30	0.07814	0.07869	0.07925	0.07980	0.08036	0.08092	0.08148	0.08204	0.08260	0.08316
0.31	0.08373	0.08429	0.08486	0.08543	0.08599	0.08656	0.08713	0.08770	0.08828	0.08885
0.32	0.08942	0.09000	0.09057	0.09115	0.09173	0.09231	0.09289	0.09347	0.09405	0.09463
0.33	0.09521	0.09580	0.09638	0.09697	0.09756	0.09814	0.09873	0.09932	0.09991	0.10050
0.34	0.10109	0.10169	0.10228	0.10288	0.10347	0.10407	0.10466	0.10526	0.10586	0.10646
0.35	0.10706	0.10766	0.10826	0.10886	0.10946	0.11006	0.11067	0.11127	0.11188	0.11248
0.36	0.11309	0.11370	0.11430	0.11491	0.11552	0.11613	0.11674	0.11735	0.11796	0.11858
0.37	0.11919	0.11980	0.12042	0.12103	0.12164	0.12226	0.12288	0.12349	0.12411	0.12473
0.38	0.12534	0.12596	0.12658	0.12720	0.12782	0.12844	0.12906	0.12968	0.13031	0.13093
0.39	0.13155	0.13218	0.13280	0.13342	0.13405	0.13467	0.13530	0.13592	0.13655	0.13718

D = 125 mm

AFVOER IN M^3/SEC.

BEREKEND UIT DE FORMULE: LOG Q= 0.2466 [illegible] 2.5081 LOG H + -0.[illegible] $(LOG H)^2$ (H IN M,Q IN M^3/SEC)

H(M)	0	1	2	3	4	5	6	7	8	9
0.08	0.00280	0.00289	0.00299	0.00308	0.00318	0.00328	0.00338	0.00348	0.00359	0.00370
0.09	0.00380	0.00391	0.00403	0.00414	0.00426	0.00438	0.00450	0.00462	0.00474	0.00487
0.10	0.00500	0.00513	0.00526	0.00539	0.00553	0.00567	0.00581	0.00595	0.00610	0.00624
0.11	0.00639	0.00654	0.00670	0.00685	0.00701	0.00717	0.00733	0.00750	0.00766	0.00783
0.12	0.00800	0.00818	0.00835	0.00853	0.00871	0.00889	0.00908	0.00927	0.00946	0.00965
0.13	0.00984	0.01004	0.01024	0.01044	0.01064	0.01085	0.01105	0.01127	0.01148	0.01169
0.14	0.01191	0.01213	0.01236	0.01258	0.01281	0.01304	0.01327	0.01351	0.01374	0.01398
0.15	0.01423	0.01447	0.01472	0.01497	0.01522	0.01548	0.01574	0.01600	0.01626	0.01653
0.16	0.01680	0.01707	0.01734	0.01762	0.01790	0.01818	0.01846	0.01875	0.01904	0.01933
0.17	0.01963	0.01993	0.02023	0.02053	0.02084	0.02115	0.02146	0.02177	0.02209	0.02241
0.18	0.02273	0.02306	0.02339	0.02372	0.02405	0.02439	0.02473	0.02507	0.02542	0.02577
0.19	0.02612	0.02647	0.02683	0.02719	0.02755	0.02792	0.02829	0.02866	0.02903	0.02941
0.20	0.02979	0.03017	0.03056	0.03095	0.03134	0.03174	0.03213	0.03254	0.03294	0.03335
0.21	0.03376	0.03417	0.03459	0.03501	0.03543	0.03586	0.03628	0.03672	0.03715	0.03759
0.22	0.03803	0.03847	0.03892	0.03937	0.03982	0.04028	0.04074	0.04120	0.04167	0.04214
0.23	0.04261	0.04309	0.04357	0.04405	0.04453	0.04502	0.04551	0.04601	0.04651	0.04701
0.24	0.04751	0.04802	0.04853	0.04905	0.04957	0.05009	0.05061	0.05114	0.05167	0.05220

