**rijkswaterstaat**

Public Works Department
of the Netherlands

REPORT

# BED PROTECTION, OLD MEUSE,

# BY MEANS OF GEOCONTAINERS®

VXT/HJ 88.168



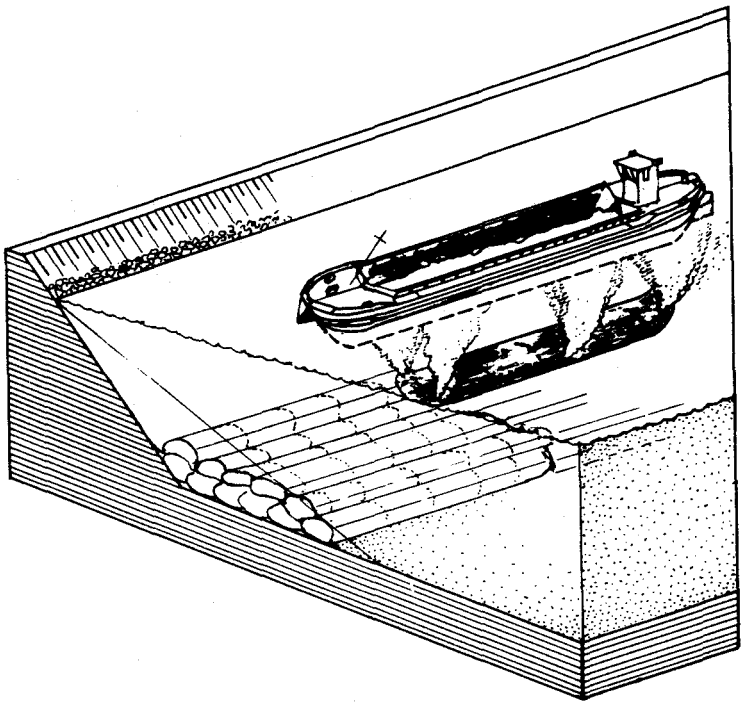

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# REPORT

# BED PROTECTION, OLD MEUSE, BY MEANS OF GEOCONTAINERS (R)

# VXT/HJ 88.168



Dir. of Lower Rivers
Public Works Department
Dordrecht, April 1988

Project number 3810
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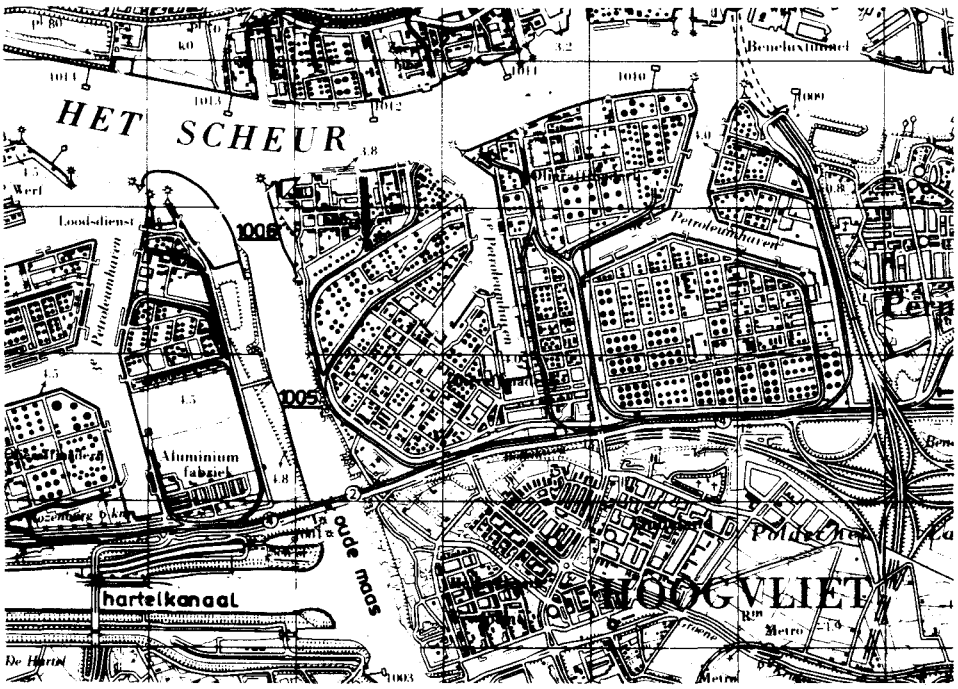
Bibliography

## 1. INTRODUCTION

Since the closure of the Haringvliet, there has been an increasing incidence of bed and bank erosion, as a result of which critical situations have now been reached at various points. At kilometre marker 1005 the left bank was eroded to such an extent that the underwater slope had become steeper than 1:1 at various points. Consequently a large proportion of the underwater revetment disappeared, and the level of the paving dropped in a number of places (see Appendices 4 and 5). In order to restore the slope to a gradient of 1:4, approx. 36,000 m3 of filling material would be required. The usual solutions provided for this include the use of pit stone, slags or sand, protecting collar sections with revetment.

Following an alternative proposal put forward by Van den Herik Kust- en Oeverwerken BV, in Sliedrecht, it was decided to carry out the bank filling in 1987, by way of a trial, using **Geocontainers(R)**, according to the BER 2303 and BER 2356 agreements. The Geocontainer (R) is a product manufactured by Nicolon BV in Almelo, and Van der Herik Kust- en Oeverwerken BV, and consists of an oblong bag of plastic filter fabric ('geotextile'), filled with approx. 200 m3 of sand, which is conveyed to the place of destination in a split barge. Experience with such containers had already been gained in Weekeborg (Germany) in the construction of a breakwater on the Ems, the containers being used as core material. The experience in Germany provided the basis for assembling the containers for the Old Meuse, but an important difference between the two situations was the depth at which the containers were processed: in Germany the maximum depth was approx. 6 m, on the Old Meuse approx. 20 m. The name Geocontainer(R) is a registered trade mark, and a patent on the product has now been applied for.

This is a report of the trial conducted with Geocontainers(R) on the Old Meuse.



## 2 STARTING POINTS

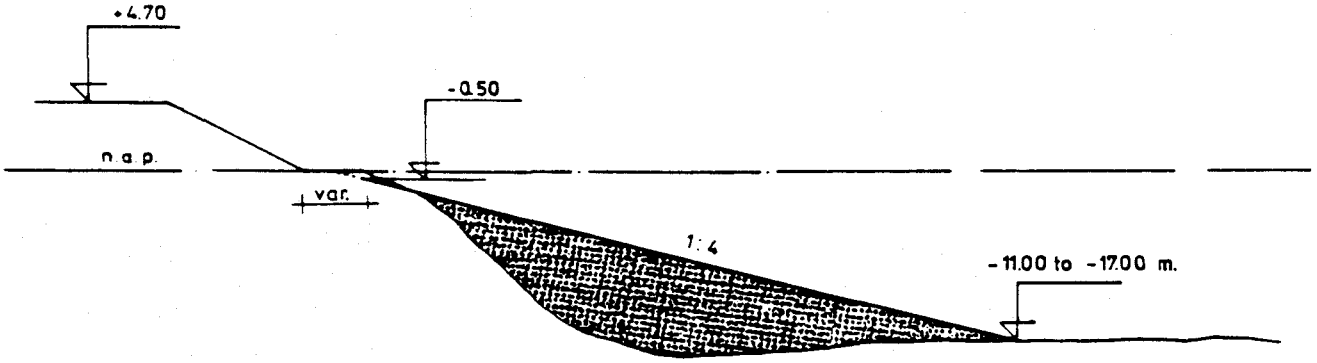
### 2.1 General

The purpose of this work on the Old Meuse, according to agreements BER 2303 and BER 2356, was to study the possibility of restoring a gradient of 1:4 to a steep bank by means of Geocontainers(R), and to this end the work was divided into 2 sections: a test section at km marker 1006, and a section of work to be done, at km marker 1005.

The test section at km marker 1006 was a deep hole in the river bed down to a level of approx. -20 m (see Appendix 2). The intention was to fill this hole with containers, then to study their composition and behaviour. In doing so, the following aspects had to be examined:

- composition of the container: materials, method of filling, degree of filling, wet or dry, method of sealing, etc.;
- method of positioning and holding the split barges and sinking the containers;
- behaviour of the container when being unloaded and when being deposited on the bottom, method of depositing (flat, spread, turned, etc.) and deviation from planned position;
- possible damage and its cause;
- the importance of weather conditions, tide and current.

Once this knowledge was obtained, the bank filling at km marker 1005 could be carried out as shown diagrammatically below.

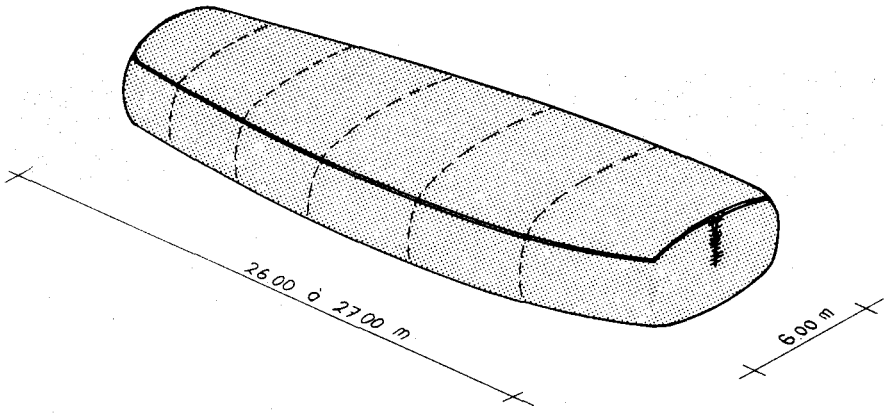



Explanation

dimensions in metres
height dimensions in metres above underground water-level
filling with geocontainers(R)

## 2.2 Composition of Geocontainers(R)

The containers consist of 450 m2 of geotextile (30x15m) and approx. 200 m3 of sand. The 'basic model' of the containers, as used at the beginning of the work, is shown diagrammatically below:




The containers were 'prefabricated' so that they could simply be suspended in the bin of the split barge, filled and sealed with a hand sewing machine.

### Geotextile

3 types of geotextile were tested, with a variation in strength and mesh width. The containers were designed 'type 130', 'type 180' and 'type 300', referring to the O-90 value of the fabric in question (for detailed specifications see Appendix 9).

### Sand

The sand was 'moderately coarse', with a D-50 of 260 mu, and a D-90 of 380 mu (see Appendix 9). It was extracted by means of a trailing suction dredger, on the Nieuwe Waterweg, level with km marker (km.) 1016.

### Sand density

The ratio of the mesh width of the geotextile to the grain distribution of the sand must be such that no appreciable sand loss occurs. The following requirement has been formulated by Ogink with regard to the sandtightness of the geotextile:

- **A fabric is sand-tight, under static loading conditions, if the following requirement is met:**

  **O-90/D-90 < 1.**

However, this requirement is extreme. The investigation described in 'Plastic filters in Coastal and Bank Works' shows that failure to comply with this sandtightness requirement does not result in an erosion of material. The reason for this is the formation of a natural filter after erosion of the fine fractions from the uppermost strata. It was shown that a sandtightness coefficient of between 1 and 2 could be selected.

The sandtightness coefficients of the three types of geotextile used, combined with the sand used, were in all cases less than 1, but this was not a problem.

## 2.3 Procedure

### Km. 1006

The hole in the river bed, at km. 1006, was used for testing out the containers. The depth was approx. u.w.l. (under-water level) -20 m, and the distance from the right bank approx. 100 m. In view of the intensity of shipping on the river, it was not possible in that location to use a pontoon with spud piles for the positioning of the split barge. Use was therefore made of 2 tugs, and a flat-bottomed boat from the Weights and Measures Department, which was fitted with an echo sound and an Artemis position locating system. On the right bank a system of markers was set out, and this was also fed into the memory of the locating system. The position of the split barge was determined firstly visually, by means of this system of markers, and secondly by means of the sounding boat which was lying in the predetermined position (see Appendix 3).

The planned position of the containers was parallel with the bank (see Appendix 2) because in this case, very minor deviations were expected due to the current, and because this was also the desired position of the containers in the work to be constructed at km. 1005.

The sand was extracted with a trailing suction dredger which was moored at a pontoon, with a grab crane. The split barge, with the prefabricated container inside it, was located on the other side of that pontoon. The container was then filled with sand and sealed with a hand sewing machine. A second split barge was located on the outside, already prepared with the suspended container, and could be loaded as soon as the first split barge was moved to the unloading location. When it was empty, it was again moored on the outside of the second split barge, and prepared for filling.

To enable the unloading of the containers to proceed as flexibly as possible, a number of measures were taken on the split barge. The sides of the bin were covered with geotextile, thereby minimising the frictional resistance, and plates were welded to the front and rear of the bin to prevent the containers from being damaged when the slot in the bin was opened (see photograph 17 in Appendix 11).

To determine the position where the container was to be deposited, soundings were carried out immediately before and after sinking. For marking the position of the first containers use was made of buoys which were secured to the container. Just before sinking a current measurement was carried out by the surrey boat. The maximum rate of current flow was noted down, together with other data such as date, time, tide, water level and sinking position, on a record form such as that reproduced in Appendix 10.

The inspection for damage was threefold:

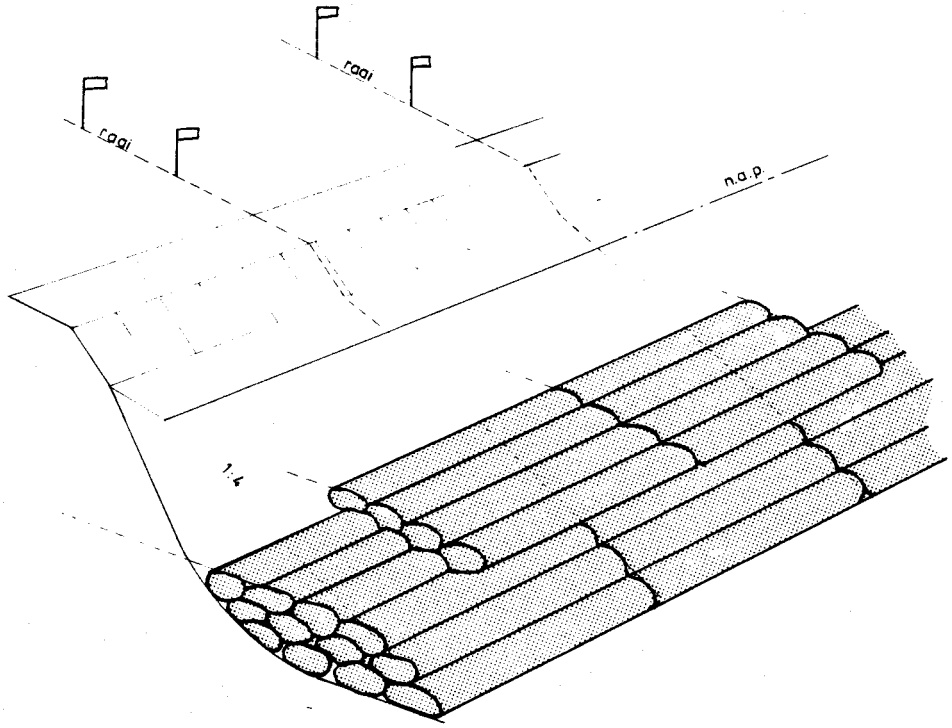
- visual, during unloading from the split barge;
- by means of enclosed wooden blocks which drift up in the event of damage;
- by diver survey after sinking.

**Km. 1005**

At km. 1005 the left bank, which was too steep, had to be restored to a gradient of 1:4 (see Appendices 4 and 5). To achieve a stable structure, the following basic criteria were applied:

- containers placed as flat as possible on the bed;
- containers positioned with the longitudinal axis parallel with the bank;
- direction of working from outside to inside;
- construction in horizontal layers;
- each container placed between two other containers (half-brick joint in cross-section);
- every 3 layers, displacement of half a container length in the longitudinal direction;
- as uniform a construction as possible for the section to be filled in.

Positioning the containers horizontal and parallel with the bank was not only required for the desired structure, but also had the advantage that the influence of the current was minimal during sinking. This is shown in the figure below.




Just as at km. 1006, use was made here of a system of markers which was set out the left bank, and which was fed into the memory of the Artemis locating system (see App. 4). The distance between the markers was 5 m, and every 5th marker was set out on the bank. The 25m 'laying compartments' thus formed, were used as a visual aid in sinking.

Because work was being done here just under the bank, use was made of a pontoon with spud piles. The pontoon was brought into position by means of the sounding boat, or by means of a drag wire. The split barge was brought into position and retained by 2 tugs and 2 winches from the pontoon (see Appendix 6).

Here too good recording was essential:
- recording forms for position data, sinking conditions and comments on the result; - transverse lines of soundings were taken for determining the position of containers already laid, and containers yet to be laid;
- laying diagrams for a survey of containers already laid, and for determining the position of the pontoon (when using spud piles this work already constructed outside must remain!).

The inspection for damage was again threefold, using enclosed blocks, with surveying by divers.

# 3 RESULTS

## 3.1 Assembly and installation

### Km. 1006

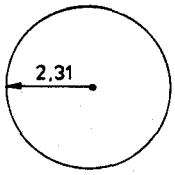
At km. 1006 the basic container model was tested with the 3 types of geotextile. Various methods of loading were tried out, varying the quantity of sand in the container, the distribution of the sand in the bin, and carrying out wet and dry loading.

### Quantity of sand

The quantity of sand in the container depends on a number of factors:
- the capacity of the bin;
- the capacity of the container;
- the container flexibility required to be able to gain access through the open bin, and to absorb the impact from depositing on the bed.

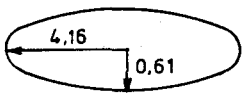
The bin capacity of the split barges used here is approx. 240 m3, and the capacity of the container depends on its shape. A round, cylindrical container can hold approx. 440 m3, but when flattened in shape, this capacity (with the same circumference!) is much smaller; an elliptical container only has a capacity of approx. 200 m3. All this is shown in the figures below.

**Container cross-sections:**




round shape

circumference = 14.5 m
area = 16.7 m2
volume of container =
16.7 x 26 (length)
= 440 m3




flat shape

circumference = 14.5 m
area = 7.7 m2
volume of container =
7.7 x 26 (length)
= 200 m3

It has been shown that approx. 200 m3 of sand is the maximum quantity which can be used to ensure that the split barge remains flexible.

### Distribution in bin

The distribution of the sand in the bin has a considerable influence on the method used to unload the container. If the front and rear of the bin are not well filled, the result is that the side of the container facing the current is unloaded quickly and sooner than the rest, which not only makes it difficult to position the split barge ('stirring action'), but may also give rise to tearing in the bin across the container. For uniform unloading of the container it is necessary, when loading, to place the sand uniformly on a flat surface, and fill the ends well.

## Sliding fabrics

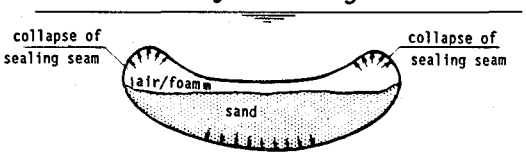
To facilitate unloading, pieces of geotextile measuring 25 x 5 m were arranged on the sides of the bin in the split barge. Moreover, the slots on the end faces of the bin were protected by means of plates which were welded to one side. The 'sliding fabric' appeared to work well: without this fabric loading was more cumbersome. The 'end bulkheads' were not a success: they were too small, during unloading the corners of the containers were pushed down, then damaged by the bulkheads carried along with them. The omission of the end bulkheads meant that the containers suffered damage on the cylinders of the hydraulic system provided for the split barge. The solution to this problem was found by also using sliding cloths measuring 5 x 5 m on the heads, running a short distance over the bottom of the bin. The weight of the container kept the end fabrics in position, preventing the container from moving forwards or backwards.

## Wet or dry

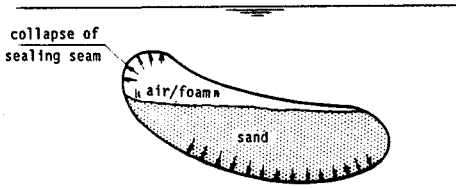
Initially the containers were unloaded dry. This appeared to present major problems, particularly in the case of the thicker types of fabric. Besides 200 m3 of sand in the container, approximately 30 to 40 m3 of air is contained in the pores of the sand, and between the sand and the fabric. During unloading and underwater sinking, one or two large air bubbles were formed, which frequently caused the top seams to spring open with a loud bang. This occurred mainly with the type 130 containers. The reason for this was that the fabric, although water- and airtight, is no longer able to release such a quantity of air in one go, and must therefore be regarded as relatively 'tight'. Some containers which remained intact during unloading then collapsed when deposited on the bottom. The reason for this was also the large quantity of air which cannot be removed immediately during the 'change of shape' which the container undergoes when deposited.

Collapse during unloading was directly visible, and collapse during depositing could have resulted from the upward drifting of the enclosed wooden blocks. The location and extent of the damage was then established by the diver, thus enabling the weakening behaviour to be evaluated, as represented in the following figures.

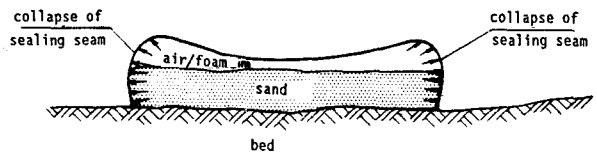
Key to diagrams



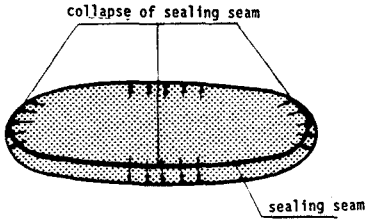

uniform unloading




"over the top" unloading




side view




top view

If the container collapsed during unloading, no further damage was found by the diver beneath. Where collapse occurred on the bed, damage was found on seams at the ends and/or seams in the centre; in most cases this damage was caused to the sealing seam.

To overcome the 'air problem' it was decided to place the bin under water after sealing the container. As a result of this unloading was now carried out without any problem, but weakening on the bottom continued. The probable causes of this were the absence of air, increasing the rate of sinking, the impact from landing on the bottom was harder, and the water present, instead of air, which was forced out during depositing.

**More on km. 1005**

Up till now collapse at the test section at km. 1006 applied to all types of containers, both in wet and dry unloading.

Because it was not certain that collapse would occur at a lesser depth, and because the technique of assembly, positioning and sinking had now been mastered, it was decided to stop at km. 1006, and to continue at km. 1005, where the bottom depth varied from u.w.l. -11 to u.w.l. -17. At a number of points further containers are installed wet on the inside of the work to be constructed. At depths down to approx. -12 m containers remained intact, but at greater depths they still collapsed.

