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INSTITUUT VOOR CULTUURTECHNIEK EN WATERHUISHOUDING
Wageningen

# RE-USE OF DRAINAGE WATER III

## Data administration

## Evaporation Model

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Report of a mission to Egypt
June 11 - June 26, 1982

ADVISORY PANEL FOR LAND DRAINAGE IN EGYPT

## 1. INTRODUCTION

The present assignment was carried out in the framework of the activities of the Advisory Panel for Land Drainage in Egypt, a technical cooperation project between the Dutch and the Egyptian Governments.

In this connection, and in relation to previous missions the author was requested to carry out a short mission to give:

- some lectures on "modelling re-use of drainage water" in a course on "Groundwater Hydrology for Arid Regions";
- lectures and demonstrations on computer data administration and the use of simplified models for training as well as for testing of data to the staffmembers of Open Drain Division of the Drainage Research Institute.

The mission was carried out in the period June 11 to June 26, 1982. The itenary is given in Annex 1.

The author had to rely on the assistance of the staff of DRI and the Dutch team in this Institute. He wishes to express his gratitude to Dr. Mohammed Hassam Amer, director of the Drainage Research Institute, to Dr. Samia El Guindi and Dr. Dia El Din El Quesi, senior staff members of DRI for their hospitality and pleasant cooperation. The personal contacts with the engineers of the Re-use Division have been very pleasant.

The author had regularly contact with Ir. H. van der Zel, leader of the Dutch team.
Eng. Mohammed Abdel Khalik of the Open Drain Division was assisting in the preparation of the computer programme of the evaporation model on the HP 85 microprocessor.

The lecture on "Modelling Re-use of Drainage Water" for the course on "Groundwater Hydrology for Arid Regions" were mainly based on the report: Re-use of Drainage Water - Model Analysis - Advisory Panel for Land Drainage in Egypt. Report nr. 81 - VIII.06.

The present report deals with the subjects discussed with the DRI-staff:

- proposals for computer data administration;
- programme for evaporation calculations.

## 2. DATA COLLECTION AND ADMINISTRATION

A re-use model, that can be used as a tool in water management, has to forecast the possible effects of future water management measures, on both the quantity and the quality of the drainage water. The model has to simulate the effects of improved water management on the salt and water balances in the region. For a correct judgement of the water management systems the effects of the changes in water and salt balances, including chemical reactions in the soil and the effects on crop production of each location in the region must be considered.

Before a regional water management model becomes operational, a large quantity of information must be collected and the problem must be formulated in such a way that it can be handled by a computer.

In the following sections attention will be given to the required data collection and administration and to the problem formulation.

It is necessary for the determination of the irrigation water requirement and the quantity and quality of the drainage water, to make complete water and salt balances for each location in the region. It means that for each location in the region a complete set of data must be made operational giving:

- crop rotation
- soil type
- hydrological conditions
- quantity and quality of available irrigation water
- soil salinity
- aquifer salinity
- drainage conditions.

In many cases only point observations are available, which have only validity for the place of observation.

## 2.1. Basic data collection

The first step required for the determination of the areas present with a certain combination of factors in the region is the presentation of the single factors on basic maps. This presentation of each factor on a separate basic map is a prerequisite, as many data are available as point observations.

For the classification of the standard unit areas in the region under investigation the following basic maps have to be prepared:

- location map of the standard units;
- map of the irrigation water distribution system;
- map of the drainage catchment areas, as well as the drainage transport system;
- soil classification map, soil texture, soil physical data, soil chemical proporties;
- soil salinity maps for different layers;
- map of the land surface elevation;
- map of the clay cap thickness;
- map of the piezometric pressure of the deep groundwater;
- map of the clay cap permeability;
- map of the height of the phreatic water table;
- map of the aquifer salinity;
- map of drain distances;
- map of depth of drainage;
- map of the cropping pattern;
- maps of climatic conditions, potential evapotranspiration, precipitation.

The presentation of the required basic data on maps has the advantage that the spatial variation of each factor can be controlled very easily. Moreover, the grouping of point observations in classes and the spatial distribution of these classes can be easily identified. When the information of many maps has to be combined in calculations, mapping of these combinations in a single map becomes impossible.

## 2.2. Data administration

The legend of each basic map can be represented by a code. The combination of the codes of the various maps results in a code number for each standard unit, which specifies all relevant characteristics. The codes used will be explained in the discussion of the various factors.

### 2.2.1. Identification of the standard unit

The location of each standard unit, used in the calculations can be given by the coordinates of the centre point of each unit. Depending on the size of each unit the coordinates must be specified in more or less detail. For instance, when working with units of 1000 feddan, or 400 ha, one can operate with a grid system of 2 x 2 $km^2$. The coordinate system can be specified in that case in units of 2000 m. A grid system of 1 x 1 $km^2$ is required for standard units of 100 ha, resulting in coordinate units of 1000 m. When units of 25 ha are used the coordinate units are 500 m. The choice of the dimensions of the grid system depends on: the area of the region for which the calculations must be performed; the accuracy of the basic data and the variability of these data over short distances; the expected sensitivity of the model for the variation of a given factor. For the Niledelta, with an area of 1.5 $10^6$ ha, using a standard unit of 400 ha, it results in 3750 units which must be completely specified.With a standard unit of 100 ha the number of units becomes 15 000, while with 25 ha 60 000 units need to be specified. The use of big standard units on the other hand results in the loss of detailed information which might be locally of great importance. When working in units of 400 ha or 100 ha the x- and y-coordinates can be specified by a number of 3 digits, with units of 25 ha the specification of the coordinates requires generally 4 digits.

The grid area is generally taken as a constant over the whole region, but in special cases at borders of subsystems it might be useful to have a more dense network of grids. When such a decision is made, one should realize that a grid code must be used following the coordinates. This grid code is an one digit number. The following code can be used:

| grid code | area in ha |
|---|---|
| 0 | 400 |
| 1 | 100 |
| 2 | 25 |

With the introduction of a variable grid size, one has to define the coordinate with a number of 4 digits. The location size code is for instance 175008352= 1750/0835/2 and reads as x-coordinate is 175.0 km, y-coordinate is 83.5 km with a grid code 2, indicating a unit of 25 ha.

The grid code can be extended, to specify special points of the irrigation system or the drainage transport system. The grid code 3 indicates that the given coordinates locate a special point in the irrigation transport system, which is specified in the irrigation system code. The grid code 4 gives the same indication for the drainage system and this is followed by a further specification in the drainage code.

2.2.2. Identification of the irrigation system

The origine and history of the irrigation water used in each grid must be completely described. The code used for the irrigation system has to describe the pathway travelled by a unit volume of water from the Deltabarrage to the point of application. The code must also indicate the number of locations where mixing with water from other origine can take place.

Starting at the Deltabarrage the number of the main canals, including the two Nile branches, can be indicated by a code 0 - 9 as the first digit of the irrigation system code. In the main canals recharge can be present, with mixing of water from other origine. This can be either the overflow of the tail end of an other irrigation canal or recharge from a drainage pumping station. For a description of the number of locations in the main canal for recharge the second digit can be used with a code 0 - 9. This code specifies 9 locations for recharge as the figure 0 indicates no recharge. The third digit is used to specify the number of first order branch-canals after each recharge point, also with a code 0 - 9. The number 0 indicates that no branch-canal is present. The fourth digit is used for recharge in the first order branch-canal. The fifth digit is used to specify the second order branch-canals after each recharge point in the first order branch-canals. The sixth digit is reserved for recharge locations in the second order branch-canal. The next two digits are reserved for the number of the distributary. The ninth and tenth digit are used to indicate the distance of the grid from the distributary inlet, expressed in grid length. Finally the last digit is used to specify the distance of the grid from the distributary. The code 0 indicates that the distributary passes through the grid.

The irrigation system code is a number of 11 digits, that can be summarized as follows:

x.......... = number main canal
.x......... = number recharge point main canal
..x........ = number first order branch-canal after recharge point
...x....... = number recharge point in first order branch-canal
....x...... = number second order branch-canal after recharge point
.....x..... = number recharge point second order branch-canal
......xx... = number distributary after recharge point
........xx. = number of grids distance from the inlet point
..........x = number of grids distance from the distributary
61221012043 = the grid is situated at 3 grid distances from the distributary at 4 grids distance from the inlet of the twelfth distributary of the first second order branch-canal after the second recharge point of the second first order branch-canal after the first recharge point of the sixth main canal.

### 2.2.3. Identification of the drainage system

The drainage system code must describe the pathway of the drainage water from the grid to the outfall in sea. The code must identify all points where mixing with water from other origine can be present, as well as the points where official re-use in the irrigation system can be realized. The code starts from the outfall at sea, backwards to the grid where the drainwater has been generated. The code gives the following information:

number of outfall = number of main drainage canal (2 digits);
number of drainage water measuring point in main drainage canal (1 digit);
number first order drainage branch-canal after measuring point (1 digit);
number measuring point in first order drainage branche-canal(1 digit);
number of second order drainage branche-canal after measuring point (1 digit);
number of the drain collector after the measuring point (2 digits);
number of tail end outlet of the irrigation transport system, after each measuring point or at the drain collector.

12131200701 = the first tail end discharge to the seventh drain collector of the second order drainage branche-canal after the first measuring point of the third first order drainage branche-canal after the first measuring point of the twelfth main drainage canal.

06030000011 = the eleventh tail end discharge to the third first order branche-canal of the sixth main drainage canal.

The drainage system code must be followed by the first 8 digits of the irrigation code of the tail end under consideration.

2.2.4. Identification of the re-use system

Official re-use is present in the following situations:

- tail end discharge from an irrigation canal to an other irrigation canal;
- recharge of the irrigation system through a pumping station using drainage water.

The origine of the re-use water must be specified. As far as it concerns the tail end losses of the irrigation canal system, it can be done by the first 8 digits of the irrigation system code. The re-use of drainage water can be specified by the first 7 digits of the drainage system code. So the complete code for the specification of the re-use code can be a number of 9 digits starting with 00 when drainage water is used and starting with 1 in the case of recharge with tail end water from an other irrigation canal system. The same code, but starting with 2 can be used to specify the tail end losses to the drainage system.

001203121 = re-use of drainage water at the first measuring point of the second order branche drainage canal after the first measuring point of the third first order branche drainage canal of the twelfth main drainage canal.

141200000 = re-use of tail end water of the second first order irrigation branch-canal after the first recharge point in the fourth main irrigation canal.

210103000 = tail end outlet of the third second order irrigation branch-canal of the first first order irrigation branch-canal of the first main irrigation canal.