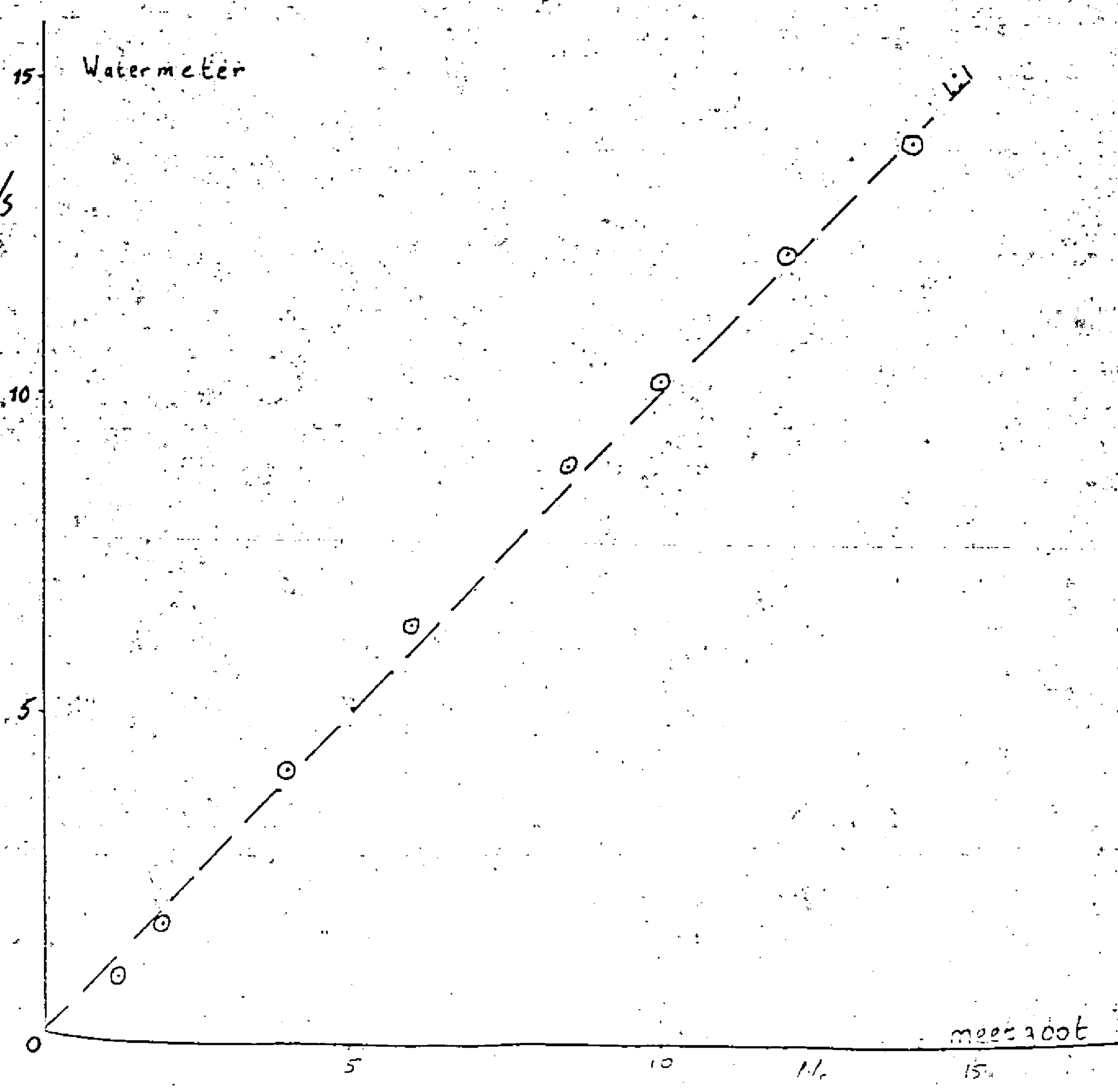
AFVOER IN M^3/SEC.

BEREKEND UIT DE FORMULE: LOG Q=-0.2407 + 1.0361 LOG H + -1.1491 $(LOG H)^2$ (H IN M,Q IN M^3/SEC)

H(M)	0	1	2	3	4	5	6	7	8	9
0.25	0.05236	0.05287	0.05338	0.05389	0.05440	0.05492	0.05544	0.05596	0.05648	0.05700
0.26	0.05753	0.05805	0.05858	0.05912	0.05965	0.06018	0.06072	0.06126	0.06180	0.06234
0.27	0.06289	0.06344	0.06398	0.06453	0.06509	0.06564	0.06620	0.06675	0.06731	0.06787
0.28	0.06844	0.06900	0.06957	0.07014	0.07071	0.07128	0.07185	0.07243	0.07300	0.07358
0.29	0.07416	0.07474	0.07533	0.07591	0.07650	0.07709	0.07768	0.07827	0.07886	0.07946
0.30	0.08005	0.08065	0.08125	0.08185	0.08245	0.08306	0.08366	0.08427	0.08488	0.08549
0.31	0.08610	0.08672	0.08733	0.08795	0.08856	0.08918	0.08980	0.09042	0.09105	0.09167
0.32	0.09230	0.09293	0.09356	0.09419	0.09482	0.09545	0.09609	0.09672	0.09736	0.09800
0.33	0.09864	0.09928	0.09992	0.10056	0.10121	0.10185	0.10250	0.10315	0.10380	0.10445
0.34	0.10511	0.10576	0.10641	0.10707	0.10773	0.10839	0.10905	0.10971	0.11037	0.11103
0.35	0.11170	0.11236	0.11303	0.11370	0.11437	0.11504	0.11571	0.11638	0.11705	0.11773
0.36	0.11840	0.11908	0.11976	0.12044	0.12112	0.12180	0.12248	0.12316	0.12385	0.12453
0.37	0.12522	0.12590	0.12659	0.12728	0.12797	0.12866	0.12935	0.13005	0.13074	0.13144
0.38	0.13213	0.13283	0.13352	0.13422	0.13492	0.13562	0.13632	0.13703	0.13773	0.13843
0.39	0.13914	0.13984	0.14055	0.14125	0.14196	0.14267	0.14338	0.14409	0.14480	0.14551