**Adaptations of geotextile**

In order to solve the problem of collapse, the containers were adapted as follows:

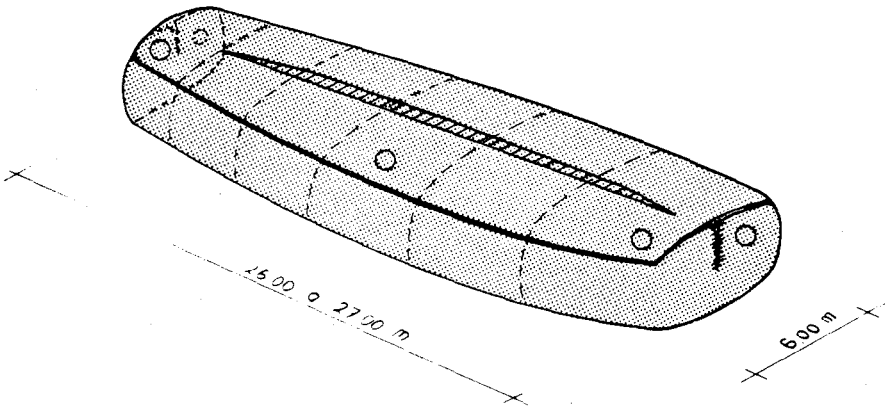
- both the factory and sealing seams were strengthened. The seams were now stitched 3 times (originally twice), and instead of nylon thread, the strong polyester thread was used. In the case of the sealing seam produced with a hand sewing machine, work is carried out from inside to outside, with the stitching overlapping each other. Thus stitching which breaks is covered by the stitch behind it, thereby preventing 'tearing open' over a long length.

- in order to be able to carry out dry unloading, grills were fitted to the containers to serve as 'outlet valves' for the air which is forced out during unloading and depositing on the bottom. The grills had a diameter of 750 mm, and were manufactured from fabric with a 0-90 of 1000 mu (see Appendix 9). There were secured to the inside with threefold stitching of polyester thread. The recesses for the grills were 'sealed' to prevent fraying at the edges. The grills were fitted at the points where the sealing seam failed in most cases, two at each end, and one in the centre;

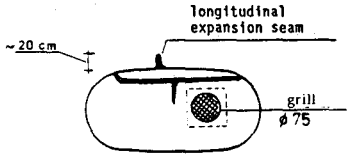
- experiments were carried out with so-called 'expansion seams'; of these either one seam was stitched over the full length of the container, or two at the ends. The principle was a sewn-in fold, with a weaker stitch than that of the sealing seam, which is the first to collapse under loading, and in doing so receives a section of the flap;

- finally it was decided not to proceed with containers of the type 300; because of the difference in quality between warp and weft, particularly the tensile strength of the warp, which is too low, this type of fabric did not appear to be suitable.

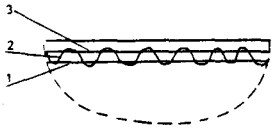
The adaptations are shown in the figures below.




container with 5 grills and longitudinal expansion seam




front view of container




sequence of stitches made

**The adaptations appeared to be successful:**
- the grills worked very well, which could be seen from the enormous tracks of bubbles;
- the diving survey showed that the expansion seams had disappeared, and therefore worked;
- the (strengthened) seams, and hence also the containers, remained intact for the most part (> 80%); - dry unloading was now possible.

In order to reduce the collapse (failure) percentage still further a number of other things were tried out. It was shown that containers of type 180, with 5 grills, are suitable down to a depth of approx. -12 m, and among other things the collapse percentage increases slightly in this type. At depths greater than -12 m, the stronger type 130, with 5 grills, and a longitudinal expansion seam, appears to work.
The sand tightness coefficient of the grills for the sand used here was a little on the high side (2.6). Although this did not result in a loss of sand, containers were sunk, as test 4, whose grills had a O-90 of 520 mu (sand tightness coefficient 1.4). 2 of these then collapsed (probably due to closing of the grills), whereupon it was decided to continue using the original grills. Both the longitudinal and end expansion seams worked, however, there was doubt about the useful effect of the end expansion seams. In view of the work involved, it was decided only to proceed with the longitudinal expansion seam.

**Accuracy of installation**
The installation accuracy does not appear to depend on the behaviour of the container during sinking but on keeping the split barge in position during unloading. This took place at km. 1006 by means of two tugs and with a sounding boat equipped with Artemis. If the unloading takes a little more time, which is the case in dry loading, there seem to be problems at higher current speeds in keeping the split barge in position. Deviations of several metres from the planned position may then occur. If two tugs and a sinking pontoon, as at km. 1005 are used, these problems do not arise, and accurate sinking is possible in the transverse direction, to an accuracy of 1 m, and in the longitudinal direction to 2 m. A container, once 'unloaded', moves vertically downwards and no longer deviates from its position, not even at the maximum current speed (1.5 m/s). The average sinking speed appears to be approx. 5 m/s.

**Influence of external conditions**
The influence of factors such as tide, current and weather conditions on the results obtained with the containers is generally small.

As mentioned, high current speeds only cause problems when sinking is only carried out with tugs. However, if conditions warrant using this method, preference should be given to sinking around the turn of the tide.

It has been shown that frost may have a negative influence on the results. Because of the stiffness caused by freezing of the sand on the fabric and the formation of lumps of ice in the containers, these may collapse even during unloading. If the geotextile is stored dry and frost-free, and if the split barges are not loaded and 'left' over night, work can continue in a moderate frost (-5_ C).

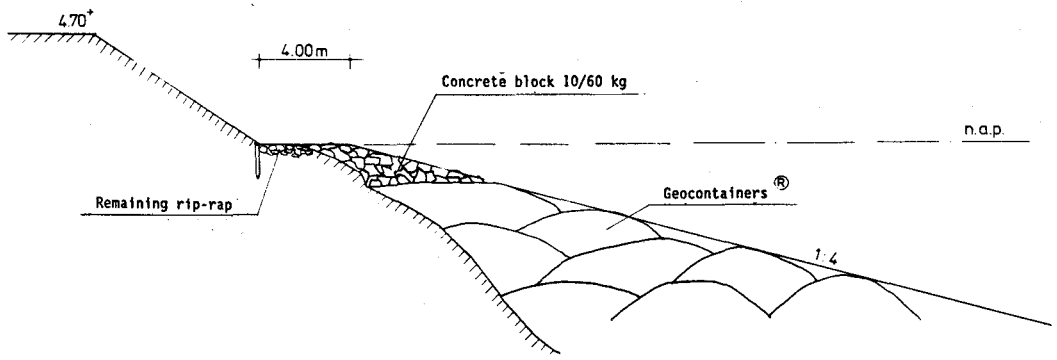
## 3.2 Production of bank structure

The production of a stable bank structure of under 1:4 at **km. 1005** presented few problems; the principles outlined in 2.3 were effective. Important conditions are:
- accurate positioning of the split barge during sinking;
- up to date recording forms, laying diagrams, soundings and cross-sections for good planning of new laying locations and uniform, layered structure.

The dimensions of the containers were approx. 26.5 x 6m. To enable the containers to connect effectively together in the longitudinal direction, 25 m was allowed for the length of the dumping zone. 5 m was allowed for the centre to centre distance of the containers in the transverse direction, which also ensured a good overlap in this direction. A deviation of 1 to 2 m from the planned position did not present a problem; because of its flexibility each new container was adapted to the subsoil, and filled the gap, as it were, between the underlying containers.

Towards the end a problem arose in installing the uppermost layers. Because of the shallow depth of approx. 3 m, the sinking rate was lower, thereby preventing the corners of the containers from being completely filled during depositing, and causing them to continue floating. This sometimes resulted in damage from the propellers of the tugs. The problem was overcome using containers with less 'excess' fabric. This was achieved by adapting the fabric model to the shape of the bin, thereby reducing the amount of loose space in the corners and reducing the circumference by 2 m. Four of these adapted 'bin models', with 3 grills on the top, were tested with a satisfactory result.

Between the 4 m wide berm and the containers, and to prevent damage, the upper edge of the work was covered with a layer of broken concrete, as shown in the figure below.



## 3.3 Summary

18 containers were sunk in the **test section at km. 1006**. The total weight (measured in the trailing suction dredger) was 5650 tonnes, which works out at 314 tonnes per container (approx. 174 m3, calculated on the basis of a weight per unit volume of 1.8 tonnes/m3). Of the 18 containers, 17 collapsed; the basic models of types 130, 180 and 300. Later another adapted model of type 180, with 5 grills, was sunk and remained intact.

At the **bank filling at km. 1005**, a total of 233 containers were used:
- 17 of type 300;
- 152 of type 180;
- 64 of type 130.

A total of 76,019 tonnes of sand (approx. 42,230 m3) was used in 104,850 m2 of geotextile. As an avarage 326 tonnes of sand was used in each Geocontainer (R) (181 m3_). This average is a little on the low side because initial experiments were carried out on the degree of filling; if this initial period is ignored, an average of 346 tonnes of sand (approx. 192 m3) was used in each container.
It is not as simple to gain a clear picture of the collapse percentage. All in all 51 of the 233 containers collapsed, amounting to 22%. However, this includes the basic models, the experimental models and the containers which are damaged by propellers in the uppermost layers.
If we only look at the modified containers, on which further work had been carried out, and take into account that a solution was found to the problem in the lower layers, then the collapse percentages would appear to be as follows:
- type 130 with strengthened seams, 5 grills and one longitudinal expansion seam, used at depths exceeding 12 m: 5%;
- type 180 with strengthened seams and 5 grills, used at depths shallower than 12 m: also 5%.

In order to restore the eroded bank at km. 1005 to a gradient of 1;4, approx. 36,000 m3 were needed in theory. A total of approx. 42,230 m3 sand was used, the loss of sand resulting from all the collapsed containers (including the test models) being approx. 2100 m3 (estimate from soundings). The percentage of **settlement and subsidence** is calculated as follows:

| | |
|---|---|
| sand used | 42,230 m3 |
| sand loss | 2,100 m3 |
| | 40,130 m3 |
| difference between in and out soundings | 35,992 m3 |
| settlement and subsidence | 4,138 m3 |

The percentage of settlement and subsidence is therefore approx. 11.5% of the theoretical rise.

## 4. CONCLUSIONS AND RECOMMENDATIONS

### 4.1 Technical possibilities

The conclusion may be drawn from the results of the trial at km. 1006 and km. 1005 on the Old Meuse **that the filling and protection of (too steep) an underwater bank by means of Geocontainers is a technically viable solution.** If the correct materials and a good method of construction are used, a stable bank can be obtained with a gradient of 1:4 with a minimum of material loss, even at higher current velocities (1-2 m/s). The general conditions under which this should be carried out are indicated in 4.3 'Recommendations'.

The collapse percentage of the containers was finally reduced to 5%. The loss of sand can be limited to a fraction of this if collapsed containers are immediately covered.

In view of the low deviations from the planned position when installing the containers, it may be assumed that even a slope of 1:3 can be provided without any problems. However, it cannot be stated definitely whether a gradient of 1:2 is also feasible for bank filling. The accuracy of installation will be more sensitive in any case, and the stability of the bank will also be in question. In other applications (e.g. underwater dams), a slope of 1:2 or steeper may well be feasible using a different method of stacking.

As already mentioned, the upper edge of the constructed work was covered with a layer of concrete blocks. It is difficult to make a statement about possible damage to containers lower down in the slope from ships, anchors etc., but it is expected that a damaged container will remain (partially) empty. However, the construction of the slope is such that no problems are anticipated in this area. The constructed work will in any case be regularly checked by soundings in the future.

**Other possible applications of Geocontainers(R)** are:
- their use in the cores of groynes, sills, breakwaters and piers;
- protection of underwater mains, pipelines and pipe caps;
- emergency closing of dike breaches.

## 4.2 Financial viability

**Costs of Geocontainer(R)**
At km. 1005 233 containers were processed with approx. 76,000 tonnes of sand and 104,850 m2 of geotextile. For the work constructed at k.m. 1005, one container costs approx. 6,500 glds. (excl. VAT). On average one container contained 181 m3 of sand, which amounts to approx. 36 glds./m3, including start-up problems and development costs. Now if we assume that one container can hold approx. 200 m3 of sand, and that a production of 5 containers per day is feasible, then the costing will look something like this:

Per container:

| | |
|---|---|
| - 450 m3 of geotextile at 6 glds./m2 (average type 130 and 180) | 2700 glds. |
| - 200 m3 of sand = 360 tonnes at 4 glds./tonne | 1440 glds. |
| - sinking | 800 glds. |
| sub-total | 4940 glds. |
| - shed, aids, vessel, supply and discharge position locating system, construction costs, total 10% | 494 glds. |
| sub-total | 5434 glds. |
| - general costs, profit and risk, total 8.5% | 462 glds. |
| total, excl VAT | 5896 glds. |

Per m3:

The price per m3 therefore amounts to 29 to 30 glds. (excl. VAT).

**Other materials**
A comparison with other materials gives the following:
- supply and processing of unsorted pit stone costs approx. 30 glds./m3. With a percentage loss of 30%, the price amounts to 39 glds. per m3 filled;
- supply and processing of sorted pit stone costs approx. 34 glds./m3. With a percentage loss of 10%, the price amounts to 37 glds. per m3 filled;
- supply and processing of LD slags costs approx. 50 glds./m3;
- supply and processing of sea gravel costs approx. 40 glds./m3. The prices are exclusive of VAT.

**Conclusion**
From the point of view of price the use of Geocontainers (R) is a good alternative.

## 4.3 Recommendations

For works in which Geocontainers(R) can be used, the following recommendations can be given.

- Depending on the water depth, working with the following **types of containers:**
  . at depths > 10 m: containers of type 130 (Nicolon 66786 fabric) with 5 No 750 mm dia. grills (Nicolon 66448 fabric) and a longitudinal expansion seam;
  . at depths < 10 m: containers of type 180 (Nicolon 66392 fabric) with 5 No 750 mm dia. grills (Nicolon 66448 fabric)
  . the last 2 layers of a slope structure: containers of type 180 according to the 'bin model', with 3 grills on the top (see page 13).

- The ratio of the mesh width of the geotextile to the grain distribution of the sand must be such that there is no appreciable sand loss. In this case the grills are determining components: a **sandtightness coefficient (O-90/D-90)** of 2.6 for the grills has so far proved viable.

- The **loading** should be carried out as follows:
  . fill each container with 195 to 200 m3 of sand;
  . place the sand firmly and uniformly on a flat surface, and fill the front and rear of the bin well so that the container leaves the bin uniformly.

- To allow the containers to be unloaded flexibly, fit **sliding fabrics** in the bin (sides 25 x 5 m and ends 5 x 5 m).

- **Transverse seams** (factory seams) 3 stitches with polyester thread, with a centre to centre and edge distance of the stitches of 15 mm (total overlap approx. 60 mm).
  **Longitudinal seams** (sealing seams) stitch 3 x with hand sewing machine, also with polyester thread. Stitch from the inside to the outside, each stitch overlapping, as shown on page 11.
  **Grills**, strengthen with 3 polyester thread stitches;
  'seal' the recesses for the grills.

- Carry out the **construction** as follows when repairing the underwater slope:
  . place the containers as flat as possible on the bed;
  . install the containers with their longitudinal axes parallel with the bank;
  . direction of working from outside to inside;
  . construction in horizontal layers;
  . build up the section to be filled as uniformly as possible;
  . connect the containers together as smoothly as possible. For this purpose, in the same layer, work with centre to centre distances of 5 m (in transverse section) and 25 m (in longitudinal section);
  . place each container on top of two other containers on the layer below (half-brick joint in cross-section);
  . over the 3 layers move half a container length in the longitudinal direction.

  **Aids to this are:**

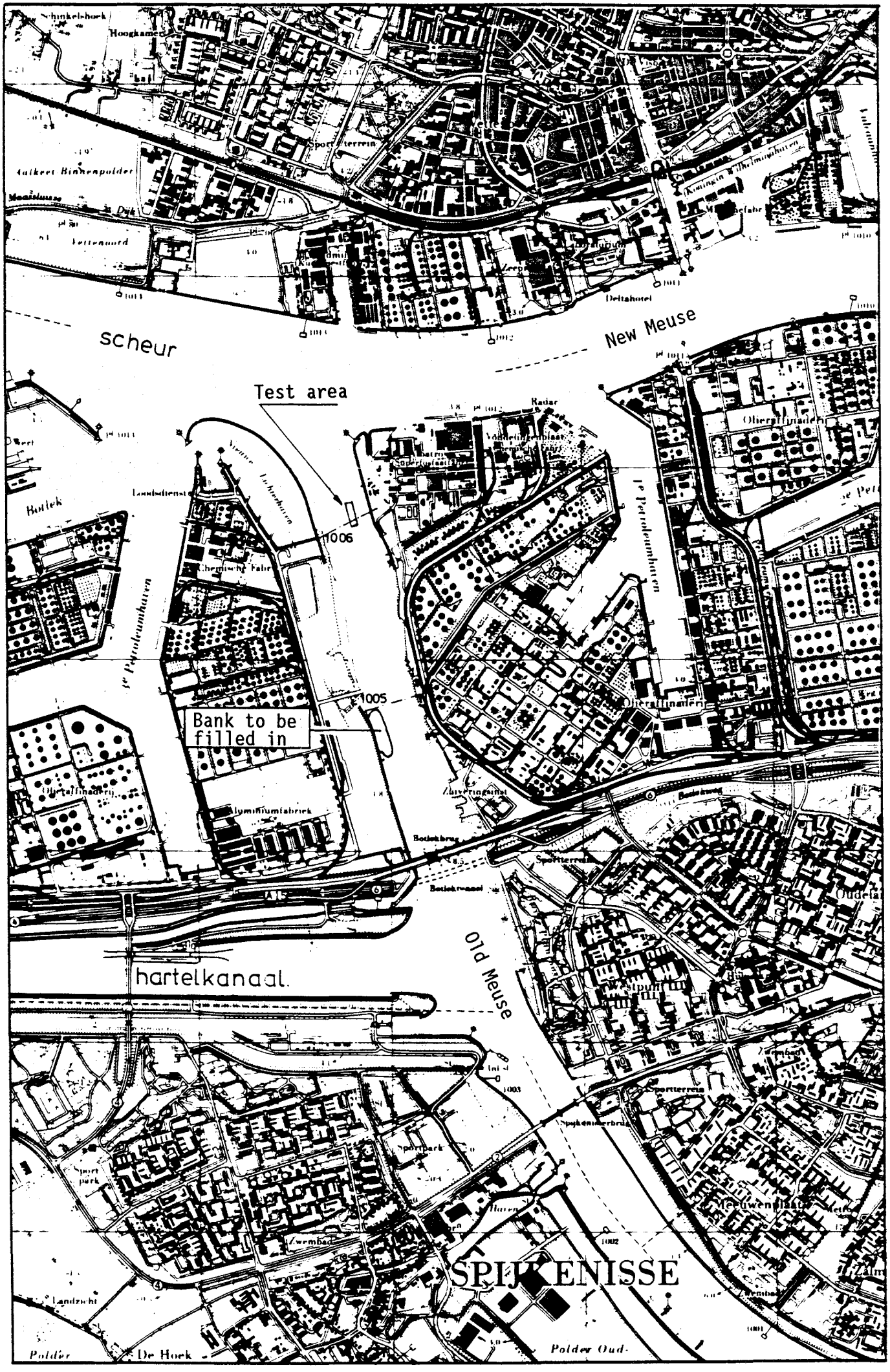
  . a system of markers set out on the bank ('concrete mattresses');
  . a sinking pontoon and/or a flat-bottomed boat with position locating system (depending on location, intensity of shipping and current);
  . laying diagrams for position locations;
  . soundings (each layer) and cross-sections for position locations (determinations);
  . record forms for position data and sinking conditions.

- Cover containers which **collapse** with the next container as quickly as possible. To be able to detect collapse, provide each container with about 20 wooden blocks (50x50x50 mm), indicating the number of the container.

- In the event of a light frost, store the geotextile in a **dry, frost-free** place, and do not allow any loaded containers to lie in 'demurrage' overnight. Do not process any containers at temperatures below 5_ Celsius (moderate to severe frost).

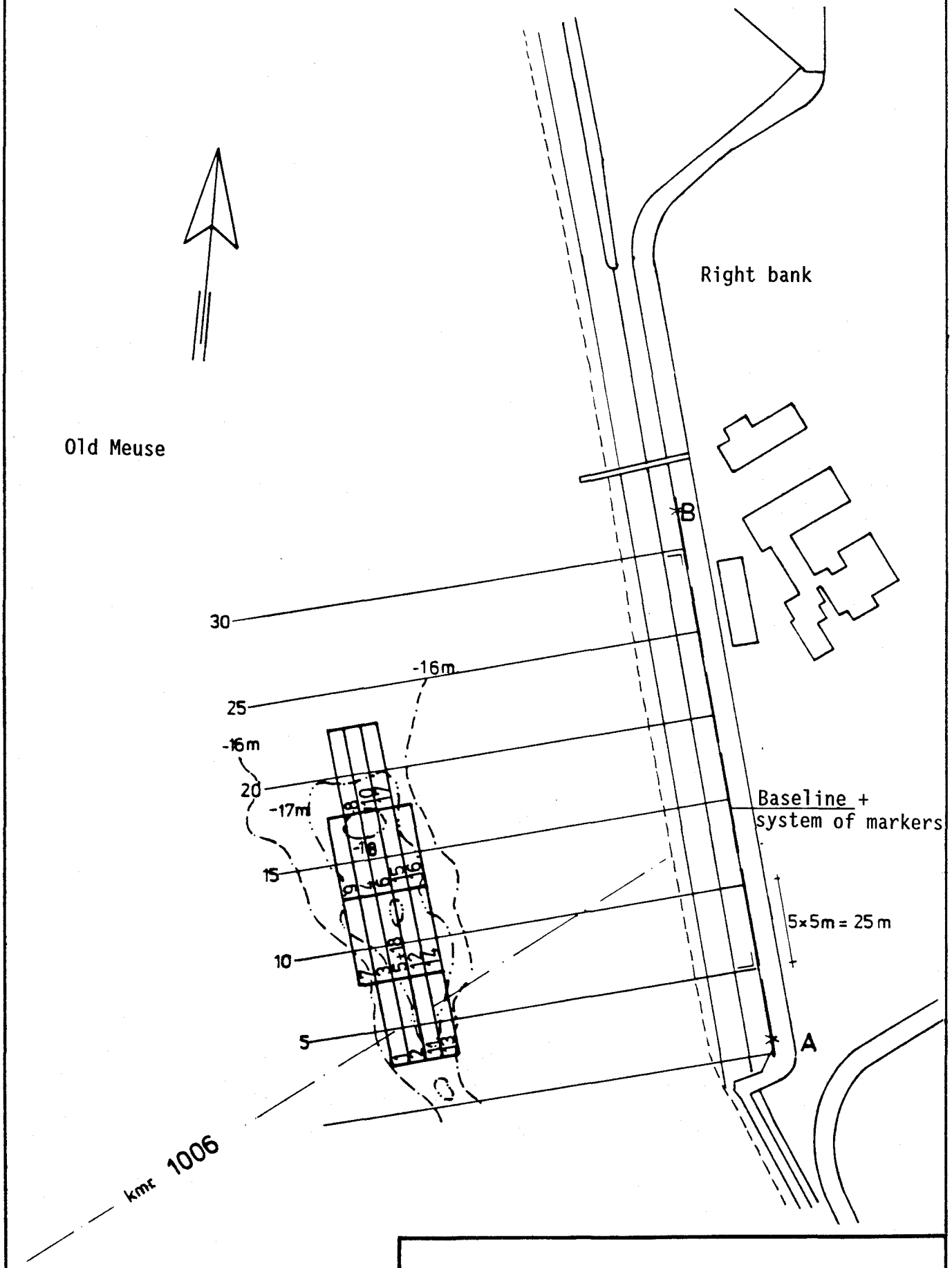
Appendix 1

## General survey


scheur
New Meuse
Test area
Bank to be filled in
1006
1005
1e Petroleumhaven
hartelkanaal
Old Meuse
SPIJKENISSE
Polder
De Hoek
Polder Oud-