The non-official re-use is determined by the availability of drainage water, when a lack of irrigation water is present. Two situations must be distinguished; availability of drain water with a high water level and with a low water level. In the first situation the farmers can transport the drain water by gravity to the tail ends of the distributaries. In the second case they have to pump the water. In this situation the re-use will generally be restricted to the land situated near the drain collector or the drain canal. The non-official re-use of high level drainwater started with 30 followed by the first 7 digits of the drainage system. With low level drainagewater the code starts with 4, followed in the last two digits by the maximum percentage of the grid that can be supplied with drainage water. In this case it is assumed that the quantity of water is obtained from the nearest drain collector.

300302031 = non-official re-use of high level drainage water after the first measuring point of the third second order drainage branch-canal of the second first order drainage branch-canal of the third main drainage canal.

400000035 = non-official re-use of low level drainage water on maximal 35 percent of the grid.

Some examples

| Coordinates x | Coordinates y | Grid code | Irrigationsystem | Drainagesystem | Re-usesystem |
|---|---|---|---|---|---|
| 1250 | 0870 | 0 | 20312008062 | 07130200800 | 400000025 |
| 1273 | 0846 | 3 | 20310000000 | | 131100000 |
| 1396 | 0925 | 3 | 41210000000 | | 000810000 |
| 1564 | 0575 | 3 | 51102011000 | | 300601000 |
| 1495 | 0773 | 4 | | 08120300000 | 230203000 |
| 1554 | 0673 | 4 | | 07100000000 | 006100000 |
| 0235 | 1065 | 4 | | 02120301405 | 210301012 |

### 2.2.5. The soil identification code

The soil identification code contains information directly related to the properties of the soil, as well as data which are dependent on the location as quantity and type of solid salts and information concerning the initial soil salinity.

When distinguishing 10 soil types, this can be indicated by one digit for soil texture. Moreover a small data file has to be introduced specifying the physical and chemical properties as they are related to the soil texture code. An example of such a soil texture code, with accompanying data file is given in table 1.

The soil code also contains data of solid salts present in the soil, when possible specified into $CaCO_3$, $MgCO_3$ and $CaSO_4$, and expressed as the fraction of the bulk density. Each salt has its own code of 1 digit, ranging from 0 to 9.

Table 1. Soil texture code with data file, giving total soil porosity, moisture fraction at field capacity and at wilting point, as well as the plant available moisture fraction; the bulk density of the soil in g/cm3 and the cation exchange capacity (CEC) in meq. per 100 grammes of dry soil

| soil code | soil texture | Por. | moisture f.c. | content w.p. | available fraction | bulk density | CEC |
|---|---|---|---|---|---|---|---|
| 0 | medium fine sand | .396 | .080 | .023 | .057 | 1.60 | 2 |
| 1 | loamy fine sand | .415 | .195 | .061 | .134 | 1.55 | 10 |
| 2 | sandy loam | .415 | .224 | .087 | .137 | 1.55 | 15 |
| 3 | silt loam | .434 | .320 | .125 | .195 | 1.50 | 20 |
| 4 | sandy clay loam | .453 | .355 | .160 | .195 | 1.45 | 30 |
| 5 | silty clay loam | .453 | .385 | .185 | .200 | 1.45 | 40 |
| 6 | clay 1 | .472 | .410 | .210 | .200 | 1.40 | 45 |
| 7 | clay 2 | .472 | .440 | .235 | .205 | 1.40 | 50 |
| 8 | clay 3 | .491 | .460 | .255 | .205 | 1.35 | 55 |
| 9 | basin clay | .509 | .500 | .290 | .210 | 1.30 | 60 |

The code gives also the data of the quantity of total dissolved salts (TDS) in meq. per liter and the fraction of $Ca^{2+}$, $Mg^{2+}$, $HCO_3^-$ and $SO_4^{2-}$. The fractions of $Na^+ + K^+$ and $Cl^-$ are not specified as they can be calculated as rest terms. An example of such a soil chemical code is given in table 2.

Table 2. Codes of the different solid salts, as fractions of total bulk density, TDS in meq per liter and the fractions of the cations and anions

| code | $CaCO_3$ | $MgCO_3$ | $CaSO_4$ | TDS | $Ca^{2+}$ | $Mg^{2+}$ | $HCO_3^-$ | $SO_4^{2-}$ |
|---|---|---|---|---|---|---|---|---|
| 0 | .000 | .000 | .000 | 10 | .05 | .05 | .05 | .05 |
| 1 | .025 | .025 | .025 | 25 | .10 | .10 | .10 | .10 |
| 2 | .050 | .050 | .050 | 50 | .15 | .15 | .15 | .15 |
| 3 | .075 | .075 | .075 | 75 | .20 | .20 | .20 | .20 |
| 4 | .100 | .100 | .100 | 100 | .25 | .25 | .25 | .25 |
| 5 | .125 | .125 | .125 | 150 | .30 | .30 | .30 | .30 |
| 6 | .150 | .150 | .150 | 200 | .35 | .35 | .35 | .35 |
| 7 | .175 | .175 | .175 | 300 | .40 | .40 | .40 | .40 |
| 8 | .200 | .200 | .200 | 400 | .45 | .45 | .45 | .45 |
| 9 | .225 | .225 | .225 | 500 | .50 | .50 | .50 | .50 |

If we want to define the salt distribution in 4 layers of .5 m depth, we can get the following code: 5 10023332 11033242 10184334 20093333.

### 2.2.6. The aquifer identification code

Under certain hydrological conditions leakage to, or seepage from the aquifer can be present. The magnitude of this leakage and seepage depends on:

- clay cap thickness
- clay cap permeability
- piezometric head in the aquifer
- piezometric head of the phreatic water.

The water quality in the aquifer must also be specified, when seepage from the aquifer is present. This specification gives the total quantity of dissolved salts in meq per liter and the relative fractions of $Ca^{2+}$, $Mg^{2+}$, $HCO_3^-$ and $SO_4^{2-}$. The fractions of $Na^+ + K^+$ and $Cl^-$ need not to be specified as they can be calculated as rest terms.

As the piezometric heads are used to calculate seepage flux, they must be specified in sufficient detail to prevent unrealistic estimates of seepage or leakage. Due to the fact that the piezometric head changes considerably from Cairo to the coastal area, a three digit code is required for the piezometric head. The aquifer identification code can be specified as follows.

| code | clay cap thickness m | permeability $m.day^{-1}$ | piezometric head 10m | m | 0,25m | TDS meq/l | $Ca^{2+}$ | $Mg^{2+}$ | $HCO_3^-$ | $SO_4^{2-}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | fractions | | | |
| 0 | 2 | 0.020 | 0 | 0 | 0.00 | 10 | 0.05 | 0.05 | 0.05 | 0.05 |
| 1 | 4 | 0.010 | 10 | 1 | 0.25 | 50 | 0.10 | 0.10 | 0.10 | 0.10 |
| 2 | 6 | 0.005 | 20 | 2 | 0.50 | 100 | 0.15 | 0.15 | 0.15 | 0.15 |
| 3 | 8 | - | - | 3 | 0.75 | 200 | 0.20 | 0.20 | 0.20 | 0.20 |
| 4 | 10 | - | - | 4 | | 300 | 0.25 | 0.25 | 0.25 | 0.25 |
| 5 | 12 | - | - | 5 | | 400 | 0.30 | 0.30 | 0.30 | 0.30 |
| 6 | 14 | - | - | 6 | | 500 | 0.35 | 0.35 | 0.35 | 0.35 |
| 7 | 16 | - | - | 7 | | 1000 | 0.40 | 0.40 | 0.40 | 0.40 |
| 8 | 18 | - | - | 8 | | 1500 | 0.45 | 0.45 | 0.45 | 0.45 |
| 9 | ⩾20 | - | - | 9 | | ⩾2000 | 0.50 | 0.50 | 0.50 | 0.50 |

Example:

The code 5203284221 gives a clay cap thickness of 12 m, a clay cap permeability of 0.005 $m.day^{-1}$, a piezometric head of 3.5m, TDS of 1500 $meq/l^{-1}$ with a fractional distribution of 25% $Ca^{2+}$, 15% $Mg^{2+}$, 15% $HCO_3^-$ and 10% $SO_4^{2-}$ leaving a contribution of 10% $Na^+$ and 25% $Cl^-$ as rest terms.

### 2.2.7. The drainage specification code

The drainage specification gives information concerning depth of drainage, drain distances, depth of drainage barrier and the depth of the phreatic water table. When stating that the mean water table depth equals the drainage depth, it is necessary to introduce in the drainage code also the specification of the elevation of the land surface above mean sealevel.

The drainage code can be given as follows:

| Code | Drainage depth m | Drain distance m | Depth drainage barrier m | Land elevation 10m | m | 0.25m |
|---|---|---|---|---|---|---|
| 0 | 0 | 10 | 2 | 0 | 0 | 0.00 |
| 1 | 0.5 | 20 | 4 | 10 | 1 | 0.25 |
| 2 | 1.0 | 30 | 6 | 20 | 2 | 0.50 |
| 3 | 1.5 | 40 | 8 | 30 | 3 | 0.75 |
| 4 | 2.0 | 50 | 10 | - | 4 | - |
| 5 | - | 60 | 12 | - | 5 | - |
| 6 | - | - | 14 | - | 6 | - |
| 7 | - | - | > 14 | - | 7 | - |
| 8 | - | - | - | - | 8 | - |
| 9 | - | - | - | - | 9 | - |

Example:

The code 354131 gives the drainage specification of a grid with a depth of drainage of 1.5 m a drain distance of 60 m, the depth of the drainage barrier at 10 m and a surface elevation of 13,25 m above mean sealevel.

### 2.2.8. The crop rotation code

The crop rotation code is one digit code,which is sufficient to specify 10 different crop rotations. The code can be given as follows for the present crop rotations.

| Code | Crop rotation |
|---|---|
| 0 | vegetables - berseem (long) - maize - berseem (short) - cotton - wheat |
| 1 | rice - berseem (long) - maize - berseem (short) - cotton - wheat |
| 2 | rice - berseem (short) - cotton - wheat |
| 3 | rice - berseem (long) - rice - berseem (short) - cotton - wheat |
| 4 | fruittrees |

Now there are still 5 places left to specify new future crop rotations. The crop rotation code must be further specified with a data file giving for each crop in its crop rotation:

- planting data
- crop development data, as soil cover and crop height in relation with time
- harvesting data
- irrigation regime, both frequency of application and 'ideal' quantities.