Bijlage 21 IJkkromme Debietmeter

Aangeboden debiet meetgoot [l/s]	Meetwaarde watermeter [l/s]	Opstuwing [cm]	Afwijking (geg-meet)/geg. [1]
1.30	1.00	1.50	-0.23
2.00	1.81	1.50	-0.09
4.01	4.22	3.00	0.05
6.00	6.48	6.00	0.08
8.58	8.98	10.50	0.05
10.02	10.30	14.00	0.03
12.03	12.30	19.00	0.02
14.00	14.04	22.00	0.00



APPENDIX V.

THE DAMS IN RAHEENMORE BOG.

On November the 16 th 1989 a digging machine came over to Raheenmore bog to do some repair works on the bog. Some months before a big ditch had been dug on the north-east side of the bog, which had to be filled up again because its function had become superfluous. Special attention has been paid to this filling up. To prevent any waterflow in this old ditch in the future, four dams have been made with black humified peat. For this peat is far less permeable than peat of the toplayer. The following figures will give an impression of the work that has been done:

1. The old situation:

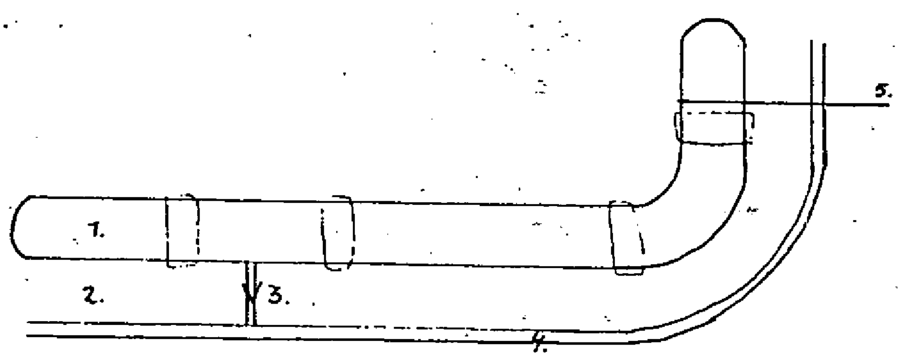


Figure 9: the old ditch with the location of the four dams.
1: old ditch; 2: old embankment; 3: weir; 4: new drain;
5: transect C-C'.

2. The dams:

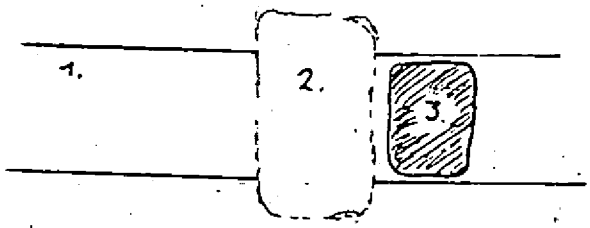


Figure 10: how the dams are made.
1: the old ditch; 2: the dam; 3: the hole (black humified peat).

3. The new situation:

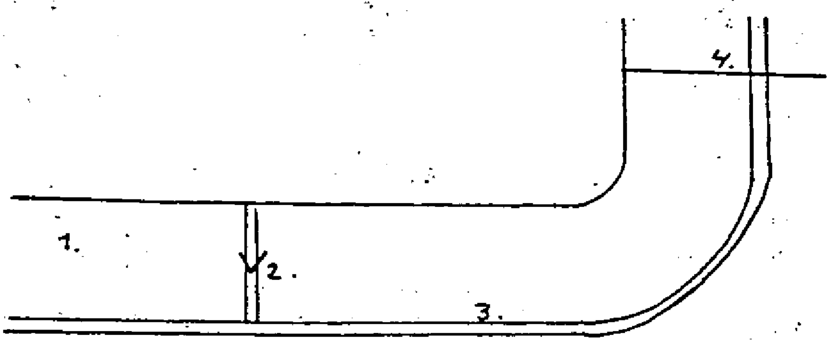


Figure 11: the new drain with the old ditch filled up.
1: the new peat surface; 2: the weir; 3: the drain;
4: the transect.