Appendix 2

## Laying diagram, test area km. 1006




Laying diagram, test area km. 1006

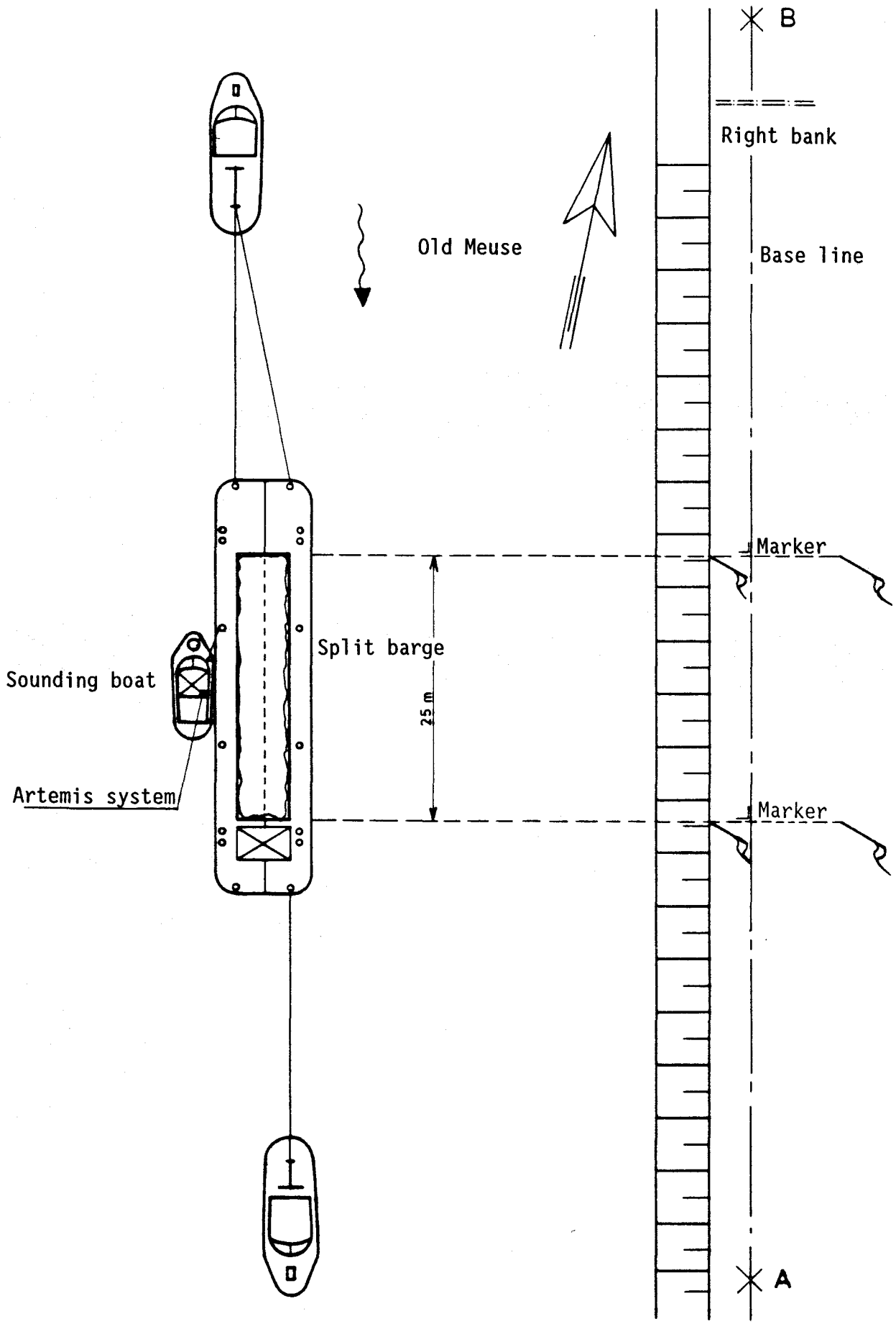
Department of Public Works
Directorate of Lower Rivers

210×297

Scale 1:1500

Appendix 3

Method of sinking, km. 1006.




Method of sinking, km. 1006

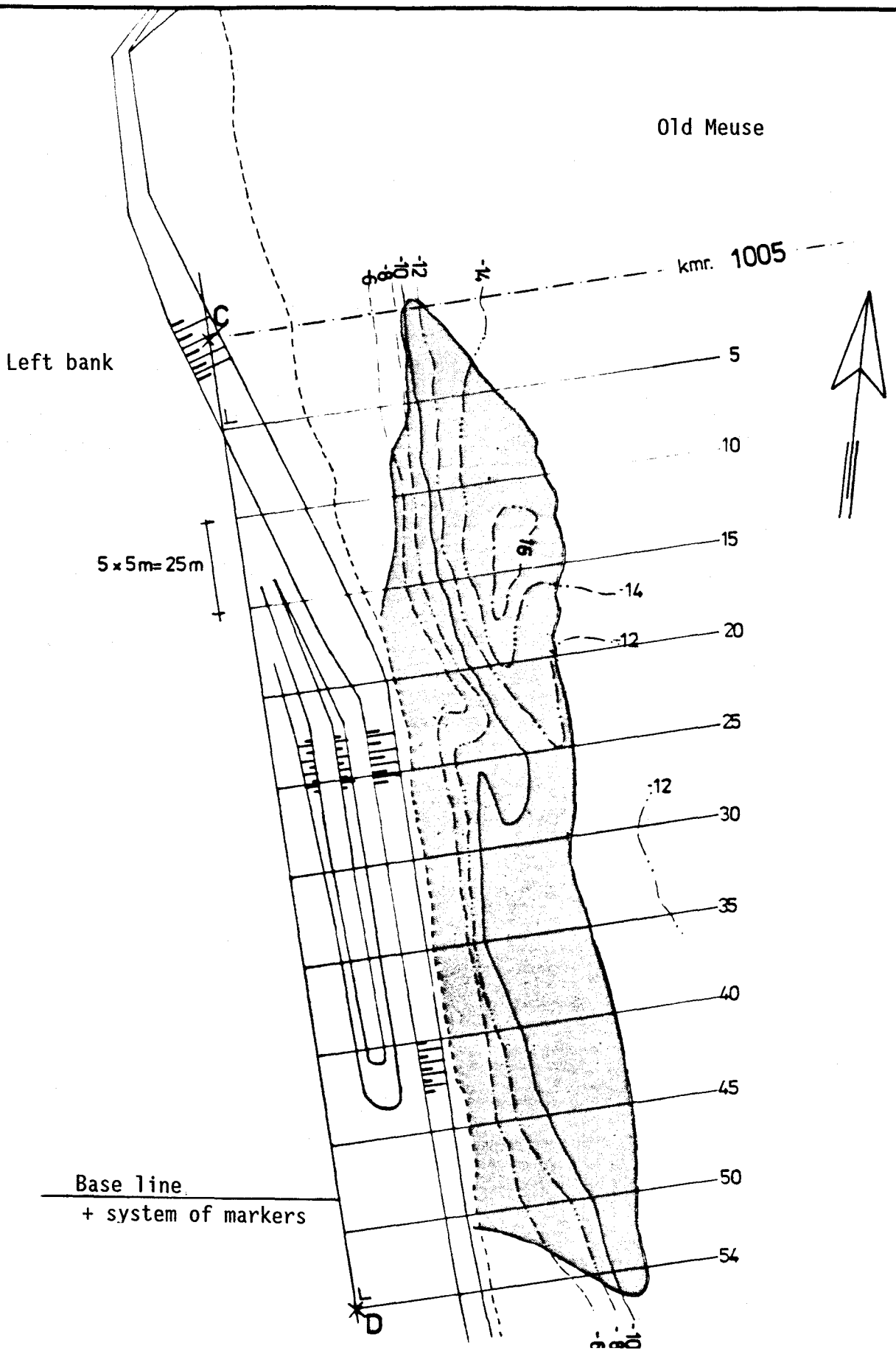
Department of Public Works
Directorate of Lower Rivers

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Scale 1: 500

Appendix 4

Survey of bank filling, km. 1005.




Survey of bank filling, km. 1005

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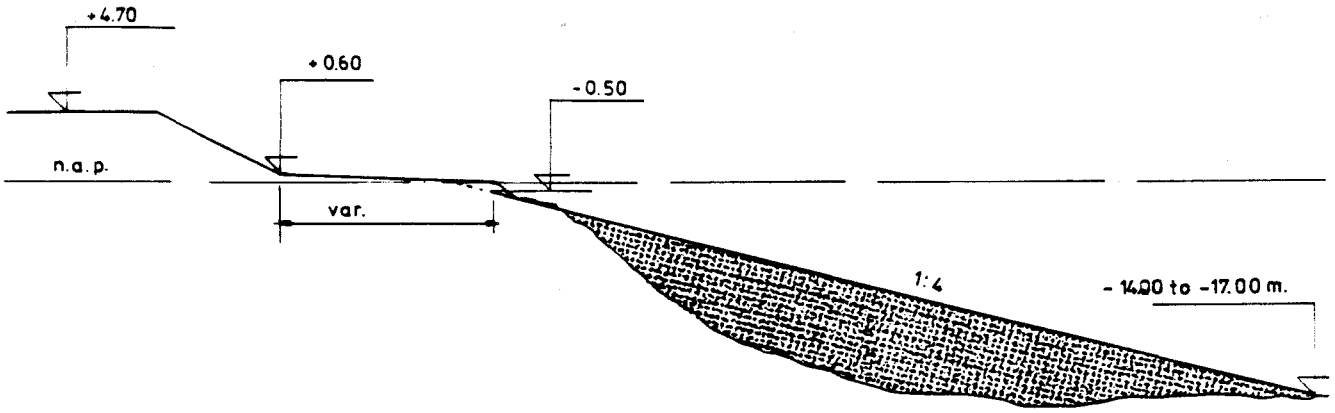
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Scale 1:1500

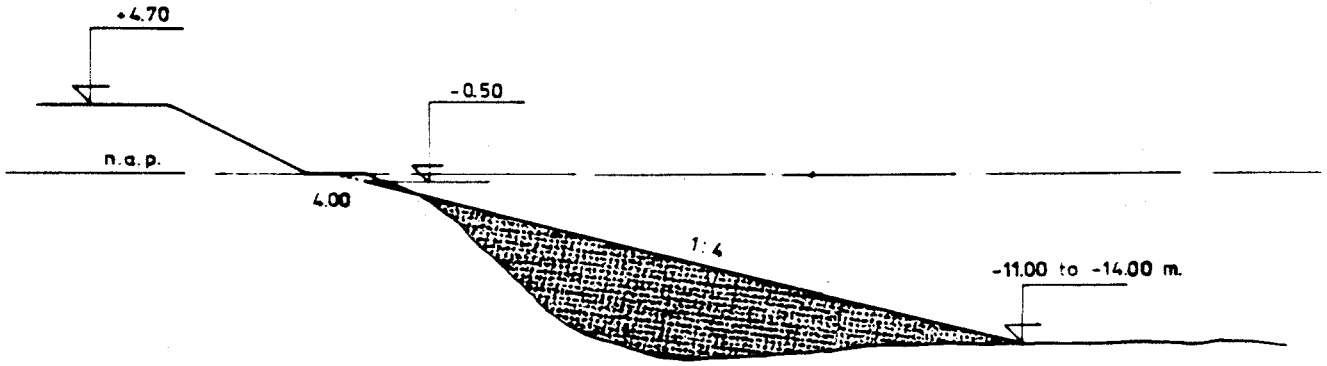
Appendix 5

## Diagrammatic representation of cross sections at km. 1005

1. Diagrammatic representation of location of marker 1-22




2. Diagrammatic representation of location of marker 22-54

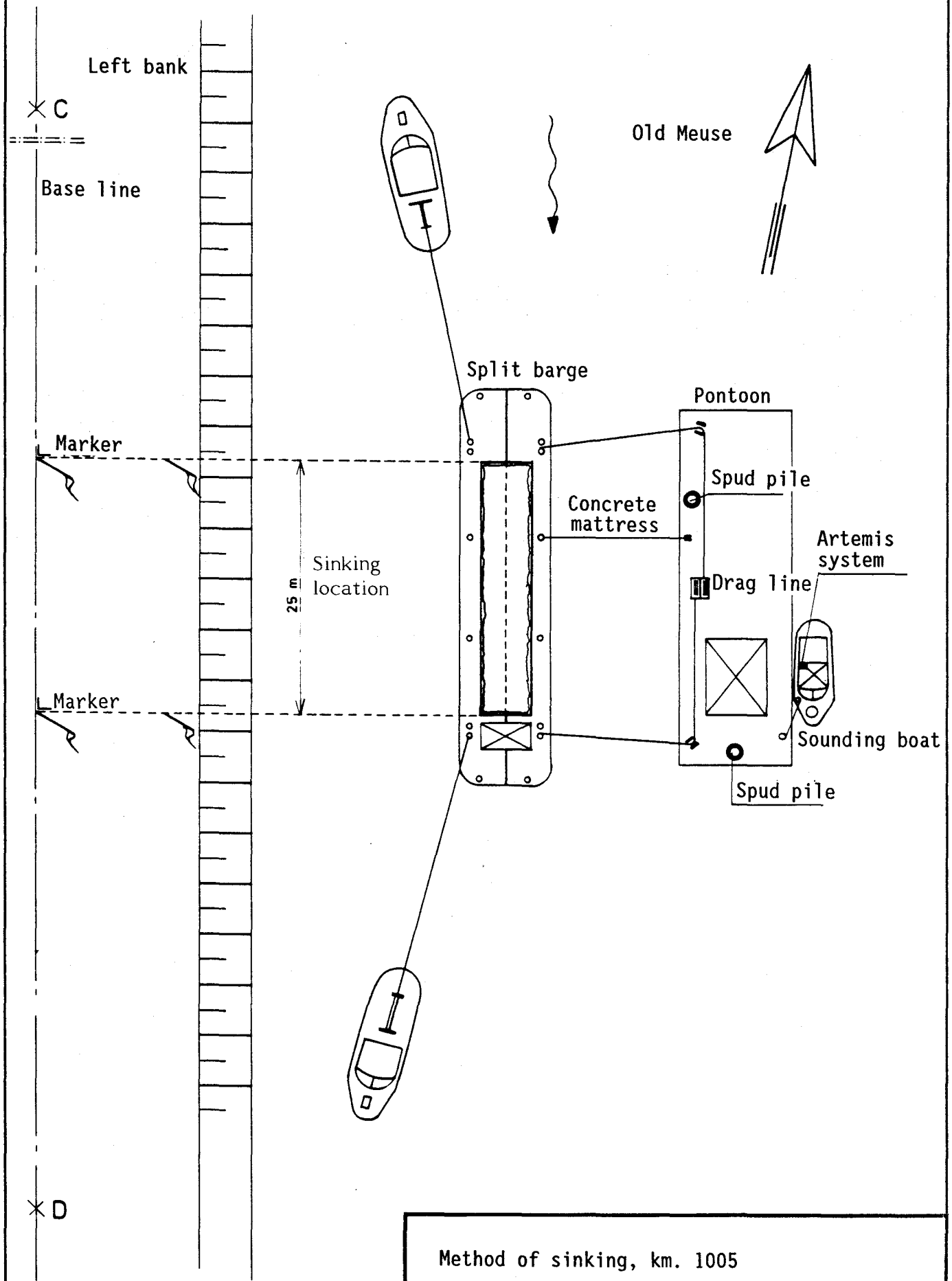



Explanation
Dimensions in metres
Height dimensions in metres relative to underwater level
Filling with geocontainers (R)

| | |
|---|---|
| Diagrammatic representation of cross-sections, km. 1005 | |
| Department of Public Works<br>Directorate of Lower Rivers | 210 × 297<br>Scale 1: 500 |

Appendix 6

## Method of sinking, km. 1005




Method of sinking, km. 1005

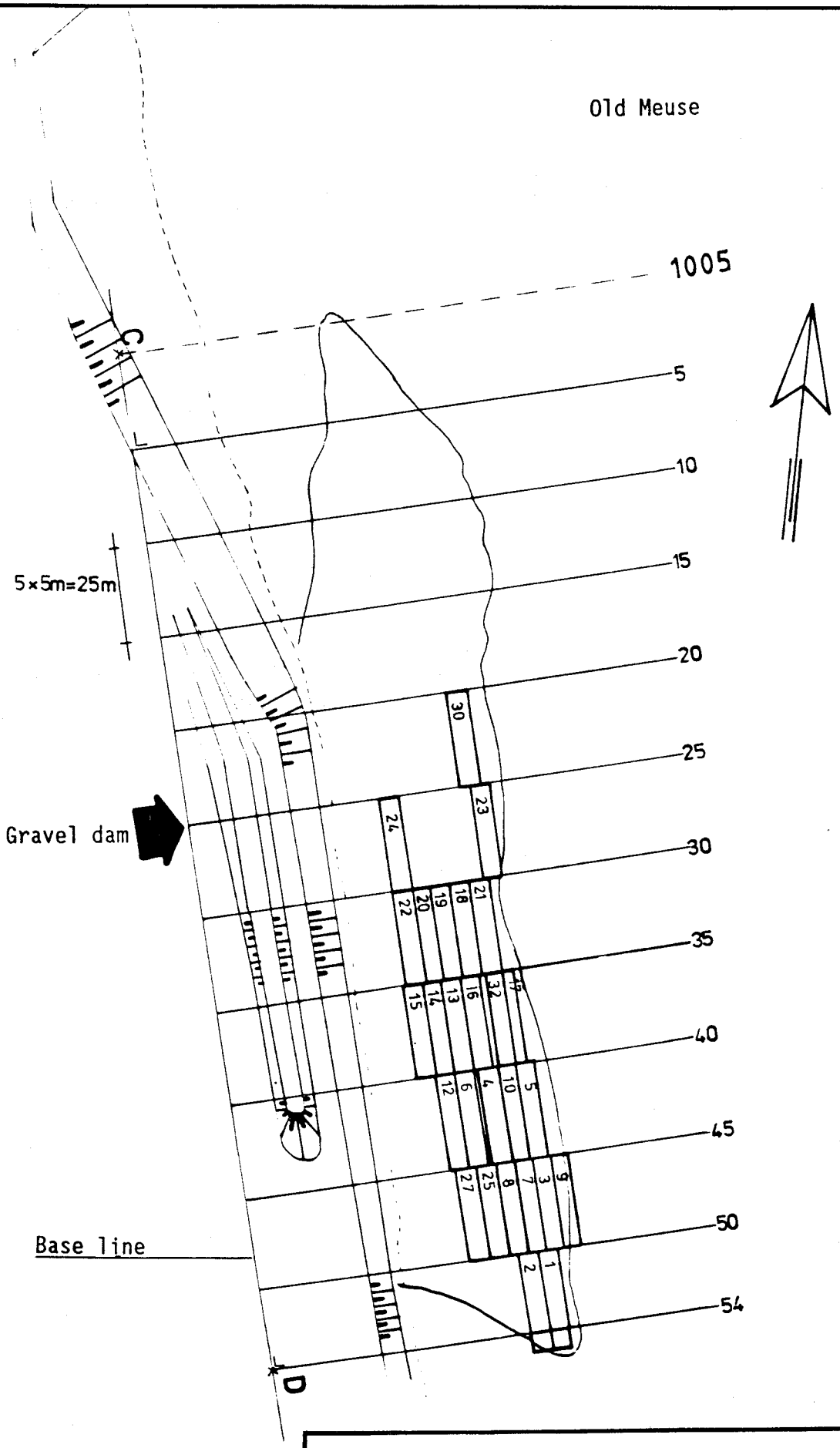
Department of Public Works
Directorate of Lower Rivers