The heading of such a data file can be as follows

Code 0

| Period | Vegetables | | | Irrigation regime | | Berseem long | | | Irrigation regime | |
|---|---|---|---|---|---|---|---|---|---|---|
| | planting date | soil cover | crop height | number | quantity | planting date | soil cover | crop height | numb. | quan. |
| J 1 | | | | | | | | | | |
| J 2 | | | | | | | | | | |
| F 1 | | | | | | | | | | |
| F 2 | | | | | | | | | | |
| M 1 | | | | | | | | | | |
| M 2 | | | | | | | | | | |

2.2.9. The climate specification code

The climate has to be specified in terms of maximum evapotranspiration and precipitation. The climate specification code is a two digit code of which the first one specifies the evaporative conditions and the second one the precipitation. The codes must be followed by a data file.

| Code | Evaporation | Precipitation |
|---|---|---|
| 0 | Southern and dessert borders delta | Southern delta |
| 1 | Middle delta | Middle delta |
| 2 | Northern delta | Northern delta |

An example of the data file for evaporation is given in table 2(pag 7)
Report no.81 VIII.06. Advisory Panel for Land Drainage in Egypt.
The amount of precipitation is small, compared with the amounts of irrigation water required. The mean monthly precipitation in the three regions

regions is specified as the average of different meteorological stations in the Delta.

Mean monthly precipitation

| Code | J | F | M | A | M | J | J | A | S | O | N | D | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 7.5 | 4.2 | 2.7 | 0.8 | 1.6 | - | - | - | - | 1.5 | 4.9 | 4.9 | 28.1 |
| 1 | 10.8 | 8.8 | 5.3 | 2.2 | 3.4 | 0.3 | - | 0.8 | 0.1 | 3.9 | 6.7 | 14.0 | 56.3 |
| 2 | 37.5 | 20.6 | 12.0 | 2.1 | 2.1 | - | - | 0.1 | 1.0 | 11.2 | 20.6 | 46.1 | 153.3 |

## 2.3. Data sorting

Using a code system in data administration has the advantage that with rather simple standard sorting programmes alle relevant data for a calculation can be collected from the data file.

Examples:

If one wants to know all the information available of the grids served by the irrigation system after the first recharge of the third main canal, the computer can be ordered to list all grids with the irrigation system code between 31000000000 and 32000000000.
If we want to know all the grids served by the irrigation transport system after the first recharge point of the second first order branch canal of the fourth main canal, the computer is ordered to list all grids with an irrigation code number between 40210000000 and 40220000000.
The area served by the irrigation transport system after the first recharge point of the first second order branch canal of the second first order branch canal of third main canal is given by the grids with code number from 30201100000 to 30201200000.
The area served by the fourth distributary of this second order branch canal is determined by the grids with the irrigation code number between 30201104000 and 30201105000.
The selected collection of grids with the aid of the irrigation system code is mainly based on the areas served from recharge point, because at these points both water quantity and water quality of the available irrigation water changes.

The grid selection on basis of the irrigation system code will list generally grids with more than one drainage system code. A second sorting programme can be used to select in the listed file all the grids with the same main drainage code.

Example: List all data of the grids served by the irrigation system after the first recharge point of the second first order branch canal of the second main canal.

| Coordinates X | Y | Grid code | Irrigation system code | Drainage system code | Re-use system |
|---|---|---|---|---|---|
| 1396 | 0925 | 3 | 20210000000 | 01201200000 | 000120120 |
| 1396 | 0926 | 0 | 20210000010 | 03120000600 | 000000000 |
| 1396 | 0928 | 0 | 20210000011 | 03120000600 | 000000000 |
| 1397 | 0928 | 0 | 20210000020 | 03120000600 | 000000000 |
| .... | .... | . | ........... | ........... | ......... |
| 1399 | 0930 | 0 | 20210001010 | 03120000600 | 000000000 |
| .... | .... | . | ........... | ........... | ......... |
| 1407 | 0934 | 0 | 20210002093 | 03120000700 | 400000025 |
| .... | .... | . | ........... | ........... | ......... |
| 1508 | 0936 | 0 | 20211012092 | 04010200400 | 400000015 |
| 1509 | 0946 | 3 | 20211013000 | 02011000000 | 300201100 |
| 1510 | 0947 | 4 | 20211014000 | 04010200007 | 220211014 |
| .... | .... | . | ........... | ........... | ......... |

The sequence of the calculations is strongly dependent on the re-use code, as the quality and the available quantity of the re-use water must be known. The calculations of the quantity and quality of the drain water produced by the grids generating the re-use water must be calculated first.

The initiation of calculations in the irrigation water transport system start with the water requirement calculation for the whole Delta, split up for each main canal. This calculation starts with the listing of the irrigation system code for each main canal. From this listing the ideal water requirements for each main canal can be calculated using the data of:

- crop rotation code
- evaporation file

- precipitation file
- the soil code
- the aquifer code
- the ideal irrigation schedule
- the ideal irrigation gifts
- idealized leaching fractions and field irrigation efficiencies
- idealized tail end and conveyance losses.

From these calculations the idealized distribution of the available water at the Delta barrage can be calculated for the main canal system.

For each main canal the grids with the irrigation system code x0x0x0xxxxx can be used in the first step of the calculations of actual evaporation and both drainage water quality and quantity, applying the different submodels. The grids with this code have no official re-use, so the quality of the water in the irrigation transport system equals the quality at the Delta barrage.

The re-use code must be equal to 000000000 or 4000000xx. In the latter case the quantity available and the quality must be calculated from the grids without re-use, before the water and salt balances of the grids with non-offocial re-use can be calcutated.

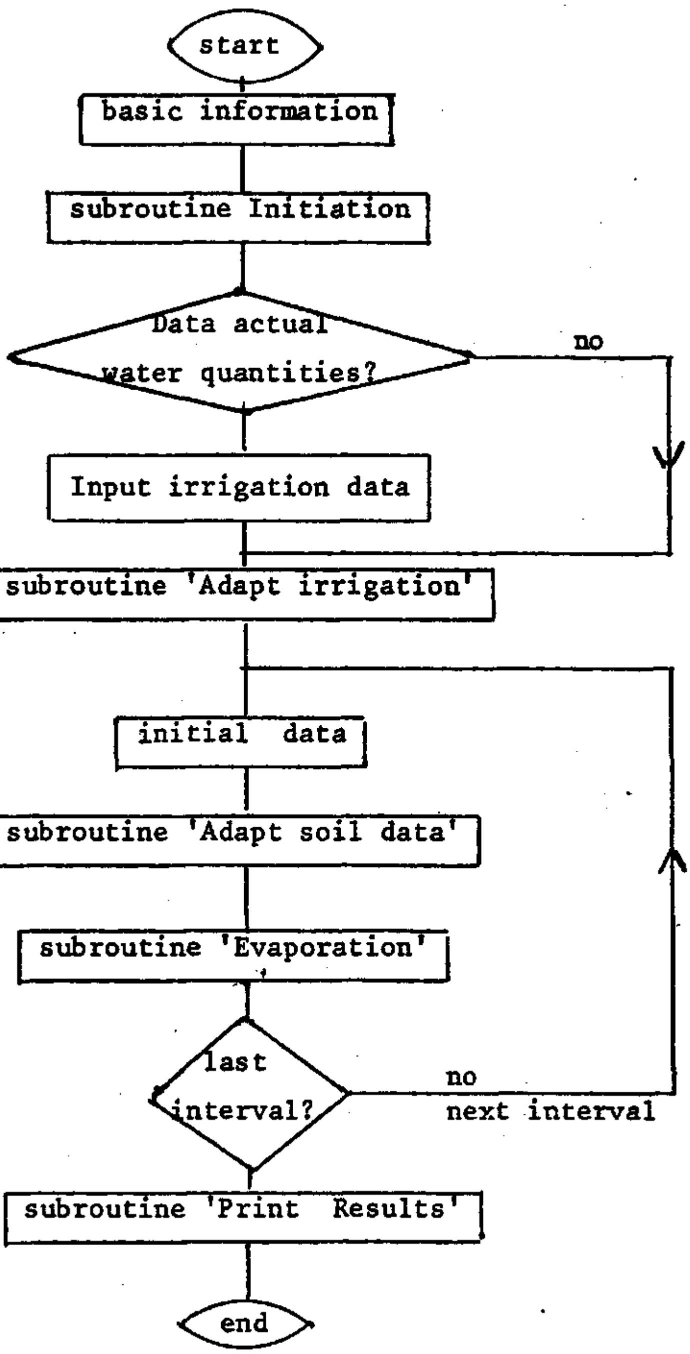
The water use and drain water production of grids with an other re-use code can only be calculated if the quantity and quality of drainwater specified by the re-use code is known. For the re-use code 1x0x0x000 only the available quantity must be known, as this code specifies the re-use of the tailend losses of an irrigation canal without recharge, so the quality equals the water quality at the Delta barrage.

The sequance of the sorting of the grids with the same water quality in the irrigation transport system is as follows:

| | |
|---|---|
| x0x0x0xxxxx | x0x2x0xxxxx |
| x0x0x1xxxxx | x0x2x1xxxxx |
| x0x0x2xxxxx | ........... |
| ........... | x1x0x0xxxxx |
| x0x1x0xxxxx | x1x0x1xxxxx |
| x0x1x1xxxxx | ........... |
| ........... | x1x1x0xxxxx |
| | x1x1x1xxxxx |
| | ........... |

Evaporation model

On basis of the formulation given by Rijtema, 1981*, a computer programme for the HP-85 Microcomputer of DRI has been constructed. The programme of the model is operating interactively and is constructed such that it is as friendly as possible for the user. The 'main' flow diagram of the evaporation model 'RIJTICW' is as follows:




*P.E.Rijtema: Re-use of drainage water - model analysis. Advisory Panel for Land Drainage in Egypt. 1981. Report no.81.VIII.06

At the computer's request the following basic information must be supplied by the user:

| | |
|---|---|
| - Moisture fraction at saturation | M 1 |
| - Moisture fraction at field capacity | M 2 |
| - Moisture fraction at wilting point | M 3 |
| - Initial moisture fraction before first irrigation | M 4 |
| - Depth of root zone in cm | D 1 |
| - Depth of drainage in cm | D 2 |
| - Seepages from aquifer in mm/day$^{-1}$ (pos.sign) | F 1 |
| - Leakage to aquifer in mm/day$^{-1}$ (neg.sign) | F 1 |
| - Water available for non-official re-use in mm | R 1 |
| - Number of irrigation intervals | I |
| - Climate conditions and crop rotation | |

With respect to the question of climatic conditions and crop ratation the programme has been supplied with 7 data files combining 3 different climatic conditions and 4 different crop rotations.
The climatic conditions considered are representative for the Southern Delta and the Desert Border area's, the Middle Delta and the Northern Delta.
They are identified on the computer display as:

| | | |
|---|---|---|
| Soud 00 | = | Southern Delta; crop rotation: Berseem - Maize - Berseem - Cotton - Wheat - Vegetables |
| Midd 11 | = | Middle Delta; crop rotation: Berseem - Maize - Berseem - Cotton - Wheat - Rice |
| Midd 12 | = | Middle Delta; crop rotation: Berseem - Cotton - Wheat - Rice |
| Midd 13 | = | Middle Delta: crop rotation: Berseem - Rice - Berseem - Cotton - Wheat - Rice |
| Nord 21 | = | Northern Delta; crop rotation: Berseem - Maize - Berseem - Cotton - Wheat - Rice |
| Nord 22 | = | Northern Delta; crop rotation: Berseem - Cotton - Wheat - Rice |
| Nord 23 | = | Northern Delta; crop rotation: Berseem - Rice - Berseem - Cotton - Wheat - Rice |