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Scale 1: 500

Appendix 7

Laying diagrams, km. 1005



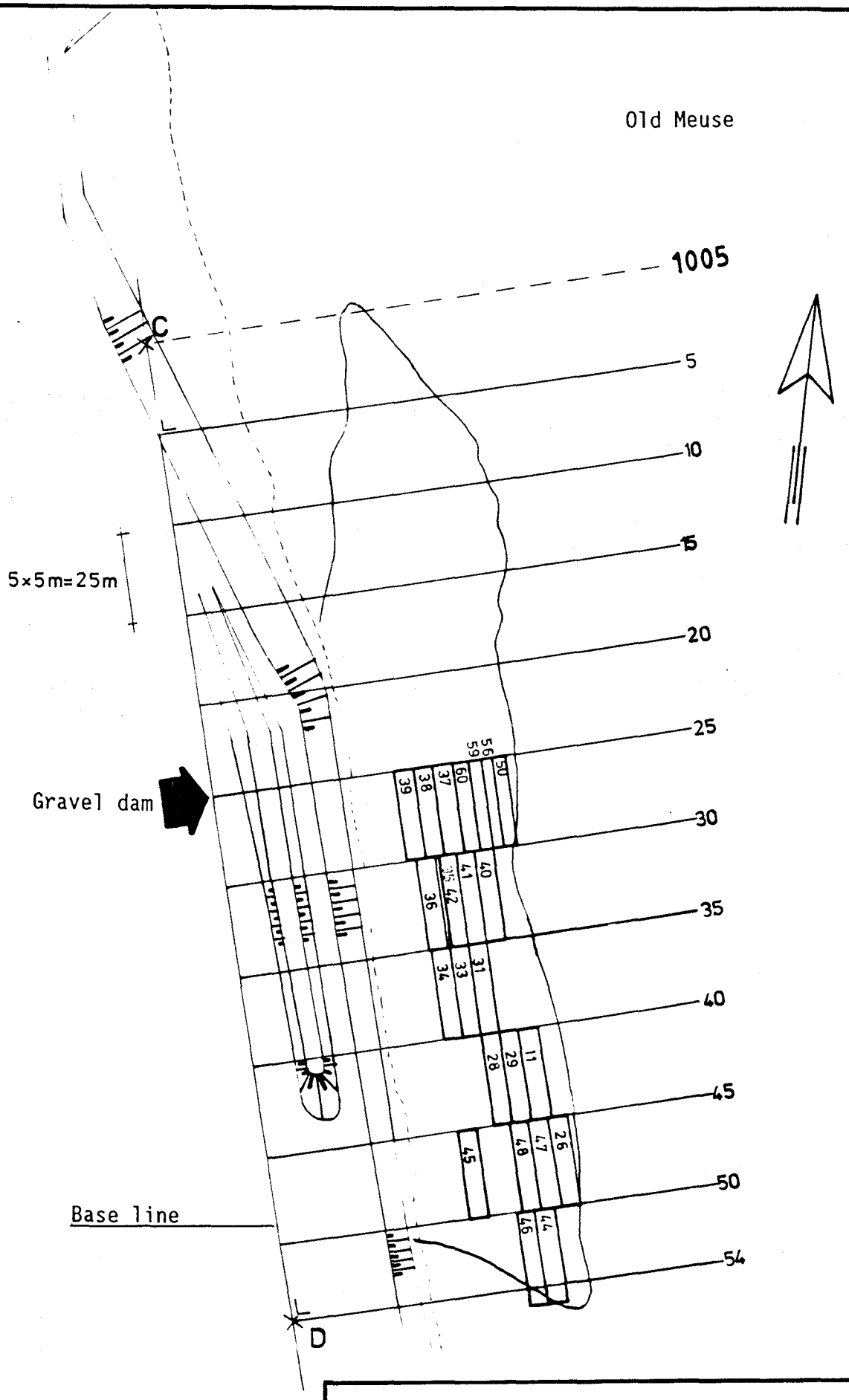

Laying diagram, km. 1005

sheets 1

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Scale 1:1500



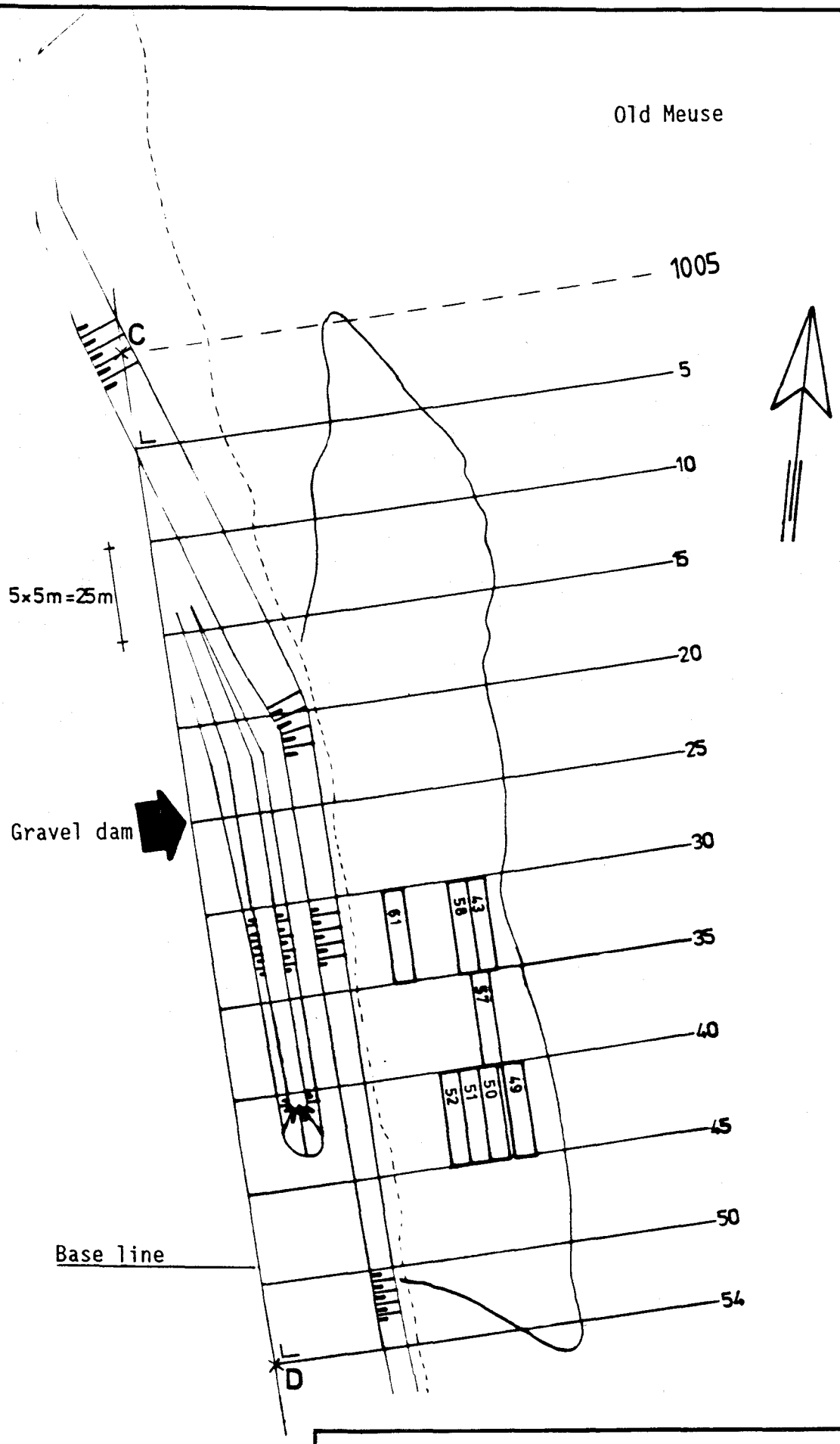

Laying diagram, km. 1005

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Scale 1:1500



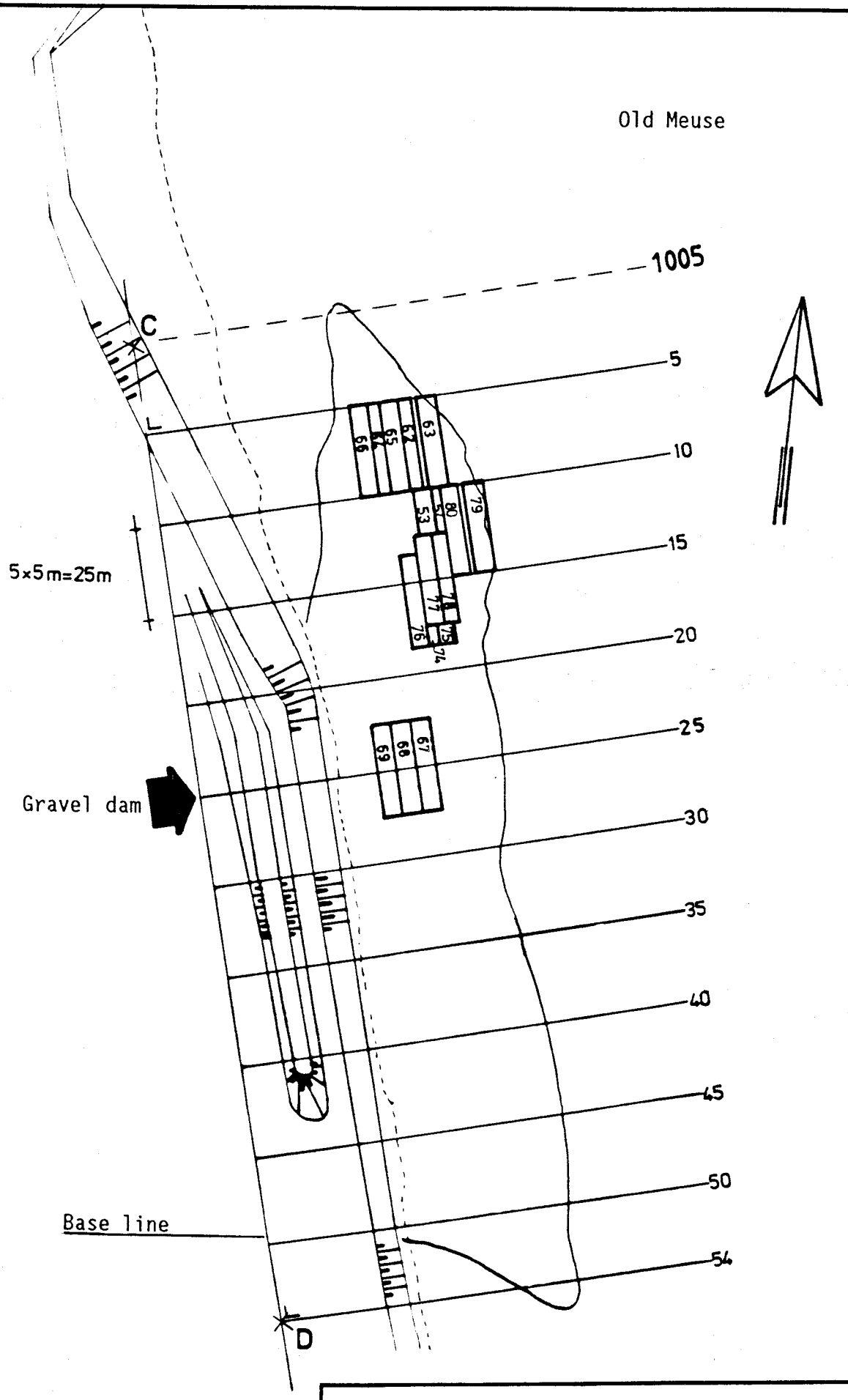

Laying diagram, km. 1005

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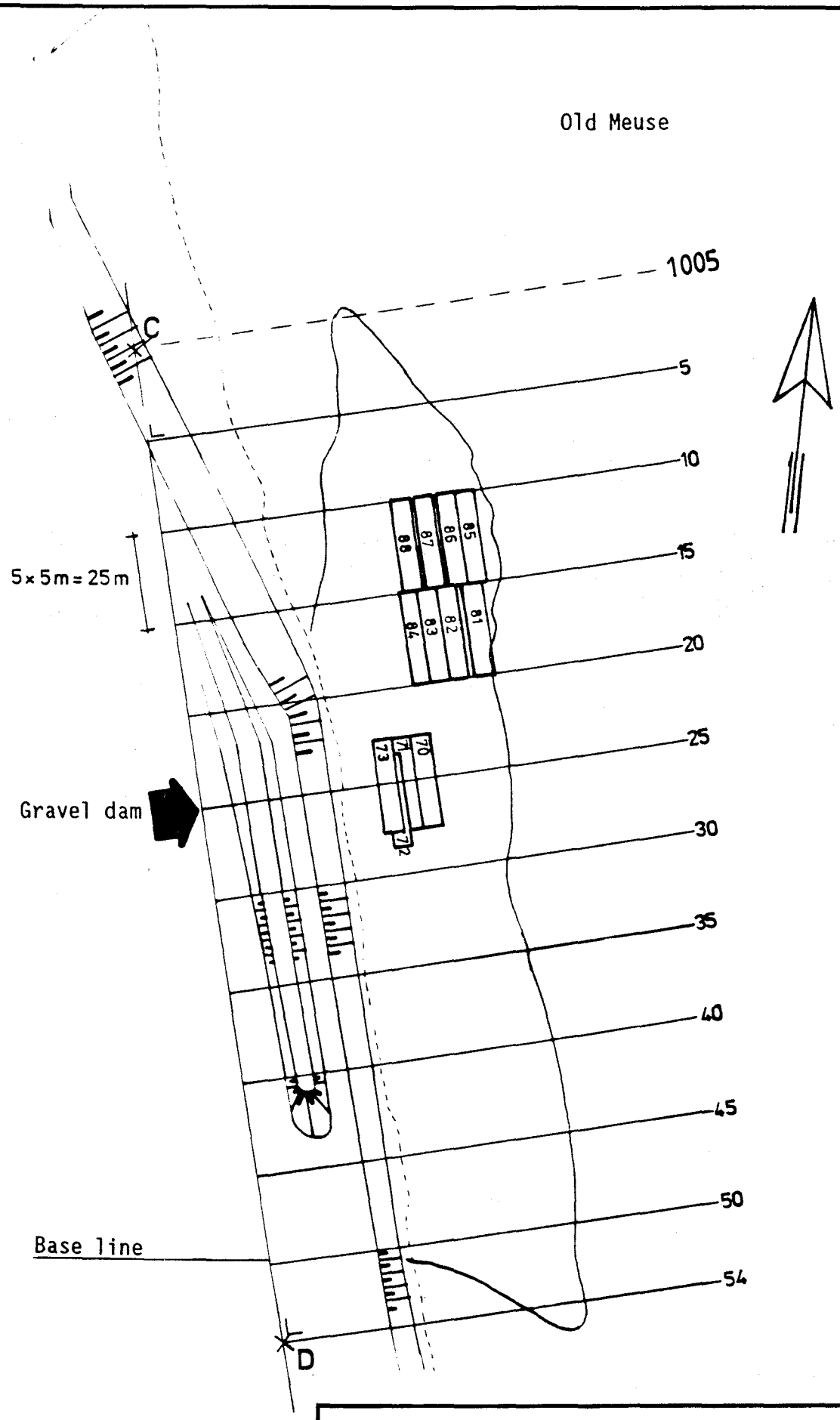

Laying diagram, km. 1005

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210×297

Scale 1:1500



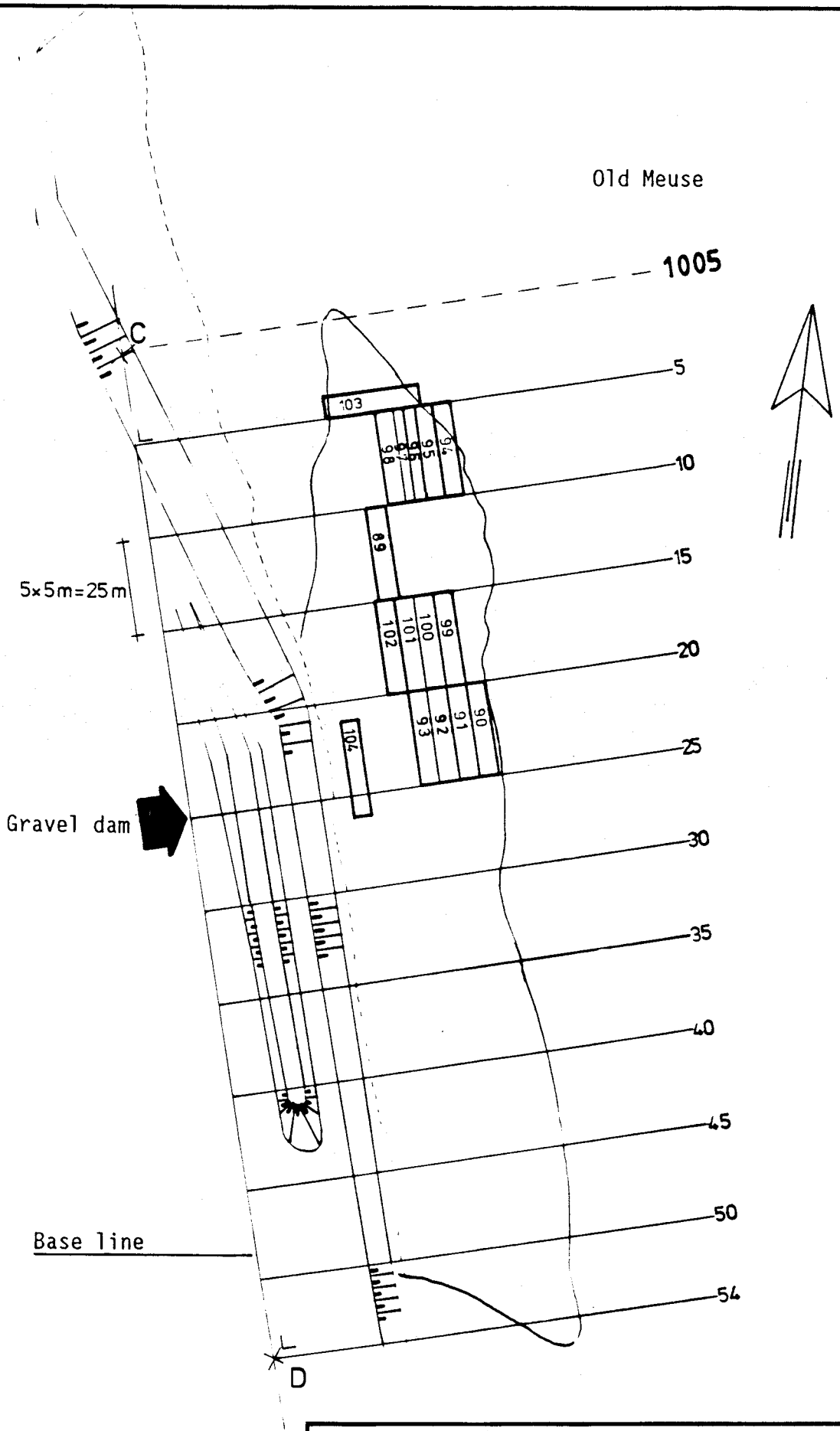

Laying diagram, km. 1005

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Department of Public Works
Directorate of Lower Rivers

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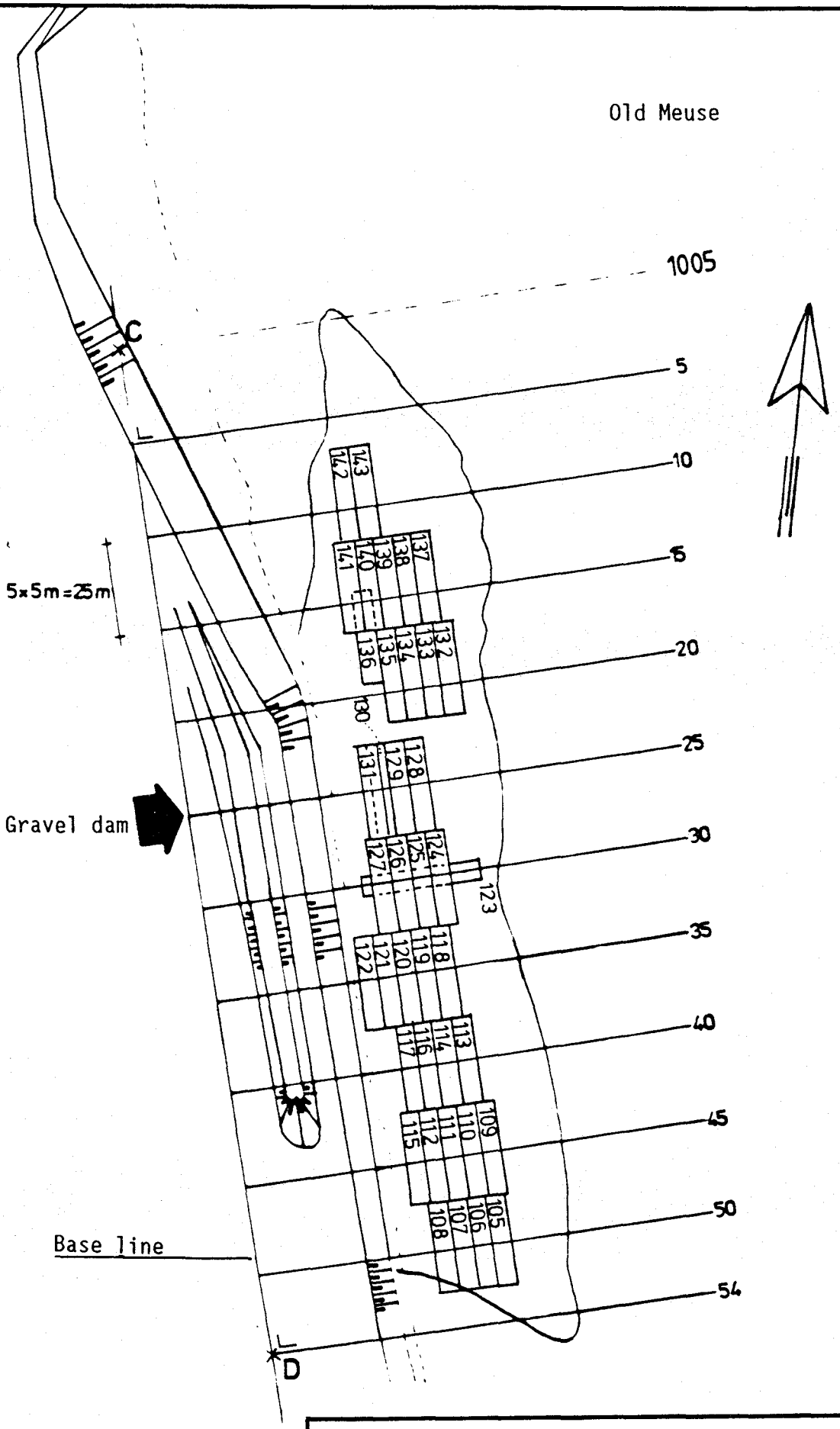

Laying diagram, km. 1005

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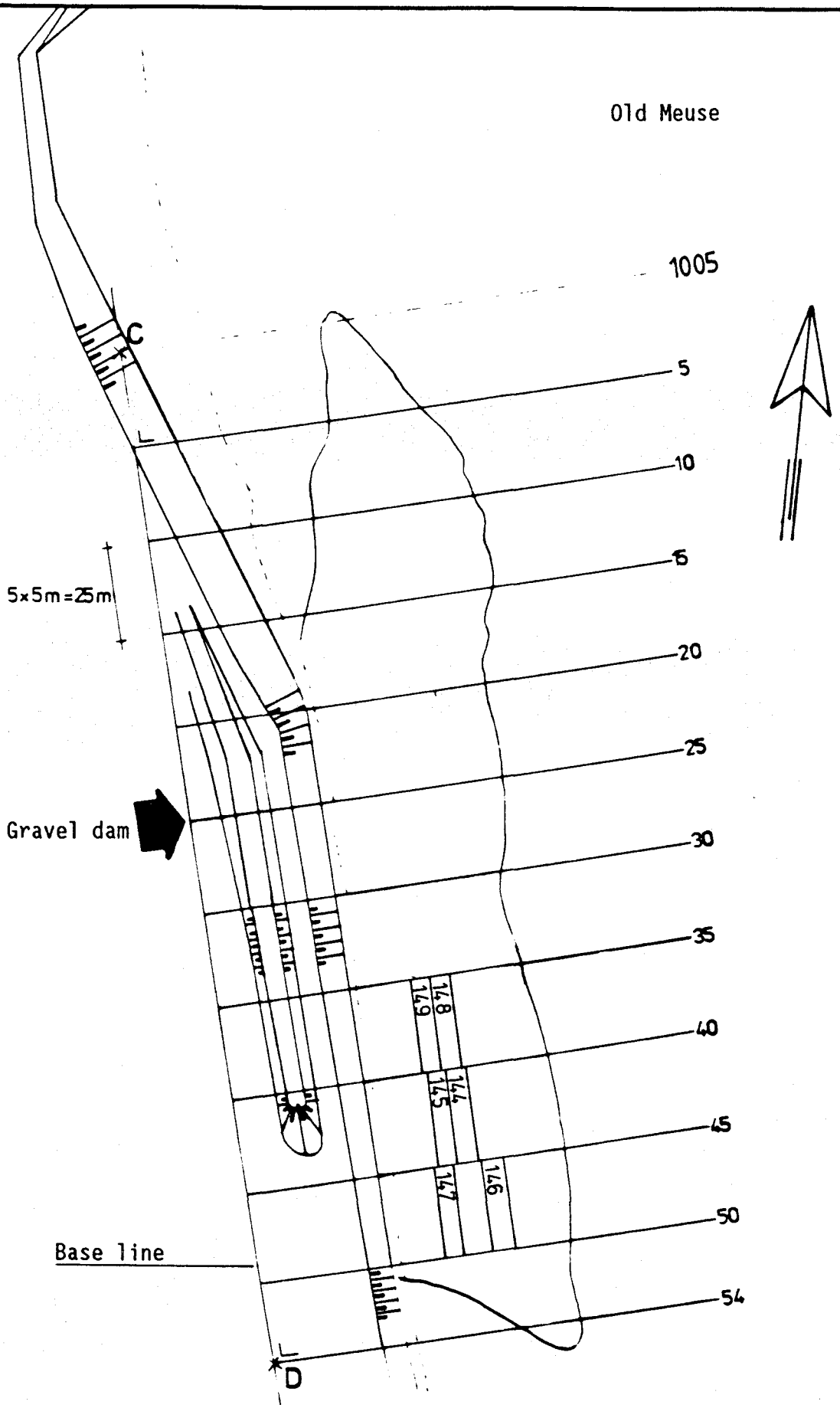

Laying diagram, km. 1005

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Directorate of Lower Rivers

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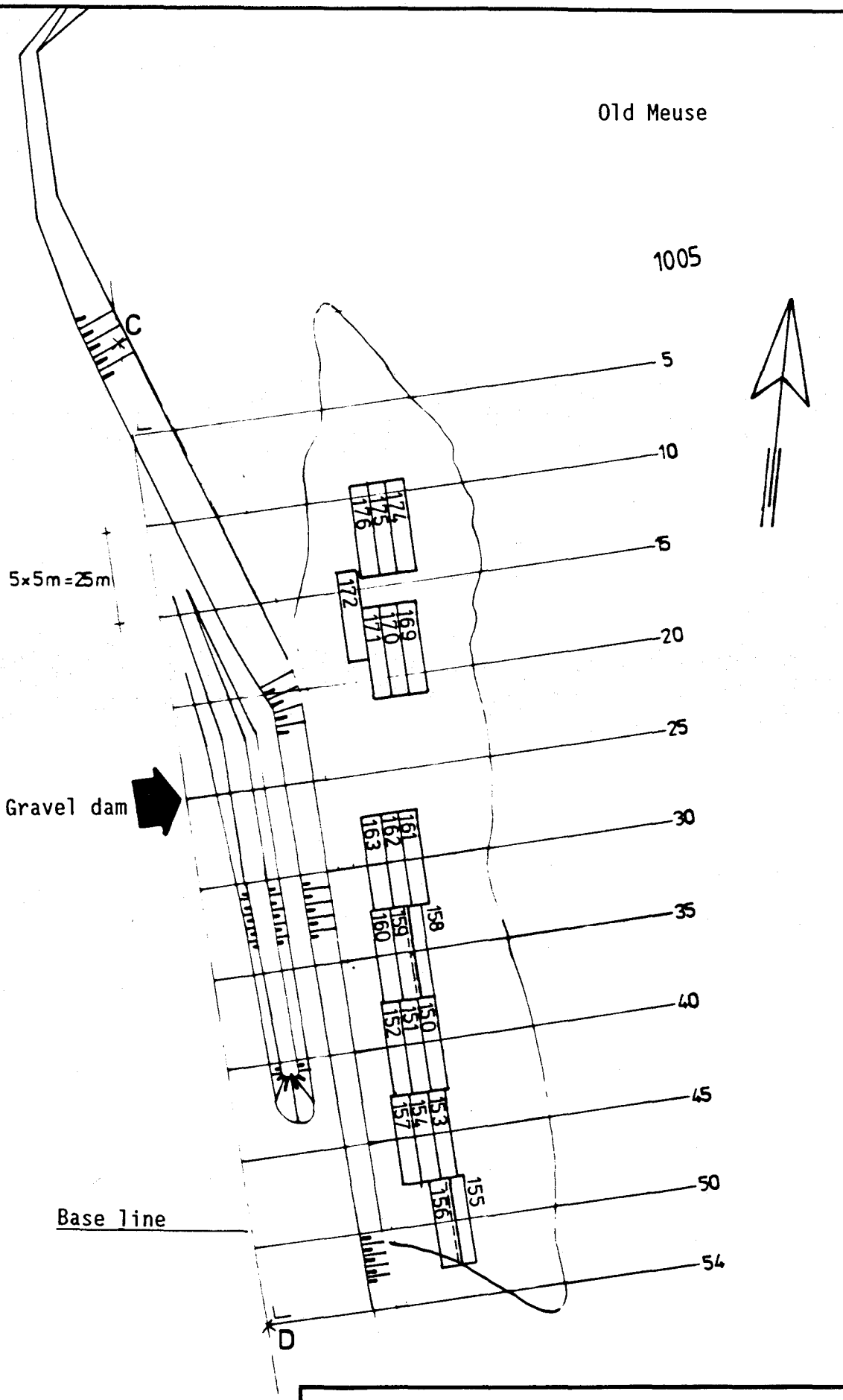

Laying diagram, km. 1005

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Directorate of Lower Rivers

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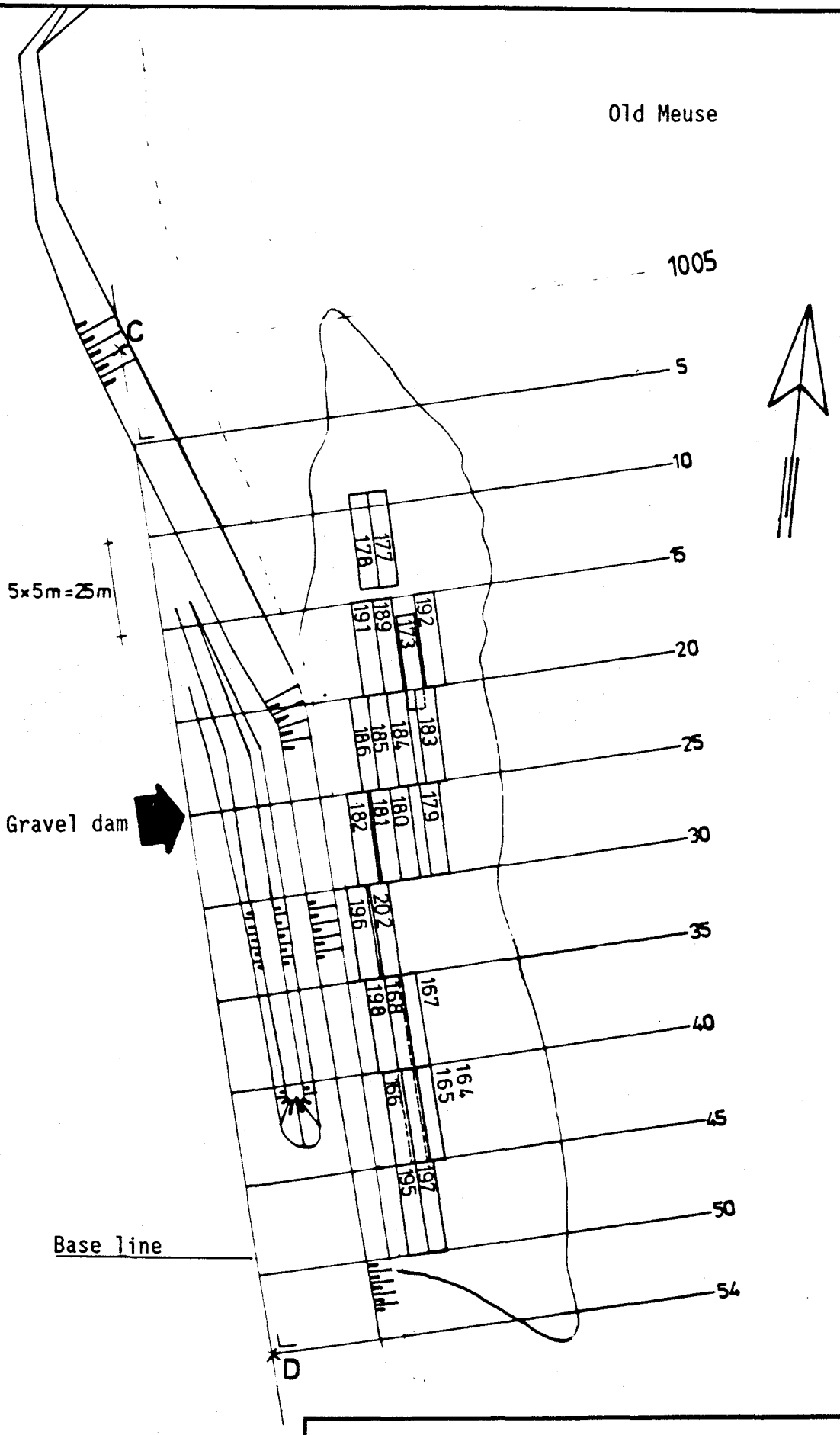

Laying diagram, km. 1005

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Department of Public Works
Directorate of Lower Rivers

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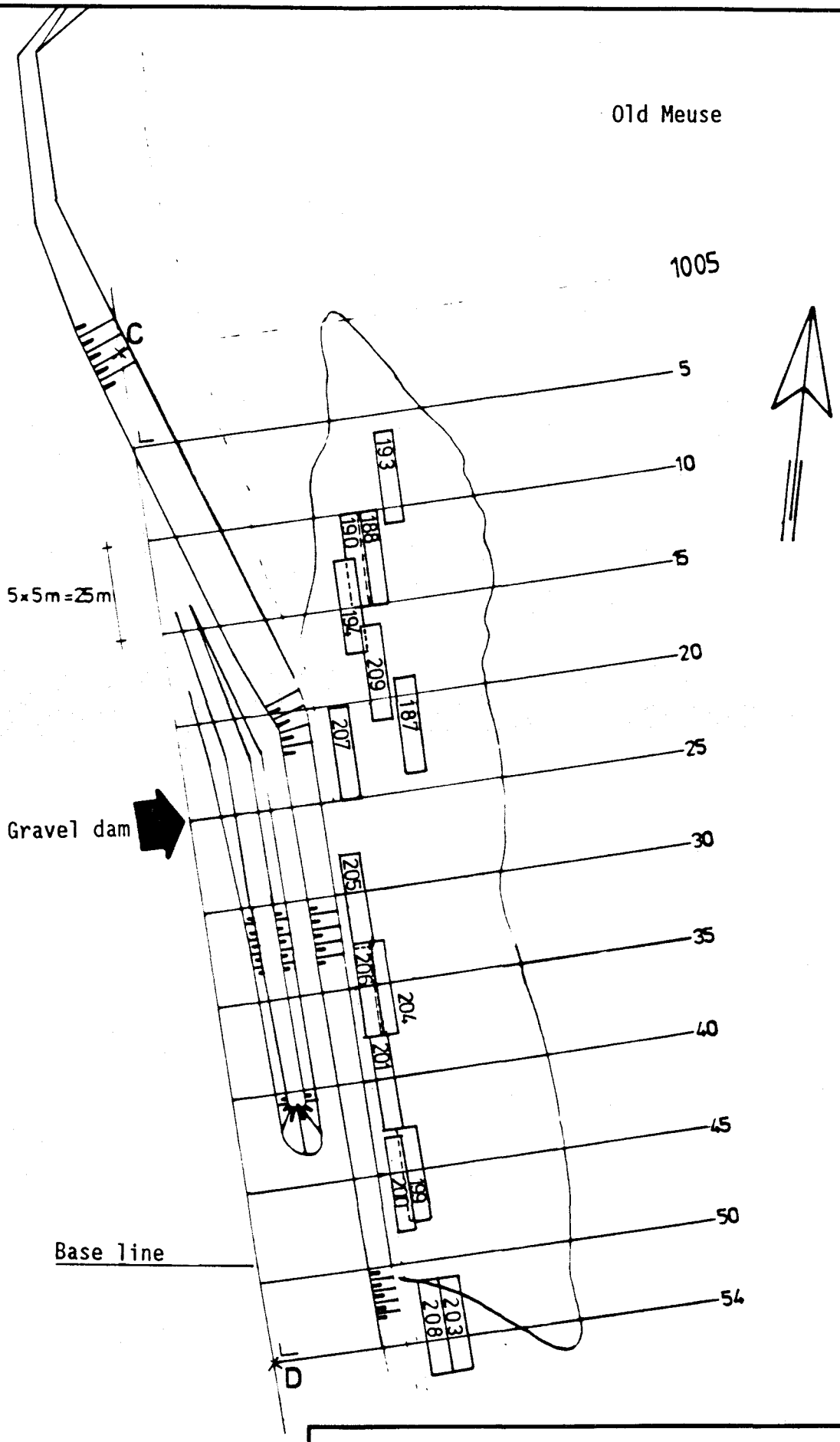

Laying diagram, km. 1005

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Directorate of Lower Rivers

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Scale 1:1500



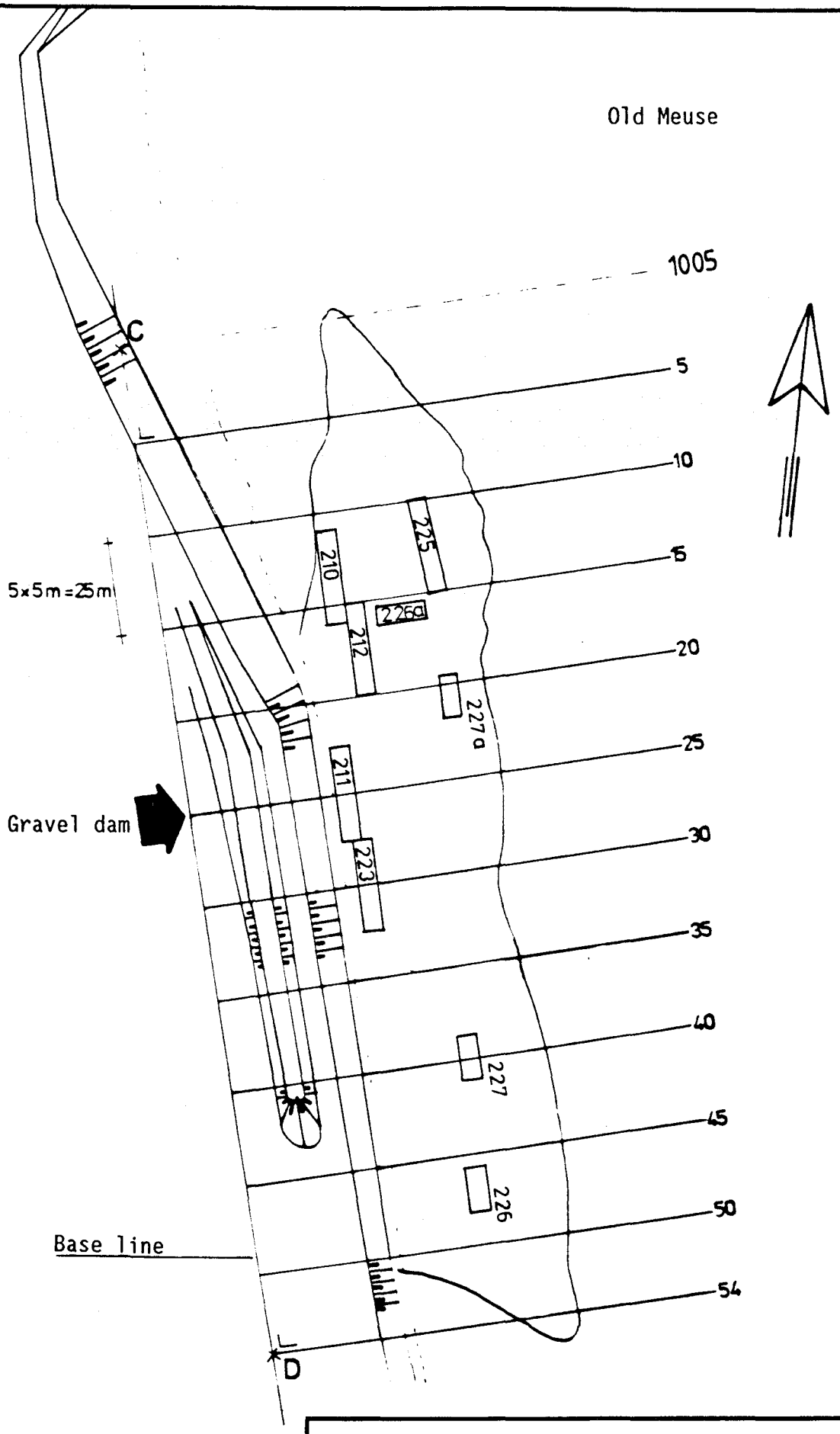

Laying diagram, km. 1005

sheets 11

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Directorate of Lower Rivers

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Scale 1:1500



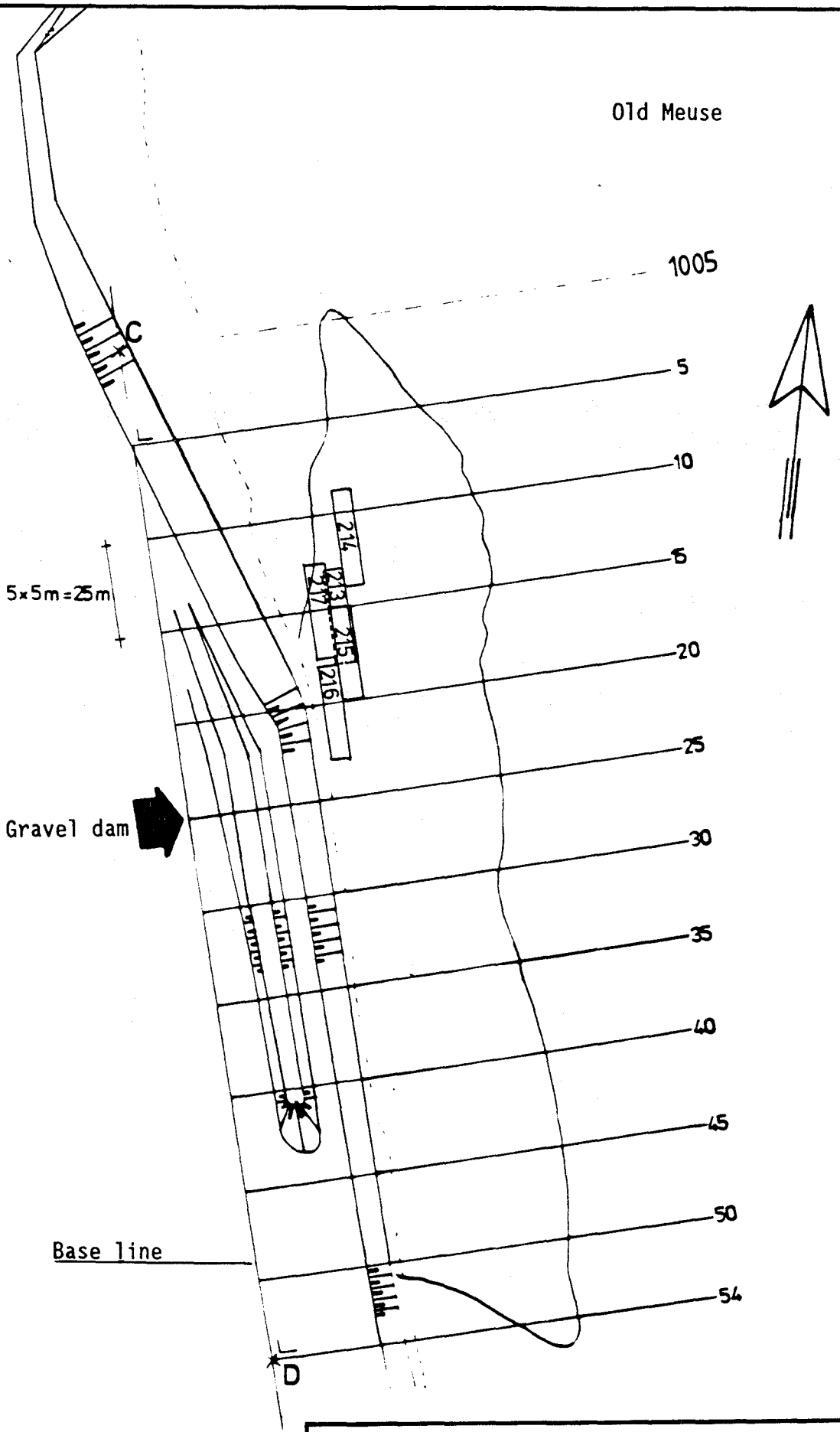

Laying diagram, km. 1005

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Directorate of Lower Rivers

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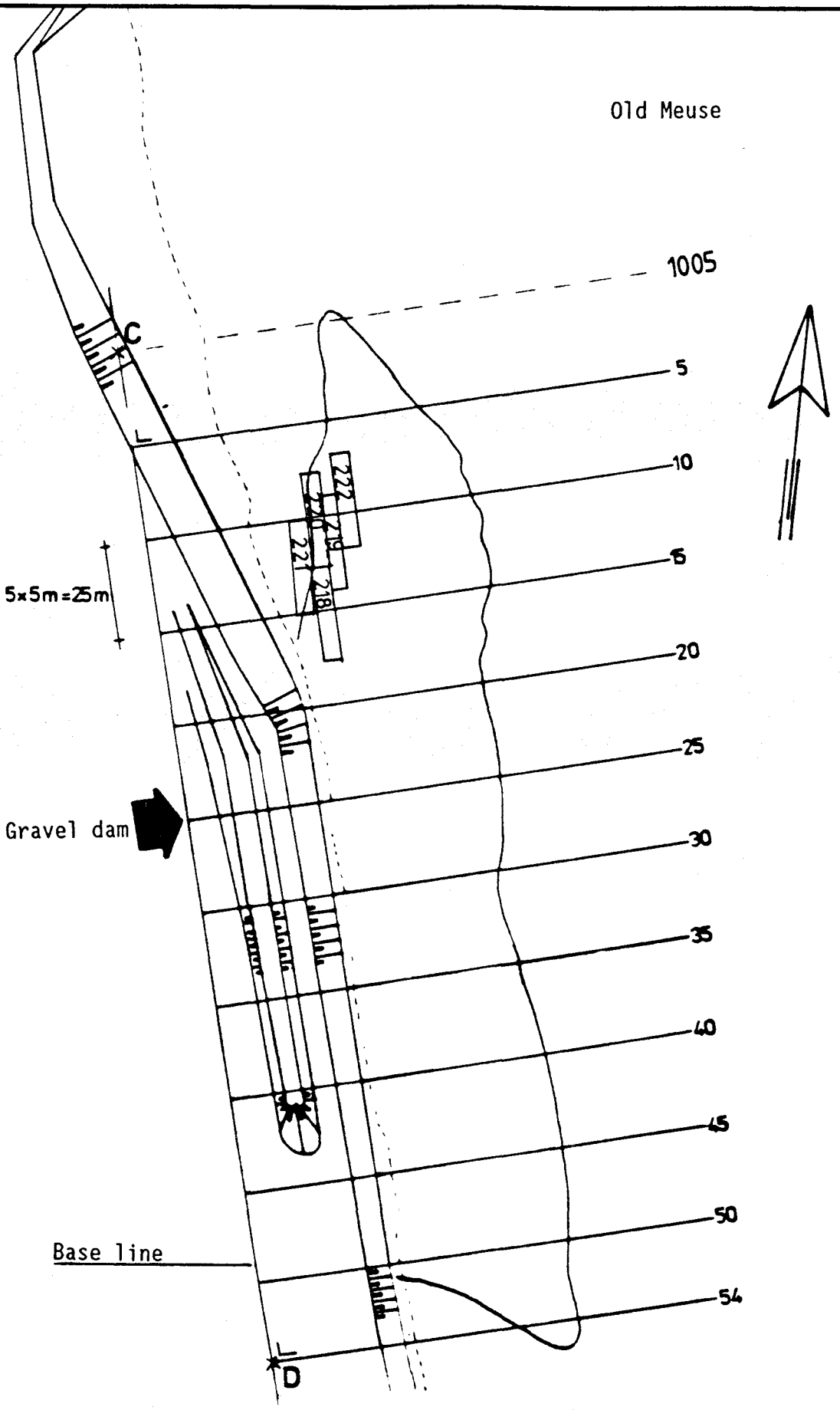