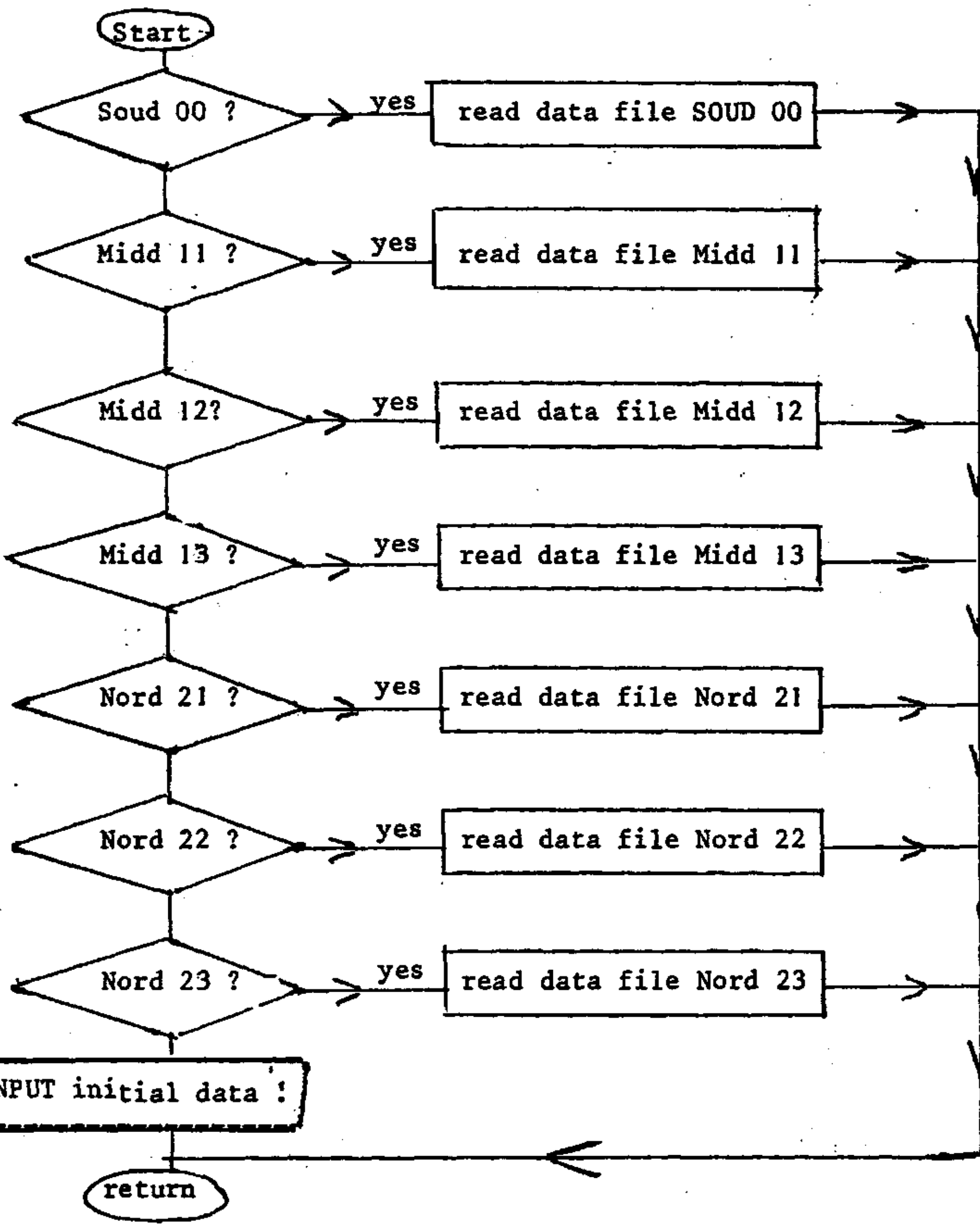
The heading of the data files is:

| | | | |
|---|---|---|---|
| I | = | number of irrigation interval | no |
| T (I,1) | = | length of irrigation interval in days | T |
| T (I,2) | = | theoretical net irrigation application in mm | $I_t$ |
| T (I,3) | = | maximum evapotranspiration in $mm.day^{-1}$ | $E_{max}$ |

The data files are given in Annex 2

The subroutine 'Initiation' gives the command read the requested data file.

Flow Diagram 'INITIATION'

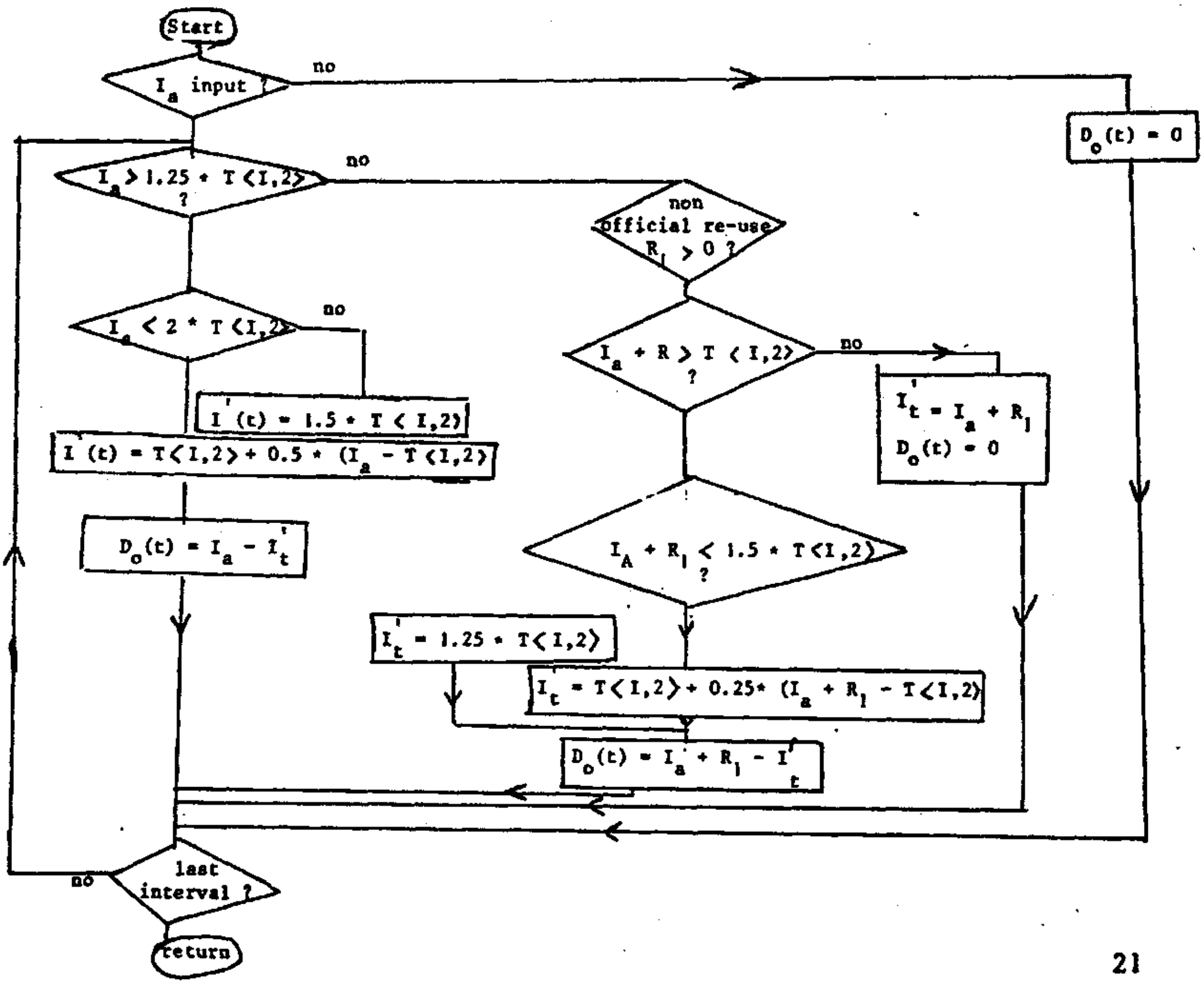


When the question of the computer, concerning the availability of actual irrigation water quantity data is answered with 'no', the computer uses automatically the theoretical irrigation water quantities, that are given in the mission report 81.VIII.06. When actual data are present, the computer will ask for the input for each irrigation number I.

When actual water quantities available in the irrigation canal system are given as input, the actual quantities taken by the farmers must be calculated. This is done in the subroutine 'Adapt irrigation'. The flow diagram 'Adapt irrigation' shows a first approach to 'farmer's behaviour', when plenty of water is available and under conditions of water shortage. In future this subroutine must be extended, taking also into account the crop and the quality of the drainage water used for non-official re-use.