Laying diagram, km. 1005

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Directorate of Lower Rivers

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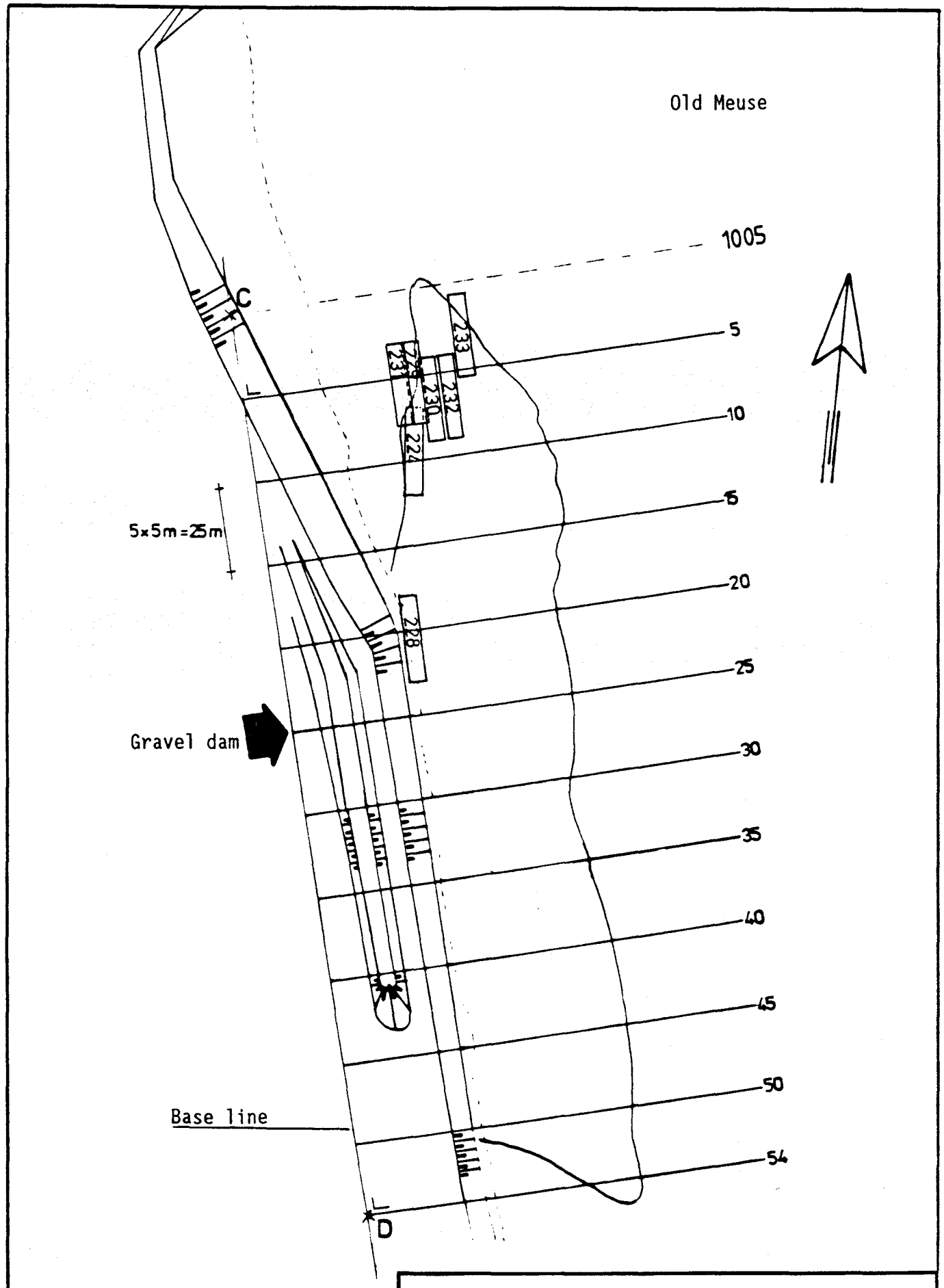

Laying diagram, km. 1005

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Laying diagram, km. 1005

sheets 15

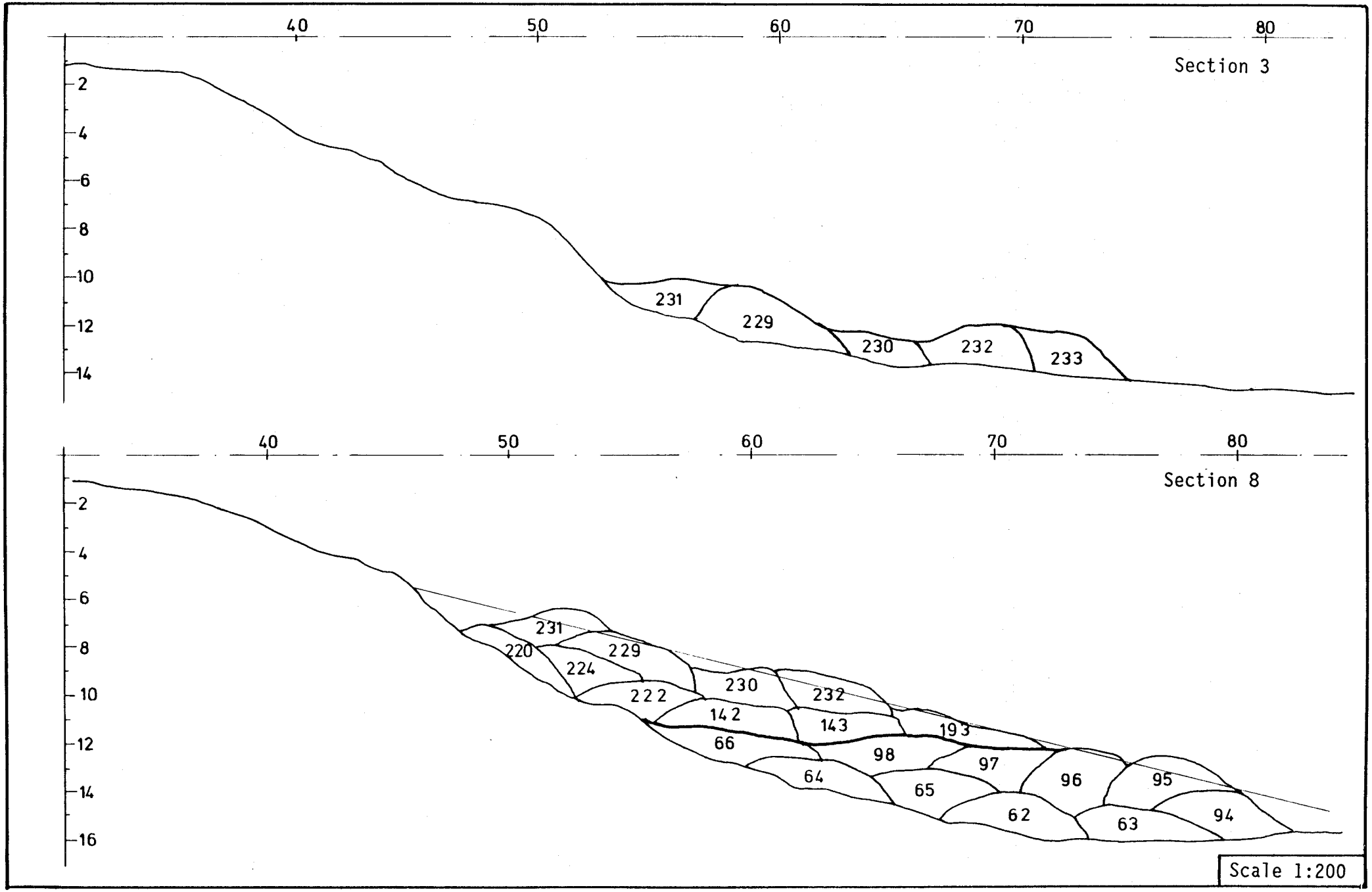
Department of Public Works
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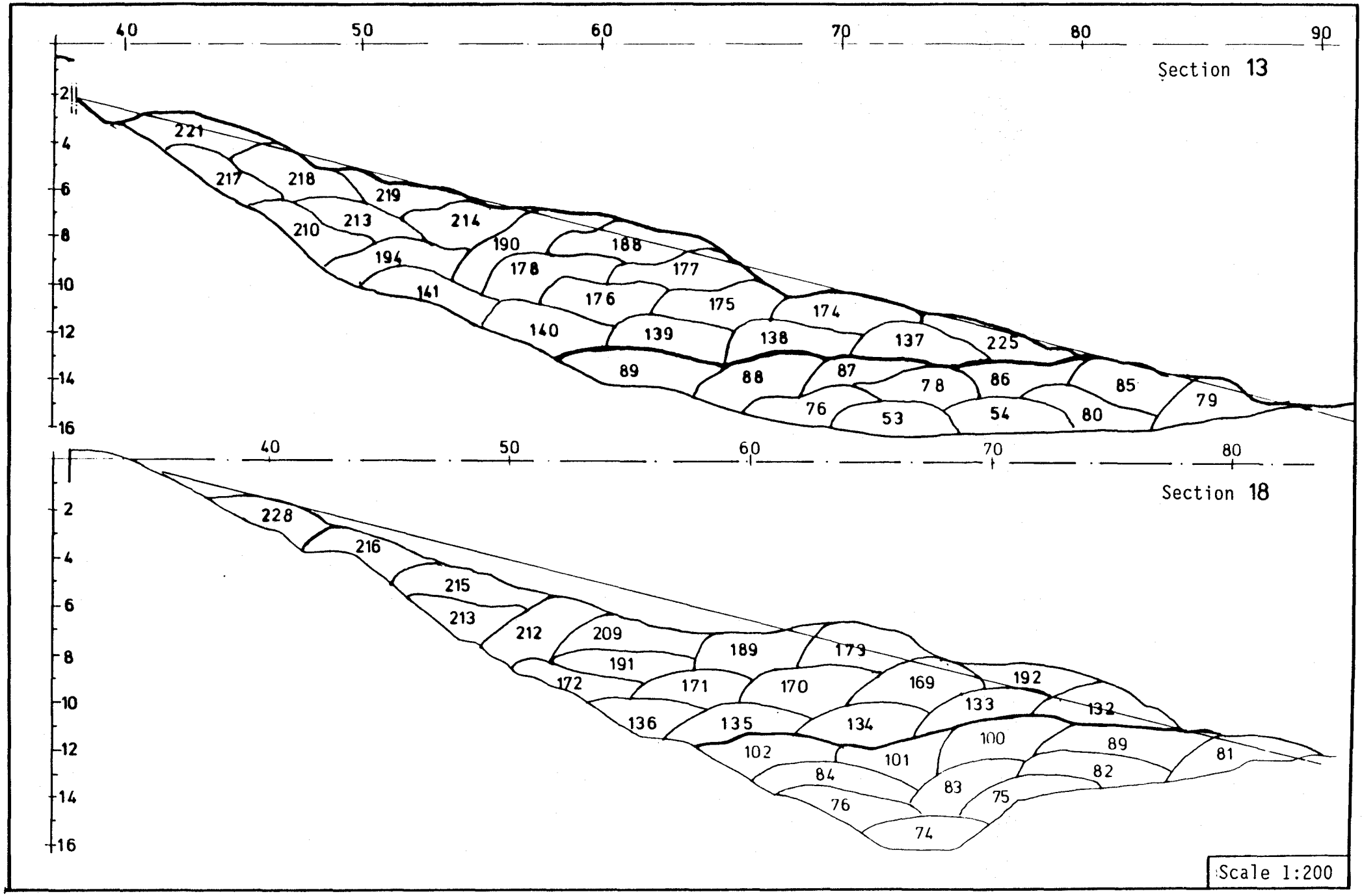
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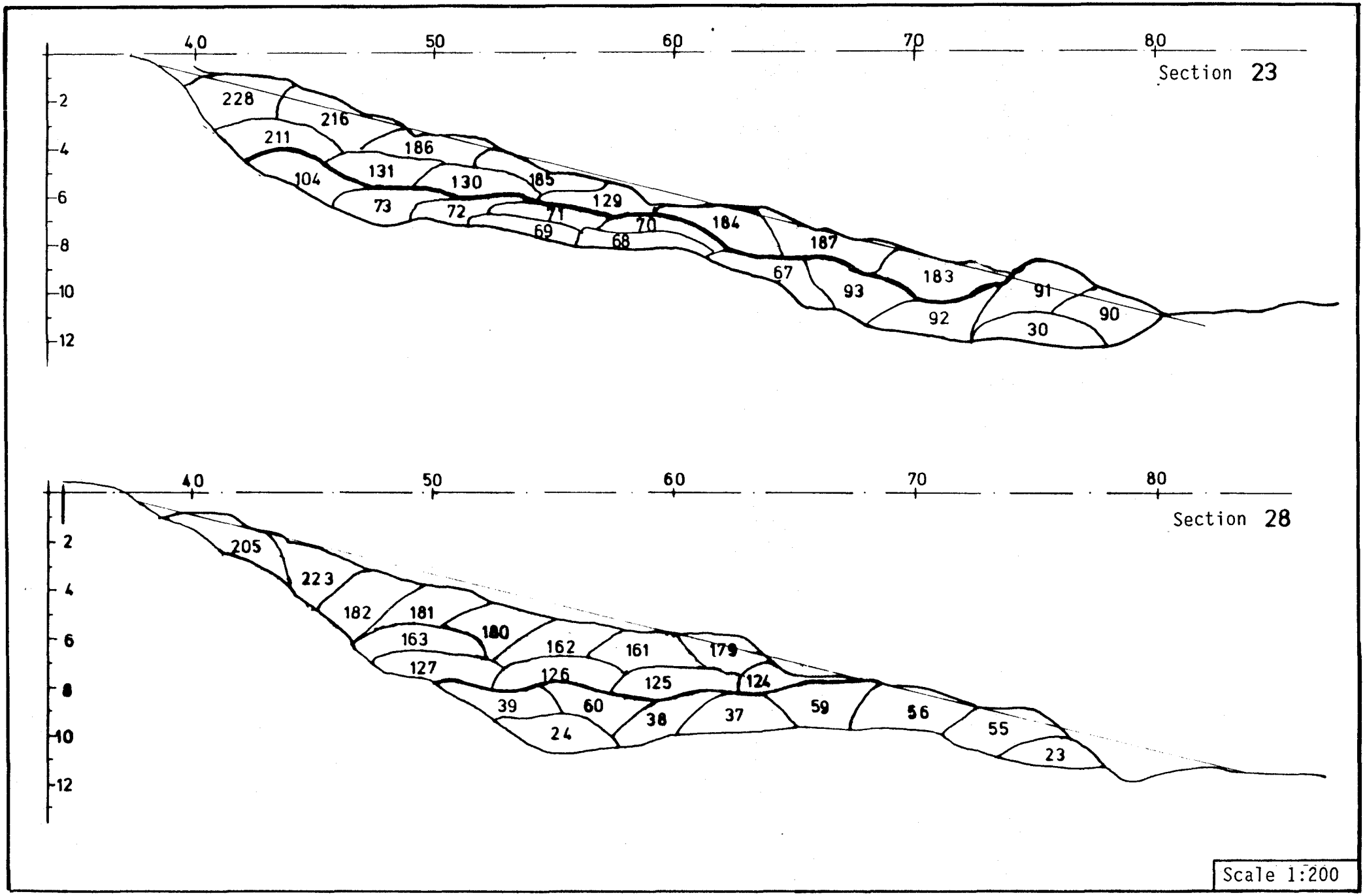
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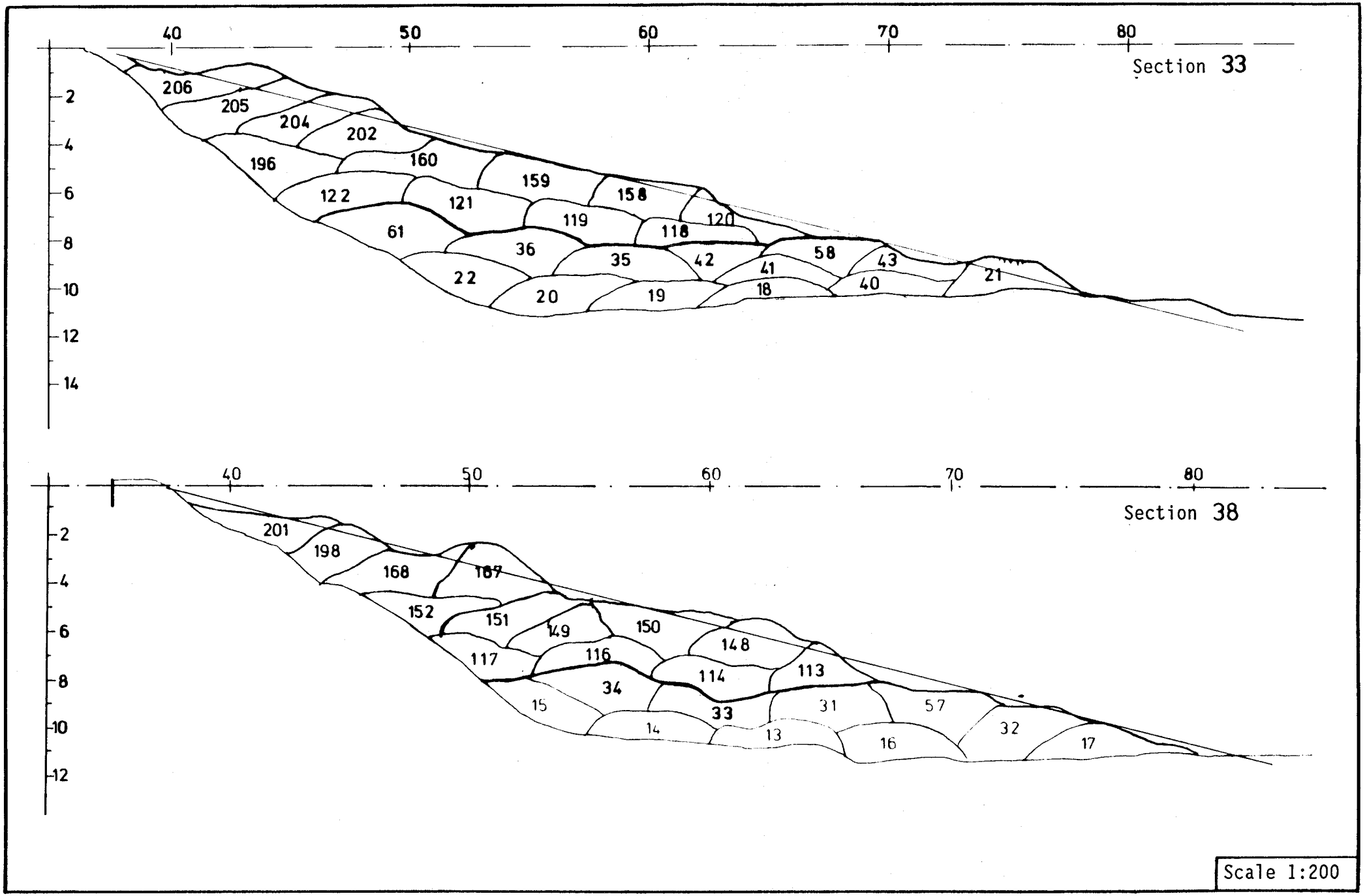
Appendix 8

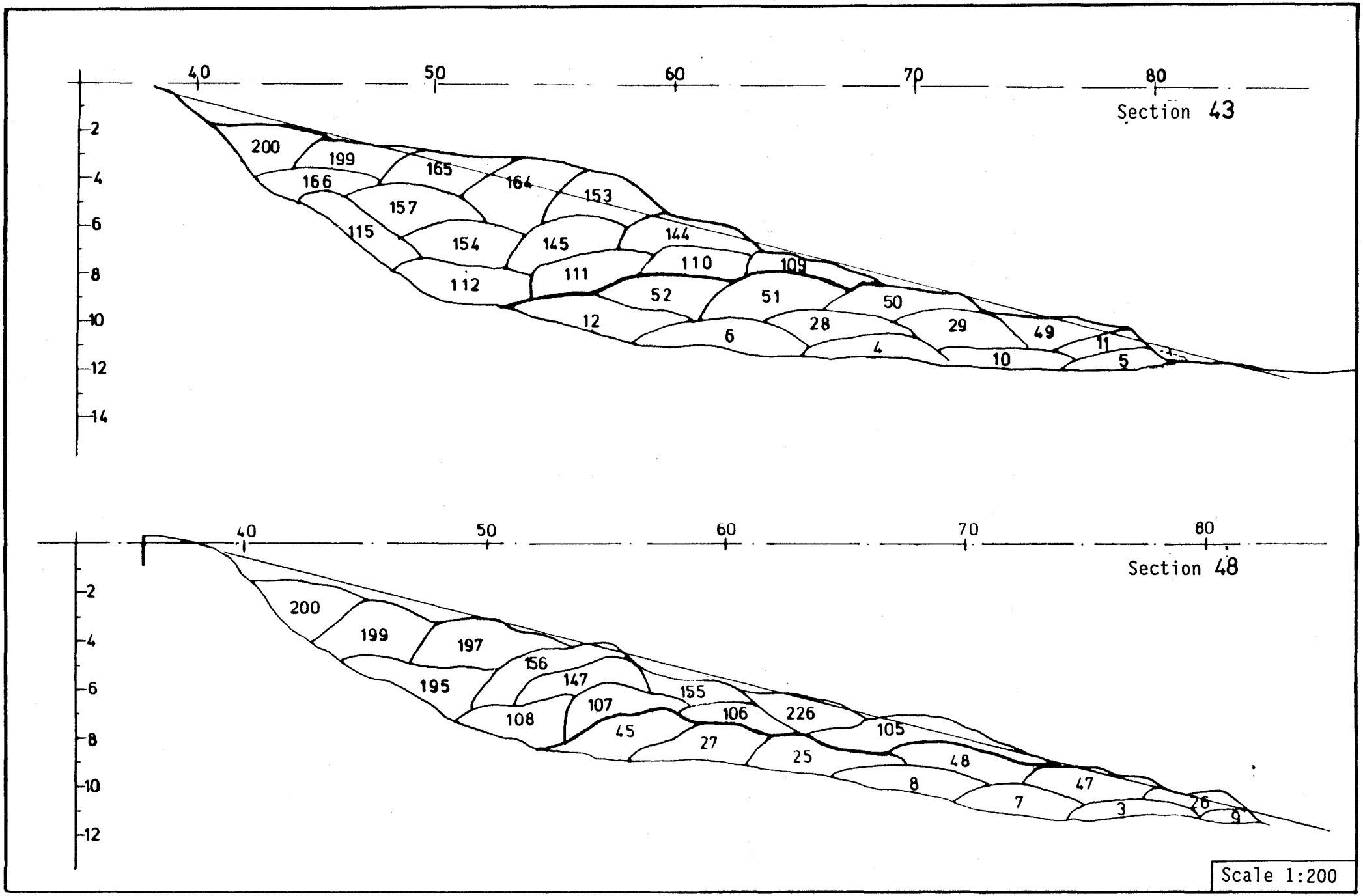
Cross-sections, bank filling, km. 1005.