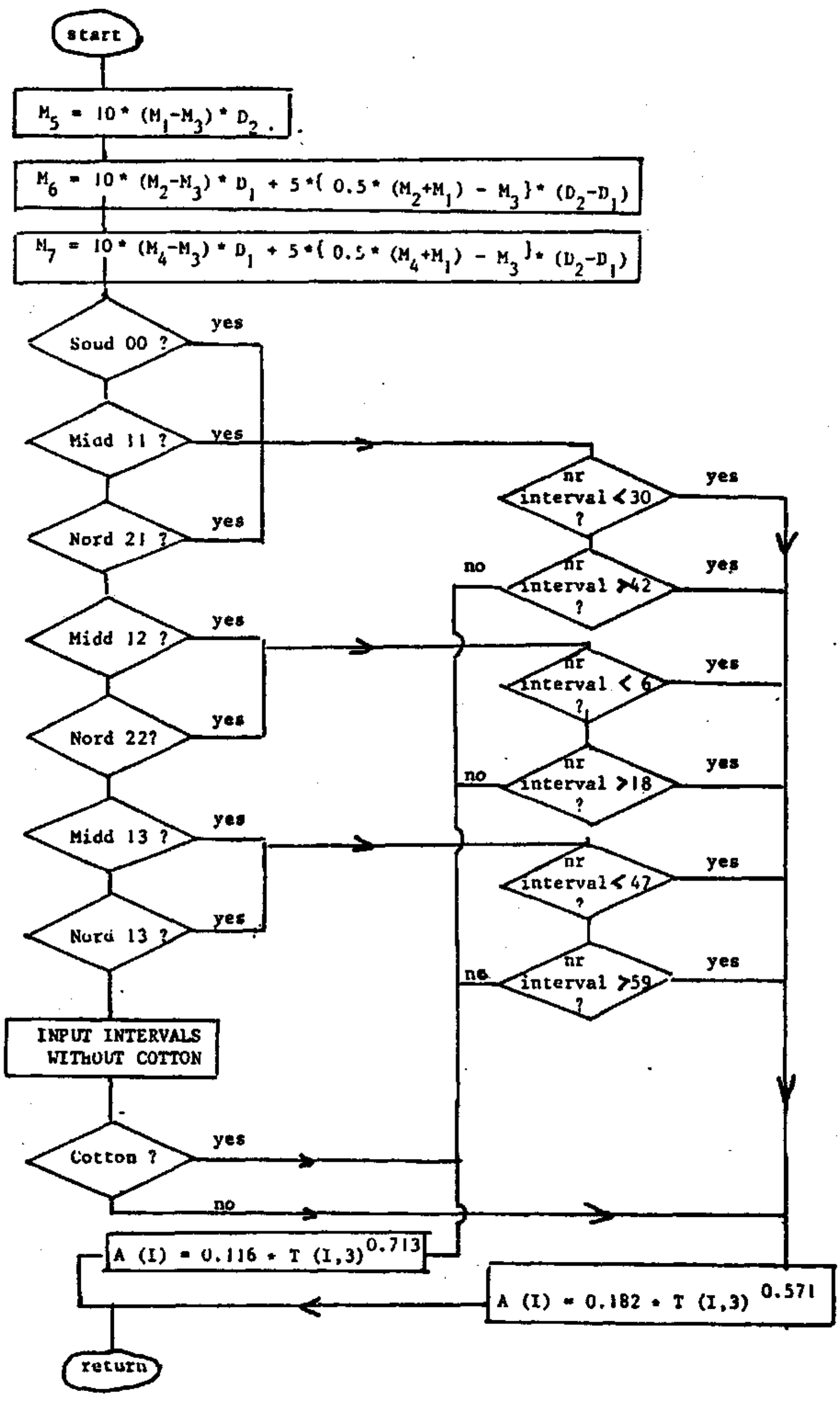
With the subroutine 'Adapt irrigation' the actual irrigation water quantities, required for the calculation of the actual evapotranspiration, are determined by the computer.

Flow diagram 'ADAPT IRRIGATION'

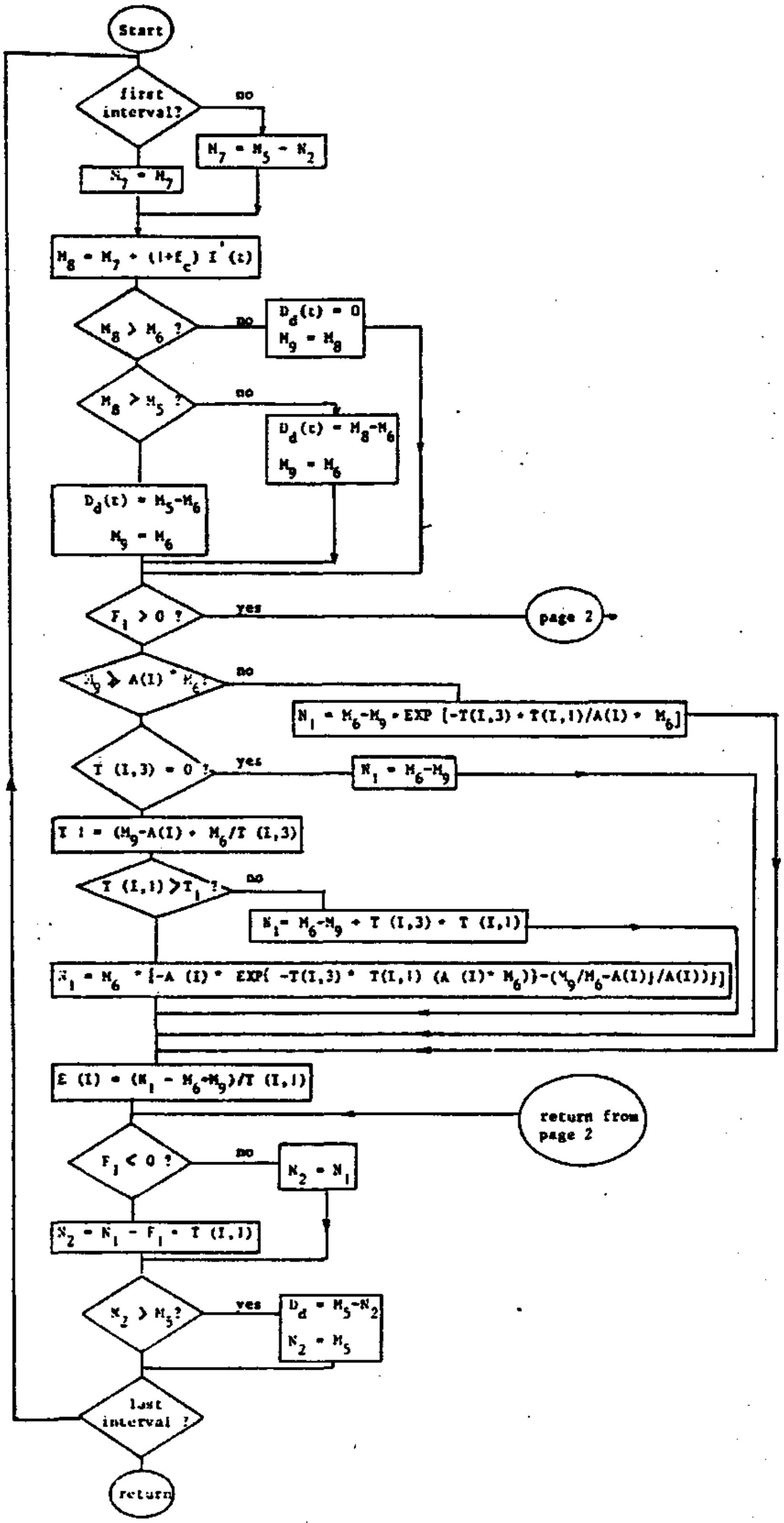


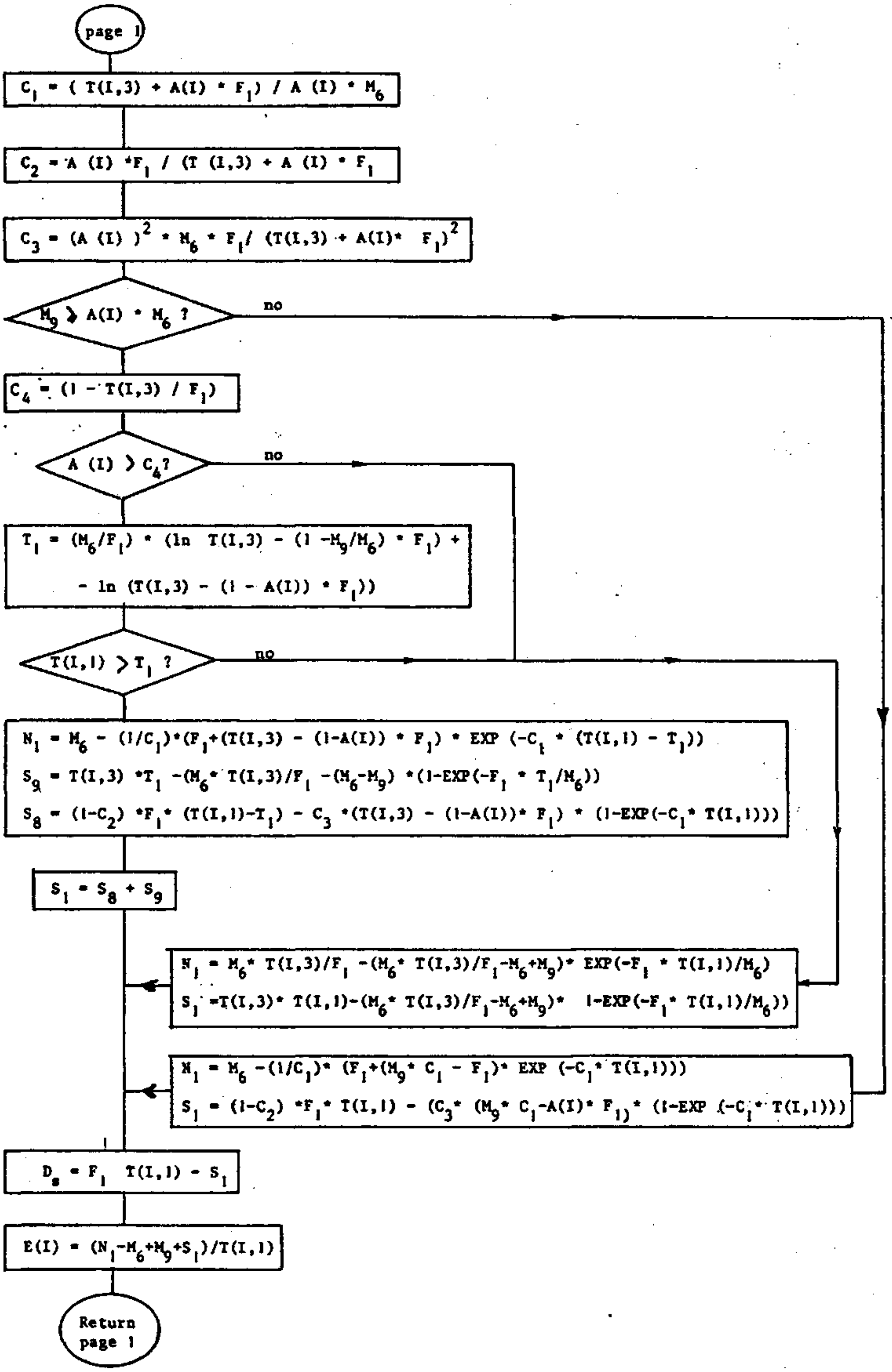
The subroutine 'Adapt soil data' calculates the volumes of water present in the soil above drainage depth at saturation, equilibrium (field capacity) conditions, and the initial moitsure volume in the soil before the first irrigation. Moreover the relative moisture volume in the soil at which, in relation to maximum evapotranspiration, stress conditions start are calculated for different crops. In the present programme, the calculations has been splitted up into cotton and other crops, but in future this programme can be extended.

Flow Diagram 'ADAPT SOIL DATA'



Finally the subroutine 'Evaporation' calculates the actual evapotranspiration for the given set of input data. The flow diagram gives the routing of the calculations.




page 1
C1 = ( T(I,3) + A(I) * F1) / A (I) * M6
C2 = A (I) *F1 / (T (I,3) + A (I) * F1
C3 = (A (I) )2 * M6 * F1/ (T(I,3) + A(I)* F1)2
M9 > A(I) * M6 ?
no
C4 = (1 - T(I,3) / F1)
A (I) > C4?
no
T1 = (M6/F1) * (ln T(I,3) - (1 -M9/M6) * F1) +
- ln (T(I,3) - (1 - A(I)) * F1))
T(I,1) > T1 ?
no
N1 = M6 - (1/C1)*(F1+(T(I,3) - (1-A(I)) * F1) * EXP (-C1 * (T(I,1) - T1))
S9 = T(I,3) *T1 -(M6* T(I,3)/F1 -(M6-M9) *(1-EXP(-F1 * T1/M6))
S8 = (1-C2) *F1* (T(I,1)-T1) - C3 *(T(I,3) - (1-A(I))* F1) * (1-EXP(-C1* T(I,1)))
S1 = S8 + S9
N1 = M6* T(I,3)/F1 -(M6* T(I,3)/F1-M6+M9)* EXP(-F1 * T(I,1)/M6)
S1 =T(I,3)* T(I,1)-(M6* T(I,3)/F1-M6+M9)* 1-EXP(-F1* T(I,1)/M6))
N1 = M6 -(1/C1)* (F1+(M9* C1 - F1)* EXP (-C1* T(I,1)))
S1 = (1-C2) *F1* T(I,1) - (C3* (M9* C1-A(I)* F1)* (1-EXP (-C1* T(I,1)))
Ds = F1 T(I,1) - S1
E(I) = (N1-M6+M9+S1)/T(I,1)
Return
page 1

Annex 1

Itenary

11-6 Travelling to Cairo; discussions with Mr.v.d. Zel.

12-6 Discussions with Mr. v.d. Zel, Dr. Dia El Din El Quesi and Dr. Samia El Guindi.

13-6 Discussions with Dr. Mohammed Hassan Amer, director DRI and Dr. Soleiman, Ein Shams University, on the lectures in the course on 'Groundwater Hydrology for Arid Regions'. Preparation of lectures.

14-6 Preparation of lectures.

15-6 Lectures on 'Modelling Re-use of drainage water' in the course on 'Groundwater hydrology in Arid Regions', held at the Ein Shams University.

16-6 Work at DRI, Discussions with Dr.Dia El Din El Quesi and Engineer Nadia on evaporation models.

17-6 Visit to Mashtoul Pilot Area with Mr.v.d. Zel. Discussions on results and research programme of the pilot area. Dinner at Mr.v.d. Zel's residence.

18-6 Public holiday. Preparation of a simplified evaporation model.

19-6 National holiday. Preparation of a simplified evaporation model.

20-6 Work at DRI

21-6 Visit to Fayoum depression with Dr. Dia El Din El Quesi and Mr. Meijer. Discussions on the set up of a water- and salt balance model for this region.

22-6 Work at DRI, preparation of a flow chart for evaporation model.

23-6 Discussion with Dr. Mohammed Hassan Amer, Dr. Dia El Din El Quesi, Dr. Samia El Guindi and Mr.v.d. Zel.
Lectures and demonstrations on computer data administration, followed by discussion with DRI staffmembers.
Preparation flow chart for evaporation model.

24-6 Lectures and demonstrations on the use of simplified drainage and evaporation models, for training purposes and testing of field data, followed by discussions with DRI staffmembers.
Programming of evaporation model.

25-6 Public holiday. Work at DRI-office, testing of the programme for the evaporation model;
Ramadan breakfast at Dr. Samia El Guindi's recidence.

26-6 Travelling to the Netherlands.

Annex 2

Data file: Soud 00
Crop rotation: Berseem, Maize, Berseem, Cotton, Wheat, Vegetables

| I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 100 | 2.0 | 33 | 15 | 75 | 10.2 | 65 | 8 | 50 | 9.6 |
| 2 | 16 | 0 | 2.1 | 34 | 16 | 100 | 10.7 | 66 | 8 | 50 | 9.2 |
| 3 | 14 | 0 | 2.9 | 35 | 15 | 100 | 13.7 | 67 | 8 | 50 | 9.2 |
| 4 | 14 | 100 | 3.3 | 36 | 15 | 125 | 13.4 | 68 | 8 | 50 | 7.8 |
| 5 | 15 | 50 | 4.8 | 37 | 15 | 100 | 12.3 | 69 | 7 | 50 | 7.8 |
| 6 | 16 | 100 | 5.3 | 38 | 16 | 100 | 11.9 | 70 | 8 | 50 | 7.4 |
| 7 | 15 | 100 | 6.3 | 39 | 15 | 100 | 9.5 | 71 | 8 | 50 | 7.4 |
| 8 | 15 | 100 | 6.8 | 40 | 16 | 100 | 9.1 | 72 | 8 | 50 | 6.6 |
| 9 | 15 | 100 | 9.0 | 41 | 15 | 0 | 8.2 | 73 | 7 | 50 | 6.6 |
| 10 | 15 | 0 | 9.0 | 42 | 15 | 0 | 7.8 | 74 | 8 | 50 | 6.2 |
| 11 | 16 | 150 | 3.5 | 43 | 15 | 0 | 0 | 75 | 7 | 50 | 6.2 |
| 12 | 15 | 65 | 5.2 | 44 | 16 | 0 | 0 | 76 | 8 | 50 | 5.5 |
| 13 | 15 | 75 | 10.1 | 45 | 15 | 0 | 0 | 77 | 7 | 50 | 5.5 |
| 14 | 16 | 75 | 10.9 | 46 | 15 | 150 | 0 | 78 | 7 | 50 | 4.9 |
| 15 | 15 | 75 | 9.3 | 47 | 15 | 0 | 1.0 | 79 | 8 | 150 | 0 |
| 16 | 16 | 100 | 9.0 | 48 | 16 | 0 | 1.3 | 80 | 15 | 0 | 0.9 |
| 17 | 15 | 100 | 8.2 | 49 | 15 | 100 | 2.0 | 81 | 15 | 50 | 1.8 |
| 18 | 15 | 0 | 7.8 | 50 | 16 | 0 | 2.3 | 82 | 15 | 50 | 1.8 |
| 19 | 15 | 0 | 2.4 | 51 | 14 | 0 | 3.6 | 83 | 16 | 50 | 1.6 |
| 20 | 16 | 50 | 3.6 | 52 | 14 | 100 | 3.8 | | | | |
| 21 | 15 | 50 | 3.0 | 53 | 15 | 0 | 6.4 | | | | |
| 22 | 15 | 50 | 2.7 | 54 | 16 | 100 | 6.9 | | | | |
| 23 | 15 | 50 | 1.9 | 55 | 15 | 100 | 8.1 | | | | |
| 24 | 16 | 50 | 1.7 | 56 | 15 | 0 | 8.7 | | | | |
| 25 | 15 | 100 | 2.0 | 57 | 15 | 0 | 11.0 | | | | |
| 26 | 16 | 0 | 2.1 | 58 | 10 | 0 | 12.0 | | | | |
| 27 | 14 | 0 | 2.9 | 59 | 6 | 150 | 0 | | | | |
| 28 | 14 | 100 | 3.3 | 60 | 7 | 50 | 6.2 | | | | |
| 29 | 14 | 0 | 4.8 | 61 | 7 | 50 | 6.2 | | | | |
| 30 | 17 | 150 | 1.5 | 62 | 8 | 50 | 8.8 | | | | |
| 31 | 15 | 50 | 3.5 | 63 | 7 | 50 | 8.8 | | | | |
| 32 | 15 | 0 | 5.0 | 64 | 8 | 50 | 9.6 | | | | |

Data file: Midd 11
Crop rotation: Berseem. Maize, Berseem, Cotton, Wheat, Rice

| I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 100 | 2.1 | 33 | 15 | 75 | 9.3 | 65 | 4 | 50 | 9.0 |
| 2 | 16 | 0 | 2.2 | 34 | 16 | 100 | 9.7 | 66 | 3 | 100 | 9.0 |
| 3 | 14 | 0 | 3.4 | 35 | 15 | 100 | 10.9 | 67 | 4 | 100 | 9.0 |
| 4 | 14 | 100 | 3.5 | 36 | 15 | 125 | 10.7 | 68 | 4 | 100 | 9.0 |
| 5 | 15 | 50 | 4.2 | 37 | 15 | 100 | 8.9 | 69 | 4 | 100 | 9.0 |
| 6 | 16 | 100 | 4.7 | 38 | 16 | 100 | 8.5 | 70 | 3 | 50 | 8.0 |
| 7 | 15 | 100 | 6.3 | 39 | 15 | 100 | 7.7 | 71 | 5 | 50 | 8.0 |
| 8 | 15 | 100 | 6.8 | 40 | 16 | 100 | 7.3 | 72 | 2 | 50 | 8.0 |
| 9 | 15 | 100 | 8.0 | 41 | 15 | 0 | 6.6 | 73 | 5 | 50 | 8.0 |
| 10 | 15 | 0 | 8.0 | 42 | 15 | 0 | 6.2 | 74 | 8 | 100 | 8.0 |
| 11 | 16 | 150 | 3.0 | 43 | 15 | 0 | 0 | 75 | 8 | 100 | 8.0 |
| 12 | 15 | 65 | 4.4 | 44 | 16 | 0 | 0 | 76 | 7 | 100 | 7.5 |
| 13 | 15 | 75 | 7.6 | 45 | 15 | 0 | 0 | 77 | 8 | 100 | 7.5 |
| 14 | 16 | 75 | 8.0 | 46 | 15 | 150 | 0 | 78 | 8 | 100 | 7.1 |
| 15 | 15 | 75 | 7.5 | 47 | 15 | 0 | 1.0 | 79 | 8 | 100 | 7.1 |
| 16 | 16 | 100 | 7.1 | 48 | 16 | 0 | 1.4 | 80 | 7 | 100 | 6.6 |
| 17 | 15 | 100 | 6.6 | 49 | 15 | 100 | 2.1 | 81 | 8 | 100 | 6.6 |
| 18 | 15 | 0 | 6.2 | 50 | 16 | 0 | 2.4 | 82 | 7 | 100 | 6.2 |
| 19 | 15 | 0 | 2.0 | 51 | 14 | 0 | 4.0 | 83 | 8 | 100 | 6.2 |
| 20 | 16 | 50 | 3.1 | 52 | 14 | 100 | 4.3 | 84 | 15 | 0 | 5.7 |
| 21 | 15 | 50 | 2.5 | 53 | 15 | 0 | 5.5 | 85 | 14 | 0 | 4.7 |
| 22 | 15 | 50 | 2.4 | 54 | 16 | 100 | 5.9 | 86 | 17 | 150 | 0.8 |
| 23 | 15 | 50 | 1.9 | 55 | 15 | 100 | 8.3 | 87 | 15 | 50 | 1.5 |
| 24 | 16 | 50 | 1.8 | 56 | 15 | 0 | 8.8 | 88 | 15 | 50 | 1.9 |
| 25 | 15 | 100 | 2.1 | 57 | 15 | 0 | 10.0 | 89 | 16 | 50 | 1.8 |
| 26 | 16 | 0 | 2.2 | 58 | 4 | 100 | 6.0 | | | | |
| 27 | 14 | 0 | 3.4 | 59 | 4 | 100 | 6.0 | | | | |
| 28 | 14 | 100 | 3.5 | 60 | 4 | 100 | 6.0 | | | | |
| 29 | 14 | 0 | 4.2 | 61 | 4 | 100 | 6.0 | | | | |
| 30 | 17 | 150 | 1.3 | 62 | 3 | 50 | 9.0 | | | | |
| 31 | 15 | 50 | 3.4 | 63 | 4 | 50 | 9.0 | | | | |
| 32 | 15 | 0 | 5.0 | 64 | 3 | 50 | 9.0 | | | | |