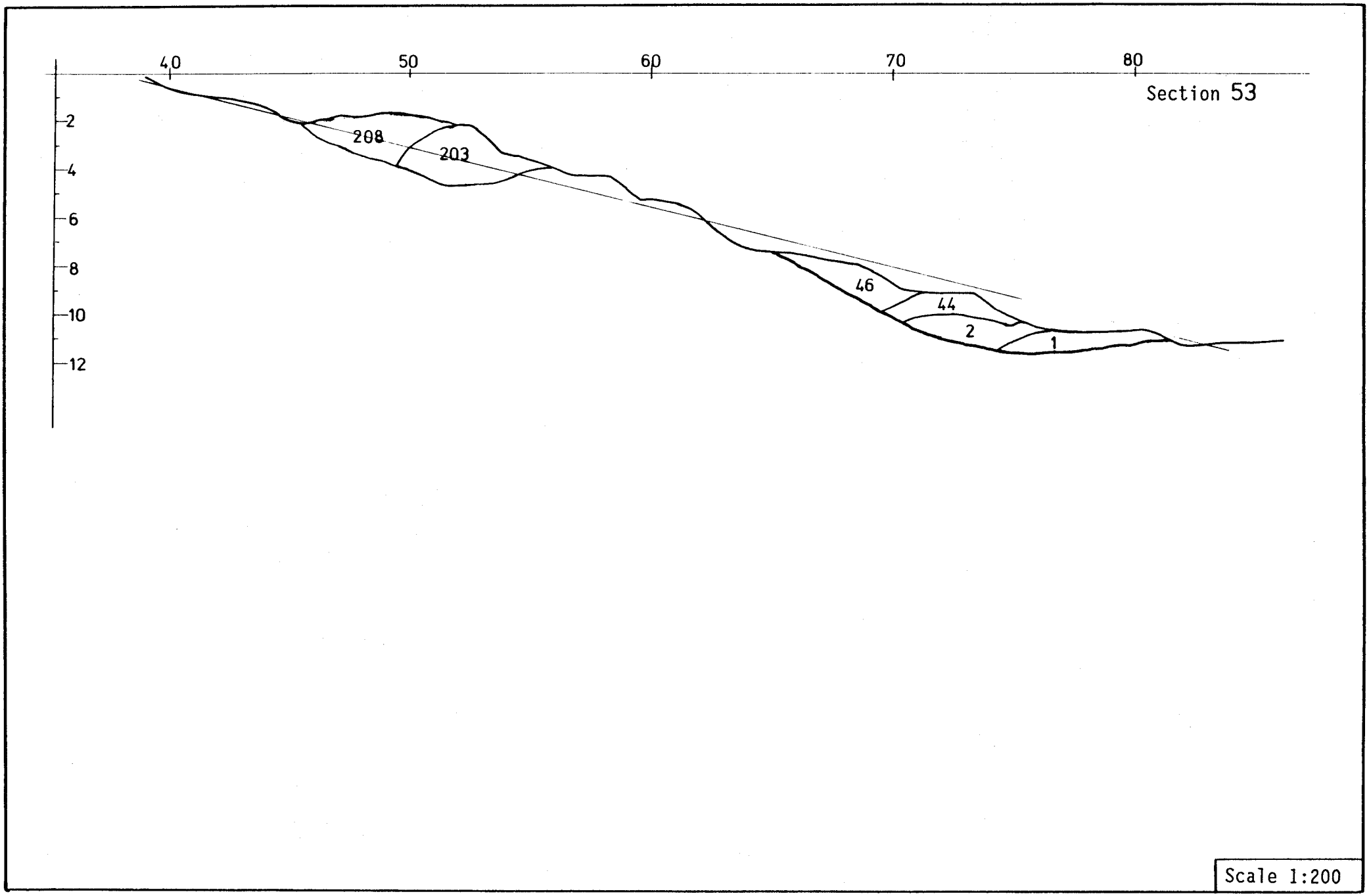

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Scale 1:200


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Scale 1:200


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Section 33
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Section 38
201
198
168
167
152
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Scale 1:200


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Section 43
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Section 48
200
199
197
156
147
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226
108
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Scale 1:200


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Section 53
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Scale 1:200

Appendix 9

# Specifications of materials and equipment

## GEOTEXTILE

Supplier: Nicolon BV

| Container | Without straps | With straps |
|---|---|---|
| **Type '300'** | **NICOLON 66530** (prod. no.)<br><br>polyethene<br>warp: monofilament<br>weft: tape<br>weight: 165 gr/m_<br>tensile strength:<br>warp 40 kN/m<br>weft 20 kN/m<br>sieve analysis 0-90: 300 mu | |
| **Type '180'** | **NICOLON 66424**<br><br>polyethene<br>warp: monofilament<br>weft: tape<br>weight: 235 gr/m_<br>tensile strength:<br>warp 40 kN/m<br>weft 40 kN/m<br><br>sieve analysis<br>0-90: 180 mu | **NICOLON 66392**<br><br>polyethene<br>warp: monofilament<br>weft: tape<br>weigth: 235 gr/m_<br>tensile strength:<br>warp 40 kN/m<br>wert 40 kN/m<br><br>sieve analysis<br>0-90: 180 mu |
| **Type '130'** | **GEOLON 70 (NICOLON 66786)**<br><br>polypropene<br>warp: multifilament<br>weft: multifilament<br>weight: 250 gr/m2<br>tensile strength:<br>warp 70 kN/m<br>weft 70 kN/m<br>sieve analysis<br>0-90: 130mu | |
| **Grills O 75** | **NICOLON 66448**<br><br>polyethene<br>warp: monofilament<br>weft: monofilament<br>weight: 200 gr/m2m<br>tensile strength:<br>warp 40 kN/m<br>weft 40 kN/m<br>sieve analysis<br>0-90: 1000 mu | |
| **Sliding fabrics** | | **NICOLON 66525**<br>polypropylene<br>dimensions. 25x5 and 5x5 m |

**Explanation of terms:**

- warp: longitudinal direction of a fabric.

- weft: width direction of a fabric.

- monofilament: this is produced when the spinning plate through which the material is pressed in the liquid condition has one outlet opening.

- multifilament: this is produced when the spinning plate has several openings.

- tape: this is produced when the spinning plate has one slot-shaped opening.

- O-90: average sand diameter of the fraction, 90% of which remains on and in the geotextile after 5 minutes of screening.
  For example, if geotextile has a O-90 of 300 mu, this means that 90% of sand with an average diameter of 300 mu remains on that fabric.

**SAND.**

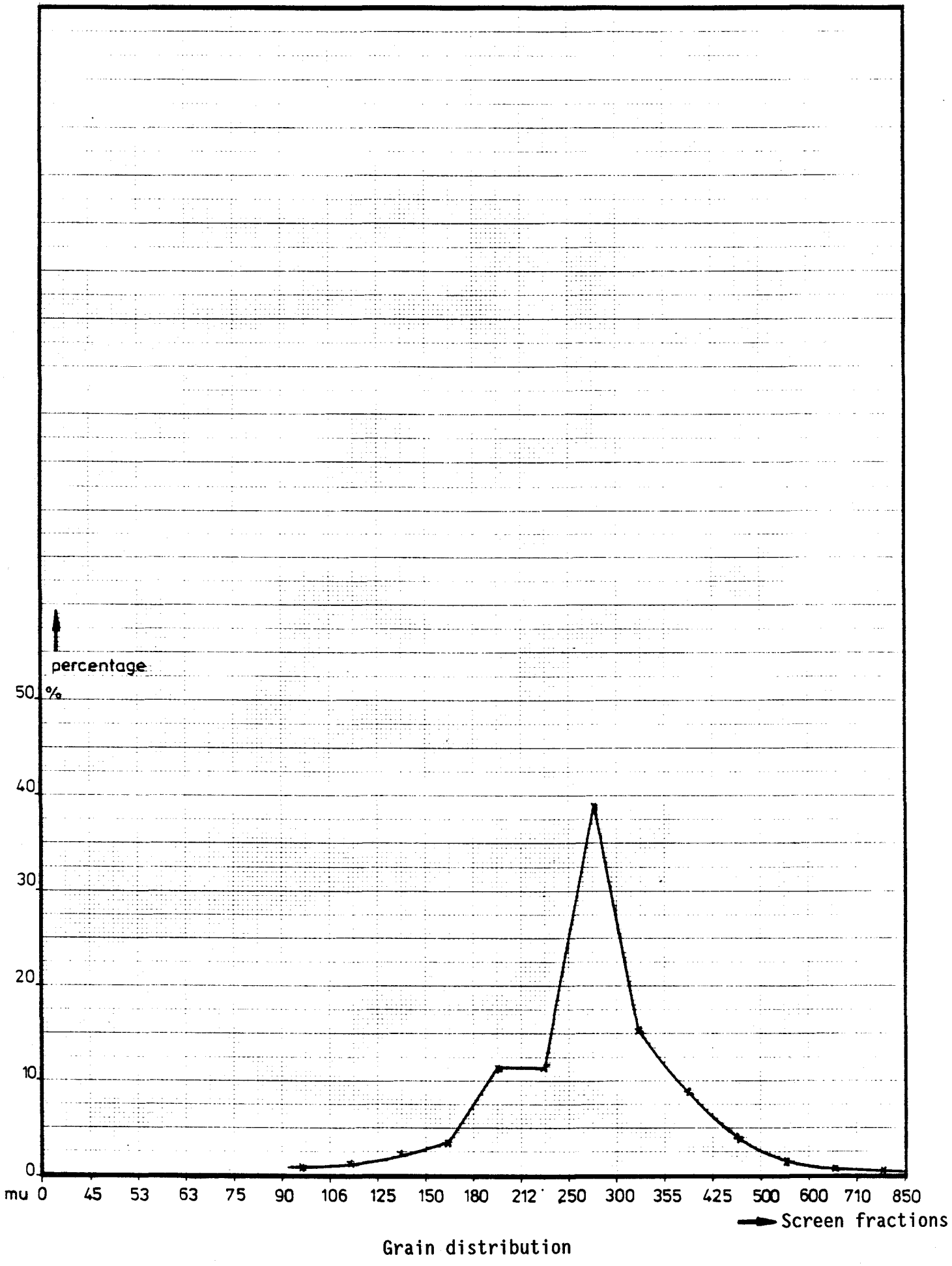
Subject: Basic survey of sand sample, New Meuse - Zeefkromme
To : TV
From : JR
Date : 3 February 1987

==========

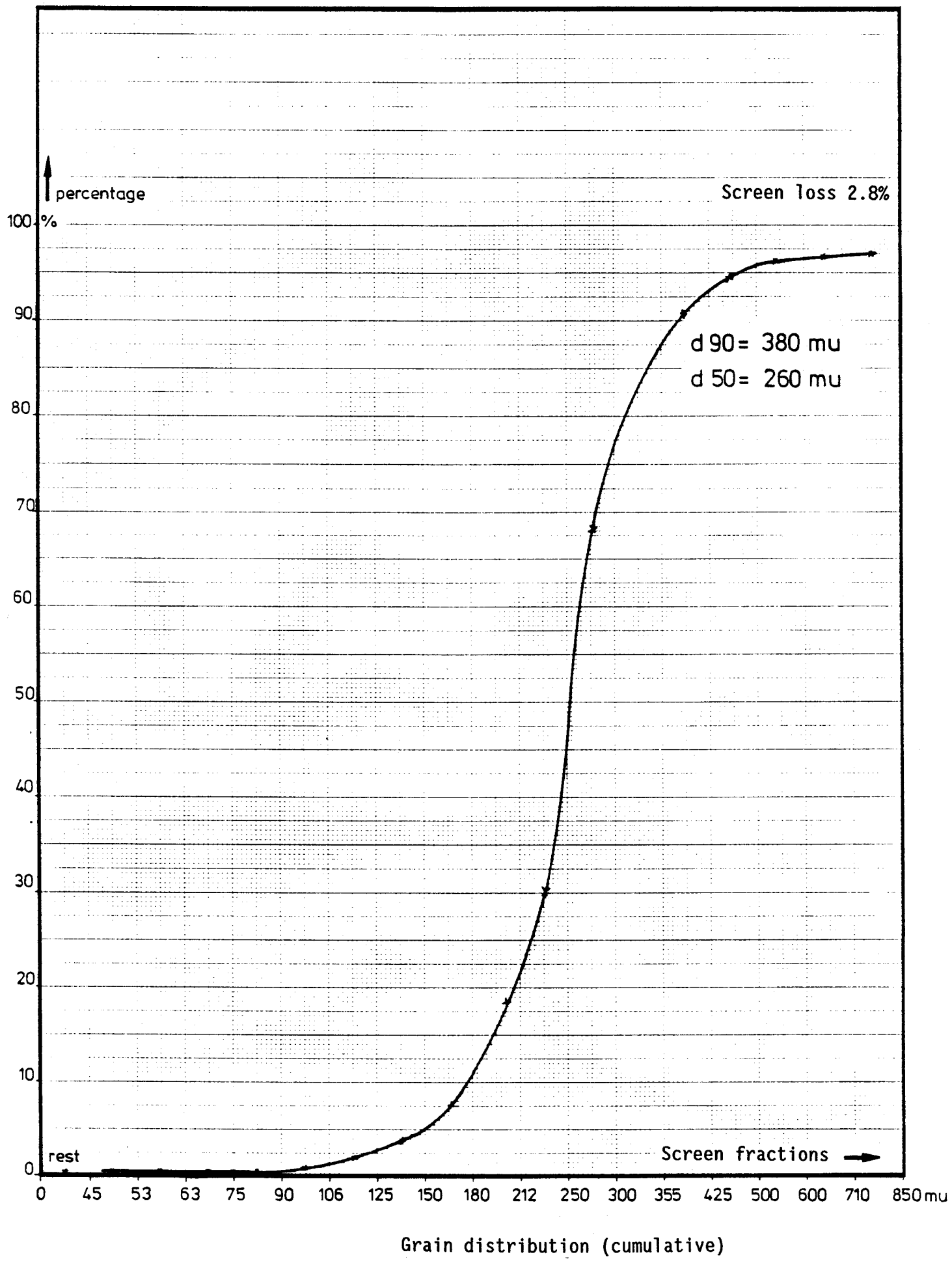
| | grams | % | sieve loss 2.80% |
|---|---|---|---|
| 1000 µ | - | - | - |
| 850 | - | - | - |
| 710 | 0.68 | 0.34 | 97.18 |
| 600 | 1.33 | 0.67 | 96.84 |
| 500 | 2.00 | 1.00 | 96.17 |
| 425 | 7.85 | 3.93 | 95.17 |
| 355 | 17.52 | 8.76 | 91.24 |
| 300 | 29.12 | 14.56 | 82.48 |
| 250 | 76.43 | 38.22 | 67.92 |
| 212 | 22.65 | 11.33 | 29.7 |
| 180 | 22.33 | 11.17 | 18.37 |
| 150 | 6.34 | 3.17 | 7.20 |
| 125 | 4.27 | 2.14 | 4.02 |
| 106 | 1.82 | 0.91 | 1.89 |
| 90 | 0.99 | 0.50 | 0.98 |
| 75 | 0.30 | 0.15 | 0.48 |
| 63 | 0.25 | 0.13 | 0.33 |
| 53 | 0.13 | 0.07 | 0.20 |
| 45 | 0.12 | 0.06 | 0.13 |
| residue | 0.13 | 0.07 | 0.07 |

Note: - Small stones and twigs » 1000 u not included in the test.
- 1000 u and 850 u, no sieve residues.

JR/gj, 3/2/87




Grain distribution




Grain distribution (cumulative)

## EQUIPMENT

- **Van den Herik Kust- en Oeverwerken BV**

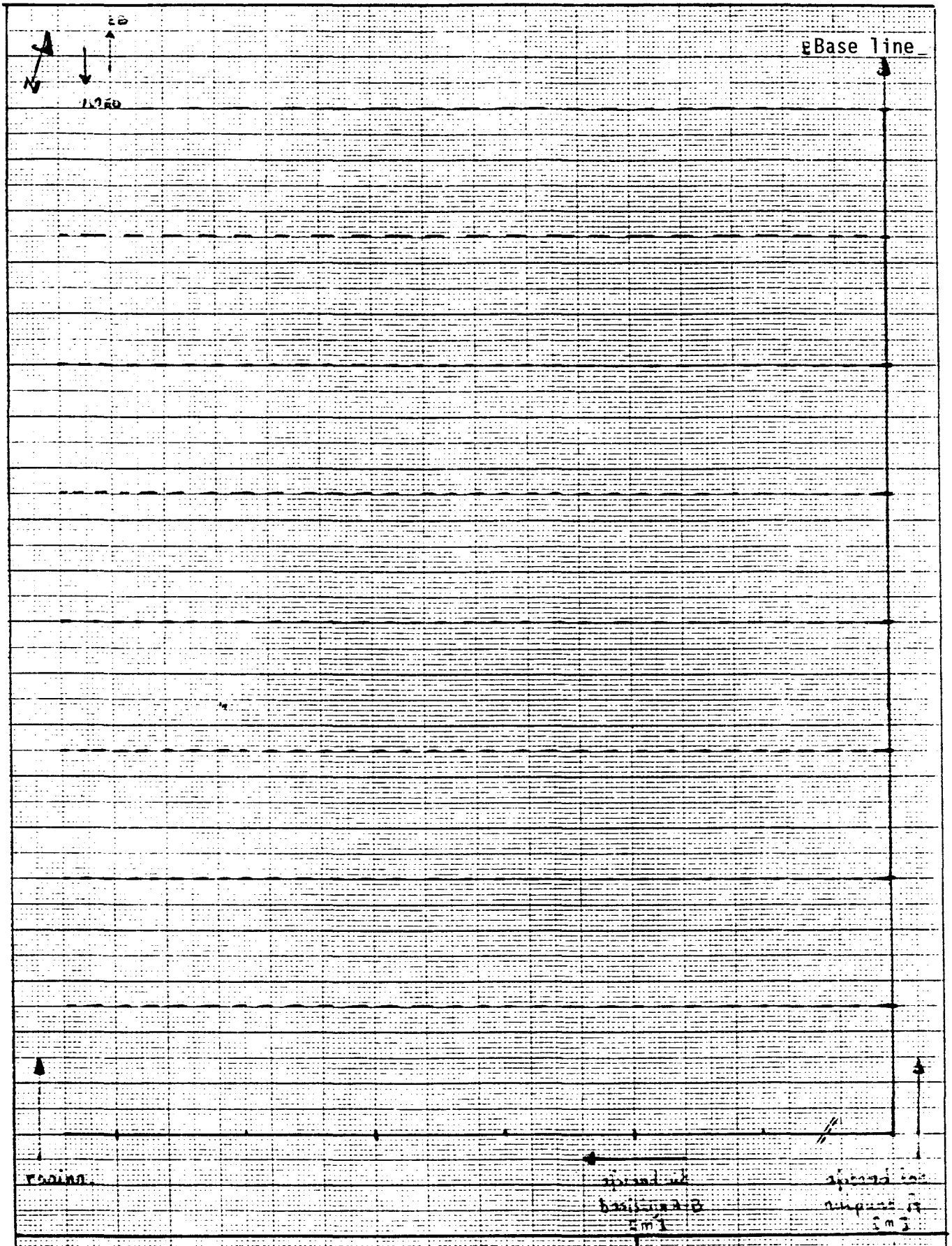
| | |
|---|---|
| ASOPOS trailing suction dredger | : capacity: 500 to 600 m3/hour<br>loading capacity: 2291 tonnes (approx. 1155 m3) |
| Split barges B26 and B27 | : length: 38 metres<br>width: 7.82 metres<br>draught: empty 0.69 m<br>loaded 2.35 m<br>loading capacity: 452 tonnes (approx. 240 m3) |
| Floating crane KARMA-4 | : crane: 8 tonne lifting capacity<br>25 metre span |
| Pontoon H39 | : ... 35 x 11 m<br>2 spud piles 22 m long |
| 2 Tugs | : power 240/380 kW |

- **Boat from Weights and Measures Department**, with echo sound, Artemis position locating system and current velocity meter

- **Set of fabrics** from J. Storm

Appendix 10

## Registrationsforms



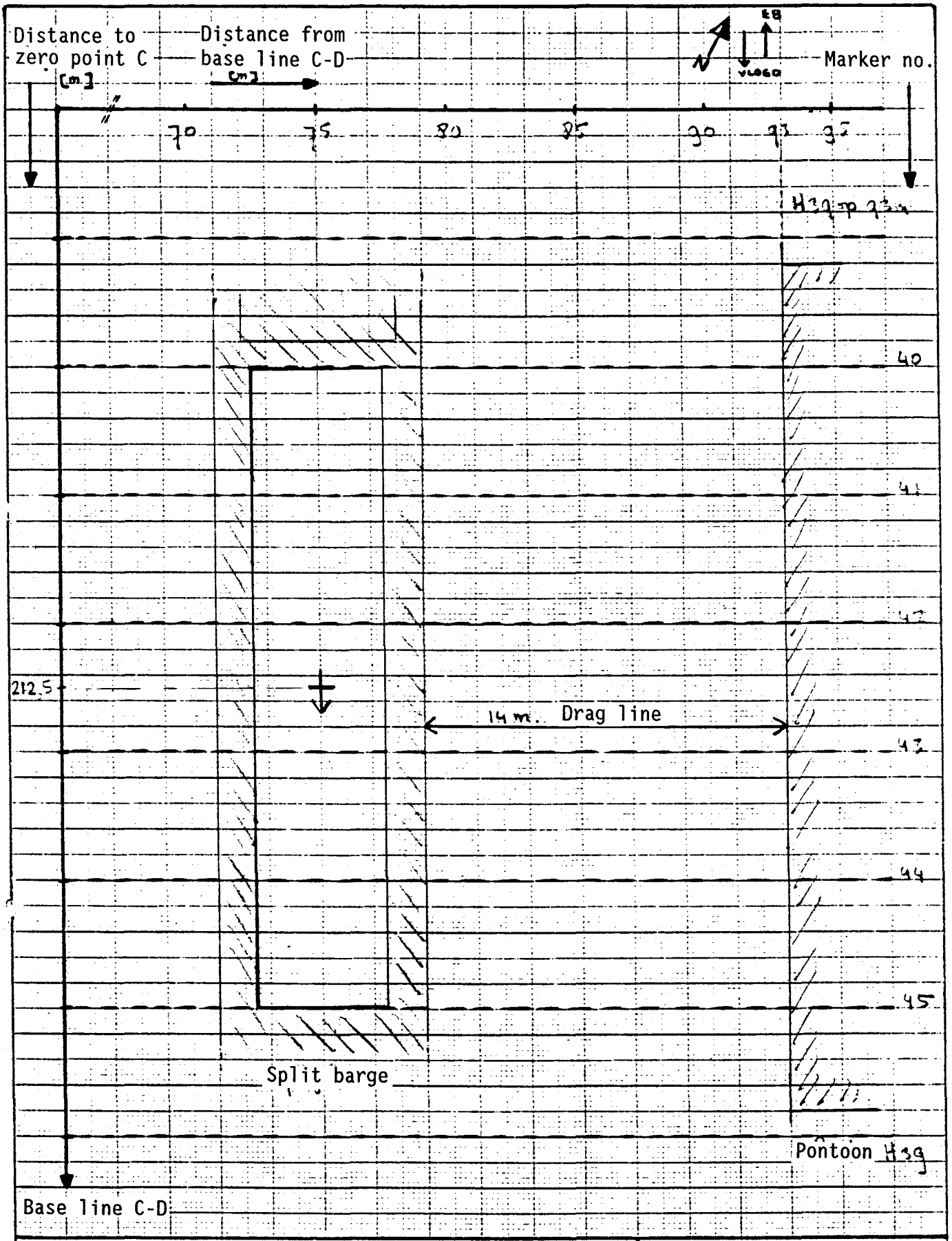

Date :
Time :
Tide :
Current velocity :
Water level :
Notes :

Km marker 1006

Container no.