Data file: Midd 12
Crop rotation: Berseem, Cotton, Wheat, Rice

| I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) |
|---|---|---|---|---|---|---|---|
| 1 | 15 | 100 | 2.1 | 33 | 15 | 0 | 10.0 |
| 2 | 16 | 0 | 2.2 | 34 | 4 | 100 | 6.0 |
| 3 | 14 | 0 | 3.4 | 35 | 4 | 100 | 6.0 |
| 4 | 14 | 100 | 3.5 | 36 | 4 | 100 | 6.0 |
| 5 | 14 | 0 | 4.2 | 37 | 4 | 100 | 6.0 |
| 6 | 17 | 150 | 1.3 | 38 | 3 | 50 | 9.0 |
| 7 | 15 | 50 | 3.4 | 39 | 4 | 50 | 9.0 |
| 8 | 15 | 0 | 5.0 | 40 | 3 | 50 | 9.0 |
| 9 | 15 | 75 | 9.3 | 41 | 4 | 50 | 9.0 |
| 10 | 16 | 100 | 9.7 | 42 | 3 | 100 | 9.0 |
| 11 | 15 | 100 | 10.9 | 43 | 4 | 100 | 9.0 |
| 12 | 15 | 125 | 10.7 | 44 | 4 | 100 | 9.0 |
| 13 | 15 | 100 | 8.9 | 45 | 4 | 100 | 9.0 |
| 14 | 16 | 100 | 8.5 | 46 | 3 | 50 | 8.0 |
| 15 | 15 | 100 | 7.7 | 47 | 5 | 50 | 8.0 |
| 16 | 16 | 100 | 7.3 | 48 | 2 | 50 | 8.0 |
| 17 | 15 | 0 | 6.6 | 49 | 5 | 50 | 8.0 |
| 18 | 15 | 0 | 6.2 | 50 | 8 | 100 | 8.0 |
| 19 | 15 | 0 | 0 | 51 | 8 | 100 | 8.0 |
| 20 | 16 | 0 | 0 | 52 | 7 | 100 | 7.5 |
| 21 | 15 | 0 | 0 | 53 | 8 | 100 | 7.5 |
| 22 | 15 | 150 | 0 | 54 | 8 | 100 | 7.1 |
| 23 | 15 | 0 | 1.0 | 55 | 8 | 100 | 7.1 |
| 24 | 16 | 0 | 1.4 | 56 | 7 | 100 | 6.6 |
| 25 | 15 | 100 | 2.1 | 57 | 8 | 100 | 6.6 |
| 26 | 16 | 0 | 2.4 | 58 | 7 | 100 | 6.2 |
| 27 | 14 | 0 | 4.0 | 59 | 8 | 100 | 6.2 |
| 28 | 14 | 100 | 4.3 | 60 | 15 | 0 | 5.7 |
| 29 | 15 | 0 | 5.5 | 61 | 14 | 0 | 4.7 |
| 30 | 16 | 100 | 5.9 | 62 | 17 | 150 | 0.8 |
| 31 | 15 | 100 | 8.3 | 63 | 15 | 50 | 1.5 |
| 32 | 15 | 0 | 8.8 | 64 | 15 | 50 | 1.9 |
| | | | | 65 | 16 | 50 | 1.8 |

Data file: Midd 13
Crop roration: Berseem, Rice, Berseem, Cotton, Wheat, Rice

| I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 100 | 2.1 | 36 | 15 | 0 | 5.7 | 71 | 16 | 100 | 5.9 |
| 2 | 16 | 0 | 2.2 | 37 | 14 | 0 | 4.7 | 72 | 15 | 100 | 8.3 |
| 3 | 14 | 0 | 3.4 | 38 | 17 | 150 | 0.8 | 73 | 15 | 0 | 8.8 |
| 4 | 14 | 100 | 3.5 | 39 | 15 | 50 | 1.5 | 74 | 15 | 0 | 10.0 |
| 5 | 15 | 50 | 4.2 | 40 | 15 | 50 | 1.9 | 75 | 4 | 100 | 6.0 |
| 6 | 16 | 100 | 4.7 | 41 | 16 | 50 | 1.8 | 76 | 4 | 100 | 6.0 |
| 7 | 15 | 100 | 6.3 | 42 | 15 | 100 | 2.1 | 77 | 4 | 100 | 6.0 |
| 8 | 15 | 100 | 6.8 | 43 | 16 | 0 | 2.2 | 78 | 4 | 100 | 6.0 |
| 9 | 15 | 100 | 8.0 | 44 | 14 | 0 | 3.4 | 79 | 3 | 50 | 9.0 |
| 10 | 4 | 100 | 6.0 | 45 | 14 | 100 | 3.5 | 80 | 4 | 50 | 9.0 |
| 11 | 4 | 100 | 6.0 | 46 | 14 | 0 | 4.2 | 81 | 3 | 50 | 9.0 |
| 12 | 4 | 100 | 6.0 | 47 | 17 | 150 | 1.3 | 82 | 4 | 50 | 9.0 |
| 13 | 4 | 100 | 6.0 | 48 | 15 | 50 | 3.4 | 83 | 3 | 100 | 9.0 |
| 14 | 3 | 50 | 9.0 | 49 | 15 | 0 | 5.0 | 84 | 4 | 100 | 9.0 |
| 15 | 4 | 50 | 9.0 | 50 | 15 | 75 | 9.3 | 85 | 4 | 100 | 9.0 |
| 16 | 3 | 50 | 9.0 | 51 | 16 | 100 | 9.7 | 86 | 4 | 100 | 9.0 |
| 17 | 4 | 50 | 9.0 | 52 | 15 | 100 | 10.9 | 87 | 3 | 50 | 8.0 |
| 18 | 3 | 100 | 9.0 | 53 | 15 | 125 | 10.7 | 88 | 5 | 50 | 8.0 |
| 19 | 4 | 100 | 9.0 | 54 | 15 | 100 | 8.9 | 89 | 2 | 50 | 8.0 |
| 20 | 4 | 100 | 9.0 | 55 | 16 | 100 | 8.5 | 90 | 5 | 50 | 8.0 |
| 21 | 4 | 100 | 9.0 | 56 | 15 | 100 | 7.7 | 91 | 8 | 100 | 8.0 |
| 22 | 3 | 50 | 8.0 | 57 | 16 | 100 | 7.3 | 92 | 8 | 100 | 8.0 |
| 23 | 5 | 50 | 8.0 | 58 | 15 | 0 | 6.6 | 93 | 7 | 100 | 7.5 |
| 24 | 2 | 50 | 8.0 | 59 | 15 | 0 | 6.2 | 94 | 8 | 100 | 7.5 |
| 25 | 5 | 50 | 8.0 | 60 | 15 | 0 | 0 | 95 | 8 | 100 | 7.1 |
| 26 | 8 | 100 | 8.0 | 61 | 16 | 0 | 0 | 96 | 8 | 100 | 7.1 |
| 27 | 8 | 100 | 8.0 | 62 | 15 | 0 | 0 | 97 | 7 | 100 | 6.6 |
| 28 | 7 | 100 | 7.5 | 63 | 15 | 150 | 0 | 98 | 8 | 100 | 6.6 |
| 29 | 8 | 100 | 7.5 | 64 | 15 | 0 | 1.0 | 99 | 7 | 100 | 6.2 |
| 30 | 8 | 100 | 7.1 | 65 | 16 | 0 | 1.4 | 100 | 8 | 100 | 6.2 |
| 31 | 8 | 100 | 7.1 | 66 | 15 | 100 | 2.1 | 101 | 15 | 0 | 5.7 |
| 32 | 7 | 100 | 6.6 | 67 | 16 | 0 | 2.4 | 102 | 14 | 0 | 4.7 |
| 33 | 8 | 100 | 6.6 | 68 | 14 | 0 | 4.0 | 103 | 17 | 150 | 0.8 |
| 34 | 7 | 100 | 6.2 | 69 | 14 | 100 | 4.3 | 104 | 15 | 50 | 1.5 |
| 35 | 8 | 100 | 6.2 | 70 | 15 | 0 | 5.5 | 105 | 15 | 50 | 1.9 |
| | | | | | | | | 106 | 16 | 50 | 1.8 |