Scale 1:200

A4



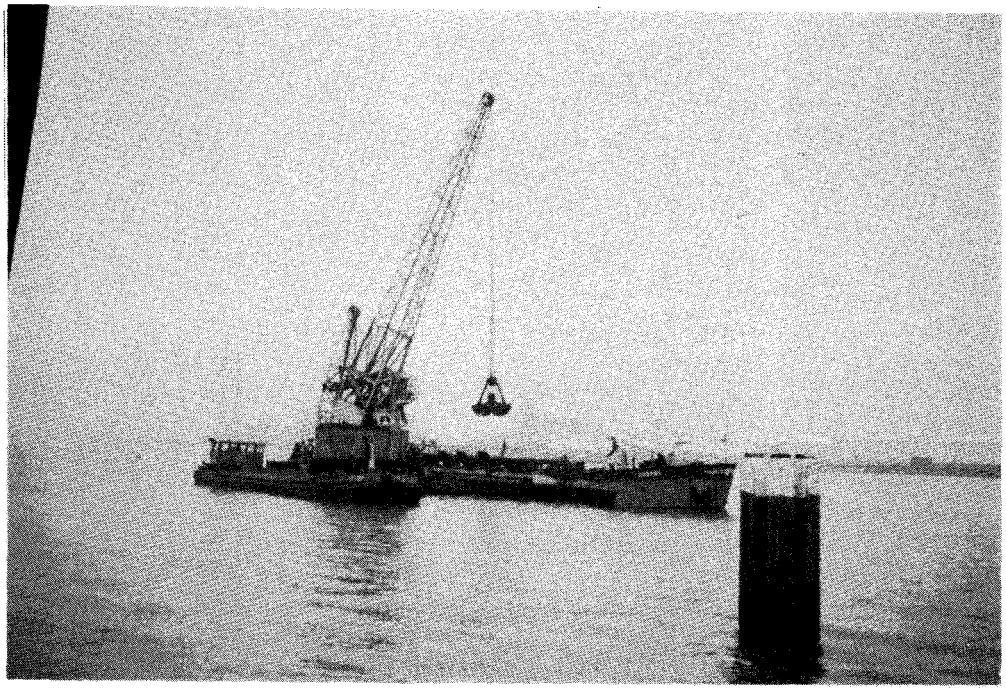

| | |
|---|---|
| Date : 20-3-87 | Km market 1005 |
| Time : 8.50 hrs. | |
| Tide : Eb | |
| Current velocity : - | Container no.: 49 16. |
| Water level : nap + 0.90 m | (type 180, no. ) |
| Notes: : Model with 5 grills, dry unloading | |
| INTACT. | Scale 1:200 A4 |

Appendix 11

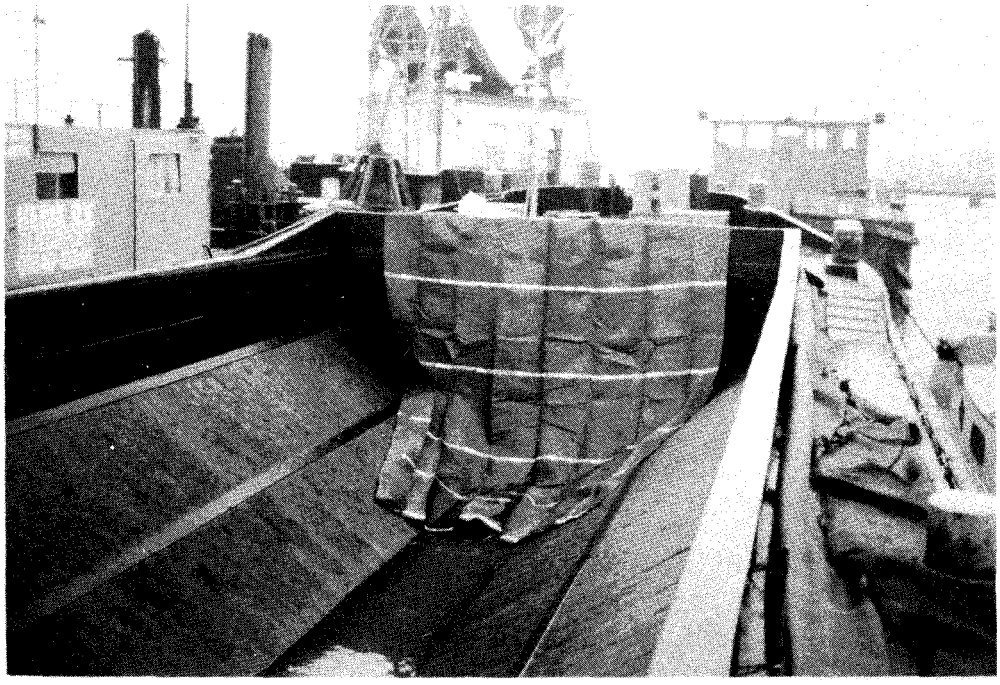
## Photographs

Explanation of photographs

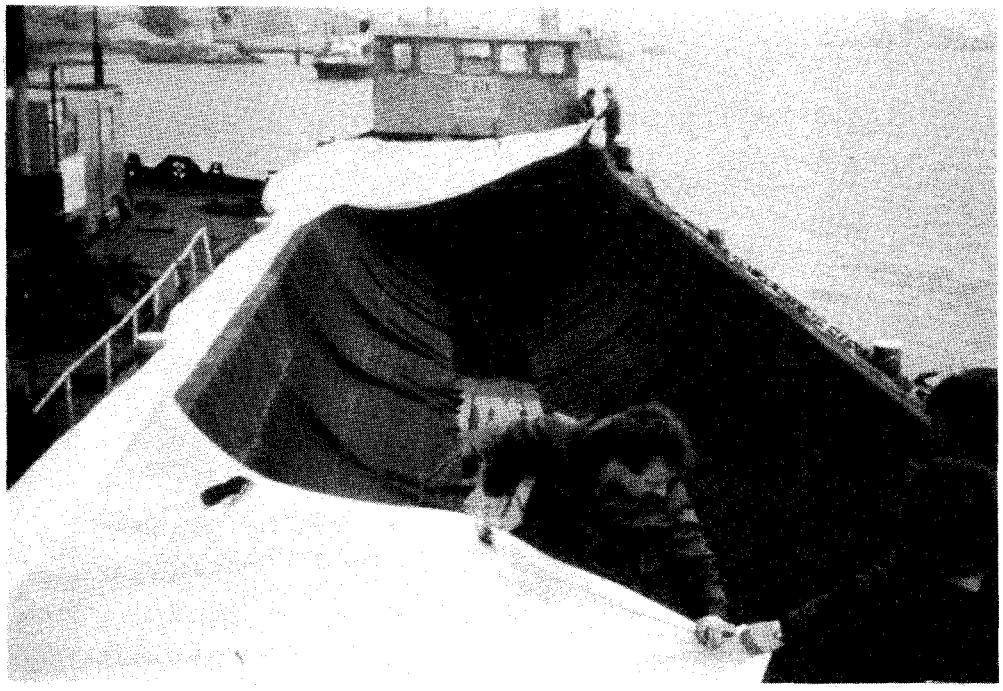
Photo 1 Location for suspending and loading container
2 Protective end fabrics
3 Placing container type 130
4 Placing container type 180
5 Placing sand uniformly in the barge
6 Ends completely full
7 Sealing seam with the hand sewing machine
8 750 mm diameter Grills
9 Arrival at sinking location km. 1005
10 Positioning split barge
11 Unloading container (1)
12 Unloading container (2)
13 Unloading uniformly
14 Unloading from one end
15 Bubble tracks
16 Checking by taking soundings
17 Experiment, bulkheads
18 Experiment, wet unloading
19 Diving survey



-1-



-2-



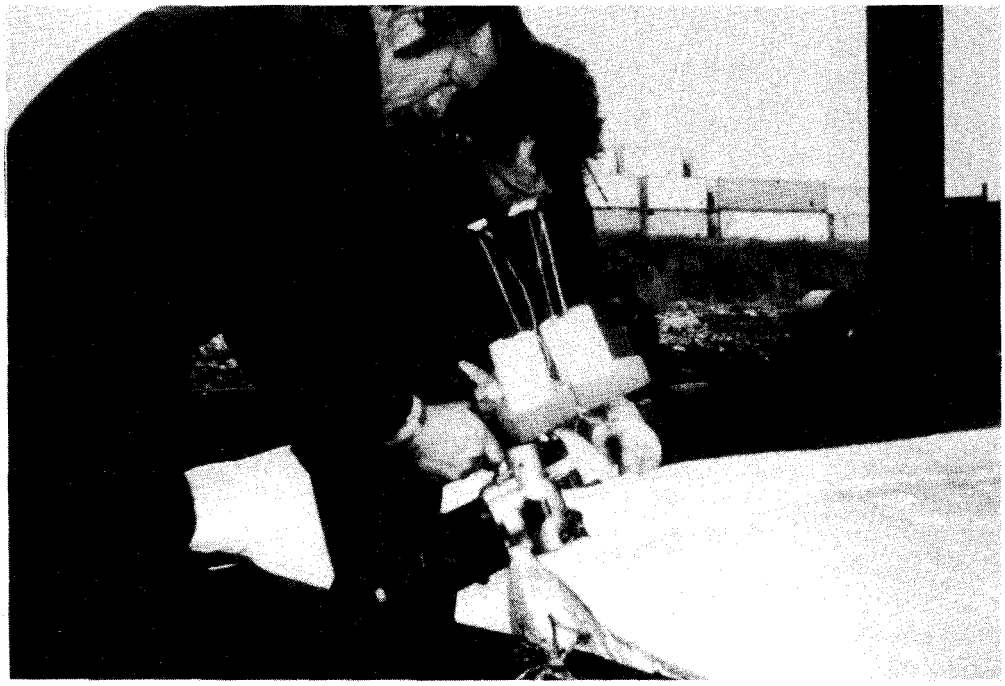




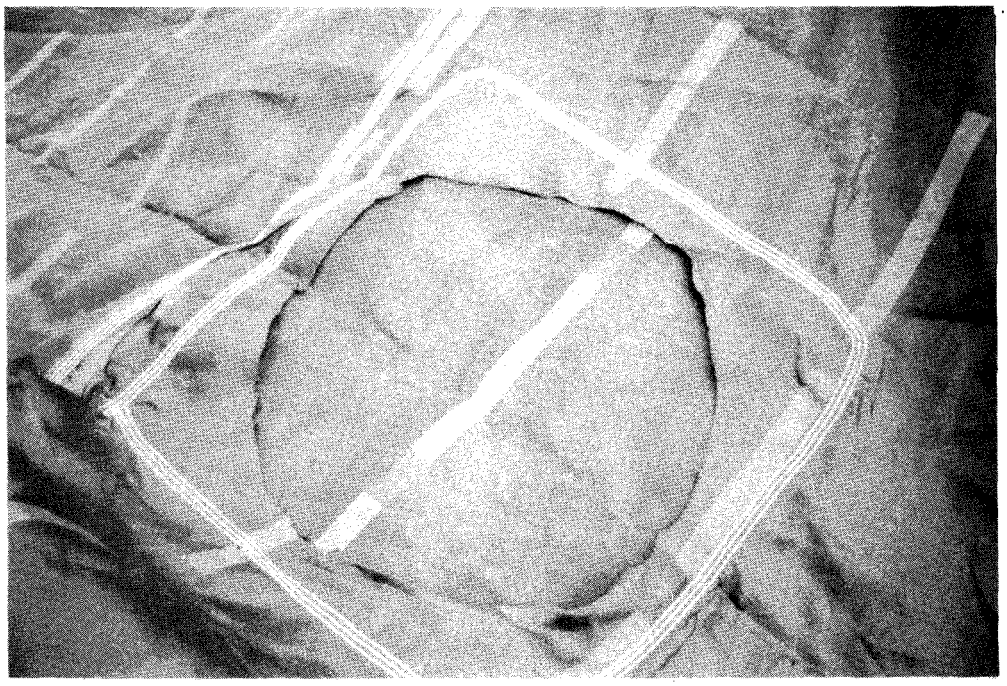


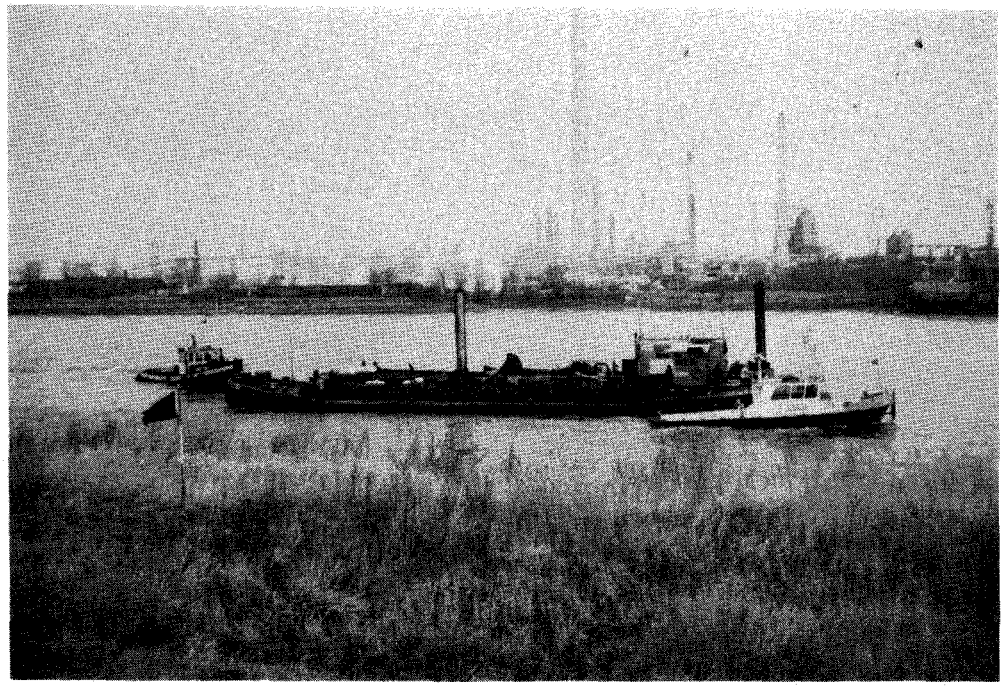










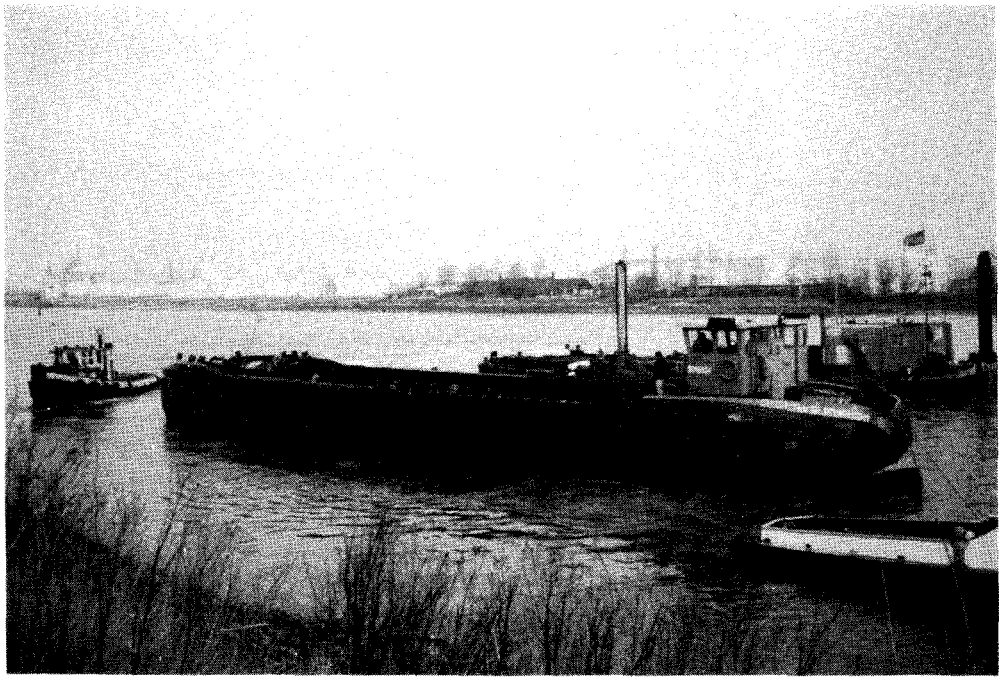






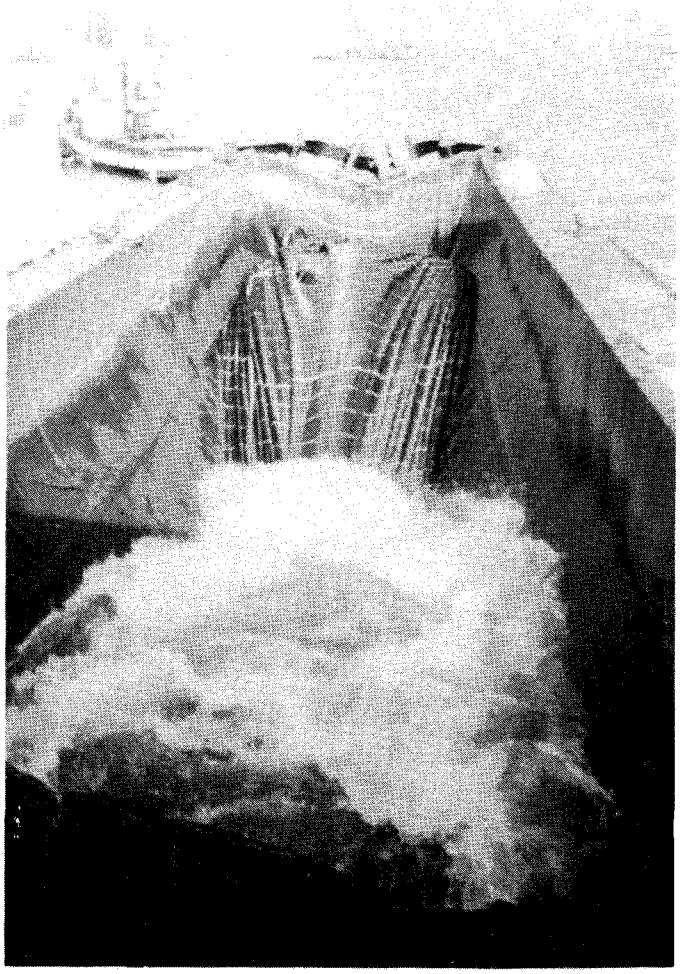


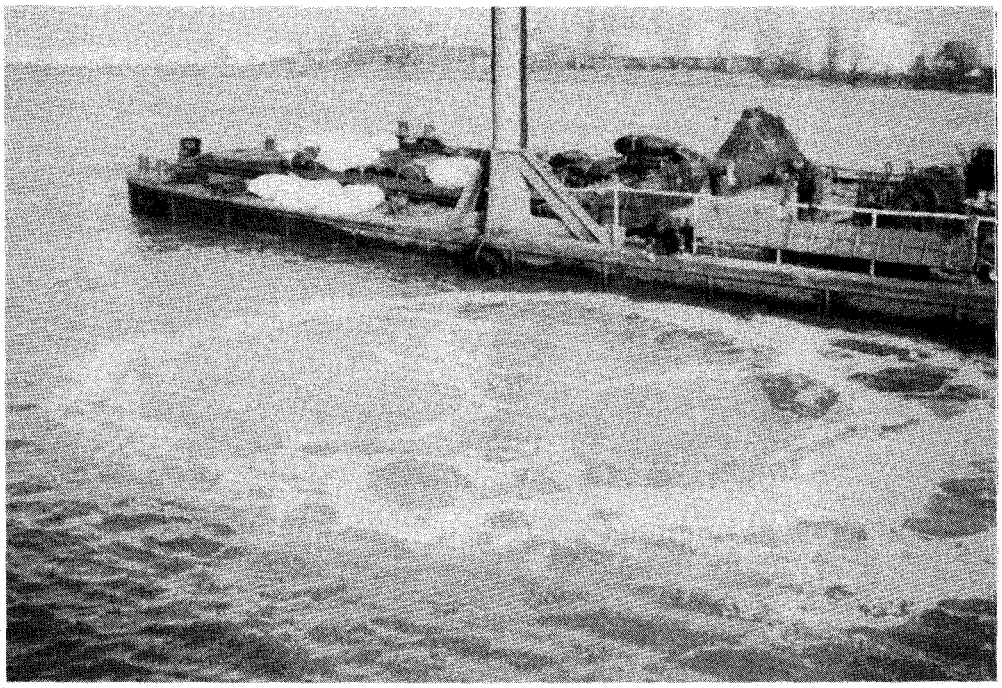












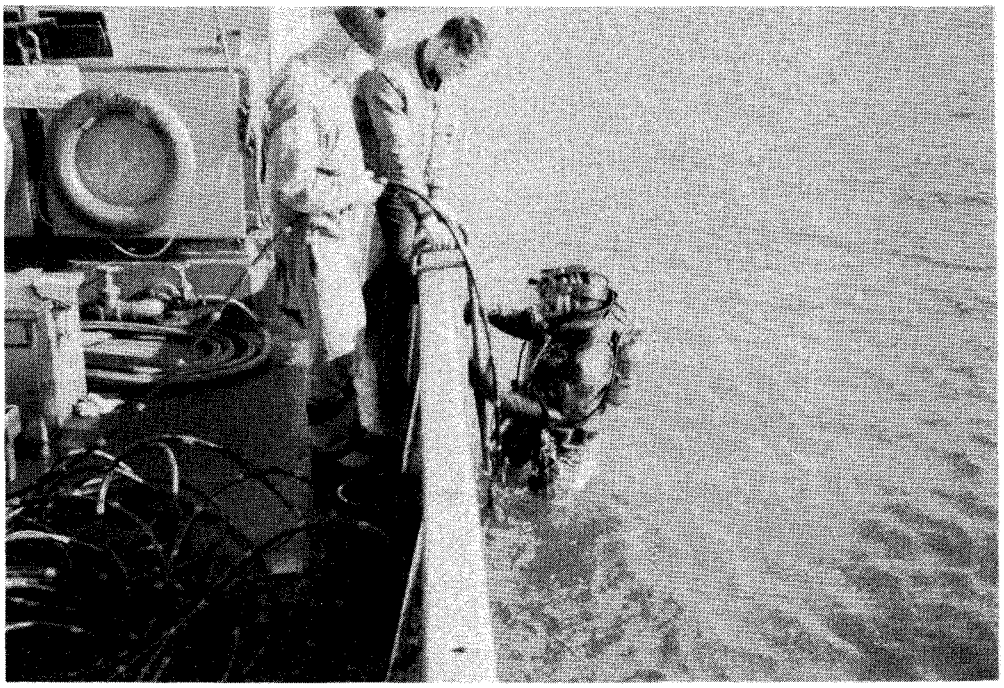



westplast









Bibliography

- Kunststoffilters in Kust- en Oeverwerken (Plastic filters in Artificial and Bank Works) - Dutch Association of Coastal and Bank works.

- Report on the construction of a breakwater in the Ems at Weekeborg (Germany) - Nicolon BV.

- Geotextiles and geomembranes in civil engineering - Published by A.A. Balkema, Rotterdam.