Data file: Nord 21
Crop rotation: Berseem, Maize, Berseem, Cotton, Wheat, Rice

| I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 100 | 2.3 | 34 | 16 | 100 | 8.0 | 67 | 4 | 100 | 7.9 |
| 2 | 16 | 0 | 2.6 | 35 | 15 | 100 | 9.1 | 68 | 4 | 100 | 7.9 |
| 3 | 14 | 0 | 3.7 | 36 | 15 | 125 | 8.9 | 69 | 4 | 100 | 7.9 |
| 4 | 14 | 100 | 4.2 | 37 | 15 | 100 | 9.6 | 70 | 3 | 50 | 8.8 |
| 5 | 15 | 50 | 4.8 | 38 | 16 | 100 | 9.2 | 71 | 5 | 50 | 8.8 |
| 6 | 16 | 100 | 5.3 | 39 | 15 | 100 | 9.1 | 72 | 2 | 50 | 8.8 |
| 7 | 15 | 100 | 5.8 | 40 | 16 | 100 | 8.7 | 73 | 5 | 50 | 8.8 |
| 8 | 15 | 100 | 6.2 | 41 | 15 | 0 | 8.5 | 74 | 8 | 100 | 8.8 |
| 9 | 15 | 100 | 6.7 | 42 | 15 | 0 | 8.0 | 75 | 8 | 100 | 8.8 |
| 10 | 15 | 0 | 7.1 | 43 | 15 | 0 | 0 | 76 | 7 | 100 | 8.9 |
| 11 | 16 | 150 | 2.7 | 44 | 16 | 0 | 0 | 77 | 8 | 100 | 8.9 |
| 12 | 15 | 65 | 3.9 | 45 | 15 | 0 | 0 | 78 | 8 | 100 | 8.4 |
| 13 | 15 | 75 | 8.3 | 46 | 15 | 150 | 0 | 79 | 8 | 100 | 8.4 |
| 14 | 16 | 75 | 8.8 | 47 | 15 | 0 | 1.0 | 80 | 7 | 100 | 8.2 |
| 15 | 15 | 75 | 9.0 | 48 | 16 | 0 | 1.7 | 81 | 8 | 100 | 8.2 |
| 16 | 16 | 100 | 8.7 | 49 | 15 | 100 | 2.4 | 82 | 7 | 100 | 7.5 |
| 17 | 15 | 100 | 8.5 | 50 | 16 | 0 | 3.0 | 83 | 8 | 100 | 7.5 |
| 18 | 15 | 0 | 8.0 | 51 | 14 | 0 | 4.7 | 84 | 15 | 0 | 6.7 |
| 19 | 15 | 0 | 2.3 | 52 | 14 | 100 | 4.9 | 85 | 14 | 0 | 5.4 |
| 20 | 16 | 50 | 3.4 | 53 | 15 | 0 | 6.3 | 86 | 17 | 150 | 1.0 |
| 21 | 15 | 50 | 3.5 | 54 | 16 | 100 | 6.5 | 87 | 15 | 50 | 2.0 |
| 22 | 15 | 50 | 3.2 | 55 | 15 | 100 | 7.4 | 88 | 15 | 50 | 2.2 |
| 23 | 15 | 50 | 2.4 | 56 | 15 | 0 | 7.9 | 89 | 16 | 50 | 2.0 |
| 24 | 16 | 50 | 2.0 | 57 | 15 | 0 | 8.0 | | | | |
| 25 | 15 | 100 | 2.3 | 58 | 4 | 100 | 5.0 | | | | |
| 26 | 16 | 0 | 2.6 | 59 | 4 | 100 | 5.0 | | | | |
| 27 | 14 | 0 | 3.7 | 60 | 4 | 100 | 5.0 | | | | |
| 28 | 14 | 100 | 4.2 | 61 | 4 | 100 | 5.0 | | | | |
| 29 | 14 | 0 | 4.8 | 62 | 3 | 50 | 8.0 | | | | |
| 30 | 17 | 150 | 1.5 | 63 | 4 | 50 | 8.0 | | | | |
| 31 | 15 | 50 | 3.1 | 64 | 3 | 50 | 8.0 | | | | |
| 32 | 15 | 0 | 4.6 | 65 | 4 | 50 | 8.0 | | | | |
| 33 | 15 | 75 | 7.7 | 66 | 3 | 100 | 7.9 | | | | |

Data file: Noord 22
Crop rotation: Berseem, Cotton, Wheat, Rice

| I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) |
|---|---|---|---|---|---|---|---|
| 1 | 15 | 100 | 2.3 | 33 | 15 | 0 | 8.0 |
| 2 | 16 | 0 | 2.6 | 34 | 4 | 100 | 5.0 |
| 3 | 14 | 0 | 3.7 | 35 | 4 | 100 | 5.0 |
| 4 | 14 | 100 | 4.2 | 36 | 4 | 100 | 5.0 |
| 5 | 14 | 0 | 4.8 | 37 | 4 | 100 | 5.0 |
| 6 | 17 | 150 | 1.5 | 38 | 3 | 50 | 8.0 |
| 7 | 15 | 50 | 3.1 | 39 | 4 | 50 | 8.0 |
| 8 | 15 | 0 | 4.6 | 40 | 3 | 50 | 8.0 |
| 9 | 15 | 75 | 7.7 | 41 | 4 | 50 | 8.0 |
| 10 | 15 | 100 | 8.0 | 42 | 3 | 100 | 7.9 |
| 11 | 15 | 100 | 9.1 | 43 | 4 | 100 | 7.9 |
| 12 | 15 | 125 | 8.9 | 44 | 4 | 100 | 7.9 |
| 13 | 15 | 100 | 9.6 | 45 | 4 | 100 | 7.9 |
| 14 | 16 | 100 | 9.2 | 46 | 3 | 50 | 8.8 |
| 15 | 15 | 100 | 9.1 | 47 | 5 | 50 | 8.8 |
| 16 | 16 | 100 | 8.7 | 48 | 2 | 50 | 8.8 |
| 17 | 15 | 0 | 8.5 | 49 | 5 | 50 | 8.8 |
| 18 | 15 | 0 | 8.0 | 50 | 8 | 100 | 8.8 |
| 19 | 15 | 0 | 0 | 51 | 8 | 100 | 8.8 |
| 20 | 16 | 0 | 0 | 52 | 7 | 100 | 8.9 |
| 21 | 15 | 0 | 0 | 53 | 8 | 100 | 8.9 |
| 22 | 15 | 150 | 0 | 54 | 8 | 100 | 8.4 |
| 23 | 15 | 0 | 1.0 | 55 | 8 | 100 | 8.4 |
| 24 | 16 | 0 | 1.7 | 56 | 7 | 100 | 8.2 |
| 25 | 15 | 100 | 2.4 | 57 | 8 | 100 | 8.2 |
| 26 | 16 | 0 | 3.0 | 58 | 7 | 100 | 7.5 |
| 27 | 14 | 0 | 4.7 | 59 | 8 | 100 | 7.5 |
| 28 | 14 | 100 | 4.9 | 60 | 15 | 0 | 6.7 |
| 29 | 15 | 0 | 6.3 | 61 | 14 | 0 | 5.4 |
| 30 | 16 | 100 | 6.5 | 62 | 17 | 150 | 1.0 |
| 31 | 15 | 100 | 7.4 | 63 | 15 | 50 | 2.0 |
| 32 | 15 | 0 | 7.9 | 64 | 15 | 50 | 2.2 |
| | | | | 65 | 16 | 50 | 2.0 |

Data file: Nord 23
Crop rotation: Berseem, Rice, Berseem, Cotton, Wheat, Rice

| I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) | I | T(I,1) | T(I,2) | T(I,3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 100 | 2.3 | 36 | 15 | 0 | 6.7 | 71 | 16 | 100 | 6.5 |
| 2 | 16 | 0 | 2.6 | 37 | 14 | 0 | 5.4 | 72 | 15 | 100 | 7.4 |
| 3 | 14 | 0 | 3.7 | 38 | 17 | 150 | 1.0 | 73 | 15 | 0 | 7.9 |
| 4 | 14 | 100 | 4.2 | 39 | 15 | 50 | 2.0 | 74 | 15 | 0 | 8.0 |
| 5 | 15 | 50 | 4.8 | 40 | 15 | 50 | 2.2 | 75 | 4 | 100 | 5.0 |
| 6 | 16 | 100 | 5.3 | 41 | 16 | 50 | 2.0 | 76 | 4 | 100 | 5.0 |
| 7 | 15 | 100 | 5.8 | 42 | 15 | 100 | 2.3 | 77 | 4 | 100 | 5.0 |
| 8 | 15 | 100 | 6.2 | 43 | 16 | 0 | 2.6 | 78 | 4 | 100 | 5.0 |
| 9 | 15 | 100 | 6.7 | 44 | 14 | 0 | 3.7 | 79 | 3 | 50 | 8.0 |
| 10 | 4 | 100 | 5.0 | 45 | 14 | 100 | 4.2 | 80 | 4 | 50 | 8.0 |
| 11 | 4 | 100 | 5.0 | 46 | 14 | 0 | 4.8 | 81 | 3 | 50 | 8.0 |
| 12 | 4 | 100 | 5.0 | 47 | 17 | 150 | 1.5 | 82 | 4 | 50 | 8.0 |
| 13 | 4 | 100 | 5.0 | 48 | 15 | 50 | 3.1 | 83 | 3 | 100 | 7.9 |
| 14 | 3 | 50 | 8.0 | 49 | 15 | 0 | 4.6 | 84 | 4 | 100 | 7.9 |
| 15 | 4 | 50 | 8.0 | 50 | 15 | 75 | 7.7 | 85 | 4 | 100 | 7.9 |
| 16 | 3 | 50 | 8.0 | 51 | 16 | 100 | 8.0 | 86 | 4 | 100 | 7.9 |
| 17 | 4 | 50 | 8.0 | 52 | 15 | 100 | 9.1 | 87 | 3 | 50 | 8.8 |
| 18 | 3 | 100 | 7.9 | 53 | 15 | 125 | 8.9 | 88 | 5 | 50 | 8.8 |
| 19 | 4 | 100 | 7.9 | 54 | 15 | 100 | 9.6 | 89 | 2 | 50 | 8.8 |
| 20 | 4 | 100 | 7.9 | 55 | 16 | 100 | 9.2 | 90 | 5 | 50 | 8.8 |
| 21 | 4 | 100 | 7.9 | 56 | 15 | 100 | 9.1 | 91 | 8 | 100 | 8.8 |
| 22 | 3 | 50 | 8.8 | 57 | 16 | 100 | 8.7 | 92 | 8 | 100 | 8.8 |
| 23 | 5 | 50 | 8.8 | 58 | 15 | 0 | 8.5 | 93 | 7 | 100 | 8.9 |
| 24 | 2 | 50 | 8.8 | 59 | 15 | 0 | 8.0 | 94 | 8 | 100 | 8.9 |
| 25 | 5 | 50 | 8.8 | 60 | 15 | 0 | 0 | 95 | 8 | 100 | 8.4 |
| 26 | 8 | 100 | 8.8 | 61 | 16 | 0 | 0 | 96 | 8 | 100 | 8.4 |
| 27 | 8 | 100 | 8.8 | 62 | 15 | 0 | 0 | 97 | 7 | 100 | 8.2 |
| 28 | 7 | 100 | 8.9 | 63 | 15 | 150 | 0 | 98 | 8 | 100 | 8.2 |
| 29 | 8 | 100 | 8.9 | 64 | 15 | 0 | 1.0 | 99 | 7 | 100 | 7.5 |
| 30 | 8 | 100 | 8.4 | 65 | 16 | 0 | 1.7 | 100 | 8 | 100 | 7.5 |
| 31 | 8 | 100 | 8.4 | 66 | 15 | 100 | 2.4 | 101 | 15 | 0 | 6.7 |
| 32 | 7 | 100 | 8.2 | 67 | 16 | 0 | 3.0 | 102 | 14 | 0 | 5.4 |
| 33 | 8 | 100 | 8.2 | 68 | 14 | 0 | 4.7 | 103 | 17 | 150 | 1.0 |
| 34 | 7 | 100 | 7.5 | 69 | 14 | 100 | 4.9 | 104 | 15 | 50 | 2.0 |
| 35 | 8 | 100 | 7.5 | 70 | 15 | 0 | 6.3 | 105 | 15 | 50 | 2.2 |
| | | | | | | | | 106 | 16 | 50 | 2.0 |